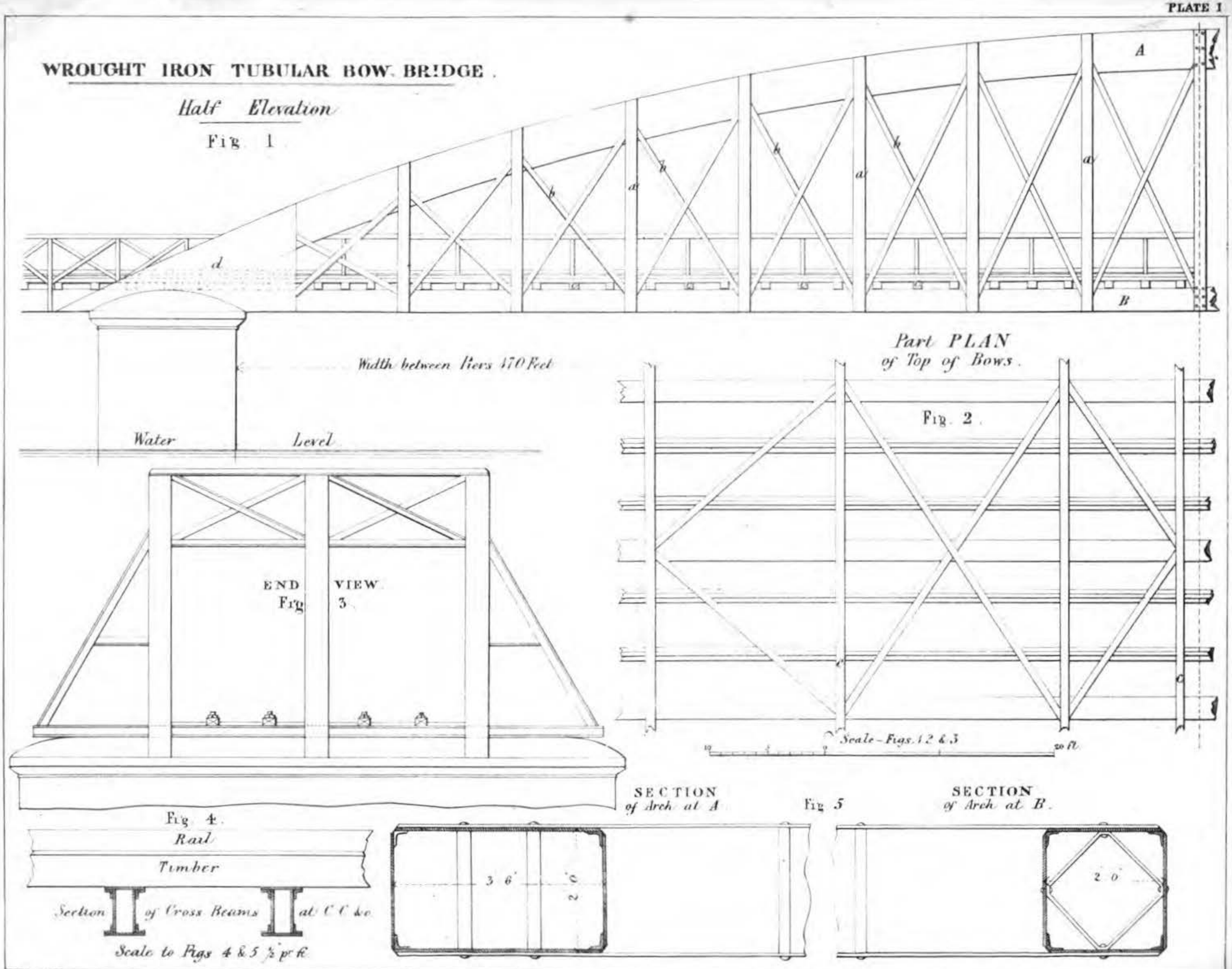
WROUGHT IRON TUBULAR BOW BRIDGE.
Half Elevation
Fig. 1
A
B
a
b
d
Width between Piers 170 Feet
Water Level
Part PLAN
of Top of Bows.
Fig. 2.
C
Scale - Figs. 1 2 & 3
10
0
20 ft
END VIEW
Fig. 3.
Fig. 4.
Rail
Timber
Section of Cross Beams at C C &c.
Scale to Figs 4 & 5 ½" pr ft
SECTION
of Arch at A
Fig 5
SECTION
of Arch at B.
3 6
2 0
2 0

C Basler

THE

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THE

CIVIL ENGINEER AND ARCHITECT'S

JOURNAL.

WROUGHT-IRON TUBULAR BOW BRIDGE.

(With an Engraving, Plate I.)

In consequence of the tubular form becoming a favourite mode of constructing bridges of wrought-iron for railway purposes, we are induced to give an engraving of a wrought-iron tubular bow suspension bridge for crossing the Ouse river in Norfolk, designed by Mr. W. C. Harrison, who has had considerable experience in the construction of some large timber bow suspension bridges on some of the Norfolk railways.

Mr. Harrison observes,—"The facility with which a bow bridge of this construction, with boiler-plate, could be put together, appeared so evident, that he felt convinced of its practicability and usefulness for railway purposes, in crossing rivers and valleys, to almost any extent. A bridge of this kind could be easily put together, by the same kind of workmanship as in steam boilers, in a manufactory in any part of the country, and in certain convenient lengths of 10, 15, or 20 feet each, for the purpose of transporting to its destination, so that there will be but a few joints to rivet up when put in its place. The bow being hollow, and also the tie-beam, or string as it may be termed, gives the opportunity for a man to get inside to hold up the rivets for the workmen outside to rivet the parts together.

"The bow and string are to be made of plate-iron, of such a thickness as is most suitable to the size of the bridge intended to be constructed, and joined at the angles with angle-iron; and it will be perceived from the engraving how perfectly well connected the extreme ends of the tie-beam and bow will be by the manner shown, which is a plate extending over the tie and bow, firmly rivetted to each, thereby answering the purpose of an abutment to the bow, and giving perfect security in a vital part.

"The elevation of the bridge shows both the suspending and cross-brace bars, being all of plate-iron, from the facility of getting bars in this shape so easily made, and requiring so little workmanship—namely, the rivet holes made in their ends.

"The design is for a span of 170 feet and two lines of rails; consequently, there are three bows. Fig. 1 is the elevation of one-half the span, with the suspending bars *a a* and *b b*; *d d*, the abutment plates, as they may be called; *c*, the cross-beams, which may be of iron or timber. Fig. 2, a view on the top of the bows, with some of the cross-beams, *c*, extending outside (as also seen at fig. 3, the end elevation), to receive the lower ends of the struts going up to the top of the outside of the bows, to give steadiness to the whole; but these can be used or not. Fig. 3 shows the distance-pieces and cross-frames between the bows. Fig. 4 is a section of the cross-beams or girders, which may also be made of wrought-iron plate and angle-iron, or wood, to carry the timber sleepers of the rail. Fig. 5 is an enlarged section of the bow and string, and the distance-piece between the suspending bars."

Mr. Harrison proposes for a bridge of the span shown in the engraving, that the bow should be constructed of half-inch plate-iron, 4 feet deep by 3 feet wide; and the tie-beam or stringer 2 ft. 6 in. deep by 3 feet wide.

Next month we will endeavour to offer some remarks on the construction of bridges of the tubular form, as to their applicability for railway purposes.

A DEFLECTION OR VIBRATION GAUGE.

By George Howard Fenwick, C.E.

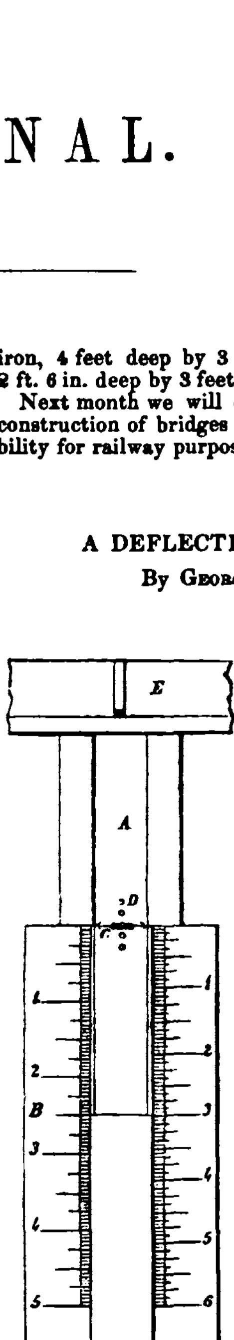


Fig. 1, Elevation.

The accompanying engraving, fig. 1 (drawn to one-third the full size), is a gauge for registering the vibration or deflection of railway girders. A is a piece of wood or metal, made to slide in another piece, B, which is held in position by a slight pressure of two springs, G and F, as shown on plan fig. 2 (drawn full size). On the face A are two arrows at C, which can be moved to any of the holes at D for adjustment. It is supposed to be set at zero, and as it receives the pressure from the girder E it is pressed down, thereby registering the deflection of the girder on a decimal or mechanical divided scale on B. This gauge may be applied by being supported by a frame let into the sides of the walls which the girders span, and so made to travel to any particular place, such as the centre or springings; or may be placed upon a staff for convenience, similar to a levelling staff.

G. H. F.

[This simple and ingenious contrivance might, perhaps, be improved by fixing a vernier on the slide D, divided so as to indicate the hundredth parts of an inch; the side scales being divided into inches and tenths.]—Editor.

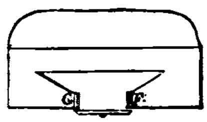


Fig. 2, Plan.

NOTES ON ENGINEERING.—No. VIII.

By HOMERSHAM COX, B.A.

On the most Economical Forms of Suspension Bridges.

Of all kinds of bridges suspension bridges are capable of being constructed with the greatest span. Notwithstanding this advantage and the facility of construction, the use of these structures has been restricted by their flexibility and tendency to undulate. They have fallen into disrepute in the modern practice of engineering, on account of the difficulty (generally deemed insuperable) of making them sufficiently rigid for the purposes of heavy traffic, such as that upon railways. Another, though less obvious, objection is that the ordinary methods of calculating the proper form and dimensions of suspension bridges, and the different strains to which they are subjected, are exceedingly complicated. The intricacy of the investigations leaves a degree of uncertainty and distrust as to the actual strength which the several parts of a suspension bridge may be assumed to possess.

The object of the present paper is to examine how far these difficulties may be removed, and to show what method of arranging the different parts of the structure secures the greatest amount of strength for the whole.

Suspension bridges may be distinguished generally into two classes: 1st., those of the ordinary form, that of a main chain or catenary, with the roadway suspended from it by vertical rods; 2nd., those in which the roadway is suspended directly from the abutments by straight rods, the catenary or curve chain being altogether dispensed with. It will be shown, on strict statical principles, that the first method involves a great waste of material, and that, by a proper arrangement of *straight* rods, a given amount of strength may be secured with a smaller quantity of iron, or a greater amount of strength with a given quantity of iron, than by the use of a main catenary. Of course, methods of using straight rods may be employed which involve greater waste of material than even the employment of the curved chain. The most economical arrangement of straight rods is not a merely arbitrary matter, but depends, like every other branch of engineering, on sound deductions from the laws of mechanics.

Before proceeding with the investigation, it may be as well to remind the reader that the object of these Notes on Engineering is to simplify the practical applications of theory, and to explain them, as far as possible, in familiar, untechnical language. This important rule should be constantly remembered by all who teach and all who study the mathematics of engineering—*that long formulæ are never put into practice.* In practice, simple general principles are far more useful, because capable of being applied with far more certainty and facility, than the most elaborate results of scientific research.

We now proceed to establish the following important general

PROPOSITION.—*In a suspension bridge the material required to sustain a given load will be the least when each point of support in the roadway is directly connected with a point of suspension in the nearest abutment by one independent straight rod.*

To begin with the simplest case, it will be first of all supposed that only two points of support in the roadway are connected with the point of suspension. Suppose that B (fig. 1) is the point of

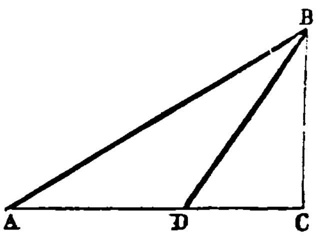


Fig. 1.

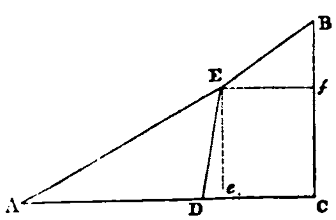


Fig. 2.

suspension; A and D the two points of support in the horizontal platform A C. Then it will be shown that to sustain a given load, the most economical arrangement of the suspension bars consists in connecting B with A D independently and directly by two rectilinear rods, A B and D B. If, however, as in fig. 2, the connection be *indirectly* made by suspension rods meeting at an intermediate point E, more material will be required for a given amount of strength.

In order to prove this proposition, which has so important a relation to the most usual methods of constructing suspension bridges, it is necessary to ascertain the quantities of material in the rod A B and B D (fig. 1), and the rods A E, D E, and B E (fig. 2), and to compare the aggregate amount of material used in both cases. It is, of course, presupposed that the strength of the rods is proportioned to the strain upon them. In ascertaining the thickness to be given to the rods of a suspension bridge, the first point to be settled is the amount of strain which the material will bear on each square inch of the sectional area. For the purpose of mere *comparison*, it is indifferent what amount be assumed: it may therefore be supposed that the rods are to be calculated to bear a strain or tension of t lb. per square inch of their sectional area. Consequently, multiplying the sectional area of any rod by t, we have the whole strain to which it is subjected. Further, for purposes of comparison it is indifferent what be the load on the bridge, so that in both cases the weights at corresponding points of the platform be supposed the same: let it therefore be assumed that both in fig. 1 and fig. 2 the point A has to sustain a vertical weight w, and also (for the sake of simplicity) that the point D in both figures has to sustain the same weight w.

It will (at first) be taken for granted that the platform contributes nothing by its rigidity to sustain the load; that the whole weight is borne by the suspension rods, which are kept in their oblique position by the connection of the platform. The amount of material requisite to support w at the point A will first be considered.

Commencing with the case of fig. 1, we have, since the rod A B sustains the weight w at A, the vertical component of the tension of A B equal to w. Supposing the sectional area of this rod to be k square inches, its tension, by what has been already said, will be $k\,t$.

$$\therefore\ w = k\,t \sin \mathrm{BAC} = k\,t\,.\,\frac{\mathrm{BC}}{\mathrm{AB}};\quad k = \frac{w}{t}\cdot\frac{\mathrm{AB}}{\mathrm{BC}}.$$

Consequently, the mass of the rod = its sectional area multiplied by its length $= \dfrac{w}{t}\,\dfrac{\mathrm{AB}^2}{\mathrm{BC}}$ .... (1).

Proceeding now to the case of fig. 2, and still confining attention to the suspension of the point A, by reasoning exactly the same as that for fig. 1, the mass of the rod $\mathrm{AE} = \dfrac{w}{t}\,\dfrac{\mathrm{AE}^2}{\mathrm{E}e}$, (E e being drawn vertical.)

It is clear that the connection between the point B and the point E may be supposed to be established, not by a simple bar, but by a compound bar of two or more parallel lengths. In fact, this method is that usually adopted in actual practice, the several links of the chain commonly consisting of several bars or iron plates laid side by side, and connected at their extremities. Their relative thickness is a matter of indifference, provided that the total thickness be sufficient to sustain the strain. In fig. 2 the rod B E, provided it have the thickness necessary to sustain the united effects of the two weights at A and D, may be supposed to be made up of any number of parallel bars of any relative thickness whatever. Now, supposing B E to be a compound bar, let k' be the sectional area or thickness of metal due to the effect of the weight at A, k'' the thickness due to the weight at D: $k' + k''$ will be the total thickness of B E.

Taking the thickness k' to be that requisite to sustain w at A, and $k't$ the consequent amount of tension of that part of the compound bar, we have the vertical component of $k't$ (= vertical component of tension along A E) = w. Hence, if E f be drawn horizontal, $w = k't \sin \mathrm{BE}f = k't\,\dfrac{\mathrm{B}f}{\mathrm{EB}}$, $\therefore k' = \dfrac{w}{t}\,\dfrac{\mathrm{EB}}{\mathrm{B}f}$.

Multiplying this quantity by the length E B, and adding the mass of the rod ascertained above, we have the total mass of metal required to connect A and B $= \dfrac{w}{t}\left\{\dfrac{\mathrm{AE}^2}{\mathrm{E}e} + \dfrac{\mathrm{EB}^2}{\mathrm{B}f}\right\}$ .... (2)

Hence subtracting the expression (1) from the expression (2), it will be easily found by some simple analysis, which is here omitted for the sake of brevity, that the mass required for the indirect connection A E B, fig. 2, exceeds the mass required for the direct or rectilinear connection, A B fig. 1, by a quantity

$$\frac{(\mathrm{BC}\,.\,\mathrm{E}f - \mathrm{AC}\,.\,\mathrm{E}e)^2}{\mathrm{BC}\,.\,\mathrm{B}f\,.\,f\mathrm{C}}\cdot\frac{w}{t},$$

which is positive in all cases. Hence, more material is always required for the indirect than for the direct connection of A and B.

The same mode of reasoning applies to the weight suspended at D.

The form of the analysis is such that it applies to this case as well as the last, and leads to a similar conclusion—that the indirect or bent connection, D E B, requires more material than the direct or rectilinear connection, D B. Now it is evident, that what is true of the several parts of the system individually, is true of the whole collectively—that if less material be required for each of the direct connections than for each corresponding indirect connection, the total material required for all the former will be less than the total material required for the whole of the latter. In other words, *the system of suspension in fig. 1 is the most economical.*

The same result might have been obtained by supposing B E a simple, undivided bar, and the amount of material given by that hypothesis would be the same as that on the hypothesis here adopted. But the method of investigation given above leads more easily to the general results for which we are seeking. It has the advantage of admitting immediately, and without any more mathematical analysis, the following important

COROLLARY.—*The method of suspension* (fig. 1) *is more economical than the method* (fig. 2), *for* ANY *number of points of support in the platform.*

For the reasoning given above is not affected by supposing the rod B E to divaricate at E into three or more radial bars proceeding to as many points of support in the roadway. Whatever might be the number of indirect connections by this method, each of them would require more material than the corresponding direct connection of fig. 1: and therefore the total quantity of metal required by the former method exceeds the total quantity required by the latter method.

We have hitherto considered, in the second or indirect method, only one point of divarication, E: the inquiry will be completed by considering several other such points to exist—as at B, B′, B″, B‴, &c., fig. 3.

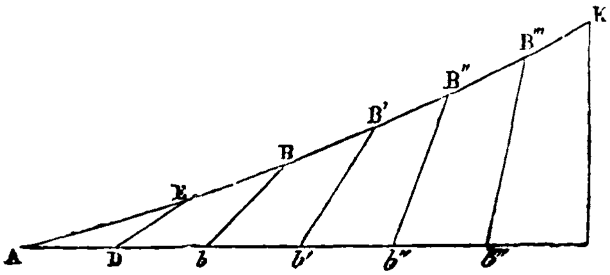


Fig. 3.

The connection of A and D with B, by bars meeting at E, has been already considered. Less material would have been required to support the weight at A and D, if, instead of the method shown in fig. 3, there had been separate straight rods from A and D to B. In this latter case, B′ (the next point of suspension) would be connected with the *three* points A, D, *b*, by three straight rods, divaricating from the end B of a common rod B B′.

The "Corollary" given above shows that this triple divarication involves a waste of material. Had there been in the place of it, three straight rods from A, D, and *b*, to B′, less material would have been required to support the corresponding weight. But this triple divarication itself requires less material than the method shown in fig. 3. Hence, *a fortiori*, the direct connection with B′ would require still less material than the method shown in the figure. And so, by continuing the same mode of reasoning for the other points, B″, B‴, &c., we come at last to the general conclusion that, if all the points of support had been directly and independently connected with K (the ultimate point of suspension), less material would have been required to sustain given loads than by the method shown in fig. 3.

This conclusion is independent of the inclination of the rods E D, B *b*, B′*b*′, B″*b*″, &c., and remains true when they are vertical. Hence, in the common suspension bridges, such as those at Charing-cross, Hammersmith, &c., with a main chain or catenary hanging between the abutments, and connected with the platform by vertical rods, there is a waste of material. The same conclusion applies to all suspension bridges having radial bars radiating from any point except the points of ultimate suspension at the abutments—and, therefore, hold with respect to the bridges on Dredge's principle, some of which are erected in the Regent's-park, and of which one recently gave way and was destroyed near Calcutta.

The amount of saving effected by connecting all the points in the platform with the abutments by independent straight rods, may be best shown by an example. The Hungerford bridge, at Charing-cross, may be taken as a familiar example—and we will, therefore, proceed to compare the material required for that bridge by the method actually adopted, and the quantity which would be required by the method here advocated.

The quantity of material required for suspending the bridge by a catenary and vertical rods will first be considered. The position of the centre of gravity of the half-span depends on the form and weight of the chain, and the manner in which the load is distributed along the platform. When the load is small compared with the weight of the chain, the centre of gravity of half the bridge and load will be nearer the abutment than the centre of the bridge: for the curvature of the chain, its increase of thickness near the point of suspension, and the increased length of the vertical rods, all tend to make the weight preponderate towards the abutment. But when the bridge is supposed to be loaded with a breaking weight greatly exceeding the weight of the chain, and uniformly distributed along the platform, it may be assumed, without sensible error that the horizontal distribution of the weight of the *whole* system is uniform. In this case, the centre of gravity of the half-span will be midway between the abutment and centre of the bridge.

At this latter point the tension of the catenary is horizontal. Let moments be taken about the point of suspension for the equilibrium of the half-span: then, since the horizontal tension in question acts below the point of suspension, at a vertical distance equal to the deflection of the chain, and since the weight acts at a horizontal distance from the same point equal to the quarter-span, the products of each of these forces into the corresponding distance will, by the Principles of Moments, be equal. Hence, calling W the total weight of the half-span (including the half-chain), T the horizontal tension, *d* the deflection, *a* the quarter-span,—it follows that

$$W a = T d; \quad \text{or } T = W\frac{a}{d} \text{ ....(1).}$$

That is, *the horizontal tension = the weight of the half-span multiplied by the ratio of the quarter-span to the deflection;* a simple rule, from which the horizontal tension of the chain of any suspension bridge loaded with its breaking weight may generally be calculated with sufficient accuracy.

It has been assumed that the load is uniformly distributed, or that any portion of the weight is proportional to the length of the corresponding portion of the platform. It follows, that if any distance, x, be measured along the platform from the lowest point of the chain, the weight corresponding to that distance is $W\frac{x}{2a}$.

Also, if y be the vertical ordinate of the chain at the same distance, a known principle which applies to catenaries of every form gives

$$\frac{dy}{dx} = W\frac{x}{2a} \div T = \frac{W x}{T 2a} \text{ .... (2)}$$

By another known principle which also applies to all kinds of catenaries, the tension at the point (x, y) is equal to

$$T \cdot \left(1 + \frac{dy^2}{dx^2}\right)^{\frac{1}{2}}.$$

And since the sectional area of the chain at any point is supposed proportional to the strain at the same point, we have, if K and k be sectional area at point (x, y), and the lowest point of the chain respectively

$$K = k\left(1 + \frac{dy^2}{dx^2}\right)^{\frac{1}{2}}.$$

The mass of each small portion of the length of the chain is the product of that element of length, and the corresponding sectional area: hence it will be easily seen that the

$$\text{mass of the half-chain} = k\int_0^{2a}\left(1 + \frac{dy^2}{dx^2}\right)dx.$$

And this quantity by substitution from (2) will be found equal to $2ak\left(1 + \frac{W^2}{3T^2}\right)$. Finally, if the tension per square inch be t, and consequently $T = kt$, and if a be put $= 170$ feet, and $d = 50$, it will be readily ascertained that the

$$\text{mass of the half-chain} = \frac{w}{t} \times 1189{\cdot}3.$$

(which are almost exactly the values of those quantities in the Hungerford Bridge.)

To obtain the whole quantity of material required for the purposes of suspension, we must add to the quantity last obtained, the mass of the suspension rods. The length of these increases from the centre to the abutment, and is equal to that of the vertical co-ordinates of the catenary.

The integration of equation (2) gives the relation of y to x, which will be found such that *the proportion between any two vertical co-ordinates is equal to the square of the proportion between the corresponding horizontal co-ordinates*—a very simple rule for determining the form which the chain will nearly assume when subject to its breaking weight.

It follows from this rule, that when

x is	$\frac{1}{20}$th of the half-span,		y is	$\frac{1}{400}$th of the deflection	
x	$\frac{2}{20}$ths	,,	y	$\frac{4}{400}$ths	,,
x	$\frac{3}{20}$ths	,,	y	$\frac{9}{400}$ths	,,
x	$\frac{4}{20}$ths	,,	y	$\frac{16}{400}$ths	,,
	&c.	,,		&c.	,,

Now, if we suppose the half-platform attached to the half-chain at every 20th of the length of the former, we shall, by adding up all the y's in the above scheme, get the total length of all the vertical rods together, which, therefore, is equal to

$$\tfrac{1}{400}\,(1 + 2^2 + 3^2 + 4^2 + \ldots\ldots\ldots\ldots\ldots + 19^2) \times \text{deflection};$$

and this by actual calculation is equal to the deflection × 6·175. Therefore, since the deflection is 50 feet, the total length of all vertical rods is 308·75 feet. This supposes that the platform meets the chain at the centre, the value of y at that point being zero.

Each rod sustains one-twentieth of the weight of the half-span, and therefore has a tension $= \frac{1}{20}w$. Therefore, if, as before, t be the tension per square inch of the sectional area, that area, by principles already laid down $= \frac{1}{20}\frac{w}{t}$. The mass of all the rods equals this quantity × the length 308·75 feet, just obtained $= \frac{w}{t} \cdot 15{\cdot}4$. Adding this to the mass of the half-chain, we have finally

the mass of the half-chain and its rods $= \frac{w}{t} \times 1204{\cdot}7 \ldots\ldots\ldots$(A).

Next, let it be ascertained what is the quantity of material required when the load is supported by straight rods exclusively. It has been shown that if $\frac{1}{20}w$ be sustained at A by a straight rod A B, the mass of that rod $= \frac{1}{20} \cdot \frac{w}{t} \cdot \frac{AB^2}{BC}$. This expression (since A B C is a right angled triangle, and therefore $AB^2 = AC^2 + BC^2$,) is equivalent to $\frac{1}{20}\,\frac{w}{t}\left(\frac{AC^2}{BC} + BC\right)$. When

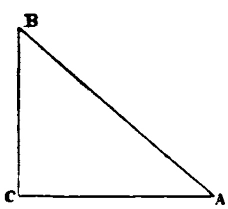


Fig. 4.

A C is	$\frac{1}{20}$th of the half-span,		$AC^2 =$	$\frac{1}{400}(2a)^2$
A C	$\frac{2}{20}$ths	,,	AC^2	$\frac{4}{400}(2a)^2$
A C	$\frac{3}{20}$ths	,,	AC^2	$\frac{9}{400}(2a)^2$
	&c.			&c.

Adding up all the values of AC^2, we get for the total mass of the rods

$$\frac{1}{20}\,\frac{w}{t}\left\{(1 + 2^2 + 3^2 + \ldots\ldots\ldots 19^2)\,\frac{(2a)^2}{400\,.\,BC} + 19\,BC\right\} =$$

$$\frac{1}{20}\,\frac{w}{t}\left\{6{\cdot}175\,\frac{(2a)^2}{BC} + 19\,BC\right\} = \frac{w}{t}\,761{\cdot}3 \ldots\ldots\ldots\ldots\ldots\ldots \text{(B)}.$$

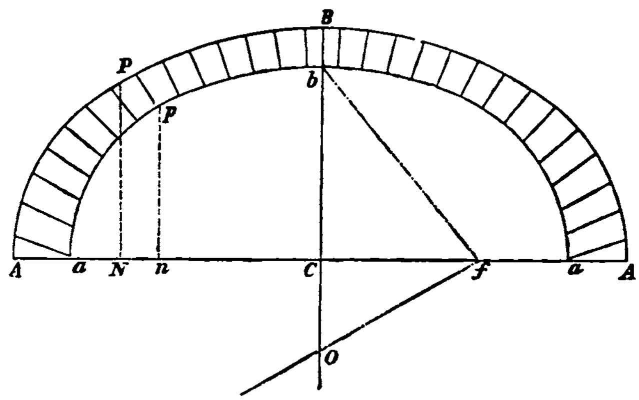
Comparing the expression (B) with (A), we see that the material required in one case is about $\frac{7}{12}$ths of what is required in the other case. In other words, *if a suspension bridge, of the dimensions of the Hungerford bridge, were sustained by independent oblique rectilineal rods, instead of a main chain and vertical rods, a saving of nearly half the material would be effected.*

It will be hereafter shown, that great as is this advantage with respect to the power of the bridge to sustain a statical load uniformly distributed, still greater advantages belong to the method of suspension here advocated, when the effect of moveable loads is taken into consideration.

THE OBLIQUE ARCH.

On the Focus to which the Joints on the Face converge.

Suppose a right-angled plane triangle formed of any flexible material, having its two sides respectively equal to L, the axial length, and πr, the semicircle obtained by taking a section of the bridge perpendicular to the axis. If the side L be placed along the top of the abutment of an oblique bridge, and the triangle wrapped over the laggings, the hypothenuse will form a spiral line, which is the intersection of the coursing joints and soffit. If a straight line move along the axis of the cylinder, so as always to intersect it at right angles, and pass through the hypothenuse of the above triangle, it will generate the twisted surface proper for the beds of the stones. Mr. Buck was the first to show that the joints that appear on the face of the arch, pass through a point O, below the centre C, when the "section on the square," or section perpendicular to the axis, is a *circle*. A similar expression for the length of the line C O may be obtained when the sections of the intrados and extrados, made by a plane perpendicular to the axis, are similar ellipses.



Let the figure represent the elevation of an oblique bridge, circular or elliptic "on the square"—if it be segmental, the ellipses must be supposed completed. Take the axis of the cylinder for the axis of y, and let the plane xy be horizontal. A, B; a, b, are the semi-axes, major and minor, of the extrados and intrados respectively. A × E, a × E, the lengths of these semi-ellipses. S = arc A′P, where C N = A cos θ; and s = arc $a'p$, where Cx = arc $a'p$. L = axial length. Ω = acute angle between the directions of the roads. ϕ = angle of extrados; and, therefore, $\tan\phi = \frac{AE}{L}$.

The equations to the extradosal and intradosal spiral are, respectively,

$$\left.\begin{aligned} X &= A\cos\theta \\ Y &= \frac{L}{AE}S \\ Z &= B\sin\theta \end{aligned}\right\}(1) \qquad \left.\begin{aligned} x &= a\cos\theta \\ y &= \frac{L}{aE}s \\ z &= b\sin\theta \end{aligned}\right\}(2)$$

and the equation to the face of the arch is $y = x\cot\Omega + d$. (3)

Let X′ Y′ Z′, x' y' z', be the co-ordinates of the points in which the corresponding extradosal and intradosal spirals meet the face of the arch. Then X′ Y′ Z′, x' y' z', are co-ordinates of a point in the face of the arch, and must satisfy equation (3).

$$\therefore\ Y' = X'\cot\Omega + d;\ \text{and}\ y' = x'\cot\Omega + d;$$

$$\therefore\ X' - x' = (Y' - y')\tan\Omega = \frac{L}{E}\left(\frac{S}{A} - \frac{s}{a}\right)\tan\Omega =$$

$$\frac{A}{\tan\phi}\left(\frac{S}{A} - \frac{s}{a}\right)\tan\Omega.$$

In order to determine the length of CO, it will be sufficient to confine our attention to the projection on the plane xz, of a straight line passing through X′Y′Z′, $x'y'z'$. The equation to this projection is

$$z - Z' = \frac{Z' - z'}{X' - x'}\left(x - X'\right);$$

and if $x = 0$, $z = $ CO, $\therefore$ CO $= -\dfrac{Z'x' - z'X'}{X' - x'} =$

$$-\frac{B\sin\Theta\, a\cos\theta - b\sin\theta\, A\cos\Theta}{X' - x'} = -\frac{Aa\sqrt{1-e^2}\sin(\Theta-\theta)}{\frac{A}{\tan\phi}\left(\frac{S}{A}-\frac{s}{a}\right)\tan\Omega} =$$

$-b\cot\Omega\tan\phi\dfrac{\sin(\Theta-\theta)}{\left(\frac{S}{A}-\frac{s}{a}\right)} = -b\cot\Omega\tan\phi$ nearly, since the difference of Θ and θ is always very small.

Hence, whether the "section on the square" be circular or elliptic, at the point b make the angle $fbC = 90 - \Omega$; and at the point f, where bf meets Ca, make the angle $CfO = \Phi$, the angle of the extrados; the point O where fO meets bC produced is the focus to which the joints on the elevation converge. $CO = Cf\tan\phi = CB\tan(90-\Omega)\tan\phi = b\cot\Omega\tan\phi$

If the section perpendicular to the axis be circular, f will be the focus of the ellipse $a'ba$, and may be readily found by describing from the centre b, with radius Ca, an arc of a circle which will cut Ca in f, the focus of the ellipse $a'ba$. If we had considered this case alone, the preceding calculations would have been much simplified, for then $A = B = R$; $a = b = r$; $AE = \pi R$; $aE = \pi r$; $S = R\Theta$; $s = r\theta$; and $CO = -r\cot\Omega\tan\Phi\dfrac{\sin(\Theta-\theta)}{(\Theta-\theta)}$.

The line fO may be readily and accurately drawn by setting off with any scale of equal parts fh = axial length, and erecting a perpendicular hk equal the semicircle or semi-ellipse in which a plane perpendicular to the axis cuts the extrados.

F. Bashforth.

CANDIDUS'S NOTE-BOOK.

FASCICULUS LXXVII.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. I must confess to being completely disappointed by Hay's book on the "Laws of Harmonious Colouring;" nor at all the less so for its having reached a sixth edition, when had reviewers reported of it conscientiously at first, its futility for any purpose of real instruction would have been pronounced long ago. It is not to be denied that it contains some useful information in regard to the colours—that is the pigments, employed in house-painting; which may have caused a demand for the book among the operatives in that humble branch of art. But as to any direct insight which it affords into the theory and principles of artistic colouring, as one main auxiliary to architectural design and effect, it is altogether null. Or, at the very best, it merely affords a faint glimmering here and there of something like approximation to the subject promised by the title-page. Possibly, Mr. Hay is fully capable of clearly explaining to others the doctrine which, it may be presumed, he has satisfactorily established for himself. Nevertheless, he has thrown very little, if any, light upon the matter. To say the truth, his book shows no disposition to communicate more than he can possibly help; in which respect, however, he is by no means singular, there being many other books of a similar description, in which the information is studiously concealed,—either evaded, or else wrapped up in oracular brevity, or in verbiage overclouded by more than oracular obscurity. Had Mr. Hay, instead of theorizing so much, *ins blane*, as the Germans say, condescended to exemplify harmony of colouring in decoration by a few positive instances—both such as were distinguished for the observance, and others which proved its value by showing the errors arising from neglecting it—he would have supplied his readers with some really useful lessons; whereas now he leaves them entirely to themselves to take their chance for making out what he, as their professed instructor, should have carefully explained step by step Where he ought to have been most of all full and explicit, he is more vague and brief than elsewhere. On the other hand, he is somewhat loquaciously prolix in regard to the work done by him at Abbotsford, notwithstanding that it does not in the slightest degree serve to illustrate the Laws of Harmonious Colouring, the painting being there confined to the mere imitation of oak and wainscotting. In short, the book is a rather humbugging affair, for the light which Mr. Hay has thought proper to afford us amounts to no more than "darkness visible," and there he leaves us to grope about

II. The fresco scheme for the decoration of the Palace of Westminster does not, it seems, answer expectation,—at least so does not what has been done in the House of Peers, where the experiment has been first of all made, instead of the artist acquiring proficiency in that mode of painting, by being employed in less important parts of the building before touching that which ought to display, not the efforts of "'prentice hands," but the mastery acquired by matured proficiency. Among other defects and oversights complained of, it is now discovered that, partly owing to the profusion of gilding and vivid colours of the other decorations, the frescoes do not produce the anticipated effect, they being in a great measure overpowered and eclipsed by what is mere embellishment. Thus they are in a manner converted from principal objects as works of art, into quite secondary ones as regards the general *ensemble*,—a serious defect, that will be further increased when all the windows shall have been filled with stained glass, whose brilliant hues will inevitably cause the frescoes to appear, by contrast, feeble and faded, more especially as the windows occupy so very large a proportion of surface. The only remedy which is now left, is to moderate the scheme of colouring for the windows, by executing them nearly entirely in chiaro-scuro, with only a few touches of positive colour here and there. Yet even this would be unsatisfactory in another respect, because such sparing application of colour in the glass would be out of keeping with the showiness in regard to colour of much of the ornamental work. The fact is, the decorations of the "House" have been studied only piecemeal, and those employed upon them have considered no more than their own particular share, without at all calculating the general effect. As far as the frescoes are concerned, it would surely have been easy enough to ascertain their effect beforehand, by filling in all the six compartments with the cartoons for the respective subjects. Yet, obvious and simple as such mode of preparatory trial was, it seems, somehow or other—perhaps owing to the fatality which hangs over all our public undertakings in art—to have been overlooked. Bold as it may be thought to say so, a determined system of blundering seems to be established for them. Certainly not the slightest pains are taken to prevent blunder, by proper experiment previous to the work being actually commenced. On the contrary, the chief precaution taken is to keep matters entirely in the dark, until some irreparable mischief has been committed; and the only satisfaction left us is to amuse ourselves by wondering that they should have been managed so perversely.

III. Of so-called religious subjects in painting, some are audaciously profane, others the most trivial in matter, and one and all equally fabulous; giving us only the fancies of artists for the representations of historical events. Religion may have been the patron of art, but art has been but a very questionable, if not positively treacherous, ally to religion. It served Popery during the middle ages, for the impostures of the one were in keeping with the impostures of the other. But for pure Christianity, art can do just as much and no more than it can for the advancement of pure mathematics. There is a great deal of very palpable and maudlin cant afloat in regard to religious art. Hardly were any of the great masters inspired; on the contrary, many of them were anything but exemplary in their lives, and exercised their pencils on the lewd traditions of pagan mythology with quite as much gusto as they did on the traditions of the Church. Mediæval art has, besides, contributed not a little to that fundamental superstition of popery, Monolatry, against which worship of the pretended "Queen of Heaven," the Salic law ought to be enforced amongst Catholics.

IV. Notwithstanding their piddling and minikin pedantry, architectural writers are apt to be exceedingly careless in their language, frequently employing expressions and terms after a truly nonsenical fashion. They will speak, for instance, of an order as being "of colossal *proportions*"! the proportions being all the while precisely those which are generally followed for the particular order in question. Of course, they mean "dimensions" or "scale;" therefore, to use the other term, betrays strange confusion of ideas and the meaning of words. Nothing, again, is more common than the truly barbarous solecism—one for which a schoolboy would be corrected as a dunce—of employing the term "Intercolumniation," not in its own proper sense, but in that of "Intercolumn;" which is nothing less than marring technical language, and doing away with those distinctions in it which are essential to its accuracy. If there be anything that can excuse such a truly vulgar blunder, it is the authority it receives from our architectural-dictionary-makers, some of whom among their other qualifications seem to have been totally ignorant of the languages from which most of the terms of the art have been borrowed for our own. The confounding together the terms "Intercolumniation" and "Intercolumn"—or rather the rejection of the latter altogether, notwithstanding they are quite distinct in meaning—is peculiar to English writers, those of other countries properly observing the distinction between them. Just as well might we use "Columniation" in the sense of "Column," and speak of a portico as consisting of so many columniations, as call "Intercolumns" "Intercolumniations"—the latter term signifying, not the actual *spaces* between the columns, but the *mode of spacing* adopted for the columns. The inaccuracy of language here corrected may be thought a fault of no consequence; yet, as it is just as easy, it is surely just as well to employ terms correctly as not; and the correctness thus recommended is surely also far less finical than that puerile affectation of antiquated orthography, which insists upon a final *k* in the word "Gothic," now invariably written "Gothick" by those who pique themselves upon their orthodoxy; the *k* serving as a badge of it—perhaps, like other badges, as a substitute for it.

V. If Bunning's design for the new Coal Exchange be not wickedly caricatured in a wood-cut of it that has been published, it must be a mortally queer one, still more queer than the Gothic exhibited by him in the City of London School, the taste displayed in which can be accounted for only by supposing that Guildhall diffuses an architectural malaria throughout the whole of that neighbourhood—a supposition rather confirmed than contradicted by the specimen of Italian at the corner of King-street.—To keep to the Coal Exchange, it seems the design of some architectural coal-heaver. I say "seems," for though it is made to appear such, it may prove the contrary; and that is all the more likely because, as has been shown, a good deal in it is utterly unintelligible. There is room, therefore, for suspecting that it has been greatly misunderstood and misrepresented. According to what, it is to be hoped, is a very gross caricature, Mr. Bunning's design is absolutely architecture run mad—madder than any of Borromini's freaks. In short, it is impossible to believe that such extravagant uncouthness and unmeaningness of forms as are there exhibited, will be actually perpetrated; therefore judgment ought to be suspended until the work shall have been executed. Still, it is difficult to conceive how such a degree of misrepresentation could have occurred. Surely the wood-cut in question must either have been taken from an exceedingly rough and random sketch indeed, or have been the work of some arrant bungler.

VI. A story is told of a lecturer who was cut short in a long-winded rambling preamble, consisting of truisms and commonplace dressed up in high-flown phraseology, by one of his auditory getting not only impatient, but also getting up and saying: "You will excuse the interruption, Sir, but I must beseech you to bear in mind that we have not come provided with nightcaps!" This sally was succeeded by such a grand chorus of laughter, that before it had subsided the unfortunate lecturer had thought proper to vanish. Like many other so-called anecdotes, the above may be pure invention, it being, perhaps, too good to be exactly true. Its *moral*, however, is a tolerably significant one, and deserves to be attended to. If it be not an Hibernianism to call that strange which is so generally practised, it might well be called strange that so much mere school-boy stuff should be served over and over again in lectures and written essays; sometimes to the exclusion of anything besides such frothy matter, it being poured in so unsparingly, that there is actually no room for what would be substantial and nutritious. Now, people may be excused for not knowing more than what is already familiar to every one at all acquainted with the subject professedly treated of; but there is no occasion for them to betray to others that such is really the case. It was not very long ago that conversing with an acquaintance who had been to hear some lecture upon architecture, he told me that little as he himself knew of the subject, he knew enough to be able to engage to produce something infinitely more to the purpose than what he had heard, it being utterly stale, and barren of the least fresh information; much of it consisting of mere metaphysical moonshine, better calculated to mystify than to enlighten the auditory.

VII. It may fairly be questioned whether sculpture for the pediment of the British Museum might not just as well be spared, inasmuch as such partial decoration will only serve to render the absence of ornament in the rest of the structure all the more painfully striking. Even without such addition to the main building, there is a most unartistic want of keeping between that and the wings,—a defect which it is now so utterly beyond the power of any mere ornamentation to remedy, that it is more likely to be increased by attempting it. At present it is not so apparent as it will be when the old buildings, which serve in some degree as a foil to the new ones, shall have been completely cleared away, and the entire line of the latter become fully exposed to view. What sort of a *tout ensemble* may easily enough be guessed, since it may even now be plainly foreseen. If there be any doubt at all in regard to it, it is only because it still remains to be seen how it is intended to inclose the court from the street. Should it be done by any such sort of palisading as that before the Post-office, the effect will be mean and tasteless in the extreme. Whatever it is to be, that and the sentry-boxes were probably not included in the model, which, it might reasonably be fancied, did not even so much as exhibit the wings, otherwise their incongruousness with the central structure could hardly have failed to be noticed and objected to by those to whom the model was submitted—at any rate, if they were at all qualified for exercising any judgment in the matter. One question not wholly undeserving deliberate consideration there is which does not seem to have occurred to any one, namely, whether it would not have been more advisable, instead of adhering to the arrangement of the original edifice, to advance the new façade up to the street or nearly so, thereby extending the plan, by taking in the court-yard. That would have provided the accommodation that will in a few years be required, should the collections continue to increase as they hitherto have done. Much available space has also been thrown away elsewhere, since without entirely filling up the inner court, it was obviously practicable enough to occupy a portion of that quadrangle (317 and 238 feet) by one or more ground floor galleries within it, lighted from above, and not so high as to obstruct the windows towards the court, which are besides at a considerable height from the ground. Or the apartments there formed might have been on a somewhat lower level than the court itself. It will, perhaps, be said that should it be found requisite, this may still be done, but certainly not so well as it might have been, had it been planned at first, since it would call for some alterations in what is already built; besides which, had it been thought of at first, the cost of the inner façades of the quadrangle might have been spared, since plain brick walls—quite shut out of view, as they would have been—would have been just as well in such a situation as the present ones faced with stone. Even had the court been partly built upon below, the upper part of it—that is, as much of its sides as could be seen from within through the windows, might still have been finished as at present, with the omission however of the columns and antæ, so that its general appearance as so viewed would have been quite as satisfactory as it is now; nor need buildings within the quadrangle have been at all visible from any of the surrounding galleries or other apartments.

VIII. The plan of the National Gallery was in a great measure sacrificed to the unlucky and obstinately-persisted-in whim of letting St. Martin's church be seen from Pall-Mall East. Since it has been thrown open by the removal of the Mews, that building, said the wiseacres, must on no account be shut out of sight again as it was before; as if such would really have been the case were it not visible from Pall-Mall East, when it would have shown itself as well, or perhaps even better—more picturesquely than it does now, from Cockspur-street and Trafalgar-square. But for that stupid whim, which prevented the architect from bringing his portico at all forwarder than he did, and also compelled him to set back the extremities of his façade very considerably, the building might have been nearly twice as much in depth as it now is, and in some parts even more than that. It must be admitted that notwithstanding the disadvantages forced upon him, Wilkins might have arranged it much better, there being at present a great deal of space thrown away, that might by a little contrivance have been turned to good account. As to the dome, I have not a word to say in excuse of it, it being so decidedly bad. Excuse for Wilkins, upon the whole, there is much, for never, perhaps, was architect more worried and thwarted than he was in that unfortunate building.

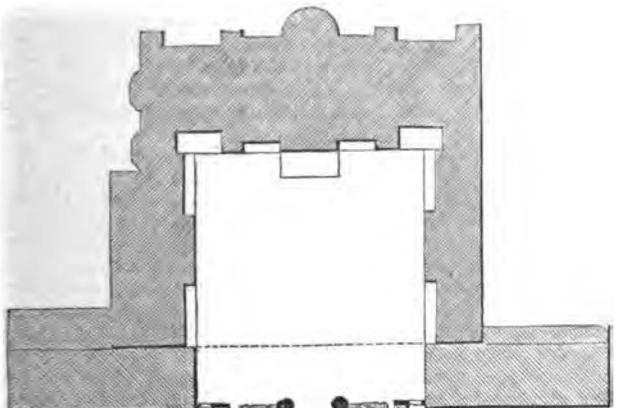
IX. "Eminent" must be an epithet of exceedingly doubtful meaning when we find it applied to an individual recently deceased, who, as an architect, was of no note whatever. However eminent Mr. * * * may have been *in* the profession, he was certainly not at all eminent *out* of it, his name being totally unknown to the public. Rather was he eminently obscure, since so far from being quoted in evidence of his talent, not a single building by him has ever obtained notice at all. As a man, he may have been a very worthy character; so he might, had he been an "eminent cheesemonger," in which case eminence and obscurity might have been allowed to go hand-in-hand together. Truly grievous is it that harmless nobodies should be so vilely daubed over as soon as they are dead. It looks too much like thanking them for going out of the world and leaving their snug places and appointments for others. The professional life of the eminent architect alluded to, would, I fancy, form a more curious than interesting contribution to the biography of artists.

BUCKINGHAM PALACE AND THE MARBLE ARCH.

But one opinion has been expressed of this unfortunate Palace, for if it finds favour at all with any, they have not the courage to utter so much as a syllable in defence of it. We may accordingly spare ourselves further censure of what is actually done, our present purpose being to point out what might have been done, and doubtless would have been, had aught like due or decent consideration been given to the matter, the idea here submitted being so very obvious a one that it is difficult to conceive how it could have by any possibility been overlooked. Or if it was not overlooked, but purposely rejected, it becomes desirable to know on what grounds it was set aside, since the reasons must have been more than ordinarily cogent ones to lead to its rejection.

Looking at the Palace as it stood before the alteration was commenced, no one would have ever imagined that the blocking it up by another building, merely in order to obtain additional rooms, and thereby depriving all the original portion of the building of those advantages of situation and prospect which in some degree atoned to its occupiers for its architectural deficiencies, would have been resorted to without all other expedients being first tried. The preserving the same view as before into the Park should have been made a *sine qua non;* instead of which Mr. Blore seems to have had a *carte blanche* to do just as he pleased, and he seems to have studied nothing more than merely providing the extra accommodation required, in an additional building merely tacked on to the first one. To say that he at all considered the circumstances of the case—the opportunity which it held out for architectural improvement, would be to accuse him of downright incapacity. The most prudent excuse for him is that he was called upon so suddenly to prepare drawings for the purpose, that he had no time to collect his thoughts, much less any ideas, those which he might else have had being put to flight by the expeditiousness imposed upon him. Whereas had he been allowed to apply himself to the task leisurely and quietly, he would have devised some means of preserving the Marble Arch, and not only retaining it, but giving it increased value and importance, as the focus point of a new façade.

General, vague suggestions of this kind, it will perhaps be said, are very easily made, but we here offer somewhat more than a mere shapeless, unembodied idea, by showing in the annexed cut



how the Arch could have been retained and connected with the advanced line of new buildings. We would have continued the stylobate and order of the Arch by two sweeping double colonnades (quadrant in plan). This would not only have given greater privacy to the court-yard, the stylobate being sufficiently high to prevent its being looked into, but would also have given it greater apparent space than before, when that space was so indistinctly defined by the palisading, that as seen from the Palace the Arch appeared to stand as quite a distinct and insulated object in the Park. According to the plan here shown, it would, on the contrary, in connection with the colonnades attached to it, have formed a highly scenic piece of architecture, full of play of light and shade and perspective effect, and admitting a view of the landscape scenery in the Park in the background. As an embellishment to the court there might have been parterres in the quadrant portions of it, with a fountain in the centre of each quadrant. To specify other matters of decoration not indicated in the plan—statues and candelabra for gas-burners placed alternately in the intercolumns of the colonnades, and a colossal sitting figure of Britannia on the summit of the Arch, giving to the latter what it has all along wanted, a pyramidal termination to its mass, would have produced a more than ordinarily striking architectural picture, whether viewed from the Palace or the Park. As seen from the latter, it would have been a sufficiently effectual screen to the buildings within the court, and after the sun had passed off from the east side of the Palace, would have been continually lighted up by its rays striking upon some of the columns during the whole day. In combination with additional buildings carried out to the right and left in extension of the original wings, such a colonnaded centre might have been made to produce a façade not at all inferior to, perhaps even more picturesque, than that of any other royal palace in Europe; whereas now—but we can hardly speak with decent patience of the miserable and truly contemptible abortion which Blore has perpetrated, both to his own disgrace, and the disgrace of those who employed him. Had such a design for enlarging the Palace been sanctioned by William IV., though our mortification would have been the same, our surprise would have been considerably less. His taste and feeling for art never extended beyond the figure-head of a ship. That it should have been perpetrated under the auspices—at least under the very nose of a Prince who affects the character of a connoisseur and patron of art, fills us not only with astonishment, but dismay. We account for it only by supposing that he was *overruled* in the matter, he being no more than Prince Consort.

To show, as we have, what might have been done, when the opportunity for doing it has passed away, may seem ungracious. Our reply is, it is no fault of ours that the opportunity was not afforded us, and not ourselves alone, but others also perhaps far more able, of making suggestions at a time when advantage might have been taken of them. At any rate, we hope that Buckingham Palace will now prove an efficacious lesson for the future; and it is also some consolation to find that it is not only poor, but so desperately bad, that there is very little danger of its corrupting public taste, because it will be now more mocked, and more an object of general derision than ever. Admiration it will excite none whatever, that's certain; but then it is equally certain that it will excite a vast deal ot astonishment. It will completely astonish the natives, and all foreigners into the bargain.

As the Marble Arch—which might have been so easily retained, and not only retained but greatly improved, and made the nucleus of an extended piece of decoration in the foreground of an extended line of façade—is to be taken down, the question now is, is it to be destroyed, or re-erected on some other spot? Nobody except those actually in the secret, knows; though why it should be made a secret at all nobody can tell, unless it be because the intention in regard to it is so preposterous that were it divulged it would excite strong opposition. Our idea is that the street front of the Horse Guards would be a very suitable situation for it. It would there fill up what is now too much of a gap, and the two smaller arches would serve admirable as the recesses for the sentinels on horseback. It has, indeed, been rumoured that both the Horse Guards and Admiralty are to undergo architectural transformation by Mr. Barry. But instead of that interposing any obstacle, it would rather facilitate such application of the arch, since Barry would only have to bring it into his design, and treat the rest of the composition in accordance with such feature.

BUCKINGHAM PALACE.

Sir—It seems not a little singular that none of the critics who are disposed to animadvert in such severe terms on the new front of Buckingham Palace, not even your lynx-eyed "Candidus" himself, should have discovered that it is only a reduced copy (about two-fifths in length) of the Palace at Caserta; so that the faults or merits, be they which they may, are not Mr. Blore's, but Vanvitetti's. In proof of which, I beg your acceptance of tracings of the perspective view of the front and of the plan, after Vasi.

It is to be feared that the imitation will be confined to the part of Vanvitetti's design upon which he appears to have bestowed the least pains, that is the outside, and that there are but faint hopes of an equal imitation of the splendid staircase and vestibule.

Vasi states the length of the north and south fronts of Caserta to be 918 palms (Neapolitan, I presume), which, at 10½ inches, would give 873 ft. 10 in. for the length of the front. The east and west fronts, by the same reckoning, would be 618 ft. 10 in.; and, as the length of Buckingham Palace is stated in the *Journal* at 350 feet, the proportion is exactly two-fifths. The height of Caserta is 120 feet; of Buckingham Palace, 77 feet.

I visited Caserta thirty years ago, in company with Mr. Woods and M. Soiss, the eminent Belgian architect, and the notes of that day are now before me.

"The central passage or vestibule leading from the entrance is 24 feet wide, and 24 feet high to the springing of the semicircular vault. The steps of the middle flight of the stairs are 22 feet long, and the two return flights each 14 feet long (100 steps in all), and are of white and reddish variegated marble: there are statues, trophies, &c. The vestibule above is handsome, but (in my eyes at that time) in bad style. The chapel (which is opposite to the staircase) has coupled columns, of Sicilian marble. The lower part of the chapel is lined with slabs cut from the Giallo Antico columns, removed from Purruoli," &c. &c.

Let Mr. Blore give to the Palace a staircase at all resembling this, and the world will forgive him the faults of his front; many of which have, no doubt, been forced upon him, as upon his great predecessor, by the necessity of providing accommodation for so many people.

I have read Mr. Elmes's Epitome of the Lives of English Architects with great satisfaction, and beg to express my hope that he will carry out his "present intention" without delay. I would take the further liberty of suggesting to him that the illustrations he promises ought to consist mainly of unedited specimens, or at least of those of which the engravings are least accessible, or the works containing them least known. A list, referring to the books in which the most meritorious of each architect's productions are to be found, would be very valuable.

It should be remembered that size is not the criterion of merit. How many of us country architects are forced to take the counsel of our excellent friend, Percier, and in despair of executing large works, to bestow greater care upon lesser ones?

I am, &c.,

York, Dec. 13, 1847. ROBERT SHARP, Architect.

COWPER'S INVERTED ARCH BRIDGE.

SIR—In reflecting on the construction of Mr. Cowper's bridge, I think it is interesting to notice that the boiler plates are *rivetted together*, so that the pressure on the piers and abutments must now be *vertical* instead of *oblique*, as in the common suspension bridge.

Hence, then, in *principle* it may be said to coincide with the ordinary girder bridge, but its alteration in *form* suggests an important advantage, which it possesses; for, in the girder bridge (and especially when dealing with long bearings), there must always be this objection, viz., that by reason of the gravity of the material itself, independently of any additional influence of a load placed upon it, it is constantly tending to assume a curved form, and such curved form not being the natural position of its particles, it is constantly tending to rupture; but in the "inverted arch bridge" the material is thrown into that form (or nearly so) which it *would* take if perfectly *flexible*, and *then* is made perfectly *rigid*. So that, as regards its *own* gravity, there is no further alteration of form, of any practical importance, to be apprehended.

With regard to the alteration of form which might result from a load being put upon it, Mr. Cowper has already pointed out the preventive measure, viz., the giving to the vertical dimension of the plate such a magnitude as to bring the line of strain *within* the plates.

I think the name might have been more aptly chosen: "Inverted arch" is suggestive only of *form*, and not of *principle*, and might (it seems to me) with equal propriety be applied to the ordinary suspension bridge.

I am, &c.,

G. W. RICHARD.

*** It is not clear that it would be practicable to make the "inverted arch bridge" so rigid as to exert only vertical pressures on the abutments, and to act as a curved girder.

Suppose its span 200 feet and depth 4 feet, and that a weight of 30 tons (engine and tender) rests at its centre. Then, by the ordinary principles of statics which apply to girders, we may easily find the horizontal strains of tension and compression which this weight *alone* produces at the centre. Considering the half-structure as a separate statical system, the forces acting upon it have equal moments about the point of support in the abutment: or half the weight $\times$ the half-span $=$ the moment of the couple of tension and compression created at the centre of the bridge. The length of the arm of couple is indeterminate, but (since the total depth is 4 feet) it is a favourable supposition to take it at 3 feet. Hence, calling the horizontal strain P, we have

$$P \times 3 = 15 \times 100, \text{ or } P = 500 \text{ tons!}$$

The metal must be tolerably thick to resist *five hundred tons* pressure on the upper, and tension on the lower, side of the bridge at its centre! This difficulty is formidable enough when the structure is considered as all one piece, but becomes insuperable when the effect of joints is taken into account. It is not to be overcome by any system of rivetting and dove-tailing, however intricate.

Though it be easy to calculate the amount of the horizontal strains at the centre of the curved beam, it is not easy to estimate the sectional or transverse dimensions necessary to resist those strains; for our knowledge of the transverse strength of wrought-iron is much less than of cast-iron. Some idea may, however, be obtained from analogy. The "inverted arch," if it sustains itself by its rigidity as a girder, may, for all purposes of calculating the strength at its centre, be considered as a horizontal beam 200 feet long and 4 feet deep, with an effective width of 1 foot to 1 foot 6 inches at the utmost. Now, the proposed Menai tubular bridge will be 450 feet long, but its depth will be *thirty feet*, and width *fifteen feet*: also its upper and lower sides will be composed of several thicknesses of metal, as the former will consist of two, and the latter of one, series of cellular compartments. The analogy between the Menai bridge and the inverted arch is complete in several respects: both are tubular, both are to be composed of rivetted wrought-iron plates, and both are designed for railway traffic. The sectional dimensions of the Menai bridge are suggested by actual experiment, and are never considered too great. Is it not, therefore, abundantly evident that a beam of $\frac{4}{9}$ths the span of the Menai tube, but with only an eighth or twelfth its depth and width, would not be rigid enough to sustain itself as a beam?

If suspended from, instead of resting upon, the abutments, it might perhaps be prevented from actually falling, but it would certainly bend. If the point of suspension be supposed to be at the upper edge of the end of the beam, the transverse strains of deflection will be somewhat reduced by the curvature of the beam; but it would be difficult to show that this advantage would not be far more than compensated for by the increase of length, and therefore of material, which the curvature renders necessary.

It is important to remark, that if the *only* requisite for security were that the depth of the chain should "include any alteration in the curve of the strain," that depth should not be uniformly 4 feet. It should be *nothing* at the centre of the span and the point of suspension, and gradually increase up to some intermediate part. The highest and lowest points of a catenary may be always chosen arbitrarily.

The argument that the chain would not be distorted because it is "of such depth as to include any alteration in the curve," is vague and inconclusive. It certainly cannot stand ground against deductions from the fundamental equations of statical equilibrium. The reasoning given above is a simple, ordinary application of the elementary principles of mechanics; these are not to be opposed by a mere hypothesis, which is too subtle to be made the subject of rigid investigation. All that can be said of this hypothesis is, that it is not *necessarily true*. A number of independent chains might be hung from the abutments, and to each might be given that form which it would, if perfectly free, assume of itself when the load at some particular stage of its transit hung from that chain alone. Then it is clear that, while no connection existed among the several chains, the load acting on each in succession would not tend to distort any of them, *i. e.* would not produce transverse strains. But it does not follow that this would be the case when all the chains were bound up together in one connected mass.

The "inverted arch bridge" does not seem to be an advantageous compromise between the principle of the girder and the suspension chain. An intermediate condition misses the advantages of both those structures: for if the inverted arch be only partially rigid it is subject to needless and prejudicial transverse strains;—if it be as rigid as a girder, why unnecessarily increase its length by curving it? The idea of our correspondent that the curvature obviates its tendency to deflect by its own weight, seems to us unfounded; for however much the structure was bent when first put up, it would tend to bend still more when its ends merely rested upon the abutments. We cannot positively undertake to assert that the *suspension of a curved beam* has no peculiar advantages; but they have not yet been pointed out, and we are unable to discern them.—EDITOR.

ELECTRIC TELEGRAPHS.

It is extraordinary that we should have had to wait so long for the introduction of a system of electric telegraphs, seeing that a century ago it was known that the electric fluid could be sent through a coil of wire two miles long, as was done in the experiments at Hampstead, while a coil had also been carried across the Thames. Papin, too, in the beginning of the last century, had sought a means of communicating power and motion to a distance. Had, however, such a means of communication as that by the electric telegraph been adopted, it would have languished in the then state of the roads, and the then state of society, for it would not have answered commercially, and its failure might have been most prejudicial. It has been reserved for our day to apply this invention, and to give one to the many characteristics which make it an era of progress. Beside the locomotive, the steamship, and the daguerreotype, the electric telegraph may take its place; and the day is perhaps not very distant, when our furthest islands will by the telegraph be brought under our immediate rule.

Having been among the first in the field, and having by the Slough line proved the practicability of the system, we have allowed the Americans to get in advance of us, for they had in 1846 sixteen hundred miles in practical commercial working, while we can hardly be said, even at present, to have any great extent of telegraph in use, although we have a great length laid down. Next year will redeem us from this charge, for we shall have two thousand five hundred miles, but it will not exculpate the government for having so long neglected this admirable invention. It is some comfort that we are ahead of France and all the European kingdoms. In the want of machinery for extending electric telegraphs we have to regret the neglect of the government in withholding the introduction of railways in India, where the telegraph would be invaluable in governing territories so vast, and where the number of English functionaries is unhappily limited.

We have now arrived at an era in the telegraph, for at the date of this publication, the metropolis has been brought into immediate communication with Liverpool, Manchester, and many of the great centres of trade and manufactures. The Electric Telegraph Company have brought their operations to that stage that they can convey intelligence to sixty great towns, and this seems an appropriate time for laying some account of their proceedings before the public, the more so as the full effect of this admirable invention does not seem to be so well appreciated as it might be in comparison with its vast capabilities, and the influence which it will exercise upon every class of the community, both morally and physically.

The operations may be considered as having begun with Mr. Cooke and Professor Wheatstone, who, after labouring singly for some time, in 1837 took out their first patent. It is understood that Professor Wheatstone applied himself more to the purer philosophical experiments, and that Mr. Cooke has taken charge of the practical detail, and at last brought the invention to its present bearing. We say nothing of other parties who have laboured on this subject, for our business is now with the Electric Telegraph Company. Soon after Messrs. Cooke and Wheatstone took out their patent, they laid down a line nineteen miles long on the Great Western railway, between London and Slough, the working of which was most successful, although of course it did not satisfy those who thought the system might fail if extended to Liverpool or York. It took many years to urge the system forward, and it was not till 1846 that a company was incorporated, called the Electric Telegraph Company, for carrying it out on a large scale. Contracts had however been made, and works carried on, so that before the act of incorporation the company was already in activity, and had by the end of 1846 laid down 1000 miles of telegraph. At the same date Professor Morse, in America, had laid down 1600 miles.

The system has been chiefly carried out in connection with railways, because the value of the telegraph to the railway companies has induced the latter to adopt it, and to make advantageous arrangements for laying it down. The years 1846 and 1847 have therefore been chiefly employed in laying down the wires, and their working on a large scale has been retarded until now by the non-completion of the wire between London and Rugby, on the North Western railway. On the 13th November this link was completed, and the London prices were at once conveyed to Manchester. The new metropolitan station has likewise been partially opened, and by the new year the whole plan will be in full operation. During the present year the metropolitan station has been in the Strand, and the working has been chiefly for government purposes along the South Western line to Gosport, although latterly much general business has been transacted. The organization of a new system has called for the exercise of much labour and ingenuity in the engineering and the signals departments, the principal officers of which are Mr. Hatcher, recently of King's College, and Mr. Whishaw, author of the "Railways of Great Britain," and the inventor of the hydraulic telegraph. In the standard work on the "Railways of Great Britain," Mr. Whishaw proposed uniformity of railway time, and a mode of communication between guard and driver, which with many other practical suggestions are now carried out. At a given time every morning a signal will be made from the central station, and the needle will be brought to the vertical indicating Greenwich mean time, by which all the telegraph clocks will be set. As this arrangement, most important to travellers, will now be carried out over the country, we may observe that local clocks and watches can be made with a double minute-hand, so as to show local time and mean time. Although much controversy has been raised about mean time, and many eminent men have opposed it, it has received the sanction of the astronomer-royal, who has proposed the adoption of it for the great clock at the palace of Westminster, which is to be set by electric telegraph from Greenwich. The system of codes adopted by the Electric Telegraph Company, has been, we believe, entirely constructed and arranged by the same gentleman. On account of the extent of the operations of the company a great many mechanics have been employed in making the various apparatus and in laying down the wires, and many works of great nicety in their execution have been carried out.

The company is not restricted to Messrs. Cooke and Wheatstone's patents, but has power to avail itself of all inventions in which electric power is used. They have therefore purchased many patents and inventions, among the chief of which may be mentioned Bain's electrical clock, an invention, the full value of which is far from being known. At the offices in the Strand is a model-room, which contains a large collection of telegraphs of various construction, and of clocks. This model-room does great credit to the company, and is a museum of great value to the practical man. It will be recollected that at Sir John Rennie's conversaziones in the spring, among the many novelties which the learned president brought before his guests, was a collection of telegraph apparatus. This was contributed by the Electric Telegraph Company, and formed not the least interesting contribution to the temporary museum in Whitehall Place.

In the model-room in the Strand, the collection in which will, we presume, be removed to the city, there is every thing necessary to illustrate the subject, though of course it does not contain every telegraphic invention. Several apparatus show the improvements which have been gradually made in the needle instrument, so as to make it capable of working. Two ingenious telegraphs communicate by sound. One of these, the invention of Professor Wheatstone, strikes two bells of dissimilar sound, the combination of the two producing the letters, as in the double needle telegraph. Another, the discovery of a workman, gives a humming noise from a wire. The effect is singular, and was a chance discovery. At present it is of no moment, but the preservation of a model by the company serves to encourage the spirit of discovery, while what is now merely trivial may become the germ of a valuable application. It is deserving of note that already the officers and workmen employed on telegraphs have been the means of making many useful suggestions, and we may anticipate the best results from an energetic body of employees, if the company are liberal. Notwithstanding all that has been said about railway improvements, it is well known to practical men that very great improvements have been effected by railway officers, and that a large amount of talent is constantly and energetically directed to the perfection of the system. The names of George and Robert Stephenson, Brunel, Braithwaite, Booth, Gooch, Gray, Edmonson, are only a few as a specimen of those who have contributed to the practical improvement of railways. In a few years the Electric Telegraph officers will, we hope, have given equal proofs of zeal and ingenuity.

The printing telegraphs in the model-room are illustrated by several apparatus of various forms, some for printing by letters, and others by signs. The company make use at their stations of the needle telegraph, but as the working of this is doubtful, and other telegraphs move quicker, it is quite open to them to change their instruments, as they have the wires laid down, and the wires are used under whatever system. While adverting to printing telegraphs, which print their message in black, we may observe that it is perfectly competent to make a telegraph which shall use different colours, and indeed a mode of shading was long ago suggested by Mr. Hyde Clarke.

The business of the company in electric clocks will no doubt be very large in the end, as they admit of such useful application in public and private establishments. In the course of a short time no public office will be without a clock dial in every department, and when the example has been set wide enough there will be few private houses without a dial in every room. It is a small thing, but it is no mean thing to increase habits of punctuality in a population. Those who have noticed in foreign countries the disregard of the value of time among unenterprising populations, know the worth of our greater luxury in time-pieces. The Electric Telegraph Company, however, will be satisfied with the pecuniary result, without seeking further as to the public benefit they may effect. The price of a clock is at present of course rather high, namely, sixteen guineas, and of companion clocks, ten guineas each. A great objection to electric clocks at present is, that depending on the electric currents of the earth or on a battery, their regularity cannot be depended upon.

The metropolitan station, designed by Mr. Hunt, is very well situated. It occupies what was lately Founders' Hall and the adjacent premises, having entrances in Lothbury from Founders' Hall-court, and in Moorgate-street. The doorway in Founders' Hall-court is handsomely carved in stone, and though small makes a good façade. The central hall or counting house is one of the handsomest works lately executed. This station is within a few minutes' walk of the Bank, Stock Exchange, Royal Exchange, Lloyd's, the joint stock and private banks, assurance offices, in the heart of business, and not far from the Corn Exchange, Commercial Rooms, Coal Exchange, and the seat of the Manchester warehouses and colonial produce warehouses. The newspaper offices are further removed, but in the end means will be found of accommodating this class. The government offices, houses of parliament, courts of law, and places of west-end business are also at a distance, but the city is the district which will pay best, and it is impossible to provide for all at once. So far as the city office is concerned, the judgment of the managers has been well shown in its selection.

The principle of Cooke and Wheatstone's telegraph is founded on the discovery of Professor Œrsted in 1819, that a magnetised needle has a tendency to place itself at right angles to a wire along which a current of electricity is passing. By the movements of such a needle on a dial an alphabet is formed, which serves as the means of communicating messages.

In the other forms of telegraph a disc is made to rotate, bearing on it letters or signs, and this is effected in virtue of the property soft iron has of becoming temporarily magnetised by an electric current being passed along a wire coiled in a spiral around it. The same principle is adopted in all the apparatus for ringing the alarum in order to give notice that the telegraph is in action. It is to be observed that the telegraphs in the United States, France, and Prussia, are on the disc system; in Baden Highton's telegraph has been used. Most of the telegraphs in England are needle telegraphs, that on the South Devon is a disc telegraph, and that in the Box Tunnel on Nott and Gamble's plan.

The disc telegraphs are worked either by the voltaic battery or the magneto-electric machine, power being derived from a permanent magnet. With these telegraphs, two wires only are necessary, one for the telegraph and one for the alarum; but the needle telegraphs, for commercial purposes, require three wires, two needle-wires for the telegraph and one wire for the alarum.

As now laid by the Electric Telegraph Company, on their best system, two wires are employed for each principal station, the wires used being of iron, of No. 8 gage, and one-sixth of an inch diameter. These are galvanised, and come very cheap. The weight is about 38lb. to the hundred yards, or 480lb. per mile. The wire is welded together in lengths of about a quarter of a mile each. These wires are fixed to standards, at distances varying from 45 to 55 yards apart, and at each quarter of a mile is a stronger standard, where a connection is made. The wires are kept taut by a simple arrangement, which it is unnecessary to describe. In consequence of this mode of suspending the wires on standards, which was first adopted in 1842, a great economy is effected, and the system admits of a more extensive application, as now it may be laid anywhere wherever the standards can be put up; and as the population get accustomed to this invention, it can be put up as safely in the streets, or in the roads, as gas-lamps are now left; though of course it is premature to anticipate such advancement at present. Under Brett and Little's system it can, we believe, be laid much cheaper than now.

The original method of laying the wires was to cover them with silk or cotton thread, and then with pitch, resin, caoutchouc, or some other non-conducting substance, enclosed in earthenware tubes, in wood trunks, or in iron pipes. At that time, there were several inventions for laying the telegraph wires in asphalt. The great expense of the system was one of the obstructions to its extension at an earlier period. Our readers will recollect that pipes were used on the Great Western and Blackwall Railways. One purpose in the pipes was to prevent any interference with the telegraph wires; but this precaution is now considered unnecessary. The connecting wires between Nine Elms and the Strand stations, and between Euston-square and the metropolitan stations, are laid in pipes (Mr. Freeman Roe being the contractor); but, as we have already observed, they will in the end be, in most cases, laid on standards in the streets. At the present moment, our main streets are filled with cast-iron pipes for gas, for water, and for electric telegraphs. Liquid manure is also to be laid on, and we believe Professor Wheatstone contemplated a sound telegraph, which should play music. The professor contemplated the conduction of sound; but waiting till that is accomplished, it is quite easy to play music at a distance by the present resources of science. With a sufficient number of wires, a grand piano might be played in London and Liverpool at the same time; and nothing would be easier than for one organst to play in two cathedrals, or to play a set of chimes in St. Paul's and in York Minster simultaneously. Professor Wheatstone's bell telegraph, in the model-room of the Electric Telegraph Company, gives the elements of such an apparatus. In Flanders, every town has its set of *carillons* or chimes, playing elaborate tunes, and having its carilloneur, who plays on Sundays. In time, the whole of these may be worked together, or perhaps the towns of England supplied with the luxury of *carillons*. Professor Wheatstone, however, proposes to go beyond this, and to convey musical sounds to a distance.

A great economy has already been effected in the number of wires used. In the earliest Slough instrument, five needles were used, and double wires for each. The application of the principle that the earth could be made to serve as half of the circuit, and its adoption by Mr. Cooke in his patent of 1842, at once abolished half the wires, and by successive improvements, the number of needles was brought down to four, to three, and to two, and, for some purposes, even one. Thus, where twelve wires were necessary in 1842 for one station, two are now sufficient, while the cost is decreased in a very much greater ratio by the wires being galvanised instead of wound in cotton or silk, and by their being suspended in the air instead of being laid in pipes. Perhaps, in the end, a lighter wire will be used, and the system will be indefinitely extended. It is impossible to consider the system as being otherwise than in its earliest infancy, and we may expect, as in railways, to see very great modifications. The locomotive, after being increased in size to the magnitude of the "Great Western," is now likely to be brought down to the proportions of a steam-carriage. Nothing is so dangerous in new inventions as to prejudge.

The instruments used are Cooke and Wheatstone's, and are either single or double needle instruments. The latter is preferred. They are both on the same principle, except that the latter is double the former. As seen from the outside, the double needle telegraph shows two needles suspended like clock-hands on a dial. Each of these needles is the duplicate of another within the instrument, and behind the dial, and which latter is the real needle. This needle is suspended in a light hollow frame of wood or metal, round which are wound two sets of fine copper wire, coated or insulated with silk or cotton. About 200 yards of wire, $\frac{1}{150}$th of an inch diameter, is used for these purposes. This coil is connected with an electro-galvanic battery. A great difficulty of the needle telegraph is to stop the oscillations or vibrations of the needle when set in motion. This is attempted by giving a greater extension and weight to the lower limb of the needle.

On the instrument, below the dial, is a handle, which is so formed as to turn on or break off the connection of the battery with the conducting wires, and so to transmit motion to the needle, which, according to the way in which the current is passed, may be deflected to the right or left.

In the double-needle instrument, the alphabet is formed by the production or repetition of three combinations. The needles being placed parallel, the right-hand needle may be worked or the left-hand needle, the two together, or the two alternately; accordingly as this is done once, twice, thrice, or four times, a large number of alphabetical or other characters is obtained. The double needle has this additional economy over the single needle, that in many combinations the two handles are worked together; in other telegraphs of a simpler construction the saving would be still greater.

The needle being itself a magnet, is subject to disturbance from the free electricity of the atmosphere in particular states of weather, so that its working is very uncertain; and although some modifications and improvements are made, this does not obviate the objections. To prevent the needle from traversing too far, it is confined by pins on either side. On a recent occasion all the telegraphs throughout England were deflected for so long a period that business was wholly stopped.

It is to be noticed, that the communication is carried through the instrument, which is a part of the chain of connection. At each station used, must be an instrument; but where the correspondence is small, several instruments may be used with the same wires; but of course two stations cannot be worked together,—one only can use the telegraph at a time. Where there is larger correspondence, separate wires and instruments are used for each station. An objection at present is that one instrument being disordered, which is not unfrequently the case, the whole set suffer.

Where several instruments are put on one set of wires, there is an advantage in sending a simultaneous message. Thus, in the case of the Queen's speech and proroguing Parliament next year, it may be simultaneously communicated to sixty stations by one clerk in Lothbury; and we may conceive the period when a public functionary may simultaneously convey instantaneous instructions to a thousand subordinates, thus surpassing all that the printing-press has ever yet accomplished. Already, the superintendents of railways, seated in their London offices, can give general instructions every morning to their station-masters attending in the telegraph-rooms. For most of the purposes of the subscribers'-rooms, the whole system of telegraphs put in communication will allow of one message or list of prices or quotations being used for all, which is a great economy. Thus the price of shares at Manchester, of cotton at Liverpool, of sugar in Mincing-lane, or of corn at Wakefield, will be simultaneously announced all over the country.

The bell, or alarum, may be considered at present an essential part of the telegraph system. By setting the alarum in action, notice is given to the telegraph clerk that a message is going to be sent. We question, however, whether the bell will in the future be necessary at large telegraph stations, where clerks are on duty day and night, and the instruments, perhaps, in constant use. At present, the alarum may be set in action from the telegraph wire, or a separate wire may be used. The defect of the former plan is, that if the clerk, on finishing his message, does not leave his alarum in the circuit, the alarum cannot be set in action, and the only way to attract his attention is the chance of his seeing the needles working. As this contingency virtually neutralizes the use of the alarum, it is considered preferable to have a separate bell for the alarum. The alarum is a piece of clock-work, to be set in action by the connection or disconnection of two pieces of soft iron, formed into a horse-shoe magnet, and covered with a coil of fine copper wire insulated with silk or cotton. When this horse-shoe is magnetised, it attracts an armature of soft iron, which moves on an arbor, and lets loose a catch, which sets the clock-work in motion. Formerly, the magnet was made to act directly on the hammer of the bell. Lately, great improvements have been made in alarums by other inventors.

The single needle telegraph is sometimes used for railway purposes, where a limited number of signals is required; but for all others, the double needle is used, and the difference in price is not sufficient to justify the use of a less effective instrument. As, however, in the case of the double needle instrument, accident may happen to one of the wires, the clerks are taught the use of the single needle signals, so that communications may still be carried on. This is the more necessary from the liability to disorder. We may observe, that in case of injury to a particular line of wires, as that on the old Manchester and Birmingham Railway for instance, the communication with Manchester could still be carried on by forming a circuit with Sheffield, Leeds, Liverpool, or any other of the places remaining in connection with it and the metropolis. Unless all the wires round a town be disturbed, the communication cannot be stopped, so readily can a line of correspondence be formed; and it is at present considered of little importance to send a message round by any distance, as no perceptible difference in speed or efficiency is found between a direct or a circuitous route in the transmission of electric messages. Hitherto, all correspondence with Manchester has been sent circuitously by Rugby, and over the Midland Railway. In a political, and even in a commercial point of view, this fact is of some importance, as it guarantees the stability of this mode of communication. It is to be noted, however, that the Electric Telegraph Company have hitherto worked their messages by relays, and this is the case on the South Eastern, which argues some defects. The company's telegraph is a failure on the South Devon line, and in the Summit Tunnel on the Sheffield and Manchester railway. Nott and Gamble's telegraph has also failed in the Box Tunnel.

The mode of transmitting messages by telegraph has already been subjected to revolutions. When the idea was put forward of spelling words, of course it was suggested that combinations might be formed of signals standing for words. This was not, however, then found to work well, and the competent author of the article on electric telegraphs, writing in "Weale's Pocket Book," in the end of the year 1846, says—"This method has been fully tried, and has been relinquished only upon a conviction of the greater certainty and eventual quickness of the literal communication." At the present moment, the company are again working by signals or words, and with great success, upon Mr. Whishaw's system. It will strike every one who has given his attention to the subject, that each subject relating to shipping, to the stock exchange, to produce markets — will have its own technical language, in the cognate business of short-hand writing, called "arbitraries," and for which signs may be used as they are in short-hand. The merit of Mr. Whishaw's system consists in its special application, while the failure of the previous attempts was in their generalization. All successful codes of signals, or telegraph communications, have been special; and the same may be said of short-hand arbitraries. A law short-hand-writer will find constantly recurring—"plaintiff, defendant, affidavits, plea," and a number of other terms, which it would be a work of supererogation to write in full; and so in each department; but this has been left to systematization by the individual rather than made a work of science. Sea signals have been rendered very simple by their application to nautical purposes, though the attempts to apply them to more extended communications have failed.

In Mr. Whishaw's system for the Electric Telegraph Company, a code of signals is applied to each class of communications. Thus there is a code for shipping intelligence, a code for racing, a code for share lists, a code for corn-market prices, and so forth. On the message being commenced, a signal is made what code is used, so that the clerk who receives the message is prepared for the nature of the signals. As the number of signals which can be made in a given time is limited, it is evidently of great importance to economise time by the adoption of arbitraries, instead of spelling every word, letter for letter. Indeed, if an expedient of this kind were not adopted, it would be impossible to carry on the correspondence between the great towns. As it is, it may be reasonably expected that business will so far increase on the organization of the system, as to require the adoption of more than one line of telegraphs between the metropolis and such towns as Manchester and Glasgow. We may note here, that it will be curious to observe whether the number of telegraph messages will bear any correspondence with the number of post letters sent to each town. There can be no doubt, however, that to give accommodation to the public new companies will be formed, as in other branches of enterprise.

On a message being delivered in writing at the telegraph office, it is "translated" into telegraph language, transmitted by a telegraph clerk, received by a telegraph clerk at the other end, retranslated there, and written out and given to a messenger for delivery. Each message is accompanied by preliminary signals, to call the attention of the clerk to be addressed, and to signify to him the nature of the message, and the code to be used. It may readily be conceived that it is of great assistance to the clerk to know the class of message he is going to receive, as he is thereby better prepared to understand its import. It is like a reporter in the gallery of the House of Commons understanding the speaker whom he is following, and which enables him more fully to catch and express his meaning, than if the subject were unfamiliar to him. In time, no doubt, the telegraph clerks will divide among themselves the labour of transmitting the several classes of intelligence, and this will have a tendency to ensure greater accuracy and rapidity. In order to obtain more accurate delivery of a message, the company offer, on the payment of an advanced price, to have it repeated, so that there may be a security for its being fully understood; and this is necessary, as errors must be expected to creep in from frequent imperfection in the instruments, from unintentional error on the part of the sender, and from misinterpretation on the part of the receiver. These kinds of messages will be peculiarly open to those "equivoques," now known as "errors of the press," in printing, where the insertion of one wrong letter alters the whole meaning of a word or sentence. We may be prepared, therefore, for letters addressed to the great censor of the age, headed, "Shameful Mismanagement of the Electric Telegraph Company," "Shameful Oppression," "Shameful Negligence," "Shameful Monopoly," and so forth, in which the real or fictitious correspondents declare the dreadful sufferings to which they have been exposed by the errors and delays of the telegraph clerks—how "owls" were ordered for dinner, instead of "fowls,"—"pigeon" for "widgeon," "veal" for "teal," "cats" for "skates," "swipes" for "snipes," and many sundry grievances, which could not be complained about hitherto, as there were no telegraph offices to be belaboured by the querulous, dissatisfied, and inconsiderate. The telegraph grievance will be a great safety-valve to the railways, for the former will so occupy the *Times* and *Punch*, as to leave no room for the last case of neglect by Mr. Hudson, or the last instance of being five minutes behind time on the Eastern Counties. When telegraphs come to be abused as well as railways, it will be a sign that they have done some service, and have merited well of the public.

The lowest charge for the delivery of a message at present is half-a-crown, for which thirty words are sent thirty miles—though it is to be hoped for the public accommodation that the prices will be reduced. The charge increases, of course, in the double ratio of the number of words and number of miles. In many cases, the charge will not be greatly above that which was made a few years ago for general post letters for mercantile purposes; and, indeed, merchants will have been relieved from the charge of postage, to give them a revenue for telegraph purposes. If there are any who doubt that the mercantile classes will be ready to avail themselves of the telegraph, they should be put in mind of the large sums formerly disbursed for postage, and, indeed, of the large sums still disbursed for Indian and foreign postage.

The Electric Telegraph Company, as a matter of necessity, give notice, that they do not hold themselves responsible for the speed with which the messages are transmitted, nor for delay caused by the state of the weather or apparatus. At present, the state of the weather often affects the rate of working of the machines, and sometimes to a serious extent.

The rate at which messages can be transmitted is rather lower than might be anticipated, and this arises from using the needle telegraph. It is found that about six words a minute is as much as can be practically telegraphed at present, the words being spelled literally. The last Queen's Speech was sent seven words a-minute. By using the codes, longer messages can of course be sent. The number of words which can be written by short-hand in a minute is seventy; the number of words which can be read rapidly in one minute is 280. The number of characters passed by Professor Morse is 117 as a maximum, 99 as an average. We may be prepared for the much greater rapidity of the electric telegraph in other hands. Mr. Bain promises, in the course of time, 1,000 characters: but the present rate of speed is ample for all present purposes, though we have that faith in the extension of telegraph business, that we believe it must be shortly increased. By using well-trained clerks at the chief stations, and by frequently relieving them, the utmost use will be made of the telegraphs; and they are likely to be worked night and day. For many classes of correspondence, all the words must be spelled, and no arbitraries or codes can be used; but still a large mass of correspondence will admit of profitable abridgment. Professor Morse, and many telegraphers, undertake to do a much greater number of words than those assigned by us as the present rate in England; but what one individual can do in an isolated case, is very different from the working of a miscellaneous correspondence, through a public office.

That the undertaking will turn out productive, we have no manner of doubt, because, in many cases, the company have not the property of the lines, which belong to the railways, but work them at a toll, while the revenue to be received must be very great. A line between two principal stations will yield five thousand a-year; and as the outgoings are chiefly in clerks, it will be seen that there must be a large surplus to pay the wear and tear of instruments, the cost of management and superintendence; and after yielding a toll to the railway companies, afford a very handsome return to the Electric Telegraph Company for all the capital they may be called upon to employ. They enjoy, too, the advantage of a ready-money business. A thousand a-year would, however, yield a dividend. At present the company have not wires enough for the public business, and great complaints are made of the delay.

The length of line laid down by the Electric Telegraph Company, or in progress, is now, we believe, about 2,000 miles; and the following is a list of telegraphs, with the date when laid down, and the length of line, though the materials from which we have compiled it are imperfect. It will, however, in some degree, serve to show the progress of the system:—

			Miles
1839	Great Western ...	... London to Slough	19
1842	Blackwall	...	5
1844	Yarmouth and Norwich	...	20
1845	South-Western ...	... London to Southampton	99
„	Eastern Counties ...	... Colchester line	51
„	„ ...	... Cambridge do.	58
„	„ ...	... Hertford branch do.	7
„	„ ...	... Ely and Peterborough	29
„	„ ...	... Thames Junction	3
„	South-Eastern	... London to Dover	88
„	„	... Ramsgate line	30
„	„	... Margate do.	4
„	„	... Maidstone do.	10
1846	„	... Tunbridge and Tunbridge Wells	6
„	„	... Bricklayers' Arms line	6
1847	„	... Deal do.	9
1845	Norfolk Railway ...	... Norwich and Brandon	38
1847	„ ...	... Lowestoft line	10
„	„ ...	... Dereham do.	13
1846	Midland Counties ...	... Rugby and Derby	49
„	„ ...	... Birmingham & Derby	41
„	„ ...	... Derby to Normanton	73
„	„ ...	... Nottingham and Lincoln	41
„	„ ...	... Sheffield line	5
„	York and North-Midland	...	23
„	„	... York & Scarborough	43
„	Hull and Selby ...	...	40
„	York and Newcastle ...	...	84
„	„ ...	... Durham line	2
„	„ ...	... Sunderland do.	5
„	„ ...	... Shields do.	8
„	„ ...	... Richmond do.	9
1845	Sheffield and Manchester	... Summit Tunnel	3
1846	South Devon	...	20
1845	London, Brighton, and South Coast	London and Croydon	8
1846	Preston and Wyre ...	... Preston & Fleetwood	20
„	Eastern Union	...	17
„	London and North-Western...	Wolverton and Peterborough	57
1847	Midland	... Syston and Peterboro'	40
„	Leeds and Bradford ...	...	15
„	Manchester and Leeds	...	61
„	York and North-Midland	... Hull and Burlington	27
„	Newcastle and Berwick	...	60
„	South Devon Extension	...	27
„	London and North-Western...	London and Rugby	$82\frac{1}{2}$
„	„	... Rugby to Newton	$111\frac{3}{4}$
„	„	... Liverpool and Manchester	$31\frac{1}{2}$
„	„	... Crewe to Chester	$30\frac{3}{4}$
„	Southampton and Dorchester...		60
„	Midland	... Bristol & Birmingham	$90\frac{1}{2}$
„	Edinburgh and Glasgow	...	46

The length of line laid down previously to 1845, was not more than 45; in that year, about 500 miles; in 1846, 600 miles; and in 1847, 1,100 miles. The total done and in hand is above 2,300 miles.

The towns to which communication will be made are above sixty, including London, Manchester, Glasgow, Liverpool, Edinburgh, Leeds, Sheffield, Birmingham, Bristol, Newcastle, Hull, Wolverhampton, Wakefield, Derby, Leicester, Norwich, Nottingham, Portsmouth, Northampton, Bradford, Coventry, Dover, Canterbury, Halifax, Rochdale, Maidstone, Southampton, Gloucester, Cheltenham, Yarmouth, Cambridge, Colchester, Ipswich, York, Darlington, Margate, Stafford, Barnsley, Hertford, Ramsgate, Deal, Folkestone, Rotherham, Tunbridge, Winchester, Dorchester, Peterborough, Huntingdon, Chesterfield, Wisbeach, Lowestoff, Chelmsford, Berwick, Scarborough, Burlington, Stamford, and St. Ives. With Bristol, the communication is circuitous round by Birmingham and Gloucester, as the Great-Western, although first in the field with the Slough line, have neglected to apply the telegraph throughout, which seems to arise from dissatisfaction with the needle telegraph, for they have allowed partial applications of two other systems. Every town in the country having above one hundred thousand people, is brought into communication with the metropolis; and the only great towns still unsupplied are Plymouth, Chatham, Preston, Exeter, Bath, Brighton, and Oxford. The number of shire towns brought into connection is near thirty; all the chief seaports and seats of manufactures, and several watering-places.

Besides the places already enumerated, many considerable towns can be served, being already placed on the line of telegraph, as Worcester, Sunderland, Stockport, Kingston, Lichfield, Tunbridge Wells, Poole, Croydon, Watford, Maldon, Droitwich, Thetford, Beverley, Braintree, Ashford, Newark, Alnwick, Dunbar, Loughborough, Crewe, Wolverton, Leighton Buzzard, Driffield, Reigate, Romford, Bishops Stortford, Thirsk, Northallerton, Market Weighton, &c. In fact, within a very short period, the company will be able to supply the prices of above a hundred market towns, if wires enough are laid down.

In the United States, New York, Philadelphia, Boston, Baltimore, Washington, Albany, Newhaven, and Hartford, have the means of intercommunication, and a line of a thousand miles long runs to Quebec.

With regard to submarine telegraphs their practicability is indisputable. The great essay will be the line between Dover and Calais, when the two great cities of western Europe will have instant parley. Already the money markets of the two sympathise, the capitalists of the two cities are bound up with each other, and it is to be hoped these ties will be drawn closer, and the peace of the two great nations be maintained. A continuous line between London and Vienna is talked off as in progress; at any rate, we shall soon have, by a telegraphic communication with Marseilles or Trieste, the means of abridging our East Indian correspondence. The value of such correspondence to the London houses engaged in East India business and expecting remittances would have been very great during the late crisis.

If the steamboat threatens us with greater hazard of invasion during any future war, the telegraph comes in good time to counteract any unfavourable influence, by giving us instant intelligence of any danger to our coasts, and allowing of immediate, and as it may be called, personal communication between the statesmen of England and France, so as to allow negociations for peace to be carried on with more rapidity than by mean of envoys.

To the Admiralty the electric telegraph offers the means of superseding the cumbrous semaphore, and of rapid intercourse with the naval stations. We consider the Admiralty greatly blameable in not having sooner availed themselves of the system, after the success of the Slough experiment. As it is, they have only a line to Gosport. There is none to Plymouth, Chatham, Sheerness, or Milford. We do not see why a submarine telegraph should not be carried out to the anchorage at Spithead, so as to allow of readier correspondence with the admiral or officers afloat. It is no testimony in favour of government management in England and France that the clumsy semaphores, useless at night and in a fog, and useable only for a fifth of the year, should have been so long persisted in; but we entertain no doubt that so soon as the electric telegraph system is fully applied for public service, the governments will become candidates for taking its control into their own hands, or for interfering with it as they have with the railways.

A submarine telegraph which will be of great use will be between England and Ireland, and nothing but the want of energy of the government prevents them from applying it in the present crisis, when it will be a means of economising money, and most probably of saving human life. Such a telegraph is properly a government experiment, and not a commercial experiment; and for that reason it is not likely to be done until it cannot be put off any longer, and when done to be badly done.

It is to be remembered that the telegraphic establishment will be a new post-office, operating almost instantaneously, and with this advantage—that instead of the whole business being restricted to one fixed time, or to two fixed times, communication will be made at the moment desired by day or night. The way in which such an establishment must operate on society must be most beneficial. All those interested in markets, whether belonging to the agricultural interest or the mercantile interest, will, in every part of the kingdom, wherever they may be, know the state of all the markets open within a few minutes of operations being effected, while they will have the means of making purchases or sales hundreds of miles off, whereby transactions will be much quickened, and a general and uniform rate of prices will be established throughout the country. The charge for subscription is only two guineas yearly, and the subscriber, wherever he may be, has admission to the subscription rooms, in which are posted the shipping lists, the share lists from the London and provincial share exchanges, the prices current, the prices of corn, live stock, and produce, and every event of public or mercantile interest. No one concerned in any business can well avoid this payment, for it will in the end become *de facto* a tax, for no one will dare to be placed under a disadvantage to his neighbour. It will be as common as to read the newspapers.

It will readily be seen that even the man of pleasure cannot escape contributing to the revenues of the telegraph company, for political intelligence and sporting intelligence will be recorded, and wherever he may wander he will always have access to information. On going into the telegragh station he will see the state of bets at Tattersall's, and regulate his own proceedings accordingly, or learn who is the winner at Epsom or Newmarket. During the late general election, had the system been in full work, intelligence would have been sent of the state of the poll from sixty boroughs and thirty places of county elections, which are now telegraph stations. A parliamentary division will be known within a few minutes all over the country, and the faction which triumphs or which falls at St. Stephen's will within a brief period be brought under the comment of thousands of its supporters or opponents. Now the divisions are telegraphed to Liverpool and Manchester, and posted in the rooms.

The sending of private messages must be most various in its influence, and the effect of time and experience only can enable its bearing to be fully appreciated. New modes of doing business will spring up, new branches of business will be created, some perhaps be superseded, but that the result will be beneficial on the whole no reasoning man can doubt. Whoever has a sick relative at a distance, in the hourly peril of death, with life quivering on a breath, in all the agony of hope and fear, will know the value of an establishment which can give him frequent and immediate intelligence of the state of one whom he holds dear. After this example it is of little moment to picture the many ways in which personal interest will seek gratification in a correspondence which extends the power of wealth and enterprise, and widens their sphere of action. A Rothschild, a Goldsmid, or a Baring, may rule by agents in London, in Paris, in Madrid, and in Lisbon at once; but henceforth their most distant affairs will be under their own guidance, and their personal influence will be made to act in cities they have never entered, and with men they have never seen. The confidential agent or the junior partner will be a zero, and the means of safely conducting an available operation will no longer be limited by the necessity of intrusting it to a subordinate. Indeed it is impossible to contemplate, without excitement, the new world which is as it were opening before us, and to which the effects of railway and steamship intercourse, great as they are, are as nothing.

To the press the electric telegraph will be a new arm of power: the money which is now spent in horses and expresses will be appropriated in a large proportion to keeping up a greater number of agents and correspondence. It may appear at first sight that the telegraph rooms by affording so much intelligence will be curtailing the sphere of the newspapers, but they will only be interfering with them in some departments to give them greater facilities in others. The Electric Telegraph Company may announce that the mail steamer has brought to Liverpool the American president's speech, and its purport, bnt the special edition of the *Times* must give its words sent up by telegraph. Country meetings of importance will be sent up by telegraph, and it is not impossible that before long such arrangements may be made as to allow of the reporter's notes being used for telegraphic transmission. The difference in the number of signs between long-hand and short-hand (discarding most of the arbitraries), is as 275 to 170, or nearly as 5 to 3; this gives a saving in favour of short-hand of two-thirds, and allows five hours' work to be done in three, for it is to be observed in telegraphic communication, the great object is to economise the time used at the telegraph. The short-hand system was tried on the South-Western and found to answer.

It seems by no means improbable that an influence will be exerted on the jurisprudence and police of the country by the telegraph system. Perhaps we ought to say that it has already done so. The arrest of Tawell, the quaker, for murder, and the arrest of so many other criminals has given a greater efficiency to the law; the respite and afterwards execution of the convict at Maidstone, show the ready means of communication with the central authorities. But though a telegraphic message may be a sufficient authority to arrest for felony, it will be necessary to provide some new process to make this establishment available in cases of misdemeanour, and in the end it is likely to be applied in civil cases, in which already it is calculated to quicken many stages of proceeding. It may hereafter not be uncommon to have a witness at Edinburgh examined by telegraph during a trial at Westminster Hall, and other evidence be sought for five hundred miles off. It may cease to be necessary to bring up a prisoner to the superior courts on ordinary applications, when a correspondence may be made with him at any distance.

As a means of railway administration the electric telegraph has proved its efficacy, and it is impossible to conduct single lines properly without it. Already the convenience to passengers has been very great, and that to the companies cannot be undervalued. It extends the supervision of the central authorities, and allows the most effective action to take place on every emergency, whether of accident or otherwise. Lately, some half-dozen gentlemen were on business at a minor station on the Eastern Counties line, and being desirous of proceeding early to Cambridge, they made application to stop the next train, which would otherwise have passed the station. The message was passed to the superintendent at Shoreditch, leave granted, and within half an hour the gentlemen were on their way to Cambridge, where it was of great importance they should arrive early. A lesser case, which happened on the South Eastern a month or two ago, may be worth notice. An old woman proceeding from Minster to Tunbridge, or some intermediate station, after paying her second-class fare, in her hurry left her money on the counter. On arriving at Canterbury she found out her loss and wished to return to Minster, but the superintendent persuaded her to go on, in the hope that she might be able to learn something of it at Ashford. On her arrival there she was told that the money had been found on the counter at Minster to the amount she described, and at the next station the sum was handed to her; but though glad to receive the money, she could not repress her fears that the railway officers to whom she was indebted had dealings with the powers of evil. In the United States it is said that a marriage was contracted by railway between two parties hundreds of miles apart. Under the law of Scotland a telegraph marriage might, we believe, legally take place. Telegraph clerks are sometimes however able to help themselves, and a case lately occurred of a superintendent, having to convey to a branch bank notice of stoppage, drawing out his own balance before he delivered the notice.

In the progress of such an invention, and in its greater economy, its application must be very extensive. In the last session a telegraph was worked between the House of Commons and the committee rooms, and it is evident that it can be usefully employed in large offices and factories, where in time the telegraph wire will be as extended as the bellwire. The greater the extension the greater the prospect of improvement and economy to the public, and we can only wish, though we scarcely hope, that a system so valuable will be received in a favourable spirit on the part of the public, and meet with a greater degree of encouragement than is usually afforded to new inventions.

ON THE LAP AND LEAD OF THE SLIDE VALVE.

The slide valve is that part of a steam engine which causes the motion of the piston to be reciprocating. It is made to slide upon a smooth surface, called the cylinder face, in which there are three openings to as many pipes or passages: two for the admission of steam to the cylinder, above and below the piston, alternately; while the use of the third is to convey away the waste steam. The first two are, therefore, termed the induction or steam ports, and the remaining one the eduction or exhaustion port.

The slide is enclosed in a steam-tight case, called the slide-jacket; and motion is communicated to it by means of a rod working through a stuffing-box.

The steam from the boiler first enters the jacket, and thence passes into the cylinder, through either steam port, according to the position of the slide, which is so contrived that steam cannot pass from the jacket to the cylinder through both steam ports at the same time, or through the eduction port at any time.

CASE 1.—WHEN A SLIDE HAS NEITHER LEAD OR LAP.

Fig. 1 represents the cylinder face for a "Murray slide" without lap; *a* and *b* being the induction ports, and *c* the eduction.

Figs. 2, 3, and 4, are similar sections of the nosle, showing the slide in its central and two extreme positions. It occupies the mid-position, fig. 2, when the piston is at either extremity of its stroke; the extreme position, fig. 3, when the piston is at half-stroke in its descent; and that shown in fig. 4, when the piston is at half-stroke in its ascent.

When a slide has no lap, the width of its facing, at *f* and *g* (fig. 2), equals that of the steam ports; the lap being any additional width whereby those ports are overlapped.

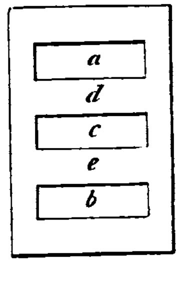


Fig. 1.

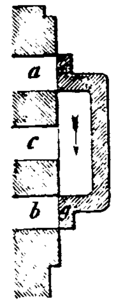


Fig. 2.

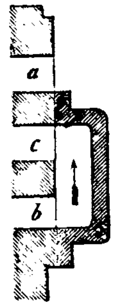


Fig. 3.

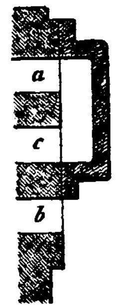


Fig. 4.

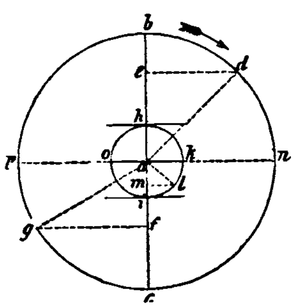
That the waste steam may have unobstructed egress, the exhaustion port *c* must be made of no less width than the steam ports; and, for the same reason, the bars *d* and *e* should correspond with the slide face at *f* and *g*. The three ports, together with the bars between and beyond them, are therefore drawn of equal width; the total length of the slide being equal to the distance between the steam sides of the steam ports.

The distance through which the slide moves, in passing from one extreme position to the other, is called its *travel;* which, in this case, equals *twice the port.*

When the motion of a slide is produced by means of an eccentric, keyed to the crank shaft and revolving with it, the relative positions of the piston and slide depend upon the relative positions of the crank and eccentric.

Demonstration.

Diagram 1.



Let *a b*, diagram 1, represent the crank; then *b* being the crank-pin, and *a* the centre of motion, the larger circle represents the orbit of the crank, and its diameter *b c* the stroke of the piston. Supposing the cylinder to be an upright one, having the crank-shaft immediately above or below it, the connection between the piston-rod and crank being merely a connecting-rod, without the intervention of a beam, it is evident that when the position of the crank is *a b*, the piston will be at the top of the cylinder, and at the bottom when its position is *a c*. The relative positions of the crank and piston, at any point of the stroke between the two extremes, depend upon the length of the connecting-rod: for the present, however, let us suppose the connecting-rod to be of infinite length, and therefore always acting upon the crank in parallel lines, so that when the crank is at *d*, *e* will be the apparent position of the piston, and *f* the same when the crank is at *g*; the piston being represented by the sine of the arc described by the crank from either of the points *b* and *c*, in the direction of the arrow.

The diameter *h i*, of the inner circle of the diagram, represents the travel of the slide, and its radius the eccentricity of the eccentric; or, regarding the eccentric as a crank, the radius may be said to represent that crank, as *a b* represents the main crank. The travel of a slide, without lap, being equal to twice the port, the two steam ports are represented by the spaces *a h* and *a i*, but transposed, *a i* being the passage to the top of the cylinder, and *a h* that to the bottom.

Supposing the piston to be at *b* (the top of the cylinder), the position of the slide will be that shown in fig. 2, the direction of its motion being downward, so that the port *a* (same figure), or *a i* in the diagram, may be gradually opened for the admission of steam above the piston, until the piston has arrived at half-stroke, when it will be fully open, as shown in fig. 3. The direction of the slide's motion is then reversed, so that when the piston has completed its descent, the port *b*, figs. 1 to 4, or *a h* in the diagram, will begin to open for the admission of steam beneath it, and exhaustion will commence from above it through the port *a*, or *a i*, and exhaustion port *c*, the slide being again brought into its central position, fig. 2.

Now the slide being at half-stroke, when the piston is at either extremity of its stroke, if we make *a b* the position of the crank, *a k* will be that of the eccentric; and the axis of the crank being likewise that of the eccentric, they must necessarily revolve in equal times, and always at the same distance apart; therefore, when the crank has reached the point *d* (supposing it to move in the direction of the arrow) the eccentric will have advanced to *l*, and *e d* and *l m* represent the positions of the piston and slide respectively; showing, that when the piston has descended to *e*, the steam port *a i* in the diagram, or *a* figs. 1 to 4, will be open to the extent *a m*. Again,—when the crank is at *n*, and the piston consequently at half-stroke, *a i* will be the position of the eccentric, the port *a i* being fully open, and the slide occupying the extreme position shown in fig. 3. The direction of the slide's motion is now reversed, and the port is again gradually covered by the slide face until the positions of the crank and eccentric are *a c* and *a o*, when the piston will have completed its descent, and the port *a i* will be completely closed, the slide being again brought into its central position, fig. 2. The opposite steam port *a h* now begins to open for the admission of steam, and the direction of the piston's motion is reversed; the port continues to open until the crank and eccentric reach the points *p* and *h*, when the piston will again be at half-stroke, and the slide in its extreme position, fig. 4. Meanwhile, exhaustion from above the piston has been taking place, to the same extent, through the port *a i*. Finally,—the piston having completed its ascent, the slide again occupies its original position, fig. 2, and, its course being downward, steam is again admitted into the cylinder, through the port *a*; the piston then begins to descend, and, at the same instant, exhaustion ceases from above, and commences from below it, through the port *b*.

It is sometimes urged against the use of the eccentric, as a means of actuating the slide, that the steam ports are opened and closed too slowly; but it must be remembered that the piston does not move at a uniform velocity, as the crank does; for example, while the crank describes the arc *b d*, the piston descends only from *b* to *e*, the versed sine of that arc; and its velocity is gradually increased as it approaches the middle of its stroke, where it is greatest, being equal to that of the crank. Again,—as the piston approaches the end of its stroke, its velocity is diminished in the same ratio as that in which it had previously increased, until the completion ot its stroke, where it remains stationary during the small space of time in which the direction of its motion is reversed.

Now, it must be obvious that less steam is required to impel the piston at a slow rate than at a rapid one; and a glance at diagram 1 shows that the steam admitted into the cylinder, when the slide is actuated by an eccentric, is at all times proportioned to the velocity of the piston, the port being least open when the piston is near the end of its stroke, and fully open when it is at half-stroke.

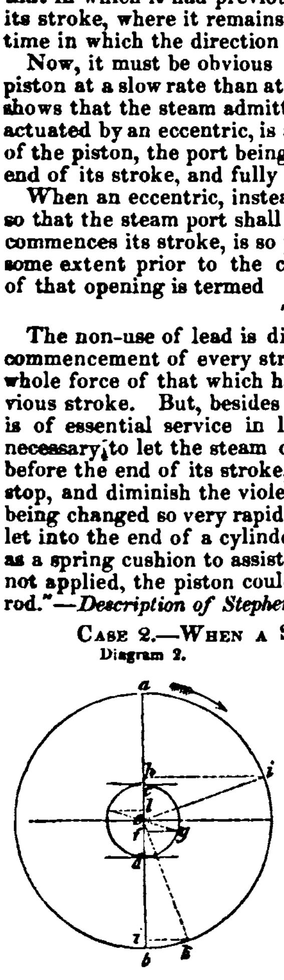
When an eccentric, instead of being set, as in the preceding case, so that the steam port shall only begin to open when the piston commences its stroke, is so placed that the port shall be open to some extent prior to the commencement of the stroke, the width of that opening is termed

The Lead.

The non-use of lead is disadvantageous, chiefly because at the commencement of every stroke, the steam has to contend with the whole force of that which had impelled the piston during its previous stroke. But, besides obviating that disadvantage, the lead is of essential service in locomotive engines, "where it is found necessary to let the steam on to the opposite side of the piston before the end of its stroke, in order to bring it up gradually to a stop, and diminish the violent jerk that is caused by its motion being changed so very rapidly as five times in a second. The steam let into the end of a cylinder before the piston arrives at it, acts as a spring cushion to assist in changing its motion; and if it were not applied, the piston could not be kept tight upon the piston-rod."—*Description of Stephenson's Locomotive Engine*, "*Tredgold.*"

Case 2.—When a Slide has Lead without Lap.

Diagram 2.



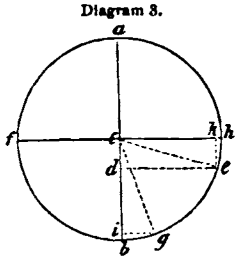
Let *a b*, diagram 2, represent the stroke of the piston; *c d* the travel of the slide; and *e f* the *lead*; then, supposing the piston to be at the top of the cylinder, *e a* is the position of the crank, and *e g* that of the eccentric. Following the course of the crank, in the direction of the arrow, we find the port *e d* fully open, not, as in the former case, when the piston is at half-stroke, but when it has descended to the point *h*,—the arc *a i*, described by the crank, being equal to the arc *g d*, described by the eccentric. Again,—we find the port re-closed when the piston has descended to *i'*, at which point exhaustion commences from above the piston through *e d*, and steam enters below it through *e c*, for the return stroke, at the commencement of which the port *e c* is open to the extent *e l* (equal to *e f*) for the admission of steam, while *e d* is open to the same extent for exhaustion.

It is to be remarked, that the amount of *lead* is necessarily very limited in practice, its tendency being to arrest the progress of the piston before the completion of its stroke. The greatest possible amount of lead equals half the travel of the slide. The eccentric would in that case be set diametrically opposite to its first position, which would have the effect of reversing the direction of the piston's motion.

In the case of a slide having lead without lap, the distance of a piston from the end of its stroke, when the lead produces its effect, is proportional to the lead as the versed sine of an arc is to its sine, supposing the radii of the crank and eccentric to be equal.

Demonstration.

Diagram 3.



Let *a b*, diagram 3, represent both the travel of the slide and the piston's stroke; then *c a* and *c b* represent the steam ports. And let *c d* represent the lead; then *c a* and *c e* represent the crank and eccentric, the piston being at the top of the cylinder. Now, steam will enter the cylinder, below the piston, when the eccentric is at *f*, and the crank at *g*; for the arcs *a e g*, and *e b f* are equal. Again,—the arc *g b* is equal to *h e*; therefore, *i g* is equal to *k e*, and *i b* to *k h*. Now, *k e* is the sine of the arc *h e*, and *k h* (equal to *i b*) is its versed sine: hence

Rule I.—*To find the distance of the piston from the end of its stroke, when the lead produces its effect:—*

Divide the lead by the width of the steam port, both in inches, and call the quotient sine; multiply its corresponding versed sine, found in the table, by half the stroke, and the product will be the distance of the piston from the end of its stroke, when steam is admitted for the return stroke, and exhaustion commences. Or,

Rule II.—*To find the lead, the distance of the piston from the end of its stroke being given:—*

Divide the distance in inches by half the stroke in inches, and call the quotient versed sine; multiply its corresponding sine by the width of steam port, and the product will be the lead.

Example 1.—The stroke of a piston is 48 inches; width of steam port $2\frac{1}{2}$ inches; and lead $\frac{1}{2}$ inch: required the distance of the piston from the end of its stroke, when exhaustion commences.

Here, $\cdot5 \div 2\cdot5 = \cdot2 =$ sine; and versed sine of sine $\cdot2 = \cdot0202$.
Then, $\cdot0202 \times 24 = \cdot4848$ inches.

Example 2.—The stroke of a piston is 48 inches; width of steam port 2·5 inches; and distance of piston from the end of its stroke, when exhaustion commences, ·4848 inches: required the lead.

Here, $\cdot4848 \div 24 = \cdot0202 =$ versed sine;
and sine of versed sine $\cdot0202 = \cdot2$.
Then, $\cdot2 \times 2\cdot5 = \cdot5 =$ lead.

When the lead of a slide is equal to the width of steam port multiplied by any number in the first column of the following table, the distance of the piston from the end of its stroke, when steam is admitted on the exhaust-side, will be equal to half the stroke multiplied by the corresponding number of the second column. Or, if the distance of the piston from the end of its stroke, when steam is admitted on the exhaust-side, be equal to half the stroke multiplied by any number in the second column, the width of steam port multiplied by the corresponding number of the first column equals the lead.

When the lead is equal to the width of steam port multiplied by	The distance of the piston from the end of its stroke, when steam is admitted on the exhaust-side, equals half the stroke multiplied by
0625	·0019
·09375	·0044
·125	·0078
·1875	·0176
·21875	·0242
25	·0317
·28125	·0403
·3125	·0501
·34375	·0609
·375	·0730
·40625	·0862
·4375	·1008
·46875	·1166
·5	·1339

The Lap.

A slide is said to have *lap* when the width of its face is greater than that of the steam ports, the ports being thereby overlapped, as in fig. 7.

It is to be remarked that slides should have some degree of lap on both the steam and exhaustion sides of the passage, because, although in theory an aperture may be said to be completely closed when covered by a bar of similar width, yet, in the construction of a slide without lap, we cannot insure such accuracy of *fit* as to preclude the possibility of steam entering or leaving both steam ports at the same time.

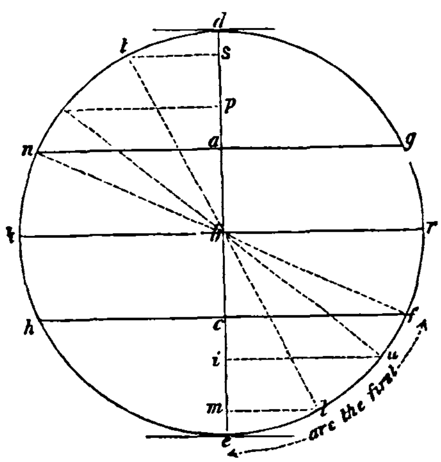
Lap on the steam side has the effect of cutting off the steam from the cylinder, by closing the port before the completion of the stroke, the remainder of the stroke being effected by the expansion of the steam already admitted.

Demonstration.

Case 3.—When a Slide has Lap on the Steam side, without Lead.

Let *a b* and *b c*, diagram 4, represent the lap at both ends of the slide; and let *a d* and *c e* represent the two steam ports; then *d e* will represent the travel of the slide, which, in this case, equals twice the steam port, plus twice the lap.

Diagram 4.



Supposing *d e* also to represent the stroke of the piston, and that the piston is on the top stroke, then *b d* and *b f* are the respective positions of the crank and eccentric; for the slide, instead of occupying its central position, when the piston is at the end of its stroke (as in Case 1), must be set in advance of that position to the extent of the lap, that steam may enter the cylinder when the piston begins to move. (See fig. 5.)

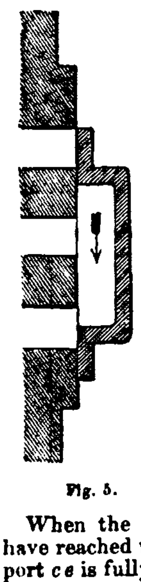


Fig. 5.

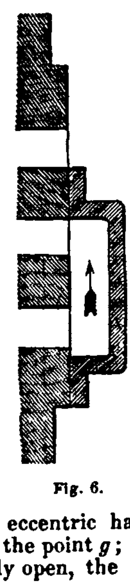


Fig. 6.

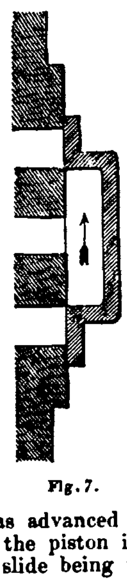


Fig. 7.

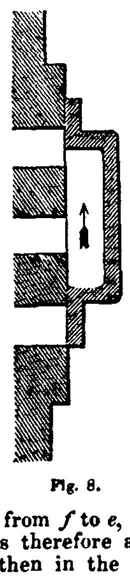


Fig. 8.

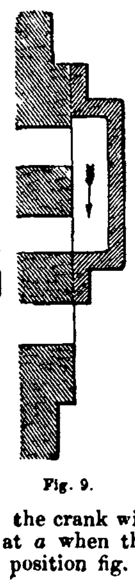


Fig. 9.

When the eccentric has advanced from *f* to *e*, the crank will have reached the point *g*; the piston is therefore at *a* when the port *c e* is fully open, the slide being then in the position fig. 6. Again,—when the eccentric has reached the point *h*, the port *c e* will be re-closed (fig. 5), and *i* will be the position of the piston; therefore, the distance of the piston from the end of its stroke, when the steam is cut off, is proportioned to the whole stroke, as *i e* is to *d e*.

When the eccentric arrives at *k*, the slide will occupy its central position (fig. 7), and the piston will be at *m*, where exhaustion commences from above it; but steam is not admitted below it, for the return stroke, until the eccentric has reached the point *n*, where the port *a d* begins to open, the position of the slide at that moment being that shown in fig. 8.

When the eccentric arrives at *d*, the port will be fully open, the slide being then in its extreme position, fig. 9; and it will be re-closed when the eccentric arrives at *g*, and the piston at *p*, where the steam is cut off, the position of the slide being again that shown in fig. 8. Again,—when the eccentric reaches the point *r*, exhaustion ceases from above the piston, which is then at *s*, and commences from below it, the slide being then in its central position, fig. 7, and moving downward. Finally,—the crank having arrived at *d*, and the eccentric at *f*, the piston will have completed its ascent, and the slide will occupy the position fig. 5, as at starting.

The steam was shown to be cut off when the piston had descended from *d* to *i*, the crank having described the arc *d g u*, and the eccentric the arc *f e h*. Now, *d i* is the versed sine of *d g u*, and *e c* is the versed sine of half *f e h*; and *d g u* and *f e h* are equal arcs. Hence

Rule III.—*To find at what part of the stroke steam will be cut off with a given amount of lap:—*

Divide the width of steam port, by itself, plus the lap, and call the quotient versed sine. Find its corresponding arc in degrees and minutes, and call it arc the first. If arc the first be less than 45 degrees, multiply the versed sine of twice that arc by half the stroke in inches, and the product will be the distance of the piston from the *commencement* of its stroke, when the steam is cut off.

If arc the first exceed 45 degrees, multiply the versed sine of the difference between double that arc and 180 degrees by half the stroke, and the product will be the distance of the piston from the *end* of its stroke when the steam is cut off.

Rule IV.—*To find the amount of lap necessary to cut off the steam at any given part of the stroke:—*

If it be required to cut off the steam before half-stroke, divide the distance the piston moves before steam is cut off, by half the stroke, and call the quotient versed sine. Find the arc of that versed sine, and also the versed sine of half that arc. Divide the difference between the versed sine last found and unity, by the versed sine, and multiply the width of steam port by the quotient; the product will be the lap.

If it be required to cut off the steam at a point beyond half-stroke, divide the distance of the piston from the end of its stroke, when steam is cut off, by half the length of stroke; call the quotient versed sine; find its corresponding arc, and subtract it from 180 degrees. Find the versed sine of half the remainder, and subtract it from unity. Divide the remainder by the versed sine, and multiply the width of the steam port by the quotient; the product will be the lap.

Example 3.—The stroke of a piston is 36 inches; width of steam port $1\frac{1}{2}$ inch; and lap 6 inches: required the point of the stroke at which steam will be cut off.

Here $1{\cdot}5 + 6 = 7{\cdot}5$; and $1{\cdot}5 \div 7{\cdot}5 = {\cdot}2$ = versed sine;
arc of versed sine $\cdot 2 = 36^\circ\ 52'$ (arc the first);
and $36^\circ\ 52' \times {\cdot}2 = 73^\circ\ 44'$ = arc of versed sine, $\cdot 7198$.

Then $\cdot 7198 \times 18 = 12{\cdot}95$ inches = distance of the piston from the commencement of its stroke when the steam is cut off.

Example 4.—The stroke of a piston is 36 inches; width of steam port $1\frac{1}{2}$ inch; and extent of lap $1\frac{1}{4}$ inch: required the point of the stroke at which steam is cut off.

Here $1{\cdot}5 + 1{\cdot}25 = 2{\cdot}75$; and $1{\cdot}5 \div 2{\cdot}75 = {\cdot}5454$ = versed sine of arc $62^\circ\ 58'$ (arc the first).

Then $62^\circ\ 58' \times 2 = 125^\circ\ 56'$; and $180^\circ - 125^\circ\ 56' = 54^\circ\ 4'$ = arc of versed sine, $\cdot 4131$; $\cdot 4131 \times 18 = 7{\cdot}43$ inches = distance of the piston from the end of its stroke when the steam is cut off.

Example 5.—The stroke of a piston is 36 inches; width of steam port 1·5 inches; and distance of the piston from the commencement of its stroke, when the steam is cut off, 12·95 inches: required the lap.

Here $12{\cdot}95 \div 18 = {\cdot}7198$ = versed sine of arc $73^\circ\ 44'$;
$73^\circ\ 44' \div 2 = 36^\circ\ 52'$ = arc of versed sine $\cdot 2$.

Then $1 - {\cdot}2 = {\cdot}8$; and $\cdot 8 \div 2 = 4$; $1{\cdot}5 \times 4 = 6$ inches = lap.

Example 6.—The stroke of a piston is 36 inches; width of steam port 1·5 inches; and distance of piston from the end of its stroke, when steam is to be cut off, 7·43 inches: required the lap.

Here $7·43 \div 18 = ·4131 =$ versed sine of arc $54° 4'$.

Then $180° - 54° 4' = 125° 56'$; and $125° 56' \div 2 = 62° 58' =$ arc of versed sine ·5454.

$1 - ·5454 = ·4546$; and $·4546 \div ·5454 = ·8335$;

$·8335 \times 1·5 = 1·25$ inches = lap.

Exhaustion was shown to commence when the piston was at *m* in its descent, and at *s* in its ascent; *l* and *t* being the corresponding positions of the crank at those times. Now *d* and *f* were the respective starting points of the crank and eccentric; and the arc *d g l*, described by the crank, is equal to the arc *f e k*, described by the eccentric. Therefore, *r f* and *e l* are equal arcs. Hence,

To find the distance of the piston from the end of its stroke when exhaustion commences, subtract arc the first (found by Rule III.) from 90 degrees, and multiply the versed sine of the remainder by half the stroke. The product will be the distance required.

Example 7.—Arc the first (Example 3) $= 36° 52'$; and $90° - 36° 52' = 53° 8' =$ arc of versed sine ·4

Then $·4 \times 18 = 7·2$ inches, the distance required.

Example 8.—Arc the first (Example 4) $= 62° 58'$; and $90° - 62° 58' = 27° 2' =$ arc of versed sine ·1092.

Then $·1092 \times 18 = 1·9656$ inches, the distance required.

From the foregoing examples, it is obvious that whatever may be the relative proportions of the length of stroke and width of steam port, the lap must be some multiple of the port, that the steam may be cut off at any given point of the stroke.

The annexed table exhibits a series of multipliers for determining the amount of lap necessary to cut off the steam at any part of the stroke from $\frac{1}{8}$ th to $\frac{7}{8}$ ths, *when the slide has no lead.*

		Multipliers.
Portion of the stroke to be performed by the piston before the steam is cut off.	$\frac{1}{8}$ th	14·48
	$\frac{1}{4}$	6·46
	$\frac{3}{8}$	3·77
	$\frac{1}{2}$	2·41
	$\frac{5}{8}$	1·58
	$\frac{3}{4}$	1·00
	$\frac{7}{8}$	·54

We shall next month proceed to examine the conditions of the slide valve with both "lead and lap."

R. B. C.

HEALTH OF TOWNS—THE GOVERNMENT AND THE PROFESSION.

Now that the sanitary movement is likely to bear fruit, it will be well for our professional readers to turn their attention to the share which they are to have in the rewards, after having borne their part of the labour. While engineers, architects, and surveyors have been working hard in carrying out sanitary reform, in improving the drainage, in reducing the cost of sewers, in mitigating the smoke nuisance, in warming, in ventilating, in the construction of dwellings, in the application of sewage manures, and in many other ways,—medical men and members of parliament have been making speeches, and claiming the honours of the campaign, as it seems they claim the emoluments. With what justice members of the constructive professions can be kept out of sight, we do not know; but there is a determined set on the part of the medical men to keep them out, and to monopolise the merit and the patronage. Of the five Metropolitan Sanitary Commissioners, two are medical men, viz., Dr. Southwood Smith and Professor Owen; and not one is engineer, architect, or surveyor. The commissioners, at page 51 of their First Report, speak as follows:—

"It has appeared to be our duty to state, that we have had presented to us ground of exception against one class of appointments to these commissions, namely, that of surveyors, of architects in practice, of builders, traders, agents, and professional persons connected with building operations in their respective districts."

We think the bias of this passage is readily to be seen, though it does not impugn the appointment of engineers, architects, or surveyors, as paid commissioners, such officers not practising. There is no reason given why an architect and an engineer should not be appointed on the Metropolitan Sanitary Commission in addition to the physician and surgeon, or naturalist. We will show afterwards what reason there is why the two former should be appointed.

The following paragraph of the Report contains an insinuation, well worthy of notice, for it has its object:—

"The more the investigation advances, the more is it apparent that the progressive improvement and proper execution of this class of public works, together with the appliances of hydraulic engineering, cannot be reasonably expected to be dealt with incidentally, or collaterally to ordinary occupation, or even to connected professional pursuits, but require a degree of special study which not only place them beyond the sphere of the discussion of popular administrative bodies, but beyond that of ordinary professional engineering and architectural practice. In justification of this conclusion, and to show the evil of the perverted applications of names of high general professional authority, we might adduce examples of the most defective works which have received their sanction."

The aim of this is, that the abuse shall be an argument against the use: because some architects have laid down expensive sewers, engineers, architects, and surveyors shall be excluded; because Professor Donaldson and Mr. Joseph Gwilt approve of the old system, those who have fostered and executed the new system shall not be employed. This is what the commissioners mean, though they do not say it fully; and we put it to the public whether it is fair to professions, which by their talent and their intelligence have so much contributed to the reputation of the country.

It may be taken as a matter of course that Crown Commissioners recommend the employment of the government Caleb Quotem, "the Corps of Royal Engineers," to execute a survey of the metropolitan districts. This we conceive to be the finishing touch to the wrongs and insults which the Sanitary Commissioners have in this Report, and in their proceedings, heaped upon highly honourable professions.

If it be needful to show that engineers, architects, and surveyors can be of some use, we shall appeal to the Report of the Sanitary Commissioners, the recommendations in which are based on the evidence of Mr. Roe, the Surveyor of the Holborn and Finsbury District, Mr. Phillips, the Surveyor of the Westminster District, and other able officers. In truth, as our pages would show, Mr. Roe has, by his indefatigable exertions, already carried out much of the plans now advocated by the Sanitary Commissioners, and has only been prevented by the Commissioners of Sewers from doing more. Surely these officers are to be balanced against those who have adhered to a practice which has only recently been opposed and condemned. What do the commissioners tell us?

"All the improvements which the public have yet obtained in this branch of public works, have been the result of the special and undivided practical attentions of well-qualified paid officers, and it appears to us that further improvement must be sought by the same means, and that one of the chief objects of future administrative arrangements must be to secure, protect, and encourage the zealous, undivided attention and efficient labour of such officers."

If engineers and surveyors have already effected "all the improvements which the public have yet obtained in this branch of public works;" and if to them, as scientific officers, the public have to look for future improvements, we can see no reason for the slur cast on them by their exclusion from the present commission, by the announced exclusion from future commissions, and by the employment of the Corps of Royal Engineers, of whom—with all respect be it said—the reputation is not European. We cannot hold the appointment of Mr. Austin to the secretaryship of the commission, nor the compliment paid to the executive officers of the Commissioners of Sewers as any alleviation of the intended slight. We hope Mr. Edwin Chadwick, as commissioner, and Mr. Austin, as secretary, both of whom have done well in the cause of sanitary reform, have had no part in the exclusive policy of the commission.

We have the highest regard for the medical profession; we have the strongest feeling of the good it has done in promoting sanitary reform; but we cannot stand still while medical men arrogate to themselves the merits, the honours, and the rewards of sanitary reform. Their agitation has done good, we admit; their disinterested advocacy of the cause claims the highest praise; their evidence has given a body and strength to the movement; but it is our professions which have worked while theirs have talked,—which have improved the forms of the sewers, and reduced the price—which have cleansed them by flushing, and which by a mass of individual labour have perfected and carried out plans of improvement in every branch of construction, ministering to the public comfort, health, and life. Our pages have had their share in these discussions, and we have co-operated with our professional readers in carrying out a measure of reform, which is already great. In the Holborn and Finsbury and Westminster divisions of sewers alone, a reform has been effected, such as has not yet been seen in these matters; and we are ignorant of the share the medical profession have taken in carrying them out.

Within a period not very distant, the new Sanitary Commissioners, or Commissioners of Sewers, will lay down works to the amount of half a million, perhaps a million sterling, upon the advice, it is true, of competent professional officers, though under what competent supervision on the part of the commission, we are unaware. When Mr. Roe proposes his plan for spending a quarter of a million in getting a new outfall, which of the commissioners will consider it his special department to examine the estimates, and share in their responsibility? It will not be Lord Robert Grosvenor—it will not be Mr. Edwin Chadwick, great as is his capacity as an administrator—it will not be Mr. Richard Lambert Jones, though he is Chairman of the Bridge Committee in the City—it will not be Dr. Southwood Smith or Professor Owen. The two latter will, we apprehend, be of little use in matters like these, and will take no part in them. Thus, a member of parliament, a naturalist, a barrister, an auctioneer, and a physician, are to superintend the disbursement of hundreds of thousands of pounds in public works, and to appoint "well-qualified paid officers" in the engineering and surveying departments; who are to have "a degree of special study which [shall] not only place them beyond the sphere of the discussion of popular administrative bodies, but beyond that of ordinary professional engineering and architectural practice."

The government have not thought it necessary to give a fair representation to the profession in the new Commission of Sewers, though the names of Mr. Robert Stephenson, M.P., Mr. Locke, M.P., Mr. George Rennie, Mr. Cubitt, and others, are well enough known at Whitehall.

The constitution of the Metropolitan Sanitary Commission is, in reference to the sphere of its future duties, more monstrous than that of the Railway Commission, where three parties, who know nothing of railways—a member of parliament, an East India judge, and an officer in the army—are entrusted to meddle with railway works and administrations. We have so many of these absurd appointments of late, that we have a strong impression that unfitness is adopted as the government rule for office, and have some expectation of seeing Monsieur Jullien prime minister. Why the engineering profession should be exposed to the contumely and neglect from which it suffers at the hands of the government, we do not know; but the enumeration of the Railway Commission, the Tidal Harbour Commission, and the Metropolitan Sanitary Commission, is a sufficient proof that a degree of unfairness is displayed, which demands immediate and effective opposition. Although the reputation of English engineers is well known to the world—although their professional skill is sought in every country—it may be that they are thought by the home government a body too inconsiderable and contemptible to withstand oppression or demand fair play.

The misconduct of the government on this head has reached that height, that the professions, if they wish to maintain their public character, cannot do otherwise than take instant steps to obtain justice. They have no security at present for the appointment of competent commissioners, or efficient officers, or for the employment of professional men at all; there is no security that officers of the Royal Engineers, and other branches of the army, will not be appointed surveyors of the sewers and other public works, the present officers being superseded. We think it is the duty of the Institutions of Architects and Civil Engineers to call meetings of their members, to memorialise the government, and send deputations to Whitehall, and take every other necessary step to vindicate the rights of their members. Aggregate meetings of engineers, architects, and surveyors, should be held in the metropolis, and in provinces petitions sent to parliament, and memorials to the Treasury. The members of parliament interested in the welfare of the professions, should be requested to take steps in parliament for obtaining explanations from the ministers. Mr. Robert Stephenson, Mr. Locke, and Mr. Cubitt, would no doubt, on application, give their cordial support to any necessary measure.

While we urge these strong remarks on the injustice done to engineers by the Metropolitan Sanitary Commissioners, it must not be thought that we undervalue their Report on the practical points to which they apply themselves. We are glad to acknowledge it as a step forward in the right way.

THE FAN BLAST.

Series of Experiments relative to the Fan Blast, presented by Mr. BUCKLE, *of the Soho Works, to the meeting of the Institute of Mechanical Engineers, Birmingham, May* 17, *and October* 27, 1847.

(PAPER No. 1.)

The subject of this paper has reference to a portion of a series of experiments on the Fan Blast,—a subject which many members of this Institution are conversant with; but it is hoped that hints here thrown out may be serviceable in leading to such constructions of the fan as shall insure the greatest useful effect with the least expenditure of power. The fan has become an indispensable machine in smithies and foundries, it abridges time and labour, and is otherwise a great improvement over the old system of bellows. The uniform stream of the former admits of no comparison, by the puffy blasts of the latter. By means of the fan the smith can heat his work with precision; he can vary at discretion the size of his nozzle tweyere, without deteriorating the density of his blast. He can conveniently heat one piece of work while shaping another.

In a well-regulated smithy, the main pipe from the fan is furnished with an air chest and with nozzle pipes, varying from one to three inches diameter. The pressure of the blast is made to range from four to five ounces per square inch. A nozzle pipe of $1\frac{5}{8}$ inch diameter is found a suitable size for general engine forcings.

The position of the fan in its chest, or the one preferred and generally made use of, is an eccentric position. The continual increasing winding passage between the tips of the vanes and the chest, serves to receive the air from every point of its circumference, and forms, as it were, a general accumulating stream of air to the exit pipe. The particles of air having passed the inlet opening, and entering on the heel of the blade, would retain the same circular path were it not for the centrifugal force of the air due to its weight and velocity, impelling them forward towards the tips of the vanes; and this continued action is going on, particle following particle, till they are ultimately thrown against the fan chest, and are impelled forward to the exit pipe. It is by this centrifugal action that the air becomes impelled and accumulated into one general stream. But, as will be presently shown, there is a certain velocity of the tips of the fan which best suits this action.

An ordinary eccentric-placed fan, 4 feet diameter—the blades 10 inches wide and 14 inches long—and making 870 revolutions per minute, will supply air at a density of 4 ounces per square inch, to 40 tweyeres, each being $1\frac{5}{8}$ inches diameter, without any falling off in density. The experiments herein detailed were made with a fan 3 feet $10\frac{1}{16}$ inches diameter, the width of the vanes being $10\frac{3}{8}$ and the length 14 inches; the eccentricity of the fan $1\frac{7}{16}$ inches, with reference to the fan case, the number of vanes being 5, and placed at an angle of 6° to the plane of the diameter; the inlet openings on the side of the fan chest $17\frac{1}{2}$ inches diameter, the outlet opening 12 inches square; the space between the tips of the blades and the chest increasing from $\frac{3}{8}$ inch on the exit pipe to $3\frac{1}{4}$ at the bottom, in a line perpendicular with the centre. To the blast pipe leading to the tweyeres a slide valve was attached, by means of which the area of the discharge was accurately adjusted to suit the required density.

The guage to indicate the density of the air, was a glass graduated tube, primed with water, it being more sensitive and having a greater range than the mercurial one.

These experiments were made with a view to ascertain what density of air could be obtained, with the vanes moving at given velocities, the outlet pipe being closed, and also at given velocities with the outlet open; but its area varied at discretion. And further, to ascertain the horse-power required to drive the fan under the varied condition.

The horse-power was ascertained by an indicator, the friction of engine and gearing being deducted in each experiment. With reference to the term Theoretical Velocity, as used in the table, it may be necessary to observe, that thereby is meant the velocity which a body would acquire in falling the height of a homogeneous column of air equivalent to the required density. Having given the necessary preliminary explanations of the blast above that of the atmosphere, we come to the experiments as recorded in the table, No. 1 *a*.

The first column is the number of experiments.

The second is the number of revolutions of the fan per minute.

The third is the velocity of the tips of the vanes in feet per second.

The fourth is the density of the air in ounces per square inch, as indicated by the gauge.

The fifth is the area of the discharge pipe in inches.

The sixth is the indicated horse power.

By this paper it is intended to be shown that there are certain velocities with which the tips of the vanes of a fan should move according to the required density of air, and that there are certain laws which govern these velocities.

First.—Water is 827 times heavier than air; mercury is 13·5 heavier than water: consequently, mercury is 11164 heavier than air. A column of mercury, one inch in height, would therefore balance a column of air 11164 inches, or 930·3 feet in height. Let A be a column of mercury equal in height to any given density, and let B represent 930·3, and C 64*; then $\surd\,(A \times B \times C) = V$ or the velocity that a body would acquire in falling the height of a column of air equivalent to the density.

Second.—The centrifugal force of air coincides with the results obtained by the laws of falling bodies, that is when the velocity is the same as the velocity which a body will acquire in falling the height of a homogeneous column of air equivalent to any given density. To obtain the centrifugal force or density of air apply the following general rule.

Having given the velocity of the air, and the diameter of the fan, to ascertain the centrifugal force,—

Rule.—Divide the velocity by 4·01, and again divide the square of the quotient by the diameter of the fan. This last quotient multiplied by the weight of a cubic foot of air, at 60° Fahrenheit, is equal to the force in ounces per square foot, which, divided by 144, is equal to the density of air per square inch. Or, substituting the following formula, we have

$$D = N\,V \times {\cdot}000034$$

where D is the density of the air in ounces per square inch, and N the number of revolutions of fan per minute, and V the velocity of the tips of the fan in feet per second.

Let us now compare the results of the foregoing table. To do this, we will first take the velocity of the tips of vanes per second, and the power necessary to drive the fan. We will first take Nos. 1, 2, 3, 4, 5, and 6, and we shall find by inspecting the table that the corresponding velocities to these numbers are 236·8, 220·8, 202·1, 185·2, 171·5, and 144·1, and the corresponding densities of air per square inch are 9·4, 7·9, 6·9, 5·6, 4·5, and 3·5 ounces. The fan, it must be understood, is discharging no air; the velocity of the fan is merely keeping the air at a certain density or pressure per square inch. Under these circumstances, it requires a certain velocity of the tips of the fan to maintain a certain density of air, but not in a direct ratio.

The law which governs the velocity of the tips of the fan appears from these experiments to be $\frac{9}{10}$ of the velocity a body would acquire in falling the height of a homogeneous column of air equivalent to the density. This we have called the theoretical velocity, and by comparing Nos. 1, 2, 3, 4, 5, and 6 experiments as above, that is, by comparing the velocity of the tips of the fan per second with $\frac{9}{10}$ of the theoretical velocity, we shall find them to agree tolerably near. Thus, if the velocity of the tips of the fan per second be represented by 1, then $\frac{9}{10}$ of the theoretical velocity will be represented by

1·004	in No. 1	experiment,	The mean 1·008
·986	2	"	
1·008	3	"	
·990	4	"	
·960	5	"	
1·0007	6	"	

But we shall not only find that the $\frac{9}{10}$ of theoretical velocity governs the fan when it is not discharging air, but that the theoretical velocity governs it also when the outlet pipe is open; that is, that the maximum effect of the fan is when the vanes move from the theoretical velocity to $\frac{9}{10}$ of that velocity due to the density of the air, that the greatest quantity of air is discharged by the fan under these conditions with the least expenditure of power. To illustrate this more fully, let us refer to the table of experiments, and for our example we will take Nos. 9, 10, and 11; here the density in each is six ounces. In No. 10 the velocity of the tips of the vanes is 213·33 feet per second, while the theoretical velocity is 211 feet per second, being nearly the same. The quantity of air discharged is 77·9 cubic feet per second, and the power employed in this case amounts to 12·5 horses.

We take now No. 11 experiment. Here the velocity of the tips of the fan is 192 feet per second, and $\frac{9}{10}$ of the theoretical velocity 190 feet per second. Now these two experiments are in proportion to each other nearly, viz., in No. 11 the quantity of air discharged amounts to 35·7 cubic feet per second, and takes 6·4 horse power, while No. 10 discharges 77·9 cubic feet per second, and takes 12·5 horse-power. Thus the discharge of air is nearly 2 to 1, and the horse-power employed in the same proportion.

* The space which a gravitating body will pass through in one second is $16\frac{1}{12}$ feet; but by the principle of accelerating forces, the velocity of a falling body in any given time is equal to twice the space through which it has passed in that time, or the velocity is equal to the square root of the number obtained by multiplying 64 by the height in feet.

In the following examples we shall call the theoretical velocity per second *unity*, beginning with No. 15. In this example we shall also call the quantity of air discharged in cubic feet per second unity, and also the horse-power.

	Theoretical Velocity.	Density of Air per sq. in.	Velocity of tips of Fan.	Quantity of Air discharged.	Horse-power.
No. 15	1	5 oz.	·906	1·	1
14	1	5	1·007	2·34	1·93
12	1	5	1·150	2·67	3·16
20	1	4	900	1	1
19	1	4	1·029	2·4	3·42
18	1	4	1 133	2·02	3· nearly
17	1	4	1·225	2·30	4
16	1	4	1·280	2·12	4·27
11	1	6	·913	1·	1
10	1	6	1·009	2·18	2 nearly
23	1	3	1 050	1·59	2·53
22	1	3	1·160	2·	3·56
21	1	3	1·338	1·47	3·40
7	1·028	1·	1	1·	1·
9	·950	·857	1	1·203	1·03
12	·869	·714	1	1·35	1·06
16	·777	·571	1	1·40	1·11

To give a further illustration of this part of our subject, we will take Nos. 7, 9, 12, and 16 experiments. Here the velocity of the tips of the fan is the same, which we shall denote unity. The corresponding densities are 7, 6, 5, and 4 ounces; we shall call the highest unity, also the cubic feet discharged per second, and the horse-power.

Nearly all the preceding examples justify our conclusion, that the greatest results are obtained when the theoretical velocity and the tips of the vanes are nearly equal. It carries its own conviction that if we increase the velocity of the tips of the vanes, and only double the cubic quantity of air delivered, that it must take more than double the expenditure of power, the density of air remaining the same.

We shall now give examples of the *data* dictated by our table of experiments. And first, having given the density of air per square inch to determine the velocity of the tips of the vanes per second; also the horse power requisite to drive the fan under these circumstances, the fan not discharging air, but its velocity merely keeping the air at a certain density.

Let D denote the density of the air in ounces per square inch, and A a column of mercury equivalent in height to that density. Then by the laws of falling bodies $\surd\,(A \times 930{\cdot}3 \times 64) = V$ the velocity acquired by a body falling through a column of air of the corresponding density.

Then $\dfrac{38 \times D}{16} = P$ the number of pounds acting on the vanes,

and $\dfrac{\frac{9}{10} V. \times 60\ P.}{33000} =$ H. P. or horse-power required.

The constant number 38 is obtained by the following formula.

$$\frac{H\,P \times 33000}{\frac{9}{10}\,V \times 60} = P. \quad \text{Then } \frac{P \times 16}{D} = 38$$

Example.—Let $D = 9{\cdot}4$ oz. per square in., and $A = 1{\cdot}175$ in. of mercury, to determine the velocity of the tips of the vanes per second, and also the horse-power.

Then $\surd\,(930{\cdot}3 \times 64 \times 1{\cdot}175) = 264{\cdot}4$, the theoretical velocity, $\frac{9}{10}$ of which is $= 237{\cdot}96 = V$, or velocity of tips of vanes per sec.

Now $\dfrac{38 \times 9{\cdot}4}{16} = 22{\cdot}32 = P$, or pounds acting on the vanes of fan.

Then $\dfrac{237{\cdot}96 \times 60 \times 22{\cdot}32}{33000} = 9{\cdot}6$ the horse-power required.

Having given the velocity of the air in feet per second (or as it has been termed the theoretical velocity) to determine the density of the air in accordance with the laws of centrifugal force.

Let the velocity be 264·4 feet per sec., and the diameter of the fan 3·9 feet. Then by former rules we have

$$\frac{264{\cdot}4}{4{\cdot}01} = 66{\cdot}2 \text{ and } \frac{66{\cdot}2^2}{3{\cdot}9} = 11169 = \text{and } \frac{11169 \times 1{\cdot}209}{144} =$$

9· ounces density, the answer required.

Or by the second rule, take the velocity of the fan in feet per second, multiplied by the number of revolutions of the fan per minute, the product multiplied by ·000034 = the density required.

Here we must remark, that according to our table of experiments, that when the tips of the vanes are to move at $\frac{9}{10}$ of the theoretical velocity, that not more than 220 lb. of air are discharged per minute; but this is without any attenuation in the density.

To determine the horse-power necessary to drive the fan when discharging air, the velocity of the tips of the vanes not to exceed $\frac{9}{10}$ of the theoretical velocity, having given the density of air required, also the cubic feet,

First find the horse-power, as directed in former examples, when the fan is not discharging air.

Then multiply $\frac{1}{80}$ part of the weight of air to be discharged by the fan per minute in pounds by $\frac{9}{10}$ of the theoretical velocity, and *divide* by 33000. The quotient will give the horse-power necessary to discharge this quantity of air, which *add* to the horse-power necessary to drive the fan when not *discharging air*, for the answer required.

Example.—Let D be the density of air required = 4 oz. A, a column of mercury equal to the density = ·5 and W = the weight of air to be discharged = 220 lb. per minute, and V $\frac{9}{10}$ the velocity of fan in feet per minute.

$$\frac{38 \times 4}{16} = 9{\cdot}5 = P = \text{the pounds acting on the vane.}$$

Then by former rule, $V = \dfrac{9315{\cdot}0 \times 9{\cdot}5}{33000} = 2{\cdot}67$ horse-power necessary to drive the fan without efflux.

Now a cubic foot of common air at 60° Fahrenheit weighs 1·209 oz., therefore a cubic foot of the given density will be equal to 1·511 oz., and $\dfrac{220 \times 16}{1{\cdot}511} = 2330$ feet = the cubic quantity of air discharged per minute. And $\dfrac{220}{60} = \dfrac{3{\cdot}66 \times 9315{\cdot}0}{33000} = 1{\cdot}0$ horse-power necessary to discharge the given weight of air, and $1{\cdot}0 + 2{\cdot}67 = 3{\cdot}67$ = the total horse-power required.

When the velocity of the tips of the vanes is to move equal to the theoretical velocity, then we proceed as in the last examples, only we take $\frac{1}{60}$ instead of $\frac{1}{80}$ (as in former examples) of the weight of air discharged, which added to the horse-power requisite to drive the fan when no efflux takes place.

We should here again remark, that when the fan is moving at this velocity, that it is capable of discharging 480 lb. of air per minute without any falling off in density.

In a recent set of experiments, the inlet openings in the sides of the fan chest were contracted from 17½, the original diameter, to 12 and 6 in. diameter, when we obtained the following results.

First, that the power expended with the opening contracted to 12 in. diameter, was as 2¼ to 1 compared wiih the opening of 17½ in. diameter; the velocity of the fan being nearly the same, as also the quantity and density of air delivered.

Second, that the power expended with the opening contracted to 6 in. diameter, was as 2½ to 1 compared with the opening of 17½ in. diameter; the velocity of the fan being nearly the same, and also the area of the efflux pipe, but the density of the air decreased one-fourth.

These experiments show that the inlet openings must be made of sufficient size, that the air may have a free and uninterrupted action in its passage to the blades of the fan, for if we impede this action we do so at the expense of power.

(PAPER No. 2.)

In resuming the subject of the fan blast, I shall endeavour, as far as I conveniently can, to avoid detailed statements of the pneumatic laws involved in its consideration, as they would occupy more time than would be consistent with the present occasion; and shall proceed to remark on the most important points connected with the construction of the fan, viz.: the adoption of such forms and proportions, as shall insure the greatest results with the least expenditure of power; and effect a diminution of the intolerable noise that generally arises from the working of the fan. And although I have not been able to carry out such leading principles to the fullest extent, I trust that I have furnished materials that will be found of value to those members whose greater leisure may enable them to do so.

From a contemplative view of the action and apparent effect of that very useful apparatus, a fan blast, it would appear that the air in the fan case is impelled by the vanes along the transit pipe, or channel, to the chest provided for the blast; and that the continuous rapid motion of the vanes, compresses air in the pipe and chest, to a degree that may be shown and accurately measured, by a water, or mercurial gage, attached to the blast chest.

In my first communication, the principal investigation rested on a theoretical question, viz.: whether the tips of the blade should partake of the same velocity as a body falling freely a certain height, such height being governed by the density of air required. Recent experiments (the results of which accompany this paper) justify the conclusions then made, as will be seen on examining tables Nos. 2 *a*, 3 *a*, and 4 *a*.

Having satisfied myself with respect to the velocity a fan ought to have, when a certain density of air is required, I purpose in this paper to examine the fan under other varied conditions, the object being to establish the best proportions of inlet openings in the sides of the fan chest, and the suitable corresponding length of vanes. For this purpose, I caused the openings in the sides of the fan chest to be made of a large diameter, and I was enabled to vary those openings, by fitting in rings of wood; and I varied the fan by attaching to its arms, vanes of corresponding lengths. The experiments are classed in the following tables:—

Table No. 1 *a*, Contains the first set of experiments.
" 2 *a*, Experiments made with an inlet opening 30 inches diameter; the length of vane being reduced to 8 inches.
" 3 *a*, With an inlet opening of 24¾ inches diameter, and the length of the vane 11 inches.
" 4 *a*, With an inlet opening of 20¼ inches diameter, and the length of the vane 13¾ inches.
" 1 *b*, Shows the effect produced by narrowing the blades to 6 inches, the length being 16 inches, with outlet to transit pipe 4 inches deep.
" 2 *b*, 3 *b*, 4 *b*, are experiments showing the effect produced by contracting the outlet opening. The inlet opening, and the length of vane, being the same as the table under which it is classed.

In the concluding part of the first paper it was stated that, by impeding the free admission of air into the vane, it was done at the expense of power. Thus, by contracting the inlet opening to 12 inches diameter, we expended more than twice the power. This led to an extension of the openings, the results of which will be seen on comparing the former state of the fan, in table No. 1 *a*, with the present tables Nos. 2 *a*, 3 *a*, and 4 *a*.

In the first five experiments, no efflux of air takes place; and if, in these experiments, we take the mean of the density of the air and the horse-power, and call them *unity*, their proportions with the corresponding experiments represented in tables 2, 3, and 4, will stand thus:

Table No.	1	1·	Density of air.	1·	Horse-power.
"	2	·69	"	1·21	"
"	3	·8	"	·9	"
"	4	1·	"	1·10	"

Here the results are in favour of the fan in its original shape, and similar results appear when the fan is discharging air.

I will now proceed to examine the inlet opening, and the best length of vane.

From the experiments enumerated in the tables it will be seen that the longer vane possesses a preponderating power over the shorter one, in condensing air of the greatest density, with the least proportion of power. Thus, with a vane 14 inches long, the tips of which revolve at the rate of 236·8 feet per second, air is condensed to 9·4 ounces per square inch above the pressure of the atmosphere, with a power of 9·6 horses; but a vane 8 inches long, the diameter at the tips being the same, and having, therefore, the same velocity, condenses air to 6 ounces per square inch only, and takes 12 horse-power.

Thus, the density of the latter is little better than $\frac{6}{11}$ of the former, while the power absorbed is nearly 1·25 to 1. Although the velocity of the tips of the vanes is the same in each case, the velocity of the heels of the respective blades are very different; for whilst the tips of the blades in each case move at the rate of 236·8 feet per second, the heels of the 14 inch blades move at the rate of 90·8 feet per second; and the heels of the 8 inch move at the rate of 151·75 feet per second; or, the velocity of the heel of the 14 inch, moves in the ratio of 1 to 1·67, compared with the heel of the 8 inch blade. The longer blade approaching nearer the centre, strikes the air with less velocity, and allows it to enter on the blade with greater freedom, and with considerable less force than the shorter one. The inference is, that the short blade must take more power at the same time that it accumulates a less quantity of air.

These experiments lead me to conclude that the length of the vane demands as great a consideration as the proper diameter of the inlet opening. If there were no other object in view, it would be useless making the vanes of the fan of a greater width than the inlet opening can freely supply.* On the proportion of the length and width of the vane, and the diameter of the inlet opening, rest the three most important points, viz.: *quantity*, and *density* of air, and expenditure of *power*.

* The proportion a suction pipe bears to a pump, is an anagalous case; for, if we drive the bucket at a greater velocity than the suction pipe will supply it with water, the consequence will be, that we shall not lift so much water, at the same time that we absorb more power.

TABLES OF EXPERIMENTS.

No. 1, a.—With Inlet opening 17½ in. diam., and Vanes 14 in. long, by 10¾ in. wide.

No. of Experiment.	Number of Revolutions of Fan, per Minute.	Velocity of the tips of Vanes in feet per Second	Density of the Air, in ounces, per square inch	Area of Discharge pipe, in sq. inches.	Indicated Horse Power.
1	1160	236·8	9·4	0	9·6
2	1081·6	220·8	7·9	0	7·54
3	1000	204·16	6·9	0	6·68
4	907·5	185·28	5·6	0	5·36
5	840	171·5	4·5	0	3·82
6	705·8	144·1	3·5	0	2·21
7	1086·6	221·8	7	37·5	13·31
8	1063·3	217·09	7	38·12	11·02
9	1086·6	221·8	6	48·75	13·81
10	1045	213·33	6	38·12	12·54
11	941·6	192·2	6	24·37	6·43
12	1086·6	221·8	5	60	14·26
13	1035·8	211·5	5	65	13·05
14	950	193·9	5	52·5	8·75
15	855	174·5	5	22·5	4·53
16	1086·6	221·8	4	69·3	14·19
17	1035·8	211·48	4	75	13·3
18	963·6	196·6	4	65·6	9·5
19	870	177·6	4	78·1	11·3
20	760	155·8	4	33·1	3·3
21	983·3	200·7	3	82·6	10·15
22	885	174·5	3	92·7	10·6
23	773·3	157·8	3	189·6	7·56
24	659·2	134·5	3	56·2	2·98

No. 2, a.—With Inlet opening 30 in. diam. Vane 8 in. long by 10¾ in. wide.

No. of Experiment.	Number of Revolutions of Fan, per Minute.	Velocity of the Tips of Vanes in feet per Second.	Density of the Air in ounces, per square inch.	Area of Discharge Pipe, in sq. inches.	Indicated Horse Power.
1	1160	236·8	6	0	11·92
2	1081·6	220·8	5·3	0	10·5
3	1000	204·16	5	0	7·65
4	900	183·78	4·3	0	5·54
5	786	160·59	3·3	0	4·42
14	1170	238·8	5	30·62	12·02
16	1160	236·8	4	53·7	12·4
17	1081·6	220·8	4	46·2	10·4
18	966·6	196·6	4	60	11·2
19	878·5	179·1	4	40	6·6
21	1100	224·5	3	63·7	9·23
22	966·6	196·6	3	97·6	10·25
23	878·5	179·1	3	68·7	8·84
24	780	159·2	3	57·5	6·55

No. 3, a.—With Inlet opening 24¾ in. diam. Vane 11 in. long, by 10¾ in. wide.

No. of Experiment.	Number of Revolutions of Fan, per Minute.	Velocity of the Tips of Vanes in feet per Second.	Density of the Air, in ounces, per square inch.	Area of Discharge Pipe, in sq. inches.	Indicated Horse Power.
2	1000	224·5	5·8	0	6·1
3	1000	204·16	5·5	0	5·96
4	900	183·7	4·8	0	4·13
5	800	163·3	3·8	0	3·9
14	1000	204·1	5	31·8	7·3
17	1063·3	217·09	4	45	7
18	983·3	200·7	4	55	8·9
19	885	180·7	4	48·1	6·17
21	1100	224·5	3	63·7	8·7
22	966·6	196·6	3	70	7·29
23	870	177·6	3	82	7·8
24	786·6	160·5	3	65	6·76

No. 4, a.—With Inlet opening 20½ in. diam. Vane 13¾ in. long, by 10¾ wide.

No. of Experiment.	Number of Revolutions of Fan, per Minute.	Velocity of the Tips of Vanes in feet per Second.	Density of the Air, in ounces, per square inch.	Area of Discharge Pipe, in sq. inches	Indicated Horse Power.
2	1081·6	220·8	7·7	0	8·40
3	1000	204·16	6·7	0	7·84
4	900	183·7	5·5	0	5·2
5	786·6	160·5	4·4	0	4·45
8	1063·3	217·09	7	25	10·7
10	1063·3	217·09	6	42·5	11·47
11	966·6	196·68	6	35	10·07
14	966·6	196·68	5	65	14·04
15	878·5	179·15	5	37·5	7·3
17	983·3	200·7	4	79·6	12·7
18	870	177·6	4	66	9·9
19	773·3	157·8	4	35	5·7
23	870	177·6	3	103·6	10·7
24	786·6	160·5	3	97·1	10·42

No. 1, b.—With the Outlet opening contracted to 4 in. deep, and 7 in. wide. Inlet opening 15 in. diameter. Vane 16 in. long, by 6 in. wide.

No Efflux.	800	163·3	4·5	0	2·38
	885	180·7	5·7	0	2·89
With Efflux.	786·6	160·5	4·0	13·75	2·9
	885	180·7	4	25	4·76
	870	177·6	5	10	3·5
	773·3	157·8	3	37·5	3·2
	878·5	159·1	3	35	5·0

No. 2, b.—With the Outlet opening contracted to 4 in. deep.

No Efflux.	900	182·7	4·5	0	6·24
With Efflux.	855	180·7	4	40	7·5

With the original Outlet opening, 12 in. deep.

No Efflux.	909	182·3	4·15	0	7·35
With Efflux.	885	18?·7	4	40	8·25

No. 3, b.—With the Outlet opening contracted to 3½ in. deep.

No Efflux.	826·6	168·7	4	0	2·75
With Efflux.	760	121·8	3·5	35	2·4

With the original Outlet opening, 12 in. deep.

No Efflux.	813	166	4	0	3·46
With Efflux.	813	166	3½	40	3·98

No. 4, b.—With the Outlet opening contracted to 4 in. deep.

No Efflux.	885	180·7	5·5	0	3·7
With Efflux.	900	183·7	4	40	6·9

With the original Outlet opening, 12 in. deep.

No Efflux.	885	180·7	5½	0	4·1
With Efflux.	885	180·7	4	60·7	9·8

In the 14 inch blade, the tip has a velocity of 2·6 greater than the heel; or, by the laws of centrifugal force, the air will have 2·6 times the density at the tip of the blade that it has at the heel. The air cannot enter on the heel with more than atmospheric density, but in its passage along the vanes, it becomes compressed in proportion to its centrifugal force. The greater the length of vane, the greater will be the difference of the centrifugal force between the heel and the tip of the blade; consequently, the greater the density of the air.

Reasoning, then, from these experiments, I recommend for easy reference, the following proportions for the construction of the fan:—Let the width of the vanes be one-fourth of the diameter of the vanes.—Let the diameter of the inlet openings in the sides of the fan chest be one-half the diameter of the fan.—And, let the length of the vanes be one-fourth of the diameter of the fan.

In adopting this mode of construction, the area of the inlet openings in the sides of the fan chest, will be the same as the circumference of the heel of the blade, multiplied by its width; or the same area as the space described by the heel of the blade.

The following tables gives the sizes of fans varying from 3 to 6 feet diameter:—

TABLE 1.

Diameter of Fan. ft.	in.	Width of Vane. ft.	in.	Length of Vane. ft.	in.	Diameter of inlet opening. ft.	in.
3	0	0	9	0	9	1	6
3	6	0	10½	0	10½	1	9
4	0	1	0	1	0	2	0
4	6	1	1½	1	1½	2	3
5	0	1	3	1	3	2	6
6	0	1	6	1	6	3	0

TABLE 2.

Diameter of Fan. ft.	in.	Width of Vane. ft.	in.	Length of Vane. ft.	in.	Diameter of inlet opening. ft.	in.
3	0	0	7	1	0	1	0
3	6	0	8¼	1	1¼	1	3
4	0	0	9¼	1	3¼	1	6
4	6	0	10¼	1	4¼	1	9
5	0	1	0	1	6	2	0
6	0	1	2	1	10	2	4

I recommend the proportions in table 1, for densities ranging from 3 to 6 ounces per square inch, and for higher densities, viz.: from 6 to 9, or more ounces, the sizes given in table 2.

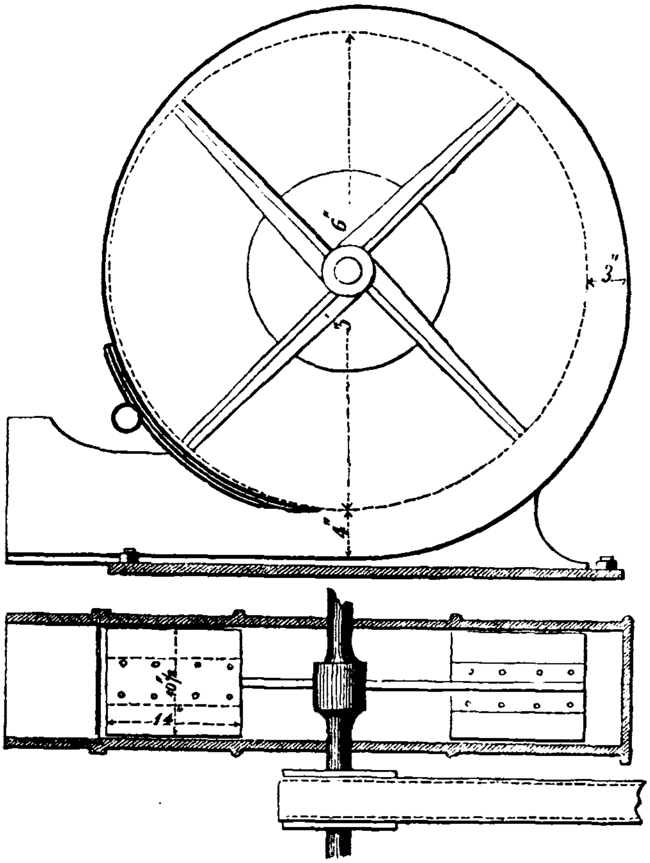
The dimensions of the above tables are not laid down as prescribed limits, but as approximations obtained from the best results in practice.

In some cases, two fans fixed on one spindle would be found preferable to one wide one, as by such arrangement, twice the area of inlet opening is obtained, compared with a single wide fan; and they may be so constructed, where occasionally only half the quantity of air is required, that one of them may be disengaged by a clutch, and thus a saving of power effected. In a single fan of great width, the inlet opening must either be made too small in proportion to the width of the vane, or if it be made large enough for the width of the vane, the length of the vane becomes so short as to be quite incapable of producing air of the required density.

It has been stated that the air from the fan chest is impelled by the vanes along the transit pipe, to the blast chest, &c.: I beg attention to the results of an experiment very recently made by me, with reference to the admission of air into the transit pipe, and which, I think, may lead to an important improvement in the fan. The experiment alluded to, was made to enable me to ascertain the result of varying the area of admission to the transit pipe, in proportion to the quantity of blast required for use; and I effected this by adapting a segmental slide to the circular chest of the fan, as shown in the accompanying section, by means of which, I vary the width of the opening into the transit pipe, from 12 to 4 inches.

The object of this arrangement is, to diminish the transit pipe opening at pleasure, in proportion to the quantity of air required, and thereby to lessen the power necessary to work the fan. The results will be seen by experiments inserted in tables 1 *b*, 2 *b*, 3 *b*, and 4 *b*. The inlet opening to the transit pipe having been contracted from 12 inches to 4 inches deep, so that the tip of the vane and the bottom of the outlet opening were nearly in a direct horizontal line, nearly the same quantity of air was impelled, as with the original opening; the noise produced by the fan had, however, nearly ceased. It therefore appears, that the less this opening is made—provided we produce sufficient blast—the less noise will proceed from the fan; and by making the top of this opening level with the tips of the vane, the column of air has little or no reaction on the vanes.

With respect to the degree of eccentricity which the fan should have, with reference to the fan chest, $\frac{1}{10}$ of the diameter of the fan has been found in practice to answer well; that is, the space between the fan and the chest should increase, from $\frac{3}{8}$ of an inch at the top of the inlet to the transit pipe, to $\frac{1}{16}$ of the diameter of the fan at the bottom of a line perpendicular with the centre. The tunnel, or main pipe, from the fan chest may for short distances,



varying from 50 to 100 feet in length, be made not less than $1\frac{1}{4}$ times the area of the transit pipe in the fan chest; and in distances varying from 100 to 200 feet in length, $1\frac{1}{2}$ times the area of the transit pipe. The length of a tunnel may be continued to 300 or more feet, provided it be made of sufficient dimensions to allow the air to pass freely along it. The experiments accompanying this paper were made with a tunnel 18 inches diameter and 160 feet in length, and no difference could be detected in the density of the air, when the gage was applied at any part of the tunnel.

Having investigated the leading characteristics of the fan, it may not be out of place to give a few hints respecting its mechanical construction.

First.—It is one of the greatest essentials, that all parts maintain a just and proper balance.

Second.—That the arms of the fan be as light as is consistent with safety: round arms are decidedly objectionable; I have known instances when their centrifugal force has torn them from the centre boss. I prefer the rectangular arm, about the proportion of $2\frac{1}{4}$ times the width, for the depth at the centre, with sufficient taper towards the tips.

Third.—The bearings and journals of the fan spindle should be made of a length not less than four times the diameter of the necks of the spindle.

Finally.—The driving pulleys should be made as large as circumstances will admit of, so that the strap may have sufficient surface to prevent slipping.

The fan from which my experiments were collected, was made with these proportions. It has been at work nine years without any perceptible wear.

The application of the fan has hitherto been chiefly applied to smithies and foundries; and in but few instances has it been applied to the smelting of iron ore. I am aware that differences of opinion exist as to the applicability of the fan to that purpose. The principal reason urged against it being the limited density to which the blast can thereby be compressed, compared with the blast supplied by the cylinder. It remains, however, to be proved whether such high densities are absolutely necessary for the smelting of iron ore; whether we may not produce as good iron by a diffused soft blast, as by the strong, and generally applied, concentrated blast. I hope it will not be thought presumptuous on my part, in thus doubting long established practices. The old maxim of "there's no way like the old way," is not always based on unerring principles.

As I have before stated, the density of blast afforded by the fan, is limited to the force arising from the centrifugal motion of the air, in passing along the vanes of the fan; the quantity not exceeding what is due to its velocity and magnitude. But may not this density be increased by using a succession of fans, so constructed and arranged, that the air may be passed successively through each; the air from the first fan being made to enter the second; the air from the second to enter the third; and the blast finally emitted of adequate density?

I cannot here enter into a further investigation of this important subject; neither are the limits and character of this paper suited to the minutiæ connected with the principles and practice of a smelting furnace; but I hope that the observations which I have made, and the principles I have endeavoured to enunciate, will be the means of instituting further inquiry; and, as the expense of constructing a fan can be no barrier, I trust that a fair trial will be made, where convenience is suited to its application for smelting purposes.

REGISTER OF NEW PATENTS.

VENTILATION OF MINES.

John Wilcock, gentleman, in the county of York, for "*certain Improvements in the ventilation of mines.*"—Granted June 12; Enrolled Dec. 12, 1847. [Reported in the *Patent Journal.*]

The patentee, in this specification, states his invention to be for the purpose of improving, and more effectually securing, the better ventilation of mines, and consists of elongating the upcast shaft of the mine, by the addition of stacks, towers, or other similar buildings, erected above, or in connection with such upcast shaft, by which the upper orifice of the upcast shaft is elevated very considerably above the upper orifice of the downcast shaft, proportionably to various circumstances—as the relative depths of the two shafts, the velocity of the current of air through the mine, the nature of the gases, &c. The ventilation of mines is effected by the passing of a stream, or current, of atmospheric air through the various ramifications of the mine, carrying with it, in its course, the various noxious gases—as carburetted hydrogen, carbonic acid, and also the vitiated air, in its course, and escapes through the upcast shaft into the atmosphere. This current is, in most cases, caused—or the velocity of it is increased—by the application of heat to the upcast shaft, either at the bottom thereof, or at the orifice at the surface. The patentee proposes, by his invention, to increase the velocity of the currents through the upcast shaft, by erecting a stack, tower, or other similar building, above, or in connection with, the upcast shaft, which forms a continuation of the shaft, and through which also continues to flow the current of air. The height to which, in most cases, it will be sufficient to raise the elongated portion of the shaft, the patentee states to be from 60 feet to 100 feet, though this will be governed much by circumstances, varying in different mines. The patentee gives several drawings, descriptive of his invention, as applied to several descriptions of mine shafts; as, first, to its application to mines having only one shaft; in this case, it is customary to make partitions down the shaft, thus forming downcast and upcast shafts. The patentee proposes leaving these arrangements as usual, but erecting over, or in connection with, the part of the shaft, a stack, tower, or other building, as a continuation of the upcast shaft. Secondly, to a mine in which the upcast shaft is also the working one; in this case, the minerals and workmen pass out of the lower part of the stack, or tower, by an aperture in the wall of it; and, thirdly, to a mine in which the upcast shaft is only employed for that purpose; in this case, a plain stack, or tower, is employed. In all cases, the patentee states, it is necessary that the sectional area of the stack, or tower, should be, at least, equal to the sectional area of the upcast shaft; and that, when it is necessary to have any openings into the lower part of the stack, or tower, the sectional area of the upper part of the stack, or tower, above the apertures, must be increased by the size of the apertures, for the purpose of not interfering with the upward current from the upcast shaft. The patentee, after describing his invention, claims the mode, or modes, of elongating the upcast shafts of mines, for the better ventilation of such mines, as described in the specification.

CONSTRUCTION OF BRIDGES.

STEPHEN MOULTON, of Norfolk-street, Strand, Middlesex, gentleman, for "*Improvements in the construction of bridges.*"—Granted April 8; Enrolled Oct. 8, 1847.

The improvements are for constructing bridges in the manner shown in the annexed engravings. Fig. 1 is a side view of a bridge

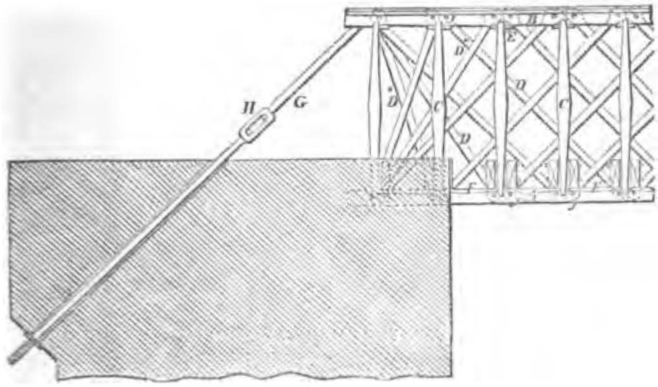


Fig. 1.

constructed according to the invention. Fig. 2 shows two transverse sections thereof, by which it will be seen that the top rail B, and the bottom rail A, are combined together by a series of diagonal bars D, so that the bottom rail A, is suspended from the upper rail B, by means of such diagonal bars D; and the rails, A and B, are kept apart by means of the uprights C, which uprights are not fixed to the upper or lower rails B, A, but simply come in between them as supports to retain the parts A, B, at the correct distance apart; and in the event of the chain being formed to act unequally on any of the diagonal bars D, by driving in wedges, as shown at E, fig. 1, the whole must be correctly adjusted. The diagonal bars D, proceed in opposite directions, and cross each other, as is shown, but they are not fixed to each other, they being simply fixed at their ends by means of pins passing through them; and the top and bottom rail, B, A, fig. 1, shows part of the side framing of the bridge.

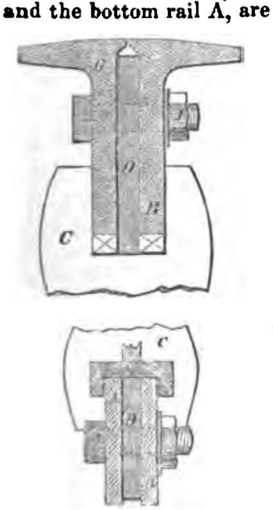


Fig. 2.

Fig. 3 shows the diagonal bars D, with the screw pins and nuts, by which they are attached to the rails A, B. The upper rail may be formed of two angle-irons, as shown at fig. 2, or in one double angle-iron, as shown at fig. 3, the diagonal bars D passing between the parts B B, and such parts will be held together by the pins and nuts J, as shown. The lower rail is composed of two bars, A, A, shown in fig. 2, and the ends of the bars D are placed between them, and held by the screw pins and nuts J, as shown. K, the beams for receiving the floor of the bridge. F, the caps which cover the upper edges of the two bars of which the bottom rail A, is composed. At the ends of a bridge it is preferred to use additional bars D*, D*, as shown at fig. 1, and also holding-bars G, with adjusting screws and nuts, as at H; but these may be dispensed with. There are opening through the uprights C, for the passage of the diagonal bars D, but these bars D should be free and not confined in the openings through such uprights C.

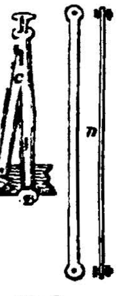


Fig. 3.

It will be found by examining the peculiar arrangement of the parts that great strength with lightness are obtained by constructing bridges in the manner described, for it will be evident that as the rails A, B, are kept separated by the uprights C, which act as stretchers, they will be rendered stiff and secure from flexure by the diagonal bars D.

LOCOMOTIVE ENGINES AND RAILWAY CARRIAGES.

GEORGE TAYLOR, of Holbeck, near Leeds, for "*Improvements in locomotive engines and railway carriages.*"—Granted June 3; Enrolled Dec. 3, 1847. [Reported in the *Mechanics' Magazine.*]

The patentee states that his invention consists: Firstly—In certain improved arrangements of the steam cylinders of locomotive engines, and the parts which communicate the reciprocating motion of the pistons of the cylinders to the axle or axles of the driving-wheels, which arrangements have for their object to concentrate the driving power of the actuated pistons, so as to communicate an even rotating motion to the driving-wheels, or to distribute the moving power (before concentrating it), in an even and uniform manner to one, two, or more pairs of wheels. The advantages which the patentee states he believes to result from this part of his invention are, diminished wear and tear of the engine, and the attainment, with safety, of a greater degree of speed, in consequence of the decreased amount of oscillation of the locomotives. The construction is as follows:—Above the boiler, and near the smoke-box, are placed, horizontally, and in juxta-position, two steam cylinders of equal capacity, each having its piston furnished with cross heads sliding in guides supported by the frame of the engine. The pistons are connected by rods to two cranks, which are attached on either side to a wheel having cogs or indentations on its periphery, and which gears into another wheel fastened on the centre of the axle of the driving-wheels. The axle is placed above the boiler, and allows of the employment of driving-wheels of larger diameter (say from 10 to 15 feet), with even a diminished amount of oscillation, in consequence of the weight of the engine being brought near the line of rails. All the wheels may be made to drive by being coupled in the ordinary manner. In order that the cog-wheels may work properly, and the bearing-springs of the engine act freely, the guides, in which are supported the journals or axle-boxes of the driving-wheels, are made slanting. Two modifications of the mode of connecting the piston-rods of the steam cylinders with the axles of the driving-wheels are specified by the patentee. The first consists in forming a slot in the centre of each of the piston-rods, in which works a short vibrating link, connected to a vertical frame on either side of the engine, which is made fast underneath the boiler by means of a pin, on which it vibrates—and in connecting each of these vibrating vertical frames by rods as is usual with the bosses of the driving-wheels, or in attaching one end of a connecting-rod to the outside end of the cross head of the piston-rod, and the other to the boss of the driving-wheel. Secondly—This invention has reference to the construction of an apparatus applicable to the locomotive, tender, and carriages, which serves to retard the progress of the train when necessary, and to support, in the case of the breakage of an axle, the weight of the carriage. To effect this, two levers are made fast to the bottom of the carriage in such manner as to allow of their acting freely, and have each at the outer end a flanged skid placed directly over the line of rail. These skids have on the under surfaces blocks of hard wood with the grain placed vertically, and are moreover connected by a strong spring. From the centre of this spring rises a vertical shaft, consisting of two pieces joined by a threaded connection, whereby it can be lengthened or shortened, as required. The top of this shaft is forked, and has between the prongs at top and bottom two anti-friction rollers; between these rollers is a cam, fastened to a horizontal rod, which is made to rotate by apparatus brought under the control of the driver or guards, after any ordinary and well-known means. When the longest radius of the cam is brought to bear upon the lower anti-friction roller by means of the rotating of the horizontal shaft, it follows that the vertical shaft is forced downwards and the flanged skids thereby depressed on to the line of rail which they bite, and thus retard the progress of the train. The flanges serve to retain the carriages on the line of rails, and the skids to support the carriage in the case of the breakage of an axle; but, in order that the vertical shaft may be relieved from the weight of the carriage, stops are inserted in the lower part thereof at the most convenient point, against which the skids catch. Thirdly—The patentee proposes to divide the tender horizontally into two parts, using the upper or open portion for coals, and the lower to contain the water, and to pass the axle of the wheels through the water or above it, in order that the weight of the tender, as in the case of the locomotive before described, may be brought nearer the rails. Fourthly—To employ axles for railway carriages composed of two pieces, one solid and the other tubular, to slide over it; one of a pair of wheels being attached to each piece, so that they may revolve independently of each other.

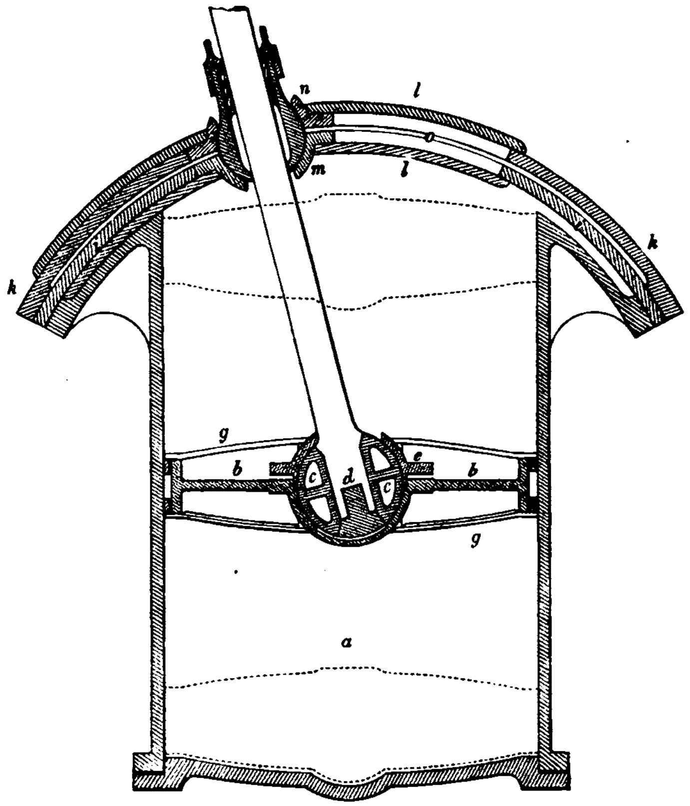
VIBRATING PISTON-ROD ENGINE.

G. V. Gustafsson, of 15, William-street, Regent's-park, late engineer, R.N. "*Improvements in the steam engine.*"

The improvements relate, first, to "the mode of connecting a piston-rod to a piston by means of a ball-and-socket joint." The advantage of this plan over the old one (where the piston-rod is connected to the piston by means of straps and keys like the crank and connecting-rod) will easily be perceived; a *large* bearing surface, its facility for adapting itself in the centre of the piston, being bored and turned at the same time, and also the convenience for holding a lubricating substance, such as oil or tallow, and thereby lessening the friction, and causing a less wear of the ball and socket. Secondly, "The manner of keeping the piston tight within the cylinder by the combined mechanical forces of steam and metallic springs." The advantage of this arrangement will also be perceived without difficulty: the skeleton of the piston is formed like a wheel; the nave receives the end of the piston-rod, from which proceeds the arms, to the extreme ends of which a ring is attached, and to which ring is bolted the top and bottom cover of the piston, which for lightness should be made of wrought-iron; within these covers, and at the outer periphery, are fitted two metallic rings of light construction, and kept in their places by means of spiral and horizontal springs, but not necessarily steam-tight, as that will be effected by admitting steam into the chamber, which incloses the packing-rings by means of a double acting valve; this will cause a more *uniform* pressure on the packing-rings than could be effected by springs alone; it also requires very little fitting and grinding, only the side of the ring nearest the cover: it has also another, though perhaps not very great advantage, of partially *pulling*, instead of entirely *pushing* the piston. Suppose the piston is moving upwards, a portion of the pressure from under it will be removed to the upper cover, which is considerably above the centre of the globe; hence the pulling property, which in such case is preferable to pushing: the same, of course, takes place on the down stroke. Thirdly, "The construction of a moveable apparatus to be adapted to the top or cover of the cylinder through which the piston-rod is to slide, and at the same time vibrate." The advantage of this apparatus over the old slide-rest shaped one is, first, being *curved* as to present nearly a *rectangular* base to the different positions of the piston-rod, whereby the friction is considerably diminished; secondly, having a *flat* bearing surface to act against, instead of the dovetailed edges in the old plan; thirdly, and last, its facility of keeping in contact with the bearing surface, which is effected in condensing engines by connecting the narrow chamber, between the two slides, with the condenser, whereby the slides are kept in their places by the pressure of steam and the atmosphere: in non-condensing engines this chamber should be in communication with the atmosphere, which may be effected by causing the upper slide to bear in the middle *only*, allowing a passage to the chamber under it, which will also lessen the friction of the upper slide: it will be perceived that the slides are portions of circles, and consequently easy of construction. And fourthly, "An apparatus (or self-acting damper) for regulating the draught of the flues and furnaces, and thereby tempering the pressure of steam in the boiler, and also giving such due notice of the state of pressure in the boiler as may prevent accidental explosion." This being a distinct apparatus, may be used with or without the other improvements, and is applicable both for land and marine engines.

The inventor states that, "a plan, somewhat similar in principle, though differing in details, was tried many years ago, but in consequence of the ill-adaptation of the slides—somewhat like the *slide-rest* of a turning-lathe—to the motion of the piston-rod, being at *right* angles to the latter *only* at the dead points of the engine, or top-and-bottom stroke, it was a very great defect."

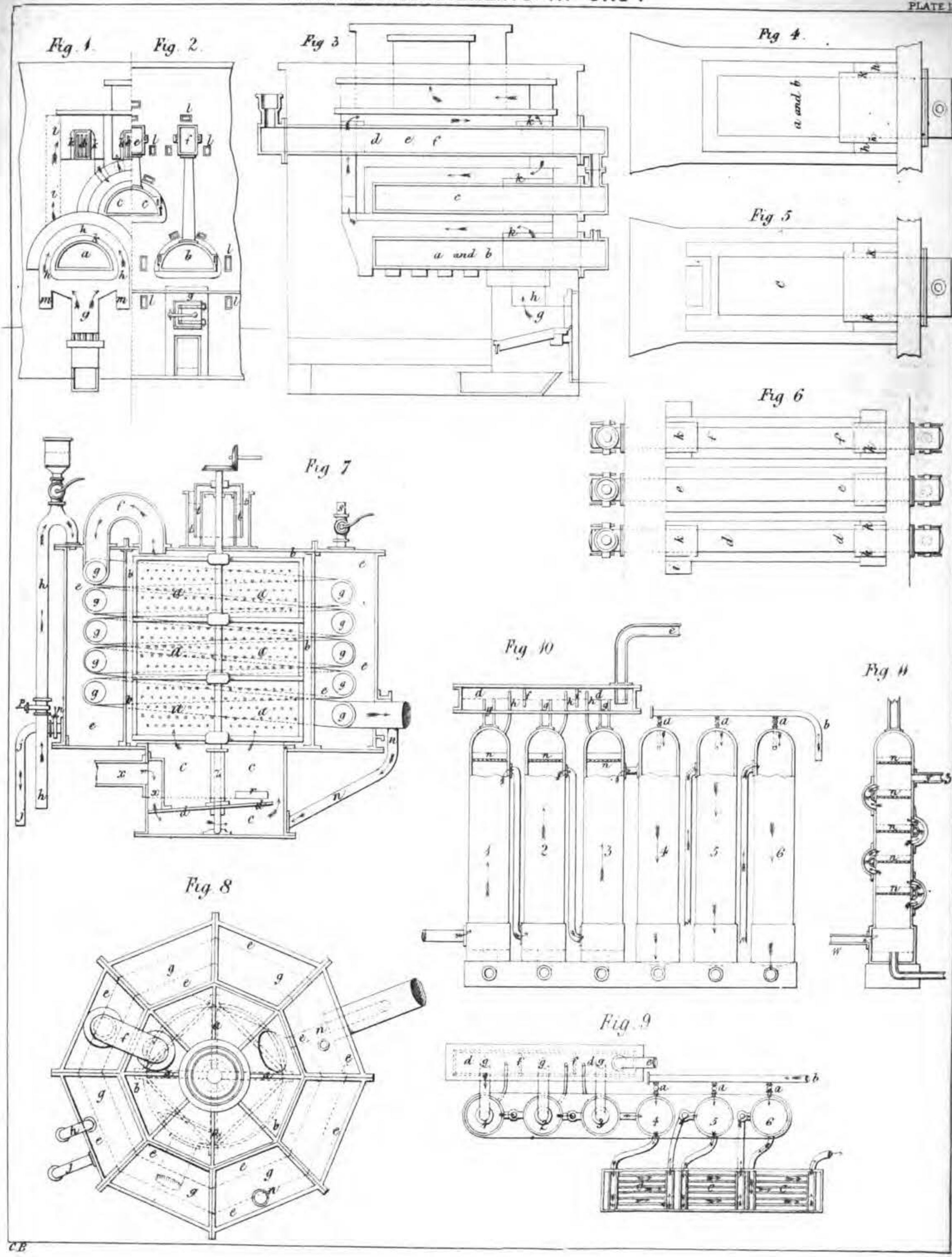
The three first improvements are shown in the annexed engraving of a vertical section of the steam cylinder. *a*, the cylinder; *b*, the skeleton of the piston, formed like a wheel for the purpose of rendering it of light construction; *c*, a hollow cast-iron globe, fitted to the end of the piston-rod and secured to it by a plug *d*, or it may be cast on to the end of the piston-rod: in the centre of the piston is a hemispherical socket, into which the globe *c* is fitted and secured to it by means of a cap *e* firmly bolted to the hemispherical socket; the arms have strengthening flanges on their under sides, and to the outer ring, at the extremity of the arms, is bolted the top and bottom covers *g g*, which, for lightness, may be made of wrought-iron. To render the piston steam-tight, two



metallic rings are placed in the annular chamber between the covers *g g*, and held in their places by means of vertical and horizontal springs, but not necessarily steam-tight, as that will be effected by admitting steam into this annular chamber of the piston by means of a double-acting valve, by which a more uniform pressure on the packing-rings is obtained than could possibly be effected by springs alone: *i* is the cylinder cover, which is made spherical, with segmental pieces to complete the arc of a circle; *k* is a segment slightly hollowed in the middle and bolted to the cylinder-cover; *l* are slides attached to the cups *m n*. To keep the radius slides *l l* constantly in contact with their bearing surface, the hollow space *o* should be in communication with the condenser, which is effected by fixing a small tube in any convenient place: in non-condensing engines this space should be in communication with the atmosphere.

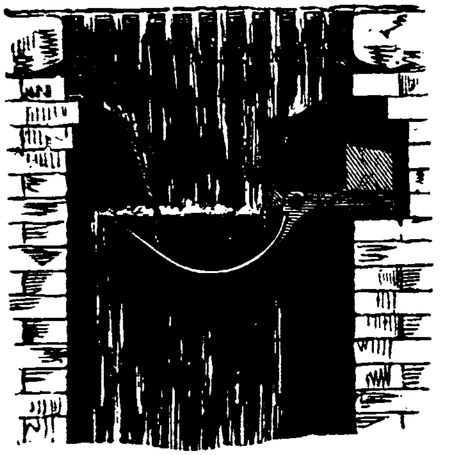
It will be seen that as the piston ascends and descends, the piston-rod will be enabled, by the lateral motion of the radius slides, to vibrate, and thereby act directly on the crank; in consequence of the angular position of the piston-rod the wear of the cylinder would be greater on one side than the other, but this may be avoided by giving to the latter an inclined position. It will be perceived that this peculiarity of the piston is of great advantage, especially for horizontal engines, as the *weight* of the piston would be supported by the pressure, and consequently prevent an unequalizing wear of the cylinder and piston, which in common horizontal engines cannot be avoided; hence the vibrating piston-rod is particularly adapted for the screw-propeller and locomotive engines. To prevent an unnecessary waste of steam, the space between the piston and the cylinder cover, where the former is on the top stroke, as shown by the dotted lines, may be filled up with hard wood and bolted to the cylinder cover.

PALMER'S IMPROVEMENTS. IN GAS.



BUNNETT'S SEWER TRAP.

Mr. Bunnett, of the firm of Bunnett and Corpe, of Lombard-street, has invented a very simple and cheap "*Self-acting Effluvia Trap*," which differs from all previous contrivances. The fault of the old invention was that they were so arranged that a very small quantity of water caused the pan of the trap to fall, and consequently during a shower of rain, or water falling upon it, the action was intermittent, continually opening a communication with the sewer, and liable to be held open permanently by any light matter being caught by the rising of the pan. In Mr. Bunnett's improved trap this is avoided by introducing a peculiar mechanical arrangement of the leverage connected with the form of the moveable pan, and application of the weight, which admits, under ordinary circumstances, of a constant flow of water through the grating into the pan of the trap and over the edge of the same into the sewer or drain, the lower part of the trap being immersed into the water, so as to form a most effectual water sealed joint, of sufficient depth to withstand the effects of evaporation from long drought, and should a stoppage be caused by a deposit of silt or other matter, the water will rise in the body of the trap, until it is about two-thirds full, at which point it raises the balance-weight, and obtains considerable leverage by the peculiar formation of the moveable pan, insuring a rapid discharge of a large body of water, which by its force most effectually cleanses the trap, and flushes the sewer or drain, and instantly recovers its position, with sufficient water to form the joint again, resuming its former action till another stoppage occurs; the form of the trap also insures on the commencement of a thaw the ready ejection of any ice that may have formed therein. The annexed figure is a sectional view of a street grating and gully hole with the trap, which is represented in its ordinary position, the water flowing from the grating into the body of it, and over the edges of the moveable part into the sewer or drain. The lower part of the body of the trap is immersed in the water which is retained in the moveable part by the counterbalance weight, thereby forming a perfectly sealed joint and effectually preventing any smell from rising.



Another advantage attending this trap is that it can easily be fixed to any gully hole, and the price is very moderate, being about £1 each.

GAS IMPROVEMENTS.

(With Engravings, Plate II.)

George Holworthy Palmer, of Westbourne-villas, Harrow-road, Middlesex, civil engineer, for "*an improved method or mode of producing inflammable gases of greater purity and higher illuminating power, &c.*"—Granted April 17; Enrolled October 17, 1847.

The first part of this invention relates to an improved mode of setting and arranging the retorts in conjunction with additional vessels called "regenerators," so as to insure their being heated uniformly to the required temperature (as shown in figs. 1 to 6), by which method not only an increase of volume, but also an increase in the illuminating power of the gas is obtained. The heating surface of the regenerators may be further increased by the introduction of metallic chippings, or by sheet iron partitions.

By this arrangement, the gas passes direct from the retorts into the regenerators, where it receives a second dose of caloric, and then flows in the usual manner through the sealed pipes in the hydraulic main, and then into the mechanical precipitator, to be next explained. The patentee recommends the retorts to be kept at a bright cherry-red heat, and the regenerators at a dull-red heat, visible by daylight.

The second improvement relates to an apparatus called a "mechanical precipitator," combined with a refrigerator (as shown in figs. 7 and 8), for the purpose of abstracting the vapours of tar and naphtha, as well as the gaseous ammonia and its compounds.

The third improvement relates to apparatus called "ammoniacal filtering towers," through which the gas passes from the precipitator, being washed in its course by liquid ammonia, descending like rain through one or more perforated plates, as shown in Nos. 1, 2, and 3, in figs. 9, 10, and 11. By this process a further portion of ammonia, contained in the gas, is absorbed without subjecting the gas to an increased pressure, and the liquid ammonia is increased in strength.

The fourth improvement relates to an apparatus consisting of a series of steam chambers and condensers, Nos. 4, 5, and 6, as shown in figs. 9 and 10, through which the gas passes from the filtering tower; each of these chambers is to be charged with a volume of pure steam equal to the volume of gas. The crude gas, with a volume of steam, passes first into No. 1 steam chamber, and then into its condensing chamber, where the steam will be condensed into water, which in its descent will carry with it a great portion of the remaining gaseous ammonia and its various compounds; after which, the permanent gases flow from No. 1 condenser into No. 2 steam chamber, when the gas will be again saturated with steam, and will again flow into its proper refrigerator, to deposit the steam charged with another portion of the product in a liquid form. The gas will then pass into No. 3 chamber as before, and thence into No. 3 condenser, where is deposited the remaining ammonia and its compounds, together with a portion of sulphuretted hydrogen. All these liquid products are to be made to flow, as fast as they are deposited in the condenser, into a suitable receiver, sealed by an hydraulic joint to prevent the gaseous vapours and gas from returning into the condenser. From this last apparatus the gas will pass, freed from impurities, into the "lime machines" or purifiers, charged with dry lime, where it is divested of the remaining deleterious gases—viz., sulphuretted hydrogen and carbonic acid, and proceeds thence to the gas holder, and lastly to the mains.

The gas now purified goes into the gas-holder, and, in its transit to the mains, may be naphthalised if required; for this purpose, apparatus may be employed similar to that described as the "ammoniacal filtering towers."

The fifth improvement is for avoiding the inconveniences which arise on opening the purifiers and removing the refuse lime from the sieves preparatory to recharging them with lime, and which is to be effected by causing atmospheric air, heated or otherwise, to be blown through the material employed for purifying the gas, and discharged through the furnace-bars or chimney-shaft, by means of a "centrifugal bellows" or other suitable pneumatic apparatus, the blast-pipe being connected to the exit pipe of the purifier; thus blowing out the contaminated air, &c., through the pipe by which the gas enters the purifying vessel, an extra pipe and valve being attached to the entrance and exit pipes for this purpose.

Reference to the Engravings.

Figs. 1 to 6 show the mode of setting and heating the retorts and regenerators: fig. 1, a sectional elevation, and fig. 2, a front elevation —each figure shows one-half of a set of retorts; fig. 3, a longitudinal section; fig. 4, a plan of one of the retorts, showing the opening through which the flame rises; fig. 5, sectional plan of the top retort; and fig. 6, sectional plan of the regenerators.—Similar letters refer to similar parts:—*a*, *b*, *c*, retorts; *d*, *e*, *f*, regenerators, showing the plates *k* to increase the heating medium, over which the gas flows from the retorts; *g*, *g*, the furnaces; *h*, *i*, flues through which the flame rises from the furnaces, and, as indicated by the arrows between and over the retorts and regenerators, to the shaft, and *l*, the blow-holes. There is one regenerator to each retort, of the capacity of about two-thirds the latter.

Fig. 7 is a vertical section of the "mechanical precipitator," and fig. 8, plan of the same; *a*, *a*, perforated revolving fans, to agitate the gas in the chamber *b*, *b*,—the shaft is stepped into the lower chamber and passed through an inclined plane, *d*, *d*, under which the gas blows through the tar passing from the pipe *x*; and adjoining is a chamber, *e*, containing a convoluted worm, or refrigerating pipe, *g*, to cool the gas after escaping from the chamber *b*, through the curved pipe *f*. To prevent the gas blowing through the aperture in the inclined plane where the shaft passes, the shaft is inserted in a pipe *z*, bolted to the inclined plane, being of an altitude sufficient to overcome the pressure of the gas; and instead of the usual stuffing-box for the shaft, an hydraulic seal *t*, is used.

The pipe is kept cool by a supply of water passing through the chamber *e*, by the pipe *h*, entering at the top and discharging by the pipe *j*. The pipes *h* and *j*, together with the chamber *e*, form a syphon; the legs or pipes, *h* and *j*, are furnished with cocks *p*, to admit or cut off the supply of water. An air-pump is used to remove the small quantity of air that may be in the syphon; it is worked, as well as the agitating apparatus, by the descent of water flowing from the long leg of the syphon, which gives motion to a small water-wheel in connection with the bevel wheel, gearing, and band; or they may be worked by a steam engine or other power. All the condensable products collected in the agitating chamber and refrigerating pipe *g*, flow through the pipe *n*, into the chamber *c*, and through the opening *r*, at the level of the dotted line, into a receiver.

Fig. 9 is a plan, and fig. 10 a sectional elevation, of the "ammoniacal filtering towers," steam chambers, and condensers, combined in one apparatus. The gas takes the course indicated by the arrows in the towers 1, 2, and 3, entering each at the bottom and out at the top, and thence into the steam chambers 4, 5, 6, undergoing the steaming and condensing before explained; *a*, *a*, steam pipes, with cocks to regulate the steam; *b*, the entrance steam pipe from the boiler; *c*, *c*, *c*, separate condensers, with the entrance and exit pipes; *d*, the tank for the ammoniacal liquor, pumped up through the pipe *e*; the tank has two divisional plates *f*, *f*, fixed to the top and sides, and descending to within a few inches of the bottom of the tank, and is sealed at the level of the dotted line by the liquid ammonia.

To insure the gas flowing from one tower to the other, each has a pipe, *g*, connected with the tank and rising in it to the height of the dotted line, at which level the ammonia flows through the pipe *g*, into its particular tower.

Instead of the arrangement of the filtering towers, several perforated divisional plates, *n*, as shown in fig. 11, may be adopted, the gas flowing from the tower into the chamber through the pipe *w*, in order finally to escape at the pipe *y*.

REVIEWS.

An Essay on the Air-pump and Atmospheric Railway; containing formulæ and rules for calculating the various quantities contained in Mr. R. Stephenson's report on atmospheric propulsion, for the Directors of the Chester and Holyhead Railway Company. By WILLIAM TURNBULL, author of a treatise "On the Strength of Cast-Iron," &c. London: Williams. 1847. 12mo. pp. 96.

The object of this excellent little treatise is a general exposition of the theoretical principles of atmospheric railways. That the leakage of the main tubes of these railways involves a loss of power, is obvious to every one in the slightest degree acquainted with the subject; but it requires much more than superficial knowledge to estimate the precise amount of loss corresponding to a given rate of leakage. Mr. Turnbull has addressed himself very successfully to the task of substituting exact principles for general notions respecting the mechanical defects of atmospheric propulsion.

The first part of this work comprises a history of the air-pump, and demonstrations of several known formulæ by which its effects are estimated. In the second part, these formulæ are applied in detail to the case of the Kingstown and Dalkey Railway. Notwithstanding the imperfect success of the method of substituting stationary air-pumps for locomotive engines, the subject is one of permanent interest to the engineer, on account of the number of beautiful scientific and mechanical problems which it presents to his attention. Considered merely as an instructive exercise, the theory of atmospheric propulsion deserves to be thoroughly mastered by every student of practical science. It is this consideration which induces us to give a brief sketch of Mr. Turnbull's method of investigation.

When a train on the atmospheric railway has attained its uniform velocity, it is obvious that, if there were no leakage, the pump-piston and the train-piston must both describe the same space in a given time—that is, the void made by the one in a given time must be filled up by the other. For example, if the relative diameters of the main tube and pump were such, that ten feet of the length of the former had the same cubic capacity as one foot of the length of the latter, the train-piston would travel ten feet while the pump-piston travelled one. Otherwise, if the pump-piston travelled at a greater relative velocity, the degree of vacuum would be raised, and the train accelerated; if the pump-piston travelled at a smaller relative velocity, the degree of vacuum would be diminished, and the train retarded: and either case is contrary to the hypothesis of uniform velocity of the train.

The exact relation, however, between the uniform velocities of the two pistons only obtains on the hypothesis that there is no leakage. The principal problem is to ascertain the modification due to that defect of the apparatus. The requisite data for this investigation are obtained by the following experiment:—After the tube has been exhausted to a certain extent, the whole apparatus is suffered to remain quiescent, no train being dispatched. The leakage will then go on till the equilibrium of the air inside and outside tube be restored. By observing the rate at which the barometer-guage falls during the interval, we get—not the rate of leakage—but data from which that rate may be calculated.

The density of air is proportional to the weight, and therefore height, of the column of mercury. Take 30 inches as the height of mercury corresponding to the atmospheric pressure; then, if the barometer-guage of the exhausted tube show, for the pressure in it, a height equivalent to 10 inches of mercury (for example), the density in the tube would be to that of the external air as 10 : 30, or would be $\frac{1}{3}$rd the ordinary density of air. If, after the leakage has gone on some time, the barometer-guage show a height equivalent to 20 inches for the pressure in the tube, the density will be $\frac{20}{30}$, or $\frac{2}{3}$rds that of common air. The *difference* between the densities in the tube at the two respective periods is $\frac{2}{3}$rds $-\frac{1}{3}$rd ($=\frac{1}{3}$rd) that of common air. Consequently, if the quantity of air which has entered the tube in the interval, be supposed to have diffused itself equably throughout the tube, that quantity is equivalent to the tube full of air at a density $\frac{1}{3}$rd that of common air, or, which is obviously the same thing, one-third the tube full of common air. This reasoning applies generally, and gives this simple rule—that the cubic quantity of air admitted by leakage during any interval, is equal to the cubic capacity of the tube multiplied by the fraction expressing the difference of densities during that interval. (The barometer-guage is so graduated, that for the words, "fraction expressing the difference of densities" in the above rule, we may substitute, "difference of gauge-heights divided by 30.")

If this quantity of air were divided by the number of minutes of the interval, the result would be the rate of influx per minute, supposing that rate uniform. This method of investigation is, however, liable to an objection, which our author well states as follows:—

> "We have calculated for the extreme indications of the vacuum gauge, and divided by the number of minutes that elapsed during the observation, for the average leakage per minute. Now this method would be perfectly just, on the supposition that the quantity of leakage is constant, or of the same amount in equal times; but the idea of a constant amount of leakage is altogether incompatible with what we know to take place, when air of atmospheric density is allowed to flow into a vessel containing air of a less density. Here it is obvious that the air in the vessel is continually approaching to a state of equilibrium with that without, and consequently the velocity of influx is continually diminishing until the equilibrium obtains."

He then proceeds to show, that in those experiments on the connecting pipe of the Dalkey line, in which the heights of the gauge were taken every minute, though the successive differences of those heights for successive minutes were nearly equal, they do not indicate a uniform rate of leakage, but lead to the directly opposite conclusion, that the leakage was far more rapid at the beginning of the experiment than at its conclusion: and he then makes the following important remark in reference to Mr. Stephenson's report:—"*We are somewhat apprehensive that, by assuming a constant amount of leakage for the connecting pipe, some very erroneous deductions must have been made.*"

> "But with regard to the valve tube the case is very different; for it is easy to conceive that, as the longitudinal slot or aperture is covered with a flexible substance, this substance will readily accommodate itself to the pressure as the exhaustion goes on, and by thus diminishing the area of the aperture as the velocity of influx increases, a constant amount of leakage, or nearly so, may happen to be maintained: at all events, it is not inconsistent with the maxims of accurate science, to admit that such may be the case, and it actually appears from experiment that the supposition is not far from the truth."

If it be conceded that the leakage of the connecting pipe is an avoidable evil, and may therefore be assumed to be wholly remedied, we have very simple means of calculating the effect which the leakage of the main tube has on the velocity of the train. As the assumption of uniform leakage in this tube is somewhat dangerous, let the leakage corresponding to any proposed working vacuum be ascertained by a separate experiment with the barometer-gauge. We have explained how to calculate, from the fall of the gauge, the quantity of external air which enters the tube per minute. It may be calculated by very simple arithmetic what, length of tube this quantity of air would by *itself* occupy, if dilated to the supposed working density. And that length of tube is the measure of the loss of speed of the train during the minute; for if there had been no leakage, the train-piston would have advanced that length further during the minute.

This is a brief and imperfect sketch of Mr. Turnbull's system. We must observe, however, that the results will agree only approximately with actual practice. The fundamental hypothesis of uniform velocity of the train, is not unobjectionable: it is true that in calculating the motion of locomotive engines, the hypothesis will lead to results of specific value; but, on atmospheric railways, the distances performed with accelerated or retarded speed must bear so large a proportion to those performed with uniform speed, that the latter can hardly be considered the normal condition. There are other reasons for concluding that calculations of the motion of trains on atmospheric railways cannot be exact. However, the partial application of sound theoretical principles to practical subjects, of which a perfect theory is unattainable, is a most important advantage. The skilful research exhibited in Mr. Turnbull's treatise, is the more welcome for being applied to a subject which has, in a pre-eminent degree, suffered the martyrdom of parliamentary and newspaper philosophy.

A Guide to the Proper Regulation of Buildings in Towns as a means of Promoting and Securing the Health, Comfort, and Safety of the Inhabitants. By WM. HOSKING, Architect and C.E. London: Murray, 1848.

This work of Mr. Hosking evidently contains so much practical and useful matter that we do not like to dismiss it with a passing notice, but we intend to devote a little time to its consideration. Meanwhile, whatever opinion we may entertain with regard to some of its recommendations, we have seen quite enough of it to feel justified in recommending it to our professional readers.

Earthwork Tables. By C. K. SIBLEY and W. RUTHERFORD.

The authors have published an appendix to these very useful tables, showing how the tables may be applied to *side-lying* ground, for which they give the following rule:—"Ascertain the ratio of the area of cross sections of the side-lying ground to the areas of similar cross sections, that is with same height on centre line, of level-lying ground, and multiply by that *ratio* the complete quantity furnished by the tables."

The Antiquarian and Genealogist's Companion. By WILLIAM DOWNING BRUCE, Esq., F.R.S.L. & E.

This is a novelty for the antiquarian student, which will be very favourably received at the present season, as it contains many curious memoranda and an archæological calendar for the year. The work is small—which may, perhaps, be an additional recommendation.

LECTURES ON GEOLOGY.

By Professor ANSTED. Delivered at King's College, London.

On the Application of Geology to Engineering and Architecture, and the Supply of Water to Towns and Cities.

Professor ANSTED commenced his fifth lecture, by considering the question of drainage, more particularly with reference to general engineering, which depended, in many cases, very distinctly on the geological structure of the rocks. And it did so naturally, as, for instance, in an ordinary road, properly made, where the drainage would ultimately have reference to the structure of the material and to the rocks in the neighbourhood. With regard to geological structure, it might happen that the beds which came close to the surface would have a strong inclination; and, in that case, where the beds were permeable, the road would be drained naturally, and, where one part lay on an impermeable bed, and the other on a material which suffered the water to percolate through it, an attention to geological structure would enable them to carry off all the water very satisfactorily. This would illustrate the applicability of geological knowledge, even to common road making; but that knowledge was still more directly available in the case of railroads, which, running through a long extent of country, involved the necessity of frequent and deep cuttings, in the execution of which drainage, as connected with structure and geological considerations, must always come in. Suppose, then, they were to take a transverse section of a railway cutting, similar to one of the diagrams exhibited—if the beds were horizontal, the two sides would be situated in a similar manner with regard to accidents arising from unequal pressure; but if that were not the case, and the bank was composed of mud, clay, sand, or any slippery earth, in beds inclined to the horizon, some parts of the superincumbent mass would be more apt to slip down than others. Some strata would carry water, and others would allow it to drain through; and if the road did not go directly on the strike, in which case there was no inclination as far as the purposes of the road were concerned, there would be a greater tendency to "slip" on the one side than on the other. Supposing the uppermost beds were composed of some heavy material resting upon a bed of sand, the rain, in draining through the sand, would wash it away gradually, and, a portion of the support being removed, the upper mass would naturally have a tendency to slide down upon the lower part. If once it began to slide, no matter how slowly—if the movement were only an inch per day, or an inch per month—any preventive measures were too late, and there would be a slip sooner or later, and especially in heavy rains, or rains combined with frost. But before the superincumbent mass were set in motion, if by any means the water could be prevented from passing through the sand, it might be prevented. That was best done by cutting a drain on the other side, by which all the water which came on the surface might be carried off before it reached the sand. There would then be sufficient cohesion to prevent the upper part from being set in motion.

A knowledge of geological structure, in making these cuttings, was exceedingly useful, not only in preventing slips, but in reducing the cost of work. For instance, when the dip was in a certain direction, a slip was manifestly impossible, and in that case the slope of the bank might be very much steeper, and the expense of its removal saved. On the continent, it was not unusual in cuttings to make the banks in a succession of terraces; but, in this country, that plan, though exceedingly useful, was scarcely ever adopted. It was, however, being partially tried at New Cross, a place where much mischief had been done by slips, and he believed with a prospect of success. That was, however, a plan which could not be carried out without a reference to geological science.

On the subject of *embankments* the same principles of drainage were applicable, though another element of construction was brought into action. If a large mass of material were heaped in a particular way, it might be perfectly safe, and answer the purpose intended very well; while if it were placed in a different way, mischief would arise. The structure of embankments ought also to be regulated by the nature of the rocks on which they rested, as well as those of which they were formed; and although, as yet, few accidents had arisen, engineers might find it worth while to pay attention to this subject. Again, if an embankment was placed on a hill side, there ought to be particular adaptation to the way in which the beds lay. If a heavy pressure were put upon beds so situated, which had already a tendency to slip, that tendency would be increased, and, unless attention were paid to the drainage, serious accidents would inevitably occur. The kind of draining required was much of the character of that necessary in ordinary roads—namely, by cutting off springs which had a tendency to run between bands of impermeable rock.

The subject of *canals*, and the way in which they were affected, introduced another element. In making canals, the engineer would constantly have to cut across springs, and through some strata which allowed water to percolate, and through others which actually produced water. In going across a district where there was much leakage, it was necessary to have a perfect knowledge of the nature of those rocks which yielded water and abounded in springs; and of those strata and substances which were impermeable. On such circumstances depended many great practical difficulties in the construction of canals. It was a remarkable fact, that Mr. William Smith, who flourished about a century ago, and who was called the father of English geology, was himself a mining engineer, and first observed the geological structure of the country, as it affected the formation of canals. His life, lately published by Professor Phillips, his (the lecturer's) predecessor at King's College, would be found very useful and interesting, as it regarded the practical application of so much of geological science as was known at that day. In the life of Smith would be found some account of the construction of canals in his day, then as important as railways were now. They would see how he brought his knowledge to bear upon the problems at issue, and in that way they might themselves learn how to apply a great deal of that knowledge of geology which they might possess.

Supply of Water.—The Professor next treated of the supply of water as an engineering subject, apart from the supply obtained from land-springs, or small Artesian wells, considered hitherto on a comparatively small scale, and rather with relation to agricultural purposes than engineering. The subject of drainage and water supply was, perhaps, connected as much with architecture as engineering; but, when he had discussed its relations to the one, it would scarcely be necessary to touch upon the other.

With respect to the supply of water, the Professor thought he could not do better than give them a short outline of what had been done lately with regard to the large and most important town of Liverpool, which had been noted, for some time, as a place which was badly supplied with water, and had been more remarkable than any other town in England, for the prevalence of fevers, the more than average illness of its inhabitants, and the short duration of life in the major part of it. The members of the corporation appeared very anxious to do all in their power to remedy that which was certainly one source of those evils—namely, the deficiency in the supply of water. Accordingly, they resolved to obtain an Act of Parliament, empowering them to adopt some measure, which should give the town a larger quantity of that important element. The town was situated on the new

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sandstone, and had hitherto been supplied from wells sunk into that stratum, which consisted of a red sand rock, sometimes very soft, sometimes rather hard, intersected with occasional bands of marl, very much faulted with large and continuous veins, often filled up with clay, and many of them completely impermeable. The new red sandstone rested upon coal measures, and certainly contained a great deal of water, which was absorbed from the immediate surface, or drained into it from the hills in pretty large quantities, of which the actual limits were ascertainable, since they knew how much fell from the clouds, and how much was evaporated; and they could calculate how much was lost by drainage into the rivers. The supply thus obtained was found to be very insufficient for the necessities of the town, and it was supposed that the quantity could not be materially increased from this source. This point, however, had to be decided upon by reference to the structure of the district, and by calculating whether they got all the available water of the district, or only a part, and it turned out that the latter was the fact. The mode in which this water was obtained was by wells, with horizontal galleries at their bottoms, to allow the admission of a large quantity of water, which was then pumped to the surface. The water obtained from the new red sandstone contained oxide of iron and some salts of lime and magnesia, which made it exceedingly hard, and ill adapted economically for many useful purposes connected with the manufactures of that neighbourhood, and in all operations in which soap was required. It was very good to drink, but unfit for other domestic purposes. The question was, whether a sufficient supply, even of this water, could be obtained from the district? The proprietors of the wells attempted to show that an increased quantity could not be obtained. It was to their interest that that should be the case, and they very naturally believed that it was so—consequently, they opposed all measures, the object of which was to obtain water from any other source. The corporation gathered all the information that could be obtained locally, and then called upon several scientific men for their opinion; and it is a fact of great interest, as illustrating the present practical position of geology, that it was thought necessary to have the opinion of persons, more noted for their geological knowledge than for simply a practical acquaintance with engineering. Professor Phillips was first invited to give his attention to the subject, but was prevented from doing so by his engagements with the Government. He (Professor Ansted) was then applied to, and after close examination and full consideration, he came to the conclusion that a sufficient supply could not be obtained from the new red sandstone formation, he being of opinion that, though a somewhat larger quantity might be had of the water which fell on the district, yet that would not be nearly enough for the requirements present and prospective of a town like Liverpool. What was next to be done? Then came in that admixture of engineering with geological science, now necessary indeed to every engineer, who wished to do his work satisfactorily, and with the consciousness that, whatever the result, every means had been adopted which the circumstances of the case would allow. The engineers looked about the neighbourhood far and near, their object being to discover where the necessary supply was to be found. One scheme, which met with considerable favour at first, was to take the water from the Bala Lake, in North Wales, and convey it to Liverpool, a distance of 60 miles, by closed canals. Great natural obstacles, however, intervened, and it was found that this plan involved an enormous expense, with the chance of incurring still greater outlay in overcoming several of those natural obstacles, which could not be well estimated until the work was attempted. This scheme, after exciting much discussion, was at length abandoned, and the engineers began to look nearer home. After again considering the supply from the wells, and again convincing themselves of its utter inefficiency, they found they must resort to other means, and thus originated the somewhat celebrated Rivington Pike scheme. The Rivington Pike district presented a hilly surface of 17 square miles, admirably adapted by nature for such a project. The plan pursued in this case was to take the district and measure its area of drainage, then to estimate the quantity of water that could be obtained from it, and, finally, to consider how the water might be best accumulated. This was a beautifully scientific problem, perfectly practical indeed; but one which had rarely, if ever before, been tried to the extent now proposed. First of all, they had to see whether the quantity of water would be sufficient; and this was effected by accurately marking the water shed, observing where all the rills and streams could be caught conveniently, and, when caught, considering whether they could be conducted into some sound and sufficient reservoir. The model on the table, which was an accurate representation of the district, would show that all those points were readily attainable. The drainage was regulated by the shape of the country, and it might be seen either by the Ordnance Map, a contour map, or a model. In this case, he was able to exhibit a model, which was the best; but the Ordnance Map was the guide originally used. Having then found the area, the question whether it would yield a sufficient quantity of water to supply the town of Liverpool was next to be decided. This calculation involved a considerable amount of knowledge of geological structure. It was easy to tell how many inches of rain descended from the sky on a certain space and in a given time; and they had only to multiply that by the whole area intended to be drained, and they would have the exact quantity which fell upon the whole. That was simple enough; but they had then to ascertain what was the nature of the surface on which the water alighted; for if it were permeable, as sand, for instance, it was obvious that a large proportion would be absorbed and lost; or, if there were many hollows, the water would lie in them and evaporate. These and other geological considerations had all to be well considered; but geological science showed that the district, being composed of the bed of hard sandstone, called millstone grit, partially covered over with shaley beds belonging to the coal measures, the whole of it might, for practical purposes, be regarded as impermeable. The sandstone rock, oftentimes very soft, was here very hard, a good deal faulted but not open—so that it would allow almost the whole of the water to run off the surface. The consequence was, that almost all the rain that fell ran into the streams, which a further examination showed might be readily collected into two principal reservoirs on the side of the district nearest to Liverpool, which would be 24 miles distant. The natural valleys, in which it was intended to place these reservoirs, had, no doubt, held water before, as the bottoms were covered with fresh water silt. There were also beds of alluvial clay—an additional indication that a considerable quantity of fresh water had at some period been there. By means of two or three embankments, these lower districts would thus accumulate that water, which the structure of the upper districts allowed to run off. The whole of the rain which falls upon an area of 47 square miles would thus be collected, producing a supply of 20,000,000 gallons per day, sufficient for the town of Liverpool were it twice the size, and also for the supply of a more useful and economical article to the mills, bleach-works, and other works in the neighbourhood. Here advantage was taken of the peculiar natural circumstances of the district, to make the *minimum* quantity of surface produce the *maximum* amount of water; but which could never have been accomplished, but for a distinct geological knowledge of the structure of the district. Had it not been for a practical application of geological science, that on a certain description of stone the whole of the water would run off, the selection of the Rivington Pike district would never have been made, and the probability was, that Liverpool would have remained for a much longer period suffering from the want of a sufficiency of so vital a fluid. This was a remarkable instance, in which a knowledge of structure had been applied to superficial objects of this kind.

The Professor dismissed the subject of draining by explaining the nature of the operation of a newly-invented draining pipe (Watson's draining pipe), which was remarkably effective. It was cylindrical, with a great number of longitudinal slits, which were wider inside than outside, and thus counteracted any tendency to clog. These pipes were most useful to insert in beds of clay, and, even after a considerable length of dry weather, might be seen giving out water very plentifully. This efficient draining caused the beds to contract and crack, and, by thus making openings for the water, rendered the draining perfect. To the proper use of these pipes a knowledge of the dip of the beds was indispensable.

The next subject was connected with *materials as required for various engineering operations, and used for a vast number of economical purposes.* These he would divide in the same manner as he had divided the various rocks, and he should commence with the clays.

Clay was either mixed with limestone or with sand, in various proportions, and was a very important material. All clays contained alumina, but a considerable number of materials existed, some known by the name of clays, and others, though belonging to the class, not recognised by the general appellation. Of clay, properly so called, there were several distinct kinds. One was the clay found in the shape of subsoil, chiefly used for agricultural purposes. In this case it consisted, not only of silicate of alumina, the base of all clays, but of limestone, magnesia, potash, iron, &c., and was none the worse for a little phosphorus; while it contained also a quantity of carbon. This admixture was indispensable for vegetation; but for "materials" clays were better without these foreign substances. The most common clay considered as a material was known by the name of *brick clay;* it was a silicate of alumina, with a certain amount of free sand in very variable quantities, which might, however, be easily determined by washing. A good brick clay should consist solely of these materials, without lime or potash, and if the free sand was not in sufficient quantities, it must be mixed with it to make it work; and, generally speaking, the purest, in the common sense of the word, was the best for making bricks. The clay derived from the decomposition of some of the old rocks was particularly valuable, and that derived from the decomposition of slate was generally most pure, and was useful, in certain districts, in the manufacture of *fire-bricks.* The best kinds were the purest, and contained neither alkalies nor salts, either of which make it run, in the great heat to which it was subjected in the furnaces. The presence of such substances helped the action of the fire, and the surface of the brick would be turned to glass. Pure clay and sand was thus the best for fire-bricks, and it was obtained, as he had observed, from slate. The London clay, one of the tertiary series, was for the most part tolerably well adapted for bricks—indeed, all London was built of it; but it was not well suited for the making of fire-bricks, though it possessed many separate portions that were so. The mischievous ingredients might indeed be separated, but generally it was not worth the trouble and expense, as there was no great difficulty in obtaining clay for fire bricks.

Pipe-clay or *potters'-clay,* another of this class, was used in the manufacture of the rougher kinds of earthenware. This was a most useful material, and did not require to be so carefully selected as that used for fine pottery and porcelain. It contained a considerable quantity of water, and it was unctious and soapy to the feel. It was necessary for the purposes of the potter that it should contain a considerable quantity of water, which usually amounted to 18 per cent. It did not contain sand; but it usually had about 1 per cent. of oxide of iron, and a small quantity of lime. The chemical composition of materials of this kind, however, was not very accurately ascertained, as they were for the most part accidental mixtures, and were apt to vary in different localities. Pipe-clay was obtained from beds situated in the midst of other clays, and they appeared to form a band of finer material associated with the coarser clays. There was a great deal of this clay found at Paris, where it was called *argile plastique*. The lower beds of the London clay were also described as *plastic clay;* but they consisted, for the most part, of gravel or pebble beds, for which that was not at all a proper name. Still, some of them contained this material.

Fullers' earth was another and a finer kind of clay, used in the fulling of cloth, on account of its power of absorbing grease readily from woollens. It contained an unusually large quantity of silica, as compared with the ordinary pipe-clay, the proportion of the latter being 43 per cent. of silica, and 33 of alumina; while that of the former was—silica, 53; alumina, 10; the other parts being made up of iron (about 9½ per cent.), magnesia (1 per cent.), and water (24 per cent.). Fullers' earth was derived from the Weald clay at Nutfield, in the neighbourhood of Reigate, and from the lower part of the oolite rocks in Wiltshire. In each case there was a considerable variation in the colour, occasioned by the condition of the oxide of iron; but the texture was the same, and the colour was a matter of very little consequence.

Porcelain clay was another important material. This was derived from decomposed felspar, obtained generally from gneiss, or granite. It was the purest of all the clay rocks, being a pure silicate of alumina, consisting of 60 per cent. of silica, and 40 of alumina. A large quantity (8,000 tons annually) of the finer kinds was obtained in Cornwall by artificial washing. Besides this, upwards of 25,000 tons of the coarser kinds was obtained from beds formed by the natural washing of the rains. The decomposed felspar was mixed with water in the artificial process, and moved along at a certain velocity, when the whole was gradually deposited in the shape of porcelain clay. The coarser parts were deposited first, when the mass moved most rapidly; next, the finer parts, as the mass moved slower; and, lastly, the finest of all.

There were other clays worthy of notice, as, for instance, the *ochres*, red and yellow, the colour being decided by the condition of the oxide of iron, which was present in them in considerable quantities. These, however, were not important as materials.

From some clays, the substance called *alum* was derived; but that, like the ochres, was not an important material, geologically speaking, although interesting from the chemical process by which it was obtained. The talented lecturer concluded by briefly describing this process.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Nov. 29.—A. POYNTER, Esq., V.P., in the Chair.

The Secretary read the Report of the Committee appointed to examine the design submitted by the Cavalier Nicolò Matas for the completion of the western front of the Cathedral at Florence. The report expressed in general terms an approval of the design; and stated that the architect has shown judgment in adopting the style of the other parts of the exterior—thus seeking to complete the noble edifice in one congruous character, in harmony with the Campanile and the Baptistery. By this unity of sentiment, the design for the western front appears a consistent and integral part of the structure.

A paper was read by J. GWILT, Esq., entitled, "*Some discursive Remarks on Pointed Architecture, in relation to its Symmetry and Stability.*"

The essay was of considerable length, and traced in a general way the origin of Gothic architecture. Mr. Gwilt stated that of a great number of writers on that subject whom he had consulted, he found that twenty were of opinion that it originated in Germany, fourteen that it was of Eastern or Saracenic origin, six that it arose from the hint suggested by the intersection of Norman arches, four that it was the invention of the Goths, and three that it arose in Italy. Mr. Gwilt was of opinion, with M. Michelet ("Histoire de France"), that when the power of the Church diminished about the year 1200 under Innocent III. the arts, particularly architecture, fell into lay hands to a considerable extent; that the impetus thus given changed its character; and that in the hands of the lodges of Freemasons which then arose Gothic architecture and all its developments were originated and taught. By the aid of diagrams and drawings the gradual growth of the fine forms of Gothic architecture were developed and its principles explained; the leading fact seeming to be that the number of sides in the polygonal apsides of the cathedrals was the governing number for all the parts of the plan and even the details of the architecture. Many curious instances of these analogies were given. Mr. Gwilt combatted the "Vesica Piscis" theory, as well as the vagaries, as he called them, of the symbolists.

A communication was read from E. I'anson, relative to some mural paintings discovered by him in the church of Lingfield, in Surrey. These paintings, fac-similes of which were exhibited by him, represented draped figures, about three feet in height, on a diaper groundwork, and appeared to have been executed in distemper. They had at some period been covered over with whitewash; on which the Commandments and scriptural texts had been inscribed.

Dec. 13.—S. ANGELL, Esq., V.P., in the Chair.

A paper was read "*On the Principles and Practice of Building Sewers.*" By E. I'ANSON, jun., Fellow.

The intention of the author was to show that sewers might be effectually constructed with a moderate fall; that no one form of section is applicable under all circumstances, but that no form should materially depart from that of the semicircular invert; that all main sewers should be of sufficient altitude to allow a man to pass through; that no impediment should be offered to the continuous flow by cross streams or accumulating deposits; and that cleansing by "flushing" is an efficient means of removing the silt and other matters in the sewers. Mr. I'anson particularly alluded to the necessity of all sewers being of sufficient, but not of more than sufficient, sectional area to contain the greatest quantity of water that may at one time have to pass off—or that, as in the case of districts below the level of high water, they may have at one time to contain. In reference to the idea of constructing sewers of small size and removing the contents by continued pumping, Mr. I'anson remarked, that as the pumping power should be at all times equal not only to discharge the average quantity of water, but also that of the greatest quantity which may at any time be required to be passed off, it was obvious that there would be an enormous continued waste of power at a cost more than commensurate to the saving effected by constructing the sewers of smaller size.

SOCIETY OF ARTS, LONDON.

Nov. 10.—THOMAS WEBSTER, Esq., F.R.S., in the Chair.

The Secretary read an address on the opening of this the 94th Session of the Society.

Mr. J. CUNDALL read a paper "*On Ornamental Art as applied to Ancient and Modern Bookbinding.*"

The author commenced by stating that the earliest records of bookbinding prove that the art has been practised for nearly 2,000 years; previous to which time, books were written on scrolls of parchment. Some inventive genius, however, to whom the Athenians erected a statue, at length found out a means of binding books with glue: the rolls of vellum, &c., were cut into sheets of two and four leaves, and were then stitched somewhat as at the present day. Then came the necessity for a covering, The first book-covers appear to have been made of wood, probably merely plain oaken boards, which were afterwards succeeded by valuable carved oak bindings; these were followed by boards covered with vellum or leather, and specimens of such of great antiquity still exist. The Romans carried the art of bookbinding to considerable perfection, and some of their public officers had books called "Diptycks," in which their acts were written. An old writer says that about the Christian era, the books of the Romans were covered with red, yellow, green, and purple leather, and decorated with silver and gold. In the 13th century some of the gospels, missals, and other service books for the use of the Greek and Roman churches, were covered in gold and silver; some were also enamelled and enriched with precious stones and pearls of great value. In the 15th century, when art was universal, such men as Albert Durer, Raffaelle, and Guillo Romano, decorated books. The use of calf and morocco binding seems to have followed the introduction of printing, and there are many printed books bound in calf with oaken boards about the 15th and beginning of the sixteenth centuries; these are mostly stamped with gold and bhud tools: the earliest of these tools generally represent figures, such as Christ, St. Paul, coats of arms, &c., according to the contents of the book. In the reign of Henry VIII., about 1538, Grafton, the printer, undertook to print the Great Bible, for which purpose he went to Paris, there not being sufficient men or types in England; he had not, however, proceeded far when he was stopped in the progress of this "heretical book," upon which he returned to England, bringing with him presses, type, printers, and bookbinders, and finished the work in 1539. Henry VIII. had many books bound in velvet, with gold bosses and ornaments; and in his reign the stamping of tools in gold appears to have been introduced. In the reign of Elizabeth, some exquisite bindings were done by embroidery, the queen herself working the covers with gold and silver thread, spangles, &c. Count Grolier seems to have been a great patron of the art on the continent, and all his books were bound in smooth morocco or calf ornamented with gold. The style of the books of Maioli was very similar to that of Grolier, or those of Diana of Poictiers, the specimens done for her being among the finest ever produced, and were no doubt designed by Petit Bernard. Rogar Paine was the first Englishman who produced a really good binding, and some of his best works, such as French romances, were powdered with the fleur-de-lis. His books on chivalry had suitable ornaments; on poetical works he used a simple lyre, and carried the emblematical style of binding as far as emblems ought to be used. The following bill of his for binding a work is a curiosity, and shows how moderately he charged:—

"Vaneria prodium Rusticum, Parisiis, MDCCLXXIV.

"Bound in the very best manner in the finest green morocco, the back lined with red morocco. Fine drawing-paper and very neat morocco joints inside. Their was a few leaves staind at the foredge, which is washed and cleaned 0 0 6

"The subject of the book being 'Rusticum,' I have ventured to putt the Vine Wreath on it, I hope I have not bound it in too rich a manner for the book. It takes up a great deal of time do these Vine wreaths; I guess within time I am certain of measuring and working the different and various small tools required to fill up the Vine wreath, that it takes very near 3 days' work in finishing the two sides only of the book—but I wished to do my best for the work, and at the same time I cannot expect to charge a full and proper price for the work; and hope that the price will not only be found reasonable but cheap .. .. 0 18 0"

Of the binders of the present century, the following deserve to be mentioned with respect—viz., Mr. Mackenzie, Mr. Clarke, Mr. Bedford, and Mr. Hayday; the bindings by the latter consist almost invariably of adaptations and modifications of ancient examples. Among the many splendid specimens of his work exhibited, that of "the Sheriffs of Shropshire," in imperial folio, deserves special notice, as being enriched with the armorial bearings beautifully coloured. The binding is of blood-coloured morocco, extending an inch and a half all round the inside of the cover, on which is stamped a bold, open border, tooled in gold.

The author, after alluding to the numerous specimens of modern bindings which have of late been produced to the public, and regretting their want of originality, concluded by urging the necessity of attempting something original and suitable to the advancing and improving taste of the time. Then we may hope that ere long ornamental art in bookbinding will be wedded to our present perfect execution, and that the 19th century will be able, like the 15th, to boast of a style of its own.

Mr. H. Cole, assistant keeper of the Public Records, exhibited a number of very curious and beautiful specimens of bookbinding, among which was one containing the deeds relating to Henry the Seventh's Chapel at Westminster, in which the monks undertake to pray for the soul of its founder as long as the world is.

Nov. 17.—W. H. Bodkin, Esq., V.P. in the Chair.

The first communication read was by Mr. Briant, on his "*Plan for overcoming the difficulties of a Break of Gauge, and of Uniting the Broad and Narrow Gauge Railways.*"

Mr. Briant commenced his paper by pointing out the difficulties which had arisen from the adoption of the two gauges in this country, and the objections which have been urged against the various plans—viz., the telescopic axles for the wheels; the shifting of the carriages from one gauge on to that of another; laying down double lines of rails; &c. He then proceeded to describe his own plan, which is as follows:—At the point of junction of the two gauges, a platform is to be fixed in the centre of the rails; the carriages are then to be placed upon wheels, the two ends of the axles of which are to be made as male screws; on the centre of the axle a pinion-wheel is to be fixed, and under it attached to the frame of the carriage a lever, upon the upper side of which is a rack, and at the lower end an anti-friction roller. The nave of the wheels is to extend under the carriage in the form of a female screw, to receive the axles. By this arrangement, while the train is travelling on the narrow gauge, the wheels would be screwed up to the required width, the racked lever hanging loosely under the pinion-wheel, and the axle would turn with the wheels; but when the train reached the point of junction, the lever would be caught up by the platform (which is to be 40 yards long), and with it the rack. The axle would thus be prevented from turning by the pinion-wheel and rack, and the wheels, from the weight of carriage, passengers, luggage, &c. pressing upon them, would immediately begin to unwind the screws, which, by the time the carriage has reached the other end of the platform, will have extended the axle to the required width—the lever would drop and free the pinion-wheel, and the axle would then turn with the wheels as before. The wheels are kept in their position when unwound by coupling-rods. In backing the train, the screw is prevented from acting by means of a stop fixed to the carriage and blocking the axle. A working model was exhibited.

The second paper read was by D. J. Hoare, Esq., "*On a Railway Telegraph and Alarum, to be used as a means of Communicating between the Guard and Driver of Railway Carriages.*"

The plan proposed is that a series of rods should be passed through the carriages of a train, and united at their extremities by a telescope-joint, so as to allow of extension and contraction: the rods being made with a universal joint, admit of a rotary motion,—the only motion which a railway train has not. At the end of the rod on the guard's carriage is a crank, which, when the rod is turned, comes in contact with a hammer, and causes it to strike a bell. A signal is then to be raised, indicating the carriage from which the signal is made; the guard will then immediately ascertain whether it is necessary that the train should be stopped, and if so, by turning the rod in the reverse direction to what the person signalling had done, will ring another bell at the driver's end of the train, or sound the whistle of the engine.—Mr. Hoare stated that it is immaterial what the curve of the railway may be, as the universal joint admits of the rod varying from a right line. It would also act in case a carriage got off the line, or even on to the buffers of the carriage preceding it.

Nov. 24.—T. Webster, Esq., F.R.S., V.P., in the Chair.

The first communication read was on Mr. Dutton's "*Railway Communicator.*"

Mr. Dutton proposes that a small metal pipe should be fixed in some convenient part of each railway carriage, and connected at its extremities with the carriage preceding and following it by means of a short length of vulcanized india-rubber tubing and a kind of bayonet fastening; at the end of the tube, near to the guard's seat, a whistle is to be fixed, which will be capable of being sounded by the passengers on their blowing into a small branch tube, to be fixed in each carriage in connection with the metal pipe. A model was exhibited.

The second communication was by Mr. F. Brothers, "*On his plan for forming a Communication between the Passengers, Guards, and Drivers of a Railway Train.*"

Mr. Brothers proposes, by means of a fly-wheel, to be worked by the rapid current of air passing through it, to set in motion a multiplying power which shall work a small air-pump, and compress air into a chamber in connexion with which two whistles shall be fixed; one of these the passengers are to be capable of sounding, by allowing the compressed air to escape. The second whistle is to be of a different size and sound, and entirely under the control of the guard, and only to be used when it is necessary to stop the train.

The third paper was by Mr. E. E. Allen, on his means of effecting a similar communication.

Mr. Allen proposes to make use of electricity as a means of sounding the steam whistle. Galvanised wires are to be carried along each of the carriages of a train, and the electric circuit is to be completed by the use of galvanised coupling chains, which, so long as the circuit is complete, magnetises a piece of soft iron and holds a detent attached to the steam-cock; but whenever the circuit is broken, the iron is demagnetised, and the detent allowed to go free, upon which the steam escapes, and the whistle thereby sounded.

The fourth paper read was by Messrs. Brett and Little, on their method of forming a similar communication.—In this plan, as in Mr. Allen's, it is proposed to use an electric current, the circuit of which is to be completed by means of wires and chains, but is to act only when the circuit is complete, when a bell is rung.

Dec. 1.—W. Wyon, Esq., R.A., in the Chair.

Five specimens of "*Painting on Glass,*" by M. De Ron, of Munich, were exhibited.—The Secretary stated that the colours used by M. De Ron are peculiar, and the method of preparing them known only to himself, and which colours are glasses of different degrees of hardness, care being taken in using them never to put a harder upon a softer metal. He also uses both sides of the glass, which enables him to obtain clearness and decision of colour.

Mr. Hall offered some remarks on the history of stained glass, and exhibited several specimens of modern manufacture.

Mr. S. Moulton exhibited a model of an "*Iron Truss Railway Bridge,*" the invention of Mr. Rider, of New York.—The peculiarities of this bridge are its simplicity, lightness, and strength. The directors of the New York and Harlem railroad have erected a bridge on this principle, the span being 70 feet, and having a double track or roadway upon it; the entire weight of metal used in its construction was 13 tons, while its cost was under £500.

A paper was read by Mr. Archer, "*on Engraving with reference to Monumental Brasses and Incised Stones.*"

The author commenced by referring to the very early period at which the art of engraving appears to have been known and practised by the lapidary and goldsmith, and the probability that those to whom the art was known were subject to a precise code of laws and connected with the priestly office, these laws having the effect of regulating the productions according to a given standard set up by the heads of their order; thus giving a singular uniformity to the numerous examples of antique art, whether in painting, sculpture, or engraving. After alluding to the Egyptian, Etruscan, Greek, and Roman specimens of engraving, and their similarity and common origin, he proceeded to point out the various purposes to which the art of engraving on brass was employed, such as the representation of geographical diagrams. In the time of Herodotus, edicts and public records were sometimes inscribed on brass tablets, a striking instance of which occurs in the preservation down to the present time of the will and acts of the emperor Augustus. Having touched upon some few instances of the ancient practice of the caleographic art, the author proceeded to detail some particulars of that process as it appeared at the general revival of art during the middle ages. In the 8th century, by a law of Kenneth, king of Scotland, it was enjoined that a cross should be put on every gravestone—*i. e.* coffin-lid; and this appears to have been done in three ways:—1st. By the use of incised lines drawn around the object. 2ndly. By producing the form in low relief. 3rdly. By a wholly excised figure.—The use of sepulchral brasses appears to have originated with the general revival of art in the 13th century, one of the earliest specimens being that of Sir Roger de Trompington, who died in 1289. The brasses of the 14th and 15th centuries contain, besides the effigies of warriors, churchmen, ladies, and civilians, many examples of beautiful decoration, derived from the architectural practice of the time. Different combinations of the letters I.H.S., composing the sacred monogram, appear in the brasses of the 15th and beginning of the 16th centuries. In the 16th century, at the time of the Reformation, these sacred monuments appear to have become obnoxious, and were accordingly swept out of the churches with an unsparing hand—few (comparatively) having escaped destruction: of some of these, however, the author produced rubbings; and, having traced the history down to the 19th century, and referred to the latest of that period (prior to those produced under his own direction), he proceeded to urge the desirableness of possessing as a nation a complete collection of the rubbings of the brasses of this country, as illustrative of the costume and history of bygone times, and the propriety of such a collection being deposited in the British Museum. The author then concluded his paper by calling attention to the cartoons of several monuments recently executed by himself, by a new process of working on brass, and which he promised to communicate to the Society at an early period.

Dec. 8.—T. Hoblyn, Esq., in the Chair.

Mr. H. Cole made some remarks in reference to Mr. Archer's paper on sepulchral brasses and incised stones, read at the last meeting. He observed that about ten years since the study of brasses re-commenced in this country. During that period, however, almost all that is known respecting the brasses has been exhausted, and several works have been written on the subject; so that there is scarcely anything to find out, unless the brasses happen to lay under pews or in parts of the churches which at present are concealed. The most remarkable have been published by the Cambridge Camden Society, and on the walls are exhibited engravings from a book of great excellence by Waller: others have also paid attention to the subject. The ordinary process of obtaining rubbings is as follows:—A sheet of paper is laid upon the brass, and kept in its position by weights; it is then rubbed over with a composition known as heel-ball. By this means, the whole of the paper where the brass under it is not cut away becomes blackened, while the incised lines remain the colour of the paper. In some cases, a kind of bronze composition is used upon a black paper, and by this means as nearly as possible a facsimile of the brass is obtained. The most important brasses to be found in London are in Westminster Abbey, St. Helen's, Bishopsgate, Allhallows, and St. Andrew's Undershaft. Passing out of London, the nearest churches where any remarkable brasses are to be found are, Willesden, Harrow, South Miuns, St. Alban's, Broxbourne, Cheshunt, Roystead, Chigwell, Windsor, Stoke-Pogis, Taplow, Westerham, Penshurst, and Cobham.

Mr. Hall made some remarks relative to the history of copper-plate engraving, and the probability that it grew out of the art of engraving monumental brasses.

Mr. Slocum exhibited two ploughs, a scythe and cradle for reaping corn, a grass scythe, three spring tempered manure and hay forks, a cast-steel hand hoe, and an American axe. He stated the peculiarity of these implements to consist in their lightness, cheapness, and durability, thus enabling the agricultural labourer to accomplish a larger amount of daily work at a less cost. The implements he exhibited were such as are commonly used in the United States.—A letter was read from Mr. Love, of Manor House, Naseby, in which he states that the ploughs were tried on a clay soil, in rather a dry state, against Adams's Northampton plough, and one of Howard's Champion ploughs. Howard's, when working five inches deep by eleven inches wide, had a draught of 31 stone; and Adams's plough, at the same width and depth, a draught of 30 stone; while the American plough, at five inches deep and fourteen wide, drew only 26 stone. "In justice to the American ploughs, I must say," observes Mr. Love, "that they cut up and cleaned their furrow quite as well as the other ploughs, and also turned the earth, completely breaking it, and putting the soil in capital position for drilling or dibbling; they are the most simple, strong, light, and effective ploughs it is possible to conceive: other experiments were also made, and the draught tested by the dynamometer."—The cost of the ploughs Mr. Slocum stated to be £2 each.

A communication was read from Mr. W. Taylor, F.L.S., &c., "*on the Cultivation of the Polygonum Tinctorium, or Dyer's Tinctoria.*"

"This plant," observes Mr. Taylor, "is a native of China, and was introduced into this country in 1776, by John Blake. It is used in China and Japan for the purpose of dying a blue similar to that of the finest indigo. The colour is obtained from the leaves of the plant, which are dried, pounded, and made into cakes. 'With these cakes,' Hunberger says, 'they dye linen, silk, and cotton.' When the cakes are boiled, they add ashes; and the stronger the decoction is made, the darker is the colour. The plant grows best in this country on soils of a medium texture, which must also be well manured before the seed is sown, which is best sown in rows about the middle of April. Two pounds of seed to the acre is sufficient, but the plants may be planted out in rows from the hot bed, at the rate of about 16,000 to the acre; and unless they are brought forward and planted out, they will not produce seed in England. The plant can be prepared for the market in three ways, viz.—1st, it may be cut in a green state and sold to the dyer, in which case an acre would produce five tons of leaves and stalks, worth about £30.—2nd, if cut and placed in vats, so as to precipitate the fecula, or indigo, the acre would produce 3 cwt. of colour, which, at 1s. per lb., would be worth £16 16s.—3rd, the plants may be cut up, dried, and packed in bundles: the acre would then yield three tons of dyeing matter, and be worth about £21. The colouring matter may be extracted either by fermentation or scalding." Specimens of the plant and colour were exhibited.

The last communication read was by Mr. W. Bennett, "*on some samples of Flax grown in Ireland in 1847.*"

Specimens of the flax were exhibited, and Mr. Bennett stated they were produced under every disadvantage possible, and in one of the most remote and destitute corners of the whole island, viz., the barony of Eoris, county of Mayo, on the western coast, and under the superintendence of Mr. G. S. Bourns, the peasantry being wholly unacquainted with its mode of culture and preparation. The flax is of good quality, and worth from 6s. to 8s. per stone. The introduction of its culture has also afforded employment to a large number of poor women in spinning. The peasantry are also being employed to manufacture linen from looms erected in the stables of a clergyman, in another most distressed locality, specimens of which were exhibited.

ROYAL SCOTTISH SOCIETY OF ARTS.

Nov. 8, 1847.—David Maclagan, M.D., F.R.S.E. President, in the Chair.

The following communications were made:—

1. *On the first principles of Symmetrical Beauty, as developed in the Geometric Harmony of the Human Head and Countenance.* By D. R. Hay, Esq.

Mr. Hay commenced his paper with a quotation from Dr. Reid's "Intellectual Powers of Man," showing that it was the opinion of that great philosopher, that, as taste might be true or false according as it was founded on true or false judgment, it must have first principles. He then observed, that by truth being properly investigated in the natural sciences, natural philosophy had arrived at its present advanced state, and its application in the useful arts had consequently produced the happiest results. But that in our search after truth in the science of æsthetics, a very different course had been followed, and that our ideas of beauty were clothed in mystery, and our attempts to produce the former in the various branches of art, depend in a great measure upon chance. This he attributed to the practice of servile copying in our schools of art, instead of studying the first principles or teachable laws of beauty; in short, that we study and imitate results without investigating causes. He asserted that there exist precise mathematical principles of a practical nature, by which the external form of the human head and countenance may be delineated, and by which the proportions and relative positions of the features may be arranged upon the facial surface so as to produce a primary species of symmetrical beauty; and that these principles were identical with those which produce beauty in architecture and ornamental design. This he demonstrated by combining in a diagram the Platonic triangles and the curvilineal figures that belong to them, showing, at the same time, that those triangles were the root of all symmetrical beauty and harmony in geometry. He showed that this diagram corresponded in all its parts to the anatomy of the human head, and that the countenance thereby produced possessed the *beau ideal* beauty of the finest Grecian sculptures. Mr. Hay stated that he believed the principles he explained were known to the ancient Greeks, and were introduced by Pythagoras, and taught by Plato in connection with mathematics, and by Pamphilus as connected with art. The drawings by which Mr. Hay exemplified his principle were larger than life, and very numerous, and we understand it is his intention to publish them on a small scale.

2. The Report of the Prize Committee, awarding the Prizes for Session 1846-7, was read.

Nov. 22.—G. Buchanan, Esq., President, in the Chair.

The following communications were made:—

1. *Suggestions for preventing Accidents on Railways.* By J. Stewart Hepburn, Esq., of Colquhalzie. These suggestions have reference to the injudicious practice of mixing light with heavy carriages in different parts of the train, and to the injudicious applications of the break, and the order in which it is applied; and propose the classification of the light and heavy carriages, and the working of the break from the rear to the front of the train. They have also reference to the permanent works of most railways as originally constructed, being too light and insufficient for the heavier loads and high velocities which are now used; and propose to give increased stability to the rail by a well laid pavement of heavy blocks of stone, along the outside of each rail. They have also reference to what is called "jumping," which is often the cause of carriages running off the line—to unequal subsidence of the roadway, and proposes Telford's plan for forming the embankments in concave layers, or that the earthworks should be allowed ample time to subside of themselves before the rail is used. Mr. Hepburn also proposes longitudinal supports under the joinings of the rails, which he considers their weakest part. The suggestions have also reference to the entanglement of the buffers, and "riding" on each other; and propose to enlarge vertically the surface of the buffer, by having in its place three elliptic springs on the lower frame of the carriage, and two on the upper part, each set connected with a horizontal bar of wood, and the whole covered with boarding. Mr. H. holds that this arrangement would prevent the carriage from turning up and rolling over each other when a collision takes place.

2. *Description of a Model of a Malleable Iron Railway Chair.* By Mr. Robb, Haddington. The advantages are stated to be greater strength, and thus giving additional security in passing sharp curves: the rails would fit much better from the chairs being all cut true to the pattern, thus securing a uniform bearing to the head of the rails: the superior manner in which the wooden keys will fit, and with less rigidity. Mr. Robb thinks they could be made cheaper than cast-iron chairs, and that they would be stronger, although one-half lighter, whereby a saving in cost of carriage would be effected to an extent of 50 per cent.

3. *Description of a proposed Improvement in Railway Switches.* By Mr. NICOLL, Arbroath. These switches are placed on iron chairs so constructed as to move along with the switch, whereby the motion of the switch is not prevented by its getting jammed with dust or rubbish; and the chairs, from their peculiar form, push aside the dust and clear a way for the switch. Mr. Nicoll also gives a description of the apparatus for opening and closing the switch, so as to prevent accidents by the motion of them by unauthorised persons.

4. *A Railway Alarum Communicator.* By Mr. MOFFAT. The object is accomplished by a tube sunk in the roof of each carriage, and to connect these are tubes of India rubber with screws. Inside the tube is a wire, and attached to it inside of each compartment of the carriage are bell-pulls or knobs. At each guard's seat are bells and knockers, and the same at the driver's, fixed near the engine. A passenger wishing to give a signal, pulls the knob, by which means the whole bells are rung. The tube can also act as a speaking-trumpet, mouth-pieces being inserted in each compartment, and the same to the guards and drivers—so that a passenger having rung the bell, communicates to the guard and driver, &c., his reason for so doing.

5. *Description and Drawing of an Alarum Rein for Railway Trains.* By Mr. M'COLL. The rein is attached to a whistle valve on the engine, and extends along the whole train on the locked side; so that any person, by pulling the rein, opens the whistle, and informs the driver that something is wrong.

Dec. 13.—G. BUCHANAN, Esq., F.R.S.E., President, in the Chair.

The following communications were made:—

1. *Description of the Overarch Suspension Bridge.* By Mr. MILNE. This bridge is so constructed that the roadway runs under the arch, and is connected to it by suspending rods, which are so disposed that a large portion of the arch sustains a small portion of the roadway, thus enabling the bridge to bear a concentration of weight at any point. The main rods of the arch lean against each other at the centre (where the key-stone of a stone bridge is situated), giving mutual support, which is continued towards each end of the arch by circular extenders, enlarging as they approach the piers. The pressure of the main rods against each other is thus turned to the utmost advantage, and gives the greatest stability possible; and from this construction the lee-side will resist a gale of wind with the full power of the arch. The model is twenty inches in length, on the scale of ten feet to an inch. The entire weight of iron is six ounces, and it safely bears a load of 56lb.—nearly 150 times its own weight.

2. *Supplementary Explanations of an improved Railway Break.* By J. STEWART HEPBURN, Esq. This is an improvement of break submitted by the inventor to the Society last session. It consisted of a rubber block of wood attached to railway carriages by a moveable frame-work; and applied, not to the wheel, like the common break, but to the rail, by a gradual pressure capable of being increased to such a degree, on an emergency of danger, as to raise the hind wheels from the rail.

3. *Improvements in Railways.* By Mr. JOHN CRANE. The first improvement is for locomotive engines to ascend or descend steep inclines. It consists in laying along the incline a toothed rail, outside of the common rail, and keying on additional wheels with teeth on the shaft of the driving wheels of the engine, outside of the bearing wheels, and working in the toothed rails, and the teeth of which are to work in the teeth of the rail; thus pulling on the train.—The second improvement consists in making the wheels with double flanges, one on the outside of the rails, as well as the usual one within them. Thus the wheels would be less liable to go off the rails.—The third improvement consists in laying the rails on longitudinal sleepers, connected together by cross sleepers, and forming a series of strong square frames.—The fourth improvement is for a break. Instead of pressing against the wheels, and thereby retarding them by friction, and eventually locking them, the break falls down at once between the wheel and the rail, inserting itself between them like a wedge, and thereby locks the wheels, and, at the same time, rubs upon the rail. Four wedges are required for ordinary carriages, one pair at each end; each pair of wedges is connected by a bar of wrought-iron, in the centre of which a chain is fastened, which can be raised by the guard, and fastened by passing one of the links over a hook. When the chain is detached from the hook or button, the break, by its own weight, and guided by a rod attached to the carriage, falls under the wheels and prevents them revolving. The guiding rod to have its centre of motion eccentric to that of the wheel, and that centre to be a pin fixed on the axle frame of the carriage, a little above it, so that the wedges when raised may be clear of the wheels.

NOTES OF THE MONTH.

Railway Precautions.—Mr. Wyndham Harding, in a letter to the Institution of Mechanical Engineers, recommends, as the most simple and best method of forming a communication between the guards and engine-drivers, "That the guards should have the means of readily getting along every train, whether a passenger or a goods train, to the engineman. This (he observes) was the original idea in narrow-gauge trains, for the means are afforded of getting from one carriage to another, but the idea has been imperfectly carried out, inasmuch as a horse-box or a luggage van afford no facilities for getting past them. Nothing is easier than to remedy this by holdfasts and a narrow foothold. In the case of flat trucks loaded with such goods as cotton, uprights at the four corners, and a rope from one upright to the other, would afford a hold for the guard, and would also, at the same time, tend to steady the load. In the vehicles which travel in passenger trains even such an addition as this would not be necessary. On the broad-gauge lines connected with the Great Western Railway, there is generally no facility afforded for getting along the train, but such facilities can with equal ease be afforded in broad-gauge trains as on narrow by trifling additions to the vehicles." Mr. Harding caused additions with this object to be made to the broad-gauge carriages on the Bristol and Gloucester Railway when he had the control of that line.

Commissions of Sewers.—The old commissions for Westminster, Holborn and Finsbury, Tower Hamlets, and for the Kent and Surrey districts, were all in one week superseded, and a new commission, consisting of the following, were nominated for *all* the districts, on the 6th ult.:—Lord Ebrington, Lord Ashley, Dr. Buckland, Mr. Hume, M.P., Hon. F. Byng, Dr. Arnott, Dr. S. Smith, Mr. R. A. Slaney, M.P., Sir J. Clark, Rev. W. Stone, Professor Owen, Sir H. De La Beche, Mr. J. Bidwell, Mr. J. Bullar, Mr. W. J. Broderip, Mr. R. L. Jones, Mr. J. Leslie, and Mr. E. Chadwick.—Mr. L. C. Hertslet, Clerk of the Westminster division, and Mr. Staples, Clerk of the Holborn and Finsbury division, were appointed clerks of those districts provisionally; and Messrs. Phillips and Roe were appointed surveyors provisionally, and Mr. Austin consulting-surveyor.

Brussels Lace.—M. Blanchet gave an account of the serious consequences resulting from the process of whitening Brussels lace to the persons employed in it. In this process the carbonate of lead is used; and a large portion of it is carried into the atmosphere, where it is inhaled, and thus produces a serious affection of the intestines. It is also very injurious to the sight and to the hearing.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM NOVEMBER 30, TO DECEMBER 22, 1847.

Six Months allowed for Enrolment, unless otherwise expressed.

William Betts and George William Jacob, of Wharf-road, City-road, for "Improvements in the manufacture of capsules, and in the application of certain descriptions of surfaces."—Sealed Nov. 30.

William Eaton, of Camberwell, engineer, for "Improvements in machinery for twisting cotton or other fibrous substances."—Dec. 1.

Gustavus Moenck, of Wellington-street, Strand, D.LL., for "certain Improvements in clocks and time-keepers."—Dec. 1.

Thomas Chandler, of Stockton, Wiltshire, for "Improvements in machinery for applying liquid manure."—Dec. 1.

Frederick William Mowbray, of Leicester, paper dealer, for "Improvements in machinery for the manufacture of looped fabrics."—Dec. 1.

Samuel Newington, of Frant, Sussex, M.D., for "Improvements in dibbling or sowing seeds."—Sealed Dec. 7.

John Scoffern, of Upper Holloway, M.B., for "Improvements in the manufacture and refining of sugar."—Dec. 7.

John Britten, of Birmingham, machinist, for "certain Improvements in apparatus for cooking, preparing, and containing human food and drinks, and in opening and closing oven doors, parts of which improvements are applicable to other similar purposes."—Dec. 7.

James Smith Torrop, of Edinburgh, newspaper proprietor, for "Improved machinery for time signals."—Dec. 7.

William Dakin, of 1, St. Paul's Church-yard, for "Improvements in cleaning and washing coffee, in the apparatus and machinery to be used therein, and also in the apparatus for making infusions and decoctions of coffee." (Communication.)—Dec. 7.

James Sweetman Eiffe, Esq., of 48, Lombard-street, City, for "Improvements in the manufacture of astronomical and other clocks, chronometers, and watches."—Dec. 7.

John Hackett, of Leicester, for "Improvements in the manufacture of pill-boxes."—Dec. 7.

David William Wire, of 9, St. Swithin's-lane, London, gentleman, for "an Improved manufacture of candles and other like articles used for affording lights." (A communication.)—Dec. 15.

Henry Winter, of Webridge-gardens, Bark-place, Bayswater, Middlesex, for "Improvements in the manufacture of rope, cord, line, and twine." (A communication.)—Dec. 15.

George Ambroise Michant, of Epieds, France, but now of New Bond-street, Middlesex, gentleman, for "Improvements in the production and application of heat, and in the manufacture of coke."—Dec. 15.

William Maltby, of Tredegar-square, Mile-end, gentleman, and Thomas Webb, of Mare-street, Hackney, gentleman, for "certain Improvements in the manufacture of spirits from grain or other saccharine matters, and in the apparatus to be used therein."—Dec. 15.

William Westbrooke Squires, of 3, Rue Chaveau la Garde, Paris, M.D., for a mode or modes of producing a vacuum, which mode or modes may be applied to pneumatic, hydraulic, and hydrostatic apparatus, and to machinery for obtaining motive power."—Dec. 18.

Richard Wrighton, of Lower Brook-street, Grosvenor-square, Middlesex, for "Improvements in apparatus to be applied to railway carriages and engines."—Dec. 22.

Charles Andre Felix Rochas, of Paris, for "certain Improvements in treating zinc ores, and in manufacturing oxide of zinc."—Dec. 22.

Pierre Augustus Puls, gentleman, of Paris, for "Improvements in apparatus for raising and lowering heavy bodies in mines." (Communication.)—Dec. 22.

Henry F. Baker, of Boston, United States of America, for "a certain new and useful improvement in steam-boiler furnaces."—Dec. 22.

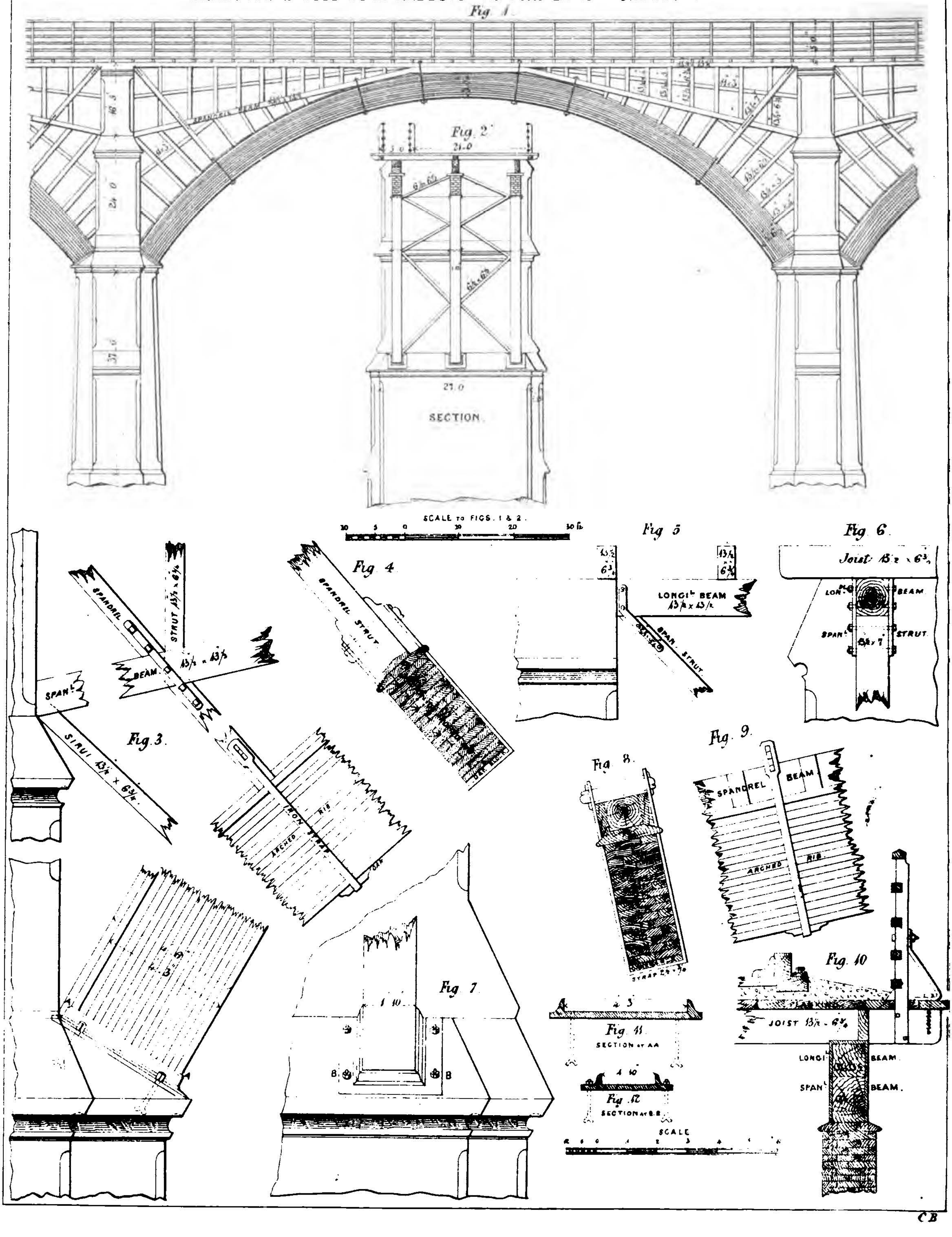
Richard Baird, of Dundee, Scotland, for "A new or improved method of communication between the guards, engine-drivers, and other servants in charge of trains of carriages and waggons on railways, and also between the passengers and engine-drivers, and other servants in charge of such trains."—Dec. 22.

Robert Stamp, of Chelsea, Middlesex, hatter, for "Improvements in the manufacture of fabrics to be used for covering hats, caps, and bonnets, which fabrics may be used for other articles of wearing apparel."—Dec. 22.

Charles William Siemens, of Manchester, engineer, for "Improvements in engines to be worked by steam and other fluids."—Dec. 22.

ARCHED TIMBER VIADUCTS.

WILLINGTON & OUSE BURN VIADUCTS · NEWCASTLE & Nh SHIELDS RAILWAY.



ARCHED TIMBER VIADUCTS.

(With Engravings, Plates III. and IV.)

(From papers read at the Institution of Civil Engineers.)

The Arched Timber Viaducts on the Newcastle and North Shields Railway, erected by Messrs. JOHN *and* BENJAMIN GREEN, *of Newcastle-upon-Tyne.*

In the formation of the numerous railways which have been completed within the last few years, perhaps that which has demanded the greatest exertion of skill, judgment, and varied ingenuity, is the construction of the bridges and viaducts, whether of stone, brick, iron, or timber. The excavation of a quantity of earth, or cutting through a hill to fill up an adjacent hollow to the required level, is in most cases a work of little more than manual labour, unless some unforeseen extraordinary difficulties occur in the strata, which may require energy and promptitude in adopting such measures as will overcome them in the most effectual and least expensive manner. But when rivers are to be spanned and ravines to be crossed, where there exist uncertain and variable beds, and, in many instances, in the vicinity of towns and populous districts, where houses, manufactories, and other buildings are on the immediate spot, the space required for filling up such ravines with a mound, (the base extending far on each side, beyond what is required for the width of the railway) would, by the consequent destruction of property, often involve such ruinous expenses, as to render the adoption of that method impracticable. Recourse must then be had to other and more scientific means, in the erection of bridges or viaducts, with piers occupying a small superficial area, built up to carry the necessary superstructure, and adapted to the locality in which they are placed. Various considerations are involved in fixing on a certain plan: yet the cost is that of the utmost importance, and invariably presents itself first in all great works of the kind. It will not be denied, therefore, that the great desideratum for the engineer, is the adoption of such means as will fully answer the purposes and the ends at which he aims, and to effect this without a waste of any kind of material; for every thing that is not fairly and usefully employed in adding to the stability and strength of an erection, can only be considered as superfluous and injurious matter; and fitness and a skilful disposition of parts, combined with correctness of design, may be said to form the great merit of all structures.

The cost of the construction of viaducts and bridges for railways generally forms so important an item in the gross amount of the cost of a railway, that the engineer is led to devise new means of completing his works in such a manner, as to possess stability and durability, without plunging his employers into unnecessary expenses.

Stone has been generally applied as the best material for bridges; in many cases, however, it cannot be used throughout, and in large arches, where the heights are too low for the spans, cast-iron is frequently adopted, and more particularly in forming trusses of various kinds, when the under side as well as the upper side of the platform is required to be horizontal, or nearly so, as in the case of a railway and turnpike-road crossing each other, and only leaving space enough between the surface of each to allow of the free passage of carriages; but the cost and weight of these bridges is generally equal to that of stone. A wood superstructure, however, effects much in this respect; provided a durable mode of construction is adopted; for the cheapness and strength of the material itself being so great, in proportion to its bulk and weight, the piers of a bridge or viaduct can be considerably lightened, and much less material be used in their formation than when the superstructure is to be of stone or iron.

Almost all the wooden bridges that have heretofore been executed in this country are constructed with straight timbers, trussed and framed like the ordinary forms of roofing. On account of the shrinking, from the number of joggles, and the weight of the work itself, the roadway sinks, and the framing generally becomes bent or crippled, often to an alarming extent; besides, such a system could never be carried beyond a certain extent, as the spans of such framing must be limited to what is usually practised in roofing.

A new system of building timber bridges, composed of layers of deals 3 inches in thickness, turned over a centre, into the form of arched ribs, has been introduced and applied extensively, in Northumberland and Durham, and in Scotland, by Messrs. John and Benjamin Green, of Newcastle-upon-Tyne.

This mode of constructing the laminated deal arch suggested itself to Mr. Green in 1827-8, when he was engaged in designing the bridge for crossing the river Tyne, at Scotswood: where the depth of water, its rapidity during floods, and the uncertainty of the foundations, would have rendered the construction of a number of piers, in the current, a very expensive operation, and Mr. Green was therefore induced to recommend to the company the chain bridge which is now thrown across the Tyne at that place, as being the cheapest durable structure, and possessing advantages over every other kind in such a situation.

The subject of wooden arches continued to engage Mr. Green's attention, and for his own satisfaction, he had a model made of an arch 120 feet span, at a scale of one-twelfth of the real size, which so satisfied him as to the advantages and safety of that mode of construction, that in 1834, when the Newcastle and Carlisle Railway Company offered a premium for the best plan of a railway bridge, for crossing the river Tyne, above Scotswood, Mr. Green submitted his model and design in competition, when they were approved of and selected by the directors, and obtained the premium.

This bridge was to consist of five segmental wood arches, each having two ribs of 120 feet span, which were to be erected upon timber piers of piles and framings, with stone abutments. The line of railway could not allow a greater elevation than 21 feet above high-water level, and the platform was in consequence suspended with iron rods between the springing of the wood arch and the crown; the roadway was therefore partly suspended from and partly supported by the ribs.

In 1833 Messrs. Green were concerned in projecting a railway from Newcastle to North Shields; and afterwards being employed by the Company for the bridges on that line, where, from the magnitude of two of them and the number that occur, the cost was a very important consideration, they were induced to recommend this plan of the laminated timber arch. Having made designs and carefully studied the details, these bridges were commenced in 1837; one at the Ouse Burn in the eastern suburb of Newcastle, and the other at Willington, about four miles further on the railway.

The OUSE BURN VIADUCT is 918 feet in length, and 108 feet in height from the bed of the burn; it has five timber arches of three ribs each; three of the arches are 116 feet span, and two 114 feet span; there are two stone arches of 40 feet span at both ends of the bridge, which were introduced to give length to the abutments, so as to prevent the mounds endangering them, by coming too close upon the steep banks of the ravine. There are five piers built of drafted and broached ashlar masonry, from the foundations to the full height, with spaces in the middle, leaving an average thickness of 5 feet of ashlar work; all the spaces are filled in with rubble masonry, made solid by grouting. On the sides of each pier are buttresses projecting 2 feet 11 inches, and diminishing with off-sets up to the roadway.

The greatest thickness of the piers at the springing is 15 feet; that of the highest pier at the foundation is 20 feet 3 inches, and at the top, immediately underneath the platform, it is 6 feet 6 inches thick; its width, including the buttresses, is 33 feet 10 inches above the footings, and 26 feet across the last or highest off-set underneath the roadway.

The springing for the arched ribs is 40 feet down the piers, where large off-sets are formed with the inner splays or slopes, radiating from the centre. On these springing stones, cast-iron flanged plates or sockets, each weighing 15 cwt. for each rib, are bedded with oakum, into spaces which are cut 2 inches deep in the masonry, and secured with wrought-iron bolts run with lead, fastened down with nuts and screws on the outer surface; the bolts are $1\frac{1}{4}$ inch diameter, and 1 foot 9 inches long. The ends of the ribs are inserted into these iron sockets as a springing and are well caulked.

The two middle piers are built upon piles driven into the clay, to an average depth of 35 feet below the surface, and the foundations generally required great attention, for it was found that considerable excavations of old pit workings had been made around and immediately under the line of the bridge. From the extreme eastern pier, a coal seam had been worked out, extending beyond the east abutment; and in digging for the west pier, a pit shaft was discovered in the centre of the area of the foundation. It was fortunate that it was not so near as to endanger the stability of the pier, and that the construction had not proceeded without its being observed. This shaft had been worked to a depth of 70 feet, and in order to render the structure secure, both it and the seam on the other side of the ravine were built up with well grouted rubble masonry. All the timber used in the carpentry was of the best quality from the Baltic, and the whole of it was subjected to the process of Kyan's patent.

The arched ribs are shown in Plate III., figs. 1 and 2; and in detail, figs. 3 to 12. The spans of 116 feet, have a versed sine of 33 feet, the radius being 68 feet. The ribs are constructed of Dantzic deck deals, 11 inches wide by 3 inches thick, dressed and cut to lengths of from 20 feet to 46 feet. The first course of the rib is two deals in width, bent over the centre, and the next is one whole and two half deals, and so on alternately until the whole rib is formed; each rib consists of fourteen deals in thickness, exclusive of the weathering or capping on the top; the ends of the deals throughout are butted against each other, and arranged so that no two of the radiating joints may come together. A layer of strong brown paper dipped in boiling tar, is put between all the joints to bed them and to exclude the wet. The whole of the deals are well fixed together with the best 1½ inch oak trenails placed 4 feet apart, and each trenail is of a sufficient length to go through three thicknesses of the deals. The ends of the deals are all inserted into the cast-iron plates already described, bedded in patent felt and tar, and well caulked.

Diagonal side braces 6½ inches by 6½ inches, (shown in fig. 2, Plate III.), are fixed between the ribs with wrought-iron bars 1½ inch diameter, at intervals of about 29 feet apart, to bind and connect the whole together. From the ribs, a series of radiating and horizontal struts, are carried up in the manner shown in the engravings; the ends of all the struts are double tenoned into proper mortices cut to receive them, in the timbers and ribs. A spandril beam 13½ inches square, (figs. 3, 4, 8, and 9, Plate III.,) is placed about the middle of the spandril, inclining upwards to the crown of the arch, and butting against a horizontal piece of the same dimensions at the top. The struts below this beam radiate to the centre, and those above are perpendicular to the roadway. One of the radiating struts in each spandril, called in the drawings the spandril strut, (figs. 5 and 6, Plate III.,) is continued on from the rib up to the longitudinal beams, and is firmly connected by iron straps and bolts to them and the spandril beams, and the former are then secured down to the masonry with iron bolts, which run 8 feet into the ashlar work. In considering this geometrical arrangement of strutting in the spandrils, it will be evident how much rigidity is produced: a weight coming upon one haunch of the arch is resisted on the opposite haunch, by the spandril strutting, and especially by the main strut, connected as it is with the weight of masonry laid hold of by the bolts, from the main longitudinal beam.

The longitudinal beams, 13½ inches square, are fixed and laid the full length of the structure, to the gradient of the railway, above which the joists, 13½ inches by 6¾ inches, are laid 4 feet apart from centre to centre, and spiked down upon them. The ends of all the joists are rounded, and project about 2 feet 6 inches over the longitudinal beams, fig. 10, and the whole are then covered with planking, 11 inches by 3 inches, laid longitudinally, and properly spiked down and caulked; this platform is then covered with a composition of boiling tar and lime, mixed with gravel whilst it is being laid on; thus forming a coating completely impervious to the wet. At the meeting of the longitudinal beam and the crown piece, an iron strap is bound over them and the longitudinal beam, and it is then run through the rib, and screwed up underneath it. Another strap is put round the rib and the spandril beam, about 12 feet further down on each side, and another at each of the spandril struts. An open railing, 5 feet high, is fixed alongside each side of the bridge, the upright standards are 8 feet apart, fixed to every alternate joist, and five horizontal rails, halved and spiked to them, run the full length.

The total width of the Ouse Burn Viaduct, measuring within the railing, is 26 feet, from which a footpath is taken, 5 feet wide, separated from the railway by a line of railing on the south side, as shown in fig. 2.

In constructing both the masonry and timber work of this viaduct, the scaffolding and the centering used were very light and simple. For the former, a temporary railway, 35 feet high, raised upon upright bearers, struts, &c., was laid the full length, on each side of the intended structure; and was afterwards raised, as the building proceeded, to within a few feet of the height of the finished platform. On this railway temporary cranes were placed, spanning from one rail to the other, connected at the top with beams of timber, and fitted up with proper winches, blocks, chains, &c. &c.; these cranes were generally worked by four men. The centering for turning the ribs and building all the timber work was exceedingly light; it was composed merely of three ribs, weighing about 18 cwt. each, or 2 tons 14 cwt. for each rib. A whole centre could be removed in a day from one arch, and fixed in its place for another arch, by about twenty men, employing the travelling cranes.

The WILLINGTON VIADUCT is precisely the same in construction and design as that at the Ouse Burn; but differs in its dimensions, and although it is not so high, it is longer, and has two more timber arches of greater span. The total length is 1050 feet, and the height is 82 feet. There are seven timber arches and six stone piers, with two stone abutments; five of the arches are 120 feet span each, and two 115 feet span each; the width between the railing on each side is 21 feet, being just sufficient for the double line of railway, as there is no footpath upon this viaduct. Two of the piers are built upon piles 36 feet long, at a depth of about 50 feet below the surface, as there is a great extent of alluvial deposit immediately on the site, which is frequently covered, during high tides or floods, by the river Tyne flowing up at the small burn.

Both these viaducts span over numerous houses and manufactories.

The method of building the viaduct at Willington was somewhat different from that adopted at the Ouse Burn, and perhaps not so unique; inasmuch as there were no travelling cranes or temporary railway, and the removal of the centres was attended with greater labour, for while at the Ouse Burn the removal of a centre occupied twenty men, with the cranes, only one day, the same work employed twenty men for ten days at Willington. The masonry of each pier was set with a fixed or jib crane, of a sufficient height to hoist all the stones, having the usual counterbalance at the opposite end of the horizontal beam.

In this system of timber bridge building, the straight trussing in the main principle of support, is dispensed with, for the spandril framing should not be looked upon as partaking of that character; it is merely a continuation of the wood-work, to convey the weight coming upon the roadway, on to the simple curved rib, and all timbers in a state of tension are avoided, for when a weight comes upon the roadway, the whole of the structure undergoes compression.

It is not meant to advocate timber bridges on this or any principle in preference to stone, or other more durable material; but it will not be denied, that the great saving of capital in the first instance is a very important argument in favour of their adoption.

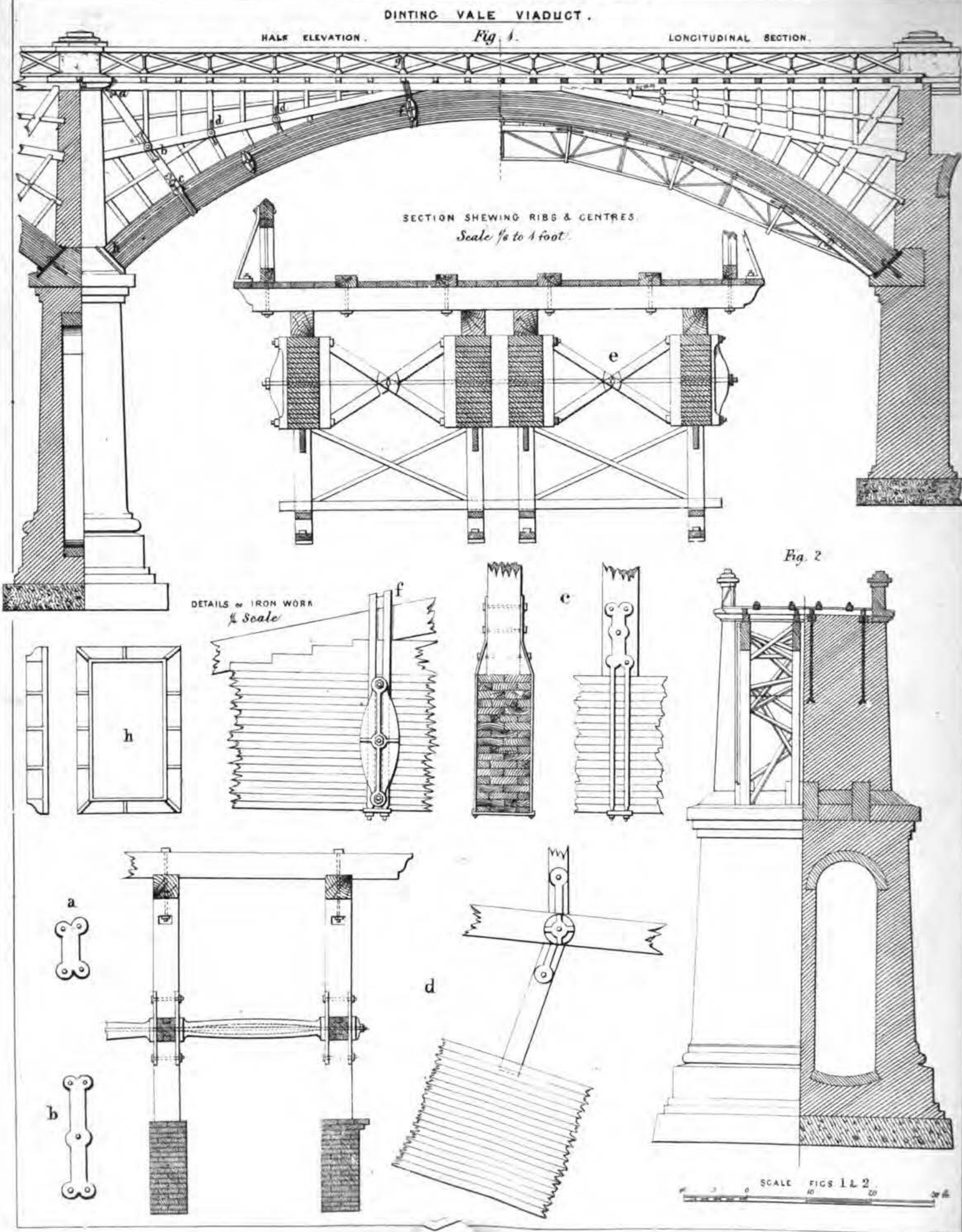
The actual cost of the Ouse Burn Viaduct, including all contingencies and extras, was:—for the masonry, 17,235*l.*; for the carpentry, 7,265*l.*; making together, 24,500*l.*

The total cost of the Willington Viaduct, was:—masonry, 13,153*l.*; carpentry, 10,349*l.*; together, 23,502*l.*

The piers, Mr. Green observes, are stronger than necessary for the weight of the superstructure, for the directors of the Newcastle and North Shields Railway not only being sceptical as to the safety of this novel mode of construction, but having a desire to finish all the bridges on the line with stone arches, wished the masonry to be made of such solidity and bulk as to bear stone arches if required, and the piers and abutments were, therefore, built accordingly. The additional cost for building stone arches, however, on a fair calculation, was found to amount to 9,000*l.* for the Ouse Burn Viaduct, which would have made a total of 33,500*l.* The centering would have cost at least 3,000*l.* for each viaduct, so that at a moderate calculation the actual saving of capital is upwards of 10,000*l.*

Messrs. Green have just completed a large viaduct, on precisely the same principle as those of the Ouse Burn and Willington Dean, for his grace the Duke of Buccleuch, across the South Esk at Dalkeith, in connexion with the Edinburgh and Dalkeith Railway, and for the transit of coal from the collieries of his grace in that neighbourhood; it has only a single line of railway and a footpath. The total length of this work is 830 feet, the height is 87 feet to the platform, and the width across between the railing is 14 feet. It has seven arches, five of 120 feet, and two of 110 feet span each, with a versed sine of 30 feet. There are only two ribs, 8 feet 4 inches apart, in each arch, and of a deal and a half (1 foot 4 inches) in width, and ten deals (2 feet 7 inches) in depth. The longitudinal beams are half balks of timber, 13½ inches by 6¾ inches. There are two stone abutments, each 40 feet long, and five stone piers. The largest pier is 91 feet high from the foundation, which is 5 feet below the surface. All the piers are 10 feet thick at the springing, 12 feet 10 inches wide, and 5 feet 4 inches thick at the top, underneath the roadway. The total cost was:—masonry, 3,617*l.*; carpentry, 3,358*l.*; together, 6,975*l.*, which is a very small amount for a work of such magnitude.

ARCHED TIMBER VIADUCTS.



C. B.

The great height and length of this bridge, and the extreme lightness of its construction, render it an imposing object, spanning a beautiful and thickly wooded ravine near Dalkeith Palace, with the river Esk streaming through it, and appearing as a mere line of water in passing under the centre arch, which is the largest and highest.

The system of arching with planks, may be carried to almost any extent, and in Messrs. Green's design for the proposed bridge across the Tyne, to connect the towns of Newcastle and Gateshead, at a high level, the largest arch over the middle part of the river was intended to have been 280 feet span, with a versed sine of 70 feet, the total length of the bridge as designed was 1,220 feet, and the height 110 feet.

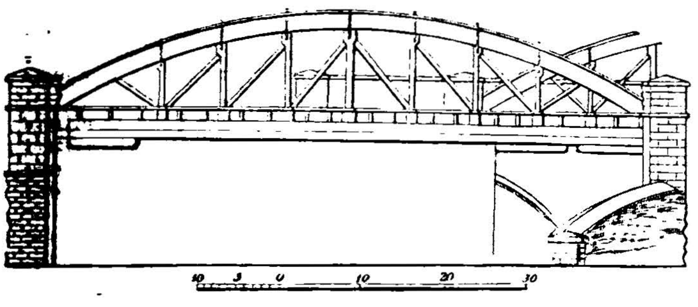


Fig. 1.

The annexed wood engravings show an oblique bridge on the Newcastle and North Shields Railway, crossing the Shields road, at Walker. The angle of the skew is 25°, and the span is 71 feet. Fig. 1 is an external elevation of one of the ribs and the piers, and

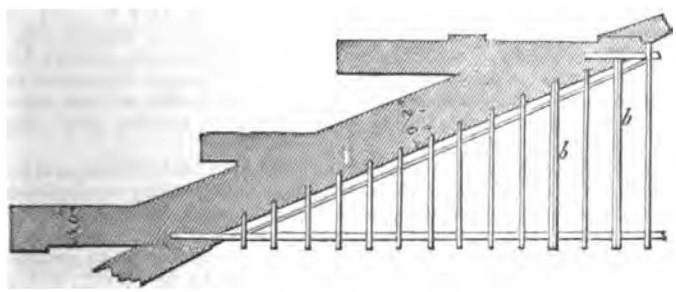


Fig. 2.

fig. 2, a plan of the joisting and piers. The joists of the platform rest upon the longitudinal beams, which are suspended by queen posts and iron straps, from two arched ribs, one on each side of the railway, and stiffened by struts and braces. The ribs are formed of deals 11 inches by 3 inches, dressed one deal and a half for the width of the rib, and nine deals in depth, as shown in figs. 3 and 4.

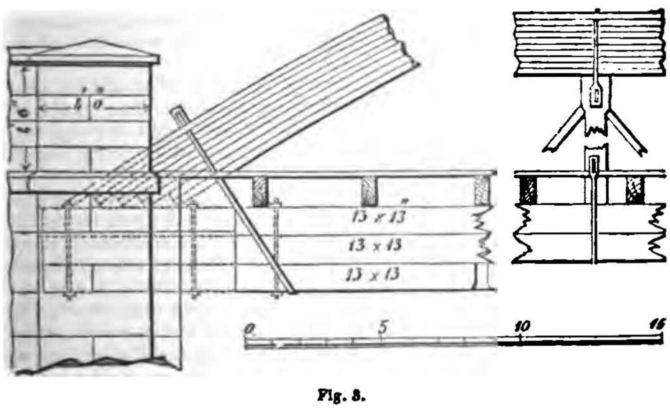
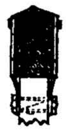


Fig. 3.

They spring from cast-iron sockets, bolted to the ends of the longitudinal beams, on which they abut. An iron strap is also keyed over each foot of the ribs, for additional security. The width for the railway on the bridge is 21 feet 6 inches. In the centre, at intervals of about 7 feet, the platform is strengthened by trusses, which are marked *b b*, fig. 2, and constructed in the manner shown in fig. 4, with wrought-iron bars keyed at the ends of the beams, and coming underneath, having three iron bearers in the full length. The cost of this bridge was about 1,300*l*.



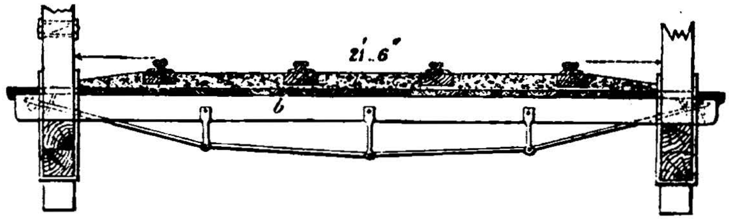


Fig. 4.

The Dintino Vale Viaduct, *on the line of the Sheffield and Manchester Railway.* By Alfred Stanistreet Jee, M. Inst. C.E

(With an Engraving, Plate IV.)

This viaduct consists of sixteen arches, five of which are of timber and eleven of brick, faced with stone quoins. The whole of the large piers, wings, outside spandrils and parapets, are of ashlar stone, of excellent quality, from the quarries in the neighbourhood. The foundations of some of the piers are laid upon the hard shale, and of others upon a bed of wet sand of considerable depth; in the latter cases masses of concrete were formed to receive the masonry. Several of the smaller piers are founded upon the marl; also with beds of concrete beneath them. The piers for the large arches are built solid, up to the surface of the ground, and above that level they are hollow, nearly up to the impost; the hollow portion having an inverted arch at the bottom, and being also arched over at the top. The portion above the impost in the large piers is solid to the top, (see fig. 3.) The smaller piers are cased with ashlar on the outside, and are filled in solid with good flat-bedded rubble, well grouted, and with through stones at intervals of 6 feet horizontally in each course.

The smaller semicircular arches of brick, at each end of the viaduct, are 50 feet in the span and 3 feet in thickness, with stone quoins, and are built in a curve of 40 chains radius. The face of each pier is parallel to that of the next, the piers themselves being wedge-shaped, on account of the curve. The abutments between the large and the small arches are hollow and are arched over in the interior, to carry the roadway. The abutments and wings at each end of the viaduct, are also hollow, being composed of longitudinal and cross walls, flagged over on the top. They are surrounded on the outside by the slope of the embankment, the material of which being clay, is kept out by a wall at the ends.

The five large arches are each 125 feet span and 25 feet versed sine, of the best Memel timber, the whole of which has been immersed in a solution of the sulphate of copper, according to Dr. Margary's patent, for the prevention of decay. There are four main ribs in each arch, composed of planking 3 inches thick, laid longitudinally, with a layer of brown paper and tar between the planks, which are fastened together with oak trenails at intervals of 4 feet. These ribs are 4 feet 6 inches deep, and 18 inches wide, and are firmly stayed by diagonal and cross braces, screwed up tight, by means of wrought-iron rods, 2 inches in diameter, passing through and secured by nuts on the outside. The uprights and diagonals in the spandrils are also stayed by iron rods, and are morticed into the longitudinal beams which carry the cross joisting. These longitudinal beams are fastened down upon the piers by iron bolts, let 12 feet into the solid stonework, to resist any tendency of the arch to rise in the haunches, when the weight of a train comes upon the centre. The cross joists are placed 5 feet apart, from centre to centre, and are bolted to the longitudinal beams underneath. Upon them is placed longitudinally a half balk of timber, to which the rails and chairs are fastened, and also a guard rail to prevent the carriages getting off the road. The whole is covered over with planking 3 inches thick, and is coated with a mixture of lime, ashes, and sharp sand, which has set hard and does not crack.

The centering used for turning of the arches is of iron, of light construction, and is shown in fig. 1.

The total length of the viaduct is 484 yards, and its greatest height from the brook-course to the rails, is about 125 feet. The roadway is level throughout. It was commenced early in 1843, and was opened for traffic on the 8th of August, 1844. Messrs. Buxton and Clarke, of Sheffield, were the contractors, and great credit is due to them for the very excellent manner in which they have completed the work.

The area of the section of the valley crossed, between the level of the rails and the ground, is 13,068 square yards, which gives an average cost of about 2*l.* 14*s.* per superficial yard, and as the viaduct is 8 yards wide, the cost per cubic yard is 6*s.* 9*d.*

The following is a detailed account of the cost of construction of the Dinting Vale Viaduct, on the line of the Sheffield and Manchester Railway.

			£	s.	d.
7,881	cubic yards, excavating foundations	7*d.*	229	17	3
2,000	,, concrete	3*s.* 6*d.*	350	0	0
342,155	cubic feet of ashlar in the abutments and piers	1*s.* 1*d.*	18,532	7	11
44,024	cubic feet of tooled ashlar ..	1*s.* 3*d.*	2,761	10	0
829	,, cornice	1*s.* 6*d.*	62	3	6
8,212	,, parapet walls ..	1*s.* 1*d.*	444	16	4
6,875	,, flagging over spandrils	10*d.*	286	9	2
2,574	cubic yards of coursed rubble, in the small piers	10*s.*	1,287	0	0
	Puddling the small arches ..		37	13	0
2,641	cubic yards of brickwork in the arches	15*s.*	1,980	15	0
40,476½	cubic feet of Memel timber ..	3*s.*	6,071	9	6
18,285	superficial feet of planking in the roadway	8*d.*	609	11	8
	Centering	..	600	0	0
Tons. Cwt. Qrs.					
32 4 1	wrought-iron	£21	676	5	3
31 2 0	cast-iron	£8	252	0	0
73,260	superficial feet of brown paper and tar	½*d.*	152	4	0
2,031	superficial yards of concrete on the roadway	1*s.* 6*d.*	152	6	0
	Patent felt	..	3	15	0
	Laying the permanent road ..	..	408	6	6
	Diverting the mill goit ..	..	110	16	8
	Interest and maintenance for 12 months	..	240	19	8
	Total cost		£35,250	6	5

THE RIVAL PALACES,

or, Blore's and Vanvitelli's.

By Candidus.

Neither Mr. Sharp himself nor any one else will be at all surprised at *my* taking some notice of the oversight imputed by him to those who have spoken of Buckingham Palace, for not discovering that it is "only a reduced copy of the Palace at Caserta." Willing as I am to accept the compliment of "lynx-eyed," I think that in this instance it rather belongs to him, though at the same time I fancy his *sharp*-sightedness has overshot the mark, and made that kind of discovery which is called finding out a mare's nest. What appears to Mr. Sharp to be such perfect similarity of design between the two buildings, that all the faults or merits of Mr. Blore's fairly belong to Vanvitelli, completely vanishes upon a critical examination and estimate of them, nothing remaining but that general or generic resemblance of forms and features which they possess in common with many other buildings in the same style. Those who talk merely at random might perhaps liken Buckingham Palace to that at Caserta, for much stranger resemblances have been fancied ere now,—one traveller having likened the palace of Charles V. in the Alhambra, to Jones's Whitehall; and another, the great temple at Balbec to St. Paul's, Covent-garden! But that an architect should be more struck by the resemblance, such as it is, than by the prodigious difference between the two buildings in question, is quite astonishing.

Let us inquire to what the resemblance amounts:—to nothing more than the general disposition of parts, both vertically and horizontally, which surely is not sufficient to constitute such similarity of design or character as to justify our calling the one a copy at all, much less "only" a reduced copy of the other. If it does, we should be warranted in setting down all the porticoes ever erected as only so many verbatim transcripts of one original; or we might call—as perhaps Mr. Sharp does—the two terraces at Carlton-gardens a copy of the Garde-meuble in the Place de la Concorde. In fact, it requires Fluellen's ingenuity in arguing to convict Mr. Blore of being, I will not say Vanvitelli's ape, but his Dromio. "There is a river in Macedon," says the Welshman, "and there is also moreover a river at Monmouth;—and there is salmons in both." Even were Mr. Blore's elevation a mere reduced draught of the other, as far as what actual resemblance there is between them extends, as a copy it could be received only as an exceedingly maimed and imperfect one, some of the most striking parts of the original being altogether omitted. One exceedingly important accompaniment to the edifice at Caserta, and which gives it an air of completeness and consistently-kept-up stateliness in regard to *emplacement*, greatly surpassing that of any other royal palace in Europe, is the spacious oval piazza in front of it on its south side, where it forms an expanding amphitheatrical area, somewhat after the manner of the piazza before St. Peter's at Rome. Many other royal residences, on the contrary, are so disadvantageously located, as to have an air of meanness *about* them in spite of their own grandeur.

One point, then, of the resemblance contended for is utterly wanting, since Mr. Blore's building has no architectural precinct or properly defined enclosure before it, but is made to stand immediately in the Park, and moreover stands out very awkwardly and abruptly from Nash's building behind, from which it appears quite distinct, except that it is tacked to it; so that instead of making the entire mass look larger than before, it causes it to have a singularly confused and huddled-up appearance. Even taking the mere elevation of the front alone, there is a prodigious difference as to outline, the angles of the building at Caserta being carried up much loftier than the general mass, by the addition of a second order, comprising two stories, and making the entire height there not less than *one hundred and ninety* English feet. My calculation is from the scale given in the large work containing plans, &c., of the palace, entitled "Dichiarazone dei Disegni del Reale Palazzo di Caserta, &c.," and which, strange to say, is not mentioned by either Milizia or Quatremère de Quincy. In the "Conversations-Lexicon für Bildende Kunst," which professes to give account of individual buildings of note, the Palace of Caserta obtains only three lines!—one of which is to tell us that there is a picture by Mengs in the chapel.—With regard to Mr. Sharp's statement as to the length, there seems to be some miscalculation or else misprint, since 918 palms (taking the palm at 10⅓ inches) give only 790 feet.

Now that so much fault has been found with his building, and no merit whatever discerned in it, Mr. Blore may possibly be disposed to acquiesce in the charge of plagiarism brought against him, in order to transfer all blame from himself to Vanvitelli. If he has copied or borrowed, he has at least, it may be said, gone to a noble model—one which is especially singled out by Mr. Gwilt, in his "Encyclopædia of Architecture," as the most complete example of a royal palace. So far, however, from reconciling us to Mr. Blore's work, by what may be thought to afford sufficient precedent for one or two objectionable points, Caserta—any comparison with or even mention of it—is likely to put us more out of conceit with it than ever. By diminishing the scale so very greatly, Mr. Blore has exaggerated the defects and entirely missed all the merits of his supposed original, transmuting grandiosity into insignificance and triviality. In the mere design of Caserta, there is little to excite particular admiration: it is one of those things of which a "reduced copy," however accurate, can no more convey the actual impression it makes than a life-sized copy of it can that of an enormous colossal figure.

Caserta is especially distinguished by a union of qualities that rarely meet together in other edifices of the same class—namely, emphatic vastness of mass and uniformity of design throughout. Its mass is such, that were the several ranges of building which compose its exterior, together with those that separate the inner courts, placed beside each other on a single line, similar to the plan of the Tuilleries, they would form a façade full three times the length of that of the last-mentioned palace, or considerably more than three thousand feet in extent. What enhances astonishment, although it adds nothing to the merit of the structure, is the extraordinary energy with which the works were carried on, the whole of the vast pile being completed in about half-a-dozen years; whereas many others, of far less magnitude, have either grown up piecemeal, or have occupied a long series of years; so as not to have been begun and terminated by the same architect.

From the way in which Mr. Sharp has expressed himself, it seems to be his opinion that—the similarity of design which he insists upon being admitted,—Blore's façade so fairly represents

Vanvitelli's (*i. e.* one of them), as to exhibit all its merits, notwithstanding that it exhibits qualities precisely the reverse. Yet, surely littleness and magnitude are very different in effect; or shall we say, that if he be similarly shaped and proportioned, a dwarf can give us a very satisfactory idea of a giant? Those who hold such doctrine, ought to show their consistency by taking a sixpence as a very satisfactory representative of, and equivalent to, a shilling. Hardly can I bring myself to believe that Mr. Blore had any idea of palming upon us a Tom Thumb Caserta, because, leaving plagiarism out of the question—and in architecture plagiarism has ceased to be any demerit or disgrace—he must have been perfectly aware that he must fall so greatly short of Vanvitelli's standard, that likeness in other respects would, if detected, only produce ridicule. No, what kind of likeness there is between the two designs is merely a coincidence, and for Mr. Blore rather an unfortunate one. Had it been intentional and "with malice prepense,"—had Mr. Blore really fancied that he could reproduce Caserta, he would no doubt have avowed the imitation, have made it a merit, and have crushed criticism in the bud, by proclaiming that he was about to give Buckingham Palace a façade "after" that of the noblest royal residence in Europe.*—In such cases, be it observed, the *after* generally means a long way *behind* the prototype; and the following comparison of the respective measurements of some of the parts of the two buildings will show that Vanvitelli's afforded no precedent for the *mesquinerie* of Mr. Blore's.

	ft.	in.		ft.	in.	
Caserta.						
Basement or ground floor, mezzanine,	47	4	high			
Gateways through ditto	16	6	wide;	36	2	high
Principal floor windows	6	10	wide;	14	0	high
Columns	49	0	high			
Buckingham Palace.						
Basement	26	0	high			
Gateways: centre one, ...	13	6	wide;	21	0	high
lesser ones, ...	10	0	wide;	18	0	high
Principal floor windows	4	6	wide;	11	0	high
Pilasters	34	0	high			

After all, had its elevation been ever so much better, Mr. Blore's building would still have been open to some of the strongest objections brought against it now, viz., that it seems to encroach upon the Park in such a very awkward manner, as to appear a more lumpish mass than it otherwise might do, and that blocking up all the rest of that side of the Palace, so far from improving the main edifice, it has frustrated that opportunity for improvement which previously existed, and which, since alteration to such extent was determined upon, ought to have been made the most of. As a range of building the new façade is scarcely more effective than the neighbouring barracks in the Birdcage Walk, to which it may in fact be likened quite as correctly as to Caserta; nor would that comparison be, though less flattering, quite so injurious as the other, inasmuch as it must then be admitted that, instead of there being any falling off, the model had been refined upon.

One defect in regard to position, now rendered very prominent by the building being brought so much forwarder into the Park, is that the Palace is not in the axis of the Park itself, but only of the Mall; whereas, were Mr. Blore's structure planted at the other extremity of the enclosure, on the site of the Horse Guards, it would there show infinitely better in every respect, and, with some slight corrections, might pass for a handsome piece of architecture. As it is, it is altogether out of place, out of character, and the reverse of satisfactory in effect; nor can I agree with Mr. Sharp that were Mr. Blore "to give the Palace a staircase resembling that at Caserta, the world would forgive him all the faults of his front;" because while those faults would be just as evident as ever, the public would have no opportunity of admiring the staircase. Besides which, it would require the architect to be the Bottle-Conjuror to get such a staircase into Buckingham Palace; and even could it be effected, it would reduce all the rest of the interior to utter insignificance.—One other remark, and I have done: for what will perhaps be considered lengthiness and loquacity I have no precedent in what Mr. Sharp's companion, Woods, says in his "Letters" of Caserta, for he dismisses it with little more than a bare mention of it,—with a degree of chilling indifference that does not say much for him either as an architect or a critic.

* Quatremere de Quincy says of Caserta: "Une plus grande conception de palais n'existe point en Europe."

ON THE LAP AND LEAD OF THE SLIDE VALVE.

(Concluded from page 17.)

The Lead and Lap.

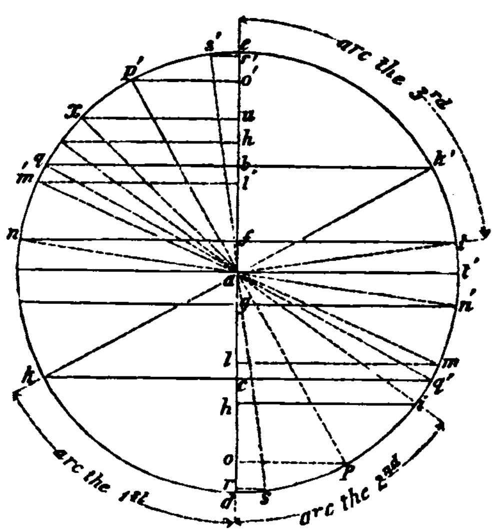
Having separately investigated the two cases of a slide having Lead without Lap, and Lap without Lead, we now proceed to consider the effect of both in combination, together with that of lap on the exhaustion side.

Demonstration.

Case 4.—When a Slide has Lap on both the Steam and Exhaustion sides, together with Lead.

Let $a\,b$, and $a\,c$, diagram 5, represent the double lap on the steam side; $a\,f$, and $a\,g$, the same on the exhaustion side; $b\,e$, and $c\,d$,

Diagram .



the steam ports; and the line $e\,d$ both the travel of the slide and stroke of the piston. Then, supposing $c\,h$ to represent the lead of the slide, $a\,i$ will be the position of the eccentric when that of the crank is $a\,e$; the slide occupying the position shown in fig. 10, and the piston being at the top of its downward stroke.

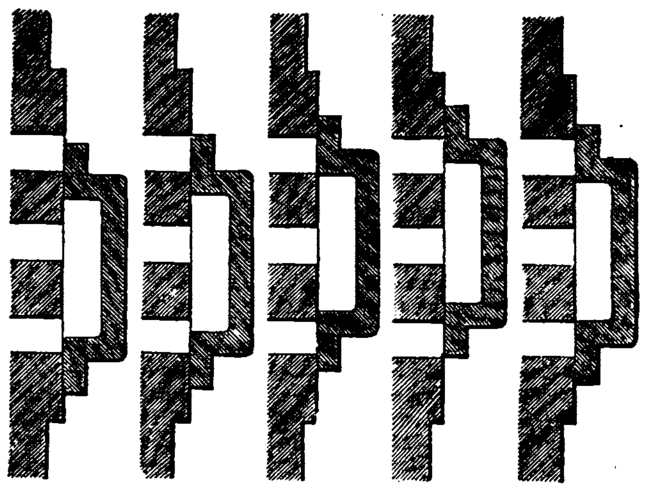


Fig. 10. Fig. 11. Fig. 12. Fig. 13. Fig. 14.

When the eccentric reaches the point k, the port $c\,d$ will be fully closed (as shown in fig. 11), and the piston will have descended to l, the arc $e\,m$ being equal to the arc $i\,k$. Again,—when the eccentric arrives at n, the slide being then brought into the position fig. 12, exhaustion commences from above the piston, which has descended to o; the arc $e\,m\,p$ being equal to the arc $i\,k\,n$. When the eccentric arrives at q, the port $b\,e$ begins to open for the admission of steam beneath the piston (see fig. 13), which has then descended to r; the arc $e\,m\,s$ being equal to the arc $i\,k\,q$. When the eccentric has reached the point i', opposite to i, the port $b\,e$ will be open to the extent of the lead $b\,h'$, equal to $c\,h$, and the piston will have completed its descent.

Steam continues to enter the port $b\,e$ during the ascent of the piston, until the eccentric reaches the point k', when the port $b\,e$ will be reclosed (fig. 13), the direction of the slide's motion being downward, and the piston having ascended to l'. Exhaustion ceases from above the piston when the eccentric reaches the point t, the piston being then at u, and the slide again in the position fig. 12. When the eccentric reaches the point n', opposite to n, exhaustion commences below the piston, the slide being then in the position fig. 14, and the piston at o'. Finally,—when the eccentric reaches the point q', and the crank the point s', opposite to s, steam begins to enter the port $c\,d$ for the return stroke, at the commencement of which the port $c\,d$ will be open to the extent of the lead $c\,h$; the crank and eccentric occupying their original positions, $a\,e$ and $a\,i$.

It is here shown that four distinct circumstances result from the use of a slide having lap on both sides of the port, with lead, during a single stroke of the piston. These are—

First: The cutting off the steam, for the purpose of expansion.

Second: The cessation of exhaustion on the exhaustion side.

Third: The commencement of exhaustion on the steam side.

Fourth: The re-admission of steam for the return stroke.

With regard to the first of these results, we found the steam port $c\,d$ closed, when the crank and eccentric had described the equal arcs $e\,m$, and $i\,d\,k$. Now, $c\,d$, the steam port, is the versed sine of $d\,k$; and $h\,d$, the steam port *minus the lead*, is the versed sine of $i\,d$. Hence,

RULE V.—*To find the point of the stroke at which steam will be cut off:*—

Divide the width of the steam port, and also that width minus the lead, by half the slide's travel, and call the quotients versed sines. Find their corresponding arcs, and call them arc the first, and arc the second, respectively. Then, if the sum of those arcs be less than 90 degrees, multiply the versed sine of their sum by half the stroke, in inches, and the product will be the distance of the piston from the *commencement* of its stroke, when the steam is cut off.

If the sum of arcs the first and second exceed 90 degrees, subtract it from 180 degrees; and the versed sine of the difference, multiplied by half the stroke, equals the distance of the piston from the *end* of its stroke, when the steam is cut off.

Example 8.—The stroke of a piston is 60 inches; the width of steam port 3 inches; lap on the steam side $2\frac{1}{2}$ inches; lap on the exhaust side $\frac{1}{8}$th inch; and lead $\frac{1}{2}$ inch: required the point of the stroke at which steam will be cut off.

Here $\dfrac{3}{3+2{\cdot}5} = {\cdot}5454 =$ versed sine of $62° 58'$ (arc the first);

and $\dfrac{3-{\cdot}5}{3+2{\cdot}5} = {\cdot}4545 =$ versed sine of $56° 57'$ (arc the second).

Then $62° 58' + 56° 57' = 119° 55'$; and $180° - 119° 55' = 60° 5' =$ arc of versed sine, ·5012. $\cdot5012 \times 30 = 15{\cdot}036$ inches = distance of the piston from the *end* of its stroke when the steam is cut off.

Exhaustion was shown to cease, during the ascent of the piston, when the eccentric had reached the point t, and the crank the point x; the crank having described the arc $d\,k\,x$, equal to $i'\,e\,t$ described by the eccentric.

Now $i'\,e$ is equal to *arc the second* (Rule V.); and $e\,t$ is equal to 90 degrees minus $t\,t'$, or the arc of versed sine $e\,f$; and $e\,f$ is half the slide's travel minus the lap on the exhaust side. Hence,

To find the point of the stroke at which exhaustion ceases:—

Divide half the slide's travel, minus the exhaustion lap, by half the travel, call the quotient versed sine, and add its corresponding arc, calling it arc the third, to arc the second. The versed sine of the difference between their sum and 180 degrees, multiplied by half the stroke, equals the distance of the piston from the end of its stroke when exhaustion ceases.

Example 9.—The several proportions being as in the preceding example,

Here $3 + 2{\cdot}5 = 5{\cdot}5 =$ half the slide's travel;

and $\dfrac{5{\cdot}5 - {\cdot}125}{5{\cdot}5} = {\cdot}9772 =$ versed sine of arc $88° 42' =$ (arc the third).

Then $88° 42' + 56° 57'$ (arc the second) $= 145° 39'$; and $180° - 145° 39' = 34° 21' =$ arc of versed sine, ·1743. $\cdot1743 \times 30 = 5{\cdot}229$ inches = the distance of the piston from the end of its stroke when exhaustion ceases.

Exhaustion was shown to commence from above the piston when the crank and eccentric had described the equal arcs $e\,k'\,p$, and $i\,d\,n$.

Now $i\,d\,n$ is equal to 180 degrees minus $n\,i'$; $n\,i'$ is equal to $n'\,i$; and $n'\,d$ is equal to arc the third. Hence,

To find the distance of the piston from the end of its stroke when exhaustion commences:—

Subtract arc the second from arc the third, and multiply the versed sine of their difference by half the stroke. The product will be the distance required.

Example 10.—The proportions being as in the two preceding examples.

Here $88° 42' - 56° 57' = 31° 45' =$ arc of versed sine, ·1496; and $\cdot1496 \times 30 = 4{\cdot}488$ inches, the distance required.

Steam was found to be re-admitted, for the return stroke, when the piston had reached the point r in its descent, the crank and eccentric having described the equal arcs $e\,k'\,s$, and $i\,d\,q$.

Now, $i\,d\,q$ is equal to 180 degrees minus $q\,i'$; i' being diametrically opposed to i. And $q\,i'$ is equal to $i\,q'$, the difference between arcs the first and second. Hence,

To find the distance of the piston from the end of its stroke when steam is re-admitted for the return stroke:—

Multiply the versed sine of the difference between arcs the first and second by half the stroke, and the product will be the distance required.

Example 11.—The proportions being as before.

Here $62° 58' - 56° 57' = 6° 1' =$ arc of versed sine ·0055.

Then $\cdot0055 \times 30 = {\cdot}165$ inches = the distance required.

RULE VI.—*To find the proportions of the steam lap and lead; the points of the stroke where steam is cut off, and re-admitted for the return stroke, being known:*—

When the steam is cut off before half-stroke, divide the portion of the stroke performed by the piston, by half the stroke, and call the quotient versed sine. Likewise, divide the distance of the piston from the end of its stroke when steam is re-admitted for the return stroke, by half the stroke, and call that quotient versed sine. Find their respective arcs, and also the versed sines of half their sum and half their difference. The width of the steam port in inches, divided by the versed sine of half their sum, equals half the travel of the slide; and half the travel, minus the width of port, equals the lap. The difference of the two versed sines last found, multiplied by half the travel of the slide, equals the lead.

When the steam is to be cut off after half-stroke, divide the distance of the piston from the end of its stroke by half the stroke; call the quotient versed sine, and subtract its corresponding arc from 180 degrees. Divide the distance the piston has to move when the steam is admitted for the return stroke, by half the stroke; call the quotient versed sine, and find its corresponding arc. Then proceed with the two arcs thus found, as in the former case.

Example 12.—The stroke of a piston is 60 inches; the width of steam port 3 inches; distance of the piston from the end of its stroke when steam is cut off 15·036 inches; and when steam is admitted for the return stroke ·165 inches: required the lap and lead.

Here $15{\cdot}036 \div 30 = {\cdot}5012 =$ versed sine of arc $60° 5'$;
and $180° - 60° 5' = 119° 55'$.

Then $\cdot165 \div 30 = {\cdot}0055 =$ versed sine of $6° 1'$.

$119° 55' + 6° 1' = 125° 56'$; $\quad 119° 55' - 6° 1' = 113° 54'$.

$\dfrac{125° 56'}{2} = 62° 58' =$ arc of versed sine ·5454;

$\dfrac{113° 54'}{2} = 56° 57' =$ arc of versed sine ·4545.

$3 \div {\cdot}5454 = 5{\cdot}5$ inches = half the slide's travel;
and $5{\cdot}5 - 3 = 2{\cdot}5 =$ lap.

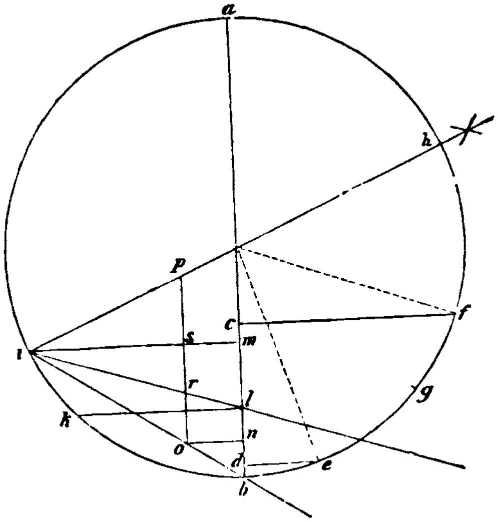
$\cdot5454 - {\cdot}4545 = {\cdot}0909$; and $\cdot0909 \times 5{\cdot}5 = {\cdot}5$ inches = lead.

To find the Lap and Lead by Construction.

The stroke of the piston; width of steam port; and distances of the piston from the end of its stroke when the steam is cut off, and when it is re-admitted for the return stroke, being known:

Let the circle (diagram 6) represent the crank's orbit, and its diameter *a b* the stroke of the piston, to some known scale. Make

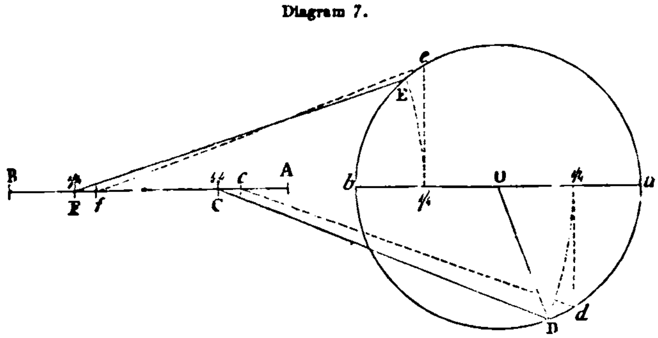
Diagram 6.



a c equal to the part of the stroke performed before the steam is cut off; and *b d* equal to the distance of the piston from the end of its stroke when steam is re-admitted for the return stroke. Draw *d e* and *c f* at right angles to *a b*, and mark the point *g* at the distance *b e* from *f*. Bisect the arc *a g*, and from the point of bisection, *h*, draw the diameter *h i*. Make *i k* equal to *b e*; draw *i m* and *k l* at right angles to *a b*; and draw *i l* and *i b* indefinitely. From the point *m*, set off *m n* equal to the width of steam port, full size; from *n* draw *n o* parallel to *i m*, and meeting *i b*, and also *o p* parallel to *a b*, and meeting *h i*: then will *s p* equal the lap, and *s r* the lead.

In all the foregoing cases, we have taken the versed sine of the arc described by the crank, from either extremity of the stroke, as the portion of the stroke performed by the piston; but, as has been already observed, the relative positions of the piston and crank depend upon the length of the connecting-rod, which will be seen by reference to diagram 7, where A B represents the stroke of the piston, C D the connecting-rod, and D O the crank. Now,

Diagram 7.



by supposing *a d* to be the arc described by the crank when the piston has performed one-fourth of its stroke, and from the length of that arc, calculating the amount of lap required to cut off the steam at that part of the stroke, we appear to be in error—for, from the oblique action of the connecting-rod, the piston would have descended only to the point *c*. But the engine being double-acting, we have to take into consideration the position of the crank when the piston has performed one-fourth of its stroke in the opposite direction from the point B: and here we find, that by supposing the crank to have described the arc *b e* (equal to *a d*), instead of the true arc *b* E, we cause the steam to be cut off when the piston has reached the point *f*; and the distance B*f* being precisely as much more than B F as A *c* is less than A C, the seeming error is self-corrective.

A Table of Multipliers to find the Lap and Lead, when the Steam is to be cut off at ½ to ⅞ths of the Stroke.

The Lap must be equal to the width of the steam port multiplied by Col. 1.
The Lead must be equal to the width of the steam port multiplied by Col. 2.

Half-Stroke.		Five-Eighths of the Stroke.		Three-Fourths of the Stroke.		Seven-Eighths of the Stroke.		
1	2	1	2	1	2	1	2	The distance of the Piston from the end of its stroke when steam is re-admitted for the return stroke being equal to half the stroke multiplied by
Lap	Lead	Lap	Lead	Lap	Lead	Lap	Lead	
2·41	·000	1·58	·000	1·000	·000	·540	·000	·00000
2·16	·145	1·41	·124	·893	·105	·477	·089	·00208
2·06	·198	1·35	·170	·851	·146	·450	·123	·00416
1·94	·268	1·27	·231	·795	·200	·413	·170	·00833
1·84	·318	1·21	·276	·754	·240	·385	·204	·01250
1·77	·358	1·16	·312	·723	·271	·363	·232	·01666
1·71	·391	1·12	·342	·691	·299	·344	·257	·02083
1·65	·420	1·08	·368	·668	·322	·327	·277	·02500
1·60	·444	1·05	·391	·644	·343	·313	·296	·02916
1·56	·467	1·02	·412	·623	·362	·298	·313	·03333
1·48	·505	·968	·449	·586	·396	·273	·343	·04166
1·41	·540	·921	·480	·554	·425	·251	·370	·05000
1·35	·570	·881	·508	·526	·451	·232	·393	·05833
1·30	·595	·844	·532	·500	·473	·215	·414	·06666
1·25	·617	·810	·554	·476	·495	·198	·434	·07500
1·21	·638	·779	·572	·454	·514	·183	·452	·08333
1·17	·657	·751	·592	·434	·532	·160	·468	·09166
1·13	·674	·724	·607	·415	·548	·156	·483	·10000

Example of its application.—Stroke 36 inches; width of port 2 inches; steam to be cut off at half-stroke; distance of the piston from the end of its stroke when steam is re-admitted for the return stroke, 1·5 inches.

$\frac{1·5}{18} =$ 0833. Find that number, or the one nearest to it, in the right-hand or last column, and take out the multipliers on the same line under the head Half-stroke.

Then $2 \times 1·21 = 2·42$ inches = the lap.
And $2 \times ·638 = 1·276$ inches = the lead.

R. B. C.

HEALTH OF TOWNS COMMISSION.

We may seem to be rather late in noticing the first report of the Metropolitan Sanitary Commissioners, but the first number of our new volume was so filled with other matter, that we were unable to do more than to call attention to the unfair way in which the profession has been treated by the commissioners and the government. Since then we are sorry to find that the design of employing military engineers in making the survey of London is persisted in, and that at a time when numbers of experienced and well qualified surveyors in the metropolis are without employment.

The first part of the Report is devoted to a consideration of the means necessary to resist the cholera. After a careful investigation, they come to the conclusion, which appears to us to be well founded, that cholera is not contagious, and that the great means of lessening its ravages are to be found in improved sanitary arrangements, particularly in connexion with the sewage.

To improve the sewage is their first step, and they have recommended and obtained the revocation of the old commissions of sewers. This is a measure to which we have already given our strongest advocacy, but we do not think that the commissioners have gone far enough. The Regent-street and Regent's-park district remains a narrow slip, running up from the Thames across the drainage of the Westminster and Holborn districts, and having a grand and deep sewer of nearly the capacity of the Fleet, which being employed as an outfall, would as we have before pointed out be immediately available in improving the drainage of a very large district. It is true that this is under the virtual jurisdiction of the Commissioners of Woods and Forests, but the commission ought to be at once revoked, and the jurisdiction transferred to the new metropolitan commissioners. The maintenance of this commission by the government is a reason which will be used for the maintenance of the City of London Commission, which is likewise left untouched, because, as the commissioners say, they have not had time to look into the case, but because, as we presume, Mr. Lambert Jones prevented it, and because the commissioners did not choose to get themselves involved in a contest with the corporation of London.

The City Commission of Sewers has certainly been among the best managed, and this, perhaps, for the reason that they have always had a regular corps of officers; but still there is no reason why the city should not derive the benefit of an amalgamation with the rest of the metropolis. Let the corporation choose a commissioner, and they will get a share of the influence, control, and patronage, as well as of the economy attendant on the new commission. If they do not accede at once they will not be able to secure the few dinners which they receive, while they will lose the power and patronage. At present the street sewers of the city are imperfect and unflushed, the gratings and gully-holes untrapped, the courts and alleys undrained, the footways and foot-pavements not cleansed, the house drains and cesspools in a dangerous condition, while the sewers convey miasma into most of the houses. The statistics of the city in the latter respect are most unfavourable, and show a fearful influence on the public health.

The commissioners have given such evidence as to the necessity of consolidating the districts, that on the strength of that evidence we call upon them to complete their measure of amalgamation. They say—

"Taking the works of cleansing as they now are, the preventive measure to which those works may be immediately applied with the greatest advantage is that of flushing. But to the general and effectual application of this most important operation, the state and separation of the several districts under the district commissions, presents itself as an insuperable obstacle; and, in fact, the operation of cleaning out the sewers by flushing them with water is in systematic use in only one of the upper districts, the Holborn and Finsbury district.

"One district may flush its sewers, but the operation will be at many points only a removal of a portion at least of the refuse into the sewers of the adjacent districts, unless the operation be continued through the intermediate districts to the outfall. The lower districts complain of being encumbered by the flushing operations in the upper districts.

"In the lower districts, which are flat, there are generally accumulations of refuse, and if in an upper district, which is under a separate jurisdiction, a part of the line of sewer is flushed to keep it free from deposit, the effect upon the lower district in which the flush exhausts itself, is to disengage more copiously the offensive emanations, for a time, by disturbing and adding to the deposit there, without removing it. Whilst the sewers of one district are left unflushed, or uncleansed, the emanations are driven by the wind into other districts, particularly from the deposits at the mouth of sewers in the lower to an upper district. When the sewers in the Holborn and Finsbury division have been clean flushed, it is stated that the inhabitants of that district, even up to the New River Head, have been annoyed by the currents of offensive gases up the sewers from the accumulations in the lower districts, where the same cleansing operations have not been carried on. For obvious reasons, additional supplies of water would require to be provided in the upper districts, and regulated, for application throughout the whole lines to the outfalls, without staying for separate and intermediate co-operation."

One great evil of the present system, and a cause of fearful expense, is the disproportion between the area of the sewage sent through sewers and the area of the sewers themselves.

"Works to effect town drainage must be constructed for the removal of surplus or waste water from two sources; the natural rain-fall on the town area, together with water from the springs derived from sources beyond the area which may often require separate arrangements; and the pipe-water, brought into the town, and any refuse matter which it may have received in suspension or chemical combination. Setting aside for the present the consideration of the house drainage, and taking in the first instance, the secondary sewers, we give the following cross section, fig. 1, of a sewer draining two or three streets comprehending between one and two hundred houses. The depths of the ordinary run of sewer-water when there is no rain, is only about three inches, and the depth of the increased run of water on the occasions of the greatest storms, just covered the invert.

"The cross section, fig. 2, is a section of a main line of sewer in the Westminster district, draining about 90 acres of town area. The ordinary run of sewer-water does not cover the invert, and on the occasion of the greatest thunder storm of which there is any historical record in the metropolis, namely, that on the 1st of August, 1846, the flow of water was only 2 ft. 3 in. deep.

"In general the flow of water in the collateral sewers of branch lines of street, even where all the houses drain into them, are mere dribbles, and rarely rise above the invert of the wide bottomed sewers as at present constructed, even in streets where all the houses drain into the sewers. The following are the consequences which take place in various degrees in nearly all the collateral sewers of every form of construction, though the best is the egg-shape form.

"The flow of water, being impeded, by the extent to which it is spread, is retarded, and a deposit is created; this deposit becomes indurated to a degree which prevents its being removed by the flow of water occurring in ordinary rainfalls, and is not often considerably affected by any other than the extraordinary storms which occur in intervals of several years.

"The accumulations continue, and during the process, the deposit from the house drains spreads on the sides, and decomposition ensues.

"The accumulations in the sewers, as well as in the large house drains which communicate with them, are exposed to the action of much air, usually at such a temperature as greatly to facilitate decomposition.

"The accumulations increase until the house drains are entirely stopped up, when the deposit in the sewers is usually removed by the offensive process of hand labour and cartage, leaving the deposit in the house drains untouched."

It is well observed that very small currents suffice to keep sewers clear of deposit, if the inclination be good, and the flow be concentrated and kept regular, for which it is considered that additions of small quantities of water would be sufficient at particular intervals and seasons. The commissioners therefore recommend the use as far as possible of glazed earthenware tubes. These were long since tried by Mr. Roe in the Holborn and Finsbury division, and afterwards by Mr. Phillips in the Westminster division, and found to discharge the water more quickly and to keep clear of deposit. They also prevent the passage of rats from the sewers into houses, because they afford no hold, and do not, like the common brick drains, allow them to make burrows.

Mr. Roe and Mr. Phillips also made observations on the flow of water from the main and side sewers and drains, which the former began so long as five years ago.

In Mr. Roe's experiments he ascertained the rate of flow of water, through the common brick drains for houses, as well as through earthenware drains of the same capacity, and with the same run of water. As a general result it may be stated that the rates of discharge through earthenware pipes are very much increased, sometimes as much as one-third. In the application of water for flushing, this is an important consideration, as by the use of the improved drains, a great saving of water will be effected.

The house drains receive the water from small $1\frac{1}{2}$-inch lead pipes from the kitchen sinks, and yet they are often made as much as 60 times the capacity of the pipes in the smaller houses. In these, square brick drains are put in, costing from *6d.* to *11d.* per foot run, exclusive of digging, while in the larger houses brick barrel drains of 9 or 12 inches diameter are put in, costing 1*s.* *4d.* or 1*s.* *7d.* per foot run. As the bottom joints are put in without mortar or cement, the sewer water percolates through the drain. and infiltrates into the houses, while the solid matter, unwashed by any stream of water, festers at the bottom, and acts as a retort for supplying nauseous gases to the houses. It is true that the object in leaving the bottom of the sewers "dry," or without mortar, is to let in the land drainage, but the effect is what we have stated, while it is rare to find a house drain free from deposit. The rats, too, by burrowing in the drains, put them out of order, so as to require their more frequent repair, and the whole working of the drains is as unfavourable as can be conceived, and as far as possible from the designs of the builders. A common house drain cannot be considered otherwise than as a nuisance.

A twelve-inch drain is an expensive nuisance, while an earthenware pipe of four inches diameter (or, proportional to the house, of from three to six inches diameter,) keeps perfectly clear, and a three-inch pipe is found quite large enough to carry away the refuse from middle-sized houses. In consequence of the adoption of this improvement, the cost of drains from houses to sewers in the Westminster division, which used to be from £10 to £25, has been brought down to a charge of from £2 15*s.* to £4 10*s.*, and even this is considered too high.

Nothing shows the error of the old system more strongly than a case given by Mr. Phillips of drains in Langley-court, Long-acre. An old small sewer, 18 in. wide by 2 ft. high, having a good fall, was nearly clean, while a new sewer, 5 ft. 6 in. high by 3 ft. wide, contained an average depth of three feet of soil, and the emanations from it caused the death of a poor man, and led to an inquest.

We think Mr. Phillips fully justified in stating [p. 30], that the sewers are bad in construction, but the house drains are worse. He states that in going along the sewers, he has often tried whether the currents of air were flowing into the sewers, or out of them into the houses. By placing the light which he had in his hand by the side of the house drains, he almost invariably found the flame carried into the mouths of the drains—showing that there must have been direct currents from the sewers through the house drains into the houses. Many of the gully drains showed an outward current into the streets, though some have a downward draught.

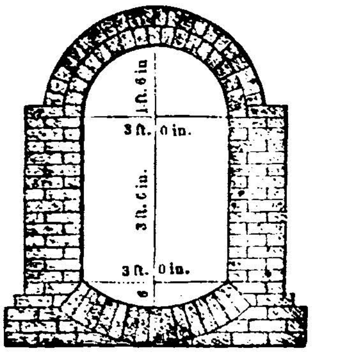


Fig. 1.

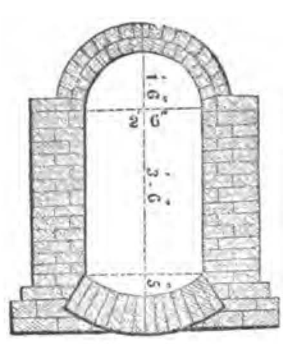


Fig. 2.

Mr. Phillips gives his support to the statement that some neighbourhoods are at times afflicted with more noxious effluvia from the sewers, than if there were no sewers whatever. He thinks the great remedies are to keep a constant supply of water in the sewers, and to circulate it through them; and to carry all the outlets under the side beds of the river, to discharge into the main stream under low-water level. Mr. Phillips has found that the atmosphere of districts near the outlets of the sewers is liable to be affected with effluvia, when the wind happens to blow up the sewers. By carrying the outlets into the stream, he expects, moreover, to get rid of the filthy mud-banks, and the myriads of worms sweltering upon them.

The Report notices the extended use of the egg-shaped sewer in the Holborn and Finsbury and Westminster divisions, but remarks that the new sewers constructed are generally of the same internal capacity as the old forms, and therefore disproportioned to the extent of the drainage. A further great saving will consequently be made in the new operations by reducing the size of the sewers. The commissioners observe, with justice, that the mere view of the ordinary run of sewer water in the sewers, or of the run of water on the occasion of heavy storms, might have led to some amendment in the construction of sewers without any gaging, had a view been taken of the flow in the lateral, as well as in the main lines of sewer; but the sizes of all classes of sewers have been maintained on the view of the main lines alone. Mr. Hertslet, the clerk to the Westminster commission, well observes that he has been perfectly at a loss to conceive, in traversing the sewers, why such immense sewers should be built to carry off such mere threads of drainage. He has seen sewers 5 ft. 6 in. high by 3 feet wide, built where, even during heavy rain, a 3 or 4-inch pipe would have carried off all the water.

Mr. Phillips makes some curious remarks with reference to the size of current which would suffice to keep an ordinary sewer clean. In passing through the branch sewers, he has noticed that the currents of water are mere dribbles, and being spread over a flat surface are not strong enough to remove the soil. Looking at the currents, and comparing them with the extraordinary sizes of the sewers, it was easy to decide that the currents might be passed through pipes of from 3 to 9 inches diameter. Indeed, in a large number of the sewers, the currents have cut narrow and deep channels for themselves, leaving the bulk of the deposit untouched, but showing, as Mr. Phillips says, that nature was trying to remedy the faults of art. Sometimes it is necessary to cut such channels through the deposit, to allow of the flow of water. Acting upon this view, Mr. Phillips proposes to improve the flat-bottomed sewers, by bedding channel tiles along their bottoms, and filling them in behind with concrete, In the middle he would place a channel tile of say 1 foot diameter, having other flat tiles sloping down to it on each side. By this means, the currents would be concentrated on smaller sized channels, kept regularly in action, and therefore clean.

Mr. Roe proposes to reduce the expense of sewage for one side of a sewer for a house of 17 feet frontage, which lately with upright-sided sewers was £9 11*s.* 3*d.*, and now is with egg-shaped sewers £6 0*s.* 5*d.*,—this he proposes to reduce to £2 19*s.* 6*d.* for first-class houses, and £1 14*s.* for sixth-class houses. In these latter charges is included the supply of water. The bottom portions of the larger sewers Mr. Roe proposes should be of well-prepared clay, moulded in blocks two feet long, and well burnt; the upper portions to be formed of radiated bricks, laid in blue lias mortar. The smaller sewers are to be likewise egg-shaped, but to be made entirely of brown stone-ware glazed. Mr. Roe's first-class largest sewer is 3 ft. 9 in. by 2 ft. 3 in., with an area of 6·6 feet, and costing 7*s.* per foot run; his seventh-class, or smallest sewer, is 15 in. by 9 in., with an area of 9 inches, and costing 3*s.* per foot run.

The greater part of the duties of the officers, Mr. Roe states, is taken up by attending to complaints of the stoppage of drains and sewers, and in superintending the removal of the soil; when, with a proper system of sewerage and house drainage, nearly the whole of the duties in that respect may cease. We agree with him that it is far better that a staff of officers should be constantly engaged in making examinations, in order to prevent filth from depositing and accumulating, than in waiting for it to collect and annoy the public with its noxious emanations, perhaps for weeks and months before complaint is made and steps are taken to remove the evil.

We think a great deal may be done by Mr. Guthrie's plan, mentioned in the *Health of Towns Magazine.* In this he proposes to separate the house drainage from the surface drainage. The house drainage being conveyed in tubes, as stated by Mr. Roe, would, under the pressure of water, be carried to the outfall, without gully holes or other communications with the external atmosphere. The surface drainage in the secondary streets could be conveyed by the kennels, and in the main streets be received by the large sewers.

The commissioners come to no decision, at present, as to the use of chimney shafts, with currents of air created by heat, for ventilating the sewers and carrying off the noxious emanations, though they express their approval of the principle.

In conclusion, we must again urge upon the commissioners the necessity of coming to some immediate decision respecting the use by the public of all sewers which have been built at the expense of the commissions, and at once abandon the extortionate demand of 10*s.* per foot run on the frontage of a house, which, if it happen to be a corner house, may amount to the sum of £20, besides £5 more for making the drain, for a fourth-rate building that cost only £200. Every facility and encouragement ought to be given to the owners of house property to make drains into the public sewers, and so to abandon the pest of cesspools.

CANDIDUS'S NOTE-BOOK
FASCICULUS LXXVIII

> "I must have liberty
> Withal, as large a charter as the winds,
> To blow on whom I please."

I. Some have acquired a reputation for having a style of their own, merely because they have repeated the very same ideas over and over again, on occasions the most dissimilar; and, so far from improving upon them, that their latest applications have been less appropriate and judicious than their earlier ones. Such decided mannerism ought rather to be taken not so much for consistency of style as for sterility and inactivity of mind. He who at all deserves the name of artist—and architects claim it by courtesy, at least—is always enlarging the stock of his ideas, and is always studying, throughout the whole of his career. Without copying others he profits by what they have done, both by shunning the faults they have committed, and into which he himself might have fallen but for such evidence of them, and by borrowing from them hints and *motifs,*—after a very different manner, be it observed, from the mere plagiarist. There is no merit in not availing ourselves of ideas thrown out by others, more especially if it has been done so very imperfectly and at random, that very much more than was at first thought of remains to be made of them. "He," says Reynolds, "who resolves to ransack no mind but his own, will soon be reduced, from mere barrenness, to the necessity of copying himself."—Unvaried uniformity of ideas is not so much a sign of consistency as of limited power of conception and expression, and, moreover, occasions not only wearisome repetition but inconsistency likewise, the same mode of treatment being resorted to upon occasions and for subjects totally dissimilar from each other.

II. "How many of us country architects," says Mr. Sharp, "are forced to take the counsel of our excellent friend, Percier, and in despair of executing large works, to bestow greater care upon lesser ones?" Well was it that the remark was put interrogatively instead of affirmatively, for in the latter case it ought to have been, not "How many," but "How few." Were Percier's excellent advice to be followed by country architects—and for the matter of that, by town ones also,—did they invariably strive to make the utmost of the occasion offered them, however inconsiderable it may be in itself, there would be far less of slovenly or else downright trumpery design than there unfortunately now is. The "making the most" of the occasion must not be misinterpreted: it is not to be understood as recommending or consisting in ambitious aim and pretentiousness of design, and in mimicking larger things, as is frequently very absurdly done now, but on the contrary, in attempting no more than can be thoroughly accomplished, and so well accomplished that for intrinsic merit of design and captivating effect the work may not only vie with, but surpass many others of greater note in ordinary estimation—chiefly, perhaps, because their size alone renders them conspicuous and imposing objects. Were this to be duly considered and acted upon, we should have less of vulgar architectural *swaggering*, and far more of real study of design, than we find now. It is precisely because there is so little of the latter, and because architects do not know how to impart to small or comparatively small buildings such character as shall be both striking and appropriate, that we have so much random copying, and injudicious imitation, which serves only to remind us of merits belonging to the original that are altogether missing in the copy.—There is much more room for fearing and also for saying that, taken in general, our smaller provincial buildings show, if not ignorance of design, very great negligence of it—sometimes to a degree almost incredible, if we may believe what profess to be portraits of them. The Masonic Hall at Cowes, and the new Ipswich Museum, are so far from bearing out what Mr. Sharp says, as rather to prove that architectural taste must be at the very lowest ebb in those places, if not in any other parts of the country. Such doings in the provinces are, it must be confessed, kept in countenance by similar Pecksniffian achievements here in town, one of the most egregious of them being the College of Agricultural Chemistry in Oxford-street, which, small as it is, is any thing but an architectural miniature, for it has neither the delicacy nor refinement of one, but is no better than a vulgar and coarse architectural daub. Exceptions there are; and for one of them, we may point to the elegant screen façade of Dover House; or, to take a quite recent one, there is Mr. Hodgkinson's newly-erected house in Park-lane, which affords striking evidence of what may be done within a very limited space —how much beauty of composition and elegance of detail may be displayed in a narrow frontage.

III. Music has, perhaps, been far more fortunate than Architecture, having escaped from the surveillance and trammels of archæological pedantry, in consequence of no musical compositions of the ancients remaining. No doubt they were altogether different in style from anything in modern European music; therefore, had they been preserved and followed as wholesome *precedents*, would have checked rather than at all advanced the progress of the art in later times. To say that had the architecture of the Greeks and Romans perished as well as their music, it would have been all the better now for the former art, would incur for me the epithet of ultra-reprobate, and would, besides, be doing violence to my own feelings. Yet it is sincerely to be wished that its examples were studied more, and aped less,—studied rationally and æsthetically; and then it would be perceived that admirable as they are in themselves, and with reference to the purposes for which they were erected, they are either ill-adapted to, or furnish but very little towards, such an enlarged and complex architectural system as we now require. For actual practice, they afford us little more than a few varieties of column and entablature, arches, pediments, and such features, in regard to which we pique ourselves upon scrupulously adhering to the authority of some one particular antique example, although the structure to which they are applied is in its composition and physiognomy the very reverse of antique. As I have said, I believe, more than once before, modern architects have converted the orders into mere *patterns*, from which they have only to choose, without being put to the trouble of shaping out a single idea of their own. So that as far as the orders are concerned, they neither are nor are called upon to act as artists at all; and as to the merit of truthful copying, that belongs rather to the operative stonemason than to themselves. There are many ancient examples that might be modified to greater or lesser extent, and in a variety of ways, without losing sight of the character of the type so followed. Nay, some might be considerably improved upon, and more consistently finished up than they appear to have been, unless they have been greatly mutilated. Take, for instance, the Ionic order of the Erechtheum,—surely such an exceedingly simple and severe cornice accords very ill indeed with such luxuriantly rich capitals, which seem to demand a corresponding florid character in what is the corresponding division of the entablature, and the crowning to the entire order. Together with want of keeping as to character, there is a falling off of effect where it ought, if any thing, to be increased rather than at all diminished. Obvious as this appears to myself, not one of those who have taken that example have ventured to depart from the exact letter of it, by supplying such a cornice as would complete and perfect it. Of the two, even an exaggerated cornice is a more pardonable fault than a starveling one. The reproach of heaviness is preferable to that of poverty and meanness.

AIR-TIGHT GRANARIES.

Three conditions are essential to the process of putrefaction of grain, viz.: heat, moisture, and still air. With wind, moisture is carried off; with cold, the decomposing process is checked, as may be seen by the carcases of animals that lie through the winter in snowy mountains, and dry up to glue. Without air, everything is locked up and remains *in statu quo;* as reptiles have been buried for ages in blocks of stone or ancient trees, and then resumed their vital functions, unchanged by time. In direct opposition to these principles are the granaries of Great Britain and other countries constructed. Their site is generally the bank of a river, or the sea side. They are built of many floors, at a vast expense. Men are continually employed to turn the grain over, to ventilate it, and clear out the vermin; and the weevil is naturalised in every crevice, as surely as bugs in neglected London beds, or cockroaches in West Indian sugar ships. It is the admission of air that permits this evil, that promotes germination, that permits the existence of rats and mice. In the exclusion of air is to be found the remedy. Granaries might be constructed under ground as well as above ground; in many cases, better. They might be constructed of cast-iron, like gasometer tanks; or of brick and cement; or of brick and asphalte, like underground water-tanks. It is only required that they should be air-tight, and consequently water-tight. A single man-hole at the top is all the opening required, with an air-tight cover. Now, if we suppose a large cast-iron or brick cylinder sunk in the earth, the bottom being conical, and the top domed over; an air-pump adjusted for exhausting the air, and an Archimedean screw pump to discharge the grain, we have the whole apparatus complete. If we provide for wet grain, a water-pump may be added, as to a leaky ship. Suppose, now, a cargo of grain, partly germinating, and containing rats, mice, and weevils, to be shot into this reservoir, the cover put on and luted, and the air-pump at work, the germination would instantly cease, and the animal functions would be suspended. If it be contended that the reservoir may be leaky, we answer, so may a ship; and if so, the air-pump must be set to work just as is the case with a water-pump in a leaky ship. One obvious cheapness of this improved granary over those existing is, that the whole cubic contents may be filled, whereas, in the existing mode, not above one-fourth of the cubic contents can be rendered available. But many existing structures might be rendered eligible. For example: the railway arches of the Eastern Counties, the Blackwall, and the Greenwich. Reservoirs might be erected in farm yards, or inasmuch as it is a certain thing that all farms must ultimately communicate with railways, by means of cheap horse-trains, or steam sidings, in order to work to profit, it would be desirable that the granary should be erected at some central railway station, where a steam mill would do the work of exhausting the air, discharging the grain by Archimedean screw when required, and grinding it into meal. No better purpose could be found to which to apply the atmospheric engines and stations of the Croydon Railway, with their existing air-pumps. Communicating with all the southern wheat-growing counties of England, and also with the Thames, no spot could be more eligible as a central depôt.—*Westminster Review.*

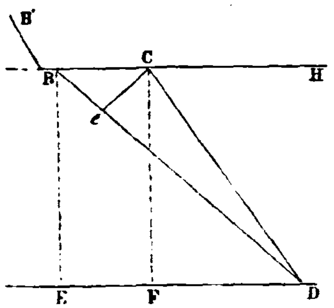
ON WING WALLS OF BRIDGES.

By R. G. Clark, C.E.

As the drawing of wing walls to railway bridges offers some difficulty when the embankments or cuttings are very high, to obviate this is the object of the present paper, which relates to the investigation of some simple formulæ to determine the angles made by the exterior lines of wing walls with the face of a bridge; the plane of projection being taken on a level with the rails or road, when the latter is level.

There are two cases to be considered.—1st. When the coping of the wing wall makes a given angle with the face of the bridge, or is parallel to the abutment, as in the case of a skew bridge.—2ndly. When the coping is perpendicular to the face of the bridge.

1st. Let B H be the line of the face of the bridge on H B E D, the plane of projection as before mentioned; C D the exterior top line of wall; C e the given batter, perpendicular to B D. The ∠H C D being given, or D C drawn parallel to B B′, as in the case of a skew bridge, draw E D parallel to B H; and BE, CF, respectively, perpendicular to E D. For the sake of simplicity, we will first determine the ∠C D B.



Let the slope of embankment or cutting be as m to 1, and the batter of wing wall as 1 to n; height of slope equal h. Now, ∠C D E = ∠ H C D. Let ∠ C D E = θ. Also, base of slope C F = $m\,h$; and batter C e of wing wall $= \frac{1}{n} h$.

Then, by the right-angle triangle C F D, we have

$$\sin\theta \;:\; m h \;::\; 1 \;:\; \frac{mh}{\sin\theta} = \mathrm{DC}.$$

Also, by triangle C e D, right-angled at e, we have

$$\frac{mh}{\sin\theta} \;:\; 1 \;::\; \frac{1}{n}h \;:\; \frac{\sin\theta}{mn} = \text{nat.}\sin\angle \mathrm{CDB}\ldots\ldots\ldots\ldots(1).$$

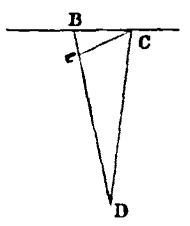
$$\therefore\ \angle\mathrm{HBD} = \angle\mathrm{HCD}\ \text{or}\ \angle\mathrm{CDE} - \angle\mathrm{CDB}.$$

Example. Given the angle of obliquity H C D = 20°, slope 1½ to 1, and batter 1 in 5, to determine the angle of wall H B D:

$$\text{By formula } \frac{\text{nat.}\sin 20^\circ}{1\tfrac{1}{2}\times 5} = \frac{2\times{\cdot}34202}{15} = {\cdot}04560 = \text{nat.}\sin 2^\circ\,37\tfrac{1}{2}';$$

therefore, $\angle\,\mathrm{HBD} = 20^\circ - 2^\circ 37\tfrac{1}{2}' = 17^\circ 22' 30''$ required.

2ndly. *When the coping is perpendicular to the face of the bridge.*



Then $\sin\theta = 1$;

consequently, $\sin\angle\,\mathrm{CDB} = \dfrac{1}{m\,n}$.

Hence, $\cos\mathrm{CBD} = \dfrac{1}{mn}$ .... (2).

Examples.

When the slope is 1 to 1, and batter 1 in 5.

Then nat. cos ∠ C B D $= \frac{1}{5} = {\cdot}2 =$ nat. cos of 78°27′.

When the slope is 1½ to 1, and batter 1 in 5.

Then ∠C B D = 82°20′.

When the slope is 2 to 1, and batter 1 in 5.

Then ∠C B D = 84° 15′.

From the above it appears, that the actual height of the slope, and the batter in feet, &c., have no occasion to be taken into consideration; but only their respective ratios, as above given.

RAILWAY AND STEAM NAVIGATION DEFENCES.

The course which the Duke of Wellington has thought fit to take, in furtherance of the measure of increasing the army under his command, has given a new strength to the alarmist party. We say, advisedly, that the Duke's letter to Sir John Burgoyne can only be taken as the statement of an advocate, using every means to make out a case; for there is evidence enough in that letter to show the impracticability of an invasion, if it were consistent to suppose that a commander so experienced could countenance a scheme, which the youngest staff-officer knows is in no way feasible. In considering the subject, we do not think it necessary to analyse the Duke's letter, because we do not look upon him as a believer in the invasion scheme; but we shall take up the question upon its own merits, which are certainly small enough, compared with the clamour which has been made by so many parties, and of which the Commander-in-Chief has so skilfully availed himself, to further the views of his own department.

It is one of the consequences of thirty-two years of peace, that the present generation know little of war or of military affairs, and it is therefore open to ignorant or restless officers to impose upon them statements, which do not meet with the countenance of men well informed in their own profession, and which are not consistent with historic proof. With the public an officer is taken as an authority in virtue of his epaulettes; but, nevertheless, he is as an officer no more an authority on this question of invasion, than the most ignorant civilian. It is one of the misfortunes of the English army, that there is no guarantee for the qualifications of its officers; and, notwithstanding the growing desire of improvement among military men, it cannot be denied that it is much rarer to find a man well acquainted with his profession than otherwise, for there is no security, and it may be said no encouragement, for proficiency. In the navy, and in the artillery, an examination must be passed; but, under the system by which the army is officered, except the few college cadets, a man may be put in command of an army, whose only qualification is that he can manœuvre a battalion on parade. Neither is the service of the English army calculated to qualify an officer for European warfare, for the staff arrangements even of an Indian campaign will give no schooling for a war in the old battle-field of Flanders. One of the defences we most want is a good staff of officers, and money cannot be better laid out than in enlarging the military colleges, and encouraging the studies of officers. In the meanwhile, we hope the public will not allow themselves to be frightened out of their wits by men who know no more of the organization of an army of fifty thousand men than a drummer-boy does; and, at any rate, to accept with caution any statements which have not the support of common sense and historical evidence.

It is very easy to start with the hypothesis of 50,000 Frenchmen on the Sussex coast, and to talk of the capitals of France, Austria, Russia, and Prussia having fallen into the hands of an enemy; but it is so difficult to conceive how a French army of 50,000 men, or of any other force, could be brought to London, that any general being offered the command of such an expedition, would give it up in despair. In order that a French army may land upon the English shore, there must be no political disorganization in France, and there must be political disorganization in England. Our great protection hitherto against invasion from France, has been the political disorganization of that country by the League, the Protestants, the Camisards, the Girondists, or the Chouans, or by the irruption of Prussians, Spaniards, or Savoyards. Napoleon never hoped to be able to make an effectual invasion of this country, unless he could make a political diversion, by securing the neutrality of parties in opposition to the government. How futile was that dependence is well known; and though some may, in the present time of calm, believe that political factions might hereafter be brought to sympathise with an invader, yet such coalition would become impossible when war shall break out, and the old feelings of bitter hatred be awakened. This is a disturbing influence which cannot be readily overcome. There is nothing more difficult than to overcome a people in their own country, with whatever force, if united in resistance. France will give the example. If, in 1814 and 1815, the allies were able to make their way to Paris in the then political disorganization of the country, yet, in the early part of the war, under the Duke of Brunswick, though France was unprepared, the invaders were driven back with loss.

The circumstances under which an invasion of England will be practicable are—the union of the French, High Dutch, and Russians, the destruction of the naval power of England, our political disorganization, and the agreement of a large part of the people to welcome the invader. This country has not yet had an enemy on its shores, and it is not to be judged like France, Flanders, Holland, Italy, Germany, and Spain.

Before coming to our own particular view of the question, we have a few observations to make upon the military and naval part. The hypothesis of an invasion must be under these forms:—of an army of 200,000 men, or of an army of 50,000; of an army with cavalry, artillery, pontoons, provisions, and train, or of an army with light mounted artillery. Confining ourselves to an army of 50,000 under either of the latter two conditions: such an army, with 10,000 horses for cavalry, 400 or 500 pieces of artillery, horses and carriages for artillery, ammunition, provisions, and train, would require greater steam accommodation, and take greater time in landing. It would, consequently, defeat itself, by giving more time for the muster of forces against it. On the other hand, a mere incursive light force of 50,000 men, would be defeated by want of means to overcome the usual obstacles of delay. It would want cavalry to drive off the swarms of local mounted skirmishers, and to make its reconnaissances; it would want means of crossing rivers; and when its brigades before concentration were brought in front of a regular force in position, it would want heavy cavalry and artillery. If the wounded men were picked up they would encumber the march, and if left behind they would be massacred by the local skirmishers hanging on the rear; so that the men would soon become demoralised. Three days' stay in a wasted country would leave such an army, even if concentrated, without provisions or ammunition, with its ranks thinned and dispirited by death and fatigue. If it attempted to fight, every man would be butchered. Indeed no worse fate can be wished for any man than to have the command of a brigade in an army of invasion of England.

Persons who are ignorant or ill-advised, may say that we have no regular force and no military spirit in the country; but those who take the trouble to calculate know that this country has at all times had great military resources, and at no time so much as at the present. Turn back the pages of the history of England, and watch the progress of preparation. The regulars in England are increased by scores of thousands at a time; sixty thousand militia are embodied and used as regulars; an army of reserve is called out; local militia are brought into the ranks of the regular army; three or four hundred thousand volunteers are enrolled; and, in 1808 for example, seven hundred thousand men are in arms in the islands, besides a vast fleet patrolling around. Since then, the population has doubled, and that seven hundred thousand men will become a million and a half, with the levy *en masse* to back them. England, without allies, can never be lost, if only true to herself, though the nations of Europe should be poured on her shores. No enterprise could be more dangerous than to land troops in a thickly-peopled country, among a brave and warlike population, strengthened with all the resources of knowledge and wealth. For what would this to be attempted? To take the land, but to fill the shores of the Atlantic, and the waters of the deep, with a fierce people, who, as the Hollanders once threatened to do, would take to their ships and seek a new country, whence they could turn upon their oppressors.

It should be noted that it is an old regulation, always renewed in time of war, that in case of invasion, all corn, cattle, and people, within twenty miles of the shore, must be driven up the country, and the district wasted, and efficient means are provided for effecting this. England in time of war, and England in time of peace, are different countries, and it is certainly not matter of blame that the government, in the thirty-second year of peace, do not harass the country with the troubles of war-time. Why are martello towers, shot furnaces, and batteries to decay upon the coast, heavy artillery to rust, and men to be taken from their shops and homes to the drill ground, when all that is wanted in this way can be done when the time comes?

As to sudden invasion at this moment, it is a bugbear; but we are always ready to urge that a consistent system of preparation for war shall be carried on: but then in our opinion the means are simpler than those usually put forward, and are not to be sought in the army estimates, but more immediately within the scope of what are commonly called the engineering operations of the country. We do not advocate an increase of the standing army; we have no faith in the fortification of Portsmouth, Plymouth, and other towns, as strong places; we do not think it necessary to lay down batteries on the coast, or to mount them with heavy artillery; still less do we advocate the calling out of the militia. We may observe, that the government of this country have always wisely shown an indisposition to put arms into the hands of the people in time of peace, because they are not under the bond of a feeling of hostile invasion, which in time of war prevents a misapplication of arms to interference in the civil government.

We consider that a due attention to railways, steam navigation, and the telegraph system, will in time of peace be the most efficient means of providing for the defence of the country. We are no longer in the position we were a few years ago, when the sudden growth of steam navigation threatened military and naval men with a new instrument of aggression, against which they had no means of defence. Then there might have been occasion for alarm, had war broken out; but since then, the development of the railway system has provided an adequate power of resistance; while, more recently, the establishment of electric telegraphs has thrown the scale of preponderance in favour of the defensive resources. We can no longer be in doubt in what direction we are to apply our means and make provision. We must avail ourselves of those three great branches of national enterprise which we have already named. Do not let any think us over-professional in taking this view of the matter, for this is the side on which the Duke of Wellington looks at it. He takes his case on a steam-navigation invasion, on this new development of scientific resources; and the fair way to meet it is to consider what resources of such kind are available for the purposes of defence. Engineers and manufacturers have created the means of invasion, and they must provide us, to some extent, with the means of defence.

Considered in reference to the defence of the nation, nothing can be more unwise than that legislative interference which has restricted railway enterprise. Even were it true that there was an undue competition for railways, and that capital was diverted into this branch of investment, still, so far as the country is concerned, it is desirable that as many railways as possible should be made. If we are asked whence the capital comes for railway construction, we can have an answer which springs from the very matter now under discussion. In time of war, we keep a couple of hundred thousand regulars and militiamen, giving no productive return. In time of peace, we can employ two hundred thousand navigators, or, in reference to our present means, four hundred thousand navigators, in making railway works. At present, out of an income of fifty-five millions, thirty millions are a mere transfer of capital, in the shape of interest on the debt; the remainder is the effective drain upon the energies of the country; and every addition of twenty thousand men to the military forces is a deduction of so many men, and of one million yearly, of so much productive labour and capital rendered unproductive. We can carry on such great railway works while other countries cannot, because France, for instance, keeps three hundred thousand, or four hundred thousand, men under arms,—doing no good, but, on the contrary, weakening its resources.

The less interference with railway legislation and management the better, for it results only in public inconvenience. Had it not been for this interference, we should now have had coast lines all round the island, and been provided with sufficient converging lines from the great seats of population. As we stand now, the southern coast line is incomplete, the line to the west coast is incomplete, the eastern coast is neglected, and indeed the communications are left in such a state, that in time of war they will require to be completed at the national expense. If erroneous views of policy had not prevented it, we should have had at present the following lines available for the south coast defence:— A line along the south bank of the Thames, to Dover, to Hastings, to Brighton, to Shoreham, to Fareham, to Portsmouth, and to Southampton, giving the means for pouring down troops most rapidly; whereas, through the fear of competition, we are left with the present inadequate accommodation. If the plan of traffic estimates and investigations had not been followed, and parliament had not undertaken the futile inquiry whether a line would pay or no, we should have had lines enough made by those who are the best judges how to invest their money. It is, however, the consequence of the meddling policy, that it always reacts to produce serious inconvenience to the country, without doing the slightest good.

Now that railway enterprise has been suppressed and knocked down, it becomes the duty of the government to aid the companies in carrying out the necessary works. Among them are the bridge over the Thames to connect the north and south railways; the branch of the Brighton railway from Croydon to Wandsworth; the union of the Portsmouth and Gosport lines; and the extension of the Brighton and Hastings line through Rye to Ashford. London is the seat of a population which will afford four hundred thousand able-bodied soldiers, between fifteen and sixty, to be poured down to any point of the coast between Dorchester and Harwich; and it is therefore necessary to provide accommodation for bringing this great reserve to bear upon any point attacked. The metropolis also is the reserve for defending the whole of the northern and west coasts, in case of insufficiency of local force.

It has been recommended that the railway companies should be encouraged to adapt their wagons so as to carry heavy artillery; but this is unnecessary, though they should have provision for carrying light artillery. This country, yielding more than one million and a half tons of iron yearly, can supply any number of heavy carronades to carry 68 lb. hollow shot or solid red-hot shot. In case of need, a thousand carronades could be cast daily. The coasts can be lined with heavy ordnance, and provided with furnaces for heating shot, the guns being worked by the local fencible artillery. If the enemy effected a landing, the guns would be spiked and left on the spot. Guns would likewise be brought up along the line of the enemy's march, and upon the fortified lines and camps, and as each position was abandoned the guns would be spiked. There would be no object in lugging about heavy pieces, and the enemy would not move spiked iron guns, if they had the train to do it.

Every encouragement should be given to telegraph companies to lay down wires, for although we have got to a certain stage of advancement, the electric telegraph system in this country is far from being in a satisfactory state. It seems very desirable that it should not be left a monopoly in the hands of the Electric Telegraph Company or the government, who, by inveterate adherence to one system, may check the course of improvement. The use of the needle telegraph by the company we believe to be fraught with great inconvenience, and indeed, in particular conditions of the weather, as the needle telegraph will not work, it may become useless either to announce an invasion or to communicate orders. It is to be observed that the electric telegraphs for the south coast are in a bad condition. The coast line is not completed, and the South Devon line is said to work imperfectly. The telegraph on the South-Eastern is worked in a complicated manner; there is no telegraph on the Brighton. There is a telegraph on the South-Western; but on the Great Western, none beyond Slough. We say nothing about military communications with the inland stations, or with Chatham, Plymouth, and Milford. All this requires looking to, so that every encouragement be given to complete the system; and in case of need, the government must themselves lay down wires.

The steam navigation resources of the country must be cultivated by a prudent legislation. On this head, as on railways and telegraphs, private enterprise is ready enough to work without requiring any great expenditure on the part of the state; but, unhappily, legislation has generally been unfavourable to private enterprise, or so tardy, that private resources have been exhausted before public aid was afforded. The Great Western Steam Navigation Company was allowed to drop, when slight aid from the public would have given it an impulse, and we might had a weekly line to the United States before now. Mr. Waghorn is still urging upon the government the packet line to Sydney, and Mr. Wheelwright has not too much reason to congratulate himself on the aid afforded to Pacific steam navigation. From the tardiness of the government, the Great Western, the Cape of Good Hope, and the Bahia Steam Navigation Companies have been ruined, the Pacific Steam Navigation Company has been kept in difficulties, and the Royal Mail and Peninsular Companies long had to struggle amid depression and neglect.

The line to Australia should at once be authorised, as also one to the Brazils. Already a steam marine has sprung up in Sydney, and it would be much extended under the impulse of a steam communication with the mother country, while a slight encouragement would fill with steamers the harbours of our possessions on the Indian ocean, and greatly augment their defensive resources.

It is very desirable that examinations should be established for masters, mates, and enginemen of steamers, but accompanied with the distribution of such prizes for proficiency as should stimulate the acquirement of professional knowledge, and raise the character of the persons employed.

With a population of fifteen or sixteen millions on sixty thousand square miles, and with vast material resources, nothing but the imbecility of a government, or the treachery of a party, would make a foreign invasion possible; and one great source of moral strength and confidence is a knowledge of those resources. What can be more desperate than the embarkation of landsmen in steamers and small craft, which, if the sea-force of England be annihilated, must still be landed on a hostile shore under a well-directed fire of red-hot and hollow shot and shells from heavy pieces. By the time a landing is effected, the local force is mustered, troops pour in from all quarters, the people, cattle, and corn are driven, the roads and bridges broken up, and the enemy would have to advance under the fire of mounted and dismounted sharpshooters, lurking in a country full of hedges, ditches, and enclosures. Every bridge and culvert would form an obstruction, every grove of trees near the roads be cut down for an abattis; barriers would be formed at the hamlets and villages, and guns mounted in the churchyards, mills, and on the hill-tops. In the face of such obstacles the enemy would have to advance, each man carrying sixty rounds of ammunition and three days' provision. Tirailleurs would have to be thrown out around the column of the moving brigade, and, after two or three miles' advance, more must be kept in the rear, as the skirmishers would get behind, in order to slaughter the wounded, for it is well understood in such affairs that no quarter is given. The brigades landed at various points along the course, would have their communications interrupted by the deep and wide mouths of the rivers, and their progress impeded by gorges and steep passes in the chalk range, which would admit of a stand being made by the local forces. The brigades would not know whether their whole army had made good its landing, and would not in many cases know the fate of the brigades on their flanks; while, at the points named for the concentration of the divisions, many brigades would not be able to get up, and movements would be necessary in flank and rear to extricate brigades which were cut off and surrounded. Every hour lost to the invaders would be thousands of men added to the protecting force, and if divisions could be got together for an advance, they would then have to carry entrenched camps and fortified positions, against a superior force well provided with cavalry and artillery, and knowing that the carrying one strong position was only shifting the field of battle to another strong position in the rear. When it is considered that in a broken country, swarming with skirmishers, a force weak in cavalry could not keep up communications without moving such a body of men as could defend themselves and cut their way through, the demoralization of the invading force within twenty-four hours would be certain. A very hard day's work would have to be done; nothing would be known as to the fate of other portions of the force; many of the men would have become the victims of the infuriated skirmishers; and a night would come on, when a large force would have to be detached for piquets and outposts, of which the sentries would be picked off on their guards, while the outposts would be driven in by night attacks. The next morning would offer the choice of a surrender, a retreat, or an attack from a superior force; and this without having got more than twenty miles from the coast. This is rather a different picture from that drawn by Lord Ellesmere, of the guards marching out of London; but then it is the true one, which those who have had experience in such matters will recognise.

REGISTER OF NEW PATENTS.

PNEUMATIC SPRING.

MOSES POOLE, of the Patent Office, London, gentleman, for "*Improvements in the construction of pneumatic springs.*"—Granted May 22; Enrolled November 22, 1847. (A communication from a foreigner.)

The nature of this invention consists in applying the elasticity of atmospheric air, or any permanently elastic gas by means of air expanding and contracting chamber or chambers, made in one, two, or more parts, and connected together by means of two or more belts of india-rubber cloth or other flexible or impermeable material, with alcohol or other liquid interposed, the more effectually to prevent the escape of the gas or air contained in the apparatus, and to aid in relieving the flexible connexion, and preventing its rupture from the action of the weight or force on the spring.

This mode of connecting two vessels being applicable without the air to other purposes, such as hydrostatic presses, &c., by forcing the water into or between the two vessels.

And the improvement also consists in providing this apparatus with one or more of what is denominated a respiratory chamber or chambers, attached to one or both ends of the apparatus, and separated from the main chamber of the apparatus by a diaphragm or diaphragms perforated with holes, which will check the passage of the air, and thus relieve the apparatus from the injurious effects of sudden shocks.

The manner in which it is preferred to construct this apparatus is represented in the accompanying drawings, in which *b*, fig. 1, is a metallic conical vessel, with a concave plate or disc at bottom. The upper edge of this vessel is bevelled inwards around its circumference to receive the edge of the belts *f* and *g*, the inner edges of which are there secured by a plate *e*, depressed or sunk in the centre, which has a bevelled and grooved flanch, so that when the plate *e*, is drawn towards the bottom plate by four or more screw-bolts *h*, the belts are griped and firmly held between the grooved edge of the vessel and the bevelled or grooved flanch. The outer edges of the belts *f* and *g*, are connected with and held by the cylindrical vessel *a*, which surrounds the vessel *b*, having space enough between the two for the working of the belts, which by the pressure of the contained air are alternately pressed against and sustained by the inner periphery of the conical vessel. The belts are secured in vessel *a*, by making its cylindrical part in two portions. The edges of these two parts, where they come together, are bevelled or grooved to receive the outer edge of the belts, which are there griped and firmly held by drawing the two parts *a* and *a* together by means of screw-bolts *i*, that pass through the head of the vessel *a*, and a flanch in the part *a*.

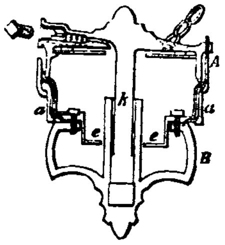


Fig. 1.

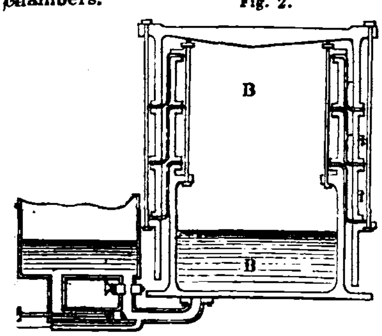
The connecting-belts *f* and *g*, are flexible hoops of india-rubber or other flexible substance impermeable to air, and the edges being firmly held, the space *j* between the two is filled with alcohol or other liquid, which not only prevents all possibility of air passing through, but brings an equal pressure on all parts to prevent rupture.

The connexion of the two vessels *a* and *b*, by means of the belt, divides the apparatus into two parts or chambers *a'* and *b'*, the plate or diaphragm *e* being the division, the inner and depressed circumference of which is perforated with holes to break the passage of the air, as the chamber *a'* is enlarged or contracted by the movement of the two vessels on each other; this perforated plate is, therefore, termed a respirator, as it permits the passage of the air from one chamber to the other, and at the same time checks its too sudden passage, and therefore avoids to a certain extent all sudden jars in cars or other bodies having such springs interposed.

The motion of the two vessels on each other is guided by a rod *k*, attached to the head of the vessel *a*, which passes into a tube *l*, which tube arises from the bottom and centre of the vessel *b*, extending through the centre of the respirator or plate *e*; or guide-rods may be applied outside. The vessel *b*, instead of being conical, may be cylindrical, but the two vessels should be so formed as to present alternately a supporting surface to the belt, which in consequence of the pressure of the air in the chamber *a'*, rolls gradually from one surface to the other, and is therefore at all times supported by either one or the other, or both of these surfaces.

Instead of one respirator or perforated diaphragm two or more may be employed, the more effectually to ease off the passage of the air as it is compressed or expanded, and this respirator may be of any desired form, and may be located in any part of the two chambers.

Fig. 2.



Instead of the double belt above described connected together at the edges, it is contemplated to place two or more single belts separated from each other, as represented at fig. 2, with the liquid in the space *t*; the holes *t*, being made through the outer casing for the introduction of the liquid and closed by a screw-plug. When this apparatus is used as a hydrostatic press, the water is forced into the chambers *a'* and *b'*, by any of the known means which forces apart the two vessels *a* and *b*, in the same manner as in the cylinder and piston press, except that the friction of the moving part is avoided. Air is to be forced into the chambers when the apparatus is used as a spring.

MANUFACTURE OF IRON.

Reginald James Blewitt, of Llantarnam Abbey, Newport, Esq., M.P., for "*Improvements in the manufacture of malleable iron.*" —Granted May 27; Enrolled November 27, 1847.

The usual mode of preparing pig or cast-iron for malleable iron is by melting such iron, or by mixing together and melting different qualities of pig or cast-iron with coke, in furnaces called refineries, and keeping it there in a state of fusion, at a great heat, with a strong blast; and the produce, run into moulds, is called refined iron, or metal plate. The patentee uses this, either alone, or mixed with different qualities of pig or cast-iron, in the puddling-furnace, and subjects it to the after process of puddling, by which it is brought into the first state of malleability. He states, he has discovered that a better quality of refined iron, or metal, may be obtained from an air furnace—such as is commonly used for casting, or foundry purposes—than from the refinery, by which there is less waste of metal, and less expense of fuel, in the manufacture. He lights and heats an air-furnace in the usual manner. For each charge about four tons of pig or cast-iron is put in of such qualities as the manufacturer may think most desirable to produce the required quality of malleable iron, as has hitherto been the practice in using refinery furnaces; and the charge, when fully melted and mingled together at the bottom of the furnace, is run into sand, or iron moulds, of any convenient size, and then subjected to the after process of puddling, which is conducted as if using refined metal produced from ordinary refinery furnaces. The fuel employed for heating the air-furnace is a white-ash, semi-bituminous coal of excellent quality, to which may be added, with good effect, 1 or 2 cwt. of charcoal to each charge.

RAILWAY CARRIAGE AXLES.

Samuel Benjamin Edward Berger, of Abchurch-lane, London, merchant, for "*Improvements in the construction of railway carriages.*" (A communication.)—Granted June 3; Enrolled Dec. 3, 1847. [Reported in *Newton's London Journal.*]

This invention relates to a mode of connecting the axle-boxes of railway axles with the framing of the carriage, whereby the axles will have a slight horizontal play, sufficient for them (when travelling over curves) to take a line parallel to the radius of the curve over which they may be passing. This is effected by connecting the axles to the carriages in the manner shown in the annexed engravings. For four-wheel carriages the apparatus is

Fig. 3. Fig. 2. Fig. 1.

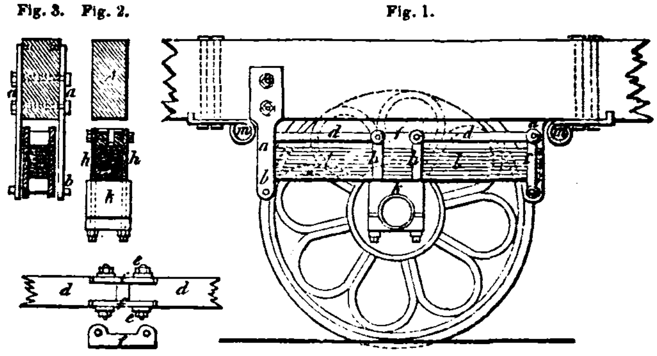


Fig. 4.

shown in figs. 1, 2, 3, and 4. A, A, is one of the two main side-beams of the framing of the carriage; and as side case of the carriage is similarly furnished for the support of the axles, a description of the parts pertaining to one end only of an axle will suffice to explain the nature of the invention.

a, *a*, are four arms or brackets, bolted, two on each side, to the beam A; and at their lower ends they are coupled together, in pairs, by a bolt or pin *b*. These pins each carry two links, *c*, *c*; and through their ends a coupling-pin is passed, and secured in its place by rivet-heads or otherwise. *d*, *d*, are two rods or bars, provided at each end with eyes, for the purpose of being connected respectively at their outer ends by the coupling-pins of the links *c*, *c*, and at their inner ends, of being jointed together by the coupling-pins *e*, *e*, and intervening links *f*, *f*. These coupling-pins *e*, which are secured in their places by screw-nuts, also pass through the eyes of pendant-links *h, h*, which pass through the step or axle-box *k*, and hold it in suspension. *l* is the bearing-spring, composed of layers of steel plates, piled one above the other, and embraced by the links *h, h*, which, when screwed tight to the axle-box by the nuts (shown in the drawing), cause the horizontal links *f* to bind tightly upon the middle of the steel plates, and hold them securely together. It will now be understood, that when it is desirable for the axle to take a position other than a right angle with the side of its carriage, such movement will be permitted by the links *c, c*, being free to oscillate. In order, however, to check an undue horizontal movement of the axle, and allow of its adjustment only to a line parallel with the radius of the curve over which the carriage is passing, elastic stop or check-pieces *m, m*, are provided, as shown at fig. 1; and placed in such a manner, as to allow of a free motion of about a $\frac{1}{4}$ to $\frac{1}{2}$ inch; so that, whenever the axle may have a tendency to sway too much, either forward or backward, the links *c, c*, will come in contact with the pieces *m*, and be prevented from moving further. This horizontal movement of the axle will only occur when the railway deviates from a straight line; but when the carriage again pursues a straight course, the axle will regain its position at right angles to the length of the carriage.

Another modification of the invention, applicable to a six-wheel carriage, is also described in the specification, fig. 5 being a side

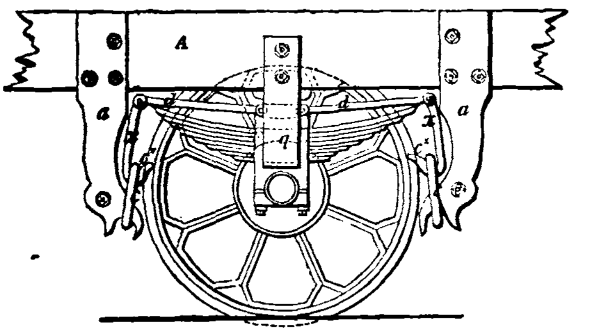


Fig 5.

elevation; to allow the axles to move laterally, as well as in a forward and backward direction, in order that, in a carriage having three or four pairs of wheels, the hind wheels may follow the front pair, not always in a straight line, as they are now obliged to do (whereby a continuous abrasion of the flanges against the rails is caused when passing curves), but that they may take a position on the rail suitable for compensating for the difference in radius of the two sides of the curve of a railway, and permit the cone peripheries to work efficiently for that purpose. In this modification, the same or analogous parts are marked with similar letters of reference. Instead of the four arms *a*, fig. 1, forked arms *a*, are made to embrace the beam A; and at the junction of the prong, filling-pieces are provided, and cross-rods are also employed, to insure the rigidity required for the arms *a*. The lower ends of the arms *a* are hook-shaped, and are intended to receive respectively the shackles or links *c, c*, which, together with the coupling-hooks *c**, pendant from the bars *d*, perform the same office as the links *c*, in fig. 1. From the peculiar construction of this coupling, it will be seen that a lateral play or movement is allowed to the axle, entirely independent of the carriage-framing (no fixed point of vibration being employed, as at fig. 1); and, consequently, the object desired, viz., giving a lateral as well as a backward and forward motion to the axle, will be obtained. In order to limit the horizontal motion of the axle, the space for oscillation is contracted at *x, x*, (fig. 5). To guard against the danger which would result from the breakage of either of the shackles *c*, a block of wood is attached beneath the framing, which, in falling, will be caught by a block resting on the coupling-links of the bars *d*. *q* is a shield for preventing the step or axle-box *k*, from getting displaced, in the event of such an accident as above alluded to.

The patentee claims the modes, herein described, of connecting the steps or axle-boxes to the framing of railway carriages, whereby the axles of such carriages are enabled to shift their positions, with respect to the frames of the carriages, for the purposes above set forth.

MANUFACTURE OF IRON.

WILLIAM VICKERS, of Sheffield, for, "*Improvements in the manufacture of iron.*"—Granted June 19; Enrolled December 19, 1847.

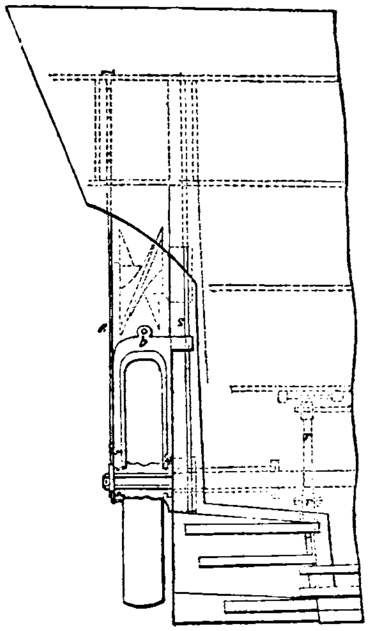
The improvements consist in melting pig-iron with wrought-iron, and running the melted mixture (when divided into streams) into water; and then converting the product into malleable, or wrought iron, in the following manner:—Pig-iron is to be melted with scrap of wrought-iron or turnings, in any suitable furnace, (a cupola furnace is recommended); and the proportions of wrought-iron with pig-iron may vary greatly, but that a very small addition of wrought-iron to pig-iron, run into water, will be found to produce a great improvement in the quality of iron manufactured therefrom. Sometimes the following proportions are employed:—To 30 parts of wrought-iron are added 70 parts of pig-iron, by weight; and, although this may not be found to answer for some purposes, it has been found to answer well. If, however, the iron should be intended to be made into steel, it will be necessary to increase the proportion of wrought-iron, by mixing with the pig-iron about 40 per cent. of wrought-iron. In the manufacture of iron intended for general purposes, there may be used, with advantage, a mixture of 30 per cent. of scrap of wrought-iron, or turnings, with pig-iron; and such mixture, when melted, may be divided into small streams, and run into water, in any convenient manner. For this purpose, the patentee states he has used the following arrangement:—He takes a cast-iron tray, perforated with holes of half-an-inch in diameter, and this is lined about half-an-inch thick, with sand or composition, such as is used for stopping cupola furnaces with; which is punctured with holes about a quarter of an inch in diameter—such punctures being immediately over the holes in the tray, and then the tray is placed about 15 feet above the level of the water in the tank (employed for solidifying the iron), which is of wood, and about 4 feet deep; and the melted metal passing from the furnace, through the perforated tray, into the water in the said tank, will be found therein in a divided state. This product is used in the manufacture of wrought-iron, and is treated the same as in the manufacture of wrought-iron from pig, or refined iron. The patentee adds, that he has used, with advantage, in the melting of pig-iron with wrought-iron, from 3 to 5 per cent. of black oxide of manganese, which he believes will be found to be advantageous. This may be added from time to time, by placing small pieces in the tuyere holes—the blast dividing it in the furnace as the mixture becomes melted. The patentee does not claim the melting of wrought-iron with pig, or cast-iron, nor the running of melted cast-iron into water, when separately considered; neither does he claim the precise mode set forth, so long as the peculiar character of his invention be retained; but what he claims, is melting pig-iron with wrought-iron scrap, or turnings, and then running it into water, and using the product in the manufacture of wrought, or malleable iron.

STEERING VESSELS.

WILLIAM HENWOOD, of Portsea, naval architect, for "*Improvements in propelling vessels, and in steering vessels.*"—Granted May 4; Enrolled November 4, 1847.

The first improvement in propelling and steering relates to screw-propelled ships or vessels, and consists in placing the screw-propeller at the aft-side of the sternpost, where the rudder is in vessels generally, and in applying the rudder on the fore-side of the screw-propeller, in the lower and aftermost part of the run, and below the propeller-shaft, the rudder being substituted for the same part of the run of the vessel, as shown in fig 1. The lower end of the sternpost meets the keelson, or timber running under the shaft, at about the height of the centre of the shaft; and the one may be united very securely to the other, by a flanch or flanches on the shaft cylinder, let into and bolted to the sternpost and keelson. This keelson, or timber, should be large in siding, because of the hole through it for the rudder-head to pass through; and it must have a rabbet to receive the bottom plank.

The propeller is connected with the sternpost and vessel very firmly by a metal coupling-box *a*, which has a metal-frame *b*, attached to it for raising and lowering the propeller; the coupling-box and hoisting-frame being formed with tongues, to slide in metal-faced grooves in the sides of the sternpost *s*, and the coupling-box having an interior collar, of the utmost requisite strength, fitted against a corresponding exterior collar round the propeller. The union of the propeller to the ship is thus made abundantly strong for pressing the shaft into the propeller, and "backing astern." An after-bearing for the shaft may be formed by the metal-rod *e*, set up with a screw to the stern; which rod would also form an additional stop for the propeller on the shaft in backing astern. Or a rod might be attached to the upper and after-part of the hoisting-frame, and set up with a screw to the vessel's stern; and a small rod may be applied at the aft-side of the hoisting-frame, for inserting a forelock in the end of the shaft, to secure the propeller in backing astern, which forelock would revolve with the shaft on the pin at *x*. The surface of the rudder may be as large as that of the immersed part of the common rudder, although as the pressure of the water on such a rudder would be once and a half as great as on the common rudder, a much smaller surface would be sufficient for steering, and the lower part might be reduced.



A large and very strongly formed rudder-band is fitted at the upper part of the rudder, with a large hole through it, of a square, hexagonal, or other form, into which the rudder-head *r* is fitted for turning the rudder; the lower rudder-bands might also be formed similarly, and the braces fitted with an internal ring, that the rudder-head being extended downward as a substitute for the rudder-pins, may revolve in the braces, whilst it is fixed in the rudder-bands for turning the rudder. The rudder-head above the upper rudder-band is cylindrical, and passes through a metal cylinder with a stuffing-box. It then surrounds the propeller-shaft so that the rudder may turn sufficiently in steering; and it extends to any convenient height to receive the tiller. Should the rudder be carried away a temporary rudder could be applied, by taking up the propeller, using sails only, and having the temporary rudder prepared with braces to slide down the sternpost grooves; by which it would be held securely to the ship, its lower end being secured with guys.

The advantages to be obtained from this improvement are, the maximum effect of the screw-propeller in propelling; the avoidance of risk of serious damage from a vessel's grounding, and the preservation of the strength, and the form, and the displacement of the after-part of a vessel.

The claim is for the right of applying a screw-propeller and a rudder conjointly to a ship or vessel in the positions above-mentioned, and as shown in the engraving. The improvement in steering vessels consists also in applying a similar rudder to a ship or vessel not propelled by a screw.

Such a rudder could be either shipped or unshipped afloat, by attaching a water-tight hose or cylinder to the rudder-head cylinder, so that the rudder-head *r*, with the rudder-pin or pins attached to it, may be drawn up in unshipping the rudder, or replaced in shipping it. The keel may extend under the rudder, as shown in the engraving, to protect it in grounding.

The advantages of such a rudder are, much less first cost, indefinite durability, through being always under water, being below the impulses of waves, so that the steering would be uniformly steady, and without hazard to the helmsman, both when a ship is laden, and when she is light; and it is quite below the reach of shot.

Another improvement in propelling vessels consists in making that part of the immersed volume, which is abaft the vertical and transverse plane in which the centre of gravity of the vessel is, of such a form, that the longitudinal stability of the after-end of the vessel may be practically equal to that of the fore-end:—in order that the pitching motion, so far as it may be caused by the form of the immersed volume, may be prevented; and that there may be the least possible resistance of the water to the propelling power. This is of especial importance in screw-propelled vessels, because pitching raises the screw above the water's surface.

The equal stability of the fore and the after-ends of a ship, is obtained by making the area of the load-water section abaft the above-mentioned vertical and transverse plane, equal to the area of the remaining part of the same water section, on the fore-side of the same plane; and the moments of those areas, from the same vertical and transverse plane also equal; and by forming the lower horizontal sections or water-lines in a similar manner; or so that the cubic contents of the immersed volumes, on each side of the same vertical and transverse plane, and the moments of the same immersed volumes from the same plane, shall likewise be equal, the one respectively to the other. A vessel of remarkably beautiful form may thus be produced. As the propelling power of the wind on the sails always depresses the fore-end of a ship, when it impels her onward, just as it depresses the lee-side, when the wind acts obliquely, it appears contrary to the dictates of reason and of science, that ships should have, as they commonly have, less stability at the fore-end than at the after-end. By making the stability equal at both ends of a ship the pitching would be reduced to the least possible degree, the propelling power would produce greater speed, the decks or gun-platforms would be kept more nearly in their horizontal positions, and the dangers and discomfort and expense of "wear and tear," in rough weather, would be materially diminished.

The claim is for making ships or vessels of the form above described, so that the longitudinal stability of the fore-end may be practically equal to that of the after-end.

LOCOMOTIVE ENGINES.

Thomas Russell Crampton, of Adam-street, Adelphi, engineer, for "*Improvements in locomotive engines.*"—Granted June 19; Enrolled Dec. 19, 1847.

The improvements relate to the construction of the locomotive engine.

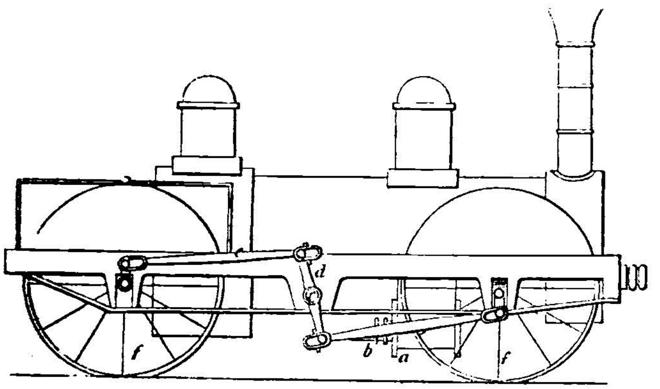
The first improvement consists in introducing two pairs of driving-wheels, one pair to be placed behind the fire-box, and the other pair forward, in such manner that the weight of the boiler and machinery may be borne equally by each pair of driving-wheels. By this arrangement, the adhesion of the wheels upon the rails will be more uniform. The two pairs of driving-wheels are to be connected on the side by rods in the usual manner, or connected separately to the driving cylinders, or in any other convenient manner. The mode preferred by the patentee is shown in the seventh improvement. If it be desirable to construct the engine with six or more wheels, the patentee proposes to place them between the two pairs of driving-wheels, but recommends that they should bear but little of the weight, by the employment of light elastic springs.

The second improvement is in the construction of the fire-boxes, for the reception of the axles of the driving-wheels, the driving-wheels of the locomotive engine being placed more forward than the back of the fire-box. If large wheels are to be used, a recess is to be formed transversely in the upper part of the fire-box for the axle; and for smaller wheels, a recess is to be formed in the lower part of the fire-box: this latter arrangement divides the fire-bars into two parts. By either arrangement, the heating surface of the interior fire-box is increased, and the evaporative power of the boiler augmented.

The third and fourth improvements consist in such arrangement of the various parts of the locomotive, that the axle of the fore or leading wheels may have outside bearings, and the axle of the drawing or after-wheels behind the fire-box, inside bearings.

The fifth improvement consists in placing the eccentrics for working the valves on the outside of the driving-wheels, by elongating the axle some distance through the boss of the driving-wheels; the crank-pin, instead of being fixed to the boss of the driving-wheel, is fixed to a separate crank fastened to the end of the elongated part of the axle, leaving sufficient space between the crank and the boss of the wheel for the reception of the eccentrics upon the axle.

The sixth improvement is for transmitting the power from the steam cylinders to the driving-wheels, by introducing a vibratory shaft in the centre between the driving-wheels, as shown in the annexed figure. The steam cylinders *a* are fixed to the under-



side of the boiler, with short connecting-rods *b*, which act on cranks or levers keyed on to the central shaft *c*; and on the ends of the latter are two arms or levers *d d*, which, through the two connecting-rods *e e*, cause the two driving-wheels *f f* to revolve.

LIGHTING BY ELECTRICITY.

William Edwards Staite, of Lombard-street, gentleman, for "*certain Improvements in lighting, and in the apparatus or apparatuses connected therewith.*"—Granted July 3, 1847; Enrolled January 3, 1848. [Reported in the *Mechanics' Magazine.*]

This invention relates to a method of lighting by electricity, as shown in the annexed engravings. Fig. 1, an external elevation of the apparatus; fig. 2, a sectional elevation on the line W*x* (fig. 3); and fig. 3, a horizontal plan on the line *y z* (fig. 1). The patentee describes his apparatus as follows:—

M, and N, are two cylinders of carbon, prepared as is afterwards described, which are used as the electrodes, that is to say, the current of electricity is passed from one to the other as they stand end to end, their ends being separated by an interval of from less than one-twentieth to about half an inch, according to the power of the electric current used. The upper electrode, N, is passed vertically through a hole in the summit of the metallic support, or tripod, K, and fixed by binding screws. The lower ends of the legs of the tripod are passed through holes in the circular main-plate, A, of the apparatus, and secured in their positions by collars and nuts, but are carefully prevented from coming into metallic contact with the plate A, by means of washers *a a*, of some dry, hard, non-conducting wood. The legs terminate at bottom in set screws L L, which connect them with a conducting wire, which passes round through the extremities of all the legs, and is connected with one end of the coil of the regulator R. The other end of this coil is led to a clamp B², with a set screw fixed at one side of the square wooden basement B, on which the whole of the apparatus is built, and which is mounted on four short supports, *b b b b*, at its corners, to allow room for some parts of the apparatus which project below the basement. The main-plate A is firmly attached to the basement B, by four pillars, *c c c c*. C, and D, are cones which spring from opposite sides of the apparatus, their common axis passing at right angles through the centre of the main-plate, A, which is bored out for the purpose. The apices of these cones are perforated, to admit the perpendicular central shaft, O, which

Fig. 2.

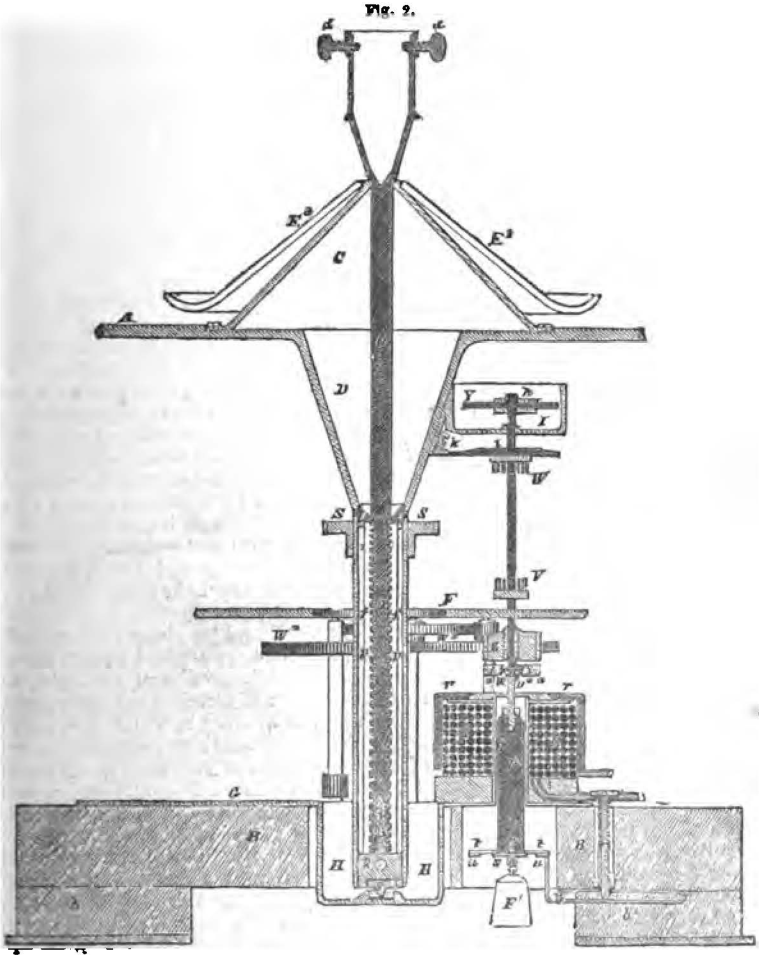
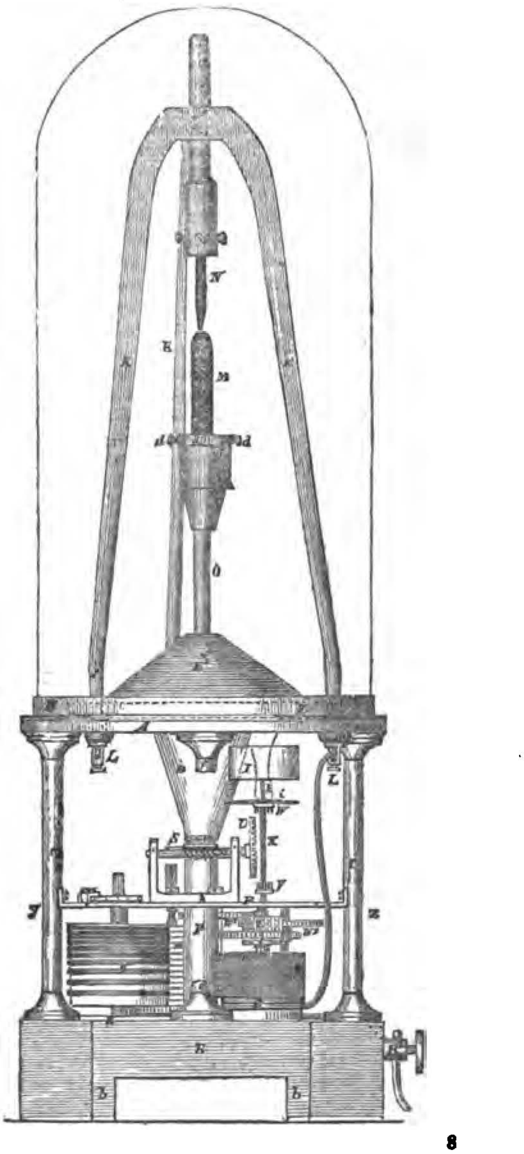
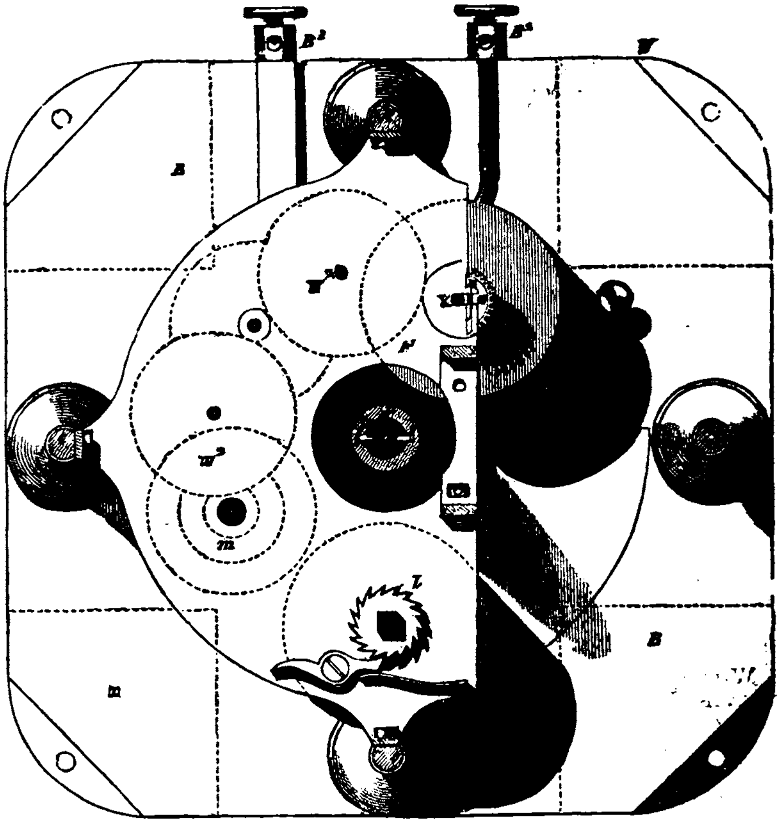


Fig. 1.



has a socket for receiving and holding the lower electrode M, at its upper end; and this socket is furnished with set screws for securing the electrode in an upright position in its centre, even though that electrode should happen to be of smaller size than the socket. At the bottom the socket is made of a conical form, in order to keep the lower end of the electrode steady and concentric, so that it may be properly adjusted by the set screws, *d d*. This shaft O has a smooth straight part, below its socket, for a length equal to the distance between the apices of the fixed cones, C and D, which is equal to the amount of rise which the shaft admits of, to compensate for the wear or shortening of one of the electrodes, while the light is in action; this smooth part of the shaft moving freely through the hole in the apex of the upper cone. Below this smooth part the shaft is continued for an equal length, screwed; the threads of the screw giving about one-twelfth of an inch of rise for every turn. This screwed part works through a nut *e*, which is set tight in the apex of the under cone D, and passes down the centre of a hollow cylinder or tube P, which is slotted internally (as shown at *f f* in figs. 2 and 3). A little cross piece of metal, Q, is set tight on the bottom of the shaft O, by being screwed fast into its end, and this cross-piece Q (which is afterwards more particularly described) fits across the tube P, taking into the slots or grooves on each side, so that it can slide up or down in them. When, therefore, the tube P is made to revolve, it carries the shaft O round with it, by means of the sliding cross-piece Q, and makes it to rise or sink by its screw working in the fixed nut *e*, so that the shaft O, carrying the electrode M in its socket, has a rotary motion combined with its vertical motion, for the purpose of equalizing the wear of the electrodes on all sides. The tube P turns on a pivot *g*, which works in the bottom of a circular box of metal H, which is screwed into a hole of sufficient size in the bottom of the brass-plate G, which is fixed to the upper surface of the wooden basement B. The touching surfaces at the pivot *g* are coated with silver, as that metal presents a surface peculiarly fitted for receiving the current of electricity. The upper end of the tube P receives the outer part of the fixed nut *e*, on which the tube turns, and is steadied as on an axis. On the upper part of the tube P, a worm-wheel S, carrying forty teeth, is attached, which is made to revolve by a horizontal double-thread tangent-screw T, the pitch radius of which is one-tenth of an inch. To one end of the screw is attached a crown-wheel U, carrying forty teeth, which is actuated by pinions V and W, on an upright spindle X. The pinions are at a somewhat greater distance apart than the diameter of the crown-wheel U, and gear into it from opposite sides, so that when the spindle X is raised a little, the lower pinion V (having eight teeth), is geared into the lower side of the crown-wheel; but when the spindle is sunk, the lower pinion is thrown out of gear, and the upper pinion W gears into the upper side of the crown-wheel; and the spindle continuing to revolve in the same direction as before, imparts a reversed rotation to the crown-wheel. When the spindle is kept at a medium degree of elevation, neither of the pinions is in gear with the crown-wheel, so that it remains quiescent. This spindle X is kept in its position by working through a hole in the middle plate, F, of the apparatus, which plate is attached firmly to three of the pillars *c*. The upper end of the spindle works through a hole in the centre of the bottom of a circular brass box I, which is fixed to the side of the under cone D, or to the under side of the main-plate A. The box I contains a centrifugal regulator Y, which consists of a bit of watch-spring bent into the form of the letter S, carrying two little weights *h h* at its ends, and fixed horizontally across the top of the spindle by the middle part of the spring, which fits into a cleft in the top of the spindle, and is secured by a small nut. When the spindle is made to revolve too fast, the weights at the end of the spring fly outwards by their centrifugal force, and begin to touch and rub against the sides of the circular box I, which friction checks the motion. This description of governor preserves the motion more uniformly than the ordinary sort of fly, which acts by the resistance of the air. Just below this centrifugal governor there is a cross-piece *i*, inserted through a transverse hole in the spindle X, so that when the spindle is at its medium degree of elevation, that is to say, when its two pinions V and W are neither of them in gear with the crown-wheel, the ends of the cross-piece *i* meet a stop *k*, which may project from any fixed part of the apparatus, such as the cone D, and so stop the revolutions of the spindle; while, as soon as the spindle is raised or lowered, the cross-piece *i* no longer meets the stop *k*, but passes over or under it, and allows the spindle to commence its revolutions just before one of the pinions gears into the crown-wheel. The spindle X is actuated and kept with a constant tendency to revolve in one direction by a toothed wheel Z, keyed on to it just below the middle plate F, and this wheel is driven by a train of wheelwork W', supported between the middle and bottom plates F and G, similar to ordinary clockwork, and which is driven by a spring in a barrel *l*, acting on a fusee *m*, driven by a cord or chain; or the wheelwork may have any other contrivance as its prime mover, as, for instance, a common barrel with a cord and weight. The wheel Z is of such thickness that the motion up and down, which the spindle X admits of, will not ungear it from the next wheel in the driving train.

Fig. 3.



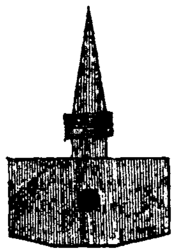


Fig. 4.

The mode in which the spindle X and its pinions are raised or lowered, so as to vary the motion of the crown-wheel U, and thereby of the electrode M, according to the exigencies of the light, is as follows:—The bottom of the spindle X terminates just below the driving-wheel Z, and rests on a plate of ivory *n*, which is supported on a short upright stem of brass *o*, which has its lower end screwed into a hole in the top of a solid cylinder of soft iron, *p*. This iron can move freely up and down in the central hole of a reel *q*, round which a quantity of insulated copper wire is wound: one end of this wire is led to the binding screw B, as before mentioned, which connects it with the positive wire of the galvanic regenerators, and the other end to the wire which passes through the binding screws L. The reel *q* of the regulator is fixed firmly to the wooden basement B, and a cap *r* of soft iron fits over it; but the iron of the cap does not extend quite to the centre of the hole in it (through which the brass stem o passes), the central part of the top of the cap being of brass soldered to the iron, of one-half of the diameter of the iron cap itself. The action of the electricity in the coil of the regulator R causes the iron centre p to rise or fall, according to the quantity of electricity passing, and in so doing, the spindle X, which rests on it, to rise or fall with it. There is a little eye attached to the bottom of the iron centre, to which is suspended a counterpoise F′ (an assortment of such counterpoises being kept for use), of such weight as to allow the iron centre to be just in equilibrium, or just ready to rise, when the distance between the electrodes is such as to allow the electric current to flow freely enough to produce a steady and certain light. There is also a little ledge s, around the lower end of the iron centre, on which rests a disc t, of brass, of about the size indicated in the drawing, fig. 2; which (when the iron centre falls below the neutral point) becomes supported around its outer edge by a circle of brass u, and is left behind on it, when the iron centre continues to descend, thus relieving it of its weight; while on the other hand, if the iron centre is disposed to rise above the neutral point, it has to lift the whole weight of the brass disc t. This arrangement gives the iron centre a tendency to remain stationary at the neutral point, which is that point at which the elevation of the spindle X enables the cross-arm i to come into contact with the stop k, and arrest the rotation, and so prevent unnecessary working of the machinery, until the electric current has varied so much as to render desirable an adjustment of the distance between the electrodes; which the iron centre effects, as before described, by rising or falling.

The neutral position at which the iron centre p should rest, is when the top of the iron centre is as far below the top of the regulator reel as is represented in fig. 2.

The brass ring u, which supports the equilibrium weight, that is the brass disc t, is secured at the proper height by being attached to a sufficiently stiff strip of brass w, of a certain length, and which is fixed by its other end to the other side of the wooden basement B. The brass ring u can be adjusted to the requisite height exactly, after the apparatus is made, by a milled-headed screw passing through the wooden basement, and screwing down on the supporting brass strip (not far from u), so as to depress it to the right position.

The sliding cross-piece Q, before adverted to, is constructed in the manner separately represented in fig. 4. A spring Q (of thin hard brass, for instance,) is attached to one side of the cross part by a small screw, so that when the cross-piece is placed in the slots of the tube P, the spring always remains in close though not forcible contact against the sides of the slots, so as to insure a good conduction to the electric current which has to traverse the shaft, and enter from the cross-piece into the slotted tube.

The tangent-screw T is made not quite horizontal, but inclined at an angle of one in twenty, because the lower pinion V is smaller than the upper one; and therefore it is necessary that the lower edge of the crown-wheel U should be tilted nearer to the axis of the spindle X. The lower pinion is made smaller, in order that it may the better wind down the main shaft O, after it has screwed itself up, until the ends of the electrodes come into firm contact, lest it should stick in that position.

The screw No. 1, which fastens the stand 3 of the tangent-screw to the middle plate F, passes through a hole 4, enlarged sideways in the stand; so that by only loosening the screw 1, the stand may turn on the other screw 2, as a centre, so as to allow of the tangent-screw T being adjusted to the right distance from the centre of the wheel S, in order that it may work properly into its teeth, or, when required, to throw the tangent-screw out of gear with it altogether.

The thread of the screw of the main shaft O, should be of a square form, so that it shall work with as little friction as may be, when supporting the weight of the shaft and electrode.

A cone of white glass or porcelain, E³, is made to slip over the upper cone C of the main plate, and is turned up at the edges (as shown in figs. 1 and 2), to reflect the light better, and to catch any dust and ash which may be thrown off from the electrodes.

A glass shade, which may be ground partially or not, as desired, fits over the electrodes, M and N, and the stand K, and is screwed down to the main-plate A, by the brass circle E, into which its lower edge is cemented, whereby the electrodes are enclosed entirely from the outer air. As soon as they have exhausted the oxygen which is within the glass shade, they are no longer so rapidly consumed. When the electrodes, however, are composed of some inferior sorts of carbonaceous preparations they give light more steadily if a very small quantity of atmospheric air is continually allowed to enter; that is to say, just sufficient to burn away the button of carbon which sometimes forms on the end of that electrode which is not undergoing decomposition by the electric current. When there are no holes in the glass shade to admit of a small quantity of atmospheric air, two light valves may be inserted in the main plate A, one opening inwards and the other outwards, which would provide for the varying pressure of the air when the temperature is altered by the presence or absence of the light within.

The coil of insulated wire of the regulator R, should be composed of wire of such thickness as to conduct the electric current quite freely. For an apparatus of the size represented in the engravings it may be about three-sixteenths of an inch in diameter; but if electrodes of a larger size are employed, the wire should be proportionally increased in thickness, and the regulator R, made as large as the dimensions of the apparatus will admit of, in order that the reel should take a sufficient number of turns of the thick wire; for with wires too thin, considerable heat is evolved from them when transmitting the current. Two circular brass weights, aa, fit one over the other around the ivory top nn, which carries the pivot of the spindle X; their use is to enable an easier and more precise adjustment of the weight on the iron centre than can be effected by altering the large weight F′, which is hung at the bottom of the iron centre.

When it is intended to use small currents of electricity, the spindle X, and all its appurtenances, should be made very light, and the iron centre may for the same object be made hollow with advantage; its sides, however, should not be less than one-twelfth of an inch in thickness.

The electric current may be obtained from a galvanic apparatus of any of the known sorts, or from any other convenient source; and it may be used of various intensities and quantities. A good degree of intensity to use, is such as would be afforded by one hundred cells in a series of the usual sort employed in galvanic apparatuses; and the quantity of the current may vary from that evolved by the consumption of less than one-and-a-half grains of zinc per minute in each cell, to that evolved by the consumption of more than fifteen grains of zinc per minute.

The wire from the positive, that is, the zinc pole of the galvanic apparatus, is clamped with the binding screw at B², which serves as the conductor through the regulator coil, and then up to the upper electrode N. The wire from the other, or negative pole of the galvanic apparatus, is to be clamped with the other binding screw at B³, which is connected by a slip of metal (copper) to the bottom plate G of the apparatus, so that the current passing from the lower end of the upper electrode N to the top of the lower electrode M, then traverses the central shaft O, passes through the cross piece Q, at its lower end, into the slotted tube P, and thence through its pivot at bottom into the metallic box or cavity H, which being in metallic connection with the bottom plate G, leads the current to that plate and thence by the slip of copper to the other clamp, from which it passes in return circuit through the negative wire of the galvanic apparatus. The current, when first applied with the electrodes in contact, flows freely, and that causes the regulator (being properly weighted) to raise the spindle X, and thus put the apparatus into gear for screwing the centre shaft O downwards, and gradually separating the electrodes, whereupon the light begins to appear between them.

The patentee then describes the method of preparing the carbon for his electrodes:—About equal quantities are taken of coal of a medium quality, and of the prepared coke, known as "Church's Patent Coke," and both reduced to a state of fine powder and intimately mixed together. The mixture is then placed in close wrought-iron moulds, which may be made either to give the mixture the form of a block, to be afterwards cut into pieces of the required shape, or to give at once to the mixture the form of the intended electrode. In all cases it preferred to make the moulded mass of not more than 3 or 4 inches in its least diameter, for when larger it is liable to have fissures, and not to be of such uniform density. The mixture being placed in these moulds, is subjected to heat and heavy pressure until it becomes consolidated into a very dense and firm mass. And when the mass is in a heated state it is plunged into sugar, melted by heat (without the aid of any liquid,) and kept therein for a short period. It is then taken out and allowed to become cold, when it is placed amongst pieces of charcoal in a close vessel, which is gradually heated until it attains a full red heat, after which the temperature is increased to an intense white heat; at which it should be kept for many hours, or even two or three days, according to the hardness and compactness desired. Or the mass may be a second time immersed in the melted sugar while hot, and the remainder of the process be again repeated as before.

By coating the mass in this way with melted sugar, any pores that may be in it (on its external surface at least), are filled up with carbonaceous matter, and any subsequent drying rendered unnecessary.

The following the patentee states to be the best dimensions for the electrodes:—The lower electrode should be as long as can be conveniently manufactured (8 inches for instance,) when used for ordinary purposes, and it should be of a cylindrical form. The smaller the diameter is, the better the light; but the larger the electrode is (in cross section), the longer it will last with a given current of electricity. The upper electrode need not be of any great length; it is well, however, to have it about one-third as long as the lower one, and of half the diameter.

The patentee concludes his specification with the following account of a method of employing currents of electricity to actuate apparatus for effecting the speedy lighting up and extinction or obscuration of signal lamps in which oil, camphine, or other like inflammable fluid is the illuminating substance employed:—Suppose, for example, there are three such lamps with different coloured glasses, say white, green, and red, which are required to be sometimes lighted, and at other times extinguished or obscured, as is usual on railways, and not all at once, but in a particular order of sequence, or each under particular circumstances only, I effect this in the following manner. The three coloured signal lamps are placed side by side, or they may be placed one above the other. A sectional elevation of one of these is given in fig. 5. A′ is a bar of

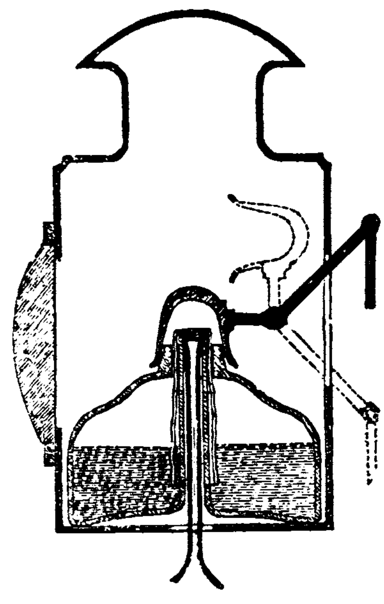


Fig. 5.

metal, having a drop bar B′, attached to it. These bars are for the purpose of working three extinguishers, one to each lamp. The figure shows one of these extinguishers as applied to a lamp; the dotted lines in the figure indicate the position which it assumes when raised up. The drop bar B′ is attached to a clockwork escapement, the detent of which is alternately retained and liberated by the passage of electric current, and by its mechanical force raises up the bar B′, and causes the light, in whichever lamp it may be, to be put out. The three extinguishers are made to move together, to save the necessity of each being provided with a separate extinguishing mechanism. In the centre of the burner of each lamp is a ring *a*, of fine platinum wire, which is so contrived as to touch the wick of the lamp, and the current of electricity being made to pass through this platinum ring, it becomes intensely heated, and thereby ignites the wick of the lamp. I do not restrict myself, however, to the employment of platinum wire, as carbon for this purpose may be used, or any other difficultly-fusible material; neither do I limit myself to the employment of a ring of any particular form. The wick may, for instance, be a flat wick, and in that case a straight piece of wire would be suitable for the arrangement.

ARTIFICIAL FUEL.

Bondy Azulay, of Rotherhithe, Surrey, printer, and Abraham Solomons, of London, merchant, for "*Improvements in the manufacture of charcoal and other fuel.*"—Granted June 10; Enrolled Dec. 10, 1847.

This invention relates, first, to the manufacture of charcoal, to avoid waste caused by breaking it. This is effected by reducing the waste to powder, and then compressing it, by an hydraulic press or other apparatus, in moulds, until the mass is reduced to from one-fifth to one-eighth of its original bulk.

The second invention relates to making fuel of small coal, breeze, coke, and cinders, with or without charcoal, by pulverizing the whole, and then compressing the powder into blocks.

The third invention relates to making a fuel for lighting fires, by mixing charcoal powder, small coal, breeze, coke, and cinders (all or any of them), with tar, pitch, resin, or other suitable inflammable substance, and compressing the mixture in moulds; and when taken from the mould, the block is dipped in the tar, &c., and covered with saw-dust and wrapped in waste paper: a block so prepared will readily ignite on the application of a lighted match.

WATER GAUGE.

Alfred Vincent Newton, of 66, Chancery-lane, Middlesex, mechanical draughtsman, for "*Improved apparatus to be applied to steam-boilers.*"—Granted April 15; Enrolled Oct. 15, 1847. (A communication.)

The principle upon which the apparatus is constructed is that of a percussive horizontal action of a flat surface upon a portion of the water to be gauged. One form of apparatus on this principle is shown in the annexed engravings, figs. 1 and 2, being an external view and section. *a*, the steam-boiler; *b*, a small cylinder

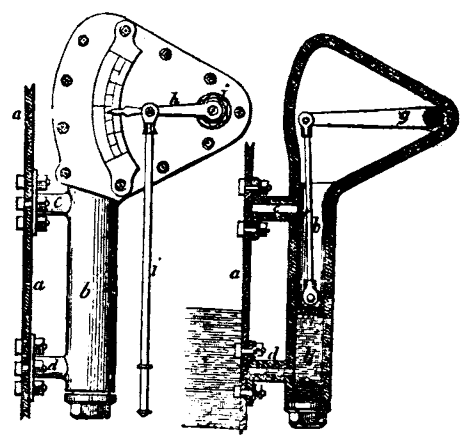


Fig. 1. Fig. 2.

communicating therewith by two tubes *c d*, the upper one with the steam, and the lower with the water; *e*, a piston, moving freely in the cylinder *b*, and connected by a rod *f*, to a vibrating lever *g*, enclosed in a quadrant-shaped chamber. The pivot of the lever *g* passes through a stuffing-box *j*, made at the small end of the quadrant, and carries externally another lever *h*, furnished with an index for indicating, on a graduated scale, the height of water in the boiler. A rod *i* is suspended from the lever *h*, for enabling the attendant to raise the piston in the cylinder, and bring it down with percussive force on to the surface of the water, in order to ascertain its exact height. It will be at once understood that the same pressure of steam and water must exist in the cylinder and its quadrant case as in the boiler, and that the working of the apparatus cannot be affected thereby.

ON THE IMPROVEMENT OF INLAND NAVIGATION.

By Hon. & Rev. A. P. Perceval, B.C.L.,
Chaplain to the Queen.

Chapter I.—*On the Comparative Prospective Value of Railways and Canals.*

In the month of December, 1844, while a party of travellers and traders were waiting at the Crewe Station the arrival of the up-train, and eagerly discussing railway matters, that mania being then at its height, they were startled from their propriety, by hearing an individual in the room address them thus: "Well, gentlemen, I will back the canals against the railways *now;* I intend to invest wholly in them, and I advise you all to do the same." If a pistol had been discharged in the midst of the company, it could hardly have produced a more striking effect. All stared; and most, by movement or ejaculation, gave token of extreme surprise. Some looked with pity upon the speaker, a clergyman, as though the saying, "*Ne sutor ultra crepidam*," was passing in their minds, and they contemplated one about to ruin himself and his family by meddling in matters out of his sphere. But when he proceeded to propound, for the consideration of the company, his grounds for the opinion which he had expressed, none were found ready to gainsay the reasonableness of them. They were these:

I. That the wear and tear on canals is so inconsiderably less than on railways, that the former, if properly conducted, must be able to undersell the latter.

II. That while lines of railway may be multiplied *ad libitum*, occasioning unlimited competition, and consequently unlimited reduction of profits, such multiplication of lines of water conveyance is almost physically impossible: consequently, that canals must always retain a comparative monopoly.

III. "Remember, gentlemen," he said, "that human talent and ingenuity have been taxed to the utmost to bring all the appliances that science can afford, to promote locomotion on railways; while, as yet, nothing, or next to nothing, of the sort has been attempted on canals."

Three years have elapsed since these opinions were expressed at Crewe: let us see what light can be thrown upon the soundness of them, by comparing, 1st, The present state of railways with its condition at that time; 2ndly, The respective condition and prospects of railways and canals, then and at the present time.

I. To take three old and well-established lines for illustration: The value of the under-mentioned was, in Dec. '44; is, in Dec. '47

London and Birmingham ...	„	228	„	150
Great Western	„	157	„	90
London and South-Western	„	77	„	50

II. Let us take for illustration the Birmingham Railway and the Birmingham Canal:

In December 1844, the Birmingham Railway furnished to the proprietors, not merely in actual dividends, the 10 per cent. (to which it had been sought by Act of Parliament to restrict the profits on railway enterprise), but advantages in new shares, &c.—in general estimation certainly not less than another 10 per cent.

We have now before us the Report of this company for the half-year ending Midsummer 1847; announcing in the plainest terms, that the second of the causes alleged at Crewe as a reason for regarding railways as offering doubtful security for investment, namely, the liability to unlimited competition, has begun to tell with fearful effect against the prosperity of this most prosperous of railway undertakings, which is no longer able to pay even the legal 10 per cent. The Chairman is stated to have said: "He hoped that before Parliament sanctioned any further extension of the principle of competition, or of reduced fares, they would bear in mind the inevitable results which must follow from pursuing such a course. They saw its effect upon their receipts now......... Competition might go on in consequence of rivalry and contention between different companies; but what would be the effect? The proprietors would interfere and force the directors to reduce the establishments of the two companies to the lowest possible point; trains would be taken off, servants would be discharged, the whole machinery of the companies would be deteriorated, and what would become of the public safety? This would be the result of those doctrines of competition which had been taken up by the legislature."—Here, then, we have the confession of the most intelligent of railway chairmen, at the head of the most influential of railway companies, avowing in the face of Europe that railways afford so insecure an investment for capital, that they cannot possibly be relied upon, unless in their behalf the doctrine of Free Trade, to which all mankind, to speak generally, have given in their adhesion, be repudiated; and an artificial protection be afforded to them, which has been denied, not only to the inland navigation, but even to the agriculture of the country!

Meanwhile, how has the Birmingham Canal been faring? In December 1844, in consequence of the railway mania, it had so fallen in public estimation, and apprehensive value, that projects for draining off the water, and converting the channels into railway beds, were seriously discussed.

We have also before us the Report of this Company for the half-year ending Midsummer 1847: from which it appears, that notwithstanding its operations have been impeded by a very questionable (in point of prudence) alliance which it has contracted with the Birmingham Railway, whereby it has placed itself, to a certain extent, under the control of the latter, on condition of receiving from it a guarantee, in perpetuity, of the customary dividend of £4 per share (a guarantee which it is doubtful whether the railway company would be able to make good, should the canal company ever be so reduced as to demand the fulfilment of it), and notwithstanding a "considerable pressure on the mercantile world," to which in common with the railway, it has been subjected, its affairs are in a state of unexampled prosperity. "The account for the last half-year," the Report says, "exhibits a considerable increase of revenue, the amount for the six months ending 30th of June last, including rents, being £86,425 7*s.* 3½*d.* [being an increase of £21,192 above the corresponding half-year in 1846]. The balance of the accounts, after providing for the payment of the half-year's interest, and the usual dividend of £2 per share (which the committee now recommend to be paid free from the income-tax), shows a surplus of upwards of £9,000."

In other cases, where the canal companies have not tied their hands from competing with rival railways, as the Birmingham Canal Company have done by their compact with the Birmingham Railway, the truth of the first of the reasons alleged at Crewe has had opportunity of being tested: and the result has been, to speak generally, to confirm and establish its truth; and Lord Ellesmere on his waters, and the Birmingham and Worcester Company on theirs, to name no others, can tell the world that they have ceased to dread any evil effects from railway competition, through fear of which the former received (according to report) from £80,000 to £100,000, by way of compensation; and the latter unprofitably expended several thousands in an abortive railway speculation.

It remains to be seen whether the third of the reasons alleged at Crewe in 1844, for preferring canals to railways for investment—namely, "that while human ingenuity has been taxed to the utmost to facilitate locomotion on railways, little or no attention has been bestowed upon the improvement of inland navigation,"—is as sound as the others (apparently) have proved to be: in other words, "*whether inland navigation is not capable of very great improvement.*" This shall be the subject of the next chapter: before entering upon which, let it be well-considered, by way of encouragement to turn attention to the subject, that *a very little improvement* will suffice to bring upon the canals the whole or almost the whole of what forms the chief source of revenue on many railways—namely, the conveyance of live stock. No grazier, or butcher, it is believed, will be found to affirm otherwise than that, if the choice were offered to him, he would choose rather to convey the stock that he has to sell, or kill, by water than by rail.

Chapter II.—*On the Improvement of Inland Navigation.*

When the mind has once been directed to devise means of rendering our lines of inland navigation more available than at present they are found to be for the commerce of the country, the small degree of attention which has as yet been bestowed upon them is apparent at every turn. Of the matters calling for amendment, some are obvious to every passer-by; others require consideration to be noted; others again require argument and proof. Again, some are in the power of the parties trading upon the waters; others in that of the proprietors or trustees of the waters; others again require either extension, combination, or the interference of the legislature.

I. Let those matters in which the want of amendment is manifest to all be first considered. Of such let these be named :—1st. *The style and condition of the animals* usually employed in the traffic. Generally speaking, these are the worst of their kind, disabled, low in condition, ill-groomed, ill-fed,—a striking contrast to those employed in land carriage.—2ndly. *The state of the trackways.* Natural earth, mud, water, deep sand, slippery chalk. Contrast these with the roads and ways employed in land traffic. By the sides of other roads care is taken to keep the cattle from trespass-ing; here nothing of the sort is attempted. On other roads, all gates, except in cases of extreme necessity, and then with some person to watch them, are carefully excluded. On these, there is usually a gate at the end of every field, the hedges running down to the water: as if a premium had been offered for the multiplication of causes of obstruction.—3rdly. *The attendance at the locks*, which correspond to the turnpikes on land roads. On land-travelling a turnpike-house is a necessary adjunct to a turnpike-gate, as close as possible. But where in water-travelling do we find lock-houses—or, if found, at what distance are they situated from the locks intrusted to the care of the occupiers?—4thly. *The construction of the bridges* so low down to the water, as to leave no room between them and it for an ordinary load to pass.

II. Among the matters in which the necessity of alteration will, probably, be admitted as soon as pointed out, are these:—1st. *The application of artificial locomotive power.* In this respect, it must be acknowledged that England is somewhat in advance of her neighbours, for she has attained to horse-power on trackways; whereas, in the inland navigation of the continent, when the wind fails, the means of locomotion usually had recourse to are either shoving with long poles; or ropes made fast to posts and drawn in by direct hand draught; or men and women yoked like brute beasts, with broad belts over their breasts, upon which (even women's breasts) the weight of the draught appears to be borne,—a sight sickening and revolting. England is in advance of these, and for such brute labour has applied brutes instead of human beings; but still only for direct draught: the living horse has as yet not been applied to leverage in this service [as is used in Canada]; nor have those cheapest and most obvious of all artificial powers, the water-wheel and the wind-wheel, been as yet applied for a purpose for which in so many cases they are so admirably adapted; nor stationary steam-engines, except in one or two instances. In a few cases, paddle-wheels have been called in, which, on many accounts, are the most undesirable of all for this particular service.—2ndly. *The construction of the barges:* first, as to their *material*, which, in almost all cases, now is of wood, more expensive, less durable, heavier, and more bulky than iron, to a very considerable proportion; secondly, so that the barge may float *on* the water, and not *below* its level, necessitating the drawing *through* it. What the specific gravity of atmospheric air is, seems a point not easy of solution, seeing that the barometer exhibits a perpetual fluctuation; but the specific gravity of water is stated on good authority to be 62½ lb. to the cubic foot. When it is considered that for every cubic foot of barge below the water-level, 62½ lb. weight of water has to be moved at every inch, one would have thought the attention of all concerned would have been directed to carry as much of the cargo above and as little below as possible. But, somehow or another, a diametrically opposite course is almost universally adopted: about three inches of the barge appears above the water-line, and all the rest is sunk below—so that the greatest resistance which the case will permit is carefully secured.—3rdly. *The means of ascending or descending from one water-level to another.* As yet, in England, we have attained only to the old lock, and that so constructed as to afford the chief cause of detention in water conveyance. The consumption of time, the strain upon the cattle, the wear and tear of tackle, now required in drawing a deep-laden barge into a lock, are well known to all who have to do with inland navigation. Yet, apparently, it requires little contemplation of a lock, to see how (even without altering the construction of the barges, and still dragging the goods *through* the water) an immense saving of time and labour may be effected, by a slight alteration: while the field for invention and experiment in perpendicular lifts and inclined planes is as yet almost unoccupied; only our neighbours in the United States of America have lately adopted one species of the former, while those in China have of long time very extensively employed the latter—of which some account and drawings are to be found in Lord Macartney's Embassy.—4thly. *The supply of water:* both in the saving it at the change of levels, and in securing supplies in dry weather, all must see how much remains to be done; while, few, probably, who apply their minds to it, will consider any great difficulty to lie in the way of improvement.

III. Of matters calling for improvement, which it requires argument or experiment to establish, it will suffice to suggest one, of a mechanical nature—which is, *the point of draught;* to which, at present, as far as appears, no attention has been paid; but which, it is hard to conceive to be a thing indifferent. But of this class, the most important is the jointed system of our lines of inland navigation—broken into short pieces, under distinct governments, like the turnpike trusts; but attempting against one another a system of injury, which the trustees of turnpike roads have, apparently, never contemplated. Between London and Birmingham, for instance, there are as many as four such, at least. It is in vain that one, two, or three of these concur in meeting the public convenience and their own general interests, by reduction of tolls or any other combined improvement, as long as it is in the power of the remaining portion or portions to profit by the reductions of the others, by either maintaining their own tolls at the unreduced rate, or even raising them in the face of the reduction of others; both of which cases are found not unfrequently to occur.

Chapter III.—*On the Formation of Inland Navigation Conveyance Companies.*

The only apparent method of overcoming the last-named difficulty in the way of the improvement of inland navigation—namely, that arising from the division of interests at work upon all our chief lines (apart from direct legislative interference, which is the last and least-desirable remedy,)—is the formation of conveyance companies throughout a whole line; offering to all the different navigation companies along the line, shares according to their mileage; and to all the parties already trading on those navigations, shares according to the amount of capital already embarked in this employment. By this means it should seem not merely practicable but easy to unite, for the common benefit of all, those interests, the confliction of which at present is found to be injurious to all.

The writer, who is a clergyman, and who has turned his attention to the improvement of this department of human industry, chiefly, or rather solely, with the view of making it subservient to the best interests, present and future, of mankind, has already in several quarters privately put forward suggestions for the formation of such companies, which have hitherto been generally favourably received;—he now desires to submit them more extensively to the consideration of his fellow-men, based upon this condition, which he has invariably exhibited—namely, *That provision for the spiritual and educational wants of all the employées of such a company, and of all who are called into being (by the encouragement given to marriage) by its prosperity—and also for their bodily wants, in sickness, accidents, and superannuation—shall form a first and necessary item of such company's expenditure to an extent not exceeding one-tenth of the whole.*

How extensively such a principle, if generally adopted by our great companies, would tend to the amelioration of society, and the comfort and well-being of all classes, drawing them together by the surest bonds of Christian faith and love, there can be no need of words to demonstrate. The more each man contemplates it in his own breast, the more (the writer believes) it will be found to commend itself, alike acceptable to God and approved of men.

Taking Birmingham as the centre of British industry, such companies may obviously with advantage be formed, respectively, on the following main lines, omitting for the present the consideration of the less important:—1. Birmingham, Worcester, Gloucester, and Bristol; 2. Birmingham, Chester, and Liverpool; 3. Birmingham, Manchester, Leeds, Halifax, and Hull; 4. Birmingham and London; 5. Birmingham and Chichester. Again, 6. Hull and Liverpool; 7. Hull and London; 8. London and Bristol; 9. London and Chichester.

To complete the line of inland navigation from Birmingham and the manufacturing districts to the British Channel, there needs but to connect the Grand Junction with the Colne, a cut of one or two miles, which falls into the Thames at Egham, from which the outlet is at Weybridge; and so by Guildford and Arundel. This at present neglected, but surely most important, line from London to the British Channel, either into Arundel or Chichester—that is to say, Langston harbour—is quite complete. By it, if a proper company were formed, and the commonest appliances brought to bear, goods discharged in either of those harbours could be landed at London-bridge easily within twenty-four hours, at a highly remunerative charge of ten shillings per ton, covering all. Thus, in time of war, all the hazard to our merchandise which the Duke of Wellington has prognosticated from French steamers in the little French ports, with the sun always on their backs, would be obviated, and the incalculable expenditure contemplated in the acknowledgedly-hopeless undertaking of making a Harbour of Refuge at Dover would be superseded. And at all times the risk of insurance from weather, the chief part of which from China to London is calculated on the passage through the Straits of Dover and round the coast of Kent, to say nothing of delays incalculable, would be removed. The present unoccupied harbour of Langston is of size to receive in safety the whole merchant fleet of the country. Again, by continuing the navigation of the Wey beyond Godalming in the direction of Alresford, and extending the navigation of the Itchin, with a cut of five or six miles to unite them, another line of inland navigation from London to the Channel would be completed; and by continuing the navigation of the Test or Auton to Whitchurch or Ash, with a cut of five miles to the Basingstoke canal, a third line would be completed: and Langston, Arundel or Littlehampton, and Southampton become the ports of London.

On the other side of the Irish Channel, conveyance companies between Dublin and Waterford (by the Barrow navigation, as thriving a water concern as any in the kingdom, and the receipts on which last year were greater than ever); and between Dublin and Limerick (by the Grand Canal, one of the finest in the kingdom, and the Shannon), obviously present themselves. A cut of three miles, or thereabouts, connecting the Slaney with the Barrow, would bring Wexford within inland navigation of Dublin. A cut of about the same length from the Grand Canal at Ballinasloe, into one of the small rivers that run into Galway Bay, would connect, in the shortest line, the Atlantic with the Irish Sea.

It is believed by the writer that every one of the twelve or fifteen lines here enumerated will be admitted by all practical men to present, if properly conducted, as safe openings for capital and industry as any in the kingdom.

REVIEWS.

A Guide to the Proper Regulation of Buildings in Towns, as a means of Promoting and Securing the Health, Comfort, and Safety of the Inhabitants. By Wm. Hosking, Architect & C.E. London: Murray, 1848.

Mr. Hosking's book may be taken as one of the signs of the times, and therefore we give our attention to it, and recommend it to our readers. The outcry for sanitary reform can no longer be unheeded; it has led to a practical movement, which must go on. The architects, engineers, and medical men, who created this movement, and have fostered it—and we rejoice that our publication has been found among the earliest advocates—may feel justly gratified that their proceedings have at length received the countenance and co-operation of the legislature. Those, however, who have held back, or thought that the agitation had no practical authority, and was merely a noise about trifles, must now bestir themselves, or they will be left behind by their more enlightened compeers. Obstinate adherence to old prejudices has already brought public ridicule on several men of standing; and reputations which have cost scores of years to build up are at once knocked down, when it is found that the parties have for scores of years been wasting the public money, in the despite of every warning. The public are now awakened, and they require at the hands of architects and builders a degree of knowledge as to structural arrangements, which formerly was never thought of. For all the better class of buildings it is no longer enough to run up a set of walls and to line them, but the buildings must be made habitable otherwise than by being mere shelters against rain. They must have proper provision for lighting, warming, ventilation, and sewage; matters about which employers and builders thought very little some years ago. The reports of the Sanitary Commissioners, the labours of Messrs. Roe and Phillips, the work of Mr. Hosking, are landmarks, whereby professional men may note the set of the current, and observe the disposition of the authorities to carry out to the full what used to be laughed at as the theories of sanitary reform. Mr. Hosking, of course, disclaims any official character for his book; but his station as one of the Official Referees for Metropolitan Buildings, will, in the eyes of the public, give an official character to his book in despite of himself; and most of what he says is so reasonable, that it will work its way with the legislature, the public, and the profession, all of whom his book interests.

Although it is perfectly true that the improved system of structural arrangements has arisen mostly from the labours of architects and engineers, yet it has not been fostered so generally among the profession as is desirable. Indeed, the public at this moment are ahead of architects and builders—a state of affairs which cannot long continue with comfort to the latter. This arises, we fear, from a want of appreciation of the value of professional literature, and therefore the want of a laudable spirit of investigation and information. If it be remembered that until our *Journal* was established, no architectural periodical had been able to maintain itself, this will show what the state of affairs formerly was; but though the number of years which this *Journal* has existed is a proof that we have effected a change for the better, we cannot but be sensible that architects are not so much alive as they ought to be to the cultivation of professional learning. To advert, as an instance, to our own publication, we feel well assured that by a great number of our readers our earlier remarks on sanitary and structural arrangements were passed over as being of no interest, or as not being immediately practical, because the reader did not take the trouble to investigate and search out for himself the truth or justice of our arguments. The consequence has been that many, instead of being gradually led and prepared to a practical appreciation of the subject, wake up as it were suddenly to a consciousness that they have got to learn a great deal immediately and with some trouble, which they might have learned slowly and easily. We have sometimes met with remonstrances because we have given attention to questions which were thought the whims of the day, but the importance of which is now recognised by all, though it should be remembered, that a periodical like our's is a link between the public and professional men, for those of the public who feel an interest in professional pursuits, or seek for information, naturally apply themselves to such a recognised source. Hence we have been enabled on many occasions to forward professional interests, and to awaken attention among the public, so as to insure co-operation in carrying out measures which were desirable. In reference to the present question of sanitary reform, however, it is particularly incumbent on professional men to apply themselves to it, or otherwise medical men and others will put themselves forward to secure, if they can, some greater share than fairly belongs to them in the new arrangements.

Mr. Hosking's book must be read by the architect and builder, because it is just the kind of book which will be read by the employer. The committee of a club who desire a superior house, the gentleman who wants a comfortable mansion, the merchant who requires a safe warehouse, the board of guardians who advertise for a healthy workhouse, are likely to look into the work before us, as a guide to the best modes of securing the health, comfort, and safety of a building. Perhaps Mr. Hosking has a leaning in favour of timber and against iron, and in favour of brick and against stone; but we hardly like to say this, for there is so much candour in stating the case, and so much practical knowledge displayed throughout, that we believe Mr. Hosking is about as fair a guide as we have yet had upon structural arrangements. There is very little of his book which is new, and it is hardly likely that there should be; but what there is new, is the careful and close consideration of what is the best and most practical mode of reaching any given end: and this may be called new, for we fear it is too general to run up buildings without the least consideration of their fitness for the purposes to which they are applied. It may be said shortly that the houses of the metropolis are made dangerous to life from their combustibility, and to health from their want of ventilation; while the sewers are so made as to form an elaborate machinery for poisoning the population, for cutting off the infant in its cradle, and taking years away from the life of every inhabitant of this immense and thickly-peopled city.

We have said that Mr. Hosking is unfavourable to the use of iron under some circumstances, and it will be useful to lay before our readers his remarks upon the subject. He says—

"There is no kind of economical structure that resists the action of fire so perfectly as brickwork does, and any structure wholly of bricks, set in and combined with proper mortar, may be deemed for all economical purposes a fire-proof structure. But floors and roofs, or roof coverings, cannot be formed in brickwork alone, without the sacrifice of space and materials, to so large an extent as to render such a mode of structure inconsistent with a due regard to economy in those important particulars. Means are to be sought, therefore, by which brickwork may be rendered available, to the greatest extent possible, consistently with economy of space, and, if it may be, of materials also. For this purpose iron presents itself as a substance wholly incombustible, and capable, in the form of beams and girders, of bearing over space horizontally, and so as to leave, for economical purposes, a large proportion of extent in height, which brick vaulting would absorb; and, requiring no such absorption of space as brick vaults require for their lateral abutments, iron, employed as a means of vertical support, in columns or story-posts, will give the requisite strength to that effect in far less space within an enclosure than brickwork requires in piers or pillars to give the requisite bed to the springings of vaults, and to carry the weight of brick vaulting. But iron, although incombustible, is fusible under the action of intense heat, and is, in its more economical condition, frangible if suddenly cooled when hot; without reference to its generally brittle character, or to the uncertainty which attends its manufacture, when applied in that condition. Beams, girders, and columns or story-posts, of wrought-iron, if such things could be produced in wrought-iron economically, would bend when exposed to a high degree of heat, and let down any structure that had been made dependent upon them; whilst beams or girders of cast-iron break when dashed with water; and columns of the same substance are liable to soften and yield, as well as to snap; in either and in any case, involving the ruin of the buildings, the destruction of the property confided to them, and danger to the lives of firemen or others within reach of the ruin.

So great is the danger apprehended from the treachery of cast-iron in buildings on fire, that the men of the London fire-engine establishment, who go unhesitatingly, in the execution of their duty, into burning buildings, are prohibited from going into parts or places which depend upon supports of cast-iron, whilst they are allowed to trust themselves to burning timber almost at their own discretion—a quality for which they are not, indeed, so remarkable as they are for headlong and gallant daring.

Cast-iron is constantly recurred to, nevertheless, as a means of economising space in the formation, and largely also in the support of the floors of buildings which it is desired to render proof against fire; and it is certain that the use of beams, girders, and story-posts of cast-iron tends to that effect: that is to say, the liability of the building to take fire is lessened by the use of iron in place of wood, but for the purpose under consideration—power of resisting the action of fire when it occurs to matters stored in a building, and is fed by such matters independently of the substances employed in the structure of the building—iron requires to be itself protected from the action of the fire."

Mr. Hosking goes on to suggest the mode in which iron can be safely used for floors and ceilings; but he adheres to the opinion that if pillars must be used, they should be of brickwork.

We ourselves have witnessed the danger of using cast-iron in exposed situations in buildings. We recollect, within the last four or five years, the fire at Fenton's wharf, London Bridge, where the warehouses were supported upon cast-iron bressummers, and which, through being heated by the fire, and the cold water of the engines falling upon them, were cracked, and in consequence the superstructure was obliged to be taken down. In other situations, we have seen the fronts of houses erected on timber bressummers which have withstood the ravages of the fire, an external coating of about an inch in depth of the timber being only injured by the flames.

The preservation of life from fire is an object in which Mr. Hosking deservedly takes great interest, and he has brought to bear the results of his remarks on buildings at Paris, which we wish we could transfer at some length to our own pages. After recommending that party-walls shall be reduced to one-brick thick, on condition of cross-walls or partitions being built throughout the house of one-brick thick, and after stating the danger of the hollow quartering partition generally used, he describes the system he observed in Paris.

"The plan referred to is, to frame and brace with timber quarterings much in the manner practised in England, except that the timber used in Paris is commonly oak, and is very generally seasoned before it is applied in building in the manner referred to; and that, as before remarked, the carpenter's work, or *carpentering*, of the French is not so good as that of the English. The framed structure being complete, strong oak batten-laths, from two to three inches wide, are nailed up to the quarterings horizontally, at four, six, or even eight inches apart, according to the character of the work, throughout the whole height of the enclosure or partition; and the spaces between the quarterings, and behind the laths, are loosely built up with rough stone rubble, which the laths, recurring often enough for that purpose, hold up, or prevent from falling out until the next process has been effected. This is, to apply a strong mortar, which in Paris is mainly composed of what we know under the name of plaster of paris, but of excellent quality, laid on from or upon both sides at the same time, and pressed through from the opposite sides so that the mortar meets and incorporates, imbedding the stone rubble by filling up every interstice, and with so much body on the surfaces as to cover up and imbed also the timber and the laths;—in such manner, indeed, as to render the concretion of stone and plaster, when thoroughly set, an independent body, and giving strength to, rather than receiving support from, the timber."

The same plan is applied in Paris to the stairs, and Mr. Hosking recommends it for adoption here. He likewise gives a detailed account of the French mode of making ceilings and floors.

"But the French render their floors also so nearly fire-proof as to leave but little to desire in that respect, and in a manner attainable with single joists, as well, at the least, as with joists framed into girders. According to their practice, the ceiling *must* be formed before the upper surface or floor is laid, inasmuch as the ceiling is formed from above, instead of from below.—The carpenters' work being complete, strong batten-laths are nailed up to the under sides of the joists, as laths are with us; but they are much thicker and wider than our laths, and are placed so far apart, that not more, perhaps, than one-half of the space is occupied by the laths. The laths being affixed—and they must be soundly nailed, as they have a heavy weight to carry—a platform, made of rough boards, is strutted up from below parallel to the plane formed by the laths, and at about an inch below them. Mortar is then laid in from above over the platform, and between and over the laths, to a thickness of from two inches and a half to three inches, and is forced in under the laths, and under the joists and girders. The mortar being gauged, as our plasterers term it, or rather, in great part composed of plaster of paris, it soon sets sufficiently to allow the platform—which, it will be readily understood, has performed the same office to the mortar which centering performs to the parts of an arch or vault—to be removed onwards to another compartment, until the whole ceiling of any room or story of a building is formed. The plaster ceiling thus formed, is, in fact, a strong slab or table, in the body of which the batten-laths which hold it up safely in the air are incorporated, and in the back of which the joists, from which the mass is suspended, are imbedded. By the process, the under surface of the plaster table has taken from the rough boards of the platform the roughness requisite to facilitate the adhesion of the finishing coat of plastering, which is of course, laid on from below.

Whether the eventual surface is to be a boarded floor or not, however, the flooring joists are covered by a table of plaster above, as completely as they are covered by a plaster ceiling below.—Rough battens, generally split and in short lengths, looking like ends of oak pales, stout enough to bear, when laid from joist to joist, the weight of a man without bending, are laid with ends abutting upon every joist, and as close together as they will lie without having been shot or planed on their edges, so as to joint them. Upon a rough loose floor thus formed, mortar of nearly similar consistence to that used for ceilings, but not necessarily of the same good quality, is spread to a thickness of about three inches; and as it is made to fill in the voids at the ends and sides of the floor-laths upon the joists the laths become bedded upon the joists, whilst they are to some extent also incorporated with the plaster, and the result is a firm floor, upon which, in ordinary buildings, and in the public and commoner apartments of almost all buildings, paving-tiles are laid, bedded and jointed in a tenacious cement to form the working floor.

It may be added in explanation of the statement, that in Paris the practice of forming a table of plaster over the joists when tiles are to be used as the flooring surface, is employed also when a boarded floor is to supervene,—that as the surfaces of the true joists lie under the mortar or plaster table, a base is formed for the boards of what English carpenters would call stout fillets of wood about 2½ inches square, ranged as joists, and strutted apart to keep them in their places, over the mortar table, to which they are sometimes scribed down, and that to these fillets, or false joists, the flooring boards are secured by nails; so that in truth the boarded floor is not at all connected with the structure of the floor, but is formed upon its upper coat of plaster. The wooden floor thus becomes a mere fitting in an apartment, and not extending beyond the room nor over the passages and landings to the stairs, the floor in any room might burn without communicating fire to the stairs, which, in their turn, if they could burn, could hardly endanger the immediate safety of any inmate of the building, because of the complete separation which the tiled and plastered floor of the landings effects between the wooden stairs and the several apartments."

The author remarks that a similar floor is used at Nottingham, where the houses are said never to be burnt, and are free from damp and vermin.

Mr. Hosking objects to timber being laid bedwise in walls, or joists being let into them, but recommends that the rafters be let in and properly secured against fire.

We may observe, upon a note of Mr. Hosking's as to Flemish bond, that he says he never saw Flemish bond in Flanders, at Rotterdam and the Hague, Antwerp, Brussels, Liege, Cologne, Mentz, and Frankfort. Now there is only one of these towns in Flanders, and this is no proof that Flemish bond is not to be found at Ghent, Bruges, Courtrai, Ostend, Ypres, Dunkirk, Lille, or other towns in Flanders.

Of French carpentry, Mr. Hosking says that it is much behind our's, so that in framing the floors no important bearing is, or indeed may be, trusted to the framed joint, dognailed stirrup-straps of iron being always brought in aid. He says, however, that their boarded floors are always tongued in the joints, and almost always parquetted, and so resolved into compartments of various figures, and being tongued and edge-nailed, no nail or bradheads appear upon the surface to dot over and disfigure the floors, which being for the most part of wainscot, are far more sightly than the best executed deal battened floor with us.

With regard to Parisian masonry our author states,

"It is by means of the girder bearing upon the solids of the walls, though with bad carpenters' work, or *carpentering* rather, that the French are able to carry up their soft stone rubble walls to heights that would frighten even a London builder, and that would certainly be unsafe if the walls were seamed with wooden plates, and shaken by floors of single joists. The author, being at Paris in 1846, measured the thickness in the ground-floor story of a newly-built coursed-rubble party-wall, in the Rue de la Banque (the Gresham Street of Paris), and found it to be exactly 18 English inches in that part, whilst the total height of the wall was not less than 85 feet. The wall ran up of that same thickness through six stories, a height of not less than 65 feet, and was terminated by a gable of from 12 to 15 feet high, of the same kind of structure; and there was besides a vaulted basement story, throughout which the wall might have been 20 inches thick, as other similar walls then in progress to neighbouring buildings proved to be. And it is by means of the solidity given to the floors by the girders, and the solid bearings which the girders obtain, that the floors are able to carry the dead weight of matter which renders them practically fireproof, in addition to the moving weights to which the floors of buildings are necessarily exposed to use."

Among Mr. Hosking's objections is that to the use of concrete as a mere footing for walls, from the notion that a foundation is thus rendered strong by depth; whereas he advocates the use of a thinner layer of concrete over the whole foundation, so as to gain strength by an increase of base.

Another objection he entertains is to the wooden skirting-board, which causes filth, discomfort, and danger, as it is often too close to the chimney flue. He also considers that the deep boxings for window shutters gratuitously make a house more inflammable, and he recommends metal roller-blinds instead.

We do not think Mr. Hosking dwells too much upon the precautions to be taken against fire; and if any of our readers do, we recommend to them the following justification:—

"It appears from an estimate appended to a Report by Mr. Fairbairn on the Construction of Fireproof Buildings, with Introductory Remarks by Mr. Samuel Holmes, published at Liverpool in 1844, that the insurance-offices paid for losses by fire in Liverpool alone, in the ten years ending December, 1842, the sum of 1,121,427*l.* This sum does not, of course, include the losses of, and other injuries to, the poor who do not insure, but who are always great sufferers in cases of fire; and some of the fires which occasioned the losses were extensive conflagrations, in which lives were lost in the attempts made to subdue the fire; nor does it include a probably large amount of property not sufficiently insured to cover the losses.

Urged by successive calamities by fire, and by the high rates of premium which the insurance offices were compelled to exact to enable them to meet the losses, the people of Liverpool applied to Parliament at length, and obtained, in 1843, an Act to compel themselves to abide by certain wholesome regulations, as it regarded the security of buildings from fire. The effect of this Act, 6 & 7 Vict. c. 109, and the provision of a supply of water available in case of fire, has been to reduce the rates of insurance considerably; but the protective measures are estimated to have cost from 200,000*l.* to 300 000*l.*, which being added to the losses above stated, with a trifling addition for the losses not included in the estimate, will show an annihilation of property in one town alone, and within ten short years, to the enormous amount of a million and a half of money."

The author is not quite clear upon the subject of ventilation—but then it is in its infancy: still his remarks are well worthy of perusal.

In conclusion, we may observe that Mr. Hosking has rendered a great service to the profession by the publication of this book, as a useful work of reference, and as a vindication of the practical claims of the architectural profession to their proper share in structural arrangements.

Railway Practice. By S. C. Brees, C.E. London: Williams and Co., 1847. Third and Fourth Series.

These are two large volumes with a profusion of plates, forming the third and fourth of the series of railway practice. They are translations from the *Portefeuille des Chemins de Fer*, by Messrs. Perdonnet and Polonceau, but derived from English materials. It is a curious thing that we should be indebted to the French for the description of our own railway works, and that there should be a want either of enterprise or zeal to publish an original account. So it is however that we are particularly deficient in accounts of our great engineering works, and this from three causes: that our great engineers have no time to write, that our young engineers have no ability to write, and that engineers generally do not buy nor read works when published. Thus we are often served at second-hand with accounts of our own works by Frenchmen, Americans, Germans, or Russians, and after the experiment has been made abroad, we get confidence enough to make a trial here. We are, perhaps, the more indebted under such circumstances to those who, like Mr. Brees, take the trouble and the risk of making us acquainted with our own works. In the present instance, we have from Mr. Brees two volumes, which will be found invaluable as records of the best practical examples of railway engineering. If we have any fault to find it is that he has not sufficiently reduced the French measurements, a labour which if performed by him or his assistants would have saved that of his readers.

The third volume is devoted to earthworks, permanent way, blocks and sleepers, rails and chairs, with turn-tables, sidings, and switches. The fourth volume describes stations, carriages, trucks, water cranes, and station plant.

When we say that there are more plates than text, we think we offer a very strong recommendation of the work to the practical man. These plates too are filled with details, so that nothing is wanted to give a correct idea of everything described.

Among the plates are:—The forms of every kind of rail in use in England and elsewhere; machinery used for making rails; navigators and platelayers' tools; switches on various plans by Robert Stephenson and others; turntables of the London and North Western, Midland and Great Western railways; locomotive turntable; weigh-bridge; level crossings and gates; double and single hoist bridges; crossings for temporary works; earthwagons of the London and North Western and Great Western; Mr. Jee's Garton station on the Manchester and Sheffield; bridges over the Wear, Clyde, and Meuse; viaducts on the Manchester and Sheffield, and Manchester and Leeds; culverts on the London and North Western. Among the carriages are those of the London and North Western, Birmingham and Gloster, Great Western, of French, German, and Belgian railways, with details of the wheels, axles, frames, buffer-springs, and breaks. These plates of carriages include passenger and mail carriages, horse-boxes, trucks and goods wagons. This part is of particular value at a time when the influence of the carrying stock on the structure and working of a line is the point which most affects the engineer. As the plant increases, and the necessity for economy in the working becomes greater, the attention of the engineer is well bestowed on a knowledge of the best construction of carriages, and the most efficient means of improving them. Hitherto very much attention has been given to the locomotive, and to systems of atmospheric traction, but a more immediate reference to the load to be carried is the point to which the engineer will for some time have most to direct himself. The establishment of lighter engines and smaller trains will call for a great deal of ingenuity to provide plant suitable for such a different system of traction.

Mr. Brees gives many examples of large stations and their details. Among them are the South Western at Nine Elms, the Euston-square terminus, the Birmingham terminus, the Nordbahn station at Vienna, the Brunn station on the latter line, stations at Versailles and Pecq, the terminus of the Versailles line at Paris, the Dublin and Kingstown terminus, and the Leeds station. Besides these leading termini and stations, plans are given of intermediate stations, as Tring, Watford, Wolverhampton, Newton, and Coventry, on the London and North Western; Thames Ditton, on the South Western; Reading and Slough, on the Great Western, and numerous places on foreign lines. Many of these stations, as those on the Paris and Rouen, are the work of English engineers, and it is gratifying to perceive that many details introduced by them have served as an example to their foreign brethren. The study of the foreign plans by English engineers will enable them to return the compliment, because the experience and ingenuity of the many men of ability employed abroad cannot fail to be productive of many valuable improvements.

In conclusion, we can only repeat what we have said in the beginning, that Mr. Brees's work will be found most useful to the engineer. It is a repertory of every practical detail connected with railway works, and it has the advantage of presenting copious examples under every head of reference. With these words we commit the work to the hands of our readers, being fully satisfied that it is well worthy of their support.

Designs for Schools and School-Houses, Parochial and National. By H. E. Kendall, jun., Architect. London: Williams and Co., 1847. Folio.

Next to churches, schools are perhaps the class of buildings most in request, owing to the necessity that is felt for providing education for the poorer and humbler ranks of society. Numerous buildings of the kind have accordingly been founded and erected of late years, yet very few are so satisfactory in point of design as they might have been rendered, at the same, or very nearly the same cost, merely by the application of a little study and judicious taste. Or if it be deemed of no moment of what kind the taste shown in such structures be, it is safer as well as more economic to attempt nothing more than what utility absolutely demands. We agree with Mr. Kendall when he says, "although some of the national schools lately erected are very creditable to their respective architects, the general result of the great movement apparent in the building of churches, schools, &c., redounds rather to the honour of resuscitated zeal than to that of architectural talent. So great is the tameness, and so apparent the mediocrity of conception, both in arrangement and style, in many of them, that were it not for the good they effect, we should regret their very existence." As regards the utter tastelessness frequently shown in things of the kind, blame rests as much with the employers as with the employed, since it is the ignorance of the former—their incompetency to judge of designs submitted to them, together with their childish determination to exercise the privilege of pleasing themselves without being accountable to any one for what they do—that encourages so much paltry design. The *tel est nôtre plaisir* will not excuse deformity in the eyes of others, who will in turn exercise their own privilege of expressing censure and ridicule where they are deserved—a consideration that ought to be seriously taken to mind by those who have the directing of far more important edifices than school-houses.

"Something of external comeliness"—we again quote from the preface—"should be assigned, as matter of course, to the humblest of such erections; and, under the direction of good taste, usefulness of purpose and beauty of design may be made mutually to subserve to each other, even when the latter is but a secondary consideration." It may be further observed, that it is not so much positive beauty as well-marked character and effectiveness of *ensemble*, that ought to be studied for buildings in which a certain degree of homeliness is no more than becoming. And this has upon the whole been well accomplished by Mr. Kendall—though, as was to be expected, more happily in some instances than in others. The collection consists of both executed and unexecuted designs, each of which is shown in a perspective or pictorial view of it, as well as by a plan and elevation; and there is also letter-press to each subject, containing remark as well as mere explanation. The unexecuted designs are five in number; the others are those of the following buildings which have been erected by the author: Childerditch School, Essex; the Poor Boys' School, the Poor Girls' School, and the Commercial School, all at Bury St. Edmund's; the building for the Battle and Langton National Schools, at Battle; Willesden School; and the Infant School at Stanmore, which last is said in the account given of it to have been erected in 1845, "at the sole expense of Miss Martin, a lady distinguished during her residence in that beautiful village for her benevolence and extended charities."

All the designs may be designated Old English in style, although it is not that of one and the same period; nor do they all show the same mode of construction, some of them being in imitation of the "half-timbered" houses, others of red brick with stone dressings and quoins. The Elizabethan style has been applied very happily in what strikes us as being the best design of all—namely, the school buildings at Battle, in which, while the character of the style itself is not only well kept up but expressed with gusto, the character of the particular kind of building is most unmistakenably pronounced. Although perfectly regular, both in the arrangement of its masses and the features of its elevation, the whole composition, as shown in the perspective view, is pleasingly varied and highly picturesque, yet sufficiently sober withal. The last subject, design No. 5, shows a rather extensive and complex group of buildings in the Tudor style, and in perspective makes a very picturesque composition. Independently of the interest and merit of the designs themselves, the artistic skill displayed in the pictorial representations of them cannot fail to excite admiration. They are very superior productions of their kind,—studies of trees and figures as well as of buildings. Owing to which, to the subject itself, and to the tasteful manner in which the work is got up in every respect, we may anticipate for it a highly-favourable reception even among those who hardly make any pretensions to amateurship in architecture.

HISTORY OF ARCHITECTURE.

We have received the following communications in reference to Mr. Elmes's papers, and which we lay before our readers:—

Sir—In your *Journal* for November last, page 338, there is a statement which, I fear, may lead some of your readers into error. In the life of Stuart it is said, "Preparations for his works were made with such rapidity, that in 1768 they were presented to the public under the title of 'The Antiquities of Athens, &c. &c.' 4 vols. folio, 1768." Now, the First Volume was published, as my two original copies show, by Haberkorn, in 1762, and nothing is said in the title-page of four volumes (although in the body of the work two more volumes are referred to, and *two* only); it is distinctly marked Vol. the First. Vol. II. was published by Nichols, in 1787; Vol. III. also by Nichols, in 1794; and Vol. IV. by Taylor, in 1816—that is, not till 48 years after the time above referred to.

In page 340, in the life of Sir Robert Taylor, is one of those commonplace and sweeping attacks so constantly directed against the late Building Act, and in which I never did, and do not now, join. That it had some defects, as well as some omissions, I am free to own, as well as that in these respects it required alteration —perhaps in no respect more than in its provision for the payment of expenses of party-walls by the owner of the improved rent, a term which the result proved to be alike uncertain and unjust. But that it was infinitely better as a whole than its successor, is, I believe, now almost universally admitted, and I could wish those who so lavishly condemn the late Act in the bulk, would condescend to explain more fully those particular parts of it against which their attacks are directed, or to which they object.

A Constant Reader.

Sir—The series of articles entitled a "History of Architecture in Great Britain," contains some opinions and remarks that appear to have been uttered rather hastily. I hope, therefore, you will allow me to animadvert on what ought not, for the interest of art, to be suffered to pass uncontradicted.

To begin by correcting some of the mistakes:—The design of the India-House is attributed to Jupp, the Company's surveyor, who was only employed to execute the works, the design itself being by Holland, as is explicitly stated in the biographical article on the latter in the Supplement to the "Penny Cyclopædia." Jupp certainly does not appear to have been of any note at all in his profession, therefore it is not very likely that he was the real author of the edifice; or at any rate, if such claim was to be substantiated for him, that of Holland ought to have been not overlooked but formally set aside.—In speaking of the College of Surgeons, Mr. Elmes describes in the present tense the original front, or rather the portico as it originally existed previously to the front being extended and re-modelled by Mr. Barry, who, he says, added two columns to the portico; were which the case, it either must have been at first only a tetrastyle, or would now be an octastyle one. The fact is, that instead of adding, Barry merely transposed two of the columns, taking them from the west end of the portico, and putting them at the other, thereby making what had been the first intercolumn from the east, the centre one, and so bringing it into the axis of the lengthened façade. He also fluted the shafts of the columns, and carved the bed-mouldings of the cornice. The writer's opinion of the College of Surgeons in its original state, appears to be infinitely more favourable than discriminating, he being pleased to refer to it as an "example of the genius of this tasteful architect," viz. Dance,—whereas, as designed by him, the whole front was a most barbarous and vulgar parody of the style affected for it. So far from the columns being "tastefully adapted" to the building behind them, there was no sort of adaptation at all, nor the slightest coherence in regard to character between the main building and the portico. Many may be unable to recollect what sort of figure the original front cut, but views of it are in existence, which assuredly strongly contradict the praise which Mr. Elmes has implicitly bestowed upon it.

With regard to the front of Guildhall, by the same "tasteful architect," we are told apologetically that it "is amenable to no laws." That, notwithstanding its aiming at Gothic or something of Gothic character, it is so far from conforming with as to violate its leading principles. Yet that might have been excused, had but consistent and artistic expression of its own been imparted to the façade. Though evidently very reluctant to admit anything to the disparagement of Dance, even Mr. Elmes is obliged to abandon the exterior of Guildhall to unmitigated censure and ridicule, and remark that its "faults are more than compensated for by his well-proportioned, original, and elegant chamber for the Common-council, &c." Admitting that the latter were very greatly superior to what it actually is, it would not indemnify for the positive and striking ugliness of the exterior, which of course stamps the character of the building in general opinion, and is so radical a defect that it admits of no cure short of an entirely new façade; whereas any defect or falling-short internally in such an apartment as the Common-council-room might have been easily remedied at any time.

In his quality of historian the writer has fallen into a most glaring mistake when he says that Jeffrey Wyatt was selected by William IV., as his chief architect, to enlarge and embellish Windsor Castle, it being notorious to every one, that he was employed by George IV., at the time of whose decease the works were advancing towards completion, for he had begun the new apartments. Equally notorious is it that it was George, not William, who changed the architect's name to that of Wyattville.

Wilkins is not treated very indulgently by the historian; on the contrary, is spoken of with a degree of asperity that contrasts rather strongly with the evident disposition to touch as gently as possible upon the delinquencies of many other architects Though the general estimate of the abilities and taste of Wilkins may be acquiesced in, it seems to have been dictated by the determination not to spare him. That he was more of the scholar and archæologist than the architect—far more of the "bookish student" than the artist—is not to be denied. As to Wilkins' pedantry, that charge against him is, no doubt, founded mainly upon his having written and published so much as he did; whereas, had he never taken up the pen at all, he might have been equally pedantic in practice, without incurring the reproach of pedantry. Downing and Haileybury colleges may be abandoned to censure, as equally frigid and tasteless in point of design; but an exception from the general sweeping condemnation ought assuredly to have been made in favour of the London University College, which exhibits both classical and artistic character, and very effective play of outline. Undeniable it is that it has, even in its present imperfect state, obtained the meed of almost unqualified—not to say exaggerated—admiration from Wightwick and other professional men. Even Mr. Elmes himself did not always entertain so mean an opinion of that work of Wilkins as at present; or if he did, he thought proper to keep it to himself, for speaking of it about the time it was erected, he says: "The council obtained designs from several architects, and after due deliberation, finally adopted that of William Wilkins, Esq. R.A., a selection in which their own judgment coincided with that of almost every proprietor who inspected the drawings." This goes far to prove that, at all events, the choice was not a hastily, inconsiderate one, or managed with suspicious secrecy. Neither is there a single remark of the writer's expressive of dissatisfaction with it. Yet he now speaks not a little contemptuously of the building, without condescending to specify other objections than what is meant to be so overwhelming a one as to outweigh all beauties and merits, namely, that "the portico is, from its situation, but of little use"—nay, "a useless application, stuck up for the admiration of gazing cabmen and hackney-coachmen, whilst loitering on their stand." With what sort of reason is the loggia at the south-west angle of the Bank so highly extolled immediately after Wilkins' portico being decried? it being nothing more than a piece of decoration which does not even carry with it any semblance of usefulness.

Of Wilkins' style it is said that it was "the very mummy of the art;" yet, if it was, he unbandaged it when he designed the building in Gower-street, for even in its present imperfect state it displays no ordinary merit in regard to grouping and the fine focus produced by the central mass. As an example of a decastyle, the portico is unique among those in the metropolis,—a circumstance which an impartial and unprejudiced critic would at least have noticed;—and it acquires additional expression and stateliness from being elevated on a substructure that forms flights of steps leading up to it, which are very picturesquely disposed. In this latter respect, too, the composition may be said to be unique—certainly is very striking and artistic. As to the dome, it is of most elegant contour and design; and if it be objected to that it is a feature unknown to pure Greek architecture, the objection is a proof that those who make such futile objection are still more straitlaced and pedantic in their notions than Wilkins himself. The value of it in the composition is such that were it removed the whole would become comparatively tame and spiritless. The portico in the east front of St. George's Hospital affords another proof that the "mummy" was occasionally unbandaged. That square-pillared tetrastyle partakes more of architectural heresy than pedantry. Still the heresy, if such it be, is a welcome one, and it has been welcomed by being adopted in the façade of the new Law Courts at Liverpool, where the columniation is carried on, on each side of the central portico, in square pillars; therefore producing contrast and variety, at the same time that continuity of design is kept up.

It begins to be time to bring to a close this long letter, wherefore I will be somewhat brief in regard to what is said of Soane. As criticism, it is far more indulgent than discriminating, or in some respects even intelligible. At any rate, it is somewhat puzzling to make out what is meant by his buildings at Chelsea Hospital, and the National Debt-office, exhibiting "a wild exuberance of novelty," since so far from any thing like exuberance, they exhibit only very unequal and fitful attempts at it. His building at the Treasury, the Royal entrance to the House of Lords, and "some *others* of his *earlier* works"—though the two just mentioned were almost his very latest—are said to show "exuberance of fancy"—a mere complimentary phrase, for his fancy was in reality exceedingly limited It exercised itself only on one or two piecemeal ideas, which he dragged into all his designs, without making any thing more of them at last than he had done at first. Soane had no consistency of style,—did not even attend to keeping, but often jumbled together the most finical ornaments and the plainest features. In his building at the Treasury, the windows were as ordinary, bare, and frigid in design, as the order was rich. There was not a single touch of Corinthianism in them.

In speaking of the Lothbury Court at the Bank, Mr. Elmes again falls into inaccuracy, describing it not as it is, but as it was intended, for instead of their being two loggias there is only one, what was meant for the west one being left unfinished—a mere open screen of columns, if that can be called a screen which exposes to view most unsightly naked brick walls and mean, ugly windows. Even the opposite finished side of the court is very unsatisfactory, the interior of the loggia, though pretty enough in itself, by no means corresponding to the sober richness and dignity of the order. As to the Rotunda, it is most vilely disfigured by the equally barbarous and nonsensical wavy lines around the arches of the recesses, which seem to have been made by a stick upon some soft material while it was moist. It is admitted that the centre of the south front of the Bank "is by no means the happiest of Soane's designs," and that is treating it far more tenderly than it deserves, for it is such a decided failure and abortion that it ought to be subjected to the same process of rifacciamento as his Treasury building has been.

Zero.

DISSERTATION ON TORRENTS.—By Guglielmini.

Translated by E. Cresy, Esq., *in his Evidence before the Metropolitan Sanitary Commissioners.*

I come now to the propositions of Guglielmini, in which he pretends that a body descending an inclined plane, will not acquire a velocity greater than it would have acquired by descending perpendicularly the height of the inclined plane.

This is most true as respects solids. The elements of a solid being bound and tied together, form a heavy mass, the parts of which press each other reciprocally, and the pressure on the plane on which they rest is likewise single, as also is the direction; one velocity, one energy, and one action being common to all the parts. On the other hand, a fluid is a mass composed of lesser solid elements, but free, and not bound together by any ties, each of which can, so to speak, move in different directions and with varying velocities, press upon each other and oscillate freely. Whence the highest parts press upon the lower, oscillate, and are easily displaced when there is no impediment. When solids descend by a plane, their individual gravity alone operates; which being less than their absolute gravity, generates, at each instant, a degree of velocity less than that which their absolute gravity would have generated, wherefore solids require a longer time to descend by the inclined plane than by the perpendicular, the length of time multiplies the action of the individual gravity, and compensates for the defect of the velocity. Wherefore a solid descending by an inclined plane, has a velocity equal to what it would have, falling the same height directly. Hence the product of the action of the individual gravity, by the time of the descent by the inclined plane, being equal to the product of the absolute gravity, by the time of the fall along a perpendicular, their velocities must necessarily be equal. But in fluids the case is different. Besides the properties which they possess in common with solids, they have another, to wit, the pressure exercised by the upper on the lower part of the fluid, the which being added to the impact, increases the motion also, and hence generates a greater effect than a solid would. Neither is it absurd to suppose that the gravity of a fluid generates a greater velocity on a plane, than when acting perpendicularly, since this generates in greater time, and with a portion of gravity which in a solid which falls remains, so to speak, idle, but, in the case of a fluid, becomes active. John Bernouilli, in his works, gives a problem to find the velocity generated by a body sliding on the hypothenuse of a triangle, whose base is sustained by a smooth horizontal plane, free from any sensible friction, and moving in the direction of the base. He decomposed the force pressing the hypothenuse, or inclined plane, into two parts, one of which is employed in giving motion to the triangle, and sliding it forward; whilst the body descends on the plane, advances the triangle, and communicates thereto a certain rate of velocity; the descending body thus requires a velocity equal to that which it would have in falling perpendicularly, and the triangle has another force generated by that which presses it, whence it results that the sum of the two motions is greater than that which a body would acquire by its simple descent. Wherefore, since the aforesaid force by pressing, generates velocity and motion distinct from that which a body, in descending, generates; in like manner it is applicable to water pressing on the lower films, and by pressing, communicating additional force to them. Besides, there are other reasons corroborative of this truth, among which is the fact, that it is necessary to spread the accelerated velocity of water passing from a larger to a narrower section over a mean of pressure.

Galileo says, "I have been carefully considering and going through various problems to investigate the acceleration of water having to pass through a narrower channel, also whether it has the same declivity in both." The greater number of authors solve the point by increasing the height of the water, and hence the pressure, thus generating a greater velocity. Eustace Manfredi thus expresses himself:—"The same water passes through a lesser as through a greater section, wherefore it is forced to pass with a greater velocity, precisely as will be the case in a vase in which the surface of the water may be at a certain height above the summit of the aperture." Guglielmini, to the same effect:—"The upper parts press the lower, and oblige them to receive a force, which being compelled to act, produces the same degree of velocity which the descent would have given them." We might quote other authors, who account for the increased velocity in narrower sections by having recourse to the pressure generated by the height of the upper parts, only they are in doubt on this subject, whether to attain so great a velocity it be necessary that the upper water should increase in height till it becomes stationary; not being able to believe that the upper water which is in the act of running is capable of producing a new increment of velocity in the lower. But experience teaches us that if the breadth of a section be diminished one-half, the water will not rise that half, as would appear necessary; if the velocity does not increase, it increases at least very little, either in section or at the base, where the reduced sections are of the same breadth, since the water retained by the narrowing of the piers of a bridge is but slightly raised. Wherefore it is necessary that the velocity increase without having regard to any new inclination, which is always the same, but only by an increase of height, which causes a pressure on the lower water which is in the act of running; whence I deduce the argument to strengthen my opinion in the case in which the velocity, arising from the inclination, is equal or greater than that which might have been generated by the pressure. Let us take two cases, one which allows the same measure of water to pass through one section twice as little as the first, preserving the same inclination, the other in which the velocity increases till it becomes twice as much.

But whence comes such an increase of velocity? what is the principle, what the nature of it? To say with Genneté, that twice the quantity of water doubles the velocity, is not to adduce a proof but to advance a mere assertion, which either supposes or requires it. I do not think that a true philosopher will perceive in the increment of so much water the principle of so great an acceleration. It behoves us to examine the genesis of such a phenomenon, and to observe the mechanism which nature adopts therein. And, firstly, two epochs of time are to be distinguished, one the first perceptible moment in which the section is reduced to half. Now, at this first instant, the water must swell and rise much above its first level, in which rise it generates a proportional velocity. But in the very act in which such a velocity is generated, the water begins to fall, wherefore the present case holds good, that the sections are in reciprocal proportion with the velocity. The water does not fall in this manner, wherefore it returns to its first level, or a little higher, there being a constant principle which compensates for a portion of the velocity destroyed by successive obstacles. Water in its course meets with continual resistance which diminishes its force, wherefore there remains in the water a constant principle which supplies and renews any decrement of velocity which the resistance may produce. Now this principle is, that whatever small increase of height above the original level causes pressure causes also velocity. Arrived at which point the water maintains the same height, which I have elsewhere designated equilibrium and constant state. Observers have not paid attention to the first epoch in which the water swells, is agitated, balances itself, but only have considered the other in which it acquires equilibrium, state, law. All this takes place so quickly that the swelling, sinking, and equilibrating hardly are evident to our perceptions. If, as I believe, the experiments of Genneté were true, according to which a river doubles or triples its water without raising its level, then it would be correct to say that it was free from any sensible resistance. This might be the case in an artificial river of short length, over a level bottom with smooth sides, and furnished with clear water. But in a natural and turbid stream, where the resistance, and that considerable, will never be wanting, it is not likely that when reduced to half its original section, it preserves its former level. This being determined, to come to the question above proposed, I resolve it thus:—Either the velocity begins to increase by the water beginning to swell, or the whole mass increases. If the first takes place, then the height being small, and hence the pressure being likewise small, the velocity generated will be also small. It is not that so small a velocity is added to so great, which it derives from an inclination, contrary to the sentiment of S'Gravesand. If the second takes place, it being then the velocity which increases, is equal to, or is less than that which results from an inclination, and not having any other generating principle than the pressure, it is clear that it acts when the velocity which generates itself is less or equal to that which was before generated by the inclined plane. Now I repeat, therefore, that the water as it strikes the bottom presses the lower films which run, spread out upon it, by which the pressure is communicated from above downwards. I agree with what Manfredi says, that "all the lower strata of water may be regarded as so many bottoms, or actual planes, with regard to the upper planes which run upon them. Hence these fluid planes are sensible of the same pressure of running water which they would sustain if it were stationary at an equal height." To me it appears an incontestable truth that water which presses the bottom should press all that portion by which the pressure is communicated, otherwise if it does not press all that which forms the middle, it will never arrive at the bottom of it, which is contrary to all experience. If this bottom be of a curved form, concave towards the water, the pressure will have the action of a centrifugal force, the which conspiring with the former, will increase the momentum, and thereby its energy and velocity.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Jan. 10.—Charles Fowler, Esq., V.P., in the Chair.

Many presents were announced. Among them were drawings from Mr. B. Perry, of the Town Hall of Morpeth, supposed to be by Vanbrugh, and a work on church building by M. de Lassaulx of Coblentz.

Mr. Layard, the explorer of Nineveh, was then introduced by Mr. Tite, and at the request of the Institute, made some remarks on the ruins of that city. Of the external architecture, or of the date of the ruins, he could say little, as hardly a fragment remained to guide the judgment, though no doubt of their great antiquity could be entertained. One proof he could give was, that though the earliest ruins were buried in the soil, graves had been dug in these by a people who lived 700 years before the common era. He was inclined to believe that some of these buildings might be three thousand years old. The rooms were covered with marble slabs, sculptured in low relief, like those in the British Museum, and they were joined together by double dovetails of iron, and the doorways were flanked by tall winged figures, higher than the side slabs. The figures were all marked with blood, as if it had been thrown against them, and left to trickle. The walls which back the slabs are of sun-dried bricks, and, where they show above the slabs, are plastered over and painted. Such beams as remain are found to be of mulberry. How the slabs have been preserved is a matter of mystery, but is perhaps to be explained by their lying under the crumbled remains of the bricks, which have returned to earth. Mr. Layard noticed that the buildings were provided with a system of sewage, a drain running from each room to a main sewer. In a small chamber which he had discovered among the ruins, he had seen vaulting of bricks regularly arched. The date of the destruction of Nineveh was 700 years B.C., while the bas-reliefs belong to earlier dates. In many cases the slabs have been used before; one slab was found with the sculptured face turned to the wall, and the back re-worked.

Mr. Bonomi observed that in Egypt the cramps were of wood, and he thought it extraordinary that at Nineveh they should be of iron.

Mr. Donaldson remarked that those of the Parthenon were of iron, and proceeded to offer his tribute of thanks to Mr. Layard for his communications. He thought that gentleman the more deserving of praise, as so much of what he had done was by his own labour and expense, and yet he had successfully competed with the explorers sent out by the French government. Mr. Donaldson wished to inquire whether the external face of the sun dried bricks were covered with plaster to keep out the wet.

Mr. Layard had not observed this. The internal face was partly coloured and enamelled, and decorated with human figures and other ornaments. As to the vaulted chamber of which he had spoken, it was covered with an arch of 12 or 14 feet diameter, very nearly a semi-arch. As to the sewers, they were not arched.

Mr. I'Anson, in correction of a statement at a former meeting, said the new sewers at Hamburgh were not oval, but egg-shaped.

Mr. Poynter read a paper on "*Leather Hangings*," illustrated by a number of specimens sent by Mr. Pratt.—The author mentioned examples of leather embossing among the Egyptians, and in the middle ages, and also of its extensive use in the sixteenth and seventeenth centuries, after its revival. The leather used was fine, and was either embossed or simply painted. It was chiefly brought into this country from Flanders and France, and there did not seem to have been any manufactory of it here. Some thought that the process had been first revived either at Venice or in Spain, but this is still matter of doubt, though at Venice embossed leather hangings were in general use in the seventeenth century. The first stage in the process was to join the skins, and then to silver the whole surface. Parts to have the appearance of gold were varnished with coloured varnish. After silvering, the leather was stamped with cut blocks under a press. The borders and more delicate work were executed with metal tools, like those of bookbinders. What is called the Titian Gallery, at Blenheim, has paintings on leather, but they are not by Titian. Mr. Poynter exhibited some fine examples, one being Antony and Cleopatra, from a series formerly belonging to the great Lord Clarendon. He recommended such specimens as suitable for museums of mediæval antiquities.

Mr. Crace stated that plaster moulds are used at Paris to emboss the leather, and that much flock is worked up to ornament the face.

The Chairman brought to the notice of the meeting the loss they had sustained in the death of two members of the profession. Mr. Kay, a member of the Institute was the first whom he should name, one whom they all knew and respected, and who had taken an active part in the establishment of the Institute.—Mr. Lonsdale Elmes was not a member of the Institute, but a most promising architect, whose works at Liverpool reflected the greatest credit upon him. A slight fall in getting out of a carriage was the more immediate cause of death, but he was suffering from disease which would otherwise have carried him off.

INSTITUTION OF CIVIL ENGINEERS.

Jan. 11.—Sir J. Rennie, President, in the Chair.

The first meeting of the session was held this evening, when the following papers were read:—

Mr. Frederick Ransome's "*process for making Artificial Stone.*"

The *modus operandi* appeared to be very simple. Broken pieces of silica (common flint) being subjected for a time to the action of caustic alkali, boiling, under pressure, in a close vessel, formed a transparent silicated solution, which was evaporated to a specific gravity of 1·600 (distilled water being 1·000), and was then intimately mixed with given proportions of well-washed sand, broken granite, or other materials, of different degrees of hardness. The paste thus constituted, after being pressed into moulds, from which the most delicate impressions were readily received, were subjected to a red heat, in a stove or kiln, by which operation the free or uncombined silica of the raw materials united with the excess of alkali existing in the solution, thus forming a semi-vitreous compound, and rendering the artificial stone perfectly insoluble. This production must evidently be adaptable to a comprehensive range of objects for decorative art, and for architectural purposes; busts, vases, flooring tiles, steps, balustrades, mouldings, capitals, shafts, and bases of columns, &c., even grinding stones and whetstones for scythes, have been made; and, in fact, from the beauty and variety of the specimens exhibited, there would appear to be a vast field opening for such a production. It was stated to be already extensively manufactured at Ipswich, and it was allowed to admit of extensive application where elaborately carved stone would be too expensive.

Mr. Richmond, of Bow, exhibited and explained "*an Engine Counter*," manufactured by him on an improved principle. The counters in ordinary use were described as either somewhat inefficient machines, liable to error, or of too expensive construction to be generally employed. This counter differed from others chiefly in its simplicity and its accuracy, whilst, at the same time, its low price of 7*l.* brought it within the reach of every one. With this machine the number of strokes made by the engine or other machine could be read off at one view without calculation. The leading or unit hand traversed the entire circumference of the large dial, and those of the three small dials revolved in the same direction. The first motion was described as being given by a sliding bar and fixed spring, instead of by a double pallet, so that the first wheel could not be thrown more than one tooth by one stroke of the engine. The hands were all moved by a train of wheels and pinions, without skip-wheels, so that the motion was regular and progressive. These were admitted to be advantages, and in the discussion upon the machine its merits appeared to be shown very decidedly.

Jan. 18.—Sir J. Rennie, President, in the Chair.

The annual general meeting of the Institution was held this evening, when the following gentlemen were elected to form the council for the ensuing year:—

President—Joshua Field.

Vice Presidents—W. Cubitt, J. M. Rendel, J. Simpson, and R. Stephenson, M.P.

Members—J. F. Bateman, G. P. Bidder, I. K. Brunel, J. Cubitt, J. Locke, M.P., J. Miller, W. C. Mylne, T. Sopwith, J. R. M'Clean, and C. May.

Associates of Council—J. Clutton, and T. H. Wyatt.

The report of the council continues to be very encouraging, and shows that the progress of the society is steadily good.

Telford medals were presented to Messrs. Jackson, Richardson, Murray, Glynn, and Frodsham, and to the two former gentlemen council premiums of books were added. Telford premiums of books were also awarded to Messrs. Elliott, Heppel, Shears, and Masters, for the communications made during the past session.

Memoirs were given of the deceased members and associates, Messrs. Thom, Giles, Lipkins, Mushet, Reynolds, Holtzapffel, Evans, Watkins, and Ball. The career of several of these gentlemen had been so varied, and possessed such points of interest, that the memoirs were necessarily extended beyond their usual length. The report noticed the increased attendance of members and visitors as evidence of its advancing career, and of the interest felt for the science of civil engineering. A pressing appeal was made to members of all classes to contribute papers, to induce animated discussions, which are the distinctive feature of the meetings of the society. The principal events of the past session were touched upon, and several private matters relative to the internal management of the Institution were fully discussed. The council then explained the changed form of the balloting papers, necessitated by the new bye-laws, and the retirement of Sir John Rennie from the post of president, which he had filled with such credit to himself and benefit to the society for the last three years. In conclusion, the report said, "Let the civil engineers remember that 'union is strength;' and that, if they are true to each other, and use the Institution as the common centre and bond of unity, they may set at nought all efforts to dislodge the civil engineers of England from the proud eminence where their talents, their practical skill, and their probity have placed them."

Before leaving the chair, Sir J. Rennie, president, addressed the meeting on the selection of the president, and impressed upon them the claims of Mr. Field; not only as one of the founders of the Institution, and who had filled for many years all positions in the society, nor because he was universally respected and esteemed as an upright, honourable, kind-hearted man, but chiefly on account of his acknowledged celebrity as a mechanical engineer, particularly in that most important department—steam navigation; and, because his election would unite more firmly the two branches of the profession, which, to ensure general prosperity, must ever go hand in hand, as they had hitherto done in the Institution, in spite of all attempts to make it appear otherwise. He then reviewed the position of the Institution during his presidentship, offering his best thanks to the vice-presidents and the members of council, and to the secretary, for the support and assistance afforded him; and then examined, with much candour, the relative positions of the civil engineers, and of the government boards and commissions, which had appeared to clash more than was desirable. This he showed not to rise from any of the acts of the civil engineers, who had ever been ready to afford their best assistance to the government in any capacity; and further, that it would be the interest of the government to take advantage of the talent, energy, and practical skill of the civil engineers, by whom they had ever been well served, rather than incur the hazard and the expense of forming a corps that would require more time for educating than could be afforded in these active times, when even hesitation was perdition.

This address was responded to very warmly by the meeting; and a vote of thanks to Sir John Rennie was received with cheers. Thanks were also voted to the council and the secretary of the Institution for their services.

SOCIETY OF ARTS, LONDON.

Dec. 15.—P. Le Neve Foster, Esq., in the Chair.

The Secretary read a paper, by Mr. A. G. Findlay, M.R.G.S., "*On the various descriptions of Lighthouses, Beacons, and Light-vessels, their Construction, and the methods of Illumination employed therein.*"

Mr. Findlay commenced his paper by alluding to the vast importance to a maritime nation like England of having a durable and efficient mode of constructing and illuminating lighthouses, light-vessels, &c., and proceeded to point out the general uses of lighthouses. The oldest structure upon record is the celebrated Pharos of Alexandria, which served as a guide to ancient mariners during a period of nearly 1,600 years. Pliny says, "It was square, of white stone, and consisting of many stories, and diminished upwards till it attained the height of 547 feet." The most ancient structure known to exist in this country is the Roman pharos at Dover castle, and this would still answer its intended purpose, after a lapse of 18 centuries. The celebrated Cordouan Tower, in the Bay of Biscay, is another instance of stability, having been built in 1611. The Eddystone lighthouse has attracted more of the attention of the public than perhaps any other. The first of these edifices was of wood, and built by Mr. Winstanley in the years 1696-8; but, owing to the sea washing over the lantern, it was subsequently raised to a height of 120 feet. In November, 1703, the entire structure was washed away, and in 1706 sanction was obtained for its being rebuilt, which was accordingly done by Rudyerd, but which was destroyed by fire in 1755. The present tower, one of the artificial wonders of England, and built by Smeaton, is 100 feet high, and has given good proof of its capability of resisting the force of the waves. The Bell Rock lighthouse is a similar structure to the Eddystone; it was built by Stevenson at a cost of £60,000. The most recent erection of this description is on the Skerryvore rock, which cost £90,700.

The author next alluded to the difficulty of constructing permanent lighthouses in exposed situations, and the advantages of them over floating lights, as well as the much smaller annual expenditure required to maintain an efficient light. The first floating light was the well known Nore light-vessel, moored in 1734. In order to insure stability in a lighthouse, Mr. Findlay stated that it is necessary that the structure should be capable of affording resistance to a pressure of not less than 6,000 lb. to each square foot of surface exposed to the action of waves. This assertion was founded on experiments made by Mr. Alan Stevenson, who ascertained and registered the force of the waves at the Skerryvore rock, on March 25th, 1845, during a westerly gale, when it was found to be 6083 lb. per square foot; this, the greatest force hitherto registered, was cited with many others. He next proceeded to point out the inapplicability of iron to the construction of lighthouses where the metal was immersed in the sea water, which has the effect of reducing it to a body similar in its chemical properties to black-lead; and instanced the effects produced on a cannon-ball taken from the *Mary Rose*, after having been sunk off Spithead for a period of 150 years: the iron shot upon being exposed to the air gradually became red hot, and then fell into a red powder resembling burnt clay.—The author next described the methods which have been suggested for overcoming the difficulty of exposing large surfaces to the action of the force of the waves, and also for obtaining a firmer foundation on a sand, and especially Mr. Alexander Mitchell's screw-pile lighthouse erected on the Maplin Sand, and Dr. Potts's method of driving piles by atmospheric pressure, as applied at the South Calliper beacon on the Goodwin sands, in 1847, and to other beacons on various shoals at the mouth of the Thames, as on the Blyth sand, and on the shingles in the Prince's channel. Another plan for the erection of lighthouses has been carried into effect at the Point of Ayr by Mr. Walker; it consists in constructing hollow cylinders, which are filled with concrete and then sunk, and from them the piles rise. Capt. Sir S. Brown has also proposed a plan for the erection of lighthouses in deep water upon bronze standards, and a modification of his plan was adopted by Captain Bullock. The author further alluded to Mr. Bush's Light of all Nations, and to Mr. A. Gordon's iron lighthouses at Jamaica and the Bermudas, in which the cases are filled with a solid mass of concrete; and alluded to the fact that Rennie had proposed iron for this purpose as early as the year 1805 for the Bell Rock.

Having thus shown the different methods employed in the construction and erection of lighthouses, Mr. Findlay proceeds to remark on the various plans of illumination which have been employed: of these the earliest was the coal fire and the Cordouan billets of oak. In 1752 the South Foreland lighthouse, previously illuminated with an open coal fire, was covered with a lantern with large sash windows, and the fire was kept bright by means of large bellows; the lantern was subsequently removed, and afterwards, at the commencement of the present century, fifteen large lenses with separate lamps were placed in it. In 1790, the only exception to the coal fire was the Eddystone lighthouse, which had a chandelier with 24 wax candles, and the Liverpool lighthouses with oil lamps and rude parabolic reflectors. An interesting historical fact was then mentioned—viz.. that parabolic reflectors were used at the Liverpool lighthouses (built in 1763), as Mr. W. Hutchinson, in his "Practical Seamanship," published that year, describes the apparatus then in use—the larger reflectors of wood lined with small pieces of looking-glass, the smaller of polished tin: this was the more curious, as it had been claimed by the French for M. Teulere in 1783, and first used in Scotland in 1786. The parabolic reflectors, of which some beautiful specimens were shown to the meeting, are now constructed upon the formula of the celebrated Captain Huddart. Having explained the catoptric or reflecting principle of illumination, which received so great an improvement in the invention of the Argand lamp in 1780 or 85, several other lights were exhibited and described—viz., the Drummond light, the voltaic light, and the causes of their inapplicability. The present mode of lighting is from lamps constructed on a modification of the Argand principle. A first-order pneumatic lamp with four concentric wicks, showing a most powerful light, was exhibited. The dioptric principle, in which the rays of light emanate from a central lamp, and are controlled and directed by a series of lenses placed before and around it, next occupied attention. The author claims the priority of its suggestion for an optician in London, as mentioned by Smeaton, who proposed, in 1759, to grind the panes of the Eddystone lighthouse into a sphere of 15 feet diameter. The present form of lens, generally known as Fresnel's, was first suggested by the celebrated Buffon, to whom it is probable the catoptric system owes its origin. Sir David Brewster, in 1811, showed the practicability of constructing a lens of separate pieces, and this was first used in France by Fresnel, and has since become universal in French lighthouses. A comparative view of the catoptric and dioptric systems is afforded by the fixed lights of the South Foreland, the higher being from the dioptric principle and the lower from Huddart's reflectors, which to a distant observer appear equally bright—the only test of their efficiency. The cata-dioptric principle was illustrated by a beautiful fourth-order apparatus, lent by Messrs. Wilkins, in which, above and below the light, a system of totally reflecting prismatic zones is arranged, the suggestion of Mr. A. Stevenson. Mr. Alexander Gordon's cata-dioptric system, a union of the reflector and refractor, was also described.—Some particulars respecting the power of light in penetrating mist were also brought forward. During fogs the attendants of light-vessels sound a bell at intervals, or, as now used by the Trinity Board, a Chinese gong. Instead of this, Lieut. Sheringham, R.N., proposed, in 1842, to use a whistle worked by bellows, and Mr. Gordon proposed to place the whistle in the focus of a parabolic reflector, to direct the sound. Mr. Findlay concluded his paper by suggesting the use of Mowbray's chemical whistle, which was exhibited and described.

ROYAL SCOTTISH SOCIETY OF ARTS.

Jan. 10.—George Buchanan, Esq., F.R.S.E., President, in the Chair.

The following communications were made:—

1. *Description with Drawings of a Portable Cofferdam, adapted specially for the use of Harbour and other Marine Works in exposed situations.* By Thomas Stevenson, Esq., C.E.

This cofferdam was used at Hynish barbour works, Argyllshire, for excavating rock which was seldom left dry by the tide, and was covered with two feet of sand. It was found impossible to form a common cofferdam, owing to the shallowness of the sand, which could not afford any support to piles, and to the violence of the sea, which would in a single tide either wholly break it up or render it leaky. The cofferdam adopted being portable, was moved from one compartment of the cutting, when finished, to another. It consisted of two double frames of timber, each complete in itself, being bound together with iron rods, forming a dam about 10 feet by 14, and 3 feet high. One of these double frames (being somewhat less than the other) was placed inside of the larger, so as to admit two piles being driven between them. In this way the piles could, from the depth of the frames, be driven perfectly straight, and were also quite independent of support from the sand. As each compartment of the excavation was completed, and before the dam was removed, one row of piles was driven down to the bottom of the pit and left standing, so as to be a guide for again superimposing the frames over them, and in this way it was impossible for any of the rock to escape being removed. The peculiar advantages are its portability—its ready adaptation to a sloping or to an irregular bottom—the ease and certainty with which the partitions between each section of the rock were removed, and the double-framed walings that supported and directed the driving of the piles. Whenever excavations require to be made in a rocky beach covered by a stratum of sand, however thin, this form of dam may be used, as there is no kind of lateral supports such as shore wanted, the structure containing within itself the elements necessary for its stability. It possesses, indeed, the properties of a caisson, with the additional advantage of accommodating itself to an irregular bottom.

2. *Description of a Cast-iron Skew Bridge, of two arches—of* 100 *feet span each—now being erected to carry the Leeds, Dewsbury, and Manchester Railway, over the River Calder at Ravenswharfe, near Dewsbury.* By Thomas Grainger, Esq., C.E.

This bridge is a skew at an angle of 56 deg., and consists of two arches of 100 feet span, with a pier about the centre of the river; each arch is formed with six cast-iron segmental ribs, having a rise of 12 feet,—each rib is cast in five pieces, having flanges or lugs at the joinings, and bolted together with 2-inch bolts; the section of the ribs at the abutments is 3 feet deep, the web 2¼ inches thick, the top and bottom moulding or flanges 8 inches by 3 inches, presenting an area of 123 inches; the section at the crown is 2 ft. 9 in. deep, and otherwise the same as at the abutments, and presents an area of 115½ inches. The spandrils are cast along with the ribs—the joints being formed at the uprights instead of at the intermediate spaces, as shown on the model. The ribs have dovetailed sockets cast upon them to receive the cast-iron braces which are keyed into them; these braces, 10 in number, stretch across the bridge at right angles to the ribs; there are also 8 wrought-iron tie-rods, 2 inches diameter, placed parallel to the line of the abutments, to connect the whole structure together. The ribs abut against and are keyed into massive iron bed-plates sunk into the stone-work of the abutments. The roadway is supported by transverse timber beams 12 inches by 9 inches, bolted to the top of the spandrils at intervals of 3 feet from centre to centre; the planking is 3 inches thick, and is laid diagonally across these beams, and spiked to them with 6-inch spikes; and over the planking a coating of asphalte is to be laid. The outside ribs are surmounted by a cast-iron cornice to correspond with the masonry, and having a cast-iron railing on the top. The estimated weight of the cast-iron in the bridge is 603 tons 4 cwt., and the expense of fitting up the iron and timber work has been contracted for at 8,598*l*.

3. *Observations on the means by which Time may be communicated by Signal Balls from one Station to another.* By John Adie, Esq., F.R.S.E. The author of this paper remarked, that the distance of the Nelson Monument from Leith, and more so from Leith Roads, would allow a time-ball placed on the Monument to be distinctly seen only in very clear weather, which is confined to a limited number of days, rendering it of little use to the shipping in the Frith of Forth. He next described a method by which the ball on the Monument, and one at Leith, might be dropped at the same second of time, by a person in charge at the Royal Observatory, Calton Hill. This he proposed to do by making use of the great force induced on artificial iron magnets, the wires surrounding these magnets being brought into contact with the poles of a galvanic battery placed in the Observatory, and em-

ploying this force to draw bolts or catches to free the balls and allow them to drop; a number of magnets in communication will develop their forces at distant stations at the same moment, and allow balls at several stations to indicate the same second.

4. *Description of a Safety-Wheel Ring-Revolver, to prevent Wheels of Carriages from flying off the Axles.* By Rev. Graham Mitchell, A.M.

The object of this invention is to prevent disasters, by rendering it impossible for any wheel flying off the axle, whether from tear and wear, or concussion. Independently of all former contrivances of security for human life, there is here superadded a brass or iron ring attached to the wheel behind the bush, which apart revolves along with the large wheel itself round a nitch cut in the axle of the carriage, and which is designed to act as a preventive against a wheel ever flying off, whatever be the velocity of revolution.

INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

Dec. 14.—Col. H. D. Jones, President, in the Chair.

The following papers were read :—

"*Description of a Clock with a Registering Machine attached.*" By Mr. Sharp.—An ordinary clock was exhibited, with the addition of a certain number of projecting pins on the dial; the interval between every two pins expressed a certain portion of time, being that which elapsed while the hour hand of the clock, in its ordinary motion, passed from one pin to another; a lever was attached to the back of the dial, by means of which the hour hand could be pushed in at any time against the face of the dial, and, by coming in contact with one of the projecting pins immediately under it, push it in also, and the pin so pushed in would register, within but a few minutes, the exact time the hand was brought in contact with the dial. Mr. Sharp explained how, by means of a sufficient number of pins on the dial, very small intervals of time might be registered. This invention he conceived could be used for all the purposes of a noctuary, and might, by means of an additional mechanical contrivance, be made to register the times of the arrival and departure of the trains, by means of the trains themselves. He also explained how the movement of the clock was not in the least injured by this addition, and that this means of registering might be also applied to clocks already constructed.

"*A short account of the Fall, during a violent storm, of part of a Roof in progress of erection over the Dublin terminus of the Midland Great Western Railway.*" By Mr. Hemans.—The total length of the roof of this building is 475 feet, and the width 120 feet, divided into two spans of 60 feet each, the roof resting on walls at either side, and on columns in the centre. The centre columns are 62 ft. 6 in. apart, and are connected by flat arches and gutter-plates. The whole structure, with the exception of the columns, gutter-plates, tie-washers, and sockets, is composed of rolled iron. The principal, which are the only rafters, are 38 in number to each half-roof, and are 12 ft. 6 in. apart. They are formed of what are called "deck beams." The cover of the roof is of corrugated galvanised iron, and connected by bolts and rivets similarly galvanised, and provision is made for expansion and contraction. Twenty-five of the principals were erected on each side, and the whole centre line of columns and arches complete, when the storm, the cause of the accident, began. The principals not being connected together by temporary diagonal braces (none would be required when the corrugated covering was fixed), were exposed to the powerful action of the gale in the direction in which no temporary provision had been made to withstand lateral pressure; and the consequence was, as might naturally be expected, that the greater portion of them were blown down one over the other, like a pack of cards; and the whole of them had snapped their sockets.

Several members expressed their satisfaction at Mr. Hemans having placed on record this failure through inattention to the necessary precautions in the execution, which would prove an useful lesson.

"*An account of the removal of a Mill at the Cutts, near Coleraine.*" By Col. H. D. Jones, President.—The paper was accompanied by several drawings explanatory of the subject, and detailed the mode adopted for the removal of a large mill, the height of which, to the eaves, was 65 feet, and the walls were of proportionate thickness, being three feet at the level of the ground story. The execution of the works in connection with the drainage of Lough Neagh, rendered the removal of this mill necessary, and the use of gunpowder was considered the most economical means of effecting this object; but the contiguity of the mill to several houses by the roadside rendered it necessary to guard against accident, by limiting the charge of powder. A detailed account was given of the quantity of powder used, the mode of applying the charges, and the effect produced, and very satisfactorily proved the economy of the measure. This work was conducted under the superintendence of Mr. C. S. Ottley, the district engineer for Lough Neagh drainage.—The President stated that he had used gunpowder with much advantage, both as regarded effect and economy, in the removal of large buildings, but especially in the removal of a large storehouse at Flushans.

Mr. M'Mahon stated the great advantage of adopting the plan which had been so successfully tried in the present instance.

Mr. Clarendon described the mode by which the high dock wall had been removed at the site of the Dublin and Drogheda railway terminus in Amiens-street, which had been effected expeditiously and economically, and without the use of gunpowder.

Mr. Dean called the attention of the Institution to the inefficient state of the sewerage of Dublin.

HINTS TO PLANTERS.

A correspondent of the *Gardeners' Chronicle* says, "In rambling through the New Forest, I have been much struck by observing how much the beauty of natural woods depends upon the open glades; or intervals bare of trees, which there so frequently occur, and have often wondered why the landscape gardener so seldom imitates nature in this respect. In the disposition of the open and the wooded spots, it may be observed that nature commonly fills up the valleys with wood, and leaves most of the brows and eminences bare, and in an undulating country, nothing is more pleasing to the eye than thus to see the woods creeping up the hollows and gradually feathering off, and disappearing as they approach the summits of the hills, which rise bare of trees above them. The landscape gardener almost invariably does the reverse. He commonly plants all the eminences (probably from the notion of making a more conspicuous show at a distance), leaving his vacant spaces in the valleys and lower grounds. By this means (putting appearance out of the question) he subjects his trees to the double disadvantage of a more exposed situation, and a shallower soil; consequently his trees grow incomparably slower than they would do in the deeper soil and more sheltered situation of the lower grounds. Trees differ so much in the soil and situation suitable to the different kinds, that it is of the utmost consequence to the planter that the one should be adapted to the other; and if planters could be induced to look after these things themselves, instead of entrusting them to the nurseryman, one would not so often see plantations filled with such worthless trees as beech and sycamore, where more valuable sorts, such as elm, ash, and chesnut, would flourish equally well. With this view, I have thrown together a few observations on the sorts of trees commonly planted. The larch would, no doubt, be the most valuable tree that can be planted, were it not unfortunately subject to that peculiar disease, called the heart-rot, which, I believe, is not known to affect any other kind of tree. After growing vigorously for twenty or more years, the heart of the tree up to a considerable height becomes entirely rotten, without any apparent external decay. The cause of this singular disease is as yet unknown. I am myself inclined to believe that it usually arises from too great dryness in the soil. In Switzerland the native habitat of the larch is in situations abounding in moisture, viz., the sides of slaty and granitic mountains; and the plantations in which, in this kingdom, it seems to flourish best, are in similar situations in Scotland and Wales. In England it has principally been planted on dry sandy heaths—a situation which affords the greatest contrast to its native habitat, and which the prevalence of the heart-rot shows to be uncongenial to its nature. In point of beauty little can be said in favour of the larch; it never forms a handsome mass of foliage; and the spiky outline even of the oldest woods always has a poor, unpleasing effect. It must, however, be acknowledged that a single tree of larch often has an elegant appearance. The Scotch fir is of so hardy a nature that it will flourish in almost any soil or situation. It is in very bad repute as a timber tree when grown in England, which is a very singular fact, as it is well known that the same species of pine, when grown in the north of Europe and the highlands of Scotland produces that excellent timber known as the red deal. Different causes are assigned for this extraordinary difference in the timber grown in England and grown abroad. Some persons suppose that the home and foreign grown fir are different varieties of the same species, one of which always produces hard and the other soft wood; some suppose that the colder climate and slower growth of the Baltic timber is the cause of its superiority; and any one who will take the trouble of counting the number of annual rings in Baltic timber must see that its growth is in general excessively slow; others consider that age alone is wanting to render the timber good, and that if we were to allow English grown fir to attain the age of one or two centuries, as is the case with the Baltic grown, our timber would be equally valuable. That English fir timber does improve as the trees grow older, is a fact well known to timber merchants; and I can instance the roof of the house in which I am now writing, which was framed of English fir, of very large scantling, about forty years ago, and which to all appearance is now as sound as the day it was put up. It must also be observed that the English fir is commonly cut down of small dimensions, and full of sap wood, while most of the sap wood is cut away from the Baltic balks before we get them. But there is still one point, which I have never seen noticed, which, perhaps, may go far to account for the difference of quality. I mean the season in which the timber is felled. It has never yet been ascertained that resinous trees ought to be felled in winter, as is the universal practice in England, and it is not unlikely that the resinous juices with which firs abound in summer may tend to increase the durability of the timber felled in that season. I would strongly impress on those who have the opportunity, how desirable it would be to institute experiments on this point. It is stated, on what appears to be good authority, that both in Norway and the rest of the north of Europe fir trees are always felled in summer. In Switzerland, as in England, the timber of the Scotch fir is reckoned of very little value. As an ornamental tree the Scotch fir is gone much out of fashion, yet when allowed to attain a sufficient age its rounded top and red-coloured bark and contorted limbs produce a grand and picturesque effect in the landscape which scarcely any kind of tree can surpass. The spruce fir delights in a light soil and a very moist situation. In such situations, when not crowded by other trees, so as to have plenty of light, it forms a beautiful mass of thick foliage, towering to a great height. It is quite useless to plant it in very dry, shallow, or rocky soils. I have seen young spruce firs flourishing in stiff clay, though I believe ultimately such soils do not suit it. It often deceives the planter by growing vigorously for 15 or 20 years, and afterwards becoming stunted, exhibiting nothing but a few ragged leaves on the ends of the branches, being then one of the most unsightly objects in nature. It is singular that a native of Norway should seem in our climate not patient of wind or frost. It affords a soft wood, useful for many purposes, but always very full of knots, unless it has either been severely pruned, or grown in such close woods as to lose its side branches by natural process of decay from want of light. The silver fir flourishes in stiff wet clays, and throws up its tall head quite perpendicularly, even in the most exposed situations, apparently uninjured by the utmost fury of the wind. It is a tree which the landscape painter never thinks of introducing in a picture; yet it is not without a peculiar beauty of its own, and often produces a grand effect, either in the stiff formal avenue, or when seen towering above other trees. Its timber is much like that of the spruce fir, but of rather better quality."

OBITUARY.

MR. HARVEY LONSDALE ELMES.

It is scarcely surprising that the death of Mr. Harvey Lonsdale Elmes should have produced such a strong feeling of regret, as has been manifested at Liverpool by so many of its leading men, for the death of a man of genius in the early prime of life is well calculated to awaken sympathy, and most in a town adorned by noble monuments of his taste, in his devotion to which he hastened the progress of disease and death. Our readers will think that such an artist deserves at our hands a more lengthened notice than he has yet received, for there is always a sentiment of personal interest, which attaches to the career of one so young in life, and so rich in endowments. Harvey Lonsdale Elmes was born in 1813, we believe in London, and was the son of James Elmes, Esq., the surveyor of the Port of London, and himself distinguished as a large contributor to architectural literature. With him he was brought up, and the natural abilities he early showed were fostered by association with the many men of genius with whom his father was intimate, or in connexion. Young Mr. Elmes's talents were decidedly of an artistic tendency, but chiefly directed towards architecture and music, and he showed a peculiar delicacy of mind, stimulated perhaps by delicacy of physical organization. His zeal was ardent, and his powers of application great, while his love of fame gave him the stimulus for great exertion. With such qualifications Mr. Elmes began under his father's care his architectural studies, which he afterwards pursued under Mr. Elger of Bedford, and Mr. H. E. Goodridge of Bath. He was likewise employed by Mr. John Elger, a builder in London, until he acquired the charge of works of his own.—In 1836 or 1837, when Mr. Elmes was in his twenty-fourth year, the Liverpool Committee advertised for designs for St. George's Hall, which was then intended to be a separate building. The advertisement was put into Mr. Elmes's hands by a friend, as being worthy of his notice, and he took it to the late Haydon, one of the earliest friends of his youth, to ask his advice whether he should compete, as Haydon knew many persons at Liverpool, having received commissions for pictures from the Blind School and other institutions. "By all means, my dear boy," said Haydon; "they are noble fellows at Liverpool. Send in a design, and mind, let it combine grandeur with simplicity. None of your broken-up and frittered abortions, but something grand." Following this exhortation Mr. Elmes set to work, and when he had made his first sketch, took it to a friend's house, where a trifling incident gave him the augury of success, for a little boy looking at the drawing very gravely, threw it down, saying emphatically, "Very good, very good, indeed; it's worth five hundred pounds." When the design was sent in, it was successful against eighty-five competitors, and Mr. Elmes received the premium of five hundred pounds. Afterwards he carried off in other competitions the premiums for the Assize Courts at Liverpool, and for the Collegiate Institution there. He was likewise the winner in a competition for the Assize Courts and St. George's Hall combined. These several victories gave Mr. Elmes the prestige of a reputation, which his own attainments were calculated to support. Entered upon a new career, he now devoted himself zealously to carry out in detail the several designs on which he was engaged, and his professional business greatly increased. He obtained the prize for the County Lunatic Asylum, at West Derby, in Lancashire, and was employed in erecting mansions for Mr. George Hall Lawrence, late Mayor of Liverpool, for Mr. Hardman Earle, and Mr. Hugh Hornby.

These labours, borne by a weak frame, at length brought their own end. In the early part of last summer Mr. Elmes showed such strong symptoms of consumption that change of climate became necessary. He wished to go to Italy to study the monuments of his art in that country, but his health was so much shaken that Dr. Chambers urged him to go immediately to the West Indies, and travel from island to island. Before he left he made arrangements with Mr. Cockerell to superintend the architectural detail of St. George's Hall, for which he had finished the whole of the plans.

In 1841 Mr. Elmes had married the daughter of C. D. W. Terry, Esq., and accompanied by that lady he set out on that journey from which he was never to return, for he died at Spanish Town, Jamaica, on the 26th of November last, aged 34, leaving one child.

Thus he was cut off in the prime of his life, and when only beginning to enjoy the honours and rewards due to his exertions. When Prince Albert visited Liverpool, he was so delighted with St. George's Hall that he sent a gold medal to Mr. Elmes, and the architect only awaited the completion of his work to receive plaudits on every hand. As it is, those honours must be paid to his tomb; and indeed the Town Council of Liverpool on the announcement of his death, gave a public expression of their strong feelings of regret for what they felt to be a heavy loss.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM DECEMBER 30, TO JANUARY 20, 1848.

Six Months allowed for Enrolment, unless otherwise expressed.

Thomas Hancock, of Stoke Newington, Middlesex, and Reuben Phillips, of Islington, Middlesex, chemist, for "Improvements in the treating or manufacture of gutta percha, or any of the varieties of caoutchouc."—Sealed December 30.

Felix Edwards Pratt, of Fenton Potteries, Stafford, earthenware manufacturer, for "Improvements in manufacturing articles composed of earthenware or china."—Dec. 31.

Mary Jenkins, of Atton, Warwick, widow, for "Improvements in the manufacture of pins, hooks, eyes, and other fastenings."—Dec. 31.

Edward Humphrys, of Holland-street, Surrey, engineer, for "certain Improvements in steam engines, and in engines or apparatus for raising, exhausting, and forcing liquids."—January 4.

William Froude, of Darlington, Devon, civil-engineer, for "Improvements in the valves used in closing the tubes of atmospheric railways."—January 5.

Read Holiday, of Huddersfield, manufacturing chemist, for "Improvements in lamps."—January 5.

Charles De Bergue, of Arthur-street west, city, engineer, for "Improvements in carriages used on railways."—January 5.

Alexander Robertson Arrott, manager of the Union-place Glass Works, St. Helens, Lancaster, for "Improvements in manufacturing common salt."—January 5.

Charles Lambert, of Two-Mile Hill, St. George's, near Bristol, pen-maker, for "certain Improvements in machinery for making nails."—January 5.

Josiah George Jennings, of Great Charlotte-street, Blackfriars-road, for "Improvements in cocks or taps for drawing off liquids and gases."—January 5.

George Bell, of the city of Dublin, merchant, for "certain Improvements in the arrangement of wheels and axles for steam and other carriages, which facilitate travelling on railways and common roads, parts of which improvements are applicable to other machinery."—January 7.

James Montgomery, of Salisbury-street, Middlesex, for "certain Improvements in pianofortes and other similar finger-keyed instruments." (Being a communication)—January 11.

Alfred Augustus de Reginald Hely, of No. 11, Cannon-row, Westminster, and Joseph Emmett Norton, of Saint Mary-le-Strand-place, Kent-road, Surrey, wine-merchant, for "certain Improvements in bottles or vessels for containing liquids, and in the mode of and machinery or apparatus for filling and stopping the same."—January 11.

Gardner Stow, late of King-street, Cheapside, but now of New York, gentleman, for "Improvements in apparatus for propelling ships and other vessels."—January 11.

William Thorold, of Norwich, engineer, for "Improvements in turn-tables."—January 13.

Robert William, M.A., Greenock, for "Improvements in certain kinds of rotatory engines worked by steam or other elastic fluids, part of which improvements are applicable to rotatory engines worked by water, or by the wind; also, an improvement in safety-valves for steam boilers."—January 13.

Sydney Edwards Morse, of Ampton-place, Gray's-inn-road, for "Improvements in the manufacture of plates or surfaces for printing or embossing."—January 13.

Benjamin Mitchell, of Huntingdonshire, farmer, for "Improvements in the manufacture of manure."—January 13.

Robert Heath, of Heathfield, Manchester, gentleman, for "certain Improvements in the method of applying and working friction brasses to engines and carriages used upon railways."—January 18.

Job Cutler, of Spark Brook, Birmingham, civil engineer, for "certain Improvements in welded iron pipes or tubes to be used as the flues of steam boilers."—January 18.

John Gilmore, Lieutenant in the Royal Navy, for "certain Improvements in ventilating ships and other vessels."—January 17.

Charles Crane, of Stratford, Essex, manufacturing chemist, and James Thomas Juillon, of the same place, analytical chemist, for "Improvements in the manufacture of certain acids and salts, and a new apparatus applicable to the said improvements."—January 18. Four months.

Samuel Cunliffe Lister, of Manningham Hall, in the parish of Bradford, esq., for "Improvements in stopping railway trains and other carriages, and generally where a lifting power or pressure is required."—January 18.

John Hickman, of Birmingham, for "Improvements in the means of constructing and connecting parts of bedsteads, couches, and other articles of furniture to which such improvements may be applicable, and also in the means of attaching knobs or handles to drawers, doors, and other parts of furniture."—January 18.

William Newton, of 66, Chancery-lane, Middlesex, civil engineer, for "Improvements in the manufacture of sugar from the cane." (Being a communication.)—January 18.

John Frederic Bateman, of Manchester, for "certain Improvements in valves or plugs for the passage of water or other fluids."—January 18.

Thomas Robert Sewell, of Carrington, in the parish of Basford, Nottingham, chemist, for "Improvements in preparing flour."—January 18.

Joseph Clinton Robertson, of 166, Fleet-street, London, civil engineer, for "certain Improvements in the manufacture of textile fabrics, stuffs, and tissues, and of certain new products obtained by the aid of such improvements." (A communication.)—January 19.

John Duncan, of Brentwood, Essex, gentleman, for "certain Improvements in tanning of hides."—January 20.

CANDIDUS'S NOTE-BOOK
FASCICULUS LXXIX.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. There is reason for concluding that the peripteral temples of the Greeks were so planned rather for the sake of architectural dignity and effect, than, as is generally supposed, for that of any particular convenience or advantage. The cella itself being narrow, colonnades along its sides served to give greater importance to the edifice by enlarging its entire bulk, its ends or fronts being increased from tetrastyle to hexastyle, or from hexastyle to octastyle, if the lateral colonnades consisted of only a single range of pillars; or if the columniation was of the kind called dipteral, increasing the width of the fronts by four more columns beneath their pediments: thus, a cella, with a tetrastyle in front of it, would acquire an octastyle portico, by having dipteral colonnades erected along its sides. This last-mentioned mode (the dipteral) certainly does provide a greater sheltered-in space on the sides of the edifice; still, hardly sufficient for any real use of it as an ambulatory—at least, not for a number of persons. Such purpose was far better accomplished by the *pseudo-dipteral* plan, in which the middle row of columns, or those between the external ones and the walls of the cella, were omitted, whereby a clear space was obtained equal to the width of two intercolumns and one column. Yet, if much was thereby gained in point of convenience, not a little was lost in regard to effect and richness of character; and the body of the temple showed as a comparatively diminutive structure, standing within an open though covered colonnaded inclosure. As to the single peripteral, its colonnades must have been more for show than for real service, since they were very ill-calculated for accommodating a multitude of persons. Even in the Parthenon, the clear space between the external columns and the walls of the cella was not more than six feet wide; consequently a mere passage, rather than either an ambulatory or a shelter for a large concourse of people.

II. With regard to the Parthenon, a most extraordinary error occurs in the English edition of Gailhabaud's "Ancient and Modern Architecture" (second series), it being there stated that "its length, measured on the top of the steps, is 114 feet, its width 51 feet;" according to which, the area of the building is not above *one-fourth* of what all other accounts make it, for they make it both twice as long and twice as wide! To puzzle us the more, there is a foot-note calling particular attention to those measurements, from which it would seem that pains had been taken to insure more than usual accuracy, they being there said to be upon the authority of a "recent"— and therefore, it is to be presumed, a more correct—measurement by Mr. Travers. Yet, no notice is taken of the enormous discrepancy between them and the usually-reported dimensions, or of the equal discrepancy from the plan and its scale given in the work itself. The scale being in metres—to which one in English feet should have been added to the plates in the English edition—the contradiction between the text and engraving is not so immediately obvious as it would else be; but, on applying compasses and calculation, we find the length to be 69 metres and the breadth 51, which converted into English measure, give 226 and 101 feet respectively, or double what is stated in the text! Had either the English writer or editor compared the description and plan together, their total want of agreement must have been discovered, which done, Mr. Travers's measurements would perhaps have been discarded as quite untenable. Some as strange or even stranger mistake perplexes us a little further on, where we are told that the external columns are three feet in diameter (or only half what they are usually stated, viz., six feet and a fraction), yet *thirty-four feet four inches* high, which would make their height between eleven and twelve diameters! and how such extraordinary proportions could have escaped notice when the proof was read over is incomprehensible. Neither does error terminate there, since, besides the palpable contradiction in regard to the diameter and height assigned to the columns, the latter measurement and that of the entablature (10·10′) renders the entire height of the order 45 feet; which, though in itself it may be correct, is altogether irreconcileable with the width of the front being only 51 feet, or little more than a square in height,—the proportions not of an octastyle but a tetrastyle, and such as it is impossible to give to the former. Here, then, we have a pretty complication of blunders, and those of the most serious kind, in a publication which ought to be scrupulously accurate in regard to the measurements which it gives of buildings. There is what looks like sufficient pledge for editorial responsibility and carefulness, the title-page assuring us that "the translations are revised by F. Arundale and T. L. Donaldson, Prof. Arch., Univ. Coll., London;" therefore, to those gentlemen may be left the task of accounting for or explaining away the egregious mistakes here pointed out, and which compromise the credit and character of the work to such degree as to demand correction—if in no other way, by cancelling the pages where they occur. Not the least awkward part of the matter is, a detection of the kind naturally excites mistrust as to other articles, where mistakes either of a similar or different kind may have escaped the English *revisors*. In that very article on the Parthenon, one paragraph that ought to have been omitted, was uuluckily suffered to remain—namely, that which says: "We give with this notice a splendid specimen of polychromatic architecture of the Parthenon, being a perspective view of the entablature and capitals, restored with the utmost care by Mr. Travers, from traces which he discovered in the monument itself." There is, however, no such plate in the work—at least, not in the English edition, although it would have been particularly acceptable, and far more valuable than all those of such unarchitectural subjects as Cromlechs and Celtic monuments, put together. Of *them*, two or three specimens at the utmost would have sufficed: still better would it have been had they been excluded altogether from a work which, were it to be extended to a hundred volumes, could not possibly illustrate all that is worthy of notice in "Ancient and Modern Arcbitecture."

III. It is not only with regard to the notion of Blore's façade to the Palace being a copy of that of Caserta, that Mr. Sharp and myself differ materially, my opinion of Elmes's "History of Architecture in Great Britain" being so very dissimilar from his, that I think the Editor has very great reason to complain of such a carelessly-executed and inaccurate performance being passed-off upon him under the responsibility of Mr. Elmes's name. While there is a great deal of mere garrulous filling-up anecdote, quite out of place in an historic outline, and out of all proportion to the brevity and rapidity of the record itself, there are not a few omissions, and some of them truly unaccountable ones. Both Kent and his patron, the Earl of Burlington, may be said to be passed over in silence, since they obtain no further notice than the complimentary mention of their names as "two accomplished architects of the Anglo-Palladian school," without a syllable about any of their works—either the "Holkham" of the one, or the "Chiswick" of the other. The name of "Holkham," indeed—and it is the name only—occurs elsewhere, but wrongly, for the credit of that palatial mansion is taken from Kent, and assigned to Brettingham, who merely published the designs of it, with his own name on the title-page. It would seem, then, that "accomplished" architects as they were, Kent and Burlington are not entitled to figure at all in a history which brings forward such a mere nobody as John Yenn. Neither is any mention made of Carr, of York, although he was of considerable repute in his day, and erected many important mansions and other structures in the northern counties. Harrison, of Chester, too, is similarly passed over without being so much as named; and to him may, among others, be added Porden. Besides omissions of that kind, there is, with just here and there an exception, the general and pervading omission of all attempt at satisfactory critical estimate of the architects and buildings that are recorded. So little real substance is there in it, that Mr. Elmes's "History" amounts to very little more than a dry catalogue of names. What is worse, it is not trust-worthy: on the contrary, is so full of obvious mistakes as to excite general mistrust, for nothing is to be depended upon it which the reader cannot verify for himself. The Royal Exchange at Dublin, which "everybody" knows to be by Cooley, whose talent and taste are very happily displayed in it, is erroneously attributed to Chambers. Gandon is misnamed, for he is called *William* instead of James,—a mistake, perhaps, of no very great moment, but which, coming along with so many others, evinces the writer's habitual carelessness. It would, too, have been as well to have stated, that a "Life" of Gandon—such as it is, was published about a twelvemonth ago. Connected with Gandon, there is another mistake, for after he had been spoken of as having edited the two last volumes of the "Vitruvius Britannicus" (viz., the 4th and 5th), we are told that "Colin Campbell published his useful work, the 'Vitruvius Britannicus,' *in four consecutive* volumes, between the years 1715 and 1771"—therefore, the last of them about forty years after his death—"to which, Woolf and Gandon *respectively* added supplementary volumes of equal skill and correctness." This is so ambiguously worded, that it seems to say, each of the two latter editors separately added more than a volume to the original work, instead of bringing out conjointly two other volumes to accompany the three that had been published by Campbell. When he was mentioning that collection of designs, Mr. Elmes might as well have observed, that it is by no means so complete as it ought to have been; for while it is made to contain several very dull and uninteresting subjects, others are omitted which are either of considerable celebrity or merit,—such as Lord Burlington's Casino, at Chiswick (since altered by Wyatt), and St. George's, Bloomsbury.

IV. In speaking of Wyatt's Pantheon—of which greatly, if not extravagantly, admired structure, it is equally matter of surprise and regret that no engravings were given, either in Gandon's last volume of the "Vitruvius," or in the subsequent work by Richardson,—Mr. Elmes sadly neglects his proper duty as an architectural historian, to gossip very provokingly about Lunardi's balloon, instead of entering into any description of the edifice itself, which he merely calls a "fine work," without particularizing any of its beauties and merits. The only part of it on which he makes any remarks, is that which least of all required notice—namely, the front; it still remaining pretty nearly what it was at first. He speaks, however, of the portico as having been of the Ionic order; and if so, the Doric one, which existed before the building was converted into a bazaar, cannot have been that which Mr. Elmes alludes to, although he does not say as much. In what is said of that front, the term "wings" is not very correctly applied, the whole of it forming only a single general mass, without such subdivision into distinct collateral masses as properly answer to the denomination of "wings," which Mr. Elmes elsewhere applies equally vaguely, as when noticing the "Trinity House," and the "Society of Arts" in the Adelphi. Another instance of his indefiniteness in what ought to be explicit technical phraseology, is his very untechnical mode of describing a recessed portico or loggia, calling it sometimes an "inverse" portico, sometimes a "retrocessed" one, or by some other more fantastical than intelligible epithet.

V. The admiration professed for what is Soane's happiest piece of composition has not extended itself beyond words. We may say of it *laudatur et alget*, since no one has testified his estimation of it by borrowing an idea from it, notwithstanding that similar striking effect and picturesque expression might be obtained without falling into direct imitation. Nay, Mr. Elmes would make out Soane himself to have been there only an imitator,—at least, to have "had in his mind the semicircular porticos of the transepts of St. Paul's," as if, without them, the idea would not have emanated, as no doubt it immediately did, from his studies of the Temple at Tivoli, whose order—an equally beautiful and peculiar example of the Corinthian, that had previously been ignored by all modern architects and all the systematisers of the Five Orders,—was adopted by him at the Bank as a decided novelty, with unimpeachable classical authority for it. Still, though he adopted it, even Soane himself does not appear to have comprehended its character, for it is only at that angle of the Bank that he has exhibited it entire, having in the other parts of the building employed the columns only, without the entablature which belongs to them, not only in conformity with the original example, but in conformity with the laws of æsthetic design. By suppressing—as if such change was of no moment at all—the rich embossed frieze, which is absolutely necessary for keeping up harmony and perfect agreement in the *ensemble* of the order, he converted the entablature altogether into one which contrasts rather than at all agrees with the columns themselves. Their fluted shafts become too rich, and their capitals look too heavy, in comparison with the emasculated entablature. The energy of expression, as well as the degree of decoration assumed for the columns, stops short with them, instead of being carried on consistently, and extended to the horizontal division of the order, where, if anything, increase rather than diminution of decoration is requisite, since otherwise, a most disagreeable falling-off takes place: *amphora cœpit institui,—urceus exit.* If decoration is to be moderated at all, it should at least be done consistently, and so as not to throw one part out of keeping with another; the doing which—and it is by no means uncommon—betrays either downright ignorance, or wilful and most unpardonable disregard of both precedent and principle. What is not least of all extraordinary is, that those who are gifted with such very microscopic vision as to be struck by the profile of a mere moulding in a cornice, or some equally minute detail, take no notice of such wholesale omissions as the suppression of sculpture on a frieze amounts to. In some portions of the Bank the frieze is not, indeed, left entirely blank, it being ornamented with a Vitruvian fret; which, however, has a tame and insipid look in comparison with the boldness of the capitals. If deviation from the original there was to be at all, it would not have been amiss, perhaps, to increase the cornice, and also give it something of richness; thereby rendering the entablature equivalent in force of expression to that of the columns.

VI. With regard to that particular feature in the architecture of the Bank which has given rise to the preceding remarks, it has obtained more of professed admiration for its striking effect than of inquiry into the cause of that effect. For such inquiry, perhaps, there is no great need; because no one who has any eye at all for the picturesque in architecture, can be at a loss to determine in what the peculiar piquancy of that composition consists. Still, it is necessary that its merits, in that respect, should be distinctly pointed out, if only in order to force such earnest attention to them as might lead to similar happy results in composition. Precisely the same columns are used in other parts of the buildings, yet nowhere with anything at all approaching the same effect; and why? because here the composition is such as to be unusually productive of those "*accidents*" which give life and spirit to architecture—namely, vigorous *chiaro-scuro*, play of perspective, and richness of combination. There is not merely light and shade in a greater than ordinary degree, but variety of it—deepening shadows and brilliantly-touched lights when the sun begins to strike upon that angle of the building. Of perspective appearance, also, there is great variety, owing to the apparent changes of position between the external columns and the inner ones, and also to the contrasted disposition of them, the former being upon a curved line, the latter on a straight one. There is also another point of contrast between them which is equally judicious and happy, the outer columns being fluted and the others plain. This, while it adds to the variety of the composition, prevents confusion; and such is the value of the two inner columns, that without them the whole would be many degrees less admirable. They are, besides, both motived by and serve to warrant the mode in which the attic is carried across the loggia in a straight line. The only exceptionable thing is the door, or rather the appearance of door, when there can be no entrance from without, and where therefore a window or window-door—even had that also been only in appearance—would have been less of an impropriety. But a statue of some sort, sufficiently important in size, would not only have been an interesting object of itself, but have done away with all necessity for appearance of access into the loggia, since the latter would in such case have had an ostensible purpose as a piece of decoration.

VII. We get architectural criticism—as far as we do get any of it at all—merely by a mouthful of it at a time. What professes to be such is seldom more than a single condensed opinion expressed in the lump, wrapped up perhaps in a mass of cumbersome verbiage, or else enunciated in a tone of oracular decisiveness, intended to awe into silence and stifle inquiry and discussion. Even Horace Walpole's critical verdicts, albeit they were sometimes turned epigrammatically enough, were both flimsy and unjust, shallow and superficial. What he says of the campanile of St. George's, Bloomsbury, amounts to a mere sneer, and convicts him withal of being quite obtuse to picturesque effect in composition, and other architectural merits. As to Gothic architecture, Horace disqualified himself for setting up as a judge of that by his own precious Strawberry Hill, which would have absolutely horrified him had he possessed the slightest feeling whatever for that style. Yet, even vile as it is, Strawberry Hill has been deliberately praised by another discerning critic and writer on architecture, who says that the connoisseur would there find "all that is fascinating in the Gothick style." All that is fascinating with a vengeance! Were it possible to conceive that Dallaway was there merely joking, we could account for such praise as being condemnatory irony; but he seems to have been quite serious, and must accordingly have been exceedingly stupid also. In what its fascinations consist he does not say, although if any such merits there were, it behoved a critic to point them out, and to do so in such manner as so fix attention upon them. The comfort is, we lose very little by Dallaway's confining himself to only very hurried and superficial remarks on modern English buildings and architects, since what he does say, indicates but very mediocre critical talent and taste. What sort of an architectural critic Allan Cunningham was,—how well qualified to undertake the "Lives of British Architects,"—may be judged from the censure he passes upon the large open arches and loggias above them in the river façade of Somerset Place,—the most striking features, or rather the only striking ones, in that composition. In a fit of hypercriticism, Allan affects to be shocked at those very picturesque parts of the structure, as being quite contrary to all architectural principle and propriety, he asserting that the columns over the void of the arch produce "an appearance of insecurity that is altogether intolerable;" which is as much as to say, that instead of suggesting the idea of strength and perfect security, the arch looks unequal to the due support of the columns. Nevertheless, it is certain that those arches are capable of safely bearing the weight of the columns, and can also safely bear the weight of what is much heavier still—namely, Allan's own leaden criticism.

VIII. Very great pity is it that St. Martin's Church stands just where it does, because it was in consequence allowed to interfere very injuriously both with the National Gallery and Trafalgar Square. Owing to its being obstinately insisted upon as a *sine qua non*, that the portico of the church should be exposed to view from Pall-Mall-East, the front of the Gallery was obliged to be set further back than it otherwise needed to be, and the site of the building—at best a very cramped-up one in its rear—considerably reduced in depth; in some parts, to little more than half. Hence, the interior of the structure does not at all realise the promise made by its extent of façade. Admitted it must be, that the architect did not economise what space he had so well as he might have done; still, that does not excuse those whose capricious whims thrust difficulties upon him where, without such addition of them, there were many to contend with.—On the other hand, as regards the "Square," its symmetry and rectangularity have been sacrificed for the sake of keeping its east side in a line with the portico of St. Martin's, which would still have shown itself, even had it not been made to come actually into that corner of it. After all, does the church display itself to such advantage, as to reconcile us to the inconveniences and deformities which it has been allowed to give rise to? The reply will be: "Hardly." Thrown open to view from such a distance as it now is, that portico is not so impressively striking as it formerly was. As it stood originally, the situation seemed altogether unworthy of it, owing to its being much too confined, and to the meanness of the houses huddled-up round the church—a species of contrast more picturesque than becoming or agreeable. Nevertheless, as it was then seen, the portico showed imposingly; and all the more so, because the view was confined nearly to that—the steeple not being seen unless it was directly looked up to; whereas now, as seen from a distance, the entire structure, that is, both portico and steeple—the latter of them anything but a graceful and well-composed object of its kind—are seen together; owing to which, the portico loses considerably, and the classical character that would else stamp it, when beheld at such a distance that only its exterior or columns are visible, is greatly interfered with, if not altogether forfeited, by the uncouth appendage which rises up immediately behind it. By no means is the view of the portico from Pall-Mall-East a prepossessing one.—Trafalgar Square itself falls very far short of what was only reasonable expectation for it. Strange perversity of judgment, bungling, and disregard of architectural disposition have been allowed to manifest themselves in it. Although the area itself seems to have been expressly planned for the reception of the Nelson monument, the column is, after all, not placed within it, but is pushed just out of it. The only assignable reason for such downright preposterousness is, that had it been erected in the centre of the area prepared for it, so lofty an object put just there would have had an unfavourable effect upon the front of the Gallery. Very true; but then that consideration ought to have been a *raison de plus*, and an all-sufficient reason in itself, for *not* adopting a column, more especialy as there was another thing of the same kind just by. There were many other designs which, besides being sufficiently well adapted to the situation, were far more original and artistic. It was, therefore, to be presumed that the second competition was for the purpose of enabling the committee to retrieve the error of their first choice; when lo! to the amazement of every one, the result was just the same as before,—which was only making matters worse than before. Far better—far more honest and honourable would it have been to have abided by their decision, than to make such show of intending to retract it. The least they could in decency have done, would have been to justify by some show of reason for it, a choice so strangely persisted in, and so strangely acquiesced in by those who had been trifled with. The best that can be said of the humdrum Nelson monument is that it serves to render the façade of the National Gallery perfectly satisfactory in comparison with it.

RAILWAY SECTIONS IN SIDELONG GROUND.

On Tables for Setting out the Width of Cuttings and Embankments on Sidelong Ground; and also Formulæ for Computing the Area of Vertical Section.

By R. G. Clark, C.E.

The object of this paper is to investigate some simple formulæ, and from thence to construct some tables, to enable the assistant engineer or contractor to set out the widths of cuttings and embankments on sidelong ground; and also to calculate the solid content of any portion of the ground. The subject may be resolved in the following proposition:—

Given the $\angle$ of inclination of ground, the depth (from field-book, &c.) of ground to the centre of balance or formation level, and the ratio of the slopes; to determine where they will meet the ground at surface.

Let H A F B D (fig. 1) be a vertical section of the ground; A B the formation line, represented by $2b$; the given angle of inclination of ground H D with the horizon by θ; the given depth O F from the stake O perpendicular to centre of formation level denoted by a.

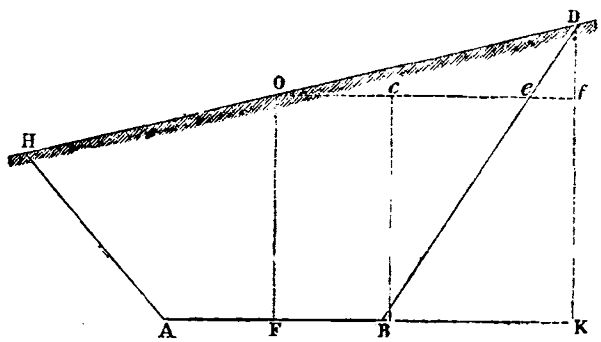


Fig. 1.

1. We will proceed first to determine a formula for O D. Let it be x; draw D K perpendicular to A B produced; O f parallel to A B K. Let D B be the given slope m base to 1 perpendicular; draw the vertical B C.

Let D $f = y$; then O c = F B $= b$; $ef = my$; also by similar triangles, C $e = ma$. $\therefore$ O $f = b + ma + my$.

Now, by triangle OfD, right-angled at f, we have

$$1 : x :: \sin\theta : y. \quad \therefore y = x . \sin\theta.$$

$$\text{Again, } 1 : x :: \cos\theta : b + ma + my.$$

$$\therefore x . \cos\theta = b + ma + my.$$

$$\text{Eliminating } y, \text{ then } x (\cos\theta - m\sin\theta) = b + ma;$$

$$\text{therefore, } x = \frac{b + ma}{\cos\theta . - m\sin\theta} \quad \text{.........................} \quad (1)$$

From the factor, $\dfrac{1}{\cos\theta - m\sin\theta}$ of the above formula, the Table No. I. is computed from 5° to 20°.

2. To find an expression for O H measured from O on the descent.

Draw H M (fig. 2) perpendicular to A B produced. Let H A be

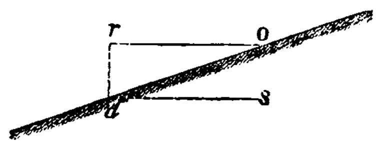


Fig. 2.

the given slope, ratio as before. Let H M $= y'$; then will A M $= my'$. Therefore, H G = N F $= b + my'$; also O $g = a - y'$.

$$\text{By the triangle H}g\text{O we have } 1 : x' :: \sin\theta : a - y';$$

$$\text{therefore, } a - y' = x' . \sin\theta; \text{ and } y' = a - x' . \sin\theta.$$

$$\text{Again, } 1 \quad x' :: \cos\theta : b + my'.$$

$$\text{Eliminating } y, \text{ we have } x' (\cos\theta + m\sin\theta) = b + ma;$$

$$\text{therefore, } x' = \frac{b + ma}{\cos\theta + m\sin\theta} \quad \text{.........................} \quad (2)$$

From this expression, Table No. II. is calculated by the factor $\dfrac{1}{\cos\theta + m\sin\theta}$,

3. We shall now investigate an expression for the area of the vertical section; the inclination of ground, depth, breadth of formation level, and lengths x, x', and also the ratio of slope, being all given.

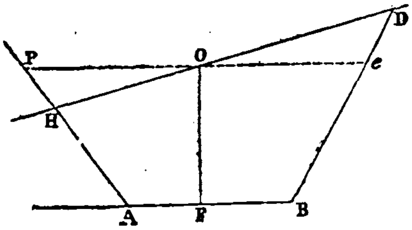


Fig. 3.

Through centre O (fig. 3), draw P e parallel to A B; then P O $= b + m\,a$. $\therefore$ area of trapezoid P A B $e = (2b + m\,a)\,a$;
area of triangle P O H $= \frac{1}{2} \sin\theta . x' \,(b + m\,a)$;
and area of triangle D O $e = \frac{1}{2} \sin\theta\, x\, (b + m\,a)$.
Consequently, the whole area of trapezium or vertical section = area P A B e + area triangle D O e − area triangle P O H=

$$(2b + m\,a)\,a + \tfrac{1}{2}(b + m\,a)\,(x - x')\sin\theta \ldots\ldots\ldots\ldots\ldots (3)$$

The first column of the table gives the angle of inclination of the ground, and the adjoining column the nat sines to three places of decimals, to facilitate working out the area, as in equation (3). We shall now commence with the following Rules.

I. *To find the two lengths* O D *and* O H:—RULE. Add the half-breadth of formation level to the product of the slope and given depth; then multiply this sum by the corresponding tabular number, then will each product be equal to each length required.

II. *To find the area of section* H A B D:—RULE. 1st. Add the formation level to the product of the ratio and depth, and multiply this sum by the depth. 2ndly. Add half the formation level to the product of ratio and depth; multiply this sum by the difference of the two lengths, and again by nat sine of angle. Add these two products, and their sum will be the area.

Example 1.—Given the angle of inclination of ground 18°; slope, 1 to 1; depth, 45 feet; and breadth of formation level, 30 feet. To find distances of centre stake, area of section, and cubic content, when 100 feet in length.

Here $b + a\,m = 15 + 45 = 60$; $m = 1$; $\theta = 18°$; its nat sin $= \cdot309$
$\therefore 1\cdot557 \times 60 = 93\cdot429 =$ O D. $\cdot799 \times 60 = 47\cdot940 =$ O H.
By formula (3) we have $(30 + 45)\,45 + \frac{1}{2}(15 + 45)\,(45\cdot48)\cdot309$
$= 75 \times 45 + 30 \times 45\cdot48 \times \cdot309 = 4099\cdot5$ area required.
Cubic content $= 409950\cdot0$.

Example 2.—Given angle of inclination of ground, 20°; slope, $1\frac{1}{2}$ to 1; depth, 50 feet; and breadth of formation level, 30 feet. To determine distances and also area.

Here $a = 50$; $b = 15$; $m = 1\frac{1}{2} = \frac{3}{2}$; $\theta = 20°$; its nat sin $= \cdot342$
$\therefore b + a\,m = 15 + 75 = 90$.
Now, $2\cdot344 \times 90 = 210\cdot96 =$ O D. $\cdot781 \times 90 = 70\cdot29 =$ O H.
By formula (3) for area we have
$(30 + 75)\,a + \frac{1}{2}(15 + 75)\,(140\cdot67)\cdot342 = \cdot7174$ area required.

Example 3—Given the inclination of ground, 18°; slope to be 2 to 1; depth from field-book, 20 feet; breadth of formation level, 30 feet. To find area and distances.

Here $b = 15$; $a = 20$; $\theta = 18$; $m = 2$. $\therefore b + a\,m = 55$.
$55 . \times 3\cdot000 = 165\cdot =$ O D. $55 . \times \cdot641 = 35\cdot25 =$ O H.
By formula (3) we have
$(30 + 40)\,20 + \frac{1}{2}(15 + 40)\,(129\cdot74)\cdot309 = 2505$ area required.

Remark.—If the ground should ascend and descend, as in the adjoining diagram (fig. 4), then Table No. II. is to be used to find the distances. Table No. I will in like manner be required for ground descending from centre, as in fig. 5.

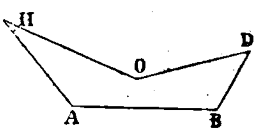


Fig. 4.

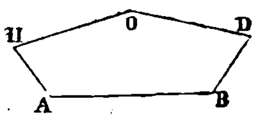


Fig. 5.

The Tables will likewise do for embankments—No. I. for the ascent from centre stake, and No. II. for the descent.

We shall now discuss the equations (1) and (2). Put them respectively under the following forms. T, T′, being tabular numbers, $A = b + m\,a$.

$$X = T . A; \text{ and } X' = T' . A.$$

Divide by T, T′, respectively; then $\frac{X}{T} = \frac{X'}{T'}$, A being eliminated.

Therefore the two distances, x and x', are to each other as their respective tabular numbers; consequently, the distances can be proved by a second operation. The Tables might have been carried up to 45°, but then they would require a greater number of places of decimals to insure greater accuracy.

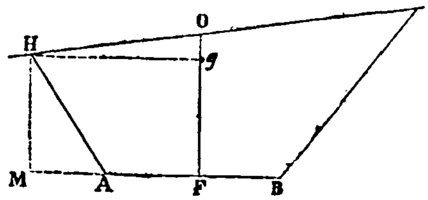


Fig. 6.

In taking the angle of inclination, the clinometer or common theodolite might be used; but if the spirit-level should be used, then we have only to measure from O downwards *any* distance, O r, (fig. 6), and then take the height with instrument; and then will the sine of angle of inclination O $d\,s = r$ O $d = \frac{\text{height}}{\text{distance}}$.

Angle.	Nat. Sin.	TABLE No. I.—For O D.			TABLE No. II.—For O H.		
		1 to 1	$1\frac{1}{2}$ to 1	2 to 1	2 to 1	$1\frac{1}{2}$ to 1	1 to 1
5°	·087	1·100	1·156	1·217	·854	·881	·926
6°	·105	1·124	1·193	1·273	·832	·868	·910
7°	·122	1·148	1·230	1·323	·802	·851	·895
8°	·139	1·175	1·280	1·404	·780	·835	·885
9°	·156	1·203	1·328	1·496	·761	·820	·873
10°	·174	1·233	1·380	1·570	·752	·804	·856
11°	·191	1·265	1·437	1·666	·736	·790	·850
12°	·208	1·279	1·500	1·778	·700	·780	·844
13°	·225	1·330	1·566	1·902	·705	·763	·841
14°	·242	1·372	1·655	2·055	·696	·752	·826
15°	·259	1·414	1·731	2·230	·676	·740	·818
16°	·276	1·459	1·825	2·463	·663	·727	·800
17°	·292	1·506	1·930	3·600	·645	·717	·801
18°	·309	1·557	2·050	3·000	·641	·710	·799
19°	·326	1·613	2·186	3·040	·630	·698	·787
20°	·342	1·673	2·344	3·913	·611	·680	·781

Erratum.—The diagrams, figs. 2 and 6, in the above article, are transposed, for which oversight the printers are accountable; but beyond such transposition the error does not extend.

REVIEWS.

The Port and Docks of Birkenhead; with Maps, Plans, Sections, and Tidal Diagrams, and an account of the Acts of Parliament relating to the Mersey and Dock Estate of Liverpool. By THOMAS WEBSTER, M.A., F.R.S. London: Chapman and Hall, 1848.

Birkenhead has been a wonder, and has had its nine days, and very many are quite ready to believe that we have had enough of it. The announcement of such a town springing up in England was calculated to create as much astonishment as that of Aladdin's palace fresh coined by his wonderful lamp. It is not so easy to create great wonders in an old and settled country like this: cities of whitewash and timber-framing, metropolitan centres of slab-houses and log-huts, we leave to the far west of the States, or the sandy regions of Australia; and we should be no more surprised by the flourishing account of a Babylonian capital newly hatched in California, than by the sight of the three last joints of the sea-serpent's tail, or the repudiation of a fresh batch of Pennsylvanian bonds. Towns grow in the virgin soils of the new world; they are a natural production—or at any rate they can be planted as easily as cotton, or what the Americans dignify with the name of corn. We can reconcile ourselves to such creations as Fleetwood, or Kingston-upon-Railway, Wolverton, or Swindon,—the resuscitation of Folkestone is a piece of the legitimate drama; but the public were truly struck with wonder to hear of the production on the shores of the Mersey of a great town, of the most solid construction and of the most magnificent proportions, provided with all the requisites of a perfect sanitary condition, with its labourers' houses, its park, schools, and market,—and this not a mere city of stone and Roman cement, but provided with such vast apparatus for commerce, that the envy of the London merchants was excited, and Liverpool gave signs how much she feared so great a rival near her throne. This, certainly, was a new phenomenon in England, for though we can add to London in one year a population equal to New York, or enlarge Liverpool with an addition as big as Albany, yet we do not throw our strength into new civic creations.

Since Birkenhead burst so suddenly on the public gaze the novelty has passed away,—and still more, from fortuitous circumstances, its glories have been dimmed, and its growth has been cramped; so that the interest it has excited has much worn off, and we shall be suspected of parading before our readers a stale subject, when we mention Birkenhead; but as we are not going to describe Morpeth Buildings, nor to investigate the statistics of the trade of the Mersey, nor to recommend the Liverpool merchants to give up and settle at Birkenhead, we may, perhaps, meet with a little attention, for Mr. Webster's book on Birkenhead gives us the opportunity of examining the plan as concerns its hydraulic features. Though Birkenhead may be a great town, and the docks a great speculation, yet there are scientific considerations involved in the harbour plan, which must render it a matter of permanent interest to professional men. If Birkenhead itself bears experiment, the walling of Wallasey is one of not less importance.

To make a dock is, in the hands of some engineers, a very simple operation; they scoop out a certain space on the shore, they run out piers into the water-way, or take in so much of the strand, and they are satisfied—though, for anything they know or care, the mouth of their docks gets choked up with sand, or the water at the entrance of the harbour is lessened, and a dock made for ships drawing eighteen feet will not take in those of fifteen. They have a great idea of dredging and sluicing power; and besides making a dock or harbour which fails in many of its essentials, they burthen it with a permanent establishment for getting rid of the silt which they have let in, and the sand-banks they have created, for it is surprising what very stupid and very careless people can do without knowing it. Mr. Rendel, when he was called in to make a plan for Wallasey Pool, thought it his duty to survey the whole water-way of the Mersey, and to make himself acquainted with the action of the currents and tides, so that, in laying down a deep-water dock at Birkenhead, he might not be shutting the outer gate to seaward—the Victoria Channel. Nothing is more common among seafaring men than to hear them complain, and complain with justice, that in consequence of new engineering works in some harbours, the depth of the water in the channel has been reduced, some dangerous shoal extended, some fixed bank made into a quicksand, or a bar which was troublesome enough before made a greater stumbling-block. If there be any up-navigation, that is sure to suffer when the point of discharge into the sea is injured, and the lighterman complains that the channels are choked, that the tide does not run up so high, or that he has less tide to carry him up; and the wharfinger finds that his frontage is stopped with sand and shingle. There is more bungling under the name of hydraulic engineering than perhaps in any branch of the profession. It is the opprobrium of engineering, that after hundreds of thousands have been spent on an hydraulic work, it is a complete failure; harbours are choked, piers pushed out only to push bars or shingle further seaward, and sea-walls are made with the most solid masonry and with the very smallest modicum of expense or capacity, so that they topple down before the walls are well set. So little is this branch of engineering appreciated by the public, that large tracts of available land—two new shires in fact—are left unsecured on the east and west coasts of England, when they ought long since to have been embanked. There is scarcely a river or water-way in the country which is not kept in a state disgraceful to the engineering science of England. Let any one leave the metropolis, and look at the shores of the Thames and Medway: marshes badly drained, or not drained at all; river walls made so steep that they are yearly cut into or undermined; and stones put year after year to be washed away, because they are put where they never ought to have been.

We do not know whether the government ought to take in hand, as in Holland, the care of our water-ways, for we place no confidence in what the government does. The constitution of the Tidal Harbour Commission is not such as to inspire any great hopes from government interference, for while that commission is ornamented with a military engineer in due course, there is not one civil engineer upon it. The one great remedy is by the exertion of the members of the engineering profession to improve the state of hydraulic engineering, and particularly to execute carefully whatever duties they undertake. This, we think, Mr. Rendel has done; and though we differ from him in some points, we have no doubt that he has carefully, conscientiously, and laboriously exerted himself in this survey for Birkenhead.

It is tolerably well known that Liverpool is one of the worst harbours in the country, with long and tortuous channels, among dangerous banks, and all the doubts and uncertainties of a bar-harbour, so that its very continuance as a harbour is precarious, and has, before this, been endangered. While Liverpool is a bad harbour, it is a bad harbour on a large scale; and those resources of science which are available for the improvement of small harbours can do very little on miles of sea-channel and acres of sand-bank;—still they can do a little, and it becomes of great importance, that in any operation within the estuary, all care shall be taken to prevent injury to the outer channels. Mr Rendel has tried to improve them.

The form of the Liverpool estuary is peculiar. It is wide above and narrow below, so that it has been compared to a bottle with the neck seaward. It is, however, outside the neck of the bottle that the sea-channels and banks are stretched out. Perhaps we may improve upon the bottle simile, by calling the estuary a curved powder-flask. Liverpool lies on the neck, on the concave side, and Birkenhead opposite, on the convex side. The wide part stretches up to Runcorn. Liverpool formerly had an inlet called the Liver Pool. This has been dammed up, and built upon; by which so much has been taken from the breakwater. The whole of the docks of Liverpool have likewise been taken from the breakwater, being constructed upon the strand. Thus the neck of the bottle has been narrowed very much more than it was originally.

Just above Liverpool a bank and shelf, called Pluckington Bank and Shelf, have been formed, which are not very advantageous to the docks before which they lie.

The Birkenhead shore has been untouched. It has a large inlet running up, named Wallasey Pool, and this has shown a tendency of late years to silt up. Indeed, considering Wallasey Pool, Pluckington Bank, and the general evidence, we should say that there is a decided action unfavourable to the good condition of the harbour.

The deepest water lies on the Birkenhead shore, so that it has a depth below the lowest dock-sills on the Liverpool side.

It will be seen, that whatever works are undertaken at Birkenhead, they may act upon the upper part of the flask, upon the neck and so affect Liverpool outside, and so operate upon the Victoria Bar and Channel. Whether this action was to be for good or evil very much depended upon Mr. Rendel; and he might have done as others have done—made his docks, and cared no more about it: but he has wisely taken a wider view, and tried to do all that was possible to improve the state of the harbour. This was done wisely, because the continuance of Birkenhead depends upon the good condition of the Victoria Channel; and if vessels cannot get over the bar outside, they will never be able to get into docks either on the Liverpool or Birkenhead side. Mr. Rendel's plan, therefore, is not one merely for making the Birkenhead docks, but for improving the harbours of Liverpool.

Wallasey Pool has a wide mouth, and runs, narrowing as it goes, about two miles inland, taking the drainage of a small district. This Pool is mostly dry at low water. The opening of this Pool is perhaps a mile across.

This Pool may be taken as two parts, the mouth or funnel, and the upper part. Mr. Rendel's plan is to take advantage of a ledge of rock which runs across the neck, and shut off the upper part by a great dam with lock-gates, and having a line of sluices as hereafter described.

The upper part constitutes a float of 150 acres, kept up at high-water mark, and on the sides of which docks, wharfs, warehouses, and building-yards may be formed. Around this float a river-wall is to be built as frontage to the wharfs.

The mouth of the Pool is to be embanked, except a low-water basin of 37 acres open to the Mersey.

The sluices in the dam are to be so arranged as to be near the bottom line of the outer low-water basin, so that on being run out they shall sweep the bottom of it. This they are to do during a part of the tide only, so as to concentrate the action, to keep the basin and its mouth free from silt, and to send the water down to the Victoria Bar at the best time for action on it. By the construction of the sluices, the water, instead of being poured down to tear up the bottom of the basin, will be sent along in a sheet, so as to prevent the silt from depositing itself. This sheet will be sent below the water in the basin, and Mr. Rendel thinks it will act to sweep the silt 2,000 feet.

It will be seen that by blocking up the Pool and inclosing the greater part of the strand, a considerable body of tidal water is displaced.

Mr. Rendel expects by straightening the shore on the Birkenhead side that the access of the tide to the upper Mersey will be improved, and that the scour being increased Pluckington Bank, on the Liverpool side, will be reduced, a better entrance will be made to Wallasey Pool, and a more favourable action will be exerted on the Victoria Bar.

The plan seems open to the objection that injury must ensue from the tidal displacement at Birkenhead, particularly as by the construction of new docks on the Liverpool side a further displacement takes place there.

Mr. Rendel says that this is of no importance in the case of the Mersey. If the river were of a funnel shape an obstruction below would impede the passage of the tide up, and diminish the quantity of water available for scour. He allows that injury will ensue if an obstruction takes place in the upper Mersey, because there will be less room for the water to accumulate; and therefore there will be a less body to scour down on its ebb. He contends, however, that the displacement on the neck of the flask is of less importance, as the water there is of less power for the scour than the water returning from the upper Mersey. The tide will always have time and power to force its way up the neck to supply the reservoir in the upper Mersey; and the state of the channels in the neck is determined by the state of the upper Mersey, and not of the neck. He contends on the ground of the improving state of the Victoria Channel, and, notwithstanding the displacement by the docks at Liverpool, that operations at the neck cannot injure the Victoria Channel. Pluckington Bank, he affirms, is formed by the set of the current on the irregularly-shaped shore of Birkenhead. By straightening the Birkenhead shore, and making it parallel with the Liverpool shore, the neck will be made more efficient, the tidal body passing up will deepen it, and Pluckington Bank will be worn down, though he does not say it will sweep it away altogether.

This is really a summary of the harbour question; and we believe we have put it with sufficient succintness and clearness to enable our readers to exercise their judgments upon it.

The arguments and researches of Mr. Rendel in support of his case are well worthy of perusal, for they exhibit very able treatment and high powers of mind. It is in the preservation of these that the practical value of Mr. Webster's book consists; and it is fortunate that the editorship fell into Mr. Webster's hands; for as it is chiefly an abstract of the evidence, a mere lawyer would have got rid of the practical points, and the book would not have been of the least service to engineers,—whereas it is one which will be usefully added to the library of every member of the profession.

The formation of a harbour at Birkenhead is not new to engineers, for, in 1828, Telford, Stevenson, and Nimmo were employed on a plan by Mr. Laird, sen., and Sir John Tobin, and recommended the formation of a canal from Wallasey Pool to the Dee at Hilbree island, near its mouth, so as to get another access to the sea. This is a resource which Birkenhead still has, and which with its progress it will avail itself, but which will not checkmate Liverpool. Liverpool has, by the plan proposed for an out-harbour at Formby Point, a cheap means of providing more efficiently for all that could be done by a new sea outlet to Birkenhead. Formby Harbour could be made cheaply; while two short cuts to the Leeds and Liverpool Canal, and to the Liverpool and Southport Railway, would allow of goods being carried cheaply and quickly into the Liverpool docks; and for steam traffic, Formby Harbour would beat the Hilbree Canal. Mr. Rendel's plan may be considered as novel in its whole arrangements and treatment. Mr. Telford in looking at the Mersey is reported to have said: "They have built Liverpool on the wrong side of the river."

We shall now take some stray gleanings from Mr. Webster's book. Lieut. Walker, R.N., says that Pluckington Bank is caused by two opposing tides or eddies from Wallasey Pool meeting and causing the silt held in suspension to deposit itself. The straightening of the Birkenhead shore would remedy this.

Birkenhead, we may note, besides being the deep-water side, has the advantage of being the weather-side; while the docks on the Liverpool side, most exposed to the waves breaking over the sand-banks, are the most liable to silt up.

The area of the float at a high tide is 208 acres, the frontage 4½ miles. In the dam, Mr. Rendel proposes a pair of tide-gates of 70 feet opening, the level of their sills being the same as that of the Prince's dock, at Liverpool. This float would allow steam-tugs to enter, which is not the case at Liverpool. Mr. Rendel calculates on the movement of the steamers likewise in keeping his channels clear. Besides the tide-gates of the great float, Mr. Rendel proposes a lock of 50 feet wide and 200 feet long, which could be worked during ten hours out of every twelve, in a spring tide, for vessels drawing 17 feet water.

We shall give in Mr. Rendel's own words his plan of sluicing:—

"It is proposed to run down daily any quantity of water between the level of the tide of the day and that which may be considered best as the permanent level of the water: so that, supposing the water were retained at a permanent level of thirteen feet above the old dock datum, the average high-water of spring tides being 18 ft. 3 in. above that level, there would be 5 ft. 3 in., the difference between the permanent level and the tide of the day. The running off the water is a very important feature in the plan: the idea is to make sluices, or apertures, under the great gates and the tide-gates, passing out near the level of the bottom of the great basin, and consequently under the whole of the gates. The openings for the discharge of the water will be between the bottom of the basin and the level of the sills of the tide-gates and of the locks, as low as we can conveniently get them; say for argument sake, ten feet below the level of low water of average spring tides. The sluices will be so formed as to be five feet square at the top on the inside, and they will be gradually widened in horizontal dimensions, so as to produce a kind of sheet of water within two feet of the bottom of the great basin, and inasmuch as the separating piers of those apertures will only be at the point of outfall about two feet thick, the effect will be to have one wide sheet of water of the width of the basin; the consequence of that is, that we shall be able to operate upon the bottom of the basin, not in the usual way of a large bore of water tearing up everything before it, but a sheet of water which we can regulate to any degree of force which we like, by the sluices on the inside. I should also say further, that we have the sluices there, because they will operate most efficiently upon the straight part of the basin; we propose to have the same kind of sluices between the little dock which we have called the Bridge End Dock, and the arm of the basin running up to it, operating in the same way precisely. I wish it to be distinctly understood, that we do not propose to run those sluices in the ordinary way of sluicing. I want to give the water, which is to be discharged out of this great basin, more the effect of a river passing through with a gentle current, than a great body of rushing water, and I arrange the sluices with this view. It is also manifest that a basin of such capacity as this basin, will have lying in it a number of vessels, say of from six to ten feet draught of water; those very vessels will be the means, with a gentle current, of keeping the basin clear with the daily operations we shall employ in running off this water.

If the basin were unoccupied the effect would not be so great as it will be the basin being occupied. If the basin were formed at the level of low water, or if it were not occupied, the effect of the sluicing would not be so great as it will be from the fact that vessels are floating in the basin, whether in large quantities, or small; if the quantity of vessels is small, I would then give the water a greater current; if it is large, I would then give it a gentler current, so that we can command that kind of current passing under those vessels from their being afloat, which will keep the bottom clear of the daily accretions.

Also we can run off the water at those periods that experience will dictate to be the best. We are not bound to run it off at low water, or any particular period of the tide: that would be regulated by a regard to all the circumstances of the case.

I know from considerable experience, that many harbours are kept open entirely by the vessels lying in those harbours; the river is forced to pass under their bottoms, and in that way the water is kept at a proper depth. I believe that is notorious."

There will be the power of running off 1,600,000 cubic yards of water at spring tides, which will be available for scouring. The most available water for scouring now passing out of Wallasey Pool is 1,390,000 cubic yards; that is to say, the water passing off after half-tide.

Mr. Rendel's estimate is, for cofferdams and other temporary works, £15,323; excavations, £80,470; masonry, £198,513; gates and bridges, £21,268; draining, £22,572; land and contingencies, £53,379. Total, £391,908.

The peculiarity of Mr. Rendel's plan is the damming-up of the upper Pool, so as to make a float. Messrs. Mawdesley and Smith had proposed simply to deepen and wall the Pool, which was supported by some of the opposition parties. Mr. Rendel affirmed that this would do no good, but leave the Pool even more liable to fill up, as it would receive the water at an earlier time of the tide, when charged with a larger quantity of matter.

Mr. Rendel's researches on the tidal actions of the Mersey were very minute; but to be fully understood require the explanatory maps and sections accompanying Mr. Webster's book. We shall, however, attempt to give an abstract of Mr. Rendel's evidence in the House of Lords:—

"The estuary of the Dee, and the estuary of the Mersey, and the character of the two rivers are manifestly wholly different—their forms are different. They are different in this respect; the Dee is for the whole extent of it a shallow estuary; the Mersey, from the contraction at its mouth, has an exceedingly deep channel opposite Liverpool, containing an enormous mass of water, but immediately that it widens out in the same form as the Dee, it loses its depth and becomes a shallow estuary; therefore, suppose the tide to come up, as I describe it with reference to the large chart, as at present—and nothing in our works can prevent that, for the works are within the gorge—it comes up in a large body, presenting to all intents and purposes, the head of a wedge, and it gradually tapers out, losing its solid and compact form as it advances up the estuary. It is manifest that if we can make that wedge into a uniform column, as we shall do by these works, we shall perfect the efficiency of the channel after these works are made; the part outside Seacombe is perfectly untouched; we do nothing to that. Then, in order to ascertain precisely the whole economy of this tidal action in the estuary, and to satisfy my own mind, and in order to give evidence before your Lordships, I had tidal observations taken at Formby, which is, in fact, the headland on the Lancashire shore; observations were simultaneously taken at Prince's dock, which is the narrow part of the gorge of the estuary; also at New Brighton, Fiddler's Ferry, and Warrington Bridge, so that I have been able to trace the relative heights and the relative times of high water of the same tides at all those points, and I have done it at spring and at neap tides. The results I will give from the diagrams I have before me.

The width of the river at Egremont—the point which corresponds with the north end of the Liverpool docks—at high water, is 4,030 feet; the sectional area of the channel at that point at high water spring tides is 236,449 square feet. At Seacombe, only 3,000 feet within that point, the width is reduced to 3,060 feet, and the sectional area to 184,622 feet; it is altogether a gorge at that point; it is completely the gorge of the estuary, which has been defined by the works of the dock trustees on the one side and the natural rock of Seacombe on the other. At Wallasey Pool the width is 6,640, it will be reduced by building the wall to assimilate with the other sections, namely to 3,350 feet. At Woodside pier, the width is 3,500 feet, therefore the effect of the wall is to make the shores parallel, and consequently to take off this great width which Wallasey Pool occasions. That wall, when made, will in my opinion, improve the channel and course of the river; it will directly accomplish that object, and one immediate result likely to follow is the taking away of Pluckington Bank formed by the tide setting into Wallasey Pool and occasioning an eddy. The consequent good effect will be, that the quantity of water at the least, if not more, which now goes into Wallasey Pool, would go up into the estuary, and by going up into the estuary it must necessarily be of greatly more value to the maintenance of the estuary and the scouring power of the river than passing into the pool. There will be nearly 300 feet greater width opposite our works than at Seacombe. The minimum section of the river being at Seacombe, the next smallest section is at Woodside, and the next at Tranmere. The sections at Seacombe and Woodside will continue the smallest sections after the works are completed. If Pluckington Bank be swept away, it will make a difference greatly in favour of the narrows as they exist at present; it will make a larger section, and improve the estuary above. After Tranmere, the estuary becomes very wide; after you get above the bulb the bottle commences.

This section is the profile of the river; it is on an exaggerated scale as to height compared with length. Here is the Victoria Bar, then the Crosby Channel fall into this enormous cavity; here we have Seacombe, which is the narrowest part of the river; the bed rises up again opposite Garston to the level of low water. The river has excavated for itself within these narrows, within which it has been confined, a channel quite down to the rock in this particular place. The greatest depth at Egremont at low water spring tides is 67 feet. The greatest depth at Seacombe, which is determined by the rock, for it is scoured down to the rock, is 52 feet; the greatest depth opposite Wallasey Pool is 62 feet; opposite Woodside the greatest depth is 64 ft. 7 in., this is at low water spring tides. At Tranmere, we get 61 ft. 4 in. according to our soundings. It would appear that except in hollows in the rocks the sand has been scoured down to the rock, but as the current passes in and becomes impaired in efficiency by those hollows or irregularities on the shore, there are parts where banks have begun to accumulate, and it is only in certain parts that we can detect rocks by the plummet. The Mersey presents the character of a deep narrow channel supplying the estuary above; it presents the character of a narrow artificial gorge supplying a shallow extensive estuary.

According to the observations I have made there can be no doubt that the supply of water into the estuary above, depends upon the momentum generated in those narrows. The bulb at Wallasey Pool detracts from the momentum. The straightening the wall in the manner described would improve the current and increase the momentum, inasmuch as the present irregular shores make irregular currents; those irregular currents act upon each other and impair the general effect. If they can be made direct they are made more efficient, and consequently they will send a larger body of water up into the estuary, or at all events they will send that water up into the estuary which now runs into Wallasey Pool. I am as great an enemy as any one to the general question of abstracting water from estuaries, but there is peculiarity in this case which takes it out of the general class of causes of the abstraction of water from estuaries.

To ascertain the strength of the currents, I had accurate observations (with watches adjusted) at Egremont, Seacombe, Wallasey, Woodside, and Tranmere, and having a fleet of boats and a steamer to attend us, we put down floats, so far submerged that the wind could have no effect upon them, in the centre of the stream and on either side, far enough from the shore to feel the strength of the current, and the floats were observed as they passed each of the lines of the sections at the above places. The distances were great enough to give as accurate a result as could be obtained by any experiment of the kind, none of them being less than 2,600 feet, and the greater part from that to 3,000. The mean velocity of the tide upon the flood from Egremont to Seacombe was 6·173 feet per second, from Seacombe to Wallasey it was 7·211 feet per second; which expresses this, that the tide heaps up on the seaward side at Seacombe Point faster than that section can pass it through, so that it runs faster to relieve itself on the inside of the Seacombe Point than it does from Egremont to Seacombe. You have that increased velocity by the increased head outside Seacombe. From that section to the section at Woodside, the velocity is reduced to 5·891 feet per second. That arises from the current being impaired by passing into the bulb; it has, in fact, the effect of cross currents and eddies, as I have described. From Woodside to Tranmere the velocity is 5·33 feet per second. The ebbs are the very reverse. It will be observed that on the flood the tide was strongest from Seacombe to Wallasey Pool; upon the ebb, the strongest current is from Seacombe to Egremont; there the velocity of the ebb tide was 6·703 feet per second; the velocity of the ebb from Wallasey to Seacombe was 6·139, and from Woodside to Wallasey 5·49. These are ordinary spring tides. The velocity of the ebb from Tranmere to Woodside was 5·54 feet per second, which proves that the water is heaped up by the tide at Seacombe Point faster than it is vented; anything which can be done to improve the channel of the estuary between those narrows and the upper narrows must necessarily tend to vent that quantity of water with greater facility. Those were the results of actual observation, the theoretical results on a comparison of the sections agreeing with them as nearly as can be expected.

The object of these tidal sections is to show how the tides flowed on the days of observation. At the time stated it was high water at Formby, which is quite at the mouth of the estuary. At the same time, if you carry on your eye to the Prince's dock you find that the tide is heaping up, actually rising up, at the Prince's dock. Then if you go on to Ellesmere Port, you find that the tide is still rising; although at the time it is rising there it has fallen at sea; and so, all the way on to Runcorn and Fiddler's Ferry; and you get the profile at all the points by the different lines laid down here, which in words is this: that inasmuch as the tide had by flowing into the estuary attained a velocity in passing through these narrows at Liverpool, its own acquired velocity or momentum carried it forward, and heaped it up in the estuary according to all these lines, for it would be impossible if that were not the case to account for the fact, that the tide does so rise; and it is just this—I will suppose the fluid to be a solid; if a solid has acquired a given velocity, we know perfectly well in mechanics that unless some force interposes to stop the velocity of the body it will be carried on; and it is precisely so in this case, the water flows on by the impulse that it has received at that narrow gorge, and it rises above its level. If the elevation were due to nothing more than statical pressure, which is merely the pressure of the head without the velocity, it would terminate its course, for there is no law of nature to make it go further. What would be the state of things in an estuary like the Dee, would be determined by the form of the shore and other questions, but here you have the peculiarity so strongly marked, that you cannot mistake the cause. The effect there would be, that as the mouth of theDee is wider than its head, it would receive a larger wave than would be due to the upper part of the Dee, and, therefore, if it had acquired sufficient velocity, the water would accumulate up the Dee to a certain extent; but inasmuch as the extent to which it would accumulate is due to the velocity of the stream, it could not attain the same head in the upper part of the Dee as it does in the Mersey; it depends on the velocity. I should say this, that inasmuch as the profile represented is that which is due to the statical pressure (which is nothing more than head without force or velocity); all that is above that must be due to impetus: for we see here in the Mersey what we see in every river, and what we see in the Dee: instead of the narrow part being at the top, the narrow part in the Mersey is at the mouth; therefore, so far as is due to momentum, if you could make the Mersey and the Dee at all agree, it would follow, that you would in the Dee have an enormous heaping up compared with what you have in the Mersey. If you could by any possibility give to the water entering the Dee the same velocity as the water entering the Mersey, keeping the section the same, it would heap up here quite in the same way as it does in the Severn; but it cannot have that velocity, because there is not the same cause to excite it, namely, the contraction.

For determining how much the tide has risen up the estuary above its level at the gorge, I take the level at Prince's Basin, which is in the gorge. I will take the tide on the 1st of June, which was a spring tide. Suppose we start with the tide at high water at Prince's dock, which is in the gorge at Liverpool, it would be 1 ft. 1 in. higher at high water at Ellesmere Port, and fifteen minutes later in arriving at that point; 1 ft. 10 in. higher at Runcorn, and would be thirty-five minutes later than at Liverpool; it would be 1 ft. 9 in. higher at Fiddler's Ferry, one hour after it was high water at Liverpool; it would be 2 ft. 3 in. higher at Warrington bridge, 1 hour 25 minutes after it was high water at Liverpool. Without going through the details of each observation, the mean of three spring tides was 1 ft. 1 in. higher at Ellesmere, 1 ft. 10 in. at Runcorn, 1 ft. 8 in. at Fiddler's Ferry, 2 ft. 3 in. at Warrington. On the mean of the three neap tides, of the 8th, 9th, and 10th of June, there was still an elevation, but it was reduced on account of the stream not being so strong at the gorge, to 5 inches at Ellesmere Port, 11 inches at Runcorn, 10 inches at Fiddler's Ferry, and only 9 inches at Warrington; these differences are due to the differences of the neap and spring tides, or in other words, the differences of the velocities through the gorge are as 8 inches at Ellesmere Port, 11 inches at Runcorn, 10 inches at Fiddler's Ferry, 1 ft. 6 in. at Warrington; and it follows, that anything that would strengthen the velocity through the gorge at neaps, would necessarily tend to make the approximation nearer between the elevations at those different places at neap tides, as compared with springs.

The difference in the quantity of water which passes up the estuary at springs and neaps, I have taken from Captain Denham's survey; and if you could get the water at neap tides to stand at all those different points with the same differences above the Prince's dock as it does at springs, you would get an increased quantity of water (18,000,000 or 20,000,000 of yards) up the estuary; any increase of the momentum in the gorge would tend to increase the quantity going up. The observations led me to that conclusion, and I come to no other from the phenomena; at all events I am perfectly convinced that all the water that now passes into Wallasey Pool, would go up into the estuary. It is a mathematical question which I am not going to touch, whether more would go up; but philosophers have endeavoured to show, that a bulb upon a pipe (all other things being equal) would prevent the same quantity of water being discharged as would be discharged in the same time if the pipe were parallel, and this is a similar case, but I am not going into that question."

Random Hints on Railways and Railway Legislation. By Alexander Doull, C.E., Assoc. Inst. C.E. London: Weale, 1848.

This is a timely warning against the bill of the Railway Commissioners, particularly addressed to the engineering profession. It is so clear and practical, that we hope it will not be without its proper effect; at any rate, Mr. Doull deserves the warmest thanks for this exposure of the mischievous measures of the commissioners.

After showing the inconsistencies of the standing orders, and explaining the process adopted in preparing a line of railway for parliamentary examination, Mr. Doull goes on to analyse the amended bill. The chief amendment is the lowering the deposit by way of security from £500 to £200; but which for a line of 200 miles, would still leave the enormous sum of £40,000 in the hands of the Railway Commissioners, to be fooled away in such manner as they may think fit,—but which, at all events, is a serious impediment in the way of all new lines of railway. Mr. Doull very well observes, that the commissioners are quite ready enough to do work for the money,—indeed, the way in which they make work would deserve credit for its ingenuity, if it were not so objectionable from its decidedly mischievous tendency.

As is very well known, a preliminary survey, often extending over miles in breadth, is necessary to select the line which is to be surveyed in detail. No provision, however, seems to be made for this, or the bill is inconsistent with its performance. Most probably, Colonel Brandreth and Sir Edward Ryan are unaware how the survey of a railway is carried out. The fourth clause of the bill requires that "the promoters of any proposed railway shall apply to the commissioners for authority to make the surveys necessary to enable them to determine the line and level of such railway," &c.; but the fifth clause requires that "ten clear days at the least before making such application, the said promoters shall give notice by advertisements, each in the same words and form, in the *London Gazette* and in some newspaper published or circulating in each county through which the railway is proposed to pass, such intended application specifying the course of the line of such railway," &c.

Of course this cannot be done without a preliminary survey, and how is this to be effected ten clear days before the engineer can apply to the commissioners for leave to go over the ground?

Again, if this notice and this permission be as a protection to the occupiers, it is difficult to conceive how a notice is to be framed to cover the wide extent of country over which it is necessary for the engineer to go, if he is to choose the best line of railway.

It is evident to all practical men that a very large expense must be incurred for advertising voluminous notices (drawn up by lawyers) in the *London Gazette* and a number of country newspapers. It will be worth the while of the enterprising proprietor of the *Surrey Times* to publish it all the year round, instead of bringing it out as now for the occasion of the advertisements of intended applications to parliament for railway bills.

Mr. Doull thinks from the sixth clause that the permission to survey only extends to the very lands through which the proposed line of railway is to pass. If so, a large sum of money has to be paid down, much time has to be wasted, and a cumbrous process to be gone through, for a permission which is worth very little.

The tenth clause, regulating the return of any remaining portion of the £200, provides that "one month after the bill for giving power to make the railway, in respect of which such deposit was made, shall have passed or been thrown out or withdrawn by leave of either House of Parliament, the commissioners shall by a draft or cheque signed by two of the commissioners order the balance standing to their (the depositors) account, in respect of such deposit, to be paid to the promoters by whom the deposit was made." —Mr. Doull observes, that the framers of the bill do not appear to have contemplated the return of any portion of the deposit to those promoters who may not advance so far as the threshold of the legislature. We may add, that there is an opening for litigation, in case of any dispute among the promoters of a new company, such as has happened before, and such as may happen again, under the auspices of Mr. Spackman and others. If Mr. Spackman should give notice to the commissioners not to return the remaining deposit to the committee of the railway company, the commissioners may be very well disposed to act upon the hint, and wait for the direction of a court of law.

The thirteenth clause provides that "before the said promoters, or any of their officers enter upon any lands to survey the same, or to mark out the line of their proposed railway, as hereinafter mentioned, they shall give to the occupying tenant thereof not less than two nor more than seven days' notice in writing of their intention to enter and survey the lands." The object of giving not less than two days' notice explains itself, but the restriction as to not giving more than seven days' notice must often be most inconvenient to surveyors and engineers, for within seven days many circumstances may occur to delay the survey, while no inconvenience can accrue to the occupying tenant from any length of notice. Under this clause, it might frequently become necessary to serve a fresh notice, the first seven days' notice having expired.

Mr. Doull contends, and with justice, that the number of occupiers who would require to be noticed previously to commencing the survey or levels, would be considerably more than the number at present necessarily included in a railway book of reference, even supposing the survey to extend only to the usual breadth of 20 or 30 chains. It would therefore be necessary to get up a reference-book before commencing the survey; and this would be attended with very great expense, besides the risk of some occupier being left without a reference.

The fourteenth clause is in keeping with the rest. It enacts, that "the said promoters shall mark out the line of the proposed railway by means of stakes fixed in the ground not more than thirty yards apart, and in such manner as clearly to point out the proposed line of such railway; and they shall put up posts along the line, so marked out at convenient distances for the purpose of showing the level of such line, and shall mark on such posts in legible characters the number of feet and inches at which the rails are proposed to be laid above or below the surface of the ground."

Our readers will agree with Mr. Doull, that staking out a line of railway, and exhibiting the levels in feet and inches along the line, is a very difficult and complex operation. He estimates that it would double the expense of preparing parliamentary plans and sections. A higher class of surveyors would have to be employed, and a number of devices must be resorted to and superior instruments used to stake out curves of given radii with accuracy, in the face of the numerous obstacles to be encountered, and of the variety of circumstances to be met with, on an extended survey.

As more damage must be done by staking out the line than by an ordinary survey, another charge will be imposed on the companies, and further claims for compensation be given to the landowners and occupiers.

A new set of parties must be employed in painting the level-posts.

What good is to be got from stating, in "inches," a level which will differ whether the land be ploughed or unploughed, whether it be trenched or in grass, we do not profess to see. It can only cause a serious expense without answering any useful purpose.

At present, staking out is delayed to the period when it can be undertaken for a purpose of practical utility, and when it can be conveniently performed.

As landowners and occupiers can now refer to the plans without having the line staked out, and as engineers can check the levels of rival lines from those plans, going over the ground with the plans in their hands, it does seem very hard upon the companies that they should incur such expense for the officers of Royal Engineers, who are to be employed to inspect the line. In fact, if such parties cannot go over the ground without having the line staked out, they must be utterly incompetent for the discharge of the duties properly belonging to their own profession, and to the performance of which it is desirable they should be restricted. It will be open to a factious opposition to cavil about every one of the posts; and the military engineers and the whole party may be employed in ascertaining that the post is wrong by two inches above or below the line.

Clause 21 provides that the plans are to be deposited and inspected. The inspector, who knows as much about civil affairs as he does about civil engineering, is to hold courts along the line of the proposed railway "for the purpose of receiving information or suggestions from any persons interested in such proposed railway, either as the promoters thereof, or as the owners and occupiers of lands on or near to such line or otherwise" A very cheap way of annoying the companies and putting them to expense, will be by the landowners and farmers attending the inspector's court, and occupying the time of the staff by raising all kinds of objections.

The twenty-fourth clause is an ambiguous one, giving the commissioners power to allow the promoters to amend their plans after inspection.

Clause 25 provides that a second deposit is to be made; and this is followed by another ambiguous and inconsistent clause.

Mr. Doull thinks that Clause 32 contemplates a second inspection of the line of railway.

It behoves engineers to be on their guard against this most tyrannical, mischievous, and vexatious measure, which will place them under the inspection of their inferiors, the military engineers, in every operation of a survey; and they are to be subjected to the judgment of these latter, whether a level be rightly taken or a curve properly laid out.

It will be seen that this bill subjects railway projectors to the following new extent of unprofitable expenditure:—

The depositing of £200 per mile with the Railway Commissioners.

The advertising of the intention to survey.

The preparing a reference book for the survey, and the serving of the notices on the occupiers.

Staking out the line, marking the levels in feet and "inches," and setting out the curves

Making two deposits of the plans.

Preparing amended plans.

Attending the inspector in his inspection of the line as staked out; and fighting for the accuracy of the line, and against the objections of the local parties.

After all this has been done, the old preparations for encountering the ordeal of standing orders have to be made; for the new regulation of the Commons, providing for notices being sent through the post is quite inoperative, as service has to be proved, and the Lords require the old mode of service.

Our readers will agree that any system of legislation more disgraceful to a country than that by which railway companies are harassed, was never attempted or perpetrated.

Ancient and Modern Art, Historical and Critical. By George Cleghorn, Esq. Second Edition. Blackwood, Edinburgh and London, 1848.

It is stated that the object of this work is to present, in a popular form, a brief sketch of ancient and modern art; and to avoid the faults of other publications, which are of no use to the ordinary reader. By way of carrying out this pledge, the two volumes are filled with long passages from the French and Italian, and snatches of Greek and Latin, which are not likely to be very well understood by the public, which are not needful in themselves, and which do not even prove the learning of the author. As to the execution of the work, without being original, it is loose and unsatisfactory; there is a hash of the opinions of foreign writers on art, and the only novelty is the criticism of the author on English writers and reviewers. It especially fails in giving a clear idea of any one work, school, or style, and a reader taken from the public would acquire the smallest amount of definite information from its pages. It is a very difficult task to give an abridged view of an extensive subject, so as to communicate exact ideas; indeed, an abridgement requires as high a degree of ability as an extensive work. It is not surprising, therefore, if Mr. Cleghorn should utterly fail in this attempt. As from some petty provincial feeling, there is more space devoted to the buildings, sculpture, painting, and painters of Edinburgh than of any other place—indeed, a large part of the two volumes—the public who buy this book on its title, will have no more reason to be satisfied with the quantity than with the quality. The work has such small merits, that we should not feel called upon to notice it, if it were not that it is likely to be taken for a popular work, as being a second edition emanating from publishers of reputation.

A popular manual of art has yet to be written and is much wanted; but it must convey definite information and descriptions suited to practical men, and less general criticism of artists and works unknown to the public and not particularised. Mr. Cleghorn's account of the Munich school is the best that he has given us, but it is quite inadequate; while a proper account of what has been done and is doing there is one of the best incentives to the encouragement of art here.

We must do Mr. Cleghorn the justice to say, that so far as his abilities go, he is sincerely desirous of promoting the interests of art. It may be some excuse for his defects that the present work is the offshoot of a pamphlet in favour of the imitation of the Parthenon on the Calton Hill at Edinburgh, under the name of a National Monument for Scotland. He is, therefore, a partisan of pure Greek and what he calls idealism; he allows of Gothic; but seems to hanker most after Italian. If it were not for the metaphysical bent which effects all who are born north of the Tweed, and leads him into the discussions about idealism, he would be catholic in his artistic predilections. His idealism is, however, more confused than that of any German, because he is attached to the study of nature; and while holding up the imitation of nature as the great end of art, he cannot make out how to reconcile it with idealism. He has been born in the faith of idealism,—and though his convictions are starting arguments constantly against his faith, and though his practice is opposed to it, yet idealism he persists in maintaining. What it is he has not been successful in describing; in one place it seems to be the genius and imagination of the artist which constitute idealism: but this again does not agree with statements elsewhere. The late Haydon, although he talked very much about it, could never make himself understood. The upshot always was "Nature. and the Elgin marbles." Mr. Cleghorn is strenuous in his abuse of what he calls the sect of naturalists, but without producing any arguments except in their favour.

He seems to be much more successful in reproducing M. Quatremère de Quincy's definition of imitation. This is a fitting introduction to a treatise on artistic criticism. Imitation in the fine arts, says M. de Quincy, is the production of the likeness of a thing, but in another thing which becomes its image. It is not a reproduction of the thing, it is not its exact likeness, which can only be the result of a reproduction; but it is the image of a likeness, to be animated by the mind of the observer. Hence, an attempt at illusion fails because the artist takes on himself to perform the functions of the spectator, and leaves the latter little or nothing to do. The originals of most of the figures of Raffaelle, Rubens, or Murillo would produce much less interest than the paintings: they would often excite the reproach of being ugly or clumsy women. The best illustration of this fundamental principle of the fine arts, but one which Mr. Cleghorn has not adduced, is that derived from the drama. On a small stage, and in a short time, we are made to see the greatest men of antiquity, the revolutions of years, and the consummation of the most important events —the actors being men familiar to us even through the disguise of costume. The mind, however, takes its part with the actor, and shares in the realization. We do not want

> "A kingdom for a stage, princes to act,
> And monarchs to behold the swelling scene."

These accessaries are useless when the audience can supply their absence. The great dramatic poet explains the theory of imitation well, when he says to his audience;

> "—— 'Tis your thoughts that now must deck our kings,
> Carry them here and there; jumping o'er times;
> Turning the accomplishment of many years
> Into an hour glass."

As a perfect illusion is not necessary, but hurtful, so there are bounds placed to limit the extent of art, and to limit the extent of each department of art,—bounds best observed in the greatest height of art, and soonest overstepped in its decadence.

On the legitimate application of imitation all the fine arts depend, and this is their bond of union; it is only in the vehicle used, or the sense addressed, that they differ. We are now agitating for the catholicity of the three arts of design—painting, sculpture, and architecture; but we cannot expect a perfect development of the fine arts, unless their three other branches—music, the drama, and poetry—be likewise cultivated. The attempt to sever single arts, which has failed, is a ground for want of confidence in any system which steps short of completeness. In what do all our complaints and all our inquiries as to the low state of art end? In a conviction of the low mental condition of the professors of art. When the painter has once taken his brush in hand, the sculptor his chisel, and the architect his compasses, he bids farewell to education and enlightenment, he gives himself up to what he calls his art, and narrows and cramps his mind just at that time when it should be freest in its expansion. Precisely for the reason that the artist has no education, the scholar has no knowledge of art; and art is kept back from this state of affairs, and not from the want of manual capacity in our artists, or of adequate encouragement from the public. There have been opportunities enough lately, but they bring forth only Buckingham Palace or Trafalgar Square, art-union pictures or pigtail monstrosities. The schoolmaster has been sent abroad; but till our artists are better educated men, and more on a level with those of Greece and Italy, art can have little hope. We do not want academies of art so much as we want schools, liberal training, and the power of reasoning justly.

Among the six fine or imitative arts, there are marked distinctions. Painting or design, sculpture, and architecture are material in their production; poetry, the drama, and music are immaterial, and the latter two in their performance are transient or fleeting. The three latter have, however, the power of reproduction of the model work to such a degree as materially to extend their social influence. Painting by the means of engravings, and sculpture by means of casts, have this power of reproduction in a less or more modified degree, but the progress of science promises to give these arts greater resources; and although some look unfavourably on the machinery of copying and piracy, we cannot but believe that the artist will gain by being brought into communion with a greater mass of the public. The artist and the public must work together, they must feel for each other, they must join to produce the wished effect. Shakspeare working for the public of his day, and Dickens for the public of this, are under a stimulus which the artist at the present time too rarely feels. The incentive to immortality, the conscientious discharge of a patriotic duty, the inspiring influence of the goodwill and fellow feeling of applauding millions ought to operate on the artist as they do on the statesman, the general, or the poet, and ought to produce greater results than the grovelling selfishness which yields up its task on the payment of the stinted and allotted price, careless of anything but the money reward and the personal gratification.

Architecture has for its province the execution of single and isolated monuments. It is not easy to reproduce the Parthenon or St. Peter's, and the architect has every inducement to devote himself to the production of works the merit of which he will not divide with the copyist, the printer, or the engraver,—which he wants no translator to make known to other nations, but which are felt and understood by people of all countries and all ages. Architecture has, too, this distinction, that it has an immediate and an obvious utilitarian character. The painter, the sculptor, and the musician minister indirectly to the uses of society; the poet and the dramatist may propose a moral end, but it is not needful they should do so; whereas there are few works of architecture which do not bear the stamp of usefulness. It may be thought by some enough to appeal to this sense of usefulness, but until the architect can satisfy himself that Newgate or Bedlam engrosses the favour bestowed upon Westminster Abbey and St. Paul's, he will do well not to be unmindful of the artistic relations of his profession. As the mighty dome of St. Paul's is seen from so many points towering over London, how well does it mark the wide expanse of population crowding below. There is a greatness in the sight which cannot pass unacknowledged, while the statesman and the moralist knows too well the influence of great thoughts and great associations on the public mind to neglect those means by which they can be awakened and upheld. Athens, it is true, sank with the glories of the Parthenon untarnished, but not until the living spirit of art had been quenched.

The imaginative or creative power of the artist is what is not allowed for in Mr. Cleghorn's theories. His idealism resolves itself into the study of nature and the adaptation of the fine part of one individual to the fine part of another to constitute an ideal or perfect whole. He quarrels with Hazlitt for affirming that the ideal is the preference of that which is fine in nature to that which is less so; but he does not set up in its place anything which is clearer. Perhaps there is no difference. The naturalists, as represented by Mr. Hazlitt, say, "There is nothing which is fine in art, but what is taken immediately, and as it were in the mass, from nature." Mr. Cleghorn, for the moderate idealists, does not traverse this, but says, that "Ideal art is finer than nature;" though from what we can make out, ideal art is only selected nature.

As to the question whether it is better to represent individual nature with individual defects, accidents, and peculiarities, or to represent Jupiter with some of the features of the lion, and Hercules with the neck of a bull, to say nothing of fauns, satyrs, and centaurs,—this seems to us a question which, if solved in favour of the latter side, does not give any valid support to the idealists. Indeed, there is nothing which has ever yet been brought forward which shows that the Greeks owed their excellence to anything but the study of nature, or that there is any other mode of attaining excellence in art. We are therefore the more hopeful of the future of English art, as at any rate we have the groundwork of a study of nature; and this, supported by a prudent reference to the old masters, as confirmatory of the course of study, will, with a more liberal education and a more catholic feeling of art, give us artists of whose works we shall not be ashamed.

Railway Engineering; containing a General Table for the Calculation of Earthworks. By T. BAKER, C.E. London: Longman, 1848. 8vo. pp. 64.

We regret to perceive that Mr. P. Barlow has permitted this book to be dedicated to him, for we are sure that he was ignorant of the dubious character of the honour conferred on him by the unscrupulous author. There need not be the slightest delicacy or hesitation in affirming that the whole performance is a collection of gross plagiarisms. The formula for the super-elevation of the outer rail of a railway curve is taken from De Pambour. Methods which have long been published for setting out curves, the author claims as his own, on the plea that they were *privately* communicated to his pupils, and that some years ago he sent to the "Gentleman's Diary" a paper on the subject, *which was rejected.*

The "General Table for the Calculation of Earthwork on Railways, &c." is a direct copy from the "General Table for facilitating the Calculation of Earthworks for Railways, Canals, &c." by Mr. Bashforth. There is not even a colourable variation from the original in the copy,—*it is an exact reprint, line for line and figure for figure;* with a few additions, *but not a single omission.* Every one of Mr Bashforth's tabular numbers re-appears in Mr. Baker's table. We had intended, in order to render the plagiarism palpable, to print a column from one table by the side of the corresponding one in the other table; but after getting half way through the labour of copying the figures, we found that there was not a single alteration or omission, and therefore abandoned the task as useless.

A general reader, not familiar with the character of earthwork tables, might deem the similarity accidental or inevitable—just as if two persons published different tables of common logarithms or square roots, the tabular figures must coincide where both are correct. The slightest consideration, however, will show that the present is not an analogous case. A great number of earthwork tables has been published, but none except Mr. Baker's has the same figures as Mr. Bashforth's: and for this plain reason,—that other tables, such as Mr. Bidder's or Sir John Macneill's, are applied by methods, and for purposes, entirely different. Sir John Macneill's, for instance, are not general, but have the results for *particular* slopes and bases, worked out ready to the engineer's hand. Mr. Bidder's table, on the contrary, is general, and considers the prismoid in three separate portions. Mr. Bashforth's is also general, but considers the prismoid in two portions; one of which has no real existence, but being merely assumed for facility of calculation, is ultimately subtracted. Now considering the perfect independence of these methods, it is clear that the tables founded on them, though entirely different from each other, may lead to identical results. But the only person who has adopted Mr. Bashforth's very original plan of considering the slopes to be hypothetically *continued* till they meet in an apex, is Mr. Baker. He therefore is the only person who *could* use the same figures.

We have too much confidence in the right feelings of engineers, to suppose for an instant that this attempt to take the fruit of high talents and unweared toil from the lawful owner will prove successful. In our apprehension, the literary offence is much aggravated by the attempt made in the work under review to throw dust in the eyes of the reader, by abusing the author whose tables are copied. The attacks commence in the preface, and are continued at intervals to the end of the book, with all the emphasis which italics and capitals can give them. For example, speaking generally of other previous tables, our author allows that "none of them are accompanied with directions for finding the contents from the sectional areas, which is the most important part of such tables, except Mr. Bashforth's; *but his method of applying them is erroneous.*" Now, the assertion, which we have given in the author's own italics, is not only untrue, but it would not be uncharitable to assert that it is put forth to disguise the real relation of his own method to Mr. Bashforth's. The supposed error refers to the calculation for side-long ground (or cuttings or embankments on the side of a hill, where the height of the slopes is unequal), and is established by taking a perverse and preposterous example—that of two sections, 4 chains apart, of the areas 10,324 feet and 400 feet, respectively. As if in a length of 4 chains, no intermediate sections would be taken where the first section was more than *twenty-five times* the last!

Setting aside the extravagant nature of the case supposed, Mr. Bashforth's method, even if so applied, is just as likely to give a true result as that which Mr. Baker would substitute. We are told, that by neglecting the area of the triangle, the former method gives a result 7½ per cent. too small: but it is just as likely that the substituted method gives the result as much too great; for the ground may undulate so much, that the error may be either in excess or diminution. In a case like the present, where the ground falls so much in the direction of length, that the heights of one end-section are only one-fifth those of the other end-section, great irregularities of surface must be supposed to intervene. For instance, suppose a valley or deep hollow occurred somewhere in this length of four chains of cutting, Mr. Baker would tell the contractor that he had to remove all the contents of the valley, which, in reality, nature had already excavated for him. There is no guarding against such errors, except by the precaution which every reasonable engineer adopts where the ground varies considerably—which, in the present case, would be practically inevitable—and which Mr. Bashforth's method supposes,—that of taking *frequent* sections.

Our worthy author has not borrowed his predecessor's table of Proportional Parts,—which, as we explained in a former review, is printed on card, with a moveable index of wood sliding in a groove. It is estimated that by this ingenious contrivance, the table is made to contain all the calculations which, extended, would occupy a surface 42,250,000 times its present area. To have adopted this table also, would have been too palpable a plagiarism; Mr. Baker, therefore, contents himself with copying, *figure for figure*, the first twenty-one lines of it, which constitute *his* (!) "Table No. 2;" and the reader is informed (p. 48), that in cases which this "Table No. 2" does not include, he must work out the calculations for himself.

It is not to be expected that every practical person who calculates quantities for contractors, should understand the mathematical principles on which the particular tables which he uses are based. But it is within the simplest comprehension, that the two methods under comparison—and they alone—proceed on the assumption that the slopes are hypothetically continued to their intersection. It is also not a matter of reasoning at all, but one of mere eyesight, that Mr. Baker has re-printed Mr. Bashforth's calculations identically. The only differences are these—Mr. Baker's table is printed in a less distinct manner; to Mr. Basforth's table of 65 heights (reprinted without a single omission) seven more heights are added: lastly, of the table of Proportional Parts, the first twenty-one lines are reprinted, and as to the 42 millions and odd remaining calculations, which the sliding index ingeniously effects—why, the reader is left to calculate them for himself.

The Steam Navy.—Mr. Edward Whitley Baker has been appointed by the government to go out with James Brooke, the Rajah of Sarawak. Mr. Baker is attached as engineer to the Mæander frigate, and is to have charge of a steam launch, to be used in getting up the small rivers and creeks for surveys and in search of pirates, and is to be at the service of the Rajah in Sarawak and Labuan as mechanical engineer. We are glad to see from this appointment that the Admiralty are really desirous to improve the engineering service of the navy, by employing efficient practical men like Mr. Baker.

REGISTER OF NEW PATENTS.

BALANCE BRIDGE.

JOHN HARVEY SADLER, of Holbeck, Leeds, iron merchant, for "*Improvements in constructing bridges, aqueducts, and similar structures.*"—Granted July 7, 1847; Enrolled January 7, 1848.

This invention relates to the construction of cast-iron girders for continuous bridges, viaducts, or aqueducts, and other improvements relating to railways. Fig. 1, is a side view made according to this invention of cast-iron girders *c*, strongly jointed and bolted together at *a*, standing upon piers of stone or brick *b b b*, each girder *c*, being cast from one and the same pattern, or where no very great length is required, two parts *c c'*, may be cast as one piece; in either case from the points *d*, will constitute one girder, which is from centre to centre of two arches, and the two parts on

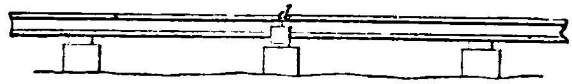


Fig. 2.

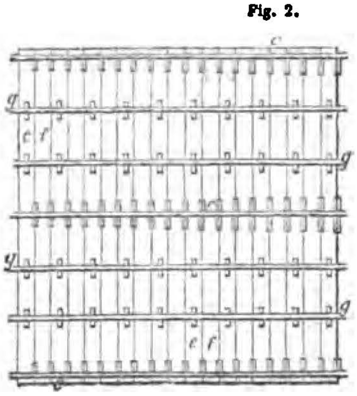


Fig. 6.

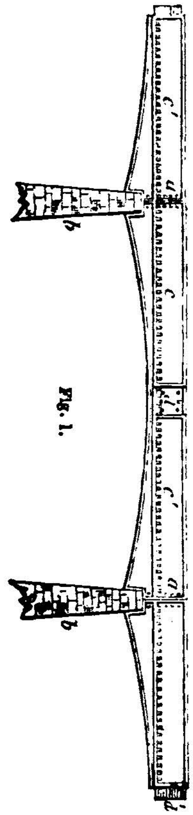


Fig. 1.

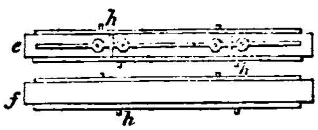


Fig. 4.

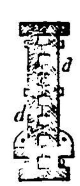


Fig. 5.

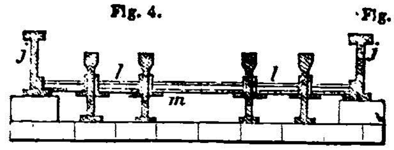


Fig. 3.

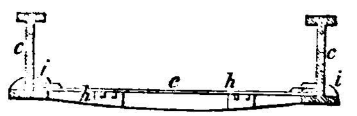


Fig. 7.

either side of a bar *b*, will balance each other, consequently, there is no weight or sway comparatively speaking in the centre of each arch. It will be seen that each girder is loose and at liberty at the centre of each arch *d d*, and though strongly jointed together by means of plates on each side, they will allow for any contraction or expansion required by change of the atmosphere; and fig. 2, is a transverse section of this joint, showing how the toothed-plates fit into similar teeth at the ends of each girder where they meet at the centre. Fig. 3, is a plan of the cast-iron flooring for bridges, &c., consisting of plates of cast-iron. Fig. 4, shows these plates upon an enlarged scale, the underside uppermost and not closed together, the better to explain how strength may be given to these plates to bear the rails and any weight required to pass over them; and fig. 5, is a transverse section, showing how these plates are fastened together, and bolted to the girders by the brackets *i i*. The covering or flooring-plates *e* and *h*, are shown to be a foot in width, and of the length from girder to girder corresponding to the width required for the railway.

The plate upon which the chairs are securely bolted is seen to have three ribs or flanches cast upon the underside in order to give the requisite strength, and also holes cast through it for bolting and securely fixing the chairs for holding the rails. There are studs about an inch square cast upon the sides of each plate, and each plate has holes cast of a size exactly to fit and receive these studs, (see *h*, fig. 5, which is a side view of these plates,) it will therefore easily be understood that if these plates were shut or closed together, these studs would enter into the holes cast in each for that purpose, clearly showing that the whole covering or flooring will be so united and securely fastened, so as to form one general mass of support to the rails and the weight passing over them.

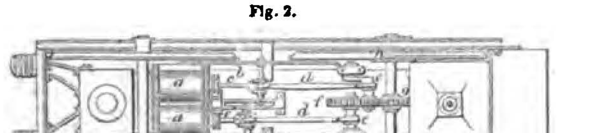
LOCOMOTIVE ENGINES AND BREAKS.

George Taylor, of Holbeck, near Leeds, Yorkshire, mechanic, for "*Improvements in the construction of engines and carriages to be used on railways.*"—Granted June 3; Enrolled December 3, 1847.

This invention relates, firstly, to improved arrangements of the cylinders of locomotive engines, and the parts which communicate the reciprocating motion to the driving-wheels, for the purpose of concentrating the driving power of the actuated pistons, so as to communicate an even rotating motion to the axles of the driving-wheels, and also to distribute the moving power (without first concentrating it) to one, two, or more pairs of driving-wheels in a uniform manner. Secondly, this invention refers to an improved break, for stopping the progress of carriages along the line of railway; such apparatus being also suitable for sustaining its carriage on the rails, in case of the breaking of an axle. Thirdly, this invention relates to an improved arrangement of tender. Fourthly, to certain improvements in mounting the wheels of railway carriages.

The improved arrangements are shown in the annexed engravings. Fig. 1 is a side elevation, and fig. 2 a plan, in which the

Fig. 2.



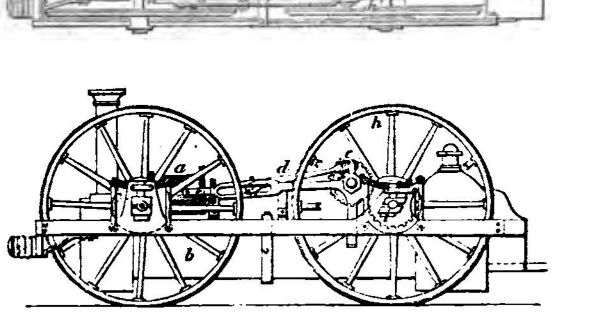


Fig. 1.

motive power, communicated to the pistons of the working cylinders, is concentrated in a line drawn longitudinally through the centre of the plane of the engine. *a*, *a*, are a pair of cylinders, placed over the end of the boiler *b*, nearest to the smoke-box; *c*, are the piston-rods, with cross-heads, which slide in guides fixed to the outside casing of the boiler; *d*, *d*, are rods for connecting the piston-rods to the cranks *e*, which cranks are attached one to either side of a central wheel *f*. The periphery of this wheel is provided with cogs, for gearing into or driving a wheel *g*, keyed to the axle of the driving-wheels *h*. In order to insure the proper gearing together of the wheels *f* and *g*, and allow of the play of the bearing-spring, the guides, in which the axle-boxes or journals of the driving-wheels *h* slide, are made at an angle, as shown at *i*, fig. 1. By referring to the figures, it will be seen that the axles are placed above the boiler, and, therefore, wheels of large diameter (say from 10 to 15 feet) may, if required, be employed with safety; the oscillation of the engine being, in great part, avoided, by the central and uniform driving of the axle of the wheels *h*, and the weight of the engine being near the ground. When it is desired to make all the wheels driving-wheels, their shafts may be connected together by rods and crank-pins, as now generally employed.

The specification describes two other arrangements of mechanism, for communicating the reciprocating motion of the pistons to the axles of the driving-wheels.

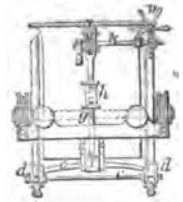


Fig. 4.

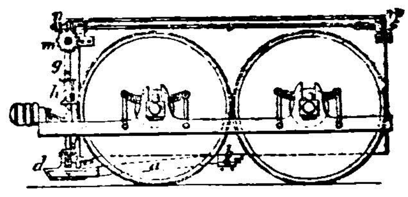


Fig. 3.

The improved apparatus or break for retarding and stopping the train is shown at fig. 3, a side elevation of a tender, with the apparatus attached thereto; and fig. 4 being an end elevation. *a* is one of two levers, attached to the bottom of the carriage, and intended to vibrate slightly upon centre-pins *b*. At their outer ends these levers are connected together by a cross-rod *c*, and are thereby caused to move simultaneously when any motion is communicated to them. *d*, *d*, are flanged skids, attached to the outer end of the levers *a*; and they are provided, at their under surface, with a block of wood, the grain of which is vertical. These skids are intended to be depressed on to the rails, when the speed of the train is to be ckecked; and the flanges, which are formed on the inner side of the skids, will act as guides and keep the carriages on the line of rails, in case of the breakage of an axle. *e* is a strong spring, stretching across from one skid to the other, and taking into slots or openings formed in the upper part of the skids. This spring is embraced, at the middle of its length, by a hoop *f*, which is jointed to a vertical shaft *g*, composed of two parts, and capable of being adjusted, in its length, by a threaded connecting-piece *h*. The upper end of the shaft *g* is forked, and between its prongs two antifriction rollers *i*, *i*, are mounted. In the sides of these prongs, and between the centres of the rollers *i*, longitudinal slots are cut, for the purpose of receiving the axle *k*, of a cam *l*, which is in contact with the peripheries of the antifriction rollers. The axle *k* is mounted in bearings affixed to the end of the tender, and to its outer end a worm-wheel *m* is keyed. This wheel gears into a worm *n*, mounted on one end of a shaft *o*, which turns in bearings at the side of the tender; and at its other end a hand-wheel *p* is keyed, for the purpose of giving it a rotary motion. Let it now be supposed that the skids are required to be let down on to the rail,—the hand-wheel *p* is turned, in order, by means of the worm *n*, to move round the wheel *m* and its axle, which carries the cam *l*; the larger radius of this cam being now brought into contact with the lower antifriction roller, it will depress the vertical shaft *g*, and communicate, through the spring *e*, an elastic pressure to the skids, whereby they will be made to bite the rails, and retard the progress of the train.

The third improvement consists in carrying the axles of tenders through or above the water-tank, whereby the weight is brought near the rails, in a manner similar to that of the engines. By this arrangement larger wheels than usual may be employed with safety; the weight of the load which the tender carries being brought much nearer the rails, whereby the oscillation is in great part prevented.

The fourth part of the invention relates to improvements in mounting the wheels of railway carriages,—the railway axle being composed of two parts, one being solid and the other tubular. The solid axle is made to carry one of a pair of wheels, and the tubular axle, which is slidden over the solid axle, or otherwise placed over it, receives the other wheel. The advantage of mounting wheels in this manner is, that they will be allowed to turn independently of each other. In applying the improvement to axles, as now constructed, one boss is turned down, and a collar merely is left; the axle is then coated with "Paris white," or other suitable substance, and afterwards heated in a furnace to a dull red heat. When in this state a tube or hollow axle is cast around it,—the ends of the hollow tube being inclosed between the boss and the collar of the inner axle. On the contraction of the metals, the inner and outer axles will, by reason of the intermediate filling substance, be enabled to revolve independently of each other, but will be in no danger of separating, as the collar keeps them securely together. When, therefore, the wheels are respectively secured in their places by the ordinary means, they will be free to revolve independently, and be as little liable to derangement as if mounted on one solid axle.

SANITARY IMPROVEMENTS IN THE SEWAGE.

(With Engravings, Plate V.)

The importance of the sanitary question increases every day, and the large extent of works which will evidently be carried out to obtain a perfect system of sewage make it of great consequence to engineers to be well informed of the most approved modes of construction. For this reason we have given copious extracts from the evidence of Mr. Austin and Mr. Phillips, before the Metropolitan Sanitary Commission, and to which we beg leave to direct the particular attention of the profession.

H. Austin, Esq., C.E., at the request of the commissioners made a survey of the Surrey and Kent district of sewers, and gave the following evidence relative to the flat district of Lambeth, the Borough, and Rotherhithe, as shown in the plan, fig. 1, Plate V.

"There is little doubt that much improvement might be effected in the present system of sewage, but it could only be carried out at vast expense; and to extend this system over the whole district, so as to render it general and complete, even under such improved arrangements, would not only be ruinous in cost, but the great evils after all would only be lessened, not removed. With a district so situated, nearly flat, and for the most part several feet under high-water mark, all attempts at providing an adequate natural drainage, direct into the river, must end in failure. Do what you will, it must be a cesspool system still. A small additional current of two or three feet may certainly be obtained in some cases by lowering the outfalls to low-water mark, but the advantage of this, carried over a distance of two miles or more, would scarcely be appreciable, and could be carried out only at immense expense. It appears to be absolute that this artificial state of things should be treated artificially, and mechanical appliances brought to bear to lift and discharge the refuse constantly as it is produced. Intermittent drainage is somewhat more barbarous than intermittent water supply. It does seem extraordinary, that with the steam-engine applied in almost every useful relation of life, its adaptation to this great purpose for the relief of flat districts of towns of its refuse and water should never have been attempted. It was very satisfactory to me to find, on proposing the system to Mr. Chadwick, that the idea of its practicability had already been impressed on his own mind, from observation as to the efficiency and small expense of pumping, for the purpose of agricultural drainage. We have ample experience as to the facility with which refuse may be pumped, in its application, in several instances, to agricultural purposes. It only remains a question as to the best arrangement of the drainage to realise the object in the most efficient and economical manner.

The district to be drained should be apportioned into convenient sections or divisions, the drainage of which would be totally independent and distinct, converging to the centre of each division with any desired current, and from these centres the liquid would be raised by steam-engines, placed at any convenient point in connection with them by pipes. The skeleton plan (fig. 1, Plate V.) of the populous part of the Surrey and Kent district will best explain my meaning, it being understood that the divisions of the district there represented, the position of the centre points or wells, and the situation of the engine power, are only assumed for the purpose of illustration, without at all presuming that they would be the most desirable to adopt. These are matters, the correct determination of which would demand much consideration and study of local circumstances and arrangement. Beyond the consideration of these circumstances, the extent of each division would be limited only by the amount of fall that it would be necessary to preserve to allow of a certain maximum size of drain, and the depth of digging that might be thought desirable.

The most important consideration appears to be the size and material of the drains, and I have founded my calculations on the basis that the maximum size of the main outfall drains should not exceed a dimension that would be conveniently manufactured in pottery clay, so as to allow of the establishment, *throughout, of a complete system of pipe drainage rather than of brick sewers.* I therefore fix the limit of the largest drain at 2 feet diameter, that being a practicable size to manufacture. Taking then a perfectly flat area—which is the worst case for calculation—assuming a total fall of 15 feet from the extreme points to the centre, upon an area of half of a square mile or 320 acres, this will give a current of 1 in 250 as a minimum, and a 2-feet drain, with that fall, will be more than sufficient to discharge the whole refuse of the densest population upon that extent of surface, with an improved constant supply of water of 100 gallons per day per house. With such arrangements, there would have to be discharged from each division of half a square mile nearly one million gallons per day; but as by far the largest quantity is used in the busy time, from nine to one o'clock, I calculate a capacity sufficient to discharge the whole quantity in that time.

It would be essential that these drains should be capable of removing also the whole external refuse of the streets and houses. I assume, therefore, that the system should be capable of accommodating a fall of rain equal to an inch and a-half in 12 hours, a good soaking quantity that would soon cleanse the whole surface of the streets and houses, and convey away the refuse. This amount being added to the house supply of water, the total quantity produced at such times in each division would be 200,000 cubic feet per hour.

The only question for consideration as to fall, would be to fix a safe limit for the total inclination of those continuous lines of the drainage that would have to convey the water from the extreme points to the centre. Having decided upon that, the rate of inclination should be graduated from one end to the other; because the accelerated velocity of the stream, as it would approach the centre outfall, would admit of considerably less inclination of the drainage than at the commencement; or, on the other hand, would admit of a great reduction in the size of the pipes. All the collateral or intermediate branch-drains, it will be seen, would have so considerable an amount of fall, as to afford the opportunity of putting them all in of a very small size.

The engines may be fixed in any spot most convenient and advisable, and there need be only one pumping establishment for the whole district (as shown in the skeleton plan, fig. 1), to which main pipes would lead from the several centre wells, precisely as would be practised in raising so much water from a well at a distance. From the engines, one or more discharge-pipes, to convey the whole refuse, would lead to the most convenient outlet in the river, as shown by the double dotted line. The arrangement here submitted would offer this great advantage, that the pollution of the whole southern bank of the river would at once be avoided, as the liquid refuse could, with equal facility, be discharged at any spot lower down the river, where no inconvenience would arise from it. By-and-bye, when the public mind is brought to appreciate the value of this material, and to apply it to its legitimate purpose, instead of throwing it away, there would be nothing more required than to lay down the distributing-pipes from the engines in the direction of the demand. The discharge pipe would then serve its proper purpose of a waste-pipe into the river, when the supply of the liquid exceeded the demand for it, or it would lead into depositing reservoirs.

I calculate that it would be necessary to provide four times the amount of steam power for the removal of the refuse during wet weather that would be necessary on dry days, and this is the very amount that would probably be necessary to raise the refuse the additional height required for its application to agriculture. Thus, in wet weather, when there would be no demand for the sewage manure, the whole power of the engines would be employed in raising the greater quantity of liquid sufficiently high only for its discharge from the district; and in dry weather the full power would be engaged in raising the smaller quantity the additional height necessary for its intended application to agriculture. The system would so work together very satisfactorily as a perfect whole.

The cost of this improved system of drainage will not amount to more than one-fourth of the system now pursued in the Surrey and Kent district. This commission has recently given notice of the intended execution of works, involving an outlay of £100,000, to be expended in a few main lines of drainage, which, for the real and important purposes of sewerage—the removal of the liquid refuse from the houses—will be of no earthly benefit to the inhabitants, but will serve only to obstruct future improvement; whereas the outlay of this amount on the plan proposed would actually suffice for the construction of the entire street drainage, including every court and alley, of more than one half of the most populous part of the district comprised within an area of four square miles immediately south of the river. The perfect drainage of the most crowded district on this system would cost on the average £2 per house, with an annual charge of 2*s.* per house, for annual expense of engine power. To repay in 30 years, with interest, the whole cost of the public or street drainage, together with complete private or house drainage, with stone-ware water-closet basin, and including the above annual charge for engine power, would involve a rate of 7*s.* per annum, or about a third of the annual cost of emptying a cesspool, where at all decently kept."

Mr. PHILLIPS, C.E., gave the following evidence as to the system of sewage adopted by him:—

"Solidity of execution in construction, economy of materials and labour, combined with strength to bear the lateral and vertical pressures of the ground, and efficiency in affording the best channel for quickly conveying away the sewage, are the essential requisites for a sewer. The circle affords the most capacious area of all plane figures having the same circumference, and conversely its circumference is less than any other figure of the same capacity. It, therefore, supplies the greatest capacity for receiving the water, with the smallest frictional surface, and the least consumption of materials. As regards strength: when the pressure from the ground around a circle is the same, it is equally distributed throughout the entire thickness composing the arch; for, as the extradosal length is greater than the intradosal length, the arch is necessarily made up of a series of wedges all pointing to the centre of the circle; hence the circular form prevents the earth outside of it from forcing it in, and from disturbing it, provided the pressure be equal, while upright walls in the same circumstances would most probably be unable to withstand the pressure.

The removal of sewage and prevention of deposit of matter in sewers are entirely dependent on the quantity and velocity of the water running through them. In order therefore to keep them well washed out and cleansed, the utmost scouring force should be imparted to the streams. A semicircular, or still narrower and deeper-curved channel of a semi-elliptical or catenarian form, concentrates the flow on a small area of friction, heaps it up, and so increases its velocity, and makes it more powerful in lifting, holding in suspension, and carrying away all matters which may find their way into the sewers, than a wide and flat channel. A sewer, therefore, having an arched crown, curved side walls, and a narrow and deeply-curved bottom, which, combined together, give *the shape of an egg with the small end placed downwards*, is, in my opinion, the best and most efficient form for all branch sewers. It would appear however from what has been stated, that the circle, from having a more capacious area and less rubbing surface than any other figure, is the best shape for *all* sewers. But this is not the case; for although the surface of contact of the egg-shaped sewer is somewhat greater than a circle of the same area, yet by contracting the channel and so raising the height of the stream, the ratio of velocity and consequent *power to scour* is increased thereby, as will be evident on experiment being made. It is the prerogative of the egg-shaped sewer, therefore, to combine in its form, capacity, economy, strength, and efficiency.

For the short collateral branches of the sewers in street, courts, &c., the smaller they are, (provided they be large enough to receive and carry off storm waters in addition to the ordinary run), the less chance will there be for them to choke up. In the course of my experience I have examined hundreds of drains, and I have always found small drains and sewers which had a moderate fall, and anything like a good supply of water, quite clean and perfect in that respect. I anticipate, indeed I confidently entertain an opinion, that with a combination of the water supply and a tubular system of sewerage and house-drainage, the whole of the annoyance now experienced by the public from defective drains and sewers may be made to cease.

If constant currents of water be carried through the drains and sewers, though the currents may be small, yet provided they be constant and concentrated on very narrow and smooth bottoms, they will keep the sewers clean. Where the supply is intermittent, the matter discharged from the house-drains, meeting with no current, accumulates. In order to prevent deposit in drains and sewers, there must be a certain degree of velocity and force given to each current, so as to produce agitation equal to, or rather greater than the *vis inertiæ*, or weight, mass, figure, and superficies, of the sand, silt, mud, and other substances, to be lifted, and kept always moving, or united and incorporated with the running water, added to the friction of the bottom and sides of the channel.

The chance of any sewer keeping itself clean is dependent on four things,—namely, its capacity, its form, its fall, and the quantity and force of the water running through it. It is only from observation and experience, and the application of rules deduced therefrom, to the proportioning the capacity, the form, and the fall, as also the quantity and force of water requisite to prevent deposit, that we can hope to arrive at perfection in sewerage. From observation and experiment, I find that it requires a constant velocity of current to be running through the sewers equal to about $2\frac{1}{4}$ feet per second, or $1\frac{3}{4}$ mile per hour, to prevent the soil from depositing within them.

There is less water running in the sewers on Sundays than on other days of the week; and most on Saturdays. The height of the flow every day goes on increasing from an early hour in the morning until about noon, when it is highest; it then gradually subsides to its lowest level. The period of the greatest flow every day is between 11 a. m. and 1 p. m.

The fall of sewers should be proportioned to the quantity of water that is to pass through them. For, with the same fall, the greater the body of water the greater will be the velocity and scour; and conversely, the less the body of water the less will be the velocity and scour. Again, a large body of water will, with a little fall, run with the same velocity as a small quantity will with a great fall. Hence the recipient of many branch sewers may have less fall than the branches themselves. A fall of a quarter of an inch in 10 feet has been considered the least fall that should be given to branch and summit-level sewers; but this fall is not enough to keep the sewers clean. No; such sewers should, in my opinion, have not less fall than half an inch in 10 feet. In some districts it is found impossible to get even so much fall as a quarter of an inch in 10 feet. In districts where proper fall cannot be obtained, it is necessary to resort to flushing to keep the sewers free of deposit and clean.

When a main stream receives a branch stream, the united body of water causes the height of the main stream to increase, consequently the surface rises somewhat higher than the surface of the divided streams; hence the water flows back, producing deposits of heavy substances about the junctions, which deposits draw back and impede the flow of the two streams. Now, in order to remedy this evil, the bottom of the main sewer, immediately below the junctions should be made some inches deeper than the bottoms above the junctions. By this mode of forming the bottoms, the surface of the main and branch streams will have a uniform inclination, and the acceleration of this fall will prevent regurgitation and deposit, and the united streams will flow onwards with increased speed.

In order to determine the depth below the junctions, it is necessary to calculate what height the body of water falling from the branches will increase the stream in the main. The capacity of the united stream is very much less than the sum of the capacities of the divided streams, and the velocity in the former is considerably greater than either of the latter. The ratio of increase of velocity follows the ratio of decrease of capacity. It follows, therefore, that a gradually accelerating velocity takes place immediately below the confluence of the sewers throughout the ramified system from their sources to their outfalls, and such I have found to be the case.

Egg-shaped sewers, varying in capacity according to the area, the number of houses to be drained, and the quantity of water to be discharged, from 9 inches wide by 1 ft. 3 in. high, to 1 ft. 6 in. wide by 2 ft. 6 in. high, would suffice for sewers on summit levels, and also for branch or collateral sewers which had to receive the drainage of from one to twelve or more ordinary-sized streets. Of course the secondary mains which would have to carry off the water from these branch or collateral sewers, as well as the principal main lines into which the secondary ones would discharge themselves, must be larger in proportion; but under a proper arrangement, fewer principal lines would be required.

Instead of discharging a large body of water uselessly, as to any power of sweep, I would, under the system of constant and concentrated supplies and smaller sewers, economise the water by using it to scour several small sewers instead of one large one. For this reason I would prefer having more outlets, or at least more catch-water sewers, instead of discharging all the drainage by one large main sewer throughout, although at or near the outlet, I might probably be obliged to lead the whole of the water into one main line; but I should not like to part with it into a main line until I had made it serviceable in sweeping as many sewers as possible. As the keeping of all sewers thoroughly washed out is necessarily dependent upon an abundant supply of water, the principle which I have thought it best to follow for that purpose is to tie and connect all the sewers together upon a uniform system of levels so as to use the water running along sewers on high levels for washing out those on low levels. For this purpose, as will be seen by the plans, (Plate V., figs. 2, 3, and 4), I would connect the heads of adjoining sewers below with the superior sewers above them, and arrange the connections so that, as the currents of water running along the latter sewers arrive opposite the connections, they may divide and subdivide themselves by the ridges or groynes formed by the meeting of the inverts. By this means the water would traverse from one sewer to another, and so keep up a perpetual flow throughout the entire system. There can be no doubt that with much smaller sewers than those now in use, and a more regular and abundant supply of water, the sewers would, by this system of arranging them and economising the currents, keep themselves thoroughly clean.

All head sewers, from want of backwater, have a tendency to choke up, and their ventilation is also very bad, consequently there should be as few of them as possible.

The general surface of the metropolis, on the north side of the Thames, is most admirably situated for being efficiently drained, as the ground continues to rise with an easy acclivity from the river to the hills some miles to the northward. The surface is divided into several natural areas, each of which has its main outfall sewer running through the lowest level of the valley, and discharging into the Thames, and into these main or valley sewers the whole of the sewers on the sides of the declivities discharge themselves. This mode of drainage is a very objectionable one, and should never be resorted to if it be possible to avoid it. The declivities of all natural areas are generally in two directions, namely, transversely towards the valley line, and longitudinally towards the outfall. Now, if attention be paid to the levels, and the sewers on the sides of the declivities be judiciously arranged, a perpetual circulation of water may be kept flowing throughout the whole of them from the sewer on the summit at the head of the natural area to the outfall in the river; that is to say, a system of collateral or concentric sewers should rise one above another from the valley line to the ridge or water-shed line of the district; each collateral sewer skirting the entire area, and discharging itself into the river by a separate outlet, or in the manner previously referred to. It will be seen that, when the sewers running transversely are connected at their upper and lower ends on the same levels with those running longitudinally, a facility is afforded for the drainage to circulate from the highest sewer to the one immediately below, from this to the one next lowest, and so on throughout.

Mr. Phillips proposes fourteen graduated forms of branch secondary and principal main lines of sewers of the egg-shape for the drainage of a district in which the sewers and the water supply are under one and the same authority. Fig. 13, Plate V., shows the form of one of the sewers together with the radii of the several curves.

No.	Height.		Width.		No.	Height.		Width.	
	ft.	in.	ft.	in.		ft.	in.	ft.	in.
1	6	8	4	0	8	3	9	2	3
2	6	3	3	9	9	3	4	2	0
3	5	10	3	6	10	2	11	1	9
4	5	5	3	3	11	2	6	1	6
5	5	0	3	0	12	2	1	1	3
6	4	7	2	9	13	1	8	1	0
7	4	2	2	6	14	1	3	0	9

Much caution is required in the building of sewers in a clayey soil; otherwise, from the treacherous character of this ground—its liability to expand and slip,—the sewers may be forced in. The thickness of a sewer should be proportioned to the nature of the ground and the pressure it has to bear; but its stability is very much dependent on the goodness of the workmanship. A half-brick sewer, under ordinary circumstances, will, if executed well and soundly, the joints made thin, and the sewer worked true to the curve, be quite strong enough, and would be found to answer every required purpose. The thicknesses depend upon the material and strata. The equilibration may be altogether destroyed by a want of uniformity in the working of the curve. The greatest pressure of the ground acts laterally from the sides downwards. Much of this pressure may be prevented by leaving in the trench from the surface downwards short lengths of earth, say of 10 to 20 feet, and about 50 to 80 feet apart, to be tunnelled through for the sewer to pass. These benchings, as they are termed, will keep the sides of the trench from sinking and slipping, and so from pressing against the sides of the sewer.

The smoother the surface the less will be the friction, and consequently the greater will be the velocity and discharge; and the friction in a glazed pipe must be considerably less than in a brick drain, as commonly built. I am not prepared to say that the friction would be diminished so much as one-third; I think not so much. The smoothest glass pipes throw off transverse motions which greatly impede the flow. There is a difference in the flow of pure clean water and of sewage water; the latter moves more sluggishly. This is caused by its being *thicker* and more viscid, from having matter chemically combined and mechanically suspended in it.

As the velocity increases, so does the transverse section of the area occupied by the stream decrease. This is a natural law observable in all moving streams, for we see that in a moving mass of water the discharge is the same, whatever form and size the channel may assume, the velocity being greater where the channel is narrow and deep, and less where it is wide, flat, and irregular; but the exact ratio of decrease of area, from decrease of friction and increase of flow, can only be determined by actual experiment and by taking into account all the attendant circumstances which influence and govern the motion of the stream.

Have you at all considered the capacities of sewers necessary for draining different areas of ground?—Yes, I have given the subject much attention. If the consideration of the sizes of sewers was confined solely to the carrying off the water supplied by the several water companies, then I apprehend that pipes somewhat larger in size than the supply-pipes themselves would suffice; but provision has to be made for receiving and conveying away the waters of heavy rains. In London continuous heavy falls of rain are not of long duration, lasting seldom more than from one to four hours. About one-fifth of the quantity that falls is absorbed partly by the dryness of the surface of the roofs, the paving, and the ground, and partly by the porosity of the ground itself. A farther proportion is also prevented from flowing to the drains and sewers at all by hollows in the surface, and again reascends into the atmosphere as vapour. There is also a small quantity that enters into the composition of animal and vegetable bodies. Then there is the resistance the flow experiences from the friction of the entire surface, being accelerated or detained in proportion as the surface is more or less inclined. To provide for the discharge of a fall of rain of two inches in depth has been considered by Mr. Hawksley, C.E., the extreme datum upon which to proportion the capacities of town sewers generally. Now I believe that, practically, the sizes in his table, although they may appear theoretically correct, are (excepting for the smallest sizes) too large for sewers in London. It is extremely violent rains alone that produce a depth of two inches per hour, and such rains occur only once in four or five years, if so much. I am of opinion that it is unnecessary to proportion the sizes of the sewers to meet an extraordinary occurrence that may probably happen only once in so many years. My reason for not fearing any serious damage from an excess of rain at remote intervals being provided for in surface channels, excepting, perhaps, in situations peculiarly liable to inundation (for instance, at the foot of a long or steep declivity, or where the waters may, from any cause, be suddenly congregated at one focus) is, that I have observed, that in towns entirely destitute of underground drains, no such inconvenience is felt as would justify the formation of enormously large sewers, or the expenditure of large sums of money to provide against it. In August 1846, a most extraordinary fall of rain occurred in London. The storm lasted nearly two hours, and from the best information I have been able to obtain, the depth of rain amounted to about four inches. Much damage resulted therefrom, by the water in the principal main lines situate in the valleys flowing up the drains and branch sewers, and inundating the rooms and cellars below its level by the influence of its pressure. The inundation of lands and the damaging of property in the valleys could not happen if there were parallel catch-water lines of sewers on the sides of the declivities to convey the drainage into the river by separate outlets. The average fall of rain in London is about 22 inches in a year, or about $2\frac{1}{2}$ inches in depth per thousand hours. Now after observing and calculating the depths of different falls of rain in London, it appears to me that if the sewers were of sufficient capacity to receive and discharge, as fast as it falls, *a quantity of water equal to the produce of a fall of rain of one inch in depth per hour*, they would be found large enough, and that more particularly if they were built on the intercepting or catch-water principle, and so as to communicate with each other, and all be filled with running water at the same time. The steps to be taken to proportion the capacities of sewers to receive and convey away the waters of heavy rains should, I think, be as follow, although I fully admit our present knowledge of the subject to be very elementary:—

To ascertain the number of superficial yards or acres to be drained by each sewer separately; progressing in a uniform gradation from the entire natural area to be drained by the largest outfall sewer, to the small tract of land to be drained by the least sewer on the summit. Taking the hourly fall of rain, therefore, upon one acre at one inch in depth, we must provide for the discharge of a quantity of water ($\frac{43560}{12}$) = 3630 cubic feet per hour, or one cubic foot nearly per acre per second. Then taking into account the loss from absorption, the detention from friction, and otherwise, that quantity might be reduced to four-fifths of a cubic foot, but as the carrying off the waste water of the entire of London must be provided for at the same time, one cubic foot may, I think, be considered as the datum upon which to calculate the capacities of sewers sufficient for conveying away that quantity of water per second multiplied by the number of acres to be drained. The quantity of rain-water draining from an acre of ground in one second of time may be determined by first ascertaining the exact area of surface drained by some large main sewer; and, secondly, during the time of the storm, the quantity of water passing through the sewer in one second; then the number of cubic feet of water discharged, divided by the number of acres drained, will give the number of cubic feet of rain draining from the surface of each acre per second.

The area of surface that a sewer will drain, and the quantity of water that it will discharge in a given time, will be greater or less in proportion as the channel is inclined from a horizontal to a vertical position. The ordinary or common run of water in each sewer, due from house drainage alone, and irrespective of rain, should have sufficient velocity to prevent the usual matter discharged into the sewer from depositing. For this purpose it is necessary, as I have previously observed, that there should be in each sewer a constant velocity of current equal to 2½ feet per second, or 1¾ mile per hour. The inclinations of all rivulets, brooks, streams, and rivers gradually and proportionally diminish as they progress from their sources to their outfalls. In proportion as the inclinations diminish so does the quantity of water increase. If the inclinations were the same throughout, the velocity of the united stream at each confluence would increase in nearly the same ratio as its quantity, or equal to the sum of the previous velocities of the recipient and the feeder, and thus would the velocity ultimately become so very impetuous as to tear up and sweep away the materials of its bed, and cause destruction along its banks. If the force of the waters of the river Rhone were not absorbed by the operation of some constant retardation in its course, the stream would have shot into the Bay of Marseilles with the tremendous velocity of 240 feet in a second, or 164 miles every hour; and even if the river Thames met with no system of impediments in its course, the stream would have rushed into the sea with a velocity of 80 feet per second, or 54½ miles in an hour. The result, however, of the operations of nature is a compensation for the increased body of water by a diminution of the inclination of the bed, and so an economising of the force of the gradually accumulating current. The inclinations of the sewers of a natural district should be made to diminish from their heads to their outfalls in a corresponding ratio of progression, so that as the body of water is increased at each confluence, one and the same velocity and force of current may be kept up throughout the whole of them.

In some situations I would build side entrances to a tubular system of sewers; but I believe their use, in some degree, might be superseded. Means of access to the sewers, so as to be able to get at and remove accidental obstructions, would readily suggest themselves. A shaft, having a strong moveable grating on top, could be built over the sewer, with ladder-irons built in the angles, to admit a man to go down and up, with a recess at the bottom on one side to give room. This shaft may be also made to serve as a ventilator. (See figs. 5 and 6, Plate V.)

Gully Drains.—I have constructed gully drains with terro-metallic and glazed stone-ware pipes of 6 inches and 9 inches diameter, as shown in figs. 7, 8, 9, and 10. I was led to recommend the adoption of this mode of construction from the following causes:— In passing through the sewers I found lying opposite the vents of a large number of the gully drains heaps of stones, and all kinds of streets refuse, which it was utterly impossible for the water to remove. The dams thus formed caused the sewage to accumulate behind them, and the noxious effluvia evolved from the decomposing matter escaped into the streets by the gullies, and occasioned much of the annoyance felt by passengers. The best remedy for this evil appeared to me to be to prevent the stones and street refuse from passing into the sewers, t build the drains so that they would not choke up, and to prevent the emission of foul air from the sewers into the streets by the gullies. We have accomplished these things most perfectly, by reducing the width of the spaces to ¾ inch between the bars of the gully grates, by constructing the drains of the form shown by the section from the gully to the sewer, and by fixing at the vent an air-tight cast-iron valve or flap, hung with shackles, as shown in figs. 11 and 12. A grating of trellis-work or cullender is placed under the top grating, at the bottom of the box, for the purpose of catching small stones and rubbish that may pass between the bars of the grate above, and so to prevent them from falling into and choking up the sewers. I have not, as yet, made use of the lower grating, but probably, I should be induced to do so in connection with a tubular system of sewers, as it is important to keep large and heavy substances and refuse out of the drains and sewers. I may state that as a proof of the efficacy of the foregoing mode of constructing the gully-drains with the improved grate, the labour and expense of cleaning, not only of the gully-drains, but of the sewers as well, is now, comparatively speaking, nothing compared to what they used to be, and I confidently entertain an opinion that the labour and expense will be still less and less."

Mr. Phillips has just produced his report on the improvement of the drainage of Westminster, and which has been printed. This document is of great importance, and we are pleased to see that most of our suggestions on this subject have been adopted, particularly with reference to turning part of the drainage into the Regent Street Commissioners' Sewers. Mr. Phillips proposes to divert the high level streams to a station at the east end of Duncannon-street in the Strand, to bring the Westminster drainage to the same station, and to apply the natural power thus to be obtained to work two water-wheels of the most approved construction, with revolving buckets and plunger-pumps attached, to lift the drainage from the well or receiving reservoir below, and discharge the same into channels communicating with the upper stream on a level with high water, beyond the tail of the wheels. The sewage will then be carried under the side-bed of the river into low-water stream.

Below we give a summary of Mr. Phillips' estimates, which make a total of £28,874 14*s.*

Summary of the Estimates.

Feet Run.	Class No.	Internal Diameter.	Sectional Area.	Price per Foot.	Totals.
		in. in.	feet	s. d.	£ s. d.
8,118	1	50 × 30	8·19	14 0	5,682 12 0
4,524	2	40 × 24	5·23	10 0	2,262 0 0
2,086	3	30 × 18	3·64	6 0	625 16 0
9,599	4	20 × 12	1·31	4 6	2,159 15 6
18,709	5	17½ × 10½	1·	4 0	3,741 16 0
53,284	6	15 × 6	0·73	3 3	8,658 13 0
7,699	7	12 × 7½	0·56	2 6	962 17 6
9,742	8	9 × 6	0·29	2 0	974 4 0
113,761	(= 4*s.* 5*d.* per foot run, nearly.)				£25,067 14 0

Estimate for building a Gully Drain, average length 20 feet.

	£	s.	d.
Six cubic yards Digging, &c., at 1s. 6d.	0	9	0
Twenty feet run of 4 in. Pipe, at 8½d.	0	14	2
Gully Grate (about 1½ cwt.) including bedding and fixing	0	16	0
Total	£1	19	2

About 400 Gully Drains will be required, which at, say 2*l.* each, amounts to £800 0 0

Estimate for building a Sewer along Pall-Mall-East, Trafalgar-square, Duncannon-street, Strand, and Villiers-street, for diverting the Western and Eastern branches of the Hartshorn-lane Main sewer,—being a length of 2,230 feet, at 18s. per foot £2,007 0 0

Estimate for Two Water Wheels, with complete Lifting Machinery attached, and including all necessary work.

	£	s.	d.
Brickwork—say 40 rods at 10*l.*	400	0	0
Two Water Wheels, at 200*l.*	400	0	0
Lifting Machinery—say	200	0	0
Total ..	£1,000	0	0

REFERENCE TO ENGRAVINGS, PLATE V.

Fig. 5.—Section of Shaft on A A.
Fig. 6.—Plan of Shaft.
Fig. 7.—Section of Gully Drain from Grating to Sewer.
Fig. 8.—Plan of Gully and Grating.
Fig. 9.—Transverse Section of Gully and Grating on A B.
Fig. 10.—Longitudinal Section of Gully and Grating on C D.
Fig. 11.—Section of Drain and Flap at Vent.
Fig. 12.—Front View of Flap.
Fig. 13.—Mode of Striking the Curves.

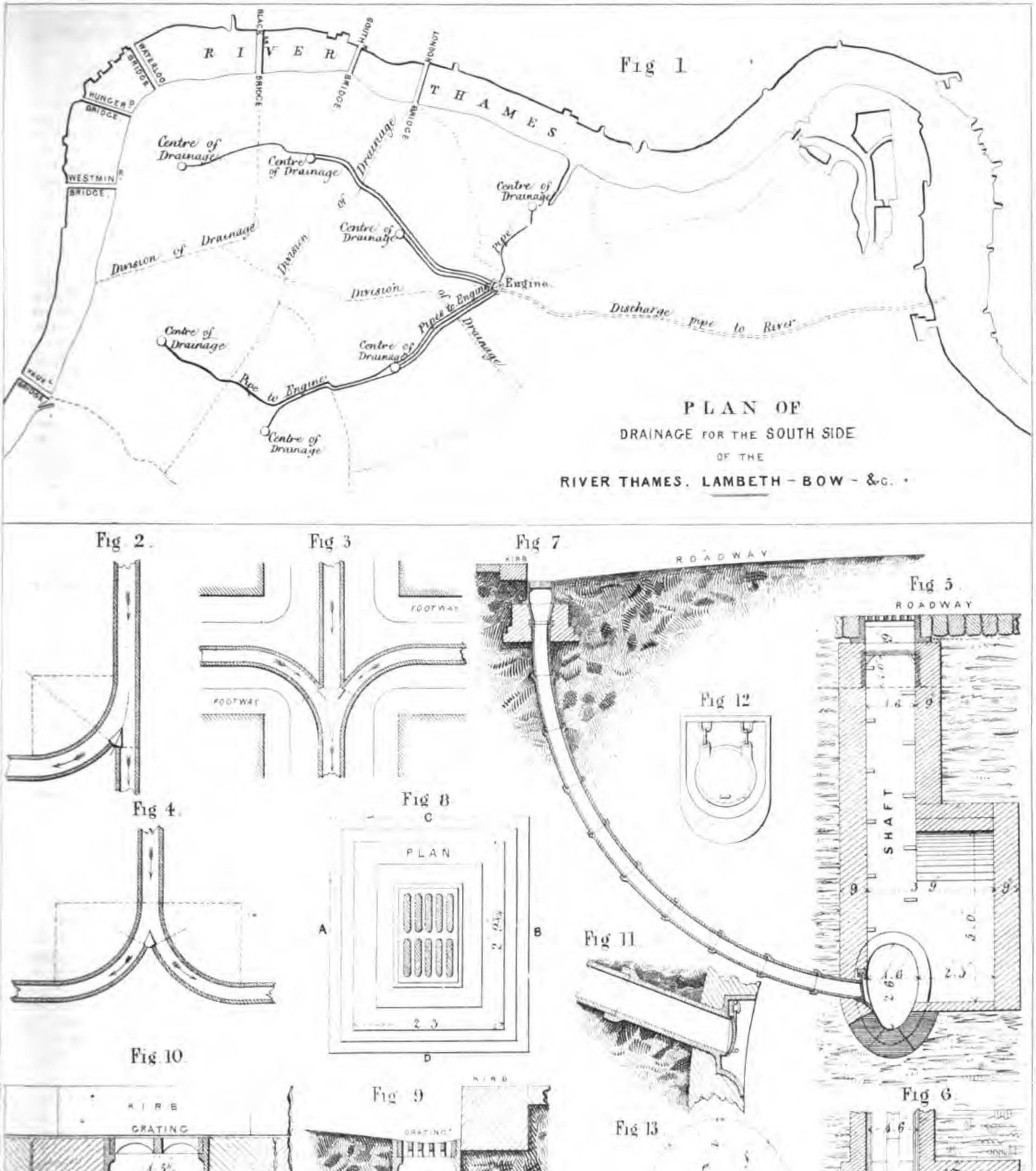


Fig 1.
RIVER THAMES
WATERLOO BRIDGE
BLACK FRIARS BRIDGE
SOUTHWARK BRIDGE
LONDON BRIDGE
HUNGERD BRIDGE
WESTMINR BRIDGE
Centre of Drainage
Division of Drainage
Pipe
Engine
Pipes to Engine
Pipe to Engine
Discharge Pipe to River
PLAN OF
DRAINAGE FOR THE SOUTH SIDE
OF THE
RIVER THAMES, LAMBETH - BOW - &c.
Fig 2.
Fig 3
FOOTWAY
Fig 4.
Fig 7
KIRB
ROADWAY
Fig 5.
ROADWAY
SHAFT
Fig 12
Fig 8
PLAN
Fig 11
Fig 10.
KIRB
GRATING
PIPE
Fig 9
KIRB
GRATING
PIPE
Fig 13
Fig 6.
SEWER

ON THE MOTION OF WATER.—By Guido Grandi.

Translated by E. Cresy, Esq., *in his Evidence before the Metropolitan Sanitary Commissioners.*

Our author has taken considerable pains to construct a parabolic table, given in his work (Book 2, cap. 5); by a reference to which much labour will be saved by those who desire to make similar investigations; he thus describes it:—

"This table is divided into three columns. The first containing a natural series of numbers from 1 to 1800, representing equal parts, as inches or other measures. These numbers are the heights from which the water falls. The second column contains the roots of the opposite numbers in the first, and expresses the velocity of the water, corresponding to the height in the first column, in integers and decimals: when the root is somewhat greater than the truth, the sign + is prefixed, and when less −. The third column contains the product of the first and second, and must be read off as exceeding or falling short of the truth, according as the sign + or − is prefixed to its second factor.

It is clear that if the numbers of the first column express the height of a parabola, the numbers in the second will be its ordinates when its *latus rectum*, or parameter, is 1; or at least, they will be proportional to the ordinates in subduplicate ratio of unity to the *latus rectum* of a given parabola, and the numbers in the third column will be the rectangles circumscribing the parabola which has unity for its *latus rectum*, and will be moreover proportional to the area of the parabola, which is always $\frac{2}{3}$rds of the circumscribing rectangle.

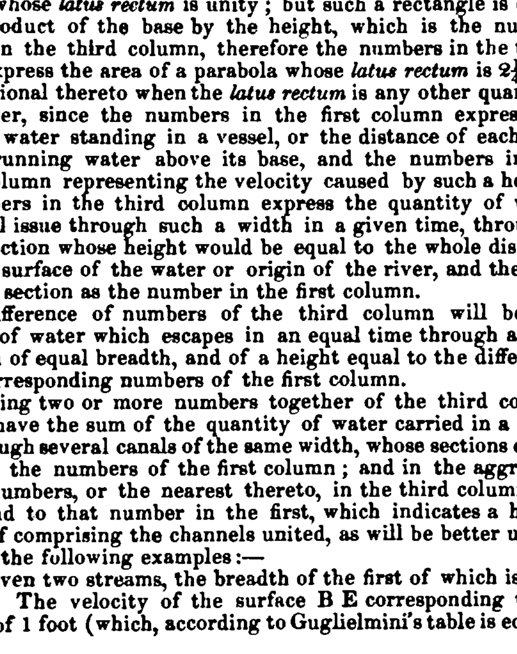
If the parabola has $2\frac{1}{4}$ for its *latus rectum* in terms of the first column, all its ordinates are to the ordinates of the parabola of the same height, having 1 for its *latus rectum*, in subduplicate ratio of $2\frac{1}{4}$ to 1, that is, as $1\frac{1}{2}$ to 1, or as the circumscribed rectangle to the parabola, it is clear that the parabola whose *latus rectum* is $2\frac{1}{4}$ will be equal to the rectangle which circumscribes the parabola whose *latus rectum* is unity; but such a rectangle is equal to the product of the base by the height, which is the number opposite in the third column, therefore the numbers in the third column express the area of a parabola whose *latus rectum* is $2\frac{1}{4}$, and is proportional thereto when the *latus rectum* is any other quantity.

Moreover, since the numbers in the first column express the height of water standing in a vessel, or the distance of each particle of running water above its base, and the numbers in the second column representing the velocity caused by such a height, the numbers in the third column express the quantity of water which will issue through such a width in a given time, through a hole or section whose height would be equal to the whole distance from the surface of the water or origin of the river, and the base of such a section as the number in the first column.

The difference of numbers of the third column will be the quantity of water which escapes in an equal time through a hole or section of equal breadth, and of a height equal to the difference of the corresponding numbers of the first column.

By adding two or more numbers together of the third column we shall have the sum of the quantity of water carried in a given time through several canals of the same width, whose sections correspond to the numbers of the first column; and in the aggregate of such numbers, or the nearest thereto, in the third column will correspond to that number in the first, which indicates a height capable of comprising the channels united, as will be better understood by the following examples:—

1st. Given two streams, the breadth of the first of which is L = 760 feet. The velocity of the surface B E corresponding to the fall A B of 1 foot (which, according to Guglielmini's table is equivalent to 216 feet 5 inches per minute, that is, $3\frac{3}{5}$ feet in a second, or $2\frac{2}{5}$ miles per hour), the height of the surface B C = 30 feet, whence A C 31 feet; then the whole parabola A E D C, according to the third column of our table opposite 31 feet, will be found 7175·88, from which subtracting the parabola A E B, which is found in our third column to be 41·52, the parabolic trapezium B E D C will be 7134·36, and this will be the scale of the velocity of the section B C, which multiplied by the breadth L gives a quantity of water = 5422111360.



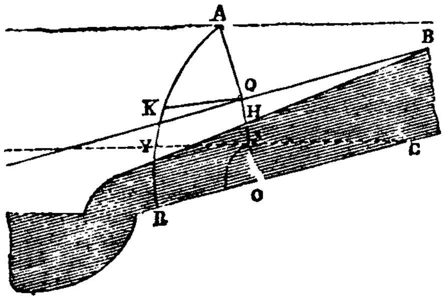
The second stream having a width M = 139 feet, its superficial velocity will be G K, depending on the height F G, 8 inches (which gives, by Guglielmini's table, a velocity of 176 feet in a minute, rather less than 3 feet in a second, and 2 miles 56 perches in an hour). The height of its surface G H is 11 feet, and consequently F H 11 feet 8 inches, corresponding in our third column to the value of 1656·20 for the parabola F K I H, from which subtracting the parabola F K G, which our table gives opposite 8 inches as 22·64, there remains the trapezium G K I H 1633·56, which is the scale of the velocity of the second stream, which, multiplied by the width M, gives the quantity of water passing in a given time through this river = 227064·84; whence the two quanties carried by both the rivers will be 5649178·44. Supposing they flow together, without increase of velocity, B E = O R; and let the height O P, at which the united water runs, be the unknown quantity, then since O N = B A through R, and with the axis N P, describe the parabola N R Q P, the truncated parabola O R Q P will be the scale of the velocity of the united rivers, which multiplied by L = the sum of the two quantities = 5649178·44, which divided by L gives a quotient 7433·13 = the parabolic trapezium O R Q P, and adding the parabola N R O = 41·52, we shall have the parabola N R Q P = 7474·65, the nearest number to which in the table is 7464·28, corresponding to a height of 31 feet 10 inches. This number sought being rather more than the tabular value, it will be found by proportional parts that $\frac{1}{3}$ must be added. Therefore N P = 31 feet $10\frac{1}{3}$ inches and O P = 30 feet $10\frac{1}{3}$ inches; therefore the union of the streams raises the level B C $10\frac{1}{3}$ inches.

But if, at the conflux of the rivers, the velocity B E augments, becoming O R, so that the height N O depending on it exceeds A B by 1 inch, the parabola N O R, corresponding to a height of 13 inches, will equal 46·93, which, added to the trapezium R O P Q, found previously to be 7433·13, we shall have the total parabola N R Q P = 7480·06, the nearest number to which, 7464·28, corresponding to 31 feet 10 inches; but since this is rather too little, we must add $\frac{1}{2}$ for the proportional part of the difference, whence N P = 31 feet $10\frac{1}{2}$ inches; from which N O = 1 foot 1 inch being subtracted, there remains O P = 30 feet $9\frac{1}{2}$ inches, making the total increase in this case $9\frac{1}{2}$ inches.

But if we suppose with Guglielmini, and which is not improbable according to actual observation, that the scale of a velocity in a given section is an entire parabola and not a truncated one, the velocity, as in the case of vessels depending only on pressure, whence the surface alone acquires velocity when it is communicated by the lower water which transports it, the calculation will then be more quickly effected. Wherefore A C = 30 feet, the height of the first river, and F H = 11 feet, height of the second. The parabola A E D C = 6829·20, in our table, which, multiplied by the width L 760 feet, gives for the quantity of water 5190192·00, and the parabola F I H = 1516·68, which multiplied by the width M = 139 feet = 210818·52, whence the sum = 5401010·52, which, divided by the width L, gives, when the velocity of the surface is not increased, the parabola N Q P = 7106·59, corresponding to a height of 30 feet 10 inches, corresponding in the table to the number 7118·80, which is rather more than the preceding; wherefore the rise will be 10 inches.

Then if the velocity of the two rivers increases at their confluence, the height will be reduced in the reciprocal ratio of that velocity; so that if the velocity be increased $\frac{1}{100}$, the height will be reduced to $30\frac{1}{2}$ feet, that is, the increase will only be about 6 inches; if the velocity increases $\frac{1}{36}$, the height will be 29 feet 8 inches; so that the height, in place of increasing, will actually be reduced about 4 inches by the union of the two streams; so likewise the height 30 feet, will remain precisely the same when the velocity is increased by $\frac{1}{36}$, since 37 : 36 :: 30 feet 10 inches : 30 feet.

Example 2.—The influent C B D R in a given point of its bed has the height O H, having a free influx into the recipient R M, when it is low, and its superficial velocity in H is what would correspond to a height A H of 4 feet. Then, raising the level N S of the recipient, regurgitation follows through the level of the influent. It is required to find the increase in the height O H = 7 feet? Suppose it to increase as far as Q, draw the parabola A K R, with its ordinates H Y, Q K; let O S, cut off by the prolongation of the level of the recipient, = 3 feet; the whole height A O will be 11 feet, and by the table the parabola A O R = 151668; the other, A H Y, 4 feet high, will be 332·64; whence the trapezium H Y R O will be the scale of the velocity, and the quantity of water passing in a given time through the section H O = 1184·04. If the parabola S P O be 3 feet high, its value in the table = 216·00; then the parabolic trapezium Q K Y H, being equal to the aforesaid parabola S P O, will be 216·00, which substituted from the total value of A H Y, there remains the parabola A Q K = 116·64.



This number not being precisely to be found in our table, find the next highest, = 117·60, which corresponds to a height of 2 feet; whence we arrive at the conclusion that the regurgitation at the point O has raised the water 2 feet more than the first, supposed to be 4 feet."

To facilitate the practical application of the principles contained in Grandi's proposition, the following rules will be found convenient:—

The height and width of the section of both the influent and the recipient being given in each case and their velocity being equal.

1. When the velocity of the united streams is the same with that of each separately, to find the increased height of the united section.

Find in the table the parabolic value in the third column corresponding to the given height of the recipient in the first. Multiply this value by the given width. Perform the same operation for the influent, we shall then have obtained the quantity of water brought down by each. Add these two quantities together. Divide their sum by the width of their united section, which may be either that of the influent, or of the recipient, or greater or less than either. Find the quotient obtained by such division in the third column of the table, opposite to it in the first will be found the height of the united sections.

2. When the velocity of the united streams is increased, to find the height of their united section.

Divide the height found by the preceding rule by the number of times by which the velocity is increased, the quotient is the height of the united sections.

3. When the velocity of the united streams is diminished, to find the height of their united section.

Multiply the height found by our first rule by the number of times by which the velocity is diminished, the product gives the required height.

4. When the height of the united streams remains the same, to find their increased velocity.

Divide the height as found by the first rule by the original height, the quotient will give the increased velocity.

5. When the height of the united streams is increased, to find their velocity.

Divide the height found by the first rule by the increased height, the quotient gives the diminished velocity.

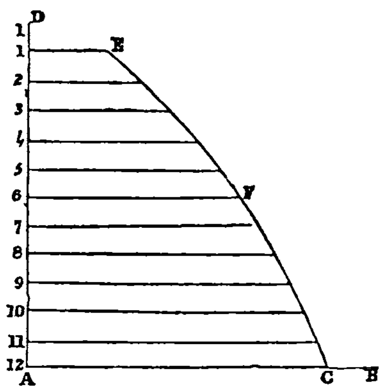
6. When the height of the united streams is diminished, to find their increased velocity.

Divide the height found by the first rule by the diminished height, the quotient will be the increased velocity.

To exemplify these rules a small table is subjoined, constructed from Grandi's data, that is, supposing a stream 760 feet wide and 30 feet high to receive successively 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, similar influents. The first column contains the number of influents; the second, the height caused by the addition of these successive streams as calculated by our first rule, that is, supposing the velocity to remain the same; the third column shows the increased height found by Genneté, the original height, 30 feet, being here increased by the addition of $\frac{1}{48}$, $\frac{2}{48}$, $\frac{3}{48}$, &c. The fifth column shows the increased velocity requisite to produce the height shown in the third; thus supposing a stream 760 feet wide and 30 feet high to receive two other similar streams, the increased height, according to Genneté, will be 30 feet 7·6 inches, and to produce such a height the required velocity will be 1·97233. Either of these numbers is deducible from the other by one of the preceding rules; thus, supposing the height 30 feet 7·6 inches to be given, and the velocity to be required, by Rule 5, dividing 62 feet 4·6 inches by 30 feet 7·6 inches we obtain a quotient of 1·97233. Supposing, on the other hand, the velocity 1·97233 to be given, we obtain the height by Rule 2, since 62 feet 4·6 inches ÷ 1·97233 = 30 feet 7·6 inches. The fourth column shows the increased velocity required to maintain a constant height of 30 feet, and is found by Rule 4.

No of Streams.	Increased Height for a Constant Velocity.			Height as given by Genneté.			Velocity to maintain a Constant Height.	Velocity to produce Genneté's Height.
	Ft.	In.	'	Ft.	In.	'		
1	30	0	0	30	0	0	. .	. .
2	47	7	6	30	3	9	1·58475	1·34203
3	62	4	6	30	7	6	2·07916	1·97233
4	75	8	0	31	3	0	2·52222	2·42133
5	87	8	0	31	10	6	2·92222	2·75032
6	99	1	0	32	6	0	3·30277	3·04897
7	109	10	0	33	1	6	3·66111	3·31572
8	120	0	0	33	9	0	4·00000	3·55555
9	129	9	0	34	4	6	4·32500	3·77454
10	139	2	0	35	0	0	4·63888	3·97618
11	148	5	0	35	7	6	4·94722	4·66081
12	157	3	0	36	3	0	5·23333	4·33793

It is found that the several increments of either height or velocity are as the ordinates of a parabola whose axis is divided into the same number of parts as there are required velocities. Hence an elegant method of finding the intermediate heights or velocities when the two extremes are given. Suppose, for example, we require to find the several heights indicated in our first column. Find the height required for twelve streams by our Rule 1. Draw A B, and from a scale of equal parts set off 157 feet 3 inches from



A to C, at A erect a perpendicular A D to A B, and set off twelve equal parts thereon, and draw through the points 1, 2, 3, &c., lines parallel to A B, on the parallel I E, set off the first height 30 feet from the same scale as A C. Then by Rule 1 find the height of any one of the intermediate streams, as 6, and set it off from 6 to F, then through the points E, F, C, describe a parabola, the portion cut off on each ordinate by the curve will be the several numbers given in the table as measured by the scale from which I E, 6 F, and A C were taken; the abscissæ 1, 2, 3, &c., may be set off by any scale, providing they are equidistant, and according as they are wider or narrower, will the parabola increase or diminish its curvature. It is evident that in the case of 100 additional streams the labour of calculation will be materially shortened, as no more than three values need ever be found arithmetically.

In like manner either of the other values shown in our table may be represented parabolically. Column 5, for example, by setting off 1·34203 on I E, 4·33793 on A B, 3·04897 on 6 F, and describing a parabola through those points.

BLACKWALL RAILWAY MACHINERY.

Description of the Machinery erected by Messrs. Maudslay, Sons, and Field, at the Minories Station, for working the London and Blackwall Railway. By Andrew John Robertson.—(Read at the Institution of Civil Engineers).

The London and Blackwall Railway is about $3\frac{3}{4}$ miles in length, and is worked by stationary engines of the estimated force of 448 H. P. and 280 H. P.,* at the London and Blackwall termini respectively: the carriages being attached by grips to a rope, which is wound off and on to large drums situated at each extremity of the line. The greater power is required at the London station, in consequence of there being a total rise in the railway, in this direction, of between 60 and 70 feet (average 68 feet); the steepest inclination being 1 in 100. There are seven intermediate stations on this line; the Poplar, West India Docks, Limehouse, Stepney, and Shadwell stations, communicate with the Fenchurch-street terminus; whilst those of the Minories, Cannon-street, Shadwell, and Stepney, communicate with the Blackwall terminus. This arrangement is effected by appropriating a separate carriage from the termini for each intermediate station, communicating with the same; these are detached whilst the trains are moving, and by means of breaks they are stopped at their respective destinations; as soon, however, as the terminal train arrives at either end of the line, and the rope ceases its motion, these intermediate carriages are attached to the rope, whilst it is in a state of rest; so that when the engines are again started, the carriages are also simultaneously set in motion, and arrive successively at the termini, in the order and at intervals corresponding with the position of the places from which they started; as they arrive they are released from the rope, though in motion, by the sudden withdrawal of the grip iron, and then their momentum carries them forward to their proper places in the station. It will be perceived, that the intermediate traffic is by this means provided for, without causing any detention to the through trade.

The peculiar mode of working the line, and the circumstance of so many carriages being attached to the rope at different places, rendered it absolutely necessary to provide some quick and certain system of signals between the termini and the intermediate stations. These objects being deemed attainable by means of the electric telegraph, that system was adopted, although it was of greater extent than any which had been previously tried, and it was executed by Mr. Cooke, one of the patentees. The telegraphic wires are inclosed, for security, within welded iron pipes, with screwed joints like gas pipes; there is a duplicate set of such wires and pipes, in case of one set being accidentally fractured. One pipe runs along each side of the railway throughout its length.

The machinery at the London end, for working the railway, is situated at the Minories station. The carriages in coming towards London are disconnected from the rope, a little before they arrive at the Minories, and they perform the rest of the journey to the terminus in Fenchurch-street by their momentum. The upward inclination of the rails at this place is 1 in 150.

When the down-train leaves the terminus in Fenchurch-street, it descends the incline to the Minories by its gravity, where it is stopped by the breaks, to allow of the passengers being received at that station, and to permit the attachment of the rope; there the train remains for a short time, until signals have been received by the electric telegraph, from each of the intermediate stations, that the carriages are ready for starting, and are properly attached to the rope, in the manner already described. It being thus known at the Minories that all is ready, the signal for starting is sent from thence to Blackwall; the engines there are then put in motion and begin to draw the rope with all the carriages towards Blackwall.

At the same time that the down-train leaves the Minories, the up-train leaves Blackwall, the arrangements being similar to those above described. The train runs by gravity from the Blackwall station to beyond the engine-house, where it is stopped by the breaks, in order to attach it to the rope, and as soon as signals have been received at Blackwall, from each of the intermediate stations, that all is ready, the signal for starting is sent from Blackwall to the Minories, and the engines there are put in motion, and begin to draw the rope and all the carriages towards London. The machinery at the Blackwall end is situated a little way along the line from the terminal station; the distance from thence to the place where the carriages going to Blackwall are disconnected from the rope, being somewhat farther from the station than the engine house, and the carriages run that distance by momentum, in the same manner as at the London end; the rise towards the Blackwall station being there also 1 in 150. During the winter the railway is worked from half-past eight o'clock in the morning until nine at night; and in the summer, from eight o'clock in the morning until ten at night. A train leaves each end every quarter of an hour (giving in winter 51 trains, and during the summer 57 trains per day). The whole time occupied in passing between the termini is thirteen minutes; but the engines are at work only from eight to nine minutes. The engine-house at the Minories is situated beneath the railway. It is 48 feet long by 72 feet wide, and the extreme length, into the recess in front of the drums is 69 feet. The rails are carried over the machinery on cast-iron girders, which are supported at two intermediate points by cast-iron pillars. The flooring over the engine-house is carried in like manner upon girders.

Beneath each line of railway there is a large drum for the rope, and on the axes of each drum is a mortice spur-wheel, which is driven by another iron spur-wheel of larger diameter, on a prolongation of the axis of the cranks of the steam engines; the prolongation forming a line of shafting which extends all across the engine-room, with a pair of engines at each of its extremities. Only one pair of engines is worked at a time, the other pair being disconnected at the cranks. Under ordinary circumstances, one pair is worked for about six weeks, and then the other pair for a similar period; the object being to secure the traffic from interruption, by having a duplicate pair of engines always ready to be connected at all emergencies and in case of any accident happening to the other pair, as well as to give time for the ordinary cleaning and repairing of that pair of engines which is not at the time in use. When one pair of engines is connected to the axis of the two larger spur-wheels, the other part must be disconnected from it. This is done by removing the pin of the crank on the extremity of the said axis, and also removing the drag-link, by which that pin is connected with the pin of the engine-crank, on which latter pin the connecting-rod is jointed. The rope on one line must be wound up round its drum, whilst that on the other line is allowed to unwind from off its drum, so that the two drums will revolve in contrary directions. The trains travel alternately backwards and forwards on the same line of rails, instead of one line of rails being always travelled over in one direction and the other line in the contrary direction, as is the case on other railways. For instance, if the first train in the morning goes down from London to Blackwall along the north line, the second train down in the same direction will go along the south line, and the third train down along the north line, and so on. One end of each rope is wound around one of the drums at the Minories, and the other end of the same rope around a corresponding drum at Blackwall; and whenever one of those drums is turned round by its engines for winding up that end of the rope, the drum at the other end of the same rope must be disconnected, and left free to turn round as the rope is pulled off it. This requires some ready means of disengaging either of the drums from the engines, which is done by withdrawing the pair of spur-wheels from each other until their teeth become disengaged. The plummer-blocks, in which the two ends of the axes of each of the drums revolve, are mounted on rollers, and are capable of being moved horizontally by screws, until the spur-wheels are out of gear. The two screws for the plummer-blocks of the same drum, are moved simultaneously by gearing, worked by a handle on the platform in the recess in front of the drums; so that a man by turning that handle, either connects or disconnects the gearing, as may be required.

The main axis upon which the two large spur-wheels are mounted, may be considered as a single axis, but is, in fact, two lengths of shaft, connected together by cranks and drag-links at the mid-length of the prolonged axes, which two lengths can be disconnected at pleasure, by removing the drag-links and crank-pins. Hence there are two sets of machinery exactly similar, and capable of being connected and disconnected in such manner, as to admit of either of the two drums being worked by either of the two pairs of engines, whilst the other drum is wholly disconnected; each line can thus be worked by either pair of engines, independently of the other line or pair of engines. The engines always revolve in the same direction, causing the drums to wind up the ropes around them; but when the drums turn round in a contrary direction for unwinding the ropes, they are disconnected from the engines. A wheel is attached to each drum for the purpose of being acted upon by a break, not only for stopping the motion of the drum, after the arrival and stoppage of the down-train at

* The nominal power of these engines is, 224 horse-power for each pair at the Minories; and 140 horse-power for each pair at Blackwall. There are duplicate engines at each station, making 448 horse-power at the Minories, and 280 horse power at Blackwall.

the Blackwall end of the line, but also for maintaining a suitable degree of tension on the part of the rope behind the train, whilst it is in motion. The object of keeping the tension on the rope is to prevent it from being unwound from off the drum faster than the train proceeds, and to secure the rope against the risk of breakage, to which it would be liable, if it were allowed to become slack and then to be suddenly tightened, by the acceleration which takes place in the motion of the train, after it has commenced the descent of a steeper gradient than that on which it was previously travelling.

The engines being only worked for eight or nine minutes out of every quarter of an hour, the vacuum in the condenser might during the remaining six or seven minutes become imperfect from leakage, or from air contained in the injection water; in which case the restarting of the engines would be difficult, except by previously blowing steam through the condenser, to displace the air,—for the greatest power is required at starting, when the machinery, he drums, the rope, and the train, have all to be set in motion from a state of rest, and there must be a good vacuum in the condenser to enable the engines to start promptly. For this object an engine of 12 horse-power is provided, and constantly works two auxiliary air-pumps, which maintain the vacuum in the condensers of the large engines, independently of the action of their own air-pumps.

In the arches upon which the railway is carried to pass over the engine-house, *eight water-tanks* are placed, all connected together by pipes. The overflow of waste water from the hot cisterns of the engines, is conducted from the usual overflow-pipe into the most distant of the eight tanks. From that tank the water passes into the next, and then to the next, and so on to the last of the eight tanks, in which it is mixed with fresh cold water, and the mingled water is then conveyed into the engine-room, for supplying the injection cocks of the engines. The surface of the water in the eight tanks is exposed to the atmosphere, and the hot water thus becomes cooled in passing through them. At first there were only three tanks, in which, as they exposed a large surface to the air, it was expected the cooling of the water would proceed with sufficient rapidity to render it fit for injection upon arriving at the third tank, and being there mixed with fresh cold water; but, as it was found that there was not a sufficient cooling effect, five more tanks were added, and the eight tanks now in use are scarcely sufficient for cooling the water to the extent required. The supply of cold water, for mixing with the water in the tanks, is pumped by the 12 horse-power engine from a well in the adjoining part of the building, and, in addition to this supply, a small pipe is laid on from the main of the New River Company. The temperature of the injection water in summer is about 80°, and often higher, and the vacuum then obtained is about 24 inches of mercury; in winter there is no difficulty as to the temperature of the water, and the mercury stands at from 27 inches to 28 inches. Each of the tanks is 24½ feet square and 6 feet deep, so that the capacity is 3,600 cubic feet, and the surface of water exposed is 600 square feet in each tank.

The steam-pipe from the boilers passes through the wall, and is carried inside the engine-room to the right and left to each pair of engines, with a valve-box, from which two branches proceed to supply each engine. The valve in the box is opened and shut by a screw, worked from below by a handle, by which the engineman regulates the speed of the engines.

The governor is placed beyond the outer frame of the pair of engines, and the number of its revolutions is to the number of strokes made by the engines as 3 to 2. It is worked from the crank of the engines by a pair of bevil wheels on a small axis passing through the outer frame. The governor acts upon a throttle-valve placed in the steam-pipe, immediately beyond the shut-off valve. The resistance the engines have to overcome varies so much, that the governor was found not to be capable by itself of regulating the speed, and therefore it was assisted by the man closing the shut-off valve by its screw handle; but latterly the governor has been disconnected, and is not now used.

To avoid snatching the rope, by which it might be broken, great care is taken to start the engines as gradually as possible, in order that all the slack of the rope may be gathered up around the drum, and then the train be started slowly, and gradually accelerated to the full speed. The valve is therefore only partially opened at first, and is afterwards opened fully by degrees; as the engines acquire speed, the valve is closed again gradually, to restrain the speed, as the carriages arrive one after another, and the resistance diminishes.

The Boilers.—The boiler-house is beneath the railway, the five boilers being placed under the arches on which the continuation of the railway is carried beyond the engines. Two of them are square marine-boilers, with the ordinary internal furnaces and rectangular flues; the other three boilers are constructed on the Cornish system, being circular, with two internal tubes through their entire length, and the furnaces in the front ends. The two marine-boilers, which are equal in power to the three Cornish boilers, are capable of supplying steam for one pair of engines. The two marine-boilers, or the three Cornish boilers, are worked together as a set, the two sets being used alternately in the same manner as the engines, but for about three months at a time. The chimney is situated between the two sets of boilers. The flue from each separate boiler, enters into a main flue, which extends along the back of each set to the base of the chimney; each is provided with a separate damper, and there is another damper at the end of each main flue, where it joins to the base of the chimney.

On the top of the steam-chest of each boiler is a shut-off valve box, joined by a branch to the main steam-pipe, which leads to the engines. By these valves, any boiler may be shut off from the rest, in case it is required to be cleaned whilst the others are at work. At the mid-length of the steam-pipe are two safety-valve boxes, each having an aperture of 12 inches diameter; they communicate with each other, and from one of them a discharge-pipe proceeds into the chimney; one of these safety-valves is out of the control of the men, but the other may be lifted by means of a lever worked from below, in order to discharge the steam at the end of the day's work.

The feeding of the boilers is effected from a tank situated above the arches, at the side of the chimney, at such a height as to give the column of water entering the boiler a greater pressure than that of the steam. This feeding-tank is 10 feet in diameter, by 6 feet high, and is capable of holding 471 cubic feet of water. The water is raised into this tank by the pumps of the engines, and feed-pipes proceed from the tank to the feed-cocks in the pipes, at the front of the several boilers. During the time the engines are at work, no water is admitted to the boilers, but as soon as they are stopped, the feed-cocks are opened, and the water is allowed to flow in until the proper level is restored. At the same time a fresh supply of coals is thrown on the fires, to raise the steam for starting. This is so managed as to waste very little steam by blowing away at the safety-valve.

The *chimney* is 6 feet square inside, at the base, and 4 ft. 3 in. diameter at the top, and 164 feet high from the foundation. The draught is exceedingly good. The spaces opposite to the row of furnaces of the five boilers are stores for coal. Beneath the centre of the passage, in front of the row of furnaces, is the drain for carrying off the waste water.

The *steam-engines* of 112 horse-power (nominal power) are on the marine construction, with side levers, the same as Messrs. Maudslay, Sons, and Field made for steam-vessels a few years ago. That construction was adopted, as it was requisite that the centre of the shaft should be elevated. The diameter of the cylinders is 56 inches; the length of stroke is 5 feet; and the average number of strokes 22 per minute. The motion of the piston is therefore 220 feet per minute. The plunger feed-pump is 6¼ inches diameter, and 2 ft. 6 in. stroke; only one pump is worked at a time. The cranks are all of cast-iron, with axes of wrought-iron, 12 inches diameter in the bearings.

The *large spur-wheel* on the main axis is 17 feet in diameter at the pitch line, with 120 teeth; the pitch of the teeth is 5¼ inches, and their breadth is 23 inches. The centre boss of this wheel consists of two circular pieces bolted together externally, including between them, and closing over the roots of the arms, which are eight in number, cast separately, and bolted to one another, and to the boss. The rim is in eight segments, each having 15 teeth, and the junctions of the segments are made at the ends of the arms. The weight of the wheel is 16½ tons; that of the rim by itself being 8 tons 13 cwt. The *drum* is 23 feet in diameter outside, and 16½ feet in diameter at the bottom of the V-shaped groove, wherein the rope is coiled. The width of this part, at the bottom, is 1 ft. 6 in., and at the top 3 ft. 2 in.; when all the rope is wound on it, the diameter of the outside coil of the rope is 20 feet.

The *break-wheel* at the side of the drum is 14 feet in diameter, and 1 foot broad.

The *mortice spur-wheel*, on the axis of the drum, and at the same side as the break, is 11 feet in diameter at the pitch line: it has 78 cogs, which are also 23 inches broad.

Although the drum, the break-wheel, and the mortice-wheel, have hitherto been mentioned as separate, they are in fact all framed together so as to form one combination. The total weight is 30 tons. The axis of the drum is of wrought-iron, 12 inches diameter in the bearings. The cogs of the mortice-wheel are made of hornbeam.

The break is formed of two straps of wrought-iron, side by side, each 5 inches wide, to which are rivetted plates of copper in lengths of 3 feet each, 12 inches wide and $\frac{3}{4}$ inch thick; the copper applies to the lower half of the circumference of the break-wheel. One of the extremities of the break is suspended by rods from the girder above, and the other end is connected to the hoop around an eccentric-wheel, the axis of which is mounted in a frame fixed to the girder. On the axis of this eccentric-wheel is a spur-wheel, into which a pinion works, and on the axis of the pinion is a ratchet-wheel, to be worked by a lever-handle and click, by a man standing on the platform over the engine-room, the handle end of the lever passing up through the platform. The length of this lever-handle is 6 feet; the diameter of the pinion is $11\frac{1}{2}$ inches, and that of the wheel is 16 inches; the eccentricity of the eccentric-wheel is $2\frac{3}{4}$ inches. Hence the force of the man's arm applied at the upper end of the lever-handle is multiplied about 36 times $\left(\frac{72 \times 11}{2\cdot75 \times 11\cdot5} = 36\cdot4,\right)$ when the leverage is the least—namely, when the eccentric-wheel has made a quarter of a revolution; but for obtaining a greater power on the break, a piston is fitted into an air-cylinder 10 inches in diameter, which is fixed under the girder; one end of the cylinder is open to the atmosphere, and the other is closed, but communicates by a pipe with the condenser of the steam-engine below. In this pipe is a cock, which can be opened by the breaksman when necessary; a chain connected to the rod of the piston of the air-cylinder, is carried round the spur-wheel and fastened to it. If the breaksman opens the cock to establish a communication with the condenser, the air is exhausted from the air-cylinder, and the pressure of the atmosphere on the area of the piston acts by the chain on the circumference of the wheel. Supposing the vacuum to be 27 inches of mercury, this pressure is 1,060lb., equivalent to about 100lb. applied to the upper end of the lever-handle.

Each of the moving *plummer-blocks*, in which the drum-shaft revolves, is mounted on six rollers; three on each side. Beneath the plummer-blocks and attached to it, in the space between the rollers, is a long nut in which a screw 3 inches in diameter works; the pitch of this screw is such as to move the nut and the plummer-block 3 inches by seven revolutions. The axis of the screw is prolonged by a shaft to reach the platform, and this prolongation has on its end a bevil-wheel 2 feet in diameter, into which works a bevil-pinion 6 inches in diameter; the cross axis of this pinion extends across the breadth of the drum, parallel to its axis, and carries another such bevil-pinion of 6 inches diameter, which acts in another bevil-wheel of 2 feet diameter, on the prolongation of the axis of another screw beneath the plummer-block, for the other end of the axis of the drum. By this connection both screws are turned round simultaneously and act on both plummer-blocks alike. On the cross axes of the two bevil pinions is a cog-wheel 2 feet in diameter, into which works a pinion 16 inches diameter, on the axis of which is a winch-handle, so that to produce one revolution of the screw, the winch-handle must make six revolutions. The thread of the screw making seven turns in 3 inches, and the winch being 10 inches long, the pressure applied to it is multiplied 868 times. The winch is worked by one man, and the time occupied in disconnecting one drum and connecting the other, is little more than a minute.

The rollers on which each plummer-block moves, are made of wrought-iron, case hardened, $3\frac{1}{4}$ inches in diameter, and $2\frac{1}{2}$ inches broad. At first, the rollers worked against the cast-iron surfaces of the frame and of the plummer-block; but after having been at work two or three years, the pressure had caused so much indentation into the two surfaces of cast-iron, as to render it difficult for a man to connect and disconnect the large spur-wheels. To remedy this defect, a strap of steel was let into the frame and another into the underside of the plummer-block for the rollers to act against, and no inconvenience has been since found. The weight upon each of the rollers is about 5 tons. The weight of the drum, break-wheel, and mortice-wheel being 30 tons, and of the axes 3 tons 7 cwt., the rope remaining on the drum when unwound 1 ton, and the additional weight of rope when the whole is wound on, 23·10 tons, makes a total weight of 57·17, or 58 tons, to be sustained on the twelve rollers beneath the two plummer-blocks; and, therefore, supposing each set to bear the same weight, each roller has to carry nearly 5 tons; each end of the axis of the drum being 12 inches diameter in its bearing, the breaks must sustain 29 or 30 tons.

Power.—When all the train is in motion, the engines making 22 strokes per minute, the pressure of the steam on entering the cylinder being $2\frac{1}{4}$ lb. above that of the atmosphere, and the mean pressure 9·95 lb. per square inch, the power for the engines, rope, and train, is 323·74 horse-power.

When the rope, without any carriages attached to it, is drawn by the engines making 24 revolutions per minute, the pressure of the steam being 6 lb. above the atmosphere, and the mean pressure 7 lb. per square inch, the power expended on the rope and machinery is 250·76 horse-power.

When the drum is disconnected from the engines, and they are allowed to make 22 strokes, the pressure being $13\frac{1}{2}$ lb. above the atmosphere, and the mean pressure 8lb. per square inch, the power expended on the friction of the engines unloaded, is 26·09 horse-power.

Since the power expended on the engines, rope, and train, is 323·74 horse-power, and on the engines and rope, 250·76 horse-power; the difference, namely, 72·98 or 73 horse-power is due to the train alone.

The number of revolutions made by the engine-shaft per minute being 22, the number made by the drum in the same time is 33·84. The circumference of the drum when the rope is off, is 52 feet; when all the rope is wound on, it is 63 feet, the velocity of the rope will therefore vary from 1,760 feet per minute, to 2,132 feet, that is, from 20 miles to 24 miles per hour.

The Rope.—When the railway was first opened, the rope employed was of hemp, $5\frac{3}{4}$ inches in circumference, or $1\frac{3}{4}$ inches in diameter. After it had been in use for a very short time it broke, and continued to do so frequently; in consequence of which, a wire rope was substituted. This rope $3\frac{5}{8}$ inches in circumference, or $1\frac{1}{4}$ inch diameter, is formed of six strands, each composed of six wires, or thirty-six wires in the rope. It is covered over with small hempen rope or tarred yarn. The breakages of this rope are much less frequent than with the hempen rope, but still they do occur occasionally. In order to make the rope wind evenly on the drum, it is guided by two levers mounted on one centre pin, and crossing one another in the form of a pair of scissors, the levers having rollers on their inner side. These levers are worked by a man, standing on the platform below, and he guides the rope by pressing them alternately against either side as his eye directs, so as to wind the rope evenly around the drum. The weight of the hempen rope was 8 lb. per yard, that of the wire rope is $6\frac{1}{2}$ lb. per yard; therefore, the weight of the rope lying on the railway was, in the former case, $19\frac{1}{2}$ tons, and in the latter, $16\frac{1}{2}$ tons. Swivels are introduced at intervals in the length of the rope, to allow it to twist and untwist itself in working. The weight of the rope is sustained by bearing-sheaves, disposed at intervals along the line, in the middle of the space between the rails; some of them being laid at angles to suit the curves of the road.

The auxiliary engine.—The cylinder of the 12 horse-power engine is 20 inches in diameter, the piston makes a stroke of 3 feet, and 34 strokes per minute. The two air-pumps which are worked by it are 13 inches in diameter, with a stroke of $10\frac{1}{2}$ inches, and are placed one on each side of the centre of the main lever.

The *air-pumps* of the large engine are 31 inches in diameter, with a length of stroke of 2 ft. 6 in.; so that the capacity of the stroke of each pump is 13·1 cubic feet, or 26·2 cubic feet for the pumps of a pair of engines; therefore, the capacity per minute, is 26·2 × 22 strokes = 576·4 cubic feet. In like manner, the capacity of the small pumps, per minute, is 55 cubic feet, or nearly $\frac{1}{10}$th that of the large pumps in the same time.

The well from which cold water is obtained is 10 feet diameter inside, and is steined partly with brick and partly with iron. In this well are two sets of three-barrelled pumps, but only one set is worked at a time. The barrels are each 7 inches in diameter, the stroke is 18 inches, and they make twenty strokes per minute; so that the quantity of water raised by one set, per minute, is 150 gallons. These pumps are worked constantly throughout the day.

The marine-boilers are 10 ft. 3 in. wide, 10 ft. 8 in. high, and 24 feet long; the steam-chests are 5 feet in diameter and 4 ft. 10 in. high; each boiler has three fires within it.

The circular boilers are each 7 ft. 6 in. in diameter, by 24 feet long; the two circular flues, through their whole length are 2 ft. 6 in. diameter. The steam chests are 3 ft. 9 in. diameter, and 4 feet, 5 feet, and 6 feet high respectively. The average consumption of fuel, is, per day, for the two marine-boilers together, $7\frac{1}{2}$ tons, and for the three circular-boilers together, 8 tons. In these quantities is included what is required for getting up the steam in the morning.

The time of working, corresponding to this average is 13 hours. The weight on the safety-valve is 4½ lb. per square inch.

The engines and machinery at Blackwall are similarly arranged, but on a smaller scale. The railway there passes by the side of the engine-house on the ground, and therefore the ropes are gathered on at the lowest part of the circumference of the drums, instead of at the highest part, as at the Minories, where the railway passes over the engine-house. The engines, constructed by Mr. Barnes, are of the marine side-lever form, of the nominal forces of 70 horse-power each, the pistons are 45½ inches diameter, with 4 feet stroke, and their average speed is 25 strokes per minute. The large spur-wheels are 17 feet diameter to the pitch line, with 120 teeth, 5½ inches pitch, and 14 inches broad, working into mortice spur-wheels on the axes of the drums, 10 ft. 10 in. diameter, with 80 wood cogs. The drums are 16½ feet diameter when empty, and 22 feet diameter outside. The small steam-engine for working the air-pumps, is 8 horse-power; it was constructed by Messrs. Miller and Ravenhill.

Remarks made at the Meeting after the reading of the above Paper.

Mr. Farey stated that the wire rope consisted of six strands, each of six wires, coiled round a hempen core, and the whole of the strands were also laid round one centre core of hemp. Wherever the wires were in actual contact with the core, corrosion appeared to take place, which of course augmented the rapidity of the destruction of the rope. It was, however, now merely a question of expense, as, since the adoption of the wire rope, breakage seldom occurred. He thought that the old hempen rope had frequently been broken by the undue strain which was suddenly brought upon it, by its slipping on the drum. He imagined that a modification of the method used in cotton spinning for regulating the coiling of the filaments, might be adopted with advantage, instead of as at present coiling it by hand.

Mr. Bidder said he had noticed the peculiar tendency of the hemp rope to twist, which caused its frequent fracture. The first rope was 5½ inches in circumference, with a lay of 4½ inches; this was soon diminished to 3 inches, and it broke continually. It was replaced by a rope from which the tar had been expelled by pressure; that was soon worn out, and the fibre appeared completely destroyed. Wire ropes of various kinds were then tried; and at last, by the introduction of swivels, and recently by an improved construction of them, the bad effects of the twisting were obviated, although it still took place. In spite of the rapid destruction of the hemp rope, he was of opinion, that as a mere question of cost, it would be found cheaper than wire rope, as, when partially destroyed, the former had still a certain value, but the latter was comparatively valueless.

Mr. R. Stephenson stated that he was unable to account satisfactorily for the twisting of the rope. He imagined that it might be caused, in some degree, by its being coiled over the drum at the Minories end, and under the drum at the Blackwall end of the railway. The lateral action of the groove of the inclined guide pulleys might also influence it, particularly on the sharpest curves. Ropes composed of lengths, with a right-hand and a left-hand lay alternately, had been tried, but ineffectually; the twisting still continued, and the bad effects were only counteracted by the swivels. It might have been imagined that the rope would have untwisted, and thus have lengthened; but, on the contrary, it became more tightly twisted, its diameter diminished, and still its length increased, apparently from the pull of the engines upon it. It was evident from the appearance of the fracture, when one occurred, that the material was wrenched asunder by a twisting action. The breakages occurred, however, very seldom at present; not oftener than once or twice in a month, during which time nearly three thousand journeys were made, and then they arose generally from the carelessness of the breaksmen, who, it must be remembered, received their instructions from a distance of three miles, by the electric telegraph. The were six swivels in the rope, one at every half-mile. The destructive effects of the twisting would probably be diminshed by a larger number of swivels, but they were very objectionable, in preventing the regular laying of the rope upon the drum. On the inclined planes in the north of England, where ropes had been used for many years, this twisting was not observed; but there the engines were at one end only; whereas, on the Blackwall railway, the engines at both ends working simultaneously, might probably have a tendency to cause the twisting. Twenty years ago he had tried, in the North, machinery similar to that suggested by Mr. Farey, for laying the rope on the drum; but in consequence of the general diminution of diameter of the rope from the stretching, and the inequalities occasioned by the splices, the machinery was constantly put out of order, and was eventually destroyed. On the Blackwall line, the men had acquired considerable dexterity in directing the rope with the levers or shears, and he thought it would scarcely be possible to improve that part of the system.—Some difficulty had been apprehended from the use of condensing engines, on account of the time required for forming the vacuum; it had, however, been met by having a small engine constantly working to keep up the vacuum and to pump water. High-pressure engines were generally used with rope traction, in order to avoid this difficulty. He, however, preferred the use of condensing engines, with a small supplementary engine, and believed them, at the same time, to be more economical.

Mr. A. Wightman stated that the wire rope was manufactured by Messrs. Newall, of Gateshead, The wire was unannealed, and the weight of the rope was 10 lb. per fathom, except two lengths of half a mile each, which weighed 12 lb. per fathom; these lengths were so placed, that the main trains to or from Blackwall, were always attached upon them. The swivels were at first rivetted into the rope, but it was found that at least two-thirds of the fractures of the rope occurred where the first rivet was inserted. In order to prevent this, the swivels were spliced into the rope; this was done by unstranding about a yard and a half of the rope, passing the strands through an eye in the swivel, and then splicing them back into the rope. Swivels thus inserted would last three months without renewing, and the lay of the rope had been preserved by them. Breakages, however, still occurred, but (except from carelessness), they rarely, if ever, took place in a rope less than a year old; after that time the rope began to lose its strength, from the oxidation that took place, wherever the strands came in contact with the hemp core, and although a rope might appear sound after it had been in use for a year and a half, yet on opening it, a considerable extent of oxidation would be discovered. The rope-makers in the North attributed this, in a great measure, to the serving of the rope with spun yarn, which had been adopted on the Blackwall railway, chiefly to prevent the noise occasioned by the rope passing over the sheaves. Experiments were in progress, with a view to doing away with the serving of the rope, by covering the sheaves with hard leather, which, if successful, would be the means of saving the company a large expense in keeping up the serving, and would take a weight of about 12 tons off the engines, and reducing also the cost of fuel. With regard to hempen ropes, both tarred and white ropes had been tried, but they had totally failed, some of them not lasting more than two months. These ropes had a great tendency to twist, and from their bulk it was very difficult to counteract it by the insertion of swivels. The wire ropes were, consequently, the cheapest; for although there was a difference in the original cost, as also on the return for the old ropes, yet the duration of the wire rope was so much greater, that it more than compensated for the increase in price.

The charges for the motive power, for the year 1845, amounted to £11,302 1*s.* 2*d.*; during that time there were run 105 trains per day, 3¾ miles each, or 38,325 trains per annum, at an average cost of 5*s.* 10¾*d.* per train, or 1s. 6¾*d.* per mile.

Although the present cost of working the line by the rope system was high, yet by no other system had they been able satisfactorily to effect the accommodation of stopping at the various stations, without interfering with the "through traffic."

FOSSIL FOOTMARKS IN THE COAL FORMATION.

Mr. Lyell delivered a lecture at the Royal Institution, on February 4th, "*On the Fossil Footmarks of a Reptile in the Coal Formation of the Alleghany Mountains.*

Mr. Lyell began by observing that, notwithstanding the numerous remains of land plants in the carboniferous strata and the evidence they afford of the existence of large tracts of dry land (the exact position of which is often indicated by seams of coal and buried forests), no monuments of any air-breathing creatures had been detected in rocks of such high antiquity until Dr. King, in 1844, published his account of the foot-prints of a reptile occurring in sandstone in Pennsylvania (see *Silliman's Journal*, vol. 48, page 343). These fossil tracks were found in a stone quarry five miles south-east of Greensburg, and about twenty miles east of Pittsburgh, appearing on the under surfaces of slabs of argillaceous sandstone extracted for paving. They project in relief, being casts of impressions formed in a subjacent layer of fine unctuous clay, and they are accompanied by numerous casts of cracks of various sizes, evidently produced by the drying and shrinking of the clayey mud. These cracks occasionally traverse the foot-prints, showing that the shrinkage took place after the animal had walked over the soft mud, and before it had begun to dry and crack. Mr. Lyell exhibited a slab which he had brought from the quarries, having visited them with Dr. King; and then proceeded to point out the differences between these foot-prints and those of the European cheirotherium found in Saxony and in Warwickshire and Cheshire, always in the upper part of the new red sandstone or trias. In the European hand-shaped foot-marks, from the form of which the animal was called by Kaup, cheirotherium, both the hind and fore feet have each five toes, and the size of the hind foot is about five times as large as the fore foot. In the American fossil the posterior foot-print is not twice as large as the anterior, and the number of toes is unequal, being five in the hinder and four in the anterior foot; as in the European cheirotherium the fifth toe stands out nearly at a right angle with the foot, and somewhat resembles the human thumb. On the external side of all the Pennsylvanian tracks, both the larger and smaller, there is a protuberance like the rudiment of another toe. The average length of the hind foot is 5½ inches, and of the fore foot 4½. The fore and hind feet being in pairs follow each other very closely, there being an interval of about one inch only between them. Between each pair the distance is six to eight inches, and between the two parallel lines of tracks there is about the same distance. In the case of the English and German cheirotherium, the hind and fore feet occur also in pairs, but they form only one row, in consequence of the animal having put its feet to the ground nearly under the middle of its body, and the thumb-like toes are seen to turn to the right and to the left in the alternate pairs; while in the American tracks, which form two parallel rows, all the thumb-like toes in one set turn to the right, and in the other set to the left. Mr. Lyell infers, therefore, that the American cheirotherium belongs to a new genus of reptilian quadrupeds, wholly distinct from that which characterises the triassic strata of Europe; and such a generic diversity, he observes, might have been expected in reptilian fossils of such different ages. The geological position of the sandstone of Greensburg is perfectly clear, being situated in the midst of the Appalachian coal-field, having the main bed of coal, called the Pittsburg seam, a hundred feet above it worked in the neighbourhood, and several other seams of coal at lower levels. The impressions of lepidodendron, sigillaria, stigmaria, and other carboniferous plants, are found both above and below the level of the reptilian footsteps. Mr. Lyell then adverted to some spurious fossil foot-prints of dogs, hoofed quadrupeds, birds, and other creatures seen on the surface of ledges of a soft quartzose sandstone in the neighbourhood of Greensburg, which had been confounded with the fossil ones. He pointed out the proofs that these had been carved by the ancient inhabitants of America, whose graves are seen in the vicinity; and that the Indian hunters had sculptured similar bird-tracks, together with human foot-prints, in solid limestone of the State of Missouri,—the true origin of which was first explained by Mr. D. D. Owen, of Indiana.

To illustrate the mode of interpreting fossil foot-prints in geology, Mr. Lyell gave a sketch of the discovery of three distinct species of cheirotherium in Europe,—and explained how, after it had been conjectured by Link that they might belong to gigantic batrachians, Mr. Owen found, by examining the teeth and bones of reptiles of triassic age, that three different species of air-breathing reptiles of the batrachian order, referable to a new genus, labyrinthodon, had existed, both in Germany and England, at that period; their fossil bones indicating that they were air-breathers, and there being as great a disparity in size between the bones of their anterior and posterior extremities as between the fore and hind foot-prints of the several cheirotheria. To account for the sharpness of the casts of cheirotherium on the under surfaces of slabs of sandstone, Mr. Lyell adverted to the manner in which he had seen, on the sea-beach, near Savannah in Georgia, a cloud of fine sand drifted by the wind filling up the foot-prints of racoons and opossums, which, a few hours before, had passed along the shore after the retreat of the tide. Allusion was also made to the recent foot-prints of birds called sandpipers (*Tringa minuta*), which Mr. Lyell saw running, in 1842, over the red mud thrown down every tide along the borders of estuaries connected with the Bay of Fundy, in Nova Scotia. These consist both of impressions on the upper surfaces and of casts in relief on the under sides of successive layers of red mud (see Lyell's "Travels in North America," vol. ii. p. 166),—of which he has presented a specimen to the British Museum. The ancient foot-prints of more than thirty species of birds found fossil in the new red sandstone or trias of the valley of the Connecticut river, in Massachusetts, were stated to be analogous to these modern bird-tracks; and the size of the largest, although they indicate a biped more huge than the ostrich, is exceeded in magnitude by the gigantic deinornis of New Zealand—of which nearly the entire skeleton has just been found fossil by Mr. Walter Mantell. The absence hitherto of the bones of birds in the ancient American strata of the triassic period appears to Mr. Lyell quite intelligible; for the circumstances which combine to cause foot-prints of sandpipers in the recent mud of the Bay of Fundy, repeated throughout many superimposed layers, have no tendency to preserve any bones of the same birds,—and none have yet been ever observed in cutting trenches through the red mud, where it has been laid dry by artificial embankments and drained.

In all the cases of foot-prints, both fossil and recent, and whether made by quadrupeds or bipeds, the lecturer insisted on the necessity of assuming that the creatures were air-breathers, for their weight would not have been sufficient under water to have made impressions so deep and distinct. The same conclusion is borne out by the evidence derived from the casts of cracks produced in the same strata, by shrinkage, and so generally accompanying the impressions of feet; and it was remarked that similar effects of desiccation are observable in the recent red mud of Nova Scotia, where thousands of acres are dried by the sun in summer, between the spring and neap tides. The ripple mark also so common in strata of every age, and among others in the coal measures, and new red sandstone of Germany, England, and America, exemplifies the accurate preservation of superficial markings of strata, often less prominent than those caused by the tread of reptiles or large birds. As the discovery of three species of cheirotheria was soon followed by the recognition of as many species of labyrinthodon, so the announcement by Dr. King, in 1844, of reptilian foot-prints in the coal strata of Pennsylvania, has been followed by the news lately received from Germany, that in the ancient coal measures of Saarbruck, near Treeves, the antiquity of which is vouched for by Von Dechen, Prof. Goldfuss has found the skeleton of a true saurian. Dr. Falconer, after a cursory examination of the original specimen, has stated his opinion in favour of its reptilian character, and although the evidence has not yet been rigourously tested by the most eminent comparative osteologists of Europe, Mr. Lyell believes that the opinion of Prof. Goldfuss and Dr. Falconer will be confirmed. Such facts should serve to put us on our guard against premature generalizations founded on mere negative evidence, and caution us not to assume the present limits of our knowledge of the time of the first appearance of any class of beings in a fossil state to be identical with the date of the first creation of such beings.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF MECHANICAL ENGINEERS.

Jan. 26.—J. E. M'Connell, Esq., V.P., in the Chair.

The first annual general meeting of the members of this Institution took place at Birmingham, in the theatre of the Philosophical Institution, for the purpose of receiving the Report of the Council and for the general transaction of business. There were present nearly 100 members.

Mr. M'Connell said that as this was the anniversary of the establishment of the Institution, he would content himself with referring to the Report about to be read for the confirmation, he might say, of the more than realised hopes of the most sanguine promoters of the Institution. He was gratified to see so large a meeting, and regretted the unexpected absence of the President.

The Report of the Council was then read. It contained a brief outline of the proceedings of the Institution for the past year:—The desirableness and importance of founding a society such as this was known to have been long and extensively felt by the engineering and mechanical profession in all parts of the kingdom, and it is not too much to venture to say, that the best expectations of the active and zealous promoters of the Institution have been fully realised, and a great amount of scientific and valuable information has been beneficially and mutually interchanged and diffused amongst the members. In reviewing the matter and subjects brought under the notice and discussion of the members, as recorded and detailed in the minutes and proceedings of the Institution, the Council felt it their duty to acknowledge and particularise the following valuable aid:—the two papers on the "Fan-Blast," by Mr. Buckle; on a "Self-Acting Break," by the President; on an "Inverted Arch Bridge," by Mr. Cowper; on "Locomotive Engines," by Mr. Beyer; on a "Turn-Table Lathe," by Mr A Slate; on "Jones's Gas Exhauster," by Mr. Clift; on a "Direct Action Steam Helve or Hammer," by Mr. H. Smith.

The following recommendation of the Council was then read:—

"The Council, having had under their consideration the question of the number of the members of the Council, have resolved to recommend to the members of the Institution to authorise the Council for the present year to add to their number, so as to place one member of Council, or more, as may be considered desirable, in each district where such may be advantageous to the interests of the Institution."

A resolution to the above effect having been proposed, was carried unanimously.

The officers for the ensuing year were then re-elected, viz.:—Mr. G. Stephenson, President; Mr. C. Beyer, J. E. M'Connell, and J. Miller, Vice-Presidents; Messrs. W. Buckle, E. A. Cowper, B. Fothergill, E. Humphreys, and A. Slate, Council; Mr. C. Gooch, Treasurer; Mr. A. Kintrea, Secretary.

After the conclusion of the business connected with the annual general meeting, the following papers were read:—

HYDRAULIC LIFTING JACK.

"*Description of a New Hydraulic Lifting Jack.*" By Mr. Ald. Thornton.

The principle of this jack is the same as that of the hydraulic press, but not having been before applied to a lifting jack, it is thought that the present application of it will be useful for a variety of purposes. Its advantages are, the ease and steadiness with which a great weight can be raised by one person; the facility with which the lowering of the weight can be regulated without labour, and from there being no circular motion of the handle, there can be no tendency in the jack to twist from the position in which it is placed; also by the use of strong wrought-iron tubes for the cylinder and ram, the weight of the jack is less than others now known. This jack can be used in all cases where others are available, and in some where others are not so, for the motion of the lever being vertical instead of lateral, it can be used wherever there is sufficient width to place it. With a jack of the size shown one man can lift from 15 to 20 tons weight. Mr. Thornton said although the jack was not new in principle, one of its great advantages was to be found in the additional power which it gave to one man to raise so great a weight.

The Chairman said he presumed they all understood the description given by Mr. Thornton. The jack displayed itself by its own appearance and the drawing. So far as the trial he had had with it went, he had every reason to be satisfied. It was very simple, acted very nicely, and he thought it was a very ingenious improvement.

Mr. Crampton wished to know if it had ever tumbled down?

Mr. Middleton said all persons acquainted with such things must be fully aware that they could not get a jack boxed up. Until, however, an alteration could be made in the handle, it could not be considered a good thing practically.

Mr. Slate observed that though a jack might not be practically good when placed in a tumbling position, it might be good in other cases. A jack like the one now before them might be useful in lifting a great weight, where the ordinary one would not be sufficient.

Mr. Buckle thought that the jack was an exceedingly useful instrument. An ordinary jack would be much more liable to be put out of order than the one before them; besides, it presented greater facilities for lowering weights.

Mr. Milner was of opinion that as it was it could not be generally useful. If it was thrown from a tender to the ground it would be destroyed, and their endeavours should be to prevent it, if possible, from capsizing.

The Chairman said Mr. Thornton's object in introducing it was to have the benefit of their experience.

Mr. Peacock said, that for locomotive purposes it was not equal to Heeley's jack; still, if in other respects it possessed advantages over it, they ought not of course to condemn it.

In answer to other questions by various members, Mr. Thornton said it would lift 20 tons; it weighed about 65 lb.; and its price was 12 guineas.

Another member said he should give the preference to Heeley's jack. Lifting jacks when laid aside, like fire-engines in a country town, not being generally required, get out of order, and he was afraid that the one before them would be much more liable to injuries of that kind than the ordinary jack.

The Chairman said, it appeared that it was objected against the jack, that it was liable to get out of order, and that it had not the advantages of Heeley's jack in lifting from below, but from the top; at the same time it would be admitted that it was steady in action, and that in lowering weight it was necessary to have power and command, so as to do it slowly and easily. There was one important point in which it had not the advantage, and that was in price. In articles of that kind, the price was a consideration.

Mr. Henderson thought that the jack possessed advantages where there was a great weight to lift, and only one man to work it. Another advantage was the steadiness of its action. The great objection against it was its liability to get out of order. If they wanted a jack to raise 20 tons, he was not aware that they could get any other to do it with the same degree of steadiness.

CYLINDER-BORING MACHINE.

"*On the Fitting-up of Cylinders for Locomotive Engines, and a Description of a Machine for Boring them.*" By Mr. C. Beyer.

The desirableness of having all the cylinders of every class of locomotive engines perfectly alike, so that they may, at any time, be changed in case of accident, or be replaced by spare ones, it is presumed will be admitted by all; the difficulty of accomplishing this with the tools hitherto employed, will be known to most who are engaged in this branch of the business. These considerations, and the defect of cylinders, the author, from time to time, found necessary to have rectified before passing them to be used, induced him, in 1843, to direct his attention to the boring-machine.

The conditions which a good cylinder boring-machine should fulfil, may be stated as follows:—1. That it should make the cylinder perfectly round in its diameter, and parallel in the direction of its axis. 2. That the bored inside should be perfectly concentive or parallel with the outside of the barrel. 3. That the projections beyond the flanches, if there be any, should be true with the internal bore. 4. That every strain or pressure upon the barrel of the cylinder whilst boring should be avoided. The boring-machine hereafter to be described has been found, during several years' practice, to have answered these conditions.

Messrs. Sharp, Brothers & Co. cast their cylinders from wood patterns in green sand, and commence the process of fitting-up by describing or gauging off a circle upon each end of the cylinder, concentive to the barrel, and having formed this circle the ends are bevelled inwards by chipping to an angle corresponding to that of the plates of the cone mandrill. The cylinder being fastened to the mandrill is put into a two-foot slide lathe, with facing motion, and has its ends faced to a gauge, and its projections turned to a gauge, and cut to a length to gauge. There are further two notches cut out of two cone discs, so as to allow of applying an internal gauge for the out-and-out length of the cylinder. Thus prepared by turning, it is removed to the boring-machine, inserted between two plates, the faces of which are planed, and the holes for receiving them bored from the boring-bar in their places; it is at once perfectly concentive with setting, and needs nothing but clamping to the plates by headed bolts or clamps by its flanches to be ready for commencing boring. For placing the tops of the steam-chests and valve facings the turned ends are again made use of for setting, by placing upon the planing-machine table brackets placed on their faces and bored out to the same gauge; the cylinder is turned to, in order to insure the parallelism of these parts with the axis, as for similar reasons the inside of the cylinder could not be otherwise than concentive with the outside of the barrel. The author prefers making a separate set of gauges, tackling, &c. for each size of cylinders rather than economise by making one do for many, and risk the chance of mistakes; and be believes that the plan here described, to work always from the same point, is most likely to insure accuracy, as the faults made by neglect of the workmen are not multiplied by subsequent operations.

The boring-machine bores by two cylinders at the same time, and is arranged to bore cylinders of 2' 6" strokes and from 10 to 20 inches diameter. The bed is that of a common slide lathe, sufficiently long to carry a double set of driving gear, and admits of a sufficient traverse of the boring-carriage. The boring-bar is supported by three bearings, the former of which is stationary and firmly fastened to the bed to resist the end and pressure of the cub when boring; the latter are fixed upon the carriage and travel with it along the boring-bar, and serve for securing the cylinder during boring, as will be shown hereafter. To cause the boring-carriage to move endways, a train of wheels descends at the back of the machine to give motion to the shaft, and is transferred by means of a feathered worm to the worm-wheel and pinion, both of which move loose above the fast stud of the carriage. This same stud serves as a folcrum for the lever, carrying upon opposite projections the intermediate pinions, which gear into the stud pinions. It will be clear, therefore, that by setting the lever in such a position as to bring one pinion into gear with another pinion fast on the rack-pinion shaft, motion will be given to the boring carriage in one direction; and in an opposite or contrary direction by moving the lever so as to bring the pinions to gear with each other; and this carriage will be stationary or independent of the driving gear altogether, by keeping the lever in its middle position. The rack pinion shaft is extended towards the front of the machine, to work the carriage by hand when putting in or taking out the cylinder. A provision is also made in the train of wheels for varying the traverse of the carriage by changing the pinion.

To hold the cylinder while boring, the top of the carriage is formed into a kind of square frame, by means of two plates, planed on the inside and fastened to the sides of the bearings or standards and two cross stretchers. These latter are also placed upon their inner faces and are secured to the sides and top of the boring-carriage, and have holes bored in them when secured in their places, by means of the boring head upon the bar corresponding in diameter to the turned projecting ends of the cylinder to be bored. It will be seen, therefore, that if the figure of the cylinder to be bored be turned to the same gauges as the holes are bored to, it needs only inserting and clamping fast by the T bolts to be ready for boring without requiring any setting in its pan whatever. One of the cross stretchers is a fixture, whilst the other is removed every time a new cylinder is to be fixed. The boring head is a fixture upon the bar, and has only one plain square tire for boring, ground to cut either way. This tool fits into a planed recess made slightly dovetailed, and is held fast by a set screw, and easily adjustable to any diameter by another of these machines. We employ three of these machines—two double ones and a single one, and one man attends to these and the lathe for facing and turning the ends of the rough castings of the cylinders. The cylinders are cast as hard as we are able to cut them with the best cutting tools we can make, and we find it more advisable to complete the boring in three cuts; the first is often as much as ⅜ inch in depth, the second we leave about ⅛ inch, and the third can hardly be called cutting, but is merely clearing up or finishing. The advance, or traverse, we rarely change, and is set to $\frac{1}{8}$ of an inch for each revolution of the boring-bar; or is, for quickest speed of the bar, 3 revolutions per minute; in the second, 1·8 revolution per minute; in the third, or lowest speed, 1·2 revolution per minute. For boring 15 inch cylinders—for roughing out, 1·8 revolution per minute, or cut at 7 feet per minute; for boring, 3 revolutions per minute, or cut at 11·78 feet per minute; and for finishing, 1·2 revolution per minute, or cut at 5·65 feet per minute.

Mr. Crampton said they should be doing very great injustice to the very valuable paper they had heard read were they to discuss it at that late hour, and he should propose that the further consideration of it should be adjourned till the next meeting. The suggestion was adopted and the meeting terminated.

JACQUARD PERFORATING MACHINE.

"*Description of a Perforating Machine,*" made for Mr. Evans, the contractor for the iron tubular bridge which is to carry the Chester and Holyhead Railway over the river Conway. By Mr. Fothergill.

This machine is employed to perforate the plates for the above-named bridge, and is at present adapted to punch such pitches only as that work requires, viz, 3 inches and 4 inches from centre to centre of rivet holes, with latitude for departing considerably from those (general) pitches in the lateral rows of the holes. This machine is constructed to perforate, at each stroke, a row of holes across a plate 3 ft. 5 in. broad; but, by employing a series of card plates (similar to the cards used in the Jacquard loom), any number of punches may be put out of action at pleasure; and by means of a blank card at the end of the series, the machine is put out of action at a point where no obstacle is presented to the taking out of the perforated plate and putting a blank plate in its stead. The operation of changing plates, weighing six or seven hundredweight each, is performed by half a dozen men in less than one minute, and whilst one plate is being punched, these men get another ready to put into the machine. As these machines take eleven to twelve strokes per minute, it follows that (with a 4-inch pitch) a 12 feet plate may be punched in less than four minutes, and consequently that (allowing one minute for changing) it may perforate twelve such plates per hour. Many of the plates in the bridge are 12 feet long, 2 ft. 8 in. broad, and ⅝ inch thick, and are punched for rivets 1 inch in diameter. As there are but few engineering concerns where such a perforating machine as that at Conway could be employed more than an hour or two per day, it appears to be very desirable that ironmasters should have them, and that they should also have machines for straightening and bending plates; by which means they would be enabled to supply their customers with plates in a fit state for being rivetted together. Were this system brought into practice, engineers would turn their attention to adapt their work to the capabilities of the perforating machine, and thus great perfection, dispatch, and economy of construction would be the result. A drawing represented a machine (similar in principle to that already described) adapted to perforating paper and thin sheet metal, such as sieves and window-blinds are made of, in which plain perforations, arranged in squares, may be made by a single row of punches; and perforations, arranged quincuncially, may also be made by a single row of punches, by giving to the plate a lateral alternating motion; but a double row of punches, arranged intermediately to each other, is preferable. Each of these arrangements admits of a great variety of fancy patterns by the application of the Jacquard principle. A large class of patterns may be produced by punches of various forms and sizes, which shall be so grouped together as to give to the work a columnar effect; and the range of this class may be extended by giving the plate a zig-zag or waved motion, and still further extended by combining it with the Jacquard. Another class of patterns may be produced by employing two distinct sets of punches of different size or form, and with each set a Jacquard, to bring punches of the one or other set into action as required, and thus be made to produce representations of figures, landscapes, &c., at pleasure. A further variety of patterns might be produced by the introduction at intervals of punches containing set patterns, such as sprigs, flowers, &c., and perforating the ground with small punches.

The foregoing is but a brief description of the capabilities of the Jacquard Perforating Machine, which in good hands would be found to be nearly co-extensive with those of the Jacquard loom. Another drawing represented a double-acting machine for shearing (at the one side) and punching (on the other), at the same time, plates of iron $\frac{3}{4}$ inch in thickness with holes $1\frac{1}{4}$ in. in diameter, and to perform both processes to the extent of 18 inches from the edge of the plate.

The CHAIRMAN said it was a machine represented as peculiarly adapted for perforating plates used in ship steam-boilers, girders, &c. But, from the description, it appeared to him to be a very useful machine for steam-boilers generally. Seeing the great accuracy with which the punch is made, it would be rather interesting to follow out the applicability of the machine.

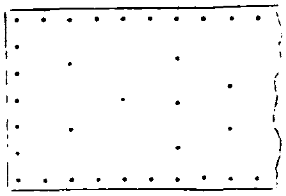
Mr. ALD. THORNTON asked if the machine punched in any other than a straight direction?—Mr. FOTHERGILL said it did, and it would punch twelve holes at once.

Mr. BEYER thought it was a very excellent punching machine, and it might be applied to a great extent, and to all ordinary-sized boilers.

In answer to questions by various members, Mr. Fothergill said, all the punches acted upon the plate at the same time.

In order to give an idea of the nature of the work to be performed by this machine, we subjoin the annexed diagram and description, taken from the *Manchester Guardian*:—

"The diagram represents a portion of a wrought-iron plate, which we will assume to be, when entire, 12 feet long by 2 feet wide, and $\frac{3}{4}$ inch in thickness, and requiring to be perforated, along each sides and ends, by a row of holes *exactly* four inches asunder from centre to centre, and each an inch in diameter; as well as by certain intermediate holes of the same size, the situation of which will be best understood from the diagrams.



"On looking to the left hand of the diagram representing the entire end of the plate, it will be seen that there is vertically a row of seven dots, representing seven perforations or rivet-holes. These perforations the machine makes at one moment, by bringing down with immense force seven punches of tempered steel, upon that part of the plate which at the time rests upon the same number of dies, also of tempered steel. These perforations being made, the punches are lifted clear of the plate, which is then moved forward longitudinally, exactly four inches; and then the striking peculiarity of the machine comes into play.

"It will be seen on looking carefully at the diagram, that the second row vertically of perforations, counting from left to right, instead of seven contains only two, one at the upper and the other at the lower margin, each forming a part of the two side rows of rivet-holes. These two holes the machine perforates also at one blow; but as there are seven punches, and only two are required, the five intermediate ones are thrown out of use by a contrivance exactly similar in principle to that of the Jacquard loom, by which figures are produced in silks and other fabrics. The third vertical row of holes, still continuing from the left, consists of four, the fourth again of two, the fifth of three, and so on, the number varying through the whole length of the plate; and, in each case, the machine itself, without the slightest interference of the workman, moves the plate on to the required distance, selects the proper number and right situation of the punches, makes the requisite number of perforations, and throws itself out of action when the plate is completed. Those who are aware of the force necessary to perforate an iron plate of moderate thickness, even with a single punch of small size, may form some judgment of the enormous power required to impel seven punches, each an inch in diameter, through plates three-quarters of an inch thick; and it is a little singular to see this enormous power regulated in its operation by the identical means employed in producing figures in the most delicate fabrics. The machine is calculated to make, when necessary, *twelve* perforations by one stroke, and to produce any requisite combination of twelve or any smaller number of punches, at distances of three or four inches from each other. The speed with which the work is performed may be understood from the fact, that it regularly completes the perforation of one plate of the size above described,—namely, 12 feet long and 2 ft. 4 in. wide,—in four minutes; and if the plates were so quickly supplied as to prevent any loss of time, which might easily be done, it would complete them regularly at that rate. As it is, fifty have been completed in four hours. But the facility and dispatch resulting from the use of the machine are not, perhaps, its greatest merits, so far at least as the construction of tubular bridges and beams are concerned. In such cases, the strength of the fabric depends in a great degree upon the whole of the rivets completely filling the perforations, retaining a regular cylindrical form, continuing perfectly straight, and being, throughout their length, exactly at right angles with the faces of the plates. As each of the perforations represented in the diagram is intended to correspond with a similar perforation, either in another plate, or in an angle or T iron, it must be obvious that deviations in opposite directions of a sixteenth of an inch in each, would prevent them fitting each other by an eighth of an inch altogether; and, whatever might be done by enlarging one or both of the holes, to bring them a little nearer each other, the firmness and strength of the work must be impaired by the direction of the rivet being rendered in some degree oblique, instead of being exactly at right angles with the plate; whilst, in the work performed by the machine, the perforations are set out with such accuracy that they always correspond precisely, and the rivets retain their proper form and direction."

The Dinner.—In the evening the members and friends, amounting to about 100, dined together at the Queen's Hotel—Mr. M'Connell presiding.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Jan. 24.—Mr. CHARLES FOWLER, V.P., in the Chair.

The donations included a number of works by the celebrated archæologist, M. de Caumont, of Caen, a corresponding member of the Institute. Mr. Wallen sent a portion of the mosaic pavement found nine feet below the present level, while digging the foundations for the new warehouses of Messrs. Morley, at the corner of Gresham-street and Wood-street. Mr. Wallen thought a Roman temple formerly stood on the spot.

Professor DONALDSON read a paper on "*Caen, its Quarries and Buildings, with a few words on Arras.*" This paper we have given in full in another part of the *Journal.*

Some very high compliments were paid to Mr. Donaldson on this valuable paper.

Feb. 7.—Mr. ANGELL, V.P., in the Chair.

Among the donations reported were Canina's work on Etruria, sent in the name of the Queen of Tuscany; Mr. Sharpe's "Architectural Parallels;" and eleven volumes of the "Bau Zeitung," the architectural journal of Vienna, edited by Mr. Forster; and parts of Billings' "Antiquities of Scotland."

Mr. Wright sent a set of drawings illustrative of the ceiling at Carpenters' Hall, London-wall.

Mr. G. L. TAYLOR read a paper in reference to the New Western Gas Company, entitled "*Some observations on Gas-works, and the details of the Manufacture of Gas; with the view of showing that it is capable of being rendered so Pure as to be introduced beneficially throughout Houses, Manufactories, and Public Buildings,*"

Mr. BURN observed that formerly he resided at Edinburgh; that he had twice as many burners as he now has in London, and paid at a much higher rate, being 9*s.* per 1,000 cubic feet. The gross charge at Edinburgh was however only one-half of the London gross charge, arising from the superior illuminating qualities of the Edinburgh gas. It is true, the latter is made from Cannel coal; but there is an unfortunate temptation to gas companies to deteriorate the quality of gas, in consequence of the charge being made on the quantity. He further observed, that though the Edinburgh gas is superior in illuminating power, it is not free from impurities; in proof of which he said all the book-binding and leather furniture of a new club-house at Edinburgh had been destroyed by the gas, as the book-binding of the Athenæum club-house, in London, has likewise been injured.

Mr. PALMER dwelt upon the importance of the purification of gas, and said that the new plan showed its practicability.

The Western Gas Company have their works in a building at Kensal-green, 166 feet in diameter. They propose to use Cannel coal, and supply gas at 6*s.* per thousand feet, which they say is as cheap as common gas at 4*s.* per thousand.

INSTITUTION OF CIVIL ENGINEERS.

Feb. 1.—Joshua Field, Esq., President, in the Chair.

The President, in taking the Chair for the first time since his election, addressed the members at considerable length, dwelling chiefly on the intimate connection between the civil and mechanical engineers, their dependence upon each other, and the importance of maintaining that union between the two branches of the profession that had ever been one of the main objects of the Institution. He showed, that originally engineering was confined to the constructive or mechanical branches; raising heavy weights, building mills, draining mines, and all the primitive wants of mankind; by degrees, as civilisation extended, the exigencies of the world became greater; luxuries were required, that could only be supplied by greater exercise of talent and skill; manufactories were multiplied, manual labour could no longer suffice, the steam-engine was generally employed, and the consequence of this increase of production was, that the roads required to be amended, rivers and canals to be cut, for carrying this abundance of merchandise and passengers, whilst docks and harbours required extending, for the reception of the shipping for the increasing export trade. These wants called into being another class of men, who, with great mechanical skill, combined more than ordinary theoretical knowledge and business habits, to enable them to combine and use the powers of all other classes. These men were termed civil engineers, in contradistinction to military engineers, whose education and experience fitted them solely for the art of war; and by these men, Great Britain had been placed first in the list of the civilizers of mankind. Mr. Field, as the first president elected from among the mechanical engineers, dilated, at length, upon the immense strides made within the last century in the production of the mechanic arts and in public works, under the combined efforts of the two classes alluded to. He then entered more minutely upon the subject of steam navigation, to which he had principally devoted his personal attention, and gave most interesting details of the subject, ending by apologising for occupying so much of the time of the meeting by saying, that he must be permitted to feel more than ordinary pride in being elected the president, when he looked around him, and saw that the association of six young engineers, who, in 1818, met occasionally to chat over mechanical subjects, had extended, in the course of twenty-nine years, into a society consisting of upwards of 600 members, and comprising within it almost all the engineers of eminence in Great Britain.—The address was vehemently applauded, and the president was requested to allow it to be printed in the minutes of proceedings.

The discussion was then renewed upon Mr. Ransome's paper, "*On the Manufacture of Artificial Stone.*"

The Dean of Westminster, Sir Henry De la Beche, Mr. John Phillips, Dr. Garrod, Mr. Barry, and other visitors, took part in the discussion with the principal members of the Institution. The remarks turned chiefly upon the chemical and physical properties of the material, and the cost of its production in the moulded form as compared to that of carved stone. In its chemical properties it was shown to be at least equal in purity to the production of Nature; for, on the statements of the eminent chemists who had subjected it to severe tests, it was proved to be totally insoluble in boiling water, however long immersed, and also to be capable of resisting the action of mineral acids. In this respect it differed from glass, which always yielded a portion of its alkali to the action of water. It was further stated, that it had perfectly resisted the action of frost, vases filled with water having been repeatedly frozen without their sustaining any injury. Satisfactory statements were adduced as to its strength and other physical properties, and some very interesting remarks were made on the subject, comparing the substance produced artificially with certain sandstones found in this country, which, by the action of compression and heat, had attained a degree of hardness equal to quartz. The experiments of Hall and Watt on the production of artificial stones were also alluded to as bearing upon the question. Experiments made on the strength of the artificial stone proved it to be superior to those natural stones with which it had been tested—viz.: Caen, Bath, York, or Portland stone. Numerous specimens were exhibited to the meeting, showing its universal applicability to constructive and decorative purposes; fractured pieces were shown of every variety of texture, from the porous sandstone to the most compact granite. The price of the material was stated to be such as to render it available for all useful and ornamental purposes.

Feb. 8.—Joshua Field, Esq., President, in the Chair.

The paper read was "*An account of the recent Improvements in the Drainage and Sewage of Bristol.*" By Mr. James Green.

From this account it appears, that for many years past, great reformation had been requisite in the sewage of several parts of the city of Bristol, and more especially in the localities adjacent to the course of the River Froome, whose channel had become a large cesspool, spreading miasma and disease all around. This river formerly emptied itself into the River Avon, in the city; and then all that was brought down by the stream was carried away by the tide; but, when to form the floating harbour, the old course of the Avon was dammed across by lock-gates, and a new cut was made for carrying off the contents of the sewers emptying themselves into the Froome, a nuisance of the most serious character was created, and the bed of the river became permanently affected. Mr. Mylne, some years since, constructed a lateral culvert from the *embouchure* of the Froome, *debouching* in the new cut; this did partial good; but still the general state of the river remained unimproved; and, in deference to the universal demand for sanitary reform, the authorities of Bristol employed Mr. Green to devise and execute plans for the improvement of the sewage of the part of the city most demanding it. He laid out comprehensive plans, but the estimate of their cost exceeded the funds at the disposal of the council; so he modified them, and the result had proved most successful. The proceedings were to bring the channel of the river into an uniform width, by building side walls, with gutters in the upper slopes, conveying the sewage into the stream, obliterating the shoal, and cleaning up the bed, thus bringing it to an uniform inclination; removing the obstructions caused by the pier of the Castle Mill-street-bridge; lowering the height, and extending the length of the Wear at the castle moat, with new flood-gates, &c.; deepening the bed of the upper part of the stream, and thus making convenient arrangements for cleaning out and flushing the channel, and passing off the products through Mylne's culvert into the new cut, whence it was conveyed away by the tide. The Dock company's culvert was also cleansed and repaired at the same time, and brought again into operation. Many difficulties attended these proceedings, but they were skilfully combated, and the result has been most complete success; and it is to be hoped, that the further ameliorations of which the general sewage of the city is susceptible, may be equally successful under the control of Mr. Green, who has so ably conducted them upon a modified scale. For, as the actual expenditure was not more than £4,537, as stated in the paper, and such beneficial effects have been obtained, there can be no reason why any proper measure of sanitary reform should not be carried into effect.

In the discussion which ensued, several very able men took part, bearing testimony to the satisfactory nature of the improvements made by Mr. Green at Bristol. The conversation then turned upon the employment of the contents of sewers for agricultural purposes. The system proposed by the various companies were detailed and canvassed. The lands which had been rendered fertile by the application of liquid manure, near Edinburgh, and near Mansfield, were quoted as examples of the efficacy of the system; but, on the other hand, it was shown that these were not fair examples, as the localities were peculiar; the cost of the establishing was much larger than could usually be borne; and that, in general, if the distribution of the contents of the sewers was to be made by pipes and pumping, the returns would never repay the outlay.

Feb. 15.—The discussion upon Mr. Green's paper, was renewed, and continued throughout the evening, to the exclusion of all other business. The main object of the paper appeared, unfortunately, to be lost sight of by the speakers, in their anxiety to bring forward, or to defend, the positions assumed by various companies, which had been formed at different periods for using the products of the sewers for agricultural purposes, but which, in the former part of the discussion, had been somewhat impugned upon commercial grounds. The statements made at this meeting were only repetitions of what has been repeatedly printed in reports, and in evidence before the sanitary commissions; and the whole evening may have been said to have been wasted, in spite of the attempts of some of the members to bring the discussion to the real question of the best modes of laying out a system of sewage for large towns, the forms of the sewers, based upon the laws governing the conveyance of fluids—which, it had been stated in some of the "blue books," were not understood by civil engineers, a statement which was shown by some of the speakers to be not consonant with facts; for that, if the selected, rather than collected, evidence given before the Health of Towns Commission were analysed, it would be seen that the exploded dogmas of the older writers on hydraulics had been received and adopted, rather than the formulæ of modern writers, or the actual practice of civil engineers of eminence, whose experience on such subjects was necessarily great. It was true, that hitherto, in consequence of the absorbing topic of railways, eminent engineers had not devoted themselves to the subject of sewage to the extent they might have done; but, when the time arrived for their doing so advantageously, or the exercise of their skill was demanded by the government, or by private enterprise, they would be found quite prepared to devote themselves to the work.

SOCIETY OF ARTS, LONDON.

Jan. 19.—William Fothergill Cooke, Esq., in the Chair

The Secretary read a paper by Dr. Harding, "*On some ancient Greek Vases, excavated by him from Tombs near Hexamili, in the Isthmus of Corinth.*"

"In the autumn of 1840, having obtained by private influence, an order from the prime minister, permitting me to excavate for antiquities, I proceeded (observes Dr. Harding) to Corinth, and hearing that the peasants frequently found ancient tombs, containing vases, under the village of Hexamili, I proceeded thither with a party of labourers. Hexamili lies between Corinth and its ancient port of Chincre, within three miles of the spot where the Isthmian games were celebrated. The ground about Hexamili is, for the most part, rudely cultivated, and grows good crops of wheat; ancient quarries also abound. The plan adopted in searching for tombs is that of boring the ground with augers, seven feet long, till the instrument meets with some obstacle to its further progress, when it is withdrawn, and the ground is again pierced in other directions, to ascertain the size and nature of the obstruction; this is also tested by the sound of the instrument striking against it. When a tomb is discovered, and this is generally at a depth of about four feet, the earth is excavated in the usual manner in which graves are dug in England; and as soon as sufficient of the covering of the tomb is exposed, a man sits down with a heavy hammer (such as is used by masons), and with this a hole is made in the lid or covering to the tomb. A hand is then carefully inserted, and human bones, vases, &c., are generally extracted. The greatest number of vases I found in any one tomb was fourteen, and children's tombs had proportionally small vases. Having in three days collected enough to load one of the small horses of the country, I got them to Corinth, whence they were sent to Athens, and afterwards by sea, *via* Malta, to London."

Mr. Birch, of the British Museum, was in attendance, and stated that he was unable to give any account of the chemical constituents of the vases, or the particular manner of their fabrication; still he should be glad to offer a few remarks in reference to the specimens exhibited. It is only of late years (he observed) that the conclusion had been come to that large manufactories of vases existed in Greece; they had always been supposed to be of Etruscan produce. The fictile art had been supposed to be confined almost exclusively to Italy, although numerous excavations had been made at Athens, and a few at Corinth, which had produced specimens similar to those exhibited, and which he divided into classes. The most ancient vases (and which are distinguished from all others by the material of which they are composed) are of a light yellow clay, and have figures and animals painted on them in a maroon colour. Their date is supposed to be about 616 years before Christ. About this period the fictile art is reported to have been introduced among the Etruscans by the Greeks. The second class of vases are of a pale red clay, and the figures, instead of being of a maroon colour, are traced in black, in order to show the details more distinctly. This style appears to date from the fifth to the middle of the fourth century before Christ. The third class is one in which the colour was laid on by means of a reed. But perhaps the highest style, and one which is peculiar to the vases found at Athens, is that in which the outline, &c., is traced in white paint, or a sort of carbonate of lime. The vases exhibited he thought peculiarly interesting, as deciding that the vases of Italy may be considered to be the manufacture of Greeks settled in Italy, and not imported from Greece into that country.

Dr. Harding stated that the tombs at Hexamili seem to have been scattered in irregular patches; but the cemetery appears to have been very extensive, measuring nearly half a mile in each direction. No inscriptions or marks whatever are visible on the stones of the tombs, nor is there any other apparent difference externally than that of size. The bones in them were tolerably perfect, and the skulls nearly entire. He found but one piece of metal, apparently part of a large bronze needle or bodkin. Generally, the contents of the tombs were in a wonderful state of preservation, considering that they were, in all probability, at least 2,000 years old.

Jan. 26.—George Moore, Esq., F.R.S., in the Chair.

The Secretary read a letter from Mr. Dwyer, in which he states, as the Society is to meet for the purpose of investigating the forms of *Ancient Pottery*, he begged to present for its acceptance a series of sketches, believing that they might prove of some utility in assisting its researches. He says that having observed that ancient art generally originates through the imitation of natural objects, he was led to infer as highly probable that the beautiful outlines of the Grecian vases emanated from similar sources; and proceeded to point out the exquisite forms of leaves and fruits, suggesting the probable manner in which they had been used to give character and beauty of outline to those manufactures.

The second communication was from Mr. W. T. Griffiths, and accompanied a copy of his work "*On the Natural System of Architecture.*"

The communication alluded to the work as pointing out the geometrical proportions of the temples of Greece, and calling attention to the applicability of geometrical design to domestic architecture, and as also affording a ready means of obtaining beautiful patterns for oil cloths, carpets, &c. The author then proceeded to point out the improbability of the ancient Greek vases being constructed on any other than pure geometrical principles, as is proved by analysis; and concluded by alluding to the mistaken but very prevalent notion that to produce a beautiful building, it is necessary to overload it with meretricious ornament,—instead of feeling that the more simple is often the more beautiful design.

Mr. Varley made some remarks in reference to Mr. Dwyer's communication, and stated that although we have many artists of highly-cultivated taste, still they have not the necessary knowledge to enable them to produce good art. In reference to a leaf having given rise to the forms of the Greek vases, he would observe that a leaf in itself is a pendant body, and as such is very beautiful: but no single leaf would stand upright. We might take some pendant fruits, such as the apple,—which might be said to have a base, and some vases might be compared to it; but he did not think that they gave rise to the forms of the Greek vases, although he must admit that Nature was the first teacher of everything that is beautiful. There are certain rules, Mr. Varley said, which Nature suggests, and which we find the Greeks used; and he proceeded to point out the following method which might be used for producing agreeable forms, such as the bodies of the vases exhibited—viz., by taking one-quarter of an hyperbola, parabola, or ellipse, according to the outline desired; and by rotating it on its axis at any given angle, it would be made to produce the figure desired. Similar simple methods for obtaining the necks and stands for vases were also described.

The Secretary made some remarks on the forms of vases, and stated that if beauty consisted in the imitation of Nature, as suggested by Mr. Dwyer, a man would have nothing to do but to take the first leaf of a tree as soon as he came to it; instead of which, discontented with the first fifty leaves, he goes on seeking and seeking, till at last he finds one which pleases him, because it comes up to the ideas in his own mind, and which he had preconceived as the standard of beauty.

Mr. Wyndham Harding considered that the effect of vases and other domestic utensils, as well as the architecture of everyday life, should produce on the eye an effect equally pleasing with music on the ear; and that, as in order to obtain harmony in music it is necessary that the cords or wires should each vibrate a proportionate number of times, so should the proportions of one part of a vase bear a given relation to those of another. In relation to architecture, several persons have considered that certain numerical simple proportions can be traced as existing in the various members of ancient Greek temples, and Mr. Donaldson had stated that he has revived the means of determining the precise proportion of various parts of all Gothic buildings: and these geometric and harmonic relations must have been known to the Greeks in the formation of their works.

Mr. Smith stated that he did not consider that geometry was used by the ancients to the extent which is generally attributed to them, but rather that their works were the result of a practised eye and hand, guided by a highly-cultivated taste.

Feb. 9.—Baron Goldsmid, V.P., in the Chair.

The Secretary introduced the business of the evening by some remarks on "*Polygonar Decorations*," as follows.

The discussion on the construction of ancient Greek vases, which had lately occupied the meetings of the Society, had occasioned several treatises to be written and a great amount of attention to be paid to the subject. It is continually alleged as a fault of the art in our day, that instead of boldly creating forms and trusting to our own minds, and carrying out those feelings according to what we consider the enlightened principles which we have struck out for ourselves, we are contented to take for granted that the ancients were artists truly unapproachable, and such we can never hope to equal, much less to excel; and, therefore, the best thing that we can do is to abandon altogether originality, and give ourselves up to the study and copying of the antique forms. The Secretary then pointed out the effect of a design upon the mind and senses in the case of polygonar art, and called attention to the effect of such a combination of colours and forms as shall produce upon the mind the effect of a design standing out from the wall or pavement, but which, if felt by the hand or foot, is perfectly flat. He next proceeded to point out the forms of the tesseræ and geometric figures which had hitherto been used in combination to produce design, and pointed out the beauty and variety of design which might be obtained by the combination of a form of tessera, which, although not new, had not up to this time been used as the base of a pattern. The figure which was pointed out as most applicable to mosaic decorations was the triangle of Plato, any number of which might be arranged round a point and made to cover an entire surface, forming bands either horizontally, diagonally, or any variety of diamond figures, as the sides of the triangle bear a peculiar ratio, namely, 30, 60, and 90 degrees; whereas, where figures of inharmonious ratios are used, the same variety cannot be obtained.

Having thus pointed out the applicability of geometric figures to the production of beautiful forms, the Secretary gave several extracts from a paper on the "Beau Ideal Head," by Mr. D. R. Hay; from Mr. Blashfield's paper on the "Construction of Fictile Vases;" Dr. Wampen's communication on the "Geometrical Proportions of the Human Figure;" and Mr. Digby Wyatt's paper on "Ancient Tesseræ;" also a letter from Mr. J. Jopling, as to the improbability of ancient vases having been constructed on any other than purely geometrical principles.

Dr. Harding made some remarks as to the uses to which the various cups and vases excavated by him had been applied, and gave the following quotation from an ancient Greek play, as illustrating the purpose to which the Lecythé had been applied. The play is one in which a young man is represented as jeering an abandoned old woman, and is saying—

"But you old wretch, I greatly dread your lover."
"Who?"
"Why, that first of artists."
"Who is that?"
"He who for dead men paints the Lecythé."

Another quotation as pointing out the use of these vessels, is as follows:—

"You left me like a corpse laid out; only uncrowned and with no Lecythés on me."

After alluding to the probable purposes to which the several other specimens of vases were applied, Mr. Harding stated that what had been said by Mr. Birch at a former meeting (as to the manufacture of vases having been introduced into Italy by Eucheir and Eugrammus, artists who had fled from Greece), was a myth, and could not be received. Corinth, he observed, has been celebrated at all times, according to Strabo, for its politicians and for the promotion of the useful arts, both graphic and plastic, and for every species of useful application of them; also for some beautiful, but not numerous, specimens of objects connected with sepulchral rites.

ROYAL SCOTTISH SOCIETY OF ARTS.

Jan. 24.—George Buchanan, Esq., F.R.S.E., President, in the Chair.

The following communications were made:—

1. *Description of a Marine Hydrometer, adapted for ascertaining the comparative Saltness and Freshness of Sea and River Waters.* By George Buchanan, Esq., President.

This is an instrument which Mr. Buchanan stated he had found extremely useful in inquiries connected with the prevalence of sea and river water in different estuaries, and therefore he thought a short notice of it might not be uninteresting to the Society. In the great question connected with the salmon fisheries in regard to the respective limits of the river and the sea, the prevalence of fresh or salt water had been considered an important element; but finding the usual methods of measuring the specific gravity by weighing the waters in a delicate balance, not very applicable where numerous specimens were required to be tried on the spot, it occurred to him that something on the principle of the hydrometer might be used, and this was the instrument which was exhibited, consisting of the bulb of a spirit hydrometer, loaded so as just to sink the bulb in salt water, and having a long stem attached, which, in fresh water, becomes almost wholly immersed. Same difficulty was found at first in adapting the scale, as it must not only be thin but light, otherwise it tends to overbalance the instrument. A slip of whalebone or ivory answers sufficiently well, and several instruments were shown of this description, and one entirely of brass. The use of the instrument was clearly exhibited in several experiments with fresh water, and with the waters of the Forth, some from Granton Pier, some from Queensferry, and some from Alloa. From Granton Pier the water, even at low tide, has a very little impregnation of fresh, as compared with the German Ocean, which he had found, along the eastern shores of Scotland, seldom to exceed the specific gravity of 1026, fresh water being 1000. At Granton Pier the average of high and low water was found 1024½, or about one part fresh in sixteen salt. At Queensferry it was found 1023, or about one part fresh in eight salt. At Alloa the waters at low tide are almost quite fresh; and at high water the specific gravity was found nearly 1012, or nearly half fresh, half salt. A considerable difference is found between the surface and bottom waters. The specific gravities of different seas were then stated. The Arctic ocean 1027; the waters under the equator 1028; and the Mediterranean, which is nearly the saltest of any sea, 1029. But the heaviest of all waters are those of the Dead Sea, which are strongly impregnated with sulphurous and bituminous ingredients, as well as with salt, and have been found about eight times heavier than sea water as compared with fresh, having the extraordinary gravity of 1211. By the use of this simple instrument, many interesting observations might be made by voyagers in different seas.

2. *Description and Drawing of a Glass-Blowing Apparatus, being a new invention in the Blowing of Glass.* By Mr. WILLIAM COOPER.

This invention consists in effecting the blowing of glass by means of double bellows placed under the floor, acted on by the foot of the glass-blower, and the air is carried to the blow-tube by means of a flexible tube, easily attached and detached from the nozzle of the ordinary iron tube. The advantages are stated to be, that larger articles can be blown, that the glass is freer from "cockle," and that the lungs of the workman are saved, and his muscular energies not being so severely taxed, he will be able to produce a great deal more manufactured goods in a given time. The air blown by the bellows being of a much purer quality than that from the lungs, produces a better article. That larger sizes and a thicker substance of blown plate may be obtained by this new process, and the sheet-glass manufacturer will be able to compete with the cast plate-glass monopolist. That "carboys" to contain twelve and sixteen gallons have been successfully blown by this process. Mr. Cooper then recommended that this process should be adopted in Edinburgh and Leith, where coal is cheaper than in Staffordshire by 4*s.* per ton, and where living and house-rent are about one-fourth less; the workmen all preferring Leith, from its healthy situation, cheapness, and family conveniences. Locality, he stated, is now looked at; economy in carriage is itself a profit to the manufacturer, now that the duties are removed, and all the English manufacturers circumscribing their connection.

3. *Description of an Elevator, for raising Building materials or other bodies,—and capable of being used as a Fire-Escape—containing a new application of the Pulley.* By Mr. ROBERT DAVIDSON, Engineer.

Mr. Davidson stated that this machine or elevator was applicable as a fire-escape, and well suited to the raising of small weights to great heights, such as in mills and factories; or in the raising of scaffolding for workmen, such as painters, plasterers, masons, &c. It consists of a number of sliders, moving within each other by means of a fixed pulley attached to the top of a fixed upright, which is hollow, containing all the other sliders, which are hollow also, except the last one, which may be solid, the top of which contains a platform enclosed by a railing. There is a chain or rope fastened to a hook in the bottom of the top slides, passing over a moveable pulley, made fast to the top of the next slide, and passing down the outside of it and made fast to the top of the next slide following, on the top of which is also a moveable pulley, over which passes a rope or chain made fast to a hook in the bottom of the slide immediately preceding, the other end of which is made fast to the top of the fixed hollow upright, on the top of which is placed a fixed pulley, which guides the chain whereto the power is applied; the one end being made fast to a crane barrel, and the other end attached to the bottom of the slide next adjoining, which compels a simultaneous movement of the whole machine.

NEW PALACE OF WESTMINSTER.

RETURN (*dated December 20, 1847*) *of the Aggregate Amount already paid, or agreed to be paid, to Contractors and other Persons for the Purchase of Land and Houses for the Erection of the Palace of Westminster* (*or Houses of Parliament*).

	£	s.	d.
1. The cost of the purchase of the lands and hereditament	82,054	19	3
2. The cost of the wharfing, terrace, and foundations for the building..	139,185	7	10
3. The cost of the carcase or shell already executed (exclusive of alterations as under)	453,648	12	0
4. The cost of the principal alterations made from time to time. These alterations (involving changes in the original plan) consist of official residences for the librarian and clerk of the House of Commons, accommodation for the law courts, alterations of the Victoria tower, offices for the clerk of the crown, and works contingent upon the warming and ventilating arrangements, &c., which were severally reported to her Majesty's Commissioners of Woods, &c., and sanctioned by parliament in March 1843. Also, of an increase in the size and height of the Victoria hall, sanctioned by her Majesty's Commissioners of Woods, &c.	25,469	0	0
5. The cost of interior finishings	74,134	6	0
6. The cost of the internal decorations of the House of Lords and its adjuncts, as far as they have been completed (including preparations for lighting)	21,600	0	0
7. The amount of commission and other charges paid, or to be paid, to the architect on account of works and services already executed[1]	26,315	2	11
8. The amount paid to surveyors, valuers, clerks of the works, and all other persons who have been employed, and not included in the architect's or builder's charge	10,861	5	8
The amount of the whole expenditure of every description, under these principal heads, for purchases made and work done at the Palace of Westminster, and its appendages, up to 31st day of December, 1846.	£833,268	13	8

ESTIMATE *for the Sums which will be required to pay for such other Lands and Hereditaments intended to be purchased for the completion of the Palace and the Approaches thereto; of the Sum required to finish the Houses of Lords and Commons and their Appendages; of the Sum necessary for the Victoria Tower, and all other Works proposed to be executed to finish the Palace.*

	£	s.	d.
1. The cost of lands and hereditaments intended to be purchased[2]	—		
2. The cost of the completion of the terrace and foundations of the buildings	18,747	0	0
3. The cost of the carcase or shell yet to be executed	356,328	0	0
4. The cost of the principal alterations. None proposed	—		
5. The cost of the interior finishings	172,648	0	0
6. The cost of the internal decorations of the House of Lords and its adjuncts (including lighting and furniture)	20,044	10	0
7. Amount of the commission to be paid to the architect:[3]	—		
8. Amount to be paid to surveyors, valuers, clerks of works, and others, not included in the architect's or builder's charge	uncertain		
	567,767	10	0
Brought forward ..	833,268	13	8
Total Cost	£1,401,036	3	8

The total cost of works executed, and estimated cost of the works to be executed to finish the New Palace of Westminster, is thus £1,401,036 3 8; but which is exclusive of extra finishings, works of decoration, fittings in libraries and refreshment rooms, &c.; fixtures, furniture, and upholstery;

[1] This amount includes (besides the professional remuneration to the architect on account of works executed to the general building) the commission upon works to the cofferdam, river wall, &c., and the sum paid for a detailed estimate, in accordance with the approved design.

[2] It is proposed, under Treasury authority, dated November 28th, 1842, to obtain possession eventually of the buildings on the south side of Bridge-street, Westminster: the probable cost of these buildings has not been ascertained.

[3] By Treasury letter, dated February 25, 1839, the sum of £25,000 was directed to be paid to the architect as professional remuneration for superintending, directing, and completing the Houses of Parliament in conformity with the original design and estimate. (It is right to state that the principle of this arrangement has never been acceded to by Mr. Barry). The remuneration to the architect on account of works not included in his original estimate, but subsequently authorised, has not yet been the subject of consideration.

warming, ventilating, and lighting, &c., except so far as such works are already executed in the finished portions of the building; also, of the restoration of St. Stephen's crypt as a chapel, if it should be so determined; the formation of landing-places towards the river, the paving of the several courts, &c., of the building, the altering of the levels, and the re-paving as well as lighting of the streets in its locality, &c. &c. The cost of which must depend on the nature and extent of the works ordered.

In this amount there is a sum of £524,099 6s. for charges upon the purchase of lands and hereditaments, the cost of the river wall and embankment, the warming and ventilating arrangements, and the contingent fireproof construction of the building throughout; the additional residences and other accommodation ordered from time to time to be incorporated in the building, the increased depth of the foundations of the entire building, the main sewers for the drainage of the building and its locality, the various modifications of plan suggested and recommended by committees of parliament and other authorities, and for miscellaneous works; all of which formed no part of the original design and estimate.[4]

MISCELLANEOUS EXPENDITURE *connected with the building of the New Palace of Westminster, not being for Purchases made or Work done at the New Houses of Parliament, or included in the Architect's Estimate for the same, but defrayed out of Grants voted by Parliament for that service.*

	£	s.	d.
Preliminary Measures.			
Premium and expenses connected with competition designs; the expense of a tour of inspection, and of experiments made with reference to the selection of the particular description of stone to be used in the building; also payment to engineers for surveys of the bed of the river	4,992	3	10
St. Stephen's Chapel.			
The expense of making drawings in detail of the chapel previous to its being taken down, and engraving the same for publication.[5]	2,712	12	0
Government Wood Carving Works, Thames Bank.			
These premises were taken to facilitate the progress of the interior finishings of the new buildings, by the erection therein of carving machines, and the employment of carvers and other workmen in the immediate pay of the Department of Woods, and under the supervision of superintendents appointed for this service, and direction of the architect.			
The expense of erecting additional buildings to afford the necessary accommodation for carrying on the works, supply of water, precautionary measures against fire, rent (to the crown), rates, lighting, &c.[6]	11,191	3	6
The expense arising from damage done or re-instatement made to adjoining property during the progress of the works	1,522	5	4
Payments on account of frescos	538	19	9
Experimental Ventilation, &c. (Dr. Reid's system).			
The expense of works, apparatus, salaries, and allowances in experimentally carrying out Dr. Reid's system of warming, ventilating, and lighting at the present temporary Houses of Parliament, with a view to its adoption in the new building	8,328	7	3
The expense of inquiry and reference as to the applicability of Dr. Reid's system of warming and ventilating to the new Houses of Parliament	946	13	6
Minor expenses	97	12	6
	£30,239	17	8

STATEMENT *of the Amount of each* ORIGINAL CONTRACT, *and of every Alteration or Deviation therefrom, and the Amount paid, or to be paid, for each Contract and Alteration, and under what Authority such Alterations or Deviations have been severally made.*

CONTRACT, No. 1 (in Gross).	£	s.	d.
For the river wall, and a part of the foundations of the river front of the building	74,373	0	0
Additional works in the river wall, reported to her Majesty's Commissioners of Woods, &c., and sanctioned by parliament	2,104	13	9
	£76,477	13	9

CONTRACT No. 2 (at Prices).	£	s.	d.
For the remainder of the foundations of the river front, main sewers, &c., estimated at	7,442	1	9
Subsequent estimates and accounts reported to her Majesty's Commissioners, &c., and sanctioned by parliament	4,720	16	4
	£12,162	18	1

CONTRACT No. 3 (in Gross).	£	s.	d.
For the carcase of the river front, and a portion of the north and south fronts	157,615	0	0
Change of stone, 8,500*l.*; fire-proofing, 7,200*l.*; warming and ventilating works, 10,150*l.*; reported to her Majesty's Commissioners of Woods, and sanctioned by parliament: Total	25,850	0	0
Additional cost of fire-proof floors, roofs, &c., and for warming and ventilating arrangements executed under the general authority of her Majesty's Commissioners of Woods, &c. to the architect to comply with Dr. Reid's requirements	15,275	0	0
Cost of stone carving upon the arrangement authorised by her Majesty's Commisioners of Woods, May 13, 1841	23,829	14	0
Miscellaneous works ordered by the architect, under the general authority given to him to carry out his plans	6,000	0	0
	£228,569	14	0

CONTRACT No. 4 (at Prices).	£	s.	d.
The foundations of the central masses of the building from north to south, including the Houses of Lords and Commons, and their respective lobbies, corridors, and contiguous offices and apartments, and the foundations of the Victoria and other towers, estimated amount ..	17,822	1	6
Subsequent estimates and amounts reported to her Majesty's Commissioners of Woods, &c., and sanctioned by parliament .. —	25,312	16	8
	£43,134	17	8

CONTRACT, No. 5 (at Prices).	£	s.	d.
For the carcase of the superstructure above the foundations comprised in Contract, No. 4, estimated at ..	219,969	0	0
1. Change of stone, 9,460*l.*; fire-proofing, 8,400*l.*; warming and ventilating arrangements, 14,616*l.*; reported to her Majesty's Commissioners of Woods, &c., and sanctioned by parliament: Total	32,476	0	0
2. For slating to flats and roofs, asphalting walls, lengthening sewers, &c.; reported to the Office of Woods	4,299	14	8
3. For floor plates and other structural arrangements required for ventilation, executed under the general authority given to the architect to comply with Dr. Reid's requirements; not yet brought to account and reported	12,180	0	0
4. For iron roofs and additional cost of girders and arches rendered necessary by the warming and ventilating arrangements, and reported to her Majesty's Commissioners of Woods, &c...	26,500	0	0
5. For cost of stone carving, under the arrangement sanctioned by her Majesty's Commissioners of Woods,	21,137	17	9
6. For miscellaneous and contingent works ordered by the architect under the general authority given to him to carry out his plans	15,000	0	0
7. For the official residences for the librarian and for the clerk of the House of Commons, accommodation for law courts, alterations of Victoria tower, enlargement of Victoria hall, increased height of Victoria hall, offices of the clerk of the crown, and works contingent upon the warming and ventilating arrangements, reported to her Majesty's Commissiouers of Woods, and sanctioned by parliament	25,469	0	0
	£357,031	12	5

CONTRACT, No. 6 (at Prices).	£	s.	d.
The foundations and carcase of the superstructure of St. Stephen's hall and lobby, and the public approach from Westminster hall and St. Margaret's-street; estimated and reported to her Majesty's Commissioners of Woods, &c., at	57,631	0	0
For change of stone, 4,040*l.*; and warming and ventilating arrangements, 3,234*l.*; reported to her Majesty's Commissioners of Woods, and sanctioned by parliament	7,274	0	0
For iron roofs and other warming and ventilating arrangements, executed under the general authority given by her Majesty's Commissioners of Woods to the architect to comply with Dr. Reid's requirements	5,000	0	0

[4] A credit in aid towards defraying the above total estimated cost will arise from the sale of old materials, estimated to produce 14,000*l.*, and also from the sale of the materials of the cofferdam, when it has served its present purpose.

[5] A credit will arise under this head from the sale of the publication.

[6] As these premises will, after they have ceased to be used as at present, be available for other public purposes, and the additional buildings will permanently enhance the value of the crown property upon which they have been erected, this expense is not wholly to be considered as a charge on account of the New Houses of Parliament.

	£	s.	d.
Brought forward..	69,905	0	0
Estimated cost of the stone carving under the arrangement sanctioned by her Majesty's Commissioners of Woods, &c., May 13, 1841	3,520	0	0
	£73,425	0	0
CONTRACT, No. 7 (at Prices). For interior finishings: Amount	£21,407	6	0
CONTRACT, No. 8 (at Prices). For interior finishings: Estimated amount	£165,375	0	0

A COPY OF THE ORIGINAL ESTIMATE (1837).

	£	s.	d.
River Front and Returns	211,047	19	0
King's Tower	79,844	15	0
Clock Tower..	18,013	19	0
Old Palace Yard Front..	50,491	1	0
New Palace Yard Front	36,112	12	0
Public Entrance Approaches	82,617	4	0
House of Lords	31,140	15	0
Offices, Approaches, &c., to ditto ..	62,906	6	0
House of Commons	35,306	9	0
Offices, Approaches, &c., to ditto ..	48,614	15	0
Law Courts	51,408	5	0
	£707,104	0	0

ON CAEN STONE.

From a paper read at the Royal Institution of British Architects, on January 24th. By T. L. DONALDSON, Esq.

Being about to employ a large quantity of Caen stone in a work which is on the point of commencing, I was anxious to make myself fully acquainted with its properties and varieties, and the quantity of well-seasoned blocks that might be available in the market. I therefore determined to go to Caen itself, and visit the quarries. A few hours carries one over to Havre from Southampton, and a steam-boat conveys passengers from Havre to Caen in four hours. The last hour is occupied in mounting the river Orne, which, in its course from the sea to some distance above Caen, has a flat country on the left bank of the river, but, on the right, generally a lofty bank, at times immediately overhanging the stream, at others receding from it, but again joining it. Not far from the mouth of the Orne, at a place called Ranville, quarries are worked in the face of this bank. It is a harder and coarser variety of the same stone as that near Caen, and of more open texture, with a more crystalline character, hence more adapted for hydraulic works than for buildings. I am informed by our friend, Mr. H. C. Smith, that these coarse varieties, which doubtless are very durable, resemble in several particulars the stone from Weldon, in Northamptonshire, of which the oldest buildings at Cambridge are constructed.

The material generally known to us under the appellation of Caen stone is of the oolitic formation, presenting a close analogy in its general, and even in some of its minor divisions, with the rocks of a similar kind in the south of England. The quarries whence it is derived are situated at Allemagne, a parish and village on the right bank of the river, at the distance of about a mile and a half, or two miles, above the city. The quarries heretofore worked occupy a superficial area of about four square miles. Some are worked by means of shafts, which afford access to the quarries under ground, branching off on all sides in long galleries, or multiplied by chambers, which are about 18 feet wide, and the ceiling-bed upheld by massive rude piers, which are left 9 feet square and 18 feet apart, the height being about 15 or 20 feet. These quarries, which are immediately on the bank of the river—here abruptly rising from the water—have an access from the side of the bank, and are approached by inclined roads, leading from the summit of the bank above and from the water's edge below. The openings to these dark and gloomy caverns have a very picturesque effect, and a continued series of them present themselves one after the other. The galleries penetrate to a considerable distance. The extraction of the stone is done by contract or task work, at so much per cube, the quarrymen removing the blocks and dressing them, and another set of men contracting for their carriage from the quarry to the quay at Caen.

Immediately under the soil there are some thin courses of hard coarse stone and rubble, but the immediate ceiling-bed is called the *banc cloutier*, and is about 2 ft. 6 in. thick. It is of a hardish quality, but is not applicable for building purposes, as it contains a great quantity of pebbles, which offer great difficulties in the sawing and working. There are about six beds of good building stone, the five uppermost ones calculated for outside work, the lowermost adapted only for inside work, as it has soft portions, which do not well resist the atmosphere.* Much of this is used in the interior of the new Parliament buildings. The aggregate height of these six beds is from 22 to 25 feet. It is to be observed that all these beds are not to be found in every quarry, one or other of them disappearing and re-appearing in the same manner as in England. The names which I am about to give do not obtain in all parts of the district; and some of them have various designations given to them by the quarrymen. The uppermost bed is called the *banc pourri*, about 3 feet thick, which is a very good quality of stone; but occasionally it has in some portions the hard pebbles, previously alluded to, as prevailing to so great a degree in the *banc cloutier*, and therefore it is not so much esteemed for finer building purposes as the lower beds. The *gros banc* is the next bed, and has an average depth of 5 feet, but as it is inconvenient to work to that large size, it is generally split into two, in heights of 3 feet and 2 feet; and the smaller one is called the *banqueret* of the *gros banc*. *La pierre franche* bed comes next, about 3 feet deep, which is of a harder quality, and well adapted for cornices, sills, copings, and the like exposed positions in a building. Next to this is the *banc de quatre pieds*, a very fine bed, which has the same appellation, and depth of 4 feet, in all the quarries, as also the next bed, called *la pierre de trente pouces*, being 30 inches deep, a good hard bed of stone, and forming the lowest of those fit for outside purposes and exposure to the weather. The sixth and lowermost bed of the building-stone is termed the *franc banc* and has a total depth of from 4 feet 6 inches to 5 feet, but this being, like that of the *gros banc*, an inconvenient depth, it is divided into a lower thickness of 3 feet, and an upper *banqueret* of 20 or 24 inches deep. The whole of the stone of these beds is soft and tender in the quarries, and the blocks are extracted with great ease. They are produced of regular size and squareness. When taken to the outside, and exposed to the atmosphere, they gradually part with much of their humidity, and harden; and, if exposed on the quays during the winter, they are covered over to protect them from the frost. They saw freely with a common peg-toothed saw, without either sand or water, and are easily worked for building purposes; and, being of a compact fine grain, they produce very sharp arrises, and receive a very smooth surface on the face.

During the winter little work is done in the quarries in regard to extracting blocks of stone; but the men occupy themselves in sawing and squaring slabs about 12 or 15 inches square, and from an inch to an inch and a half, or more, thick, which are used for paving halls, galleries, and even some rooms inside their buildings. But the most extraordinary use to which I have seen these square slabs applied, was in the church of the Trinity of the Abbaye aux Dames. Two of the openings between the piers have been closed up, for the purpose of some repairs going on. I passed through a door in the partition or inclosure, both of which appeared to me of the same thickness. My surprise was great, and I examined the edge of the opening, and found it of stone, and discovered, upon closer inspection, that the opening, about 10 feet wide by 20 feet high, was inclosed by these square thin slabs, about an inch and a half thick, placed on edge, put to gether with plaister, sufficiently stable to allow a door to work in its aperture. I subsequently was told, upon inquiry, that the inside partition in rooms, 10 feet high, are formed of the same material, and secured by occasional upright studs, 10 feet apart. These partitions are admirable, for they are very light, occupy little space, and form an excellent ground to receive the plastering on the surface.

The general character given of the Caen stone is, that all the beds are of the same quality, and all equally adapted for building purposes; but evidently. from the information which I collected on the spot, and subsequently in London, from Messrs. Luard, there are modifications in each bed, as may be reasonably supposed, and as experience teaches us in the quarries of other oolitic stones in Bath and Portland. Various veins traverse the beds in all directions, and have a white appearance; this white substance is equally hard with the stone itself, and if a stone be laid with its bed parallel with the direction of these veins, it is of little consequence, but they, of course, indicate a certain unsoundness or division in

* This is also the case with all the oolitic quarries in England. The uppermost beds are hardest to work, but most durable; the lower beds are soft, and will not stand the weather so well as the upper ones.

that part; and if the stone be laid with this vein in a vertical direction, the block will run the chance of being fractured by a weight, or, if near the surface, it probably may admit the wet. These veins are not like those in the Bath stones, which are hard, consisting of crystallized carbonate of lime, and running always in a vertical or inclined direction, and not liable to separation. In general it is considered that the blocks of Caen stone may be placed in construction in any direction, except when the white veins are perceptible. It is said that the most experienced eye can hardly detect the different qualities of the stone in the block, when once they have been removed from the quarry, as the action of the quarryman's tool on the surface hardly offers any indication; and there is no appreciable difference in the appearance of the granular formation.

There are in the vicinity of Caen, even to a considerable distance, many beautiful varieties of this formation. At Falaise, about 20 miles off, higher up the Orne, is a fine compact stone, much harder than the Allemagne. Its texture is beautifully equal, and fine grained. Its price is one-third more than that of Caen stone, and, of course the labour upon it is considerably increased. It is well adapted for exposed situations, and is used, I believe, in the quays and dock basin now constructing at Caen.

I was, of course, anxious to ascertain whether the magnificent and ancient buildings in the city could be relied upon as proofs of the quality of the stone in the Allemagne quarries, of which there is a traditional report handed down from one generation to another, that they are constructed. And, certainly, the lofty pinnacles and spires, and the solid high square towers, which rise up in clouds, defying the fury of the elements, for many years exposed to storms, hail, rain, snow, and frost, acted upon by all the alternations of heat and cold, wet and dry, present a sharpness of arris and smoothness of surface, as seen from below, that prove a considerable degree of hardness in the stone of which they are constructed. Less reliance can be placed upon the indications on the parts within reach, for exposed as they have been to the Vandal wantonness of the revolutionary phrenzy of destruction, and the Calvanistic zeal of misguided religious feelings, there are many of the lower parts broken away and considerably worn. But the attenuated and refined details of some "*renaissance*" finials, pinnacles, and flying buttresses, in the lady-chapels and apsidal altarends of the churches of S. Pierre and S. Sauveur, and S. Sauveur-le-Marché of the beginning of the sixteenth century, more minutely enriched and elaborately carved and subdivided than even the most refined details of the flamboyant parts near them, are as fresh and sharp as if executed within the last fifty years. Time and weather have not had, on the monuments of Caen, the same corroding hideous influence as on the edifices of Chester, Coventry, or Oxford. The graceful spire of S. Pierre, the summit of which is 250 feet above the market-place, and itself more than 100 feet high, does not appear to be thicker than 9 inches in the lower part, and is reduced, it is said, to 4 inches thick at top. The immense weight and exposed situation do not seem to have affected it in the least degree; and it may be quoted, if not for size, at all events for its grace, daring construction, and state of preservation, after 540 years' trial, with its sister spire of our own Salisbury, erected at the same period.

At the same time, I am not prepared to assert whether the stone employed was all taken from the Allemagne, or from some other superior quarries; but the appearance of the stone justifies the tradition of its origin, and I know not how to question it.

CONWAY TUBULAR BRIDGE.

Experiments on the Completed Structure.

We are glad to be able to quote from a contemporary an account of the experiments on the tubular bridge just completed, as given by Mr. Fairbairn himself, in a letter to a friend :—

"We have solved an important problem in practical science; and, despite the prognostication of some eminent mathematicians, the whole of my experiments at Millwall have been more than realised. On Wednesday last, the tube was suspended upon temporary piers, 400 feet span; and with its own weight (1,300 tons), the deflection did not exceed, but was under, 8 inches. With 300 tons of loaded trucks, the deflection was increased to 11 inches—being, as near as possible, in the ratio of 1 inch to 100 tons of load. The computed breaking weight of the tube is 2,200 tons equally distributed, exclusive of its own weight; and, having its perfect retention of form and great rigidity, I am of opinion that it would sustain 3,000 tons before fracture took place."

It appears from this account, that the deflection under a load of 300 tons, is less than one foot—an amount which Mr. Fairbairn considers so small as to demonstrate the successful issue of the undertaking in which Mr. Stephenson, with the able co-operation of himself and Mr. Hodgkinson, is engaged. Certainly, when we consider the length of the structure, the multiplicity and complexity of the component parts, and the number of joints and rivets—the accuracy of adjustment, and the extreme nicety of workmanship which effect the result stated, must appear wonderful; and the superintendents of this great work, who have concerned themselves in its minutest details, and therefore have the fullest sense of its difficulties, must naturally estimate this amount of success more highly than comparatively uninterested persons can do. But iron, even of the best quality, is not perfectly elastic; bolts and rivets, though ever so carefully formed, are not mathematically true; and, therefore, it may reasonably be asked, if the structure sink one foot now, how much will it sink when the bolts have been worn, the bolt-holes enlarged, and the plates strained by the wear and tear of six months' railway traffic?

It is to be remembered, also, that the dynamical effect on the structure of a load in motion, is much more than the statical effect of a load at rest. In the case of a jointed structure, of which the elasticity is imperfect, the dynamical strain and deflection would be certainly double the corresponding statical effect.

These remarks are not intended as forebodings as to the ultimate success of this magnificent undertaking. All that we wish to do is to point out how much of the problem is solved, and how much remains in doubt. Considering the question abstractedly, we cannot deny the possibility of making the structure strong enough to bear its load. Theoretically, a tubular bridge may of course be made strong enough to bear any assignable load whatever—ton after ton of metal might be added till the requisite strength would be obtained. For as each ton of metal would be disposed so as to bear something more than its own weight, we should, by continuing the process of increasing the thickness of the plates, arrive ultimately at a point where the strength was sufficiently in excess to sustain any load assigned.

But the question is, not whether the bridge may be made strong enough, but whether it be made so at the least expense of material. It is to this point our doubts refer. Mr. Fairbairn says, that his experimental results contradict the conclusions of some eminent mathematicians; and, except for the laudatory epithet, we should be disposed to think that he refers to investigations which have, from time to time, appeared in this *Journal*, in which alone, we believe, the mathematical principles of the tubular bridge have been discussed on an extensive plan. But leaving the personal question, it is enough to explain that we call in question not the effect, but the means; not the sufficiency of the structure, but its economy. It has been already shown (Vol. IX. for 1846, p. 300), that *straight* tension rods, proceeding in right lines from high suspension towers to several joints along the tube, would act with the greatest possible efficiency. It is not even now too late to apply the suspension rods to the bridge: only let it be by rectilineal rigid diagonal bars—not by flexible or catenary chains. Comparing equal quantities of metal disposed—first, in increasing the thickness of the tube—secondly, in *diagonal bars*, acting either as struts beneath the tube, or as tension rods above it,—it has been mathematically demonstrated that the efficiency of the metal may be trebled by the second method. Were it not dangerous to prophesy on a subject so novel and so difficult, we should be inclined to predict that this second method, in one or other of its forms, of diagonal tension rods or diagonal struts, will be found necessary after the structure has been some time in use.

NOTES OF THE MONTH.

The Tabernacle.—Among the interesting exhibitions now open is that of the Tabernacle of Israel, at 58, Pall-Mall. The Rev. R. W. Hartshorn, a clergyman of the University of Dublin, feeling an interest as to the form and structure of the Tabernacle, has had a model made, with all the details elaborately executed, as gold and silver candlesticks, brass sacrificial instruments, and embroidered curtains. The models are two in number, and are executed in strict conformity with the texts in the bible, which describe the arrangement of the original Tabernacle of the Jews. The first of these models represents the Jews encamped in the plain of Moab, with the tribe of Levites and the Tabernacle in the centre. The tents of Ephraim are shown in the distance, and afar off the Dead Sea and the mountain range. This is a most interesting tableau. The other model is devoted to the illustration of the court of the Tabernacle in greater detail. Here are shown the sixty pillars, the altar of burnt offering, the embroidered curtains, and all the accessories of the place of worship. The water-vessels are copied from authorities in the British Museum; the pillars are gilt, the candlesticks and vessels are of gold and silver, and the model of a high priest stands at the altar, superintending a sacrifice. This exhibition is an extraordinary example of the practical illustration of a text, and is likely to excite very great interest, from the nature of the subject and the mode in which it is carried out.

Sewage Pipes.—Glazed-ware pipes for sewers have become a large article of manufacture since the late sanitary agitation.

Water Works.—In the new sanitary bill, provision is made to enable the new commissioners to set up water and gas works.

Death.—Mr. Charles Dyer, a member of the Institute of British Architects, has died of paralysis. His works are chiefly at Bristol; and include the Victoria Rooms, with a large Corinthian portico; the Bishop's College, in the Gothic style; Christ Church, Clifton; Bedminster, New Church; and the Female Orphan Asylum.

New Theatre.—The Royal Polytechnic Institution has been nearly doubled in size by the erection of a very large theatre, capable of holding a great number of persons.

Decoration.—Regular courses of lectures are now being given at the School of Design, Somerset House.

New Gallery.—In consequence of the gift of the Vernon collection, the government have obtained a committee of the House of Commons to inquire into the accommodation at the National Gallery, and what provision ought to be made for the national collections. This will result in a new building.

Builders' Foremen.—The Institution of Builders' Foremen has reached its third year. Its first investment of £100, 3½ per cents. has been made.

Windows.—An agitation is being carried on to get rid of the window tax, and as it is supported on sanitary grounds it is likely to be successful, though the government have refused to do anything this year.

Death.—The newspapers announce the death of Lieut. Col. Henry Brandreth, R.E., one of the paid Railway Commissioners. He was a very distinguished member of the Corps to which he belonged. His death was sudden.

Dividends.—The railway dividends declared at the half-yearly meetings have been more satisfactory than was expected; while a complete denial has been given to the charge that dividends have been paid out of capital.

Broad Gauge.—The course of litigation has been latterly in favour of the broad gauge, and it is expected the Great Western will be left masters of the Birmingham and Oxford line.

Telegraph.—Mr. Wishaw is, it is stated, engaged on an hydraulic telegraph, of which system, as is well known, he was the inventor. He organised the establishment of the Electric Telegraph Company.

Colonies.—Colonial railways are quite at a stand-still: the Demerara works are stopped, the new Jamaica lines given over, and the Trinidad and Barbadoes Companies defunct.

Survey.—The ordnance surveyors have begun the survey of London, for fear they should be stopped. Mr. Wyld gave some opposition in the House of Commons, but the surveyors have been so supine, that the government have been able to carry out their own system.

Blackburn.—On the 18th ult., a new market-house was opened at Blackburn. It is by Mr. Terence Flanagan, C.E., and is 181 ft. 6 in. long, and 109 ft. 6 in. wide. The roof is in three spans. The tower is 18 feet square, and rises 90 feet high. The material is Longridge stone, and the cost £800.

Flaxman.—A collection of 150 works of Flaxman has been presented to the University College by Miss Denman, his executrix.

Saltash Bridge for the Cornwall Railway.—The estuary of the Hamoaze at Saltash Passage, is, at high water, about three-quarters of a mile wide, 10 fathoms more or less deep, and, from its narrowness compared to other parts, the stream runs there with a most powerful force. It is designed to carry over the river, at this passage, a bridge of three arches, 95 feet above the surface of high-water spring tides. To aid in the accomplishment of this great object, the Cornwall Railway Company have purchased two 14-gun packet brigs—the *Pigeon* and *Magnet*—of 300 tons each, and have moored them at the passage about midway. By a series of moorings, it has been ascertained that the bed of the river is covered with mud to depths varying from 18 inches to 15 feet. On the Cornwall side, a stage being moored 20 feet from the beach at low water, and a 30-bar ladder with weights attached, let down to rest on the ledge of a steep rock, a diver had yet to descend 9 feet before the bottom was obtained. On the Devonshire side there is not so much declivity. The company have just received from Bristol, by Bristol and Exeter and South Devon Railway to Totness, and thence by sea, an immense cylinder, weighing 23 tons, 85 ft. 9 in. long, and 6 ft. 3 in. diameter. It is designed to let this cylinder down perpendicularly between the two brigs, when it will be about 25 feet out of the water, and in that position to moor it with hemp cables, fastened to four or five anchors, some of which weigh 1 ton each, purchased expressly from her Majesty's dockyard. An effort will then be made to pump the cylinder dry, by steam-engines to be fixed on board the brigs. Should the experiment with this cylinder prove successful, it will have to give place to one of much greater magnitude, weighing 130 tons, of the same length, but having a diameter of 30 feet—thus providing an area of sufficient extent to lay foundations for the piers of this formidable work. At the present season there are not more than about 30 men employed at Saltash; but a far greater number will shortly be employed. They are under the control of the resident engineer, Capt. Douce, who is aided by Mr. Pope, the gentleman who so ably assisted in floating the *Great Britain* steam-packet.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM JANUARY 22, TO FEBRUARY 23, 1848.

Six Months allowed for Enrolment, unless otherwise expressed.

Henry Heywood, of Blackburn, Lancashire, for "certain Improvements in looms for weaving."—Sealed January 22.

William Hudson, of Burnley, Lancashire, machine-maker, and John Dodgeon, of Burnley, same county, overlooker, for "certain Improvements in looms for weaving."—January 22.

Henry Hornblower, late of Dalgleish-place, Commercial-road, Middlesex, but now of Devon's-lane, Bromley, engineer, for "certain Improvements in machinery for exerting motive power, and for raising and forcing fluids."—January 25.

Thomas Topham, of Ripley, Derbyshire, manufacturer, for "Improvements in the manufacture of time-tables."—January 25.

George Fergusson Wilson, of Belmont, Vauxhall, gentleman, for "Improvements in treating and manufacturing certain fatty or oily matters, and in the manufacture of candles and night-lights."—January 25.

Henry Highton, of Rugby, master of arts, and Edward Highton, of Regent's Park, Middlesex, for "Improvements in electric telegraphs."—January 25.

James Barr Mitchell, M.D., and Thomas Best Woolryche, chemist, for "Improvements in the manufacture of soda, and in treating products obtained in such manufacture."—January 25.

John Collins, of Leominster, in the county of Hereford, architect, for "certain Improvements in furnaces, stoves, grates, and fire-places, and in kilns and other apparatus for preparing vegetable and other substances, and the generation and application of heat." January 27.

Thomas Robinson, of Coventry, ribbon manufacturer, for "Improvements in looms for weaving ribbons and other fabrics."—January 27.

William Watson Pattinson, of Felling, near Gateshead, Durham, chemical manufacturer, for "Improvements in the manufacture of soda."—January 27.

William Henry Barlow, of Derby, civil engineer, for "Improvements in the manufacture of railway keys."—January 27.

William Russell, of Lydbrook, in the county of Gloucester, iron master, for "an Improvement in the preparation of such bar-iron as is used in the manufacture of certain kinds of rod-iron."—January 29.

Alfred Vincent Newton, of Chancery-lane, mechanical draughtsman, for "Improved machinery for manufacturing shot and other balls." (A communication.)—January 31.

James Blackwell, of Winsford, in the county of Chester, salt proprietor, for "certain Improvements in evaporating furnaces."—February 2.

Robert Fowles, of North Shields, Northumberland, gentleman, for "certain Improvements in propelling."—February 8.

James Bird, of the Cwm Avon Works, Taibach, Glamorgan, gentleman, for "certain Improvements in propelling."—February 8.

Godfrey Anthony Ermen, of Manchester, cotton spinner, for "certain Improvements in machinery or apparatus for twisting cotton and other fibrous substances."—February 8.

Richard Clarke Burleigh, of Featherstone-buildings, Middlesex, gentleman, for "Improvements in burners for obtaining or producing light and heat, and in apparatus to be used therewith."—February 8.

Jacob Brett, of Hanover-square, Middlesex, gentleman, for "Improvements in electric printing and other telegraphs."—February 8.

William Heywood, glover, of Stone Bridge, Chester, chemist, for "Improvements in the manufacture of oil from blubber."—February 8.

William Sangster, of Regent-street, Middlesex, for "Improvements in umbrellas and parasols."—February 8.

Jean Napoleon Zermen, of Greenwich, Kent, captain in the French navy, for "Improvements in ships and other vessels."—February 8.

Luke Hebert, of Ryde, Isle of Wight, civil engineer, for "Improved mechanism for reducing, grinding, and sifting bark, sugar, coffee, seeds, and other substances."—February 8.

William Peter Piggott, of Oxford-street, Middlesex, and Wardrobe-place, Doctors' Commons, city, for "certain Improvements in nautical instruments, and in the manufacture of cases for containing instruments, goods, or merchandise."—February 8.

Jean Marie Magnin, of Ville Granche, (Rhone,) France, avocat, for "Improvements in machinery for sewing, embroidering, and for making cords or plaits."—February 9.

Gustav Adolph Buckholz, of Forston-street, Middlesex, gentleman, for "Improvements in obtaining motive power."—February 9.

Felix Douche, merchant, of Rouen, France, for "certain means, processes, and apparatus used for saving and applying the lost heat in general and sometimes direct heat, to many useful purposes." (A communication.)—February 10.

William Jeary Cannon, of Cambridge, solicitor, for "Improvements in the construction of carriages for the conveyance of sheep and other animals on railways."—February 11.

The Right Hon. Thomas, Earl of Dundonald, Vice-Admiral of the White squadron of Her Majesty's fleet, Knight Grand Cross of the Most Hon. Order of the Bath, for "Improvements in marine steam boilers and apparatus connected therewith."—February 11.

Horatio Black, of the town and county of Nottingham, lace-maker, for "Improvements in evaporation."—February 14.

John Watson, merchant, and Edward Cart, gentleman, both of Hull, for "Improvements in the manufacture of gas."—February 14.

James Timmins Chance, and Edward Chance, of Birmingham, for "Improvements in furnaces, and in the manufacture of glass."—February 14.

William Tottie, of Crosby-square, London, merchant, for "Improvements in distilling." (A communication.)—February 14.

John Weston, of Portland-town, Middlesex, machinist, for "certain Improvements in obtaining and applying motive power."—February 16.

Joseph Barber Haxby, of Dewsbury, for "Improvements in making communications between the guards, engineers, and other servants in charge of railway carriages, and also between the passengers and such servants, which improvements are applicable generally where speedy and certain communications are required."—February 16.

Edward Massey, of Middleton-square, Middlesex, watchmaker, for "Improvements in logs and sounding apparatus."—February 18.

Edward Duncombe Lines, of Chelsea, and Samuel Lulz Freemont, of Love-lane, City gentleman, for "Improvements in the manufacture of colours, oils, and varnishes, and in the manufacture of charcoal, and also in treating vegetable substances for, and in obtaining extractive matters therefrom."—February 18.

William Irving, of Trigon-road, Kennington, engineer, for "Improved apparatus for cutting or carving ornamental forms in wood, stone, and other materials."—February 23.

James Nasmyth and Holbrook Gaskell, both of Manchester, engineers, for "certain Improvements in machinery or apparatus for forging, stamping, and cutting iron and other substances."—February 23.

CANDIDUS'S NOTE-BOOK, FASCICULUS LXXX.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. Caryatides completely contradict Vitruvius's conceit, as to Ionic and Corinthian columns being proportioned respectively after Grecian mammas and misses, for the real feminine or lady-like pillars are far more bulky and robust than even the most masculine examples of the Doric order,—to such degree, in fact, that they would be positively clumsy were they mere pillars, whereas variety of form and play of outline entirely dissipate the heaviness which would attend simple masses of stone of the same bulk. Of the effect and value of Caryatides in architectural composition scarcely anything is said by architectural writers, although it is that which chiefly demands their consideration and remark; for as to the origin or first introduction of such figures to perform the office of columns, that in reality matters not a rush, notwithstanding it is what exclusively occupies the attention of those who speak of them. The current legend respecting the adoption of them into Greek architecture, may be true or may be false; but at all events it is not necessary in order to account for pillars being shaped to resemble human figures, such figures being frequent in the Egyptian style,—of course with very wide differences as to taste and design, the fundamental idea being nevertheless one and the same. Far more to the purpose is it to consider the æsthetic effect of such statue-columns, and their value in architectural composition. That while they greatly extend the resources of the latter, there is direct classical authority for them, and that in an example fraught with the most exquisite taste, is undeniable; notwithstanding which, the propriety of the taste so displayed has been called in question, or rather has been peremptorily condemned. It is contended that such figures both suggest painful ideas, and partake of the preposterous. With regard to the first of these objections, it is difficult to understand wherefore statues performing the office of pillars should excite any idea of pain if they themselves express no such feeling—which of course they ought not to do—but stand calm, immoveable, and indicate perfect ease and tranquillity. As to the preposterousness of employing human forms for offices which living human beings could not possibly perform, if there be absurdity in that, it is of a species which extends itself—or I might say, incorporates itself—with a very great deal of both architectural decoration and ornamental design generally. It has been said that whatever is contrary to common-sense is contrary also to good taste. The validity of such dictum depends very much upon the latitude allowed to the term "common-sense." If we are to understand by it merely the knowledge based upon actual experience, a very great deal that has hitherto been regarded as manifesting refined taste, must be set aside altogether, and pronounced to be in very false taste. If Caryatides are to be condemned as inconsistent with good taste, because they represent the human form contrary to what we know by common-sense it is capable of, the same authority of common-sense must pronounce statues employed as pinnacles and acroteria on pediments or elsewhere to be equally repugnant to good taste, they being placed for a continuance where real persons—if they could stand there at all—could remain for only a few minutes, and that at the peril of their necks and limbs. Again, how can we reconcile with plain common-sense such classical monstrosities as arabesques or human and animal figures terminating in foliage? Nay, is there anything of common-sense—that is, of plain, honest, matter-of-fact common-sense—in the cramming a crowd of figures into a pediment, where half of them are, perforce, crouching down? Or what shall we say to such conceits as corbel-heads, or to statues fixed in between the mouldings of the head of an arch, in such manner that some of them are nearly in a horizontal position? If common-sense is not startled by them, it may surely excuse what are less at variance with it—namely, Caryatides, which last are at once so picturesque and elegant in effect, that their being so rarely employed may well excite our wonder. Their being frequently employed is not to be looked for, on account of their expensiveness as compared with other pillars of the same dimensions; still what prevents their becoming too common by being applied on ordinary occasions, should operate as a strong reason for introducing them where magnificence is affected, and cost becomes a secondary consideration.

II. From what Mr. Gwilt says on the subject, in his Encyclopædia, it would seem that Caryatid figures are by no means uncommon features in architectural composition, for he tells us that "the variety in quest of which the eye is always in search, and the picturesque effect which may be produced by the employment of Caryatides, leads *often* to their *necessary* employment." How he reconciles the epithet "*necessary*" with the opinion uttered by him just before, viz., that the purpose of support can be not only as well but even better accomplished by a small order,—must be left to himself to explain, which it would, perhaps, puzzle him to do; and puzzle him also it would to justify the expression "*Often*," by enumerating examples. On the contrary, they are exceedingly rare indeed, in this country more especially, for I can call to mind only one instance of the kind in the metropolis, namely, that afforded by the church of St. Pancras. Yet, though he evidently entertains no partiality for Caryatides, Mr. Gwilt appears to regard with favour Inigo Jones's idea for the circular court in the palace of Whitehall, which was intended to have two orders of colossal figures, answering to two entire stories of the edifice, which enlargement of scale for figures of the kind is certainly no improvement upon the tasteful Athenian example.

III. It would be well were we to ask ourselves what is likely to be the result of the present system of architectural copyism and mere reproduction. The works so formed and fashioned will, by and by, come to be looked upon, at the best, only as so many clever counterfeits and imitations of what were previously living styles of the art, fraught with vitality and with the actual impress of the period when they respectively flourished. Just now, while we are imitating, our imitations may interest ourselves, but they will be of no interest or value to those who come after us. Historic interest they will have none, except as testifying to our skill in mechanical mimicry, and our utter want of inventive and creative power. Do what we will, imitation of something done before there always must be in architecture; yet, as if that were not sufficient, we affect and pique ourselves upon direct and express imitation. We must always have "something after somebody," or after something else. And this of itself constitutes a prodigious difference between the art at the present day and in former periods, our own being little better than a blank with regard to original ideas. So that with all our reverence—real or pretended—for precedent, we refuse to recognise the artistic liberty to which we are indebted for those styles and examples of them which we now cry up as patterns of excellence.

IV. The free exercise of invention in design is not to be confounded with mere arbitrary innovation. The inventive power for which such freedom is claimed must, however, be of a legitimate kind,—that is, be directed by sound principles of art. With them and a cultivated taste for his guidance, he who has the spirit of an artist in him may safely be trusted to his own impulses and ideas; whereas he who has no insight into artistic principles, who has never applied himself to æsthetic study, cannot be trusted at all beyond the limits of the most ordinary common-place and jog-trot design, for if there be a possibility of blundering he is sure to do so. No matter in what style he attempts to disguise himself, his vulgarity is certain to betray him, and his irrepressible Pecksniffism breaks out, without being at all suspected by him, or it being in his power to guard against it, for the simple reason that it is his nature, and he has no idea of what he ought to guard against. Daily experience confirms the truth of this: how many atrociously vile and vulgar copies—or rather parodies and caricatures, although intended for copies—do we see of styles and modes of design and composition that happen to have been brought into vogue—as, for instance, the astylar "Palazzo" fashion introduced by Barry, which has in many cases been either positively vulgarized, or else treated in the most prosaic manner,—as if the intention were to prove what miserable taste may be displayed in things that affect to conform to precedent and to be perfectly free from caprice.

V. As to caprice, that term is frequently applied very unmeaningly. It is very common for people to set down at once for caprice whatever deviates from general rule and usual method; thereby perplexing that ordinary and petty criticism which has no other standard of judging than established routinier precepts, interpreting them, moreover, to the very letter. Such criticism is unable to discriminate between what is mere caprice and what is not,—wide as is the difference between them. The capricious is that for which no satisfactory reason can be assigned by the author of it; but, however contrary it may be to usual practice, that is not caprice which is done with deliberate intention and well-studied aim at effects previously untried. And if to do well merely according to precedent be meritorious, much more so must i be to do so and at the same time go beyond actual precedent, creating what in its turn will be recognised as valid precedent and authority. It is proper enough to be perfectly well acquainted with precedent, but to be tied down to it—to be made a slave to it, is ill. Those who are incapable of thinking for themselvs, take refuge in precedent, and make it their stronghold, since it enables them to assume a tone of authority, and to decide dogmatically without any trouble of thinking.

VI. Careful observance of rules will enable any one to avoid positive faults; but between them and positive merits there is an immeasurable distance—one which defies calculation. In art, it is very possible to be at once faultless and valueless—without any specific fault, but also without any interest or any charm,—in a word, to be altogether humdrum. Perhaps it is rather unfortunate than not for architecture, that a great deal of humdrum is of necessity tolerated in it: however worthless or unworthy they may be as productions of architecture, buildings may as buildings completely answer the purpose for which they are erected. Besides which, they must, when once erected, remain indefinitely, to the discredit of the art and the corruption of public taste. Humdrum poetry becomes serviceable as waste-paper; humdrum pictures find their way into lumber-rooms and garrets; but buildings of the same or even worse quality cannot be so got rid of, or put out of sight; otherwise a good many that might be mentioned would now disappear.

VII. There is something startling, perhaps diverting also, in the decidedly opposite opinions entertained by two of our architectural professors with regard to Vitruvius. While Professor Hosking speaks of him, in his Treatise on Architecture, in the most unqualified terms of contempt, Professor Cockerell venerates him;—as to vindicating him, that is quite a different matter, and what he does not even so much as attempt, but leaves altogether unnoticed the highly depreciatory remarks thrown out against his idol, not by Hosking only, but by the author of the "Newleafe Discourses," both in that publication and elsewhere. The ignoring them may be prudent enough, but assuredly does not show much of either courage or ingenuousness, keeping quite out of sight as it does the fact that Vitruvius has of late years been violently impugned by professional writers in this country, and his work declared valueless to the architectural student;—nay, not only valueless, but in some degree mischievous also, by filling him with absurd and idle notions, and affording him no insight whatever into his art,—as art. If Vitruvius has been unjustly aspersed and vilified, it was for Professor Cockerell to defend him—if he could; instead of which, in his closing lecture this season at the Royal Academy, he gave his hearers reason to suppose that the chief accusation brought against him had been by his German editor, Schneider, on the score of his Latinity. Schneider, it seems, was a mere philologist, and honestly avowed his ignorance of the subject-matter of Vitruvius's writings, which I take to have been rather in favour of his author than the contrary, because, had he been capable of judging of the value of the matter also, hardly would he have entertained a higher opinion of him. The name of Vitruvius is, undoubtedly, one of great traditional fame—one sanctified by inveterate prejudice, partly or even principally because his books *De Architecturâ* represent to modern times all that remains of similar writings by the ancients. That mere accident has conferred upon him a monopoly of reputation, there being no one to share it with him; and it has been too lightly taken for granted, that, writing in classical times, he must himself have been a competent judge and expounder of classical architecture. He shows himself, however, to have been at the best of a very plodding turn of mind—notwitstanding his pompous and priggish proems, and to have been what would now be called a mere "practical man," acquainted only with matters of routine and the technicalities of his craft. While there is a very great deal in his work which is utterly irrelevant, it being only in the remotest degree connected with the professed subject, there is absolutely nothing whatever that gives evidence of the artist or the æsthetic critic. There is not so much as any attempt to lay down and explain principles of correct taste in architecture. There is neither argumentative criticism, nor reasoning, nor remark; but everything is treated in the dryest manner conceivable, and for the most part very obscurely also. What is to us his obscurity may partly be laid to the charge of our own ignorance—our not being better informed as to various matters that were sufficiently well understood by those to whom he addressed himself, but which, after all attempts to explain them, can now only be guessed at. The question then, is, of what value is Vitruvius to us, especially at the present day, when by means of various ancient buildings and examples that have been from time to time discovered, explored, and delineated, we have obtained a far clearer insight into the principles and practice of the architects of antiquity than can possibly be derived from the writings of Vitruvius? In some instances, obscurities in his text have been explained by what has been observed in extant monuments; yet that only proves that the latter are infinitely more intelligible instructors than Vitruvius, and that accordingly he may now be dismissed by us, for any real advantage to be derived from the study of him. Such study will, indeed—if that be any advantage—enable the architect to talk learnedly, but will not help in the least towards making him an artist; rather will it be apt to render him a pedant, and obstruct the advance he might else make in his capacity of artist, by withdrawing his attention from what is his proper study as such; as has too frequently been the case. Many would have been far greater proficients in their art, if, instead of poring—perhaps stupifying themselves also—over Vitruvius, they had thrown him entirely aside, and exercised their own powers freely in composition and design.

VIII. The subject of the invisible—perhaps altogether imaginary—curves in the lines of the Parthenon has been again brought forward before the Institute, though it was to be hoped we should hear no more of it. Matters of far greater immediate importance than such *nugæ difficiles* and refined subtilties and speculations, claim our attention, ere we advance so far as to be able to appreciate such exquisite niceties in architectural optics as those attributed to the Greeks. Little less than ludicrous is it for us to pretend to interest ourselves with them, when we complacently tolerate the most crude and spiritless school-boy imitations of classical architecture, which chiefly show how very ill the pretended originals have been understood. So long as we shut our eyes to the glaring barbarisms in taste, and the harsh contradictions with regard to style, that are allowed to manifest themselves in copies of that class, it is in vain to expect that we shall ever open them wide enough to discover such philosophically-studied minutiæ as are the curvatures in question, which certainly were not even so much as suspected till very recently, notwithstanding the diligence with which the Parthenon has been examined, not only by Stuart, but by many others since his time. It has been ascertained beyond contradiction, that Polychromy was—to a certain extent, at least—employed as an effective and legitimate mode of architectural embellishment, both for the Parthenon and other Greek structures; and yet even that discovery has been altogether useless to us in practice, inasmuch as we have not attempted to avail ourselves of it on any occasion: and if we forego a trait of Grecism that would be plainly perceptible to every one, hardly is it to be supposed that we shall ever think of making any use of refinements in optical effect that would not be perceptible to one person in ten thousand. Let us provide the shirt before we think of the ruffles for it: when we can show that we are capable of fully entering into the character of classical architecture with genuine artistic sentiment for it, it will be time enough to think of those exquisitely subtile and delicate touches which are now imputed to the Parthenon. For us, who show ourselves so obtuse as we do to many even tolerably palpable qualities in Greek design, to concern ourselves with its finest imperceptible workings, is nothing less than absurd. Besides which, Grecian architecture has of late fallen into discredit with us, we having at last found out that, as our buildings are necessarily constituted, it is nearly altogether inapplicable by us in actual practice. Copy Greek orders we may, but we cannot keep up—except in very particular cases indeed—anything like the genuine Greek physiognomy; so that the degree of resemblance aimed at and obtained, only serves to render the departure from the original style the more evident, particularly if the order be the Doric, since that refuses to accommodate itself to any other purpose than a simple colonnade.

IX. So very far are we from studiously calculating optical effects with mathematical precision, that we do not seem to understand—at least, not to be able to foresee—that difference of appearance which takes place between a geometrical elevation, in which every part shows itself equally distinctly to the eye, and the building executed from it, in which last it is perhaps afterwards discovered that much of the detail does not tell at all. Seldom is any calculation made with reference to the actual locality, and the distance from which the structure itself will generally be viewed. Hence, when erected, it is sometimes discovered that a building can be seen only so far off that its lesser features are scarcely distinguishable at all, or else only from so close a point of view, that all the upper part of it becomes so greatly foreshortened as to become quite distorted, and altogether a different object from what the geometrical design promised. It is not uncommon, again, to find that while those parts which can be but imperfectly seen—or at the best seen only in their general forms—are elaborately decorated, those which being almost close to the eye show themselves distinctly, are comparatively neglected and treated as subordinate ones;—and so they may be with regard to the design as seen upon paper, but not as it is seen in the building itself. In many cases, the merest indication of detail and finish would answer the purpose just as well as that degree of the latter which is now deemed indispensable, although the parts to which it is applied may be out of sight, or nearly so. Therefore, I cannot help taking the river front of the new Palace of Westminster to be a very great mistake, and a very costly one also. However exquisite may be its beauties of detail, they are valueless if, as really is the case, they are invisible, and cannot be enjoyed by being admired.

X. What is or is not a palace seems to be difficult to say, when we find among the examples referred to under that designation, in the index to Cresy's translation of Milizia's Lives, not only Barbers' Hall, the Horse Guards, Heriot's Hospital, and other buildings which do not seem to belong at all to that class, but also the Monument on Fish Street Hill! We may therefore congratulate ourselves on having besides that, two more palaces which we have not reckoned before—namely, the Nelson and the York Palaces. A most agreeable surprise must it be to Mr. Railton, to find that he has erected an entire palace when he attempted only to stick up a single column.

THE HOTEL DE VILLE, PARIS.

Hotel de Ville de Paris, Mesuré, Dessiné, Gravé, et Publié, par VICTOR CALLIAT, *Architecte; avec une histoire de ce monument, par* LE ROUX DE LINCY. Grand folio. Paris, 1844.

As the seat of the Provisional Government of the new French Republic, this edifice has recently acquired a degree of interest even with those who would be wholly indifferent to it as a work of architecture. Of course, it is as the latter alone that we notice it, and had the same means of doing so been afforded us, should have done so before. Still, late as we are in our notice of the splendid architectural publication whose title heads this article, we are not at all behind others, for we are, we believe, the very first to make mention of it in this country. It may sound oddly to say that we *hasten* to give our readers some account of it; nevertheless such is the case, because, anxious to speak of it without further delay, just at the moment when circumstances give the building an incidental importance, distinct from that which it possesses as an architectural subject, we are at present prepared for reporting only of the graphic part of the work, having no time to examine the literary one. The latter is, in fact, so exceedingly copious, and contains such a vast mass of historical matter, as to require very patient study, more especially as the form in which it is given is a highly inconvenient one for either perusal or reference. In our opinion, it would have been greatly better to publish the plates by themselves, or with only so much letter-press as was requisite for explaining them, and describing the present edifice architecturally; the history being made to form a separate octavo volume, either as a distinct work or not, as might be deemed expedient. Had that been done, both the folio volume or atlas of plates, and the octavo of text, would have answered their respective purposes much better than is now accomplished. The former would not have been so inconveniently bulky; the other would have been a readable volume, whereas now, however readable the matter itself may be, hardly can it be said to be in a readable shape; whence the probability is, that very few will encounter the fatigue of reading it at all. The perusing the text continuously in its present shape would, to ourselves at least, be a formidable task; yet, fortunately, we are not particularly solicitous about matters of mere historical record,—events and transactions which have no other relation to the edifice itself than what is derived from the latter having been the locality where they occurred.

Leaving M. Le Roux de Lincy's portion of the work, we shall confine ourselves to M. Victor Calliat's department of it, who, we should observe, holds, or lately did hold, the office of *Inspecteur* of the building, and who employed five years in carefully measuring and delineating the various parts of the structure, having, besides, free access to the designs of MM. Godde and Lesueur, the architects employed for the new work. Until the recent amplification and alterations, which have rendered it one of the most important monuments of the French capital even in its present greatly improved and embellished state, the Hotel de Ville was of little architectural note, except as a *souvenir* of old Paris. The style of it had been voted "*Gothique*" and obsolete; and the actual design showed much more of the grotesque than the beautiful. All that Woods says of it in his "Letters," when speaking of the buildings of Paris, is: "It has a certain richness of appearance, although it is not in a style of architecture capable of great merit (?) and even not one of the best examples of the sort. It is, however, as good as our Guildhall." As good as our Guildhall!—as well might he have called it at once intolerably bad.

The original edifice that forms the nucleus of the present greatly extended mass, was commenced in the reign of Francis I., viz., in 1533, after the designs of Domenico Boccadoro, or Boccardo, otherwise called Domenico di Cortona, assisted by Maitre Jehan Asselin, and the façade and the "Cour d'Honneur," now the middle one of the three courts, were completed in 1541; and much was subsequently done from time to time. At the period of the first Revolution, the edifice suffered greatly; many sculptures and embellishments that were obnoxious to the enlightened populace were destroyed; among others, a series of portraits from the 16th century, and a number of large paintings by Porbus, de Troyes, Largilliere, Mignard, Vanloo, and other masters,—or if not actually destroyed, removed, nor is it now possible to ascertain what has become of them.

During the Empire and the Restoration, the edifice underwent some partial alterations; but it was not until 1836 that it was determined to undertake improvement upon a comprehensive scale; and great as it was, the scheme has been carried out so successfully that the Hotel de Ville may be placed foremost among the architectural monuments that mark the reign of Louis Philippe.

If not particularly remarkable in itself, remarked it may be, that this edifice, which is, in some degree at least, similar in purpose, is also contemporaneous with our own new Palace of Westminster, except that it is already completed, while the completion of the other cannot at present be calculated upon. Further, being in the Renaissance style, it shows what might have been made of our our own building at Westminster, had the stipulated-for Elizabethan or Anglo-Renaissance style been adhered to, but at the same time treated with the same freedom and refinement as are shown by MM. Godde and Lesueur, in their *rifacciamento* and enlargement of the Parisian Hotel de Ville. Among the improvements which the structure has received from them, not one of the least is that whereas it before showed only a single front—that towards the Place de la Grève—it now forms an entirely insulated mass (405 feet by 272), with four regular façades, the original or west one (now greatly extended) towards the aforesaid *Place*, the corresponding or east one towards the Rue Lobau, and of the two shorter ones, that facing the north towards the Rue Tixerandie, and that on the south facing the Quai de la Grève. So far, if in no other respect, it has greatly the advantage over our Palace of Westminster, one side of which, and that which according to the design is the principal façade, is altogether inaccessible, so that its elaborate decoration, requiring as it does the closest inspection, is completely thrown away.

The former west front, or that towards the *Place*—which was all of the edifice that then showed itself externally—was not quite 200 feet, but is now extended to upwards of twice that length, by the addition of two more lofty pavilions, similar in character, but somewhat varied in design, from the original ones. Hence, the general composition is now increased from three to seven divisions or compartments, two of them being the intermediate *corps de bâtiment* connecting the two pavilions (the old and the new one) on either side of the centre. We may refer our readers to two different views, which they will probably be able to turn to at once, one of them being in Pugin's "Paris," the other in Allom's "France;"* for from them they will immediately perceive how great is the improvement as well as change that has taken place. That façade, however, is not the one which best satisfies us, there being in the original portion of it a good deal in a rather *mesquin* taste, to which the architects were obliged to conform for the rest; whereas in the three other fronts, and also the inner courts, they have, instead of allowing themselves to be tied down to precedent, given artistic scope to their ideas, seizing on the better spirit of the style by which they were to be guided, and refining upon it by preserving all its really valuable characteristics and *motifs*, and avoiding its uncouthnesses, its harshnesses, and its mere eccentricities. Compared with the other principal front—the eastern one, facing the Rue Lobau—the original one has, in spite of all im-

* Pugin's representation of the building is so exceedingly poor as to be scarcely intelligible, all the features being so very rudely expressed, that it is impossible to make out more than the mere general design. Allom's, on the contrary, is tastefully touched, and shows as much as can be expected in a general view of the whole front in so small an engraving; at the same time, there are inaccuracies in it which ought to have been guarded against. That so able an architectural artist as Mr. Allom is, should have given only a single exterior, and not so much as one interior view of so important a public monument, is to be regretted. Perhaps he himself, or his publishers, regret it now that circumstances have given a particular interest to that particular building. Let us hope then, that Mr. A. will visit the French capital once more, and give us a "Paris after the Third Revolution," since he may there find many subjects for his pencil which he had passed over;—among others, the Church of St. Vincent de Paule, and the Ecole des Beaux Arts, both of which would require to be illustrated by more than one drawing.

provement, a confused, crowded-up look, and shows not a few disagreeable inequalities of taste. The new façades, on the contrary, exhibit not only greater simplicity, but greater richness also. There is infinitely more of homogeneousness of character, the character itself of the style adopted being purged from its littlenesses of manner and other defects. The architects—or perhaps we should say M. Godde,* for the other appears to have been only his *adjoint* in the execution of the works—may be said to have given us the ideal of Renaissance—that is, French Renaissance, modified so as to be applicable at the present day.

Previously to its assuming its present shape and greatly extended dimensions, the Hotel de Ville had only a single inner court—a trapezium in plan, whose eastern side, or that facing the entrance, is considerably wider than the latter. Besides this, which is denominated the "Cour d'Honneur," there are now two other more spacious ones, that on the south side being the "Cour du Prefet," and on the north the "Cour des Bureaux." Yet, in the letter-press account—description it can hardly be called—of the building, in Allom's "France," no notice is taken of this very material enlargement of the plan, but we are left to understand that there is only a single court,—"a spacious (?) quadrangle, entered through the lofty arches in the principal front;" whereas those entrances lead into the two separate new courts. The letter-press writer, the Rev. G. N. Wright, M.A.—don't let us forget the M.A., though it does not mean Master of Architecture,—is one of those ready writers who pay more attention to quantity than quality; for he gives the credit of the present structure to Molinos, an architect who was only employed on some additional constructions to the building in the time of Napoleon, which have since been entirely swept away. He also assures us that all the additions have been made "in the most exact and complete harmony" with the original façade, which, as far as it means anything at all, means that they are little more than a mere copy of it.

Although not very spacious, the inner courts are not the least beautiful parts of the structure; it is, however, easier to judge of their design than their effect, for they are shown only sectionally, whereas subjects of that kind require to be represented perspectively also. For an external façade—more especially if it consist of little more than a single general plane of frontage, without advancing or receding parts—a geometrical elevation may be sufficient; but where several façades or sides—be they those of a room or of a cortile—are seen in combination with each other, the aid of perspective becomes requisite in order to convey an idea of the actual appearance. There ought, in fact, to have been a perspective view also of at least one of the façades, and it should have been of that facing the Rue Lobau, it being the finest of them all, and moreover distinguished from the others by a circumstance that is likely to escape notice in a geometrical drawing, more especially one merely in outline, where there are no shadows to express the various degrees of relief:—the distinction we allude to is that in that front, instead of being engaged ones, the columns of both orders are completely detached from the wall behind, at least along the whole of the central portion of it (extending to fifteen arcaded intercolumns in its length, and having a large and highly-enriched lucarne over each alternate intercolumn).

From the exterior alone, a very imperfect idea is to be obtained of the magnificence of this noble pile of building, which may be one reason for its not having obtained the notice, or anything like the notice, which it may justly claim. Truly palatial in outward appearance, it is equally so within, containing as it does, besides a very great number of various offices and other mere business rooms, no inconsiderable number of state apartments for municipal *réunions* and entertainments, which are not only spacious and handsome, but even truly splendid and sumptuous, and withal afford an unusual variety of scenic effects in architecture. Yet, of all of them, only one, and that by no means the most remarkable of them as a room, is pointed out by the M.A. description-writer in Allom's "France"—namely, the "Salle du Trone," which is in the original portion of the building towards the *Place*.† Of the new apartments, nothing whatever is said in that publication; not even the "Galerie des Fêtes" itself is so much as mentioned, although that, and the approaches to it, constitute a group of varied and well-combined architectural beauties, that taken altogether has not its equal in any royal palace of Europe.*

To give—what is no easy matter—something like an adequate idea of this part of the interior:—from the lower vestibule is seen extending to the right and left (or north and south) a magnificent staircase, consisting of two wide successive flights of steps, carried in a straightforward direction, between arches supported on marble columns in the upper part of it, where there are galleries or open corridors along its sides. On ascending to the upper landing, a highly enriched dome, though one of moderate dimensions, presents itself; and through this, and three ornamental compartments over the stairs,† the staircase is lighted. On looking back from that upper landing, a most striking architectural *coup d'œil* presents itself,—an exceedingly rich perspective vista through an open saloon (the "Salle des Cariatides," over the vestibule below), into the other staircase.‡ It is, therefore, not without just reason that the staircase is spoken of in the text as a *chef-d'œuvre* of its kind. Even admitting that either of the staircases, in some respects, and among others in spaciousness as to width, yields the palm to the one in the Bibliothek at Munich, the *ensemble* produced by the two greatly surpasses it; for as here managed, it is far more striking than it would have been, had the entire space been thrown open from end to end. In one respect, these staircases have a decided advantage over that at Munich, they being lighted from above, in the manner described,—consequently more picturesquely. Besides which, the Munich one leads architecturally speaking, to nothing, there being merely a number of plain shelved book-rooms, after all the extraordinary parade of approach to them.

Such highly-disappointing falling-off, both with regard to purpose and effect, is most assuredly not experienced in the Hotel de Ville, when on passing from either staircase through a noble ante-room, the "Galerie," with its thirty-two fluted Corinthian columns, profusely enriched pendentives and plafond, and other elaborate decorations, expands itself in all its magnificence. This apartment, which comes in the centre of the Rue Lobau front, is 160 feet by 42, and 40 feet high, with thirteen intercolumns on each side, and three at each end. The cove is divided into arcs-doubleaux and lunettes; of which last, the thirteen on the side facing the windows are open, so as to form a gallery or series of tribunes for spectators, who, through open arches, have a view down into the "Galerie" from the "flat" or roof above the staircases, which space glazed all over, and having pillars along its sides, is thus ingeniously turned to account, and made to produce much novel effect. A similar view is there obtained into the "Salle des Cariatides," through similar openings and the gallery carried around the upper part of that room, to which they afford access. The room just mentioned—which derives its name from eighteen caryatides resting on its cove, so as to form the gallery in its upper part, and support the plafond—comes in between the "Galerie des Fêtes" and the "Salle du Conseil Municipal," as well as between the two staircases; so that from this point—a most happy "*episode*" in the plan—a striking architectural picture presents itself in every direction, whether we look towards the "Salle du Conseil" with the "Cour d'Honneur" beyond it, or towards the "Galerie," or towards either of the staircases. In fact, this part of the plan is eminently replete with piquant complexity—or what seems to be complexity—and variety of effect; and it is all the more striking, because it unexpectedly opens a vista branching out from one side of the "Galerie," and which, therefore, breaks up that excessive sameness of arrangement which, so dull and unartistic in itself, is so prevalent—we might say so uniformly a defect in continental buildings.

There is, besides, a more than usual degree of variety and play in other parts of the plan; for instance, in the several saloons in connection with the "Galerie" at either end of it. One of these bears the name of the "Salon Louis Philippe"—an appellation, that will now, doubtless, be *reformed;* another that of the "Salon Napoleon." Then there is the "Salle des Banquets," respecting which, however, no information is afforded, nor does it show itself

* From what is said of him in Nagler's "Kunstler-Lexicon," we find that this architect (who was born in 1781) was employed, among other works, on the restorations of the Cathedral of Ameins; and that while he was inspecteur en chef de la 2me section des Travaux Public, he made plans, elevations, and sections of various churches at Paris, amounting in all to about three hundred drawings; yet whether they were ever published is not stated.

† It is mentioned chiefly for the purpose of informing us that it was from the central window, Louis XVI. addressed the people with the cap of Liberty on his head; and Louis Philippe afterwards addressed them, when Lafayette told them, that in him they beheld "the best of all Republics!"—words which the present Revolution and the new Republic will probably verify most disastrously.

* After all, such omission on the part of the letter-press was perhaps judicious, because to have spoken of those parts of the interior as they deserved to be, would have been accusing the artist of culpable omission on his part, in not describing any of them with his pencil, more especially as his forte lies in interior subjects.

† From the perspective view of the staircase, it appears that these compartments in the vaulting of the ceiling are not exactly what we should call skylights, but ornamental panels filled in with figured glass, either coloured or plain, in the same plane as the other panels. This ought to have been explained in the letter-press, as likewise ought many other particulars with respect to decoration—colour included—which are now left to be conjectured.

‡ Thus, in regard to mere general disposition of plan, these staircases are somewhat similar to those in our National Gallery; but other resemblance there is none. In all other respects the difference is amazingly great, nor need we say on which side the marked superiority lies.

in any of the sections; and a grand saloon of reception on the south side of the building, which forms altogether a space of 80 feet by 50, but is so disposed as to assume the appearance of three rooms thrown open to each other by means of three large arches on two opposite sides of the central one. This saloon and the "Galerie" form the subjects of two most exquisitely-elaborate perspective views, replete with a multiplicity of the richest and most delicate details, all rendered with a precision truly marvellous. The other perspectives are, a view of one of the new staircases looking from the upper landing towards the "Salle des Cariatides," and one of the old Staircase as seen from below. There is also a detailed elevation of one end of the "Salle du Trone," showing one of its chimney-pieces and the large caryatid figures, between which is placed the spacious mirror over it. Unfortunately, we are left to desiderate a perspective of the "Salle des Cariatides," which would have been highly welcome, because, although it comes into two several sections, it is on such a scale, that little more than its general architectural design can be made out, and the effect—which is of a peculiar kind—is left to the imagination. Many of the plates are occupied by details and ornaments of both the old and new portion of the edifice, and show how elaborately it is finished up.

One important apartment and architectural feature in the building, which we have not yet mentioned, is the "Salle des Elections." This is on the ground-floor, immediately beneath the "Galerie des Fêtes," and of the same dimensions, except that it is somewhat shorter, and, as may be supposed, considerably less lofty. The columns here are of the Doric order, and are brought forward to a greater distance from the walls than in the upper "Galerie." We will now conclude this account—after all, but an imperfect one—by saying, that not only is the edifice itself a most noble and tasteful monumental work, but M. Victor Calliat's publication illustrates it—if not altogether so completely as could be wished—with admirable diligence and taste. We have no English work of the kind that can compete with it, or with the similar splendid one by Joly, on the "Chambre de Deputés" (1840). We have got a Royal Institute of Architects, but architectural publication does not thrive under its fostering auspices. And so wretchedly low is the remuneration of architects in this country, that even those who are most employed cannot afford to risk any of ther earnings in endeavouring to promote architectural study and taste. We can —or rather we *will* only say: *Valdè deflendum est!*

ARTS MANUFACTURE EXHIBITION,

AT THE SOCIETY OF ARTS' ROOMS, ADELPHI.

The Exhibition at the Rooms of the Society of Arts deserves particular notice, because it shows that the workmen of this country have taste and artistic skill, as well as mechanical proficiency. This is the second exhibition of the kind, and it shows very great progress, while it is most remarkable in this very good feature—that whereas before, manufacturers had to be begged and sought to send their works, they have this year sent them freely and with good will. This is going forward in the right path, for it shows that the manufacturers now feel an earnest in the cause, and that gives us another body of yoke-fellows. The artists and workmen have likewise shown their feeling, by the greater care and skill they have bestowed; which is the more pleasing, as it is an encouragement to all those who have come forward in behalf of manufacturing art.

We cannot however help saying, that so much has not been done as ought to have been done in this way, and that still more remains behind. It is pleasing to witness the skill which has been shown; but we are yet far from the goal, and leave foreign nations ahead of us, while we have not means enough to enable us to beat them. We are not yet even with the old Schools of Design in France and the Gewerbe-Instituten of Germany, which we set out to follow, while of late years they have made further way. We call the Central School of Design a mockery; and as for the others, they are only good drawing-schools. The whole is a failure as to quality and extent; and we might just as well think to beat the hosts of Prussians with the Lumber Troop, or set Tom Thumb againt the Spanish giant, as to meet the French, Prussians, Belgians, Swiss, and Italians with the paltry staff we have. Drawing must be taught in all schools to the sons and daughters of workingmen; there must be a high school for drawing in every town, and there must be good schools of design in the great seats of manufacture. The buyers at home must be taught as well as the sellers; we must have our people brought up to a knowledge of art, and then we shall be able to go into the markets abroad on a fair footing.

This question of teaching design is one of trade more than of anything else: we were pinched in our pockets before we thought of bestirring ourselves. It was only when we found out how much we were giving to the French for silks, flowers, fancy paper, bronzes, and paper-hangings,—to the Prussians for iron castings and embroidery patterns,—and to the Italians for objects of art, that we began to set up schools for giving our workmen knowledge of design. The tax we pay to foreigners for our lack of knowledge is so great that it would hardly be believed; we spend millions yearly for goods that we ought to be able to make as well: nor does the evil end here, for as we cannot make for ourselves, so neither can we meet the foreigner in the market abroad. This loss falls, too, upon those who have no need of a knowledge of design. Because the French can bring out silks, satins, muslins, cottons, and shawls with better patterns, the English spinner and weaver of plain goods, the machinist, the drysalter, and the merchant, lose a very large share of employment.

It is good that it should be so, that there should be a tie by which all are bound to work, for otherwise there would be no getting any change, for many would give no help to bring it about. Nothing is easier than to show that the machinist, who deals with hard and stiff forms, and who thinks taste is as much beyond as beneath his care,—nothing is easier than to show that even he, working largely for the manufacturers of this country, has a share in the welfare of art. If more silks and cottons, fancy and stained papers, carpets, shawls, furniture, and glass can be sent abroad, more machinery must be wrought for their production. Mr. Fairbairn and his brethren at Manchester, the machinists at Glasgow, at Belfast, and in every manufacturing town, must and ought to know that they have a fellow-feeling in the right growth of the arts of design. If a School of Design be good for anything, it ought to be good for making the trade of the town in which it is greater: it ought not only to better the goods now made, but it ought to enable the town to send out goods such as we now take from the foreigner, or such as we cannot now send abroad. Therefore, we say this has as much to do with the machinist as with any one; but we say that art has to do with all.

Pleased as we were with the Exhibition now open, we cannot but see that what has been done as yet has not carried art down among the people. The works in the Adelphi are either for the higher or middling classes, those who are already cared for—and not for the people. We have always held, from the first time that we undertook to write about it, that art must not only bring forth good works, but cheap works; that it must show itself in the dwelling of the working-man, as well as in the drawing-room of the rich. The earthenware, the glass, the paper-hangings, the furniture in the smallest cot may be as well made as those in the abode of a king,—while taste shown in them will do much more good. If knowledge be power, it is so in the arts as much as in anything else; and we cannot have a people powerful in the art, unless they be well taught. The Society of Arts have the chance of leading in this path—indeed they have given a few prizes; but we call out again, that more ought to be done. Many working men and women and their children will, no doubt, see this Exhibition, but they will go away with the thought that such things are not for them, and that the rich only are happy in being able to glad their eyes with such sights. Thus, the great teaching of the Exhibition will be thrown away; for we hold that working-men will have a greater feeling for the arts of design, as giving a charm to their own dwelling, than as a mere means of livelihood at the will of the rich.

Felix Summerly has taken upon himself a task which is truly worthy in these days; but we want a Felix Summerly for the kitchen as well as the drawing-room: and we hope if he does not take this further task upon him, that some one else will. Mr. Cole, as Felix Summerly, by choosing this path in art, has made himself a good name, as Mr. Hay has by choosing house-painting; and we wish that other men who have taste and skill would follow, and take each some branch in which he can make his artistic knowledge useful. Sir Walter Scott spoke most wisely when he led Mr. Hay to follow house-painting instead of high art; for although Mr. Hay's powers of mind cannot be doubted, we could much better have spared a Landseer or a Wilkie, than one who by his works and his writings has done good to a whole trade, and has taught hundreds of workmen that they may use their heads and eyes as well as their hands.

In the late free-trade speeches in the House of Commons, we were much struck by what Mr. Wilson said, that the only goods sent out in 1847, on which there was no falling off, but which were more in worth, were silks sent to France, a trade which has grown very much, and which some few years ago would hardly have been believed. If we try we can push the French home, but then we must set about it in the right way, not narrow-mindedly as we have hitherto done, but boldly and skilfully. The workman must be as well taught here as he is in France, or he will do no good. We must not have him kept back for fear he should turn out a painter, and come in the way of some Royal Academician hereafter; but we must have him as well taught as the Royal Academician. The groundwork of art is one and the same, whether for a paper-hanger or a weaver, a Landseer or a Gibson; and we believe that often, more taste is shown in a glass jug or in a common shawl, than in the many landscapes and Art-Union paintings which deck the walls of the Royal Academy. So sorrily has the School of Design been managed by the Board of Trade, that we are still no better off than we were eight years ago; nay, we believe that there was a better and a stronger feeling for the arts of design then than now. Since Somerset House lost the spur of the Society for Promoting Practical Design, in Leicester-square, it has gone on but slowly, and it has done nothing for spreading a knowledge of the arts of design among the people.

The Board of Education is as much behind-hand. Though drawing is as useful to the child of a working-man as reading and writing, and though Mr. Wyse has for years brought this before them, masters and mistresses in National and British and Foreign schools know next to nothing of drawing, and do not teach it. The few who do, teach drawing only to a small number of the elder boys, however willing the younger ones or their fathers are that they should learn.

Little or nothing too has been done to teach drawing to girls, so as to fit them to earn a livelihood in many trades where a knowledge of it is of use. When we bethink ourselves how few trades are open to women, we feel how very needful it is that every means should be taken to enable them to earn their own bread; and nothing seems so likely to forward this, as by giving them a kind of knowledge which is so much wanted in England. The trade of flower-making, which is a new one, and in which in 1841 there were a thousand women at work, has now grown very much; but still, many thousand pounds' worth of these flowers, which are better made, are brought over from France.

It is hardly fair to say anything about the Exhibition without speaking of the Catalogue, which will do as much good as the Exhibition itself. It not only tells us what the Society of Arts did last year, and what is shown this year, but it lays down a plan for spreading wider the good the Society is now doing. This plan is two-fold: first, to send round to the country Schools of Design the objects shown in London each year, and thereby to bring it to bear upon the scholars and workmen throughout the country; and second, to have a great show every three or four years, to be held in a building raised at Charing-cross. Altogether, there is such earnest shown to uphold the arts of design, that we feel truly thankful to the Society for the work they have done, and we hope they will have the help of the Board of Trade, and of the Board of Works, in carrying out the two plans. Indeed, the former Board have already made known their goodwill towards it.

There are so many things worthy of being named, that we are almost kept back from saying anything, because we cannot speak of all.

The bronze and iron castings show that we have made way; but we must not hold till we have got beyond the Prussians and the French. The iron castings from Coalbrook Dale, from Messrs. Stewart and Smith, and Mr. Messenger, are very good; and the last has sent some good bronzes, as Mr. Hatfield has likewise done.

Messrs Leighton, the book-binders, have sent a few designs by Luke Limber (John Leighton), and some book-covers in papier-maché, which are very ably done, and show that their trade is not behind-hand. Indeed it is perhaps doing more than others to spread taste among the people.

The carvings in wood by Mr. Jordan's machinery are truly wonderful. They are as good as those of Grinling Gibbons, or of any of his school. There is a freedom about them which shows the hand of a master, rather than of a machine.

Mr. Drayton, it will be seen, has brought forward his new way of silvering glass, by which he can now silver the inside of cups and bowls, plain or carved.

The cartoon decorations by Mr. W. B. Simpson are sure to strike the looker-on, for there is a power in them beyond what has been before seen in decorations. The cartoon of "Loyalty," from Mr. Redgrave's fresco in Westminster Hall, is so good, that it seems the handiwork of a skilful painter; and we can hardly believe that it is not so, for it is so unlike what we see in the generality of decorations.

We think this new process very likely to spread a knowledge of art among the people. There are many places where it can be used, and many joint-stock undertakings which will give it their help. For first-class waiting-rooms in railway stations, for board-rooms, for the counting-houses of banks, assurance companies, and docks, it might be well applied. These great undertakings would, we are sure, willingly lay out a little money in what would please the public, and do credit to themselves. A set of likenesses of engineers would fit a waiting-room well. We would name Watt, Trevithick, the two Stephensons, Brunel, and Locke. Many paintings bearing on trade might be shown, as Mr. Lee finding out the stocking loom; Queen Elizabeth giving a charter to the East India Company; Drake teaching ship-building to Prince Henry in the Tower; the Marquis of Worcester likewise in the Tower making a steam-engine; King William giving a charter to the Bank; the Duke of Bridgewater and Brindley overlooking the works of the Bridgewater canal; Arkwright and the spinning jenny; Watt and Dr. Robison making experiments on the steam-engine; Don Ricardo Trevithick directing the putting together of a steam-engine in Peru; Peel, Huskisson, and George Stephenson witnessing the starting of a locomotive on the Liverpool and Manchester railway. Some of these have been already painted, and there are many other subjects shown in Westminster Hall which might be chosen by Mr. Simpson, as an early English trial by jury, Alfred manning his ships, King John signing Magna Charta.

The inlaid work from Messrs. Holland and Sons shows that in this branch the French and Belgians are not before us, and give hopes that we shall in time drive them out of the furniture trade to America. The taking the duty off foreign woods now allows our cabinet-makers to send goods abroad. The only fault we find is with the centres of some of the tables, which in Nos. 7 and 8 are very ugly.

The copy of an antique shield (No. 10) is a favourable specimen of iron casting.

Nos. 11 and 12 are a very good application of papier-maché to picture frames, by Mr. Bielefield.

The papier-maché cheval screen by Jennens and Bettridge has been got up with great labour. It is called in the Alhambra style and decorated with Arabic inscriptions, but we neither like the style nor the composition. We think the labour misapplied. The colouring of the frame, gold upon a warmish white, looks tame without being rich.

Most of the encaustic tiles by Minton and Co. are dull in colour, which arises from the attempt to apply all colours, instead of sticking to those which do best. Mr. Minton has been happier in glazed tiles. We cannot but wish that the old Flemish glazed chimney-tiles, or something like them, were brought out again. An old chimney-corner, with its set of bible tiles or Flemish landscapes is a story-book in itself, and pleasing to old and young. Tiles for walls, with drawings of interesting objects, or with maps, would be welcome in schools and many other buildings.

Mr. Copeland seems a worthy follower of Wedgewood. His works in earthenware are among some of the best in the Exhibition. The taste and care shown in them cannot be gainsaid, and they keep up our fame in this trade, which is worth so much to us. The English earthenware is now the best in the world, and much of it is sent abroad. Indeed, it is a great staple, and worth the more to us as the work and the ware are all our own, only some of the colours being brought from abroad. By the care given to the higher kinds of porcelain, we shall in time be able to put down foreigners in that branch of the trade likewise.

There are so many good works of Mr. Copeland's that we can name very few. An earthenware wash-stand (No. 37) is a very good design. It has a blue ground and white borders tastefully drawn. There are many other jugs and bowls well worthy of praise. The wash-stand No. 88 we do not like so well; its effect would depend wholly on the hangings which might be used in the room. The enamelled porcelain cups and saucers, Nos. 139 and 140, show the resources of the establishment in decoration.

The chimney slabs show the progress which has been made in the application of porcelain and painting for this purpose. The lock-furniture and bell-lever, likewise in porcelain (No. 170), are richly ornamented with gold. Porcelain is now being much used by builders, as is likewise glass for ornamental purposes.

The large collection of works and groups in statuary porcelain shows Mr. Copeland's power in what may be considered a more purely artistic department. This material has been employed by the Art-Union for prizes, and promises to be very useful in spreading a knowledge of the works of our best sculptors, for in effect it comes near marble, and in cheapness near plaster. It takes a middle place between marble and plaster, and being more lasting than the latter, is likely to be very much used by the middle classes. We fear, however, that it will give us in sculpture a school of statuettes, as we have in painting a school of cabinet pictures, and so far draw away the public mind from high art. Still, we welcome the statuary porcelain and the Parian as a good beginning, and we can take the evils when they come with the less remorse, as now sculpture is far from being in the most palmy state. This kind of copy promises likewise a better reward to the artist, for marble is a material costly in itself and hard to work, and therefore the sculptor gets few orders for a good study, and few are fond of casts. Now, a small gallery of groups can be had for a very small sum, and no one need be ashamed of having such works in his drawing-room. Among Mr. Copeland's productions we would notice the Narcissus, after Gibson (No. 209); Innocence, after J. N. Foley (No. 210); Paul and Virginia, after Cumberworth (No. 211); the Return from the Vintage (No. 212); Apollo, after Wyatt (No. 214); Cupid chained (No. 218); and Ondine, after Pradier (No. 219). The busts do not tell so well.

The Cupids holding a Tazza (No. 182) is a very good design for a flower-stand, in statuary porcelain.

Mr. Copeland is very successful in the Portland jug (No. 202), of the same material.

Another work of his we shall name is the Armada bottle (No. 217). We are likewise pleased with this vase after Cellini (No. 223).

Messrs. Chamberlain, of Worcester, have sent some very gorgeous porcelains, gilt, painted, and enamelled.

Mr. Magnus, of the Pimlico Slate Works, has sent slate chimney-slabs, likewise table tops, which are worthy of notice by builders.

Mr. Pratt's Anglo-Etruscan vase, in the Great Room, is very praiseworthy.

The prize candelabrum must be the work of an architectural student, and have been chosen for the prize by an architect. It is what some architects call classical, and what other people call tame, stiff, and bald. We think the prize is thrown away, and we should have been much more pleased with a copy of one of the candelabra in the British Museum.

The prize lamps are not much better. They may catch some eyes, being in silver, but are poor and common-place. We wish there had been more designs for silver-plate. One very good is No. 348, an adaptation of the trumpet lily for a dessert-stand.

The papier-maché productions to our mind show much more splendour than taste. They are too much in the gewgaw and Vauxhall way.

The "Repose" arm-chair (No. 242), is very unluckily named, for there is no repose in its composition, and there can be none within its arms. Mr. J. C. Horsley is the designer, but his skill is quite thrown away, for the reliefs have no effect. The terminal figures, in whatever material they may be finished, will be indistinct.

Mr. Nicholson has shown a very elaborate shell cameo (No. 258), but the subject is too complicated, and therefore indistinct. Miss M. A. Nichols has sent five imitation cameos. Cameo cutting is worthy of care, for in Paris it gives work to many hundred men.

The glass works (Class XII.) are so very good that we hope they are an earnest of our making a great trade in glass, and becoming free from the Bohemians and Germans.

The Decorative Art Society is doing so much good, that we look forward to see some other society raised which shall take in a lower class of workmen. There is room for a great deal to be done, and we feel very strong hope from what we call the small exhibition of the Society of Arts—small because we are sure we shall soon see much larger exhibitions held under its care.

INDIAN RAILWAYS.

Indian Railways and their Probable Results, with Maps and an Appendix, containing Statistics of Internal and External Commerce of India. By an Old Indian Postmaster. Third Edition. London: Newby, 1848.

We are now in 1848, and Indian railways remain where they were, though the East India Railway Company has got a guarantee and leave to begin. This is a hard lesson, but one which is of no good so far as the present is concerned, and will, we fear, be found little better in the future. Governments are not ready scholars, even in the matter of revolutions. We have always upheld the freedom of joint-stock undertakings, as the best safeguard against speculation and the want of it. The East India government were fearful in 1845 of the gambling madness of the times. Scheme after scheme was brought before them, money was held out freely, but they drew back frightened, and set themselves down in what they held to be a quiet and orderly way, to lay down rules on which railways should be carried on and shareholders should pay their money. Following in the path of the Board of Trade here, they sent out to India a railway board, with Mr. Simms at its head. He did his work as well and carefully as he could, and sent home some long blue-books, from which, however, we are sorry to say, we have learned no more than we knew before, so that they have in no way put railways forward one inch. Everything has to be tried still; Mr. Simms has given us no answer as to embankments in the valley of the Ganges, long bridges over the streams, how wood will serve for sleepers, how works are to be carried on, nor one single point in engineering has he settled,—and from no fault of his, because experience is the only guide and judge. Therefore, three years have been lost on this head, and instead of beginning with three or four years' experience, we are as far behind-hand as we were before. It is during the first three or four years that the greatest changes are made, because it is the time of experiments; every day shows something, and instead of trying to settle the engineering of India before-hand, a wise man would wait for practice to guide him in fixing any lasting system.

India has needlessly lost so many years of railway transit; by this time the traffic of the Ganges would have had some small help from railway works. Perhaps a couple of hundred miles of railway would have been open; and if only so much, or even less, still the results would have been great, because each hundred miles of railway is the saving of a day in the communication with the upland. The opening of a railway would have been felt by the steamboats, and more of them would have been put on the river, while branch roads would have been laid down to reach the railway. The making of a railway is, as is well known, only a small part of the good which is to arise. The railway will be the trunk towards which steamboats will run, and roads be made. The traffic will be always growing, so that at each step food for new railways will be found. The steamboats have shown this, though not so much. At first six small steamboats were run, sometime after six more, and latterly six large steamboats have been put on, and there is a call for more. All are paying well, though there is more than four times the power that was in the first instance held needful. We have heard of railway carriages carrying their own railways with them, but it may be said of Indian railways that they will carry their own traffic with them.

When we come to the money part of the question, and say that three years have been lost, we do not give a right idea of the evil which has been done. Time in the share-market cannot be trifled with, and cannot be got back again. The fatal event of Louis Philippe's death or fall has been long hanging over us; it was known that it must happen, and that when it did the share-market would be utterly upset. Never was it so needful to make hay while the sun shone; the storm was hanging about, it was looming in sight, and there was no time to be lost. In the years 1845 and 1846, any money could have been raised; in the years 1847 and 1848, no money can be raised,—and who dares look forward with hope?

If the share-market were as law-makers wish it, and as they have tried to make it, it would be very well; but unhappily it is not so. It does not work so smoothly as they think it may; it has its ebbs and its floods; sometimes setting in with a full tide, whirling and eddying round, the waters rising to the top of the flood, then the stream pouring out with a quick rush and leaving all bare. People were wonder-stricken that there should be gambling in 1846, as if there never were before; and though they were quite ready to say that a heavy fall would follow, they did none the more wisely. Time has shown that while share-gambling is going on, railway-making is going on; and when share-gambling is at an end, money cannot be raised even for the most useful undertakings. There is a cloud hangs over all, the good and the bad; and though those who have helped to make the storm worse may wish it otherwise, the good feel it as much as the bad.

While the share-market flourished, and the East India government were besought to give their leave for the railways to be begun, they stopped short, as if they had time in their own hands, and could wait as long as they pleased. They have so often set up kings in the east and put them down—they so often send out their word, and a mighty kingdom springs up or is cast down, that they thought they had only to speak, and railways would be made whenever they liked. Had they then, as they were told, given the lines without guarantees, the money would have been raised; whereas now, even with a guarantee, the undertakings linger, and, as we have said, how long they may linger no one knows. The share-market when once shaken does not recover at a fixed date; it is not within the power of any one to know when it will recover, while the shock is now very great. The banks throughout Europe are breaking, the hoarding of gold and of silver has begun, money will go out of sight, war may spring up, the government may give as formerly six or seven per cent. for loans, and then the common returns of joint-stock undertakings do not hold out hope enough to the shareholder or lender.

By the blundering of the government has the welfare of India been threatened, and it is only by acting otherwise than they have done, that they can stop the evil from spreading further. India has felt a great loss in the want of railways, but if she is to be kept without them for years, the mischief which will be done will be great. India has to struggle in trade with America and the West Indies, where railways and steamboats are widely spread; and unless India have the same help, she cannot keep up in trade against them. India can raise cheaply—none can beat her; but so much time and so much money is spent in carrying goods to market, that they come dear and bad, instead of cheap and good.

It will do little for India that English gold is now not likely to be sent abroad to France, Flanders, Italy, and Spain for railways; shareholders are sick of them, and will be afraid to have any thing more to do with them. This is however no help, we fear, for India, for the call for money at home cannot be met, as so much has been lost.

Among the undertakings which were brought into the market in 1845, none hardly were more useful than that of the East India Railway Company, for making a railway from Calcutta for 800 miles up the valley of the Ganges. Mr. Macdonald Stephenson, its managing director, gathered together all that could be learned in India, and in his works gave the heads of what Mr. Simms has written since. There was quite enough to show the likelihood of the undertaking, and when it was brought forward it was hailed by the leaders of the money market as a railway well worthy of their help. The heads of the East India Railway Company were some of the richest merchants here, and there was such trust given to it that its shares rose very quickly in price.

Thanks to the Board of Trade, the Company was withheld from taking more than five shillings a share when they could have had two pounds; so that now, instead of having some hundreds of thousands of pounds in hand, enough to make a good beginning, they have hard work to raise a hundred thousand pounds, which is to be lodged with the East India Company.

The East India Company has in the end given to the Railway Company leave to go on, and offered a guarantee of interest, which in 1845 or 1846 would have sent up the shares to such a price as to have made them among the best in the market. There were then no shares in the market guaranteed by any of the English governments, and such was the call for guaranteed shares that those guaranteed by the great railway companies were eagerly sought. Therefore the market was clear for the Indian railway shares, and nothing but the utter blindness of the government kept India back at such a time. On what good grounds it could have been done no one can readily see, for India is always in want of money, and when there was a hope of getting it from England it should not have been let slip.

We have still the utmost trust in the East India Railway Company, for we believe that the line must be made, and we hope therefore that everything will be done at once to help it on. We see no good in leaving a hundred thousand pounds in the hands of the government, that should be dropped at once. The Company should likewise have full power to borrow money here and in India, in whatever way they can. If there be any need of it, the government of India must lend them money to begin, so that they make a start, for there is no time to be lost. If there should be a war in Europe, and the overland way to India be stopped or hindered, then it will be still more needful that there should be a quick transit between Calcutta and the north-west.

On these grounds we say to the East India Railway Company "Hold on;" for if the government do their share, the undertaking will become one of the first in the world. Much of the railway can be readily made, and as cheaply as those of America, while it has only to be opened to have a good income at once. We have always believed, and we do still, that when a start is made, a great deal of money will be got from India: India finds money for banks, assurance companies, steamboats, coal mines, indigo works, sugar mills, and tea plantations, and we do not see why she should not for railways. The Indian mind is awakened. What has been seen of late years has laid the way for railways. The steamboat has shown the Hindoos that speed can be got, that goods can be brought up quickly, and they are ready to believe that railways will do for them what it has been held out they can do. India waits only for a beginning, and then railways will spread as many arms over the land as they have in England or America.

In Southern India the companies are still less ready to begin work, so much have they been weakened by the loitering of the stand-still government, but as railways are fully as needful there as in Bengal, we hope very little time will run before steps are taken to bring them forward. The growth of cotton in Bombay and Madras is kept back by the want of railways, and a little help only will enable the merchants and people of those two presidencies to make their own railways. They have come forward most warmly, and although their late losses have lessened their means, they will be found ready to follow up the lead of the government.

Railways in India must be made, and they must be carried out as joint-stock undertakings; for whatever may be the want of power of these latter now, the government in India are no stronger, and always find it hard to raise money. Let us hope, as so much blame belongs to them for the hindrances they have hitherto thrown in the way of railways, that they will see good to make a change, and do all they can to make up for lost time. If they do not do it of themselves, the parliament of England must do it for them; for if the cotton-growers of India cannot be heard there, they will be heard here, and the cotton-weavers of Manchester have already spoken out. We cannot be left in the power of America for the cotton, on which our great staple manufacture depends, and whereby so many Englishmen earn their scanty livelihood.

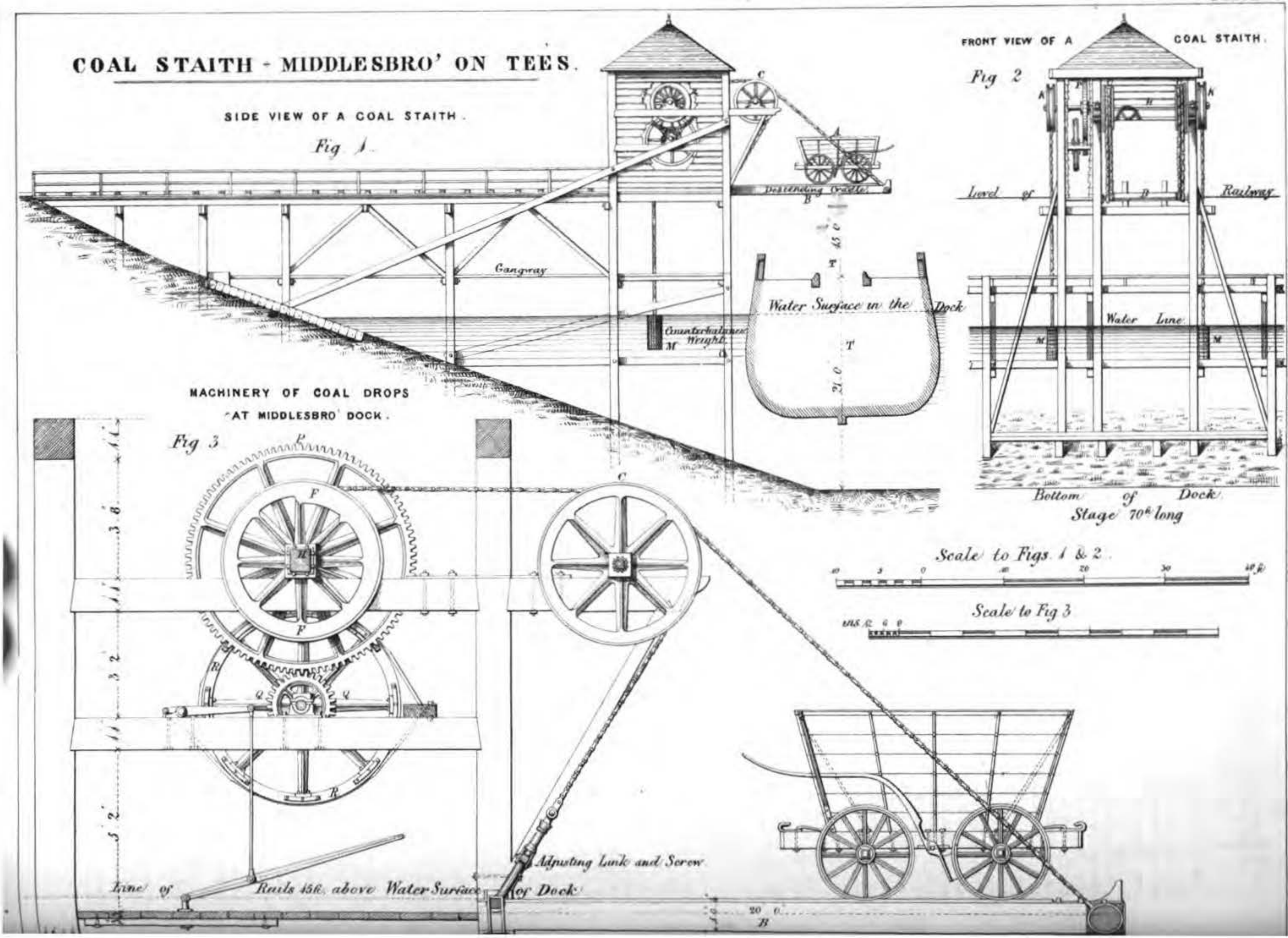
The third edition of the book before us is on the same plan as those that went before it. It is enlarged by some new extracts, which are put together without any great regard to order, and the staple is still from the works of Mr. Macdonald Stephenson. The right title would be "Indian Railways from the works of Mr. Macdonald Stephenson, with other matter by an Old Indian Postmaster." Except Mr. Stephenson's materials, the best thing in the book is a map of the lines of railway in Northern India.

THE WICKSTEED ENGINE.

Mr. Wicksteed was the first to introduce the Cornish engine into the metropolis, and he deserves great credit for his exertions. The first engine was put up about four years ago, when a description of it was published in this *Journal*. The second, which is larger, is named the Wicksteed engine, and is erected at the East London Water Works. It was started to supply water to that company's district in June 1847, and is the largest engine hitherto erected in London; it was designed by Mr. Wicksteed, who is engineer to the company, and was erected under his superintendence. It was manufactured by Messrs. Sandys, Carne, and Vivian, of the Copperhouse Foundry, Hayle, Cornwall. The diameter of the cylinder is 90 inches, the diameter of the pump 44 inches, length of stroke 11 feet, and it pumps 20 imperial barrels at each stroke. When working at the rate of eight strokes per minute, it raises 5,792 gallons per minute, or 8,340,480 gallons per diem, or 84,563,200 imperial barrels per annum. The power when working at this speed is 200 horse-power. The main beam is 39 feet long, and weighs 33 tons—it vibrates on a cast-iron main gudgeon 16 inches diameter, and the whole is supported by four columns and an entablature of cast-iron, designed in the Grecian-Doric style. The plunger with its appendages weighs 43 tons, which mass of matter is raised 11 feet high at each stroke of the engine. The pump-work is supported by two iron girders weighing each 10 tons, and is strongly bolted down to a mass of masonry in the foundations. The boilers, four in number, are cylindrical, 34 feet long, 6 ft. 6 in. diameter, with an internal fire-tube four feet in diameter. The diameter of the steam-pipe is 16 inches.

The total weight of the engines, pump-work, and boilers is 414 tons, and the whole cost was £10,000, or £50 per horse-power, or about £24 per ton.

The quantity of coal consumed by this engine, if working at full power night and day, would be 2,000 tons per annum, and the quantity of coals that would be consumed by the best of the ordinary non-expansive engines in doing the same work would be 4,500 tons; showing a saving in favour of the Cornish engine of 2,500 tons, which at 13*s*. per ton is £1,625 per annum, or 16¼ per cent. upon the cost of the engine for coals only.


COAL STAITH - MIDDLESBRO' ON TEES.
SIDE VIEW OF A COAL STAITH.
Fig 1.
Gangway
Descending Cradle
Water Surface in the Dock
Counterbalance Weight
FRONT VIEW OF A COAL STAITH.
Fig 2
Level of Railway
Water Line
Bottom of Dock
Stage 70ft long
MACHINERY OF COAL DROPS AT MIDDLESBRO' DOCK.
Fig 3
Scale to Figs. 1 & 2.
Scale to Fig 3
Adjusting Link and Screw
Line of Rails 45ft. above Water Surface of Dock

COAL DROPS, AND MIDDLESBOROUGH DOCK.

(With Engravings, Plate VI.)

Account of the Drops used for the shipment of Coals at Middlesbro'-on-Tees, with a description of the Middlesbro' Dock. By George Turnbull, M. Inst. C. E.—(From a paper read at the Institution of Civil Engineers.)

The dock was commenced in the spring of 1840, and was opened for trade on the 12th May, 1842. The general form of the dock and its position with respect to the river Tees will best be understood by reference to the annexed engraving. It possesses an area of 9 acres at the water surface; the approach is by an entrance channel, rather more than a quarter of a mile in length, cut through the sand banks of the river, and kept open by means of occasional sluicing from the lock-gates, and also through culverts built in the lock walls for that purpose. Some apprehensions were entertained of the practicability of keeping open the entrance channel by these means, as there is much shifting sand in the bed of the river Tees, and every interference with the current of the river produces marked alterations in the form and position of the shoals or sand banks. After due deliberation, the scheme was at length carried into execution, under the sanction of the Tees Navigation Company, and the result has been marked with the complete success which was anticipated by the projectors; the channel was dredged out to its full depth, the slopes and banks were covered with a paving of rough chalk and stone, and after a trial of nearly three years the channel is now in a better state than when it was first made, and is kept up at a very trifling cost.

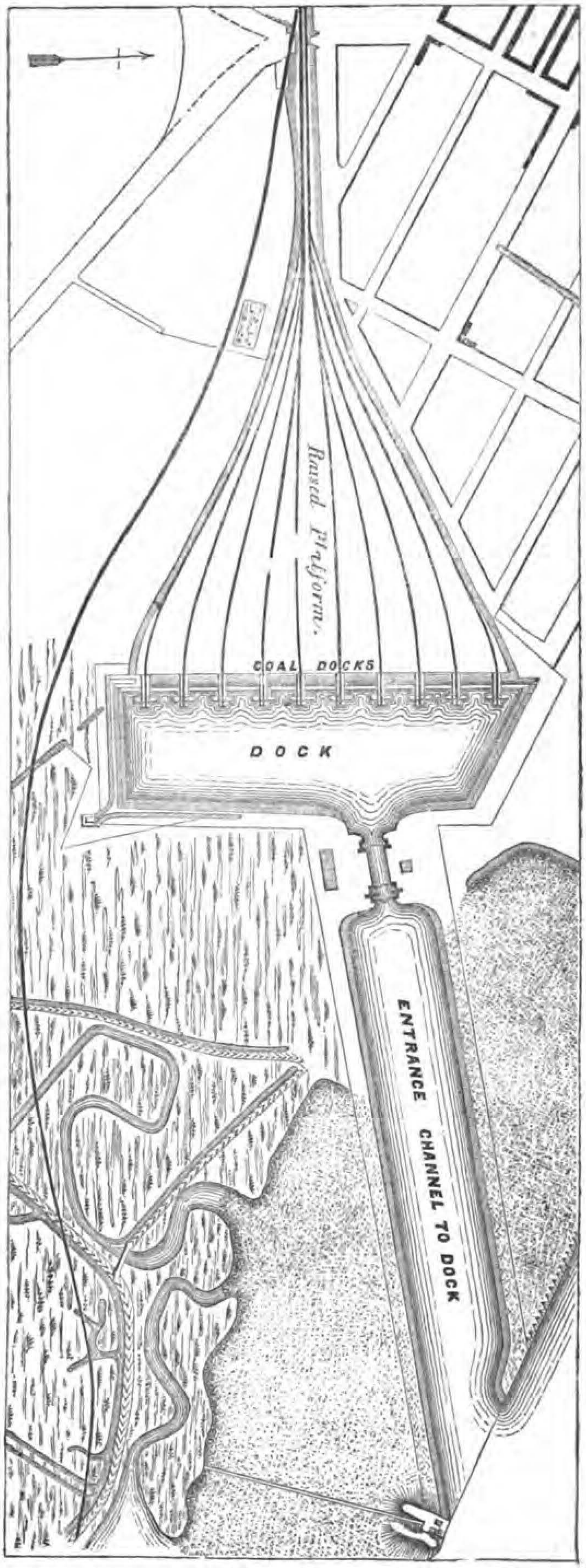
The entrance lock is built principally on a foundation of hard sand, and on account of the quantity of water found in it, an unusually large proportion of piling and wooden platforms were required in the foundations. The lock is built of stone, chiefly from the Byker quarries, on the river Tyne; it is 132 feet long and 30 feet wide; the depth of water is 15 feet at neap tides and 19 feet at spring tides: the bottom of the dock was excavated to the depth of 3 feet under the level of the lock cills.

In connection with the dock, a branch line was laid down, diverging from the Stockton and Darlington Railway and terminating in ten double lines, leading to the ten drops (1 to 10) situated on the west side of the dock. The raised platform of a triangular shape, covered by these diverging lines of railway, comprises an area of 15 acres, and affords spare room for 1,200 loaded wagons, or more than 3,000 tons of coal, besides means of egress for the locomotives with their trains of empty wagons. This great amount of standing room forms a principal feature in the arrangement of these works, as in the district, of which this is the shipping port, there are numerous descriptions of coal, several of which come down the railway in the same train; a separation is made on the platform, and each colliery having its own drop assigned to it, the wagons, with the proper description of coal, accumulate in one branch, and descending along the railway, which is so inclined as to permit the wagons to move by their own gravity, the shipment is carried on with much facility. An inclination in the contrary direction is given to the empty line, sufficient to allow the unloaded wagons to move of themselves, by which means some saving of horse labour is effected.

The cost of all the works connected with the dock, including the branch railway, raised platform, permanent rails, dock work, entrance lock and channel, and breastworks along the shore of the river Tees, with the ten coal drops, amounted to the sum of £122,000.

These works were designed by Mr. W. Cubitt, V. P., and the author was the acting or resident engineer.

The coal drops are peculiar in their construction and are probably not much known beyond the district in which they are used; they are distinguished from the drops in common use on the Tyne, by the coal wagons being lowered perpendicularly to the ships' decks, whereas in the latter the wagons are lowered by means of a cradle and vibrating frame, which describes the arc of a circle in its descent. In places where the wagons have to be lowered from a height of 30 feet and upwards to the ships' decks, which is a common circumstance in the Tyne and the Wear, the vibrating frame (originally invented by the late William Chapman of Newcastle) are found well adapted for the purpose; but where the height is limited, or where the railway is so low that the wagons are just clear of the taffrail of the light ships, the perpendicular drop becomes more convenient. This ingenious contrivance was first suggested to the Clarence Railway Company by Mr. George Leather, of Leeds (M. Inst. C. E.), and was carried into effect at



Port Clarence on the river Tees, where several of them have been in use for some years, and are very effective.

The ten drops erected on the west side of the Middlesbro' Dock are almost similar, in every respect, to those at Port Clarence. The principle of their construction and mode of operation will be readily understood by a reference to the engravings, Plate VII. Fig. 1 shows a front elevation, and fig. 2 a side elevation of the drop and its machinery; fig. 3 shows the machinery, with the cradle and wagon, drawn to a larger scale; the same letters refer to the same parts in the different drawings.

The wagon A, weighing about 30 cwt., and containing one chaldron or 53 cwt. of coal, is shown standing on the moveable stage or cradle B, which is suspended by means of chains passing over the sheaves C, C; the ends of the chains are attached to the large sheaves F, F, the latter being cast with grooves of unequal depth, to accommodate the two chains, which it will be seen are of unequal length, and require a corresponding inequality in the sheaves, to preserve the cradle in a horizontal position. These sheaves are fixed on a strong iron axle H, on the extremities of which are two other sheaves or pulleys K, K, to take the chains which sustain the counterbalance weights M, M. The break machinery for lowering the wagons consists of the toothed wheel P, 7 feet diameter, fixed on the same axle H; the pinion-wheel Q, 2 feet diameter; and the break-wheel R, 6 feet diameter, having a break over its whole circumference, worked by a strong lever-handle, which controls the descent of the loaded wagon, and its ascent when empty.

When the machinery is at work, the loaded wagon is run on to the cradle, or stage, B, and is stopped by wooden chocks in its proper position, directly over the hatchway of the vessel to be loaded (T, T, fig. 1.) The breaksman then releases the break-wheel, when the cradle and wagon descend perpendicularly, the suspending chains winding off the sheaves F, F, the counterbalance weights rise, and their suspending chains wind on to the sheaves or pulleys K, K. The cradle, with the wagon upon it, still maintaining its horizontal position, having nearly reached the ship's deck, the contents are discharged by a man who descends with it for that purpose; the counterbalance weights then have the preponderance and the operation is reversed, by the weights descending and the empty wagon and cradle rising to their original position. The whole is so guided and controlled by the breaksman, and the counterpoise weight so adjusted, that the wagon can be made to descend and ascend quickly or slowly, or be stopped with ease in any position, either ascending or descending.

The drops at Middlesbro' Dock are constructed of strong wooden framework fixed on Memel fir piles, and the cost of the ten drops was £7,300, or £730 each, including all the timber, iron-work, machinery, and the labour in fixing.

Each of these drops can ship a wagon load of 53 cwt. in a minute, or about 150 tons in an hour; but as the coals cannot be trimmed off so quickly in the ship's hold, about thirty wagons an hour may be taken as the ordinary rate of working. Forty wagons, containing a chaldron each, which are = 5 keels or 106 tons an hour, may be considered the limit of working.

In the year ending 1st July, 1845, 505,486 tons were shipped by means of the ten drops here described. The shipment in the six months ending 31st December, 1845, amounted to 264,180 tons.

ON THE RESISTANCE TO BODIES IN FLUIDS.

On the relation between the Velocity and the Resistance encountered by bodies moving in Fluids. By John Mortimer Heppel, Grad. Inst. C.E.—(Read at the Institution of Civil Engineers.)

The determination of the relation between the velocity and the resistance encountered by bodies moving in fluids, has always been an interesting topic of inquiry, as well to the speculative philosopher as to the practical mechanist, and perhaps on no portion of physical science have more pains been spent; whether looking to the sagacity with which experiments have been devised, the liberality with which they have been carried out, or the mathematical acumen with which their results have been classified and brought under general laws. To enumerate the names only of the men, illustrious by their science, who have brought their energies to bear on this subject, would fill a larger space than these few remarks are intended to occupy. It is sufficient to mention Newton, who in this, as in so many other departments of philosophy, first shed the light of his brilliant genius on the former obscurity;—after him the scarcely less celebrated Daniel Bernouilli, and in latter times Bossut and De Buat, whose patience and accurate research opened such a multitude of observed facts to the contemplation of the theorist. Again, the valuable experiments of the French Academicians; the indefatigable labours of the late Colonel Beaufoy, so liberally made available for the objects of science by his son; and lastly, though not among the least, must be mentioned the excellent experiments on canal boats by Palmer and Macneill, given in the Transactions of the Institution (vol. I. pp. 165-237). After such a retrospect it may appear presumptuous in a young and unknown individual, attempting to add anything to a subject already enriched by such contributors; as his remarks, however, are brought in an humble and modest spirit, and so far as he is aware, have not been anticipated by any precisely similar, he begs to lay them, without further introduction, before the Institution.

It will no doubt be recollected, that in the cases already glanced at, the almost invariable method of experimenting has been to attach a weight, or other known motive force, to the body in question, and to determine, by direct observation, the quantity of this, corresponding to an uniform velocity of progression. From this method it has necessarily followed, in most instances, that the bodies subjected to experiment were of moderate dimensions, and the theoretical views derived from the observations, have been extended to those which from their magnitude have been placed beyond the range of direct experiment. In the experiments of Palmer and Macneill, the same mode of proceeding was adopted, by applying the dynamometer to boats moving on canals, and from the magnitude of the scale of these experiments, as well as from the care and accuracy with which they appear to have been conducted, they must be very valuable. Gigantic, however, as these bodies were, as compared with those which had previously been brought under investigation, they become dwarfs in respect of the vessels, the knowledge of whose properties is every day becoming a matter of deeper practical importance. It has often surprised the author, that these vessels themselves had not been made the object of experiments, with reference to this question, and more especially, if it can be shown, as is here attempted, that those propelled by steam, more especially, unite all the conditions requisite for obtaining easily and simply, accurate and important results. The form, however, of these experiments, must differ from that of former ones, as the tractive power requisite to maintain a high velocity, in such large bodies, would be far greater than could be conveniently disposed for such a purpose.

There is, however, another no less certain mode of inferring the amount of resistance encountered by a body, which is, to remark the diminution of velocity produced in a given small portion of time, when the body is exposed to the action of this resistance alone, from which diminution of velocity, the force which produced it may be inferred with mathematical precision. Let it be presumed, in the first instance, that the velocity with which the vessel is at any instant moving through the water, is capable of being measured and observed; then having set the vessel in motion, with a given velocity, let the action of the motive power be stopped. The only forces to whose action it will then be exposed, are the resistance of the water and the air, of which the former will be by far the more considerable; but of both of which it will always, under ordinary circumstances, at the same velocity, have the same amount to encounter, and whose amount therefore constitutes the obstacle to be overcome by the motive power, and determines the quantity of that power always required to maintain that velocity. From the instant when the engines are stopped, the speed of the vesssel will obviously diminish, and let the amount of its diminution during some small interval of time, say a second, be noted; that is to say, the difference between the velocity at the commencement and at the end of that interval. Now if the vessel had been subjected to the action of a force equal to its whole weight, the amount of velocity destroyed in a second would have been 32 feet per second, therefore, as 32 feet is to the observed loss of velocity in feet per second, so is the whole weight of the vessel, as shown by its displacement, to the force by which this loss of velocity has been produced; that is, to the united resistance of the water and the air, corresponding to the velocity in question. It is here assumed, that the force of resistance, for the small period of the observation, may be regarded as uniform; a supposition which is not precisely true, as the resistance diminishes with the velocity; the smaller, however, the interval of time which is taken, the nearer will this supposition be to the truth, and if the inferred resistance be taken to correspond neither to the initial nor the final velocities, but to their mean, the error will become infinitesimal. A more important source of error would be found in the circumstance of the resistance of the paddles, or the screw, where they are arranged so as to be disconnected, being included in the determined resistance; and in these cases, this would have to be allowed for and be deducted. As however the resistance to flat surfaces has been so fully investigated, this would occasion little difficulty. An example perhaps will serve better to render the foregoing proposition clear. Suppose a vessel to be going through the water with a velocity of 15 feet per second, and on the stopping of the engines, the speed be observed in one second to sink to $14\frac{1}{2}$ feet per second, the velocity destroyed in one second of time would be equal to 6 inches; this is $\frac{1}{64}$th part of the velocity which would have been destroyed, in the same time, by a force equal to the weight of the vessel, and the force which destroyed it is therefore equal to $\frac{1}{64}$th part of that weight. Now suppose this, as ascertained from the displacement, to be 1,000 tons, then the mean force of resistance between the velocities of 15 feet and $14\frac{1}{2}$ feet per second is $\frac{1000}{64}$ tons, and the power expended in overcoming this resistance, at the mean between the two velocities, or $14\frac{3}{4}$ feet per second, is—

$$\frac{1000 \times 2240}{64 \times 550} = 63{,}36 \text{ H.P.}$$

Having thus described the mode in which the observation should be conducted, it may not be uninteresting briefly to notice the advantages which might result from a well-arranged set of experiments on this plan.

In the first place, it would offer an infallible means of testing the qualities of any particular vessel, apart from those of her machinery; since the action of the engines being stopped during the observation, has clearly no influence whatever on the rate of diminution of the velocity. The observer would thus, in case of any deficiency of speed, be enabled to fix the fault with certainty upon the vessel, or the engines, as the case might be. Indeed, if all vessels were submitted to the observation here described, there seems to be no reason why their resistance should not be as precise and definite a quantity, and as capable of accurate expression for any particular draught, as their displacement; and it might be confidently asserted, that the vessel which in this way showed the least resistance, ought to beat all others *cæteris paribus*, and if she were not found to do so, that the fault was either in the engines, or in the propelling apparatus, and certainly not in the ship.

This however, though one advantage, would not be the only one, as a series of observations made upon the same vessel, at various velocities, could hardly fail to demonstrate some expression or law of relation, between the observed velocities and the resistances, which if found to be uniform within the limits of the experiment, might fairly be presumed to extend to some distance beyond them, so that there would be a strong ground for predicting, with confidence, the increase of speed which might be expected to result from any proposed increase of power.

Again, if these observations were repeated for various draughts of water, in the same vessel, the means would be furnished of knowing, *à priori*, the precise amount of power which should be necessary for maintaining a given speed, with any required load. Or if the power remained constant, what would be the speeds which should correspond to various loads, and as before, if the performance of the vessel should fall short of what had been so determined, the fault would be in the machinery.

It may be mentioned, that although hitherto no opportunity has been afforded for testing the correctness of the views here propounded, by a practical application of them to the point in question, yet the author has on several occasions adopted a method, similar in principle, in determining the resistance of shafting and machinery, by observing the rate of diminution of the velocity, on shutting off the steam from the engine, and having had good reason for believing the results, in these cases, to have been tolerably accurate, in spite of the difficulty of correctly estimating the aggregate momentum of so many bodies revolving at various velocities, he is encouraged to suppose, that in the case of a floating body, whose momentum is so easily and precisely ascertainable, the result would be more exact and unquestionable.

The method adopted by M. de Pambour, for ascertaining the amount of resistance to the motion of railway trains, by the circumstances attending their descent and stoppage upon two consecutive inclined planes, is based upon precisely the same principle as that here advanced.

It remains only to consider, by what means the variable velocity of the vessel can be measured, so as to ascertain it, at any instant, with the necessary precision. In the absence of a better, the following arrangement might perhaps be adopted with advantage:—

To the bowsprit of the vessel (Fig. 1), sufficiently a-head to be beyond the disturbed water, should be screwed a small iron bracket, carrying a pin, which should pass through a hole in a slender rod, hanging down below the surface of the water, and prolonged a few inches upwards above the bracket. Upon this rod,

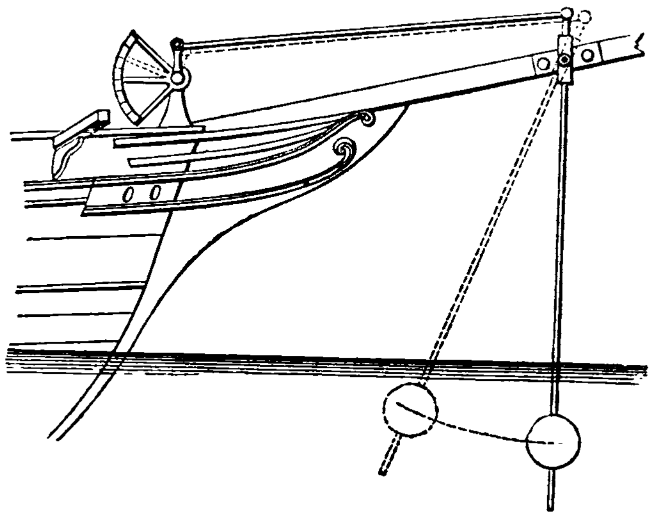


Fig. 1.

a metal sphere should be fitted, so as to be fixed at any required distance from the point of suspension; from the upper extremity of the rod, a small cord or wire should be brought, passing to some convenient spot on the fore-part of the deck, where it should be attached to one arm of a rectangular lever, whose other arm or index should move along an arc of metal.

It will be clear, that when the vessel is at rest in the water, the rod, with the sphere attached, will hang vertically, and the cord being properly adjusted, the index of the bent lever will be horizontal, at which position the zero of the graduated arc should be marked. If the vessel moves through the water, the resistance on the sphere will throw the rod out of the perpendicular, as indicated by the dotted line, and the angle which it makes with its former position, will be shown by the new position of the index on the metal arc. It is obvious, therefore, that the same degree of deflection will always be produced by the same resistance, and the same resistance by the same velocity. So that if the arc has once been carefully graduated, by moving with known velocities, which would have to be done once for all, it would always afterwards furnish a correct indication of the velocity with which the sphere, and consequently the vessel, was moving through the water, at the instant of observation. A slight consideration of the nature of this apparatus in action, will make it apparent that the position of the ball, or sphere, on the rod is indifferent, and that the same angular deflection will always correspond to the same resistance. This would contribute to render the arrangement convenient as being applicable to vessels of various heights.

The mode of using this apparatus is obvious; an observer, with a seconds watch, would note the positions of the index on the arc, at such intervals of time as should be determined upon, when the diminution of velocity and consequently the retarding forces would become known, as before described.

Mathematical expressions have in the course of this paper been expressly abstained from, as being unnecessary to a general view of the method proposed. It may however not be out of place to remark, that perhaps the best way of treating the observations when obtained, would be to endeavour to discover an expression, representing accurately the velocity in terms of the time, in which case, its differential co-efficient would be accurately proportional to the resistance.

Remarks made at the Meeting after the reading of the above Paper.

Mr. Scott Russell said he could not venture, without more careful consideration of the subject than was permitted by merely hearing the paper read, to draw any comparison between the results stated by the author and those which he had arrived at from the extensive series of experiments he had made; but his first impression was, that the method proposed was not the most direct, and that it was liable to several objections. He doubted whether there was a sufficient knowledge of the resistance of flat bodies moving through fluids, to enable the portion of resistance due to the floats of the paddle-wheels, in a state of rest, to be separated, in the general result, from the resistance due to the body of the vessel. Assuming such to be the case, he must contend, that unless some means existed of raising the paddle-wheels out of the water, simultaneously with stopping the engines, an accurate result could not be arrived at. The screw propeller offered greater facilities, as he believed methods had been devised for raising it out of the water. He was of opinion also, that unless the experiments were tried in perfectly smooth water, they could not give accurate results, on account of the dipping of the bow of the vessel, and the consequent oscillation of the suspended sphere and rod, which would become a pendulum. These were practical objections, which were raised in his mind, by the difficulties he had experienced, in determining the method of conducting his own experiments, which were all tried upon vessels of considerable bulk and tonnage. The mode he eventually adopted was, to try the vessel both light and loaded. First taking all the float-boards off the paddle-wheels, and by means of a steam-tug, of about 250 h.p., drawing the vessel through the water, ascertaining the resistance at different velocities by means of a dynamometer; then, by replacing the float-boards, varying the load, and consequently, the immersed section of the vessel, and noting carefully all the results, he found an extraordinary uniformity in the amount of resistance by similar forms at equal speeds. At first he conceived, that it would have been necessary to reduce all the oscillations of the dynamometer, but he found the motion was so uniform, that any ordinary instrument would suffice for the purpose. He used an instrument, called Pitot's tube, for measuring the velocity, and he had found it very valuable; he might say almost unerring. It consisted of a vertical glass tube placed in the centre of the vessel, through the bottom of which a hole of about half an inch diameter was bored, to pass a metal tube, continuing for a distance horizontally beside the keel, and terminating in a funnel-shaped mouth. When the vessel was at rest, the water outside, and the column within the tube, stood at the same level; but in proportion as the velocity of the vessel increased, so the column of water in the tube rose; and by graduating the tube in accordance with observed heights for given speeds, the results might be read off with great facility and accuracy. Any undue amount of oscillation was prevented, by contracting the area of the metal tube at one spot, by a stop cock, which was only opened when taking observations. He thought the method he had described, combined with the use of Pitot's tube, was preferable to that proposed by Mr. Heppel.

Mr. Rennie concurred with Mr. Russell in his opinion of the proposed method of experimenting. No subject was more difficult than the resistance of fluids. It had occupied the attention of the most learned philosophers, yet nevertheless the present state of knowledge of the subject was still very imperfect. The true theory had never been discovered. Newton to whom, after Galileo, the credit of the first precise experiments was due, had also given the first of the two theories, of which the least imperfect supposed the body to be directly struck by each of the molecules in motion. The subsequent experiments of Bernouilli, Euler, Robins, Borda, Bossut, De Buat, and others, had shown the imperfection of that theory.

The experiments of the French Academy, and the labours of Bouguet, Clairbois, Duhamel, Don Juan, Chapman, Forfait, Attwood, Dupuis, Poisson, and others,[1] had shed considerable light on the subject, and on that of the stability of floating bodies; but no extended series of experiments was tried in this country, until the question was taken up by Colonel Beaufoy, who in 1791 established a "Society for the Improvement of Naval Architecture," under whose auspices be made, in the Greenland Dock, the elaborate experiments, the first portion of which had been so munificently presented to the scientific world by Mr. Henry Beaufoy.[2] The society however sunk for want of funds, and the experiments were eventually conducted and brought to a conclusion, entirely at the expense of Colonel Beaufoy. A short notice of them in Thomson's "Annals of Philosophy"[3] induced the communication of the results of a similar series of experiments, made by Messrs. Lagerhjelm, Forselles, and Kallstenius for the Society of Ironmasters of Stockholm, at the Fahlun mine, between 1811 and 1815. Owing to the combined circumstances of the Swedish language being but little cultivated in England, and a want of mathematical attainments in those who did understand the language, the Swedish experiments remained untranslated, until after Colonel Beaufoy's decease. Mr. Henry Beaufoy then committed the book to the Rev. Elijah Smith, of Sidney College, Cambridge, who learned Swedish and completed the translation, as also that of Lagerbjelm's "Testamen Theoriæ Resistentiæ Fluidorum constituendæ." The results of these examinations occupied ten years in their reduction, and yet but few practical results had been obtained. The general deductions which appeared to be drawn were—

1st. The confirmation of the theory, that the resistance of fluids to passing bodies was as the squares of the velocities.

2ndly. That, contrary to the received opinion, a cone would move through the water with much less resistance with its apex foremost, than with its base forward.

3rdly. That the increasing the length of a solid, of almost any form, by the addition of a cylinder in the middle, diminished the resistance with which it moved, provided the weight in the water remained the same.

4thly. That the greatest breadth of the moving body should be placed at the distance of two-fifths of the whole length, from the bow, when applied to the ordinary forms in naval architecture.

5thly. That the bottom of a floating solid should be made triangular; as in that case it would meet with the least resistance when moving in the direction of its longest axis, and with the greatest resistance when moving with its broadside foremost.

Such was a short summary of the labours of Colonel Beaufoy, to whom the scientific world was deeply indebted. Mr. Rennie thought, however, that errors had been fallen into, by not sufficiently considering the question of the friction upon the sides of the various forms used in the experiments. They were moreover tried upon masses of too small dimensions.

The papers on the same subject in the archives of the Institution of Civil Engineers, presented by Bidder, Carlsund, Telford, Palmer, and Macneill, and those of Fairbairn and Colonel Page,[4] treated of experiments upon larger vessels, and produced more practical results.

The great difficulty of separating the resistance from the friction, arose out of the imperfect apparatus hitherto adopted. The balance of Coulombe, and the pendulum, had been tried with doubtful success. Profiting by the problem of the cylinder revolving in the vortex, in the Principia of Newton, Mr. Rennie undertook a series of experiments in the year 1830, which were published in the Transactions of the Royal Society, "On the Resistances of solid Bodies in Air and Water."[5] The apparatus consisted of an upright spindle of wrought iron, made to slide up and down in a frame, so as to be plunged to any convenient depth in the water, or to revolve in air only, as required.

The iron discs of square, circular, and triangular forms, as well as the cylinders and globular bodies, all of the same areas, were moved through the same spaces, and with the same velocities, in air and in water; the results were tabulated, and the conclusions arrived at were:—

1st. That the friction and adhesion were not as the surfaces, with slow velocities; being in the ratio of 1 to 3, and diminishing rapidly with the velocities, without observing any ratio.

2ndly. That the resistance of fans and globes of equal areas in air, was as the squares of the velocities up to 8 miles per hour.

3rdly. That the resistance of fans or discs with equal areas, was to globes as 2 to 1.

4thly. That the resistance of fans or discs to globes of equal area in water, was to the globes as the squares of the velocities.

5thly. That the mean resistance—

Of Circular discs in water „ Square discs in water „ Wooden balls in water	were to each other as the numbers 21 to 3, 16 to 2, and 4 to 2.
Of Circular discs in air „ Square fans in air .. „ Wooden balls in air..	were to each other as the numbers 25 to 18, 22 to 1, and 10 to 2.

Mr. Bidder doubted whether the question of resistance, or friction, could be fairly tested by a cylinder revolving in a fluid, inasmuch as a rotary motion was imparted to a portion of the water, in the same direction as the revolution of the cylinder.

The subject was one of great interest, and to which he had devoted much attention. Some years since he assisted Mr. Walker in a series of experiments in the East India Dock, and he came to the conclusion, that it was not possible to arrive at one law suitable for all cases. There were in reality three cases to be considered:—

First. The resistance due to displacement.

Secondly. The resistance due to non-pressure.

Thirdly. The resistance due to friction.

As regarded the first case; the resistance due to displacement included that of the area of resistance of the water heaped up against the bows, which augmented as the velocity increased. In such case he found, that the increase of resistance was in a more rapid ratio than the square of the velocity.

In the second case; that of non-pressure, occasioned by the filling up of the channel in the wake, vacated in the passage of the vessel through the water. In this case he found the resistance increased in a less ratio than the square of the velocity. In Mr. Walker's experiments, boats were used with bluff prows and with acute prows; it was found that at a slight immersion, and when drawn at a low velocity with the bluff prow foremost, there was the least resistance; but that when deeply immersed, all other conditions remaining the same, there was the greatest amount of resistance.

As to the third position. The formula of Du Buat with regard to friction was found applicable; as there was no distinction whether the vessel was moving through the fluid, or whether the fluid was running over the bottom of a river. In this case the resistance due to friction was as the square of the velocity.

Bossut tried a variety of experiments upon the angles of resistance, by attaching to a rectangular parallelogram various shaped prows, at angles varying from 168° to 12°, with the view of ascertaining the law of resistance due to the angle of the plane meeting the water; but he overlooked the constant deduction necessary for the non-pressure due to the rectangular form of the stern, which formed the largest portion of the resistance, and consequently invalidated the deductions from the experiments.

[1] See Bouguet, Traité des Navires; Euler, Scientiæ Navalis; Clairbois, Architecture Navale; Duhamel, ditto, ditto; Don Juan, Examen Maritime; Chapman (Sweden), Naval Architecture; Forfait, Traité sur la Mature des Vaisseaux; Attwood, Philosophical Transactions; Dupuis, Géométrie Déscriptive; Poisson, Théorie des Ondes; D'Alembert and Bossut, Recherches pour la Societe des Experiences en Architecture Navale; Lagerbjelm and Kallstenius, Experiments for the Swedish Society; Marestier, Memoire sur les Bateaux à Vapeur; Beaufoy, Nautical Experiments.

[2] Beaufoy's "Nautical Experiments." Vol. I. London, 1834.

[3] Thomson's "Annals of Philosophy." 1814.

[4] "Remarks on Canal Navigation." By W. Fairbairn. 8vo. London, 1831.

[5] Vide "Phil. Trans.," 1831, p. 423.

The view Mr. Bidder took of the mode in which the subject should be considered, was not with reference to the reflection of the particles due to the angle of incidence, but with reference to the absolute velocity imparted to the particles of water the vessel would have to displace. For instance, if the angle of the vessel was such, that the sine was one-half the radius, then the velocity of the particles in contact would be reduced one-half, and the resistance would be reduced to one-fourth; subject to the previous explanation of the heaping of the water against the bows.

With reference to a plane disc dragged through a fluid; it formed for itself a sort of natural prow of dead water, which was drawn forward with it; but the form of this prow varied with the velocity of the passing current, and hence the anomalies which had been observed in all experiments on the subject.

He could not agree with the infallibility of the Pitot tube; for he thought, that in proportion as the vertical tube was moved from the stem, an error must arise from the lifting of the stem and the dropping of the stern as the velocity increased.

Palmer's experiments gave anomalous results. The resistances came out as the tubes rather than the squares of the velocities. This Mr. Bidder thought must be attributed, in a great degree, to the friction arising from the small area of the channel, as compared to the surface of the body of the boat, and that of the sheet of pent-up water between the flat bottom of the boat and the bottom of the shallow canal.

In trying experiments upon large vessels, he conceived, that a tug boat could scarcely get up sufficient speed to obtain satisfactory results, and that it was necessary for the vessel to be floating in perfectly still water, in calm weather; or else the circumstances being changed the results must be modified accordingly.

As regarded the resistance offered by the paddle floats, when they were dragged through the water, as alluded to by Mr. Heppel, when it was remembered that the absolute velocity of the paddles impinging upon the water did not usually exceed 4 miles per hour, to propel a vessel at the rate of 12 to 15 miles per hour, it would follow, that as soon as the engines were stopped, unless the paddles were disengaged simultaneously, they would be dragged through the water at the same velocity at which the vessel was proceeding. In that case, the resistance offered by the paddles, would be so enormously disproportionate to that offered by the body of the vessel, as to render the results entirely nugatory.

Mr. Walker confirmed Mr. Bidder's statement of the results of the experiments tried in the East India dock, which were communicated to the Royal Society in 1827.[7] The machinery employed for those experiments was very simple. It consisted of a crab-winch with a barrel 3 feet in diameter, and handles of a sufficient length for the necessary number of men to work at it. The line, of ½ inch diameter, was attached at one end to the barrel, and at the other to a dynamometer in the bow of a boat, 18 ft. 6 in. long, by 6 feet broad, with a depth of immersion of 2 feet; the greatest immersed cross section was 9 feet. The experiments were tried in the Import Dock, where there was a space of 1,410 feet in length, 560 feet in width, and 24 feet in depth; so that there was no resistance from the sides or bottom of the dock. The velocities were calculated from the time of passing through 176 yards, or one-tenth of a mile; that length being marked off in the middle of the distance traversed by the boat. The speed was attained by a given number of men working at the winch, and was regulated by the vibration of a pendulum.

The results obtained were, that in almost every instance the resistance showed an increase, amounting to the square of the velocity for the distance traversed; but where the velocity was considerable the resistance followed a still higher ratio. In a narrow channel the increase would have been considerably greater. The excess beyond the square, must, he conceived, be attributed, in a great degree, to the raising, or heaping, of the water against the bows at high velocities, and to the simultaneous depression of the stern.

In these experiments the weight, or power, required, was of course, at least, in the ratio of the cube. For instance, if one man at the winch produced a velocity = 1, eight men were required to produce a velocity = 2; but as in the same time double the space was passed over, the exertion of power over the same space was the half of 8, or 4; but the velocity being twice the former velocity, it required twice the power, or eight men while they were at work; the distance was, however, traversed in half the time, so that the expense of power by doubling the velocity was only as 4 to 1.

The results shown by dragging the bluff prow or the sharp prow foremost, at various velocities, showed clearly, that very different figures should be taken for vessels intended for carrying cargo, from those intended for great speed.

Mr. Bidder said, that Mr. Barlow, in his deductions from Mr. Palmer's experiments,[8] stated, "that in the case of loaded canal boats the resistance varied in a higher ratio, viz.: as the cube of the velocity very nearly, if not exactly," and from the experiments he had computed the power of traction on a canal, thus:—

At 4 miles per hour 1 lb. would draw 200 lb.
At 2 miles „ 1 lb. „ 1600 lb.

The rule adopted by some of the principal marine engine makers (as Messrs. Boulton, Watt, and Co.),[9] for ascertaining the sailing qualities of the vessel, viz.: multiplying the sectional area by the cube of the power, and dividing the product by the velocity, had, he believed, been found a true test; and if when the power in the same vessel had been increased, the quotient had been found uniform, which he had also reason to believe was the case, another proof was afforded of the correctness of the theory, of the resistance being as the square of the velocity.

Mr. Spiller thought the results of Mr. Palmer's experiments were to have been anticipated, from their being tried in a narrow and shallow channel; the progress of the boat was necessarily retarded by the friction of the water against the sides and the bottom, a mass of water was carried along with the boat, and not having space to expand, reacted against the boat, unduly increasing the resistance, particularly at high velocities. Under ordinary circumstances the resistance would be as the square of the velocity, and a vessel going at a given velocity required eight times the power.

Mr. Scott Russell, thought the incongruities in the results of the experiments arose from want of due attention in noting all the circumstances attending them. The forms of the vessels were not particularly registered, nor were the various forms experimented upon, under similar circumstances. Now, as the law of resistance must vary with every difference of form, although a general rule might be given, it could not be relied upon in practice, and it became essential to analyse every experiment carefully before any deduction was made. One point to be particularly noticed, was the resistance of different forms of the bows of vessels, and of the quarters, as the law would vary as they were changed. Any experiment made in a channel of contracted dimensions, perhaps only three or four times that of the area of the midship section, could not be trusted; the law of resistance would vary with the form and dimensions of the channel, and great allowance must be made for lateral friction. In short, as a practical man, and speaking upon the authority of nearly ten thousand experiments, made upon large vessels in open spaces, under every variety of circumstances, he must still think the mode of experimenting by the steam-tug that which was best calculated to furnish accurate results.

Nor was he less wedded to the observations by Pitot's tube, using it as an instrument for measuring velocity. He would of course have the zero point adjustable; and its delicacy might be further tested by having another tube beside it; one of them indicating the immersion, and the other the velocity.

Mr. R. Stephenson said, the object appeared to be, to ascertain the law of resistance with respect to large vessels, as deductions from the experiments on small bodies did not seem to apply. He could scarcely agree in the propriety of relying upon the results obtained by dragging a vessel through the water by a steam-tug, which was only capable of obtaining low speeds. He thought that a steam vessel contained within itself the best mode of trying experiments, by means of the indicator attached to the engines. He was of opinion, that method would be found preferable to any other, if the vessel was tried at various rates of immersion, different speeds, and under circumstances that enabled deductions to be drawn.

Mr. Bidder replied, that in practising such a mode of experimenting, it would be first necessary to ascertain with accuracy the slip of the paddles, and the allowance to be made for the angles of impact and the depth of immersion, all which difficult problems were as yet little treated of and but imperfectly understood.

He was not satisfied with the accuracy of the Pitot tube, even as a measure of velocity, as the statical pressure must be affected by the varying velocity, and false results would be indicated.

Mr. Scott Russell said, it was true that if the tube and the funnel mouth

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[7] Vide Phil. Trans., 1828, vol. cxviii, p. 15.

[8] Vide "Trans. Instit. C.E.," vol. i, p. 165.

[9] Extract from a letter from J. Brown, Esq., dated January 28th, 1833:—

In the years 1818 and 1819, Mr. Watt made a series of experiments with his vessel, the 'Caledonia,' to ascertain her velocity under different circumstances, and amongst the rest, the effect with one engine disengaged from the other. Each was nominally 14 h.p., and the operation of uncoupling one occupied about five minutes, so that the trials in both instances were precisely under the same circumstances as to tide and wind.

A measured mile in Long Reach was run with and against the tide six or eight times, and the average taken.

In 1818, with paddle-wheels of 10 feet 6 inches diameter, the results of these experiments were as follow:—

	Miles.
With both engines at work, eight experiments gave average	8·01
With one engine ditto, eight experiments gave average	6·17
In 1819 these were repeated with paddle-wheels 13 feet diameter:—	
Both engines working during eight experiments, gave an average of ..	8·83
One engine „ eight ditto	6·64
Again, both ditto „ eighteen ditto	8·29
One ditto „ eighteen ditto	6·24
Similar trials were made with the 'Magnet' in 1827. Two engines of 60 h.p.—with	Miles.
Both engines at work during four experiments, the average speed was	9·72
One engine ditto „ four ditto	7·42

You will remark, that the velocity with one engine in all these experiments, is something under what should arise, but is accounted for from the circumstance, that the number of strokes per minute, was reduced below the maximum, from the excess of load.

The results are however sufficiently near to establish the fact, that the power required is as the cube to the velocity, and according to this the 'Caledonia' experiments in 1818, with one engine, should have given 6·35 miles, instead of 6·17 miles; and in 1819, 6·72 miles, instead of 6·64 miles; and 6·58 miles, instead of 6·24 miles.

In none of these experiments was the indicator applied to the engines; the actual power exerted by each was, therefore, not ascertained, but the nominal power was taken.

In those of the 'Magnet' this instrument was used in the experiment quoted, and the actual power, when both engines were at work, was ascertained to be equal 227 h.p., giving 9·72 miles velocity; with one engine 108 h.p., 7·42 miles velocity; which is within the second place of decimals what it should be, say 7·47 miles.

[6] Vide Minutes of Proceedings, 1842, vol. ii. p. 192.

were large and the orifice was near the surface of the water, the effect apprehended by Mr. Bidder would be produced; but with a small tube and a proportionate orifice, with a proper arrangement of the apparatus, having the orifice immersed from 10 feet to 15 feet beneath the surface, the statical pressure was so uniform at all velocities, that no sensible variation could be observed, and he must record his conviction, that if properly graduated, and conveniently arranged, no instrument he had hitherto seen possessed the same amount of advantages for trying experiments.

ON REACTION WATER-WHEELS.

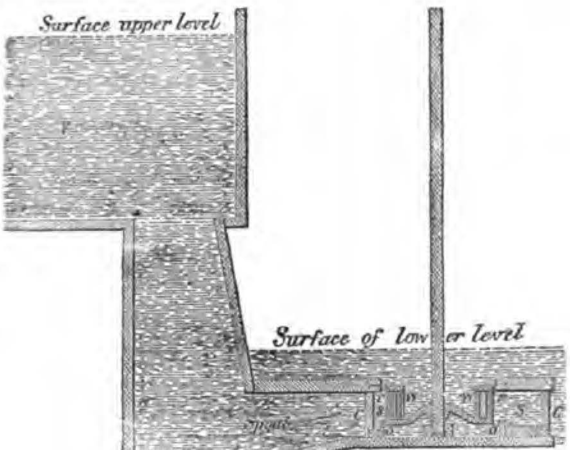
Communicated to the Franklin Institute, United States, by Z. Parker, of Philadelphia.

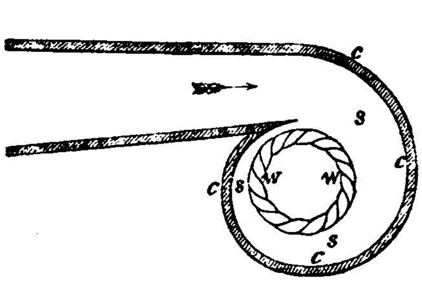
On the subject of Barker's wheel, which, with a few exceptions, appears to be the only reaction wheel noticed in the elementary books till recently, I have seen no notice of any variation in the discharge, caused by variations in the velocity of the wheel; from which I infer that the writers regarded them as uniform in their discharge under all velocities. In practice, however, it has been observed that, when the wheel runs without resistance to its free motion, the orifice moves with a velocity considerably greater than that due to a pressure of the head of water, and that the discharge is greater than the theoretic discharge. So far as I am informed, no experiments have been recorded, or rules given for determining the ratio of discharge under different velocities of such wheels.

The following rule, I think, will be found to hold good for all wheels of the reaction kind which discharge the water at their verge, and into which it enters without circular motion, or in which a circular motion of the water is caused by the wheel itself—the supply being full:

"To the head of water actually pressing at the orifice, add such a head as will, by its pressure, produce a velocity equal to the circular motion of the orifice; the velocity through the moving orifice will be the same that it would be if stationary, and under the pressure of the sum of the heads." For example:—

Suppose such a wheel to have an issue of 36 square inches, under a head of 9 feet, and that the orifice move at the rate of 16 feet per second; the discharge will be the same that it would be if the wheel were standing under a head of 13 feet. Consequently such





a wheel would, by this theory, discharge, standing, 6 cubic feet per second, and running at that rate, 7·2 cubic feet. And if the orifices were suffered to move at the rate of 24 feet per second, the discharge would be the same as if standing under 18 feet head; in which case, the discharge should be 8·48 cubic feet per second.

It is obvious that, in applying this rule in practice, such deductions must be made (as in other cases) as may be due to the form of the orifice, the angles in the passages, and the friction on surfaces.

The following experiments were made with a centre discharge reaction wheel of the form and proportions represented in the accompanying sketch. The wheel was 34 inches in diameter at its outer verge; the inner diameter of the annular rim 26 inches. It had 16 issues (8 by 1·8 in.) = 230 square inches. It received the water at the verge, from an involute sluice embracing the whole circumference. The water was conducted to the involute through a large spout; the discharge of which into the involute 24 in. wide by 14 inches deep, = 336 square inches. The terminus of the involute was within an inch of the verge of the wheel. The circular motion of the water caused by the involute coincided with the motion of the wheel.

	Power Expended.				Effect Produced.			
No. of Experiments.	Fall of water in feet, $= h$.	Cubic feet of Water used per minute, $= d$	Pounds of Water per minute, $d \times 62.5 = w$.	Whole power of water, in lb. descending 1 foot per minute $h \times w = p$.	Weight on lever of break $= w'$	Revolutions per minute $= v$.	Effective force of wheel, $w' \times v \times 60 = f$.	Ratio or practical efficient $=$ R.
1	8·66	1125·5	70,312·5	608,996	30	143	255,600	·411
2	8·62	1119·0	69,937·5	602,861	39	138	312,920	·518
3	8·61	1119·0	69,937·5	602,861	45	130	351,000	·582
4	8·59	1104·0	69,000·0	592,711	66	87	344,520	·579

The condition of the works at the time the experiments were made was favourable to the wheel. It had run about two months after being repaired and adjusted, and the proprietor (Mr. A. Atwood, of Troy, N.Y.,) stated that it was performing as well as it ever had. There was a fault, however, in the construction. The "spout" (so called) conducting the water from the flume had an elbow of nearly a right angle, first descending from the bottom of the flume and then passing horizontally to the involute; the section at the commencement of the horizontal portion being about 16 by 36 = 576 square inches. The opening into the "spout" from the bottom of the flume was about 30 inches square, with sharp angles. All things considered, I am of the opinion that this method of employing the "pressure" of water, with a good structure, in good condition, is capable of giving about 62 per cent. of available power.

A remarkable feature of inward-discharging reaction wheels is found in the smallness of their discharge, and its tendency to uniformity under all velocities of the wheel, obviously arising in this application, from the outward pressure of the circular motion of the water in the involute sluice and wheel.

The theoretic discharge of 230 square inches, under a pressure of 8·61 feet, is 2,249 cubic feet per minute. The actual discharge is only ·498 of this. Had the discharge been outward, through the same aggregate aperture, and with the same circular motion of water, in the portion of the wheel occupied by the vanes, the discharge (judging from the results of my experiments made in 1844), would have been ·884 of theoretic discharge; and had it been outward, and *without* circular motion, it would have been about 1·289, at the speed of maximum power.

ON THE VELOCITY OF ATMOSPHERIC JETS.

The following table (communicated by Z. Parker to the *Franklin Journal*) of the velocity of atmospheric jets, under the given pressures, may be useful.

The table is constructed under the assumption that all fluids acquire equal velocities under the pressure of equal heights, without regard to their specific gravities; allowing the superincumbent column to be homogeneous with that portion at the jet. The formula is $V = \sqrt{64\,h}$; and for a pressure of 15 lb. per square inch, $h = 27,600$ feet of homogeneous atmosphere. The height for other pressures in proportion.

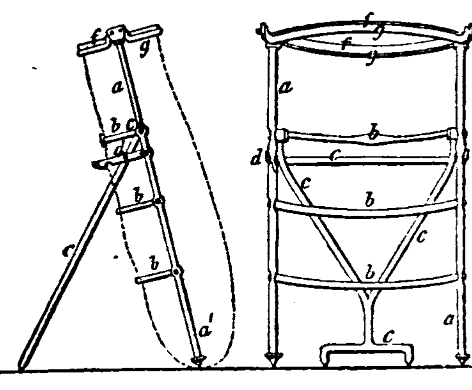
Pressure per square inch.	Velocity, feet per second.	Pressure per square inch.	Velocity, feet per second.	Pressure per square inch.	Velocity, feet per second.
¼ oz.	42	2¼ lb.	514	13 lb.	1237
½ ..	60	2½ ..	533	14 ..	1284
1 ..	88	2¾ ..	569	15 ..	1329
2 ..	121	3 ..	594	20 ..	1534
3 ..	148	3¼ ..	615	30 ..	2004
4 ..	171	3½ ..	642	40 ..	2170
5 ..	190	3¾ ..	665	50 ..	2406
6 ..	210	4 ..	686	60 ..	2658
7 ..	227	4½ ..	728	70 ..	2871
8 ..	242	5 ..	760	80 ..	3069
10 ..	271	5½ ..	804	90 ..	3240
12 ..	297	6 ..	840	100 ..	3431
14 ..	321	7 ..	908	110 ..	3600
1 lb.	343	8 ..	970	120 ..	3759
1¼ ..	383	9 ..	1029	130 ..	3912
1½ ..	420	10 ..	1085	140 ..	4060
1¾ ..	453	11 ..	1136	150 ..	4202
2 ..	485	12 ..	1208	160 ..	4340

REGISTER OF NEW PATENTS.

SACK HOLDER.

Henry Gilbert, of St. Leonard's-on-Sea, surgeon, for "*Improvements in apparatus for holding sacks to facilitate the filling of them with corn or other materials.*"—Granted May 27; Enrolled November 27, 1847.

Heretofore when filling sacks it has been usual for one person to hold up the sack whilst the other fills the same. In other cases the sack has been hung from hooks or instruments from a wall or post or some other permanent structure. The object of this invention is so to arrange apparatus that it may be carried about with facility, and stand in a field or other place, and uphold a sack in an open state so that the sack may be filled with facility; the invention simply requiring such an arrangement of parts that it may be independent of a fixed or permanent structure, and be capable of being moved from place to place, and yet uphold an empty sack in an open state and allow of a person readily filling the same. The annexed engraving shows a side and back view of the apparatus. *a* is the main frame, having two legs *a'*.



The sides *a* are combined together by the bars *b*, which are bent to receive the sack as it rests against it; *c* is a diagonal frame which turns on axes, and *d* are two studs or projections fixed to the side rails of the frame, by which the legs or feet can be caused to stand a greater or less distance apart, there being notches in the projector to receive the studs or projections. At the upper part of the apparatus is fixed an elliptical frame *f*, through which the mouth of the sack is to be drawn. The upper part of the sack is to be folded over the bars *f*, and the clamping-bars brought down, which will clamp the upper parts of the sack securely between the parts *f f*, and *g g*, by which means the sack will be held open at the mouth and supported or suspended from the frame *f*, and the apparatus may be placed in the position shown in the side view.

STEAM-ENGINES.

William Bacon and Thomas Dixon, of Bury, Lancaster, engineers, for "*certain Improvements in steam-engines.*"—Granted August 19, 1847; Enrolled February 19, 1848. [Reported in the *Patent Journal.*]

The invention of improvements specified and enrolled under this title applies generally to that class of steam-engines usually termed Woolf's engine, or the compound-cylinder engine; that is, an engine having two cylinders, where the steam is admitted into one cylinder, at a high pressure, where having actuated the piston of that cylinder, it is admitted thence to the larger cylinder, where it again produces a motive power, and usually subject to condensation. In one case also, herein specified, it is applicable to single-cylinder engines. The patentee states that in the ordinary arrangement of compound-cylinder engines, the area or content of the passages from the expansive valve for the high-pressure cylinder to the inside of the low-pressure cylinder are such as to form a large proportion to the cubical content of the high-pressure cylinder; and that this content or space is filled, at the conclusion of each stroke of the engine, whether it be the upward or downward stroke of the low-pressure piston, with steam of a similar density as that produced by its admission into the low-pressure cylinder, which in many cases is five or six pounds, or even more, below the pressure of the surrounding atmosphere. When the return-stroke of the piston takes place, the steam admitted to effect the preceding stroke of the high-pressure piston is passed into the passage or space before-mentioned, thence to the low-pressure cylinder, where it joins with the before-mentioned rarified steam, and therefore the steam in, or escaping from, the high-pressure cylinder, is considerably reduced in pressure, without producing a corresponding amount of force on the piston. The principal object of these improvements is to obviate in a great measure the before-mentioned deterioration of the steam in its passage from one cylinder to the other, and also to simplify the construction and at the same time to obtain an increased amount of duty from the steam in compound-cylinder engines. To attain the advantageous results just enumerated, the patentees construct their improved engine so that by a peculiar arrangement of the passages, valves, and openings, the exhausting-valves for the high-pressure cylinder, or admission-valves for the low-pressure cylinder, are placed as nearly as possible to the ports or entrances to the low-pressure cylinder. On account of this arrangement of the passages between the steam-valves for either of the ports of the low-pressure cylinder, and the opposite end of the high-pressure cylinder, these passages are constantly filled with steam of the same density as that in the high-pressure cylinder; therefore, the content of the passage from the valve to the entrance of the low-pressure cylinder is the additional extent of the space the steam admitted to the high-pressure cylinder will have to occupy, and the steam always be in reserve for the commencement of the stroke of the low-pressure piston; consequently the pressure of the steam will be reduced but to a very trifling degree; and, therefore, they argue that a more perfect expansion of the steam in the low-pressure cylinder is obtained, which is attended with a corresponding additional result in the motive-power. These improvements consist:—First, in so arranging the valves, passages, and openings, that one valve-box, one double hollow valve (or two sliding-valves of the common construction) are adapted to serve for both the high and the low-pressure cylinders. The same passage in the valve which admits steam to the top of the low-pressure cylinder from the bottom of the high-pressure cylinder, in a downward stroke of the pistons, also forms the passage from the top of the low-pressure cylinder to the condenser, in the upward stroke of the pistons; and the same passages in the valve which admit the steam to the bottom of the low-pressure cylinder from the top of the high-pressure cylinder, in the upward stroke of the pistons, also forms the passage from the bottom of the low-pressure cylinder to the condenser, in the downward stroke of the pistons. The same part of the valve which admits the steam to the low-pressure cylinder forms the exhausting-valve for the opposite end of the high-pressure cylinder. Secondly, these improvements consist in using separate plate or other valves for the admission of the steam to the high-pressure cylinder, and using these valves as expansion-valves with which to cut off the steam from the high-pressure cylinder, and so arranging them that the amount of expansion may be varied to any required extent in the high-pressure cylinder without interfering with the ingress or egress of steam to or from the low-pressure cylinder. Thirdly, these improvements consist in arranging conical-valves, Cornish, or other description of disc-valves for compound-cylinder engines, so as to effect the same result as by the slide-valves above-mentioned, and in arranging each valve to be raised by a separate tappet (or by other mechanical means), so that any one valve can be closed without interfering with any of the others; by reason of which arrangement any amount of expansion or compression of steam in either the

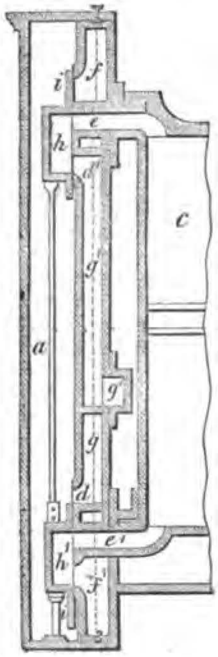


Fig. 1.

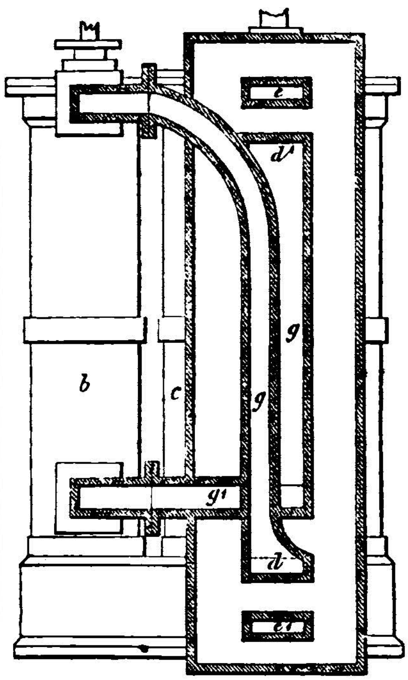


Fig. 2.

high or low-pressure cylinder can be effected. Fig. 1 represents a vertical section of a low-pressure cylinder, together with the steam-passages, so arranged that by one valve-box, six openings, and two common, single, hollow sliding-valves, they are adapted to serve both the high and low-pressure steam-cylinders; and fig. 2 is a transverse vertical section of the passages through the line 1, 2, showing also the position of the cylinders. *a* indicates the admission and exit openings for the top of the high-pressure cylinder; and a^1 the opening for similar purposes to the bottom of the high-pressure cylinder; and *b*, and b^1, the ports for the admission and escape of steam to or from the top and bottom of the low-pressure cylinder; *c*, and c^1, the passages to the condenser; *d*, and d^1, steam-passages to the high-pressure cylinder; *e*, and e^1, the hollow sliding-valves; and *f*, and f^1, the lap or covering for the condenser-ports *c*, and c^1. The action of this arrangement is as follows:—Steam being admitted from the boiler to the valve-box *a*, enters at *d* (when the valves are in the position shown), and passes thence by the passage *g*, to the top of the high-pressure cylinder *b*, where, having performed the downward stroke of the engine, the position of the valves *h*, h^1, will be reversed, and the steam will return by the passage *g*; and the opening *d* (as well as the port e^1), being now covered by the valve h^1, the steam will be conducted thereby below the piston of the low-pressure cylinder *c*, and, on a subsequent stroke taking place, it will escape through the valve h^1, to the port f^1, and thence by a suitable passage to the condenser. For the upward stroke of the engine, the port d^1 will be uncovered by the valve *h*, and steam will enter, passing by the passage g^1, to the bottom of the high-pressure cylinder, and by the change in the valves it will escape from thence by the passage g^1, through the valve *h*, into the top of the low-pressure cylinder *c*, where, having performed its office, it is exhausted by the condenser through the passage *f*, which, in its turn, will be covered by the valve *h*. The ports *f*, and f^1, are always covered either by the valves *h*, and h^1, or by their projecting-pieces *i*, and i^1. Fig. 3 represents a vertical section of a valve-case, together with the requisite passages, by which arrangement one valve-casing, five openings, and one double hollow slide are made to serve for two high-pressure cylinders and one low-pressure cylinder, these being arranged, in the drawings, one on either side of the low-pressure cylinder, to which the slide-case and slides are attached; the different valves, openings, and passages are lettered severally, as in the last figures, and to which the description thereof will be equally applicable, as the steam is conducted precisely in the same manner as in that case. Fig. 4 is a vertical section of a low-pressure steam-cylinder, with its valves and openings so arranged that by one valve-box, eight openings, two plate expansion-valves, and two common, single, hollow slide-valves are adapted to serve one high-pressure steam-cylinder, and one low-pressure steam-cylinder. Fig. 5, a section through the line 3, 4, showing the arrangement of the passages, with the relative position of the two cylinders. A, represents the valve-case; B, the high-pressure cylinder; C, the low-pressure cylinder; *a* is the opening in the valve-face, which is connected with the top of the high-pressure cylinder by the passage *b*, which passage also serves to convey the steam from the top of the high-pressure cylinder B, to the bottom of the low-pressure cylinder C. a^1 is the opening in the valve-face for the admission of steam to the bottom of the cylinder B, the passage b^1 communicating thereto; this passage

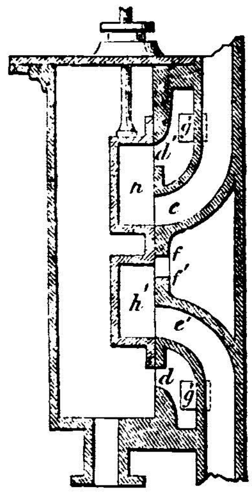


Fig. 3.

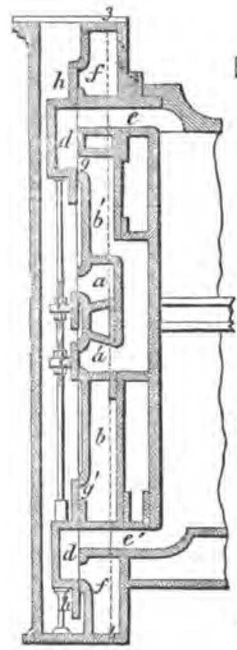


Fig. 4.

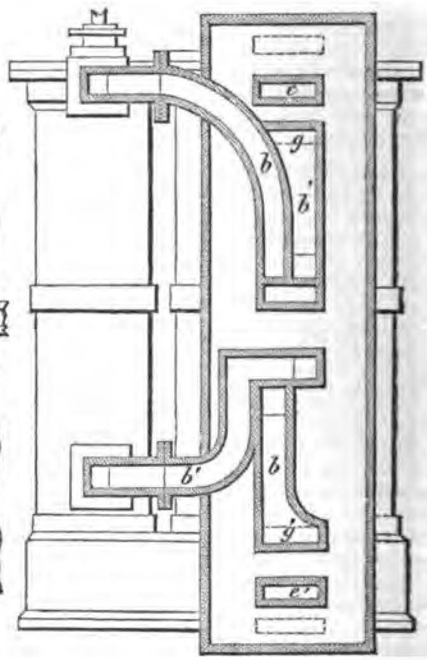


Fig. 5.

serves as a communication between the bottom of the high-pressure cylinder B, and the top of the low-pressure cylinder C. These openings *a*, and a^1, are covered alternately by two expansive plate-valves *c*, and c^1; which valves are furnished with suitable apparatus for varying the amount of expansion, and are placed on the same rod as the valves *d*, and d^1, which are for the purpose of controlling the direction of the steam in its entrance and exit to and from the low-pressure cylinder C. *e*, and e^1, are the steam-passages to the cylinder C, and *f*, and f^1, the openings in the valve-face to the condenser; *g*, and g^1, are the openings in the valve-face to the steam-passages *b*, and b^1; and *h*, and h^1, the laps of the slides *d*, and d^1, for the purpose of covering the openings *f*, *g*, g^1, and f^1. Steam being admitted to the valve-jacket from the boiler, at a high-pressure, it enters at *a*, to the passage *b*, which is filled as far as g^1; that opening being covered by the lap of the valve d^1, it is conducted thereby to the top of the high-pressure cylinder B, where, having performed the down-stroke of the piston, the position of the valves will become changed, the steam in the top of the cylinder B, will escape by the passage *b*, through the opening *g*' in the valve-face, which will now be covered by the valve *d*', and by it directed through the passage *e*' into the bottom of the low-pressure cylinder; the opening *a*, to the passage *b*, during this part of the stroke, being covered by the expansion-valve *c*. During the upward stroke of the pistons the high-pressure steam in the valve-case will pass in at the opening *a*', thence by the passage *b*' to the bottom of the high-pressure cylinder, the opening *g* to this passage being now covered by the lap of the valve *d*; but the valves being again changed, the steam will rush from the bottom of the cylinder B, through the passage *b*', where it passes through the opening *g* in the valve-face, and is directed by the valve *d* into the top of the cylinder C, by the passage; when the down-stroke takes place, during this part of its course through the passage *b*', the opening *a*' is covered by the expansive-valve *c*', preventing any admission of steam from the valve-case. The steam from the top and bottom of the low-pressure cylinder is exhausted by the condenser through the passages *f*, and *f*', which communicate alternately therewith by the change in the valves, *d*, and *d*'; when the opening is covered by the valve *d* and the steam directed thereby to the condenser, the opening *f*' is covered by the lap *h*' of the valve *d*, and when the opening *f*' is covered by the valve *d*', *f* is in its turn covered by the lap *h* of the valve *d*.

The object aimed at in these improvements, besides the simplicity of construction, are, that a more effective pressure is obtained from the admission of the steam immediate on the opening of the steam-valves to the low-pressure cylinder, and, consequently, a more effective result is obtained Drawings are represented in the specification, showing the application of Cornish or disc-valves adapted to effect the admission of steam to the low-pressure cylinder in a similar manner, and so as to obtain a similar beneficial result, as with the slide-valves already described; but, from the simplicity of the principle of the invention, it will be unnecessary to give any description. In combination with these foregoing improvements, they also specify an improved apparatus for what is techically termed "blowing through" when an engine is to be started, the improvements being for the purpose of preventing the engine starting in the wrong direction. The improvement consists in arranging two passages from the blow-through valve to the low-pressure cylinder, one of these passages being connected from the blow-through valve to the top of the low-pressure cylinder, and the other passage from the blow-through valve to the bottom of the low-pressure cylinder—the openings into these passages being so regulated by a three-way cock or valve, that when the operation of blowing through is performed, the steam enters simultaneously on each side of the piston in the low-pressure cylinder; and that when the said valve is closed, any communication between the passages will be entirely prevented. Having described the nature of their invention, and in what manner the same may be carried into practical effect, they remark that they do not claim the application of one valve-box to high and low-pressure cylinders, but what they claim as their invention is:—First, the peculiar arrangement of the valves and openings as they are represented in the cuts and hereinbefore described in detail; that is to say, the adaptation and application of a reduced number of valves, of the ordinary construction, to effect the necessary communications between the steam-chest, cylinders, and condenser; and the arrangement of ports or openings, whereby the steam is reduced as little as possible in passing from the high-pressure cylinder to the low-pressure cylinder. Secondly, they claim the application of two high-pressure steam-cylinders to one low-pressure steam-cylinder, and in so arranging the ports or passages that the same number of valve-boxes and openings which serve for one high-pressure and one low-pressure steam-cylinder, will also be sufficient for two or more high-pressure cylinders and one low-pressure cylinder. They desire it to be understood that they do not confine themselves, in the application of the improvements, exclusively to compound-cylinder engines with condensation, but also claim the application of their improvements to compound-cylinder engines without condensation, passing the steam from the second or low-pressure cylinder into the atmosphere instead of into the condenser. Thirdly, they claim the application of their improvements in the methods of blowing through for the purpose of starting engines, as applicable to every description of double-acting condensing engines, whether with compound cylinders or a single-cylinder engine. They also claim any combination of the improvements herein specified, whereby similar objects may be accomplished.

CONSUMING SMOKE.

William Edward Kyan, of Westbourne-park-villas, Paddington, clerk, for "*Improvements in consuming the smoke and economising the fuel of steam-engines, breweries, and manufactories generally.*"—Granted July 25, 1847; Enrolled January 25, 1848.

This invention consists of a combination of mechanical means, to be applied to the furnaces, ash-pits, flues, fire-doors, door-frames, and chimneys of steam-engines, boilers, coppers, stills, and pans generally, for consuming the smoke and gas and lessening the expense of fuel.

First, to regulate the draught of the chimneys, whatever may be their altitude, so that their area of cubical capacity shall not exceed the conjoint areas of the furnace,—the space above the bridge and the fire-flue under the boiler, &c. Secondly, by adjusting the admission of atmospheric air, at given points, to afford the precise proportion of air needful to effect the perfect combustion of fuel, and its products of gas and smoke.

Fig. 1 is a longitudinal vertical section of a steam-boiler of cylindrical form, with its furnace. *a*, the furnace-doors; *b*, the plate; *c*, the fire-bars; *d*, the bridge; *e*, the air-flue; *f*, the fire-flue under the boiler; *g*, the lateral or side fire-flues. Fig. 2 is an enlarged view of the furnace-doors, which are in two heights; the upper one has ventilators with

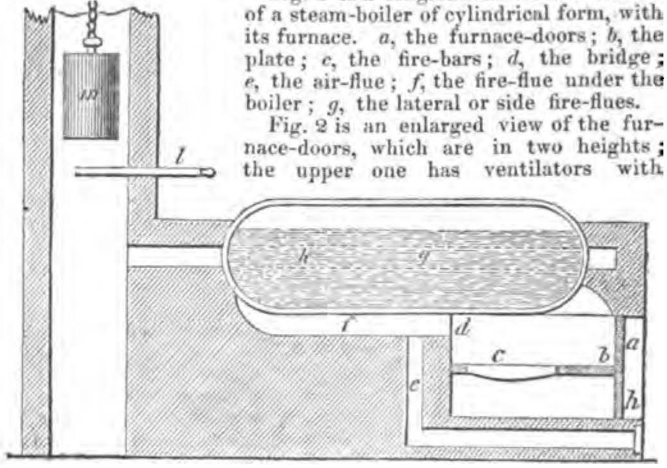


Fig. 1.

regulating slides to admit the air over the fuel (without lessening the temperature of the furnace which partly opening the door occasions), and is opened to supply fuel; and when that is done, it is closed, and the lower (plain) door is then opened to arrange the position of the fuel on the bars. *e* is the air-flue with ventilator to regulate the air admitted. *h*, *h*, are the ash-pit doors with their ventilators, by which the needful quantity of air is allowed to enter. There is a second air-flue marked *k*, which enters the side flue into which the blaze first passes from the boiler, and this has likewise a ventilator marked *l*.

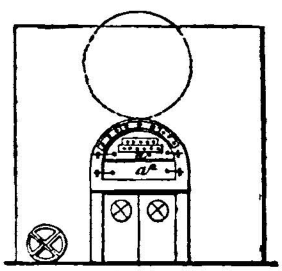


Fig. 2.

In addition to the horizontal damper in the machinery to contract and regulate the draught, there is also a vertical damper fixed on one side of the chimney with a counterpoise weight, which damper is raised as occasion may require, to supply a volume of air to the chimney, and thereby lessen or stop the draught through the furnace at the time when fuel is supplied and arranged on the bars.

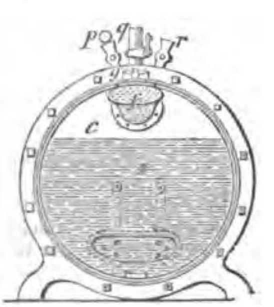
The air is to be admitted gradually as required. Thus—by the admission of a moderate quantity through the ventilators of the ash-pit doors, the fuel is ignited—by the supply of air through the ventilating holes regulated by slides in the door-frame, above the doors, or in the upper door (as the case may be), combustion is afforded to the gas and smoke while arising in the body of the furnace, by the air supplied from the ventilator in the air-tube or flue which communicates to the back of the bridge, any gas and smoke which escapes from the furnace to the flue under the boiler, is ignited. And again, by the ventilator in the second air-flue, marked *k*, entering the side flue at the end of the boiler, near the chimney, still further ignition is attained, and the full completion of the combustion is thus secured by the conjoint action of the whole of these arrangements, which could not be effected by the admission of a large volume of air with undue force at any of these given points above enumerated.

These arrangements are also applicable to boilers of marine steam-engines. Thus, where the boilers are set in brickwork, with flues or fire-bed passing under the boiler, and side flues surrounding the boiler, like those of stationary land-engines, the same method of applying the arrangements as before described will answer the purpose, and where the furnace and ash-pit are within the boiler, the ventilators are to be applied to the ash-pit doors, to the furnace door-frame and upper door, and to a metallic pipe to convey air to the back of the bridge, and should there be a slide-flue, one also to that; the regulating damper to the chimney and a vertical damper enclosed for safety in a case open at the bottom to admit air.

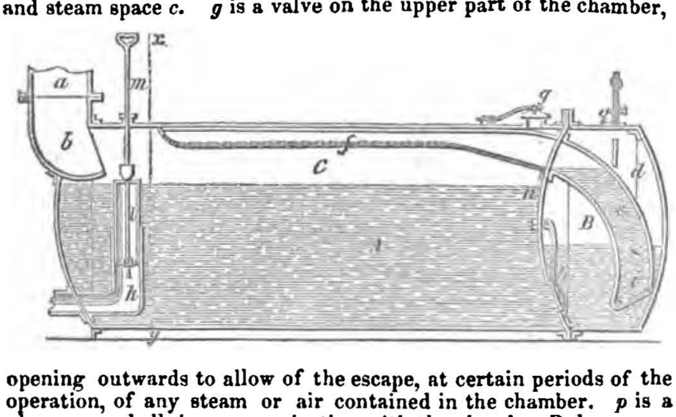
As some of the arrangements herein described are old, or have been in use, such as the horizontal damper, the divided furnace-door, with apertures therein, and the admission of air at the back of the bridge, the patentee does not claim any one of these separately, but claims their application combined with the following improvements (that is to say) the vertical damper marked *m*, the openings in the door-frame, and slides to cover them occasionally, the side air-flue, and ventilator *k*, and that marked *e*, the ventilators in the ash-pit doors, and the tube for conveying the air to the back of the bridge, marked *e*, in the manner set forth, to produce, by their regulated and united action, the effect of more complete combustion, by igniting the gas and smoke, and thereby saving fuel to a considerable extent.

CONDENSER FOR STEAM-ENGINES.

Christian Schiele, of Manchester, mechanician, for "*Improvements in machinery or apparatus for condensing steam.*"—Granted May 27; Enrolled November 27, 1847.



The new condenser consists of a cylinder A, one end of which is divided off, forming a separate chamber B; the two chambers are connected by a valve *h*, in the partition *n*, and a tube *e*, leads from near the bottom of the small chamber into the large one, proceeding along the upper part of the cylinder, and having its lower surface pierced with holes. The cylinder contains water, and on steam being admitted from the engine, through the pipe *e*, into the large chamber A, it forces the water through the valve *h* in the partition into the small chamber; but as soon as the steam begins to condense, and the pressure on the surface of the water is released, the compressed air in the small chamber forces the water up the connecting-tube *e*, and which, flowing along, passes through the orifices *f* in a shower, and completes the condensation. *k* is an elbow-pipe, in connection with the force-pump of the boiler, to carry off the condensed fluid; it is provided with a vertical tubular slide *l*, to be raised to any suitable elevation by a rod *m*, to regulate the level of the condensed fluid, and steam space *c*. *g* is a valve on the upper part of the chamber,



opening outwards to allow of the escape, at certain periods of the operation, of any steam or air contained in the chamber. *p* is a glass gauge-ball, in communication with the chamber B, by means of a small pipe, which depends from the top of that chamber to about one-fifth of its depth. This ball *p* is intended to show the diminution of the air in the chamber B, by the rise of the fluid into it. *r* is a small pipe with a stop-cock, for supplying air to the chamber when required. A third pipe *q* is connected with the chamber B, and is intended to furnish a fresh supply of water from an elevated cistern, in order to compensate for the fluid lost by leakage.

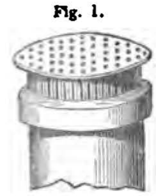
GAS BURNERS.

John Hunt, of Birmingham, brass-founder, for "*Improvements in the combustion of gas, oil, camphine, and other substances which are or may be burned for the production of light.*"—Granted July 3, 1847; Enrolled January 3, 1848.

This invention relates to the application of caps or discs, made of perforated metal or wire gauze, to the tops of the chimneys or glasses of gas, oil, or other lamps, as shown at fig. 1.

The second part of the invention relates to the manufactuer of argand burners and the chimney-holders attached thereto. Fig. 2 is a vertical section of a burner and chimney-holder. In the ordinary method of making them, the several pieces are joined by soldering at the parts marked *a*, *a*; but the patentee proposes to cast in one piece either the outer cylinder *b*, and the bottom *c*, and rim *d*, of the glass-holder, or the inner cylinder *e*, and the bottom and rim of the glass-holder; or, instead of casting, it can be made the same by stamping from sheet-metal. The completion of the burner by the addition of the inner or outer cylinder, as the case may be, is effected by the ordinary process of soldering.

Fig. 1.



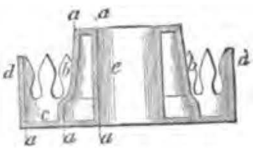


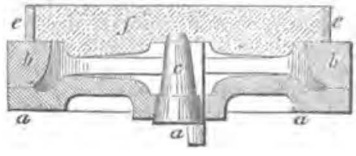
Fig. 2.

RAILWAY BREAK.

Frederick Chaplin, of Bishops Stortford, Hertfordshire, tanner, for "*Improvements in wheels of railway carriages.*"—Granted June 29; Enrolled December 29, 1847.

The improvements consist in applying to the tyres of railway wheels belts of hide, skin, or leather, in such a manner that they will come in contact with the rails on which the wheels travel, whereby the driving-wheels of a locomotive engine will be enabled to take a firmer hold of the rail, and the wheels of the railway carriages will travel more slowly and with less noise.

Railway Wheels.—Patented June 28, 1847, by W. E. Newton, of Chancery-lane, consisting of a peculiar method of casting the iron wheels for locomotive engines and railway carriages, the object being to cool uniformly all parts of the casting at the same time, and thereby preventing fractures from irregular shrinking. From the time when wheels with a chilled hub and flange were first brought into use, the difficulty of casting them has been known, for the chill sets and cools the metal of the rim before the spokes or parts connecting it with the hub, and these, in cooling, shrink, and either break, or become so weak as to break on the least strain. To obviate this, the hub was for a long time made in sections, to enable it to open and yield to the contraction of the spokes, but this was attended with a diminution of strength, and the necessity of putting on wrought-iron hoops or bands. The patentee avoids these objections, which is effected by casting the whole wheel in a chill, and cooling all the parts at the same time, and without undue strain on any part. For casting a wheel of this kind a circular metal mould is to be constructed in several pieces, as shown in the annexed engraving, which, when put together, will leave an internal recess, or chamber, to receive the molten metal, corresponding to the figure of the intended wheel when complete. A quantity of molten metal being poured into the mould, the cast wheel will be produced, the inner face, flange, and outer periphery of the felloe being chilled and hardened by the cold metal surfaces, against which the molten iron has come in contact, and by which means all parts of the casting, as it cools, will shrink uniformly, and have no tendency to strain and crack,



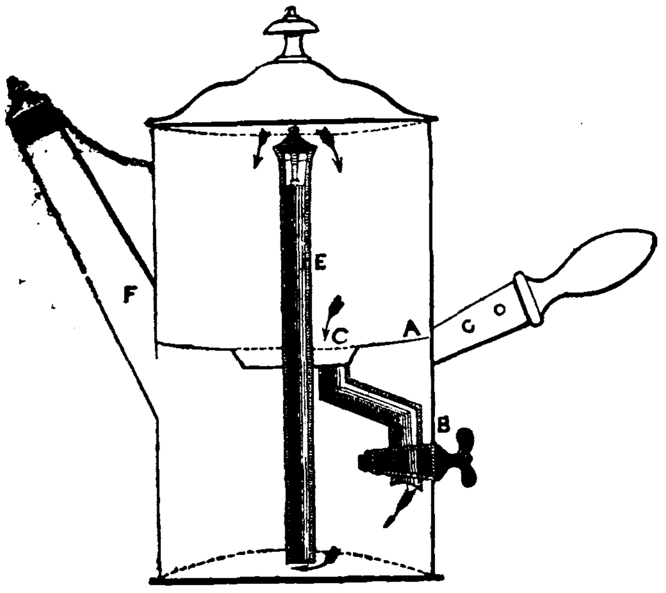
or separate one portion from another. *a* is the circular metal plate, and *b* a metal ring, accurately fitted together; *c*, a conical metal plug forming a core, with a feather *d* affixed, to form the recess for the key to fasten the wheel to the axle.

Silvering Speculums.—Patented August 3, 1847, by T. Fletcher, of Birmingham. It consists in coating glass, after it is silvered with metal, by the electrotype process, whereby the quicksilver is protected from injury, and a stronger power of reflecting light given to the speculum. The silvered glass plate is lightly and carefully coated on the back, or silvered side, with a varnish composed of two ounces of shellac, half a pint of highly-rectified spirits of wine, and half an ounce of the best lamp-black; this varnish protects the quicksilver from damp, and from the acid used in the subsequent process. Before the varnish is quite hard, shake over it from a muslin bag, finely-pulverised plumbago, black oxide of manganese, or any other metallic powder, or cover it with thin metal, so that the whole surface will be covered with a perfect but thin coat of metal; after which it is submitted to the electrotyping process, and by this means a thin coating of copper, or other metal, will be precipitated over the entire back of the plate.

Direct Application of Steam-Power to Mills.—Patented July 29, 1847, by J. Hastie, of Greenock. It consists in the application of direct action of steam-power to turn mills, by making the axis of the crank of the engine serve also for the axis of the mill—whether the same be vertical or horizontal. The shaft is provided with a fly-wheel, which receives an endless belt for driving flour-dressing machines, and on the shaft there is an eccentric for communicating motion to the slide valves. When two pairs of mill-stones are required to be worked by the same engine, it may be effected by causing the piston-rod to pass through both ends of the cylinder, and connecting it at each end with the shafts of the upper mill-stones; and, in case it should be at any time desirable to work only one of the upper stones, the other may be disconnected.

WALLER'S PATENT COFFEE-POT.

This invention consists of a vessel divided into two equal parts by a dished partition A, with the centre depressed and pierced by a hole; around the edge is attached a bent tube connected with a cock B, forming a passage through the strainer C, from the upper to the lower half of the vessel; the strainer is finely perforated



metal. Ascending from within a short space of the bottom of the lower chamber to within nearly the top of the upper one, is a tube E, passing through the centre of the partition and perforated plate, and which tube is surmounted by a valve D. F is an ordinary spout communicating only with the lower division, and fitted with a ground stopper.

The mode of using the apparatus is this: the stopper being removed from the spout, the water is poured into the upper half of the vessel, the tap is then turned downwards to allow the water to run into the lower half; when it has done running, the ground coffee is put into the top division, the tap again turned horizontally, the stopper re-inserted, and the vessel placed on the fire. When the rattling of the valve, and escape of steam from under the lid have continued a few seconds, the coffee-pot is to be taken quite away from the fire and allowed to stand about two or three minutes; the tap is then turned downwards, when the infusion will rapidly filter into the lower division, and be ready for use in a beautifully bright and boiling condition.

The principle of this apparatus will be readily perceived. When it is placed on the fire, the water in the lower division is forced by the pressure of steam up the central tube, lifting the valve, and made to fall in a uniform stream, *at a gradually increasing temperature*, upon the coffee; as soon as all the water above the inferior orifice of the central tube has been forced up, then only steam arises; when the vessel is removed from the fire the valve falls into its seat, and prevents the re-entrance of air into the lower chamber, after its total expulsion thence by the steam; during the period of infusion, the steam in the lower chamber is allowed to condense, and thus a partial vacuum is produced, and preserved for any period, and rendered available for effecting rapid filtration whenever desired, by the employment of the tap.

From experience we can state that this little apparatus is one of the most useful domestic articles that can be had. It produces the most brilliant and fragrant coffee in three or four minutes. We should observe that during the process the vessel is quite closed; consequently, not the slightest quantity of the aroma of the coffee is dissipated.

ON THE FLOW OF WATER.

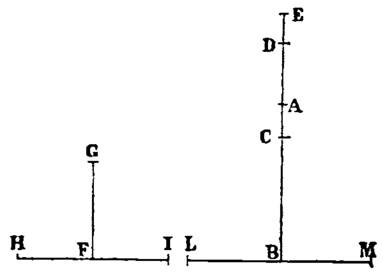
Of the Union and Division of Running Waters, with the Laws of their Increase and Diminution. By Bernardino Zendrini, della Città de Ravenna.—(Translated by E. Cresy, Esq., in his Evidence before the Metropolitan Sanitary Commissioners).

I. A river which unites with another does not cause this latter to rise in proportion to the quantity of water which it brings, as would be the case supposing water to be considered as a solid, but only increases the height by as much as the greater or less velocity of the influent or recipient may permit. On the contrary, if a river in the middle of a canal be diminished by a certain quantity of water, it ought to be lowered proportionally to the velocity of the canal of derivation and the river from which the water is abstracted, and such an alteration ought to be perceived not only at the lower part at the point where the water is added or subtracted, but also in the upper. In which law, however, there is much obscurity; what appears certain is, that both in the case of the union and of the separation that the surface continually adapts itself to the alteration in a regular progression, and although the impression arising from such an anomaly does not disturb the whole level of the river if it runs over a long course, it reduces the problem to find the point where the disturbed mixes and unites with the undisturbed surface after following the oscillation of the water, which point in geometric rigour ought to traverse the whole length to the source of the river, since it would describe a regular curve; but the course of the water encounters so many impediments and obstructions, that these laws do not really obtain. And in every river there is, in fact, a point beyond which the regurgitation does not take place. That, however, as much as possible, we shall treat of in another chapter, when speaking of the falls of rivers, of their highest rise and lowest levels.

For the present it will be sufficient to seek the elevation or depression which will be produced in a river by the addition or subtraction of a quantity of water.

II. Suppose A B to be the height of a recipient previous to the influx of another stream, let L M be its width in a given section, F G the height of the influent before the union, H I its width. Supposing this latter introduced into the recipient, it ought to experience a certain rise. What will that rise be? Since the additional water ought to conform to the width of the section of the recipient, conceive the height F G of the influent altered to that of the recipient A E, then the water of the one will have passed into the other, and since this fresh water presses upon the other, that of the recipient will be obliged to lower its surface, and from the point A will be brought down to C; likewise the point E will pass to D and E D = A C, and consequently B D will be the entire height of the recipient after the addition of the influent water.

Calling $AB = d$. $AE = x = CD$. $BD = z$. $FG = b$. $HI = a$. $LM = c$. The velocity of the recipient before receiving the influent u. Its velocity after having received it, but before it could exercise any pressure and reduce it to equilibrium; that is the same which it would have if the water of the influent ran in the width of the recipient $= t$, the velocity which the recipient



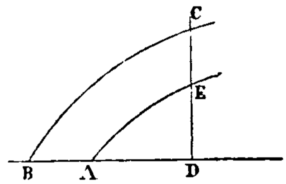
has after the union and after the waters have equilibrated in their course $= q$, and the velocity which the influent had in its own level before the union $= r$. Then since the two masses of water of the influent and recipient in a given and equal time can pass separately in the level of the recipient, they ought to be able to pass together through the aforesaid recipient. Hence the equation $d u + t x = q z$ and $z = \frac{d u + t x}{q}$ first general formula; now since equal masses of water pass in equal times both through the influent separately and through the aforesaid influent when reduced to the width of the recipient, we shall have $c t x = a b r$, whence $x = \frac{a b r}{c t}$ and $z = \frac{c d u + a b r}{c q}$ the second general formula expressing the whole height BD; wherefore AD, which is the whole increment produced by the influent above the first state of the recipient will be $\frac{c d u + a b r - c d q}{c q}$.

III. *Corollary* 1.—If the velocity be a mean proportional to the height, we shall have $AD = \frac{d\sqrt{d} + x\sqrt{x} - d\sqrt{z}}{\sqrt{z}} = z - d$, which reduces itself to $z = \sqrt[3]{(d^3 + 2 d x \sqrt{d x} + x^3)}$ and $AD = \sqrt[3]{(d^3 + 2 d x \sqrt{d x} - x^3)} - d$, in which $x = \frac{b^3\sqrt{a a}}{^3\sqrt{c c}}$, as is obtained by substituting in the formula $c t x = a b r$, the values of t and r, which are $\sqrt{x}, \sqrt{b}$, which value of x if substituted for that of t, will give the value of AD.

IV. *Corollary* 2.—On the supposition of Castelli and of Barattieri, that the velocity will be as the height, we shall have $x = \sqrt{\left(d d + \frac{a b b}{c}\right)}$ and $AD = \sqrt{\left(d d + \frac{a b b}{c}\right)} - d$.

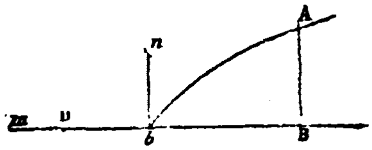
V. *Corollary* 3.—And consequently if $u = d^m - r = b^n\ q = z^\varphi$ where m, n, φ are numbers which may be integers or fractions expressing any power of the height by the velocity, we shall have the general formula $z = (d^{m+1} + a \times c^{-1}\ b^{n+1})^{\frac{1}{\varphi+1}}$, in which x being already eliminated, it only remains to substitute the values of d, a, c, b, taking the aforesaid exponents as fixed, supposing $z\ d$ unknown, the aforesaid formula will give the general equation of the whole curve of the increment of the river by the addition of the other stream, the abscissa of which will be z, the ordinate d, or more generally making $u = d^{\frac{m}{p}}$, $r = b^{\frac{n}{p}}$, $q = z^{\frac{\varphi}{p}}$, we shall have $c\ z^{\frac{\varphi+p}{p}} = c\ d^{\frac{p+m}{p}} + a\ b^{\frac{p+n}{p}}$, and that $z^{\varphi+p} = \left(\frac{c\ d^{\frac{p+m}{p}} + a\ b^{\frac{p+n}{p}}}{a^p}\right)^p$, and we shall be able to determine the relation of z to d in the following manner:—

Let $d^{\frac{p+m}{p}} = b^{\frac{m}{p}}\ y$; now $d^{p+m} = b^m\ y^p$; we shall have $z^{\varphi+p} = \left(y + \frac{a\ b}{c}^{\frac{n+p-m}{p}}\right)^p \times b^m$. Construct the curve AE expressed



by the equation $d^{p+m} = b^m\ y^p$. Take $BA = a\ b^{\frac{p+n-m}{p}}$, and from the point B describe another curve, which has for its equation $z^{\varphi+p} = \left(y + \frac{a b}{c}^{\frac{n+p-m}{p}}\right)^p \times b^m$, we shall have $DE = d$, $CD = z$, and the intercepted portion CE will be the increment required.

VI. *Scholium* 1.—In the simplest case of the velocity in proportion to the height, using the first formula of the preceding corollary, change this into $d\ d = z\ z - \frac{a\ b\ b}{c}$, the equation of the equilateral



hyperbola $b\,A$, of which as well the parameter $b\,n$ as the diameter $b\ m = \frac{2\ b\ \sqrt{a}}{\sqrt{c}}$, wherefore DB will be the height after the union of the water, and BA the height which the recipient will have on first receiving it. And by the properties of the equilateral hyperbola, the square of BA being equal to the rectangular $Bm \times bB$, that is, to the difference of the squares DB, Db, we shall have analytically $d\ d = z\ z - \frac{a\ b\ b}{c}$, which is the equation proposed; whence appears the method of describing such a hyperbola, so as to contain every possible case of increment arising from an addition of water. And calculating with the second formula the two parabolas of the preceding corollary, we shall have $d\ d = b\ y$, $BA = \frac{b\,a}{c}$, and $z\ z = b\ y + \frac{b\ b\ a}{c}$; and if for $b\ y$ we substitute its equivalent $d\ d$, we shall have $z\ z = d\ d + \frac{b\ b\ a}{c}$, the equation which is found and constructed above.

VII. *Scholium* 2.—If the velocity is as the root of the height, the equation resulting from the first formula of § V will ascend to the sixth dimension of the unknown quantity, and the progression will be $c^4\ z^6 - 2\ a^2\ b^3\ c\ c\ z^3 + a^4\ b^6 - 2\ c^4\ d^3\ z^3 - 2\ a^2\ c^2\ b^3\ d^3 + c^4\ d^6 = o$, which does not transcend the limits of a cubic equation; but with the second formula $\frac{m}{p} = \frac{n}{p} = \frac{\varphi}{p} = \frac{1}{2}$ we shall have $z^3 = \left(y + \frac{b\ a}{c}\right)^2 \times b$; and supposing $d^3 = b\ y^2$, AE will be the parabola expressing the aforesaid equation, and BC that of $z^3 = \left(y + \frac{b\ a}{c}\right)^2 \times b$, without otherwise embarrassing itself in the resolution of the aforesaid equation, already sufficient complicated.

VIII. The converse proposition to § II. deduced from the formula there enunciated, which gives the height of a river from which a quantity of water is deducted, to find the section of a canal, such as shall discharge the same quantity of water, and whose height BD shall descend to BA. The equation $c\,q\,z = c\,d\,u + a\,b\,r$ is then changed into $a\ b\ r = c\ q\ z - c\ d\ u$, which solves the problem. Let it be required to diminish it by such a quantity of water as may have to the first, before the subtraction, the ratio of l to p, whence we shall have the analogy $c q z : c d u :: l : p$, by making $r = b^n$, and $u = d^m$, and we have $b = \left(\frac{c}{a} \times \frac{l-p}{p} \times d^{m+1}\right)^{\frac{1}{n+1}}$ whence we deduce the height of the canal of deduction $d = \left(\frac{a}{c} \times \frac{p}{l-p} \times b^{n+1}\right)^{\frac{1}{m+1}}$ formula, which denotes the height which that river from which the water has been subtracted will have acquired after such deduction.

If the water of a river be diminished by a given height after the canal or derivation be opened, and the height of the effluent b is noted, required its breadth a. Let the first height before the deduction be to the second, after the latter has taken place, as e to f; hence $z : d :: e : f$ whence $z = \frac{d\,e}{f}$. Therefore by substituting this value in the general formula, since we have already $r = b^n$, $q = z^\varphi$, and $u = d^m$, the equation will be reduced to the following; $a = c\,\dfrac{e^{\varphi+1}\,d^{\varphi+1} - f^{\varphi+1}\,d^{m+1}}{f^{\varphi+1}\,b^{n+1}}$, in which a and d are the unknown quantities, and c, f, b, z, the given quantities; or else, if a certain breadth be given, and the height remains unknown, we shall have $b = \left(c\,\dfrac{e^{\varphi+1}\,d^{\varphi+1} - f^{\varphi+1}\,d^{m+1}}{a f^{\varphi+1}}\right)^{\frac{1}{n+1}}$. Now in the case of horizontal, or nearly horizontal streams, the canal of derivation being open, whose bottom regulates also the height of the water of the river; that is to say, the portion which acts to produce the greater or lesser quantity which it deducts, the other remaining inactive in regard to such a canal of derivation, the formula will be $d = \left(\dfrac{e}{f} \times \dfrac{c\,z^{\varphi}}{a+c}\right)^{\frac{1}{n}} = b$.

IX.—*Corollary* 1. In the second formula of the preceding paragraph let $m = n = 1$ we change it to $d = b \times \sqrt{\dfrac{a\,p}{c\,l - c\,p}}$ in which if $l = 4000$, $p = 3500$, numbers expressing the quantity of water which passes through a given section of the river both before and after the subtraction of the water, $b = 10$ feet, $a = 200$ feet, $c = 300$ feet, performing the proper operation, the logarithm of $d = 1{\cdot}3345034$ answering to $21\frac{127841}{203034}$. The value of the first height before the diminution will be $z = \dfrac{d\sqrt{l}}{\sqrt{p}}$, where d being known, all the other quantities will be known also, and will be $23\frac{8858}{92117}$ feet.

X.—*Corollary* 2. Making $m = n = \frac{1}{2}$, which is the case of Torricelli, Mariotti, and others, transmuting the aforesaid second formula into $d = b\,\sqrt[3]{\dfrac{a\,a\,p\,p}{c\,c\,(l-p)^2}}$, and $z = \dfrac{d\,\sqrt[3]{l\,l}}{\sqrt[3]{p\,p}}$, substituting the proper quantities and placing the values of the quantities l, p, b, a, c, as above, the logarithm of $z = 1{\cdot}4846658$, the number to which is $30\frac{75446}{132463}$, from which it appears that if the river be lowered by the water, diminished by the effluent so that the first height shall be to the second after the diminution as $23\frac{8858}{92117}$ to $21\frac{127841}{203034}$, the quantity which passes through a given section below the point of diminution, before the water is subtracted, will be to the quantity which passes through the same section after the water is subtracted as 40 to 35 in the first case, and the height in the second case as $30\frac{75446}{132463}$ to $27\frac{146407}{1075812}$.

XI. *Corollary* 3. Taking the third formula of the preceding paragraph, in which we have supposed e, f, d, b, c given, making $n, \varphi, m = 1$, by the hypothesis of Castelli, let us seek the width of the canal of derivation. We shall have $a = \dfrac{c\,d\,d}{f\,f} \times \dfrac{(e\,e - f\,f)}{b\,b}$. Suppose $e : f :: 9 : 8$, $d = 20$, $b = 18$, $c = 300$, the logarithm of $a = 1{\cdot}9929051$, corresponding approximatively to the number 98, of so many feet will be the width of the canal of derivation, that the first height may be to the second, after the water is diminished, as 9 to 8; but on the supposition that $m, n, \varphi = \frac{1}{2}$, will be the formula changed to $a = \dfrac{c\,d\sqrt{d}}{f\sqrt{f}} \times \dfrac{(e\sqrt{e} - f\sqrt{f})}{b\sqrt{b}}$, and the logarithm nearest to a will be $1{\cdot}8900925$, whose nearest number, 78, will be the width required.

XII. *Corollary* 4. Using the general formula, $z = \dfrac{c\,d\,u + a\,b\,r}{c\,q}$, to obtain the residual height of a river, after a certain quantity of water has been subtracted, we shall have $d = \dfrac{c\,q\,z - a\,b\,r}{c\,u}$. Now by substituting for q, r, u, their respective values $z^{\varphi}, b^{\delta}, d^{m}$, we shall have $d = \left(\dfrac{c\,z^{\varphi+1} - a\,b^{\delta+1}}{c}\right)^{\frac{1}{m+1}}$; if then φ, δ, m will be equal each to $\frac{1}{2}$, we shall have the equation,

$$d^6 - \frac{2\,a^2\,b^3\,d^3}{c^2} + z^6 - 2\,d^3\,z^3 - \frac{2\,a^2\,b^3\,z^3}{c^2} + \frac{a^4\,b^6}{c^4} = 0.$$

Or if, for greater simplicity, we reduce it to the following expression, $d = \sqrt[3]{\left(z^3 - \dfrac{2\,z\,c\,x^2\sqrt{b\,z}}{a\,b\,b} \times x^3\right)}$; and since $x = \dfrac{b^3\sqrt{a\,a}}{\sqrt[3]{c\,c}}$, we shall have $d = \left(\dfrac{\sqrt[3]{c\,c\,z^3 - 2\,c\,a\,b\,z\sqrt{b\,z} + a\,a\,b^3}}{\sqrt[3]{c\,c}}\right)$.

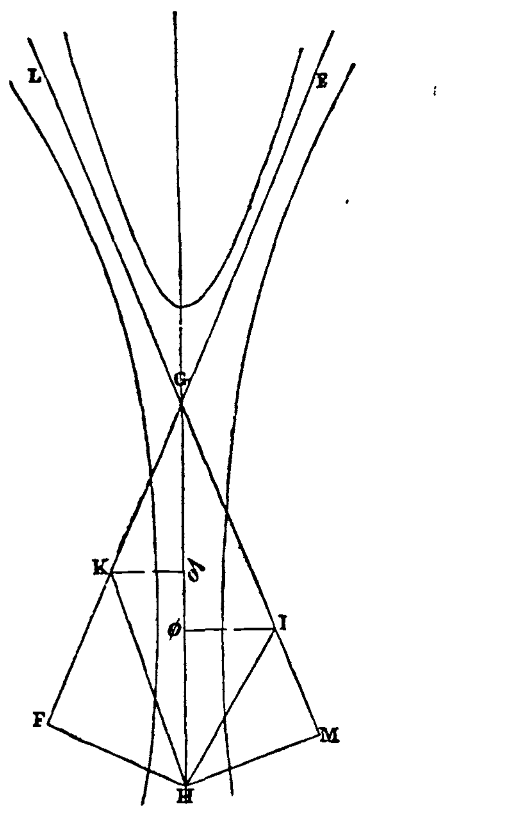
XIII. *Corollary* 5.—Using the preceding formula, in which we have constructed two parabolas, according to what has there been laid down,

$c\,d^{\frac{p+m}{p}} = c\,z^{\frac{\varphi+p}{p}} - a\,b^{\frac{p+n}{p}}$, and thence $d^{\frac{p+m}{p}} = z^{\frac{\varphi+p}{p}} - \dfrac{a\,b}{c}^{\frac{p+n}{p}}$, now $d^{p+m} = \left(z^{\frac{\varphi+p}{p}} - \dfrac{a\,b}{c}^{\frac{p+n}{p}}\right)^{p}$, and making $z^{\frac{\varphi+p}{p}} = b^{\frac{m}{p}}y$ we have, making the necessary substitution $d^{p+m} = \left(y + \dfrac{a\,b}{c}^{\frac{p+n-m}{p}}\right)^{p} \times b^{m}$. Now let B C be the curve whose equation is $z^{\varphi+p} = b^m\,y^p$. Take B A $= \dfrac{a\,b}{c}^{\frac{p+n-m}{p}}$, and from the point A describe another curve A E, expressed by the equation $d^{p+m} = \left(y - \dfrac{a\,b}{c}^{\frac{p+n-m}{p}}\right)^{p} \times b^{m}$, we shall have D E $= d$, C B $= z$, and C E the required difference of height.

XIV. *Scholium* 1.—We shall give some examples of the fall of the surface of rivers, produced by derivative canals, as they have been called, and these examples will be taken from the Adige, which, as is known, affords many such, and on which I had cause, at various times, to make several observations for its general regulation. It was found

1st. That the Bova della Badia, in flood time, measures 10.7.4 Venetian feet, or 1528 lines, above the sill; a its breadth is $12\frac{1}{2}$ feet, or 1800 lines. The reduced height of the Adige, opposite it, at flood time, was 11.3.1, or 1621 lines, being 402 feet wide, or 57888 lines; now by a preceding rule, § VI., in which we supposed the velocity as the height, having $x = \dfrac{b\sqrt{a}}{\sqrt{c}} = 269$, and consequently $d = \sqrt{(z\,z - x\,c)} = 1598$, which being subtracted from the height of the Adige before the diminution, there remains 23 lines, that is 1 inch 11 lines for the required diminution.

2nd. At the mouth or sluice of the Sabbadina we found that $z = 19.1.11$, or 2759 lines; $b = 9.2.11$, or 1231 lines; $a = 27\frac{1}{2}$ feet, or 3960 lines; $c = 2280$ feet, or 30240 lines, whence $x = 554$ and $d = \sqrt{(z\,z - x\,x)} = 2703$, which, deducted from 2759, the first height, gives 56 lines or $4\frac{2}{3}$ inches.



3rd. At the sluice of the New River, when it was of wood, it was found that $z = 10.8.4 = 1480$ lines, $b = 4.10.8 = 704$

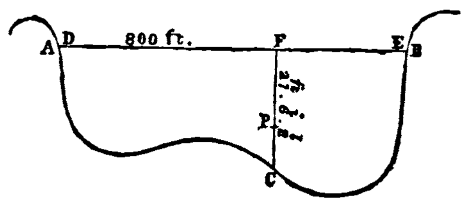
lines, $a = 60$ feet $= 8640$ lines, $c = 318$ feet $= 45792$ lines, and $x = 306$, and $d = 1441$, giving $2\frac{3}{4}$ inches for the diminution of the Adige.

4th. At the Fossa Bellina which is the lowest of the derivatives with respect to the sea, it was found that $z = 10.11.8 = 1580$ lines, $b = 4.4.2 = 626$ lines, $a = 60$ feet $= 8640$ lines, $c = 258 = 37512$ lines. Whence $x = 301$ and $d = \sqrt{(zz - xx)} = 1531$, which subtracted from 1580, leaves 29 lines for the diminution of the Adige, that is 2 inches and 5 lines.

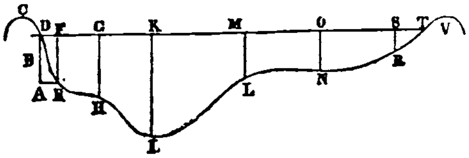
5th. But at Castagnaro, which is the first and farthest from the sea of all, it was found that $z = 14.2.10 = 2050$ lines, $b = 1491$ lines, $a = 35064$ lines, $c = 95040$ lines; dimensions taken above the two falls on each side of the Cunetta, which remains in the middle, the result of which calculated separately will be $x = 250$ lines and $d = 1816$ lines, a sum which diminished by 2050 lines, leaves 234 lines, or 1.7.6, for the diminution of the Adige at the flood time, by reason of the diversion, which the two falls are able to produce on each side of the Cunetta. Calculating then the diminution of this, we have $z = 2050$ lines, $b = 2127$ lines, $a = 3816$ lines, $c = 95040$ lines, as above, whence $d =$ nearly 2000 lines, which, subtracted from 2050, leaves 50 lines, or 4 inches 2 lines, wherefore we have for the whole diminution of the Castagnaro 1.11.8, or within 4 lines of 2 feet.

XV. *Scholium* 2. The celebrated Abbate Guido Grandi, mathematician of the Grand Duke of Tuscany, in his treatise on the motion of water, professes "that if two horizontal rivers, L G, F G, moved with a velocity, I G, G K, be united in one trunk, whose velocity and direction will be G H; and, on the other hand, supposing the said trunk H G, has the velocity H G, it ought, with the retrograde motion to divide itself into two branches, G L, G F, they will not regain the velocity, I G, K G, equal to the first, unless the angle, L G F, be a right angle," the which being different from what we have before established, we are obliged to examine, according to our power, the foundation on which the aforesaid proposition rests. Grandi resolves the total velocity, G H, which arises from the two, G K, G I, by means of the complement of the parellelogram with the two lines expressing the force, H E, G E, of which H E is the perpendicular let fall on G K produced; but if conversely, says he, the trunk, H G, he resolved into branches, whose velocity shall not be the same as on entering the trunk, it may be greater or less, and will only be equal in the case when the angle, L G F, is a right one. The direction of the velocity, G H, resulting from the conjunction of the two laterals, G I, G K, is exactly what all staticians have laid down. To have a clear proof: on the line G H raise the perpendiculars, K δ, I ϕ, and the velocity, G K will be obtained, resulting actually from the two G δ, δK, and the velocity G I, in the two others, G ϕ, ϕ I, of which K δ, ϕ I, nowise contribute to the progressive motion, but only G δ, G ϕ, then G δ + G ϕ are equal to G H, as is more easy to demonstrate; then each quantity denotes really the velocity with which the water in the trunk moves after receiving the influents, and it is to be noted that the prevalence of one perpendicular K δ, above the other I ϕ will only oblige the branch to bend a little from its course. Wherefore the illustrious author then considers the converse of the proposition, that is, when the trunk passes into the branches, to resolve the velocity, H G, into two, H E, E G, and says, that in G F the water will run with the velocity G E, greater by the acute angle than G K, the which will be true, whatever bend and through whatever arm, G E, all the water of the trunk may flow, whilst H G does not express all the velocity, the same quantity not going through G E, which did when G F was considered as an influent, it results that H G ought to resolve itself in another shape than that which is the case, that is, considering G ϕ by the velocity G I, and G δ by the velocity G K, whence the original velocity, G K, G I, in the two canals respectively, will be precisely restored, now reputed as different branches, G F, G L; whence the conversion of the influents into diffluents will not change the velocity; in either case it will be retained, provided it be not changed by any external circumstance.

XVI. *Scholium* 3.—I think it would not be superfluous to give an example of the increase of height which a river really acquires from the reception of another. We will suppose the velocity a mean proportional of the height, using the preceding formula $z = \sqrt[3]{(d^3 + 2dx\sqrt{dx} + x^3)}$. The average depth of the section of the recipient $= 3962$ lines $= d$, its breadth 115200 lines $= c$. The true section of the recipient is figured, in which A and B denote the profile of the banks, C the bottom, D E the surface of the water, P F the average depth; the next figure is the section of the influent in which the shoal E H appears much more elevated than the bottom I and B M S the surface. The better to adapt it to practice and calculation, I shall divide the section into several parts, reducing them one by one to the section of the recipient, which then added together, gives the amount of increase. In the



section of the influent, D E H I L N R T, D E denotes the right bank, R T V the left, E H the bottom of the shoal at the toe of the right bank, L N R the bottom on the left bank, and H I L the bottom of the influent. The portion B F E must be considered of the mean height 3.0.4, that is taking half E F by reason of the triangle B F E or B A E, the base B F is 11 feet, or 1584 lines, wherefore performing the necessary operation, we shall have $z = 3963$ lines, from which subtracting 3962 lines, the average height of the section, there remains one line for the increase of that portion B F E. Likewise through the portion F G H E, 17 feet wide, and 6.0.9 feet high $= 873$ lines, we shall have $z = 3968$ lines, from which subtracting 3962 lines, there remains 6 lines for the increase of the recipient in height by reason of the aforesaid ad-



dition. G H I L M will have a mean height of $13.5.3 = 1935$ lines, and a width of 126 feet $= 18144$ lines, whence $z = 4102$ lines, and this third increment will be 11 inches 8 lines. M L N O formed by the left lower shoal will have a mean height of 1333 lines and 100 feet 14400 lines, whence z will be 4026 lines, and the height required for the increase caused by its addition $5\frac{1}{3}$ inches. The shoal O N S R is 26 feet $= 3744$ lines wide, and the mean depth 3 feet 6 inches 3 lines $= 507$ lines, and $z = 3966$, giving 4 lines for the increase. Finally, the portion comprising the escapement of the bank may be considered 8 feet wide, and 1.9.1. Its reduced height not giving any sensible increase, collecting together all the aforesaid measures, we shall have the total increase of 1 foot 5 inches 11 lines.

XVII. *Scholium* 4.—According to what is registered in the visitation of the Po and Reno made in 1693, by Cardinal d'Adda and Barberini, to calculate the increase produced in the Po by the addition of the Reno, it will be necessary only to use the preceding formula, as likewise to find the same effect at the general visitation of 1720. Taking the data of 1693 aforesaid, supposing the average height of the Po without the Reno at Lagoscuro 31 feet $= 372$ inches, the height of the Reno at the pass of Annegati, that is $b = 9$ feet $= 108$ inches; the width of the Reno there $189 = a = 2261$ inches; the width of the Po at Lagoscuro 760 feet $= c = 9120$ inches, where $x = 3$ feet 6 inches, $d^3 = 51478848$; $2dx\sqrt{dx} = 3906000$ and $x^3 = 74088$ numbers, which added together make 55458936, whose logarithm is 7·7439015, which divided by 3, to obtain the cube root, gives log. 2·5813005, the number to which is $381\frac{3165}{10000}$; and since the fraction answers to 4 lines, if 372 is subtreated from 381.4, there remains 9 inches 4 lines for the increase required according to the aforesaid supposition.

XVIII. *Scholium* 5.—In a report presented by Guglielmini at the time of the visitation, and which was registered in the Acts of it, and printed in the Florence collection, in which he calculates the rise at 8 inches 9 p. only, but the difference between us arises from his having taken the nearest numbers neglecting fractions. Eustace Manfredi, in answer to Giovanni Ceva, says in reply to the other proposition, "To say truly we shall find that the $9\frac{1}{4}$ inches found by Ceva, is one inch more than what results from the former calculation of Guglielmini, and that by a small error of a fraction," &c. [See Manfredi's notes to Guglielmini's book on the nature of rivers.]

XIX. *Scholium* 6.—In all the above examples we have supposed for the calculation of the velocity that it is either a direct or mean proportional to the height of the water, and that so as not to differ from what has been laid down frequently by many renowned authors; and also to give a proof of the manner of employing the formula we have discovered, when greater precision is required, the velocity must be found by an instrument (the hydraulic pendulum), and the formula used which we have given in a preceding chapter. It is possible that in some cases we may not be able to employ the rules above referred to for the velocity without making great errors; thus to seek out the truth as unequivocably as possible, in cases of much importance it is well to calculate by many different methods, observing the difference resulting from each to determine afterwards the most probable.

FRENCH RAILWAYS AND FRENCH REVOLUTIONS.

At length the time has come when the French are awakened to the truth about their railway undertakings. There were very few who withstood the plan of government interference; it was thought quite right that the government should take charge of the railways, and private enterprise was crushed. We say crushed, because it had not free play, and because the concession system was a clog on those lines which were left in the hands of shareholders.

France is behind-hand with her railways: private enterprise when most wanted is dead, and the finances have been upset by the wasteful manner of making the government lines. M. Garnier Pagès, the new Minister of Finance, says this plainly, and names among the causes of financial embarrassment those great jobs, the government railways, made for placemen and not for the country. Thus a burden is put upon France, which she will very much feel, for taxation is at all times burdensome to the people, but always most in their times of greatest need. It was wrong that railways should be made by loans and taxes; but it was still more wrong, when the private enterprise of France was in its childhood, to take away from it the food, as it were, of growth. France has always been backward in such public works, and when there was a fair chance of getting the French to take shares in railways, they ought to have been put forward instead of being kept back. It has not been so, and France is burdened with the government railways, and the springs of private undertakings are broken up and can do nothing, when France wants them most.

If, however, the late government struck a great blow at joint-stock undertakings, the future government holds out no hope, for with the growth of socialist ideas, shareholders are frightened as to what may be their share in anything they may undertake. The working-man comes in now, and asks for his share in the newly-opened lines, and though it may be small at first, it may be very much afterwards, or it may be all. Railway undertakings are not those where this plan can be best tried, for the clerks and workmen have no very great means of making the traffic greater; for when a railway is made, the bulk of the traffic flows upon it, and though it may be nursed, yet, as we have said, the underlings can do but little for it. The shareholder does the most in making the line, and the working does not much want the care of others.

What may be the end to English shareholders in French railways we cannot undertake to say, but whatever may befall—if indeed all they hold now should be lost, there will be no loss on the whole, because the sale of shares to the French in 1845 and 1846, will more than make good whatever may be lost hereafter. On the first stake in French railways, the English made enough to make good their old stock, so that what they have left is only their gain. It may be, that so far as some are bound up in French shares, they may be losers; but most of the holders, as we have said, have made themselves safe. If, too, we take the income which has been had on the old stock and put by, there must be more than enough to meet any loss. We wish the shareholders were as well off in Flanders, but there the railways are only half made, no income has been had from them, very few shares have been sold, and there is little hope of a sale to the Flemings or the French. Therefore, so far as French railways go, there is no room for the outcry that English gold has been wasted abroad.

If there be no loss to the English in the end on French shares, the French themselves will lose, for there will be a withdrawal of that help which the English have given, and which has made and worked the few French railways now open. At a time when the French government must give up railway making, when French shareholders are borne down by heavy losses and cannot make the railways themselves, the French cannot look abroad, for the trust of the foreign holders is broken. However right it might have been to give the workmen a share in the income of the Great Northern Railway, and however needful it may have been, yet this step is the deed of the chairman alone, without one word from the shareholders whose income is handed over. M. de Rothschild, in taking this step, has taken it in haste; and it looks more like giving in to fear, than making a fair and careful bargain between the shareholders and the workmen. No one can help seeing that fear of the Communists wrought upon M. de Rothschild, for it was not enough to hold out the hope—they would not trust to that, he had to give at once all that they wanted. Every one will feel that when they ask again, and ask more, it must be given: the Communists are to ask, and the shareholders to yield. If the stake the shareholders have lately had be too much for them, so that they now have may be held to be too much; it is not left to the shareholders to say what is right—they have not even to make a bargain: the Communists have the might, and they have the right, and if they say five in the hundred is too much, the shareholders must give way. It is very true that lately the income of the holders in stocks and savings banks has been raised, but this only lays a heavier weight on France, and the day must soon come when these burdens will have to be lightened. Then it will be said, holders in savings banks take so much, stockholders take so much—railway shareholders must do the like. On these grounds, the holders here will be frightened, and will take no share in any new railways, whatever the wants of France may be.

If the late government of France had upheld joint-stock undertakings, there would have been a better knowledge of them, and the new government would have been more careful of meddling. They would have looked to them as a help and a stay when so many in France are out of work, and they would have found in them the best way of making the wealthy give food and work to the poor. A tax, however mild on the whole, can never fit itself to the means of every one; the golden mean will be broken—on one the tax will fall lightly, another will sink under it. A joint-stock share undertaking is a free-will loan, or a tax made by a man himself, knowing his means, and taxing himself to the utmost in the hope of gain hereafter. There is no fear of a man putting down too little, there is no fear of smuggling or shifting from under the yoke. A loan raised for railway works partakes of this in so far, that each gives as his means allow; but the hope of gain is not so strong to draw him on, while he is not the master of his own money, it is not laid out under his own care, it wants the eye of the master. It is on these grounds, as much as anything, that we uphold joint-stock undertakings in England; they bring to bear not only the money of the people, but their skill and powers of mind; and we shall grieve whenever in this country joint-stock undertakings shall be given over to the government, as Mr. Morrison and his followers have been so earnest that they should be. What the French did led them on, but we hope they are cooled by what has lately happened there; though we are not so strong in our belief that the government will leave off meddling while berths can be found for their many greedy hangers-on.

The turning out of France of the English workmen need not give us any sorrow, though it will do France no good. It is neither more nor less than self-slaughter by the French. Why did English workmen go there? Not as wanderers seeking a livelihood, not like the Swiss and others who crowd to Paris, and earn bread which Frenchmen might earn; but they have been asked to go there—they have been sought. English skill and English knowledge were wanted for French railways, French power-looms, and French engine works. There were no Frenchmen to do the work, and Englishmen were brought over to teach them. So far from the English doing as the Swiss—working under the French, taking away their livelihood, or shortening their earnings—the English have been always paid higher than the French, and have followed new callings in which no Frenchmen came in their way, while they have given help to the others by teaching them trades, which they did not know before. The power-looms and other weaving and spinning works of the north of France have been set up by the English, and carried on by English foremen; and thus the French have been brought into the market against us. The English foreman is to be found all over Europe, not because he is liked, but as they cannot do without him. This not in France only, but in Flanders, Holland, Germany, Italy, and Spain.

The withdrawal of English masters and English workmen from France is a blow struck at France, and not at us. Instead of Frenchmen fighting us with English weapons, they must take to their own, and be beaten as they were before. We do not believe that this swarm of Englishmen abroad did us the least good. They mostly laid out in France what they made there—they seldom brought anything back; and if we had not to keep the few thousands who lived there, still we must have lost by the Englishmen put out of work at home, who if they had to deal with the French only would have beaten them, for after all the English are far better in all the higher work. We shall have so many men brought home, and we shall have to keep them: it will be most likely by our taking trade from the French, perhaps by sending goods into France itself.

The French have a great fear of our trade, they believe that we sway the world by our trade, and they wish to wrest it from us—they begin the struggle by throwing aside their best weapons. To be great in trade, France should draw money and skill from the whole world; it should have chosen and picked men, whether from France or abroad. It should be the star to which men of mind and skill should look, as shining with the best hope of reward. The blow dealt at the English strikes elsewhere. It is not only the Englishman who is forbidden to take his stock, his knowledge, and his skill to France, but it is every man who is willing and ready to do so. The Italian, the Spaniard, the German is forbidden, and shut out as much as the Englishman. France is shut against the world as much as China was,—there is no field for any but Frenchmen.

We wish we could speak more hopefully, that we could cast a brighter look on France, but we feel we cannot with truth speak otherwise than we have. We believe we have spoken fairly, while we are sure that England, however it may wish that it had been otherwise, is the least harmed by the breach which has thus been made in the ties of fellowship which so lately knit the two together.

HEALTH OF TOWNS BILL.

The promised bill for securing the health of towns is again before the legislature; and we hope with some prospects of success. To the general principles of the measure we are most favourable, because we have long laboured to obtain an amendment of the very serious evils which so much affect the public health. At the same time, there are many clauses which require great and grave consideration before they become law; and in making some remarks upon them, we do so without any hostility to the bill generally.

In clause 8, fifty householders have the power of putting the act in motion. In large towns, such a number gives the power to an insignificant minority; and in small towns, fifty may be found too many. There ought either to be a proportional number, according to the population of the town.

Although the eighth clause speaks of existing local boards, we do not find any provision for their abolition; and we therefore expect that great confusion will arise between the new local boards of health and the old local boards, for paving, cleansing, highways, sewers, and for other purposes. Great confusion must likewise arise from the election of new officers, who will be brought in conflict with the present clerks and surveyors.

The qualification of elected members of local boards seems too high for small towns. The number of inhabitants rated at thirty pounds a year is so small as to restrict the choice of the electors.

We think the provision for contour lines in clause 27, is useful; but if the lines are taken at every ten feet elevation, it will be quite enough.

By clause 29, the board of health will have the power of carrying a sewer or drain "*through or under any lands whatsoever.*" Surely this will never be allowed to pass; this power will enable any sewer to be carried across a garden, pleasure-ground, or park, without any notice or compensation.

Clause 35 requires that notice of building a house shall be given to the local board of health fourteen days, and that works shall not be begun without leave of the board. Seven days seems to us quite time enough, and the works should proceed unless the board can show some objection to them.

It appears very unlikely that clause 42 will be found practicable. It provides for engine and factory chimnies consuming their own smoke.

Clause 49, although aimed at great evils, is very objectionable; and however effective it may be in checking tramp-houses, it will not touch the evils of overcrowded Irish lodging-houses. It makes all houses, other than public-houses, liable to registry and inspection, where persons are lodged for a single night or less than a week. Unless some exception be made for Brighton, Margate, Gravesend, and other watering places, the inconvenience and annoyance will be great; as house-holders are glad to accommodate visitors who run down by steamboat or rail on the Sunday, and return on the Monday.

The clause 54, giving control to the commissioners for regulating the levels and plans of new streets, is arbitrary in its interference with private property, while six weeks is very much too long for any inquiry to be made by a local board or its officers.

In the next clause, 30 feet is too wide for a mews; 24 feet is ample.

The clause 58, for enabling local boards to set up waterworks, however necessary in itself, is likely to do evil by throwing impediments in the way of private enterprise, for the existence of any company to be set up is precarious and dependent on the local board.

After all that has been said about graveyards in towns, it is a pity to see the countenance given to this abuse by clause 67, which allows of graves being made with only thirty inches of soil over the coffins,—a shameful and fearful nuisance.

The clause 78 is inconsistent with the general tenour of the act, for after making it compulsory on each house to have the water laid on, the measure of cutting it off for non-payment of rates, is one not favourable to the public health.

REVIEWS.

The Theory and Practice of Ship Building. By Thomas White, jun. London: Johnstone, 1848. 8vo. pp. 101, with volume of folio plates.

The science of ship building appears to us one of those in which the precise application of mathematics is not to be attempted; but of which, nevertheless, the leading principles should be based on the theoretical laws of mechanics. For ship building, mathematical formulæ can do nothing—mathematical principles everything. The former cannot take account of the thousand and one practical requisites of a good ship—the latter leave sufficient margin for the attainment of the needful qualifications; the former impose laws which are not always just, and even where they are just, are too minute and restrictive; but the latter establish a more liberal and lenient code—one more easy to be obeyed and more deserving of obedience. In choosing between a scientific principle and an analytical formula, the ship builder chooses between a friend and a master.

There is, however, a great difference between general principles and *vague* principles. It is the latter which are now almost exclusively observed in the public dockyards. Grave official personages have a great horror of matters whch they themselves do not understand, and consequently the range of their antipathies is very comprehensive. It includes science. It is no great scandal to assert that in the government dockyards, the most profound science is not so useful a personal commodity as kinship to one of the Lords of the Admiralty. Let a man prove by rigorous scientific demonstration, that some established rule of ship building is essentially erroneous—and will he be rewarded for his pains? Will he be thanked for making an advance in science? Will the obligation under which he has laid society to him, be discharged? Quite the contrary. The chances are, that he will be frowned down as a visionary, or rebuked for pretending to know more than his betters. In the eyes of men in office, to be set right is to suffer *lese-majesté*.

There is one chance, however, that a scientific discovery may be useful, if not to the discoverer, at least to the public;—some one who dines occasionally at the Admiralty, may think it worth while to appropriate it.

Our respect for government science, for the researches of royal commissions, the mathematics of blue-books, and the investigations of official inspectors, is extremely limited. In matters of experimental philosophy, we should lay it down as a general rule, that the persons least likely to find out the truth are—the "properly constituted authorities." What a satisfactory affair the Gauge Commission turned out! How well Sir William Symonds' ships sail! With what universal and unhesitating deference did the railway engineers receive the reports of Sir Charles Pasley! And to go still further back, how admirably the Irish Railway Commissioners executed their task! of which the most favourable thing that can be said is—that their report suited the character of the country affected by it. The blunders of admeasurement in the plans and sections were not *much* more egregious than some which have been detected by the Standing Orders committees: and Mr. Barlow's investigations of the effect of gradients are not very much worse than a mathematical student would write in his first year.

It seems to us quite clear, that for the future advancement of the practical sciences we must trust entirely, or almost entirely, to private efforts. At rare intervals, indeed a commission will be competent for the scientific investigation assigned to it: it is reasonable, for instance, to expect much benefit from commissioners selected as those appointed to consider the use of cast-iron girders on railways have been. But on the whole, these cases must be looked upon as exceptions and happy accidents. In naval matters the inefficiency of official philosophy is especially deplorable, because of the enormous expense which it entails upon the nation. After all the visits of the Lords of the Admiralty to Portsmouth —after all the parliamentary returns and parliamentary debates— after all the enormous cost of ships built on new models, to be subsequently remodelled and patched as the prevailing caprice dictated—after all the exploits of experimental squadrons—we have come to the very gratifying conclusion that our most weatherly vessels were taken from the French in the late war. O, for an *Ecole Polytechnique* in England!

The author of the work before us professes no more than "to give some plain directions for actual building," and to put the reader in possession of just so much information as is requisite for carrying him to "larger and more scientific works on the subject." But the present treatise, though it does not aim at extreme profundity, has the greater merit of expressing in simple terms some very important views respecting the application of hydrostatics to the theory of ship building. The *stability* of a vessel is properly insisted upon, as a perfectly indispensable requisite—one without which all other merits are valueless. The form of a vessel may enable her to sail fast, but if, at the same time her pitching and rolling motion be excessive, the practical utility of the vessel is proportionably lessened, her security endangered, and her durability diminished by the constant strains to which she is subject. Sir William Symonds' vessels are, our author remarks, liable to these grave objections. In his vessels, the rake of the stem is sometimes so great, that the stem is inclined to the keel at an angle of thirty degrees. By thus cutting away, so to speak, a large portion of the fore body, it is clear that when the vessel pitches ahead, there is less immersion or sustaining power to bring her up again, than there would be if the stem were more upright. He committed a similar error with respect to the lateral rolling. The lateral stability, of course, depends in a great measure on breadth of beam; but the general form of section amidships must be duly proportioned in reference to it. "Here," says our author, "we consider, is to be found the great defect in the surveyor's midship section; it is comparatively straight from the keel to the water-line; and, as such, is manifestly deficient in bearing, until its extreme immersion takes place, which is sudden almost to a jerk; whereas a rounder line would prevent the great degree of lateral inclination, and what must take place would be much more easy. The advantage of this, in comfort upon the deck, efficiency at the guns, wear and tear of the rigging, and indeed, the safety and comfort of the whole, must be apparent."

The conditions of stability, either laterally or longitudinally, are not after all so very difficult to ascertain. The problem is practically a hydrostatical, not a hydro-dynamical one, and therefore much easier than that of determining the forms best adapted for speed. If navy surveyors had only a moderate acquaintance with the properties of the METACENTRE—if their appointments depended rather on their knowledge of hydrostatics, than on their government influence, or aristocratical connections, we should have to pay for much fewer of those great wooden coffins which now disgrace our navy. As far as we may judge from Sir William Symonds' actual performances, he either does not know the meaning of the word "metacentre," or he cannot have studied its properties. He may possibly have an idea that they have some influence on the stability of a vessel—but he certainly cannot know that they are, not merely important, but all-important—that in the question of stability, the properties of the metacentre constitute the question, the whole question, and nothing but the question.

Mr. White's practical directions we will not venture to criticise at length. The accuracy of his general views, however, and his long experience in his profession, seem just grounds of dependence on his authority in matters of detail. The folio plates are carefully drawn and admirably executed: and the descriptions which accompany them are very minute, and appear well suited to the purposes of the ship builder. The work concludes with an account of the methods now in use for measuring tonnage, and with remarks on the complexity and inefficiency of the new method established by law. We conclude with the following brief extracts, the first selected for its scientific importance, the second for its curiosity:—

"The form of body best adapted for steam vessels, is a primary consideration. It will be found that most of the principles which constitute a good sailing ship, will also apply to a steamer. We have repeated instances in which first-class steam ships that have afterwards proved of superior character, have gone as fast, under jury rig, and with not more than half the momentum of canvas allotted to sailing ships of equal tonnage, as they have subsequently gone under the full power of the engines. Many valuable inferences may be drawn from this fact; and we unhesitatingly bring to our aid, in building steam ships, the whole experience of the profession, to a much greater extent than was at first adopted. Experience shows that the long bow and clean run are indispensable; for, whatever may be the laws of fluids, the great speed of river boats thus built, the increase obtained by lengthening so many of the earlier formation, and the increased acuteness of each succeeding class, amount to a demonstration on this point."

"The ark in Scripture was of these proportions, namely, six times the breadth for the length, and one-tenth the length for the depth. Other proportions may in particular circumstances promote speed; but for stability and security at sea, the proportions of the ark, destined as she was to endure the greatest commotion of waters the world has ever known, are, we fearlessly assert, infallible, since the experience of four thousand years has only confirmed them; a collateral evidence, at least, of the truth of the Scripture narrative. The ark was twice as long, and twice as wide and deep, as the West-India mail steamers, and consequently would make eight of them, considered as regular figures."

An Historical, Practical, and Theoretical Account of the Breakwater in Plymouth Sound. By Sir JOHN RENNIE, F.R.S., F.S.A., F.G.S., President of the Institution of Civil Engineers. London: Bohn and Weale, 1848.

Sir John Rennie could not have more worthily devoted himself than to the commemoration of the great work of his father, the Plymouth Breakwater, and he could not have erected a monument more munificent than the volume now before us,—one which while it records the merits of his father, and gives proof of his own enlightened spirit, will be of value to the engineering profession for many generations. Well may we describe it as a monument more lasting than brass, while it bears a more noble inscription than was ever sculptured on marble. Of Sir John Rennie's works we will not speak, for others can put forward a claim to the production of works of equal magnitude and merit, but we cannot refrain from saying that this book is another public service rendered to the engineering profession. As President of the Institution of Civil Engineers, Sir John has upheld the social rank of the profession, and has maintained its public hospitality; by the contribution before us, he has shown his earnestness in the cause of professional literature. These are to our mind merits in addition to the material monuments of his skill, and speak powerfully of his enlarged and liberal mind, and of his public and disinterested spirit. They show that his heart and soul are engaged in the career he pursues, and are a guarantee of his professional independence and integrity.

We speak warmly, because it is rarely we have the opportunity of speaking of a book from the hands of one of the higher members of the profession, and therefore it comes more welcome to us. It is true there are excuses for the silence of those members, and Sir John has himself very well explained them, but that does not exempt us from our duties towards him, who stands a brilliant example of successful exertion. Sir John Rennie's words merit attention, for they must be the exculpation of our engineers in the eyes of Europe. He says—

"Continental engineers have generally more time than English engineers for writing and reflection. The former, confined for the most part to a single work at one time, have leisure to study and reflect upon every operation connected with it, and to deduce general laws from them which may be applicable in similar circumstances. Their sphere of action nevertheless is limited, compared with that of English engineers, and they have not the same facilities of acquiring that readiness of application, that versatility of inventing remedies to meet every case which occurs in practice, and which alone can be derived from extensive and greatly-varied experience in all kinds of works, such as falls to the lot of English engineers. This defect is necessarily inherent in the continental system, notwithstanding the numerous able engineers we find there. The whole of the works, as well as the engineers, being in the employ and under the control of the government, their energies are impeded, their talents are fettered, and they are deprived of that strongest of all inducements to exertion, viz., competition, which has been productive of so much benefit in this country. Here, as regards engineering, everything has been free and untrammelled; thus every member of the profession has been at liberty to study and follow out that course which appeared to him best calculated to acquire public favour, and secure his own interest; and the public, on the other hand, has never found any deficiency of talent to carry out any work as often as the emergency required.

The government also have equally profited by this system, for they can always enter the market upon the same terms, and obtain any degree of talent they may require without the necessity of training a corps of civil engineers of their own, which, for the reasons above stated, would be found very difficult, and perhaps not without entailing the expense of numerous failures, which is the more unnecessary, as they can obtain the experience ready-made without any such sacrifice. Nearly all the great works and improvements in the public establishments have hitherto been obtained in this manner; of which the Breakwater and many others may be termed excellent examples, and by pursuing the same system, the same beneficial results will continue to be produced. On the continent the superiority of our free system of competition is in many cases much admired, and will probably be introduced where circumstances render it practicable; and English engineers are highly esteemed and much employed on the continent."

This is spoken fairly, and Sir John takes care that he shall not be understood as speaking invidiously, or as depreciating the continental engineers. He says—

"In saying thus much, I wish to be distinctly understood, that I should be extremely sorry to be considered as undervaluing in the smallest degree the numerous able engineers in every department on the continent, or the magnificent works which have been constructed by them, or the excellent books they have written, which have been productive of so much benefit to the profession of civil engineering."

In these sentiments we fully concur; we honour our continental brethren, but we demand for them as for ourselves the benefits of what we believe to be a better system—that of the competition of civil engineers. We advocate for their interests a wider field of exertion, and emancipation from the thraldom of the government bureaucracy, protection for men of ability, and no false encouragement for men of no ability.

In expressing himself thus boldly, Sir John Rennie has done very great service to the profession by vindicating it from the injurious and insidious designs of the government here, who are always seeking to establish military engineers in capacities for which they are utterly unsuited. We wish other members of the profession of equal reputation would display the same dignity of feeling and disinterestedness, by publicly expressing their unfavourable opinion of the government assistance. We hope the fear of losing some small amount of government patronage does not keep them back from doing what Sir John Rennie has unhesitatingly expressed.

We wish too they would imitate him in the production of books, such as his. At any rate, their pecuniary means enable them to imitate him in the lavish outlay he has made on drawings and engravings. They have the drawings in their own offices, and if they merely put them in the hands of the engravers, without any text, the plates will prove of value to professional students. We have seen so many examples of liberality among the profession, that we hope it will be equally displayed in contributions to engineering literature. Money only is required, their time is not required; and though they can plead they have so little of the latter, they have been well enough rewarded to deprive them of such a plea in the expenditure of money.

We have been apt to adduce as a merit in professional works that they were profusely illustrated, and we believe our readers will agree with us, for such books are thereby of a more practical nature. In this respect, Sir John Rennie's volume has few to surpass it; and it is undoubtedly one of those great works, which must at once take its place in the standard library of engineering. No expense has been spared, we may say no care has been spared, to make that portion of the work complete which speaks to the eye, illustrating the words of Horace—

> "Segnius irritant demissa peraures
> Quam quæ sunt oculis subjecta fidelibus"

The eye of the practical man seizes at once the construction and proportions in a drawing, while the most copious description fails to convey an impression so complete. Again, it is more easy for those who wish to copy a good example to do so from a drawing than from a description, and when we consider that a work of this kind is to be a text-book for hundreds of engineers, it appears most desirable that it should be, as it is, really and truly useful.

On leaving the presidential chair, Sir John Rennie has not retired from the public service. He never could retire into obscurity, but he could well have claimed exemption from further contribution. That he has completed this magnificent work gives him an additional title to future fame, as it does to the gratitude of his contemporaries for his maintenance of the dignity of their profession.

The Young Surveyor's Preceptor. By John Reid, Surveyor. Parts I. and II.

The object of this work is to explain the present system of measuring and estimating builders' work;—for this purpose the author has given the plans of a first-rate building, and explains how the measurements are taken, commencing with the digger, and going on with the bricklayer and carpenter. The dimensions are all given in detail as taken off in estimating, and are accompanied with a specification of each trade. Mr. Reid appears to have adopted the practice of the most experienced surveyors, and has produced a work which is likely to be of great benefit to the pupil, in *assisting* him in his professional pursuits. In saying this, we must caution him not to imagine that he can obtain a sound practical knowledge of the duties of a surveyor or architect, from merely reading or studying this work, or any other book or lecture: it can only be attained by accompanying an experienced surveyor in measuring or making an estimate of the building itself.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF CIVIL ENGINEERS.

Feb. 22.—Joshua Field, Esq., President, in the Chair.

The paper read was by Mr. A. Mitchell, of Belfast, Assoc. Inst. C.E., "*On Submarine Foundations; particularly the Screw-pile and Moorings.*"

Considering that the entire subject of the various sorts of piling, of solid stone foundations, of cofferdams, of masses of concrete, and the numerous modes adopted by ingenious men for overcoming local difficulties, would occupy too much time, and scarcely possess novelty, the author restricted himself almost entirely to the description of the works executed by him with the screw-pile, as that had been chiefly employed for supporting structures on loose sand or mud banks, wholly or partially covered by the sea, where it had been previously considered very hazardous, if not impracticable, to erect any permanent edifice; and in his narrative, he scrupulously avoided all comparison with other modes of proceeding, even when they had the same object. The origin of the screw-pile was the screw-mooring, which was designed for the purpose of obtaining, for an especial purpose, a greater holding power than was possessed by either the ordinary pile or any of the usual mooring-anchors or blocks, of however large dimensions. It was proved by experiment, that if a screw, with a broad spiral flange, were fixed upon a spindle, and forcibly propelled by rotary motion to a certain depth into the ground, an enormous force would be required to extract it by direct tension; and that the power employed must be sufficient to drag up a mass of earth of the form of the frustrum of a cone reversed—the base being at the surface of the ground, and the section of the apex being equal to the diameter of the screw. The extent of the resisting mass must, of course, depend upon the natural tenacity of the soil. Even in this reasoning, it must be evident that a vertical force was calculated upon; but as, practically, that seldom if ever occurred, the angle of tension and the curve of the buoy-cable again gave the moorings greater power. This was found to be correct in practice, and the application of the moorings became very extensive. An arrangement was made with the port of Newcastle-on-Tyne, by which, for the sum of 2,500*l.*, the right of fixing these moorings in the Tyne was given; and Mr. Brookes, the engineer, showed that last year, whilst in the neighbouring port, damage was done to the shipping to the extent of nearly 30,000*l.*, no injury was sustained in the Tyne, entirely owing to the sound holding of Mitchell's screw-pile moorings. It naturally occurred to Mr. Mitchell, that the same means of resistance to downward pressure might be used; and he proposed to apply it for the foundations of lighthouses, beacons, and other structures, which, for maritime purposes, it might be desirable to place upon sand and mud banks, where hitherto it had been considered impracticable to place any permanent edifice. In the year 1838, a plan for a structure of this nature for a lighthouse, on the Maplin Sand, at the mouth of the Thames, was laid before the corporation of the Trinity House, supported by the opinion of James Walker, Esq., their engineer. The nine iron piles, 5 inches diameter, with screws 4 feet diameter, were accordingly driven 22 feet deep into the mud, and, with proper precaution, they were allowed to stand for two years before any edifice was placed upon them. The lighthouse was subsequently constructed, and, as was testified by Mr. Walker, had stood perfectly until the present time. Pending this probation, it was determined to erect a lighthouse to point out the entrance to the harbour of Fleetwood-on-Wyre, and under the advice of Captain Denham, R.N., the screw-piles were adopted. The spot fixed on was the point of a bank of loose sand, about two miles from the shore; seven iron piles, with screws of 3 feet diameter, were forced about 16 feet into the bank, and upon them timber supports 48 feet in vertical height were fixed to carry the house and lanthorn. This structure was completed in six months, and was perfectly successful, never having required any repairs to the present time. A similar lighthouse was erected near Belfast; and since then several others, with a great number of beacons, have been fixed in situations heretofore deemed impracticable.

A project was started by the Earl of Courtown, in the year 1847, for adding to the length of the pier at the Harbour of Courtown, on the coast of Wexford, which had proved an entire failure, from the channel between the solid pier being continually choked up with sand. Iron piles, with screws of 2 feet diameter, to be driven from 11 feet to 15 feet into the sand, and blue clay, were decided to be used in order to form an open jetty through which the sand could be washed by the current, and the platform would be used for loading and discharging the shipping. The surf was so heavy on the coast that the usual barges or floating rafts could not be used for putting the piles down—so an ingenious plan was designed by Mr. Mitchell, for projecting a stage forward from the solid part, rigging a large grooved-wheel upon the top of the pile, passing an endless rope-band around it, and round a pulley fixed 150 feet back, and then, by a number of men hauling upon the band, a rotary motion was communicated to the pile, which screwed it down very fast. By these means one bay of the pier, 17 feet long, was finished daily, even in very rough weather. The entire length of the jetty was 260 feet, its breadth 18 feet, with a cross-head 54 feet long, with landing stages at each end, and two lines of railway throughout. The entire cost of this extension was 4,150*l.*, or about 47*l.* 10*s.* per lineal yard—an extremely small sum compared with the cost of stone piers; but even that was more than the expense would be now, as the system of work is better understood, and materials are now cheaper. The account of the difficulties incurred in the execution of these works was most interesting, and ample testimony was borne by engineers of eminence, and men whose maritime experience gave weight to their opinion, of the superiority of Mr. Mitchell's screw-piles and moorings over every other system for holding buoys, or for supporting beacons and lighthouses, and their use was suggested for the foundation of bridges, viaducts, and numerous railway and other works, as well as a multiplicity of applications which had not hitherto been thought of.

Mr. W. A. Brooks gave an account of the method of laying down the moorings at Newcastle-on-Tyne, under his directions. A heavy chain, formed of 3¼-inch round iron, in links of 3 feet long each, was stretched along the bed of the river, in the direction of the current. To this chain, beneath each tier, was attached a 2¼-inch mooring-chain, fixed to the head of a screw mooring; another screw being also placed beneath each tier, and driven down between 10 and 20 feet into the clay, and sometimes full a foot into the shale rock. The screws were 4 feet in diameter, and were placed in depths varying from 15 feet to 24 feet at low-water spring tides. They were screwed down to the depth of 15 feet in an hour and a half, and sometimes 21 feet in two hours. Each mooring screw was intended to have borne the strain of four heavy ships; but, during the last winter, the port was so crowded, that more than double the proper number of vessels were moored upon each; and yet there were no signs of weakness; and whilst nearly 30,000*l.* of damage was done at Sunderland, during a heavy storm, no casualties occurred at Newcastle, which Mr. Brooks stated was entirely owing to the sound holding of the screw moorings. He argued, therefore, that the small sum of 2,500*l.*, paid by the harbour commission of Newcastle for the right to put down these moorings, was a very wise expenditure.

Mr. T. Smith, Pilot Master of the Port of Shields, corroborated Mr. Brooks's statement.

Captain Washington, R.N., had, in the course of his surveying duties, seen the screw moorings in almost every position, and had heard them universally eulogised, as being the best and safest moorings hitherto known. He strongly recommended their employment. He had also examined carefully the screw-pile lighthouses, and had every reason to be satisfied with them, as affording a means of placing lighthouses and beacons where they were before impracticable, and enabling floating lights to be generally superseded by fixed lights, which latter he proved, from documentary evidence, to be one-third less annual cost than the former, and certainly more useful to sailors; for, in spite of all the care, attention, and even lavish expenditure of the Trinity Board to moor the lightships securely, they did go adrift just at the time when they were most required. He, therefore, advocated fixed lights in every situation where a foundation could be obtained; and he believed that, with the screw-pile, there were scarcely any situations where this could not be accomplished.

Messrs. Walker, Cubitt, Rennie, Murray, Moorsom, Mitchell, Scott Russell, and others, took part in the discussion, adducing instances of the efficiency of the moorings and the piles, and of their applicability to numerous engineering works, for which they expressed their intention of employing them. The high price hitherto charged for the right of using them had somewhat retarded their general introduction; but it was explained, that Mr. Mitchell had feared to entrust to others the fixing of them, lest a failure might ensue before his system was perfected, which, however, he now thought it was. Now, however, as the right of granting licenses for their use was transferred to men of business who had purchased it, there was no doubt of their being brought within the reach of every application.

Feb. 29.—The paper read was entitled "*Remarks on the Formation of the Entrances to Docks, situated upon a Tideway.*" By Mr. J. B. Redman, M. Inst. C.E.

After illustrating the subject by the example of the position and direction of all the principal dock entrances on the borders of the Thames in the port of London—showing that the variation in the opinions and practice of engineers had been very great—the paper detailed the ordinary methods of docking and undocking ships, and the precautions to be taken in constructing entrances, which should be best adapted for facilitating these operations; and, although it was difficult to lay down any positive rules upon the subject, as the engineer must, in almost every case, be guided by local circumstances, yet in ordinary cases the following general rules were recommended:—For graving docks, an angle of about 45°, pointing up the stream; for wet docks, an angle of about 60°, in the same direction; and a right angle, with the stream, for building ships. These, it was believed, would be generally found the most available.

March 7.—In the discussion upon Mr. Redman's paper, the merits and defects of the several dock entrances in the Thames and in other situations were examined, and the general result appeared to be, that although the engineer must be guided by local circumstances, yet, that in situations where the river was sufficiently wide, and the position of the land permitted, an acute angle pointing up the stream, was the best for docking vessels with the flood—that the reverse would be best for undocking ships. In ordinary widths of rivers, therefore, the end would be attained by forming a bay sufficiently deep to render the water still in front of the dock, the wing walls being so much splayed as virtually to give the directions up and down the stream as circumstances required. The peculiar positions of the docks at Ipswich, by Mr. Palmer, the alterations of the Duke's Dock at Liverpool, by Mr. Cubitt, and other cases, were sustained in support of the arguments of the speakers, who all united in praising the industry and talent of Mr. Redman, in bringing forward the subject in the complete manner he had done.

March 14.—The paper read was "*An account of the effect of the Storm of the 6th of December* 1847, *on the coast near Edinburgh, as illustrating the Principles of the Construction of Sea Defences.*" By W. J. M. Rankine.

The principal example given was the sea wall of the Leith branch of the Edinburgh and Dalkeith Railway, built by the author in the year 1837, from Mr. Walker's designs. Just after it was completed, a violent storm occurred, which injured almost every similar work within its range, but produced no ill effect upon that structure. On the 6th of December 1847, a still more violent storm occurred, which did great damage all around, but the railway wall still escaped without injury. The total length of the wall was about 760 yards; its height was 18½ feet above the beach at the highest point, diminishing to about 6 feet at the ends. The height of the top was 4 feet above equinoctial spring tide level. Its least thickness was 5 feet and its greatest 10 feet; the back was vertical, but the face had an inclination at the lower part of 5 inches in the foot, gradually becoming curved as it rose upwards, until at the top it overhung slightly. The foundation course was composed of large flat stones, laid horizontally 4 feet below the surface of the beach, upon a stratum of fine sand and gravel, firm when dry, but moveable when wet. The face was of hammer-dressed ashlar, about 2 feet thick; the back of rubble, 18 inches thick. The interior was filled with concrete. The coping was composed of stones each weighing about half a ton, connected by means of cast-iron dowels. The stone used was Craiylieth sandstone. The face joints were laid in cement for a depth of 4 inches. The foundation was protected by a pitching of trap boulders, laid on the natural level of the beach. They were partially disturbed by the storm referred to, and the author ascribed this to their weight being insufficient to resist the vertical oscillation of the waves.

The second example was a vertical sea wall near Trinity, the foundation of which was protected by a dry stone bulwark sloping at angles of from 30 deg. to 40 deg. The wall was injured by the the storm, but the pitching was breached at several points.

The third example was another wall near Trinity, of a hyperbolic section. The lower part had a slope built dry up to a little below high-water mark. At this point there was a sharp curve, and the upper part was nearly vertical, and laid in mortar. The waves extracted the stones of the curved portion, and the upper part, being undermined, was destroyed to a great extent.

The last example was the bulwark of the Granton line, the lower part of which sloped at about 20 deg.; the upper portion was curved, and was covered by a heavy projecting stringcourse and parapet. It was built dry, and the stones of the lower part weighed not less than half a ton each. This bulwark suffered damage to a slight extent on its upper portion.

These examples were stated to confirm the following principles:—That the principal action of the waves in front of a sea wall was a vertical oscillation, produced by the combination of the direct and the reflected waves; that a sloping bulwark gave rise to a sloping oscillation, tending to overturn any portion which projected above the line of slope; that where the strength of a sea wall depended on the pressure of the superincumbent masonry, and the adhesion of mortar and cement, the position of greatest stability was vertical; and that when the strength depended on the weight of the individual stones, the position of greatest stability was a very flat slope.

In the discussion which ensued, instances were adduced of the duration of vertical walls under the attacks of heavy seas, and, on the other hand, of their destruction when flat slopes had effectually resisted the waves; and it was agreed that in this, as in all other cases of engineering, no empirical rules should be laid down, but that the skill of the engineer should be exerted to adopt such forms of construction as were best adapted to the locality and the circumstances.

March 21.—The discussion on Mr. Rankine's paper was continued. Letters were read from Mr. Maclean, describing the Barras and Piel sea embankments; and from Mr. Macdougall Smith, on the importance of using stone of great specific gravity in sea-works.

Mr. Bateman stated the necessity of using hard and tough stones, which would resist disintegration by the friction of the shingle moved by the waves.

Mr. Murray corroborated the statements of Mr. Bateman, and recommended groynes as the best means of collecting sand and gravel, to protect exposed coasts, and the foundations of sea-works.

Mr. Rankine replied to some of the remarks which had been made. He referred to Mr. Scott Russell's paper on sea walls, as being partly confirmed by his observations. He disavowed the intention of laying down universal rules for the construction of breakwaters in deep water, from observations on walls built on a flat beach; but, to show how the principle of such walls could be applied, he referred to the Cherbourg breakwater, where the top of a stone embankment formed an artificial beach, on which a vertical wall was founded.

The paper read was descriptive of "*A Method of Setting out a Railway Junction.*" By A. Beaulands.

The object of the paper was to supply a methodical rule for setting out that portion of a branch line of railway included between the rails of the main line. The author observed, that in all ordinary cases the curve of a branch line could not be set out from the main line, which was supposed to be straight, by the ordinary methods of setting out railway curves, since the junction was required to make an offset of 4 to 5 inches on the length of the switch-rail, which was much greater than the offset made from the tangent in the same length by a curve of moderate radius, so that it was necessary to make the junction line start abruptly at a finite angle with the main line. He, therefore, considered the junction-curve, to be determined by its passing through three given points—namely, the two extremities of the switch-rail, and the furthest point of crossing; and from these data, he showed how the radius and centre of the circular arc might be found, as well as the positions and angles of the various crossings. To render the method more easy of application, the author gave a table, calculated from the principles and formulæ laid down in the paper, assuming an ordinary form of the switch, and a series of valves of the lead, a distance of the furthest crossing extending to the greatest limit likely to occur in practice.

In the course of the discussion which ensued upon this method, as compared with the ordinary system of setting out junctions by a comparatively empirical rule, well understood and practised by the platelayers on railways, Mr. Wyld's switch was alluded to, and exhibited. In this switch all notching and inequality in the bearing surfaces of the fixed rails were shown to be avoided, by the ends of the tongues being housed under such surfaces, instead of being notched into them: the tongues being consequently at their points, and for some distance between them, lower than the fixed rails, exercised when they were weakest merely a lateral action against the wheels, without bearing any of the weight of the passing trains. Several engineers who had employed these switches extensively, expressed themselves relative to them in very commendatory terms, and stated that they were not only manufactured in a very superior manner, but that their action was very perfect, and that they tended greatly to the prevention of accidents in railway travelling.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Feb. 21—The Earl de Grey, President, in the Chair.

Mr. G. Bailey, the honorary secretary, read the report of the council relative to the medals for the session 1847-8.

With reference to the Royal Medal, it was stated that, in pursuance of notification in the various publications, English and foreign,—"On the 31st of January, 1848, the council met to receive nominations and applications of candidates, when sixteen names (eight Englishmen and eight foreigners) were given in and considered. The meeting being adjourned to the 14th of February, the claims of the several candidates were further considered; and a ballot being taken, the majority of votes were found to be in favour of Mr. Cockerell; and it was accordingly—'Resolved, That the Royal Medal of the Institute be awarded to Charles Robert Cockerell, Esq., R.A., Professor of Architecture in the Royal Academy of Arts, London, Member of the Royal Institute of France, &c., in testimony of his distinguished merits as an architect.'

For the Silver Medal of the Institute, offered for the best essay 'On the application of sculpture and sculptured ornament to architecture, and the principles which should regulate their introduction into buildings generally, both with regard to beauty of embellishment and propriety of style,'—Three essays have been received, distinguished by the following mottos: No. 1. '*Junius*;'—No. 2. '*Rule*;'—No. 3. '*Nisi utile est quod faceimus frustræ est gloria.*'

The three essays display much ingenuity and a praiseworthy habit of observation; they contain many judicious observations on the higher branches of sculpture, but in general the remarks are too indefinite, and are deficient in the illustration derivable from immediate reference to examples.

The authors appear to have mistaken the immediate aim of the question proposed:—the subject is of a practical and positive nature, in relation to a specific architectural purpose, and was not intended to elicit a disquisition upon the abstract attributes of sculpture.

Sculptured ornament, a most important section of the programme, appears in two of the papers to have totally escaped the attention of the writers, and in the third is only casually alluded to.

The council, however, are of opinion that the author of the essay headed '*Junius*' has evinced considerable talent, and that he is justly entitled to the medal offered.

For the Soane Medallion, the subject being 'A design for a building to contain public baths on a comprehensive scale, with all suitable accessories, and combining the magnificence of the ancients with the usages and puposes of modern times,'—Five designs have been received:—A. Four drawings and MS. description, motto '*Quod potui perfeci.* No. 1.'—B. Four drawings, motto '*Quod potui perfeci.*'—C. Six drawings, motto '*Ne nimium expectes annis prudentiæ crescit.*'—D. Three drawings marked '*Aquarius.*'—E. Two drawings and MS. description, marked '*Christophorus.*'

The council cannot refrain from noticing the little attention which appears to have been given by some of the candidates to the printed conditions, and particularly as respects the adaptation of the buildings, 'to the usages and purposes of modern times.'

Although the several designs are formed on a scale sufficiently comprehensive to embrace all imaginable as well as suitable accessories, in some no indication is given of provision being made for the varieties of medicated or other baths so much in use at the present day; nor reservoirs, nor the requisite apparatus for heating the large quantities of water that would be required to supply such extensive warm and tepid baths as are shown in the drawings; neither are chimneys or shafts provided to carry off the smoke, steam, &c., which it would be impracticable, under any circumstances, to consume.

The council are of opinion that the design marked '*Christophorus*' possesses, on the whole, the greatest degree of merit, notwithstanding the unfavourable manner in which it is represented in the drawings of the elevations and sections, and sufficient to justify the bestowing on it the award offered."

The author of the essay marked "*Junius*," is Mr. Henry Bayly Garling, associate; and of the design marked "*Christophorus*," Mr. James M'Laren, of Edinburgh.

Mr. Penrose read a paper "*On some of the Geometrical Lines and Optical Corrections of the Greek Architects,*" which will be given next month.

March 6.—C. Fowler, V.P., in the Chair.

A paper was read, "*On the Ancient Buddhist Architecture of India.*" By J. Fergusson, Esq.

Mr. Fergusson commenced by showing that the generally assumed primeval antiquity of Indian buildings was not borne out by facts; as the oldest monuments in the country, whether cut in the rock or structural, belonged to the Buddhists, and the founder of that religion died only 543 B.C.: and that even that date was too early, as it did not become the religion of the state till after 250 B.C., in the reign of Asoka,—by whom the earliest monuments hitherto found in India had been erected. After showing that there was no real similarity between the architectural styles of Egypt and India, he proceeded to point out that the latter country was occupied by two distinct races of people,—the one aboriginal, and occupying the southern portion of the Peninsula; while the other, or Indo-Germanic race, came into the country, at a tolerably recent period, as conquerors or colonists, and settled in the valleys of the Indus and Ganges. It was among the latter race that the Buddhist religion arose and flourished for more than a thousand years, or from before 250 B.C. till after 750 A.D.,—though at the time of the Mohammedan invasion it seems to have been entirely extinct; and now there was not a Buddhist, or an institution of that religion, in the country of its birth. After alluding to the curious fact of the names of Ptolemy Antiochus, and other Greek kings, being mentioned in the inscription of this Asoka, Mr. Fergusson dwelt for some time on the existence of a purely Greek honeysuckle ornament being found on the pillars set up by this king at Allahabad, and on which one of his inscriptions is engraved. He then proceeded to classify the religious edifices of the Buddhists,—dividing them into three classes, the first being the Topes, or Dagobas, large domical buildings erected to contain relics, many of which still exist in Afghanistan and Ceylon as well as India. After describing the various parts of a dagoba, Mr. Fergusson showed how the tee, or ornament on the top of them, gradually became taller and taller, till it became a three or nine storied tower, not only in India, but in China,—as in the instance of the celebrated Porcelain Tower at Nankin. The circular inclosure of the topes was next illustrated, from a curious example at Sanchee, in Bhopal, which still retains its singular gateways. These likewise were shown to be the original of the Pailoos, or what are improperly called the triumphal arches of the Chinese. The next class of monuments were the Chaityas, or churches, which in India are known to us only from the caves; as are also the third class or Viharas, or monasteries,—which served as residences for the priests, and of which two or more are attached to every chaitya in every series of caves in India. After pointing out their general plans and arrangements, Mr. Fergusson proceeded to illustrate the beautiful mode in which the chaitya caves were lighted by one large opening or window over the entrance; and then explained the construction of the roofs,—which, though always circular in form, were never copies of arches (which were not to be found in India till long after the Mohammedan invasion), but of wooden construction; and in some of the earlier caves the original wood-work still existed, though in the more modern ones its forms were repeated in the rock. After concluding the Indian part of his subject, Mr. Fergusson pointed out the striking similarity that existed between the arrangement of the buildings he had been describing and those of Stonehenge,—which he had no doubt whatever was a Buddhist building; and he thought every part of that hitherto mysterious erection admitted of easy explanation on that supposition. He concluded by showing how domes were constructed in India; and pointed out the similarity that existed between the Indian examples and the well-known tomb at Mylasæ, in Asia Minor—and the curious circumstance that the hog-backed Lycian tombs, discovered by Sir Charles Fellows, strongly resembled, not only in form, but in construction, those Indian buildings which had formed the subject of the lecture; while the language of the inscriptions on them was a dialect of the Sanscrit, about as far removed from the mother tongue as that found on inscriptions in the Indian examples.

March 20.—Mr. Eaton Hodgkinson was elected honorary member, and Mr. Thomas Penson and Mr. Edmund Sharpe, M.A., fellows.

The honorary secretary announced the following as the subjects proposed for the medals:—

"Her Majesty having been pleased to grant her gracious permission for the *Royal Medal* to be conferred on such distinguished architect or man of science, of any country, as may have designed or executed any building of high merit, or produced a work tending to promote or facilitate the knowledge of architecture, or the various branches of sciences connected therewith, the council will in January, 1849, proceed to award the Royal Gold Medal to the *author of some literary publication connected with architecture.*

"*The Silver Medals* of the Institute will be awarded—

"1. To the best essay on the peculiar characteristics of the Palladian school of architecture, and a comparison and contrast of its elementary principles and details with those of ancient art.

"2. On the best manner of covering the roofs and forming the flats and gutters of buildings; the nature of the several materials used in various parts of the country for these purposes; their most effectual and economical application; the inclination to be given to the different parts, and the other practical precautions to be adopted to prevent snow and rain penetrating into the building.

"*The Soane Medallion* to the best design for a building to serve as a national repository and museum for the illustration and exhibition of the productions of the industrial arts.

"The successful competitor for this medal, if he go abroad, will be entitled to the sum of 50*l.* at the end of one year's absence, on sending satisfactory evidence of his progress and his studies."

Amongst the books presented were an essay, on "Cyclopean Walls" (*Kyklopischen Mauern*,) by Dr. Forchammer; parts of M. Daly's "*Révue Générale de l'Architecture*," and of Mr. Fergusson's beautiful work on Indian architecture. The foreign secretary, in commenting on the donations, pointed attention to an article in the *Révue Générale*, complimentary to the Institute for not restricting the competition for the Gold Medal to this kingdom.

Allusion was made to the circumstance that all the impressions of Mr. Leitch's translation of Müller's "Ancient Art and its Remains" (of which a copy was presented to the Institute at the last meeting), had been destroyed by fire.

Amongst the letters read, was one from Herr Lange, of Fülda, acknowledging the honour of his election, and setting forth several subjects on which he could afford information, especially the Carlovingian monuments (eighth and ninth century), of his neighbourhood, and a collection of terms in use amongst the workmen of the middle ages.

Mr. T. H. Wyatt read a paper on the "*History, Present Condition, and Proposed Restoration of Llandaff Cathedral.*"

ROYAL SCOTTISH SOCIETY OF ARTS.

Feb. 28.—George Buchanan, Esq., F.R.S.E., President, in the Chair.

ON CAST-IRON.

At the request of the council, an exposition "*On the Strength of Materials, particularly Cast-Iron and Malleable Iron, and their application in the construction of Railway Bridges* (Part I.)," was given. By George Buchanan, Esq., President.

On this subject, so important at the present time from the extensive use of these materials in the construction of bridges for railways, and from the new and extraordinary forms and dimensions which they are now beginning to assume, the council of the Society had requested their President to make a communication on the present state of our knowledge and practice, and this evening he read the first part of this communication, illustrating his subject by various interesting experiments and models, more particularly a large and beautiful model, with drawings and elevations, of the high level bridge across the Tyne at Newcastle, which, through the liberality of Mr. Robert Stephenson, the engineer of the bridge, he was enabled to exhibit, and to explain the situation, extent, and construction of this great work in all its details.

Mr. Buchanan began by stating that he did not profess to communicate anything new or original, but would be happy if he could only draw from the stores of information which had of late years been accumulating on this subject, under the hands of very eminent, scientific, and practical men, such leading facts and maxims as might prove a safe guide for our practice; and such truths, when they became known and established on the unerring grounds of experiment and calculation, could not, he thought, be too widely disseminated. The various strains might be all reduced to two kinds, according as the material is either distended or compressed by any force or pressure. From these two all others arise, and either consist or are compounded of them. The tensile strain is the simplest of all, depending neither on the peculiar form of the materials, nor even on the length, but only on a single element, namely, the Section of Fracture. This peculiarity of the tensile force was explained and illustrated. In regard to cast-iron, the result of the extensive and interesting experiments by Messrs. Hodgkinson and Fairbairn was given, and it was found from the mean of 16 different trials of English, Welsh, and Scotch iron, both hot and cold blast, that this material will sustain about $7\frac{1}{2}$ tons per square inch before breaking, the weakest specimen being 6, and the strongest $9\frac{3}{4}$ tons. The limit of fracture, however, can never be approached with safety, not even within a long distance, seeing that this material is liable to unseen imperfections, and, above all, to snap in a moment without distending itself or giving any warning of danger. Malleable iron, again, is much superior in tensile strength, and, by its remarkable ductility, inspires confidence in a still higher degree; bears no less, at an average, by various experiments of Telford and Brown, than 27 tons—the weakest 24, and the strongest 29 tons; but, before the half of this load is applied, it begins to stretch, and continues stretching, up to the limit of fracture. It is, therefore, not only three times stronger than cast-iron, but may be safely loaded with five times the breaking weight, or about eight or nine tons.

In regard to the strength of compression, this depends also, as long as the length is limited, on the same element—the Section of Fracture; but when a long rod or slender pillar is loaded or compressed, it is liable to bend, not for want of strength, but for want of stability, the least flexure turning it off its centre, and breaking it by lateral force, deranging entirely the simple law applicable to short lengths. In regard to cast-iron, by far the most satisfactory experiments are those by Hodgkinson and Fairbairn. The mean result gives very nearly 50 tons on the square inch—the weakest $36\frac{1}{2}$ tons, and the strongest 60 tons. It is thus six times stronger in compression than in distension, and hence it is peculiarly recommended for sustaining any superincumbent weight, as in the case of pillars and of bridges, provided the construction is such as to resolve the strain arising from the load into a longitudinal compression. This is often in our power by proper arrangements, chiefly giving a sufficient height and curvature to the arch; but in cases where, for the want of head-room, the arch is unduly flattened, or resolved into a straight beam or girder, the danger is that we bring the tensile force into play, and then the use of cast-iron is objectionable, or at least requires extreme caution. No direct experiments have been made on malleable iron of short lengths; but from some facts brought out by Mr. Hodgkinson, its strength appears much inferior to cast-iron, chiefly from ductility, whereby it gives way much sooner under a load. It will bear 27 tons, probably much more, without fracture; but with 12 tons it yields to the load, contracts longitudinally, and swells out laterally; and this is another very important fact for our guidance in the use of those different materials. In regard to stone, experiments have been generally made on specimens rather too minute. Like cast-iron, the crushing strength is superior to the tensile, and hence its adaptation for buildings, particularly bridges. Craigleith stone will bear $2\frac{1}{4}$ tons on the inch, or upwards of 400 tons on the square foot; Aberdeen granite 600 tons. In regard to bricks, he had occasion to make experiments in relation to the great chimney of the Edinburgh Gas Works. It became matter of consideration whether the ordinary brick could withstand the pressure of so lofty a column. Trials were therefore made with a powerful hydrostatic press, not on small specimens, but on the actual brick. The ordinary stock brick was found to bear 140 tons on the square foot, and the common fire-brick 157 tons; but the brick of which the chimney is constructed, consisting of a mixture of fire-clay and ironstone, bore, a single brick on its bed, no less than 140 tons, equal to 400 tons on the square foot.

The effect of the transverse strain was then considered and illustrated by various experiments and models. This strain is a compound of the tensile and compressive strain, the one part of a beam loaded in the middle being compressed and the other distended, and the beam itself becoming a lever, and acting often with enormous power against its own strength. Hence it became easy to calculate the strength, this being in every case proportional in the first instance to the area of the Section of Fracture, and this original element modified by the length and depth of the beam, diminishing in exact proportion to the length, and increasing in proportion to the depth.

The transverse strain acting with such severe advantage against our materials, various methods have been contrived for eluding its effects, and of these none is more remarkable than the principle of the arch, the effect of which was illustrated by experiments, and particularly the necessity in flat arches of having secure abutments to resist the horizontal thrust, and this was frequently accomplished, where there is sufficient head-room, by uniting the extremities of the arch by strong malleable iron rods, in the same manner as in the case of the roof, the feet of the rafters are united and prevented from spreading by the tie-beams; and this is the principle, the securest of all, on which the great iron bridge at Newcastle, now in progress, is constructed the object of which is to cross the river and valley of the Tyne, on the highest level of the railways on each side, so as to unite them in one uninterrupted line from London to Berwick, and unite the termini of the different railways, now separated three quarters of a mile or more, into one grand central station, a little to the west of the ancient Castle. The distance between this station and the present terminus of the York and Newcastle Railway is 3,457 feet, consisting chiefly of the space occupied by the bed of the river Tyne, and the steep banks on each side, well known to travellers in descending from Gateshead Fell on the south, and Dean Street on the north, both to be now superseded by the smooth and level surface of the railway, and by a turnpike road running on the same bridge directly under the line of rails. The steep banks on each side are spanned by stone arches of a very substantial character, the river and low banks by six metallic arches, all of the same dimensions and structure, resting on solid piers and lofty columns of masonry. In the bed of the river the piers are laid on very solid foundations of piles and planking, with concrete, many of the piles 40 feet in length, and driven to this depth through hard gravel and sand till they reach the bed of freestone rock. Nasmyth's celebrated pile-driver is in full operation here, and with wonderful effect, and has come most opportunely in aid of the work; driving night and day, at the rate of 60 or 70 strokes a minute, the pile heads being often set on fire by the rapidity and violence of the blows of the ram. Piers laid 2 feet below low-water mark, and raised about 100 feet to the springing of the arches. The arches consist each of 4 main ribs of cast-iron, each in 5 segments bolted together, and forming one entire arch 125 feet span, and rising 17 ft. 6 in. in the centre, and the level of the rails on the upper platform 108½ feet above the level of high-water mark of the Tyne. Depth of the rib 3 ft. 9 in. at the springing, and 3 ft. 6 in. at the crown, with flanches 12 inches broad, external ribs 2 inches thickness of metal, internal ribs 3 inches. Total sectional area at the crown 644 square inches, which would bear with safety a load of 5,000 or 6,000 tons, and would form, with proper abutments, a strong arch in itself; but for the fullest security, and to prevent the possibility of inconvenience or risk from deflection or vibration, or otherwise, each rib is united at the springing by strong malleable iron bars or ties, 7 inches broad and 1 inch deep, of the best scrap iron, and in all 24 in number. The railway is supported above the arch, and the roadway suspended from beneath, by hollow cast-iron pillars 10 feet apart, and each 14 inches square, through which are passed strong malleable iron circular bars, binding the whole into one stiff and solid mass. The sectional area of the horizontal bars is 168 square inches, which would sustain upwards of 4,000 tons without breaking, and 1,500 tons with perfect safety, but the whole weight of the bridge will not exceed 700 tons, leaving 800 tons of surplus strength. The railway, which is at the summit level, runs on a level 4 feet above the crown of the arched rib, and is supported in the middle by hollow cast-iron trough girders resting on the top of the pillars 10 feet apart, and united by longitudinal timbers laid with strong planking. The roadway runs nearly on a level with the malleable iron ties, leaving a space of about 20 feet clear head-room.

In the whole of the work the utmost pains has been bestowed on materials and workmanship, and in making everything complete, the surfaces, which abutt together, being regularly planed or turned, as in machinery; and, from all the arrangements, the most successful results may be anticipated from this bridge. The cost of the iron work and roadway, by the estimates, comes to £112,000, and the contracts for the bridge and viaducts to something above £300,000.

CONWAY BRIDGE, CHESTER AND HOLYHEAD RAILWAY.

We give the following details of floating the tubular bridge at Conway, on account of their highly interesting character. Next month we hope to be able to give full particulars of the raising of the tube and the machinery.

In sight of a large concourse of people, covering the whole space of the suspension-bridge, the towns and walls of the noble old castle, and the fields in the background of the spot on which it was built, the wonderful effort of science, the tube-bridge, was floated at 11 a.m., on the 6th ult., and moved from the piles and stays on which it was constructed, and fairly brought into the tide-way of the Conway, while its flood-tide was running at the rate of at least two miles per hour. It appeared to float with the greatest ease, and not immersing the six pontoons on which it rested (three at either end) to within at least 3 feet of their decks. The precautions taken by Capt. Claxton, R.N., to whose sole direction the transporting of this enormous mass was committed, were admirably contrived to keep the machine suspended over the fixed piers, to await, as it were, the decision of the engineer as to whether the perilous step of launching into the deep (for deep indeed is the river, 12 fathoms at low water) should be proceeded with, or whether the valves should be lifted, and the tube dropped, as it were, again in place, upon its piers—many circumstances appearing to bear upon that determination; the strength of the current; the height to which the tide promised by its comparative rising; and the strength of the wind. At about 11 a.m., [illegible], the tide appeared to slacken, and the resolution was formed [illegible] the chains and ropes were hove upon, and in ten minutes [illegible] the first Rubicon—gradually but steadily it approache[illegible] for it. Mr. Stephenson, with Mr. Edwin Clarke and Mr. Brunel, accompanied Capt. Claxton, who directed the proceedings. He used two figures, of large dimensions, Nos. 1 and 2: when the red side was shown of the former number, a capstan fixed on the road from Conway to the tube works was hove upon; when the white side was shown the heaving stopped, and a similar operation with No. 2 governed the operations of a powerful capstan (lent by the Admiralty), fixed on the railway on the Chester side, with its rope made fast to the inside of the tube, on that end. In the pontoons three enormous masses of timber, 95 feet long by 25 feet wide, and 8 feet deep, bound together by powerful crabs worked by 44 men, hove upon the chains, which had previously been tightened up by a large crab, at which a dozen or more men strained with their utmost efforts at either end on shore, one end of each chain being fixed at the piers of the suspension-bridge, while the other ends were fast to the aforesaid crabs, on the opposite side of the river: on these chains the pontoons appeared to traverse. The western, or Conway end, was pointed first, but did not come quite home afterwards. The eastern, or Chester end, was dropped in after, or while the ebb was making; but before it reached by about a dozen feet the exact berth, it took the mason-work, and no effort could disengage it. Nevertheless, it was over its bed sufficiently to be landed and bedded up with timber previously prepared from a lower bed, which had been provided in case the tide should fall before the upper bed could be reached. The most extraordinary efforts were made with screws and tackles, no less than four of which latter were at one time applied, besides the Chester side crab, manned by 60 people, while the tide was falling, to overcome the obstacle; but they appeared to be ineffectual, and Capt. Claxton was heard to give orders for bedding up, which was speedily accomplished. The barges were then sunk a little, and the noble fabric rested very near the hydraulic presses which are to be used in raising it. Eighty men were in each set of pontoons—one set commanded by Capt. Dunce, R.N., an assistant of Mr. Brunel, and the other set by Lieut. Blatchley, R.N., the crews under them performing the principal work, being sailors from the "Home," of Liverpool. In the tube attending the hawsers, were the officers and some of the crew of the *Great Britain*. On the top, on the Conway side, Mr. Fairbairn, of Manchester, had the direction; and on the Chester side, Lieut. Glenny, R.N. The great difficulty to be overcome was apparent—the small space to play in—for on the Conway side it wants 9 inches, by actual admeasurement, of being home, or in place; while on the Chester side, it is fairly jambed against the masonry—so that in fact there were barely 9 inches free in 400 feet. No sooner had the tide fallen sufficiently than the obstacle to the exact fixing in position became apparent to all. The inner pontoon was butting at its end against and partly on a rock. It took the ground which had been blasted away from the solid rock in consequence of having got a little twisted previously to starting, we were assured full 4 feet. On the 11th ult., the tube was again floated by the pontoons, and was finally placed with its two ends resting upon the shelves of masonry constructed to receive it, prior to its being raised to the elevation at which it is placed, about 15 feet or 16 feet above. The lifting of this enormous mass of iron, which weighs about 1,800 tons, is to be effected by two hydraulic presses, with 18-inch rams, and pumps ⅞ of an inch diameter. These pumps are to be worked by steam-engines, which will give a pressure equal to 3 tons on the circular inch, or a total lifting power for each press of 972 tons, which, of course, will be amply sufficient for the purpose. Each press has a lift of 6 feet; and, as the ends of the tube rise, the masonry which is intended to support them will be carried up from the shelves on which they now rest.

AUXILIARY STEAM-POWER FOR VESSELS.

Sir—In consequence of the great extension of railways, and the facility they give for quick transit of goods, they are operating seriously against the shipping interests and coasting trade; and unless some mode can be adopted by which coasting vessels can be made to compete with the railways, this trade will be completely destroyed, which will be a serious loss to many harbours, and also the mercantile interests of the country; as railways will obtain not only the light and best-paying goods, but also many of the more bulky articles, in consequence of the want of regular sailing traders.

I think it would be interesting to many of your readers who feel a deep interest on this subject, to ascertain what has been done in many places by employing small steam-power auxiliary to sailing vessels; and as you have the means of doing so, I have taken the liberty of directing your attention to this important subject, which many of your correspondents could easily supply, and answer such queries as the following:—

The best system of applying auxiliary steam-power to vessels in the coasting trade, of 150 to 200 tons burden per register?

A description of any such?

Whether wood or iron preferable, and the cost?

The size of engine or horse-power, and whether applied to screw or paddles?

The draught of water, &c. &c., and any particulars as to the trade [illegible] may be engaged in, and how they are answering?

N.B.—Some time ago, a vessel was tried on the Thames (no notice of which has been taken in the *Engineer's Journal*),* called the Albion, with a new system of propellers, patented by a Mr. Simpson, which was very favourably spoken of as being adapted for the purposes referred to by me. —Could you state any particulars connected with it?

Trusting you may not consider my suggestions as out of place, and that any notice you give in your *Journal* of such improvements, will be very interesting, and give much information to many of you readers,

I remain, &c.,

A. B.

[* We were not present at the experiment, and not having much faith in newspaper reports, is the reason we have not noticed them.—Ed.]

NOTES OF THE MONTH.

An hydraulic telegraph is now being exhibited in the arcade at Exeter Change. It is on a very small scale, but works well.

On the Monmouth and Hereford line, a wooden bridge over the Wye is to be erected, at a height of 50 feet above high-water mark. The embankments are now in a forward state, and the frame-work is being prepared at Bristol.

Mr. John Fairfull Smith, secretary of the leading Glasgow railways, has addressed a letter to the Lord Provost, in reference to the late riots, and urges the necessity of aid, by a government loan being given to the railways. He says that 10,000 men, who are now supported by the public, might be employed on the railways in the neighbourhood of Glasgow, which are stopped by the state of the money market. The same views are spreading among the railway interest, and the mischief is felt of the repressive measures which were connived at by the established companies, thinking they should not feel the pressure. We always deprecated the government tampering, and the propriety of the cause we have advocated is fully justified by events. We do say the great question is, whether so many hundred thousand powerful and uneducated men should be left in a state of idleness, or whether they shall be employed on public works? They are already maintained by their own savings, by the contributions of their friends, by credit given by the small shop-keepers, or by theft, or in jail, or in the workhouses. The question is not one of finding mere food, but of giving work which shall do good to the common stock, and put the men in a happier condition. We hope the legislation will immediately be amended, the power of sueing for calls be withdrawn, and the power be given of allowing interest on calls, likewise a further power of raising money on debenture, or on loan notes. As the government have by their measures brought railway works to a stand, or dead lock, temporary and exceptional measures might be allowed, in order to set the machinery of investment again in action. We would even countenance the issue of railway notes, which should be a legal tender for all railway payments and calls, or the advance by government of exchequer bill loans; though on all ordinary occasions, we have always been opposed to their interference in any shape. The abolition of the Railway Board, founded on wrong principles of legislation, and calculated to preserve their memory, we consider an essential preliminary to a healthy course of action on the part of the government to the railways.

The electric telegraph is now taken up by the publicans. A dial is used in a smoking-room, marked with the various articles wanted, and corresponding with a similar dial in the bar.

A Royal Institution of Engineers has been founded at the Hague, which has two hundred members.

On Annealing Glass Tubes.—M. Bontemps read a paper at the Industrial Society of Mulhausen, on the causes of the breaking of glass tubes and cylinders. In order that a glass tube be in good condition, it is necessary that the interior particles should give way at the same time as the exterior. For this purpose, the tubes—such, for instance, as thermometer, barometer, and pressure-gauge tubes—are placed in a baking or annealing furnace, called the baking furnace, a brick casing of 6 inches diameter, and the length the tubes may require. This furnace is heated at one end to a dull red heat, at which the glass is nearly malleable, but not put out of shape; they are then (being in sheet-iron carriages, on wheels) drawn gradually to the cool end of the furnace, but so slowly, as only to traverse the distance in from 15 to 24 hours, according to the nature of the glass thus drawn gradually through a diminishing temperature to that of the atmosphere. There is a vast difference between glass baked and that unbaked—the latter is not so homogeneous, and polarises the light in passing through it. By applying, therefore, a fragment of a tube to a polarising apparatus, it can be ascertained if the tube has been baked.

A Rare Shot.—Commander Mackinnon in his "Steam Warfare on the Parana," mentions the following almost incredible instance of a shot passing through both of the paddle-wheels of his vessel, without touching any part of either:—"It struck the paddle-box on the enemy's side, 3 feet or 4 feet above the shaft, went clean through the wheel without touching any part of it, and then passed across the deck and through the other paddle-box, not above 18 inches from the shaft, still not touching a single blade, or any portion of the paddles. At the rate the wheels were revolving (about 17 times a minute), it appeared quite impossible to fire a pistol-ball through without striking some part of them; and yet this 18 lb. shot had gone through both wheels, leaving no mark but the hole at entering on one side and departing on the other.

Curious Phenomena of Fire.—At the Royal Institution, on the 17th of February last, a furnace was erected for the purpose of making some experiments on glass manufacture by Mr. Pellatt. In consequence of some accident, the lecture-room was nearly set on fire, but by timely aid the flames were extinguished. After a lecture at the Institution on the following Friday, Prof. Faraday called the attention of the members to two circumstances of philosophical interest which had happened during the momentary apprehension of fire.—1. At three different times the water poured on the cinders of the temporary furnace, when, on the fire being drawn, they fell on the hearth, became decomposed by the ignited carbon; and the hydrogen, driven by the sudden expansion of steam, &c., having penetrated the hot and porous hearth-stone, found its way to the heated beams and space which were immediately beneath.—2. This gas, though not in the state of flame as it passed through the hearth-stone and pugging, was after being mixed with the air below sufficiently hot to enter into combustion,—producing three gushes of flame downwards from beneath the hearth:—and it was experimentally shown that a temperature so low as barely to scorch paper, and in which the hand may be held for some seconds without inconvenience, is yet able to ignite a jet of coal or hydrogen gas in air.

Liverpool Waterworks.—The two Companies which supplied the town with water, and the Corporation of Liverpool who were empowered by Act of Parliament to purchase the existing interests for the purpose of taking the whole supply into their own hands, appointed Mr. Robert Stephenson as sole arbitrator to determine the amount of compensation to be paid to each Company. After a patient hearing of all parties, and a minute inquiry into the works, he has made his award, by which the Harrington Water Company are to receive £330,719 and the Bootle Water Company £354,000. The former claimed £570,000 and the latter £354,000.

Carlton Club Designs.—A correspondent informs us that in a former number of the *Journal*, we were in error in attributing to Mr. Sidney Smirke the "*sole* designing" of the Carlton Club, now erecting in Pall Mall, as well as "the adaptation of Sansovino" in the exterior. He also states that the designs were *entirely completed* and *sent in* under the arrangement of the late Mr. Basevi and Mr. Sidney Smirke, during the lifetime of the former,—and that though Mr. S. Smirke may possibly make some deviations from their *joint* arrangement, yet the designs are, in the main, *to be executed* as agreed on between them.

Prevention of Accidents in Coal Mines.—The *Staffordshire Mercury* describes an invention by Mr. Edward N. Fourdrinier, of Cheddleton Mill, a very simple and ingenious, but important contrivance, for preventing the accidents which are constantly resulting from the breakage of the chain or ropes, and drawing the skip over the pulley, or the whirl, or run. The apparatus is now in daily use at one of Mr. Sneyd's pits, at the Sneyd-green Colliery, between Hanley and Burslem. In one instance the merit of the invention was fully tested by the chain being unintentionally drawn over the pulley; no disastrous consequences, however, resulted, the skip or rather cage being detached from the chain, and remaining safe on the guides. A heavy load was subsequently lowered about 40 yards down the pit, and the chain cut at about 20 yards above the surface, by which means no less than 60 yards of chain fell down the shaft. A man having been let down by a rope to ascertain the result, found the machine perfectly secured, and the chain safely coiled on the top of the cage in which the man ascends and descends. The man immediately attached the rope to the chain, which having been drawn up and repaired, was again let down and fastened to the apparatus. The whole was then safely drawn up, with the man in the skip, the experiment having occupied no more than 20 minutes, and no injury whatever having been sustained either by the machine or the guides. There can be but one opinion as to the great advantages to be derived from the general adoption of this invaluable invention, and it is to be sincerely hoped that no time will be lost in making this arrangement for the more effectual preservation of human life.

On the Electro-Bronzing of Metals.—MM. Brunel, Bessin, and Gaugin presented to the *Académie des Sciences*, at Paris, specimens of metals bronzed by electro-chemical means. M. de Ruolz, in 1841, communicated to the academy a process for bronzing metals, by depositing upon them, by the aid of the galvanic battery, layers, more or less thick, of brass or of bronze. This process, which required the employment of the double alkaline cyanides of copper and zinc, or of copper and tin, was not adopted in practice, on account of the great expense of the cyanides, and for other reasons. MM. Brunel, Bessin, and Gaugin, have substituted for the cyanides, a solution in water, of 500 parts of carbonate of potash; 23 chloride of copper; 40 sulphate of zinc; and 250 nitrate of ammonia. To produce bronze, a salt of tin is substituted for the sulphate of zinc. By means of these solutions of brass or of bronze, a coating can be given to cast or wrought-iron, steel, lead, zinc, tin, and alloys of these metals, with one another, or with bismuth and antimony, after a previous cleaning according to the nature of the metal. The operation is conducted with a cold solution. The metal to be coated is placed in connection with the negative pole of a Bunsen battery, a plate of brass or of bronze being employed at the positive pole. When the objects have been covered with a coating of the metal desired, and have received their proper colour, they will be found to rival the finest bronzes.

The Ventilometer.—An instrument the invention of a French naval officer, in command at La Rochelle, where it has been tried during four years, with singularly true results, and found to be a most valuable marine instrument, whereby the crews and ships stationed off the coasts may often be saved—the officers having several hours' notice, and knowing when to run out to sea or into harbour. The instrument itself, exteriorly, exactly resembles a mariner's compass; and, having been fixed due north, the needle will take up its position, and whatever point it designates, that wind will arrive in the 24 hours, but generally within the 12 to 18 hours; according to the time that the needle remains at such point, so long will the wind blow from that quarter; and according to the inclination of the needle from its horizontal and natural position, so will be the violence of the wind. The principle upon which the ventilometer has been constructed seems feasible. The magno-electric fluids surround our globe, and their direct action is visible in the workings of the mariner's compass. Winds being the result of electrical changes, are produced by a disturbance in these fluids, and continue until the exact equilibrium is obtained; neither do these winds burst forth immediately over our heads, but take their origin within a circle of immense circumference—taking our own position as the centre. Any undue action in any part of the fluids within this circumference, will have more or less influence upon the whole; but our ordinary senses cannot mark these changes, although we sometimes find nervous invalids remarkably sympathetic, and able to fortell what the healthy man cannot—yet, when the change does arrive, a few hours afterwards he is obliged to admit his own grosser senses. The delicate mechanism of the ventilometer forms itself into the centre of a certain undefined circumference, but the extent of whose influence does not exceed a space of 24 hours; any change taking place within this circle is notified—so that, suppose the vane to be pointing north, but that the ventilometer at the same moment points to south, then, within the 24 hours, the south wind will blow; but the ordinary change is from 12 to 18 hours, and should the ventilometer remain for hours, or days, at the same point, the same wind will continue blowing; but when it changes within the 24 hours, the wind will change also. This instrument is not influenced by the lighter breezes; when a strong wind blows, the needle, or indicator, is horizontal—but as the winds, or atmospheric changes, gradually increase in violence, the point is elevated by the weight of the atmosphere, and thus not merely preindicates the wind that is to blow, but its exact strength and duration. If the principle be proved to be correct, then, possibly, improvements may be made, by which even the highest breezes may be preindicated. It is about to be tried by the Admiralty.

Sulphate of Iron for Purifying Gas.—M. Martens, of the University of Louvain, has made a discovery in the use of sulphate of iron for the purification of coal gas. By this arrangement, the gas passes through two purifiers: in the first is placed 1 cwt. of sulphate of iron, dissolved in 83 gallons of water, and in the second milk of lime, made by adding 83 gallons of lime to 375 gallons of water. On passing from the second purifier, the gas is almost completely deprived of its sulphuretted hydrogen, that it scarcely changes the colour of paper moistened with a solution of oxalate of lead. By this process, there is a greater deposit of tar in the solution than when water alone is employed; and there is a much more abundant condensation of aqueous and ammoniacal vapours—so that during long-continued frosts, the pipes have been kept entirely free from ice, which causes considerable trouble and expense. The cause of tar depositing in a ferruginous solution more readily than in water, arises from the sulphate of iron having a greater affinity for the tar, which it condenses, and carries down with it; and the greater condensation of vapours contained in the gas is caused by a more complete absorption of ammonia, which always has a tendency to mix with other vapours. The above quantity of sulphate of iron is sufficient for purifying the gas from 25 to 27 tons of coal; the solution is then so impregnated to saturation, as to require changing. It is probable the residue of this plan may become a valuable article of commerce.

White Paint Manufactured from Antimony.—At the Liverpool Polytechnic Society, Mr. J. A. Forrest described a new mode of manufacturing white paint of an excellent body, superior to that manufactured from lead. It is made from oxide of antimony, and has many advantages. He had ascertained, that though it was now high in price, were there a demand for antimony, that metal could be obtained in abundance at about £12 a ton, whereas the lead used costs £24 10s. The new paint was, consequently, much cheaper; it was not so apt to lose its colour, and would spread over a much larger surface than an equal weight of the paint manufactured from lead.

Sound made Visible.—A method has been discovered and matured, by which sound will be made visible to the human eye, its various forms and waves demonstrated to sight, and the power to discriminate between the tones of one musical instrument and another be as complete as to observe the action of water when disturbed by any material cause. The experiments are likely to be ere long repeated in the Royal Society. The exhibition of effects on fine sand has probably led to this astonishing issue.

Friction Hammer.—A novel machine, just completed, is now at work at the Great Western Works, at Bristol, the invention of Mr. John Jones, manager of the works, who also invented the "Cambrian Engine." The machine is called a "Friction Hammer," and consists of frames of cast-iron, in which are vertical slides acting as guides to the hammer, and also supporting the machinery necessary for putting the hammer in motion. The hammer consists of a plane bar of flat wrought-iron, so arranged as to work in the slides, and is raised by means of two vertical rollers turning in opposite directions, which are made to bear upon the bar by an exceedingly simple arrangement of levers. A slight pressure upon the handle of one lever raises the hammer to any height not exceeding 7 feet; the pressure being removed it falls by its own gravity; this lever is also arranged so as to stop the hammer in any part of its descent, should circumstances render it necessary. The friction rollers are put in motion by means of straps and pulleys, fly-wheels being also fitted on each strap.

New Method of Treating the Ore of Platinum.—Instead of the tedious operation of obtaining pure platinum from the ore, employing 8 or 10 parts of acid to one of platinum, M. Hess suggests the following as an improvement:—Melt one part of platinum ore with two or three of zinc, which will form an alloy very friable, and easily reduced to a fine powder. This powder is then to be sifted, and on it poured dilute sulphuric acid at the common temperature of the atmosphere. The temperature is then gradually raised, and the metals allowed to macerate as long as there is anything to dissolve; the acid in a short time separates all the zinc from the alloy, and the principal part of the iron contained in the ore. A solution is obtained in which hydrosulphuric acid produces no precipitate. Having poured off the liquid, the residue is a fine powder, which, having been well washed, is treated with nitric acid, which dissolves the copper, and other foreign metals; the platinum is then dissolved in nitrochloric acid, and then proceeded with in the usual way.

Gas Motive Power.—At the *Academie des Sciences* a report was read on a "gas-propeller," invented by the late M. Selligue, in 1844. It consists of an iron cylinder in the form of a U—one end is closed; water is poured in to a certain height, and in the open end is placed a piston and rod, in the usual manner. On introducing any explosive gases over the water, in the closed end of the tube, and effecting their combustion, the resulting gases press, by their sudden expansion, the liquid on which they rest, and force up the piston to a certain height, which is again depressed by the cooling and condensation of the gas, and the atmospheric pressure on the piston. A regular reciprocating motion is thus obtained, which, of course, can be applied to every description of machinery. In closely experimenting on this principle of motive power, it has been found, that eight volumes of air, and one of gas, obtained from the decomposition of water, by passing steam through cylinders filled with red-hot charcoal, consist of hydrogen, 66; carbonic oxide, 28; carbonic acid, 8. The gas can be manufactured for one-fifth of a halfpenny per 140 quarts, which is considered equal to 8 cubic inches of steam at one atmosphere pressure, and costing one halfpenny and three-fifths. The inventor found, that 35 quarts of gas, and 280 quarts of air, gave an explosive force equal to 126 tons, and 2,400 explosions can be made per hour.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM FEBRUARY 28, TO MARCH 22, 1848.

Six Months allowed for Enrolment, unless otherwise expressed.

Elizabeth Wallace, of Laurel-lodge, Cheltenham, Gloucester, spinster, for "certain Improvements in facing, figuring, designating, decorating, planning, and otherwise fitting up houses and buildings, parts of which are applicable to articles of furniture."—Sealed February 28.

John Craft Roberts, of Holywell, Flintshire, surgeon, for "a simplified and improved mode of communicating intelligence, by means of electricity and magnetism, combined, or not, with steam on railways, between the carriages on the line and the engine or tender, so that the guards and passengers may give notice to the engineer or engine-driver, for the prevention of accidents or casualties, or the mitigation of the evil thereof, and the protection of human life and property from loss or injury; and, also, of communicating signals by the same agency, describing the cause or causes of alarm, and a new mode of securing the passage of electricity, for the above purposes, to be substituted or not for the side chains, and of communicating intelligence between distant places on the line."—February 28.

William Palmer, of Sutton-street, Clerkenwell, for "Improvements in melting fat and in the manufacture of candles."—February 28.

Charles Ritchie, of Aberdeen, Scotland, engineer, for "certain Improvements in locomotive and other engines."—March 2.

Francis Whishaw, of Hampstead, Middlesex, civil engineer, for "a certain manufacture of pipes of earthenware, pottery, and glass, and of certain applications and arrangements thereof."—March 8.

William Exall, of Reading, Berkshire, engineer, for "certain Improvements in thrashing machines, and in steam-boilers, engines, and other apparatus for driving the same, which apparatus is applicable to driving other machinery, part of which improvements is a communication, and the remainder is his own invention."—March 8.

James Lockhead, of Milton, Gravesend, Kent, for "certain Improvements in ventilation."—March 8.

Theodorus Cornelius Seeger, Knight of the Order of Reiderlandsche Lion, of Saint Gravenhage, Holland, but now of Leicester-square, Middlesex, physician, for "Improvements in the construction of railway carriages."—March 8.

William Beckett Johnson, of Liverpool, engineer, for "certain Improvements which are applicable to locomotive, stationary, and marine steam-engines."—March 8.

Warren de la Rue, of Bunhill-row, Middlesex, manufacturer, for "Improvements in machinery used in the manufacture of cardboard and pasteboard." (A communication). —March 8.

John Houston, of Stepney, Middlesex, surgeon, for "Improvements in obtaining motive power by the aid of atmospheric air, and in obtaining combustion."—March 8.

George Royce, of Fletland, Lincolnshire, for "Improvements in machinery or apparatus for depositing, cleansing, and grinding corn and seed."—March 8.

George Lloyd, of Stepney, Middlesex, iron-founder, for "certain Improvements in furnaces and blowing machines, and improvements in engines and machinery for driving the same, which improvements are also applicable to other purposes where motive power is required."—March 8.

Joseph Maudslay, of the firm of Maudslay, Sons, and Field, of Lambeth, engineers, for "certain Improvements in obtaining and applying motive power, and in the machinery and engines employed therein."—March 8.

John M'Conochie, of Liverpool, engineer, and Louis James Claude, of Bootle, Lancashire, engineer, for "certain Improvements in locomotive engines."—March 8.

Alexander Alliott, of Lenton works, in the county of Nottingham, bleacher, for "Improvements in apparatus used in the working of steam-boilers, also in apparatus used in cleansing flues."—March 8.

John Henderson Porter, of Blackheath, Kent, engineer, for "Improvements in iron girders, beams, trusses, and supports, and in rendering the floors of buildings fire-proof by the use of iron."—March 8.

Henry Bashard Hobdell, of the city of Oxford, goldsmith, for "Improvements in studs and buttons."—March 9.

George Coode, of Haydock-park, Lancashire, for "an Improved method or methods of distributing over land liquids and substances in a liquid or fluent state, and certain improved apparatus and machinery employed therein."—March 11.

John Ashbury, of Openshaw, near Manchester, for "certain Improvements in the construction and manufacture of wheels for use upon railways and common roads, and in the methods of preparing and constructing the tyres used thereon."—March 11.

Alexander Alliott, of Lenton Works, Nottingham, bleacher, for "Improvements in spring apparatus and in balances, also in breaks, and in the means of working breaks."—March 14.

James Porritt, of Edenfield, Lancashire, for "certain Improvements in carding-engines for carding wool and other fibrous substances."—March 14.

Frederick William Michael Collins, and Alfred Reynolds, both of Charterhouse-square, Middlesex, engravers and printers, for "Improvements in the art of ornamenting china, earthenware, and glass."—March 14.

John Hosmer, of New Cross, Surrey, surveyor, for "Improvements in apparatus for supplying water and for cleansing drains and sewers."—March 16.

George Ellins, of Droitwich, Worcestshire, salt manufacturer, for certain "Improvements in manufacturing salt, and in apparatus for manufacturing salt."—March 22.

William Edward Newton, of Chancery-lane, Middlesex, for "an Improvement or improvements in making coupling joints for pipes, nozzles, stop-cocks, still and cylinder heads, and other apparatus." (A communication.)—March 22.

Henry Bessemer, of Saint Pancras-road, Middlesex, for "Improvements in the manufacture of glass."—March 22.

William Henderson, of Park-head, Lanarkshire, Scotland, chemist, for "Improvements in treating lead and other ores."—March 22.

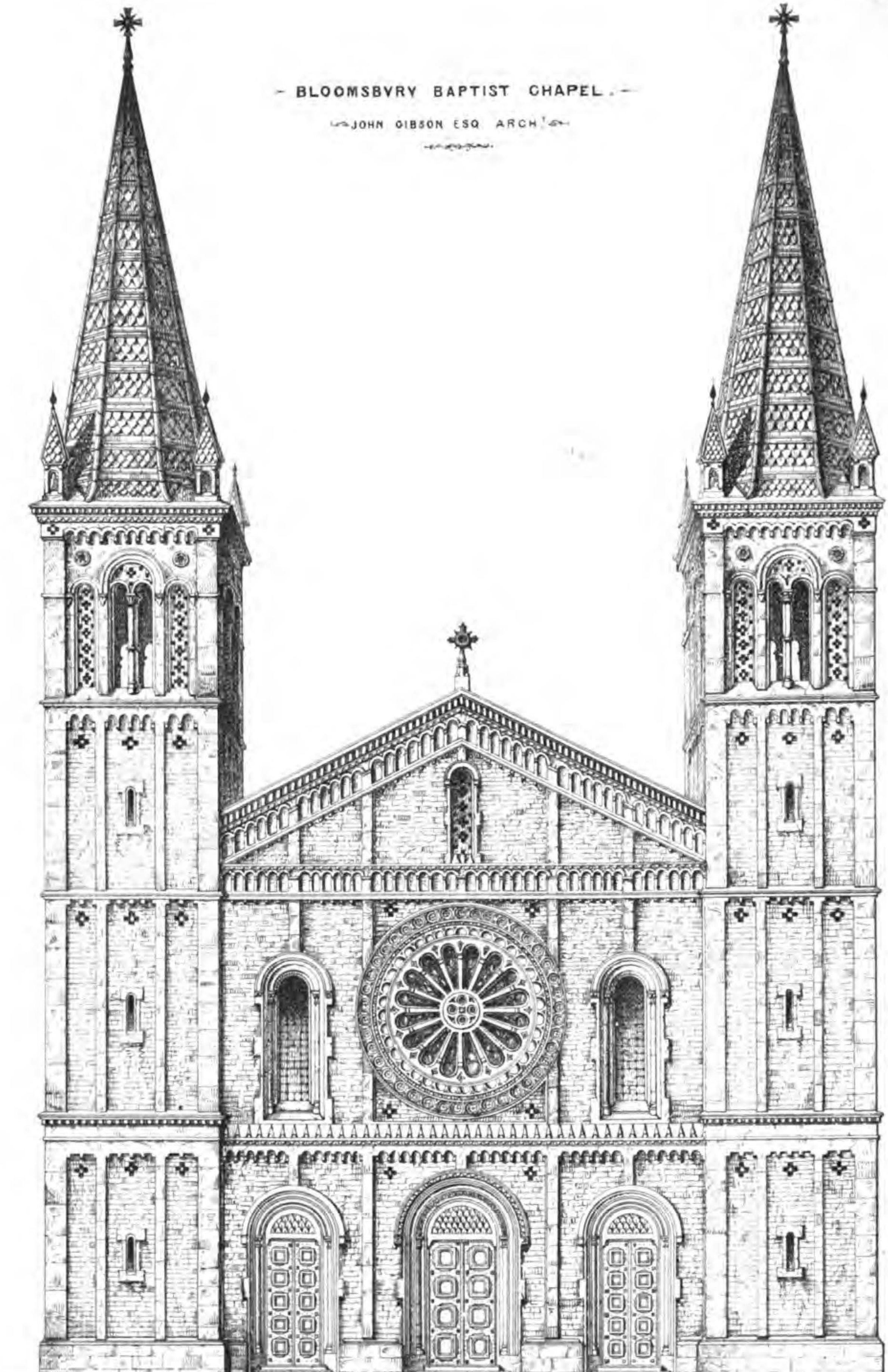
Joseph Oral, of Guildhall-chambers, gentleman, for "certain Improvements in the manufacture of artificial stone, cements, ornamental tiles, bricks, and quarries." (A communication.)—March 22.

William James Dailey, of Lambeth, Surrey, lithographer, for "certain Improvements in machinery for propelling."—March 22.

John Lawes Cole, of Lucas-street, Middlesex, for "certain Improvements in steam-engines."—March 22.

- BLOOMSBURY BAPTIST CHAPEL. -

JOHN GIBSON ESQ. ARCHT.



BLOOMSBURY BAPTIST CHAPEL.

JOHN GIBSON, Esq., Architect.

(With an Engraving, Plate VII.)

Bloomsbury-street now presents a very unusual, if not altogether unprecedented, assemblage of church architecture, there being there no fewer than three churches—at least, places of public worship—together in a line by the side of each other. With general similarity of purpose, they display great variety, or we might say contrast. That to the north—namely, Bedford Chapel, or what used to be so called, and which was originally of a most dismal "tabernacle" appearance,*—was merely re-dressed externally a year or two ago; a circumstance that perhaps excuses many defects and inequalities in the design, the architect being compelled to retain all the former openings, both doors and windows, —and it would seem, the former turret and a bit of the gable also, which are seen sticking up most awkwardly over the now horizontal line of the front. Were it not for that, and for the meanness of the doors, the front would have been passable.

The second of the three buildings in point of date is the south one,—a French Protestant church, with a small residence for the clergyman attached to it. For this, the style adopted is Gothic; but the design is exceedingly sober and unpretending, there being scarcely anything in it except the large window to give it expression. Even that feature is not made so much of as it might have been; for although sufficiently correct as to mere form and composition, it has a tame and spiritless look.

The Baptist Chapel, which comes in immediately between the two other buildings, is by far the most ambitious and conspicuous of the three. It is that which announces itself most distinctly as a church—in fact, much more as a "church" than as a dissenting place of worship, the latter having hitherto generally eschewed instead of at all affecting, the ecclesiastical orthodoxy of towers, and spires; while here we have not only tower and spire, but a pair of them. And here they produce a most agreeable diversity of outline, not only as regards the structure to which they belong, but the general group of all the three; more especially as the aspect of their fronts is an east one,—wherefore they are invariably in shadow, except early in the morning. Standing out in bold relief against the sky, and catching the light on one of their other sides, the towers serve to produce some play of light and shade, as well as form and outline. They tell very strikingly in the view from New Oxford-street,—perhaps more so just now than they will do some time hence, for at present they occasion something like surprise also, they seeming to have started into existence all at once, as the building was begun only last autumn. Owing to a singularly happy accident—to mere accident, and nothing more—one of the towers displays itself very picturesquely from Hart-street—near by St. George's, Bloomsbury,—at the end of a vista, formed by a cross-street that runs obliquely from New Oxford-street, into Bloomsbury-street.

The style of this Baptist Chapel is of exotic character to English eyes, it being mediæval Italian or Lombardic; but whether selected on account of its being unlike our own Anglo-ecclesiastical style of the same period, we cannot say; but, we must observe, the addition of campanili partakes very much more of English Gothic than of Lombardic physiognomy and mode of composition. As our engraving explains the design itself much more intelligibly than the most accurate description could possibly do, we need not even attempt any; accordingly, we shall confine ourselves to a few remarks. While we readily confess that the architect (Mr. John Gibson, whose name was quite unknown to us before) has shown competent knowledge of the style generally, we also desiderate more regard to the spirit of it in some of the details. The uppermost story of the towers, and the large circular window, are satisfactory enough; not so, however, the doorways, which might very properly have been made far more important features,—important, we mean, not as regards size, but with regard to design and execution. Such parts of a building being those which are most clearly of all seen,—in fact, those which subject themselves to the closest inspection, they naturally demand more elaborate ornamentation and finish than others which can be seen from, comparatively, only a distance. Such at least seems to have been the principle generally observed by mediæval architects, whose doorways and portals were frequently most profusely adorned, even when all the rest of a façade was either featureless or left quite plain. The bestowing particular attention upon them is indispensably requisite for any adequate characterization of the Lombardic style; more especially as, unlike the Gothic, it affords very few resources of design for windows (circular ones alone excepted), which were seldom more than mere small single openings, without any of that variety and richness which arise from mullions and intersecting tracery. If not richer in their general design, the doorways of this chapel might very well have been considerably bolder in their details and execution. Were they more deeply recessed, and their mouldings in greater relief, they would make a far better appearance.

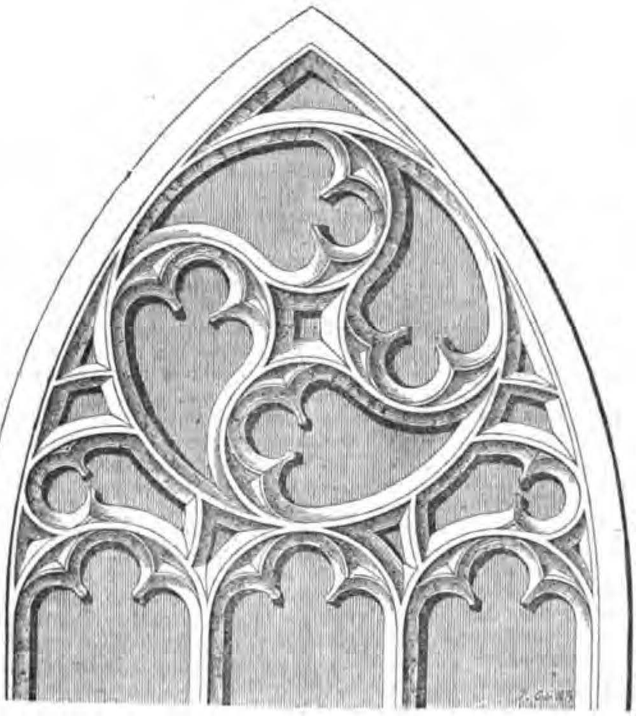
The building is of white brick, with ornamental dressings of Caen stone. The spires are constructed of timber, and are covered with ornamental tiles. The width of frontage is 70 feet, and the height to the top of the spires 115 feet.

The interior affords accommodation on the ground floor for about 460 persons in pews, with a vestibule and two vestry rooms. In the towers are staircases leading to the basement and gallery floors, the whole extent of the former being set apart for two schools, for boys and for girls. The galleries occupy three sides of the chapel, with an organ gallery on the fourth—these will accommodate 470 persons in pews, with a separate gallery for 250 children; total accommodation, 1,180.

The span of the roof, clear of supports, is 65 feet. The height from the floor to the ceiling is 39 feet. The whole building is nearly a square, and covers a superficial area of 5,150 feet.

* When alteration was going on, it would surely have been worth while to remove the entrances to the "wine vaults" beneath the chapel, from the front to the side;—or better still, if it could have been done, to the rear of the building, where they would have been entirely out of sight.

GOTHIC WINDOW.



SIR—During the autumn of 1846, in which I stayed some weeks at Boppart, on the Rhine, I met with, in an old church at that place, a Gothic window, of which I made memoranda. From these, a friend has been enabled to send me the inclosed. I now forward it to you, in case you may think it worthy of insertion in your very useful publication.

I am, yours, &c.,

I. J. CHAPMAN.

Athenæum Club, Pall Mall,
March 16, 1848.

CANDIDUS'S NOTE-BOOK, FASCICULUS LXXXI.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. We are never, it would seem, to have more than one view of the new Palace of Westminster; for though many representations of it—or what call themselves such—have been published in various shapes, they are merely copies either of the first one, or of each other; all of them showing only the river front, as taken from the south-east. What sort of fidelity and taste stamps such barefacedly piratical manufacture, may be more readily imagined than decently—at least temperately expressed. Nothing less than nerves of iron—or else a thorough callosity of mind that is hardly conceivable in such an artist, can enable Mr. Barry to endure some of the abominable libels so inflicted upon him. Schinkel, Kleuze, Gärtner, and other foreign architects, have been similarly libelled, and perhaps more grievously still; but then there are their own authentic representations of them, as well as their buildings themselves, to show to those who have no other means of judging of them, what the latter really are; whereas, without such incontrovertible evidence to the contrary, some of them might be supposed to be the most barbarous and miserable things ever erected,—at least, such would be the case were it not that the very vileness of the representation comforts us with the assurance that the structures themselves cannot, by any possibility, be so hideous.

II. That plodding adherence to precedent, which is now made a *sine-qua-non* in design by those whose influence and authority—more especially in matters of church-building—amount to dictation to architects, has a tendency to operate injuriously to art, in various ways. For art—in the worthy meaning of the term—is substituted what is or quickly will become mere routine, sufficiently dexterous, perhaps, and clever, but still routine. As far as design is concerned, all, it may be said, that is now required of architects is, that they shall be skilful mimics. Such talent will stand them in stead of imagination, invention, artistic feeling, contrivance, and much else besides. The architect is in fact degraded from his position as artist, the exercise of the faculties which such character implies being interdicted him, and all that is expected of him being that he shall scrupulously adhere to express patterns for the particular style he is called upon to imitate. Daily experience convinces—at least might convince us that, somehow or other, the spirit of the originals is not transfused into the copies, or else the peculiar sentiment and associations connected with the former evaporate altogether in the latter. Moreover, the example of mediævalism itself is, so far from affording any *precedent* for, rather opposed to that system of torpid imitation which is now regarded by many as the most salutary and efficacious for art. During the middle ages, there was continual change and innovation in architecture, by means of which transition was made from one marked general mode or style to another. So far was precedent from being regarded, that not even uniformity of design and style was attended to in edifices which were carried on by successive generations of builders; and some of which exhibit in themselves, not only different, but the two extreme phases of the Pointed style, including, perhaps, portions in an anterior style. The architects of those days did not suffer themselves to be trammelled by precedent—to be tied down to repetition and copying, even where they would have contributed to unity of *ensemble*. Then, instead of that *stand-still* in art, which we seem to consider essential to the maintaining it in its integrity, all was innovation, progress, productiveness. The art was productive, because artists wrought out of their own minds; consequently, infused mind, intelligence, spirit, and spontaneity into their productions. They did not then reject new ideas merely because they were new, nor the suggestions of imagination out of the timid apprehension of being censured as incorrect, if not absolutely heretical in taste. They did not, as we now do, abide by ready-made, and ready cut-and-dried patterns, but designed all their details freely, for they employed what was to them their vernacular language—their own mother tongue in art, whose character and idioms they helped to frame, and in which they expressed themselves instinctively. To us at the present day, the style they used has become a dead language; one in which, by dint of study, we may attain to considerable proficiency; but which we do not think in, and which does not supply words and expressions for modern things and modern ideas. We may indeed so call it, but mediæval English architecture is no longer our National style, if by "National" we are to understand the prevalent style of building generally employed by us for all purposes and occasions alike. We may be mediæval in our churches, just as we may be Ciceronian in Latin orations at colleges and schools. But we ourselves are all the while getting further and further off from mediævalism every day. Free Constitutions, Republics, and Chartism, do not indicate any great attachment to the spirit of mediævalism.

III. We are now, it seems, likely to have, for the very first time, a work that shall fairly answer to the character of a Dictionary of Architecture, which those which have hitherto appeared under such title have been very far indeed from doing. They have, almost without an exception, been little better than mere trading speculations,—things manufactured for the market; and some of them have been such arrant scissors-and-paste work, that hardly any market could be found for them. The epithet, "Architectural," applied to Nicholson's, is little less than an arrant misnomer; therefore, I am not at all surprised at the present proprietor of the copyright having been told, as I happen to know, by one whom he was solicitous to engage to bring out a new edition of it, that in order to be rendered at all what it would now require to be, it must be entirely re-written from beginning to end, and amplified to almost double the quantity of letter-press. As the Dictionary now promised us is to be the undertaking of a society, there is reason for expecting that it will be uniformly well-executed throughout. Very great room for improvement upon everything there is at present of the kind either in our own or any other language there certainly is, if only because materials have so greatly accumulated, and so many matters and subjects have come up that ought to be not merely noticed, but treated of pretty fully. At the present day it would, for instance, be unpardonable to omit such terms, and the information connected with them, as Cinque-cento, Renaissance, Rococo, and numerous others either of a similar or different class.

IV. If the Dictionary *in petto*, here alluded to, is to contain articles of architectural criticism and æsthetics, it will have to supply a very great deal indeed merely in that single department of it. In fact, the artistic philosopy of architecture has scarcely been merely touched upon at the best, and that very vaguely, loosely, and drily,—whereas it requires to be fully elucidated by actual instances and examples. Character, Composition, Contrast, Effect, Grandiose, Grotesque, Heaviness, Picturesque, Purity, Richness, Simplicity, and many other terms, might be made to furnish exceedingly interesting and instructive articles—such as would assist very much in popularising the study of architecture. That it greatly needs to be popularised can hardly be disputed. Of very little use is it for its professional followers to call architecture the queen of the fine arts—or rather their so calling it partakes of the ridiculous, while the public are for the most part utterly indifferent to it as a fine art; and that such is the case the exhibitions at the Royal Academy strongly testify, where the picture of a "posy-faced" girl, or of a damsel painted "in buff," will attract crowds of spectators, while the architectural room is a desert, or used only as a thoroughfare. The pictures, in fact, possess so much stronger attraction for the many, that the architectural drawings are comparatively quite disregarded, or if looked at, are looked at rather as pictures than as designs, and judged of not so much according to the architectural merits and ideas which they display, than according to ability of execution, and the pictorial qualities put into them; which last species of artistic recommendation is quite distinct from architectural value, and is what may be imparted by a skilful pencil to very poor, or even wretchedly bad designs.

V. If the notices bestowed upon the Fine Arts by the newspaper press may be taken as a fair criterion by which to judge of the favour in which they are respectively held by the public, Architecture san be scarcely above zero according to such thermometer of popularity. Although the class of publications just mentioned professes to be *au fait* on every subject, architecture is ignored by it; and why?—because it can be done with impunity. Is it to be supposed that such a journal as the *Times* could not, if it thought it worth while to do so, command as able assistance in the department of the Fine Arts generally, and architecture among them, as in any other? Most undoubtedly it could; and would do so, were there, on the part of the public, any demand for such information and instruction. We may therefore fairly conclude that there is none. This seems discouraging enough, but is said not for the purpose of discouraging, but, on the contrary, of stimulating architects, and inducing them to make an effort to create greater general interest in behalf of their art. Their vaunting it to each other is useless, and little better than so much idle vapouring. It is the public, not they themselves, who require to be convinced of its importance and excellence. Yet, what has the

"Institute" done towards promoting and disseminating architectural taste among the public? The answer must be—just nothing at all. The mere idea of anything of the kind does not appear to have even so much as occurred to them. Nay, the "Institute" might be extinguished to-morrow, and neither the art, nor the profession, nor the public would miss it. Although I do not pretend to be a particular admirer of the "Institute," I am, in one sense, its warmest well-wisher, since most earnestly do I wish that it would signalize itself, by doing, or attempting to do, some real service to architecture, as a branch of Fine Art. At present, that body is not only exceedingly drowsy itself, but its torpidity has a benumbing effect which extends beyond its own immediate sphere. Still, I am not for having the "Institute" abolished; but I do wish that it were entirely re-constructed. If I cut it up, it is only for the purpose of its being thrown into Medea's cauldron, to be resuscitated in a better form, and come forth again vigorous and energetic. Or if a fresh and more genial spirit—if greater activity, and greater sympathy with Fine Art, can be infused into it, without resorting to the process of re-construction, the sooner it be done the better. Were I less devoted than I am to architecture, the "Institute" would not be thus reproached by me; and if to be so enthusiastically devoted to that art, as to be quite regardless whom I please or offend while advocating its interests, should subject me to reproach in return, I can endure it with far more of pride than of shame.

VI. The natural death of Ludwig the First of Bavaria would have been many degrees less distressing than is his moral and political one, by which he has terminated his career that forms an epoch in the history of art, as an infatuated old dotard. Scarcely ever before has so much been done by an individual prince for the embellishment of his capital, as has been accomplished by Ludwig for Munich; whose name has in consequence become a familiar household word in the mouths of artists throughout all Europe. What other princes have done for art has been in a great measure out of either ostentation or policy; but the ex-king of Bavaria seems to have been all along warmly attached to art for its own sake. It was himself personally that originated the idea of, and sedulously watched through their progress, monumental structures, some of which would of themselves highly sufficed for recording architecturally an entire reign. No very excessive hyperbole is it to say, that the reign of Ludwig has been equivalent to the lengthened rule of a dynasty, when we compare Munich with what it was some thirty years ago and now *is*. And *now*!—why now, the tears shed over his coffin would have been far less painful than the sigh which we give to his folly and his fate.

VII. There is a vast deal of prate and palaver about Proportions, as if all beauty in architecture were referable to them alone, independently of all other qualities that go to make up beauty, and independently of all circumstances. It is so convenient to have what looks like irrefragible and authoritative doctrine, and a theory so compact that it may be put into anutshell, or carried on the tip of one's tongue, ready to dart out the magic word —Proportions. Yet, so far from being on that account a simple one, such theory is an exceedingly complicated and abstruse one. If we ask what are beautiful Proportions, we shall be told "just" ones; when, if not satisfied with such elucidation, we return to the charge and inquire what are just Proportions, we shall, perhaps, be further enlightened by being assured that they are those which are harmonious and conduce to beauty. For the human figure and other animal forms, there are standards of normal Proportions, fixed by nature herself. But in architecture, there is no immutable standard of Proportion for any one style, much less one applicable to all styles alike. In the Greek orders, we find the very extremes of proportion—such as could not be exceeded either way without falling into deformity and disproportion—in the Pæstum Doric, and the slender, comparatively too slender, Corinthian. Yet, utterly dissimilar as they are, all the orders may be said to be admirably proportioned in themselves; which, however, instead of at all simplifying the matter, only renders the subject of Proportion the more abstruse and perplexing. The very best Proportions are only relatively good, for differently applied they might be far from pleasing, or even be absurd;—at the utmost, only average proportions, suitable for general guidance and for ordinary cases; and so far from being abided by, such average may frequently be greatly exceeded with the happiest effect. What, for instance, is loftiness but an unusual degree of height in comparison with breadth, or height exceeding the usual relative proportion which it bears to width? To attempt to fix invariable Proportions by rule is worse than nugatory, since it is positively mischievous, and detracts from the privileges of art; rendering that a merely mechanical process which ought to be determined very differently. After all, it is the eye which judges of Proportions; therefore, surely the eye of the architect—supposing him to be at all worthy of such name —ought to be able to decide what are pleasing Proportions quite as well as that of other people. And so that they be pleasing, it matters not at all how much they deviate from ordinary routine and its rules. Undue stress is laid upon Proportion, because it is generally spoken of as if it were all-sufficient in itself alone, and capable of ensuring excellence; whereas, it is only one element of beauty in design. Besides which, the term itself is usually understood in only a very limited meaning—namely, with reference to that mechanical species of it which concerns itself with merely parts and individual members or features, without that higher artistic one being included in the idea of it, which regulating the whole of a composition, stamps it to the eye at once as a captivating *ensemble*, all whose parts are in perfect keeping. That kind of Proportion is quite beyond the reach of rules. Those who cannot find out for themselves how to produce it, must dispense with it, trusting that it will never be missed by those who are content with Proportion in pieces and bits,—by hairbreadth measurers of columns and mouldings.

VIII. Odious as the Window-tax may be as a tax, I cannot at all agree with those who consider it, or talk as if they did consider it, to operate injuriously upon architectural design. So far is appearance from being at all benefitted by a multiplicity or frequency of windows, that the fewer the windows the more satisfactory is external appearance; for unless sparingly introduced, such openings sadly interfere with breadth and repose. We certainly do not find that in designs produced as specimens of their author's taste, consequently composed without the slightest regard to the Window-tax, they are at all prodigal of windows. If the Window-tax be felt a peculiarly onerous and oppressive one, let it by all means be got rid of; but in the name of common-sense, don't let its effect upon architectural design be urged as a reason for its removal, because if taste is to have any voice in the matter, it might find a very strong plea for the obnoxious tax being doubled, or even trebled. With regard to the purpose for which windows are necessary at all, rooms may have too much light, or too much window-surface, as well as too little. The cheerfulness of a room does not depend so much upon the quantity of light admitted into it, as upon many other circumstances; and foremost among them is the air of comfort, or of both combined, which it exhibits itself. Much also depends upon situation; for the latter may be such as to render the minimum of exposure to our view of it desirable. Again, the sort of cheerfulness derived from window-light is entirely dependent upon the weather: if that be gloomy and cheerless,—*triste* and dull. In dismal weather—no very great rarity, by the by, in this climate,—a blazing fire is far more exhilarating than the mere daylight. Of *quantum* of window or aperture for light in a room, there may be excess just as well as deficiency. Yet, because light is indispensable, it is thought that there cannot possibly be too much of it.

IX. While some of the studies and qualifications enumerated as requisite for the architect are very remotely connected with either the practice or theory of his art, even if they can be said to be connected with it all, others there are which are overlooked—at least passed over in silence. It is difficult to repress a smile when we find History and Biography included among the studies which an architect ought to be conversant with—for why not Geography also—more especially *Poliography*, or descriptions of cities and their public monuments. The *quantum* of History, however, is so far from being formidable, that it dwindles down into a mere homœopathic dose,—no more of it being insisted upon than what relates to architecture. Just the same is it with Biography; for architectural biography is exceedingly scanty indeed, and does not at all tend to encumber biographical dictionaries. Mr. Donaldson points only to one source for it—to Milizia alone, without so much as mentioning Temanza, Quatremère de Quincy, and Cean-Bermudez. Of biography in general, it may safely be predicated that it is "a most attractive branch of history;" but the same cannot possibly be averred of architectural biography as a particular species of it, because, as it has hitherto been treated, it is particularly dry; a fault that might be forgiven, were it not also particularly *jejune*. Biography, says Mr. Donaldson, when speaking of its importance to the architect, "teaches us the course by which great men have attained to eminence;" yet that cannot be said of the species of it which he must be supposed to have had exclusively in view. On the contrary, it leaves us wholly ignorant of the studies and mental impulses to which the "eminent" in the profession have been indebted for their ability, and their distinction in the art. Nay, we very rarely learn what were the external matter-of-fact circumstances that shaped out and attended their professional career. Biographical notices of architects we most undeniably have, yet scarcely anything really deserving the name of architectural biography,—nothing written *in extenso* and fully developed. Passing over other studies which are strangely claimed for the architect, I will point out what, although overlooked, I myself conceive to be very essential qualifications—I say essential, not indispensable, —because daily experience convinces us that dispensed with they are. Now I should say that talent for Invention and Contrivance stands almost foremost among the qualifications for an architect. Without it, he can be little more than a barren copier,—the creature of *comme-il-faut* routine; a very respectable automaton, but not an artist. If we care only for mechanical skill and excellence, let us boldly say so at once, and desist from that maudlin, namby-pamby prating about architecture as art,—except it be just that brevet grade of the latter, by virtue of which tailoring and cookery claim to be enrolled among the so-called arts. For the display of other talent and merits, the opportunities are comparatively few; but those for the exercise of Contrivance are continually presenting themselves. It is what so far from requiring favourable circumstances, is most of all called into operation by disadvantageous ones, and by difficulties and untoward circumstances which, by a little exercise of it, might be overcome, not only sufficiently well, but even happily, and so as to be productive of both conveniences and beauties that would not have been thought of but for the obstacles which prevent compliance with usual matter-of-course proceeding. A taste for and acquaintance with art generally, as well as his own particular branch of it, is also highly desirable, if not indispensable, for the architect—a taste not so much, perhaps, expressly for painting and sculpture themselves, as for pictorial and sculpturesque decoration; and as regards an eye for colour, effect, and various combinations of form.

ON THE STABILITY OF ARCHES.

On the Stability of Arches, with practical methods for determining, according to the Pressures to which they will be subjected, the best form of Section, or variable depth of Voussoir, for any given Intrados or Extrados. By George Snell, Assoc. Inst. C.E.—(From a paper read at the Institution of Civil Engineers.)

The first section of this paper treats of the general conditions of stability in structures composed of many blocks of materials, as walls, arches, &c. The second and third sections discuss the conditions of stability of an arch, the form of which and the pressures sustained by it, as regards position, direction, and amount, are similar on either side of the crown of the arch; such as an arch sustaining its own weight only, or that of a symmetrical superstructure. In the second section the arch is supposed to be formed of blocks of an incompressible material; but in the third section the limited strength of materials is taken into consideration. The fourth section discusses the conditions of stability of an arch, acted upon by forces of any amount, applied in any position and direction in the plane of the section, or of an arch whose form is not similar on both sides of the crown.

The effect of the adhesion of the cement is not taken in any case into consideration.

Section I.

Art. 1.—A structure built of blocks of stone or other material, as A B C D, diagram 1, may yield under the pressure to which it is subjected; first, by the slipping of certain of its surfaces of contact

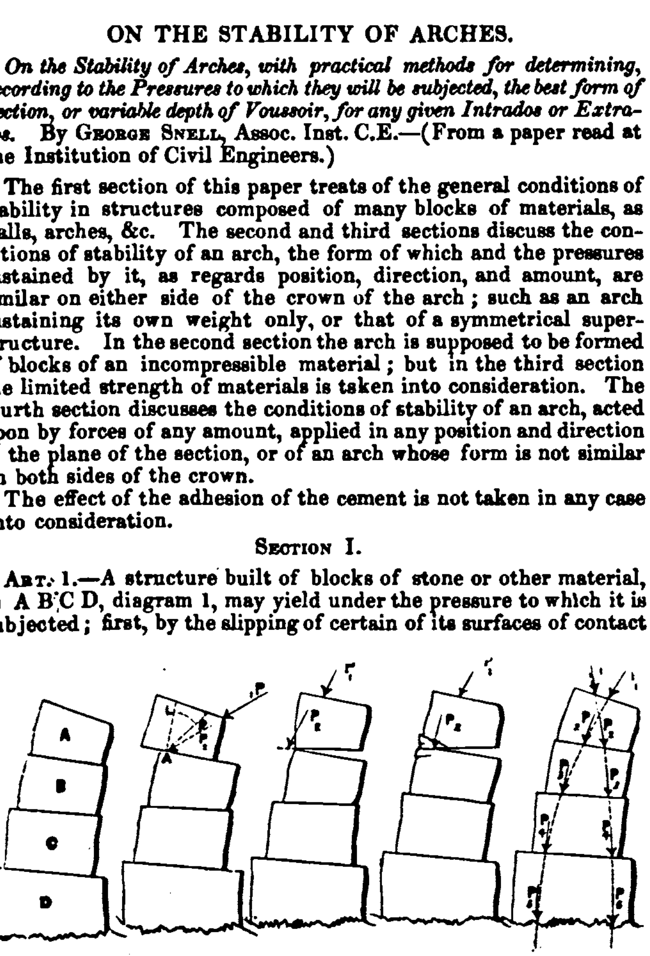


Diagram 1. Diagram 2. Diagram 3. Diagram 4. Diagram 5.

one upon another, as diagram 2;—secondly, by the blocks turning over one upon the edge of another, as diagram 3;—or thirdly, by the yielding of the materials of which the structure is composed, as diagram 4. For the first effect to take place, it is necessary that the resultant P_2, of the pressure P_1, on one of the blocks A, and weight of A, should act in a direction inclined to a perpendicular drawn from the surfaces of contact, at an angle greater than L A R, the "limiting angle of resistance" of those surfaces. For example, if the materials are calcareous oolite, this angle, L A R, is 36° 30′; and if, as in diagram 2, the direction of the resultant is more inclined from the perpendicular than this angle, failure will take place, from the one block slipping on the other.

For the second effect to take place, the resultant pressure must act in a direction which passes without the joint, as in diagram 3.

The third effect depends, first, on the strength of the material; secondly, on the amount of the resultant pressure; and thirdly, on the position and direction of that pressure. Thus the material may be capable of sustaining the pressure, if it acts through the axis of the stone; the pressure in that case being equally distributed over the whole surface of contact; but if the direction of the pressure approaches very closely to one of the edges, so that one portion of the block sustains a much greater pressure per square inch than another, then the material may yield and failure ensue, as in diagram 4.

If, however, none of the resultant pressures P_2 P_3 P_4 P_5, diagram 5, fulfil any of the above conditions, that is, if none are inclined from a perpendicular to the surface of contact at an angle greater than the limiting angle of resistance of those surfaces, nor fall without the joint, nor approach so near to the edge as to cause the material to yield, then the structure will withstand the pressure P_1. Also, if instead of the pressure P_1, the structure be acted on by a pressure p_1, and the resultants p_2 p_3 p_4 p_5, do none of them fulfil any of the conditions of failure, it will withstand this pressure. In like manner, an endless variety of pressures, or systems of pressures, may be sustained by the structure, each giving a different series of resultants on the successive joints.

Art. 2.—If any other joints are made in the structure, the position and direction of the resultant pressures on them, also, must be drawn and examined, before the stability of the arch is determined; if, however, a curve such as that in diagram 5 could be traced, the property of which curve should be, that at any point in it the tangent should represent the position and direction of the resultant pressure, as the arrows P_2 P_3 P_4 P_5, which are tangents to the curve, and which also show the position and direction of the resultants; then if no part of this curve passed without the structure, or so near to the edges of it, as to cause the material to yield, the structure would be stable, however numerous, or in whatever direction the joints might be, provided that the perpendicular from the joint were inclined to the tangent to the curve, at an angle less than the limiting angle of resistance. This curve is known as the "line of resistance," and its properties were discussed for the first time by Professor Moseley, in essays published in the "Cambridge Philosophical Transactions;"* it can be traced by application of difficult mathematical analysis, as shown in the fourth part of the "Mechanical Principles of Civil Engineering and Architecture," p. 403. If, however, the resultant pressures are determined for a series of joints, the line of resistance can be traced with sufficient accuracy from joint to joint, by means of a bent whalebone, or a metal spring, or by hand as in diagram 5.

Art. 3. *Problem* 1.—To find the position, direction, and amount of the resultant pressure on every joint of a structure, the resultant pressure on one of the blocks being given in position, direction, and amount, and the specific gravity of the material forming the structure being also known.

Diagram 6 represents a structure of seven blocks of stone, or other material, the pressure on the first block being 80 cwt., and its position and direction represented by the arrow; it is required to determine the position, direction, and amount of the resultant pressures on all the other blocks.

Construct a scale of equal parts, each part to represent one cwt., or one pound, &c., as may be convenient. In this figure each equal part represents one cwt. Calculate the weight of each stone (*in this example, if the first block weighs* 15 *cwt., the weight of the others are as figured on them in the diagram*).

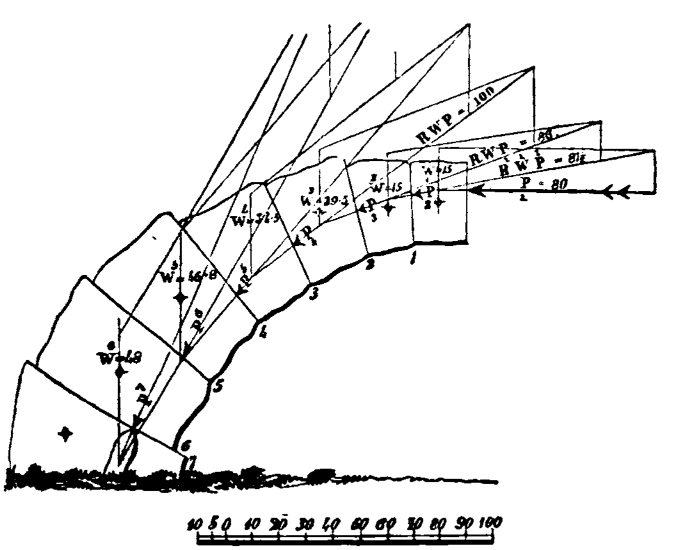
Find the centres of gravity of the blocks: (*they are indicated in this and the following diagrams by this mark* ◆).

Then the pressures on the second block are, first, the weight of the first block = 15 cwt., which may be represented by a pressure of 15 cwt. acting vertically downwards through the centre of gravity of the block; draw the line W_1, representing the position and direction of this pressure: secondly, the pressure on the first block, which acts in the direction and position indicated by the

* Vide Phil. Trans., Cambridge, vol. v. p. 293; vol. vi. p. 463.

arrow; continue this direction till the line intersects the vertical, through the centre of gravity; from the point of intersection of these two lines measure off, on the vertical line, a distance equal to 15 parts of the scale, making the side W_1 of the parallelogram; and on the line in the direction of the pressure on the block, measure off a distance equal to 80 parts of the scale, making the second side P_1 of the parallelogram; draw the other two sides; and the diagonal $R_1\ W_1\ P_1$, will represent the direction of the resultant of these pressures; its length, equal to 81½ parts of the scale, will give the amount of its pressure, 81½ cwt., and the line, continued till it intersects the joint No. 1, will represent the point of application of this resultant pressure on the second block; that is to say, that point will be the centre of pressure of all the pressures, communicated throughout the surfaces of contact, from the first block to the second, and the amount of the resultant, 81½ cwt., will be the aggregate of these pressures.

Diagram 6



Scale of equal parts, representing Cwts.

If the line W_1, representing the weight of the block, is drawn from the point of intersection, in the direction in which it acts, that is, vertically downwards, then the line P_1, representing the pressure on the block, must be drawn in the direction in which it acts, that is, from right to left. If, however, as in the present case, it is more convenient, the lines may be drawn each in the direction opposite to that in which the pressures act, that is, the weight represented by a line vertically upwards, and the pressure by a line from left to right, in which case the resultant pressure will act in the direction of the diagonal, but *towards* the point of intersection of the two lines, that is, from right to left in the present example.

The resultant pressure on the third block is determined in a manner precisely similar to that described above, with regard to the second; a vertical line is drawn through the centre of gravity of the second block, and the direction of the resultant pressure on the same, P_2, is continued till the lines intersect; 81½ parts measured from this intersection on the latter line, form one side of the parallelogram, and 15 parts measured on the vertical line from the other, for the amount of the resultant pressure on the second block is 81½ cwt., and the weight of the second block is 15 cwt.: the parallelogram being completed, the diagonal produced determines the position and direction of the resultant pressure on the third block, and its length, measured by the scale, determines the amount of the pressure to be 86 cwt. In like manner, the pressure on the fourth block is 100 cwt., and its position and direction are shown by the arrow P_4; also $P_5\ P_6\ P_7$, show the position and direction of the resultant pressures on the fifth, sixth, and seventh blocks, and their respective amounts are determined by the length of the diagonals of the fourth, fifth, and sixth parallelograms, and if any of the blocks were removed, and replaced by a prop, in the position and direction shown by the arrow: as for example, if the seventh block were removed, and replaced by the prop there shown, then all the remaining portion of the structure would be balanced on the point of the prop. Each of these arrows are tangents to the line of resistance, which can be drawn from point to point by the eye, or by means of a piece of whalebone, or a metal spring.

If, instead of the pressure on the first block, the pressure on any other block be given, the resultant pressure on all the others may be found in a similar manner. Thus, if the pressure on the fourth block is known, the pressure on the fifth, sixth, and seventh will be found in precisely the same manner as above described. Then with regard to the third block, it will be acted on by its own weight, and the pressure from the second block, and the given pressure on the fourth block, is the resultant of these two pressures; if, therefore, a vertical line is drawn through the centre of gravity of the third block, and another line is drawn in the direction of the given pressure on the fourth block, and from the point of intersection of these two lines there is measured off on the vertical, as many parts of the scale as there are cwts. in the weight of the block, and on the other line, as many parts as there are cwts. in the given pressure on the fourth block; then there have been measured the side W_3 of the parallelogram and the diagonal $R_3\ W_3\ P_3$, and these two lines determine the parallelogram, the second side of which, from the point of intersection, represents the pressure on the third block. This pressure on the third block being determined, that on the second and that on the first block may be found in the same manner, the lines drawn being the same as those in the example.

Art. 4.—In nearly all cases of arched structures, the pressure on any one of the voussoirs is unknown, and this constitutes the difficulty of the subject: the point of application, the direction, and the amount of the resultant pressure on any of the voussoirs being determined, the conditions of stability of the whole structure are found by the application of the foregoing problem. To determine the stability of the arch with regard to the first condition of failure, diagram 2, that is, supposing failure to take place, by the slipping of one voussoir on another, the direction only of the resultant pressures is required; but to determine whether the arch will fail (as in diagrams 3 or 4), by the voussoirs turning on their edges, or by the material failing, not only the direction, but the points of application and the amount of the pressures must be determined. The theories of the arch, which preceded that of Professor Moseley, take into consideration only the first condition of failure (Art. 1, diagram 2), it being supposed that if the arch failed, it would be by one of the voussoirs slipping on another. The experiments of Rennie, Morin, and others, had not then been made, and the resistance of the friction of one stone on another was much underrated, so that it was considered necessary for stability, that the direction of the pressures should always be perpendicular to the joints; of course this could only be the case for one particular system of pressures, and if the weights on the voussoirs and other pressures were so arranged, that the resultant pressure on each joint acted in a direction perpendicular to it, then if any weight were added to the system, or any taken away, the positions and directions of the resultant pressures would, of course, vary also, and their directions be no longer perpendicular to the joint. It seems to have been the practice of bridge-builders, to take the weight of the arch-stones and backing for the fixed system of pressures; and this weight being very great in proportion to that of the wagons, carriages, and people passing over, the effect of the latter was not an important consideration, and the old problems sufficiently answered the purpose. In the case, however, of a light railway bridge, traversed by a heavy train, which, coming upon it suddenly, has twice the effect of a stationary pressure of the same weight, the effect of such traffic must not be omitted from the calculation; but if the arch is designed and the weights on the voussoirs arranged, so that the resultant pressures shall be perpendicular to the joints when the train is on the bridge, then, when the train has moved off, all the resultant pressures will have taken new positions and directions, no longer perpendicular to the joints; so that, according to the theories themselves, the arch would fail. These theories are also quite useless in determining the stability of vaults on high walls; there is not, perhaps, a single vaulted roof now standing, that does not prove their fallacy.

Art. 5.—Without taking into consideration the adhesion of the cement in the joints, the limiting angle of resistance for the surfaces of all materials used in arches, is so large, that it would be difficult to design an arch and loading, in which the first condition of failure would be fulfilled; in the pier or abutment, however, such failure is likely to occur, and must be carefully guarded against.

The second condition of failure, diagram 3, is, strictly speaking, impossible, for no block will turn on its edge upon another, without some abrasion, or elastic yielding, of the surfaces, in which case it becomes that shown in diagram 4, or the third condition of failure; however, as the failure takes place from the tendency of the pressures to turn the blocks on their edges, it seems that the subject is best discussed by first supposing that the materials are incompressible, and tracing the conditions of stability on this hypothesis, and then by examining in what respect those conditions are modified by the limited strength of the materials.

ART. 6.—In applying the following methods to analyse the strength of any given structure, the first question to be solved is: Is the structure, when acted on by the given pressure, on the balance between standing and falling? The problems determine if this is the case, and if not, if the tendency is towards stability or instability. If the structure be on the balance between standing and falling, then the slightest alteration in the pressures may cause it to fail, and it would therefore be condemned as unsafe. If the tendency be towards instability, unquestionably the arch will not stand. If, on the other hand, the tendency be towards stability, then another question arises: How great a degree of strength does the structure possess? When it is decided in what terms this strength is to be measured, the problems in the following pages can be applied to answer the question. Thus, the strength may be measured by the weight in different positions and directions, that will be required to produce the state of unstable equilibrum, or the balance between standing and falling. Or, again, the strength of the material may be hypothetically diminished, until this unstable equilibrum is produced, and thus a measure of strength is obtained; as for instance, if the hypothetically diminished strength of the material is one-tenth the actual strength of the material used, then the structure is ten times stronger than is theoretically necessary.

SECTION II.

ART. 7.—On the conditions of stability of an arch whose voussoirs are incompressible; the form of which, and the pressures sustained by it, as regards position, direction, and amount, being similar on either side of the crown of the arch.

In such an arch, the conditions of failure are, as before stated, the first and second; that is, the voussoirs may slip on one another, or turn over on their edges: the latter condition will first be discussed.

It need not be proved, that if in one part of an arch the voussoirs turn over on their edges at the extrados, causing the joint to open at the intrados, then at some other positions, other voussoirs must turn over on their edges at the intrados and the joints open at the extrados. Also it need hardly be proved, that if the arch is similar in form and similarly loaded on either side of the crown, that if failure takes place, in the manner above described, one of the points of rupture will be at the crown of the arch: this is nearly self-evident, and may be proved by experiments on any model of an arch; it is, however, proved geometrically by application of the problem in Section 4. If the arch fails at the crown, by the voussoirs turning on their edges A_1, at the extrados, as in diagram 7, then at some point in the haunches, the voussoirs will at the same time be turning on their edges A_2, at the intrados, in which case the crown will sink and the haunches will spread.

If the arch fails at the crown, by the voussoirs turning on their edges at the intrados, as in diagram 8, then at some point in the haunches, the voussoirs will, at the same time, be turning on their edges A_2, at the extrados, in which case the haunches will sink and the crown of the arch will rise.

ART. 8.—When the arch is failing, as shown in diagrams 7 and 8, then the points of application of the resultant pressures at the places of failure are beyond the edge of the voussoir, as shown in

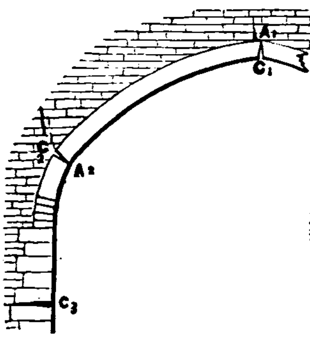


Diagram 7.

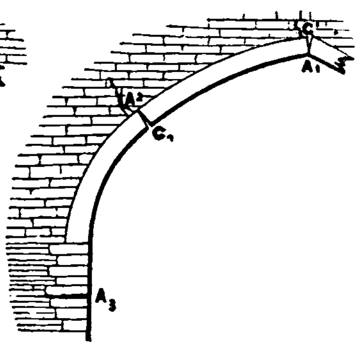


Diagram 8.

diagram 3. But when the arch is in the condition of unstable equilibrium, that is, when it is on the balance between standing and falling, and when the voussoirs are on the point of turning on their edges at A_1, A_2, &c., then the point of application of the resultant pressure must be at the extreme edge of the voussoir, and its direction must also be that of the tangent to the intrados, or extrados, at A_1, A_2, &c., because if not, the line of resistance passes without the boundary of the voussoirs, either on one or other side of the point A, and the structure has already failed, by the turning over of some other voussoir. Therefore, when the arch is in the condition of unstable equilibrium, then, at all the points of rupture, the directions of the resultant pressures are tangents to the intrados, or extrados.

ART. 9. *Problem* 2.—To find the second point of rupture, in an arch whose voussoirs are incompressible, the form of which and the pressure sustained by it, as regards position, direction, and amount, being similar on either side of the crown of the arch.

Also to find the amount of pressure at the crown and at the second point of rupture.

Take for example an arch with a backing, or superstructure, diagram 9. It is required to find the second point of rupture, that

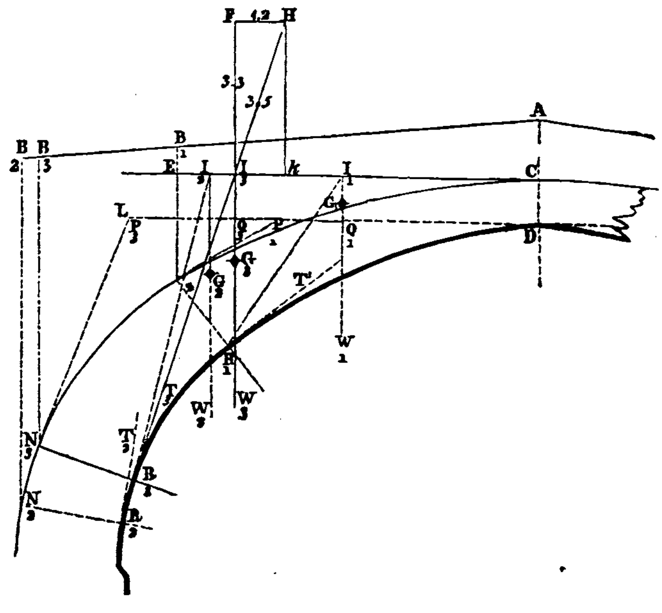


Diagram 9.

is, that point in the haunches, at which the voussoirs will be about to turn on their edges, when the arch is in the condition of unstable equilibrium.

As the form of the structure leads to the supposition, that, if failure take place, it will be by the sinking of the crown and the spreading of the haunches, let it be first assumed that the arch is about to fail in that manner. Then the point C, in the extrados, at the crown, will be the first point at which the voussoirs are about to turn; and the horizontal line C E, will represent the direction and position of the pressure upon the side of the arch drawn in the figure, caused by the weight of the opposite and similar side: see Art. 8.

Choose some point R_1, in the intrados, and, for trial, suppose that to be the second point of rupture. Then the voussoirs will be on the point of turning on their edges at R_1, and the resultant pressure will act through R_1, in the direction R_1 T_1, of the tangent to the intrados: see Art. 8. Draw the joint or normal to the intrados R_1 N_1, and the vertical line N_1 B_1. Find the centre of gravity of the mass A D R_1 N_1 B_1; and draw the vertical line G_1 W_1, and produce it till it intersects C E, at the point I_1. Then the only pressures acting on the point R_1, are the pressure of the opposite arch, acting in the direction C E, and the weight of the mass A D R_1 N_1 B_1, acting in the direction I_1 W_1; and since the direction of these two pressures intersect in the point I_1, therefore, by the well-known law of Statics, the direction of their resultant also passes through the point I_1; but when the arch is about to fail at the point R_1, R_1 T_1 is the direction of the resultant, and this does not, if continued, pass through the point I_1. Therefore, R_1 is not the second point of rupture, and some other point must be tried. If the line R_1 I_1 be drawn, it will be seen that its direction is less inclined to the vertical than R_1 T_1; and this leads to the supposition that the point of rupture is lower down, at some point where the tangent to the curve is less inclined to the vertical. Therefore, choose some other point R_2, and pursue a precisely similar method to that described for R_1, as shown in the figure.

Then, since the tangent $R_2\,T_2$, produced, does not pass through the point of intersection I^2, but is less inclined to the vertical than the line $R_2\,I_2$, the point of rupture is above R_2. Also since the line $R_2\,T_2$, more nearly coincides with the line $R_2\,I_2$, than the line $R_1\,T_1$, with the line $R_1\,I_1$, the point of rupture is nearer to R_2, than to R_1.

One more subsequent trial generally suffices to determine the correct point, which, in this example, is the point R_3. For the tangent $R_3\,T_3$, produced, passes through the point I_3, which is the point of intersection of the direction of the weight of the mass A D R_3 N_3 B_3, and the pressure of the opposite of the arch. Therefore, if the arch fails by the sinking of the crown, the second point of rupture is R_3.

The second case is now to be considered: Where will be the second point of the rupture, if the arch fails by the rising of the crown? Draw the horizontal line D L, which will, in this case, represent the position and direction of the pressure of the opposite side of the arch. Let the point N_1 be tried; then if N_1 be the point of rupture, the tangent to the extrados at N_1 N_1 P_1, will, if produced, pass through the point Q_1, which is the point of intersection of the directions of the pressures of the opposite side of the arch, represented by the line D L, and of the weight of the mass A D R_1 N_1 B_1, represented by the vertical line W_1 I_1. But N_1 P_1 intersects the line D L, far from the point Q_1. Also if the point N_3 be tried, it will be found that the tangent N_3 P_3 is far distant from the point of intersection Q_3; and in like manner it will be found, that at no other point above N_3, will these conditions be fulfilled, except at the point C. Therefore the arch will not fail by the rising of the crown. Therefore the arch will, if it fails, fail by the sinking of the crown and the spreading of the haunches; and the point R_3 is the second point of rupture.

Art. 10. *The second part of the Problem.*—It is required to determine the amount of pressure at the crown, and at the second point of rupture.

Construct a scale of equal parts, as in Problem I, each division representing some unit of pressure, as pounds, hundred-weights, or tons. Through the point of their intersection I_3, produce the lines R_3 I_3, and W_3 I_3; then on the line W_3 I_3, produced, measure off the distance, I_3 F, containing as many equal parts of the scale as these units of weight, in the mass A D R_3 N_3 B_3, and from the point F, draw a line parallel to C E, intersecting the line R_3 I_3, produced at the point H. Then, by the well-known principle of the parallelogram of pressures, the line F H contains as many equal parts of the scale as there are units in the pressure of the opposite side of the arch on the crown at C, and the diagonal of the parallelogram H I_3, contains as many equal parts as there are units in the pressure on the point R_3. Thus, in Exampe 1, if the weight of the mass A D R_3 N_3 B_3, is 3 tons 3 cwt., then the pressure at the crown will be 1 ton 2 cwt., and the pressure at the point R_3, 3 tons 5 cwt.

Art. 11.—Thus the resultant pressure on one of the blocks of the structure is determined in direction, position, and amount, which is the datum required in Problem 1; and therefore, that problem may be applied and the line of resistance be traced, as in the example in Art. 3, through the whole structure, commencing either from the crown, or from the second point of rupture; and this line will represent the resultant pressures at every part of the structure, when it is on the balance between standing and falling, that is, when it is in the condition of unstable equilibrium.

If the line of resistance, at any point, passes without the boundary of the voussoirs, the structure will unquestionably fail. If it touches the extrados, or intrados, at other points, and at the base, then the structure is in the condition of unstable equilibrium. If the line of resistance passes through the base of the structure, some distance within the mass, then the arch has a certain degree of stability, which may be tested, as described in Art. 6, by the methods given in the following Sections.

The stability of the structure, with regard to the first condition of failure (Art. 1, diagram 2), has to be considered, and is at once determined by inspecting the line of resistance, drawn as described in the foregoing examples. If at any part of the structure a joint is made, in such a direction, that a perpendicular drawn from it shall be inclined from the tangent to the line of resistance, at that point, at an angle greater than the limiting angle of resistance of the surfaces of contact, the structure will fail at that place; if, however, this is not the case at any position in the arch or pier, then the structure will not fail by the slipping of the blocks one upon the surface of the other, and the first condition of failure will not be fulfilled.

Section III.

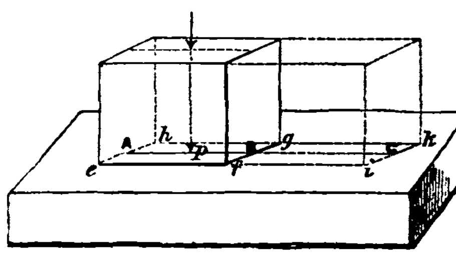
On the conditions of stability of an arch, the form of which, and the pressures sustained by it, as regards position, direction, and amount, are similar, on either side of the crown of the arch; the limited strength of the materials being taken into consideration.

Art. 12.—By reference to Art. 6 it will be seen, that it is there proposed, that the conditions of stability in an arch should first be discussed on the supposition that the materials were incompressible, and that then it should be examined in what respect those conditions were modified by the limited strength of the materials used in building. The first part of this proposition has been considered in Section II. It is the purpose of this section to consider the second part.

The arches in the examples in the last section could not stand if they were built of any material at present known, because at the points of rupture, the resultant pressures act at the extreme edge of the voussoirs, and therefore all the pressure has to be resisted by these extreme edges, or by a single line, which cannot be the case, unless the material is incompressible. So that in all practical cases of arches, even the condition of unstable equilibrium cannot be attained, unless the position of the line of resistance is some distance within the section of the arch. The question which then arises is, how near to the intrados or extrados can the line of resistance pass, without causing the failure of the materials?

Art. 13.—Experiments to determine the strength of stones to resist compression, have for the most part been made by the application of pressures on cubes of the stone, in a direction perpendicular to the face of the cube, as in diagram 10. The resultant of this pressure, and the weight of the stone, acts in the direction

Diagram 10.



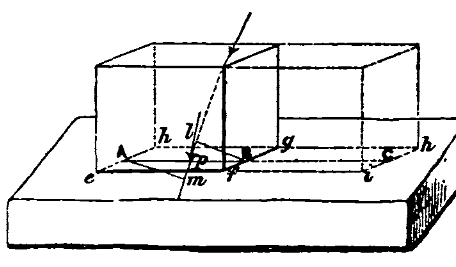


Diagram 11.

of the axis of the cube, its point of application being in the centre of the base at p; so that if any line be drawn through this point p, to the edges of the block, as the line A B, the portion p A is equal to the portion p B: and as, by the principle of the equality of moments, the pressure on the point A, multiplied by the length A p, is equal to the pressure on the point B, multiplied by the length B p; since the length A p, is equal to the length B p, the pressure on the point A, is equal the pressure on the point B; and similarly the pressure on the whole edge of the stone $e\,h$, is equal to the pressure on the opposite edge $f\,g$.

Now let the block of stone, as shown in diagram 11, be acted upon by a pressure whose direction is inclined to the axis of the block, but which is applied in such a position, that the resultant of it, and the weight of the block, acts through the point p, in the centre of the base. Draw any line A B, through the point p, to the edges $e\,h$, and $f\,g$, and draw another line through p, in the direction of the resultant, and from the points A and B, draw lines A m, B l, perpendicular to this line. Then, by the principle of the equality of moments, the pressure on A, multiplied by the length A m, is equal to the pressure on B, multiplied by the length B l. But since p B, is equal to p A, the angle A p m, is equal to he angle B p l, and the angles A m p, B l p, are right angles; therefore, the length B l, is equal to the length A m, and therefore, the pressure at A, is equal to the pressure at B, and similarly the pressure on the whole edge e h, is equal to the pressure on the whole edge f g. Therefore, in both cases, diagrams 10 and 11, the the pressure will be sustained in a similar manner, by the base e f g h. So that if the resultant pressure at p, diagram 10, is equal to one ton per square inch of the surface e f g h, and does not crush the particles in that surface, then, if the resultant at p, diagram 11, is equal to one ton per square inch of the surface e f g h, the particles in that surface will not be crushed.

If in either of the cases, Diagrams 10 and 11, the portion f i k g, be added, it is evident that the pressure on the base e f g h, will not be increased. And therefore, if a stone, as in diagram 12, be acted on by a pressure, the resultant of which, and the weight

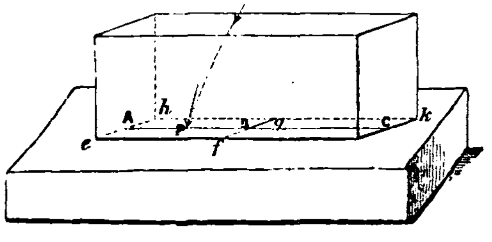


Diagram 12.

of the stone, passes through a point p, in the base e i k h: Draw a line A C, through the point p, to the edges e h, and i k; then measure off, on the line p C, a portion p B, equal to the length p A, and draw the line f B g, perpendicular to the line A C. Then, if the resultant pressure at the point p, divided by the number of square inches in the surface e f g h, is not greater than the pressure per square inch, that (by the experiment in diagram 10) the material was found capable of bearing, then the stone will not fail when acted upon by the given pressure.

It is of course implied, that no natural fault, or laminated structure, of the stone, should cause it to yield, it being evident that the judgment of the engineer must be called into requsition, to guard against such a catastrophe.

ART. 14.—The method here proposed, for the determination of the proper section, &c., of arches, or for discussing the stability of arches already designed, the limited strength of the material being taken into consideration, is founded on the above-mentioned principle.

SECTION IV.

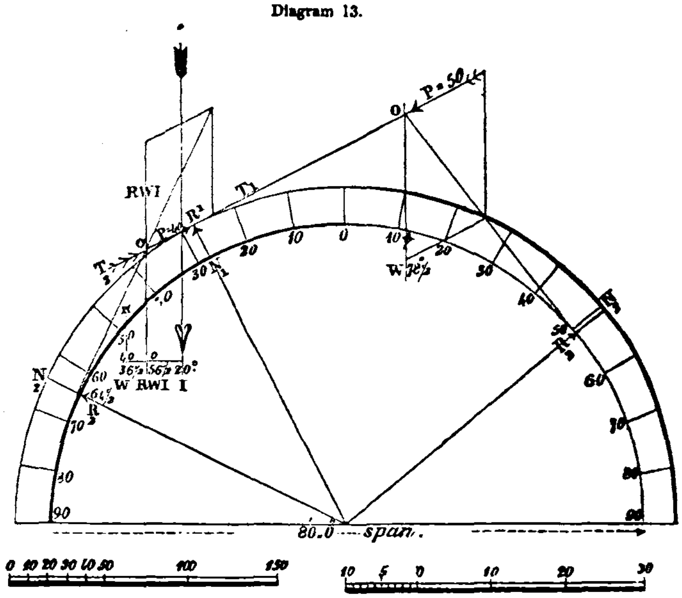
On the conditions of stability of an arch, acted upon by forces of any amount, applied in any position and direction in the plane of the section; or of an arch, whose form is not similar on both sides of the crown.

ART. 15.—In an arch under the conditions stated at the head of this section, the first point of rupture is not necessarily at the crown, and it is this which constitutes the difficulty of the question. It may here be remarked, that when the terms first, second, and third points of rupture are used, it is not meant that the failure of an arch commences at the first point, and then spreads to the second point of rupture, and so on; for theoretically speaking, the structure will fail at all those points at the same time; but by the first point of rupture is merely meant the point of rupture first determined, and by the second point of rupture, the point of rupture secondly determined, as by the process detailed in the preceding sections, one point of rupture being already known.

ART. 16. *Problem* 3.—To find the first point of rupture in an arch acted upon by any given pressures, in any given position, and the arch itself being of any given shape. The method proposed to solve this problem will, it is thought, be more easily shown, by reference to the example of the arched vault in the previous sections, than by a general diagram and demonstration.

Example.—Let the arched vault shown in diagram 13, of 80 feet span, and whose depth of voussoir at the crown is equal to one-ninth of the radius, be acted on by a pressure, equal to the weight of a portion of the arch of 20° length of intrados, and one foot in length of transverse section, and applied vertically to the extrados, at a distance of 30° from the crown. Required the first point of rupture, under these conditions; the materials being incompressible. First, suppose for trial, some point R_1 in the extrados, to be the first point of rupture, say 28° from the crown, as in diagram 13. Draw a tangent T_2 R_1 T_1, to the extrados at R_1. Then if R_1, be the first point of rupture, R_1 T_1, and R_1 T_2, represent the direction of the pressure of one portion of the arch on the other,

Diagram 13.



Scale of weights of Degrees.

Scale of Feet.

when the arch is about to fail at that point; for then the line of resistance touches the extrados at R_1. Also R_1 being the first point of rupture, and the arch being about to fail, the pressure of the lower portion of the arch, in the direction T_2 R_1, must be equal to the pressure of the upper portion, in the direction T_1 R_1; for the pressures must be in equilibrium about the point R_1, and if one is preponderating, then the arch has already failed somewhere else, and the voussoirs, if about to turn on their edges at the point R_1, are moving in the direction of the preponderating pressure. On the supposition that R_1 is the first point of rupture, find the second points of rupture, R_2, on the right and left hand sides of the arch, in the same manner as described in Section II. Problem 2.

In this case, the second point of rupture on the right hand side, is at the intrados, at 51° degrees from the crown; for the vertical line, drawn through the centre of gravity of the mass R_1 N_1 R_2 N_2, intersects the tangent to the extrados, at the crown R_1 T_1, at the point O, and the tangent to the intrados at R_1, also passes through the same point. Also the second point of rupture, on the left hand side, is at the intrados, 64° distant from the crown; for the direction of the resultant of the weight of the mass R_1 N_1 R_2 N_2, and the force impressed on the arch, intersects the tangent to the extrados at R_1, and the tangent to the intrados at R_2, at the same point O.

Next, construct the parallelograms of pressure, as shown in diagram 13; in that for the left side, the vertical line marked R W I, represents the resultant of the weight of the mass, 36°, and the impressed forces equal to the weight of 20° of the arch; and these being pressures in the same direction, this resultant equals the weight of 56° of the arch, and the side of the parallelogram R W I, is equal to 56 parts of the scale. The directions of the other two pressures are sufficient to determine the parallelogram, by which it appears, that the pressure of the lower portion of the arch on the point R_1, in the direction T_2 R_1, is equal to the weight of 40° of the arch.

In the same manner it will be found that the pressure of the upper portion of the arch on the point R_1, in the direction T_1 R_1, is equal to the weight of 50° of the arch. But the pressure in the direction T_2 R_1 is equal to the weight of 40° of the arch, therefore the pressure at the point R_1, of the upper portion of the arch, upon the lower, is greater than that of the lower portion and its impressed force, on the upper. Therefore R_1 is not the first point of rupture.

Take therefore, for trial, some other point nearer the crown of the arch, for the point of rupture; for it is evident, that as the point of rupture approaches towards the crown, the pressure on it from the left side, will be greater; and that from the right side be less. Let this second trial point be 15° from the crown; repeat with regard to this point, a process similar to that above described, and as shown in the diagram; and it will be found, that the pressure from left to right is equal to the weight of $42\frac{1}{2}°$ of the arch, and that from right to left, equal to the weight of 44°; so that the pressures are very nearly in equilibrium; therefore, the first point of rupture is very near this trial point; and the pressure of the right side of the arch preponderates: therefore, take for the next trial, a point a few degrees nearer the crown.

Thus the first point of rupture will soon be arrived at, which, in this case, is at the extrados, 10° from the crown, for when the voussoirs are about to turn on their edges, at this point, the pressure from the left equals the pressure from the right; each being equal to the weight of 41° of the arch.

The second point of rupture on the right side, is at the intrados, 55° from the crown, and the pressure there is equal to the weight of 71° of the arch; then Problem 1 can be applied, to trace the line of resistance through the rest of this side of the structure, and it will be found, that for the arch to be in the condition of unstable equilibrium, about the springing, it is necessary that the voussoirs should be deepened about 12 inches, at 86° 40′ from the crown.

The second point of rupture on the left side, is at the intrados 62° from the crown, and the pressure there is equal to the weight of 90° of the arch, and Problem 1 being applied to trace the line of resistance through the rest of the structure, it will be found, that for it to be in the condition of unstable equilibrium, at the springing, the voussoir must be notched at the extrados, to the depth of about 6 inches.

Art. 17.—The principles and the method described in Section III. may be applied to the arch sustaining pressures, as described in the heading of this section, and of unsymmetricical form; as well as to that arch whose pressures and form are similar on both sides of the crown, as described in Section II.

It is also evident, that the above method will apply to any irregular form of arch, and that the principles and method described in Section III. might also be applied.

ON A GENERAL THEOREM TO CALCULATE THE AREA OF A CROSS-SECTION OF A RAILWAY ON SIDELONG GROUND.

By R. G. Clark.

The intention of this paper is to investigate a formula, free from surds or any approximation, to compute the area of a cross-section, without having regard to the side stakes. We have given (fig. 1)

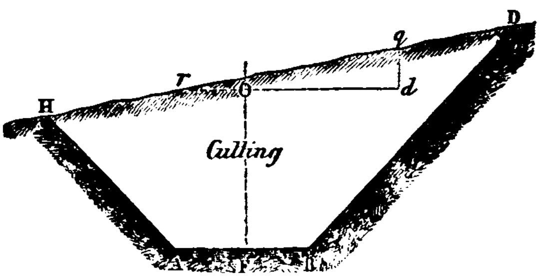


Fig. 1

the breadth of formation level A B; the depth O F from centre stake; the difference of heights $q\ d$, taken by the spirit-level; the corresponding hypothenusal length $q\ r$; and the ratio of the slopes. On referring to page 68, present volume, article "Railway Sections in Sidelong Ground," to formula (3), which is

$$(2\,b + m\,a)\,a + \tfrac{1}{2}\,(b + m\,a)\,(x - x')\sin\theta = \text{area};$$

where $b = \frac{1}{2}$ formation level; $a =$ depth or height from centre stake to centre of formation level; x and x' equal the distances O D, O H; $\theta =$ angle of inclination of ground; and m base of slope to one perpendicular. Also let $h =$ difference of heights by level $r\ d$; and $l =$ O d, the hypothenusal length on surface.

From (1) and (2), page 67, in the article above referred to, put

$$\text{T} = \frac{1}{\cos\theta - m\sin\theta}, \text{ and } \text{T}' = \frac{1}{\cos\theta + m\sin\theta};$$

then the above formula becomes, by substituting T and T′,

$$(2\,b + m\,a)\,a + (b + m\,a)^2\,(\text{T} - \text{T}') \times \frac{\sin\theta}{2} = \text{area} \,\ldots\ldots\ldots (4)$$

But $(\text{T} - \text{T}') \times \frac{\sin\theta}{2} = \frac{2\,m\sin\theta}{\cos^2\theta - m^2\sin^2\theta} \times \frac{\sin\theta}{2} =$

$$\frac{m^2\sin^2\theta}{\cos^2 - m^2\sin^2\theta} = \frac{m\tan^2\theta}{1 - m^2\tan\theta^2}.$$

Now consider, in the right-angle triangle $q\ d\ r$, the height $q\ d = h$ to be a tangent, the horizontal distance $d\ r$ the radius; therefore, $\tan^2\theta = \frac{h^2}{l^2 - h^2}$. Substitute this value in last expression, and then in (4); we have for the required general formula:

$$(2\,b + m\,a)\,a + (b + m\,a)^2\,\frac{m\,h^2}{l^2 - h^2 - m^2\,h^2} = \text{area H A B D } (5)$$

Let the slope be 1 to 1; then $m = 1$; ∴

$$(2\,b + a)\,a + \frac{(b + a)^2\,h^2}{l^2 - 2\,h^2} = \text{area} \,\ldots\ldots\ldots\ldots\ldots\ldots\ldots (a)$$

The general formula is more simple than it appears: when these numbers are large, we shall only require a table of square numbers to work out any question. Two examples are subjoined:—

1. Given length on slope of ground = 20 feet; the difference of heights, 6 feet; slope to be 2 to 1; depth of cutting, 20 feet; and breadth of formation level, 30 feet. Find area by the formula (5).

Substitute the above values in (5):

$$(33 + 40)\;20 + (16{\cdot}5 + 40)^2\,\frac{2 \times 36}{400 - 180} = 2504{\cdot}7, \text{ area required.}$$

2. Given the length 20 feet on descent of ground; difference of heights by level, 6 feet; intended slopes, 1 to 1; depth of cutting, 45 feet; and breadth of formation level, 33 feet. Find the area. (*See* fig. 1; and for embankment, *see* fig. 2.)

By substituting the above values in (a):

$$(33 + 45)\;45 + \frac{(16{\cdot}5 + 45{\cdot})^2\;36}{400 - 72} = 3925, \text{ area required.}$$

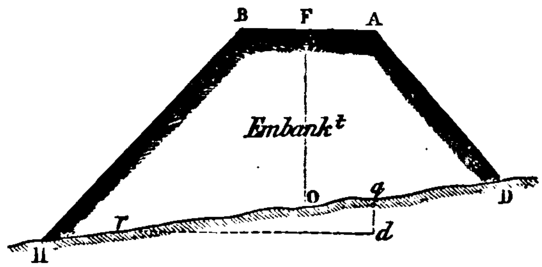


Fig. 2.

From the above it may be observed, that when a centre line of railway is ranged and staked out, and the depths known on inclined ground, we can always find most expeditiously the area of any vertical cross-section, by means of the spirit-level, without requiring the distances of the side stakes from the centre. By way of comparison, I have to refer to an article for a similar purpose, page 263, vol. VII. of this *Journal.*

SOCIETY FOR THE PUBLICATION OF ARCHITECTURAL KNOWLEDGE.

From what has been said of it, the main purpose of this Society—which, perhaps, may not mean to call itself exactly by the title for the present assigned to it—seems to be to bring out what shall be a complete Dictionary or Encyclopædia of Architecture—a very meritorious undertaking, and one which, as the want of such a work is felt, might have reasonably enough been expected on the part of the Institute. That the present Dictionaries which we have of the kind are all more or less defective and unsatisfactory, even considered with reference to the time when they were produced, is universally admitted. Even had they no other deficiencies, they have one and all lagged very much behind the actual time when they made their appearance, whereas every work of the kind ought to bring down its information to the latest possible moment. Let us hope this important point will be attended to in the one now promised, and that it will duly notice all those improvements, both in matters of construction and those of embellishment, which have come up of late years, and to which every year adds something. As the Society in question of course looks to usefulness and reputation, rather than to anything in the shape of pecuniary profit, we may fairly anticipate from it something greatly superior to everything else of the kind. Much will depend upon their most carefully maturing the whole of their plan beforehand,—a work of no small labour in itself, but which would save them innumerable difficulties and perplexities. Let nothing be overlooked: let them not have to say, when midway in their task, we did not think of this, or of that, and it is too late to think of it now. Beyond this we cannot attempt to give any sort of special advice, because if anticipated by themselves it might be construed into downright impertinence. We can only say that we shall gladly open our columns to any more correct and fuller information as to its objects which the Society may deem proper to communicate.

REVIEWS.

GEOMETRY FOR THE MILLION.

Principles of Geometry, Mensuration, Trigonometry, Land Surveying, and Levelling. By THOMAS TATE. London: Longman and Co., 1848.

We have read this work with sincere regret: for in every point of view it is calculated to be injurious. It will be injurious to those who take it as a guide for the study of geometry; and it will materially injure the character which Mr. Tate had fairly established by his previous writings, both as a mathematician and an instructor. We could, indeed, scarcely believe, whilst turning over the pages, that we had not taken up the wrong work; and we once actually (under the impression that it could not have been written by Mr. Tate) turned back to the title-page to verify our unbelief!

Of Mr. Tate's other works, without exception, we think very highly. His treatise on "Factorials" bespeaks considerable analytical power; and though rejected by the Royal Society (which we deem to be no criterion of the merit of the work), it contains much that is new, and the whole system is developed with perspicuity and elegance. His "Arithmetic," again, is just what a treatise on arithmetic should be:—the rules are given clearly, and such reasons or approximations to reasons as could be comprehended by the minds of young students, are attached to the rules. The efficient demonstration of the rules of arithmetic constitutes the basis of algebra; for we hold that algebra is *fundamentally* only a statement of the rules for arithmetical operation, obtained by induction from the particular instances supplied in actual computation. We have no faith (because we have no proof) in the doctrine of "the permanence of equivalent forms," as a fundamental principle, apart from the evidence of induction, and of the verification afforded by deductions from it. Again, in the "Exercises on Mechanics and Natural Philosophy," Mr. Tate has manifested consummate skill, by exhibiting very simply and very clearly, the primary laws of mechanical action; and the exercises are admirably chosen from amongst the most familiar combinations of machinery, and the phenomena of daily observation, which tend to elucidate the principles very happily.

Our readers (and even Mr. Tate himself) must, then, be convinced that we are actuated by no hostile or unkind feelings towards that gentleman, when we express our objections, and very grave objections too, to his "Principles of Geometry." For no other reason, indeed, should we have said so much by way of proem.

Our objection then is—that Mr. Tate has either *misconceived* or *misrepresented* the fundamental character of geometrical evidence and of geometrical reasoning. Either of these charges seems almost alike improbable:—the former in consideration of his intellect, his reputation, and his cleverness; the latter, in consideration of his scholastic position and his high character for probity. We have no alternative to the one hypothesis but the other; and we have no hesitation in saying that *misconception* is the real cause of the objectionable principles of this work. We will state our reasons for thinking so.

Mr. Tate, like nearly all our "analysts," appears to have never acquired a clear view of the essential principles of geometrical evidence. Analysis (employing the word as synonymous with algebra, after the dictum of D'Alembert) is a system of inductions only—at least, as far as operations and what are called "principles" are concerned. Its most general theorems are wholly dependent upon induction for their evidence—as much so as the parallelogram of forces, or the law of gravitation. In geometry, on the contrary, the only *principle* employed is the syllogism; and the only *appeals to experience* are the few axioms respecting the visual and tangible properties of figures which are put down at the opening of Euclid's first book, together with those fundamental conceptions respecting multiples which are prefixed to the fifth book. The fact is, that Mr. Tate has not discriminated between the essential characters of geometry and of algebra; and he has thereby been led to import into the discussion of the former subject, the methods which are not only legitimately available in the latter, but in a great degree essential to its development.

There may be an additional reason, dependent on Mr. Tate's professional position, for his vagueness of conception on this head. The Battersea Training Institution was formed, we believe, for the purpose, not so much of education itself, as for training the humbler order of schoolmasters in the *art of teaching*. Most certainly the object was a noble one: for probably no one of our social classes stood relatively so low in respect to skill in their particular duties as the general mass of schoolmasters. A good teacher, or even a moderate scholar, was the exception to the rule rather than the rule itself. This has been sufficiently established by the reports of the "Government Inspectors of Education"—even after all allowance has been made for the over-colourings in those Reports, which in some cases cannot be denied to have been made. The formation of suitable schoolmasters, especially for the rural districts, required them to be trained to a ready and popular exposition of the ordinary phenomena of nature and of mechanism, as well as of mere methods of computation. Popular rather than technical language is often found to be convenient; and, below a certain grade of mental development, it is essential in such a case. In the devising of such popular modes of exposition, Mr. Tate has been for many years employed; and, as is always the case, his daily routine of duties may be supposed, without any diminution of our respect for his talents, to have destroyed that vividness of perception and rigorous spirit of reasoning, which mathematical science naturally produces in respect to the force of evidence.

We look, of course, to the preface of a work to ascertain the objects for which that work is written, and the principles on which the author composed it. A reference to Mr. Tate's preface, with one or two specimens of his method of proceeding, will, we are sure, convince every reader that we have not formed our unfavourable opinion of his work without adequate reason.

Mr Tate considers that "it will be instructive to trace the origin of *our ideas* in geometry, with the view of suggesting to us *the means whereby first notions on the subject should be conveyed to the mind of the learner.*" Now, the ambiguity involved in the word "our"—which leaves it uncertain whether he referred to the conceptions of the first geometrical speculists of our race, or to those who in our time have been trained in the terminology and popular traditions of geometry—is very objectionable. The former would appear, from his subsequent remarks to be his view: but it is not at all clear. Under either aspect, however, his maxim is very questionable; and certainly by writers of the highest scientific and philosophical authority, it is always rejected. In truth, the actual order of discovery is almost invariably found to be the most inconvenient for the systematic exhibition and development of scientific truth. The universal history of science is at variance with this conundrum of Mr. Tate's.

The author's delineation of that creature of his brain, the primeval geometer, is a sufficiently ludicrous piece of seriousness: but his talk about "the vast amount of facts accumulated *independently of the formality of definitions, or the tedious verbiage of a rigorous demonstration,*" really startles us. It is more like the raving of an illiterate person than the language of an accomplished geometer. Neither can this be called a stray passage accidentally expressed in an offensive form; for the *animus* is the same throughout the work. For instance, he says a little further on (p. vi.): "In the demonstrations contained in the following treatise, conciseness and simplicity have been preferred to *the artificial verbiage of a technical logic;*" and he has created his primeval and philosophical geometer, "without any precise views relative to *the origin of ideas*, or the *formulæ of a technical logic*, [with whom] demonstration would consist in a simple appeal to *common-sense*, or in such an exposition as might be sufficient to *carry conviction to the mind.*" This primeval geometer is created, too, as the Battersea-pattern for the formation of Englishmen of science; and Mr. Tate has falsified Euclid's assertion as respects "a royal road to geometry!"

We wish, however, to ask Mr. Tate a question or two on these subjects. What does he mean by "common-sense" in connection with the acquisition of science? We often hear the phrase used, it is true, by men who call themselves "practical:" but as far as our memory goes, we have never heard it used by a scientific person in the way it is here used by Mr. Tate, though very often so by persons destitute of all science. In geometry we can attach no other notion to it than that it is intended to express the inference which we may draw from visual evidence, or from instrumental evidence at the least—in short, the evidence of experiment performed with the ruler and compasses, or perhaps with a somewhat sensible balance, such as those made by Bate, of the Poultry. Be it so—but do not degrade science by calling this "geometry."

Again, what does Mr. Tate consider to be "such an exposition as might be sufficient to carry conviction to the mind" of a learner? Judicious teachers, we have often heard, lament the imbecile facility with which conviction is carried to the minds of the most slothful pupils: they are most readily "convinced" by the bare words of the enunciation, provided they are excused the trouble of understanding it, and still more readily if they can be excused the trouble of proving it. Common-sense people, and people without any sense at all except the five physical ones, are alike adroit learners under these conditions; and it would seem that the founders of the Battersea Normal School knew pretty well what they were about, when they conceived that extraordinary scheme. Our own wonder is, not hat Messrs. Shuttleworth and Tuffnell should have founded at college for such purposes:—it is, that Mr. Tate should not only have ministered to this extraordinary system of training schoolmasters, but that he should have pushed himself forward into such unenviable notoriety (for a scientific man) as the Coryphæus of a conspiracy for the abolition of pure geometry in England.

Let not the import of our remarks be misunderstood. We take no objection, but directly the reverse, to the composition of works on practical geometry, apart from the demonstrations of the processes. The Elements of Euclid were never intended as a work to serve the wants of the artisan or draughtsman in his operations; and it is very certain, that infinitely better constructions *for practical purposes* of the few problems given in the "Elements" might be easily framed. Their *proofs*, however, must depend on properties not laid down by Euclid. Yet it shows the paucity of resource which our "common-sense" geometers possess, when we remark that nearly all these writers follow in the wake of Euclid in the most servile manner, and adopt not only his constructions, but even their very order, and almost his language. Let us have a good work on practical geometry by all means: let the constructions be accompanied by demonstrations or not, as may be deemed advisable by the author; but still, let us not be beguiled into a belief that our constructions are true, by a few rambling, inconclusive, or utterly irrelevant sham-demonstrations,—alike discreditable to him who offers them as evidence as to him who so receives them. Give perfect demonstrations, or none. Take water, if you please, gentle reader, from the fountains of science; but do not pollute, or allow others to pollute, the pure streams with such adulterations as those which we shall presently quote from the work before us.

Mr. Tate does, indeed, pay some rather inflated compliments to the geometry of Euclid,—some "very fine writing," no doubt: but the very form in which they are expressed is obviously intended for disadvantageous contrast with his own system of primeval geometry. The only book, in the author's view, better than Euclid's is Tate's! In our view, the only book worse than Mr. Tate's is Mr. Andrew Bell's, in "Chambers's Educational Course"—not even Euclid's Elements' excepted. After his eulogy of Euclid, he proceeds:—

"However, it must be conceded, that whatever may be its excellences *as a book of reference to the mathematician, its defects, as an initiatory system of geometry, are too apparent to admit of even an apology.* A great book is, in many respects, a great evil; the very elements constituting its greatness,—its refinement and comprehensiveness,—tend to throw over it an air of mystery and dignity, which distracts and overawes the uninitiated student, in the place of giving him that encouragement and sympathy, which he certainly requires, in his first feeble efforts in the pursuit of abstract knowledge. The geometry of Euclid is a *highly artificial system, which can only be read, thoroughly, by a person who is already a mathematician, and who can enter into its metaphysical subtilties, and beautiful yet operose demonstrations.* The principle of motion gives a simplicity and clearness to many geometrical conceptions, but from an imagined inconsistency in the use of such a method, Euclid employs it, neither for the purpose of demonstration nor illustration. The *method of superposition*, which, in reality, lies at the very basis of geometrical demonstration, and, in many cases, *gives a graphic interest to an investigation*, is employed in the fourth proposition of his first book, and then, as *if ashamed of the lowly origin of geometry*, he scarcely uses it afterwards. *Many* of his problems are solved by methods which are never used in practice, for example, when a given portion is to be cut off from a straight line, instead of supposing the given portion to be simply transferred to, or placed upon the straight line, &c., which we really do in practice, Euclid must describe circle after circle, in order to accomplish the problem. The *doctrine* of similar triangles is, unquestionably, one of the most *important propositions* in the whole range of geometry, yet the student is not permitted to understand this proposition, until be has gone through the fifth book, which, to a large class of students, must for ever remain a sealed book. It is desirable that practical men should comprehend the leading propositions in solid geometry; *but Euclid's method of treating this subject, is so operose and refined, as to place it beyond the reach of persons whose time for study is limited, or whose mathematical talents are not of a superior order.*"

Now the gist of all this appears to be, that Euclid's Elements may do well enough as a "book of reference for professional mathematicians," but that it is preposterous to talk of it as a book suited to educational purposes, either for the masses, or for intelligent persons in general. It is represented as a great book, remarkable only for its metaphysical subtilty and operose demonstrations—for its refinement and comprehensiveness—and for the affectation of mystery and dignity which overawes and distracts the student. It is hard to conceive that such a description of the "Elements" could have proceeded from any man who has *read* and *understood* that remarkable production.

We deny in toto, the statement that the geometry of Euclid is "a highly artificial system," in the ordinary sense of the words, "that can only be read thoroughly by a person who is already a mathematician." If the order in which truths are capable of being successively deduced be a criterion of natural order, then the designation of artificial system as applied to the "Elements" becomes most signally inappropriate; and as to the structure of the syllogism (or rather enthymeme) in which Euclid delivers his reasoning, it will surely bear comparison, even for *real simplicity*, with the vague, unmeaning, slip-shod sentences which Mr. Tate has substituted in its place.

Euclid, it seems, was "ashamed of the lowly origin of his geometry"—viz. the method of superposition. Mr. Tate considers that it "gives a graphic interest to an investigation." Now, it surpasses our power to conceive what sort of interest a "graphic interest" is: but we suppose the author to mean that the mind is interested in having its own reasoning functions performed for it by the eye and hand conjointly. Even then we cannot understand on what ground mere superposition can be supposed to give *graphic* results. Did space allow, we could easily explain the cause of Euclid's sparing use of the principle, without suffusing the cheek or blanching the lip of the geometrical patriach with "shame."

As to the employment of the principle of *motion*, we have simply to ask, what advantages Mr. Tate thinks he can confer upon *accurate geometrical reasoning* by the introduction of it into geometry? Nay, more, will he tell us *how it would aid demonstration*? What organic definition would he give of a straight line? What could he get from the organic definition of the circle, which is more or less than Euclid's definition? Can he have forgotten that the cone, sphere, and cylinder are actually defined by their geneses? Can he have forgotten that the favourite method of superposition is not discarded from the subsequent parts of Euclid's Elements, where the principle could be made to facilitate the objects aimed at? We are sorry to come to the conclusion, but we can scarcely avoid the inference, that Mr. Tate has never "read and inwardly digested" the work which is the object of his animadversions—and we can have no scruple in concluding that he has never understood its objects, seized its import, or fully comprehended the system of philosophy of which it is one of the most enduring specimens.

Mr. Tate says that "*many* of his [Euclid's] problems are solved by methods which are never used in practice;" and he instances a *single one*. Can he instance *another*? We can with tolerable confidence answer for him:—that with this single exception, there is not a construction given in the whole range of the "Elements," of a problem which occurs in practical geometry, which we could not point out as being copied into recent, or comparatively recent works intended for the use of practical men. It is a perversion of the fact, and an abuse of the confidence placed in him by his readers, to make such unfounded assertions. That better *practical* constructions than many of them may be given, we have already said; but that does not affect the present case.

The objection that the doctrine of similar triangles is deferred so long, simply amounts to this: that proportion is made the fifth book instead of the first—which it might have been, and may, according to Euclid's treatment of the subject, be made to follow the third proposition of the first book. Would Mr. Tate obtain the doctrine of similar triangles without all consideration of proportion? On referring to his own way of treating the subject (p. 43), we find an illogical attempt to explain the idea of proportion, and to demonstrate the properties of proportionals. It is at best illustrative. If we must have similar triangles at an earlier stage of our geometrical career, it may be easily accomplished in a much better manner than this; for instance, as Legendre has done,—by assuming the doctrine of proportion as one already known and demonstrated by means of algebra. We do not ourselves recommend the method; but it has this merit, that it is all fair and open, and does not conceal the difficulty by a series of demonstrative evasions, which merely delude the pupil into a belief that the doctrine is proved, when no real proof has been given.

In the last place, Mr. Tate affirms that "Euclid's method of treating the solid geometry is so operose and refined as to place it beyond the reach of persons whose time is limited, and whose mathematical talents are not of a superior order." It is known to every one who is acquainted with the 11th and 12th books of Euclid, and the manner in which they are used in this country, that the first twenty-four or five propositions are as simple in their reasoning as the first book of the "Elements;" and that all the properties of solids which relate to volume or surface, form no part of our systems of academical reading. Mr. Tate must know this as well as we do; and we cannot consider it ingenuous to represent the difficulties which are inherent in the parts which are *discarded* from our usual systems of education, as attaching to those which are *retained*. Let us look to Mr. Tate's own work as regards these things. We find that with respect to the line and plane, he has nearly followed Euclid's views, leaving out however some *essential steps* of the demonstrations, and modifying some others after Legendre. Then, with respect to the others, which have in modern times been turned over to the calculus in some of its forms, Mr. Tate settles the question very summarily, by the aid of, we suppose, his "common-sense," or his "graphic interest." He settles it, in short, as "common-sense" usually does settle these things, by a gross mutilation of "the arithmetic of infinites." There is, indeed, no novelty in this: the only novelty is in seeing it done by any man who had previously acquired the title of a mathematician —and in our own day too!

We promised a specimen of Mr. Tate's tutorial scheme. Here it is:—

"Nearly all the geometrical knowledge contained in this work may be conveyed to the pupil in this manner.

Teacher. What is the line A B called? A———B

Pupil. It is called a straight line.

T. Of the two straight lines A B and D C, which is the greater? A———B D———C

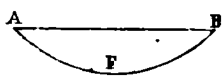
P. The line A B is the greater.

T. How should you ascertain this with certainty?

P. By laying the line D C upon A B.

T. What sort of line is A F B?

P. It is a crooked line.



T. True; but it is also called a *curved* line. Whether is the curved line A F B or the straight line A B the shorter?

P. The straight line A B.

T. If you wanted to go from Battersea school to the church, in what line should you walk?

P. In a straight line. (Why?) Because a straight line is the shortest distance between the school and the church.

T. What have you to say relative to the two straight lines A B and C D? A———B C———D

P. They appear to be of the same length; and moreover they appear to lie even with each other.

T. In other words you might say, C D = A B; and also C D is *parallel* to A B. Is C D now parallel to A B? A———B C———D

P. No; for C D would meet A B on the left side.

T. On which side would they now meet? A———B C———D

P. On the right hand side.

T. What is therefore the peculiar property or definition of parallel lines?

P. That if they be carried out ever so far, on either side, they will never meet.

A surface is called a *plane*, or flat even surface, when the line between any two points upon it is straight. Thus the surface of the table is a plane if a straight-edge exactly fits it when applied in every direction. To ascertain when a surface is a plane, bring your eye on a level with it, and if you find that every point in the surface can be seen at the same time, it will show that the surface is a plane. Our figures are supposed to be drawn on planes."

Such is the substitute propounded by Mr. Tate for the artificial *verbiage* of a "technical logic," and "the tedious *verbiage* of a rigorous demonstration," such as geometers give us! It is very possible that some readers may consider the substitute to be little else than the vulgar and illiterate *verbiage*, worthy only of the scientific charlatan, rather than of Mr. Tate and the Battersea Training College.

Were this book merely thrown on the market for those who may wish to purchase it, our concern would be less than it is about such a work: but we have heard that all the schools in England which are under the control of the Government Board of Education, are likely to have it forced upon them, as the condition of their receiving any part of the sums voted by the House of Commons in aid of those schools. The dedication of the work to Dr. Kay Shuttleworth is ominous; and the rumours which have reached us since we sat down to write, appear in perfect consistency with such a suspicion. Yet we can scarcely credit the rumour; and we believe that such an adoption of it would create a degree of dissatisfaction with that decision of that Board amongst scientific men and the friends of real education, which would be very disagreeable to the Government, and which might endanger its possession of the *patronage* which it is the policy of the Government to extend in all directions.

Oh, no! despite the misrepresentations and perversions with which the "Elements" is assailed, let us keep to the good old Euclid of our earlier days—unmutilated, and in his own venerable costume. The *true spirit* of geometry will be lost in England as it is elsewhere, if Euclid shall cease to be our text-book for the Elements of Geometry.

A Treatise on Practical Surveying, as particularly applicable to New Zealand and other Colonies, containing an account of the Instruments most useful to the Colonial Surveyor and Engineer, &c. By ARTHUR WHITEHEAD, late Civil Engineer to the New Zealand Company. London: Longman, 1848. 8vo. pp. 196, with plates.

The title of this work sufficiently explains its object. The author, acquainted by experience with the particular difficulties and exigencies of colonial surveying, has here recorded a large amount of useful knowledge, which has probably been acquired amid many toils and hardships. To the English surveyor, accustomed to *well-cleared* country, the task of mapping-out the untrodden wilds of New Zealand must be a new and formidable undertaking. The greatest difficulties of surveying at home, sink into insignificance in the colonies. Here we have open country, and the use of the instruments is little impeded by obstructions to vision—there the thick forest closes in on every side, impenetrable to the eye and almost to foot of man. Here there are well-known way-marks and boundaries, of which every particular is already accurately ascertained and delineated—there everything is new and uncertain; the endless, unvaried scene presents nothing but intertangled thicket, without mark or vestige beyond the rare and fading traces of the hatchet of the savage. Here we have high-ways and bye-ways for chariots and horsemen—there the pioneer forces his way through a fence which is as thick as it is long. Or else his journey lies over the treacherous morass. Or he must swim the unbridged, unfordable torrent. Or his path mounts up the steep hill-side, with some 110° of Fahrenheit, and 45° of angular acclivity against him. No cheerful hostel for him where he may turn in to tarry for the night. He must not ask, with Falstaff, "May I not take mine ease in mine inn?" *His* inn is his blanket. His kitchen and larder are the basket which accompanies him at every step. To hap on a place where food might be obtained by barter, would be as surprising to him as to meet a policeman or postman. He pioneers without a road, and thinks himself fortunate if his course be along the mazes and rapids, the rocks and shoals, of a mountain stream.

It requires no ordinary energy to face such difficulties. And we may congratulate ourselves that the spirit of our nation renders Englishmen especially fit for occupations so arduous. The mania for enterprise which renders the English tourist the wonder or annoyance of the untravelled German or Italian, is turned to useful account when the wilds of the antipodes are to be marked out and plotted into farms and townships. Without this spirit there could be no sufficient inducement to begin this first attack upon nature. For these colonial surveyors are not civilizers, but the pioneers of civilization. They lead the forlorn hope. When they have made the breach practicable, others enter in and gather the spoil.

The first chapter of the work before us gives descriptions and accounts of the methods of adjusting the instruments chiefly employed in colonial surveying. For instruments used in the bush, portability is of course rather more important than it would be on the Sussex Downs. There are various risks from rough usage to be guarded against or remedied in the former situation which are comparatively immaterial in the latter; and on all these points our author gives minute instruction. Chapters II. and III. detail the methods of laying out town and country lands, and the particular objects which demand the attention of the explorer are carefully explained. The fourth chapter (on practical astronomy) does not from its nature admit much that is new, but appears to be a useful compendium. There are two other chapters, on marine surveying and colonial roads, and some tables of mean refraction, corrections for the sun's declination, &c. On the whole, we are inclined to think that when the English surveyor packs up for the colonies, he ought to put Mr. Whitehead's treatise in a accessible corner of his portmanteau.

IMPROVED MODE OF WORKING EXPANSIVE STEAM VALVES.

Communicated to the Mining Journal, by Mr. Thomas Craddock, *of Birmingham.*

Fig. 1 is an end elevation; and fig. 2 a side elevation. In this design, one eccentric, which is shown at 4, 4, 4, is made to give motion to both the steam and expansive valves. The time at which it is

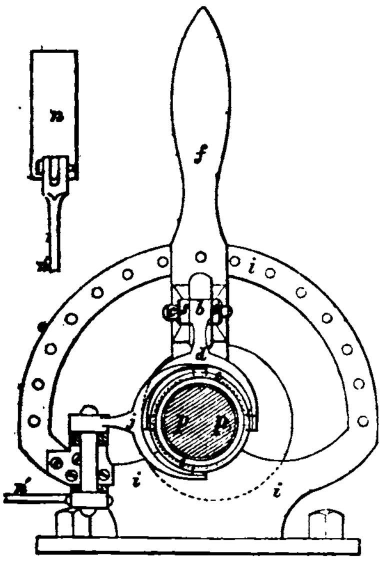


Fig. 1.

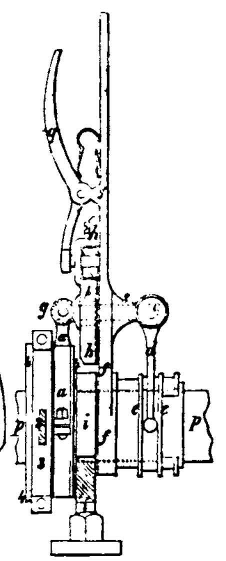


Fig. 2.

desired to open and close the expansive valve, in relation to the stroke of the piston, will be understood from the following description of the parts:—*a a* is the clip and eccentric rod, which communicates motion from the eccentric 4, 4, 4, to the expansive valve *n*, through the right angular lever *b* and *d*, which moves upon the pin *c*, which is attached to the small projecting parts *s s*, which project from the lever *f f*—the lever *d d*, terminating in a forked end, which takes into the groove of the circular ring *e e*, which ring is moved longitudinally by the action of the eccentric through the aforesaid lever *b* and *d*; *j* is another right-angular lever, which communicates motion to the expansive valve *n*, through the valve-rod *n'*. The part represented at *i i*, receives its support from the foundation, or other fixed part, to which the main shaft of the engine is attached, and has a projecting socket, on which the lever *f*, and ring *e* work—so that these parts have no direct communication with the main shaft. The ring does not revolve, but only partakes of the longitudinal motion imparted from the eccentric, and from thence through the levers *l* and *n'*, to the expansive valve. The arc of the part marked *i i*, supports the lever *f*—it being also graduated, indicates the point at which the steam is cut off; as it will be seen that, by moving the lever *f*, the whole of the parts *a a*, *b*, *d*, *h*, and *s s*, are carried round with it to any desired angle in relation to the main crank of the engine, whereby the same thing is effected as if the eccentric 4, 4, 4, itself were moved round, which governs the time of opening and closing the expansive valve. The part marked *h h*, is attached to the lever *f*, and serves the purpose of steadying the eccentric clip, and also embraces the arc *i*, so as to keep the lever *f* firmly attached thereto. At *q* is seen a small lever, acted upon by a spring, having at the opposite end a pin, which, on passing through the lever *f*, and arc *i*, holds the lever *f* firmly in the desired position; whereas, on pressing the smaller lever with the hand, the lever *f* is liberated and moveable: S, S, is the eccentric clip, which is supposed to work the steam valve.

LLANDAFF CATHEDRAL.

The History, Present Condition, and Proposed Restoration of Llandaff Cathedral. By Mr. T. H. Wyatt.—(Read at the Royal Institute of British Architects, March 20.)

Upon the history of the cathedral, I shall not detain you at any great length. The first bishop is stated to have been Dubritius, who died in 522, on an island off the Caernarvonshire coast, and whose bones were in 1120 translated to Llandaff by Bishop Urban, the founder of the present cathedral.

Urban was consecrated the thirtieth bishop of Llandaff in 1108; and to him all concede the honour of having founded the present cathedral. At his first coming, he found his bishopric in a very poor and miserable condition,—the church razed almost to the ground; and complaining thereof to the King and the Pope in 1119, he procured letters and gathered large sums together; he pulled down the old church, which was but 28 feet long, 15 feet broad, and 20 feet high; and in 1120, according to Leland and Godwin, —or in 1129, as stated by Dugdale,—he commenced the fabric dedicated to St. Peter and St. Paul. Bishop Godwin (who wrote in 1601) describes this building as "a very elegant one, 300 feet long, 80 feet broad, and adorned at the west end with two stately towers of great height, and a neat chapel of our Ladye: a work truly magnificent, and to be remembered with honour by posterity." Urban died in 1133, whilst travelling towards Rome. From this period to the beginning of the last century there is no further record of any kind that I can find relating to the cathedral, and here conjecture must commence.

If Bishop Godwin be correct in supposing the church commenced by Urban to have been completed by him with two towers and a Ladye chapel, and to have been 300 feet long, it must have disappeared between the period of his death (1133), and 1180 or 1190, which will, I think, be conceded as the earliest date at which the present Early English structure could have been commenced. The extreme length of the present building is only 260 feet, and its breadth 76 feet. Of pure Norman work, such as we may believe Urban to have executed in the beginning of the twelfth century, we only have the large arch between the presbytery and Ladye chapel; the remaining portion of a window on the south side of the presbytery, so curiously stopped up at a later period; portions of a Norman string-course, with a fret ornament, running round the walls of the presbytery (being the string-course of the Norman clerestory); a variety of Norman fragments walled into the presbytery; and the two doors at the west end of the north and south aisles, which, though later in their detail and finish than the large arch, may fairly be considered as of Urban's time, particularly if he commenced at the east end and worked westward toward these doors.

The size of the chancel arch, and the importance and decoration of the aisle doors, clearly prove that they could have formed no portion of the early and insignificant church knocked about by the Normans, and eventually demolished by Urban; for although the preservation of doorways and chancel arches of Norman churches, rebuilt in the thirteenth and fourteenth centuries, is of frequent occurrence, yet in this instance I think they must have originated with Urban and not have been removed or perpetuated by him.

The character and finish of the large arch at the east end of the presbytery, clearly proves that it must have opened into a chancel or Ladye chapel: and thus we may believe Urban so far to have realised Godwin's description as to have completed, "a neat chapel of our Ladye." And the existence of pure Norman work, so far westward as the two aisle doors, may be taken as presumptive evidence that Urban completed "a work truly magnificent, and to be remembered with honour by posterity," even if his western towers were fabulous. Certainly these doorways are of rich and beautiful design, and the general character of all the Norman work remaining is of a pure and good period, corresponding with Urban's prelacy. What befel this Norman church, or how it could have been so completely destroyed in the short period between Urban's death and 1180 or 1190, as to have rendered necessary the almost entire rebuilding of the church in a new and distinct style, remains a mystery. Here are no traces of that gradual and clearly-marked transition from Norman to Early English, which we find so evidently and so instructively displayed at Canterbury, Norwich, Gloucester, St. David's, and Buildwas Abbey. With the single exception of the western doorway (in which the circular arch is retained, though the detail of the shafts and mouldings are Early English), the new work was commenced free from any taint or prejudice of a past style, and stands forth as pure and beautiful an example of Early English composition and detail as any with which I am acquainted. An able writer in the *Ecclesiologist* thus speaks of it:—"The exquisite Early English work of this part of the church is truly beautiful; not the least idea is obtained by the wretched drawing given in 'Winkle's Cathedrals.' To stand opposite the western front—itself once a marvel of art—and view through the now vacant and ruinous windows the paganized nave beyond it, with its flat pedimental roof, its ridiculous vases and urns, its stuccoed walls, is inevitably to feel the most forcible contrast between the speaking graces of the Christian and the burlesque absurdities of the revived pagan style."

Although from the affinity of England to Wales, where our ancestors sojourned, if not as absolute conquerors, yet as authorised visitors, we may fairly believe architecture to have been almost on a level in point of date, we can have no reason for imagining that the Welch were some 70 or 80 years in advance of the English in the periods of their architecture, or that the change from the circular to the pointed arch, by us called "Early English," should more properly have been called "Early Welch." If this is allowed, I am unable to believe that any antiquary can assign an earlier date than 1180 or 1190 to the west front and nave of this cathedral; for though it is perfectly impossible to fix with peremptory certainty the exact date when one particular stage or style of art ended and another commenced, yet we find that from the period when the pointed arch first made its appearance and became blended with the Norman semicircle, years elapsed before the newer style or form had shaken off the influence of its predecessor.

We find in numerous instances, as at Gloucester, Canterbury, the Temple Church, and St. David's Cathedral, that this transitional feeling existed in full force—nay, that the Norman preponderated—although the portions I allude to are well known to date about the end of the twelfth century. You will, I think, share my disbelief in the theory that the pure and pointed work at Llandaff could have been commenced sixty or seventy years before the Norman arch had elsewhere ceased to prevail. In Buildwas Abbey, which is one of the earliest transition works I know (the date of which is stated to be about 1135), the indication of Early English form or feeling is very slight. In the section of one of the bays of the nave of St. David's Cathedral, built in 1180, you find the only Early English work consists of a small arcade, between two series of clearly-defined Norman arches!—certainly not a very convincing proof that Early English work was in existence in the sister cathedral of South Wales sixty years before this work was commenced.

Henry (prior of Abergavenny) was consecrated bishop of Llandaff in 1191, and died in 1218. He may, with at least as much probability as belongs to some antiquarian assertions, be supposed, if not actually to have recommenced the erection of his cathedral in the new style of his day, at least to have promoted works, the character and period of which are so evidently coeval with his twenty-seven years of power.

The lower portions of the north tower, and all the remaining part of the south tower, the nave, and clerestory remaining, are all of the same pure Early English character. In the columns and arches of the nave and choir a slight variety of arrangement occurs without deviating from the style: somewhat more ornament is introduced, and by the time they reached the Ladye chapel, the gradation of style becomes apparent; and with a view to give increased richness to this more sacred portion of the building, or from the more "decorated" fashion of the day, when they arrived thus far east, vaulting is introduced, mullions and circles are executed in the side windows, and in the easternmost window tracery becomes apparent, until it almost assumes the character of a "decorated" window.*

In the two bays of the presbytery a fault (as geologists might term it) occurs, which it is difficult to account for. These arches are evidently of a later and more depressed form than those in the nave and choir, and from their form and detail are of a later date than the Ladye chapel. Whether this portion of Urban's work may have remained uninjured and undisturbed until after the completion of the Ladye chapel, when they may have thought it necessary to assimilate the Norman piers and arches more closely to their pointed neighbours, or whether some injury took place to this part of the cathedral, which rendered rebuilding necessary at a later period, I have no means of determining, but it is curious that in this portion of the building we find more Norman remains than elsewhere. There still exists the Norman string-course in its original bed, with a sort of "embattled fret" carved upon it, running round the three sides of the presbytery: we find plinths and portions of cylindrical shafts, which may have formed (as at Norwich) the arch between the choir and presbytery: there is the large Norman arch over the screen; the curious remains of a Norman window, so unceremoniously blocked up by the Early English architect who built against it; and in the rough masonry of the walls of this part we find walled-up numerous fragments of Norman mouldings and ornaments. One might almost suppose this portion of Urban's original cathedral to have escaped the early destruction I attribute to the rest of his building, and to have been preserved intact by the Early English architects who rebuilt it. At some later period, for fashion's sake, or from decay, we can imagine these arches to have been reconstructed or remodelled, leaving, as I believe they did, the Norman clerestory undisturbed. The string-course even now remains; and in the view given of the north front by Godwin, in 1713 (when it was almost perfect), it will be observed that a semicircular and apparently Norman line of windows is shown in the clerestory of this part, as distinguished from the Early English in the nave. Of the history of this alteration or portion of the work, I can find no trace.

The "decorated" altar-screen is stated, in Browne Willis's, and all the other histories of the cathedral, to have been erected by a Bishop Marshall, who was consecrated in 1478; but as the detail is pure "decorated," it must have been completed, in all probability, 100 years before this time. I have little doubt but that the piers and arches of the presbytery and this screen were erected at the same time, or by the same architect—an opinion which is confirmed by the fact of the base moulding on the south side being raised considerably above the opposite pier on the north side, and corresponding exactly with the level of the base of screen and the base of the sedile which it immediately adjoins. The decoration and enrichment of this screen, attributed to Bishop Marshall, have, no doubt, reference to the painting and gilding upon it. "There are eleven niches in the principal level, painted with roses and hyacinths interchangeably." The centres of the roses and flowers of the hyacinths are gilt. The roses are white (which quite identifies the decoration with Bishop Marshall),—the white rose being the device of the house of York, used for decoration only in the reign of Edward IV. and Richard III. Bishop Marshall having been preferred to this diocese by Edward IV., the adoption of his badge was a natural and proper compliment. "Under these eleven niches is a row of eight niches, painted in fresco, exactly like the former. At each end of these are three real niches painted in the same manner; within these are two little ones, with a pilaster between; the ground-work throughout is interchangeably blue and red, and the ornaments over all the niches are gilt. At each end is a door leading into a vestry." Thus far I can confirm, from the remains of this screen, the description given by Browne Willis. He then proceeds to say—"Above the altar-piece are two rows of large niches, in which formerly there have been figures. In both rows the middlemost niche is larger than the rest; and on each side are two lesser ones. The two largest niches probably contained the images of our Lord and the blessed Virgin, and the other twelve were for the twelve Apostles. Under the two large niches are the ten commandments, written with gold letters, within a frame, and over all is a handsome freestone window." Unfortunately, the destruction of this upper portion of the screen has been complete (doubtless the work of puritan or political fanaticism). Nothing remains above this line, but we have found walled into the various portions of the structure fragments of corbels, canopies, and buttresses, which evidently, from their size and form of moulding, belonged to this screen.

From the period when Godwin described Urban's church to have been complete, of certain dimensions, and a work truly magnificent," there is no notice of the cathedral until 1719, when Browne Willis, an antiquary of that day, as he says, "collected together various records and matter, and gave with his work certain draughts of the said church, in order to illustrate the descriptions thereof." These draughts, as you may imagine, are not very clear in their distinctions of style, or in the best possible perspective, but they are most valuable as helping the description, as being the only records we have of what the old cathedral was (before lightning, storms, and Wood of Bath played such havoc with it); and, consequently, as being our principal guide and authority in the restoration. It was then falling into a state of deplorable decay, though perfect in its internal arrangements. There was a large building in front of the south Norman doorway, which he calls the "Consistory Court;" and a porch opposite the "decorated" south door. Both these excrescences have disappeared, and I should much doubt if they formed any portion of the original design.

Soon after Browne Willis's survey, destruction had full sway. On the 20th of November, 1720, the remaining battlements and pinnacles of the north tower (which had escaped the storm of 1703) were blown down, and destroyed a considerable portion of the north aisle. On the 6th of February, 1722, the "roof and floor of the south tower fell in, and destroyed a good deal of the church." The complete ruin of this old structure must have followed very rapidly on Willis's visit; and in 1724 we find the Archbishop of Canterbury interesting himself in its proposed rebuilding (I cannot say restoration). He obtained 1,000*l.* from George I., and, like our bishop of the present day, tried in vain to get anything from the Prince of Wales. Sufficient funds were, however, eventually raised to erect the frightful shell which now encases the original piers and arches.

About 1735, Wood of Bath, commenced the desecration of this fine old work, and of his own prior fame: for most assuredly a more barbarous or tasteless grafting of uncongenial modernism upon an ancient stem was never perpetrated; and never was the sarcasm of the historian Whitaker more justly deserved than in this instance. He says—"The cloven foot will appear! for modern architects have an incurable propensity to mix their own absurd and unauthorized fancies with the genuine models of antiquity! They want alike taste to invent, or modesty to copy." All that can be said in extenuation is that the corrupt taste of that day gave a fashion to this work, the power of which Wood may have been unable to resist; I wish it was in evidence that he had tried to do so. That this fashion approved such barbarism may be inferred from the accompanying letter, which I find copied in the "Cole's MSS." in the British Museum. It is written by a Rev. Thos. Davies to Browne Willis, who appears still to have taken much interest in the old wreck:—

"23rd Nov. 1736.—The church on the inside, as far as 'tis ceiled and plastered, which is something beyond the west end of choir, looks exceeding fine, and is a very stately and beautiful room. The area of the whole church is to be considerably raised, so that when finished it will (in the judgment of

* There is good reason to believe that the Ladye chapel was the addition of William de Breos, the forty-third bishop, from 1266 to 1287. He was buried close to the altar, and his tomb still remains.

most people who have seen it) be a very neat and elegant church, unless, indeed, the altar-piece, which looks like a huge portico, spoil the whole effect."

Mr. Cole illustrates his amusing MS. by elevations of the west and south fronts, and a view of the altar portico, which it was feared (and not without some reason) might mar the whole effect.

We find no traces of the portico at the west end, nor can I learn that the pigeon-house cupola was ever carried into effect. The altar was removed some few years ago.

The bishop's throne, the pulpit, and stalls consist of an Ionic colonnade, with niches at the back; they still exist in their pristine propriety and beauty, and I can conscientiously recommend them to any architect about to build assize courts; the pulpit and throne would form admirable judge's seats, and the stalls a most dignified row of seats for the magistracy.

I do not imagine that much was done to Mr. Wood's structure until 1840, when the plaster ceiling and lead over the nave being in a very bad and unweathertight condition, a considerable sum was expended in repairing and making good as it then existed.

So much for the history of the cathedral. A very few words will describe its condition when the present restorations were commenced.

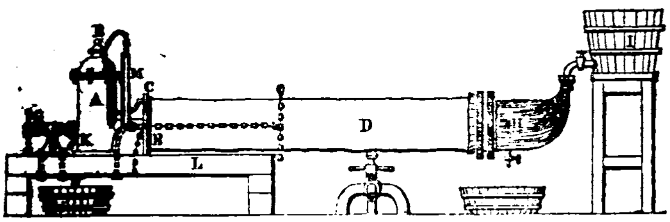
REGISTER OF NEW PATENTS.

PRESERVING AND COLOURING WOOD.

Francois Augustin Renard, of 40, Rue du Rocher, Paris, merchant, for "*Improvements in preserving and colouring wood.*"—Granted August 19, 1847; Enrolled February 19, 1848.

This invention consists in a mode of constructing apparatus in which a vacuum can be produced, after the same has been applied to one end of a log of wood; so that a preserving or colouring liquid, contained in a suitable vessel or receptacle at the other end, will be caused, by atmospheric pressure, to pass through the log in the longitudinal direction of the fibres.

The annexed engraving is a side elevation of the apparatus employed. A is a metal cylinder, provided with a top-piece B, from which is suspended a rod, with a piece of perforated metal or wire



gauze attached to its lower end. C is a metal disc, fixed to the cylinder A, having an opening at its centre, communicating with the interior of the cylinder; and between this disc and the end of the log of wood D, a narrow leather washer E, is interposed, so that there will be a small space left between the log and the disc. The position of the log upon the frame L, is to be adjusted by the chain and the screw G; F is a collar, placed around the log of wood, having a chain attached to it, and by which the wood may be moved to and fro, as required, upon the frame L, by means of the screw G: in turning the screw, by means of the lever, the chain will act upon the collar F, either to bring the block nearer or remove it farther away, as may be required. The other end of the log is enclosed in a bag H, of impermeable material, which is connected to the cock of a vessel I, containing the preserving or colouring liquid. Now if a vacuum be produced in the cylinder A, the pressure of the atmosphere upon the surface of the liquid in the vessel I, will force it through the log. The vacuum may be obtained by any convenient method; but the patentee prefers to produce it by dipping the wire gauze, carried by the rod of the top-piece B, into some inflammable matter (such as alcohol), and introducing it in an ignited state into the cylinder A; the air will then escape through the cock K, which is to be left open for that purpose, and is to be closed as soon as the required vacuum is obtained, as indicated by a small barometer M, connected by a tube with the interior of the cylinder A. When the moisture of the wood, or the preserving or colouring liquid, has been forced by the pressure of the atmosphere into the cylinder A, the vacuum will be destroyed, as will be indicated by the barometer M; the cock K being then opened, the liquid will run into a vessel N, beneath; after which, a vacuum is to be produced in the cylinder A, as before.

The passage of the liquid through the log may be accelerated by a force-pump or other suitable means. Although the log is shown in a horizontal position, yet it may be operated upon in a similar manner when in a vertical position, by substituting for the bag H, and vessel I, a vessel with a suitable opening in the bottom of it to receive the end of the log. When the log or piece of wood is square, then, instead of the bag H, and vessel I, a trough is used to contain the preserving or colouring liquid, and the whole of the log is immersed therein, excepting the end to which the metal disc is applied.

REFINING SILVER AND LEAD.

Arthur Harry Johnson, of Gresham street, City, assayer, for "*Improvements in refining silver and lead, by effecting a saving in one of the materials used.*"—Granted September 23, 1847; Enrolled March 23, 1848.

The improvements consist in restoring after use, and rendering again available, the phosphate of lime or bone-ash, whereof the cupel or test used by refiners of silver lead is composed, and in the process saturated with lead, and a portion of silver. For extracting this lead and silver, the course usually adopted is to return the used cupel to the furnace, by which means the whole of the saturated bone-ash is destroyed; while portions of the lead and silver, combining with the phosphoric acid of the bone, pass off, and are lost. By the improved method, little or no waste occurs of either the bone-ash, silver, or lead.

To carry out the invention, a solvent of the oxide of lead is used in the following manner:—First reduce the used cupel to a fine powder; then add a sufficient quantity of pyroligneous or acetic acid, varying from 1·009 to 1·048 specific gravity, according to the per-centage of lead contained, to render it of a thin consistence, that it may be thoroughly stirred in a dolly-tub, or some such convenient machine, or by allowing the acid to percolate through the powdered test. After allowing the powdered cupel and acid to remain together for two days (during which time occasionally stir them well together), the bulk of the lead becomes dissolved. The mixture is next put into cloth or flannel filters, or other percolators, to allow the lead solution to drain off; this done, remove the remaining soluble salt of lead, by washing it with water and by the application of pressure, previous to drying the resulting bone-ash.

After the above process, the silver, and some lead, still remain in the bone-ash, though not sufficient lead to materially interfere with its absorbent powers, on again using, provided it has been properly freed from the lead solution. If, however, it be wished to extract the lead more perfectly, add a second portion of the acid to the filtered or drained bone-ash, and again thoroughly stir it in this second acid—the washing and pressing, as before described, following this second operation. To bring the lead, contained in the solution, into a marketable form, after due saturation, either simply evaporate it in proper pans to make sugar of lead, or by means of the several re-agents commonly employed, form respectively the carbonate, the sulphate, the sulphuret, or other compounds of lead that may be desired.

Instead of pyroligneous acid, a solution of caustic potash may be used, or soda, containing about 20 per cent. of the pure alkali; but this has not been found so useful in practice.

GAS STOVE.

William Brockedon, of Devonshire-street, Queen-square, Middlesex, for "*Improvements in heating rooms or apartments.*"—Granted September 9, 1847; Enrolled March 9, 1848.

This invention relates to heating rooms with gas. It consists in so constructing stoves or fire-places which are open in front that gas may be burned therein, and the decomposed air and products of combustion pass into chimneys, as from open fire-places or stoves when burning coal. The stove or fire-place may be constructed as nearly as may be like those now used with open fire-bars, and may have a bottom grate similar to what are used for burning coal, and they may be made to fit the fire-places as at present constructed, or the stoves and fire-places may be greatly varied in design, so long as the stoves or fire-places are capable of consuming gas in an open fire-place communicating with a chimney or flue.

In order to give a gas stove constructed according to this invention, as much as possible the character of the present open fire-places used for consuming coal, they are to be made with a front grating or bars, against which is to be placed lumps of pumice-stone or other substances which will allow of being heated by the flame of gas and yet not consume. The front bars should be made nearer to the back of the stove than when for burning coal, and so that there shall be but small space between the back of the stove and the front bars; or such substances may be placed in a wire or other frame suspended near to or amidst the flames of gas where the form of the stove or fire-place is not otherwise adapted to receive such substances; and in some cases the front bars of the stove or grate are made hollow, so as to allow gas to pass from a supply-pipe into them, and thence to pass out through perforations so as to produce numerous small flames which may be partly inward towards the pumice-stone, so as to heat the same, and other flames may be outwards through between the front bars of the stove or grate, and the front bars in place of being simply across the fire-place may be made into any fanciful form, such as basket work or otherwise, to hold the pumice-stone, or other substances. Or in place of having the front bars or open grating hollow and perforated to produce numerous jets of gas, the jets of gas may be wholly or partially from the bottom or the back or sides of the open fire-place or stove. And it should be understood that it is essential to this invention that the apparatus should be open to view, and also be open to a chimney or flue, so that the gas in burning may give heat to the room or apartment without the decomposed air and products of combustion caused thereby coming into the room or apartment, and at the backs and sides of such stoves or fire-places, bright steel, glass, china, or other reflectors, may, with advantage, be placed. It is not essential to this invention that the open gas fire-place should have a receptable for the pumice-stone or incombustible substances, as the same may be dispensed with, but it is preferred to have an arrangement for receiving such substances, as thereby the cheerful character of the old English fireside is retained. And the inventor believes that the most elegant result may be obtained by using jets of gas from front bars or grates combined with jets of gas from bars or apparatus at bottom, so arranged that air may (as is now the case when burning coal) pass up between the bottom, the lower bars in such case supporting the pumice-stone or other substance, for by such means, by a comparative small consumption of gas, the appearance of a large flaming fire may be produced.

JENNINGS'S PATENT INDIA-RUBBER TUBE COCKS.

This improved cock is made by placing a flexible india-rubber tube of any required size within one of metal, as shown in fig. 1;

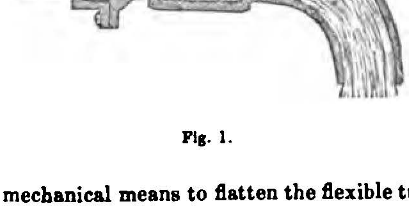


Fig. 1.

and then by mechanical means to flatten the flexible tube, as shown in fig. 2.

The advantages which the patentee states this cock possesses over any at present in use are—1st. The ease with which it can be at all times opened or shut, and the means used for that purpose being so simple, it cannot be set fast by corrosion or become injured by frequent use. 2nd. When open it is part of the main or pipe, as shown in fig. 1, and presents the same uninterrupted passage as the pipe itself, and as the means used for closing or stopping the circulation have no communication with the gas or water passage, leakage is impossible. 3rd. It will be seen by fig. 2, if the vulcanised india-rubber tube be properly flattened the cock must be sound. 4th. These cocks are capable of standing any pressure, as

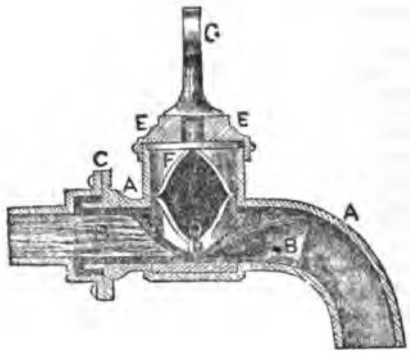


Fig. 2.

the elastic material of which the cock is composed never can become injured by pressure, as long as the metallic casing which surrounds the flexible tube remains perfect.

SEPARATING IRON FROM ORE.

Arthur Wall, of India-row, East India-road, Middlesex, for "*a new or improved apparatus for a method of separating oxides from their compounds and each other.*"—Granted October 14, 1847; Enrolled April 14, 1848.

The apparatus is for separating iron from the ores of copper, &c., and consists of two hexagonal drums with an endless chain passing over them, made by connecting with links a number of horse-shoe magnets; on the extremities of each of the magnets a number of steel blades are so fixed as to stand out at right angles to the magnets. These drums are made to revolve over a trough in such a position that while the chain of magnets passes immediately above the trough the steel blades reach nearly to the bottom; the bottom of the trough being inclined at each end, so as to correspond with the direction of the blades. The ore (previously roasted and ground) being introduced at one end of this trough the blades, as they pass through it, will take up all the iron contained in it and carry it to the other end; and, indeed, would bring it all back again in the next revolution but for the following arrangement. Opposite the point where the blades emerge from the trough, a set of magnets are fixed to a frame with their poles in the reverse order to those forming the chain, so that when the steel blades come opposite these fixed magnets, their magnetism is neutralised, and the iron which they had collected in the trough falls off, and is collected in another trough placed beneath to receive it. The patentee does not confine himself to the permanent magnets, but he claims also the use of electro-magnets, though he prefers to use the former as being more convenient.

Plate-Glass.—Patented October 7, 1847, by James Hartley, of Sunderland. The improvements relate to the manufacture of rough plate-glass immediately prior to the pouring of the melted glass or metal upon the table, and rolling.—Instead of lading the melted metal into a separate cistern as usual, the patentee lades it direct from the melting-pot to the pouring-table, where it is immediately poured and rolled. The patentee employs, for the purpose of lading the melted metal, should the quantity required be large, two or more ladles; and he states, it is not absolutely necessary that the whole should be poured at the same moment upon the table; but the second ladle may commence to be poured at nearly the termination of the pouring of the first ladle. After the manufacture of the rough plates, they are to be piled and annealed in the same kind of furnace and in the same manner as crown or sheet glass, thus dispensing with the more expensive annealing furnaces employed for plate-glass.

PORCELAIN KILN.

Alfred Vincent Newton, of the Office for Patents, 66, Chancery-lane, Middlesex, mechanical draughtsman, for "*an invention of an improved kiln or oven, for firing porcelain and other similar ware.*" (A communication.)—Granted July 29, 1847; Enrolled January 29, 1848. [Reported in Newton's *London Journal.*]

The inventor, in order to explain more fully the nature of his improvements, has prefaced his specification with the following observations, explanatory of the ordinary mode of firing or baking hard porcelain, and the difficulties and objections incident thereto.

The employment of pit-coal as a fuel for firing or baking *hard* porcelain has hitherto been thought impossible, or at least subject to almost insuperable difficulties. It was thought that the hardness and infusibility of the clay (kaolin), and the high degree of heat necessary to fuse or melt the glaze which is employed to cover hard porcelain, were insurmountable obstacles. A long and sufficiently large or extensive flame to occupy the whole space of the oven or kiln is indispensable for this kind of manufacture; and the liability of the matters composing the hard porcelain to become discoloured, rendered this superabundance of flame the more necessary, in order that no smoke might be allowed to remain in the kiln or oven. It is requisite, therefore, to cause pit-coal to develope such an amount of flame as would have the same effect, and would act within a given time in the same manner as wood.

The matters of which hard porcelain is composed, are divided into two classes,—first, the paste or clay, which is a principal element; and second, the glazing or enamelled covering. The paste or clay consists essentially of two elements; the one is an infusible argillaceous matter,—this is kaolin, either alone or mixed with plastic clay, or with magnesite,—the other, arid and infusible, is given by felspar or other stony minerals, such as siliceous sand, chalk, or gypsum, either separately or mixed together in different combinations. The enamel or glaze consists of quartzoze felspar, sometimes alone and sometimes in combination with gypsum, but always without either lead or tin. Hard porcelain must, in fact, be considered as hard compact impermeable pottery-ware, which is essentially translucid, and ought not to be confounded either with stone-ware, delph-ware, pipe-clay, or even with the ordinary tender English porcelain. The kilns or ovens for firing or baking hard porcelain are generally cylindrical, and divided into two chambers or laboratories, one placed above the other. The upper laboratory is supplied with heat from the flame of the lower laboratory, and serves to warm or heat the articles, which, when taken from thence, are dipped into the glazing composition, and afterwards exposed to the great heat in the lower laboratory, which may be properly said to constitute the kiln. The fusion of the glaze or enamel, as is above said, requires a very high temperature; and it is in the laboratory where this operation is carried on that the temperature is raised to the highest degree. In both these laboratories the articles must be inclosed in fire-clay vessels or seggars, which should be carefully closed, in order to prevent the admission of deleterious matters. The necessary amount of flame and heat may be obtained by increasing the number of fire-grates and openings for the flame: thus a kiln or oven, six yards in diameter, which, when heated with wood, requires six openings, must have ten when pit-coal is employed. A kiln or oven, five yards in diameter, would require only five fire-grates for wood, but must be furnished with eight for coal. A kiln or oven, four yards in diameter, heated by wood, would require four fire-grates and apertures for wood, but must have six for coal. In order to make the flame sufficiently long and abundant for the requirements of the manufacture, the combustion ought to be supplied with a double draft, or additional currents of air. Thus, besides the supply furnished between the fire-bars from the surrounding atmosphere in the workshop, air obtained from outside is conducted by horizontal channels to the fire: that is to say, besides the ordinary supply of air, an additional quantity, obtained from the external atmosphere, is made to act with energy on the fires in the grates. By this means, the kiln is supplied with a very large and superabundant supply of air, which furnishes the fuel with a much greater quantity of gas to decompose.

The engravings represent a kiln or oven, constructed according to the present improvements; and it should be observed, that it is always easy to obtain the necessary quantity of air, by taking it from the atmosphere of the workshop, either by having an aperture or grating at the end of the ash-pit, or by making openings below the fire-bars in the two side walls of the furnace.

The improved system of firing or baking may be applied to all kilns, whatever may be their form or dimensions; and, by means of a double roof in the upper laboratory, hard and tender porcelain may be fired in the same kiln simultaneously: that is to say, hard porcelain may be baked or fired in the lower laboratory, at the same time that tender porcelain or common earthenware is being fired in the upper laboratory. In manufactories where at present the baking of biscuit-ware and glazed ware is carried on in separate kilns, it will be evident that these kilns may, by the application of a double roof, be more advantageously employed in the following manner:—In the biscuit kiln, heretofore employed, delph, or earthenware, or unglazed tender porcelain, may be operated upon in the lower laboratory, while hard porcelain may be dried and heated in the upper laboratory; and in the other kiln, formerly used for glazing, the hard porcelain should, on the contrary, be placed in the lower laboratory, to be baked or fired; and glazed delph, or earthenware, or tender porcelain, may be operated upon in the upper laboratory,—the heat in which will be found sufficient for this kind of ware.

The kilns being furnished with the required quantity of fire-places, the combustion must be kept up, by supplying an excess or superabundance of air, obtained either from the external atmosphere or from the workshop, and supplied in some convenient and suitable manner, depending of course upon the situation of the kilns, their peculiar construction, and other circumstances. The fire should be gradually supplied with fuel, at first at long intervals, then at short intervals. The state of the fire-place should be looked to carefully, for it is the rapidity of the combustion of the coal which indicates the quantity of fuel that is required, and the moment when the charges are to be thrown on quickly. The fire-places must be well watched, for the purpose of levelling the fuel, so that the fire-bars may be suitably and evenly covered, and that air to support combustion may always find a proper passage. It is also necessary to rake the fire frequently, in order to clear out the cinders, and to prevent the fire-bars from getting foul, and to remove clinkers therefrom, which would otherwise stop or diminish the combustion. Holes through the mass of fuel should never be allowed to exist, and the flame should always be well watched; and the baking or firing operation always be carried on with a long flame. All these precautions are necessary, in order to obtain very pure and white porcelain, as the defects of the firing operation arise most frequently from the want of a proper flame.

Fig. 1 represents a transverse vertical section, taken through the centre of a kiln of the improved construction; and fig. 2 is a

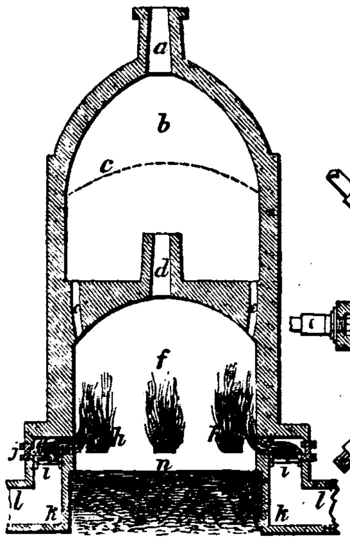


Fig. 1.—Section.

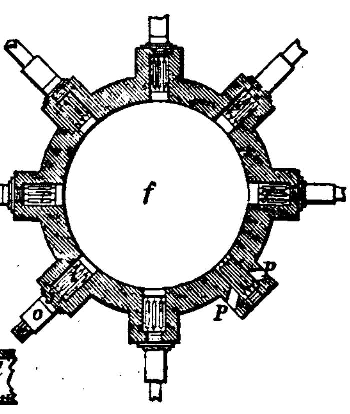


Fig. 2.—Plan

horizontal section or plan of the same. *a* is the outer chimney or flue of the upper second laboratory; *b* is an upper chamber, which may be used for drying or heating; *c* is a roof (shown by dotted lines), which will be required if it is intended to bake or fire both tender and hard porcelain in the same kiln; *d* is the flue of the lower chamber or laboratory; *e e* are passages or openings, of which there are the same number as there are fire-places in each kiln; these passages should be placed between the fire-places, and open a communication from the lower to the upper laboratory. *f f* is the lower laboratory, where the principal firing or baking operation is carried on; *g g g*, are the fire-places; and *h h h*, openings, to allow the flame to pass therefrom into the interior of the kiln. *i i*, are the fire-bars; *j j*, the fire-doors; *k*, the ash-pit; and *l l*, passages communicating with the ash-pit from the external atmosphere, to supply air to the fire: this object may, however, be effected by making an aperture in the front wall of the fire-place, immediately below the fire-box and grate-bars. *n n*, is the floor or hearth of the kiln. *o o*, are holes, covered up in any suitable manner, but communicating with the ash-pit, and intended to allow of the scoria, cinders, and clinkers being removed. *p p*, in fig. 2, show another manner of supplying air to the fire-places, by making openings in the side walls of the same. *q* represents another mode, by which air is supplied from the atmosphere of the workshop through a grating communicating with the ash-pit. The inventor remarks that, whatever may be the mode adopted for supplying the air to the fire, the same plan should be invariably adopted in all the fire-places of the same kiln.

The patentee, in conclusion, states that he is aware of coal having been used for heating the kilns in which common earthen or delph-ware, and even *tender* English porcelain is commonly baked or fired,—he does not, therefore, intend to claim the employment of pit-coal for such purposes as constituting part of the present improvements; but he claims, First,—the application of coal for heating the kilns or ovens in which hard porcelain is submitted to the baking or firing operation; and, Secondly,—the arrangement or construction of kilns or ovens, as herein shown and described, or any mere modification thereof, whereby pit-coal may be employed as the fuel for heating such kilns or ovens for firing or baking hard porcelain, in the place of wood, which has heretofore been employed for that purpose.

ON GEOLOGICAL CHEMISTRY.

A lecture on "*The Application of Chemical Principles to the Science of Geology*." By Professor Daubeny.—(Delivered at the Royal Institution, Albemarle-street, March 24th.)

The Professor commenced his lecture with some preliminary observations, in which he said, he had for the last twelve months devoted his leisure to the accumulation and study of facts in relation to volcanic forces; and having, in this pursuit, travelled a good deal along the great boundary line dividing the two kingdoms of geology and chemistry, he had obtained glimpses of truths, which neither the pure chemist, nor the pure geologist might have had the same opportunities of observing—the result being, his entire acquiescence in the opinions of some of the greatest authorities of the present day, that geological inquiries ought, in future, to take more exclusively a chemical direction. The learned professor then proceeded to allude to a subject of geological inquiry, which seemed to him above all others to demand the assistance of the chemist—namely, the metamorphic action which had taken place between certain contiguous but dissimilar rocks—the one of eruptive, the other of sedimentary origin. A large amount of information had been collected by geologists, in respect to different kinds of metamorphic action, and their effects; but as to the manner in which these effects were produced, they would look in vain, unless the chemist also were appealed to. One thing appeared to be established—namely, that the production of mineral veins was connected with the intrusion of plutonic rocks, and with the changes brought about by them in the contiguous strata.

Few metallic deposits occurred in the secondary formations, and even these only when there was dislocation or metamorphic action in their neighbourhood; while, on the other hand, metallic veins were never found in modern lavas, or in volcanic products that had been erupted in the open air, though several geologists had brought forward facts to prove a connection between metallic matter and basaltic or trappean dykes. There were various theories to account for the formation of mineral veins—the first supposed them to be the result of infiltration, the water which percolated the substance of the contiguous rocks carrying with it the several mineral matters they contained, and afterwards depositing them upon the walls of fissures caused by the contraction of the surrounding parts; the second supposed the materials of the vein to have been held in solution by water, but deposited in an insoluble form, owing to slow electro-chemical action; the third hypothesis assumed, that the contents of the vein, being separated from the other materials by sublimation, found their way into fissures, existing either in other parts of it, or in the contiguous formations. No doubt many facts might be alleged in favour of each hypothesis. In the first place, granting that a given rock contained, disseminated through it, any quantity of an oxidisable metal, such as iron, copper, lead, or tin, and that these were already in combination with sulphur, the action of water and air, by generating sulphuric acid, would gradually give rise to soluble sulphates, which might find their way into the contiguous fissures, where, owing to certain electrical or chemical reactions, the metals would be deposited in an insoluble form. Decomposition could be brought about by weak electrical currents; and thus the second hypothesis might be brought in to explain what was left unaccounted for by the first. But both presupposed the existence of metallic matter in the rock from which the veinstone was derived, for it was evident that these several metals could not be present, in the requisite quantity, in strata deposited from water, or all our mineral springs would contain traces of them, just as they did of the silica and other substances supplied by the rock through which they had been percolated. He could not, therefore, help supposing, that the mineral matters, which had been confined to the neighbourhood of plutonic rocks, were, in the first instance, derived by igneous agency, which constituted the machinery by means of which the more uncommon metals were brought originally from the depths to the surface of the earth. It was remarkable, however, that they were not confined to the intrusive rock itself, but, in many instances, were in the metamorphic strata contiguous. There was, also, evidently a connection between the metallic matter in the vein and the character of the enveloping rock, seemingly showing, that the ingredients of the former were not sublimed directly from the interior of the globe, but had been introduced from the formation in contact with the vein. Thus Fournet had stated, that at Andreasburg, in the Hartz, the veins became poorer in metal when they passed from the clay-slate formation into the flinty-slate; and Voltz mentioned a vein in the Vosges which, in traversing successively different varieties of gneiss, had its contents modified in each. Thus, in the first variety, which was charged with mica, the vein was small in its dimensions, and wholly destitute of metal; in the second, which had more of the character of clay-slate, it swelled out to a width of 18 inches, and contained silver, combined with antimony, copper, &c., together with sulphate of barytes; in the third, which contained hornblende, the former were wanting, but the last-mentioned ingredient continued; while, in the fourth, which was wholly destitute of mica, the silver returned for a certain distance down, but was afterwards replaced by selenite, galena, and sulphur, in small quantities. Sir H. de la Beche mentioned similar cases in Cornwall; and the frequency of their appearance compelled the admission, that the materials of the vein were, in many instances at least, dependent upon the character of the rock which it traversed; so that, supposing them derived originally from the same igneous source, a process of segregation had subsequently taken place, by which particular bodies were determined to certain kinds of rock, to the abandonment of others.

In order to pave the way to a solution of these and other difficulties, he submitted two questions—the first, whether igneous rocks did not contain, disseminated through their substance, minute and, probably, infinitesimal quantities of many of those rarer bodies, which were found collected together in mineral veins?—and the second, whether all these substances might not possess a certain amount of volatility, at temperatures below their freezing point, and thus become transported from place to place, at periods long subsequent to that at which they were originally evolved from the interior of the earth, in a state of admixture with other more abundant ingredient? In adopting the affirmative, with reference to the former of these questions, it was not necessary to go so far as to assume, that every basaltic dyke, or even every great volcanic formation, contained, as an integral part, minute quantities of *all* the metals that existed in nature—for, considering how infinitely small was the proportion which they bore to the entire bulk of the crystalline igneous rocks, their absence could not be safely inferred from the fact of their not having been discovered. The facts which inclined him to suspect that they might exist, were the circumstances—first, that the discovery of phosphoric acid, in so large a number of volcanic products, led to the conclusion, that this body, at least, was derived from volcanic emanation, and, by analogy, that metals were also so derived; secondly, the observation made by Henry Rose, that in every crystalline rock traces of copper might be detected by the test of sulphuretted hydrogen—thus suggesting, that if we had any equally delicate test for the other metals, they also might be ascertained to be present; and, thirdly, the fact, that not only iron, arsenic, and selenium, existed amongst the products of Vesuvius, but likewise lead, copper, zinc, and titanium, while tinstone also was ejected by Mount Etna. Now, assuming the existence of metals, and other bodies of rare occurrence, amongst the matters evolved from the interior of the earth by igneous processes, the second hypothesis stated would enable us to account for the diffusion of such matters through the substance of the contiguous strata, as well as for their local accumulation in fissures, or veins; for it was evident, that if these bodies were severally capable of undergoing volatilisation, at temperatures below that of their fusion, the heat, which, originating in the intrusive rock, pervaded the formations contiguous for a great distance around, would drive out portions of all these substances, causing them to become disseminated throughout the latter, and, where fissures existed, to enter in, and contribute to fill them. For this purpose, however, the heat must be long continued, as well as of a certain intensity; and hence, whilst metallic veins were frequent in connection with granite, they were entirely absent from sub-aerial lavas, owing to the more rapidly cooling that would take place in the latter, than where the matter was thrown out under the sea, or at great depths beneath the surface. Thus, according to this theory, the accumulation of metallic matter in veins would have arisen, not from the latter having been the original receptacles of whatever was disengaged from the interior of the globe—for he agreed with Prof. Bischoff, in considering that the idea of metallic, or indeed of any description of veins, being injected in a state of fusion from below, as trap and granite dykes were supposed to be, was encumbered with insuperable difficulties—but owing to the subsequent action of the heat upon the erupted matter, by which the metal might have been slowly volatilised, and thus have found its way into the fissures and cavities contiguous, when the principle of adhesive affinity, described by Prof. Faraday in his "Memoir of the Limits of Evaporation," would come into play; and no sooner was a thin layer of metallic, or other body, collected along the walls of a cavity, than the portions subsequently sublimated would be determined to the same point, until the whole cavity was filled up.

The learned professor also alluded to Tilgman's discovery with regard to the decomposing influence of steam at high temperatures, which accounted for the decomposition of many rocks, and the formation of combinations between the alkalies and fixed acids. Various facts also proved that a certain exaltation of temperature would favour the segregation and new combination of minerals, though that was not essential. To influences of this kind such formations as that of nodules of flint in chalk had been referred, but he thought it more probable that the deposition of silica was the result of the extraction of carbonic acid by the decomposition of animal matter.

He, therefore, suggested the importance of ascertaining by more precise experiments what were the laws which regulated the vaporisation of solids at temperatures below that at which they were fusible. Assuming the truth of this principle, it threw considerable light upon the alterations which contiguous strata underwent from the intrusive rocks—for, the supposing a certain degree of mobility to be produced by heat, without actual fusion, would enable us to understand these changes. The learned lecturer then proceeded to discuss the difficult question of dolomisation, which he contended might be solved by a reference to the same principles, aided by analogous facts known to chemists, with respect to carbon and other substances. The whole question, however, appeared to be open to further inquiry, both as to the degree of volatility possessed by magnesia and its several combinations, its power of penetrating the substance of a calcareous rock, and combining with its ingredients in atomic proportions—neither body being in a state of absolute fluidity—its transmissibility to great distances through an intervening mass of rock, and the circumstances which caused it to accumulate in certain sets of beds, and to pass over others. Experiments should, likewise, be made as to the changes which augitic rocks sustain under the influence of a high temperature, and as to the possible disengagement from them of magnesia under the circumstances supposed; nor was chemical research less called into request, for the purpose of enabling us to explain such phenomena as were produced by igneous causes at the present day, than for the elucidation of processes of higher antiquity. When he reflected upon the assemblage of chemical phenomena which presented themselves during the several phases of volcanic action—the enormous and long-continued evolution of carbonic acid—the inexhaustible supplies of sulphur, arising from deposits, originally caused by the decomposition of sulphuretted hydrogen—the volumes of steam and muriatic acid disengaged by those volcanoes which were in a state of activity—the sublimations of common salt, sal-ammoniac, &c., which generally accompanied an eruption—the nitrogen gas evolved incessantly for centuries from many thermal springs—when he saw these, and other results of internal chemical action, come so prominently into view in every part of the world where opportunities for studying the operations of internal heat were presented, it did excite his surprise that philosophers of high name should have rested content with a theory which professed to ascribe everything to the mere protrusion of some of the fluid contents of the globe through parts of its crust, without regarding features so important, and apparently so essential, as those to which he had alluded.

He thought that much was to be learned with respect to volcanoes, by minute chemical examinations of the solid products ejected, with a view of comparing their constitution one with another, and of the gases and vapours evolved before, at the time, and subsequently to, a volcanic crisis. The learned lecturer then referred to Prof. Abich's experiments with regard to felspar and to the recent discoveries at Vesuvius, representing the evolution of hydrogen from an active crater, and to the results which might be expected from further discoveries. In the meantime, even with our imperfect knowledge of these mysterious workings, we might obtain glimpses of a beautiful system of compensation—of an adaptation of means to an end—which struck the observer all the more, when it was displayed, as in this case, in the midst of those terrible manifestations of irresistible force, which the workings of a volcanoe, or an earthquake, revealed. This was shown by the useful purposes performed on the surface of the globe by the carbonic acid evolved from its interior, and was also illustrated by the occurrence of metals in veins, and the diffusion of phosphates in minute quantities so generally through the strata. Had not this been the case, the former would not have become known to us, and the latter would not have been available for the nutrition of plants.

Such were a few of the facts to which he had been desirous of directing attention, by way of inducement to his auditory to pursue the science of geology with a frequent reference to chemical principles; and he wished to impress upon those just entering upon the study more particularly, the great truth, that in all kinds of research, chemistry was to be regarded as the grammar to the language of Nature—the key to unlock her most secret mysteries; and that those who were ambitious of following in the footsteps of the great men who had adorned, and still adorn, that noble Institution, by fathoming the depths of some one of those sciences which were there cultivated—nay, even those who, with humbler aspirations, were content, like himself, to snatch a mere superficial glance of several—would ever find it impossible to proceed without its assistance. His own experience justified him in assuring his auditory, that whether their chief interest might chance to lie in physiology—vegetable or animal; in scientific husbandry; or in those cosmical phenomena which presented themselves to the explorer of mountainous regions—chemistry would suggest at once the right principles for interpreting the facts observed, as well as the soundest practical application that admitted of being deduced from them.

THE TIDES OF THE IRISH AND ENGLISH CHANNELS.

Report of Experiments made on the Tides in the Irish Sea; on the similarity of the Tidal Phenomena of the Irish and English Channels; and on the Importance of extending the Experiments round the Land's End and up the English Channel. By Captain F. W. Beechey, R.N.—(Read at the Royal Society, March 9 and 16, 1848).

The author commences by stating, that the set of the tides in the Irish Sea had always been misunderstood, owing to the disposition to associate the turn of the stream with the rise and fall of the water on the shore. This misapprehension, in a channel varying so much in its times of high water, could not fail to produce much mischief; and to this cause may be ascribed, in all probability, a large proportion of the wrecks in Carnarvon Bay. The present inquiry has dispelled these errors, and furnished science with new facts. It has shown that, notwithstanding the variety of times of high water, the turn of the stream throughout the north and south channels occurs at the same hour, and that this time happens to coincide with the times of high and low water at Morecombe Bay,—a place remarkable as being the spot where the streams coming round the opposite extremities of Ireland finally unite. These experiments, taken in connection with those of the Ordnance made at the suggestion of Professor Airy, show that there are two spots in the Irish Sea, in one of which the stream runs with considerable rapidity without there being any rise or fall of the water, and in the other the water rises and falls without having any perceptible stream; and the same stream makes high and low water in different parts of the channel at the same time; and that during certain portions of the tide, the stream, opposing the wave, runs up an ascent of one foot in three miles with a velocity of three miles an hour.

The author enters minutely into the course of the stream, shows that the point of union of the streams from the opposite channels takes place on a line drawn from Carlingford through Peel in the Isle of Man on to Morecombe Bay; and concludes his remarks on this part of the subject by adverting to the great benefit navigation will derive from the present inquiry. He then notices a chart of lines of equal range of tide, which has been compiled partly from the ranges published by the Royal Society, and partly from observations made on the present occasion; and has annexed a table by the aid of which the seaman will be able to compare his soundings taken *at any time of the tide* with the depths marked upon the Admiralty charts. Next follows the mention of a feature in the motion of the tide-wave, which Capt. Beechey thinks has hitherto escaped observation; viz. that the upper portions of the water fall quicker than the lower,—or in other words, that the half-tide level does not coincide with the place of the water at the half-tide interval; that this difference in the Bristol Channel amounts to as much as four feet, and that the law seems to be applicable to all the tides of the Irish Sea.

We are next presented with a table exhibiting the various curves assumed by the tide-wave, and with the durations of the ebb and flood at each place. Having explained these observations in the Irish Sea, the author proceeds to apply to the tides of the English Channel the law which he found to regulate the stream of the Irish Channel,—availing himself of the observations of Captain M. White and others for this purpose. There was no difficulty in adapting the rule in the upper part of the channel; but below the contraction of the strait, the apparent discordance was so great that nothing but a reliance on the general accuracy of the observations prevented the inquiry being abandoned. It seemed that the streams are operated upon by two great forces, acting in opposition to each other; viz. that there is a great offing stream setting along the western side of the British Isles, and flowing in opposition to the tides of the channel above the contraction, turning the stream with greater or less effect as the site is near to, or removed from, the points of influence. By pursuing this idea, it was seen that the observations in the English Channel respond to it; and then applying it to the offing of the Irish Sea, and considering that channel to comprise within its limits the Bristol Channel, as the English Channel does the Gulf of St. Malo, it was found that the observations there also fully bear out the idea. So that there was afterwards but little difficulty in tracing the course of the water, and bringing into order what before appeared to be all confusion. The author then traces the great similarity of tidal phenomena of the two channels, and proceeds to describe them. For this purpose he considers the Irish Channel as extending from a line connecting the Land's End with Cape Clear to the end of its tidal stream, or virtual head of the tide at Peel; and the English Channel from a line joining the Land's End and Ushant, to the end of its tidal stream off Dungeness.

With these preliminary lines, he shows that both channels receive their tides from the Atlantic, and that they each flow up until met by counter streams; that from the outer limit of the English Channel to the virtual head of its tide the distance is 262 geographical miles—and in the Irish Channel, from its entrance to the virtual head of its tide, it is 265 miles. In both channels there is a contraction about midway; by Cape La Hogue in the one, and by St. David's Head in the other, and at nearly the same distance from the entrance. In both cases this contraction is the commencement of the regular stream, the time of the movement of which is regulated by the vertical movement of the water at the virtual head of the channel; situated in both cases 145 miles above the contraction, and that the actual time of this change, or Vulgar Establishment, is the same in both cases. Below the contraction of the strait, in both cases the stream varies its direction according to the preponderance of force exerted over it by the offing stream. In both cases, between the contraction and the southern horn of the channel there is a deep estuary (the Bristol Channel and the Gulf of St. Malo) in which the times of high water are nearly the same, and where, in both, the streams, meeting in the channel, pour their waters into these gulfs, and in both raise the tide to the extraordinary elevation of forty-seven feet. From the Land's End to the meeting of these streams in one case is seventy-five miles, and in the other the same.

In one channel, at Courtown, a little way above the contraction, and at 150 miles from the entrance, there is little or no rise of the water; and in the other, about Swanage, at the same distance from the entrance, there is but a small rise of tide also (five feet at springs). In both cases these spots are the node or hinge of the tide-wave, on either side of which the times of high water are reversed. And again, near the virtual head of the tide, in both cases, there is an increased elevation of the water on the south-east side of the channel of about one-third of the column—the rise at Liverpool being thirty-one feet, and at Cayeux thirty-four feet.

The author traces a further identity in the progress of the tide-wave along the sides of both channels *opposite to that of the* node. In the first part of the channel the wave in each travels at about fifty miles per hour; in the next, just above the node, this rate is brought down to about thirty miles in one, and to sixteen miles in the other; it then in both becomes accelerated, and attains to about seventy-six miles per hour. Lastly, the author observes that the node or hinge of the tide, placed by Prof. Whewell (in his papers on the tides) in the North Sea, is situated at the same distance nearly from the head of the tide off Dungeness, as the node near Swanage is on the opposite side of it; and that in the Irish Channel, at the same distance nearly as the node at Courtown is from the head of the tide off Peel, there is a similar spot of no rise recently observed by Capt. Robinson. Capt. Beechey's letter was illustrated by charts and diagrams, showing the identity and singular phenomena of these two great channels.

MR. HAY'S THEORY ON SYMMETRICAL BEAUTY.

On the Production of the Beautiful—an attempt to prove that the Theory advocated in the Papers read by Mr. D. R. HAY *before the Society, founded on the development of the Harmonic Ratios, is fallacious.* By Mr. THOMAS PURDIE.—(Read at the Royal Scottish Society of Arts, March 13 and 27).

PART I.

Mr. PURDIE commenced his paper by referring to the opinions of those philosophers of the Socratic school whose names had been used in support of the theory under consideration. He endeavoured to show, by quotations from Lord Jeffrey's "Essay on Beauty," and from Dr. Reid's works, that these opinions were hostile to all theories of such a nature. He next adverted to Vitruvius, and stated that he propounded a theory of a similar character to that whose fallacy he had undertaken to prove. One of the diagrams used by Vitruvius in applying his principles to practice was exhibited; the same diagram being used by the author of this theory in explaining the harmonies of the Parthenon. He stated, however, that Vitruvius could not be considered as an authority in regard to the principles on which styles are founded, having been led away by his fondness for metaphysical distinction and refinement, to refer them to sources with which they had no connection. This statement was supported by quotations from the works of Vitruvius himself, from Lord Aberdeen's "Principles of the Beauty of Grecian Architecture," and from the article *Architecture* in the "Encyclopædia Britannica."

As the second division of his subject, Mr. Purdie referred to the labours of Kepler in proving the harmonies and analogies he supposed to exist throughout nature—to prove which, great part of his "Mysterium Cosmographicum" and "Harmonices Mundi" were written. He investigated the reason of the Zodiac being divided into 360 degrees. It led him into some subtle considerations in relation to the divisions of the musical scale. Mr. Hay investigates the properties of the number 360, and his investigation seems to lead to a conclusion of a similar nature.—(See p. 24 of his book on Symmetrical Beauty). A quotation was read from one of Galileo's Dialogues, denouncing the belief prevalent in his time as to the beauty supposed to reside in the harmonic ratios, that being the principle on which the present theory is founded. He quoted a passage from Bacon, tending to show that he considered the ideal beauty of the Greeks, and that formed by geometrical proportion, to be antagonistic. In it Bacon contrasts Albert Durer, "who would make a figure by geometrical proportions," with Apelles, "who would choose the best parts out of diverse faces to make one excellent."—Numerous quotations were given from various authors, as to the universal prevalence, in the 15th century, of the "dangerous ideas of the aptitude and congruence of numbers," and of the absurdities to which the style of reasoning from analogy lead. By this, Francesco Sizzi attempted to disprove the existence of Jupiter's satellites. A celebrated musician held that God created the world in six days, and rested the seventh, because there are but seven notes in music; and Kepler, by a similar process, explained the music of the spheres, in which Saturn and Jupiter were proved to take the bass, Mars the tenor, the Earth and Venus the counter-tenor, and Mercury the treble.

As the third division of the subject, Mr. Purdie gave a short account of the theory advanced by Alison, advocated by Lord Jeffrey and others, and generally recognised by modern metaphysicians. He did not feel himself qualified to enter on the differences existing between Alison, Lord Jeffrey, Payne Knight, and Dugald Stewart. They appeared to be as much of a philological as a metaphysical nature, and did not affect his branch of the subject. He had not had time to make himself acquainted with Sir George M'Kenzie's refutation of Alison, and could not say what effect it might have had in modifying his opinions on the subject. In the meantime, although he could not say this theory accounted satisfactorily for every phenomenon connected with beauty of form, it seemed to him to account for far more of them than any other he had yet met with.

As the fourth branch of the subject, he stated the nature of the theory under consideration, and attempted to show the fallacies contained in it, and in all others of a similar nature which attributed beauty to proportion. The grand principle of this theory—that by which it must stand or fall—appeared to be (p. 66. Symmetrical Beauty), that there exists in the human mind "an universal inherent mathematical principle of harmony which gives a response to every development of its laws, whether in sound, form, or colours." He devoted some time to the consideration of this faculty. His arguments went to prove, that if such a faculty existed, it could be nothing else than what is commonly called instinct. To combat this idea, he quoted a motto from Mr. Hay's publication on Form, itself a quotation from Burke:—"Wherever the best taste differs from the worst, I am convinced that the *understanding* operates, and nothing else." He argued, if the faculty by which we distinguish the musical intervals be that by which we become sensible of the beauty of form, the result is inevitable,—that all animals, such as the mocking bird, which can distinguish these intervals and follow them, must be conscious of the beauty of form also. He stated that the only proof advanced in favour of this theory was drawn from analogy, because wo find the harmonic ratios are necessary to the primary beauty of a musical chord. These ratios have been applied to form, as being necessary to constitute its beauty also. He argued, if we are to conclude that these ratios are necessary to constitute the beauty of form, simply because we find they are so to the primary beauty of a musical chord, we must, on the same grounds, conclude they are necessary to the objects of the other senses; but that this would involve the absurdity of attempting to account, on mathematical principles, for the same man partaking with equal relish of things sour and sweet, salt and fresh,—eating pickles to his animal food one day, and currant jelly the next; for an European lady preferring the scent of aromatic vinegar to asafœtida, while some tribes of savages infinitely prefer the latter. He spoke at some length on what he conceived to be the unphilosophical nature of such a mode of establishing a theory. What is true in regard to a theory founded on the science of acoustics, may be, and is indeed likely to be, utterly false when applied to and founded on the laws of perspective. A sound always reaches the ear precisely of the same pitch as it left the sounding body, while a form makes a different impression on the eye with every change of position. Thus, supposing the beauty of the Parthenon to depend, as asserted by the theory under consideration, on the harmony of the diagonals drawn within the various rectangles which can be described within the building, it could not in reality be beautiful at all, as there is no point from which all these diagonals could possibly be presented to the eye in their true position. Even standing immediately in front of the building, the diagonals drawn in the rectangles between the nearest columns would necessarily present to the retina a much more acute angle with their base line than those farther removed. Take one step to the right hand or the left, and the angle of 75 becomes one of 76 or 77, and so changing with every step until the columns are seen close together, and every one of these angles becomes a straight line.

Mr. Purdie followed this with some remarks tending to prove the fallacy of all theories which assume proportion as their basis. How could any such a theory account for the beauty we discover in a human figure and in a horse? Yet the principle must be the same, by our recognising beauty in styles of architecture so various that some of them seem to be beautiful from the want of qualities which some of the others possess—as the Moorish, the Grecian, the various kinds of Gothic, and Elizabethan; none of them having a single feature in common, either in their proportions or their details. That these differences are not confined to the different orders, but exist in various examples of the same order,—a drawing was exhibited of four specimens of Corinthian: from the Choragic monument in Athens—the temples of Jupiter Stator and Tonans, in Rome—and of Vesta at Tivoli; all exceedingly beautiful specimens of the order, but without a single feature in common, either in their proportions or details. He adverted to the universal agreement as to the fundamental principles of harmony in music, and the proverbial differences on the most fundamental points as to beauty of form—to our recognising beauty in the figure and dress of a modern belle, and our considering it an outrage on taste to transfer the same costume to marble, although the same form and face be preserved. The origin of our feelings, he said, is here too obvious to escape notice. A statue lives a thousand years, a man threescore. Our taste for sculpture has been modelled on that of antiquity, and cannot now change. Our dresses last not a lifetime, but must be changed as necessity requires. Makers of them will exercise their skill and ingenuity in devising new forms—hence change of fashion; and hence our ideas also change, and attach themselves to those forms with which we are in the habit of associating all that is graceful and elegant. A modern statue, even in a modern costume, would, in ten years, address us in antiquated language, without having the respect due to antiquity. The Grecian statues speak to us in a dead language which changes not, and they speak to us of hoar antiquity—of the knowledge, the skill, the taste, and the cultivation to which that wonderful people had attained, and from whom they are descended to us.

Mr. Purdie concluded his paper by characterising all attempts to establish a theory on such grounds as this, in the words of Lord Jeffrey, as "dogmatising from a few examples, instead of defining any general comprehensive principle, in which all beauty may be supposed essentially to consist." An attempt, he continued, as reasonable, and of precisely the same nature, as that of a man who, setting out with the premises that every oak tree is a vegetable, attempts therefrom to prove that every vegetable must be an oak tree.

Mr. Purdie then intimated that he would be prepared, in the second part of his paper, to go somewhat more into detail, and to prove the fallacy of the theory from its own inherent defects and self-contradictions; for of these he conceived it contained sufficient for the purpose, although he might have failed in convincing any one on the general question.

Part II.

Mr. Purdie commenced the second part of his paper by recapitulating shortly the contents of the first. He then proceeded to explain the scope of the theory he had undertaken to refute. It was intended to be applied to universal nature. This was sufficiently shown by the "universal mathematical principle of harmony" assumed to be "inherent in the mind," for the purpose of giving a response to the laws of the theory. It followed that no object could be beautiful in which those principles were not developed. He quoted two passages from Mr. Hay's book on Symmetrical Beauty as still farther explaining this, and showing *how* these laws are extended to universal nature.—"In these" (the organic forms of nature) "the first principles of symmetrical beauty are so blended with the picturesque, and operate in a manner so exquisitely refined and subtile, that mankind have as yet been unable to systematize them."—p. 2. "In compositions of high art, the principles of symmetrical beauty are so subtilely imparted as not to exhibit themselves."—p. 4. To these he requested particular attention, this being the point at which all such theories fail, *i. e.* in the attempt to account for beauty of dissimilar or of opposite descriptions,—such, for example, as that which we discover in a child and in a full-grown man—in a horse, a Newfoundland dog, or a greyhound; or a building—Doric, Ionic, Corinthian, Elizabethan, or Gothic. He said this was a mere begging of the question, a counterpart of Alexander the Great's mode of *unloosing* the Gordian knot. It would make the principles of this theory to be somewhat like the music of the spheres—filling heaven and earth with their strains—strains so "*exquisitely refined and subtile,*" as to be altogether imperceptible to moral ears. Would not the natural conclusion rather be—"*De non apparentibus et non existentibus eadem est ratio?*" It was admitted these principles of symmetrical beauty did not show themselves in works of high art. The admission was correct. They did not show themselves—only because they did not exist. Mr. Purdie next referred to the Parthenon, whose proportions it was attempted to show were in accordance with the principles of the theory. In making the attempt, however, it was admitted that several "*discords*" existed—the outer intercolumniations being closer than the others. It is attempted to get rid of this difficulty by saying that the outer intercolumniations are relieved against the sky, while the others are seen against the body of the building—that an open space between two columns, seen against the sky, appears wider than when seen against a background in shade; and this assists in harmonising them.

Mr. Purdie then showed, from the ground plan of the building, that there is visible a space of only two feet through the outer intercolumniation, while nearly four feet can be seen through that next it. This, therefore, instead of assisting the theory out of its dilemma, only increased the difficulty. Besides, a glance at the ground plan would have shown that the same intercolumniation was applied to the inner row of columns, which were so close to the building, they could never be seen against the sky at all. He then explained the reason usually assigned for the nature of the intercolumniation used in Grecian Doric, which is connected with the arrangement of the triglyphs and metopæ. He said, Mr. Hay stated that the line of the tympanum formed with its base an angle of 15 deg.; that "as the angles of the pediment in Plates 6, 7, and 15 (of Stuart's Athens) all differ," he "adopted that of the latter, as being the most likely to be correct, because the pediment is there given by itself."—(Symmetrical Beauty, p. 72). Mr. Purdie showed, by reference to the text of Stuart's Athens, that Plate 15 did not refer to the dimensions of the pediment at all, but was only intended to convey an idea of the sculpture, and was given without measurements. The measurements were correctly given on the elevation,—although the elevation itself was not in accordance with them. By a calculation made from these measurements it would be found to form an angle of 13 deg. 24 min. There was a statement in the text, noticing the inaccuracy of the elevation. The real angle was there stated to be 14 deg. If the rest of the angles given had been taken from the elevation by means of the protractor, as they appeared to have been, they must be all wrong together, as the tympanum, as there represented, is 18 inches too low.

This was the second attempt made to set the Parthenon to music. The first was proved and acknowledged to be a failure. Of that attempt the *Athenæum* remarked, June 10, 1843—"It is easy to see that a general notion of this kind is a most insufficient basis even for a plausible theory. * * Mr. Hay is wrong when he asserts that certain proportions are beautiful *because* they are those of the notes which, in all the combinations of harmony and melody of sounds, are most pleasing. His proportions as assigned to form are most correct and most beautiful. They are not, however, those of the beautiful sounds to which he assigns them."

The Grecian Doric, therefore, was not in accordance with the principles of this theory. Perhaps the attempt might be more successful when tried with the other orders; but if it failed with the Doric, the proportions of which were comparatively invariable, the Ionic and Corinthian must be still more perplexing, the latter of which varied so much that the writer of the article *Architecture*, in the "Encyclopædia Britannica," said it was scarcely possible to give any general description of it. If it failed with any of these, there would remain for it but a small chance of success with the Gothic or the Elizabethan.

Mr. Purdie said, it might save the introduction of much irrelevant matter, if it were kept distinctly in recollection that he was not attempting to refute some imaginary theory which might be brought forward in the course of the discussion, but that advocated before the Society by Mr. Hay, and contained in his published works. That theory was founded on the harmonic ratios. No doubt, order, proportion, and harmony were all necessary to the beauty of architecture; but it was not by the harmonic ratios these were to be obtained. The "Greek architects allowed themselves to be fettered in their general proportions only." This theory did not establish general proportions at all. In music, the application of harmonic ratios, while they allowed all latitude as to general proportion, limited beauty to certain fixed points or coincidences, from which when the slightest departure was made, discord ensued. Thus a difference of a semitone would make as disagreeable a discord as a full tone, and one quite as easily recognised. It mattered not whether too high or too low. The application of the harmonic ratios to forms was intended to produce a similar effect. Thus in the case of a well-proportioned column, six inches added to its height would be as easily observed as 18, and quite as destructive of its beauty; and were the height diminished by 18 inches instead of being increased, it ought to be no more so, the departure from the harmonic ratio in either direction being equally discordant. The instant the correct proportions were departed from, deformity would be the result; but let the alteration be continued a little farther in the same direction, the deformity would be got rid of—a new chord struck, and beauty and symmetrical proportion again obtained.

Mr. Purdie stated shortly what he conceived to be the source of the beauty of architecture and sculpture, and referred, as the best sources of information with which he was acquainted, to Lord Aberdeen's inquiry into the principles of beauty in Grecian architecture—Gwilt's Preface to Chambers's Works—the Essays of Alison and Lord Jeffrey, and the lives of Christopher Wren and Michael Angelo Buonarotti, published by the Society for the Diffusion of Useful Knowledge. It was not necessary to seek for any mysterious geometrical law. The taste of a nation, and their power of producing and appreciating beauty, depended on their progress in civilisation, on education, and the refinement these naturally produce. "The beauty and perfection of the school of Phidias accompanied the great moral and intellectual improvement of the times, and art was most perfect when Æschylus, Sophocles, and Euripides, produced their tragic poems; and Socrates and Plato, and the great Grecian statesmen, by their writings and example, improved the moral and political state of mankind."—(Life of Michael Angelo.) That this tended to prove the general correctness of Lord Jeffrey's definition of taste—"That the power or faculty of taste is nothing more than the habit of tracing those associations by which almost all objects may be connected with interesting emotions."

Mr. Purdie then took notice of some of the methods given for applying the theory to practice, and contended it was equally potent to produce the ugly or the beautiful. According to the method given by Mr. Hay for drawing the human countenance, an oval was first described, and within it a triangle, its apex undermost. At the apex the mouth was placed, and the eyes at the two upper angles. But no rule was given for placing the apex of the triangle undermost. One might, if he felt so disposed, reverse both the triangle and oval; it might be some bungling Grecian sculptor who thus reversing his triangle, invented the Cyclopean type, with one large eye in the centre of the forehead, and a mouth extending from ear to ear at its base.

A similar effect would take place with the profile, in drawing which an oval is given for the face and a circle for the back of the head. He said the profile is not an oval, nor is the back of the head a circle. To render the back of the head a circle, a large slice must be taken from "self-esteem;" and "philoprogenitiveness" would suffer an amount of reduction which might seriously interfere with the increase of the population. The back of the head was, strictly speaking, no more a circle than a square; and if it were a square, or a rectangle, provided always it were a harmonic one, its consistency with the principles of the theory might have been quite as easily manifested.

Mr Purdie then proceeded to consider what are styled (p. 81, Symmetrical Beauty) a series of peculiarly symmetrical rectangles, which are evolved by using the diagonal of the square as the base of the first, the diagonal of the first as the base of the second, and so on. Mr. Hay, however, did not adopt these as they naturally arise. They did not accord with the harmonic ratios, and were altered to suit.

Mr. Purdie pointed out on a diagram the amount of the alteration. He said Mr. Hay referred to the temperament used in music in its justification. Mr. Purdie explained the nature of musical temperament, and showed there was no analogy between it and the process adopted with these rectangles. He stated the temperament in music was a modern invention, and seemed somewhat out of place in a treatise which claimed support as elucidating the principles of the ancient Greeks. Were such a principle as this tempering admitted into science, it would be easy to obtain any results. Such an arbitrary alteration of a series of figures in a science claiming mathematical accuracy, would have been conclusive against it, had it been in other respects unassailable.

Mr Purdie next referred to the egg oval, and Mr. Hay's method of producing it, which might be new to many of the members, and was (leaving out the harmonic ratios) the simplest and best method. He said, whatever merit its application to the drawing of vases might possess, it had not that of novelty to recommend it, but had long been familiar to every one who had given any attention to the subject. He exhibited in Nicholson's "Architectural Dictionary" several good examples of vases so constructed, along with a variety of methods of producing the figures on which they were based.

Mr. Purdie explained the effect of engrafting the harmonic ratios on them, and exhibited a variety of diagrams to test whether any one could point out the discordant from the harmonic. But the method adopted in forming these ovals was, he contended, altogether subversive of the theory. Four pins are put in at certain fixed points, and a string tied round them, for the purpose of obtaining the form of two harmonic triangles; but, before proceeding to produce the oval, one of the pins is pulled out. For this no reason could be assigned but the will of the operator. It did away at once with all idea of harmonic relation. A figure so constructed could bear no mathematical relation to the triangles on which it was based. Extend the radii to infinity, and a circle would be obtained independent of the shape of the triangles: reduce the string to a sufficient tension, and it would become a triangle. A figure so constructed vibrates between the circle and triangle. At no possible point between the two could it bear any harmonic relation to the triangle on which it is based.

In conclusion, Mr. Purdie said, that the origin of the fallacies contained in this theory appeared to be an extravagant fondness for analogy, through which the idea had been conceived of engrafting the principles of music on form: that, instead of analysing the phenomena of mind, and deducing the principles of a science from the facts so ascertained, the mental phenomena had been left out of view altogether, and the theory formed on a mathematical basis depending on the harmonic ratios: and that the result was a theory utterly at variance with those very phenomena on which it ought to have been founded. The only method of investigating the truth in metaphysical science was by inductive philosophy, the slightest attention to the principles of which would have saved the author of this theory from the manifold blunders into which he had fallen.

After the reading of the above paper, Mr. Hay made some remarks "*On the effects of Perspective upon Proportion, being the first of a series of short papers upon the Harmony of Form.*"

Mr. Hay commenced by apologising to the members of the Society generally, for calling their attention to a fact, with which he believed they were familiar. But that fact had been denied at the previous meeting, in an attempt to prove a fallacy in his system of applying the numerical harmonic ratios to the proportioning of rectangular forms; and its denial seemed to be well received by the younger members. Mr. H. therefore, felt called upon to state the fact, and to demonstrate it. The fact, be stated was "that whatever system of proportion may be applied in arranging the parts in the geometric elevation of a building, will also operate upon the effect of that building, in whatever degree of obliquity it may be viewed." He exhibited five drawings, two of which fully explained his system of applying the numerical harmonic ratios, and the other three demonstrated the fact which had been denied at the previous meeting; and therefore concluded that the attempt to prove the fallacy of the system, by the denial of this fact, had failed.

Mr. Hay observed, that an attempt had also been made, at the previous meeting, to assimilate his system of the application of numbers to symmetrical beauty, with the mystical application of particular numbers by the alchymists, and some of the philosophers of the middle ages; and offered to prove that this attempt was also a failure, inasmuch as he employed numbers in an intelligible, not a mystical manner.

PECULIARITIES IN THE CONSTRUCTION OF GREEK ARCHITECTURE.

Abstract of a paper "*On the Geometrical Lines and Optical Corrections of the Greek Architects.*" By F. C. Penrose, Esq.—(Read at the Royal Institute of British Architects, February 21st.)

I will observe, that although the scrupulous accuracy with which the measurements which I shall produce have been recorded may seem almost absurd to some, it will not appear so to those who have been so fortunate as to see the originals, and observe the perfection of the workmanship with which they are put together, and the exceedingly happy preservation of many parts from the weather, which enables measurements to be taken with precision in these, where in many buildings they could only be a matter of approximation.

I use as my standard of measurement the English foot, and divide it into 100 parts which I shall call cents.

In the beginning of the year 1846 I was at Athens. I had an introduction to M. Riedel, a Bavarian architect, who accompanied me on my first visit to the Acropolis, and pointed out to me the peculiarities of construction of which I am about to speak; it was the first time I had any intimation that there was any departure from ordinary line and rule work in these buildings, excepting a rumour which I heard from our consul at Trieste, that there was something very curious recently discovered in the ancient buildings at Athens.

These peculiarities, which were then pointed out to me, were the convexity of the stylobate on the four sides of the building, and the inclination of the columns towards the centre of the building; that is to say, on the east front the axes of the columns incline in a westerly direction, and those of the west front easterly. Those on the north and south flanks, south and north respectively. It follows that the angle columns share the two inclinations; for instance, the north-east angle column inclines in a direction south-west.

This fact has been ascertained some time; it is given with considerable accuracy in that part of the supplement to Stuart which was supplied by Mr. Jenkins. The exact amount, owing to the slight displacements which the building has suffered, is only to be obtained by a diligent survey of the whole building.

The observation of the convexity of the lines of the steps is more recent. I believe that one of our countrymen, Mr. John Pennythorne, was the first who paid any discriminating attention to these lines. I use this phrase as they cannot but have in some measure influenced our earliest investigation, as no one could ever have cast his eye along any portion of the upper members without being sensible of them. The lower lines of the building were, as I understand, quite encumbered with rubbish until the excavations of the last few years. Any measures obtained by boring must have been vitiated, and they have doubtless given many a diligent measurer a vast deal of trouble, and many have been the dimensions which have stood at dismal variance with themselves, and been cast aside without being really to blame.

Mr. Pennythorne was the first to see in these an original intention and meaning; he however kept his knowledge to himself, and the world first heard of it through the communication of MM. Hofer and Schawbert, German architects, to the *Bauzeitung*, in the year 1838.

I was very much struck, as all who have seen the Greek buildings must be, by the perfection of the workmanship, and I took such levels and dimensions as I could with the instruments I had with me, for the purpose of ascertaining the amount and nature of these adjustments. And I arrived at a sufficient degree of exactness to assure myself that it was well worth while to go deeper into the matter. I, however, (in 1846), was not able to pursue the subject any further, and I returned to England in the autumn of that year, and had the pleasure of reading a paper to this Institute on the observations.

They attracted more sensation than I had any right to expect, and I received a proposal from the Society of Dilettanti, that if I were willing to go out to Athens, for the purpose of taking more accurate observations, they would assist my operations with a sum of money. This proposal I willingly accepted, and provided myself with the necessary implements, and induced a young architect (son of Mr. E. Wilson, of Lincoln, the well-know archæologist) to accompany me, and we arrived at Athens towards the end of October last year. I was also so fortunate as to fall in company with Mr. Meyer, associate.

The first thing which we attempted was the measurement of the base line, namely, the length and breadth of the building. This was done with steel tubular measures, compared at the time of measurement with the thermometer, from which also long deal rods were graduated for the measurement of the heights, and for general purposes. The steel rods were carefully compared by Mr. Simms, both before and after my return, with his standard, and I gave the results as delivered at Athens. They are still subject to a very minute correction, but not worth troubling you with at present.

As soon as the weather allowed, and the requisite permission obtained from the local authorities, I proceeded to hoist a scaffolding at the east-end, of which I made an entire circuit, beginning with the three columns which are standing on the north side, and ending with the south-east angle column.

In this examination we plumbed every column, measured every stone of the architrave, the capital, and upper and lower stones of each column, in every direction; took careful measurements of all the cracks which have in any way modified the original form, and obtained levels of all the lines of the entablature at fixed points; and finally examined the entasis of five different columns, taking several sections of each.

We then migrated to the west-end, where I contented myself with making an exact examination only of the two angular columns, which position enabled me to obtain the levels of the upper members of the western part. I also took all such measurements in the western parts as my examination of the eastern part had pointed out to me as necessary to arrive at the exact original state. I then proceeded to examine the upper members of the posticum, and the arrangement of the tympanum, which has some peculiarities worth notice connected with the support of the statues. Then the roofing, the ceiling, and lastly, the original painting, engaged our attention.

This work in the upper part of the building was naturally very much exposed to wind, &c. It often happened that while it was impossible to do any accurate work on the scaffolding, we might be employed profitably below. But frequently it was altogether out of the question to go up to the Acropolis at all. The pavement was of course levelled in every part and several times over, until the whole system worked perfectly together, and I could satisfy myself that I had got the exact curve in every instance, or at least within one or two thousandths. We also took such measures as sufficed for the accurate position and proportions of the cella, with the arrangement of columns within it. This sums up our proceedings at the Parthenon, which occupied nearly five months. The Propylæa occupied a considerable share of attention, and I searched the temple of Theseus to find how far it was analogous to the Parthenon.

Last, but not least, we ascended the temple of Jupiter Olympus, from which we obtained various measurements and drawings.

The measurements of the breadth of the temple on the upper step, at the east and west ends, I found to be respectively 101·341 and 101·361,—north and south, 228·141 and 228·154 respectively. This exceedingly small difference in measures which were certainly intended to be equal, points out the limit of error, which can be attributed solely to inaccuracy of measurement in other dimensions, namely, about 1 in 5,000. I may just observe that I found my wooden measures, notwithstanding they had been previously saturated in oil, subject to a fluctuation in various states of the atmosphere rather greater than this amount. So that, had the eastern front of the Parthenon been set out with deal rods on a dry day, and the western on a moist day, we should have had as great a difference between them as actually exists.

It follows that all quantities which tend to proportionality must be looked at with great suspicion, in which varieties exist sensibly greater than this small admissible error.

The breadth of the temple of Theseus is 45·011, and its length is 104·23. The former is almost exactly in proportion of $\frac{4}{9}$ths of the breadth of the Parthenon: this, I think, was intended.

But a difficulty occurs if we attempt to proportion the front with the flank on the upper step. It has been suggested to try the equilateral triangle. That, however, notwithstanding its being near enough the mark to suggest the trial, leaves the quantity = ·282 unaccounted for at the end; and, besides, I do not find that in the Parthenon there are any affinities whatever to that figure.

I very much prefer to descend from the upper step, and try the proportions on the second. By this addition, the flank becomes 106·63, and the front 47·41.

We now obtain a proportion 9 to 4, differing from exactitude by so small a quantity as to be fairly admissible.

It is somewhat remarkable that the quantity 1·066 is found frequently in the measures of the Erectheum.

The proportion of solids to voids is 4522 to 1000, nearly as 9 to 2.

I have now stated the principal larger proportions: I will state a few others, which are the more important secondary ones. A very happy artifice is the walls of the pronaos and posticum being thicker than the cella walls.

The height of the columns of the Parthenon is exactly $\frac{15}{100}$ length of temple on upper step, the breadth of the abacus of six of the eastern columns is exactly $\frac{1}{15}$ breadth of temple; they are not all equal, but I have given the dimensions of those at the eastern end, which always gives the key to the main proportions.

In the temple of Theseus, the column is exactly $\frac{18}{100}$th of length of temple on the lower step, and the abacus $\frac{1}{12}$th of the breadth on the upper step. In both, this member appears to be the unit of measure for all the details.

The whole building is most accurately proportioned in every part, and I think it not unlikely that it will be possible to find a standard which shall express every dimension without any incommensurable fractions.

I now proceed to that part of the subject which is more particularly the object of the present paper, namely, the optical corrections. I shall first state the case as I found it, and lastly, say a few words on the probable origin and intention of these subtleties, which prevail, more or less, in almost all the Greek temples—in all, indeed, that I have examined, with the exception of the temple of Bassæ, on the borders of Arcadia, where I could not find satisfactory indication of either convexity of pavement, or inclination of the columns, or even entasis.

The pavement of the Parthenon is bounded by four curved lines, viz., the edges of the upper step on the four sides of the building. The four angles of this curved surface are not precisely level, the south-west angle is about ·16 above the north-east and south-east angles. I think that this is simply owing to the lines of the earlier temple, which were also curved, being made use of as far as they would go, and by being produced in one direction only, and remaining fixed at the south-west angle. The line so produced would naturally fall below the fixed point. This is the case on the west front, south and north sides. The extreme points of the upper step of the east front are exceedingly near level. The result of a number of observations gives only a difference of ·002, or $\frac{1}{500}$ feet, a quantity which we need not stop to discuss.

If these two points be joined by a straight line, the curve which forms the edge of the step will be found under the middle columns to rise to a height of ·214 above it. If the uniform curve had been preserved, it would have been ·218 in the middle, which is about $\frac{1}{465}$ breadth of front; and the curvature is so regular on the northern half of this front, where the steps rise immediately from the solid unbroken rock, and consequently no settlement can have taken place, that of four points measured at the centres of each column, three agree exactly with a circular arc: the fourth differs only by ·003. The curvature is so very slight that it might be any regular continuous curve; for instance, in so small an arc no appreciable difference could be shown between the arc of a circle or that of an ellipse or parabola, and I think that the work was set out by means of the latter figure, which might be done very easily; whereas, I need scarcely point out the difficulty, or rather impossibility, of using the circle, which would require a diameter of about $2\frac{1}{4}$ miles.

Let it be required to construct a circular or other arc of uniform curvature, whose length is 100 feet, and the rise at the centre is to be ·25, or any other small measure which must not much exceed one foot. Construct with any axis a parabola, and set off from the vertex $AB =$ the proposed rise, and draw LM at right angles with AB. Now, LM will represent the 100 feet horizontally, and ordinates drawn to the curve perpendicular to LM will determine the exact rise at as many points as may be required, full size.

The curve on the upper step north side of the Parthenon, also approximates to a regular curve very closely; its entire rise in the centre above the line joining its extreme parts, is ·356, which is very nearly in the proportion of $\frac{7}{8}$ of the rise in the east front: it is exactly $\frac{1}{610}$ length of the building. The curve on the south side seems to have been identical with the north side, but it has suffered more from the concussions which the building has undergone, especially as there is a great depth required on this side of artificial foundation. On the north side the steps rise almost immediately from the solid rock. The curve on the west front is not quite so symmetrical as on the other sides. It has, I believe, been affected by the lines of the old building. The rise is exactly the same as the east end.

The upper members on all four sides follow the steps, and are nearly parallel, but there is a little more curvature given to the steps; the entire rise of architrave is ·173 on east front, ·175 on west. The levels of those portions of the entablatures which remain on the north and south sides point out the directions which those lines had originally, and they were as nearly as possible parallel to the line of the step, excepting that just at the angle columns the step has a little the more declension. The frieze and cornice are exactly parallel with the architrave. In the temple of Theseus, also, these curves prevail; on the fronts the rise is $\frac{1}{700}$ part of its length, on the flank, $\frac{1}{950}$. The lines in the architrave are exactly parallel to the step.

There is one refinement which the temple of Theseus possesses, which the Parthenon is without. In addition to the cornice being raised, the inclined lines of the pediment have a very slight convexity, between ·02 and ·03. I was unable to fix more precisely the amount. I imagine that it was owing to some degree of haste in which the Parthenon was finished, of which there are several indications in the upper members, which prevented this final adjustment being made to its pediments; the state of the political horizon at that time making the completion of the long walls of more immediate importance than the optical corrections of the Parthenon. On a former occasion, I stated my impression that the cause which led to the adoption of this convexity of the horizontal line, existed in the contrast of the inclined lines of the pediment.

Mr. Ferguson has kindly favoured me with an illustration, which I will read to you, from a description of the construction of an iron foundry at Kasipur, near Calcutta, built in the year 1834. The foundry is covered by a single roof, with principal rafters, tie-rods, and suspension bar from the centre. The rise is 6 feet and the span 50 feet, which is exactly the same pitch as the Parthenon and Propylæa. The passage is extracted from vol. iv. of the journal of the Asiatic Society of Bengal, p. 116: "Before closing our short account of the Kasipur roof, we must notice a curious optical deception, for which we are somewhat at a loss for a correct explanation. On entering the room and looking up at the roof, it strikes every beholder that the roof has somewhat sunk, and the horizontal tie-rod is about 5 or 6 inches lower in the centre than near the walls. We were not convinced that it was a deception until Major Hutchinson, at our request, caused an actual measurement to be made by a perpendicular wooden batten from an accurately adjusted level on the stone floor. It was then proved that there did not exist a difference of level even to the tenth of an inch." The conclusion is obvious that a straight tie-rod appeared to be deflected; and I have no hesitation whatever in ascribing the cause to the contrasting lines of the principal rafters. I do not think that it is necessary to have our eyes refined by a southern climate for the appreciation of these effects. I suppose that there are very few gentlemen here who have not felt the same disagreeable effect of a flat open roof with horizontal tie-beams, unless, indeed, the latter be very much cambered. That this was the view the ancients took of the matter I am convinced by these two facts—

That the great temple at Pæstum has the convexity only in its fronts, and not on its flanks; and in the Propylæa at Athens, although the base on which the columns of the two pediments stand is perfectly straight and level, the line of the architrave was curved. For enough remains to determine this in the eastern portico—the central columns are actually about ·12 higher than those at the angles. The base in this building is cut in two by the ascending roadway, so that there could have been little or no advantage in a convex base line.

It will be well to remember that the temples at Athens were the result of the experience of several centuries in which these refinements were gradually brought to perfection. The first process was probably to raise the cornice under the pediments and entablature, by making the middle columns a little higher than those towards the angles, as I have mentioned in the case of the Propylæa. Still it is likely that to a fastidious eye the straight line of the stylobate would appear weak. The second method would be that found in the great temple at Pæstum, in which the fronts have the convexity in their steps, as well as their entablatures, the flanks being composed with horizontal lines. Perhaps a reasonable man should be content with this. I must willingly admit that I was perfectly content with the temple at Pæstum; still nothing short of perfection could satisfy the refinement of vision with which the Greeks alone, among the people of all time, seem to have been endued; and perhaps by looking at a temple constructed as above-mentioned, anglewise, and contrasting the convexity of the corona of the fronts with the straight line of that on the flanks, or more likely the comparison of the two different forms of line on the stylobate, suggested the possibility of improvement; at any rate as early as the time of Pisistratus, the Athenians had begun to demand from their architects the perfected construction, as the foundations of the temple of Jupiter Olympus testify, which we know were laid during his reign.

I also refer to his time, the earlier temple of Minerva, which occupied the site of the Parthenon at the time of the Persian invasion, in which also we find that the lines on the four sides of the building were convex. I can bear witness also to convexity on all the four sides of the temple at Nemæa, in the Peloponnesus, and Segeste, in Sicily. I could find no trace of convexity at Corinth, Egina, Rhamnus, or Bassæ.

The next subject is the inclination of the columns and the upright faces of the building. 1st. The face of the steps inclines about ·008. 2nd. The columns incline, backward, a quantity, of which I obtained the following results. From the average of the measurements of all the lower drums, (*scamillæ impares*, as Vitruvius calls them) ·229. From plumbing the angular columns of the east front, taking into consideration all the cracks and movements which have modified its original position, I obtain two results of ·230 and ·232.

In the plumbing, I observed every precaution to ensure correctness, using a very heavy weight and also watching for calm intervals of weather, which are rare at Athens. I am disposed to think that ·228, or one thousandth part of the length of the building was the amount originally intended. Those gentlemen who remember the perfection of the joints with which the Parthenon is constructed, will allow that the openings between them, which at present exist, are the exact records of all the settlements which the building has undergone, and that by a careful examination of these, the original amounts may be exactly recovered, which would be hopeless in a building which had been of less highly-finished construction.

Vitruvius directs that the columns of the pronaos and posticum should be set perpendicular, and those of the peristyle should incline towards the cella. In Cicero ad Verrem, we have an amusing passage, in which Cicero relates one of his rascalities; that having under his charge, as Roman governor, a young Syracusan nobleman, whose property was subject to the condition of repairing the temple of Castor in that city, Verres was exceedingly anxious to make a job of this; so he goes to examine the temple, but was much disappointed on finding it in perfect repair, when one of his companions casually observed, there is nothing here to be done, unless you order the columns to be set perpendicular. Verres was evidently surprised at this observation, for he knew nothing of architecture, and to his eye the columns appeared angular; but it was mentioned to him by those who were around him, and no doubt familiar with the practice of the ancients, *fere nullam esse columnam quæ ad perpendiculum esse possit*—namely, that in a temple there was scarcely any column, which by the practice of the Greeks, could be perpendicular. Verres was delighted at finding something to set his young friend about, and said, "Oh, by all means let him set the columns perpendicular;" and no doubt he took care himself to superintend the payment.

The object of this adjustment is to correct an appearance of fanlike spreading from the base outward, which takes place in columns which are all perpendicular. It may be owing to this cause that, in consequence of the diminution of the columns, the spaces between them on the architrave are greater than those on the ground (for the eye quite makes allowance for the counterspread of the capitals). Again, owing to the greater depth of shadow behind them, the upper part of the columns will have apparently more strength of light, and consequently appear greater. The effect altogether produced will cause the architrave, if equal, to appear longer than the base, and consequently the angle columns will appear to lean outwards: this is rectified by making the said angle columns lean a little towards the centre of the building. It is a proof of the wonderful judgment with which this quantity was chosen, that so many diligent and accurate observers have studied and drawn these temples without being aware of the fact. When my attention was first called to it, I could not at all perceive it; and I greatly amused a French architect, who had been for some time at Athens, by asking him which way they leaned: after some days the eye began to take cognizance of it, and I could perceive which way it went.

The impression of strength and beauty resulting therefrom is by no means confined to those who are cognizant of the fact; and I doubt not that many of our earlier investigators have been astonished that the level-and-plumb imitations of Greek architecture which we have in this country so little recalled to their minds the consummate beauties of the Parthenon and other Greek buildings. No doubt our climate is unsuited to the pure Greek, but this is not enough to account for the falling off; it is not so in our Roman and Palladian buildings.

One peculiarity which I noticed is that the antæ lean forwards to meet the columns of the pronaos. This seems to have resulted from the inclination inwards of the columns of the peristyle; those of the pronaos and posticum being perpendicular, the effect would have been to produce a strong contrast between their different positions, and the artifice must have been detected: by the influence of the contiguous face of the antæ, the column (here drawn from the posticum), which is really perpendicular, is made to appear to lean slightly in the same direction as the outer columns.

I have observed that a perpendicular pilaster, when brought very near to a column in a portico or doorway, has the effect of making the column appear to lean forward. The inclination of the antæ is not itself visible, except to a spectator in the narrow space between the inner row of columns and the wall; and when the eye is brought very near to a line, so that it cannot take it in all at once, it is scarcely possible to judge of perpendicularity.

The last peculiarities I shall mention are the differences of the abacus. Those on the east front are of the largest class, the north-east and south-east having the largest in the whole temple; they are 6·858; the others in the east front are 6·755; on the south side they are 6·580, and so are they on the west front. The north-west angle is the same as the ordinary size of the east front, 6·755; the south-west angle is somewhat less; on the north side they are 6·750 in the middle, and regularly decrease towards the angles.

The entasis of the columns is the most wonderful and beautiful of all the curves. It is so delicate, that its existence was for some time doubted; and yet I found by careful measurements, in a manner which was suggested to me by Professor Willis, which I will here describe. A fine harp wire was strained from the top to the bottom, as tight as it would bear, close to the edge of such flutes as preserved a sufficient number of points, with the original surface, and by means of a rule similar to the one I here produce, which is supplied with a vernier, I was enabled to measure from the flute to the wire with the greatest accuracy to about half $\frac{1}{1000}$ foot. I took such measures in several columns of the Parthenon, which I found to be wonderfully true and identical. I measured also the entasis of columns from the Erectheum, Propylæa (both orders), temple of Theseus, and Jupiter Olympus. In those of the Parthenon, Erectheum, and Propylæa, I find the correspondence with hyperbolic arcs, which I have calculated so exact, that the mean of from 14 to 20 measurements in each column differs from the calculated curve less than $\frac{1}{1000}$ foot, and none of them, where the surface was to be depended upon, differs by so much as $\frac{1}{300}$. The entasis of Jupiter Olympus gives also a very true hyperbolic arc. The columns of Theseus are so much worn in their outer edges that I was obliged to content myself with measures within the flutes, which never give such regular curves as the fillets, although the flutes are worked with a nicety far exceeding that found in any other style of architecture. Still, a mean from four different sections within the flutes gives a very accurate hyperbolic arc, although no one is a perfectly regular curve. These hyperbolas are all chosen with their axes, multiples, or aliquot parts of the attic foot. The Greek architects acted with great judgment and knowledge of the nature of the curve they were employing, as it is the only one of the conic sections which can produce variety in such delicate curvature as they have chosen for their entasis.

I must now advert to some of their mouldings, which are worked with the same perfection, and, as far as I have examined, are all different forms of the conic sections.

The echinus of the capitals of all the Doric columns agrees with various forms of the hyperbola. The soffit of pediment, Parthenon, and Propylæa, and I think of Theseus also, shows a hyperbolic arc. This is a magnificent moulding, and worked with the utmost perfection. That of the Erectheum is an equally true parabola. The cymatium of the Parthenon is the only certain circular form which I know, except the torus of base, Erectheum, and Ionic order Propylæa. The flutes, also, are all parts of circles, whose centres are proportioned to the width of the flutes. In this they showed their judgment, as it would have been almost impossible to have worked pure ellipses; and in these retiring surfaces the value of the perfect variety of curvature of the ellipse would scarcely have been appreciated. Talking of flutes, there is a peculiarity in the flutes of the Parthenon, which does not occur in any other of the temples of Athens. The flute at the neck is deeper in proportion to its width than in the rest of the shaft: during the whole rise, until about 3 feet below the neck, the sagitta or depth of the flute, from its chord, is $\frac{10}{66}$ths of chord. At the neck it is $\frac{11}{66}$ths, which is about $\frac{1}{7}$th part greater. This has a good deal of effect on the column, and gives a richness of effect to the upper part, at the same time that it diminishes the light in that part where it can best afford it, viz., where it is contrasted to the deep back-ground of shade of the upper part of the cella wall.

I have not yet much to say with regard to the colouring of the temple, nor have I much time to say that little, for I fear I must have exhausted your patience. The drawings which are at present made represent the architrave, band, &c., the triglyph, and the string which carries the marble beams which supported the ceiling. There is not a great deal of positive colour remaining in the Parthenon. The underside of the mutules show some vestiges of blue and red colour, and the upper part of the nook of the triglyphs, here and there on the east front, preserves some blue. One of the antæ of the posticum has a tolerable supply among its eggs of blue and green, and some red. The flowers which decorate the cymatium and other mouldings have no trace of positive colour, but the drawing of the ornaments upon them is in many places clearly to be made out.

CAST AND WROUGHT IRON BRIDGES.—(Part II.)

(Continued from page 126.)

At the request of the council of the Royal Scottish Society of Arts, the second part of a paper "*On the Strength of Materials, as applicable to the construction of Cast or Wrought Iron Bridges, including an account of the Tubular Bridges over the Conway and Menai Straits &c.*," was read, April 10th. By George Buchanan, Esq., President.

In the first part of this paper, Mr. Buchanan described, on a former evening, the principle and construction of the High Level Bridge at Newcastle, which is intended to complete the communication by railway between London and Berwick-upon-Tweed. Some inquiry having been then made from the chair regarding the bridge over the Tweed, the only remaining link uncompleted between London and Edinburgh, he had received the following particulars from Mr. Harrison, the resident engineer under Mr. Stephenson:—This bridge is to be of stone, and is to consist of 28 semicircular arches, each 61½ feet span, resting on lofty piers, carrying the level of the railway 103 feet above high-water mark, 126 feet above low-water mark, and 135 feet above the deepest part of the bed of the river. The whole length of the bridge, with abutments and wing-walls, is 2140 feet. The 28 arches are divided into two series by a broad pier, 28 feet in thickness in the middle. The piers of the arches are 8½ feet in thickness at the springing, increasing by steps towards the bottom. The bridge will not be completed for 16 or 18 months, but it is intended to have a temporary bridge ready for traffic in the month of July next. This viaduct is a work of great magnitude, and will form, when finished, a striking and imposing structure, and one of the many to which the extension of railways has given rise. While on this subject, he would mention two other remarkable works, recently designed and executed by Mr. Miller on the North British and Ayrshire Railways. The one is the viaduct over the Valley of Dunglass, between Dunbar and Berwick, not far from the once-celebrated Pease Bridge. This viaduct crosses the valley and banks by six semicircular arches, each 60 feet span, and then the deep ravine by a single arch, 135 feet span, and rising 105 feet above the bed of the stream. A large and beautiful model of this structure was exhibited, which Mr. Miller, at the President's request, had allowed to be shown to the Society. The other viaduct is that of Ballochmylé, across the Water of Ayr, on the Cumnock Extension of the Ayrshire Railway, and is similar to that of Dunglass in crossing the valley on three semicircular arches, each 50 feet span on each side, but is still more remarkable in crossing the deep ravine in the middle by a single semicircular stone arch no less than 180 feet span, and rising 150 feet above the bed of the stream—a bold and noble design, and which has been executed with complete success, the adjacent rocks furnishing such vast blocks of stone as greatly to facilitate the construction, and to render, indeed, the plan itself practicable. The arch stones are 5 ft. 3 in. deep at the springing, and 4 ft. 9 in. at the crown, and the appearance from below of the stupendous arch rising to such a height is singularly grand and striking. The whole arrangements connected with the quarrying and raising and depositing the stones on the building, by the improved machinery of modern times, have been most efficiently conducted by the contractors, Messrs. Ross and Mitchell, and the simple mode of centering adopted and shown in the Dunglass model is recommended by the advantage of preserving the timbers entire.

The subject of stone bridges opens a wide and interesting field, but extending beyond the limits of this paper. He would, therefore, resume the one more immediately prescribed, namely, the strength of materials, particularly iron for bridges. Some interesting experiments, which the time on the previous evening did not permit to be shown, were then made on the tensile strength of stone from Hailes and Craigleith quarries. The Hailes stone bore on the square inch 360 lb., the Craigleith considerably more; and a remarkable effect was observed here after the load had hung for a little: it was suggested by a member to give it a slight tap with a hammer, and, on this being done, it immediately snapped asunder, showing the effect of vibration or concussion when the materials are greatly strained in aiding and completing the fracture, a circumstance which appears to throw light on what may sometimes occur by the rapid and violent actions of the trains on railways. The compressive strength of the Hailes and Craigleith stones was then shown, by experiment, to be much greater than the tensile strength; and as it required, indeed, more weight and a more powerful apparatus than could be commanded, these experiments on different stones were deferred to another evening.

The compressive strength on posts or pillars was then considered, and the remarkable effects of the length of the pillar in diminishing its strength. On this subject much light has been thrown by the experiments of Messrs. Hodgkinson and Fairbairn. Pillars or rods were tried of different lengths, from 3 inches to 5 feet, and of different diameters; rods half an inch diameter, with 3¾ inches length, bore 11 tons; but when the length was 7½ inches it only carried 5 tons, when 15 inches long, 3 tons; and at 30 inches only 13 cwt. From these experiments, a general rule may be drawn for different lengths. Taking the strength of cast-iron as formerly given at 50 tons per square inch, this will hold good in pillars till the length reaches five times the diameter, and then it begins to diminish. When the length is ten times the diameter, the strength is reduced in the proportion of 1½ to 1; with the length at 15 times the diameter, it is reduced as 2 to 1; 20 times as 3 to 1; and 40 times as 6 to 1.

Hence the great advantage in cast-iron, of using hollow pillars or tubes in place of solid metal, whereby, with the same area or section of fracture the diameter of the pillar is increased, and with it the resistance to flexure, and an increase of strength in proportion to the length. A solid pillar, for instance, 6 inches in diameter, if extended to $7\frac{1}{2}$ feet in length, would be weakened one-half, but if cast hollow, 10 inches in diameter and $\frac{3}{4}$ inch thick, giving the same weight of metal per foot in length, it might then be extended to $12\frac{1}{2}$ feet, and still possess the same strength as the other. In all these cases a remarkable circumstance was observed in regard to the mode of applying the strain. With the ends of the pillar turned flat, and a flat plate interposed at top and bottom, which is the case in supporting buildings, this was found to sustain nearly three times as much as when the pillar was rounded on the ends, so as make the force pass directly through the axis, as occurs so frequently in machinery with the connecting rods of steam-engines, and in other cases. The effect of the length of pillars in weakening the strength was illustrated by a striking experiment with a spiral wire, quite flexible, yet, when set up as a pillar, and tied in the middle laterally, with slender threads, carried a weight of 56 lb., and would have carried much more, but the moment the threads were cut, the wire gave way by flexure, and oversetting the balance, the weight immediately sunk.

In regard to the Transverse Strain, be had already explained the nature of this compound action, and particularly the manner in which, under it, the beam becomes exposed at once to the effects of tension and compression, the one side being distended and the other compressed. On this most interesting and important subject he had still much to say, but would defer it to another evening, as the time was short, and he was anxious to proceed with another part of the paper which had been particularly referred to, namely, the subject of the tubular bridges.

The application of malleable iron had been already used in the shape of tension-rods in cast-iron girders, and was applied, as we have seen, in the high level bridge at Newcastle; but the application of girders constructed of malleable iron alone is a new idea. It has been applied on railways in the case of skew bridges of wide opening and limited depth between the railway and the road; in these cases the girder consists of a rectangular hollow tube or square box, extending over the whole span, and of such depth as can be attained. These have hence received the name of Tubular Bridges, and have excited much attention since the grand experiment has been determined on, of trying these structures on such a magnificent scale as is now in progress of execution in the crossing of the Straits of Menai by the Britannia Bridge, and the estuary of the Conway by the Conway Bridge, and which form, without doubt, the most remarkable engineering enterprises of the present day. These spots, as is well known, had already been the scenes of vast engineering operations connected with the suspension bridges of Telford to form the great turnpike road communication from the metropolis to Holyhead, and thence across the channel to Dublin; and when it was determined that this communication should be superseded by railway, it became a matter of most serious consideration how these two openings were to be spanned, keeping in view the new conditions of stability required for railway traffic; and the subject having been remitted to Mr. Stephenson, the engineer of the line of railway, namely, the Chester and Holyhead, he at once rejected the principle of the suspension bridge as inapplicable, owing to the undulations to which it was liable, and which had been proved by practice in a similar bridge for a railway across the Tees, to be both inconvenient and dangerous. How far the principle might have been modified by the introduction of proper ties and braces may be a question; but in a case of such vast magnitude and importance there might still have been risk, and, on the maturest consideration, Mr. Stephenson determined to recommend the simple and bold design of a hollow rectangular tube of malleable iron, consisting of thin plates rivetted together, such as he had already tried with success on a smaller scale upon railway bridges, and which he conceived was the best form for securing not only strength, but sufficient stability and stiffness to prevent any undue oscillations or vibrations. To carry out this plan, the assistance of the first authorities, scientific and practical, on the strength of materials was called in, and to Messrs. Hodgkinson and Fairbairn the duty was remitted of trying the effect with experimental tubes on a small scale, and finally on a model one-sixth of the dimensions of the bridge, being 75 feet long. Much valuable information was obtained during the progress of these experiments. The first thing observed was the uniform tension of the under side of the tube when loaded, and the violent compression of the upper side, forming a beautiful illustration of the nature of the tensile and compressive forces already laid down. The former, by its uniform tendency to produce the stable equilibrium, bringing the thin masses into a straight line, the line and position of repose; but the latter, on the contrary, tending to produce flexure in the plates, to push them out of the straight line, and push everything out of joint; so that when the bottom plates remained firm, and retained their form, the top plates became bagged up and puckered like a loose web of cloth. The top plates were, therefore, strengthened, and the addition of another plate to the top increased the breaking weight from 3,700 lb. to 4,500 lb.

As it was not so much strength that was wanted on the top plate as stiffness, in place of adding layer upon layer of plates, the idea naturally occurred of forming the top plate into a series of little hollow square tubes running longitudinally the whole length of the bridge, having the appearance, looking endways, of little cells, the effect of which was such, that while the top plates remained firm, the bottom ones now appeared to give way. These being next strengthened, an extraordinary effect was then exhibited when the tube broke, the sides collapsing together, and twisting and distorting the whole fabric in a singular manner, showing that the sides formed now the weak point. These, then, were strengthened and stiffened by numerous ribs of angle-iron running vertically from top to bottom, and at last, by these repeated trials, the strength and proportions of the different parts of the structure appeared to have attained a fair and proper distribution. The strength of the tube, which at first only carried seven times its own weight, was then increased to eleven times, and from these experiments the strength and proportions of the real design have been calculated, and one of these tubes, as is known, has now been actually constructed on the shore of the Conway, floated by water to its place, and raised to its proper height by the power of two enormous hydraulic rams, one at each end, lifting the gigantic mass, which is 412 feet in length, 15 feet wide, $25\frac{1}{2}$ feet high, and weighing no less than 1,300 tons. This is intended for one set of rails, and there is another tube of the same dimentions in preparation to be set parallel to it for the other.

The situation of the structure close to the suspension bridge, and close to the base of the magnificent Castle of Conway, and the effect of spanning the wide estuary of the Conway, were all illustrated by a beautiful drawing, and the nature and construction of the tube or bridge itself, was illustrated by a model which he had himself constructed. The model was composed of only three thicknesses of paper and one of cloth, and the sides were strengthened by thin slips of wood to represent the angle-iron; it was 8 ft. 6 in. long, $6\frac{1}{2}$ inches deep, and $3\frac{1}{2}$ broad, and although weighing only 4 lb. it carried a weight of 32 lb. in the centre, without visible deflection.

The dimensions and structure of the bridge he would now describe, from information for which he was indebted to Mr. Fairbairn of Manchester, and, through Mr. Stephenson, to Mr. Edwin Clarke, the resident engineer under him.

The sides of the tube, which are $25\frac{1}{2}$ feet deep at the centre, consist of malleable iron plates, only $\frac{1}{2}$ inch in thickness, rivetted together in plates 2 feet broad and from 4 to 8 feet long (as was shown in an enlarged view or elevation with cross sections), adjusted so as that the joints may break band. At the joints, however, the strength and stiffness of these plates is greatly increased by slips of angle or T iron, one of which is laid on the outside of the plate and the other opposite to it on the inside, face to face, and all the four surfaces strongly rivetted together. The top of the tube, again, consists of two separate horizontal plates, running parallel to one another, 1 ft. 9 in. apart, forming together as it were a ceiling to the tube or tunnel and an external flooring on the top. These plates are $\frac{5}{8}$ inch thick, rivetted together in breadths of 2 ft. 9 in. thick, and in lengths of 6 feet, and between them there runs seven vertical plates longitudinally, from end to end of the bridge, 1 ft. 9 in. high and $\frac{1}{2}$ inch thick, separating the ceiling from the floor or upper platform, and at the same time uniting them strongly together by rivets and joints, each vertical plate having a rib of angle-iron on each angle, running longitudinally the whole length, by which it is united into one vast cellular mass, consisting of eight separate cells or tubes, 1 ft. 9 in. square. The object of all this strength and distribution of materials is to give the necessary stiffness and strength where the compressive force acts. And on this account the top and bottom plates are merely united by butt joints with covering plates. The whole sectional area of this cellular frame consists of 608 square inches. Lastly, the bottom of the tube consists of a similar frame of cells, but only six in number. The upper plate consists of two layers of plates, each $\frac{1}{2}$ inch thick, and the under one the same; but as these plates are intended to resist tension, and ought to be formed, if it were possible, like a chain, besides being laid in two layers, the plates are arranged so as to break joint, and a covering plate 3 feet long and as thick as the plate is placed over every joint with sufficient rivets, such that the tearing strain is equal to the tensile strength of the plates they connect. The plates are 12 feet long and 2 ft. 4 in. broad, being the whole breadth of the cell. The angle iron in the bottom cells and plates is rendered continuous by covers.

The top and bottom are united to the cells by strips of angle-iron running the whole length, inside and out; the interior vertical angle-irons at top and bottom are curved round to increase the strength of attachment, and there are also gusset or angle pieces rivetted on for additional strength. The rivets used vary from 1 inch to $1\frac{1}{4}$ inch diameter, and there are about a quarter of a million in each tube. The holes were made so as to make the rivets fit well, and they were all put in red hot. The sectional area of the bottom frame of cells is 508 square inches.

These are the dimensions in the centre of the tube, but the top plates become thinner towards the ends, where they are only $\frac{1}{2}$-inch thick, and also the bottom plates, where they are reduced to $\frac{1}{4}$-inch each. The side plates again get thicker towards the ends, where they are $\frac{10}{16}$ths thick. The ends of the tube are stiffened with cast-iron frames, and there are also castings in the cells for 8 feet at the ends, and the sides are also greatly strengthened at the ends. The tube was originally curved on the top 7 inches, and was brought to the straight line by the elasticity of the material as calculated on; showing that with its own weight, 1300 tons, it only sunk 7 inches. The one end of the tube is to be fast in the stone pier or abutment, the other is to be loose to allow of expansion, which has been found quite visible in different states of the atmosphere. Mr. Clarke says that the tube is a sensible thermometer,—half-an-hour's sunshine at one end, or on the top, will move it laterally an inch and a half, and vertically two inches, and this when the tube is loaded with 200 tons in the centre.

Such are the dimensions and structure of this extraordinary work, and in regard to which, he was happy to say, the trials which have been already made appear to promise every success. A load of 100 tons only sunk the tube 1 inch in the centre. In regard to the calculation of strength he was not able to enter on these at present for want of some of the data, but expected to do so on a future occasion.

The thanks of the Society were voted to Mr. Buchanan for his excellent and instructive exposition; and also to Mr. Stephenson, Mr. Fairbairn, Mr. Clarke, and Mr. Harrison, civil engineers, for communicating the information relative to the tubular bridges at Conway and Menai, and viaduct at Berwick; and to Mr. Miller, C.E., for allowing his elegant model of the viaduct at Dunglass to be exhibited. Mr. Buchanan was at the same time requested to continue his observations, and lay them before the Society at a future time, which request he kindly promised to comply with.

At the conclusion of the above paper, the following communications were read:—

1. "*On a new Lubricant for Machinery*" By Mr. Alexander Bryson.—This paper described a new compound, possessing properties which seem to render it a better lubricant than those in use for large machinery. It is composed of oil, sulphur, and vulcanised caoutchouc.

2. "*On Economising Fuel in Gas-Works.*" By Mr. William Kemp.—The author states that he has made a valuable discovery in economising fuel, at Galashiels Gas Works, by which almost all expense of fuel is saved. Where coal tar is burned, it has an injurious effect on the furnace bars and retorts, the greatest annoyance arising from the rapid clinkering up of the furnace bars, to remove which the firemen had frequently to throw water into the furnace, which caused the rapid destruction of the bars. To prevent this, the idea occurred to the author, of using the exhausted tan bark of the tan works, which had the desired effect. The force-pump for injecting the tar into the furnace was next thrown aside, as it was found that the dry bark absorbed tar equal to its production at the works. His method is as follows:—The bark is dried and mixed with the coke of the gas coal, bulk for bulk; a pailful of tar is thrown upon it, not quite so much as it will absorb, and it is then turned over. The mixture burns with a fine clear flame, attended with less smoke than formerly; the furnace bars, by remaining unclinkered, admit the oxygen freely for the combustion of the fuel. Where tan bark cannot be had, peat moss, loose and dry, makes a good substitute. The author states that in one year £126 was saved on furnace coal; and he has pledged himself that, in future, not a penny shall be required for that article.

3. "*Description and Drawing of a new Plate-Holder for the Daguerreotype Camera.*" By Mr. Andrew K. Sparke.

Mr. Sparke's plan is as follows:—A small mahogany box is made rather larger than three times the breadth of the plate, and half an inch on each end deeper; the width is three-eighths of an inch. A hole is cut in wood the size of the plate, and in the centre of the large pieces. In this box a veneer frame is made with a place for the plate and glass, on a line with each other; this is pulled backward and forward by a piece of wire or string, through a hole made at the corner. By this arrangement the plate is instantly exposed to the lenses, and will be found admirably adapted for taking moving objects. It saves the trouble of shifting the ground glass frame for the plate-holder, and the consequent risk of moving the camera, so annoying in the old plan. The plate is also exactly the same distance from the lenses as the glass. For a camera not achromatic, the ground part of the glass may be placed outwards, so that the plate will be the thickness of the glass nearer the lenses than the image seen on the ground glass, and consequently nearer or in the chemical ray.

INSTITUTION OF CIVIL ENGINEERS.

March 28, and *April* 4.—Joshua Field, Esq., President, in the Chair.

The paper read was "*The Engineering of the Rhine and the Moselle.*" By Mr. G. B. W. Jackson, Assoc. Inst. C.E.

This communication was written during a short visit made to Holland, for the purpose of inspecting personally the works with which the author had become familiar in the writings of Beaudemoudin, Vanden Bergh, Delafontaines, Hibbert, Krayenhoff, Ockhart, and Wiebeking. It commenced with tracing the geographical course of the Rhine from its source on the Badus, in the canton of the Grisons, to its numerous outfalls into the sea. It then treated at considerable length the geological character of the country through which the river and its branches thus traversed. The ancient works, as far back as the time of the Romans, were then briefly described; and the general state of the bed of the river, with the comparative levels, the inclination and the velocity of the stream, at the commencement of the modern works, were then laid down in a tabular form, as points of data; and then the capability of the Rhine for forming banks by warping, or depositing the matter held in suspension, was discussed. The remainder of the first part of the paper was then occupied by descriptions of the modes of straightening the bed of the river, and of constructing the dams, weirs, division arms, spurs, and shore works, and the method of blasting the rocks, which latter considerably impeded the course of the stream. Our limits will not permit us to follow the details of these works, which differ so essentially from any in our own country, but the whole proceedings appeared to be given with such precision, that the paper, when it is published at length, with the copious details with which it was illustrated, will form a most interesting portion of the minutes of proceedings.

The second part of the paper consisted to considerable extent of a translation of an account of the spurs, groynes, and other works on the Moselle, for restricting the dimensions of the bed of that river, and increasing the depth of water, so as to enable the navigation to be carried on, which would otherwise be averted in the low-water seasons. It was shown, that to effect this, numerous arms of the river had been dammed across, and allowed to silt up; the course had been straightened, elbows had been cut off, and the convex shores, after being silted up by deposit between the groynes, were defended by arming of fascines, &c. Division banks had been established for the inflowing rivulets, so as to carry the gravel to a greater distance down the stream. Rocks also were removed by powder, and general improvements to such an extent were executed, that the river was comparatively under good control.

The account of the Rhine was then resumed, and, after detailing the various plans that had been proposed for ameliorating its course, giving numerous interesting and valuable tables of Blanken's and Bolstra's experiments as to the tides, the inclination of the bed of the various rivers, the duration of the ebb and flow, and average height of the river at the time of new and full moon, the height of various dykes above the extraordinary flood-line, &c., the paper finished with these general views:—"On looking at the map of Holland, and tracing its various streams, it certainly does not appear singular that frequent stoppages should take place in that country, whilst such occurrences are comparatively rare in Germany; for, as long as the Rhine retains its single course, as at Emmerick, no obstacles, excepting elbows, stay the progress of the current seawards; but, as soon as it divides at the Waal and Pannerden Canal, the evil commences and increases, according to the number of arms and channels lower down. It is generally agreed that a river should have as few outlets as possible, in order to allow it the more effectually to clear itself; and that the tide should be admitted as far as possible, whilst at the same time, the action of the winds should be diminished; again, that the more the surface water of any river is obstructed, the more quickly the sand will accumulate; and also that, if a cut be made, it is usual for ice stoppages to take place below it, so as to raise the water-level above; and it is also agreed, that if a cut be made, as capacious as the river itself, or be permitted to increase to that extent, it will soon get beyond control, whilst the sand will accumulate rapidly—and that when openings exist in dykes, the ice gets into eddies, loses its velocity, and by degrees closes up the passage below the opening, so as to raise the water above. The question, therefore, to be solved with regard to Holland and the system followed there, in order to prevent breaches in dykes, and to save the better part of the country (taking into account its weak, marshy soil, and its incapacity to withstand any great force), is whether it be the better plan to relieve the pressure on the dykes, by cuts and new channels, and local floodings, at the expense of increasing the number of ice stoppages; and, at the same time, diminishing the velocity in the main rivers, thereby greatly augmenting its liability to accumulating sand. It is true, as already stated, that the rivers are at present in such a condition, that it must be very expensive to effect anything of importance; but the question is of such vital importance to the port of Rotterdam, and the certainty of the mouth of the Meuse at the Brielle in the course of time closing up like that at Katwyk, if no improvement be attempted, is so clear, that it is very much to be regretted some steps have not been taken ere this to prevent so great a flow of water from passing out by the Hollands diep to Helloet."

The author directs the attention of the Institution to this subject, and gives the following points for the consideration of the members:—"That the object to be aimed at, in any steps which might be adopted for improving the Meuse at Rotterdam, should be to protect and strengthen the shores and dykes likely to be operated upon by the alterations; to straighten all the curves on the Leck, so as to lessen chances of ice stoppages; to separate the Waal and Meuse waters as much as possible, and to lead off the former, together with the Leck, into the sea by the Brielle; to narrow the Bresbosch channel (now divided) into one, regulating the quantity of water; to close the Krabbe, the Noord, and the Spry, with sluice gates; and, for the purpose of widening the outlet, to join the Island of Rosenburg to the main land at Vlaardingen—thereby causing the ebb water to act upon this island, and with increased velocity and an additional quantity of water, attempting to remove the bar and shoals."

April 18.—"*Observations on the Resistances to Railway Trains at different Velocities.*" By Mr. D. Gooch, of the Great Western Railway.

For the purpose of performing the experiments, a dynamometer carriage was constructed at Swindon, in which all the results required were registered upon a large scale, on the same roll of paper, thus exhibiting at one view, and in the same period of time, the tractive power exerted upon the train, and the force and direction of the wind; the registration of the results was made upon the paper at every sixteenth part of a mile, and the time was registered in correspondence with the distance traversed during every fifth part of a second. The dynamometer spring used was 7 ft. 6 in. long, and very carefully arranged. It was only necessary to count the number of seconds, or fractions of a second, in one or more of the distance divisions, and the speed was accurately ascertained. The force and direction of the wind was ascertained by a wind gauge, placed 5 feet above the top of the carriage, with the connections brought down to pencils which indicated on the same sheet all the results. Indicator cards were also taken simultaneously from the steam cylinders as frequently as was practicable, but not continuously, as it was a service of some danger, the experimenter being obliged to sit on the buffer-beam of the engine at a velocity of 60 miles per hour, and in that windy position to take off four sets of cards in three quarters of a minute. The spot selected for performing the experiments was one mile of railway perfectly straight and level, and nearly on the surface of the ground; and in the plan the height of the trees, hedges, and every intervening object which could affect the influence of the wind is clearly marked. The experimental train consisted of first and second-class carriages, each on six wheels, 4 feet diameter, taken indiscriminately from the working stock, and loaded with iron to represent a fair load of passengers, giving a gross weight for each of 10 tons. The experiments were tried with various weights and speeds up to 100 tons and to 62 miles per hour, and the results were classified and arranged in a tabular form, with copious explanatory headings, so as to render reference to them exceedingly easy.

The author first reviewed the deductions of Mr. Wyndham Harding's formula, which was given at the discussion at the Institution in 1846, and gave his reasons for dissenting from that formula. He then examined critically several experiments recorded in the tables, stating candidly all the exceptions that could be taken to them; showing that although there was a difference of as much as 52 per cent. shown between the resistance as calculated by Mr. Harding's formula and the experiments made by Mr. Gooch, that difference might be accounted for by the methods employed by Mr. Harding, which were objected to, as calculated to produce erroneous results; viz., allowing carriages to run down inclines by their own gravity, using wheels of 3 feet diameter instead of 4 feet, having a much greater length of train for the wind to act upon, &c. He reviewed the great effect of a side wind against a train—driving the flanches of the wheels against the rails; and argued that the length of a train of carriages was much more important than its own weight. The author did not offer any formula that should be applicable for calculating the resistance of all railway trains; but his tables gave examples of almost every case that could occur, and thence data could be supplied for those who wished to carry the investigation further, and make a formula for themselves. He arrived at the conclusion that in practice the friction of the axle-journals was not a constant quantity at all speeds, and thought that the number and diameter of the wheels in a train, in proportion to the weight, should form elements in any general formula. He showed by experiments that the total atmospheric resistance to a train weighing 50 tons differed but slightly from that to a train of 100 tons weight, if the carriages were small and the train long in the one case, and the reverse in the other case.

The general result of the diagram of resistance with trains of 100 tons and with 50 tons showed that the resistance calculated by the narrow-gauge formula with a 50 ton train, at 62½ miles per hour, was 37 lb.; with a train of 100 tons, by the same formula, at 61 miles, it was 31½ lb. The broad gauge resistance, with a train weighing 50 tons, at 62½ miles per hour, was under 23 lb.; and with a train weighing 100 tons, at 61½ miles per hour, was 22½ lb. We cannot, of course, give fully the results, except in a comprehensive form, but such were the general results.

The author concluded his paper by saying that it appeared to him necessary, before any general formula for calculating the resistances to railway trains could be made, that the value of the following elements, necessary in such formula, should be determined by experiments:—

1. The axle-journal friction, at different velocities and with different weights, per square inch of journal surface.
2. The resistance to the rotation of the wheels and axles per pair at different velocities and with different diameters.
3. The resistance due to the rolling of the wheels upon the rails, with different weights upon them, and with different diameters.
4. The resistance due to the passage of the train through the atmosphere, at different velocities, with different proportions of weight, and length and breadth of train.
5. The resistance due to the oscillation or unsteady motion of the train, at various speeds.

The author considers that all these values might be determined, with a considerable degree of accuracy, by careful experiment.

SOCIETY OF ARTS, LONDON.

April 12.—Sir J. V. Boileau in the Chair.

Mr. Digby Wyatt, architect, read a paper "*On the Art of Enamel, Ancient and Modern.*"

The paper commenced with some remarks on the necessity of increasing the resources of the designers of metal work, by effecting changes in the process of manufacture; and by that act, producing a novelty which might possess all the charm of freshness, without any of that extravagance so constantly resorted to in the attempt to produce variety. The art of enamel presented this so much wished for desideratum, whereby by imitating the practice of the mediæval artists in this material, we might considerably enrich our industrial resources, and facilitate the execution of beautiful works of utilitarian art.

After a hasty description of the composition of pure enamel, and the nature of the pigments usually employed to colour it, Mr. Wyatt proceeded to enumerate the six leading varieties which had been adopted, at various periods in the history of the art, to unite the vitreous paste with its metallic base; endeavouring, as far as possible, to describe each genus in the language of some contemporary authority. The first, or Byzantine process, which obtained throughout the Eastern empire, from probably the time of Justinian, down to about the year 1300, was illustrated from the particulars furnished by Theophilus, the celebrated artist monk of the 11th or 12th century; and its chief peculiarity appeared to have been the formation of casements, or cavities, for the reception of the enamel, by means of gold filigree.

The second, or early Limoges style, which was so much practised in that city, from probably the 11th century, until the frightful siege and massacre by the Black Prince, was described from a comparison of the admirable notices of Mr. Albert Way with those of MM. Petit, Dussieux, Pottier, and the Abbé Texier; and would seem to have substituted for the filigree compartments of the Byzantine mode, incisions in the thick copper plate by the graver.

The third, or early Italian mode, practised for probably some 50 years before the days of Ugolino Veri, the artist who executed the celebrated shrine in Oevieto Cathedral in the year 1338, and carried on by subsequent goldsmiths and enamellers down to the end of the 16th century, was detailed from descriptions given by Vasari and Benvenuto Cellini; about the middle of that century it appears to have held a midway position between the ancient *champ levé*, or incised, and the painted enamels afterwards produced, consisting in engraving silver after the manner of medallic relief, and then floating it over with variously coloured transparent pastes.

Benvenuto was said to have, if not invented, at least been the first to describe the improvement that took place about the beginning of the 16th century, in the art which constituted what Mr. Wyatt called Jeweller's enamel. It consisted in using as a vehicle, with the glass powder employed to cover small gold or silver objects in the round, or in the highest relief, water in which pips of pears had been steeped. This held the paste in its place until vitrifaction took place, and was yet so delicate a cement, as in no degree to interfere with the perfect purity of the enamel.

The fifth, or "late Limoges" variety, was described as having sprung at once, fully armed, from the brain of that Jupiter of enamel workers, Leonard Limousin, under the auspices of Francis the First, and differed from its predecessors chiefly in covering the entire surface of the metal with an opaque paste, and then painting on it with transparent colours; regaining the effect of a translucent ground by applying silver leaf in particular situations, fastening it with a glaze of colourless enamel, and then tinting over it. These peculiarities, as well as the *peinture grisâtre*, and touching with gold, were illustrated from the interesting manuscripts published by M. Maurice Ardent, of Limoges. This style appears to have dwindled into nonentity under the hands of the Nouailhers, a family who lived (they can scarcely be said to have flourished) during the latter part of the 17th century.

In connection with the detail of the sixth and last process—the Miniature style—honourable allusion was made to the labours of Sir Theodore de Mayorne (whose interesting manuscript we may shortly hope to see published under the auspices of Mr. Heindrie) and his connection with Petitot, the principal and best known of this school of art. The improvements effected in this style would seem to have been a great enrichment of the palette, by the addition of new pigments, the power of multiplying the number of firings, and graduating the succession of tints, their hardness, and fusibility, by the addition of fluxes, &c. Unhappily, the mystery many selfish artists have thrown over their modes of procedure, renders them exceedingly difficult to analyse or describe.

Mr. Wyatt then commencing with Egypt, gave a rapid sketch of the history of the art, noting the barbaric enamels existent in the North, probably previous to the Norman conquests; touching on the connection between the Limoges and Byzantine schools; and tracing, though necessarily very briefly, all the salient points in its existence, both as a manufacture and as an art, in our own and other countries. He glanced at what had been recently done in the *ateliers* of Wagner and Rudolph, at Paris, and the exquisite paintings of Messrs. Bone and Essex; and concluded by expressing an earnest hope that the knowledge of art possessed by those gentlemen might soon be grafted on the skill of our workmen, and that we may ere long adopt, and fully carry out, the old practice of the middle ages, so ably characterised by the Abbé Texier, in his eloquent declaration that, "in those days, Art and Manufactures were blended and identified; Art gaining by the affinity great practical facility, and Manufacture much original beauty."

Sash Line.—Messrs. Newall and Co. have greatly improved their patent copper wire cord, which is now made extremely flexible, and is well adapted for window-sash-line, hothouses, lightning conductors, picture-cord, clock-cord, bell-hanging, and many other purposes for which hempen rope has hitherto been used; the advantages being that it is cheaper, much more durable, and one-sixth part the bulk of hempen rope.

COMPOSITION OF COAL GAS.

Extracts from a lecture, by Dr. A. W. Hofmann, *delivered at the Royal College of Chemistry, Hanover-square.*

The composition of gas evolved in the distillation of coal is by no means constant; on the contrary, it varies to a considerable extent, depending principally on the nature of the coals, the presence or absence of moisture, and the temperature at which the distillation takes place. The chief elements which constitute coal are carbon and hydrogen, with small quantities of nitrogen and oxygen; and, according to the quality of the coal, a larger or smaller amount of earthy matter. Another frequent ingredient is sulphur. This sulphur occurs almost invariably in combination with iron, in the form of iron pyrites. The quantity in which it exists varies very considerably; many kinds of coal contain so large an amount that they become altogether useless for the purpose of distilling gas. If coal be ignited, and atmospheric air excluded, a portion of its elements are evolved as gas, and the remainder become coke. The gases thus evolved contain carbon, hydrogen, nitrogen, oxygen, and sulphur. None, however, of these elements, except nitrogen, are found in an uncombined state among the products of the distillation of coal.

The following tables show the different combinations into which these elements enter during distillation. These combinations are very numerous, and are divided into two groups—viz.: substances which are solids or liquids at the ordinary temperatures, and compounds which present themselves at the common temperature in the form of gas.

COAL GAS NAPTHA.

	Acid Portion.		
Hydrate of phenyle.. ..	C 12 ..	H 6 ..	O 2
	Neutral Portion.		
Benzol	C 12 ..	H 6	
Tolnol	C 14 ..	H 8	
Cumol	C 18 ..	H 12	
Napthaline	C 20 ..	H 8	
Paranapthaline	C 30 ..	H 12	
Pyren	C 15 ..	H 3	
Chrysen	C 12 ..	H 4	
	Basic Portion.		
Aniline	C 12 ..	H 7 ..	N 1
Picoline	C 12 ..	H 7 ..	N
Leucoline	C 18 ..	H 8 ..	N

Note.—The letters represent—C, carbon; H, hydrogen; O, oxygen; N, nitrogen, and so on; the figures designate the number of atoms of which each volume is composed—thus, one atom of aniline contains 12 atoms of carbon, 7 of hydrogen, and 1 of nitrogen.

The above series of substances are each of them highly interesting to the scientific chemist, whilst several are likely to become of high practical utility. These substances, along with others which are little known, constitute the complex viscid mixture called "tar;" and it is rather singular that many of them, in their separate form, are oils, possessing the most delightful odours.

The second table exhibits the different constituents of the gaseous products of the distillation of coal, as follows:—

CONSTITUENTS OF COAL GAS.

Name of Constituent.	Proportions.	Spec. Grav.	Products of Combustion.
Hydrogen	H	0·0691 ..	Water.
Light carburetted hydrogen	C H 2	0·5528 ..	Water and carbonic acid.
Olifiant gas	C H	0·9674	Water and carbonic acid.
Volatile hydrocarbons ..	C n H n	..	Water and carbonic acid.
Carbonic oxide	C O	0·9674 ..	Carbonic acid.
Cyanogen	C 2 N	1·8010 ..	Carbonic acid and nitrogen.
Sulphide of carbon ..	C S 2	—— ..	Carbonic acid and sulph. acid.
Sulphuretted hydrogen	H S	2·0620 ..	Water and sulphureous acid.
Ammonia	H H 3	0·5897 ..	Water and nitrogen.
Sulphureous acid ..	S O	2·2114 ..	——
Hydrochloric acid ..	H C l	—— ..	Incombustible gases.
Aqueous vapour ..	H O	—— ..	Incombustible gases.
Nitrogen	N	0·9720 ..	Incombustible gases.
Carbonic acid	C O 2	1·5203 ..	Incombustible gases.

In this table, the first is *hydrogen*, one of the constituents of water. From it is obtained a colourless transparent gas, remarkable for its low specific gravity, being one of the lightest substances known. It burns with a pale flame, requiring ½ a volume of oxygen, or 2½ volumes of atmospheric air, for its combustion. It is not, however, the luminous principle of coal gas. The next, *light carburetted hydrogen*, or *marsh gas*, is a compound, combining a proportion of carbon with two equivalents of hydrogen (C H 2). This gas, along with carbonic acid, is produced by the putrefaction of vegetable substances under water—hence its name of *marsh gas*. It burns with a pale bluish flame, rather more substantial than that of hydrogen—though it is also evident that it could not be, any more than the other, the illuminating principle of coal gas. The chief constituent of coal gas is *olefiant gas*—a name derived from its property of producing, when in contact with chlorine at the common temperature, a peculiar aromatic oil (of which a specimen was exhibited). It very much resembles chloroform, and no doubt but that it has also the same remarkable properties. It is far richer in carbon than marsh gas, the per centage of the latter being only 75, while that of the former is more than 85. Olefiant gas burns with a beautifully brilliant flame, and constitutes the true illuminating principle of coal gas. It requires for combustion to one volume of olefiant gas, three of oxygen, or 15 of atmospheric air. Marsh gas is composed of one atom of carbon, and two of hydrogen; while olefiant gas combines the two in equal quantities. There is, therefore, a large amount of carbon in this gas, which may be proved in a striking manner, by lighting an admixture of one volume of olefiant gas with two of chlorine, which will produce hydrochloric acid, and deposit all the carbon contained in the gas in a cylinder, in the form of a dense smoke, which renders the gas perfectly opaque.

Volatile hydro-carbons was the next constituent, but with respect to which, at present, there was not much known. The first table contained the names of several substances which had been extracted from the liquid products of the distillation of coal, called tar. These substances differed much with regard to their physical properties—some of them boiling only at very high temperatures, while others volatilised at a heat far below that of boiling water. It was evident, then, that the gas, generated along with these liquids in the retort, would carry off a certain quantity of these hydro-carbons—varying with the distance from the works at which the gas was examined. The great importance of these hydro-carbons in the luminous effects of coal gas would become obvious if their composition were considered. Benzol, for instance, contained not less than 92 per cent. of carbon, a far greater amount than that of even olefiant gas itself. This was proved by inflaming a small quantity of the liquid, so as to allow it an insufficient quantity of oxygen for complete combustion; and, in this way, a large portion of the carbon was separated. When mixed with a due amount of oxygen, the combustion of this liquid afforded a splendid light.——[The talented lecturer showed this, by passing a current of atmospheric air through the lighted benzol; and also illustrated the peculiarly rich illuminating power of this vapour, by passing it through the pale and almost invisible flame of hydrogen, which, when thus combined, gave out a volume of light, which gradually and steadily increased in vividness, until the eye could no longer bear its dazzling brightness.]

Carbonic oxide was the next constituent. Carbon combined with oxygen in two proportions, forming two compound gases; the one containing the smallest proportion of oxygen was called *carbonic oxide*; and the other, containing the largest proportion, *carbonic acid*, which appeared as the last item in the table. Both these gases were colourless, but their properties exhibited a striking difference. Carbonic acid was not inflammable, whilst carbonic oxide burnt with a pale blue flame, of little or no luminous power. Again, the latter was quite insoluble in water, while the former dissolved, particularly when the water contained a little alkali, so rapidly as to form a vacuum.—[This was illustrated by experiment.] This solubility rendered easy the removal of carbonic acid from coal gas; but no method had been discovered of separating carbonic oxide, which burns with gas, though it adds nothing to its illuminating power.

The other gases were produced in the distillation of coal gas in very small quantities; he should, therefore, only briefly notice them. There were two more compounds of carbons—the one with nitrogen, and the other with sulphur; the former of these were called *cyanogen* and the latter *sulphide of carbon*. Cyanogen was distinguished by its beautiful violet flame—carbonic acid being produced in its combustion, and nitrogen set free. It was also remarkable for its solubility in alkalies—cyanide of potassium being produced, which, with ironsalts, yielded Prussian blue. This gas occurred in coal gas in such small quantities, that its presence might, for a long time, have remained unknown, but for the very delicate test chemists possessed for cyanogen, by which the smallest traces could be detected. Sulphide of carbon was highly inflammable, burning with a blue flame, and producing carbonic and sulphureous acids. These substances had been actually found in coal gas, though they were by no means produced from every kind of coal.

Sulphuretted hydrogen was the next substance on the list; it was, however, invariably generated, and that too frequently in considerable quantities. Sulphurets of iron, or iron pyrites, which were disseminated through the mass of the coal, was the source of this gas; and its quantity, therefore, depended upon the amount of that mineral in the coal. Sulphuretted hydrogen was also the offensive principle in the exhalations from putrefying substances containing sulphur. Sulphuretted hydrogen was a colourless gas, burning with a pale blue flame; it had not only a most offensive odour, but produced a most deleterious effect upon health, even when mixed with a large proportion of atmospheric air. He had frequently witnessed, in the laboratory, fainting produced by the inspiration of this gas incautiously. Professor Faraday had proved, that a dog would die in an atmosphere of which 1-800th only was this gas; and that a bird could not exist if the gas formed only 1-1500th of its breathing medium. Fortunately, this gas was converted, by combustion, into sulphureous acid, which was very much less dangerous and offensive. It was necessary, however, in making coal gas, to obliterate every trace of sulphuretted hydrogen, for the sulphureous acid it produced, although far less injurious, independently of its effect upon health, attacked very readily every metallic surface. Besides, the small quantity of sulphuretted hydrogen which would escape unburnt between the turning of the cock and the ignition of the gas at the burner, and by leakage, was sufficient to destroy lead, painted, gilt, or silvered articles, in a very short time. The presence of sulphuretted hydrogen might easily be detected in gas, by submitting a piece of paper, moistened with the solution of acetate of lead, to the gas uninflamed.

Ammonia was another product, largely found in the distillation of coal gas, into which nearly all the nitrogen contained in coal was converted. Ammonia was a colourless gas, which, of itself, was very difficult to inflame, though, when mixed with other combustible gases, it was entirely consumable. Respecting the products of the combustion of ammonia, accurate experiments were still wanting. According to all known analogies, they were certainly water and nitrogen. Many works had stated that nitric acid was also produced; but he could find no actual grounds for this; and he believed, like many other such statements, it had been copied from work to work, and repeated until it had become received as a well-established fact, without the slightest claim to such a consideration. In all his experiments, he had never been able to find the smallest trace of nitric acid. Ammoniacal gas was very soluble in water, more so still in acids. The great avidity with which it was thus absorbed, rendered its separation from coal gas very easy.

Sulphureous acid was the product of the combustion of sulphur in the coal; and *hydrochloric acid* from the decomposition of some chlorides, when they were present in the coal. *Aqueous vapour* was the result of moisture in the coal. The *nitrogen* in coal gas was the residue of the atmospheric air contained in the retort—the oxygen of which was expended in converting a portion of the carbon and sulphur of the coal into carbonic oxide, carbonic acid, and sulphureous acid. Nitrogen was a colourless, transparent, and incombustible gas, which, being soluble neither in acids nor water, could not be separated from the coal gas. *Carbonic acid* had been considered with carbonic oxide, and that completed the whole of the constituents of coal gas.

The *illuminating principles* of coal gas were olefiant gas and the vapours of volatile hydro-carbons: there were also three other gases burning in the coal-gas flame—namely, hydrogen gas, carburetted hydrogen or marsh gas, and carbonic oxide. Besides these, the gas which we actually burn might contain traces of sulphuret of carbon and nitrogen—all the rest having been, or ought to have been, perfectly separated in the different processes of purification which the gas had to undergo. During the progress of the foregoing short description, the audience had already become acquainted with the manner in which these constituents singly burnt, but they would best obtain a correct idea of the contribution afforded by each, and the illuminating power of coal gas, if they were all lighted at once.—[Dr. Hofmann then lighted the burners attached to the vessels containing the separate constituents, so as to afford a view, at the same moment, of all the various flames.]

By the process of purification which coal gas underwent before it was fit for use, the cyanogen compounds, the sulphuretted hydrogen, the ammonia, the sulphureous acid, and the hydro-chloric and carbonic acids, were separated; and he proceeded to illustrate this process by passing coal gas, containing several of the above gases, through lime water mixed with a little potash; after which the liquid, which before was tolerably clear, became quite turgid, and the gas no longer contained the deleterious constituents.

The lecturer then proceeded to devote a few moments to describing the manner in which the distillation was effected on a large scale. In the infancy of the manufacture, the coals were distilled in iron pots, but now iron vessels of a cylindrical form were used. These were placed horizontally in a furnace—one fire heating five of these retorts. The shape of the cylinders was not unimportant; and, after various changes, ear-shaped cylinders were now generally preferred—its heating surface being greater than that of any other. The front of the retort, or mouth-piece, as it was technically called, was fixed by screws—iron cement being placed between the flanges to render it air-tight.—[These arrangements, as well as that by which the lid was fixed, were illustrated by drawings and a model.] The lid being fixed, the gas passed through a system of pipes into what was called the hydraulic main—a long, wide, horizontal pipe, half filled with water. Each retort was thus perfectly isolated, and the end of the pipe being kept immersed in the water in the hydraulic main, any one of them might be opened, in order to charge it afresh, without fear of the gas already generated rushing back through the opening. The temperature of the hydraulic main being comparatively low, a large quantity of tar and ammoniacal water was collected in this tube, which flowed into cisterns erected for the purpose. From the hydraulic main the gas passed into a system of refrigerating pipes—the temperature of which was kept low by a constant current of water, whereby another quantity of tar and ammoniac was separated. The gas entered next into the purifiers, respecting which he could not now enter into the various ingenious contrivances proposed by various clever gas engineers and chemists. It would, perhaps, suffice, if he stated merely, that now the gas was forced through hydrate of lime, merely moistened with water.

In conclusion, he begged to offer some general remarks upon the combustion of coal gas. In enumerating the constituents of coal gas, he had pointed out those compounds which must be considered as impurities, and which must be separated before combustion took place; but, at the same time, there were others, contributing little or nothing to the illuminating power of the gas, which, when once formed, could not be separated from the gas. These were hydrogen, marsh gas, and carbonic oxide. Were these, then, to be considered also as impurities? If the gas were used for illuminating purposes, to a certain extent at least, they must be considered as impurities, because they were burnt, and in their combustion, a large amount of heat was evolved; the products of their combustion impaired the salubrity of the atmosphere in which such a light was burning, and no actual benefit or increase to the illuminating power was derived from them. If, then, there were no means of separating these substances when once formed, an effort should be made to prevent their formation. With regard to carbonic oxide, it would be difficult to find a method which secured us against its formation—the entrance of the retort, when being charged, being in communication with the atmosphere. It was, however, in the power of the gas manufacturer to diminish the amount of carburetted hydrogen, and especially of hydrogen. If the temperature of the retort were too high, a large quantity of the olefiant gas contained in the coal would be converted into marsh gas, or even into hydrogen. That this was often actually the case, appeared in a most striking manner, from the following analysis, made long ago, by Dr. Henry, of coal gas made from Wigan coal:—

Analysis of Gas from Wigan Cannel Coal

Time of Collection.	Specific gravity.	C H, or olefiant gas.	C H2, or marsh gas.	C O.	H.	N.
In the first hour ..	0.650	13	82·5	3·2	0	1·3
	0·620	12	72	1.9	8·8	5·3
	0·630	12	58	12·3	16	1·7
5 Hours after the commencement..	0·500	7	56	11	21·3	4·7
10 Hours after the commencement..	0·345	0	20	10	60	10

It would be seen by this table, that it was of the greatest importance that the heat in the manufacture of gas should not be carried to too great an extent. In the first hour, 12 parts of olefiant gas, and 72 of marsh gas, were evolved—while only eight of hydrogen were generated. At the end of 10 hours, not a vestige of olefiant gas was traceable; while the hydrogen amounted to 60—evidently the consequence of the olefiant gas being decomposed by the excess of heat. It had been found that, if pure olefiant gas were passed through a particular temperature it became changed into light carburetted hydrogen and carbon. The ratio of this decomposition was as follows:—

$$C2\ H2 = C\ H2 + C,\ C\ H2 = H2 + C\ .$$

So that it would be seen, that by a judicious arrangement of the heat of the retorts, the production of hydrogen and light carburetted hydrogen, which increased the bulk without increasing the illuminating power, might be kept within certain limits. A very small quantity of these substances might be present in coal gas without injurious effects, as they then served for the suspension of the vapours of the oily hydro-carbons. A mixture, indeed, of these vapours with carburetted hydrogen, in due proportions, might be considered as an equivalent to olefiant gas. Benzol, for instance, contained 92 per cent. of carbon; while olefiant gas itself contained only 85 per cent., and carburetted hydrogen only 75 per cent.; and, therefore, by an admixture of the latter with benzol, the illuminating power of olefiant gas might be obtained. Here, again, he would mention the beautiful process proposed by Mr. Low, for increasing the illuminating power of coal gas, as based upon the most scientific principles. If he wanted to express its nature in a sentence, he should say it was a process for converting a mixture of hydrogen and light carburetted hydrogen, by passing it through naptha, into olefiant gas.

This naturally led to the question—Why did hydrogen possess no illuminating power at all? and why was the illuminating power of marsh gas so far short of the beautiful light produced by a jet of olefiant gas?—and, briefly, in what consisted the illuminating power of olefiant gas? The illuminating power of gas depended upon a portion of it being separated in the solid form, which, being deposited at a certain distance between the orifice of the burner and the rim of the flame, entered into a state of ignition, from which the light emanated. Now, the composition of coal gas was such, that if it were allowed to issue from a convenient burner, a complete combustion of the hydrogen was obtained, but only a partial one of the carbon. Another portion was separated—that which entered into a state of ignition being heated to a white heat before it reached at sufficient temperature for its combustion.

In the flame of coal gas, three different parts, or cones, might be distinguished. Immediately over the burner, it was principally hydrogen which was burnt, along with a little carbon, whilst the main portion of the carbon being thus set free, was ignited in the second cone, and consumed with the rest of the hydrogen in the outer flame. By a simple arrangement, the illuminating power of the coal gas might be destroyed altogether—namely, by mixing it, previous to combustion, with a sufficient amount of air to produce a complete combustion. The illuminating power of coal gas—and, in fact, of any flame—depended entirely upon the deposition of a fixed body in the flame. It was by no means necessary that this body should be carbon. It might be anything else—such as lime, iron, &c.—[The talented lecturer then rendered the flame of hydrogen luminous, by passing through it a chloro-chromic acid; and this interesting lecture was concluded by several clever experiments, illustrative of the various subjects it embraced.]—*Mining Journal.*

STEAM WORKING EXPANSIVELY.

On the Influence of Rapid Motion of the Piston upon the Effect of Steam in Engines working Expansively: with Experiments upon the subject. By M. Paltrineri.—(Translated for the *Journal of the Franklin Institute.*)

The researches and numerous experiments which I have made upon the application of motive power to machines, and particularly my experiments upon the effect of springs, have convinced me that in the expansion of steam there is a loss of power: a loss which should have a certain relation to the number of superimposed strata of steam which occupy the cylinder, from its bottom to the piston.

These strata, moving with the piston, should naturally develope themselves, in order to follow and push it; and it is in this development of strata, one after the other, that the steam must employ a portion of its force, a portion which is certainly lost to the engine. The greater the number of strata, the more rapid is their development; and the more power that is thus absorbed, the less will there remain for useful effect.

Suppose the steam introduced into a cylinder to be intercepted at the moment when the piston has reached a fourth or a third part of its stroke, to give place to the expansion: from this moment we may imagine the fluid mass divided into a determinate number of successive parallel strata, and beginning to develope and expand themselves to drive the piston and follow it. It will then be apparent that the stratum nearest the piston will, without doubt, be able to exert upon it all its effort, and all the rapidity of which it is capable; but it will be also apparent that the one which follows cannot do as much, because the preceding stratum constrains it, by pushing it backwards at the same time that it forces the piston forwards. By its condition as an elastic fluid, steam should naturally expand every way, and maintain at the same time, as is admitted, a uniform density throughout its volume—consequently, the stratum which drives the piston on one side, repels, on the other, at the same time, the stratum which follows it, although allowing itself to be penetrated by it; the latter repels the one which follows it, and so on to the last, which is at the bottom of the cylinder.

There must, therefore, be a collision between one stratum and another, on account of the difference in their velocities, and of the necessary compenetration of one stratum into another, in order that the uniformity of density may be maintained. This collision must evidently produce a loss of power—a loss which should be proportional to the differences of the velocities, and which will be the more considerable according as the number of successive strata is increased, and as the expansion takes place more quickly.

It is from these considerations, confirmed by the results of experiments upon the effect of helical springs, that I am persuaded that a given quantity of steam, working by expansion, will produce more disposable and useful effect acting upon a piston of a large surface and short stroke, than upon a piston of smaller surface and with a stroke proportionably longer, all other circumstances being equal. Desirous of determining the truth of this opinion by rigorous experiment, I caused two steam-engines to be constructed under conditions strictly equal, and calculated to produce the same dynamic effect, according to admitted principles. But in one of them, the relation of the surface of the piston to the length of the stroke was in an inverse ratio to that of the other: that is, if one of the pistons had a surface of 20 and a stroke of 24, the other had a surface of 80 and a stroke of 6; so that the volume produced by the movement of one piston is precisely equal to that of the other. There is, therefore, exactly the same quantity of steam entering and leaving the two cylinders at each stroke of the piston, and, consequently, when the number of strokes is the same, in a given time, in each of the two engines, it ought to be certain that there is the same volume of steam, in the same physical and mechanical conditions, used by each cylinder. These experiments, of which a table is given, were made with all possible precaution, in order that all the conditions of the apparatus should be identically the same; they were repeated several times, on different days, and in the presence of several competent persons.

The following table shows the mean of the results obtained in several series of experiments, the apparatus being always kept under the same conditions:—

No. of Experiment.	Kind of Cylinder	Weight on the Break.	Revolutions per minute.	Virtual velocity of end of break lever.	Pressure on Steam gauge.	Cut off, or space for expansion of steam.	Effect, in kilograms raised 1 metre per second.	Ratio of Effect between the two engines.
		Kilogs.		Metres.	Atmosp.			
1	Wide	1·814	150	7·854	$\frac{4}{10}$	Full.	14·247	1·00
	Narrow	1·614	150	7·854	$\frac{4}{10}$	Full.	12·676	·88
2	Wide	1·754	168	8·796	$\frac{9}{10}$	$\frac{1}{2}$	15·428	1·00
	Narrow	1·418	168	8·796	$\frac{9}{10}$	$\frac{1}{2}$	12·472	·80
3	Wide	2·127	174	9·110	$\frac{6}{10}$	$\frac{2}{3}$	19·376	1·00
	Narrow	1·277	174	9·110	$\frac{6}{10}$	$\frac{2}{3}$	11·633	· 0
4	Wide	2·116	156	8·168	$\frac{8}{10}$	$\frac{3}{4}$	17·283	1·00
	Narrow	0·916	156	8·168	$\frac{8}{10}$	$\frac{3}{4}$	7·481	·43

The numbers in this table will show, at a glance, the difference of effect between the two engines. Although every precaution was taken to avoid error in the measurements and observations, and though the numbers in the table only show the mean result of several series of experiments, I do not assert that the ratios there given are strictly those which should result from the physical law of this phenomenon. New experiments, with engines of greater power, and an exact calculation with regard to the results obtained, can alone establisb, with the accuracy desirable, all these relations. I believe, however, that the reasoning upon which my opinion is founded, and the results of the experiments which go to confirm it, authorise me to make the following conclusions:—

1. That the velocity of the piston has a much more remarkable influence upon the useful effect of steam than has been heretofore supposed.

2. That this influence is very greatly increased, and according to a certain ratio, on account of the amount of expansion which is allowed to the steam; the greater being the expansion, the greater is the difference of effect.

3. That in order to obtain from steam the greatest amount of useful effect, it is necessary to use cylinders as wide and short as may be practically convenient, and that the piston should move at a very low velocity.

It is certainly not unknown that the effect of steam has a relation to the velocity of the piston; but it has not yet, so far as I know, been recognised that the velocity of the piston has a particular and considerable influence upon the effect of the expansion; and I believe myself to be the first who has directed attention to this subject, and who has sought to demonstrate the truth by experiment. The numbers in the table show, in effect, very considerable differences, although the velocities of the two pistons appear only in the ratio of 1 to 4. The experiments mentioned have manifested two other phenomena which have attracted my attention, and which I recommend to the notice of scientific persons: the first is, that in the engines which I used, and when they were worked by expansion, the pistons were compelled, in some of the experiments, to complete their stroke while having against them (on account of atmospheric pressure) a resistance stronger than the force by which they were impelled. The other phenomenon is relative to the work done by the two engines. In most of the experiments made, the useful effect, as measured by the break, was always, and even considerably, more than the theoretical effect of the motive power. Does this difference of effect depend upon the partial vacuum created in the escape-pipe on account of the rapid passage of the steam, so that the pressure upon the piston has a relatively greater force? May this rarefaction in the escape-pipe also account for the continuance in the stroke of the pistons, although they may have been placed in equilibrium by atmospheric pressure before making a half, or two-thirds, of their stroke?

All these questions, the importance of which will be readily perceived by men of science, have need of study and elucidation, by experiments, perhaps of a different kind. On my own part, I shall do all that I can; but I call for the aid of learned persons who are conversant with such matters.

ROYAL POLYTECHNIC INSTITUTION.

This Institution was re-opened at Easter, although the additional buildings are not quite completed. When this is done, there will be greatly-increased accommodation, for the whole building will be doubled in size. The grand theatre will be one of the largest of the class in London, and capable of holding fifteen hundred persons. The screen is likewise of colossal size, so that a vast picture can now be shown on it, with all the resources of powerful instruments. Thus the Institution is in possession of a dioramic exhibition of much greater power, and possessing much more variety than any in London. In the illustration of microscopic objects, the great screen is likewise a valuable accessary, and its results present a striking contrast to what used to be a state of microscopic illustration, but a few years back. The old great theatre has been very much improved, and is now reserved for chemical lectures, the small chemical theatre at the other end of the Institution being devoted to purposes of exhibition. The grand theatre is accessible from three floors of the central hall, so that it can soon be filled and cleared, which is a great convenience to visitors. Over the screen room is a kind of bazaar of objects of ornamental art, consisting of porcelain and glass works, of great merit, from the establishments of Alderman Copeland and others. They show, even more effectively than the exhibition at the Society of Arts, the great progress of these important arts in England. When the front of the Royal Polytechnic Institution in Regent-street is finished, it will make one of the finest buildings in the street, and a very great ornament to it. The alterations have, it is understood, been made chiefly through the exertions of Mr. Nurse, the chairman of the Institution, who has evidently spared no pains or expense, and has succeeded in giving to the metropolis an establishment of a very high class, equally useful and ornamental. The works are such as to do great credit to the skill and taste of Mr. Thomson, the architect.

NOTES OF THE MONTH.

The Art-Union.—The report shows that there has been a falling-off this year of £5,000 in the income. This may be partly attributed to the badness and partly to the threatened government interference, but mainly to the reaction consequent on mismanagement and want of taste. The engravings have caused disappointment to the subscribers, and brought shame upon the committee. Their commercial value has long since been settled, the print with frame and glass being sold at the picture-dealers for seven shillings and sixpence. The engravings have not illustrated any subject of legitimate interest, and have wanted the character of high works of art; their utmost merit being that of middling wall-hangings. Upon such taste, thousands of pounds have been spent most wastefully, for any jobbing engraver could have turned out the whole lot of engravings at a much less price. In example and in practice, the administration of the Art-Union is equally bad, and is very unfavourable to the true interests of art. The plan of prize casts is most illiberal, for it is little better than desecration to break up a mould for the purpose of preventing more impressions from being taken. We must admit that there is no hope of the Society being more useful, even if the control of the prize-money should be taken from the prize-holders, and given to the council,—for the latter have shown their incompetency in everything they have undertaken, like most self-elected bodies.

Paper-hangings prepared by means of Nitrate of Silver and other Salts.—M. Larocque presented a paper to the *Academie des Sciences*, Paris, explaining a new process for colouring and designing paper-hangings. He observes, that nearly all the salts are volatilised under the influence of vapour from water or saline solutions, and that the nitrate of silver, among other salts, on account of its easy reduction, would furnish a great variety of shades of colour; and by means of reserves made in the paper, any designs in white might be obtained. The following is the process employed:—"Take of pure nitric acid, sp. gr. 1·50, two parts; and distilled water, one part. Place the mixture in a porcelain capsule and heat it, throw in about two ounces of silver, and continue to apply heat until the action of the acid on the metal has ceased; with this quantity of silver 700 or 800 sheets of paper may be coloured. In this operation but a very small loss of silver will be found, for the residue can be formed into nitrate of silver and sold; or, if calcined at a red heat in a crucible with carbonate of soda, the metallic silver may be obtained and employed for a new operation. In order to obtain good designs, it is necessary to operate in a place well lighted and out of currents of air.

Quarrying Machine.—"We took occasion (says the *Newcastle Chronicle*), a few weeks ago, to notice a new stone-drilling machine, and that it would shortly be tested upon some of the quarries in the neighbourhood of Newcastle. We can now state the result of a trial made upon the quarry of Mr. R. Cail, near Gateshead. The machine was put in motion by four men, and worked for an hour and a half, when they attained a depth of 8 feet, of 4 inches gauge. The hole was then charged with 19 lb. of powder, and the discharge produced the removal of 5,400 cubic feet of rock. We understand that it is likely to be very greatly patronised by quarry owners, from the rapidity with which it does its work."

Chemistry of the Sea.—A lecture was delivered on this subject at the Royal Institution, by Dr. Thomas Williams, of Swansea. In commencing, the lecturer demonstrated, by means of an apparatus contrived for the purpose, the effects of pressure on fishes at definite depths beneath the surface of the sea. Having shown that a gold fish, when the water in which it was placed was subjected to a pressure of four atmospheres, became paralysed, Dr. Williams stated the following conclusions as deduced from his own experiments:—1. That round fishes, having an air bladder, cannot, without injury, be exposed to a pressure of more than three atmospheres.—2. That the use of the air bladder is not so much to regulate the specific gravity of the animals as to resist the varying force of the fluid column, and thus to protect the viscera and abdominal blood-vessels against excess of pressure.—3. (Though in this case the results are less striking) flat fish exhibit a limited capacity only for sustaining pressure. From these observations, Dr Williams inferred that the condition of pressure regulated the distribution of fishes in depth. Referring to the experimental researches of Prof. E. Forbes, he expressed his conviction that pressure would be found the most important element in the problem of submarine organic life. He observed that the lower animals evinced a tolerance of pressure peculiar to each species, and determining its zone of depth. The laws of oceanic temperature were next explained. It was experimentally demonstrated, that the expansion of sea-water is considerably greater than that of pure water, under equal increments of heat. It was, however, established by the acrometer, that density did not diminish in exact proportion with the increase of volume. It was argued, that this experiment went to account for the expansion of crystals by heat, as noticed by Mitscherlich; and that it also proved that in the case of two strata of water of dissimilar temperature overlying each other in the ocean, the tendency to intermixture by vertical molecular attraction was greater than would be the case if the sea consisted of distilled water. It was contended that it was in accordance with the principles developed in this experiment, that the warm water occupying the greatest depths in the sea (as discovered by Sir James Ross) rose to the surface and escaped under the form of vapour, which by diffusing warmth through the atmosphere mitigated the rigour of polar cold. Referring to the stratum of water of uniform warmth, observed by Sir J. Ross, the lecturer stated that he had ascertained, by experiment, that water acquires a considerable increase of temperature under great pressure, and that he thought that the temperature of the deep sea could only be satisfactorily accounted for by the condensation of bulk which the "air of water" underwent. The increase of temperature measured downwards from the stratum of uniform warmth to the sea bottom was noticed as proving that the latent heat of the dissolved air was rendered sensible as the pressure—that is, as the depth increased. Dr. Williams concluded by referring to the maximum density of water, the laws governing the solution of air in water, and by explaining the influence of those conditions on the existence and distribution of plants and animals in the sea.

The Timber Duties.—The following new and reduced prices on ti and wood goods came into operation on the 5th of April:—Timber or wood, not being battens, boards, staves, handspikes, oars, lathwood, or other timber or wood, sawn, or otherwise dressed, except hewn, and not being timber otherwise charged with the load, 15s.; deals, battens, boards, or other timber or wood, sawn or split, a otherwise charged with duty, the load 1*l.* 1s.—or, in lieu of the duties imposed upon by the load, according to the cubic contents, the importer may have the option time of passing the first entry of entering battens, batten-ends, deals, deal-end planks, by tale, if of and from foreign countries, according to their different dime and rates of duty, in which a considerable reduction is made, varying from one-fo a moiety of the rates of duty hitherto levied thereon; staves, the load of 50 cub 18s.; firewood, the fathom of 216 cubic feet, 6s.; handspikes, not exceeding 7 length, the 120, 12s.; exceeding 7 feet in length, the 120, 1*l.* 4s.; knees, under 5 square, the 120, 6s.; 5 inches and under 8 inches square, the 120, 1*l.* 4s.; lathwo fathom of 216 cubic feet, 1*l.* 4s.; oars, the 120, 4*l.* 10s.; spars or poles, under 22 length, and under 4 inches in diameter, the 120, 12s.; 22 feet in length and upwa under 4 inches in diameter, the 120, 1*l.* 4s.; spars of all lengths, 4. and under in diameter, the 120, 2*l.* 8s.; spokes for wheels, not exceeding 2 feet in length, t 1*l.* 4s.; exceeding 2 feet in length, the 1,000, 2*l.* 8s.; timber, planed, or o dressed or prepared for use, and not particularly enumerated nor otherwise char duty, the cubic foot, 4d.; and further for every 100*l.* value, 10*l.*

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM MARCH 27, TO APRIL 20, 18

Six Months allowed for Enrolment, unless otherwise expresse

Benjamin Grey Babington, of George-street, Hanover-square, Middlesex, John Spurgin, of Guildford-street, Middlesex, M.D., for "Improvements in facture of metallic pens."—Sealed March 27.

John Coates, of Seedley, Lancashire, calico printer, for "certain Improv machinery or apparatus for printing calicoes and other surfaces."—April 3.

Michael Joseph John Donlan, of Abbot's Bromley House, Staffordshire, "Improved compounds or mixtures to be used for lubricating machinery."—A

James Pilbrow, of Tottenham, Middlesex, engineer, for "certain Improv propelling upon railways and canals, and in the apparatus or machinery by same is to be accomplished."—April 4.

Thomas John Knowlys, of Hetham Tower, near Lancashire, and William Shirley, Hants, for "Improvements in generating, indicating, and applyin April 5.

Joseph Foot, of Spital-square, Middlesex, for "Improvements in the manu sieves."—April 6.

Eugene Ablon, of Panton-street, Haymarket, for "Improvements in incr draft in chimnies of locomotive and other engines."—April 8.

Thomas Gill and John Edgcumbe Gill, of Plymouth, manufacturers, for " ments in the manufacture of manures."—April 8.

Thomas Potts, of Birmingham, brass tube manufacturer, for "Improvemen manufacture of tubular flues of locomotive and other steam boilers."—April 10.

Thomas Spencer, of Prescot, Lancashire, for "certain Improvements in ma apparatus for manufacturing pipes and tubes from clay or other plastic materia parts of which improvements are applicable to the manufacture of hollow earth —April 10.

James Derham, of Bradford, Yorkshire, manager, for "certain Improvemen chinery for carding, combing, preparing, and spinning cotton, wool, alpaca, mo silk, and other fibrous materials."—April 10.

John Ecroyd, of Rochdale, Lancashire, machine maker, and John Eccles, of place, mechanic, for "certain Improvements in valves or plugs for the passage April 10.

James Petrie, of Rochdale, Lancashire, engineer, for "certain Improvements engines."—April 10.

John Longworth, of Newton Heath, Lancashire, for "certain Improvements in for power looms."—April 10.

James Meacock, of Liverpool, gentleman, for "Improvements in preventing tinguishing fire in vessels, warehouses, and other buildings, parts of which impro are applicable to ventilation."—April 12.

John Masters, of Leicester, gentleman, for "Improvements in dress fastening attaching the same; and in articles made, wholly or in part, of certain flexible or fabrics."—April 12.

Henry Henson Henson, of Hampstead, Middlesex, gentleman, for "certain In ments in railway carriages and wagons, and in vessels of capacity, employed in the and conveyance of explosive substances."—April 15.

Thomas Forsyth, of New North-road, Middlesex, engineer, for "Improvement manufacture of railway wheels."—April 15.

Charles Green and James Newman, manufacturers, of Birmingham, for "Im ments in the manufacture of a part or parts of railway wheels."—April 15.

Richard Madigan, of Haverstock-hill, Hampstead-road, Middlesex, civil engine John Coope Haddan, of 14, Lincoln's inn-fields, Middlesex, civil engineer, for provements in the manufacture of wheels for railways."—April 15.

Selah Hiler, of New York, in the United States of America, for "Improvements manufacture of stair rods."—April 15.

David Davies, of Wigmore-street, Cavendish-square, coachmaker, for "certa provements in the construction of the heads of open and close carriages."—April 1

Charles Attwood, of Wolsingham, Durham, Esq., for a "certain Improvement provements in the manufacture of iron."—April 18.

John Britten, of Birmingham, machinist, for "certain Improvements in he lighting, ventilating, and closing and screwing the doors of apartments; also in li and ventilating carriages, parts of which improvements are applicable to other lik poses."—April 20.

Matthew Cochran, of High-street, Paisley, Renfrewshire, for "certain Improve in the production of coloured patterns or designs on warps of carpets, velvets, or textile materials, parts of which improvements are also applicable to the productio coloured patterns or designs on woven fabrics, or other planes."—April 20.

Samuel Clegg, of Regent's-square, Middlesex, engineer, for "Improvements in meters."—April 20.

John Strang Harradine, of Holywell-cum-Needingworth, Huntingdonshire, farmer, "an Improved mode of fitting certain girths and straps."—April 20.

Henry Gilbert, of Saint Leonard's-on-Sea, Sussex, for "an Improved mode or improved modes of operating in dental surgery, and improved apparatus or instruments to be used therein."—April 20.

6 similar girders *f*, above; and upright cast-iron stanchions *g*, on each side of the tube, to which are bolted the ends of the girders, top and bottom, and also the cross lifting girders *h*.

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Fig. 3.

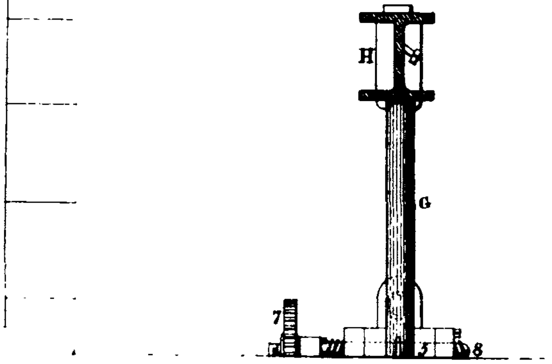
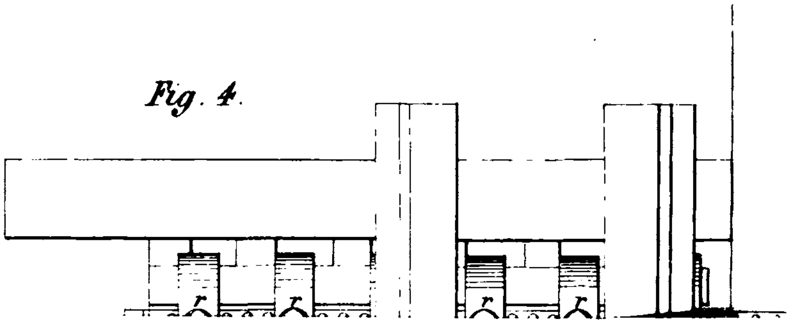


Fig. 4.



stratum of uniform warmth to the sea bottom was noticed as proving that the latent heat of the dissolved air was rendered sensible as the pressure—that is, as the depth increased. Dr. Williams concluded by referring to the maximum density of water, the laws governing the solution of air in water, and by explaining the influence of those conditions on the existence and distribution of plants and animals in the sea.

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THE CONWAY TUBULAR BRIDGE.

(With Engravings, Plate VIII.)

The great engineering event for 1848 is the raising of the Conway Tubular Bridge, and which after so much fear and anxiety has been effected with great success. This work derives its importance not so much from its greatness, as from its opening the way for the adoption of a new system of bridge building, whereby the resources of engineering are very much extended. To build a bridge greater than those which have been made before, to make a railway longer than those which have yet been opened, or to construct a more powerful locomotive, is a great work; but it is of very much greater importance to execute something entirely new. The engineer who has constructed the greatest lighthouse or the greatest dock in his day, may be overcome by some one else, and then his claim is at an end; whereas the engineer who extends the resources of his art, has a clear and unique claim to distinction. Mr. Robert Stephenson has the merit of carrying out this system of tubular bridge building, and it will be a special event in his career, beyond the many works of constructive skill he has already produced. The success of the Conway bridge is none the less important, because it settles the practicability of that greater undertaking, the Menai Tubular Bridge. Thus progress in any one direction leads most certainly to greater exertion; and it is peculiarly necessary to give every encouragement to all attempts, which open a new career for the engineer, and give him greater means of exertion.

We are glad to learn that the trials hitherto made within the tube with locomotives have been successful, though we have not had the opportunity of personally investigating the real progress of the undertaking. We shall, however, watch it with interest and attention, to see how far its continued working justifies the opinion which has been entertained of its success: at the same time, we may say we do not participate in the fears which are entertained by some of our mathematical correspondents.

We have this month given engravings of the tube, and the lifting apparatus, and next month we propose to lay before our readers drawings of the ingenious Jacquard machinery invented by Messrs. Roberts, for punching the plates.

The construction when finished is to consist of two tubular bridges, formed of wrought-iron plates, each tube being for one line of rails. We shall now confine ourselves to the description of one of the tubes, which was fixed in its place in March last, and is shown in the accompanying engravings, Plate VIII.

Fig. 1 exhibits a transverse section of one of the tubes and the masonry of the pier, together with the lifting apparatus. Fig. 2 is a side elevation of 19 feet in length of the tube, resting on the masonry, and the lifting apparatus: Fig. 3 is a section through 12 feet in length of the tube, and section of the lifting apparatus. Fig. 4 is a plan of the top of the tube to the extent of 20 feet in length, and plan of the hydraulic press. Fig. 5 is a front view of one end of the suspension girder, and fig. 6 a side view.

The tube consists of a shell or external casing, *a*, *a*, of wrought-iron plates, from 4 to 8 feet long and 2 feet wide, by $\frac{1}{2}$-inch thick in the centre, and $\frac{5}{8}$ths of an inch thick towards the end of the tube, rivetted together to T-angle-iron ribs, placed on both sides of the joints, and angle-gussets at the feet of the ribs to stiffen them; a ceiling, composed of 8 cellular tubes *b*, each $20\frac{1}{4}$ inches wide, and 21 inches high; and a floor containing 6 cellular tubes *c*, $27\frac{1}{2}$ inches wide, and 21 inches high. The whole length of the tube is 412 feet, and 22 ft. $3\frac{1}{2}$ in. high at the ends, and 25 ft. 6 in. high in the centre, including the cellular tubes at top and bottom, running the whole length, and 14 feet wide to the outside of the side plates. The upper cells are formed of wrought-iron plates, $\frac{3}{4}$-inch thick in the middle, and $\frac{5}{8}$-inch thick towards the ends of the tube, put together with angle-iron in each angle of the cells; and over the upper joints is rivetted a slip of $\frac{1}{2}$-inch iron, $4\frac{1}{2}$ inches wide. The lower cells consist of $\frac{1}{4}$-inch iron plates for the divisions, and the top and bottom of two thicknesses of plates, each 12 feet long, 2 ft. 4 in. broad, and $\frac{5}{8}$-inch thick in the centre, and $\frac{1}{4}$-inch thick at the ends, and so arranged as to break joint; and a covering plate of $\frac{5}{8}$-inch iron, 3 feet long, is placed over every joint on the underside of the tube. The external casing is united to the top and bottom cells by angle-iron, on both the inside and outside of the tube, as shown in fig. 6.

The ends of the tube, where it rests on the masonry, are strengthened by cast-iron frames *d*, to the extent of 8 feet of the lower cells; 6 cast-iron transverse I-shaped girders *e*, on the floor; 6 similar girders *f*, above; and upright cast-iron stanchions *g*, on each side of the tube, to which are bolted the ends of the girders, top and bottom, and also the cross lifting girders *h*.

In order to allow of the free expansion and contraction of the tube, the ends rest on 24 pairs of iron rollers *i*, connected together by a wrought-iron frame, and placed between two cast-iron plates *j*, *k*, 12 feet long by 6 feet wide, and 4 inches thick. The lower plate is laid on a flooring of 3-inch planks *l*, bedded on the stonework; and the tube is also suspended to 6 cast-iron beams *m*, the ends resting on longitudinal bearers *n*, 12 feet long, with a circular groove on the underside, supported by 12 gun-metal balls *o*, 6 inches diameter, standing upon an iron bed *p*, and supported on the ends of the cast-iron bearers *q*. The tubes are suspended to the beam *m*, by wrought-iron bolts *r*, and spade-pieces rivetted on to the sides of the tube, as shown in figs. 5 and 6.

The lifting apparatus for raising this enormous weight was entrusted by Mr. Stephenson, to Messrs. Easton and Amos, engineers of the Grove, Southwark, to whom great credit is due for the very successful manner the tube was lifted. The machinery consisted of 2 steam-engines, erected in the recesses B, of the corresponding tube, one on each side of the river; and each engine has a horizontal cylinder, 17 inches diameter, and 16 inches stroke, with piston-rods working through stuffing-boxes at each end of the cylinder; each piston-rod has a cross-head, and gives motion by side-rods and cranks to two fly-wheels; and the ends of the two piston-rods work 2 forcing-pumps with plungers, $1\frac{1}{8}$ inch diameter, and 16 inches stroke. These pumps inject the water into the hydraulic press C, shown in the engraving, through the small tube (3).

The press was erected on a stage constructed above the level of the top of the tube, and consisted of two cross-girders of cast-iron, each in two heights D, D′, the lower one 4 feet high, and the upper one 2 ft. 6 in. high; the ends resting upon cast-iron bearers E, imbedded in the masonry of the piers. Upon the cross-girders was fixed the casing F, of the ram, which is 5 ft. 2 in. long, by 3 ft. 9 in. wide, cast with ribs; and on the top of the cylinder are fixed 2 vertical guide-rods G, G, 6 inches diameter, passing upwards through the cross-head of the ram, and a cast-iron girder H, nearly at the top of the tower, and 18 feet above the girders D′.

The press consists of a cylinder (1), firmly fixed in the casing, $37\frac{1}{2}$ inches diameter externally, and 20 inches internally; and the ram (2) $18\frac{3}{8}$ inches diameter, with a vacuity nearly $\frac{7}{8}$ of an inch all round, to receive the water injected from the pumps already described, through the tube (3), the orifice of which is $\frac{3}{8}$ of an inch diameter; this tube is furnished with a lever-valve close to the cylinder, for safety, in case the pipes should burst. In the event of such a casualty, by an ingenious contrivance the lever-valve would be instantly closed, and the weight supported by the water in the cylinder. On the top of the ram is a cross-head (4), of solid cast-iron, 9 ft. 10 in. long, 1 ft. 10 in. deep, and 2 ft. 4 in. thick, with two apertures, 2 ft. 1 in. long, by 1 ft. $1\frac{1}{2}$ in. wide, through which the lifting chains pass; and on the top of this cross-head are fixed two clipping vices or clams (5, 5,) each consisting of a pair of wrought-iron jaws, 3 feet long, 11 inches deep, and 6 inches thick, and a winch which turns a small pinion (6), that takes into two cog-wheels (7, 7′) fixed upon the heads of two horizontal screws (8, 8′ left and right handed) passing through nuts in the two jaws of the clams. Thus it will be perceived, that as the winch is turned, the jaws are made to open or close, for the purpose of clipping the heads of the lifting chains; below these clams are two others (9 9′), for clipping the heads of the lower links.

The two lifting chains consist of wrought-iron flat bars, in lengths of 6 feet from centre of bolt-eye to centre, and each bar is 7 inches wide and $1\frac{1}{3}$, $1\frac{1}{4}$, and $1\frac{1}{2}$ inch thick, with heads having shoulders fitted to the jaws of the clams. Each chain contained nine links of 8 and 9 bars alternately, besides the two lower links, each consisting of 5 and 4 bars. The heads of the first or upper links passed through the upper lifting clams, fixed on the top of the cross-head of the ram, and there secured by the jaws of the clams being screwed up taut; the second links passed through the lower clam, the jaws of which were left open, and the heads of the two lower links were made to abut against the underside of the lifting girders, *g*, *h*. When the pumps were set to work, the ram was lifted 6 feet, its full range; when it had attained this elevation the jaws of the lower clams (9, 9′), were screwed up close and clipped the heads of the third links (11), and there held the chain firm; the jaws of the upper clams were then opened, and the ram lowered down to its original position, when the bars of the top links (10) were removed. When this had been done, the jaws of the upper clams (5, 5′) were again brought under the heads of the second links, and screwed up taut, so as firmly to clip the shoulders of the links, the jaws of the lower vice (9, 9′) opened, and the ram was then set in motion to lift the tube another six feet, when the second links were removed as before described, and the operation repeated as above, until the tube had been lifted the height required, about 22 feet to 24 feet.

The power of the presses may be thus calculated: the area of the ram being equal to 337·64 circular inches, and the force acting upon the plunger equal to 2·14 tons per circular inch, the two being multiplied together give 722¼ tons, which is the force of one of the presses, and of the two presses 1445 tons. The actual weight lifted was estimated at 1,300 tons. The quantity of water used for each press is about 66 gallons.

The tube was constructed on a platform erected on the shore of the river, close to where it was to cross; and when finished, six pontoons, something similar to the large coal lighters on the river Thames, were placed under the tube at low water, and which at high water lifted the tube off the piles upon which the stage was erected. It was then floated to its destination, and placed between the two towers, part of the masonry being left undone until the tube was put into its proper position, and as it was raised the masonry was built up under the tube. The time occupied in raising the tube and building up the masonry occupied four days; the actual space lifted per hour was 13 feet.

CANDIDUS'S NOTE-BOOK, FASCICULUS LXXXII.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. Surely there must be something wrong somewhere, when, notwithstanding all the numerous appliances and aids which Architectural study can now boast of, Architecture itself seems to have come to a dead stand. In the inability to get a step forwards, a merit is made of what an Irishman would call advancing backwards. To say nothing of the Institute, we have besides that a Royal Academy, which professes to extend its fostering protection to Architecture; also Architectural Societies, Decorative Art Societies, Schools of Design, and lastly, though not least, Professors of Architecture;—yet what is the art the better for them all? Can it do more than hash up again and again the cold remains of the banquets which it used to serve up in by-gone ages? If that "more" be not possible, there is little cause for us to vapour at the rate we do about Architecture as one of the Fine Arts. Either it has now lost, or is no longer permitted to exercise, the powers—to maintain the privileges of one. After *studying* all extant styles of the art, we are reduced to the mortifying conclusion, that we can do nothing whatever with any of them beyond copying, being ourselves wholly unable to catch and preserve the artistic spirit that pervades the best and most characteristic examples of the styles which we propose to ourselves as models. By dint of pains-taking industry, we can follow them tolerably well as far as they go; but where they stop short of what our actual purposes demand, we stop short too, and break down; and not only do they not go far enough for our present requirements, but they sometimes lead us astray, forcing more or less upon us that which is adopted merely because it is significant of the style, although at the very same time much that is incompatible with the style is tolerated on the score of necessity; so that, after all, it is generally suffered to be seen that there has been conflict between style and purpose. Without such thorough mastery over a style as can bend it, and render it quite plastic and tractable, it is hardly possible to produce more than either direct copies of former examples, or a sort of decent patchwork composed out of them. As one of the Fine Arts, Architecture might now very properly take for its motto, *Fui*:—"I was one once, but am so no longer."

II. It would not be amiss were some term introduced to distinguish those whom we now call Architects, from Builders, or else to distinguish the Artist or Fine-Art Architect from him whose practice and abilities do not extend beyond estimates, specifications, the preparing working-drawings, and the superintending the execution of buildings. Why not have the term house-architect, as well as house-painter, understanding by it those who make no pretensions, or whose works do not qualify them to make any to the more ambitious name of Architect in the sense of artist. At present, all who come under the somewhat vague denomination of Architects, assume to themselves the rank of artists—followers of what is by common assent and the laxity of language admitted to be a Fine Art. No doubt, such appellation (that of artist) is flattering enough; but then it carries with it a corresponding degree of responsibility. If it can be adequately supported, it is one of honour; if not, it becomes one of reproach and disgrace. In not being an artist there is no demerit; but the pretending to pass for, or at least rank as such, without possessing the least artistic talent, is surely not very many removes from quackery. If there can be no higher title than that of Architect for those—and they do not seem to be many—who follow their profession in the spirit of artists, a more modest designation would better become the majority, and would relieve them from the sneers and reproaches to which they now expose themselves.

III. The idea of erecting single colossal columns as monuments and architectural objects, was, no doubt, borrowed by the Romans from Egyptian obelisks. Inasmuch as they are both lofty, upright objects, exceedingly well calculated to show at a considerable distance, the column and obelisk agree; but they also differ quite as much, and the difference is decidedly in favour of Egytian taste. Whereas the obelisk is evidently a monument—a pillar erected to record some fact or facts, or dignify some locality, and is everyway fitted by its shape to stand as an insulated, independent monolith, the column plainly expresses itself to be a component member of a fabric; therefore taken by itself alone, meaningless,—in the condition of a verb without a noun, or a noun without a verb. Not only does the column suggest the idea of a superincumbent architrave, for supporting which it is intended,—but detached from it, acquires a *topheavy* and unstable look, the very reverse of that attending the *pyramidion* in which the obelisk is made to terminate, and which produces an obtuse apex, instead of the whole being prolonged to a sharp point, like a spire. Except its general proportions as to height, there is nothing that recommends a column for officiating in lieu of an obelisk. The so employing it manifests very great poverty of invention and barrenness of ideas,—the inability to devise new and more appropriate forms for new purposes. What is characteristic in the column, considered as an architectural member, destined to support either a horizontal entablature or an arch springing from its capital, ceases to have propriety or meaning in a pillar erected merely as either an ornamental object or a votive monument. Such monument may still be a pillar, but it should be one expressly adapted to its peculiar purpose; therefore, the less it resembles any of the so-called "orders," the better. In this respect, the Rostral column possesses a decided advantage: it shows itself most plainly to be neither more nor less than a *trophy pillar*. A column of that kind does not look like a fragment of a building. In a building, such form for the columns would be preposterous. To employ *Architectural* columns as detached monumental pillars, savours of pedantic and puerile conceit, akin to that which during the Elizabethan period fashioned chimney shafts into columns, designed, more orthodoxly than tastefully, according to some one of the "regular" orders.

IV. It is very possible for a man to have too much scholarship,—or to have it, if not too abundantly, too exclusively; so much of it, that he has no room in his head for any ideas of his own, nor any time for exercising his thinking faculties. In Architecture, scholarship is far more likely to prove injurious than at all profitable. While with the ignorant it may pass for deep study, it seldom amounts to more than idle display of learned frivolity; and is so far from really being study—that is, study to any purpose—that it is rather apt to check the latter, to become the substitute for it, and sometimes to lead astray into fancies as chimerical as they are extravagant. Infinitely better would it have been for Wilkins, if, instead of labouring to convince us that the Temple of Solomon was a building of the Grecian-Doric order, he had applied himself to more diligent and real artistic study at his own drawing-board. Pity that Solomon's temple, the tower of Babel, and the Parthenon too, including a good many other things besides, cannot be left at rest—or left to those who are more ambitious of displaying their pedantical erudition, than of contributing to, or in any way promoting artistic study—the very study of all others in which we are most grossly deficient. Did we find that archæological knowledge tends to enlarge the judgment, and to fertilise both talent and taste, it would deserve to be encouraged; it seems, however, to have quite a contrary effect,—to contract instead of at all expanding. Hence is it that copyism, which should be our shame, is made our pride; and much as we vapour about art—mere empty vapouring after all—we show that we have no longer any faith in it, but take it to be now actually paralyzed, and incapable of doing aught further than it already has done. To revert to a former style, for the purpose of *gradually* moulding it into one that shall be far more suitable to our present occasions and wants than the original one is, would be allowable enough. But no: that must not be done,—such mode of proceeding would be accounted downright heresy. It would be tantamount to admitting, that, excellent as former styles were for the times which produced them, they require considerable modification in order to render them, or any one of them, generally applicable at the present day. After all, it may be questioned whether what looks so much like praiseworthy reserve, and scrupulous adherence to authentic models, does not proceed from motives that are not the most laudable. Merely to copy, saves such an infinity of study, thought, and trouble, as to render the copying system, in what calls itself a Fine Art, less of a mystery than it else would be. Architects—and I say it in sorrow—are not artists, except, perhaps, just here and there one exceptionally. The majority of the profession have nothing whatever of the feeling or spirit of artists in them. It is said that it takes nine tailors to make a man; I am sure it takes ninety-nine Architects to make an artist; for, as matters go, if we get one out of a hundred who answers to the latter character, we ought to be grateful. It will be said, perhaps, that the opportunities for showing artistic and original talent are so exceedingly few, that we ought not to judge of the ability *in posse* by the little ability which manifests itself *in esse*. Opportunities do occur, nevertheless, and what is the use we make of them? Why, to pirate, in the most unblushing manner, designs from Sansovino! It is true, Count D'Orsay makes a merit of such doings: what then?—he merely shows himself a priggish coxcomb. His countship's opinion may be very good authority for the cut of a coat, or other question in tailoring, but in Architecture not worth a straw; although it had, it seems, overbearing weight with the "Armoury and Knavery Club."

V. Beloved, but most unhappy Architecture, how art thou beset! —by the merest *apes* on one side, and the merest *parrots* on the other—creatures who merely repeat by rote what they have either heard from others, or got out of books, without bringing so much as a single idea of their own to incorporate itself with, or work upon it. So long as we merely listen to them in silence, they go on fluently and volubly enough. But once begin to cross-question them, and it is all up with them. Nothing then is left for them but to express astonishment at the ignorance which cannot perceive, or the impudence which presumes to throw doubt upon excellence that has all along been universally admitted. Anything like satisfactory reasons or intelligent reasoning, is not to be expected from people whose admiration is founded upon mere prejudice—upon authority, tradition, and conventionalism. Their criticism consists of nothing better than mere cant and parrot-like rote; and their dogmatism is in proportion to their shallowness. The most innocently-put WHY disturbs them,—upsets their criticism and their temper too. Albeit, anything but poetical themselves, they firmly maintain with the poet, that "Whatever *is*, is right;—in other words, everything is excellent for which due authority can be produced. And would they but be content to stop there, a good deal might be said in their excuse. Instead of that, however, they insist upon our believing that whatever is not—*i. e.* has not been done before, consequently derives no support from direct precedent for it, but must stand upon its own merits,—must of necessity be *wrong*, even though it should evidently be warranted both by analogy and common-sense. After all, there is a particle or two of shrewdness in the narrow-minded dulness of such persons: they have just discernment enough to be aware that they themselves depend entirely upon precedent, rote, and routine; and that by insisting upon others abiding by them likewise, they bring them down and keep them down to the level of their own intellect.

ARCHITECTURE AT THE ROYAL ACADEMY;

AND THE ARCHITECTURAL DRAWINGS AT THE EXHIBITION.

Most cheering and encouraging symptoms manifest themselves this year in the Architectural Room,—that is, supposing there be truth in the saying, that when things come to the worst they are sure to mend, for to that comfortable stage of *pessimity* are matters now come. Never was there before, within our recollection, so miserably poor an architectural "spread" at the Academy—such a beggarly and ill-arranged set-out. Even before we begin to look round, we perceive that one interesting class of architectural subjects are altogether missing. Either no architectural models were sent, or they were turned away; and incomprehensible as the last may be thought, it is quite as probable as the other case—at least to ourselves, because we happen to have seen some of the rejected designs,—designs, too, by those who have been exhibitors for several years past, and whose productions have usually obtained deserved commendation, both from ourselves and others. Their productions are now missing from the walls, and their names from the catalogue, which contains very few names indeed of any note in the architectural world; and what few there are, are not by any means *pluralist* exhibitors, they having contented themselves with sending no more than what just entitles them to an exhibitor's ticket. Possibly, however, we are here in error, and do them injustice, for though only one subject of theirs is to be found here, several may have been turned away: in fact, we know this to have been the case in one instance, and in that instance the drawing admitted is precisely the one which its author cared least of all about.

Knowing as much as we do, we cannot help suspecting that a great many more ugly revelations might be made, and a good deal brought to light that would accuse the Academy of most preposterous mismanagement in this department of its exhibitions, if of nothing worse. That architecture is there most unwelcome, there can be no doubt. That has been growing more and more evident for several years past. And to the chilling coldness with which it is regarded and treated by the general body of Academicians, may perhaps be attributed the *forbearance* of their architectural brethren, and the discountenancing, as far as in them lies, the practice of exhibiting architectural drawings at all. In the days of Sir John Soane, it used to be the custom for the Academy's Professor of Architecture—at least *he* made it such—not only to contribute, but to contribute each season, and to contribute abundantly. The present Professor, on the contrary, chooses to put himself upon the shelf, where he lies wedged in between Colonna, Vitruvius, and a good many other very mouldy and musty matters,—and wedged there so fast, that it seems he cannot get down for a moment to look at and protest against the outrageous doings in the architectural room.* Most enviable state of repose! it saves him from being horrified. Mr. Barry has of course other and far better "fish to fry." Sir Robert Smirke has been all along a nonentity in the Academy—save that he is its treasurer, and keeps a keen eye upon its "*shillings*." We should just as soon expect to find a design by one of the porters as by him. Mr. Hardwick and the new associate, Mr. Sydney Smirke, are the only architects connected with the Academy who condescend to let us see anything of theirs in the Exhibition.

Such being the case, we can forgive the editor of the *Art-Union* for so strongly objecting, as he lately did, to architects being elected into the Academy. Unless they enter it with the intention and full determination of really representing their own art there,—of upholding and promoting its interests, the "R.A." so acquired becomes more of a reproach to them than an honour. They only take upon themselves the ungenerous and odious part of the dog-in-the-manger; doing nothing themselves for either the Academy or for architecture, and excluding from the former those who deserve to be in it, because they would prove active and efficient members. There being so few architect-Academicians, is the very strongest reason possible why those few should exert themselves manfully, instead of sitting by most tamely, while architecture is all but actually kicked out. For it to be kicked out altogether would perhaps be less ignominious than to be treated as it is at present. Probably, next year the architectural drawings will be thrust aside into the Octagon-room—a hole, never intended, we presume, by Wilkins to form one of the exhibition rooms,—for this season most terrible inroad has been made by the painters upon the space hitherto allotted to such subjects, and to which they might be supposed to have acquired prescriptive right. The whole of the east-end of the room is now given up to oil-paintings, —not that we should at all complain of that, provided they were strictly architectural in subject, instead of being the refuse of the works of their kind in the Exhibition, with such charmingly namby-pamby titles as "The Pet," "Affection's First Offering," and others of the same "*missy*" and lack-a-daisical stamp. Had no architect-Academician courage to protest against such an invasion of the architectural territory on the walls? Was there not in the whole Academical conclave one single Abdiel

> "Faithful found
> Among the faithless, faithful only he
> Among the innumerable false, unmoved,
> Unshaken, unseduced, unterrified,
> His loyalty kept, his love, his zeal"?

That there was not even one such seems, for had such one there been, either his remonstrances would have had due effect, or he himself would have withdrawn, and renouncing the brummagem honour of R.A., would have escaped the ignominy of being confounded with the faithless,—for as matters stand, the being an

* Wilkins, during his professorship at the Academy, exhibited only two small drawings, and those showed us his very worst work of all—Downing College, Cambridge: The present Professor has shown at least more discretion, for instead of exposing to criticism any architectural design of his own, he exhibited first what was only a medley conglomeration of Sir C. Wren's buildings; and next and lastly, merely a sculptural composition for a pediment in a building erected by another architect.

architect and Royal Academician is very much like being a traitor. Nor is it to such alone that it is reproach that they should have allowed architecture to be reduced to the degrading position in which it is now at the only Exhibition open to it at all, for it very strongly reproaches the Institute of British Architects also, who, instead of contributing to the architectural department of the Exhibition, and of coming to its rescue in the hour of its imminent peril, content themselves with standing aloof in sulky dignity. That those who act the part of cyphers in the Institute, should not show themselves elsewhere to be other than cyphers, is not much matter for wonder,—perhaps even less for regret. But its stars—the luminaries who shine so brightly in Grosvenor-street,—can it be that their talent quite exhausts itself in talking, and evaporates ere it can give any manifestation of itself in Trafalgar-square? Half the business of the Institute seems to consist in voting thanks to, and complimenting each other; which, for any good that the rest of it does, may pass for the better half of it. In the meanwhile, both the Institute and the Academy seem alike to shut their eyes to some of the consequences of their *innocent* indolence. Although they are not, it would seem, directly responsible to any one for their doings or non-doings,—for their sins of commission or of omission,—it behoves them to pay some little respect to public opinion,—and to preserve if possible, decency of appearances. After long hovering upon the verge of it, the Academy has at last overstepped that line of discretion and safety. It has this season put the "last feather" upon the camel's back. The time for remonstrance has passed away, since remonstrance has been tried, and has proved fruitless, or worse than fruitless. What has hitherto been remonstrance, and perhaps unpalatably severe admonition, will now become unsparing objurgation. Unless the architects of this country be the meanest-spirited creatures conceivable, they will now break out into open rebellion against the Academy, and then, when *proximus ardet Ucelagon*, will the Institute be able to escape unsinged? There is, indeed, what it might make use of as a "fire-escape;" yet whether it has sagacity enough ever to avail itself of such means is to us very doubtful. The probability is, that it will prefer the fate of a martyr—prefer being *roasted* alive, to making the least effort that would break the spell of its present *vis inertiæ*. Let us hope then that, come what may, its charter is written upon asbestos. At least, let that Palladium be saved; if only to be deposited in the British Museum, where it may in time come to be looked upon with—veneration.

Those who imagine that we are now writing in mere reckless *gaieté de cœur*, are exceedingly mistaken. It is with feelings of sorrow, mingled with shame and indignation, that we pen what is likely enough to be set down for mere flippancy;—with sorrow for the contumely cast upon the art we love,—with shame for those who are themselves shameless—with indignation against those Judas-like friends of architecture, who betray it with their kisses. Good, easy creatures!—do they suppose that they are unnoted and unmarked by other eyes, merely because they choose to shut their own? To the public, all may seem calm,—and a desperately *dead* calm it is; but a speck has been seen in the sky, that announces a gathering tempest. What will come of it, should anything come of it at all, will be felt in due time; and then, perhaps, "*Sauve qui peut*" will be the cry. Of that, however, no more at present.

There are, as we have already said, no productions at the Academy this season, of that class which ought to make not the least figure of all in the Architectural Room—namely, models of buildings; although there is still admitted there the usual number of works that would be far more appropriately treated, either in the Miniature or the Sculpture Room. For aught we know, architectural models may have been offered and turned away. All we know is, that things there are of the kind—and very interesting things of the kind—which neither are nor ever have been exhibited. Regret, however, is greatly mitigated, and surprise almost entirely dissipated, when we call to mind the ungracious churlishness with which—judging from the awkward, huddled-up manner in which they are generally arranged,—models seem to have been admitted. Such exceedingly glaring mismanagement is visible at the first glance, that we cannot help imputing it to intention, and to the policy which worketh by cunning and stratagem. Hardly can we give the hangers credit for so much blundering stupidity as now shows itself more stronger than ever. Policy there must be in it, and its intention seems to be nothing less than gradually to work the expulsion of architecture from the Academy, at least from the exhibitions, by disgusting architects, and so deterring them from sending at all—which is all but completely effected already,—and by rendering the show of architectural drawings as unsatisfactory and uninteresting as possible, till they come to be looked upon by the public as mere filling-up rubbish, that has no right to be there.

Nor is it the "hanging" alone which is to be complained of, similar perverseness in selecting and admitting subjects. There are a great many things which, although architectural in subject, do not belong to the Architectural Room, inasmuch as they are not fresh *designs*, nor are the ideas they show those of their respective exhibitors. They are merely views and portraits of buildings, and for the most part of such as are already quite familiar to every architectural student. We do not go into that room to look at frames containing such stale matters as the Parthenon and other ragged ruins, whether Greek, Roman, or English; or at such rarities as our own City churches. If views or other copies are admissible at all, they ought at least to be confined to such as represent unedited subjects,—which, were they sought, might be found in abundance: were there no other, one there is which has never been touched by the pencil—viz., the colonnades in the court-yard of Burlington House. Or if enow of subjects are not to be found here at home, they are to be got at without going quite so far as Athens and Egypt, for they present themselves at Paris, Munich, Berlin,—almost at every step on the continent. Without going so far as to prohibit them altogether, there ought to be some sort of restriction with regard to what are merely topographical and architectural views. Some judgment might surely be exercised in determining their admissibility. Superior talent shown in execution might fairly enough be allowed to be passport for what possessed no great novelty of subject; but to find so many things as we do, that possess no redeeming qualities that might excuse the staleness or insipidity of their subjects—and some of them occupying far better places than original designs,—is not a little provoking.

That such evident mismanagement as declares itself in the Architectural Room, should be persisted in season after season, with a growing tendency to worse instead of at all to better, is to us nothing short of marvellous. The Academy—its architect-members included—seem not only to be utterly indifferent themselves to the architectural part of their exhibitions, but also to imagine that every one else is equally indifferent. Yet, surely complaints must from time to time have reached their ears. Their being disregarded is, perhaps, to be attributed to their having been uttered in too mild a tone; and if so, they ought now to be thundered forth so loudly, that the Academy cannot possibly pretend not to hear them,—and hearing them, cannot but pay some sort of decent attention to them.

After this unusually long proem—querulous also, we admit, though not without ample reason, and perhaps more energetic than polite in tone,—we proceed to say something of the few drawings of any mark in the present Exhibition. The hangers have taken care that we shall not gratify our curiosity by the very first subject whose title excites it—viz. (No. 1095), "Design for embellishing the new Coffee-room at the Carlton Club-house, carried out in Encaustic Colours," *F. Sang*. For aught that can be discerned of the encaustic embellishments, this drawing might nearly as well have been hung with its face to the wall, or at least turned topsy-turvy, as be placed where it is—immediately next to the ceiling. We remember being much gratified by three drawings of the hall, &c., of the Conservative Club-house, exhibited a season or two ago by the same artist; and which, for a wonder, were placed where they could be inspected. The drawing now *exhibited*,—exhibited at least in the catalogue, though put out of sight in the room,—is no doubt equally interesting. Not at all unreasonable is it to suppose that it shows improvement, rather than any falling-off, on the part of Mr. Sang. Subjects of that class are not so very numerous, that we can afford to be cheated out of the opportunity of examining them. Possibly, Mr. Sang himself may feel consoled by the honour of being an exhibitor; and by getting his ticket of admission—all that many of the exhibitors seem to care for; but we have nothing to console us for the provoking disappointment to which we have been subjected.

The next—(No. 1096), "Prize design for the proposed Army and Navy Club-house in Pall-Mall," *G. Tattersall*,—occupies a similarly lofty, though certainly not conspicuous station. Having seen it before, at the exhibition of the competition designs for that Club-house, we do not at all regret that it is placed where we cannot see it again; but we think that Mr. Tattersall himself must be anything but well pleased with the hangers for putting his "Prize Design" so far out of sight, and his other somewhat queerish design for the same building (No. 1229), in a much better situation,—we do not say the most advantageous one for it. As we expected, there are many other designs for the same Club-house, including the adopted one (No. 1187), by Messrs. Parnell and Smith. This was known to us before, a copy from the same drawing having been given in a contemporary publication, wherefore we would rather have found here something that would have enabled us to judge of the interior. By not doing so, we perhaps miss very little, for, from what has been said of it, the plan appears to be excessively common-place. There are about half-a-dozen other designs for the same Club-house; therefore, instead of being scattered about on the walls, and some of them put where they are scarcely visible, it would have been better to have collected them into a group. We should have preferred seeing here the respective sections, for those drawings were not exhibited at Lichfield House, although some of the plans convinced us that the sections belonging to them must have been more than usually interesting. Sections, however, are not at all in favour with the Academy;—are things by far too prosaic to be admitted into their Architectural Room. Isometrical perspectives of prisons are in their opinion more artistic drawings and dignified subjects than sections of even palatial club-houses. Such doggrel mode of drawing as isometrical perspective tolerated on the walls of a Royal Academy!

Designs for Railway Stations are quite as numerous, perhaps even more numerous, than those for the Club-house; and they may be allowed to show a good deal of variety, with a good deal of sameness,—variety, inasmuch as they conform to no generic character, but assume all sorts of masquerade, from the costume of almshouses to that of aristocratic mansions;—and sameness, inasmuch as they nearly all affect to look prodigiously "*olden-time-ish*" —a very great propriety, no doubt, when we consider how many centuries ago it is since railways were first established. A herald would trace them back to the Conquest, at least, and make out that they came over with the Normans. Sameness, too, there is with respect to paucity of ideas, and poverty of invention. If we consider them merely as drawings, showing imitations of the respective styles and classes of buildings, some there are well enough entitled to approbation, but hardly so as *designs* for a specific and wholly *un-precedented* purpose, and accordingly demanding to be invested with some sort of specific character.

(To be continued.)

ON ARCHITECTURE AND PAINTING,

ESPECIALLY IN RELATION TO THE ERECTION OF PROTESTANT CHURCHES.

Letters written from Italy, by W. M. L. De Wette, D.D., *Professor at Basle.*—[Abridged from the German.]

If one, who like myself, is merely an amateur of art, and quite a stranger to technicism,—ventures to lay down principles and give advice, he may be sure of encountering the prejudices of artists and critics by profession. If he, moreover, steps forth, with a certain independence of judgment, on an area where tradition and custom sway all minds—fearless of touching at some of the existing prejudices, his giving offence is unavoidable. Still, I shall make the venture, and my ignorance of technicism deters me the less, as I have found that technicists very often mistake the *true scope of art*, on account of their predilection for that sort of mastership—a prejudice, from which I, at least, am free. I may possibly be taunted with other prejudices and with one-sidedness; still, I hope to give some useful hints.

I begin with a few remarks on painting; and, without wishing to enter into a definition of what it *is*, or *ought* to be, it is certain that its destination is to convey representations and feelings to the mind. But all representations, be they what they may—either intuitions of the senses, or images of the fancy, or conceptions of the reason, or ideas of the mind,—consist of *two* elements; one suggested by *experience*, and another appertaining to the activity of the *mind*: one real-sensual, and one real-spiritual and primordial. In the intuition of senses, the first element preponderates so much, that we may be tempted to consider it the *only one;* but the more accurate observer will soon perceive that the mind has also its share in it. It is *it*, which impresses form to the matter of the senses—receiving that which it has viewed, within the pale of his other observations, and converting it into an intuition. The products of imagination may appear to a superficial observer as something *produced* by the mind, but the substance of it appertains entirely to the experience of senses; imagination having merely decomposed it, and combined it in another shape and way. Even the ideas of the mind (be it in art or otherwise) are no absolute produce of our thinking faculties; being merely deduced from experience.

Undoubtedly, the arts have risen from the imitation of nature, from the representation of the really existing—and even their present process and progress are the same. Thus, while conceding, that in any art-object so much of the *real* be existing, we may be induced to doubt how far *ideality* may enter therein at all. But if we take the difference between a picture and a daguerreotype, the case will become perfectly clear. In the former, that which occurs to the external eye piecemeal, must be seized by the mind and intellect as a whole—and put forward as a self-existing, independent object. For the first, besides nature, models, antiques, anatomy, &c., are used, all which will yield materials on which the artist can and may dwell; but imagination will supplant many of these helps, as we see in Raffaelle, who, after having devoted nearly his whole talent to painting, became the *completer* of the finest modern edifice in the world; we mean the dome of St. Peter, —which will lead us to a more detailed inquiry on the art of the builder.

Architecture may be called the most difficult of arts, as it is a fact that its products have experienced the most opposite and most severe criticism. The reason for this might be found in architecture being *not sufficiently free*—being, as no other branch of art, tied up to a certain scope; and only after this is accomplished, the demands of the beautiful may and can be attended to. On the other hand, the freedom accorded to the architect is something very vague, as he cannot follow any prototypes, but (as in music) has only to be guided by the internal measure of mathematical intuition, or the judgment of proportion and æsthetics. This, however, can never afford such certain and stable rules as the other arts have deduced from the observation of nature, &c. Amongst the many styles of architecture are the Egyptian, the Greek, the Byzantine, the Moresque, and Gothic; and in *every one of them* architectural beauty can be achieved. In this incertitude of *legislation*, if we may so call it, the chance of falling into the arbitrary, burlesque, or absurd, is greater than in most other arts.

The surest way is—to start in architecture from the *scope given*, as the other fine arts start from observation of nature, which with all of them constitutes their store of reality *(Boden der Realität)*, and by which, after all, the character of the architectural style is determined. Because it is easy to conceive, that, for instance, the Grecian temple and the mediæval church are mostly shaped after the circumstances of *climate* and their respective *scope and usage*. To choose a style, not adapted to our wants, is an imitation bare of character—which, however, is frequently to be met with now-a-days. A similar tendency of imitation and dangling with the antique and the foreign, and a want of originality, pervades much of modern art, but nowhere more than in architecture, where it seems that all trace of inventiveness has exploded; still, this cannot be the case, as our most modern times must have and have wants of their own. This, most assuredly, is the case with Protestant (evangelic) church architecture, to which the particular character of our worship prescribes especial rules, which, however, have not yet been attended to. If we refer the word "Church" to the original *Ecclesia*—a congregation, the importance of the sermon becomes with us paramount; far more so than it ever had been with the old (Papal) church. Taking the sermon as the chief feature of our worship—the scope and aim of a Protestant church can easily be explained. For the sake that the aim of a sermon (like any other speech) be accomplished, the orator must not only be heard, but *seen by all*. This applies with equal force to the orator himself, as he requires to have all his hearers within the reach of his eye, to enter with them into a *living contact*, which some may call mesmeric. For this aim, the churches, as they have come down to us from Catholicism, are not appropriate. In a Basilica or Gothic church, with one or two lateral naves and a choir, the pulpit *cannot* be conveniently placed, nor the orator heard; which is the reason, that in Italy a large cover or carpet is spread over the pulpit and main nave on festival occasions. The new spirit of Christianity could not re-model everything at once, and especially in the department of architecture: it adapted itself to the already existing. Roman Basilicas were converted into Christian churches, and retained by custom their mis-appropriate form.

That which serves the purpose of the sermon is also in accordance with the spirit of a truly evangelic worship—which is, that the congregation be *conscious* of their communion and community during the time of divine service; and for this aim, not only the preacher, but *every one* attending ought to see *all*, for the sake of arriving at the conviction that they are a *community!* But the life of community, which existed in such eminence amongst the first Christians, exploded gradually, as priesthood became paramount, until all idea of a congregation (community) degenerated into that of a complete priest-hierarchy. In Catholic churches, such things as congregations, properly speaking, never exist; but one portion attends to the mass, others pray at the several altars, others come to and fro; and even the preacher has only a portion of the people around him. The priesthood, alone, form a compact, uniform body, which, however secludes itself in the choir, taken up with particular functions. In this part of Catholic churches, as well as in their whole structure, the want of community is apparent; and if it had been as easy to erect new churches as to change a creed, Protestants ought never have used Catholic churches for their worship. Necessity, however, prevailed, and some of these older structures deserved preservation on account of their beauty. Still, it is a dereliction of duty, if new Protestant churches are built in the form of Basilicas or the old cross-shape.

It is not our province to make any *specific proposals* for the erection of Protestant churches; still, it is the duty of our architects to search after, and to discover that form—provided all power of invention has not left our age! So much we may say, that, according to our foregoing reasoning, this form ought to approach the *circular* or *elliptic*. The round form may possess some disadvantages in an acoustic point of view, but we do not doubt that they can be overcome by study and research.

While the architect attends to the scope of a building, he has, especially in public buildings, also to take care of its *character of beauty*. All nations have imparted to their sacred edifices, *beauty*, *character*, and *sublimity*; and Protestantism, if it comprehend the vocation of religion, cannot neglect the above requisites of sacred buildings. The aim of worship requires an adequate and worthy expansion of space. The sentiments of holy earnest, of pious peace and adoration, will receive much additional strength from a worthy and adorned locality.

It has often been asked, *what* constitutes the beauty of an edifice? Surely *not* the costly, glittering materials which Catholicism has squandered on them in Italy, partly from heathenish spoils transferred there. Another—and we say a *superior* mind reflects from the Gothic churches of the north of Europe. The temples of Pæstum, superior to *all* the ruins of Rome, are of travertine; which coarse material, however, is deified, as it were, by the exquisite form and proportion. It is form which constitutes beauty—which, after all, is but form perfect. Both appertain to the mind; mind creates form, and then reflects, with ecstacy, on his own work—the laws of its own being brought to manifestation —beauty.

Certainly, before an intuitive observation, the distinctions of material and form vanish. Certainly, marble is more pleasing to the eye than gritstone, on account of its finer component parts and colour, which both are forms. The architect cannot disdain the nobler material on this account, as well as for its greater plasticity and adaptation to elaborate workmanship. The custom to construct public, especially sacred, buildings of noble materials, and to adorn them costly and splendidly, is most ancient, and based on a true sentiment of our mind. Everything rests here on certain proportions and measures; as also the connection between material and form obeys the same laws. Even a building, or parts thereof, the interior of a church or hall, may become heavy and cumbersome by being overloaded with ornaments, on account of form being here obscured and borne down by material. The latter is the case with the Milan Domo, the outside of which is too rich in ornament, while the inside is grand and sublime.

The beautiful in architecture can be divided into several radii which we shall attempt to enumerate, in accordance with the relation of their usefulness and adaptation. The latter may be raised to beauty, or even sublimity—if the size by far outstrips the bounds of absolute necessity. The scope of religious assemblages requires but a limited height of space; but the tendency of art soars *beyond* that, and attempts to expand, conjointly with material space, our feelings and sentiments. Another way of achieving beauty is to employ greater means and aids than are absolutely necessary. The building may, for instance, require pillars for its support; but art takes hold of this want, and increases their number to the greatest amount compatible with true proportion. Finally, the scantiness and stern simplicity of the straight line may be increased by lines arcuated and wavy. But to all this must be added *something inexpressible* by mere words—which, however, may be best termed harmony, concordance, and unity of conception. Size and height—fulness and diversity, the free scope of form, must all combine towards unity; and naught to appear as superfluous, isolated, or preponderant. By the observation and comparison of a number of buildings, and by abstracting laws therefrom, certain rules of proportion (numerical, geometric, and others) have been arrived at; to which *fanciless* architects are accustomed to adhere slavishly. But the true laws of construction lie in the impression a building will produce, and which the real artist will know how to anticipate by some sort of internal *art-intuition;* this inward conception precedes all sketches on paper or parchment.

Let us now endeavour to sketch that impression, which a Protestant (evangelic) house of God has to produce. The usual classification of the Greek, Roman, and Gothic may serve as a starting point. The Grecian temple is conspicuous for its moderate compass, and the rectilinear form of construction. It is altogether the type of the polytheistic mind of their builders, unable to seize the greatness of *One-God*. Still, it produces the effect of a clear, serene majesty; and further, the Doric may be said to be more stern than the others. It seems to us the fundamental fault of Michael Angelo, and other architects, who have taken the *antique* for their prototype, to *transfer* the Grecian-Roman style into Christian churches. The Doric colonnade would have been, no doubt, the most adapted to Christian worship; but, so far as we know, that style has been used but rarely; substituting for it the more slender, serene—nay, lascivious Ionian and Corinthian orders, where, at times, colossal dimensions were introduced to palliate the inconvenience thus arising. But already the Byzantine or Romanic style of architecture had changed the Greek into one more appropriate to the Christian mind, by adopting greater height—thereby, expanding the column to gigantic proportions, and substituting the round arch for straight lines. For the external ornament of churches, or even the upper parts of their interior, this style used thin, short columns with arches, over which a profusion of sculptural and mosaic ornament is spread. The too stern character of the *ensemble* is thereby modified, and amenity added to sublimity: just the same as the worship of the true Christian is tempered by mildness and love.

Gothic church architecture has, however, achieved the greatest sublimity of religious sentiment, by its pointed vaults; but here, also, a richness of ornamentation unites the serene and lovely Peculiar to this style of architecture, is the mysterious and awe-inspiring, which arises partly in the structural proportions and forms, and partly in the painted windows, spreading a mystic *chiaro-scuro* over the whole expanse of space. If we assume, in fine, that Protestantism has developed faith and adoration to its greatest height and freedom, there can be no doubt that the character of sublimity,—viz., the pointed arch style, has to be chiefly adopted. It can hardly be doubted, that the adaptation of this style will permit the carrying out the above-stated requisites of Protestant worship, consequent on its very essence and mind—yet, we acknowledge that a sacred edifice thus constructed will be *much different* from a Gothic cathedral. It may be thought, that the character of the structure might be somewhat modified by a greater clearness and serenity of its plan and conception. Protestantism educates towards self-thought and clear ideas; henceforth, even its external manifestations must seek for clearness and light. As the congregation has to see *itself*, as bibles and books are to be oftener referred to than with Catholics—stained windows will not be adapted,—the more so, as the frescoes proposed by us as a chief ornament for the walls of the interior, would be quite confused and obliterated thereby.

Of these we shall speak in conclusion. In this respect, also, a certain chaste economy, if we may say so, is to be recommended. In Catholic churches, not rarely a sensual profusion of marble and gold is to be regretted, and at the same time, walls and ceilings are overloaded with paintings. This medley, however, of a motley *coloration*, makes an especially confusing impression on the beholder. Against the painting of ceilings we must pronounce most strenuously, as even with the best light it is impossible to view them with the requisite quiet and ease; the outward quiet, however, of the beholder being the necessary condition of the inner satisfaction, which is the aim of all art. At times, moreover, the light for such ceiling-paintings is quite a wrong one, as is the case in the dome of Parma. How much of art and means have been wasted in ceilings, and how slight has been the the result! On ceilings, art should not effect but an adequate and harmonious display of colour; at the utmost, arabesques or facettes are to be used, as is the case in some of the churches of upper Italy. Figures and groups however, ought to be placed at a convenient distance, and in no distorted positions or fore-shortening. If our idea of a communion in Protestant congregations be assented to, pictures ought to be used but rarely, and of a simple, but grand character; else they would distract the attention of the people. Large historical compositions attract too much attention; but figures or heads of great and pious personages will be more appropriate, besides requiring only a limited space.

If we endeavour to *combine* the purport of our foregoing observations—we have to repeat, that painting has to receive a real element and *substratum*; architecture, to manifest the scope of adaptation; all pervaded by an ideality, which appertains to the subject—an intimate connection (permeation) of the real and ideal. We have to insist on compositions, clear, free, and well-combined: in fine, the preponderance of the art-scope;—viz., to bring the beautiful and sublime into external existence, and thereby to awaken art-feelings—viz., feelings of serenity, elevation, and contentment. We cannot forego to express our opinion, that great *religious* buildings can and will never be conceived but by men possessing those feelings in an eminent degree. The complication of estimates and business can hardly be avoided now-a-days; but composition and inspiration can alone produce huge structures, worthy and able to inspire the *people*—a sentiment they cannot any longer be kept without.

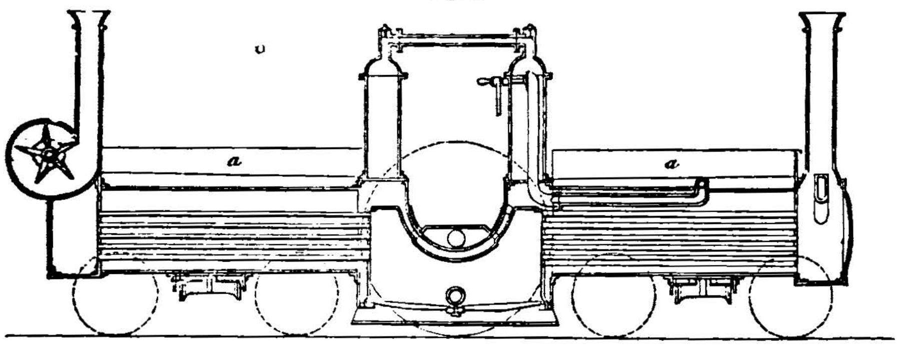
J. L——Y.

REGISTER OF NEW PATENTS.

LOCOMOTIVE ENGINES AND CARRIAGES.

James Pearson, of New North-terrace, Saint David's, Exeter, for "*certain Improvements in locomotive engines and carriages.*"—Granted October 7, 1847; Enrolled April 7, 1848.

Fig. 1.



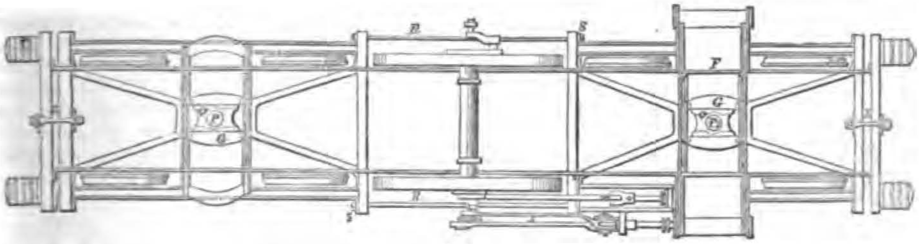


Fig. 2.

This invention applies to several parts of locomotive-engines and carriages. One part consists in the form of the boiler, which is made with the fire-box in the middle part of the boiler, instead of being at one end. The general outline of the boiler is such as would be formed if two locomotive boilers of the ordinary construction were placed end to end with their two fire-boxes about four or five feet apart, and then the parts of the fire-boxes below the fire-door were joined together by an additional piece of fire-box, so as to connect the two ends together into one large fire-box in the middle of the boiler with a chimney at each end (fig. 1); or the boilers may be entirely separate and distinct, that is to say, having two entirely separate and distinct fire-boxes butting against one another, and having water and steam communications common to both, but which may be shut off from either boiler at pleasure. The axle of the driving-wheels is placed in the middle of the boiler, above part of the fire-box and below the foot-plate, so that any desired amount of weight of the engine may be brought upon the driving-wheels, and at the same time the centre of gravity may be kept very low. The axles of the trailing-wheels are placed below the cylindrical part of the boiler, and two pairs of these are placed in one swivel-frame at one end, and two pairs in a similar frame at the other end. The two frames are coupled together by two tension-rods R, (fig. 2). Near the ends of these rods R, are placed springs S, made of vulcanised india-rubber, and beyond these springs are nuts to confine them. The use of these springs is to allow each swivel-frame to adjust itself to any inequality of the road, and to bring it back to the straight position when the road is even. The swivel centre-pin P, is fitted into a socket Q, which is allowed to slide a little endways in guides G, to allow for expansion and irregularities, and the holes in the links L, are made oblong for the same reason, and that the links may pull instead of pushing. The boiler and engines are supported on a long upper frame F, which is attached to the lower swivel-frames by the two centre-pins P, P, and by the links L, at the end of the engine. The whole forming one compound swivel-frame.

The coke-box *a*, *a*, is placed on the top of the boiler. The water-tank may be on a separate tender, or may be placed between the coke-box and the boiler, or attached in any other convenient way. The two steam-heads may be connected at such a height as is convenient to leave head-room for the engine-man.

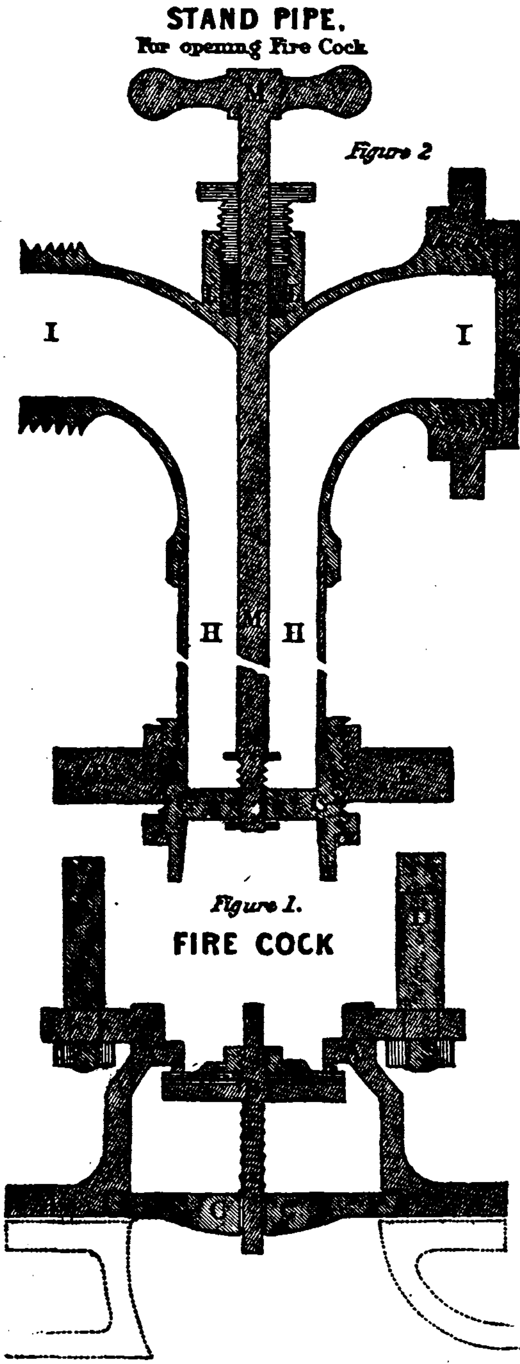
Another part of the invention consists in the application of an exhausting-fan in the smoke-box to draw the heated air through the tubes of the boiler, and to discharge it either up the chimney, as shown in fig. 1, or, if preferred, it may be again returned as hot blast into the furnace. This fan will allow the use of waste steam-pipes of a large size direct from the cylinder into the open air, and so avoid the great pressure on the back of the piston when the ordinary blast-pipes are used. The fan or fans may be driven by bands from pulleys on any of the wheels or axles, or by a small engine fixed on the side of the boiler, which may also if required work the feed pumps. The fans if driven by pulleys must each have two pairs of pulleys and suitable clutches, one pair driven by an open strap, and the other pair by a crossed strap, so as to drive the fans always in the same direction, whichever way the engine may be going. The clutch-gear may be attached to the engine reversing-gear if required.

Another part of the improvements relates to coupled locomotive engines, in which arrangement the compound swivel-frame is adopted. There are other improvements mentioned, but they are merely variations of those already explained. The patentee does not claim the invention of swivel or "bogie" frames generally, but his claims are, the compound swivel-frame, with coupling-rod, provided with elastic springs or cushions, and the various attachments to the upper frame; the form of boiler; the use of exhausting-fans for obtaining strong draught; and the compound swivel-frame, connected by rods with elastic cushions, and provided with guides and end links, as above described.

CHRIMES' PATENT FIRE-COCK.

The accompanying engraving (one-third the full size) of a fire-cock or valve, is a substitute for the ineffective wood plug, now in use in service mains. When under constant high-pressure, it forms a substitute for fire-engines, as in cases of fire it can be brought into almost instant operation, without that loss of time and waste of water which the use of the wood plug involves. It can be also expeditiously, cheaply, and most effectually applied to the watering and thorough cleansing of streets, courts, alleys, public buildings, windows, &c.; and in railway stations, to almost every use for which a free supply of water is required, including supplying engine-tenders, cleansing carriages; and it is also adapted for watering gardens and pleasure-grounds, and by the application of suitable outlets, for syringing fruit-trees. It is especially adapted for high-pressure supplies, as from the circumstance of the valve part of it being closed by the pressure of the water, the higher such pressure becomes, the more is the tightness of the valve secured, and effectual safety from leakage insured. One great advantage it has over the ordinary fire-plug is, that the stand-pipe with the hose can be placed on to the valve without the escape of any water, although the mains may be charged with water at a high pressure.

By the present system, unless a cock is attached to the branch of a fire-plug, a great loss of time unavoidably occurs in removing the wood plug, as the water has to be turned off the main pipe before the plug can be removed, and to be turned on again after it has been removed, to say nothing of the delay and difficulty which often occurs before it can be removed at all.



Description.—The Patent Fire-cock consists of a cast-iron boss, A, with aperture of such size as may be required, and flange for connecting it with a corresponding flange on branch from main pipe, as represented by dotted lines under fig. 1—the upper inner edge, *a*, of the boss being raised and faced, forms a seat for the loose valve, B, covered with leather, the spindle of which works in a brass bridge, C, and when not in use, is always closed. To the boss are attached wrought-iron inverted L-shaped lugs, D, to which the stand-pipe, when brought into use, is secured.

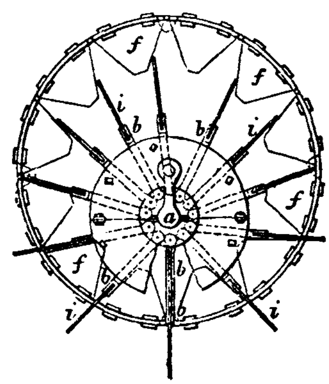
This stand-pipe consists of a copper or iron tube H, with two branches on the upper part I, furnished with screwed ends for attaching the hose; one or both of the orifices are also furnished with a brass screw-cap K. At the connection of the diverging pipes is a stuffing-box L, and at the bottom part of the stand-pipe there is a brass male-screw G, with leather washer F, working through a brass female-screwed collar E. This collar has projecting lugs, which passing under lugs D of the fire-cock, firmly secure the lug together, and form a connection of the stand-pipe with the fire-cock, perfectly water-tight.

Passing down the stand-pipe, through the stuffing-box L, is a wrought-iron rod, with brass crutch-handle at top, and a male-screw at bottom, working through a brass female-screw in the bridge G. By turning the crutch-handle M, the rod gradually presses down the valve B, of the fire-cock, and allows the water to escape all round the valve and up the stand-pipe; and at the same time by the gradual opening of the valve by the aid of the rod and screw, the flow of water is controlled, and concussion in the pipes prevented; while at the same time the sudden strain on the leather, or other hose which may be attached, is, to a very great extent, diminished.

PADDLE-WHEELS.

Thomas Hunt Barber, of King-street, Cheapside, London, gentleman, for "*Improvements in machinery for propelling vessels.*"—Granted October 7, 1847; Enrolled April 7, 1848.

This invention consists of an arrangement or combination of parts into paddle-wheels for propelling vessels. The external case of the wheel is a cylinder, which is fixed to and revolves with the driving-axle; and the floats are so arranged within the cylinder, as to be projected outwards when required to act, and are again withdrawn into the cylinder as they go out of action; such construction of paddle-wheel allowing it to be wholly immersed in the water. To govern the action of the floats, the patentee prefers to use a cranked axis, one end of which enters into the main or driving axle. On to the main-axle is placed a boss, to which arms are attached, for holding firmly the floats. The annexed diagram, which is a side-section of the paddle, will explain the manner in



which the floats are intended to act. The cylinder *b*, *b*, has as many slits or openings through it as there are floats to the wheel; and within the cylinder are angular hollow vessels *f*, *f*, which give buoyancy to the wheel, and also serve for the purpose of offering inclined guiding surfaces to the floats as they are moved outwards. The arms *h*, *h*, are attached by pin-joints to the boss or collar on the crank axis; and to the ends of the arms the floats are to be fixed. The floats *i*, *i*, *i*, are represented to be in action, whilst the others are drawn within the cylinder. The patentee says, that although he prefers to use a cranked axis for governing the action of the floats or paddles, it will be evident to an engineer that an eccentric might be substituted and produce a like result; and it will also be evident that in place of having the floats or paddles whereon are arms or spokes governed or controlled by a crank or eccentric axis, the case *b*, might revolve on and be governed by fixed eccentrics one on either side. In such case there would be a fixed axis between the eccentric bearings of the case *b*. The nave having the arms of the floats or paddles would revolve freely on the fixed axis between the fixed eccentrics, and the case *b* would receive motion by a cog-wheel affixed thereto driven by another cog-wheel actuated by the engine, or in any convenient manner.

What the patentee claims in this invention are, the modes of constructing paddle-wheels whereby floats, or paddles, or arms are combined with a case *b*, such floats on the case being governed by a crank or eccentrics.

RAILWAY CARRIAGES.

Thomas Dunn, of Windsor-bridge Iron Works, Manchester, for "*Improvements in railway wheels, jacks, &c.*"—Granted November 2, 1847; Enrolled May 2, 1848.

This patent comprises several objects connected with railway locomotion. Mr. Dunn first describes several improvements in the construction of wheels. One of the principal is the easy removal and replacement of the tyre upon the wheel when it has become worn. This he effects in several ways. His first method consists in having the nave, arms, and an inner tyre cast in one piece, upon which the outer tyre is bolted by means of a flange, which projects inwards a few inches beyond the inner surface of the tyre. The joint between these two pieces, out of which the wheel is formed, is packed with gutta percha or some other elastic substance. A second method consists in having the nave of the wheel cast with mortices in it for the reception of wooden arms or spokes, and in afterwards fixing the tyre to the nave, by bolts passing down through the middle of the spokes. According to a third method, that part of the wheel which is occupied by the arms is entirely filled in with segments of wood, between which segments there are driven wedges of either wood or iron, so that the wheel is almost entirely solid. The tyre is attached to the nave by bolts, as in the former instance.

The patentee makes his axles of wood and iron, the wood forming an internal solid core, with an outer covering of iron. He also makes axles of several pieces, by having the naves truly bored out, and driving into them a short axle, or rather part of an axle, which is formed on the outside of the wheel, into the journal or bearing, and on the inside projects only a few inches, leaving sufficient strength of material to pass a cotter through to retain the axle in the nave. The two wheels are then connected by rods of iron, which have collars formed upon them near to their ends. The portions beyond the collars are passed through holes formed in the naves of the wheels, and have screws upon their outer ends, so that the wheels are, in a measure, devoid of axles—the connection between them being formed by the rods.

The second portion of Mr. Dunn's improvements relates to the construction of jacks for moving carriages and locomotives on to the line of rails when they have got off. The chief feature of this improvement consists in providing the jacks with four small friction-rollers at the bottom of the pillar, by which the jack, with its load, is easily made to run upon a smooth surface in any direction.

A third improvement consists of a means of removing carriages from one line of rails to another, which the patentee effects by means of a low truck, running upon a set of cross rails. A portion of the main lines of rails is made to form an inclined plane at pleasure, by means of cams fixed under the rails, whereby he is enabled to run the carriages on to the low truck.

LUBRICATING COMPOSITION.

Thomas Denne, of Bermondsey, Surrey, strap manufacturer, for "*Improvements in the manufacture of grease or compositions for atmospheric pipes, and for lubricating the axles and moving parts of machinery.*"—Granted April 27; Enrolled October 27, 1847. [Reported in *Newton's London Journal.*]

The improvements consist, first, in preparing a lubricating composition by combining oil, or tallow or other grease, with certain light, soft, white, and unctuous precipitates or bodies, insoluble in water (so as to be incapable of being used as detergents), and obtainable in the manner hereafter described; secondly, in preparing a lubricating composition by combining oil, or tallow, or other grease, with vegetable black or with lamp-black; and thirdly, in mixing the compositions, prepared according to the first and second improvements, in such proportions as may be desirable, in order to render the same more suitable than when used alone for the lubricating purposes above mentioned.

The mode of carrying out the first improvement is as follows:—The patentee introduces into a vessel or tank such a quantity of *liquor calcis*, or of a saturated or other solution of sulphate of magnesia, or of sulphate of magnesia and ammonia, as he considers will be sufficient for the quantity of composition required to be prepared; he then gradually pours into and mixes with the same a strong solution of such of the vegetable or animal oils as are most suitable for the purpose, and which have been rendered miscible in water by boiling the same with alkali or caustic ley; or, instead of the solution just mentioned, he employs a strong solution of either the soft or hard soap of commerce; or he introduces the *liquor calcis*, or the solution of sulphate of magnesia, or of sulphate of magnesia and ammonia, into the pasty and saponaceous fluid, obtained by boiling either oil, or tallow or other grease, with alkali or caustic ley,—having first drawn the fire and allowed the pasty mass to cool down to 100° Fahrenheit. The patentee continues to add the saponaceous fluid so long as any light, soft, white, and unctuous precipitate continues to be produced; and then he separates such precipitate from the mother liquor, by filtration through a fine linen sieve,—preserving the mother liquor when it contains, in solution, any valuable salts, so as to make it useful for manufacturing caustic leys.

112 lb. of the precipitate, obtained as above, are to be combined with from 40 lb. to 112 lb. of palm or other oil or grease: the quantity of oil required will vary according to the peculiar character of the oil employed; but about 56 lb. will, in most cases, be sufficient. The apparatus used for effecting this combination is a cylindrical iron vessel or mill, open at the top, containing a revolving agitator, and having two pipes at the bottom, furnished with stop-cocks, for the purpose of discharging any water or other fluid that might accumulate inconveniently during the process. After the precipitate has been introduced into the mill, and the agitator set in motion, the palm or other oil is gradually added; then, as soon as the proper quantity of oil has been used, the mixture will thicken and assume a consistence considerably greater than the oil or other ingredient or ingredients possessed in the first instance; and a chemical combination will so far take place, that the greater portion of the mother liquor contained in the precipitate will be driven out, and must be drawn off by the pipes above mentioned. A supply of cold water is next allowed to run upon the grease or composition in the mill, so that it may be washed therein, in order to cleanse it from all adhesive impurities of the mother liquor; after which, the water is to be drawn off, and then a few pounds of oil are to be mixed with the composition, to separate any adhering particles of water, and to give it a finer and better appearance. The grease or composition is now ready for use; but if it should not possess sufficient consistence for the purpose to which it is to be applied, from 5 lb. to 28 lb. of melted tallow should be mixed with it in the mill; or, when the tallow is to be used, it may be mixed with the composition before the latter is washed with water, as before mentioned.

The second improvement consists in the production of a black grease or composition, which may be exposed to great extremes of heat and cold, and does not readily freeze, by combining 160 lb. of palm, olive, or other oil, or grease, with from 10 to 40 lb. of vegetable black or lamp-black. The oil is first placed in the mill before described, and then the agitator being put in motion, the vegetable black or lamp-black is added in small quantities at a time; and the mixture is agitated until the black grease or composition has acquired a sufficient amount of consistence.

The third improvement consists in combining a portion of the black grease or composition with grease or composition made in the manner described under the first improvement, to prevent the same from freezing when exposed to frost or snow, or to protect it from the action of extremes, either of heat or cold: the combination of the compositions is effected by the use of the mill before described.

BRONZING METAL SURFACES.

Charles de la Salzede, of Paris, for "*Improvements in brassing and bronzing the surfaces of steel, iron, zinc, lead, and tin.*"—Granted September 30, 1847; Enrolled March 30, 1848.

The improvements relate to coating steel, iron, zinc, lead, and tin, with brass and bronze. For the purpose of coating metal with brass, a bath is prepared, composed of the following ingredients:—5,000 parts by weight of distilled water, 610 parts of sub-carbonate of potash, 25 parts of chloride of copper, 48 parts of sulphate of zinc, 305 parts of azotate of ammonia, and 12 parts of cyanide of potassium. The cyanide of potassium is dissolved in a small portion (about 120 parts) of the cold distilled water; at the same time, the sub-carbonate of potash, chloride of copper, and sulphate of zinc, are introduced into the remaining portion of distilled water (contained in a separate vessel, and having its temperature increased from 144° to 172° Fahrenheit, to facilitate the dissolution of these matters); and when they are perfectly dissolved, and the solution has become cool, the azotate of ammonia is added. After the solution has been shaken for a long time, it is allowed to stand for 24 hours; it is then decanted with a syphon, and the solution of cyanide of potassium (which should be limpid) is added thereto. If the solution thus prepared be submitted for about five hours to the action of a volatic battery with a rapid current (such as Bunsen's, Grove's, or Daniel's battery), and at a mean temperature of 77° Fahrenheit, it will deposit a coat of yellow copper, or brass, on the metal article immersed therein. The process may be performed in vessels of porcelain, china, glass, or wood (which may be lined with bitumen, or any isolating resinous matter); and the vessels are preferred to be of a rectangular shape.

If the articles are to be coated with bronze, 25 parts of chloride of tin are to be substituted for the above-mentioned 48 parts of sulphate of zinc; the proportion of chloride of copper is to be increased from 25 parts to 48; and a plate of bronze is to be used as the electrode: in other respects the bath is prepared with the same ingredients, in the proportions above stated, and the process is conducted in the manner before described.

A bath, for coating articles with brass, is prepared, by dissolving 500 parts of sub-carbonate of potash, 15 parts of chloride of copper, 35 parts of sulphate of zinc, and 50 parts of cyanide of potassium together, in 5,000 parts of cold distilled water. After the bath has been stirred, it is allowed to stand for from 24 to 48 hours; it is then subjected, in a cold state (from 25° to 30° Fahrenheit), to the action of a voltaic battery, during the same time, and in like manner to the preceding baths. When this bath becomes impoverished by use, the salt of zinc, or copper, which has been absorbed, must be replaced. The bath last described may also be used for bronzing, by substituting about 10 parts of chloride of tin for the 35 parts of sulphate of zinc, and employing an electrode of bronze.

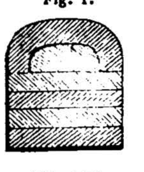
In either of the processes above described, instead of the sulphate of zinc, or chloride of tin, any neutral salts of zinc, or tin acids, may be employed, according to whether the article is to be covered with brass, or bronze, so long as the bath is sufficiently rich in potash, that there may be no action upon blue paper of turnsol. The proportions of the salts of tin, zinc, and copper, may be varied according to the colour desired to be given to the metal coating. This invention may also be applied to the coating of alloys.

RAILWAY BARS AND CHAIRS.

Richard Shaw, of Gold's-green, West Bromwich, Stafford, railway-bar finisher, for "*Improvements in the manufacture of wrought-iron railway bars and railway chairs.*"—Granted October 21, 1847; Enrolled April 21, 1848.

The improvements described in this specification relate to the constructon of railway bars and railway chairs, as also the arrangement of the machinery for their construction; and consist, First, in the mode of forming and piling the pieces of iron to form the railway-bar, for preventing the lamination of the metal. This is effected by placing and piling the bars in the manner shown in the annexed diagram, fig. 1, the lower portion of the bar being piled

Fig. 1.



in the usual manner with flat bars, and the upper portion piled with a broad bar bent into the form shown, the edges abutting upon the surface of the bars beneath, and the interior being filled and piled in the usual manner. When the railway-bar is finished, the grain of the metal is arranged in the form represented in fig. 2, and thus no laminating edges occur on the head of the working surface. The other improvements claimed by the patentee are, Secondly, the mode of manufacturing wrought-iron railway bars with protecting rails or flanges affixed thereto, in such a manner that the heads or working surface of the railway-bar stands above the support of the protecting rail or flange. Thirdly, the mode of manufacturing railway-bars with hollow heads or working surfaces in such a manner that the cheeks of the chairs may pass into the hollow of the head or working surfaces for the purposes of support. Fourthly, the mode of rolling railway-bars with rollers placed three high; as also the mode of rolling by the same means the curved bars used in placing and piling for making his improved railway-bars. Fifthly, the construction of chairs for supporting his improved form of railway-bar.

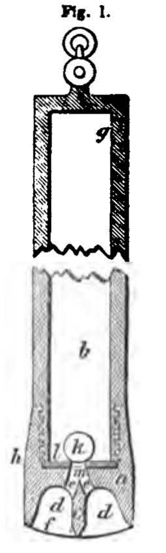
Fig. 2.

BORING AND SINKING.

William Gosswych Gard, of Calstock, Cornwall, engineer, for "*certain Improvements in machinery and implements for boring and sinking.*"—Granted October 21, 1847; Enrolled April 21, 1848.

The object of this invention is to improve the form of the cutting-tool used in boring so as to remove the debris more easily; and also to work the boring instrument more effectively. It is in the form of the tool, however, that the chief novelty of the invention consists. The cutting ends are made of a concave or inverted cap-like form, divided by a cross into four segments, with apertures leading from these segments into a hollow cylinder or shaft, screwed into a neck of the bit, whereby the bored-out materials are removed out of the way of the cutting edges. Fig. 1 represents a vertical section of the borer or bit, constructed according to this invention; and fig. 2, an under plan view of the same, showing the cutting edges. The shaft or hollow part *b*, forms the receptacle for the bored-out materials. This hollow shaft has the part *a*, which forms the cutter, screwed or otherwise affixed thereto, it being made of steel or some other hard metal. The cutting face is of a hollow form, or rather of four distinct hollows, the area being divided by a cross into four sections *d, d, d, d*, (fig. 2), each separate hollow terminating in a hole *e*, leading to a main opening *m*, in the trunk of the borer. The outside diameter of the cutter from the cutting-edge to the point *h*, is of a cylindrical form, and from the point *h*, (fig. 1), to where it joins the hollow shaft, it is tapered about half an inch in order to clear the shaft-part *b*, and allow it to pass freely after the cutter. The cutting edge, forming the circumference, is bevelled only on the inside; consequently, the material, which becomes detached by the blow, is projected inwards and upwards, leaving the external part free from obstruction in its working. The pieces detached by the cutting edges, forming the cross, are also projected upwards, and by the concave form of each section are all conveyed into the openings *e, e, e, e*, to the main channel *m*. A valve-seat of brass *c*, (fig. 2,) is secured in its place by having the stem *b*, screwed down on its surface. This valve-seat has its opening in the centre, corresponding with the main channel *m*, and is fitted with a ball-valve *k*. The detached materials pass up the main channel *m*, into the body of the stem *b*, at each successive stroke of the borer; the quantity of materials detached each time nearly filling the concavities *d, d, d, d*; but by being conveyed directly into the receptacle, they are prevented from impeding the operation of the cutters. The valve *k*, which is prevented from rising too high by a cross-pin in the stem, cuts off any return downwards of the borings. In this manner may the operations of boring be continued until the entire capacity of the stem *b*, is filled, when it is to be withdrawn from the boring, and the contents removed, which may be effected by turning the bit upside down, when they will pass out of the aperture, *g*; but the patentee prefers, when the detached materials are of a dry description, to keep the tool vertically in its boring position, and by raising up the valve from below, to allow the contents to run out.

Fig. 1.



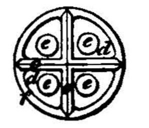


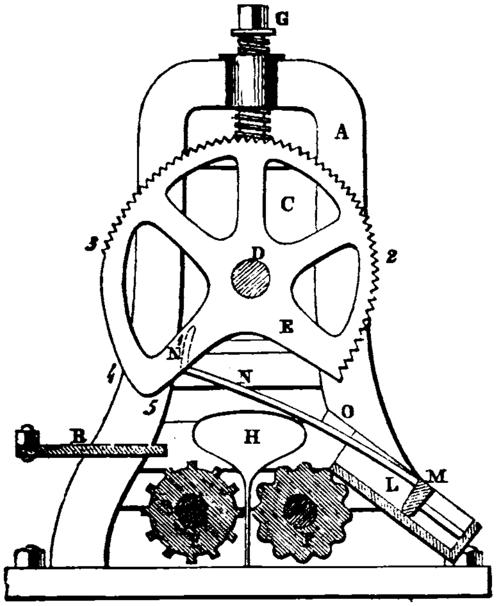
Fig. 2.

The second part of the invention, which relates to the mode of working the boring-tool, needs little description, as it contains nothing that is novel in principle. The patentee adopts the Chinese mode of boring, by fixing the tool to a chain or rope, and producing the effect by continually lifting it up and letting it fall, the height of the fall being regulated by the resistance to be overcome. There is a lever attached to the chain at the top, to one end of which weights are suspended, for the purpose of counter-balancing the increased weight of the chain as the depth of the boring increases, so that the working may be rendered as uniform as possible.

MANUFACTURE OF IRON.

Alfred Vincent Newton, of Chancery-lane, Middlesex, for "*Improved machinery for blooming iron.*" (A communication.)—Granted October 14, 1847; Enrolled April 14, 1848.

This invention is for the purpose of more effectually compressing or shingling puddles, balls, or loups of iron into blooms. The improvements are—Firstly, the mode of compressing or shingling by means of a compresser acting in combination with two rollers, and producing therefrom a bloom. Secondly, in the use of cheeks, between which the bloom is formed, having springs at their backs for the purpose of setting and keeping the ends of the blooms square and of proper shape; these cheeks act in combination with the cam-formed compresser and rollers. A third improvement consists of an arrangement of apparatus for feeding the shingling-apparatus with balls to be shingled, and for discharging the bloom when sufficiently compressed and shingled. These combined improvements are represented in the annexed sectional elevation. A, the cast-iron frame of the machine, securely fastened to the bed-plate B;



within the upper part of the frame are sliding blocks, C, C, forming bearings for the shaft D, upon which is mounted and properly secured the cam-shaped compresser E, of the peculiar form shown. The periphery of the compresser is eccentric to its centre of motion, for the purpose of squeezing and compressing the ball of iron between the periphery thereof and the rollers F, F; this eccentricity of the periphery of the cam-shaped compresser commences at the point 1, where it begins to impinge upon the ball of iron submitted to its action, and continues round three-fourths of the whole circumference of the compresser to the point 5, in the following manner—namely, from the point 1, of the periphery, to the point 2, thereon, the eccentricity is very abrupt: the periphery recedes from the centre quickly outwards from the centre of motion for the purpose of more quickly and effectually compressing the ball of iron and squeezing out the impurities therefrom; from the point 2, to the point 3, the eccentricity is more gradual; from the point 3, to the point 4, the eccentricity is still less, the point 4, being at the greatest distance from the centre of the motion; from the point 4, to the point 5, the eccentricity of the periphery is reversed, that is, it inclines very slightly inwards towards the centre of motion; the whole space from the point 5, to the point 1, being one-fourth of the whole circumference, is left open and free for the purpose of allowing sufficient time for discharging the bloom produced by the last revolution of the compresser, and for receiving into the machine another ball or loup of iron to be shingled. The periphery of the compresser is also formed with teeth or indentations thereon, for the purpose of more effectually entering into the ball or loup of iron and squeezing out the impurities from it; these teeth or indentations from the point 1, on the periphery of the compresser, to the point 2, are very deep, for the purpose of entering more deeply into the ball at the commencement than at any subsequent period of the process; from the point 2, to the point 4, the teeth gradually become less coarse, being fine at the point at 4; from the point 4, to the point 5, the periphery is nearly or quite plain. Another advantage attending the construction of the periphery of the cam-shaped compresser, is the turning the ball or loup of iron round upon the lower rollers by means of the grip or hold of the teeth or indentations, the lower rollers F, F, are placed in the position shown below the compresser E, at such a distance therefrom as to suit the size of the ball or loup of iron to be shingled and the size of the bloom to be produced; these rollers F, F, revolve in bearings fixed to the main frame A, of the machine; they are placed close together but not in contact; the peripheries of these rollers are provided with projections thereon, for the purpose of effectually turning the ball or loup of iron round while under operation, and thus subjecting every surface of it to the squeezing action of the compresser. The rollers F, F, are connected by toothed gearing with the cam-shaped compresser E, so that they revolve in different directions, also the peripheries of the rollers and the periphery of the compresser must revolve at nearly equal velocities; there is a mode of adjusting the distance of the compresser E, from the rollers F, F, to suit the quantity of metal in the ball or loup by means of the set screw G, passing through the head of the bloom frame A. For the purpose of setting up the ends of the bloom square and compressing it endways, at the same time that it is compressed by the compresser and the rollers, the patentee employs his second improvement—namely, the spring or yielding cheeks; these cheeks H, H, are placed one on either side of the compresser E, over the rollers F, F, the compresser in revolving passing between them; to the back of each of the cheeks are secured two rods or studs passing through holes in the main frame, which thereby serve as guides to them. Around the rods, and bearing stiffly against the backs of the cheek, and the inside of the main frame A, are helical springs, for the purpose of pressing the cheeks H, H, towards each other, and thereby pressing and setting up the ends of the bloom of iron when pressed outwards by the action of the compresser; the outer ends of the rods are provided with washers and pins for the purpose of preventing the springs from pressing the cheeks too near together, and thereby coming in contact with the sides of the compresser E. The front faces of the cheeks (those which act against the ends of the bloom of iron) are of a convex form, somewhat flattened in the middle. The feeding-apparatus, which constitutes the patentee's next improvement, consists of a trough or frame L, attached to the main frame A, in front of the machine in an inclined position: within this trough or frame is placed the plate or frame M, to which are attached the two bars N, N, one on either side; they move in the guides O, O; upon the base or frame M, is placed the ball or loup of metal to be fed into the machine; the frame M is kept back by a balance-weight below the foundation of the machine; the end of the bars N, N, terminate in the hooked shape shown at N'. The mode of feeding is this:—the ball or loup of metal to be operated upon is thrown upon the bar or frame M, where it remains until the compresser comes into the position shown in the engraving, that is, when the compressing surface of the compresser is out of action with the rollers, and the open or free space of the compresser from 5 to 1, is over the rollers, thereby allowing an opportunity for discharging the last-formed bloom, and receiving another ball or loup to be operated upon; at this moment two pins or studs, projecting from the sides of the compresser, come in contact with the ends N', N', of the bars N, N, which is thereby drawn upwards, and the ball or loup deposited upon the rollers F, F. At the same time also, an arm or crank, fixed upon the compresser-shaft D, outside the main frame, acts upon the bar Q, which is connected by a lever to the discharging-plate R, in such manner that the bloom of iron is discharged from the machine at the back at the same time a fresh ball or loup is fed into it at the front. The discharging-apparatus is retained in its proper position during the shingling process, by means of a spring.

The patentee claims—First, the arrangement of machinery as described, for compressing or shingling puddles, balls, or loups of iron into blooms. Secondly, the spring or yielding cheeks for setting up the ends of the blooms, as also the cam-shaped compresser and rollers as described. Thirdly, the feeding and discharging apparatus.

A CENTRE-VENT REACTION WATER-WHEEL,

Communicated to the Franklin Institute, U. S., by Z. Parker, *of Philadelphia.*

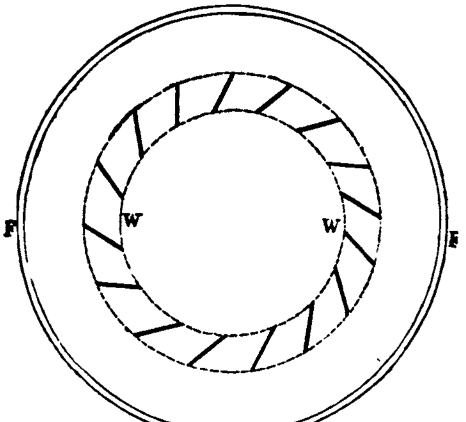
In my notes of the experiments on the centre-vent reaction wheel at Troy, I mentioned the fact of the small amount of water discharged, in proportion to the aperture, and of its disposition to uniformity under all velocities of the wheel. [See *Journal, ante* p. 110.]

I might have stated that in all cases in which the vanes of the wheel direct the water nearly tangentially to the inner circle of the annular rim of such wheels, the quantity discharged (under circumstances of full supply) appears to be about 50 per cent. of the theoretic discharge; and that this proportion appears to be but little affected by changes in the velocity of the wheel, from being held stationary, to any velocity it may acquire by the pressure of the water on the vanes;—or by any change in the circular motion of the water entering the wheel (at its verge), either with or contrary to the circular motion of the wheel.

In corroboration of this position, we have the experiments at Troy, in which the discharge (at the maximum) was a trifle less than 50 per cent., owing probably to the unfavourable form of the vanes;—and the fourth set of my model improvements (the notes of which you have), where the water passed, inwardly, through a structure, which, when the wheel was removed, was exactly similar to such a wheel,—the quantity discharged in this instance, being just 50 per cent. of the theoretic discharge.

Among the many "interesting objects" at the American Institute Fair, of the present season, there was a centre-discharge reaction wheel, in a very neatly constructed model, the wheel, about four inches in diameter, being made of brass and neatly finished. To the under side of a disk, attached to a vertical shaft, were attached plane vanes extending from the verge to a circle about one-half of an inch from the verge. To these vanes was attached the annular rim, in the usual way. The angle of the vanes directed the water somewhat without the direction tangent to the inner diameter of the annular rim, and after passing into the wheel, it fell through the opening of the rim, and bottom of flume some inches, into a basin beneath. The flume was a glass cylinder about seven inches diameter; and the supply, a constant stream of "Croton" through a lead pipe,—falling in from the top of the cylinder.

Suspecting from my former experiments that the discharge of such a wheel must be uniform under all velocities, I took the opportunity of experimenting on this, by applying friction to the shaft (about half an inch in diameter) with my fingers. *I could make no sensible variation in the height of surface by any change of velocity, from being held, to running it beyond its natural free velocity (by rolling the shaft between the thumb and fingers), nor by turning the wheel backward.*



The accompanying cut represents a section of the vanes.

TREATISES ON THE STEAM-ENGINE.

The want of a satisfactory treatise on the steam-engine has long been felt. The existing treatises, notwithstanding their general merits, do not supply the whole of the information which the engineer requires; and the looseness of scientific views, and the neglect of systematic arrangement, observable in most of them render much of the knowledge imparted either dubious or inaccessible.

We have been frequently called upon to give advice in the choice of a work on this important subject. In answer to correspondents who had made an application of this kind, we replied some time ago (vol. IX., page 392), that a complete treatise appeared to us to be one of the desiderata of engineering literature. Several subsequent letters strongly confirmed the opinion then expressed, that the existing treatises on the theory, construction, and routine management of the masterpiece of mechanical invention are not what they ought to be—*accurate*, *complete*, and SYSTEMATIC.

It is no disparagement of the efforts of those who have already written on the subject, to assert that we now know more of it than they did. This branch of knowledge is necessarily progressive. The operations of the steam-engine have been extended in diversity and magnitude, and have attained a universality which to its great inventor himself would have appeared incredible. The new demands of the manufacturer, engineer, navigator, and mechanician, stimulate and suggest new applications of the most powerful and most obedient of the agents of human industry: upon machinery so complicated, the fertility of modern invention and the boldness of modern enterprise are incessantly and successfully exerted: while the minute details of the apparatus are constantly receiving fresh improvements, as practical skill becomes more and more developed and refined.

Yet the apparatus itself is in the main unchanged. The steam-engine of WATT is the steam-engine of 1848: the great inventor bequeathed it to us almost perfect in all its principal parts, and the small amount we have been able to add to his legacy is a striking and accumulative testimony to its original value.

This consideration greatly simplifies the labour of compiling a perfect exposition of the combination of the mechanism. But though the innovations of practice be here confined to details, in other respects the changes have been fundamental. Experience has effected great alterations in the purposes, the management, and the dimensions of the engine itself; and the accessory parts, of which the boiler and furnace are the principal, have received modifications which have completely changed their character.

The *theory* of the steam-engine is also fundamentally different to that originally proposed: that Tredgold's views of the *rationale* of its action have been totally falsified by subsequent experience may be unhesitatingly asserted. It is much to be regretted that his authority, deservedly great as it in some respects is, has given weight to opinions which of themselves cannot stand the test either of theory or practice. It is still more to be regretted that mistaken partiality to his works should have induced subsequent writers to gloss over his errors, and defend that which is indefensible. When the theory of the Count de Pambour appeared, its obvious truths ought not to have been resisted by absurd prejudice in favour of our countryman. De Pambour is *right*—Tredgold and his followers *wrong*. This sounds like a very dogmatic assertion: and we intend it to be so, for if the lucid demonstrations of De Pambour fail to convince his opponents, they are either too perverse or too dull to be converted: we are driven as a last resource to assertion, *ex cathedrâ*, and to resist frivolous contradictions by the weight of great names. The theory of De Pambour had no sooner appeared, than all scientific writers renounced their previous views, and without reluctance signified their adhesion to his.

Not indeed that all his *conclusions* are absolutely indisputable. The chief problem to which he addressed himself was this:—Given the dimensions of an engine, to ascertain the resistance it will overcome at a given velocity, or the velocity at which it will overcome a given resistance. Now, the main difficulty of the question, and that which De Pambour has only partially met, is to ascertain the amount of resistance. It is an essential element, and any uncertainty respecting it affects the whole subject. Without particularising further, we may observe that he has erroneously estimated the resistance to which locomotive engines are subject, and has assumed a law of friction (Coulomb's) which is in this case inapplicable. Another difficulty is in ascertaining the actual efficiency of the boiler. Its apparent evaporation and its effective evaporation are not the same—part of the water being drawn into the cylinders in a liquid state. The amount of "priming" depends on minute and varied circumstances,—the violence of ebullition,—the foulness or purity of the water,—its level in the boiler,—and the capacity of the steam-pipes. Certainly, no mathematical formula, such as De Pambour has laid down independently of these considerations, can be universally and exactly correct.

The materials for an improved treatise are abundant; and those who enter on the task of compiling such a work, should ransack every source of information. Notwithstanding our strictures on Tredgold, we are disposed to think that his work ought to be the basis of a new treatise. There are many reasons which conduce to this conclusion. In the first place, on comparison, his plan and arrangement seem the most perspicuous hitherto published. In the second place, most engineers are familiar with it. This is a great point: readers do not like to be constantly learning out of new books, and engineers especially have seldom time to spare in familiarising themselves with new systems.

The plan which Mr. EATON HODGKINSON has pursued in his edition of the "Treatise on Cast-Iron," appears to be the best for the case before us: he has left his author's text as he found it, appending his own corrections and additions. With respect to a treatise on the steam-engine, the authorities to be searched and cited are numerous and valuable. In pure theory, the views of DE PAMBOUR should be clearly stated, with the modification above suggested. Some of Professor MOSELEY's most useful practical results should be also referred to: his researches respecting the effects of friction of the parts of the engine are too complicated, and depend on data too uncertain, to be available; but some of his investigations respecting the fly-wheel, &c., are invaluable, and have the advantage of leading to simple arithmetical rules.

The great *continental authors* require to be diligently and thoroughly examined. It is principally from the French writers, with NAVIER at their head, that foreign assistance must be expected; and the system pursued in France in the education of engineers, renders almost every treatise written in that country on practical science worthy of consideration at least. The articles contributed to our own *cyclopædias*, and the recent treatise of Mr. HANN, also furnish several useful suggestions for rules, which an intelligent artisan may understand and apply without a knowledge of mathematics.

The *transactions of learned societies* contain invaluable records of the results of experiment and routine experience. Numerous papers have appeared under the auspices of the British Association and Institution of Civil Engineers, on what we just now designated the most difficult part of the problem of the steam-engine—the resistance to which it is subject; and in reference to the locomotive engine the labours of Mr. Wyndham Harding may be particularised. The transactions of the Royal Society also contain some papers referring to the resistances to marine engines—a subject to which Mr. Scott Russell has long devoted attention.

The *scientific periodicals*—the *Mechanics' Magazine*, the *Journal of the Franklin Institute*, &c., ought also to be examined: they are storehouses of facts of the greatest importance. Of course, discretion and accurate scientific views are indispensable in selecting from the vast mass of contradictory and controversial statements, contained in the correspondence of our contemporaries, but even *extravagant* ideas coming from practical men have some use, if suggested by experience—they serve at least to put debated questions in a new light.

The *blue books* of *Parliamentary* and *Royal Commissions* contain also much that is valuable, amidst heaps of rubbish. It requires keen instinct and patient industry to separate the grain from the chaff; but such a labour must be accomplished, if a perfect work on the steam-engine is to be written. Commissions such as those upon the Gauge question and Atmospheric Railways, are convocations of all the most eminent engineers in the kingdom, and their collected evidence is a synopsis which could not be obtained in any other manner.

There are many other sources of information and separate treatises possessed of great merit, but too numerous to be here recited. These ought all to be referred to. The labour of reference is great, but is not the subject worthy of it?—*the* great marvel of the earth—the wonderful, wonder-working agent upon which the social constitution of the whole world depends—which, when the human family has become so numerous that all its labour can scarcely obtain from nature sufficiency of sustenance, co-operates in this struggle for existence. In some sense, our very lives depend on the steam-engine. Without its aid to convey the emigrant from over-crowded shores—to interchange the products of various soils and climates—to convert those products into clothing and other necessaries of society,—without, in a word, its help in carrying on the business of the world, the business of the world would become too great to be accomplished.

He who has increased by the least particle the knowledge of the steam-engine, has therefore conferred on society a benefit of which it is impossible to foresee the extent. Without hyperbole, a perfect account of the steam-engine would stand among the highest of national undertakings. It can scarcely be expected, however, that any treatise now written can be absolutely perfect, for there are many parts of the subject which it requires the experience of future years to entirely develope. Still, the present epoch is particularly favourable for systematising the knowledge already acquired. A uniformity of practice and experience has been at length arrived at, which may indeed be hereafter extended; but which, in all probability, will never suffer any great fundamental change. The chief difficulty to be encountered, is to render the knowledge *systematic*. If it be not digested—if it be not perfectly consistent with itself—if the whole observe not simple and demonstrable dependence on definite principles, the failure of the undertaking is inevitable. Simplicity and system are the two keys to the success of all works on practical science. We insist the more earnestly on the necessity of scientific connection and unity of plan, because experience has shown how far the neglect of those requisites impairs the utility of a treatise on the steam-engine. That bearing the appellation of the "*Artizan*," will always be in high repute, for the vast quantity of practical information which it contains; but this advantage is greatly diminished by the want of plan. Works which contain the labours of several independent writers should always be subject to the supervision of some controlling editor, who should be responsible for the scientific accuracy of the whole. Many readers of engineering works are necessarily obliged to receive scientific principles on trust—their own previous education being devoted to practical, and not to theoretical pursuits. It is all-important that such readers should not be misled. The slightest error of principle, the neglect of particulars in themselves apparently trivial, will frequently lead to the greatest errors. Of what importance is it then that all mechanical doctrines should be accurately conceived and strictly expressed?

Lastly, it should be carefully and constantly explained to the student, that the abstract laws of mechanics are *demonstrated*—that respecting them, debate would be as frivolous as respecting the truth of the conclusions of Euclid. *The only persons who argue about mechanics are those who are imperfectly acquainted with the science.* In the applications of mechanics to the steam-engine, the only questionable topic is the accuracy of data—the methods of calculating from those data have been long since settled beyond all possibility of dispute.*

* We observe with satisfaction, that a new and improved edition of Tredgold on the steam-engine is proposed. The name of the publisher is a guarantee for the excellence of the typography and value of the illustrations. If scientific accuracy, which we have here insisted upon as all-important, be also attained, a most valuable addition to the engineer's library will be produced.

REVIEWS.

Account of the Skerryvore Lighthouse, with notes on the Illumination of Lighthouses. By ALAN STEVENSON, LL.B., F.R.S.E., M.I.C.E., Engineer to the Northern Lighthouse Board. Edinburgh: Adam and Charles Black, 1848.

When we lately noticed the praiseworthy labours of Sir John Rennie, in bringing out his costly work on Plymouth Breakwater, we hardly hoped to be so lucky as to have brought before us so soon another professional contribution of like merit. It may be thought that we are better satisfied by this, and less ready to grumble; but we must freely own that it makes us grumble the more. It is not because Sir John Rennie and Mr. Stevenson have so well done their duty, that the ground of our complaint is gone. Our outcry is not against them, but against the other engineers of high reputation, who, having the same means, have done nothing for professional literature. We know the answer: the hackneyed one of want of time. Sir John and Mr. Stevenson have answered that, and the public are quite willing to make every allowance for any short-coming on the ground of the want of time; but it should not be forgotten that the greater share in a professional book is not in the writing, but in the plates: we may add that the greater part of the cost is for the plates. Nothing, therefore, can be more easy for those who have the money, than to put into the engraver's hands the drawings which they have by them, and then, if they cannot themselves do all the writing which is required, they must get some one to help them; and that, too, is only a matter of money. In any way in which the question can be looked at, it resolves itself into one of outlay, and of good will; and we cannot help saying, that it is far from creditable to our engineers to be so neglectful of publishing proper records of their works. We cannot free them from the charge of want of will, for it is too well known to spirited engineering publishers, to authors, and to editors of professional works, that it is next to impossible to get information, either from the leading engineers or their assistants. Thus, what is published is mostly very imperfect; and then the parties who ought to have given the information are the first to decry what has been done, and to lay blame for what is wrong, or is wanting.

We would rather believe that the wrong lies in this want of will, than in want of liberality, because many of those open to blame have always given very freely to professional institutions. Want of means we cannot allow; for those who can spend money in buying boroughs, and in getting a seat in parliament, can well give a few hundred pounds for bringing out a book. If, too, the evil lay in the want of liberality, we should be hopeless of overcoming it; but if it be from want of rightly thinking about it, or from want of the will to set to work, then we have some trust from what we know of our leading men, that they will not in the end be found wanting; but will, after careful thought, do that which they find to be right. The matter is, indeed, one of great weight, and mostly as it touches the good name of those concerned; for how can the standing of the profession be kept up, if its members lie open to the charge of mere money-grubbing, and an utter carelessness of doing anything to keep up professional knowledge? The engineer has been taught by others, and as he cannot repay those who have taught him, he must for his share teach others. By building the Eddystone Lighthouse, Smeaton laid the groundwork of the greater lighthouse on the Bell-rock; and Mr. Alan Stevenson, following in the footsteps of his father, has outdone him in his great work at Skerryvore. Had we not the first work, the last would still be wanting; but it is by storing up knowledge, by gathering little and little, that it grows until we can work out those wonders which are the pride of all time. The slight tramway has, by the work of many hands, been brought to such a height that it has become the strong arm of civilization. Time has been overcome, and the furthest ends of the land brought, as it were, within grasp. Why, however, do we talk of such things? Why do our great men take their seats at the meetings of the Institutions—why have they anything to do with them, if they do not acknowledge them to the full?

The Institution of Civil Engineers sets out with the purpose of communicating knowledge to its members, and of keeping a record of every new work. Each member is pledged to write something, and to give his mite to the common stock. This is an acknowledgment of the principle, and it would be well if the members of the Institution were, in their choice of officers, to bear this in mind, and only name those of their brethren as president and vice-presidents, who had given their fair share to professional learning. This would be a right acknowledgment to those who, like Sir John Rennie, George Rennie, Sir John Macneill, and Alan Stevenson, have done something, and would give a spur to others.

So long as engineers look after money only, and do not care for their good name, so long will they be without their right weight with the public; and so long will the government be able to trample on them, and give their emoluments to the military engineers. It is not enough that they have raised great works—the evil-willed will always say, those were done for money, and will be ever ready to take away from the honour which would otherwise be awarded. The thankfulness of the public is not so sure, that any means of earning it can safely be left undone. How many great men are there whose names are almost forgotten, and whose deeds are unknown! Very few, when they see a canal, think of the labours of Brindley, or when they see a locomotive, think of how much we owe to Trevithick. Those who were careless of their good names in their lifetime, would have little right to complain of the forgetfulness of those who came after them; and our great men of this day can look forward to nothing better. If they have tasted the ill-will of those amongst whom they live, and who see them and their works, they cannot reckon that they will fare better hereafter, when they have done nothing to show that they care for others as well as for themselves.

Smeaton lives in his writings, as much as in his other works; and he has earned for himself a share in the works of those who have followed in his path. Thus, Mr. Stevenson bears witness to Smeaton's good works. Before beginning the Skerryvore lighthouse, he carefully read what had been written by the great man who went before him. Even to the shape or bearing of a stone, or the fitting of a joint, Smeaton had carefully put down what he had done, and Mr. Stevenson was able to come to a sound judgment as to what he himself thought of doing. The knowledge of a hundred years was at once brought to bear, and the engineer has outdone the works of his great master.

Skerryvore will withstand for hundreds of years the storms and blasts which burst upon it, and those who look at it will see, with wonder, its strength and its bulk, and acknowledge its builder has done his work. A rock of stone is raised upon the crags of Skerryvore, but the even seams hide all the work within: each layer buries from sight the cunning handiwork beneath it. The very finish stands as it were in witness against the hardihood of the builder; and there is nothing scarcely to show his skill,—nothing to show the care, the sweat, the peril spent in putting stone on stone, among threatening waves and sweeping winds, which shook the narrow dwelling of the workmen, ready to dash them into the troubled sea which yawned beneath them. There is greater heroism in fighting against such risks, than in shedding blood in every field of Scinde, or in warring against the bold highlanders of Cabul. Nor can the sailor even claim the perils of the ocean for himself; but the engineer shares them with him. Great as are the risks which our seamen have to meet, they are not greater than Mr. Stevenson and his workmen underwent on the rock of Skerryvore. The first shelter they raised was wrecked in a winter's storm, and they dwelt for months in a barrack upon the rock, which they could not but believe was threatened with the same end. Cranes, windlasses, forges, and anvils, were tossed about the rock by the storm, as freely as pebbles, dashing timbers to pieces, and helping to tear away the works which were laid down. No tool could be left for a day without being lashed to ring-bolts, and even these were sometimes snapped off. The surf dashed in sheets against Mr. Stevenson's window, fifty feet above the sea; and one night, he tells us the barrack reeled so with the shock of the waters, that all the men leaped from their hammocks with a fearful wail, believing that their doom was come, and that they should be swept into the seething waters. Here were they sometimes laid up for days, unable to stand upon the slippery rock, or to face the sweeping storm; and lying in their hammocks day and night, for shelter against the bitter cold. Sometimes they were left almost without food, for the steamer could not always keep the sea; and once their stock was brought down to the wants of one day only. At all times it was hard to land, or to get the stones out of the lighters; and often they were hauled back by the steamer after snapping every warp. The rock was as smooth as glass, and so narrow that the workmen had hardly room to work. In blasting for the foundations, there was no shelter under which the men could lie down; so that Mr. Stevenson had to cover the rock with matting when blasting was going on. On this spot, they worked under the broiling sun while daylight lasted, snatching only hasty meals; and their nights they spent, the first year, in an uneasy ship, which often made them sea-sick; and afterwards in the barrack, whence the storm might have in one moment hurled them from sleep to death.

The few words which Mr. Stevenson gives to these risks he and his fellow-workmen underwent, have all the charm of romance, and may well be put side by side with any tale of the sea. They are most pleasing, however, as a record of true courage, successfully exerted in a useful undertaking. Had we not this record, we should know but little of what Mr. Stevenson has done, or how to rate him at his true worth; indeed, half of his merit would be lost, for the mere workmanship is the least which he can boast of; and others could match him even in that. The skill, the foresight, the battle with the hardships of every kind, which beset this undertaking, tasked his powers to the utmost; but he answered to the call.

Professional gallantry in meeting danger is, we are happy to say, far from rare. The engineer is ever ready to share with the workmen in every work of risk, and there are few great works which have not some tale of gallantry to tell. The lighthouses of the Eddystone, the Bell-rock, and Skerryvore, were beset with peril; in the tunnels under the Thames, Trevithick, Sir Mark Brunel, and Mr. Gravatt, risked themselves; and daily, wherever a new locomotive is tried, a new boiler is set up, a new mine opened, or a new engine built, some engineer puts his life at stake. Courage is not the virtue of a blue coat, or of a red one: the medical man who meets typhus in the abodes of the poor, is a greater hero than he who boards another's bulwarks, or who storms a breach; because he has no hope of glory or advancement, and a greater chance of danger.

The reader of Mr. Stevenson's book is sure to be struck by the thought of its value to engineers now and hereafter, but most to those in our far settlements, who have no chance of going to Skerryvore, or to the Eddystone; and who, indeed, if they had, would see the work—but not how it has been done. Mr. Stevenson has been careful fully to explain every step which he took, to account for his failures, to give the reasons by which he was led, and to describe every process, however common, or however trifling. He thought that nothing belonging to his work was beneath him; and as he looked into everything, he was enabled even to make improvements in many of the common operations. By recording what he did, he enables others to do likewise, and to follow in his path; and no one thinks that his book is too long,—but rather, each wishes that it were longer, though nothing is left out. Care in such works is highly needful, and is most wanted where there are no bounds to the outlay whicb may be made. By leaving out such dovetails and ribbands as Smeaton and Thomas Stevenson had in their lower layers, Mr. Stevenson saved above four thousand pounds in the cost of dressing the granite, and without any loss of strength or safety. By getting everything ready before-hand, he had no loss of time in running up his building on the rock, but had every stone dressed, so that it was right to the eighth of an inch; and the whole building is as well finished as if it were raised upon the main land, with every help at hand,—whereas, there was hardly room on the rock for blasting, no mooring ground, no pier, no quay, hardly room for a windlass, and everything was brought from Hynish, twelve miles off.

Whoever reads this book must think more highly of the labours of engineers; but when we look at the wonderful works which are spread over this land, we cannot but wish that we had as good records of them. The public will name many who are well able to do justice to their own labours, and the fulfilment of the public wish would greatly enrich our libraries. The history of the Liverpool and Manchester Railway, by Mr. George Stephenson, would be a hand-book for all time. Mr. Robert Stephenson, M.P., has in the London and Birmingham Railway a good subject for illustration. Mr. Locke, M.P., can do no better service to the profession than by the publication of an account of the Grand Junction Railway. Mr. Brunel has spent many years upon the perfection of the broad-gauge system, and has in the Great Western Railway achieved a success which should not be forgotten. Mr. Cubitt has allowed his assistants to give accounts of the tunnels and blasting operations on the South Eastern Railway, but a full account of the whole line is wanted from his own hands. We hope the time is not far off when we shall see these among other contributions to our professional literature.

We shall now call attention to the rocks on which the Skerryvore lighthouse was raised. They form part of a long reef, 11 miles to the south of Tyree, in the outer range of the Hebrides or Western Isles, so that they are in the sea-way between Scotland and Ireland; and ships from seaward, if they miss the north of Ireland, are often driven on Skerryvore, where many wrecks have happened. In 1814, an act of parliament was obtained for building a lighthouse, but it was not till 1834 that Mr. Alan Stevenson was sent to make the first survey.

At low tides, Skerryvore measures about 280 feet square; but it is cut up by gullies of unlooked-for depth, so that the solid part is only 160 feet by 70 feet. On this a loaf of rock, about five feet broad, rose to the height of eighteen feet above high-water level, the greater part of the rest being about six feet above that level. The rock Mr. Stevenson calls a syenitic gneiss, consisting of quartz, felspar, hornblende, and mica.

It was not till the summer of 1835 that the survey was finished, and Hynish, in the wretched island of Tyree, was chosen for the workyard. This is 12 miles from Skerryvore. In 1836 and 1837, quarries were opened in Tyree, and in the latter year the pier at Hynish was begun. Mr. Stevenson was now busy in drawing up his plans, and here he came to a weighty question.

"A primary inquiry, in regard to towers in an exposed situation, is the question, whether their stability should depend upon their *strength* or their *weight*; or, in other words, on their *cohesion*, or their *inertiæ*? In preferring *weight* to *strength*, we more closely follow the course pointed out by the analogy of nature; and this must not be regarded as a mere notional advantage, for the more close the analogy between nature and our works, the less difficulty we shall experience in passing from nature to art, and the more directly will our observations on natural phenomena bear upon the artificial project. If, for example, we make a series of observations on the force of the sea, as exerted on masses of rock, and endeavour to draw from these observations some conclusions as to the amount and direction of that force, as exhibited by the masses of rock which resist it successfully and the forms which these masses assume, we shall pass naturally to the determination of the *mass* and *form* of a building which may be capable of opposing similar forces, as we conclude, with some reason, that the mass and form of the natural rock are exponents of the amount and direction of the forces they have so long continued to resist. It will readily be perceived, that we are in a very different and less advantageous position when we attempt, from such observations of natural phenomena, in which *weight* is solely concerned, to deduce the *strength* of an artificial fabric capable of resisting the same forces; for we must at once pass from one category to another, and endeavour to determine the *strength* of a comparatively *light* object which shall be able to sustain the same shock, which we know, by direct experience, may be resisted by a given *weight*. Another very obvious reason why we should prefer *mass* and *weight* to *strength*, as a source of stability, is, that the effect of mere *inertiæ* is constant and unchangeable in its nature; while the *strength* which results, even from the most judiciously disposed and well executed fixtures of a comparatively light fabric, is constantly subject to be impaired by the loosening of such fixtures, occasioned by the almost incessant tremor to which structures of this kind must be subject, from the beating of the waves. It was chiefly on these grounds that the Commissioners of Northern Lights, after consulting a Committee of the Royal Society of Edinburgh, and Messrs. Cubitt and Rennie, civil engineers, rejected the design of Captain Sir Samuel Brown, R.N., who volunteered a proposal to build an iron pillar at the time that the erection of the Skerryvore Lighthouse was determined on in 1835. Mass, therefore, seems to be a source of stability, the effect of which is at once apprehended by the mind, as more in harmony with the conservative principles of nature, and unquestionably less liable to be deteriorated than the *strength*, which depends upon the careful proportion and adjustment of parts."

In fixing the quantity of matter needful to produce stability, and in determining the shape of the tower, Mr. Stevenson had to proceed empirically, for there is a want of sufficient experiments. Mr. Stevenson gives, however, a full discussion of the data, which are available. At this point he brings in an interesting comparison of the three great lighthouses.

	Height above first entire course.	Contents of tower.	Diameter. At Base.	Diameter. At Top.
	Feet.	Cubic feet.	Feet.	Feet.
Eddystone ..	68	13,343	28	15
Bell-rock ..	100	28,530	42	16
Skerryvore ..	138·5	58,580	42	15

The first barrack raised was swept away by the sea, so that in 1839 the summer was spent in raising another, and in excavating the foundation of the lighthouse tower. The difficulty of doing this may be appreciated from the following account:—

"It was commenced on the 6th of May, and was continued up to the last hour of our remaining on the rock, on the 3rd of September. A more unpromising prospect of success in any work than that which presented itself at the commencement of our labours, I can scarcely conceive. The great irregularity of the surface, and the extraordinary hardness and unworkable nature of the material, together with the want of room on the rock, greatly added to the other difficulties and delays, which could not fail, even under the most favourable circumstances, to attend the excavation of a foundation-pit on a rock at the distance of 12 miles from the land. The rock, as already noticed, is a hard and tough gneiss, and required the expenditure of about *four times* as much labour and steel for boring as are generally consumed in boring the Aberdeenshire granite.

After a careful survey of the rock, and having fully weighed all the risks of injuring the foundation, I determined at once to enter upon a horizontal cut, so as to lay bare a level floor of extent sufficient to contain the foundation pit for the tower. The very rugged and uneven form of the Rock made this an almost necessary precaution, in order to prevent any misconception as to its real state, for it was traversed by numerous veins and bands inclined at various angles, on the position and extent of which the stability of the foundation in no small degree depended. That operation occupied 30 men for 102 days, and required the firing of no fewer than 246 shots, chiefly horizontal, while the quantity of material removed did not greatly exceed 2,000 tons. It was a work of some hazard; for the small surface of the Rock confined us within 30, and sometimes within a dozen yards of the mines, while its form afforded us no cover from the flying splinters. The only precautions we could adopt were to cover the mines with mats and with coarse nets, which I had caused to be made during the previous winter, of the old ropes of one of the lighthouse tenders, and in each blast to apportion very carefully the charge of powder to the work that was to be done. That was managed with great skill by Charles Barclay, the foreman of the quarriers, who charged all the bores, and, along with myself, fired all the shots. So completely did the simple expedient of covering the bores with nets and mats check the flight of the stones, that, except on one or two occasions, none of the splinters reached us, and all the damage done was a slight injury to one of the cranes. Perhaps, also, our safety may, in some measure, be attributed to a change which I introduced into the mode of charging the horizontal shots, by which all the risk of pushing home the powder in the ordinary mode with the *tamping rod* is avoided. That change consisted in using a kind of shovel, formed of a rod, armed with a hollow half-cylinder of sheet copper, which contained the powder, and being inverted by giving the rod half a turn round its axis, made the powder drop out when the cylinder reached the bottom of the bore. It was in all respects, excepting size, the same as the charging-rod used for great guns. The amount of materials removed by blasting, as nearly as I could ascertain, was only about 1,000 cubic yards; and, taking all the circumstances into account, it may be doubted whether there be any instance in modern engineering of an operation *of so small an extent* occupying so much time, and involving so great risk. The blasting of the rock, however, was not the only difficulty with which we had to contend, for it also became necessary to remove the quarried materials, amounting to about 2,000 tons, into the deep water round us, to prevent their being thrown by the waves upon the rock, and so endangering the future temporary barrack. That was rather a laborious work, and occupied two cranes, with temporary runs and trucks, during the greater part of the time we spent on the rock. I am well aware that the quantity of materials which I have just mentioned, will be apt to produce a smile from those who have been chiefly conversant with the gigantic but simple operations which generally characterise the great railways of this country; but if it be remembered that we were at the mercy of the winds and waves of the wide Atlantic, and were every day in the expectation of a sudden call to leave the rock, and betake ourselves to the vessel, and on several occasions had our cranes and other tools swept into the sea, the slowness of our progress will excite less surprise; and still less will those who duly weigh the dangers of our daily life, both in our little vessel and on the rock, and who, at the same time, reflect on the many striking proofs which we almost every hour experienced of the care of an Almighty hand, be disposed to withhold their sympathy from the heartfelt expressions of gratitude which often went round our little circle in the boats, as we rowed in the twilight from the rock to the ship. Isolation from the world, in a situation of common danger, produces amongst most men a freer interchange of the feelings of dependence on the Almighty, than is common in the more chilly intercourse of ordinary life.

With a view to lessen the dangers of blasting in such a situation, I had provided a galvanic battery on the plan proposed by Mr. Martyn Roberts, but I used it less frequently than I intended. The attachment of the wires were very liable to be broken from various causes, where there were many men congregated in a small space; and as we could not venture to leave the apparatus on the rock, the frequent re-shipment of it in a heavy sea was another cause of the derangement of its parts. I soon, therefore, laid it aside, and only had recourse to it when any work was to be done under water, or in cases where the simultaneous firing of several mines (for which it is admirably adapted) was of importance in effecting any special purpose.

When the floor had been roughly levelled I again carefully surveyed the rock, with the view of fixing precisely the site of the foundation-pit, and of taking advantage of its form and structure to adopt the largest diameter for the tower of which the rock would admit. In some places I found that parts of the rock, apparently solid, had been undermined by the constant action of the waves, to the distance of 13 feet inward from its face; but none of those cavernous excavations reached the main nucleus, so that, after much deliberation and repeated examinations of all the veins and fissures, I was enabled to mark out a foundation-pit 42 feet in diameter, on one level throughout. That was a point of no small importance; and although it had cost great labour at the very outset, much time was saved by it in the subsequent stages of the work. Not only was the labour thereby avoided of cutting the rock into separate terraces, and fitting the blocks to each successive step, as was done by Smeaton at the Eddystone; but the certainty that we had a level foundation to start from, enabled us at once to commence the dressing of stones without regard to any irregularities in the surface of the rock; and the building operations, when once commenced, continued unimpeded by the necessity for accommodating the courses to their places in the foundation-pit, so that the tower soon rose above the level, at which there was the greatest risk of the stones being removed by the waves before the pressure of the superincumbent building had become great enough to retain them in their places.

The outline of the circular foundation-pit, 42 feet in diameter, having been traced with a trainer on the rock, numerous jumper-holes were bored in various places, having their bottoms all terminating in one level plane, so as to serve as guides for the depth to which the basin was to be excavated. The depth did not exceed 15 inches below the average level, already laid bare by the cutting of the rough horizontal floor which has just been described; and before the close of the season of 1839, about *one-third* of the area of the circle had been cleared, and was ready for the final pick-dressing which prepared it for the reception of the first course. The excavation of this circular basin was conducted with the greatest caution, and few shots were permitted to be fired lest the foundation should in any place be shaken by the action of the gunpowder on any of the natural fissures of the rock. The work was chiefly done by means of what are called *plugs and feathers*. In that part of the work the bores were nearly horizontal, and the action of the *plug and feathers* was to throw up a thin superficial shelf or paring of rock of from 6 to 12 inches in depth, and not more than 2 feet square. By that painful process an area of about 1,400 superficial feet was cleared. The chief trouble connected with that operation was cutting, by means of the pick, a vertical face for the entrance of the horizontal *jumpers* or boring rods; and wherever advantage could be taken of natural fissures it was gladly done. Another considerable source of labour was the dressing of the vertical edges of the basin, as that implied cutting a *square check*, 15 inches deep and about 130 feet long, in the hardest gneiss rock; and the labour attending which, can only be fully estimated by a practical stone-cutter who has wrought in such a material. The plan employed was to bore all around the periphery of the circle, 1¼ inch vertical jumper-holes, 6 inches apart, to the required depth, and to cut out the stone between them. The surface thus left was afterwards carefully dressed, so as to admit vertical and horizontal moulds, representing truly the form of the masonry which the check was intended to receive. The experience of the labour attending that operation gave me great reason for congratulation on having adopted a foundation on one level throughout, instead of cutting the rock into several terraces, at each of which the same labour of cutting angular checks must necessarily have been encountered. The cutting of the foundation occupied 20 men for 217 days in all, whereof 168 days were in the season of 1839, and the rest in the summer of 1840."

It was not till 1840 that this pit was finished, when Mr. Stevenson says—

"The rock, indeed, was in many places so hard as often to make it seem hopeless that tools could make any impression on it. The time employed in the excavation and the number of tools expended on it, were very great, as a pick seldom stood more than three strokes in the harder quartzose veins; but our perseverance was at length amply rewarded by obtaining a foundation so level and so fairly wrought throughout the whole area of a circle 42 feet in diameter, as to present to the view the appearance of a gigantic basin of variegated marble; and so much pleased were the workmen themselves with the result of their protracted toil, that many of them expressed serious regret that the foundation must soon be covered up, so as (we trusted) never to be seen again. In the dressing of the rock much inconvenience arose from the small splinters which flew out before the tools, sometimes rising to the height of 40 feet, and coming in at the windows of the barrack; and after several injuries had been sustained, I at length found it necessary to send to Glasgow for fencing masks to protect the men's faces. In all our work, nothing was more grudged than the occasional loss of half a day in *baling* out the water from the foundation-pit after it had been filled by a heavy sea."

The mortar employed in the building was composed of equal parts of Aberdda lime and Pozzolano earth, being identical with that used by Smeaton.

In 1840, six courses were set, being a mass of masonry equal to the whole of the Eddystone tower. In 1841, 30,300 cubic feet were built, being twice as much as the Eddystone, and more than the whole Bell-rock lighthouse. In 1842, the masonry work was finished.

The general arrangement of the tower is much like that of the Bell-rock lighthouse.

"The ascent to the outside door is by a ladder or trap of gun metal, 26 feet high. The first apartment on the level of the entrance door, is chiefly appropriated to the reception of iron water-tanks, capable of holding a supply of 1251 gallons. The next story is set aside for coals, which are stowed in large iron boxes. The third apartment is a workshop; the fourth is the provision store; and the fifth is the kitchen. Above are two stories, each divided into two sleeping apartments, for the four light-keepers. Over them is the room for the visiting officers; then follows the oil store, and lastly comes the lightroom, making in all twelve apartments. The nearness of the oil store to the lightroom is a great convenience to the keepers, who are thus saved the trouble of carrying the daily supply of oil to the lightroom, up a long flight of steps. The passage from story to story is by oaken trap ladders, passing through hatches in each floor and partitioned off from each apartment in order to prevent accidents and to check cold draughts."

The light was exhibited at Skerryvore on the 1st of February, 1844.

The whole cost of erection was 90,268*l.* 12*s.* 1*d.*, but of this very little was spent directly on the lighthouse. The cost may be thus subdivided:—

Establishment at Hynish	£4822
Rock barrack, No. 1	790
„ No. 2	1479
Establishment and quarries at North Bay ..	1883
Signal tower and lights at Hynish ..	1215
Wharf and railway at Skerryvore ..	257
Steamer, tender, and stone lighters ..	17145
Moorings	766
Boats and freight of hired vessels ..	5700
Labourers discharging cargoes	933
Travelling expenses	1711
Coals	1463
Gunpowder	375
Excavating platform	768
Dressing lighthouse blocks	9929
Tools and machinery	4267
Cartage	1104
Mortar	889
Lighthouse tower, putting together and fittings	8551
Lightroom	3851
Salaries	3656
Lightkeepers' houses	3915
Pier at Hynish	2591
Dock at Hynish for the tender	7055

From the whole cost, 2,839*l.* is to be taken off for the steamer and materials sold, but each item is given by Mr. Stevenson in detail.

Having thus followed Mr. Stevenson throughout his labours on the tower at Skerryvore, we must keep until next month our remarks on a subject no less interesting—that of lights, to which a great part of his book is devoted.

Electric Telegraphs. London: Bogue, 1848.

This is a shilling volume of scraps for the railway carriage, which contains more information about the Electric Telegraph, and more amusement, than any which has yet been published. There is not an invention in England, the United States, or abroad, which has escaped the author's attention.

Report on the Supply of Surplus Water to Manchester, Salford, and Stockport, with some Remarks upon the Construction of Rain Gauges, and the Annual Depth of Rain falling in different localities around Manchester. By S. C. Homersham, C.E. London: Weale, 1848.

This work relates to the great Manchester water controversy, which for the last few years has so much occupied that town. There are three candidates for the supply of Manchester with water: the Manchester and Salford Waterworks Company, the Corporation of Manchester, and the Manchester, Sheffield, and Lincoln Railway Company. Mr. Homersham is the follower of the last-named, and his work is therefore one-sided so far, though we believe it to be for the most part fair and straightforward.

The Waterworks Company suffer from a short supply and the bad quality of their water, which is got partly from peat-moss, and partly from the drainage of an inhabited district, but eked out by a supply from the Railway Company. The supply is clearly neither enough nor good enough for the growing town of Manchester. The town council have therefore got a bill to enable them to get water from Longdendale, gathered into reservoirs from a mossy surface. In the meanwhile they have likewise bought water of the Railway Company.

The Manchester, Sheffield, and Lincoln Railway Company having bought the Peak Forest Canal, were struck with the profit to be got by the sale of water to the great towns of Manchester and Stockport. Their canal, beginning in the Peak district of Derbyshire, among the steep hills, gives them a right to all the water not required by the millowners; and as there is much more than is wanted for the trade of the canal, it is a clear gain to sell it in those towns. The Company do not however wish to retail water to the householders, but to sell it wholesale and in bulk to the corporations or water companies. The Manchester and Salford Waterworks Company in July 1844, bought some of this water, and soon after contracted for 120,000,000 gallons yearly, for three years certain, at 2*d.* per 1,000 gallons, or a rental of 1,000*l.* yearly. In 1844, they agreed to take 50,000,000 gallons more. In August 1847, the Corporation of Manchester took for three years 200,000,000 gallons yearly, at 3*d.* per 1,000 gallons, or a rental of 2,500*l.* yearly. The Railway Company offer to supply the Corporation with seven millions of gallons of filtered water daily, at 1½*d.* per 1,000 gallons, or at a yearly rental of 15,968*l.* 15*s.*

By the enterprise of the Railway Company, this large supply of good water is secured; and we have no doubt that in many other cases, railway companies might have done great good to the public in the supply of water and gas, if it were not for the prejudices indulged in by the legislature, which shackle railway companies as they do private enterprise generally. Indeed, the whole drift of legislation is to thwart enterprise, even when there is the pretence of consulting the public interests. Thus, what with the Sanitary measure, threatening to interfere with the companies, and what with the Standing Orders, there is hardly a bill before the House of Commons for waterworks. The Board of Trade inspection presses likewise very heavily on small companies, besides the House of Commons fees.

Mr. Homersham thus describes the country around Manchester from which the water is drained for its supply:—

"The town of Manchester is situated at an average height of about 120 feet above the mean level of the sea at Liverpool, and is bordered on the north-west, the north, the east, and the south, by high hills and upland that, in a distance varying from twelve to eighteen miles from the town, rise 1,100 to 1,900 feet above the sea, when they begin to fall in a contrary direction. The highest points in this range of hills are Rivington Pike to the north-west of Manchester, 1,545 feet above the mean level of the sea; Blackstone Edge to the north-east, about 1,450 feet; Holme Moss to the east, about 1,859 feet; Kinder Scout to the south-east. about 1,981 feet; Axe Edge, south-east by south, 1,751 feet; and Bosley Minns, nearly direct south, about 1,260 feet. These hills rise very abruptly, and the numerous valleys and mountain gorges that intersect them in various directions contain channels, called rivers or streams, that drain off the rain which falls upon them. The names of the principal rivers deriving their waters from the sources now pointed out, are the Irwell, the Irk, the Medlock, the Tame, the Etherow, the Goyt, the Dane, and the Bollin. The waters of the whole of these rivers unite in the river Mersey, and by this channel are discharged into the sea at Liverpool.

The rivers upon which the towns of Manchester and Salford are situated, are the Irwell, the Irk, and the Medlock; the two latter streams joining the Irwell within the town. The area of land upon which the rain falls that feeds these streams before entering Machester is about 163,000 statute acres; of which about 11,300 drain into the river Medlock; 17,000 into the Irk; and 134,700 into the Irwell; these rivers, like all others having a similar origin, are very irregular as regards the quantity of water which passes down them at different seasons."

Nothing is idle in that busy district—even the water is made to work hard. Mr. Homersham says of the river-gods of Lancashire and Cheshire—

"They are made to turn innumerable water-wheels, that give motion to machinery of various kinds; they are used to supply both the means of forming and condensing steam, that, properly directed, performs such a prodigy of labour with unceasing and untiring effect; they are used to scour, bleach, and dye the goods they have helped to spin and weave; and their flood-waters, collected in reservoirs, feed with water the canals and rivers that transport both the raw and manufactured material. They supply our houses with water for domestic purposes, and they perform the office of scavenger; removing from our dwellings the excretion and filth, that, remaining near us, would undermine our health, engender fevers, and cause premature death."

Of the fall of water two very interesting tables are given, which show that the depth of rain falling at the same place is very unequal in different years, and that it seems to follow no law, but the greatest depth of water falls to the west, which is nearest to the sea:—

TABLE,—*Showing the Depth of Rain fallen per annum for a series of years in different places situated in the upland to the west, north-east, and south of Manchester, and the level above the mean level of the sea.*

	Sharples, near Bolton.	Bolton.	Bury.	Rochdale.	Blackstone Edge.	Fairfield.	Marple.	Comb's Reservoir.	Chapel-en-le-Frith.
Level..	850 feet.	329 feet.	300 feet.	500 ft.	1500 ft.	230 ft.	361 feet.	720 feet.	1121 ft.
Year.	Inches.	Inches.	Inches.	Inch.	Inches.	Inch.	Inches.	Inches.	Inches.
1832		53·77	37·96	43·32	31·63				
1833		51·70	50·61	56·73	47·37				
1834		48·98	42 48	42·41	39·94				
1835		46·44	43 94	47·97	36·43				
1836		53·78	49·57	61·11	41 25				
1837		42·25	44 05	45·30	38·17				
1838		47·85	43 28	45·42	35·55				
1839		45·26	40 70	45·76	35 79				
1840		45 03	38·83	44·00	36·90				48·48
1841		53·87	47·37	48 55	33 50				52·80
1842		3[illegible]·63	34·49	37·08	30·70				41·[illegible]0
1843	63·4	49·40	40·47	50·59	36 10	38·60			41·90
1844	50·0	34·63	28 65	34·41	24·80	26·35	29·40	42·70	33 00
1845	55·0	48·11		51·64	39 80	38·90	38·80	51·10	43·8[illegible]
1846	49·8	40·82		42·04	37·10	30·20	32 35	38·10	38 80
1847	61 4	52 32		51·72	35·70	40·75	43·70	51·30	44·00
Means	50·92	46·74	41·72	46·75	36·29	34·84	36·56	45·80	42 93
Lowest	49·8	34 63	28·65	34·41	24 80	26·35	29·40	38·10	33·00

TABLE,—*Showing the Depth of Rain fallen during the past year of* 1847, *at various places situated in the upland, east and south of Manchester, and level above the mean level of the sea.*

1847	Newton Station.	Woodhead Tunnel.	Comb's Reservoir.	Comb's Ridge.	Todd Brook Reservoir.	Brinks.
Level..	850 feet.	1,000 ft.	720 feet.	1,670 ft.	620 feet.	1,500 ft.
	Inches. 34·69	Inches. 33·12	Inches. 51·30	Inches. 35·85	Inches. 38·39	Inches. 29·50

Note.—The observations for Belmont were procured from J. Magnall, Esq.; and for Bolton from H. H. Watson, Esq.; from Bury, from J. Norris, Esq., F.R.A.S., who, since September, 1845, has removed to Howick House, near Preston; from Rochdale, from J. Ecroyd, Esq.; from Blackstone Edge, from Mr. R. Matthews, the engineer of the Rochdale Canal; and the rest from observations supplied by J. Meadows, Esq. The whole of the observations, with the single exception of Blackstone Edge, were made with rain gauges, fixed very near the ground.

Mr. Homersham charges against the corporation water that it is drained from peat land, and is charged with organic matter, which is hurtful to health. He affirms that no filtration can remedy this, as when the water is warm the peat is soluble in it.

Our author, not content with charging his opponents on every side, asserts that his own company is free from all defects, that the water is most abundant, is collected at the best time, and is little tainted by peat, while he contends that it is likewise the cheapest supply that the corporation can obtain. In his zeal, he says of the freshets impounded by the Railway Company—

"This system of collecting water is very favourable to its *purity*, as when it flows off the hill-sides during heavy rains (except in a peaty or boggy district) it is much less contaminated than water (percolating slowly from the soil, and reduced in quantity by evaporation) which forms the streams in dry weather; besides, over most large tracts of land, consisting of thousands of acres, there will be found farm-houses and a considerable resident population, and all the excretion and filth created from these sources, with the soluble parts of manures placed on the land, must, of necessity, *drain into the streams*, and tend to foul them in comparatively dry weather, although, in heavy rains and floods, the water is not perceptibly soiled from these impurities."

We must say this doctrine is new to us, for we always considered that the freshets should, if the water could be spared, be prevented from entering the reservoirs.

Under their act of parliament the corporation are to take all the water of Longdendale into their reservoirs, and supply a daily quantity to the millowners. This, Mr. Homersham affirms, will cause a greater expense for reservoirs, and will yield less water to the corporation; and he contrasts it with the system adopted on the Peak Forest Canal, where all the water above a certain gauge goes into the canal reservoirs.

When he says that reservoirs for the millowners have not answered (p. 44), and that therefore money is not laid out by the millowners in that way, leaving the inference that the corporation reservoirs will be found expensive and useless, we think he strains his case too much, for there are many difficulties in the case of millowners, as that of getting all the millowners and landowners on the stream to join, and the great expense of getting an act of parliament.

We must notice that there is a great deal of valuable matter incidental to the discussion of the several schemes, which may be usefully read by the engineer feeling an interest in this important branch of practice. Thus, Mr. Homersham discusses rain-gauges, the fall of rain, the duration of fall, evaporation, absorption, and filtration. We should like to see complete records of the movement of some considerable streams. Mr. Homersham says below that he has made such, and we wish he had published them.

"The quantity of water flowing down streams fed from rain falling on the sides of hills varies with every passing shower; *no one or two observations per day can possibly give anything like an accurate result;* a flood will sometimes last but a few hours, and yet in this time it frequently happens more water will run down the streams than at other times will flow down in as many weeks. I have had occasion to make observations on streams every hour in fine weather, and every half hour in showery weather for weeks together, day and night, and in unsettled states of the weather almost every measurement varied."

Mr. Homersham gives an estimate of the cost of the corporation works, which at five per cent. makes a yearly cost of 20,835*l.*, while he asserts that the same quantity of water, of better quality, can be had of the Manchester, Sheffield, and Lincoln Railway Company for 15,968*l.* 15*s.* yearly, being a saving of nearly 25 per cent. All this, however, depends on what the real cost of the corporation works may be, and for that purpose we should have the estimate of their engineer, and not of Mr. Homersham. Indeed, the whole gist of the question lies upon this, which must likewise be the comment on his concluding statement.

"As you are aware, in the spring of last year the corporation could have made arrangements to secure for the use of the inhabitants of Manchester, eight millions of gallons of filtered water per day (as much as will be required for the domestic use of the borough for some years to come), delivered at Marple, 320 feet above the high part of the town, for 1¼d. per 1,000 gallons: in August last year (after having spent a large sum of money in opposing your scheme), the corporation, in conjunction with the Waterworks Company, purchased of you, for three years certain, two hundred millions of gallons per annum of the same water *unfiltered*, to be delivered in the Gorton reservoirs, at 3d. per thousand gallons; or at *double* the price they might, by adopting a wiser course, a short time previously have secured the same water *filtered*."

EXPLOSIONS OF STEAM-BOILERS.

The Causes and Effects of Explosions in Steam-Engines Investigated; and their result from an explosive principle different from the force of elastic steam demonstrated; and conclusive evidence adduced that more than four-fifths of the weight and strength of the engine are required to sustain the explosive force: with an easy and certain means of preventing its destructive effects, and reducing in great part the enormous weight of the engine. By JOHN WILDER, New York. 1847.

The elaborate title of this pamphlet fully explains the views and objects of the writer, who lives in the land of steam-boiler explosions, and seems to have had much experience therein. He commences by adducing a number of facts which are valuable in their way, but his inferences from them seem inconclusive, and often very fallacious. After mentioning several instances of the explosion of cylindrical boilers, in which the ends were blown off and projected to great distances, he proceeds to make calculations of the strength of the relative parts of such boilers, and concludes, that "it is impossible that a cylindrical boiler should be rent asunder endwise by the force of elastic steam, since half the force requisite thereto would burst it open laterally." The following is a specimen of the calculations on which he found this assumption:

"The diameter of the boiler which exploded at Baltimore, is stated in the *Sun* at 20 inches; the circumference, therefore, 62·82 inches, one-fourth whereof, 15·705, multiplied by 20, the diameter, gives 314·1 square inches as the area of the end of the boiler; but the whole periphery or ring resists the pressure on the ends, and its cohesive strength is the circumference, 62·82 inches. In like manner the rectangular section of the boiler, made by a plane passing through a portion of the axis one-fourth of the circumference in length, is 15·705, multiplied by 20, the diameter, is equal to 314·1 square inches, the area; and the pressure perpendicular thereto, the effect whereof is to burst open the boiler laterally, is resisted by the cohesive strength of half the circumference, 31·41, or the two portions of the ring or periphery, each 15·705 inches long: wherefore, in all cylindrical boilers, the amount of metal which resists the pressure on the ends is double the amount of metal which resists an equal lateral pressure; and it appears impossible that they should be rent asunder endwise by the force of elastic steam, which can never exceed the strength of the boiler in which it is generated. The area of a circle is greatest in respect of its periphery, of any figure whatever; much less, therefore, can a boiler not cylindrical be rent asunder endwise by the force of steam. But numerous cases have occurred wherein boilers have been rent asunder endwise, which could only be effected by an almost unlimited explosive power. No trace of such power is found in the history of boilers other than those of steam-engines; nor in these has it been indicated by the safety-valve or steam-gauge, although they show, with sufficient precision, the variations in the strength of steam. Against the force of elastic steam, as generated in a boiler, a properly loaded safety-valve is a complete security, but it has not the least value as against the effects of explosive action."

The "explosive principle," to the action of which Mr. Wilder attributes most of the accidents in steam-engines, appears to be electricity, though it is not so stated distinctly. This force is, he conceives, generated principally in the valve chambers in the following manner.

"It has been proved (?) that explosions in steam-engines are the consequence of the escape of elementary caloric from its combination with water or its vapour, and result directly from the removal, in the valve chamber of engines, of the compressing force which kept up the combination; for when the steam-valve is opened, the steam which passes into the valve chamber has free space to expand and the caloric to escape, but that escape and the further opening of the valve must diminish in a degree the compressing force, and be followed by a farther escape of caloric; but its amount and consequent action must depend more or less on the temperature and expansive force of steam within the boiler. The occasional violence of its action is shown by the prodigious strength of the beams, cranks, &c., which are sometimes broken. It is apparent from all considerations, that if the valve chambers be disused, and the steam let directly through the ends of the cylinder, the smallest clearance of the piston from the end, which does not admit its touching, will be the only vacant space for expansion and escape, and this need not be an hundredth part of the space in the valve chamber, and of consequence the explosive action cannot exceed the hundredth part of its present violence."

Though Mr. Wilder considers he has "proved" his position as to the cause of explosions in steam-engines, we confess that his evidence is not sufficient to satisfy us; and his opinions are frequently formed on erroneous data. He adduces, again and again, as an illustration favourable to his theory, the explosion of a gun barrel when merely corked at the muzzle, but he does not seem fully to comprehend the cause of its exploding under such circumstances; which the explosive force of gunpowder is sufficient to account for, without the supposition that any new force is suddenly brought into action. High-pressure steam is, according to Mr. Wilder, "the most elastic, yielding, and manageable of all prime movers," and only requires to be kept close, so as to prevent the escape of the "elementary caloric," to become as inexplosive as water power. We might hence indeed infer, though probably Mr. Wilder is not prepared to go so far, that high-pressure steam is dangerous only when it escapes, and that what are usually considered safety-valves ought to be regarded as generators of explosive force.

Carbonic-Acid-Gas Engine.—Another attempt to apply carbonic acid gas as a motive power, has been brought before the notice of the Paris Academy of Sciences, by M. Jagu, C.E., who proves very satisfactorily the great power that may be readily gained by imparting a comparatively low temperature to carbonic acid gas; but the difficult problem of condensing the gas, to render it again available, seems not to have been solved. M. Jagu calculates that, by suitable apparatus placed at each station, six atmospheres of carbonic acid gas may be compressed for an unlimited time, from whence the receiver may be filled. To make the gas re-enter the condensing apparatus with the absorption of as little power as possible, he proposes to place a lever on each side of the engine, put in motion by eccentrics adapted to the first moving wheels; at each extremity of the lever to be placed a winch, which will move two pistons of a given diameter, so that the gas may pass in and out.

APPARATUS FOR SUPPLYING BOILERS WITH WATER.

Report (by Order of the American Government) on an Apparatus for Supplying the Boilers of Marine Steam-Engines with a Continuous Supply of Fresh Water. Invented by Captain John Ericsson.—[From the *Franklin Journal.*]

In acceptance of your invitation of the 17th ultimo, we, the undersigned, had the honour to meet together in the city of New York, with the view of testing and reporting upon an apparatus invented by Captain John Ericsson, for the purpose of supplying the boilers of marine steam-engines with a continuous supply of fresh water, and applied by him under your direction in the United States Revenue Steamer *Legaré.*

We have now respectfully to report, that on the 23rd ultimo we embarked in the *Legaré* at 12 M., proceeded to sea, and remained on board till the following morning. During this time the boiler was in operation 15 hours, and we had ample opportunity of examining the means employed for supplying it with water and the results produced.

By the ordinary method of condensing steam in marine navigation, boilers are supplied with the *water of condensation*, composed of the steam that is withdrawn from the boiler and the necessary quantity of salt water required for its condensation. Hence, a boiler in operation is constantly parting with steam (fresh water) and receiving salt water in exchange. The effect of this operation, uninfluenced by a correction, would be, that in a few hours a degree of saturation of the water in the boiler would be reached, that would precipitate upon the plates of the furnaces and flues, a scale of sufficient thickness to arrest the passage of the heat to the surrounding water and cause the destruction of the plates, by exposing them to a temperature destructive of their tenacity. The correction in use is the removal of the water as it approaches saturation, and is effected by *blowing*, or *pumping-off.*

In the operation of either of these methods, it is apparent that there is a loss of the heat that has been imparted to the water blown or pumped off, that neglect to open or shut the blow-off cock, or in the admission of the required supply of water, involves the duration of the boiler and may, as it frequently does, involve the lives of the passengers and the crew, and the safety of the vessel. Even when all practicable attention is given to blowing-off, salt scale will be deposited in long voyages, particularly in the middle latitudes, and accumulate to an extent that renders its removal imperatively necessary. This is at all times a difficult, and even under the most favourable circumstances, an imperfect operation, and when this deposit coats the surfaces of the flues, the consumption of fuel is increased to an extent unsuited to the economy of mercantile enterprise and to the duration of operation requisite for naval purposes.

This evil may be avoided by furnishing the boilers with a full supply of fresh water, and as the weight could not be accommodated, nor the space spared in a vessel for an instrument and its fuel for the sole purpose of distilling the quantity required, it is obvious that the steam furnished by a boiler must be returned to it, after being condensed by the radiation of its heat to cold surfaces, and not by the admixture of water. This method was *proposed* by James Watt, so early as the year 1776, and has been effected to some extent by an instrument invented by Mr. Samuel Hall, of England, and applied to the engines of many steam-vessels, in some of which, notwithstanding its imperfections, it is yet used. It has failed, however, to answer the full purposes desired and anticipated.

In the arrangement of Mr. Hall a great number of thin metal tubes, from one-half to three-fourths of an inch in diameter, were placed *vertically* in a condenser and exposed to a current of cold water from the sea and into which the steam from the cylinder was admitted, for the abstraction of its heat by the radiation of it to the water without the tubes. Now it is evident, that, by this arrangement, the condensed steam would run down the inner surface of the tubes, in its passage presenting a non-conducting lining to them, and in its collection at their bottom an obstacle to the current of the steam and a diminution of the effective radiating surface.

With this method of condensation, it will be perceived that this instrument provides alone for returning to the boiler, the water that has passed through the engine as steam. It follows, then, that all escapes of steam from the boiler or engine, or water-leaks from the boiler, pipes, &c., must be replaced by distillation, at an expense of fuel, directly as the evaporation. Further continued use of this instrument exhibited an oleaginous deposit upon the inner surface of the tubes from the use of oil and tallow in the steam cylinder and on the valve faces, which, acting as a non-conductor, materially obstructed the condensation of the steam.

The apparatus of Captain Ericsson was designed to obviate the difficulties and deficiencies developed in that of Mr. Hall, and is composed of two distinct instruments, a Condenser and an Evaporator; the first for the purpose of condensation, and the latter for a supply of fresh water to provide for any losses of steam or water from the boiler by escapes, leaks, gauge vents, &c.

The Condenser is a cylindrical vessel set at a slight inclination from a horizontal line, containing the requisite extent of radiating surface in metal tubes of *two inches* bore, with an open space at each end. By this arrangement there is free space for the current of steam to pass and for the condensed steam to run down the lower side of the tubes, without presenting a lining of water to intercept radiation or an obstruction to the course of the steam. Connected with this is a pump, by which water from the sea is drawn in and forced through the spaces between the tubes and the inner surface of the shell of the condenser. Thus, the latent heat of the steam is absorbed by contact with the tubes, and condensation is effected for the double purpose of affording a vacuum for the engine and of restoring fresh water to the boiler, for continuous evaporation and condensation, to meet the requirements of the engine.

The Evaporator, as constructed, is a parallelopipedon with a semi-cylindrical top and bottom, the lower portion of which is occupied by a number of tubes similar to those in the condenser, which communicate with a valve at each end of the steam cylinder, worked by the engine: around these tubes, and for some distance above them, water from the sea is admitted for the purpose of being evaporated, and the space above this water is open to the condenser and consequently *in vacuo.* This instrument being designed to furnish fresh water to replace that which way be lost, its operation is resorted to only as occasion may require, and is effected in the following manner: when the piston is near the termination of its stroke the valve referred to opens (above or below, as the case may be), and closes when the piston begins its return stroke; by this arrangement, steam is withdrawn from the engine that has very nearly performed its full expansive effect, and passing into the tubes of the evaporator its heat is absorbed by the water surrounding them, and as this water is *in vacuo* it readily boils at a low temperature, and its vapour being led to the tubes in the condenser, it is condensed with the steam from the cylinder and is supplied to the boiler.

Upon the experimental trial to which you were pleased to request our attention, all practicable arrangements for correct observations were entered into; and with a view to acquire full and progressive notes of the operations of the apparatus, the observations of the various points were confided to special committees, which upon the conclusion of the trial, reported full notes for furnishing the following, viz.:

The boiler was filled with fresh water from above the opening of the blow-off cock; below this, salt water had been left, from an impression of its effect being too inconsiderable to authorise its removal.

At the commencement of the operation of the engine, the water in the boiler as indicated by a saline hydrometer, when at a temperature of 150° Fahrenheit, was ·[illegible].*

The highest temperature of the *feed water* observed was 158° Fahrenheit.
The lowest 132°, and the average 150°.
The highest *vacuum* observed was from 16 to 18 inches.
The lowest from 11 to 15, and the average was from 12 to 15 inches.
The highest *steam pressure* was 54 lb. mercurial gauge.
The lowest was 20 lb., and the average was 48·6 lb.
The highest number of *revolutions* was 47 per minute.
The lowest number was 30, and the average 42·3
The point of cutting off was at three-eighths of the stroke.
The temperature of the sea water was 57.
Duration of *operation* of the engine and boiler 14 hours and 20 minutes.
Time during which steam was raised, 20 hours.

Dimensions of Engine, &c.

Cylinder.—36 inches in diameter, with a stroke of piston of 32 inches.
Boiler.—1,400 square feet of heating surface.
Condenser.—637 square feet of radiating surface.
Evaporator.—100 square feet of heating surface.

Upon coming-to, the freshness of the water was again tested, and when at a temperature of 150° by a different thermometer than that used at the first operation (it having been broken in the interim), the hydrometer indicated ·$\frac{15}{32}$; whether this difference in the indications is to be attributed to a change in the density of the water or to a difference in the thermometers, they being of different

* 12·32 being the point of saturation of water when at a temperature of 200°.

manufactures, we are unable to decide; fortunately the difference is quite inconsiderable, and is not regarded as deserving of further consideration.

So soon as the temperature of the Condenser was reduced to a degree that rendered an examination of it practicable, one of its heads was removed in our presence, and the tubes, when examined, were entirely free from any deposit or incrustation upon their surfaces, and the opinion is entertained, that at a temperature of feed water commensurate with economy of fuel, any difficulty from the deposit of oleaginous matter in this instrument is not to be apprehended.

Regarding the particular performances of the Condenser and Evaporator, it appeared that Capt. Ericsson had relied too confidently on a general current of the cold water through the former instrument, whereas the current was quite partial, being but directly through its narrowest part, the sides of it: hence, the upper portion of it was almost inoperative—this feature was clearly developed by the application of a hand along the surface—while the effect of it was apparent in the moderate condensation indicated by an attached mercurial gauge.

Of the Evaporator, its capacity was clearly shown, in the facility with which the level of the water in the boiler could be raised through the space between two gauge-cocks, and by a resort to its operation not being necessary for more than one-tenth of the time.

Immediately after the close of this trial, measures were taken to effect a diffused operation of the cold water, and as diaphragms could not be introduced between the tubes to alter the current of the water, without incurring an impracticable delay, the expedient of causing the steam to circulate through the tubes was resorted to, and was effected by the application of diaphragms in the open space at each end of the tubes. Upon the completion of this, a further trial was had on Friday, the 1st inst., when several observations furnished the following:—

Pressure of steam,	50 pounds mercurial gauge.
Revolutions,	47 per minute.
Vacuum,	20·5 inches.
Temperature of feed water,	150° Fahrenheit.
Temperature of sea water,	62° „

Compared with the ordinary method of condensation, the value of the method observed is determined by an investigation and consideration of the following points, viz.: Evaporation, Pressures, Consumption of Fuel, Safety and Duration of the Boiler.

1.—Evaporation. *Ordinary Method.*

Temperature of Feed Water, 100° *Fahrenheit.*

Temperature of sensible and latent heats of steam,	1192°
Deduct temperature of feed water, ..	100°
Heat to be added, ...	1092°

New Method.

Temperature of Feed Water, 150° *Fahrenheit*,

Temperature of sensible and latent heats ..	1192°
Deduct temperature of feed water ..	150°
Heat to be added	1042°

Then $\frac{1042}{1092} = \frac{\cdot954}{1\cdot00}$ which represents a gain in the evaporating temperature in the new method of 4·56 per cent.

2.—Pressures. *Ordinary Method.*

Pressure of steam—mercurial gauge ..	50 lb.
Vacuum, 28 inches	= 13·7 lb.
	63·7 lb.

Cut off at three-eighths of the stroke.

Effective pressure on the piston .. = 47 lb.

New Method.

Pressure of steam	50 lb.
Vacuum, 20·5 inches	= 10 lb.
	60 lb.

Effective pressure on the piston .. 44·5 lb.

Then $\frac{47}{44\cdot5} = \frac{1\cdot05}{1\cdot00}$ which represents a loss in pressure by the new method of 5 per cent.

3.—Consumption of Fuel. *Ordinary Method.*

In the Gulf of Mexico and between the Tropics, it is necessary to blow-off, when a hydrometer constructed similar to the one already referred to indicates $\frac{2}{32}$; in the Northern and Southern Atlantic and Pacific oceans, when it indicates $\frac{2\cdot5}{32}$. Hence $\frac{2\cdot + 2\cdot5}{2} = 2\cdot25$ the average point for blowing-off.

As the average degree of saturation of feed water is $\frac{\cdot75}{32}$; the quantity of water blown off compared to that fed to a boiler is as ·75 to 2·25, which is in the proportion of 1 to 3.

Temperature of the water blown off at the pressure and degree of saturation given .. .. 290°

Deduct temperature of feed water ..	100°
Temperature lost by blowing-off ..	190°

As the heat to be added for the purpose of evaporation is 1092° — 1092 × 3 — 1, the proportion of feed water evaporated, = 2184°

And 190 × 3 — 2 the proportion of feed water blown off 190°

The heat absorbed, is .. 2374°

Then $\frac{190}{2374} = \frac{\cdot08}{1\cdot00}$ which represents the loss of heat by blowing off in the ordinary method of 8 per cent.

Summary of Results.

Gain by Evaporation	4·56 per cent.
Ditto by Consumption of fuel	8·00 „
	12·56 „
Loss by Pressure	5·00
Total	7·56

Which is a saving in the expenditure of heat, affording a like economy in the consumption of fuel and altogether independent of the loss of heat, by the presence of scale in a boiler, when salt water is used, and from leaks incurred by the oxidizing effects of salt water.

With the *Ordinary Method*, the level of the water in a boiler is constantly varying from one or both of the following causes, viz.: the quantity of the water blown off, or the particular extent of opening of the feed-valve; while the effective operation of the feed-pump and neglect of the blow-off valve, involves the burning, or an explosion of the boiler.

With the *New Method*, these operations are set aside: thus, blowing off is unnecessary, and the supply to the boiler being first obtained from it, the transit being immediate and the communication incapable of restriction (for if the condensed water was not taken off by the feed pump, the condenser would choke and become inoperative), there can be no decrease in the level of the water, other than that arising from leaks of water and steam. Further, the use of fresh water in a boiler will extend the term of its duration from three and five years to seven and nine.

With a further modification of the condenser, establishing a more diffused current of the cold water, it is evident that a full vacuum may be obtained, as the practicability of attaining this end by external condensation has long since been developed, and with a less proportion of radiating surface than is exposed in the instrument referred to. From the analysis however here given regarding pressures and temperatures, it would appear that a full vacuum, with corresponding reduction of the temperature of the feed water is not authorised; and as such departure from the hitherto practice, furnishes the temperature necessary to prevent any oleaginous deposit upon the surface of the tubes of the condenser, practice and utility are in desired harmony.

A very effective and economical element in steam navigation arises with the operation of this new method, from the absence of scale in the boiler, the presence of which is unavoidable where salt water is used, and to avoid the formation of it as far as practicable, other than a low temperature and corresponding pressure are precluded by the waste of fuel and injury to the boiler consequent upon the existence of this scale, acting as a new conductor of the heat to the water—whereas, with the use of fresh water, higher pressures can be worked and economy of fuel attained in an increased expansion of the steam.

Reviewing the facts herein presented, we are of the opinion that the operation of the apparatus of Captain Ericsson, as far as developed, was eminently successful, and that, with the modification of the condenser suggested, a higher degree of vacuum can be readily obtained. In view of the very great importance of the successful introduction of this method of condensation in the merchant and naval services, we recommend to your consideration the propriety of sending the *Legaré* on a distant cruise, for the purpose of developing the advantages of the apparatus by continued and extended use.

Charles H. Haswell,
Engineer-in-Chief, U. S. N.
&c. &c. &c.

New York, *Oct.* 31, 1847.

DECOMPOSING POWER OF WATER.

On the Decomposing Power of Water at High Temperatures. By Richard Tilghman. (Read before the American Philosophical Society, Philadelphia. [*From the Franklin Journal.*]

It has long been noticed, that partial decomposition is often effected in attempting to render anhydrous, by heat, certain salts which require a comparatively high temperature for the expulsion of their watery crystallization. This effect is not limited to those salts which are capable of decomposition by the action of heat alone, but extends to many which, when previously rendered anhydrous, are entirely unaffected by this agent. The chloride of magnesium offers a striking instance of such an action, being almost entirely reduced to magnesia, with escape of hydrochloric acid, when its solution is evaporated by a strong heat; the anhydrous chloride, when obtained by other processes, is, on the contrary, unaffected by the highest heat.

Even chloride of calcium, a salt of much stronger radical base, has been observed to give off a portion of acid, when all its water of crystallization is driven off by a red heat. In these and many other instances, it seems evident that the escaping water of the salt is the actual decomposing agent, and that the intensity of its action depends solely upon the degree of heat which the salt can sustain before giving it off.

Contact of the salt and water, at high temperatures, appears to be the only requisite of decomposition. It was therefore thought probable, that by exposing the salt, even in its anhydrous state, to a high heat, and passing over it a current of aqueous vapour, raised to a similar temperature, not only might the above-mentioned salts be completely decomposed, but also that many others which have hitherto given no such signs of partial decomposition, might be acted upon in a similar manner.

On making the experiment, it was found, that not only the anhydrous chloride of calcium, but also the chlorides of strontium and barium could be rapidly decomposed by exposing them, at a high red heat, to a current of steam; hydrochloric acid was copiously evolved, and escaped along with the excess of steam, while the bases of the respective salts were left in a free state; the lime remaining anhydrous from the intensity of the heat employed, while the baryta and strontia combined with a portion of aqueous vapour, and were found in a state of hydrates.

In these haloid salts, it is to be observed, that the addition of the elements of water is absolutely essential to the decomposition; as neither the hydrogen which is contained in the acid, nor the oxygen in the base, existed in the anhydrous salt. The action is, therefore, the result of a double decomposition between the steam and the chloride, as well as of the affinity of the liberated acid and base for water.

The oxysalts, and the sulphates of magnesia, lime, strontia, and baryta, unlike the haloid salts just mentioned, contain, even in the anhydrous state, all the elements generally considered necessary for the separate existence of the acid and bases of which they are composed. The application of the strongest heats to these salts, causes, however, no liberation of their acid; but, as with the chlorides, this effect is immediately produced by the passage of a current of steam over them at a high temperature, the baryta and strontia being left in the state of hydrates, and the other bases anhydrous.

The intensity of the affinity between the acid and base of the respective salts, is curiously illustrated by the gradual increase of the heat necessary for their decomposition by the aqueous vapour. Thus the sulphate of magnesia gives off its acid to the current of steam at a low red heat, and consequently a large portion of the acid may be condensed in an undecomposed state. The sulphate of lime requires a high red heat for its decomposition, and on this account the greater part of its acid is resolved into sulphureous acid and oxygen gas. The decomposition of the sulphates of strontia and baryta, requires progressively higher heats, which, in the case of the last salt, must be raised even to low whiteness.

The subphosphate of lime, as it contains an acid much less volatile than sulphuric, combined with an excess of a powerful base, which adds to its stability, was selected as one of the most difficult tests of this decomposing power of aqueous vapour: by a full white heat, however, its phosphoric acid was slowly disengaged. This phosphoric acid gave a white precipitate with nitrate of silver, showing that its liberation and subsequent condensation in contact with a great excess of aqueous vapour, had not prevented that change which heat is known to produce upon this acid.

It might be expected from the decomposition of the salts of baryta, that the sulphates and muriates of potash and soda would undergo the same change with even greater facility. But it was found by experiment, that although the decomposition of these last salts commenced with facility, when they were exposed to steam at a red heat, yet the proportion of alkali thus liberated, never exceeded a very small per centage of the residual salt, however long the operation might be contained. Attributing this peculiarity to the volatile nature of the liberated hydrates of potash and soda at high temperatures, substances capable of forming non-volatile combinations with the alkalies were mixed with their salts, previously to subjecting them to the action of the steam; the acids were then found to be completely disengaged with facility. The fact that both lime and magnesia, substances capable of forming chemical combinations of but the most feeble character with potash and soda, were found to produce the above effect, was considered as confirming, in a great measure, the hypothesis that the volatility of their hydrates was the cause of the apparent difficulty of completely decomposing the salts of these alkalies.

The subphosphates and subsilicates of lime, baryta, and strontia, act in the same manner as lime and magnesia, and in all these cases the chemical combination is so feeble that, when cold, the alkali is disengaged by the solvent powers of water alone.

Alumina, which possesses so much of the acid character with respect to the strong bases, is proportionably more efficient than any of the preceding substances in aiding the decomposition of the alkaline salts: it remains in combination with the alkali, when cold, as a soluble aluminate; but is easily precipitated from its solution by a current of carbonic acid gas.

The calcination of potash alum leaves a mixture of alumina and sulphate of potash, which Berthier has long since stated to be converted into aluminate of potash by the continued action of heat alone, the sulphuric acid being expelled from the potash by the superior affinity of the alumina at a high temperature. By several careful repetitions of his experiment, in which the accidental presence of aqueous vapours was entirely prevented, no decomposition of this kind could be effected, even at a white heat. But by the contact of aqueous vapour, produced by the combustion of the fuel or otherwise, even in small quantity, and at much lower temperatures, the decomposition is rapidly produced. It therefore seems probable that the accidental contact of aqueous vapour was the actual but unnoticed cause of the decomposition in Berthier's experiment.

The powerful action of aqueous vapour upon anhydrous alum at a high temperature, suggested the possibility that a similar action might take place upon its mineral representative, the double silicate of alumina and potash, or common felspar. It will be remembered that this salt, by the simple substitution of sulphuric for the silicic acid which it contains, would be converted into anhydrous alum. To the action of heat alone, felspar presents this difference from alum, that the silicate of alumina is as unaffected by it as the silicate of potash itself; so that to produce an effect upon felspar analogous to that upon alum, the silicic acid of both the silicate of alumina and of the silicate of potash would have to be removed. Silicic acid, in a *free* state, having been long known to be slightly volatile in aqueous vapour at high temperatures, it was thought that, in the present case, it might, like the other acids, be disengaged even from a state of chemical combination, by the same agents. Steam was therefore passed slowly, for some time, over small fragments of highly-heated felspar. Beyond partial fusion, no other visible change than a considerable degree of vesicularity in the parts most exposed was produced. These fragments, being finely pulverised and boiled in water, the concentrated solution was strongly alkaline, and proved, by the usual tests, to consist of aluminate of potash.

After water ceases to extract aluminate of potash from the powdered mineral, dilute sulphuric acid will produce from the residue a small portion of alum. The actual analogy between alum and felspar, substances so distinct in their origin and general properties, yet differing only in the nature of their respective acids, is rendered still more striking by both thus yielding the same product, when deprived of their acids by the same agent. It is worthy of remark, that, although the actual contact of the steam in this experiment is confined to the mere surface of the small fragments of felspar, yet the chemical decomposition produced by it is not confined to that surface, but spreads by a "cementation action," through their entire mass: pulverization is, therefore, required to obtain evidence of the internal change which has been produced.

All the experiments, so far made, would indicate that the following was the general rule applicable to all salts capable of sustaining heat alone without decomposition:—

Whenever a salt, from its own elements alone, or by the addition of those of water, can produce a volatile acid and a fixed base, the evolution of this acid and the liberation of this base will be determined by passing a current of aqueous vapour over the salt raised to a high temperature. When either the acid or base to be liberated forms a combination with water which can resist decomposition by the heat employed, the tendency to form such hydrates adds much to the decomposing power of the aqueous vapour. Although potash and soda are not by themselves fixed bases at high temperatures, yet by the use of the substances before mentioned, they can form combinations which are fixed, and by this means their salts come under the above rule.

The actual number of salts which have as yet been subjected to this mode of decomposition, is not very large; yet, from their perfect analogy of composition with many others, there can be but little doubt of the general extension of the principle.

The chlorides of potassium, sodium, barium, strontium, and calcium, being all thus decomposed, the bromides, iodides, and fluorides of the same and all weaker bases, must probably act in the same manner. The fluoride of calcium, has, in fact, been found to do so, by experiment, hydrofluoric acid being freely evolved. In the same manner, from the decomposition of the sulphates, may be inferred that of the seleniates; from the silicates, that of the borates.

The applicability of this simple mode of decomposition to the explanation of a great variety of geological changes, is too evident to escape the attention of those conversant with that science. In a future paper I hope to be able to give a more complete account of some interesting facts which have been observed in connection with this subject, and to verify, by experiment, many points which must at present be left to inference and conjecture. In fact, although the existence of this law of decomposition was ascertained in 1842, yet it has only been within a few months that I have been able to give much attention to its investigation, which must be my excuse for the imperfect and hurried manner in which it is now communicated.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF MECHANICAL ENGINEERS.

April 26.—At the quarterly meeting which took place in the theatre of the Philosophical Institution, Birmingham, George Stephenson, Esq., President, in the Chair, the following papers were read:—

CYLINDER-BORING MACHINE.

"*On the Fitting-up of Cylinders for Locomotive Engines, and a description of a Machine for Boring them.*" By Mr. C. Beyer.

In the absence of Mr. Beyer, Mr. Fothergill described the machine introduced at the last meeting, but the consideration of which was not then entered upon. [See *Journal*, p. 88.] Its object is to attain a uniformity in the make, bore, and general size of cylinders, so that, in the event of an accident, they may be replaced by spare ones. To accomplish this difficult task, the machine now described was invented. The description of this machine, which would require diagrams to make it intelligible, is briefly this:—The bed upon which it is placed is that of a common slide-lathe, sufficiently long to carry a double set of driving-gear, and admitting of the sufficient traverse of the boring-carriage. The boring-bar is supported by three bearings, the former of which is stationary, and firmly fixed to the bed, to resist the end pressure of the cut when boring; the latter are fixed upon the carriage, and travel with it along the boring-bar. To cause the boring-carriage to move edgeways, a train of wheels descend at the back of the machine to give motion to the shaft, and are transfixed by means of a feathered worm, to the worm-wheel and pinion, both of which move loose upon a fast stud of the carriage; this same stud serving as a fulcrum for a lever, carrying, upon two opposite projections, the intermediate pinions. To hold the cylinders while boring, the top of the carriage is formed into a kind of square panel, by means of two plates, planed on the inside, and fastened to the sides of the bearings, and two cross-stretches. These latter are also planed upon their inner faces, and are secured to the sides and top of the boring-carriage, and have holes bored in them when secured in their places, by means of the bend on the bar, corresponding in diameter to the turned projecting ends of the cylinder to be bored. This arrangement is for the purpose of securing uniformity between the external and internal surface, so that the cylinder be fairly perforated, without the dangerous fault of thick and thin sides.

Mr. Fothergill proceeded to explain the diagrams which accompanied the paper, and remarked that, without offering any criticism on the machine, which appeared to him to be admirable for its purpose, he would merely direct the attention of the members to the great advantages which such an invention must confer on those by whom these cylinders were used. Say, that one of those in use split—by this machine they had the defect supplied immediately.

Mr. M'Connell also bore testimony to the advantages of a uniformity of cylinder. An accident occured to one of the cylinders in use on the line with which he was connected. An order was forthwith despatched to Manchester, and in three days he had another, which fitted exactly the place occupied by the first.

ON THE FORMATION OF TEETH OF DRIVERS OF PIN-WHEELS.

The Secretary read a paper, descriptive of "*A Machine for Forming the Teeth of Wheels.*" By F. Bashforth, M.A., fellow of St John's College, Cambridge.

The paper was accompanied by a model. Referring to Prof. Willis's demonstrations, that the proper form for the teeth of spur-wheels is a compound of portions of epicycloids and hypocycloids, he remarked that no self-acting machinery had been applied to give those forms of metal wheels when mounted on their axes. The principle of the invention submitted to the Institution was the well-known one, that if the pins be supposed to be mathematical lines, the proper forms of the teeth of the driver will be portions of the epicycloids, described by a point in the circumference of the pitch circle of the pin-wheel, when caused to roll on the pitch circle of the driver. The tracer being replaced by a cylindrical cutter, this, as it revolves on its axis, will form with accuracy the interval between the two teeth of the driver. By turning the wheel to be cut through the proper angle, the interval between the next two teeth will be formed, and so on till the whole be completed. He proposed that the pins should be formed in two parts; a solid cylinder surrounded by a tube of iron; and when the tooth of the driver came in contact with the outer case of the pin, it would revolve through a small angle, and thus all abrasion of the teeth of the driver would be avoided.

Mr. M'Connell was unable to see wherein the model before them differed from the plan now in use. In fact, it was nothing more than the old cog-and-drum plan. Probably the idea occured to the inventor without any knowledge of the existing machines, and, if so, he deserved commendation for his ingenuity.

Mr. Cowper could not entirely agree with Mr. M'Connell. The teeth, by this machine, were made by a given mathematical rule. That was the only self-acting machine he had seen that struck a real epicycloid.

Mr. Fothergill was unable to see anything in the machine practically different to those longer in use. If, however, the inventor was an amateur, great credit was due to him for the inventive ability he had displayed in the model before them.

CRADDOCK'S BOILER AND CONDENSER.

Mr. T. Craddock, of Birmingham, read a paper "*On his Improved Boiler and Condenser—their Suitability for Extending the Cornish Economy, and Preventing Boiler Explosions.*"

In submitting to the meeting the subject of this paper, it appears desirable to call attention to the well-established practical data, from which, by the Cornish system of generating and using steam, such economical results have been obtained. To this end, a very brief review of the various laws, or principles, immediately bearing upon the subject, seems to be essential for placing the matter in its proper light before the meeting. For this purpose, perhaps the classified mode is the preferable one.

1. We have to do with the laws by which heat is transmitted from hotter to colder bodies, and *vice versâ*. These demand in our steam-boilers and condensers an extensive surface; and, as far as other circumstances will allow of, that such surface be composed of thin metal. It is further necessary, if we would produce the greatest economy in the generation of steam, that the heat produced in the furnace be, to as great an extent as possible, absorbed by the water; this is best effected by a subdivision of the gases by a slow draught, and by completely surrounding the combustible matter in the furnace by the water in the boiler.

2. The hydrostatic laws require, in order to render high-pressure steam equally safe from explosion as low-pressure, that we diminish the sectional area of the interior surface of the boiler, upon which the pressure of the steam acts, in the same ratio as we increase its pressure. If we do this, then the rending force, tending to burst the boiler, remains the same at whatever pressure the steam be generated.

3. The laws relating to latent and sensible heat, when considered in combination with large volumes of water, and subjected to the casualties attending the steam-engine, suggests the diminishing the quantity of water necessary in steam-boilers, as far as practical circumstancs will permit, as one of the surest means of preventing destructive boiler explosions. The importance which attaches to the suggestions these laws present becomes apparent when we consider the effects in case of explosion, which such an amount of sensible heat produced, as that contained in the large volume of water necessitated in boilers of 60-horse-power, for instance, and of the usual construction, as the sensible heat contained in so large a volume of water would, supposing the pressure of the steam to diminish from 40 lb. to 20 lb. per square inch, generate a volume of steam, at 20 lb. pressure, equal to 30,000 cubic feet. Here we have a cause equivalent to the diffusive and destructive effects exhibited in common and large boiler explosions. The boiler to which this paper refers, reduces the danger from this cause nine-tenths, though the steam be generated in it at a temperature and pressure of 100 lb. per square inch. In this case we find the sensible

heat contained in the water required by such boilers, would give but 8,000 cubic feet of steam at 20 lb. pressure. The boiler under consideration is equally successful in diminishing the risk from explosion, arising from the rending strain due to the pressure of the steam—as, on a comparison with the common boiler, in which we suppose the steam at only 36 lb. pressure, the rending force in such common boiler is 5,400 lb; whilst in the tubular, even with 100 lb. pressure, the rending force amounts only to 900 lb., or but one-sixth of that given in the instance of the common boiler. The most obvious and certain conclusion to which such well-established principles lead, cannot fail to show how ill-grounded and unscientific must be the objections raised against high-pressure steam, when generated in such boilers.

4. The laws relating to the expansive action of steam plainly indicate the importance of the two leading features of the matter before the meeting —viz.: that of removing the atmospheric pressure from the exhaust side of the piston on the one hand, and, on the other, enabling us to make use of high-pressure steam with safety; as by the removal of the atmosphere in non-condensing engines, an economy is produced by this cause alone equal to 38 per cent.; and, by increasing the pressure of the steam at the commencement, can be obtained a further increased economy upon the Cornish system, equal to 40 per cent.

[Mr. Craddock here described, by means of plans, his boiler and condenser.]

Considerable discussion ensued upon the reading of this paper; the principal objections to the conclusion said to be arrived at were those raised by Mr. M'Connell. It was asked by him, if any trial had been made with the engine in actual work? Mr. Craddock replied, that the trial he deemed most proper to submit to the meeting was that made at the London Works (Smethwick), because it must be free from all suspicion; and that to the authenticity of the indicator figures taken off the engine when there, he had no doubt Mr. Cowper would satisfy the meeting.

Mr. Cowper said, he had taken some indicator figures off the engine, and that it was then doing 20-horse power—that is, indicator horse-power; the condenser then took 1½-horse power to work it.

Mr. M'Connell then raised an objection, that the engine was not tested with the other engines working at the London Works.

Mr. Craddock replied, that he had always expressed a wish that it should be so tested, but the firm not intimating its assent, it was not for him (Mr. C.) to insist upon anything of the kind.

Mr. Stephenson, Mr. M'Connell, and Mr. Buckle said, that the test of pumping water, or some such work, was the best test of power.

Mr. Craddock replied, that he was a little surprised that Mr. Buckle, the representative of an ancient and eminent firm, should object to the indicator as a fair test of the power of the engine, when it was well known that the indicator was the instrument used by them to test the power of their own engines.

It was argued by Mr. Crampton, that the only advantages the double-cylinder engine possessed over the single one was greater steadiness of motion; but this did not compensate for the loss of power, which, he considered, arose from the use of two cylinders, in the steam passing from the one piston to the other. Some time ago, he had made some elaborate experiments upon that very subject, and his conclusions then were, that the loss amounted to 14 per cent.

Mr. Craddock replied to Mr. Crampton, by admitting a loss in the expansion, which took place between the two pistons; but, in the small engine before the meeting, it was obvious that this was reduced to the smallest possible amount: he further called Mr. Crampton's attention to the great irregularity of motion that would result by carrying the expansive principle to a great extent into one cylinder. Mr. Craddock here referred to an experiment made on the previous evening with the small engine before the meeting; it was scarcely necessary for him to remind the meeting, that in so small an engine, when first started, the friction was considerable; yet it had worked up to its speed, with the steam cut off at 1-60th of the stroke.

Mr. Crampton replied, that the steam would lose all its power before expanding to such an extent.

Mr. Craddock said, if Mr. Crampton would favour him with a call at the Works, he would show him the fact experimentally. He wished further to remind the meeting that, from his own experiments, he was convinced that, by admitting high-pressure steam direct from the boiler into one cylinder, much of it was condensed by the comparatively cold metal of such cylinder; and that the water resulting therefrom, being in contact with the metal of the cylinder, did, when placed in communication with the condenser, again assume the form of steam, thereby uselessly carrying much heat from the boiler to the condenser, without producing mechanical effect. But as he had stated his views upon this subject elsewhere, and as it may appear to the meeting a somewhat abstruse subject, if not an hypothetical one, he would not trespass upon the meeting by any further remarks upon it.

Mr. M'Connell said, that he was somewhat surprised that after the length of time which Mr. Craddock had devoted to the subject under discussion, he had not arrived at some more accurate data, and had not made up his mind as to the real capability and comparative advantages of his boiler.

Mr. Craddock replied, that although he had certainly devoted much time to the practical consideration of the subject, he had not directly deduced such accurate data as would justify him in stating definitely the comparative merits as to economy of coals in the generation of a given weight of steam; but, nevertheless, if Mr. M'Connell would favour him with a call at the Works, he had no doubt he should be able to show him he had not been idle, but he had been driving after great points, knowing full well that on these depended the economy.

Mr. M'Connell said, that it appeared to him that the condenser was most valuable for marine purposes.

Mr. Craddock replied, that its advantages for such purpose may be stated in a few words, as the condenser would ensure water, free from deposit, for the use of the boiler, thereby rendering tubular boilers practicable, they enabling us to generate high-pressure steam with safety; and thus, by carrying out the expansive principle, with other consequent advantages, a saving of £2,000,000 sterling per annum may be effected in our steam navy.

Mr. Jackson proposed, that in order to test the relative value of the single and double cylinder engine, and set that question at rest—at least so far as that Society was concerned—Mr. Crampton be requested to prepare a paper and diagrams on the subject, to be laid before the members at a subsequent meeting.

Mr. Craddock suggested, that a more conclusive test would be that of an engine having two cylinders, one of which could be readily thrown out of action; its being connected with the same boiler, expanding the steam to the same extent, and performing the same work—the steam and coal required, in both cases, being accurately weighed—would give the most satisfactory solution.

The request to Mr. Crampton being carried unanimously, he (Mr. Craddock) consented to comply with such request.

HYDRAULIC STARTING APPARATUS.

Mr. Fothergill read a paper, descriptive of "*A Hydraulic Apparatus, for Connecting Heavy Machinery, and Disengaging the same from the Prime Mover, without producing those Sudden Shocks which the use of Ordinary Clutches occasion.*" By Mr. Jackson.

A level pinion is supposed to be connected with the engine, or other prime mover, and gears into a bevil wheel, to which is cast a rim, which is turned internally. The wheel turns loose upon a shaft, being lined with a brass bush; the shaft, however, is provided with four projections, through each of which a hole is bored—the centre lines of these holes lying in one horizontal plane, and meeting in one common central chamber. In these holes four rams, which are respectively cast of one piece, with blocks, are fitted, the blocks being lined with copper, and turned, so as to fit the internal surface of the rim. Supposing that the machinery, which is assumed to be connected with the shaft, required to be started, hydraulic pressure is applied to the under rams, by pressing the ram which is in the shaft down upon a column of water, also contained in the shaft and the common central chamber, by means of a fly-wheel, which, with its nut and a screw, forms one piece with the ram—this ram, the nut, and screw, being guided and supported by a brass box, which is screwed into the upper end of the shaft. It is evident, that on the ram in the shaft being thus pressed down, the under rams will gradually and simultaneously press the segments against the internal surface of the rim, with a power proportionate to the force applied at the circumference of the fly-wheel, until the friction produced by such pressure shall be equal to the resistance of the machine to be set in motion. The machine will, therefore, gradually assume the velocity, which, according to the speed of the driving-shaft, it ought to have; at the same time, that any extraordinary momentary resistance, such as might be supposed to occur occasionally in rolling-mills, or other machinery of a similar nature, instead of causing the wheel to break, will have a tendency to make the rim to slip on the segment until the obstacle be removed, or overcome. In order, however, that too great a pressure may not be applied to the lower rams, the upper one and the screw are perforated with a small opening, the extremity of which is closed by a valve, acted upon by a spiral spring, encased in the brass box—so that if, at any time, the pressure exerted upon the rams should exceed that to which the spring is regulated, the water would lift the valve, and escape through it into the box, and through an opening in the lid of the latter into the atmosphere, until the balance of the pressure was again established.

Mr. M'Connell wished to know, whether there was any other means than that supplied by the safety-valve, if he might so call it, whereby the maximum of pressure could be ascertained.

Mr. Fothergill remarked that, in fact, the machine was a self-acting regulator. A certain amount of resistance was required to make the rams work, and whenever the resistance became too great, the spring and the valve carried off the superfluous power.—It was resolved by several of the members, that the cone seemed to answer every purpose which this machine was intended for; but it was argued by Mr. Fothergill, that Mr. Jackson's machine removed the greatest objection to the use of the cone—viz., the backward pressure. By the present invention, the pressure was confined altogether to the direction in which it was wanted. Several other members expressed themselves highly pleased with the machine; and after a vote of thanks had been passed to Mr. Jackson, it was resolved to print the communication, and lithograph the diagram, for the use of the members.

PATENT SAFETY BUFFER.

A paper was read "*On an improved patent Safety Buffer.*" By Mr. Chesshire.

Mr. Buckle, in introducing Mr. Chesshire's invention to the notice of the meeting, took occasion to express his satisfaction with the principle of the machine, which, with the spiral break of the worthy president, would, be the means of saving many lives on railways. In a former notice of the proceedings of the Institution, we have briefly described the principle of the invention. [See *Journal*, June 1847, p. 190.] It is proposed that each railway carriage should be supplied with a strong moveable rod of iron, solid or otherwise, as might be deemed advisable, supported in the centre of the under framework by bearing sockets. This rod is merely to have an "endway" motion, and is to have a head at each end, similar to the present side buffers, although it is not intended that these heads should act against each other, except in case of collision. When the carriages are screwed up into their ordinary travelling state, there will be a space between the safety buffers of some few inches, which would permit the independent action of the side buffers. This safety buffer would be placed in the "van" at the end of the train, and also in the tender in front—so that it cannot have an endway motion, farther than being fixed against strong elliptical springs will admit of, if such springs should be considered advisable. It was shown, by experiments on a small model railway, that the effect of this continuous buffer was exactly that which its inventor claimed for it. A train of carriages supplied with the rods was brought into collision with an ordinary train; and while the former was unhurt, with the exception of the last carriage, which had broken from its couplings, the other was thrown into the utmost confusion. The whole force of the shock, in so far as the former train was concerned, seemed to be conveyed to, and spent on, the last carriage, which the inventor proposes should be filled with goods or luggage.

Considerable discussion followed the reading of the paper and the experiment. The chief objections were—that the absence of all uniformity in the size and make of carriages would, even if the principle was sound, make the invention practically useless. Then, again, the force of the shock of a collision could only be conveyed throughout the length of the buffer and to the last carriage, when the train was on a straight line. If, for example, it was on a curve that the collision took place, the centre carriages, or the one where the bend was greatest, would receive the force of the shock, and the lives of the occupants of the carriage be sacrificed. Mr. M'Connell was the principal supporter of this objection. It was, moreover, argued by Mr. Ramsbottom and others, that the application of the invention would be a practical disadvantage, except in one case—namely, as a strengthener of the bottom of the carriage. By the present side buffers, the force of a shock was distributed over the whole train—the first feeling the greatest amount of force—and thence it sensibly diminished, until the passengers in the centre, or the extremity of the train, scarcely felt it at all. Now, making the shock simultaneous throughout the whole train, as it was proposed to do, would have the same effect on the passengers as if the train had run against a dead wall. They would be thrown into each other's faces in every carriage in the train. Besides, if the train was run into, the engine and tender, and the men upon that, would be sacrificed.

Mr. Chesshire replied, that, with respect to the indisposition of railway companies to go to the trouble and expense of applying the invention, he thought that the lives of the public was the first great consideration; and no expense and no trouble should be allowed to operate against any invention that promised to reduce the number of casualties. As for the principle of the invention, he was convinced that it was perfectly sound. Accidents seldom took place in curves; there the enginemen were always on the look out. The force of a collision must be spent somewhere; and he could not understand how it could be an objection to his invention, that he carried it off from the carriages where damage to life would be done, and concentrated it where nothing of the sort was to be apprehended. He was convinced that, if the Institution would recommend some of the railway companies to adopt the invention, it would be found to act most beneficially.

After some further remarks by Mr. Wright, Mr. Peacock, Mr. Crampton, Mr. Cowper, Mr. Fothergill, and others, Mr. M'Connell recommended that the consideration of the subject should be handed over to the council, who would discuss the merits of the invention with Mr. Chesshire, which was agreed to.

BANKS'S PATENT STEEL TYRES.

Mr. Fothergill read the following paper:—"*The statement of facts relative to* Mr. Thomas Banks's *Patent Plan of Steeling the Tyres of Railway Wheels, is the result of nearly Five Years' Trial, and shows the Cost and Durability of Staffordshire Tyres, Steeled on his Plan, as compared with Low Moor Tyres.*"

The present cost of Low Moor tyres, for 3-feet wheels, will be—

		£	s.	d.
Four tyres of 3 cwt. each—12 cwt., at 22s.	..	13	4	0
Putting on the tyres ready for work ..	..	8	0	0
Twice turning up, after wearing hollow	..	1	0	0
Total cost ..	..	£22	4	0

Suppose these tyres to run 50,000 miles on an average—that is 50,000 miles at a cost of 22*l.* 4*s.*—the present cost of Staffordshire tyres will be—

Four tyres of 3 cwt. each—12 cwt., at 12s.	..	£7	4	0
Putting on the tyres ready for work ..	..	8	0	0
Steel for steeling one set—1½ cwt., at 42s.	..	3	3	0
Man's wages, for turning grooves in the wheels	..	0	10	0
Smith's wages, for inserting the steel ..	..	0	10	0
Man's wages, for turning up after steeling	..	0	10	0
Men's wages, for drilling and rivetting	..	0	7	6
Total cost ..	..	£20	4	6

These tyres are proved to run before steeling 18,000 miles, and after steeling 100,000 miles—making a total work of 118,000 miles, at a cost of 20*l.* 4*s.* 6*d.* Now, subtracting 50,000 miles—the work of Low Moor tyres—from 118,000—the work of Staffordshire tyres steeled—we have 68,000 miles which the latter will run more than the former, and at a cost of 39*s.* 6*d.* per set less. From the above statement, we see the cost of Low Moor tyres, per 1,000 miles, is 8*s.* 10½*d.*; whilst the cost of Staffordshire tyres, steeled, is only 3*s.* 5½*d.* per 1,000 miles. The truth of this statement is proved by a test of nearly five years' trial, on those lines on which the plan has been most used. We are aware that railways did not all wear out the tyres alike; but on those lines where the iron tyres will run more than stated above, the steeled tyres will run more in proportion, and the plan is attended with no danger whatever.

Note.—The above statement shows only the advantage of steeling the tyres once, but we have steeled many a second time, after they have run the above distance. The same tyres may be steeled a second time at a cost of 5*l.* per set, when they will run 100,000 miles more—making a total of 218,000, at a cost of 25*l.* 4*s.* 6*d.*, or 2*s.* 4*d.* per 1,000 miles. The advantage of steeling a second time is secured by taking the tyres in time, while they have the requisite strength for steeling the first time. The general objection against the plan is, that there will be a deal of trouble to carry it out; but this objection, if properly examined, will be found to be without foundation. When the wheels want turning up, they must be taken from under the carriage, or wagon; and, when taken from under, the cutting of the grooves in the tyres for the steel will not cost more than 5*s.* per pair in men's wages; and, when the grooves are turned, one smith and three strikes will insert steel segments with 10 pairs of 3-feet wheels in one day of 10 hours; after which, turning up the steeled wheels will take very little more time than turning up without steeling, which proves that the trouble will not be so great as some people imagine, and nothing, when the durability and saving which is effected is considered, by the tyres being steeled on this plan.

The paper was accompanied by a letter from Mr. Jenkins, of the Manchester and Leeds Railway, highly commendatory of the steel tyres.

Mr. Peacock remarked, that he had tried the wheels steeled by Mr. Banks's process, and the result was, that whereas he was formerly obliged to repair the wheels of the tenders every four months, those with steel tyres did not require repair oftener than once in 12 months. He had not fully tested their wearing qualities, but he had no doubt that they would be found to be most economical as well as useful.—Several other of the members spoke in high terms of the value of this patent.

ROYAL SCOTTISH SOCIETY OF ARTS.

April 24.—John Burn Murdoch, Esq., F.R.S.E., V.P., in the Chair.

The following communications were read:—

1. "*On the value of Gases from different Coals, and the price of Light in different places; also a new mode of estimating the Consumption of Gases, &c., and of estimating Illuminating Power.*" By Andrew Fyfe, M.D., F.R.S.E.

The first part of this paper referred to the illuminating power and durability of gases obtained from English caking coal, from English parrot coal, and from Scottish parrot coal, with which gases the towns in England and Scotland are supplied, and consequently to the value of these gases for affording light. Taking the illuminating power, and the durability, and consequently also the values of the gas from English caking coal, with which Newcastle and many other towns in England are supplied, as the unit of comparison, Dr. Fyfe stated, that he found the illuminating power of the gas from the English parrot coal, such as that from Yorkshire and Lancashire, to be, on an average of numerous trials, 1·73, the durability to be 1·12, and hence the value, bulk for bulk, as 1·85. The value of gas from the different kinds of Scottish parrot coal varies considerably, according to the place from which the coal is obtained; but, as in the larger towns in Scotland, a mixture of coals of different quality is employed, the gas in these towns is generally very nearly of the same quality. Taking the average of all the trials made at Edinburgh, Glasgow, Greenock, Dundee, and Aberdeen, the illuminating power was found to be 3·23, the durability, 1·58; thus making the value very nearly 5, compared with the English caking coal gas as 1, and 2·7 [illegible] English parrot coal gas as 1; in other words, to light an apart-[illegible] extent, and for the same time, by similar methods of con-[illegible] [illegible]ntity of gas from Scottish parrot coal required, being as 1, [illegible] from [illegible] parrot coal would be more than double, [illegible] would be five times as great. Dr. Fyfe then alluded to the value of these different kinds of coal for affording gas, and consequently for affording light by the combustion of their gases. In ascertaining this, the quantity of gas given off from the coals is taken into account, along with the value of the gases themselves for affording light. In this way he has fixed the value of the coals as follows:—English caking coal being 1; that of the English parrot coal is on an average 2·3; and that of the mixture of Scottish parrot coal, as used in different towns, as 6.

In the second part of the paper, Dr. Fyfe alluded to the methods of finding the value of coal gas, for the purpose of illumination, and more particularly to a new mode of determining the durability; in other words, the time required for consuming a certain volume of gas, and consequently the consumpt in given times, and by means of which, also, the specific gravity of the gas could be ascertained. From numerous experiments which he had performed, he had come to the conclusion, that when coal gases are burned from the same burner, with the same height of flame, the consumpt is as the square roots of the pressure necessary to keep up the combustion, at the length of flame fixed on; and that, consequently, the time required for the consumpt of equal volumes is inversely as the square roots of the pressure He had also come to the conclusion, that the durability, in other words the time required for the consumpt, depends on the specific gravity, and that the same law is applicable; consequently, the specific gravity being known, the consumpt can be determined; as the consumpt being determined, by the pressure, the specific gravity can be ascertained, the rule being, the specific gravity is inversely as the square roots of the pressures, necessary to keep the gases burning, from similar burners, at the same height of flame. Dr. Fyfe stated, that he had put these different rules to the test of experiment, with gases which he had prepared from different coals, and also with the gases found in different towns, and he exhibited numerous tables, showing the very close correspondence between the results obtained experimentally, and by calculation. He then exhibited an instrument by which the durability and specific gravity, could by the rates stated, be determined. It consists of a jet burner, of the 40th of an inch in diameter, to which is adapted a scale for measnring the height of flame, and a pressure gauge for ascertaining the pressure under which the gas is burning, at the length of flame fixed on. In this pressure gauge is fitted a graduated scale, with a burner, by which the pressure can be read off, to $\frac{1}{100}$th of an inch. Along with this a table was given, showing the consumpt of gases in a given time—the time required for the consumpt of equal quantities, and the specific gravities, according to the pressnres indicated by the gauge. In the table the pressures ranged from $\frac{40}{100}$ths to $\frac{200}{100}$ths of an inch, which embraces all the pressures likely to occur with the jet burner stated.

Dr Fyfe, in conclusion, alluded to a photometer, which, so far as he was aware, is not noticed in any publication, and which, be believed, was the invention of Professor Bunsen. It consists of a paper screen besmeared with a solution of spermaceti in oil of naphtha, excepting at a part around the centre. A candle placed behind this transmits light in such way as to make the part uncovered easily observed, but when another light is placed in front of the screen, at a certain distance, according to the intensity of the light the spot disappears, and the paper becomes uniformly of the same appearance. In using other lights, the distance at which the uniformity on the surface of the screen is occasioned, depends on the intensity of the light; and thus, according to the usual law, the illuminating power of different lights is determined by the square of the distances at which they are situated from the screen. Dr. Fyfe stated that he had put this method to the test of experiment, and found it extremely accurate, and much more easily managed than the shadow test. He exhibited the screen in connection with the pressure gauge burners, already described, by the use of which, the illuminating power, the durability, and the specific gravity of coal gases are very easily and quickly determined; and hence the value of an instrument of this kind to those travelling from place to place, with the view of ascertaining the value of coal gas in different towns; and of ascertaining the value of different kinds of coal for affording gas, and consequently for affording light by the combustion of their gases.

2. "*On the Composite Ellipse, as an element in the useful and ornamental arts,—being the second of a series of short papers upon the Harmony of Form.*" By Mr. D. R. Hay.

Mr. Hay said that the paper and illustrations he now brought before the Society would show that the composite ellipse, as he described and arranged it, was an important element in the useful and ornamental arts. He then explained the relation which his composite ellipse bore to the circle, and to the regular ellipse; also his mode of describing it, with an analysis of its composition. For this purpose he exhibited six large diagrams. He then went on to show that its beauty consisted in the variety of its parts being in an equal ratio to their uniformity; and that it was to regulate and classify the various developments of this variety, that he had in his work on "First Principles of Symmetrical Beauty," classified a series of forty-two of those figures, by an application of the laws of numerical ratio.

Mr. Hay then stated that he had brought the same subject before the Society about three years ago, as calculated to improve the practice of various arts; and that as it bore upon the humblest productions of the potter's art, the mechanic and the cottager might have, without additional cost, household utensils of forms as beautiful as the finest specimens of the antique.

Mr. Hay then observed that it had lately been stated in the Society that his composite ellipse had not novelty to recommend it, but had long been familiar to every one who had given any attention to the subject; and that Nicholson's "Dictionary of Architecture" had been referred to in corroboration of this statement. Mr. Hay, however, stated that neither the composite ellipse, his method of describing it, nor its application to the drawing of vases, was published in Nicholson's "Dictionary of Architecture," or elsewhere, before he exhibited them to the Society, as just stated.

3. "*Description of a new Ball Stop-cock for Water Cisterns, and of a Nose-cock for Casks or Vats.*" By Mr. Daniel Erskine.

The new ball-cock consists of two flat surfaces ground air-tight, having port holes for the water when in certain positions, and furnished with a spiral spring, that keeps the surfaces in contact. This spring is screwed down to the pressure of the water that it is fitted for, and as the water tends to lift it off the face, this gives it slight friction on either side, and it is not so liable to get fixed as the present ball-cocks are. The same kind will be of great advantage for gas-works, distilleries, and breweries, where large nose-cocks are required, and will be much less expensive.

4. "*Description of a Model of a Stop-cock for Corrosive Fluids.*" By Mr. James Robb.

This stop-cock is intended to obviate the tendency to stick fast, which the plugs of all the common kind have, especially when the fluids are of a corrosive or drying nature, such as common gas; and as it will have no tendency to leak, it may be employed with advantage in oil, beer, or water casks. Its principal peculiarity consists in using vulcanised india-rubber tubing, connected with the pipe by screw couplings, and compressed by means of a screw, or otherwise, to any extent required, by which the flow of gas, or other fluid, may be regulated at pleasure.

INSTITUTION OF CIVIL ENGINEERS.

April 11.*—Joshua Field, Esq., President, in tbo Chair.

The paper read was the second part of a communication made in the year 1841, descriptive of the "*Bann Reservoirs, County Down, Ireland.*" By I. F. Bateman, M.I.C.E.

The first part, of which a short abstract was read, gave the object of the construction of these reservoirs, which were undertaken with the view of regulating the quantity of water in the River Bann, and more effectually supplying water-power to the flourishing and increasing establishments on its banks; this river is, from the bare and naked character of the Mourne mountains, among which it rises, naturally liable to the greatest irregularity in its volume; devastating floods frequently pour down the channel, where, a few hours previously, there was not sufficient water for agricultural purposes. Greatly injurious as this must have been to the agriculturist, it was infinitely more so to the mill-owners, who depended entirely on water-power for their manufactories. Mr. Fairbairn was consulted on the subject; he examined the locality, and advised the formation of reservoirs; the author was then appointed the engineer, and, acting in some degree upon the suggestions of his predecessor, whom he continued to consult, the works were undertaken which are described in the present paper. The peculiarities in the Act of Parliament, granted in 1836, constituting the proprietors of the mills a joint-stock company, for the formation of the Bann reservoirs, are detailed. The works were originally intended to have been more extensive than have been really executed. The reservoir at Lough Island Reavy is alone described; the ground in that spot was admirably adapted for that work, being the bottom of a basin, which was bounded on all sides by rugged hills of granite; in the centre of the basin was a small lake, at the bottom of which was discovered a bed, several feet in thickness, of fossil conferve, similar to those discovered by Professor Silliman, at Massachusetts, North America. This interesting geological fact was first noticed by Dr. Hunter, of Bryansford; the conferve appeared like an impalpable powder, but when viewed through a powerful microscope, they were found to be regular parallelograms, many of them covered with striæ. They are described by naturalists as the fossil skeletons of minute vegetables. The situation fixed upon for the reservoir rendered necessary the construction of four embankments, between the hills, so as to raise the water to a height of 35 feet above the summer level of the lake. The particulars are also given of a series of observations with rain gauges, continued for two years, for the purpose of furnishing data for computing the extent of reservoir which would be necessary to insure a supply of water throughout the year. The continuation described the subsequent works, which consisted of the Corbet Lough reservoir, which was designed as an auxiliary pond, to receive the flood-waters of the lower part of the river, and to retain the night water, to be discharged again during the day, immediately above the more extensive mills on the river. A water-course, of considerable dimensions, was constructed to effect this, and an embankment was thrown across the narrow outlet of the lake, the water being admitted through self-acting flood-gates, which closed as soon as the lowering of the river created a current in the contrary direction. The details of the construction of all these works were given; and it was shown, by calculations based upon actual experiment, and observation of the quantity of water received, stored, and delivered from the reservoirs, that their construction had increased the value of the mill-power of the River Bann full five-

* This paper was accidentally omitted in the report of last month's proceedings.

field, at a comparatively very insignificant cost, as the actual expenditure for the works at Corbet Lough did not exceed 3,300*l.*—the closest economy, consistent with the efficiency and durability of the work, being rigidly kept in view, and the utmost attention being exercised by the resident engineer, Mr. W. L. Stoney.

May 9.—"*Observations on the Causes that are in constant Operation, tending to alter the Outline of the Coasts of Great Britain, to affect the Entrances of Rivers and Harbours, and to form Shoals and Deeps in the Bed of the Sea.*" By Mr. J. T. Harrison, M.I.C.E.

After noticing the gradual deterioration which the harbours of Great Britain are undergoing, the paper gave as the causes of these effects, the action of fresh water, of the tidal wave—the wind waves, and springs, and atmospheric changes, dwelling principally upon the tidal and wind waves. Professor Airy's and Mr. Scott Russell's views on the positive wave of translation (first order), and the oscillating wave (second order), were examined; the peculiarity of the former being, that the motion of the whole mass of the water was in the same direction as that of the wave itself; whilst, in the latter, the motion of the water was alternately opposed to, and in the direction of, the wave. The tidal wave was considered as a purely oscillating wave in the open sea, changing its character as it passed into shallow water. It was supposed that a wave of the first order was generated whenever the water, heaped up by a projecting headland, passed and made its escape into the adjoining water, at a lower level, and that it carried with it gravel and shingle into mid-channel. The regularity of the bottom of the English Channel, and the material of which it is composed, were instanced, to prove that the bottom was now in progress of formation from the aqueous action of this deposition of matter. The effects of the tidal wave along the coasts at Poole, and in the Isle of Wight, were given, to show that such a wave of translation was generated and crossed the Channel, from the Department de la Manche. The results of a series of experiments upon the action of waves on transportable materials showed that certain definite forms were assumed by sand or shingle, under given circumstances—for instance, that the depth of the end of the foreshore below the water depended upon the size and character of the wave acting upon it. It was urged that the end of such a foreshore was to be found at 90 or 100 fathoms under water, stretching from Ushant to the south-west coast of Ireland, and that the tidal wave, in its progress up the channel, drew down to the mouth the material thrown into it by the waves of translation from the headlands. The accumulative action was seen in the carriage of sand through the Straits of Dover to be deposited on the sand banks of the North Sea.

Referring to Mr. Palmer's paper "*On Shingle Beaches,*" the destructive, accumulative, and progressive actions of the wind waves were considered. The cases most favourable for the display of the effective actions of each were adduced. The influence of tides by varying the height of the water, and that of an on-shore wind in facilitating the destructive action, by retaining the water at a higher level, were pointed out. A flat foreshore, was shown to prevent, in a great degree, the destructive action; whilst, on the other hand, deep water, whether from a strong in-shore tidal current, or from other causes, had a contrary effect, facilitating encroachments on the coast. The progressive action was shown to depend principally upon the angle at which the waves strike the beach. The general question of the travelling of shingle, and of its ultimate destination, was considered at great length—instancing particularly the accumulation of shingle at the Chesil Bank and Dungeness. The state of the Great Western Bay, between the Start Point and Portland, was examined, and arguments were offered to show that it had been formed, in a great measure, by the encroachment of the sea. The process of this encroachment, and the alteration in the months of the estuaries falling into the bay, were analysed; and extracts were given from Sir H. De la Beche's work on the geology of Devon and Cornwall, to prove that this process was still in operation. The summary of the arguments in the papers was, that the observed changes in our coasts and the months of the rivers were the result of the combined action of the wind wave, and of the tidal wave; and the attention of engineers was particularly directed to these actions in different localities, in order that, by presenting to the Institution the result of their observations, an invaluable collection of recorded facts might be assembled, which would be of great benefit to the profession, and to the scientific world.

May 16.—This evening was occupied with a discussion on Mr. Gooch's paper "*On the Resistance to Railway trains at different Velocities,*" read at the meeting on April 18.—[See *Journal, ante* p. 155.]

The principal speakers were Messrs. Brunel, Gooch, Bidder, Locke, Harding and Russell, and their arguments were necessarily so complicated by calculations as to render it difficult to convey, within reasonable limits, even an outline of the discussion. It was contended on one side that the subject had been so treated in the paper as to make it almost a question of the comparative gauges; that the experiments upon which the arguments were founded could not be received as applicable to railways in general, inasmuch as it was presumed from the statements that the portion of the line was selected as being in the best working condition; that the engine and the carriages were also picked as being in the best order; and that therefore the results were due to these peculiar circumstances, and not to the ordinary working state of the line; that the amount of resistance per ton was understated by Mr. Gooch on these accounts, and that the rate of resistances arrived at by the committee of the British Association, by projecting trains of carriages down inclined planes, was nearer the truth than the expression of resistance arrived at with the locomotive and the dynamometer; that the tables were partly made up from the actual results of the experiments and by using Mr. Harding's formulæ, which had been repudiated in other cases as incorrect; that the greater weight of the trains in the late experiments, as compared with those of the British Association, &c., reduced the value of the deductions; that the atmospheric railway could alone give the resistance due to the frontage, which was not given when a locomotive was used, as it covered a portion of the carriage frontage, and the dynamometer being behind the engine, the resistance of the train of carriages alone could be arrived at; and that the valuation of the pressure of the wind upon the train at various angles was not satisfactory. Such was the general tenor of the arguments; and on the other side it was urged that Mr. Gooch had endeavoured, as much as possible, to avoid introducing, in any degree, the question of the gauges, and to give the actual results of the experiments, in order that any persons examining them might draw his own conclusions; that the portion of the line on which Mr. Gooch's experiments were tried was not selected for its good condition; that it was fixed upon by Mr. Brunel himself only the night previously to the experiments, and was not that part which had been originally intended to be used; that the engine and carriages were such as could be spared from the working stock and were not picked—in fact, that they were not the best of their class; that therefore the results were not due to peculiar circumstances, but were those of the average working of the line; but that even had the line, engine, and carriages being selected, engineers would, from the results, have been able to make allowances for other cases, and that the value of the experiments would not have been diminished; that it was believed that in descending Wootton Basset incline by gravity, without the aid of an engine, a greater velocity had been attained than the maximum recorded in the experiments of the British Association; that the tables were divided into columns, distinctly showing what resulted from experiment and what from the use of formulæ; that it was impossible, with engines of the ordinary weight, as now constructed, with an ordinary train, to limit the experiments to such small weights as had been formerly used; that in all cases the surface of the locomotive was allowed for in calculating the frontage resistance; that it was expressly stated in the paper that the apparatus for the wind gauge was not so satisfactory as could have been desired, and therefore its results were kept separate in the tables; that Mr. Gooch had not intended to cast any reflections upon the former experimentalists, but merely to point out the errors into which he thought they had fallen, and to induce, by his experiments, others which should fix more certainly the amount of resistance; this, it was still contended, was less than had been formerly stated, and although other experiments would be necessary to set the question completely at rest, it was unanimously agreed that Mr. Gooch's experiments and paper were very valuable contributions, and it was hoped he would continue his observations on this most interesting subject.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

On the 8th ult., a special meeting of the Institute was held, to take into consideration a memorial submitted to the council in April, 1847, urging the formation by the Institute, of a benevolent fund for the less fortunate members of the profession, signed by thirty-four architects. Mr. Bellamy, Vice-President, laid before the meeting a summary of the proceedings which had been taken upon it, the result of which was, that the council had adopted the report of a joint committee (part memorialists, part members of council), advising the formation of such a fund, and recommended it to the consideration of the members at large. The rule of the Artists' Benevolent Fund, that recipients must be authors of "works known and esteemed by the public," would shut out many deserving members of the profession, and those connected with it. Communication had been opened with the officers of that fund, by some who thought that the desired end might be better attained by an arrangement with them than by a fresh fund. A long discussion followed as to the mode of carrying out the views of the memorialists, and as to the necessity for the fund. An opinion was generally expressed, that if raised at all, it was quite unnecessary to give the administration of it to another society. Ultimately, on the motion of Mr. Angell, a resolution was passed, declaring the importance of establishing such a fund, and appointing a committee of nine, to consider in what way it could best be effected, and to report hereafter.

May 15.—Mr. J. W. Papworth read a paper in illustration of some drawings of Præneste, ancient and modern; and Mr. J. Thomson read some observations on the ancient village church of Leigh-de-la-Mere, Wilts.

Mr. Angell's Conversazione.—On the 25th a conversazione was given by Mr. Angell, Vice-President of the Institute of British Architects, at his residence in Gower-street, which was attended by all the leading members of the architectural profession, the Marquis of Northampton, and the heads of the scientific world. Many works of art were exhibited, and much gratification was expressed at the valuable example set by Mr. Angell to his colleagues, in affording such a *réunion* to the professors of architecture.

ON FLAME AND GASES.

Professor Faraday lately read a paper at the Royal Institution, "*On the Diamagnetic Condition of Flame and Gases.*"—Mr. Faraday having briefly recapitulated the chief subjects of his recent research into the magnetic condition of matter, proceeded to state a still more recent extension of these researches made by Prof. Bancalari at Venice. Prof. Bancalari has shown that flame, when placed between the poles of a powerful magnet, becomes *diamagnetic* (*i. e.* spreads out in the plane which is perpendicular to the line joining the poles of the magnet). Prof. Faraday's object was—first, to remove certain misapprehensions of his own published opinions in regard to this phenomenon; and, secondly, to give a philosophical account of it. Referring to his "Experimental Researches," in the *Philosophical Transactions*, read in 1845 (pars. 2423, 2433, 2435), he showed that he had never asserted, as had been imagined, that the gases were *not* subject to magnetic action; but merely that his experiments had not then established that they were affected by that force. The causes of this magnetic influence were then considered. Flame was dissected, and its complicated nature—consisting of solid matter, of a surrounding film of heated air, and of gaseous products of combustion—was experimentally demonstrated. The following experiments were then exhibited to prove (*a*) that *hot air is diamagnetic with reference to cold air*—(*b*) that *carbonic acid gas, a product of combustion, is diamagnetic*—(*c*) that *carbon, which is liberated during combustion, and imparts luminosity to flame, is also diamagnetic.*

(*a*) *Hot air is diamagnetic with reference to cold air.* The hot air rising from a glowing spiral of platina wire, placed between the poles of a powerful electro-magnet, was proved to be bent aside by the fact of its inflaming a piece of phosphorus in the equatorial plane on either side of the red-hot platinum while the magnet was active, and also by its not firing the phosphorus (as would happen in the ordinary condition of things) when this substance was placed immediately above the heated wire.

(*b*) *Carbonic acid gas is diamagnetic.* This was proved by a jet of that gas being made to diverge from the perpendicular downward current, which its gravity would cause it to take, into a flask of limewater (which it rendered turbid) placed in the equatorial plane.

(*c*) *Solid carbon is diamagnetic.* It was shown that the smoke of a taper, when placed beneath the axial line, divided itself, as flame was made to divide, into two streams in the equatorial plane, each on either side of this axial line.

The singular condition of oxygen gas, in being far less diamagnetic than the other gases, and therefore appearing as if magnetic, like iron, when surrounded by other gases or air, was demonstrated by its carrying a cloud of muriate of ammonia (itself diamagnetic) to the poles of the magnet, around which it seemed to gyrate in vortices.

Mr. Faraday concluded by noticing the apparently exceptional case of flame penetrating the pierced poles of a magnet, and coming through them in an *axial* line. He showed that in this case the maximum of force was not in this line, but in the circle of lines forming the edges of the hollow cylinder drilled through the poles. Therefore—inasmuch as the force in the vacant space was feebler than the force at its solid circumference—flame, which always goes away from the spot where the force is strongest to the spot where it is weakest, penetrated the hollow axis of the cylinder.

PROCESSES FOR UNITING METALS AND METALLIC ALLOYS.

At a recent meeting of the Berlin Academy of Sciences, M. Pulbrich, founder, of Hamburgh, communicated an account of his processes for firmly uniting metals or metallic alloys, which possess different properties and values, such, for example, as bar-iron with cast-iron, gun-metal with cast-iron, and thus to obtain pieces of mixed metal suitable to make clasps, girders, panel squares, railway bearings, wheels, axle-trees, and other parts made use of in machinery and in building, possessing the weight and the cohesion required, but much harder and more resistent in certain parts than inothers. The following is the process adopted, as described by the inventor:—

"*To Unite Bar-iron to Cast-iron.*—In order to unite bar-iron to cast-iron—to make, for instance a bar of rectangular girder, of which one-fourth the thickness shall consist of bar-iron, and the three other parts of cast-iron, or rather in the combination of one volume of these metals in any proportions, I proceed as follows:—I take a bar of iron, of the required thickness, and I plunge it into a cleaning bath composed of nitric acid or any other acid diluted with water. I then take it out of the cleaning bath, expose it to a red heat in a furnace, and plunge it again into the cleaning bath; by means of these operations, I get rid of all the oxide from the surface of the metal. To remove from this bar any acid which might remain, I wash it with any alkaline solution (for instance, sal ammoniac), and I immediately plunge it into a bath of melted tin, where I allow it to remain until it has become well tinned over its whole surface. This done, I apply to the tinned iron at the side where it is to be united with the cast-iron, an alloy or solder composed of copper and tin, in the proportions of five parts of copper, and 95 of tin. The bar of iron thus prepared is then introduced to the bottom of a mould of the form and dimensions corresponding to the bar which it is wished to be produced, and it is kept down by iron bolts or nails, which have previously been well tinned; the cast-iron is then poured in a liquid state on the bar of iron, until the mould is filled. In this state, a fusion takes place at the surface of the iron in contact with the liquid cast metal, and under the influence of the alloy of solder of copper or tin interposed, the two pieces of bar-iron and cast-iron unite so firmly the one to the other, that it is almost impossible to separate them.

"*To Unite Steel with Cast-iron.*—Follow exactly the same process as above described.

"*To Unite Copper, Bronze, Gun-Metal, or Brass, with Cast Iron.*—These alloys, as well as all those of copper, can be united by exactly similar means to those above described; except that instead of clearing the surfaces of the alloys by means of acid and alkaline solutions as above mentioned, the surfaces should be filed, and the union with the cast-iron effected at the lowest temperature possible, in order that the bar of alloy might not be melted.

"The proportion indicated above for the composition of the alloy or solder is that which appears the most suitable, where the pieces of metal to be united are of moderate dimensions; but when they exceed moderate dimensions, it will be better to increase the proportion of copper employed.

"In the examples given above, it is supposed that the different metals were united together on one side only; but one of these metals may be united at two sides, or at two opposite or adjacent faces, to the other metals, or even covered throughout its entire surface. Further, the pieces of metal may have a curvilinear, angular, or any other form, and the mmanner of oulding may be varied according to the rules which practice has long since furnished in foundries."

THE EFFECTS OF ZINC ON IRON.

A letter from Mr. James Nasmyth, of Bridgewater Foundry, Patricroft near Manchester, to the *Mining Journal*, communicates the results of some experiments recently made at the desire of the Lords of the Admiralty, with a view to determine whether old iron that had been galvanised, or coated with zinc, was rendered unfit for being again worked-up. The results of these experiments seem to prove that the quality of the iron is improved instead of being deteriorated by the zinc combined with it. The following is Mr. Nasmyth's report of the experiments:—

"A piece of galvanised iron-wire rope was welded up into a bar, and put to the most severe test. In the first place it was found, that although the iron-wire was quite covered with metallic zinc, which, although partially driven off in the process of welding, yet, so far from the presence of the metal, or its oxide, presenting any impediment to the welding of the iron (as in the case of lead), the iron-wire welded with remarkable ease; and the result was, a bar of remarkably tough, silvery-grained iron, which stood punching, splitting, twisting, and bending, in a manner such as to show, that the iron was not only excellent, but, to all appearance, actually improved in quality in a very important degree.

"Encouraged by such a result, a still further, and even more severe, trial was made—viz.: by welding up a pile of clippings of galvanized iron-plates, or sheet-iron, covered with zinc, as in the former experiments. The presence of the zinc appeared to offer no impediment to the welding, and the result was, a bloom or bar of iron—the fracture of which presented a most remarkable and beautiful silvery grain—as good, if not superior, in aspect to the finest samples of 'Low Moor' or 'Bowling' iron. Bloom of this iron were rolled out in rods, and tested in the cable-proving machine, and the result indicated from 5 to 10 per cent. higher strength than the best samples of wrought-iron—thus establishing the fact, that, so far from the presence of zinc being destructive to the strength and tenacity of wrought-iron, the contrary is the case.

"I may mention, that bars of iron were heated to a welding heat, prepared by Scarf for sheathing, in the usual manner; and, on drawing them from the fire, for being welded, a handful of zinc filings was thrown on the welding hot surface, and the welding proceeded with. In this severe test no apparent impediment to the process resulted; the iron welded as well as if no zinc had been present."

Mr. Nasmyth infers from these experiments, that some improvement might be made in the manufacture of iron, by the introduction of metallic zinc in the puddling furnace. In corroboration of this opinion, he adduces the fact that the strongest cast-iron made in Belgium, and selected for the casting of guns, is made from an iron ore in which the ore of zinc forms a considerable portion.

Mr. Leighton, of Cwmammon, following up the suggestion of Mr. Nasmyth, has communicated other applications of zinc to iron, which he had devised for the purpose of bringing anthracite coal more into use. His object was the preparation of pure oxide of zinc to be used as paint, for iron-work more especially, for making joints, &c., in lieu of white-lead. "If," he observes, "people could be once induced to make a trial of anthracite coal, worked by a blast, for several manufacturing operations, the value of this peculiar fuel would be established. It only requires a beginning; it is quite possible to treat the sulphuret of zinc—a very abundant ore, known as blende, or black jack—so that pure oxide of zinc and sulphuric acid should be prepared by the same operation. This would be a very profitable business, and create a consumption for a considerable quantity of the ore; but at the present price of the metal, it would even pay handsomely to prepare oxide of zinc from spelter. Say, in round numbers, 4 cwt. of spelter, worth £2 10s., would yield 5 cwt. of oxide of zinc, which, at the price of dry white-lead, would be worth £6; the cost of labour and fuel being trivial, there would be a profit of something like cent. per cent."

SUPPLY OF WATER FROM THE NEW RED SANDSTONE.

A paper "*On the Supply of the Town of Liverpool with Water from Shafts sunk in the New Red Sandstone*," was lately read at the Polytechnic Institution, Colquitt-street.—After some observations, as to the importance of a plentiful supply of pure water, the lecturer remarked that the original source of all water found in the earth is the rain which falls from the clouds. Though the fall of rain at Liverpool was only about 36 inches per annum, in the interior and hilly parts of the country it was far greater: for instance, in 1845, there fell at Seathwaite 151 inches; Grasmere, 121; Buttermere, 87; Keswick, 62; Whitehaven, 49; Cockermouth, 47; and at Manchester, the fall averages about 41 inches. He had examined various springs in the new red sandstone, and had never found any above the mean temperature of the climate; and concluded, therefore, that those in the new red sandstone were entirely supplied from the rain which falls from the clouds, estimated in that district at 36 inches per annum. Allowing 18 inches for evaporation and vegetation, would leave 18 inches absorbed and stored in the earth every year, giving 392,040 gallons per acre, or 250,905,600 gallons per square mile. He maintained that the strata of the new red sandstone, at a level below the surface of the sea, are naturally, fully, thoroughly, and permanently saturated with water; and that any shaft or excavation sunk to that depth, will always, through lateral percolation, be full of water to that height. He considered the most desiderable mode would be to sink shafts from 1,000 to 2,000 feet deep, which would pierce a stratum highly saturated with water, and which would be filled to within a short distance of the surface. He objected to the plan proposed by some persons to be adopted, that of bringing surface water from a distance, as all such was impregnated with millions of myriads of animalculæ, to the great detriment of public health. In conclusion, he stated as his decided conviction, that the strata of the new red sandstone formation are not yet exhausted of their water, neither do they show any symptoms of exhaustion, neither is it possible to exhaust them, so long as they maintain their present constitution and geological position; so long as they consist of innumerable beds, of variable hardness, and of variable porosity; so long as they are capable of lateral percolation; so long as the hydrostatic pressure of the sea enables them to keep their lower beds at the full point of saturation; so long as their upper beds are greedily absorbant of water; and so long as Nature, in her bountiful beneficence, is annually pouring down upon them more than 500,000,000 gallons of water upon every square mile of their surface.

THE VENTILATION OF TOWNS.

We have received from a correspondent at Liverpool, a description of a plan, which he has for a long time considered, for effectually securing the ventilation of large towns; and if capable of being carried into practice, it would have the effect of not only ventilating the houses in crowded neighbourhoods, but it would also purify the drains, the exhalations from which are frequently the cause of disease throughout large districts. The communication is too lengthy to be given entire; we shall therefore only extract those portions describing the proposed plan, which may be thus briefly stated. It is proposed that in each town one or more large, high chimneys shall be built, with which all the main-drains shall communicate; and that the fire-places of each house, instead of having chimneys carried through the roof, shall have flues carried below and entering the drains. At the bottom of each of the large ventilating chimneys, fires are to be kept burning for the purpose of causing sufficient draught. This plan, which carries out on an extended scale the mode adopted in ventilating the Houses of Parliament and other large buildings, offers important advantages as a sanitary measure, and ought not therefore to be discarded as impracticable without due consideration. The writer, who is an engineer, affirms that he has tested its practicability, by detailed calculations. We will now let him develope the plan in his own words:—

"It is proposed, that all house and factory chimneys be discontinued; that the smoke and products of combustion, instead of ascending as heretofore, and being discharged at the roof, be made to descend, pass into the house-drains, and through them into the public sewers; the factories having special communication for themselves.

"It is further proposed, that the sewers be arranged to converge and join into larger or main sewers, which would be conducted through the town, to the highest and least-occupied ground in the vicinity, where these mains, culverts, or tunnels, would terminate in chimneys of great height and capacity, placed at suitable distances apart; and in these chimneys, fires would be maintained constantly burning, for the purpose of creating the necessary draught Besides the communications for withdrawing the smoke from the house-fires, the writer proposes to provide orifices in each apartment, connected with the drains, which could be opened and shut by the inmates at pleasure, and there would also be openings at suitable distances along each court, lane, and street, communicating with the sewers. Still more clearly to illustrate his views, suppose we take the case of Liverpool, with the situation of which the writer happens to be acquainted. Let us presume that four or five large chimneys were erected along the brow of the hill which bounds that town to the east,—one to provide for ventilation of the north-end, one for the south-end, and two or three for the middle district; that leading tunnels were driven downwards towards the river, which tunnels would communicate laterally with, and receive the air and smoke from, the street sewers. Then, let us see how this plan would operate:—Suppose a powerful current upwards, was established in the large chimneys, tunnels, and sewers, it follows that—Firstly, the sewers and drains themselves would no longer give forth noxious exhalations. Secondly, by opening the apertures in the streets and courts, we would withdraw the impure air, and produce a constant influx of pure air, which would descend from above. Thirdly, by opening the orifices in the houses and apartments, although they were crowded with inmates, yet the vitiated air would be so rapidly removed, and replaced by that both fresh and pure, that no injurious consequences would ensue. Fourthly, there would be no more smoke or sulphurous vapour to destroy health, and soil everything exposed to its vile influence; the murky clouds which envelope our manufacturing cities would disappear, and give place to clear skies and a pure invigorating atmosphere.

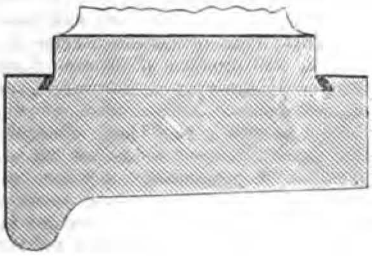
"But it will be said, there would be serious difficulties to contend with in the execution of such a plan: this is granted—but they are far from being insuperable; in proof of which, the writer will now proceed to consider some of them, only avoiding matters of engineering detail. It may be objected that such a scheme would prove costly: it is not denied that it would require the outlay of a large, though by no means extraordinary, sum of money; but can we expect to realise great benefits without proportionate expenditure? If it cost a million to supply such a town as Liverpool with water, why should we grudge a very much smaller sum to supply the same town with air? The one is surely as essential to the well-being of the community as the other; and the writer is prepared to show that a large saving of money would accrue, which is at present expended by the adoption of such a plan, irrespective of the immense benefit to the public on the score of health. There would be no factory chimneys to erect; a great saving in the arrangement for house-fires, which cannot here be detailed; smaller houses and smaller apartments would suffice for any given number of individuals,—consequently, there would be an economy in building arrangements, accompanied by lower rents. The same remark applies to streets, lanes, and courts: look at the enormous sums which would be required to alter and widen them, and by that means improve the ventilation. Then consider the control which would be vested in the authorities over the public health. At present, it is in vain you tell the poor to go dwell in larger houses and more airy situations,—they cannot afford it. It is in vain you tell them not to crowd together in their wretched apartments, or they will suffer from want of ventilation. It is in vain you impress them with the necessity of cleanliness, and of breathing untainted air: the majority disregard it,—how can they do otherwise? But with this plan in operation, let us suppose fever to prevail in some court or alley; we have only to give directions to unclose one or two apertures, and pure air *will* flow in, w eeping disease and death away."

Solvent power of Chloroform.—The powerful solvent capabilities of chloroform are now, by experiment, fully established. Caoutchouc, resin, copal and gum-lac, bromine, iodine, the essential oils, &c., yield to its solvent power. This property may, it is believed, prove extensively of advantage in many of the fine and useful arts.

LOCOMOTIVE CARRIAGE WHEELS.

EDWARD EVANS, of the Haigh Foundry Company, has obtained a patent for "*certain Improvements in the mode of constructing iron wheels.*"—Granted October 28, 1847; Enrolled April 28, 1848.

This invention consists in a mode of securing the tyre or hoop of th ewheel to the spokes or inner rim, without the use of bolts or rivets. The patentee effects this object by using a dovetail groove in the tyre, and a dovetail projection on the rim, which is a method that has been previously adopted, therefore he makes no claim to that; but the peculiarity of his invention consists in making the groove larger than the projections, and filling the interstices with melted zinc. In the words of the specification, the patentee claims "the manufacture of wheels in which the dovetail groove in the tyre is wider at its narrowest part than the dovetail projection on the spokes or the inner rim of the wheel is at its widest part, and the filling the spaces left when the tyre is shrunk on with melted metal or other hard substance. The accompanying section



of the tyre and its junction with the wheel, will sufficiently show the form of the grooves and projections. The dark portions represent the zinc or other easily-fusible metal with which the spaces are filled.

LOCOMOTIVE ENGINES.—GEORGE HEATON, Birmingham, engineer, has obtained a patent for "*Improvements in locomotive engines.*" Granted November 9, 1847; Enrolled May 9, 1848.—The object of this invention is to prevent the oscillation of locomotive engines on railways; and the patentee endeavours to effect this by the application of counter-balance weights, moving in an opposite direction to the pistons of the cylinders. The mode of applying these counter-balance weights is as follows:—On each end of the axle of the driving-wheels is placed a crank, to which is united a connecting-rod attached at the other end to the counter-balance weight, which is suspended between two rods, so as to swing readily to and fro, or it is held between fixed guide-rods, to admit of its sliding easily. The counter-balance weights should always move in the direction opposed to that of the pistons, and should be as heavy as the combined weight of the pistons and the working-gear.

COMPOUND BEAMS OR GIRDERS.—HENRY FIELDER, Maida-vale, has obtained a patent for "*Improvements in iron beams or girders.*" Granted November 9, 1847; Enrolled May 9, 1848.—The patentee constructs his beams partly of malleable, and partly of cast-iron. The lower or tension flanges are made wholly or partly of malleable iron, while the centre ribs and upper or crushing flanges are wholly or partly of cast-iron, according to the duties they have to perform. The lower flange may be made of, or strengthened by the addition of malleable iron, and the centre rib and upper flange remain of cast-iron; or, the upper and lower flanges may be of malleable iron, united to the centre cast-iron rib, and further strengthened, when exposed to vibration, by angle-iron; or, the perpendicular ribs may also be composed of malleable iron, when exposed to violent concussions. The malleable iron is united to the cast-iron by hot rivetting, and, in all cases, in such proportion that it shall be able to support, alone, the estimated weight to which the whole girder may be subjected. The invention consists secondly, in the application of the preceding principle of construction to the strengthening or repairing of existing beams or girders, with such variation of detail as the particular case may suggest; and thirdly, to the construction of beams or girders composed entirely of malleable iron, in which case the flanges are united to the centre rib by angle-iron, the coupling-joints headed, and the whole are fastened together by hot rivetting.

ELECTRICITY OF MINERAL VEINS.

MR. ROBERT HUNT (keeper of mining records at the Museum of Economic Geology) lately delivered a lecture on the "*Electricity of Mineral Veins,*" at the Royal Institution, Albemarle-street.

The lecturer commenced by remarking, that the class of phenomena which would form the subject of consideration that evening, although of the highest interest, had not yet received so great an amount of experimental examination as their importance required; and, as their curious nature was, consequently, not generally known, he trusted that, having spent many days and nights in the mines of Cornwall, in this investigation, he should be able to interest his audience by a narrative of the facts now known, as well as some of a novel character.

As a preliminary of absolute necessity, Mr. Hunt explained the nature of a mineral lode by the aid of a beautiful isometrical drawing of the lead district of Nentsford. A lode was, in fact, a fissure, formed by some disturbance of the earth, and filled with mineral deposits. Three theories prevailed as to the origin of mineral lodes; in the first place, they were supposed to be contemporaneous with the rocks themselves; secondly, it was conceived, that fissures were filled by the sublimation of matter from great depths in the earth; and, lastly, that substances were precipitated from solution in water, which flowed through those great rents in the earth. A mineral lode was not to be regarded as being entirely composed of metallic substances; on the contrary, they were most frequently found containing a large portion of earthy matter, amongst which the metallic ore was disseminated. Among the indications which appeared to support the theory of electrical action in these formations, was to be regarded the regular disposition of these substances on either side of the lode. The electrical theory might be explained in a few words. Ampere supposed that currents of electricity traversed the earth from east to west, and these currents were thought to influence the chemical changes which had gone on within the fissure during the formation of the lode, and determine the order of arrangement. The most striking conditions which appeared favourable to such a view were, that metals of various kinds were associated with peculiar classes of rocks—tin and copper being associated, in a remarkable manner, with the primary rocks; whilst lead was found more abundantly in the limestone formations. These rules, although general, were not constant—many striking exceptions might be named. In the remarkable mining county of Cornwall the rocks were granite, killas or clay-slate, greenstone, and elvan. The mineral lodes were always most abundant near the junction of the slate and granite rocks; they were generally found in a direction nearly from north-east to south-west; and where they were contrary to this, or nearly in the line of the magnetic meridian, there was almost invariably a great difference in the character of mineral substances contained in the lode. This was shown by reference to a very large map of Cornwall, upon which the lodes of lead and copper were accurately marked. Again, a very remarkable parallelism was observed in most districts between the directions of the lodes, and the veins of granite prophyry (elvan) which occurred in their vicinity; and this fact had been brought in support of the theory, which refers mineral formations to the action of subterranean heat.

The various questions which arose out of the phenomena of mineral veins, and their including rocks, had been most ably treated of by Sir Henry De la Beche, Mr. Joseph Carne, Mr. R. W. Fox, Mr. John Taylor, Mr. Hopkins, and others; he would not, therefore, dwell on that part of the subject.

Mr. Hunt next considered, whether any of the conditions known to belong to the rock formations of a mining district were sufficient to produce electrical phenomena. It had been ascertained that granite was always colder than slate—a difference of 20° or 30° was always detected at all depths. This difference might possibly give rise to weak thermo-electric currents; but, in the experiments he had made to ascertain this point, no such currents had been detected. It was also well known that a constantly increasing temperature was discovered as we descended into the earth. By this means, it was evident that any given portion would represent a bar unequally heated. The following table of temperatures, obtained in the rock and lode, exhibited the variations of temperature in the deep mine of Tresavean:—

At sea level..	..	In granite..	..	57° F.
At 170 fms..	..	Lode in slate	..	77° F.
At 196 fms..	..	Do in granite	..	83° F.
At 208 fms..	..	Do in granite	..	85° F.
At 310 fms..	..	In granite	..	94° F.

According to the generally received views of thermo-electric action, such differences would be sufficient to produce currents. That was undoubtedly the case in metallic and good conducting bodies, but no such result had been obtained from experiments on granite, slate, or greenstone.

[A series of experiments was here introduced—and, notwithstanding the use of an active galvanic series, it was shown that the voltaic current would not transverse either granite, slate, elvan, or greenstone—connection being made with them and a very delicate galvanometer, upon which not the slightest indication of any action on the needles could be observed.]

When moist, these rocks became over their surfaces conductors; and, by this means, the action on a single pair of zinc and copper plates, not more than an inch square, was detected through a considerable extent of country. Mr. W. J. Henwood had supposed that he had detected currents of voltaic electricity through the granite and slate rocks of Cornwall; but the lecturer, who had repeated those experiments with great care, was led to believe that the slight deflection of the needle obtained was due entirely to some chemical action in the wires employed at the point of contact with the rock, or within its length—such slight disturbances being of constant occurrence in all experiments of this class. Although there was not, therefore, any experimental evidence in proof of the voltaic condition of the rocks, yet the regularity of arrangement observed in the lodes themselves—in which zinc, copper and quartz, lime, pyrites, barytes, fluor-spar, argentiferous lead, and quartz, alternated in the most regular order, as was shown by specimens from the mines of Cornwall, Derbyshire, Saxony, and Mexico—present features so analogous to those which often appear in galvanic experiments, that we are compelled certainly to infer that some modification of the electric force was concerned in the phenomena. Specimens of pseudo-morphous bodies from the Cornish mines, and arrangements of brown spar upon quartz, from Schemnitz, quartz upon fluor-spar, and iron pyrites, and the double sulphuret of copper upon large quartz crystals, in all of which a uniform system of arrangement, perfectly independent of each other, was shown—and these were to be referred, in all probability, to the disposing power of electrical currents.

Such were the principal evidences to be adduced in support of the electrical theory. Mr. R. W. Fox was the first to discover any indications of electricity in mineral lodes. By placing copper wires against two portions of a lode, or of two lodes divided by a cross-course, and connecting those wires with a galvanometer, a considerable deflection of the needle was obtained—often to such an extent, that from the violence of the action, it was impossible to note the deflection. In nearly all the mineral lodes of Cornwall, upon which experiments were made, these currents had been detected. Experiments made by Mr. Fox, in Coldberry and Skeers, in Teesdale, gave, however, negative results; and the results on the lead lodes at the Mold mines were not very decided. Prof. Reich, of Freyburg, obtained very decided results upon the lead and silver lodes of that district; and, in one case, succeeded in detecting a mass of silver ore at some distance behind the rock. Von Strombeck, on the contrary, could obtain no results from the lead and copper lodes on the right bank of the Rhine. In addition to these results, others of a most satisfactory kind had been obtained by Mr. Henwood and Mr. John Arthur Phillips. The lecturer had himself almost invariably obtained very decided galvanometric indications from the copper lodes of Dolcoath, East Wheal Crofty, East Pool, and other Cornish mines—in one instance so powerfully, that the electro-chemical decomposition was produced. Mr. Fox has been successful in procuring an electrotype copy of an engraved plate by the current collected from two lodes of iron and of copper pyrites, and also in inducing magnetism in a bar of soft iron. Mr. Pattinson, at the wish of the British Association, made a series of experiments on the rocks of the limestone formation in the lead districts of the north; but he could not detect any evidence of electrical currents.

It now became a question, to ascertain if these currents of electricity, detected in mineral lodes, were in any way connected with the general currents traversing the earth, according to the theory of Ampere; or, were they of a more local character? The lecturer was induced to conclude, from all his experiments and observations, that these currents were entirely local, and due to the chemical action going on within the lode itself. In all cases where chemical action could be detected, it was certain the current acting on the galvanometer was more energetic than where no chemical change was apparent. In this way might be accounted for the failure of Von Strombeck on the lead and copper lodes of the Rhine, and of Mr. R. W. Fox himself on the lodes of Teesdale—in all probability, those lodes being in a very permanent condition. It was thought by the lecturer that the fact, that these currents often being found to traverse the lodes in a direction contrary to the currents of Ampere, and frequently at right angles to them, militated against that view which referred the one to the influence of the other. The lecturer had also detected currents from piles of ore on the surface, which had been exposed to the influences of the atmosphere; and these currents were certainly only measurers of the amount of chemical action going on in the pile.

That these local lode currents might have a powerful effect upon masses of matter exposed to their influences, was highly probable; and he was disposed to refer the conditions in which cobalt and nickel were often found in the cross-courses, between the ends of dislocated lodes, as due to this local chemical electricity. The character of many of the decomposing lodes was next described; and it was shown that, under the influence of the percolation of rain-water from the surface, charged with oxygen, and the action of the saline water rising from below, few lodes admitting water to flow through them could be free from chemical action. He had analysed the waters of many of the deep mines, and the following were the results of a few of these analyses:—

The water from Great St. George contained, in a cubic foot, 590 grains of common salt; that of the United Mines, rising hot, 481 grains; of Dolcoath, 218 grains; of Great Wheal Charles, 612 grains; Consolidated Mines, at 80 fathoms, 656 grains; and at the 250 fathom level, 918 grains. This muriate of soda was estimated quite independently of the earthy and mineral salts. It was, doubtless, derived by infiltration from the ocean; and, from its quantity, acted, no doubt, powerfully upon the lodes it traversed.

Although these currents, detected by the galvanometer, were not regarded by the lecturer as in any way proving electrical agency in the formation of mineral veins, yet the evidence obtained by Mr. Fox, by Mr. Jordan, and more recently by himself, that electricity would give to clay a schistose structure and form along a curved line, no doubt related to some line of electrical action, a miniature lode of copper (of which illustrations were exhibited), supported the general view of electrical action. Incidentally, the conducting powers of iron and copper pyrites, galena, and some other minerals, were experimentally shown; and also the decomposition of yellow ore by electrical action.

In conclusion, the lecturer carefully recapitulated all the main points of evidence, for and against the electrical views, and pointed out many very curious circumstances, evidently dependent upon some peculiar conditions of the adjacent rocks, but which could not be referred, with any certainty, to electrical action. Probably, those currents now nearly determined as in constant flow around the earth, might produce the curious results observed; but a far larger amount of experimental evidence than that yet obtained was required, before this view could be admitted as one of the received facts of inductive science.

NOTES OF THE MONTH.

Baron de Goldsmid's House.—The grand ball-room at St. John's Lodge in the Regent's Park, of which so much has been spoken and written, was lighted last week, for a party given by the Baron de Goldsmid. The effect is reported to have been most admirable. Although Mr. Barry and Mr. Poynter had exerted every care, the effect of light upon the decorations must have caused them some anxiety, and it must be most gratifying to them to have succeeded so completely. The richness of the gilding contributes to the grandeur of the room, without destroying its air of chasteness; and if Mr. Barry be reproached that there is a want of repose in the House of Lords, and too great profusion of ornamentation, the same objection cannot be made against a ball-room. This saloon is the great work of the present season, and it is pleasing to learn that the munificent patronage of the Baron de Goldsmid has been, as usual with him, displayed in the encouragement of English artists, instead of being lavished upon foreigners, as is too common with our nobility.

Mineral Produce of Austria.—The latest published government accounts give the following as the mineral produce of Austria:—Gold, 35 cwt.; silver, 547 cwt.; mercury, 166½ tons; iron, 148,379 tons; copper, 2,753 tons; lead, 6,666 tons; litharge, 1,299 tons; zinc, 227 tons; calamine, 908 tons; tin, 49 tons; antimony, 231 tons; cobalt, 132 tons; manganese, 6¼ tons; arsenic, 50 tons; plumbago, 1,327 tons; alum, 1,494 tons; sulphate of iron, 5,354 tons; sulphate of copper, 288 tons; sulphur, 1,259 tons; coal, 524 tons.

The Holyhead Steam-Packets.—The principal trial of the new Holyhead steam-packet *Llewellyn*, master, Commander Grey—vessel and engines designed and manufactured by Miller, Ravenhill, and Co., of Blackwall—took place on Monday, the 15th ult. It is stated that, under adverse circumstances, she made four uns at the measured mile, at Long Reach, which gave her an average rate of speed of 15·415 nautical miles, or nearly 17¾ statute miles per hour, never making less than 27 revolutions per minute. She then ran to the Nore light, passing the distance from the town pier at Gravesend, in *one hour and fifteen seconds*; and then ran from the Nore light to the Mouse light and back twice, during which time her greatest speed was 20½ statute miles per hour, and her lowest rate at 15·845. The latter, however, in consequence of the throttle-valve being open, was held to be a bad trial, and she was accordingly tried up and down again the 7·65 knots' distance. When working at 28 and 29 revolutions per minute, she made the same run down in 27 minutes 22 seconds, or at the rate of 16·798 knots; and the return trip in 30½ minutes, or at the rate of 15·049 knots. Taking the average of the two last runs, the speed of the *Llewellyn* was nearly 16 nautical miles an hour, or 18½ statute miles per hour.

The New Steam-Ship Basin at Portsmouth.—This national work, which has been constructed with the view of affording to steam-ships a fitting and convenient place of reception, was opened on Thursday, the 25th of May. The first stone was laid January 13th, 1845. Its original design was far of far less magnitude, but as the work progressed, enlargements and improvements were suggested, until the plans were finally extended to their present spacious dimensions. Its mean average length is 774 feet, 400 feet wide, and 31 feet deep from the coping, covering an area of more than seven acres. The entrance is 80 feet wide, and the depth of water at the lowest tides 21 feet. There is also a fine wharfage outside the basin, in the harbour, where there is water to the depth of 13 feet, which is sufficient to accommodate second-class steamers. There are two inlets on the east side of the basin, each 300 feet long by 70 wide, and 30 feet deep from the coping; these are to enable vessels, whole refitments must be completed in a hurry, to be worked upon by the artisans on both sides at once. On the west brink of the basin is a great factory, of handsome architecture, 687 feet long, 48 feet wide, and 51 high, and is partially roofed in. On the south wall is a new brass foundry, 90 feet by 110, which has been for some time in partial working. The basin is considered capable of accommodating around its sides nine steam frigates of the first class, and has employed, on the average, 1,500 men since the commencement, besides an immense body to whom it has given work off the premises—in the quarries, forests, iron works, &c. Besides the above materials, there have been used in various parts of the whole about 2,500 tons of cast iron from Staffordshire. The rough cost of the labour already turned out of hand is £400,000.

Sudden Draining of the Niagara River.—The following extract of a letter we have received from the United States, describes a very curious phenomenon, which recently alarmed the residents near the Falls of Niagara:—"The good people at the falls were greatly alarmed a few weeks ago, fearing that the bottom of the river had fallen out; for all at once the mills ceased to work, and great part of the falls on Table-Rock were bare. The river, a little above Goat Island, was bare for half the distance across. A gentleman drove his wagon on the bare rock to the middle of the bed of the river, where to have ventured the day previous would have been certain death. The worst fears were entertained; some believed the world was coming to an end—indeed, fear was stamped on every countenance till the cause was explained. The fact was, that a quantity of ice on Lake Erie had drifted to the mouth of the river, and impeded its flow."

Suspension Bridge near the Falls of Niagara.—The first car, suspended by a wire cable, crossed from cliff to cliff below the falls of Niagara on the 13th of March. Mr. Ellett, the engineer who has undertaken the construction of the suspension-bridge at that place, was the first person who crossed over, amidst the cheers of a large concourse of people. The *Toronto Colonist* observes: "Mr. Ellett must feel gratification and commendable pride that he is the first man who ever crossed in a carriage through the air, on wire, from one empire to another; thereby, it is to be hoped, leading to a happy, prosperous, generous, and reciprocal union—a firm chain of friendship between mother and daughter." We may suppose that among those who experienced alarm at the sudden draining of the Niagara river, noticed above, the shareholders in the suspension-bridge undertaking, were not less frightened than the others.

Communications in Railway Trains.—Another of the many plans proposed for establishing a communication between the passengers and the guard, and through him with the engineer, on railway trains, has been recently patented. The inventor of this plan is Mr. Edward Tattersall, of Newmarket, land surveyor; and it consists in having a cord run along the tops of all the carriages, communicating with the handle of the steam-whistle, or with a bell. The patentee claims as new an apparatus for lengthening or shortening the cord, without requiring it to be drawn out longitudinally. To enable the passengers to communicate with the guard, a lamp by night, and a signal board by day, is to be fixed to the top of each carriage, and the passenger, by pulling a string may raise a flap that ordinarily secures the lamp or signal-board, and when the guard sees this notice, he is to pull the cord to order the engine-driver to stop.

Iron Ore in Algiers.—A report presented to the Paris Academy of Sciences, on a communication made by M. Fournel, respecting the mineral wealth of Algiers, represents the iron ore to be extremely abundant and rich. In the mountains of Bou Hamra, throughout a distance of four leagues, the croppings-out of a considerable number of beds of ore may be observed, attaining sometimes a considerable size, and never less than from four to five yards in depth. At the north of Fizara there is an entire mountain (the Mohta El Hadad, or iron quarry), which rises out of the gneiss, and literally presents from its base to its summit, that is to say, a height of about 108 yards, one mass of pure oxide of iron, without the admixture of any other substance. To the east of this mountain, M. Fournel traced upwards of 16 points where the ore was cropped-out. M. Fournel has also found large quantities of ancient scoriæ, proving that these sources of mineral wealth had been worked by the Romans, or perhaps by the Vandals; there are also scattered amongst these scoriæ, specimens of the metal produced, so that by analysis it can be ascertained from which bed of ore the metal produced at such and such a point, was obtained.

Copying Electric Telegraph.—An electric telegraph which will produce at a distant town *facsimile* copies of writing applied to the instrument in London, has just been invented by Mr. F. C. Bakewell. We have seen a specimen of the telegraphic writing copied from the original by a separate instrument, only connected with the other by wires in the ordinary manner. We understand that arrangements are being made to give the invention a trial at a long distance, for the purpose of adopting this mode of telegraphic communication generally, if it be found equally applicable between distant towns as it is at short intervals. The rapidity with which copies may be made with this instrument, will far exceed the manual dexterity of the quickest writer; for the inventor expects to be able to transmit 500 alphabetical letters per minute. Where short-hand is employed, of course the rapidity of transmission would be much greater; and we understand that even plans and drawings may be copied by the same instrument.

Phosphates in the Green Sand.—The green sand formation, situated under the chalk, contains fossil substances in such abundance as to render them valuable as manures, in consequence of the phosphate of lime which is thus obtained. Attention has been recently directed to this subject, and if the fertilizing properties of green sand be as great as is represented, there exists in the south of England vast stores of manure, corresponding in chemical properties with the guano that has been scraped from distant islands, and sold at a high cost in this country. The presence of coprolite (dungstone) nodules in the upper green sand and gault, was pointed out by Dr. Fitton several years ago, in his account of the "beds below the chalk," published in the "Transactions of the Geological Society," vol. iv. second series; and Dr. F. also ascertained the large proportion of phosphate of lime contained in these bodies. Dr. Fitton's observations were chiefly made from the gault at Folkestone. But he has also noticed the existence of these nodules in various parts of the upper and lower green sand. There are cliffs of the upper green sand at Eastbourne, in Sussex, where the fossil and coprolitic nodules may be found. If we pass from the out-crop of the green sand in Sussex and Surrey, we find it again in still greater force westward, in the fertile vale of Pewsy, one of the finest pieces of wheat land in the kingdom. The whole valley from Bedwin to Devizes is coveredwith this soil, the stratum dipping under the chalk of the Marlborough downs on the north and Salisbury plain on the south.

Improved Machine for Rolling Iron.—Mr. Benjamin Norton, of Boonton, New Jersey, U.S., has recently obtained a patent in America, for an improvement in the machine for rolling iron. In describing his invention, the patentee says—"In rolling the billets of iron that are to be converted into hoop-iron, or into scroll, band, or other iron of a like character, the apparatus used, as ordinarily constructed, consists of three rollers, the axes of which are in the same vertical plane. The billet is passed through a groove in the lowermost pair, and is returned through a groove in the uppermost pair, by which it is prepared to be passed through the smooth or finishing rollers. In my improved apparatus I use but two rollers, in which the billet is first passed in the usual way; as it passes from between these rollers on the rear side, it enters a curved trough, which I call a receiver, and this trough conducts it round the rear side of the upper roller towards the workman in front, who passes it into the groove in the first instance, and who then passes it into a second groove, formed in the same rollers; by which arrangement much time and friction are saved, and other obvious advantages obtained. The patentee claims the combination of the covered trough, or receiver, with a pair of rollers, for the purpose of conveying the strand to the front of the rollers, in combination with the employment of the second groove, or grooves, in the lower roller, and thereby admitting of the widening out of the collars.

Ether a substitute for Steam.—M. Zede, Director of the Ports of France, at the request of M. Lafond, a lieutenant in the Marine Navy, has made several experiments on the employment of the vapour of ether in one of the cylinders of a steam-engine. The results were very satisfactory as far as regards the employment of the mechanical force contained in this vapour; but as regards safety, M. Zede stated that it is impossible to conceive the danger arising from the use of so inflammable a liquid as sulphuric ether. In order to remove this objection, M. Lafond has proposed to him the employment of chloroform in place of ether.

Cause of Rain.—At a recent meeting of the Paris Academy of Sciences, M. Babinet explained his theory of the cause of rain, founded on numerous observations. He supposes that a volume of humid and heated air having risen into the upper regions of the atmosphere, expands in the rarer air; consequently, the temperature becomes lowered, and the vapour condenses and is precipitated in rain. There seems to be nothing new in this theory, and it fails to assign an intelligible cause for the observed phenomena of rain. It is founded also on the questionable assumption, that the portions of the atmosphere near the earth rise when heated into the strata of air above; because, in most circumstances, the difference in the pressure of the atmosphere at higher elevations, causes a greater difference in the relative weights of equal volumes than the different degrees of heat above and below. M. Babinet, indeed, seems to admit this, as the expansion of the humid air he supposes to be caused by the rarer state of the upper atmosphere, and yet he seems to have forgotten to take into consi- that the denser and heavier air would not rise into the lighter.

Analysis of Phosphates.—Messrs. Dumas and Pelouze have reported very favourably of the process adopted by M. Raewsky, to ascertain the proportions of phosphoric acid contained in phosphates. The process consists in bringing the phosphoric acid to the state of phosphate of the peroxide of iron, and then to ascertain the quantity of iron which it contains. As the phosphate of the peroxide of iron is insoluble in acetic acid, in precipitating the phosphoric acid from an acid liquor by means of the acetate of the peroxide of iron, the salt will be precipitated pure, and can consequently be collected in a filter. After a careful washing, if it be dissolved in nitric acid, and reduced to the minimum state of oxidation by the acid of a suitable addition of sulphate of soda, there will remain only to saturate the iron restored to this state by means of the proportionate quantity of permanganic acid necessary to convert it again into peroxide.

Rotary Heels.—A patent has been taken out for rotary heels to boots and shoes, so that, however unevenly a person may tread, the heel may be regularly worn by giving it a turn daily, to expose a fresh surface at the part most trodden on.

Invisible Musicians.—Mr. A. Bain, the ingenious inventor of electric telegraphs and clocks, has obtained a patent for an invention, part of which consists in causing musical instruments to be played by electro-magnetism, without the apparent agency of any musician. He effects this by placing electro-magnets under the keys of the instrument, and these magnets are connected by wires with some other similar instrument in another room, or it may be in some other part of the same town. Whenever one of the keys of the original instrument is pressed down by the performer, it completes the electric circuit, and induces magnetism in the temporary magnet under the corresponding key of the distant instrument, and that is instantly drawn down and sounds the note. This arrangement might be continued through several instruments, every one of which would be played at the same time by one performer, who would be touching the keys of only one instrument, and that, perhaps, a mile apart from the others. In another part of Mr. Bain's invention, he proposes to dispense with performers altogether, and to make the printed music play itself. This is done by perforating holes in a sheet of paper, which is to be drawn over the openings of wind instruments. Whenever the perforated holes coincide with the orifices in the instrument, the notes are sounded; and by arranging the perforations at their proper distances, the tune is played!

Manufacture of White Lead.—Some improvements in the manufacture of carbonate of lead have recently been patented by M. Jean Marie Fourmentin, of New Bridge-street, Blackfriars. In this process, the carbonate of lead is produced by the decomposition of oxichloride of lead (obtained by the action of sea salt upon protoxide of lead), by means of carbonic acid, which decomposes the oxichloride; an insoluble carbonate of lead being produced, and a solution of chloride of sodium remaining.

Triple Railway Break.—A model of a triple railway break, invented by M. Laignet, has been submitted to the Paris Academy of Sciences. Each part of the break must be successively destroyed before any material damage can be done, and the resistance offered is calculated to be sufficient completely to overcome the momentum of the train. The action of the break is independent of the engine-driver, and it is constantly ready to act when occasion requires. The name given to this break is *Parachoc*.

New Rifle-Barrel.—A new mode of forming the spiral-inside rifle-barrels has been registered by Mr. Lancaster. Instead of making the spiral of a regular helical form throughout, that form is adopted only in the first half of the barrel, commencing at the breech; the other portion being on an uniformly accelerating geometric curve. The advantages said to be gained by this method are—diminution of the recoil, a sustained spiral motion without the present liability in rifles of stripping the ball, and a larger range with the same charge of powder.

The College at Putney.—The Admiralty experiments on coals for the steam navy, are continued at Putney College, in the buildings erected there by government for the purpose. Dr. Lyon Playfair has recently constructed for this College, the largest magnet that has bitherto been made.

Mammoth Machine.—The *Renfrewshire Reformer* notices the manufacture by Messrs. T. Shanks, of Johnstone, an immense sloting machine for cutting and dressing up, by self-action, the cranks and cross-heads of the largest marine steam-engines, finishing them throughout, from the rough block as they come from the forge. The machine is erecting for Messsrs. Fulton and Neilson, of Lancefield Forge, and the weight of the single casting which forms its base is 28 tons. This cast was executed by Messrs. John Goldie and Co., of the Hayfield Foundry, and took four months in the moulding.

Manual Power Locomotive.—A Manchester paper states, that Mr. Archibald Farrie, an ingenious mechanic of that town, has invented a locomotive to be propelled by manual labour, which was successfully tried along several of the streets of Manchester. The carriage was stopped every now and then, to allow parties to inspect the movement of the machine—the working of which appeared to cause the driver only a slight muscular effort, aided by manual dexterity. The machine weighs 8 cwt., has no cranks, and has been worked by one man up an incline of 3 feet in the yard, while twelve persons were in it.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM APRIL 27, TO MAY 26, 1848.

Six Months allowed for Enrolment, unless otherwise expressed.

William Newton, of Chancery-lane, Middlesex, civil engineer, for "Improvements in machinery for burring, ginning, and carding wool and cotton or similar fibrous materials requiring those processes." (A communication.)—Sealed April 27.

Edward Walmsley, of Heaton Norris, Lancashire, cotton spinner, for "certain Improved apparatus for preventing the explosion of steam boilers."—Apri 27.

William Henry Barlow, of Derby, civil engineer, and Thomas Forster, of Streatham Common, Surrey, gentleman, for "Improvements in electric telegraphs and in apparatus connected therewith."—April 27.

Thomas Edmondson, of Manchester, machinist, for "Improvements in marking and numbering railway and other tickets or surfaces, and in arranging and distributing tickets."—April 27.

Daniel Rice Pratt, of Worcester, in the State of Massachusetts, America, for "machinery for connecting railway carriages."—April 27.

James K. Howe, of the city of New York, in the United States of America, for "Improvements in building ships and other vessels."—April 27.

Roger George Salter, of Birkenhead, in the county of Chester, surveyor, for "certain Improvements in carts for the distribution of liquid substances, and in the construction of drains, sewers, and cesspools, and in the cleansing of the same."—April 27.

Charles Fielding Palmer, of Birmingham, for "a new or improved chalybeate water." —April 27.

Alexander Parkes, of Birmingham, experimental chemist, for "Improvements in the manufacture of metals and in coating metals."—April 27.

William John Normanville, of Park Village, Middlesex, gentleman, for "certain Improvements in railway or other carriages, partly consisting of new modes of constructing the axle-boxes and journals of wheels; also an improved method of lubricating the said journals or other portions of machinery, by the introduction of aqueous, alkaline, oleaginous, or saponaceous solutions."—May 2.

Isaac Harles, of Rosedale Abbey, Yorkshire, farmer, for "certain Improvements in machines or machinery foharrowing, sowing, and manuring land."—May 2.

Isaiah Davies, of Birmingham, engineer, for "Improvements in steam-engines and locomotive carriages, parts of which are also applicable to other motive machinery."—May 2.

Alexander Southwood Stocker, of York-place, City-road, Middlesex, gentleman, for "certain Improvements in time teachers and boxes, show cards, or holders for matches, pens, pins, needles, and other articles, and in the mode or modes of manufacturing the same."—May 2.

Felicité Raison Selligue, of 6, Boulevart Beaumarchais, Paris, for "certain Improvements in propelling, and the machinery employed therein." (A communication from her late husband.)—May 2.

Henry William Schwarts, of Great Saint Helen's, London, merchant, for "Improvements in steam engines." (A communication.)—May 2.

Lewis Dunbar Brodie Gordon, of Abingdon-street, City, for "an Improvement or improvements in railways."—May 9.

William McLardy, of Salford, Lancashire, manager, and Joseph Lewis, of the same place, machine-maker, for "certain Improvements in machinery or apparatus applicable to the preparation and spinning of cotton, wool, silk, flax, and other fibrous substances." —May 9.

Richard Laming, of Clichy la Garonne, in the republic of France, for "an Improvement or improvements in the manufacture of oxalic acid."—May 9.

Edward Haigh, of Wakefield, plumber, for "an invention for measuring water or any other fluid."—May 9.

Vincent Price, of Wardour-street, Soho, Middlesex, machinist, for "certain new or improved mechanical arrangements for obtaining and applying motive power."—May 11.

Charles Hancock, of Brompton, Middlesex, gentleman, for "certain Improved preparations and compounds of gutta percha, and certain improvements in the manufacture of articles and fabrics composed of gutta percha alone, and in combination with other substances."—May 11.

Thomas Restell, of Tooting, Surrey, watch-maker; and Richard Clark, of the Strand, Westminster, lamp-manufacturer, for "Improvements in chronometers, clocks, watches, and other time-keepers."—May 11.

George Armstrong, of Newcastle-upon-Tyne, engineer, for "an Improved water-pressure engine."—May 11.

Mark Smith, of Heywood, Lancashire, power-loom maker, for "certain Improvements in looms for weaving."—May 11.

William Taylor, of Birmingham, mechanist, for "an Improved mode of turning up or bending flat plates of malleable metals, or mixture of metals, by aid of machinery, into tubes."—May 18.

George Henry Bursill, of Albany-place, Hornsey-road, James Paterson, of Baldwin street, City-road, and John Mathews, of Norman's-buildings, Old-street, engineers, Middlesex, for "a certain Improved method or methods of treating malt liquors and other liquids or fluids, and certain improvements in machinery or apparatus for effecting such improved method or methods of treatment."—May 22.

Abraham Solomons, of London, merchant, and Bondy Azulay, of Rotherhithe, Surrey, printer, for "Improvements in the manufacture of gas, tar, charcoal, and certain acids." —May 26.

Matthew Hague, of Waterhead Mills, Lancashire, machine maker, and Joseph Firth of Huddersfield, Yorkshire, cotton doubler, for "certain Improvements in machinery fo twisting and doubling cotton yarns and other fibrous materials."—May 26.

Moses Poole, of London, gentleman, for "Improvements in propelling vessels." (A communication.)—May 26.

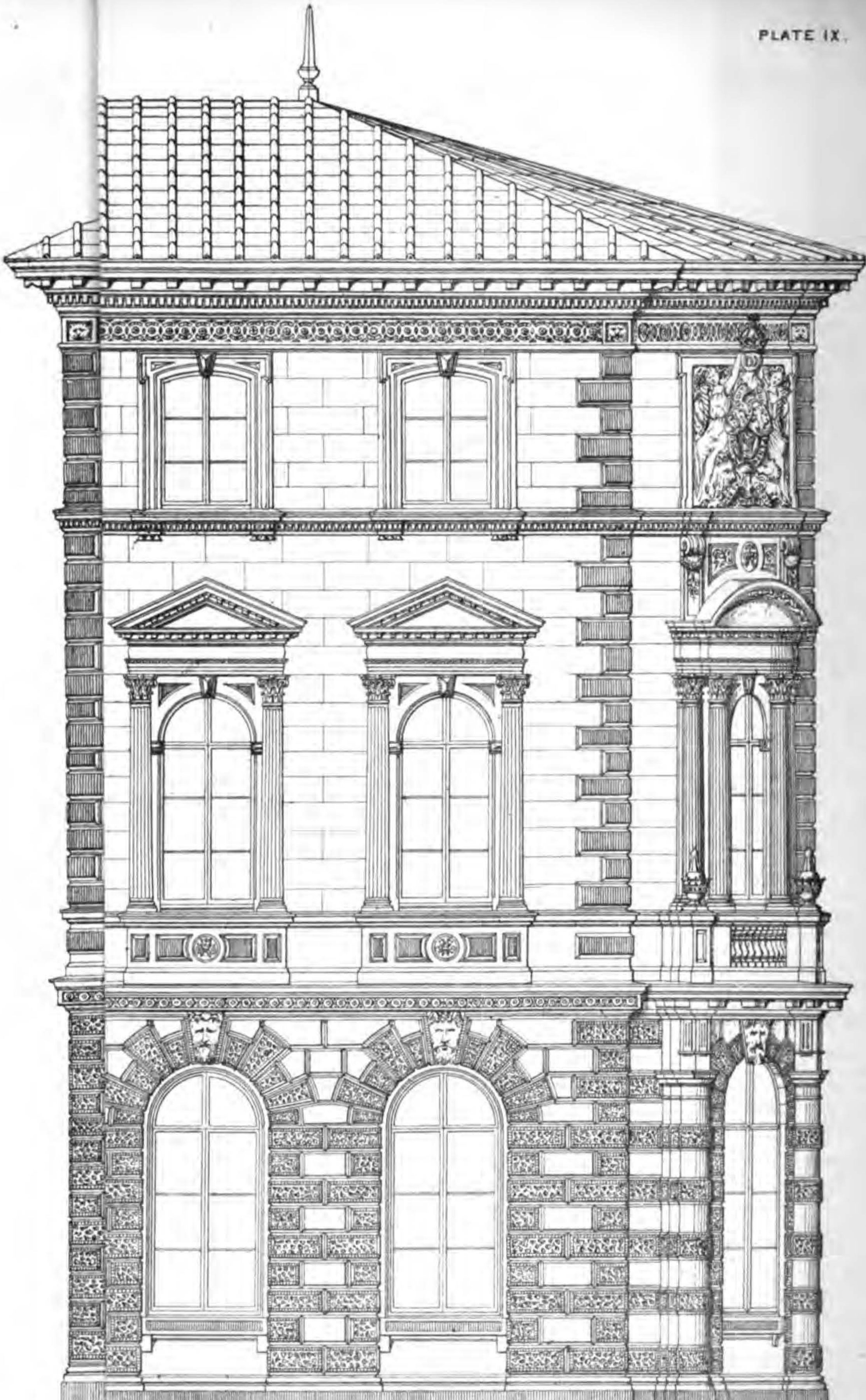
James Parker Percy, of Clarendon-place, Notting-hill, gentleman, for "certain Improvements in obtaining copper from copper ores."—May 26.

James Remington, of Warkworth, Northumberland, civil engineer, for "Improvements in locomotive engines, and in marine and stationary engines."—May 26.

Thomas Richardson, of Newcastle upon-Tyne, chemist, for "Improvements in the manufacture of manure."—May 26.

Felix Hyacinthe Folliet Louis, of Southwark, Surrey, gentleman, for "an Improv d method or process of preserving certain animal products."—May 26.

PLATE IX.



C. Bag[illegible]

Civil Engineer & Architects Journal

30 FT

IMPERIAL INSURANCE OFFICE, OLD BROAD St., CITY.

JOHN GIBSON, Esq., Architect.

(With an Engraving, Plate IX.)

The progress of insurance companies, the great interest which is felt by all classes in making a provision for the future, the establishment of new offices, and the extension of business, have caused a demand for large public buildings, of architectural pretensions, and capable of giving the required accommodation. Thus, the City, in addition to the halls of its corporations, its banks, and its dock buildings, has now many ornaments to boast of in the noble offices erected for transacting the business of the assurance companies. It has been fortunate, too, that with the rise of these establishments, there has been a concurrent improvement in public taste, which has been productive of emulation among the architects, and has given us each year a better class of works.

What the club is to the street architecture of the west-end, the assurance office is to the city; and the edifices devoted to the more useful purposes of life, it is pleasing to see, are not inferior to those which are only the appendages of luxury. Indeed, the range of assurance offices in London, constitutes in its architectural, as well as in its moral aspect, a characteristic of which England may be proud. The foreigner has hitherto envied us our charities, our parks, and our clubs; he will now have another feature in the physiognomy of London, which suggests honourable associations in connection with the private and domestic habits of the professional and middle classes, and testifies to their earnest and provident care for those to whose comfort their lives have been devoted.

The Sun, the Alliance, the Amicable, the Globe, and the Atlas, are but a few among the buildings which will readily suggest themselves as coming within the class we have mentioned, each the centre of operations of some great institution, in which property to a large amount is insured, or on which thousands of wives and of children depend for provision when widowhood or orphanage may be their lot. Of the architectural merits of most of the buildings named, we have had the opportunity of speaking on other occasions; we have now to add to our list the office of the Imperial Insurance Company.

The Imperial Fire Insurance Company was formed in 1803, under a deed of settlement by which the capital was declared to consist of 2,400 shares, of £500 each, but on which, only ten per cent. has ever been called. The invested capital now exceeds half a million, to secure a permanent dividend of twelve per cent., payable half-yearly, independently of bonuses which have hitherto been equal to as much more, and accounts for the shares being of greater value than those of any other existing similar establishment. The Life Office (which, although bearing the same name and carrying on its business under the same roof, is a totally distinct concern) was formed under a similar deed of settlement, in 1820. Its capital consists of 7,500 shares, of £100 each, on which only ten per cent. has ever been paid up; to secure a dividend on which, payable annually, an ample capital is invested in the public funds, independently of an accumulated premium fund now exceeding £700,000, and bonuses which are declared quinquennially.

The directors of these two companies, finding the accomodation afforded by the premises they have hitherto occupied in Sun-court, Cornhill, inadequate to the wants of the respective offices, determined, in September 1846, to erect others on the site they had purchased at the corner of Old Broad-street and Threadneedle-street; for which purpose, several architects were invited to furnish designs, and having done so, Mr. Shaw, one of the official referees was called in to assist the directors in their selection: that resolved on the adoption of Mr. Gibson's design, now nearly completed by the Messrs. Piper, who took the contract for the erection.

Mr. Gibson is the architect of the Baptist Chapel in Bloomsbury-street, of which we lately gave the elevation, and who may consider himself pre-eminently fortunate in being able to make his professional *début* in two public structures, produced simultaneously. The one which forms the subject of our engraving this month, is the Imperial Insurance Office, which stands at the corner of Old Broad-street and Threadneedle-street. It is an astylar composition, of the Italian Palazzo style, executed in Portland stone, and has unquestionably made a very great improvement in that part of the city, if only by removing what used to be a very ugly and inconvenient sharp corner; in lieu of which, that angle is now cut off, and is made to form a distinct and distinguished compartment of the general design, and is so placed as to present itself to the eye in a very striking manner; and, with its two neighbouring buildings—the Hall of Commerce on one side, and the Mentor Assurance Office on the other—forms a rather important architectural group, in which there is certainly no lack of variety,—the Imperial Office being as studiedly ornate as the other two are studiedly simple, not to say severe and cold in style. Or perhaps we should qualify our opinion by saying, that the façade of the Hall of Commerce would look somewhat cold and bare as an architectural composition, were it not for the panel frieze, which is in a double sense a *relief*, and which, while it sets off the façade, is in turn set off by its very subdued tone of decoration. A similar universal degree and mode of embellishment in point of sculpture, is also a trait in the design of the Imperial Office, all the key-stones of its ground-floor windows being enriched with carved masks or heads upon them—not a mere repetition of each other, but varying in character,—while the large panel in the upper part of the south-west compartment, between the Threadneedle-street and the Broad-street fronts, will display a relievo, consisting of two sitting female figures, considerably above life-size, with three shields between them, bearing the arms of England, Scotland, and Ireland:—which piece of sculpture, and the key-stones just mentioned (amounting in all to fourteen in the two fronts), are by Mr. Thomas, an artist extensively employed at the new Palace of Westminster. Highly satisfactory is it to perceive such attention to artistic finish bestowed upon a building which, had it been erected some dozen or fifteen years ago, would have been turned out of hand very differently,—both with the minimum of detail and with the minimum of design bestowed upon *that*, as witness the Alliance Office, in Bartholomew-lane, and the "Atlas," in Cheapside,—or the City Club-house, in Broad-street; all of which may claim the merit of being exceedingly simple and unartificial—provided unartifical and *unartistic* be synonymous and convertible terms. The Imperial Office has been enriched with great propriety, the ornaments being in perfect keeping throughout, and at the same time they are profuse and well-executed.

We can now only allude to the interior, as it is not yet quite finished; but every attention appears to have been bestowed upon the official arrangements, and every precaution taken to render the Offices fire-proof. The "strong-room" has been fitted by Mr. Leadbeater with wrought-iron doors, filled with a chemical compound for making them perfectly fire-proof, and ventilating gates. This room appears to be a perfect pattern of safety.

CANDIDUS'S NOTE-BOOK, FASCICULUS LXXXIII.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. One of the essays in the piquant little volume, entitled "Friends in Council," is upon the subject of Public Improvements. As to the essay itself, it is disappointingly brief, and deals too much in, or rather is confined to, abstract generalities. There are, however, one or two remarks introduced in the subsequent conversation between the "Friends" themselves, that deserve to be pointed out. The first of them which I select would furnish matter for a discourse or paper of some length:—"*Milverton*: 'There is one thing I forgot to say,—that we want more individual will in building, I think. As it is at present, a great builder takes a plot of ground, and turns out innumerable houses, all alike—the same faults and merits running through each: thus adding to the general dulness of things.'"—Such system of house-manufacturing for the market operates, it must be confessed, very injuriously for architecture. A single design is made to serve for scores—perhaps hundreds, of houses; nor is much study bestowed upon that pattern or *matrix* design. So that it provides a sufficiently commodious dwelling, with all the useful routine accommodations looked for in a "respectable" house, and a sufficiently *tasty* appearance externally—for your builders deal largely in the "tasty," though not in the tasteful,—nothing more is thought of. London houses have no individuality: never do you find a single original or pet idea carefully worked out in any one of them. One advantage of this is, that you are as well acquainted with every nook and corner of your neighbour's house as you are with your own; another, that you are relieved from all responsibility on the score of taste, it being that of the confounded builders,—not your own.

II. To continue quoting:—in *Ellesmere's*—not the Earl's—reply, we meet with this somewhat perilous question:—"'By the way, Milverton, I want to ask you one thing. How is it that governments and committees, and the bodies that manage matters of taste, seem to be more tasteless than the average run of people? I will wager anything, that the cabmen round Trafalgar-square would have made a better thing of it than it is. If you had put before them several prints of Fountains, they would not have chosen those.'" To which Milverton responds: "'I think with you, but have no theory to account for it.'"—Partly, and even mainly, accounted for it might be, by saying: It is because in all such matters, committees hold themselves to be utterly irresponsible for their acts, and because no one cares to convince them of the contrary, by formally calling them to account. So long as Committees of Taste, or whatever else their actual designation may be, are suffered to carry on their councils and operations behind the curtain, what better can be expected than mere random experimentalizing and blundering, at John Bull's expense? He it is, the British Donkey, though flattered by being drawn as the British Lion, who pays for all.

III. "'Now, Milverton,'" says Ellesmere again, "'would you not forthwith pull down such things as Buckingham Palace, and the National Gallery?'" To which the reply is: "'I would pull them down to a certainty, or some parts of them at any rate; but whether "forthwith," is another question.'"—As Mr. Blore's *improvement* of the Palace had been commenced before the book here quoted from was published, we are at liberty to suppose that, in the writer's opinion, such improvement does not render pulling down at all the less desirable,—perhaps, even more so than ever. As affairs have since turned out, the times are not at all propitious for schemes of building either new Royal Palaces, or new National Galleries. With regard to the Gallery, notwithstanding its imperfections, it is susceptible of very decided improvement as it now stands,—capable of easily being made what it ought to have been at first. Even at present, it is not so much the "Gallery" itself, as the other buildings and accessories, that render Trafalgar-square a failure. Those on the east side are in the most pert and vulgar taste, and require to be pulled down quite as much, or even much more, than the "Gallery"—if anything is ever to be made of the Square as an architectural *ensemble*. As to the west side, the best that can be said of it is, that it serves as a foil to the "Gallery," and is more lucky than the latter; probably owing to its being sheltered from the shafts of criticism by the august name of Sir Robert Smirke. Indeed, it is somewhat unaccountable, that those who are so dissatisfied with both the Gallery and the Fountains, should be so complacently tolerant of all the rest, and even go into extasies of admiration of St. Martin's Church, which, the columns of the portico alone excepted, is a compound of tastelessness, uncouthness, and deformity. There is not a single feature in it that harmonizes with the order, or is at all in the spirit of the style so professed. In one respect, the Church and the Gallery are nearly on a par, it being difficult to decide which is the ugliest—the steeple of the one, or the dome of the other. Both the one and the other may be said to contrast with the respective porticoes; but there is a very wide difference between grating dissonance and that artistic contrast which, while it introduces variety and prevents too great sameness, contributes to general harmony. Of such contrast and harmony we have example in the human countenance, where the eyes and mouth are placed horizontally, and the nose forms a vertical line coming in between them. A *regular* and well-trained critic might object to this, and contend that nature is here at fault; and that there would be more pleasing regularity were either the nose placed in the same direction as the other features, or the latter in that of the nose. Still, there is very great comfort left for him, if not for us—namely, that there is *precedent*—aye, universal precedent—for noses being placed just as they are. But now I am getting too rigmarolish; therefore, break off.

IV. I find that I have omitted an observation in Milverton's reply to Ellesmere's sneer at the taste of governments and committees, that deserves to be attended to. "'I suppose,'" says the latter, "'that these committees are frequently hampered by other considerations than those which come before the public, when they are looking at the work done. And this may be some excuse. There was a custom which I have heard prevailed in former days in some of the Italian cities, of making large models of the works of art that were to adorn the city, and putting them up in the places intended for the works when finished, and then inviting criticism. It would really be a very good plan in some cases.'"—No doubt, but practicable only for small ornamental works, such as fountains, triumphal arches, public statues, monumental crosses, &c. A full-sized model of such an edifice as the "Houses of Parliament," or even of the new building at Buckingham Palace, would have been rather too cumbrous and costly an affair for an experiment of the kind. Had any other design been chosen for the purpose than the Corinthian column—a model of which would have been altogether superfluous—the Nelson Monument might properly enough have been tried beforehand, by means of a full-sized model of it put up on the spot. Yet, when we consider what a mere farce was played with the model, or what was meant for model, of the Wellington Statue on the Archway, which was allowed to remain up only two days, when it was snatched away, lest it should be pelted at with further volleys of censure and derision,—we must pronounce trial by model—at least, when so conducted—to be altogether nugatory. If the Statue-committee made a show of "inviting criticism," they showed also wonderful alacrity in running away from it, after its very first fire. Inviting criticism before-hand, forsooth! committees have no notion of doing that. Their policy invariably is to stave it off as long as they possibly can. The public, it will be recollected, were not permitted to see the model of the façade of the British Museum, notwithstanding that there was one in existence, and that in the building itself; and notwithstanding that some of the newspapers called out for its being liberated from durance under lock-and-key, and submitted to inspection and criticism. Well, we have now the façade itself, and see both positive faults and numerous short-comings, all which might have been foreseen in the model, and ought to have been corrected accordingly. It is true, the facade is not generally ill-spoken of,—simply because it is not spoken of at all. It obtains not so much as a syllable of praise in any quarter; and such silence is tolerably expressive of disapprobation and disappointment. The new building at Buckingham Palace, is in the same unenviable predicament. It has been abandoned to mockery and contempt, without a single favourable word for it having been uttered by any one; although there are some who would most readily have done so, had they not stood in awe of general discontent, and been apprehensive that they might injure their own credit with the public for judgment and taste, by attempting to persuade them that the design is at least not unsatisfactory.

V. So long as committees, and those who have the management of public competitions for buildings, shall continue to be left irresponsible for their doings, there will be no end to both blunders and dishonesty. Persons who intend to act honourably and fairly, do not need to screen themselves behind a curtain, thereby exciting a suspicion that what they do will not bear the gaze of broad daylight. On the other hand, those who care only for the opportunity of exerting their own private influence, without regard to aught besides—even honourable dealing being left out of the question—ought to be made aware that if they so act, it must be at their own peril. There is scarcely a public competition of any importance that does not occasion complaints of unfair intriguing, and of bad faith on the part of the committee,—complaints that can very well be endured; committees being sufficiently aware that with mere complaints, the matter complained of blows over, without proceeding to the extremity of exposure. All this is deplorable enough; but then, how is it to be remedied? I should say, that what would go very far towards remedying it, if not remedying it completely, would be the making it ILLEGAL for any committee, or other body, to invite architects to a competition by public advertisement, without having a public exhibition beforehand of the designs sent in in the first instance, and without entire publicity in all other respects, the names of the committee being published, and reporters for the press being admitted to their discussions on the relative merits of the designs. As matters are *cunningly* managed at present, we only know that Mr. A, or Mr. B's design has been selected for adoption; but how many votes, or who were the persons who voted for or against, it is impossible to learn, much less the arguments they made use of. The Army and Navy Club, who, it is to be presumed, call themselves gentlemen and men of honour, have laid themselves open to the imputation of the most bungling and bare-faced trickery, by calling an unlimited competition in the first instance, and afterwards setting that aside, and having a second one *limited to six*, of course of their own choosing, after the site (at first rather an inconvenient one, and therefore tasking all the ingenuity of the first competitors) had been considerably enlarged, by taking in another house in Pall-Mall. The Army and Navy Club ought to blush at being convicted of such downright knavery; yet, they will not do so, because they know that they are behind a curtain, and that the names of the committee *cannot* be shown up, as they deserve to be, as those of a pack of tricksy jugglers. One comfort, if a comfort it be, is, that they have tricked themselves; for from what has been said of it, they seem to have got a most Pecksniffian plan for their building. Were I, as thank God I am not, a member of the Army and Navy Club, I should be tempted to hang myself out of pure vexation. After what they have done, Navy and Knavery are likely to become synonymous words.

VI. The idea of manufacturing the picturesque out of such things as labourers' cottages is not a little absurd; more especially, when two most embarrassing conditions are annexed to the task—first, that they shall be erected at a minimum of cost; secondly, that they shall be free from all those defects, discomforts, and inconveniences which accompany and contribute to picturesque quality in the works of village Vitruviuses, which marked in their raw state only by uncouthness and meanness, are touched, tinted, and mellowed down by time and weather, into objects delightful to the painter's eye, and congenial subjects for his pencil. Dilapidation, or something approaching to it, and touches of lichenous vegetable incrustation, are almost indispensable to qualify a cottage for obtaining an artist's interest and vote. Nor must paucity and smallness of apertures be forgotten. Yet all these *beauties*, and many others not here enumerated, are only so many defects in the eyes of many well-meaning, but prosaic and anti-picturesque people. In fact, a cottage *to look at*, and a cottage *to live in*, are two quite distinct things: the former requires all that constitute so many defects in the latter, and *vice versâ*. While your philanthropist would have no such things as rags in the world, the artist, on the contrary, insists upon them; not, indeed, for himself, if he can possibly help it, but rags he must and will have for his beggars and gipsies. And so is it with regard to cottages. I was speakthe other day to an artist friend of mine on the subject, and the schemes for improving labourers' cottages *secundum artem*. Shorn of sundry emphatic words, that may as well be here omitted, one of his observations was: "At this rate, we shall not have a decently down-falling-looking old tenement, nor a properly beggarly hovel in all England." It was to very little purpose, I observed, that painters might draw upon their imagination for cottages, as they now do for a good many other things, cherubim included. So far from being consoled by the comfort I held out to him, he seemed rather nettled at my remark.

VII. No doubt, cottages may be built so as to be exceedingly convenient and comfortable within, and at the same time sufficiently picturesque in external appearance—at least when Time shall have done his part to them,—until when, they would be apt to look as if they had just been unpacked and taken out of bandboxes. Moreover, they would be comparatively expensive affairs; not perhaps quite so costly as royal cottages, but more so than suits the purses or else the parsimony of the devotees to the picturesque. There are bargain-hunters even in matters architectural,—people who want things both cheap and tasty, but who generally find out in the end that by the change of a *t* into an *n*, they have got hold of what is termed the "cheap and nasty." It is, indeed, possible to produce tasteful and striking effect with comparatively little or no money cost. Nevertheless, such effect costs something; if nothing, or next to nothing, to the employers, it costs architects a very great deal,—nothing less than a life of study, and infinitely more study than many make to suffice for a whole life-time. Let me not be understood as saying, that comfortableness, convenience, and other more directly utilitarian than poetic or sentimental matters, ought at all to be interfered with for the sake of ensuring picture-like appearance. But I do contend that small dwellings, built with regard both to such comfortableness, and to strict economy in point of cost, can never be beautiful objects in any sense of the term, unless beauty and homeliness be one and the same thing. Neither are they likely ever to become even picturesque,—because what will render a mere hovel so, causes them to appear only *tristefully* squalid, and equally offensive to feeling and to taste. No one has yet discovered the way of making "a silk purse out of a sow's ear." You may, indeed, tie a silk purse to it, and one well filled with gold: and so may you trick out a cottage with much that shall be from the very first highly pleasing, on account of its being studiedly elegant and tasteful; but then it will be an expensive affair—at any rate, comparatively expensive, because if effect is to be attended to and produced, there must be a good deal more or less beyond what mere necessity would dictate. Besides which, even if cost be not at all regarded, there is very great danger of a building of the kind, when intended partly as an ornamental object, turning out a very finical-looking one. He who is a mere architect, is not capable of treating such subjects properly: in order to do so, he must have more of the artist in him than falls to the share of architects in general,—or, instead of the *artistic* or artistic-picturesque, he will only give us the *artificial*. Was ever painter so smitten by what may be called an architectural tricked-out *comme-il-faut* and *secundum artem* design, as to venture to introduce it into a picture? As soon would he think of peopling a landscape with the satin-slippered and silk-stockinged peasants of the Opera-house, instead of the vulgar worsted-stocking, or perhaps stockingless, creatures of real life,—whether in the land of John Bull, or any other. Cottages that are really and positively picturesque, are those erected by people who never thought of the picturesque, or perhaps even never heard of such word. If it should be asked what it is then that has rendered them picturesque, I answer, Accident, and all that causes builders, surveyors, appraisers, and auctioneers to shake their heads at them, as if there was anything in them—I mean in their own heads.

ARCHITECTURE AT THE ROYAL ACADEMY;

AND THE ARCHITECTURAL DRAWINGS AT THE EXHIBITION.

Since our preceding publication, matters look more and more cheering—riper for reform, and indicating the necessity for it. The *Art-Journal* scruples not to tell its readers very bluntly that architectural drawings have no business to be in the Exhibition. The editor seems to have made up his mind that there could not possibly be two opinions as to the propriety of excluding them altogether; and, to say the truth, they might almost as well be so, as experience the scurvy treatment they now do. As to the ill-will which he manifests towards architecture, we will merely say, that it is not exactly *the thing* for a gentleman to do who conducts an art-journal, and who professes to watch over the interests of art in all its branches,—and some of the lowest of them he takes under his especial patronage: much good may it do them. Considering the quarter it comes from, we are not at all surprised at the ill-will just instanced; but surprised we are, and that in no small degree, at an outrageous instance of similar feeling on the part of the Royal Academy. As the fact has been publicly noticed and animadverted upon by others, our readers will probably have guessed that we allude to a model of Miss Burdett Coutts's church having been sent in by its architect, Mr. Ferrey, and turned away! No wonder, therefore, that there is nothing of the kind in this season's exhibition. If there were any other productions of the same class that met with the same fate, we cannot say: it is just as probable as not that there were at least some; yet, whether such were the case makes no difference as to the *animus* displayed by the Academy. Had more models been sent in than could possibly be accommodated, some of them must, of course, have been excluded. But to reject while there was room—not to suffer so much as a single one to appear in the Exhibition, was really too bad, and showed singular want of tact also. If the Academy were determined not to admit models, they ought at least to have said as much in their advertisements to those who intended to exhibit. That would, at any rate, have been acting straightforwardly. They might have been well aware, that although models actually exhibited might fail to obtain notice, the entire absence of them would excite remark. Had none been sent, whatever remark had been made could not affect them, because they cannot compel persons to exhibit. But to act as they have done is nothing less than a solemn blunder, it being certain to lead to explanations and comments that are not at all to the honour of the Academy. If the painters are ashamed of having architecture in their company, let them honestly and openly declare as much, instead of resorting to every sort of mean and dirty trickery in order to force it out. If the Academy can shift without architecture, the latter can shift equally well without the Academy, there being, most luckily, another royal, and eminently public-spirited body, which only waits for architecture being dismissed from the Academy, to bring it more effectively before the public. Nothing—so we are assured—but delicacy towards the Academy, has withheld the Institute from getting up an annual exhibition of architectural designs of every class, upon an adequate scale. Well, they need not now be restrained by delicacy, for it would be entirely thrown away after the "exhibition" of the cloven-foot in their conduct towards architecture.

For our part, we are not at all sorry that the Academy have acted as they have done, because they now leave no room for doubting of their hostility towards architecture. They have now fairly committed themselves; and if architects should not now be stirred up to resent the insults put upon their art, and upon themselves as a professional body, they will richly deserve to be treated with ignominy and scorn. We would fain be of better hope. We trust that not only they will properly resent it, but that the Professor of Architecture himself will now rouse himself from his lethargy, and stand up for the honour and the interests of his own art. If he do not do so, the sooner he has a successor the better; for even should it be "Mr. Pecksniff" himself, he cannot possibly do less, and might probably do a little more. Mr. Cockerell is, we have no doubt, a very well-meaning gentleman, and sufficiently well qualified to discharge the duties of his office, so long as difficulties do not present themselves; but he does not show himself to be the man who is both capable of and determined to meet difficulties boldly, and to exert himself energetically in behalf of that art which his professorship at the Academy points him out to the public as the representative. If he has expostulated with the Academy in regard to their treatment of architecture, he does himself very great injustice in concealing it from the world; thereby leaving it to be inferred that he is altogether indifferent to the matter.

After this *tirade*, if so it should be called, though what we have said is neither uncalled for nor unprovoked, we were going to say that we resume, and proceed with our remarks on the subjects exhibited, when, as ill luck, or at any rate luck of some sort or other, will have it, we are perforce, compelled to postpone them till our next number, when we shall lay them before our readers. In the meanwhile, we have at any rate given them something to cogitate upon, inviting those who may agree with us to support us in our opinions by expressing their own, and assuring those who may happen to dissent from them that we are quite ready and willing to receive and listen to whatever they may have to advance that shall countenance the treatment which architecture receives at the hands of that specimen of royalty—the Royal Academy!

COLLISION OF TRAINS.

In the following paper we propose to determine the shock experienced at any part of a railway train during a collision, and to propose methods for obviating the mischief that ensues. To simplify our ideas, let us first suppose the weights of the separate carriages all equal, and the buffers removed. Let the number of carriages be N; the impulse on the first carriage that sustains the shock R; r_n the impulse between the nth and $\overline{n+1}$th carriage: then the velocity in all parts of the train being the same relatively, both before and after impact, the carriages being supposed inelastic, and the masses of all the carriages equal, we shall have the following equation:—

$$r_{n+2} - r_{n+1} = r_{n+1} - r_n, \text{ for all values of } n;$$
$$\text{or, } r_{n+2} - 2r_{n+1} + r_n = 0;$$

a linear equation of differences, the solution of which is $r_n = (Cn + C')$; but r_0 (the impulse on the last carriage outside) $= 0$.

$$\therefore C' = 0; \text{ and } r_N = (C\,N) = R.$$
$$\therefore C = \frac{R}{N}; \text{ and } r_n = \frac{R}{N}n.$$

If the masses of the carriages had been unequal, m_n the mass of the nth carriage, we should have had N equations of the form

$$\frac{r_{n+2} - r_{n+1}}{m_{n+2}} = \frac{r_{n+1} - r_n}{m_{n+1}}, \text{ from which to determine } r_n, \text{ \&c.}$$

From this we conclude, that *in a train of equally-loaded carriages the shock increases directly as the distance of any given carriage from the end of the train farthest from the point of impact.*

The design of buffers is to diminish the violence of the shock; that is to say, to change impulse (which is intense pressure continued for a very short time) into a lesser pressure continued for a longer time; but, as we shall immediately show, it is not practically possible to construct buffers capable of thus translating the whole or any considerable part of a violent shock—such, for instance, as is experienced when an express-engine accidentally is turned into a siding upon a heavy luggage-engine. To take an example:—Let the express-engine weigh 20 tons; its rate be 40 miles an hour; the stationary luggage-engine weigh 30 tons: then, if m, m', be the masses of the trains, v the velocity of the express, and $R = \frac{v\,(m\,m')}{m + m'}$;

v expressed in feet per second $= 60$ nearly;

$$m = \frac{20\,(2240)}{32}; \quad m' = \frac{30\,(2240)}{32} \text{ nearly, in masses of a lb. weight.}$$

$\therefore$ R = nearly 50,400 units of momentum, or the momentum is the same as would be occasioned by a mass of 3,200 lb. weight impinging on a fixed obstacle at the rate of 504 feet a second.

Let us now determine the pressure on the head of a buffer which is capable of translating this shock into a continuous pressure. Let the play of the buffer be supposed 2 feet, and the thrust vary as the distance by which the rod is depressed. Let p be the pressure when the rod is thrust in a distance x; P the pressure when the rod is thrust in a distance 1: then $p = P\,x$.

At the time t, from the commencement of the impact, let the end of the buffer have moved forward a space $= x$; the head of the buffer has moved forward a space $= x - x$: therefore, the luggage-engine has been pushed forward a space $= x - x$. Therefore, neglecting the mass of the buffer as small compared with the masses of either of the engines, we shall have these equations (the luggage-engine being supposed without buffers):—

$$m\frac{d^2 x}{d t^2} = -P x; \quad m'\left(\frac{d^2 x}{d t^2} - \frac{d^2 x}{d t^2}\right) = P x.$$

$$\text{Eliminating } \frac{d^2 x}{d t^2}, \text{ we get } \frac{d^2 x}{d t^2} = -\left(\frac{P}{m} + \frac{P}{m'}\right)x;$$

$$\left(\frac{dx}{dt}\right)^2 = C - \left(\frac{P}{m} + \frac{P}{m'}\right)x^2 = v^2 - \left(\frac{P}{m} + \frac{P}{m'}\right)x^2.$$

When $x^2 = 2$ the blow is expended, and $v^2 = 4\left(\frac{P}{m} + \frac{P}{m'}\right)$.

$\therefore P = \frac{v^2\,(m\,m')}{4\,(m + m')} = 756{,}000$ lb.; and the greatest pressure $= P \times 2 =$ twice this quantity, or 675 tons.

It is needless to say that such a buffer is purely imaginary. A far better plan would be, to have one or two carriages of *very* slight construction, and filled with any kind of soft and yielding material, at both ends of a train. There is little doubt but a contrivance of this kind would destroy entirely the effect of many shocks which, unless so counteracted, would be sufficiently violent to endanger life. In the above example, to avoid the difficulty of calculating the effect of several buffers acting at once, the case of a single engine impinging on another has been considered. But when trains are attached, it is clear that the shock will be still greater than that just calculated.

If the play of the buffers—that is, the distance through which they are capable of moving, be *extremely* small as compared with the length of the carriages, the velocity at every part of the train will be the same. Therefore, $\frac{d^2 x}{d t^2}$ is the same at every part;

and if P_n, P_{n-1}, be the pressures on the nth carriage, arising from the buffers, $P_n - P_{n-1} = P_{n-1} - P_{n-2}$ (the weight of the carriages being supposed uniform),—and, as before, if F be the pressure on the buffer of the carriage nearest the shock,—

P_n will $= \frac{nF}{N}$.

Returning to the equation $\left(\frac{d\,x}{d\,t}\right)^2 = v^2 - \left(\frac{P}{m} + \frac{P}{m'}\right)x^2$,

when $\frac{d\,x}{dt} = 0$, and the buffer is driven as far as it will go,

$v^2 = \left(\frac{P}{m} + \frac{P}{m'}\right)x^2$.

From this we see the great advantage of having a long play on the buffers: the pressure P will be diminished in a ratio varying as the square of the length to which the buffer plays—that is, if the length of one buffer-rod be twice the length of another, and the strength of the spring of the first be only one-fourth the strength of the spring of the last, the amount of shock destroyed by either will be the same.

The practical effect of buffers, as they are ordinarily disposed throughout a train, is to resolve so much of the impact as they cannot altogether absorb, into a series of impacts of lesser momentum; for let us consider what would happen supposing a train, the several parts of which are separated by buffers, to impinge on a fixed, immoveable obstacle. So long as the buffers are all acting, $P_n = \frac{n\,F}{N}$; consequently, the pressure on the first pair of buffers is greater than the pressure on those behind. Let V be the velocity destroyed by the total shock, e V the velocity destroyed by the time the first pair of buffers has ceased to act: then a velocity $(1 - e)$. V has to be destroyed in the first carriage by a force of impact,—for the pair of buffers behind will be still acting for some little time after the first pair have ceased to act.

Again, let e'V be the velocity destroyed before the second pair of buffers cease to act; then, as before, the second carriage will be suddenly brought to rest by an impact on the first carriage capable of destroying the velocity $(1-e')$.V in the second carriage. Next, the third carriage will be suddenly stopped; this, likewise, will communicate a shock to the first, though less than it communicates to the second; and so on. These shocks and motions will be somewhat varied by the resiliency of the buffer-springs, and the impulsive friction of the rails against the wheels;—this latter disturbing force we have altogether omitted, as being comparatively insignificant. On the whole, then, it appears that buffers very much diminish the intensity of a shock, although they are incapable of utterly absorbing it, supposing it to be of great intensity.

I. H. R.

ON STONE WALLS AND EMBANKMENTS FOR RESERVOIRS OF WATER-WORKS.

By R. G. Clark.

The intention of this paper is to treat of the pressure of water against walls and embankments of reservoirs for water-works and canals, and to lay down some easy formulæ to find the necessary dimensions so as to effectually resist the pressure of the water; the demonstration of these formulæ being effected by the simplest methods of investigation. We shall first exhibit some investigations for stone walls. The level of the surface of the water in all cases to be supposed on a level, or co-incident with the top of the wall or embankment, so as to favour the stability of the structure in case of floods or violent agitation of the water by storm winds,—although the water might be when in a quiescent state but two feet from the top. The following description of walls are required to inclose a few acres of water, when there is no suitable kind of earth to be obtained in the locality for forming an embankment. The walls are to be constructed in solid masonry, of a uniform connection in all its parts.

I. Given the height of the wall, the depth of the water being the same, and the batters on each side of the wall equal; to determine the thickness of the wall at the bottom:—

Let A B C D be a vertical section of the wall; D W the level of the water; let x denote the required thickness, A B, of the wall; the batter, B F or E A, by b; the height of wall by a; the specific gravity of water by unity; and that of the material by s. After some reduction, we have for the equation of equilibrium,

$$\tfrac{1}{2}abx-\tfrac{1}{3}b^2a-\tfrac{1}{6}a^3+s\mathrm{M}m=0 \;\ldots\ldots\ldots\ldots\ldots\; (a);$$

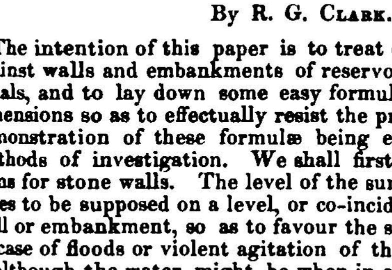


Fig. 1.

(see "Moseley's Hydrostatics," Art. 51), where M = area, and m horizontal distance of centre of gravity G from A; $\mathrm{M}=\frac{1}{2}a(2x-2b)=a(x-b)$; and $m=\frac{1}{2}x$; Therefore, $s\mathrm{M}m=\frac{1}{2}ax(x-b)s=$ moment about A; which substitute in the above general equation,

$$\text{we have } x^2+\left(s-b\right)x=\frac{a^2+b^2}{3s} \;\ldots\ldots\ldots\ldots\; (1).$$

Ex. Given the height of the wall = 24 feet; batter each side, 4 feet; and the specific gravity of the material, 2: to find the thickness at bottom and top.

Here $a=24$; $b=4$; and $s=2$.

Substitute these values in (1), we have $x^2-2x=98{\cdot}6$;

$\therefore\ x=11$ nearly = A B; and C D = 3.

II. Let the vertical section of the wall be rectangular, or the sides vertical; to find the thickness at bottom:—

Now area A B C D × ½ distance of centre of gravity from A $=\frac{1}{6}a^3$

$$\therefore\ asx=\tfrac{1}{6}a^3;\quad \therefore\ x^2=\frac{a^2}{3s};\quad \text{hence, } x=\frac{\sqrt{a^2}}{3s} \;\ldots\ldots\; (2).$$

Ex. Given the height of the wall = 24 feet, and the specific gravity of the material, 2: to determine A B.

$$x=\sqrt{\left(\frac{24^2}{3\times2}\right)}=9{\cdot}8, \text{ the thickness required.}$$

III. Let the side of the wall next the water be battered, and the side behind vertical; to determine A B, the thickness at the base.

Let A B C D be the vertical section, and let fall the perpendicular C E.

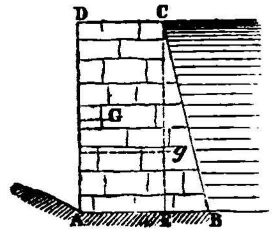


Fig. 2.

The momentum of the triangle C E B about A from its horizontal distance of centre of gravity g,

$$s\,.\,\tfrac{1}{2}ab\times(\tfrac{1}{3}b+x-b).$$

The momentum of rectangle D C A E about A from its centre of gravity,

$$sa(x-b)\times\tfrac{1}{2}(x-b).$$

Adding these two together, and substitute for $s\mathrm{M}m$ in equation (a), as in first case, we have, after transposing,

$$x^2+\left(\frac{b}{s}-b\right)x=\frac{a^2+b^2}{3s}-\frac{1}{3}b^2 \;\ldots\ldots\ldots\ldots\ldots\; (3).$$

Ex. Given the height of wall, 24 feet; batter, 4 feet; and specific gravity of stone, 2: required the thickness of the top and bottom.

By substitution of the above values in equation (3), we have, $x^2-2x=92{\cdot}7$.

Solving this quadractic, we have $x=$ A B $=9{\cdot}2$; top, $5{\cdot}2$.

IV. When the wall is battered behind, and the side facing the water perpendicular.

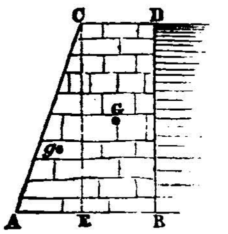


Fig. 3.

The two first terms of (a) vanish when B D is vertical; $\therefore\ s\mathrm{M}n=\frac{1}{6}a^3$.

The moment of triangle A E C about A, by its horizontal distance of its centre of gravity,

$$s\,.\,\tfrac{1}{2}ab\times\tfrac{2}{3}b;$$

and also of rectangle C E B D about A,

$$a(x-b)\times\left(b+\frac{x-b}{2}\right)s;$$

$\therefore$ substituting the sum in equation (1),

$$\text{we have } x^2=\frac{a^2}{3s}+\frac{1}{3}b^2.$$

Ex. Given the dimensions of the wall as in last example; to determine the thickness at bottom:—

$$x^2=\frac{24^2}{6}+\frac{16}{3}=96+5{\cdot}3=101{\cdot}3;$$

$$\therefore\ x=10{\cdot}=\text{A B; and C D}=6{\cdot}$$

For additional strength to the above walls, it would be well to insert at the centre of them one tier of bond, about two-thirds the height from the top, which will be at the centre of pressure.

V. We shall now give a case where earth shall be required in the construction of an embankment, of the form of a trapezoid, having a vertical clay puddle-wall in the middle, and the slope facing the water being paved with suitable material, with a puddle under. In case of any contraction of the clay, there would be a separation of the clay from the earth; therefore, the triangle D E B should be of sufficient strength alone to resist the fluid pressure, either against sliding or revolving on D. The water is supposed to be co-incident with the top of the embankment.

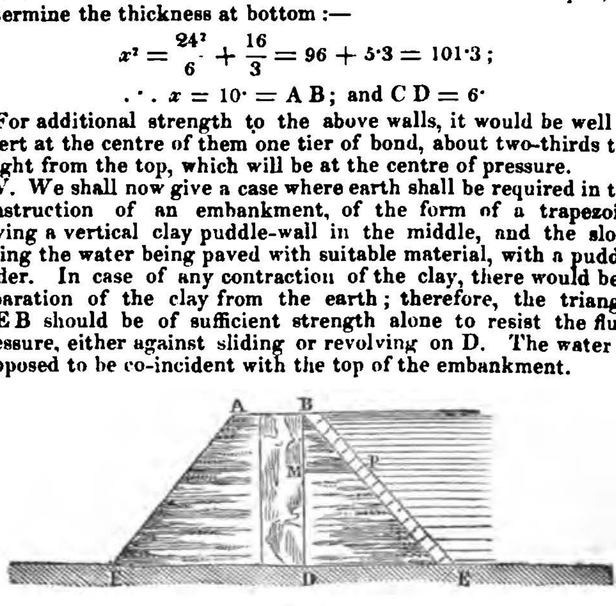


Fig. 4.

Let D B $=a$; B E $=a$. Draw P M parallel to F E; and the horizontal pressure of water = momentum B P M × horizontal distance of centre of gravity from D;

$$\therefore\ \frac{1}{6}x^3=\frac{1}{2}\int s\,y^2\,dx;\quad \therefore\ y^2=\frac{1}{s}x^2;\quad \therefore\ \text{D E}=\sqrt{\left(\frac{1}{s}\right)}a.$$

Ex. Given the height of the embankment, 20 feet; specific gravity of material $= 1{\cdot}4$ (water being unity): to determine the base D E of the triangle D E B; also the whole width of bottom, when it has a horizontal surface A B at top, 3 feet wide.

$s = 1{\cdot}4$; $BD = a$; $\therefore BE = \sqrt{\left(\frac{1}{1{\cdot}4}\right)} 20 = 16{\cdot}8$ feet required; therefore, the whole width $FE = 36{\cdot}4$.

THE CIVIL SURVEYORS AND THE MILITARY SURVEYORS.

The Surveyors' Association is proceeding vigorously in its defence of the professional rights against the government usurpation, though we very much wish that they had taken this course at an earlier period, for we long since pointed out to them the course of invasion which the military employees of the government were carrying on against the public. Among the late allies of the government jobbers is our contemporary, the *Athenæum*, usually among the foremost advocates of sound and enlightened policy; and we have no other means of accounting for the remarks contained in the number of the 17th June, than by the supposition that its sympathy in the cause of sanitary reform has been taken advantage of by some of the jobbers, to foist on the editor a mis-statement of the case. It is by alarming the sanitary reformers that the jobbers hope to hide their own designs, representing that there is an attempt to prevent the sanitary plans from being carried out in the most efficient manner; whereas the same issue is pleaded against them. The *Athenæum* cannot be expected in its literary capacity to take part in all the details of engineering questions, and it is quite excusable that it should give way to the assumptions of the military engineers. We do, however, hope that the editor will re-consider the case, and not give the weight of his advocacy to a course of policy which is eminently calculated to retard the progress of sanitary reform.

At the present day, there is an assumption on the part of the government functionaries, that it is the government which has effected the great sanitary reforms already made, and that none but government functionaries can carry them out; whereas, the whole statement is utterly untrue. The great improvements in sewage were made by the exertions of members of the engineering profession, before the government had any share in the administration; and the plans now being carried out are those emanating from the officers of the old commissions. What the government is answerable for, is—first, neglect, in allowing the old irresponsible commissions to exist; and second, usurpation, in assuming the administration of the sewers to a new set of irresponsible commissioners, instead of establishing representative commissioners. The government parties make a great fuss about the new era of sanitary reform, with which they have as much to do as a cuckoo has with the construction of a sparrow's nest; the new era of sanitary reform, and the new lights on sewage engineering, having emanated not from government, but from Messrs. Roe and Phillips, who originated the present cheap and efficient plans, and carried them into practical execution. So, similarly, the plans for the supply of water by constant service did not emanate from the government, but from the hydraulic engineers. Hitherto, all that has been done in sanitary engineering, as in every other department of engineering, which has been done efficiently, has been done by the civil engineers, and not by the government engineers; and it never can be done efficiently except by the civil engineers. For this reason alone, we should view with jealousy any attempt to supersede the civil engineers.

The *Athenæum* has given faith to the assumption that the military engineers have a superiority in their professional capacity, whereas the issue is not whether they have a superiority, but whether they have an equality. Wherever the military engineers have been put to the test, they are found most inefficient; their engineering works in Canada and the colonies are far from creditable to them, or satisfactory to the nation; their volume of scientific papers is principally the production of civilians, or on civil works; and their surveys hitherto, although they cannot be subjected to any rigid test, have nevertheless been attended with serious disappointments. In the engineering world, the military engineers have no professional standing or reputation.

The *Athenæum* does not seem to be aware that we have in London, engineers competent 'to conduct a trigonometrical survey, which involves the nicest points of astronomy, and requires all the resources of mathematical analysis,'—when a reference to the Institution of Civil Engineers is quite sufficient to show the mathematical capabilities of its members; and if the *Athenæum* had adverted to the evidence as to this, given from time to time in its own columns, it would not have had any difficulty in saying who were competent to conduct the survey. If, however, the military engineers are under a slur in their professional capacity, it must be recollected that such as they are, they are not the parties who carry out all the details of the survey, which are done by the body of privates, many of whom are got from hedge-schools in Ireland. If the *Athenæum* had been aware of this, it would not have spoken of the inferior attainments and little experience of a great many of the lower surveyors—the worst of whom are, we believe, some of the best men of the government corps, who leave it as soon as they learn something, and set up for themselves. Even in the operations which are going on, hardly an officer is to be seen in the streets, but the duty is left to the privates. Mr. Bidder, Mr. Gregory, Mr. Simms, Mr. Barlow, or Mr. Buck, is not needed to perform the lower operations of a survey, which will certainly be as well performed by the repudiated surveyors as by the government corporals and privates. With regard to Mr. Edwin Chadwick's statement, that one of the associated surveyors was five years ago a journeyman carpenter, we cannot see what that has to do with the question, unless he states how many of the assistants on the government survey were journeymen bricklayers or clodhoppers five years ago, or what impediment his own former occupations are to his proficiency in sanitary science.

We join issue as to the competency of the government engineers, and as to their merits in comparison with the civil engineers. We join issue, likewise, on the point of cheapness. Mr. Chadwick knows very well, that in any comparison of cost, the general charges of the body of military engineers must be added to the special estimates. If he were not trying to uphold a job, he would not quibble upon it. We are, however, most surprised, that after the declaration in the House of Commons, the government have determined to put the country to an expense for this military survey, while the progress of the ordnance survey will be impeded.

The *Athenæum* has been likewise misled upon the point that the case of the surveyors has been decided by a competent and impartial court; whereas, the decision as yet has been an approval of Mr. Edwin Chadwick's scheme, by Mr. Edwin Chadwick's own board,—and this is what the associated surveyors are trying to upset; for they consider, in common with the great body of the profession, that they have not yet got "a hearing," and they are now "trying for a hearing," in which we hope they will be supported by the *Athenæum*, which would not, we believe, have countenanced Mr. Edwin Chadwick's plans if it had been informed of the whole truth of the case.

The *Athenæum* boldly says, that "as the nation builds its own ships, bores its own cannon, and does all things else which can be done with its own workmen, why should it not make its own surveys?" We answer, that the government has ships and machinery made elsewhere, cannon cast elsewhere, and many other things made elsewhere; and that, on the other hand, whatever is done by the government, is neither done well nor cheaply. The ordnance works, the dockyards, the post-office, and the mint, would be a disgrace to any merchant or partnership or joint-stock company. In the present case, the military surveyors have quite enough to do in the north of England, where they are wanted to finish the ordnance *un*-survey.

Import and Export of Metals.—It appears from the return of the imports and exports of lead, copper, tin, and zinc, ordered by the House of Commons, that the total quantity of lead ore imported was 507 tons, of which 400 tons were from France, and the remainder principally from New South Wales. Pig and sheet lead imported amounted to 3,932 tons, of which 216 tons only were retained for home consumption—the rest being re-exported. Of British lead there were exported 8,259 tons, of which France took 1,765 tons; Russia, 1,754 tons; East Indies, 1,055 tons; and Holland, 806 tons. —The total quantity of foreign copper ore imported was 41,490 tons, of which 23,831 tons were from Cuba—the quantity of fine copper contained therein being 8,920 tons. The quantity of metallic copper imported was 513 tons; retained for home consumption, 70 tons. The quantity of copper exported was 15,142 tons.—The total quantity of tin imported was 1,165 tons, of which 161 tons were retained for home consumption; and the exports were 1,741 tons British, and 547 foreign.—The total quantity of zinc imported was 12,769 tons; and exported 886 tons British, and 3346 tons foreign.

NOTES ON ENGINEERING.—No. IX.

By Homersham Cox, B.A.

Synoptic Tables for calculation of Earthworks in Level and Sidelong Ground on Railways.

No earthwork tables have hitherto been published for the express purpose of facilitating calculations for SIDELONG GROUND. The present is an effort to supply this want, which is much felt on account of the number and complexity of the operations usually required for adapting the published tables to the cases referred to. According to the existing methods, it is necessary when the ground slopes laterally, to calculate the areas of the sections, and extract the square root previously to reference to the tables. By the method here proposed, these antecedent calculations are wholly avoided: the numbers are taken from the table without any previous computation, and require only to be multiplied by the natural and artificial slopes.

The tables are also easily applicable in calculation for LEVEL GROUND; and it is believed that for both purposes the methods will be found very simple and expeditious. The tabular numbers are calculated *for every half foot.* When greater exactness is necessary, the calculator is referred to the admirable tables of Mr. Bashforth. The manuscript computations for those tables have been kindly placed at the disposal of the present writer, and have enabled him to check the accuracy of a great part of his own results.

It is not intended to demonstrate at length the formula of computation, as they depend on well-known theorems: the following brief account of them is sufficient for the present purpose.

Let A C D B be a section in a railway cutting in *level* ground, C D being the formation level, and A C, B D, the artificial slopes. As A B is horizontal, the points A, E, and B, are all at the same

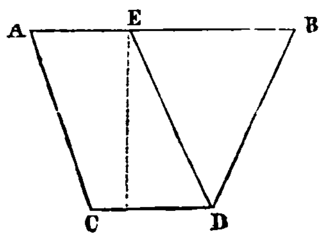


Fig. 1.

vertical height above the formation level: call this height a, measured in feet.

Let a similar section be taken at a distance along the railway of 66 feet, or one chain from the above, and let the vertical height there be b feet. The solid content in cubic yards of the solid terminating in E D B, is $\frac{22}{27}(a^2 + ab + b^2)\,r$.

The solid content is $\frac{11}{9}\,arw$; r being the "slope" of the embankments, the measurement of which will be explained more fully presently; w the width in feet of the formation level.

Next, let A C D B be a section in sidelong ground—that is, ground inclined laterally or transversely to the railway. Here

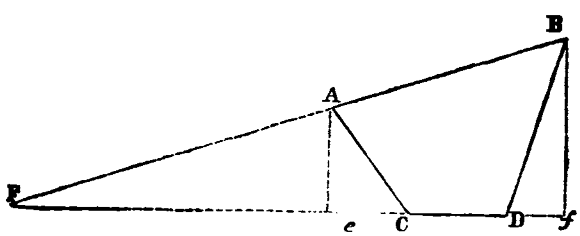


Fig. 2.

there are two sets of heights to be considered—those on the right hand, and those on the left hand of the railway: and there are two "slopes"—that of the natural ground depending on the inclination of A B; and that of the artificial embankment, depending on the inclination of either A C or B D. Call the natural slope R, and the artificial slope (as before) r. If a and A be the heights (in feet) of the points A and B respectively, above the formation level C D, the area of the triangle A F C $= \frac{1}{2}(R + r)a^2$; and of the triangle B F D $= \frac{1}{2}(R - r)A^2$.

Similarly, if another section be taken at a distance 66 feet along the railway, and b, B, be the corresponding heights, the areas of the two triangles similar and similarly situated to A F C, B F D, respectively, are $\frac{1}{2}(R + r)b^2$; and $\frac{1}{2}(R - r)B^2$.

The solid content (in cubic yards) of the solid terminating in A F C $= (R + r)\,\frac{11}{27}\,(A^2 + AB + B^2)$.

The larger of the accompanying tables gives values, or $\frac{11}{27}(a^2 + ab + b^2)$, for every half foot of the two heights, up to 50 and 60 feet, respectively. The smaller table gives values of $\frac{11}{9}a \times$ by various widths of the formation level.

METHODS OF USING THE TABLES.

For Level-lying Ground.—Multiply the tabular number in the larger table corresponding to the heights of two successive sections a chain apart, by twice the slope, and add the number from the smaller table, corresponding to each height separately. The result is the number of cubic yards required. For instance, let the heights be 29½ feet and 45 feet; the base, 30 feet; and the slope 2 (to one). In the larger table, the number corresponding to {29½, 45} is 1710. This, multiplied by twice the slope = 6840. Add, from the column for base 30 in the second table, the number for 29½ (which is 1082); and also the number for 45 (which is 1650): and the total (9572) is the quantity of cubic yards required.

The following is an example of the quantities corresponding to four sections, a chain apart, the corresponding heights being 16, 20½, 30, and 44½, respectively: the base, 33 feet: the slope, 2½ (to one—consequently, all the first tabular numbers are to be multiplied by twice 2½ (or 5).

Heights.	1st Tab. Nos.	Multiplied by twice Slope.	2nd Tab. Nos. to Base 33.	Sum.
16 20½	398	1990	645 827	3462
20½ 30	788	3940	827 1210	5977
30 44½	1717	8585	1210 1794	11589
			Answer	21028

When the sections are at greater or less distances than one chain apart, quantities between each two sections must be multiplied by the corresponding distances. For instance, suppose in the above example the sections had been 1½, 2, and 3 chains apart: repeating the *sums* in the last column of the above scheme, we have

Sums.		Distances.		Products.
3462	×	1½	=	5193
5977	×	2	=	11954
11589	×	3	=	34767
				51914 *Ans. required.*

For Sidelong Ground.—Here the larger table alone is used. There are two sets of heights, those on the right-hand side of the railway, Bf; and those on the left-hand side, Ae (fig. 2). *These sets are to be kept quite distinct.* Multiply the tabular numbers corresponding to the greater heights by the *difference* between the natural and artificial slopes, and the tabular numbers corresponding to the less heights by the *sum* of artificial and natural slopes: the difference between these products is the result required.

For instance, let the natural slope be 6½ (to one), and the artificial slope 1½ (to one): the sum of the slopes is 8, the difference 5. Also, let the heights be: 1st section, 20½, 10; 2nd section, 52, 30. The two major heights, 20½, 52, are taken together; and the two minor heights, 10 and 30, are taken together. The number in the table for the first pair is 1707; which, multiplied by 5, gives 8535. The height for the second pair is 529; which, multiplied by 8, gives 4232. The difference of the two products, or 4303, is the answer required.

Where the slopes remain unchanged for several successive sections, the sums of each set of the tabular numbers may be multiplied by the slopes, instead of multiplying each tabular number separately. For instance, let the natural slope be 3 (to one); the artificial slope, 1 (to one). Also, let the heights be, first section, 35, 10; second section, 56, 20½; third section, 39, 12; fourth section, 45, 15. The calculation is as follows:—

Greater Heights.	Tab. Nos.	Less Heights.	Tab. Nos.
35, 56	2575	10, 20½	295
56, 39	2787	20½, 12	330
39, 45	2159	12, 15	223
Total	7521	Total	848
Mult. by diff. of slopes	2	Mult. by sum of slopes	4
	15042		3392
Subtract	3392		
	11,650 *Answer.*		

If the sections were at unequal distances apart—say 2, 1⅓, 3 chains—each tabular number would have to be multiplied by the corresponding distance. The above example would then be modified as follows:—

Tab. Nos.		Distance.		Product.	Tab. Nos.		Distance.		Product.
2575	×	2	=	5150	295	×	2	=	590
2787	×	1⅓	=	3716	330	×	1⅓	=	440
2159	×	3	=	6477	223	×	3	=	669
			Total	15343				Total	1699
				2					4
				30686					6796
			Subtract	6796					
				23890 *Answer.*					

To extend the large table where either height exceeds 60, take four times the tabular number for half the given heights. For instance, the tabular number for {100, 20} is four times that for {50, 10}.

To extend the small table, where either height exceeds 55, add the tabular numbers for any two heights which together make up the given height. For instance, the tabular number for 60 is the sum of the tabular numbers for 50 and 10, or of those for 55 and 5, &c.

To find the tabular number in the greater table. Look for *either* height in the horizontal row of index figures, and for the other height in the vertical row of indices. The tabular number required is beneath the one index and opposite the other. *In the small table* used for level-lying ground, only one index figure is used: the tabular number required is opposite it in the column designated by the given width of the formation level. For other widths than those given in the table, multiply the number to "base 1 foot" by the given width.—*Example:* The number for height 27 to base 22 is 22 × 33.

Measurement of slopes.—The slopes on railways are measured by the horizontal distance corresponding to one foot vertical rise. If, for instance, the rise of one foot correspond to a horizontal distance of 2½ feet, the slope is 2½ (to one). The same mode of measurement is adopted here for the natural inclination of the ground as for the artificial inclination of the sides of the embankment or cutting.

Change of the natural slope may occur in sidelong ground where the surface is very irregular. The sections ought to be taken so near that the difference of slopes at two successive sections may not be considerable. Now, by using exclusively the greater of these natural slopes with the actual heights, the result would be too large: by using the smaller of them, too small. But as the results obtained in these two ways will not in general widely differ, the truth may be taken as a *mean* between them.

The difficulty arising from change of natural slope may however, in general be avoided. For the upper surface of the ground being undulating and irregular, the natural inclination is represented by *equalising lines* drawn so that the small curvilinear areas in excess and defect may balance each other. These equalising lines being in some degree arbitrary in position, may in general be drawn at the same inclination for several sections together.

*** These tables, and the method of using them, are original and copyright. They are published separately by Weale, Holborn.

	base 26ft.	base 27ft.	base 28ft.	base 29ft.	base 30ft.	base 31ft.	base 32ft.	base 33ft.	base 34ft.	base 1 ft.
1	32	83	34	35	87	38	39	40	41	1·22
½	48	49	51	53	55	56	58	60	62	1·83
2	64	66	68	70	73	75	78	80	82	2·44
½	80	82	85	88	92	94	97	100	103	3·05
3	96	99	103	106	110	113	117	121	124	3·66
½	112	115	120	124	128	132	137	141	145	4·27
4	128	132	137	142	146	151	157	161	166	4·88
½	148	148	154	159	165	170	176	182	187	5·50
5	159	165	171	177	183	189	196	202	208	6·11
½	175	181	188	195	202	208	215	222	229	6·72
6	191	198	205	212	220	227	234	242	249	7·33
½	207	214	222	230	238	246	254	262	270	7·94
7	223	231	239	249	257	265	274	282	291	8·55
½	239	247	256	265	275	284	293	303	312	9·16
8	255	264	274	283	293	303	313	323	333	9·77
½	270	280	291	301	311	322	332	343	353	10·38
9	286	297	308	319	330	341	352	363	374	11·00
½	302	318	325	336	348	360	371	383	394	11·61
10	318	330	342	354	367	379	391	403	415	12·22
½	334	346	359	372	385	398	410	424	436	12·83
11	350	363	376	389	403	417	430	444	457	13·44
½	366	379	393	407	422	436	450	464	478	14·05
12	382	396	411	425	440	455	469	484	499	14·66
½	398	412	428	443	458	474	488	504	519	15·27
13	414	429	445	461	476	493	508	524	540	15·88
½	429	445	462	478	495	512	528	545	561	16·50
14	445	462	479	496	513	531	547	565	582	17·11
½	461	478	496	514	532	550	567	585	603	17·72
15	477	495	513	531	550	568	586	605	623	18·33
½	493	511	530	549	568	587	606	625	644	18·94
16	509	528	548	567	587	606	626	645	665	19·55
½	525	544	565	585	605	625	645	666	686	20·16
17	541	561	582	603	623	644	665	686	707	20·77
½	557	577	599	620	641	663	684	706	727	21·38
18	572	594	616	638	660	682	704	726	748	22·00
½	588	610	633	656	678	701	723	746	769	22·61
19	604	627	650	673	697	720	743	766	790	23·22
½	620	643	667	691	715	739	763	787	811	23·83
20	636	660	684	708	733	758	782	807	831	24·44
½	652	676	701	726	752	777	802	827	852	25·05
21	668	693	719	744	770	796	822	847	873	25·66
½	684	709	735	762	788	815	841	867	893	26·27
22	700	726	753	780	806	834	861	887	914	26·88
½	715	742	770	797	825	852	880	908	935	27·50
23	731	759	787	815	843	871	899	928	956	28·11
½	747	775	804	833	862	890	919	948	977	28·72
24	763	792	821	850	880	909	938	968	997	29·33
½	778	808	838	868	898	928	958	988	1118	29·94
25	794	825	856	886	917	947	978	1008	1039	30·55
½	810	841	873	904	935	966	997	1029	1060	31·16
26	826	858	890	922	953	985	1017	1049	1081	31·77
½	842	874	907	940	97:	1004	1037	1069	1102	32·38
27	858	891	924	957	990	1023	1056	1089	1122	33·00
½	874	908	942	975	1008	1042	1076	1109	1143	33·61
28	890	924	959	992	1027	1061	1095	1129	1164	34·22
½	906	941	976	1010	1045	1080	1114	1149	1184	34·83
29	922	957	993	1028	1063	1099	1134	1170	1205	35·44
½	938	974	1010	1046	1082	1118	1154	1190	1226	36·05
30	954	990	1027	1063	1100	1137	1173	1210	1246	36·66
½	970	1007	1044	1081	1118	1156	1193	1230	1267	37·27
31	985	1022	1061	1098	1136	1175	1212	1250	1288	37·88
½	1001	1040	1078	1116	1155	1194	1232	1271	1309	38·50
32	1017	1056	1095	1134	1173	1213	1252	1291	1330	39·11
½	1033	1073	1113	1152	1192	1232	1272	1311	1351	39·72
33	1049	1089	1130	1169	1210	1250	1291	1331	1371	40·33
½	1065	1106	1147	1187	1228	1269	1310	1351	1392	40·94
34	1081	1122	1164	1205	1247	1288	1330	1371	1413	41·55
½	1097	1139	1181	1223	1265	1307	1349	1391	1433	42·16
35	1113	1155	1198	1240	1283	1326	1368	1411	1454	42·77
½	1129	1172	1215	1258	1301	1345	1388	1431	1475	43·38
36	1144	1188	1232	1276	1320	1364	1408	1452	1496	44·00
½	1160	1205	1249	1294	1338	1383	1427	1472	1516	44·61
37	1176	1221	1266	1312	1357	1402	1447	1492	1537	45·22
½	1192	1238	1283	1330	1375	1421	1467	1513	1558	45·83
38	1208	1254	1300	1347	1393	1440	1486	1533	1579	46·44
½	1224	1271	1318	1365	1412	1459	1506	1553	1600	47·05
39	1240	1287	1335	1382	1430	1478	1525	1573	1620	47·66
½	1256	1304	1352	1400	1448	1497	1545	1593	1641	48·27
40	1271	1320	1369	1418	1467	1516	1565	1614	1662	48·88
½	1287	1337	1386	1436	1485	1535	1584	1634	1683	49·50
41	1303	1353	1403	1453	1503	1553	1604	1654	1704	50·11
½	1319	1370	1420	1471	1522	1572	1623	1674	1725	50·72
42	1335	1386	1437	1489	1540	1591	1642	1694	1745	51·33
½	1351	1403	1455	1507	1558	1610	1662	1714	1766	51·94
43	1367	1419	1472	1524	1577	1629	1682	1734	1786	52·55
½	1383	1436	1489	1542	1595	1648	1701	1754	1807	53·16
44	1399	1452	1506	1559	1613	1667	1720	1774	1828	53·77
½	1415	1469	1523	1577	1631	1686	1740	1794	1849	54·38
45	1430	1485	1540	1595	1650	1705	1760	1815	1870	55·00
½	1446	1502	1557	1613	1668	1724	1779	1835	1890	55·61
46	1462	1518	1574	1631	1687	1743	1799	1855	1911	56·22
½	1478	1535	1591	1649	1705	1762	1818	1875	1932	56·83
47	1494	1551	1608	1666	1723	1781	1838	1895	1953	57·44
½	1510	1568	1626	1684	1742	1800	1858	1916	1974	58·05
48	1526	1584	1643	1702	1760	1819	1878	1936	1995	58·66
½	1542	1601	1660	1719	1778	1838	1897	1956	2015	59·27
49	1557	1617	1677	1737	1796	1857	1916	1976	2036	59·88
½	1573	1634	1694	1755	1815	1876	1936	1997	2057	60·50
50	1589	1650	1711	1773	1833	1894	1955	2017	2078	61·11
½	1605	1667	1728	1791	1852	1913	1975	2037	2099	61·72
51	1621	1683	1745	1809	1870	1932	1994	2057	2119	62·33
½	1637	1700	1763	1826	1888	1951	2014	2077	2140	62·94
52	1653	1716	1780	1843	1907	1970	2033	2097	2160	63·55
½	1669	1733	1797	1861	1925	1989	2053	2117	2181	64·16
53	1684	1749	1814	1879	1943	2008	2073	2138	2202	64·77
½	1700	1766	1831	1896	1961	2027	2092	2158	2223	65·38
54	1716	1782	1848	1914	1980	2046	2112	2178	2244	66·00
½	1732	1799	1865	1942	1998	2065	2132	2198	2265	66·61
55	1748	1815	1882	1960	2016	2084	2152	2218	2285	67·22

	0	½	1	½	2	½	3	½	4	½	5	½	6	½	7	½	8	½	9	½	10	½	11	½	12	½	13	½	14	½	15
1	·3	·7	1	2	3	4	5	6	8	10	12	14	16	19	23	26	29	33	37	41	45	49	54	58	64	69	74	80	86	92	98
½	·9	1	2	3	4	5	6	7	9	11	14	16	19	22	25	28	31	35	39	43	47	52	57	62	67	72	77	84	89	96	102
2	1	2	3	4	5	6	7	9	11	13	16	18	21	24	27	30	34	38	42	46	50	55	60	65	70	75	81	87	93	99	106
½	2	3	4	5	6	7	9	11	13	15	18	20	23	26	29	32	36	40	44	48	53	58	63	68	73	78	84	90	96	102	109
3	3	4	5	6	7	9	11	13	15	17	20	22	25	28	32	35	39	43	47	51	56	61	66	71	77	82	88	94	100	106	113
½	4	5	6	7	9	11	13	15	17	19	22	25	28	31	35	38	42	46	50	54	59	64	69	74	80	86	92	98	104	110	117
4	6	7	8	9	11	13	15	17	19	22	25	28	31	34	38	41	45	49	54	58	63	68	73	78	84	90	96	102	109	115	122
½	8	9	10	11	13	15	17	19	22	25	27	30	34	37	41	44	48	52	57	62	67	72	77	82	88	94	101	107	113	120	127
5	10	11	12	14	16	18	20	22	25	27	30	33	37	40	44	48	52	56	61	66	71	76	82	87	93	99	106	112	118	125	132
½	12	13	14	16	18	20	22	25	28	30	33	36	40	43	47	51	56	60	65	70	75	80	86	91	97	103	110	116	123	129	137
6	14	15	16	19	21	23	25	28	31	34	37	40	44	44	51	55	60	64	69	74	80	85	91	96	102	107	115	121	128	134	143
½	17	18	19	22	24	26	28	31	34	37	40	43	47	50	55	59	64	69	73	78	84	89	95	101	108	113	120	126	133	140	148
7	20	21	23	25	27	29	32	35	38	41	44	47	51	55	60	64	69	73	78	83	89	94	100	106	113	119	126	132	139	146	154
½	23	24	26	28	30	32	35	38	41	44	48	51	55	59	64	69	73	78	83	88	94	99	105	111	118	124	131	138	145	152	160
8	26	28	29	31	34	36	39	42	45	48	52	56	60	64	69	73	78	83	88	93	99	105	111	117	124	130	137	144	151	158	166
½	29	31	33	35	38	40	43	46	49	52	56	60	64	69	73	78	83	88	93	99	104	110	116	123	130	136	143	150	157	164	172
9	32	34	37	39	42	44	47	50	54	57	61	65	69	73	78	83	88	93	99	104	110	116	122	129	136	142	149	156	164	171	179
½	36	38	41	43	46	48	51	54	58	62	66	70	74	78	83	88	93	99	104	110	116	122	128	135	142	148	155	162	170	178	186
10	40	42	45	47	50	53	56	59	63	67	71	75	80	84	89	94	99	104	110	116	122	128	135	141	148	155	162	169	177	184	193
½	44	46	49	52	55	58	61	64	68	72	76	80	85	89	94	99	105	110	116	122	128	135	141	147	154	161	169	176	184	192	200
11	49	51	54	57	60	63	66	69	73	77	82	86	91	95	100	106	111	116	122	128	135	141	148	154	161	168	176	184	192	200	208
½	54	56	58	62	65	68	71	74	78	82	87	91	96	101	106	111	117	123	129	135	141	147	154	161	168	176	183	191	199	207	215
12	58	61	64	67	70	73	77	80	84	88	93	97	102	107	113	118	124	130	136	142	148	154	161	168	176	183	191	199	207	215	223
½	63	66	69	72	75	78	82	86	90	94	99	103	108	113	119	124	130	136	142	148	155	161	168	176	183	190	198	206	215	223	231
13	69	71	74	77	81	84	88	92	96	101	106	110	115	120	126	131	137	143	149	155	162	169	176	183	191	198	206	214	223	231	240
½	74	77	80	83	87	90	94	98	102	107	112	116	121	126	132	138	144	150	156	162	169	176	184	191	199	206	214	223	231	240	248
14	80	83	86	89	93	96	100	104	108	113	118	123	128	133	139	145	151	157	164	170	177	184	192	199	207	215	223	231	239	248	257
½	86	89	92	96	99	102	106	110	115	120	125	129	134	140	146	152	158	164	171	178	184	192	200	207	215	223	231	240	248	257	266
15	91	95	98	102	106	109	113	117	122	127	132	137	143	148	154	160	166	172	179	186	193	200	208	215	223	231	240	248	257	266	275
½	98	111	104	109	112	116	120	124	129	134	139	144	150	156	162	168	174	180	187	194	201	209	216	224	232	240	249	257	266	275	284
16	104	107	111	115	119	123	127	132	137	142	147	152	158	164	170	176	182	189	196	203	210	217	225	233	241	249	258	266	275	284	293
½	110	114	118	122	126	130	134	139	144	149	154	160	166	172	178	184	190	197	204	211	218	226	234	242	250	258	267	275	284	293	303
17	117	121	125	129	133	137	142	147	152	157	162	168	174	180	186	192	199	206	213	220	227	235	243	251	259	267	276	285	294	303	313
½	124	128	132	136	140	144	149	154	160	165	170	176	182	188	194	200	207	214	222	229	236	244	252	260	268	277	286	295	304	313	323
18	132	135	139	143	148	152	157	162	168	173	179	184	190	196	203	209	216	223	231	238	246	254	262	270	278	287	296	305	314	323	333
½	139	143	147	151	156	160	165	170	176	181	187	193	199	205	212	218	225	232	240	247	255	263	271	279	288	297	306	315	324	334	344
19	147	151	155	159	164	169	174	179	184	190	196	202	208	214	221	228	235	242	249	257	265	273	281	289	298	307	316	325	335	345	355
½	155	158	163	167	172	177	182	187	193	199	205	211	217	223	230	237	244	251	259	267	275	283	291	299	309	317	326	336	346	356	366
20	163	167	171	176	181	186	191	196	202	208	214	220	226	233	240	247	254	261	269	277	285	293	302	310	319	328	337	347	357	367	377
½	171	175	179	184	189	194	200	205	211	217	223	229	235	242	249	256	264	271	279	287	295	303	312	321	330	339	348	358	368	378	388
21	179	183	188	193	198	203	209	214	220	226	232	238	245	252	259	266	274	281	289	297	306	314	323	332	341	350	359	369	379	389	399
½	188	192	197	202	207	212	218	223	229	235	242	248	255	262	269	276	284	292	300	308	316	325	334	343	352	361	371	381	391	401	411
22	197	201	206	211	216	221	227	233	239	245	252	258	265	272	280	287	295	303	311	319	327	336	345	354	363	372	382	392	402	412	423
½	206	210	215	220	226	231	237	243	249	255	262	268	275	282	290	297	305	313	322	330	338	347	356	365	374	384	394	404	414	424	435
23	215	220	225	230	236	241	247	253	259	265	272	279	286	293	301	308	316	324	333	341	350	359	368	377	386	396	406	416	426	436	447
½	224	229	235	240	246	251	257	263	269	275	282	289	297	304	312	319	327	336	344	353	361	370	379	388	398	408	418	428	438	448	460
24	234	239	245	250	256	261	267	273	280	286	293	300	308	315	323	331	339	347	355	364	373	382	391	400	410	420	430	440	451	461	473
½	244	249	255	260	266	271	278	288	291	297	304	311	319	326	334	342	350	358	367	376	385	394	403	412	422	432	443	453	464	474	486
25	254	259	265	270	276	281	289	296	302	308	315	322	330	338	346	354	362	370	379	388	397	406	416	425	435	445	456	466	477	488	499
½	264	269	275	281	287	293	300	306	313	320	326	333	341	349	357	365	373	381	390	399	409	418	428	438	448	458	469	479	490	501	512
26	275	280	286	292	298	304	311	317	324	331	338	345	353	361	369	377	386	394	403	412	422	431	441	451	461	471	482	492	503	514	526
½	286	291	297	303	309	315	322	328	335	342	350	357	365	373	381	389	398	407	416	425	434	444	454	464	474	484	495	506	517	528	539
27	297	302	308	314	320	326	333	340	347	354	362	369	377	385	394	402	411	420	429	438	447	457	467	477	487	498	509	520	531	542	553
½	308	313	319	326	332	338	345	352	359	366	374	381	389	397	406	414	423	432	442	451	460	470	480	490	501	511	522	533	545	556	567
28	319	325	331	337	344	350	357	364	371	378	386	394	402	410	419	427	436	445	455	464	474	484	494	504	515	525	536	547	559	570	582
½	330	336	343	349	356	362	369	376	383	391	399	407	415	423	432	440	449	458	468	477	487	497	508	518	529	539	550	561	476	485	596
29	342	348	355	361	368	374	381	388	396	404	412	420	428	436	445	454	463	472	482	491	501	511	522	532	543	554	565	576	588	599	611
½	354	360	367	373	380	387	394	401	409	417	425	433	441	449	458	467	578	584	496	505	515	525	536	546	557	568	579	590	602	614	626
30	367	373	379	385	392	399	407	414	422	430	438	445	454	463	472	481	490	499	509	519	529	539	550	561	572	583	594	605	617	629	641
½	379	385	391	398	405	412	420	427	435	443	451	459	468	477	486	495	504	513	523	533	543	553	564	575	586	597	609	620	632	644	656
31	392	398	404	411	418	425	433	440	448	456	465	473	482	491	500	509	518	527	538	548	558	568	579	590	601	612	624	636	648	660	672
½	404	411	417	424	431	438	446	454	462	470	478	487	496	505	514	523	532	542	552	563	573	583	594	605	616	627	639	651	663	675	688
32	417	424	430	437	445	452	460	468	476	484	492	501	510	519	528	537	547	557	567	577	588	598	610	621	632	643	655	667	679	691	704
½	430	437	443	450	458	465	473	481	490	498	506	515	524	533	542	552	562	572	582	592	603	614	625	636	647	659	671	683	695	707	720
33	443	450	457	464	472	479	487	495	504	512	521	530	539	548	557	567	577	587	597	608	619	630	641	652	663	675	687	699	711	724	737
½	457	464	471	478	486	493	501	509	518	526	535	544	553	563	572	582	592	602	612	623	634	645	656	668	679	691	703	715	727	740	753
34	471	478	485	492	500	508	516	524	533	541	550	559	568	578	588	598	608	618	628	639	650	661	672	684	696	708	720	732	744	757	770
½	485	492	499	506	514	522	530	538	547	556	565	574	583	593	603	613	623	633	644	655	666	677	688	700	712	724	736	748	761	774	787
35	499	506	513	521	529	537	545	553	562	571	580	589	599	609	619	629	639	649	660	671	682	693	705	717	729	741	753	765	778	791	804
½	513	520	528	536	544	552	560	568	577	586	595	604	614	624	634	644	655	665	676	687	698	709	721	733	745	757	770	782	795	808	821
36	528	535	543	551	559	567	575	584	593	602	611	620	630	640	650	660	671	682	693	704	715	726	738	750	762	774	787	800	813	826	839
½	542	550	558	566	574	582	590	599	608	617	627	636	646	656	666	676	687	698	709	720	732	743	755	767	779	791	804	817	830	843	857
37	557	565	573	581	589	597	606	615	624	633	643	653	663	673	683	693	704	715	726	737	749	761	773	785	797	809	822	835	848	861	875
½	572	580	588	596	605	613	622	631	640	649	659	669	679	689	699	710	721	732	743	754	766	778	790	802	814	827	840	853	866	879	893
38	588	596	604	613	621	629	638	647	656	666	676	686	696	706	716	727	738	749	760	772	784	796	808	820	832	845	858	871	885	898	912
½	603	611	620	628	637	645	654	663	672	682	692	702	712	723	733	744	755	766	777	789	801	813	825	838	850	863	876	889	903	916	930
39	619	627	636	644	653	662	671	680	689	699	709	719	729	740	751	762	773	784	795	807	819	831	843	856	869	872	895	908	927	935	949
½	635	643	652	660	669	678	687	696	706	716	726	736	746	757	768	779	790	801	813	825	837	849	861	874	887	900	913	926	941	954	968
40	652	660	668	677	686	695	704	713	723	733	743	753	764	775	786	797	808	819	831	843	855	867	880	893	906	919	932	946	965	974	988
½	668	676	685	694	703	712	721	730	740	750	760	770	781	792	803	814	826	837	849	861	873	877	899	912	925	938	951	964	979	993	1007
41	686	693	702	711	720	729	738	748	758	768	778	788	799	810	821	832	844	856	868	880	892	905	918	931	944	957	971	984	998	1012	1027
½	701	710	719	728	737	746	755	765	775	785	796	806	817	828	839	851	862	874	886	898	911	924	937	950	963	977	990	1004	1018	1032	1047
42	718	727	736	745	754	763	773	783	793	803	814	825	836	847	858	869	881	893	905	917	930	943	956	969	982	996	1010	1024	1038	1052	1067
½	735	744	753	762	772	781	790	801	811	821	832	843	854	865	877	888	900	911	924	936	949	952	975	988	1002	1016	1030	1044	1058	1072	1087
43	753	762	771	780	790	799	808	819	830	840	851	863	873	884	896	907	919	931	944	956	969	982	995	1008	1022	1036	1050	1064	1078	1092	1107
½	770	779	789	798	808	817	827	837	848	859	870	881	892	903	915	926	938	950	963	975	988	1001	1015	1028	1042	1056	1070	1084	1098	1113	1128
44	788	797	807	816	826	836	846	856	867	877	888	900	911	922	934	946	958	970	983	995	1008	1021	1035	1048	1062	1076	1090	1104	1119	1134	1149
½	806	815	825	834	844	854	864	875	886	896	907	919	930	941	953	965	977	990	1003	1015	1028	1041	1055	1068	1082	1096	1111	1125	1140	1155	1170
45	824	834	843	853	863	873	883	894	905	916	927	938	949	961	973	985	997	1010	1023	1036	1049	1062	1076	1089	1103	1117	1132	1146	1161	1176	1191
½	843	852	862	872	882	892	902	913	924	935	946	967	969	981	993	1005	1017	1030	1043	1056	1069	1082	1096	1109	1124	1138	1153	1168	1182	1197	1213
46	862	871	881	891	901	911	922	932	943	954	966	977	989	1001	1013	1025	1038	1050	1063	1076	1090	1103	1117	1131	1145	1159	1174	1189	1204	1219	1235
½	881	890	900	910	920	930	941	952	963	974	986	997	1009	1021	1033	1045	1058	1071	1084	1097	1111	1124	1138	1152	1166	1180	1195	1210	1226	1231	1257
47	900	909	919	929	940	959	961	972	983	994	1006	1017	1029	1041	1054	1066	1079	1092	1105	1118	1132	1146	1160	1174	1188	1202	1217	1232	1248	1263	1279
½	919	929	939	949	959	960	981	992	1003	1014	1025	1037	1049	1061	1074	1087	1100	1113	1126	1139	1153	1167	1181	1195	1210	1224	1239	1254	1270	1285	1301
48	938	948	958	969	979	980	1001	1012	1023	1034	1046	1058	1070	1082	1095	1108	1121	1134	1147	1161	1175	1189	1203	1217	1232	1246	1261	1276	1292	1307	1323
½	958	968	978	988	999	1010	1021	1032	1043	1045	1067	1079	1091	1103	1116	1129	1142	1155	1169	1182	1196	1210	1225	1239	1254	1269	1283	1298	1314	1330	1346
49	978	988	998	1008	1019	1030	1041	1052	1064	1076	1088	1100	1112	1125	1138	1141	1164	1177	1191	1204	1218	1232	1247	1261	1276	1291	1306	1321	1337	1353	1369
½	998	1008	1018	1029	1040	1050	1062	1073	1085	1097	1109	1121	1133	1146	1159	1172	1185	1199	1213	1226	1239	1254	1269	1283	1298	1313	1329	1344	1360	1376	1392
50	1018	1029	1039	1050	1061	1072	1083	1094	1106	1118	1130	1142	1155	1168	1181	1194	1207	1221	1235	1249	1263	1277	1292	1306	1321	1336	1352	1367	1383	1399	1415

	½	16	½	17	½	18	½	19	½	20	½	21	½	22	½	23	½	24	½	25	½	26	½	27	½	28	½	29	½	30
1	104	111	117	125	132	139	146	155	162	171	179	188	197	206	215	225	235	245	255	265	275	286	297	308	319	331	343	355	367	[illegible]
½	108	115	122	129	136	143	151	159	167	176	184	193	202	211	220	230	240	250	260	270	281	292	303	314	325	337	349	361	373	[illegible]
2	112	119	126	133	140	148	156	164	172	181	189	198	207	216	226	236	246	256	266	276	287	298	309	320	332	344	356	368	380	[illegible]
½	116	123	130	137	144	152	160	169	177	186	194	203	212	221	231	241	251	261	271	281	293	304	315	326	338	350	362	374	387	[illegible]
3	120	127	134	142	149	157	165	174	182	191	200	209	218	227	237	247	257	267	278	289	300	311	322	333	345	357	369	381	394	407
½	124	132	139	147	154	162	171	179	187	196	205	214	223	233	243	253	263	273	284	296	306	317	328	340	352	364	376	388	401	414
4	129	137	144	152	160	168	176	184	193	202	211	220	229	239	249	259	269	280	291	302	313	324	335	347	359	371	383	396	409	422
½	134	142	149	157	165	173	181	190	199	208	217	226	235	245	255	265	275	286	297	308	320	331	342	354	366	378	391	404	417	430
5	139	147	154	162	170	179	187	196	205	214	223	232	242	252	262	272	282	293	304	315	326	338	350	362	374	386	399	412	425	[illegible]
½	144	152	160	168	176	184	193	202	211	220	229	238	248	258	268	279	289	300	311	322	333	345	357	369	381	394	407	420	433	446
6	150	158	166	174	182	190	199	208	217	226	235	245	255	265	275	286	297	308	319	330	341	353	365	377	389	402	415	428	441	454
½	156	164	172	180	188	196	205	214	223	233	242	252	262	272	282	293	304	315	326	338	349	361	373	385	397	410	423	436	449	463
7	162	170	178	186	194	203	212	221	230	240	249	259	269	279	290	301	312	323	334	346	357	369	381	394	406	419	432	444	458	472
½	168	176	184	192	200	209	218	228	237	247	256	266	276	287	297	308	319	331	342	354	365	377	389	402	414	427	440	454	467	481
8	174	183	190	199	207	216	225	235	244	254	264	274	284	295	305	316	327	339	350	362	373	385	398	411	423	436	449	463	476	490
½	180	189	197	206	214	223	232	242	251	261	271	281	292	303	313	324	336	347	358	370	381	394	407	420	432	445	458	472	485	499
9	187	196	204	213	222	231	240	249	259	269	279	289	300	311	322	333	344	355	367	379	390	403	416	429	442	454	468	482	495	509
½	194	203	211	220	229	238	247	257	267	277	287	297	308	319	330	341	353	364	376	388	399	412	425	438	451	464	477	491	505	519
10	201	210	218	227	236	246	255	265	275	285	295	306	316	327	338	350	361	373	385	397	409	422	434	447	460	474	487	501	515	529
½	209	217	226	235	244	254	263	273	283	293	303	314	325	336	347	359	370	382	394	406	418	431	444	457	470	484	497	511	525	539
11	216	225	234	243	252	262	271	281	291	302	312	323	334	345	356	368	379	391	403	416	428	441	454	467	480	494	508	522	536	550
½	224	233	242	251	260	270	279	289	299	310	321	332	343	354	365	377	388	400	412	425	438	451	464	477	490	504	518	532	546	561
12	232	241	250	259	268	278	288	298	308	319	330	341	352	363	374	386	398	410	422	435	448	461	474	487	501	515	529	543	557	572
½	240	249	258	267	277	287	297	307	317	328	339	350	361	372	384	396	408	420	432	445	458	471	484	498	511	525	539	554	568	583
13	249	258	267	276	286	296	306	316	326	337	348	359	371	382	394	406	418	430	443	456	469	482	495	509	522	536	550	565	579	594
½	257	266	275	285	295	305	315	325	336	347	358	369	381	392	404	416	428	440	453	466	479	492	506	520	533	547	561	576	590	605
14	266	275	284	294	304	314	324	335	346	357	368	379	391	402	414	426	438	451	464	477	490	503	517	531	545	559	573	588	602	617
½	275	284	293	303	313	323	334	345	356	367	378	389	401	412	424	436	449	462	475	488	501	514	528	542	556	570	584	599	614	629
15	284	293	303	313	323	333	344	355	366	377	388	400	411	423	435	447	460	473	486	499	512	526	539	553	567	582	596	611	626	641
½	293	303	313	323	333	343	354	365	376	387	398	410	422	434	446	458	471	484	497	510	523	537	551	565	579	594	608	623	638	654
16	303	313	323	333	343	353	364	375	386	397	409	421	433	445	457	469	482	495	508	521	535	549	563	577	591	606	621	636	651	666
½	313	323	333	343	353	363	374	385	396	408	420	432	444	456	468	480	493	506	519	533	547	561	575	589	603	618	633	648	663	679
17	323	333	343	353	363	374	385	396	407	419	431	443	455	467	479	492	505	518	531	545	559	573	587	601	616	631	646	661	676	692
½	333	343	353	363	374	385	396	407	418	430	442	454	466	478	491	504	517	530	543	557	571	585	599	614	629	643	658	674	689	705
18	343	353	363	374	385	396	407	418	429	441	453	465	477	490	503	516	529	542	556	570	583	598	612	627	641	656	671	687	702	718
½	354	364	374	385	396	407	418	429	441	453	465	477	489	502	515	528	541	554	568	582	596	610	625	640	654	669	685	700	716	732
19	365	375	385	396	407	418	429	441	453	465	477	489	501	514	527	540	553	567	581	595	609	623	638	653	668	683	698	714	730	746
½	376	386	396	407	418	429	441	453	465	477	489	501	513	526	539	553	566	580	594	608	621	636	651	666	681	696	712	728	744	760
20	387	397	408	419	430	441	453	465	477	489	501	513	526	539	552	566	579	593	607	621	635	650	665	680	695	710	726	742	758	774
½	398	409	420	431	442	453	465	477	489	501	513	526	539	552	565	579	592	606	620	635	648	663	678	693	708	724	740	756	772	788
21	410	421	432	443	454	465	477	489	501	513	526	539	553	565	578	592	605	619	634	649	662	677	692	707	722	738	754	770	786	802
½	422	433	444	455	466	477	489	501	513	526	539	552	565	578	591	605	619	633	648	662	676	691	706	721	736	752	768	784	800	817
22	434	445	456	467	478	490	502	514	526	539	552	565	578	591	605	619	633	647	661	676	690	705	720	736	751	767	783	799	815	832
½	446	457	468	479	491	503	515	527	539	552	565	578	591	605	618	632	647	661	675	690	704	719	734	750	766	782	798	814	830	847
23	458	469	480	492	504	516	528	540	553	566	579	592	605	619	632	646	661	675	689	704	719	734	749	765	781	797	813	830	846	863
½	471	482	493	505	517	529	541	553	566	579	592	605	619	633	646	661	675	689	704	719	734	749	764	780	796	812	828	845	861	878
24	484	495	506	518	530	542	554	567	580	593	606	619	633	647	661	675	689	704	718	733	749	764	779	795	811	828	844	861	877	894
½	497	508	519	531	543	556	568	581	594	607	620	634	648	661	675	689	704	718	733	748	764	779	794	810	826	843	859	876	893	910
25	510	521	533	545	557	570	582	595	608	621	634	648	662	676	690	704	719	733	748	764	779	795	810	826	842	859	875	892	909	927
½	523	535	547	559	571	584	596	609	622	635	648	662	676	690	704	719	734	749	764	779	795	810	826	842	858	875	891	908	926	943
26	537	549	561	573	585	598	610	623	636	650	663	677	691	705	719	734	749	764	779	795	810	826	842	858	874	891	908	925	942	960
½	551	563	575	587	599	612	625	638	651	665	678	692	706	720	734	749	764	779	795	810	826	842	858	874	890	907	924	941	959	976
27	565	577	589	601	614	627	640	653	666	680	693	707	721	736	750	765	780	795	811	826	842	858	874	891	907	924	941	958	976	993
½	579	591	603	616	629	641	654	668	681	695	708	722	736	751	766	781	796	811	826	842	858	874	890	907	924	941	958	975	993	1010
28	594	606	618	631	643	656	669	683	696	710	724	738	752	767	782	797	812	828	843	859	875	891	907	924	941	958	975	993	1010	1028
½	608	621	633	646	658	671	685	698	712	726	740	754	768	783	798	813	828	844	859	875	891	908	924	941	958	975	992	1010	1028	1045
29	623	636	648	661	674	687	700	714	728	742	756	770	784	799	814	830	845	861	876	892	908	925	941	958	975	993	1010	1028	1045	1063
½	638	651	663	676	689	702	716	730	744	758	772	786	800	815	830	846	861	877	893	909	926	942	959	976	993	1010	1028	1045	1063	1081
30	654	666	679	692	705	718	732	746	760	774	788	802	817	832	847	863	878	894	910	927	943	960	976	993	1010	1028	1045	1063	1081	1100
½	669	682	695	708	721	734	748	762	776	790	804	819	834	849	864	880	895	911	927	944	961	977	994	1011	1028	1046	1063	1081	1100	1118
31	685	698	711	724	737	751	764	778	792	807	821	836	851	866	881	897	913	929	945	962	978	995	1012	1029	1046	1064	1082	1100	1118	1137
½	701	714	727	740	753	767	781	795	809	824	838	853	868	883	898	914	930	946	963	980	1000	1013	1030	1047	1064	1082	1100	1119	1137	1156
32	717	730	743	756	770	784	798	812	826	841	855	870	885	901	916	932	948	964	981	998	1014	1031	1048	1066	1083	1101	1119	1138	1156	1175
½	733	746	759	773	786	800	814	829	843	858	872	887	902	918	934	950	966	982	999	1016	1032	1049	1066	1084	1102	1120	1138	1157	1175	1194
33	750	763	776	790	803	817	831	846	860	875	890	905	920	936	952	968	984	1001	1017	1034	1051	1068	1085	1103	1121	1139	1157	1176	1194	1213
½	766	780	793	807	820	834	848	863	878	893	908	923	938	954	970	986	1002	1019	1036	1053	1070	1087	1104	1122	1140	1158	1176	1195	1214	1233
34	783	797	810	824	838	852	866	881	896	911	926	941	957	973	989	1005	1021	1038	1055	1072	1089	1106	1124	1142	1160	1178	1196	1215	1234	1253
½	800	814	827	841	855	869	884	899	914	929	944	959	975	991	1007	1023	1040	1057	1074	1091	1108	1125	1143	1161	1179	1197	1216	1235	1254	1273
35	817	831	845	859	873	887	902	917	932	947	962	978	994	1010	1026	1042	1059	1076	1093	1110	1127	1145	1163	1181	1199	1217	1236	1255	1274	1293
½	835	849	863	877	891	905	920	935	950	965	980	996	1012	1029	1045	1061	1078	1095	1112	1129	1147	1164	1182	1201	1219	1237	1256	1275	1294	1313
36	853	867	881	895	909	924	939	954	969	984	999	1015	1031	1048	1064	1081	1097	1114	1131	1149	1166	1184	1202	1221	1239	1258	1277	1296	1315	1334
½	871	885	899	913	927	942	957	972	987	1003	1018	1034	1050	1067	1083	1100	1117	1134	1151	1169	1186	1204	1222	1241	1260	1278	1297	1316	1335	1355
37	889	903	917	931	946	961	976	991	1006	1022	1038	1054	1070	1086	1103	1120	1137	1154	1171	1189	1206	1225	1243	1261	1280	1299	1318	1337	1356	1376
½	907	921	935	950	965	980	995	1010	1025	1041	1057	1073	1089	1106	1123	1140	1157	1174	1191	1209	1227	1245	1263	1282	1301	1320	1339	1358	1377	1397
38	926	940	954	969	984	999	1014	1029	1045	1061	1077	1093	1109	1126	1143	1160	1177	1194	1212	1230	1247	1266	1284	1303	1322	1341	1360	1380	1399	1419
½	944	959	973	988	1003	1018	1033	1048	1064	1080	1096	1113	1129	1146	1163	1180	1197	1214	1232	1250	1268	1287	1305	1324	1343	1362	1381	1401	1421	1441
39	963	978	992	1007	1022	1037	1052	1068	1084	1100	1116	1133	1149	1166	1183	1200	1217	1235	1253	1271	1289	1308	1326	1345	1364	1384	1403	1423	1443	1463
½	982	997	1011	1026	1041	1057	1072	1088	1104	1120	1136	1153	1169	1186	1203	1221	1238	1256	1274	1292	1311	1329	1347	1366	1385	1405	1425	1445	1465	1485
40	1002	1016	1031	1046	1061	1077	1092	1108	1124	1140	1156	1173	1190	1207	1224	1242	1259	1277	1295	1314	1332	1351	1369	1388	1407	1427	1447	1467	1487	1507
½	1021	1036	1051	1066	1081	1097	1112	1128	1144	1161	1177	1194	1211	1228	1245	1263	1280	1298	1316	1335	1354	1372	1391	1410	1429	1449	1469	1489	1509	1529
41	1041	1056	1071	1086	1101	1117	1133	1149	1165	1182	1198	1215	1232	1249	1266	1284	1302	1320	1338	1357	1375	1394	1413	1432	1452	1472	1492	1512	1532	1552
½	1061	1076	1091	1106	1121	1137	1153	1170	1186	1203	1219	1236	1253	1270	1287	1305	1323	1342	1360	1379	1397	1416	1435	1455	1474	1494	1514	1534	1554	1575
42	1081	1096	1111	1127	1142	1158	1174	1191	1207	1224	1240	1257	1274	1292	1309	1327	1345	1364	1382	1401	1419	1439	1458	1477	1497	1517	1537	1557	1577	1598
½	1102	1117	1132	1148	1163	1179	1195	1212	1228	1245	1262	1279	1296	1314	1331	1349	1367	1386	1404	1423	1442	1461	1480	1500	1520	1540	1560	1580	1600	1621
43	1122	1138	1153	1169	1184	1200	1216	1233	1249	1266	1283	1301	1318	1336	1353	1371	1389	1408	1427	1446	1464	1484	1503	1523	1543	1563	1583	1603	1624	1645
½	1143	1159	1174	1190	1205	1221	1237	1254	1271	1288	1305	1323	1340	1358	1375	1393	1411	1430	1449	1468	1487	1507	1526	1546	1566	1586	1606	1627	1648	1669
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½	1228	1244	1260	1276	1292	1309	1325	1342	1359	1377	1394	1412	1430	1448	1466	1485	1503	1522	1541	1561	1581	1600	1620	1641	1661	1681	1702	1723	1744	1766
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½	1408	1425	1441	1458	1475	1493	1510	1528	1546	1564	1582	1601	1620	1639	1658	1677	1697	1717	1737	1757	1777	1797	1818	1839	1860	1882	1903	1925	1947	1969
50	1431	1448	1465	1482	1499	1517	1534	1552	1570	1589	1607	1626	1645	1664	1683	1702	1722	1742	1762	1782	1802	1823	1844	1865	1886	1908	1930	1952	1974	1996

	½	31	½	32	½	33	½	34	½	35	½	36	½	37	½	38	½	39	½	40	½	41	½	42	½	43	½	44	½	45
1	391	404	417	430	443	457	471	485	499	513	528	543	558	573	588	604	620	636	652	668	685	702	719	736	753	771	789	807	825	843
½	398	411	424	437	450	464	478	492	506	521	536	551	566	581	596	613	628	644	660	677	694	711	728	745	762	780	798	816	834	853
2	405	418	431	445	458	472	486	500	514	529	544	559	574	589	605	621	637	653	669	686	703	720	737	754	772	790	808	826	844	863
½	412	425	438	452	465	479	493	508	522	537	552	567	582	597	613	629	645	662	678	695	712	729	746	763	781	799	817	836	854	873
3	420	433	446	460	473	487	501	516	530	545	560	575	590	606	622	638	654	671	687	704	721	738	755	773	790	808	827	846	864	883
½	427	440	454	468	481	495	509	524	538	553	568	584	599	615	631	647	663	680	696	713	730	748	765	783	801	819	837	856	875	894
4	435	448	462	476	490	504	518	533	547	562	577	593	608	624	640	656	672	689	706	723	740	758	775	793	811	830	848	867	886	905
½	443	456	470	484	498	512	526	541	556	571	586	602	617	633	649	666	682	699	716	733	750	768	785	803	821	840	859	877	896	916
5	451	465	478	492	506	521	535	550	565	580	595	611	627	643	659	676	692	709	726	743	760	778	796	814	832	851	870	888	907	927
½	459	473	487	501	515	530	544	559	574	589	604	620	636	653	669	686	702	719	736	753	770	788	806	825	843	862	881	900	919	938
6	468	482	496	510	524	539	553	568	583	599	614	630	646	663	679	696	712	729	746	764	781	799	817	836	854	873	892	911	930	949
½	477	491	505	519	533	548	563	578	593	609	624	640	656	673	689	706	723	740	757	775	792	810	828	847	865	884	903	922	941	961
7	486	500	514	528	542	557	572	588	603	619	634	650	666	683	699	716	733	751	768	786	803	821	839	858	877	896	915	934	953	973
½	495	509	523	537	552	567	582	598	613	629	644	660	676	693	710	727	744	762	779	797	814	832	851	869	888	907	926	946	965	985
8	504	518	532	547	562	577	592	608	623	639	655	671	687	704	721	738	755	773	790	808	826	844	862	881	900	919	938	958	977	997
½	513	527	542	557	572	587	602	618	633	649	665	682	698	715	732	749	766	784	801	819	837	856	874	893	911	931	950	970	990	1010
9	523	538	552	567	582	597	612	628	644	660	676	693	709	726	743	760	777	795	813	831	849	868	886	905	924	944	963	983	1003	1023
½	533	548	563	577	592	608	623	639	655	671	687	704	720	737	754	772	789	807	825	843	861	880	898	917	936	956	975	995	1015	1036
10	543	558	573	588	603	619	634	650	666	682	698	715	732	749	766	784	801	819	837	855	873	892	911	930	949	969	988	1008	1028	1049
½	553	568	583	598	614	630	645	661	677	693	709	726	743	761	778	796	813	831	849	867	887	905	924	943	962	982	1001	1021	1041	1062
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½	575	590	606	621	636	652	668	684	700	717	733	750	767	785	802	820	838	856	874	893	912	931	950	969	988	1008	1028	1048	1068	1089
12	586	601	616	632	647	663	679	696	712	729	745	762	779	797	814	832	850	869	887	906	925	944	963	982	1002	1022	1042	1062	1082	1103
½	597	612	627	643	659	675	691	708	724	741	757	774	791	809	827	845	863	882	900	919	938	957	977	996	1016	1036	1056	1076	1096	1117
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½	620	636	651	667	683	699	715	732	748	765	782	800	817	835	853	871	889	908	926	946	964	984	1004	1024	1044	1064	1084	1104	1125	1146
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½	644	660	675	691	707	724	740	757	774	791	808	826	843	861	879	898	916	935	954	974	993	1012	1032	1052	1072	1092	1113	1134	1155	1176
15	656	672	688	704	720	737	753	770	787	804	821	839	857	875	893	912	930	949	968	988	1007	1027	1047	1067	1087	1107	1128	1149	1170	1191
½	669	685	701	717	733	750	766	783	800	817	835	853	871	889	907	926	944	963	982	1002	1021	1041	1061	1081	1102	1122	1143	1164	1185	1206
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½	695	711	727	743	759	776	793	810	827	845	863	881	899	917	935	954	973	992	1011	1031	1051	1071	1091	1111	1132	1153	1174	1195	1216	1238
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½	721	737	753	770	786	803	820	838	855	873	891	909	927	946	965	984	1003	1022	1041	1061	1081	1101	1121	1142	1163	1184	1205	1227	1248	1270
18	734	751	767	784	800	817	834	852	869	887	905	924	942	961	980	999	1018	1037	1057	1077	1097	1117	1137	1158	1179	1200	1221	1243	1265	1287
½	748	764	781	798	814	831	848	866	884	902	920	939	957	976	995	1014	1033	1052	1072	1092	1112	1133	1153	1174	1195	1216	1237	1259	1281	1303
19	762	778	795	812	829	846	863	881	899	917	935	954	972	991	1010	1029	1048	1068	1088	1108	1128	1149	1170	1191	1212	1233	1254	1276	1298	1320
½	776	792	809	826	843	860	878	896	914	932	950	969	987	1006	1025	1045	1064	1084	1104	1124	1144	1165	1186	1207	1228	1249	1271	1293	1315	1337
20	790	807	824	841	858	875	893	911	929	947	965	984	1003	1022	1041	1061	1080	1100	1120	1140	1161	1182	1203	1224	1245	1266	1288	1310	1332	1354
½	804	821	838	855	872	890	908	926	944	962	980	999	1018	1038	1057	1077	1096	1116	1136	1156	1177	1198	1219	1240	1262	1283	1305	1327	1349	1371
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½	834	851	868	885	902	920	938	957	975	994	1012	1031	1050	1070	1089	1109	1129	1149	1169	1190	1211	1232	1253	1274	1296	1318	1340	1362	1384	1407
22	849	866	883	901	918	936	954	973	991	1010	1029	1048	1067	1086	1106	1126	1146	1166	1186	1207	1228	1249	1270	1292	1314	1336	1358	1380	1402	1425
½	864	881	898	916	934	952	970	989	1007	1026	1045	1064	1083	1103	1123	1143	1163	1183	1203	1224	1245	1266	1287	1309	1331	1353	1375	1398	1420	1443
23	880	897	914	932	950	968	986	1005	1023	1042	1061	1081	1100	1120	1140	1160	1180	1200	1221	1242	1263	1284	1305	1327	1349	1371	1393	1416	1439	1462
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24	911	929	946	964	982	1001	1019	1038	1057	1076	1095	1114	1134	1154	1174	1194	1214	1235	1256	1277	1298	1320	1342	1364	1386	1408	1430	1453	1476	1499
½	927	945	963	981	999	1017	1036	1055	1074	1093	1112	1131	1151	1171	1191	1212	1232	1253	1274	1295	1316	1338	1360	1382	1404	1427	1449	1472	1495	1518
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½	961	978	997	1014	1032	1051	1070	1089	1108	1127	1147	1166	1186	1206	1227	1247	1268	1289	1311	1332	1354	1375	1397	1419	1442	1464	1487	1510	1534	1557
26	977	995	1013	1031	1049	1068	1087	1106	1125	1145	1164	1184	1204	1225	1245	1266	1287	1308	1329	1351	1372	1394	1416	1439	1461	1484	1507	1530	1553	1577
½	994	1012	1030	1048	1066	1085	1104	1124	1143	1163	1182	1202	1222	1243	1263	1284	1305	1326	1347	1369	1391	1413	1435	1458	1480	1503	1526	1549	1573	1597
27	1011	1029	1047	1066	1084	1103	1122	1142	1161	1181	1201	1221	1241	1261	1282	1303	1324	1345	1366	1388	1410	1433	1455	1477	1500	1523	1546	1569	1593	1617
½	1028	1046	1064	1083	1102	1121	1140	1160	1179	1199	1219	1239	1260	1280	1301	1322	1343	1364	1386	1407	1429	1452	1474	1497	1520	1543	1566	1589	1613	1637
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½	1063	1082	1100	1119	1138	1157	1176	1196	1216	1236	1256	1277	1297	1318	1339	1360	1381	1403	1425	1447	1469	1492	1514	1537	1560	1583	1606	1630	1654	1678
29	1081	1100	1119	1138	1157	1176	1195	1215	1235	1255	1275	1296	1316	1337	1358	1380	1401	1423	1445	1467	1489	1512	1534	1557	1580	1603	1627	1651	1675	1699
½	1100	1118	1137	1156	1175	1194	1214	1234	1254	1274	1294	1315	1335	1356	1377	1399	1421	1443	1465	1487	1509	1532	1554	1577	1600	1624	1648	1672	1696	1720
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½	1136	1155	1174	1194	1213	1232	1252	1272	1292	1312	1333	1354	1375	1396	1417	1439	1461	1483	1505	1527	1550	1573	1596	1619	1642	1666	1690	1714	1738	1763
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½	1174	1193	1213	1232	1251	1271	1291	1311	1331	1352	1373	1394	1415	1436	1458	1480	1502	1524	1546	1569	1592	1615	1638	1661	1685	1709	1733	1757	1782	1807
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½	1213	1232	1251	1271	1291	1311	1331	1351	1371	1392	1413	1434	1456	1478	1500	1522	1544	1566	1588	1611	1634	1657	1681	1705	1729	1753	1777	1801	1826	1851
33	1232	1252	1271	1291	1311	1331	1351	1371	1392	1413	1434	1455	1477	1499	1521	1543	1565	1587	1610	1633	1656	1679	1703	1727	1751	1775	1799	1824	1848	1873
½	1252	1272	1291	1311	1331	1351	1371	1392	1413	1434	1455	1476	1498	1520	1542	1564	1586	1609	1632	1655	1678	1701	1725	1749	1773	1797	1822	1846	1871	1896
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½	1292	1312	1331	1351	1371	1392	1413	1434	1455	1476	1497	1518	1540	1562	1584	1607	1630	1653	1676	1699	1722	1745	1769	1793	1818	1842	1867	1892	1917	1942
35	1312	1332	1352	1372	1392	1413	1434	1455	1476	1497	1518	1540	1562	1584	1606	1629	1652	1675	1698	1721	1744	1768	1792	1816	1840	1865	1890	1915	1940	1965
½	1333	1353	1373	1393	1413	1434	1455	1476	1497	1518	1540	1562	1584	1606	1628	1651	1674	1697	1720	1743	1767	1791	1815	1839	1863	1888	1913	1938	1963	1989
36	1354	1374	1394	1414	1434	1455	1476	1497	1518	1540	1562	1584	1606	1628	1650	1673	1696	1719	1742	1766	1790	1814	1838	1862	1887	1912	1937	1962	1987	2013
½	1375	1395	1415	1435	1456	1477	1498	1519	1540	1562	1584	1606	1627	1650	1673	1696	1719	1742	1765	1789	1813	1837	1861	1885	1910	1935	1960	1985	2011	2037
37	1396	1416	1436	1457	1478	1499	1520	1541	1562	1584	1606	1628	1650	1673	1696	1719	1742	1765	1788	1812	1836	1860	1884	1909	1934	1959	1984	2009	2035	2061
½	1417	1437	1458	1479	1500	1521	1542	1563	1584	1606	1628	1650	1673	1696	1719	1742	1765	1788	1811	1835	1859	1884	1908	1933	1958	1983	2008	2033	2059	2085
38	1439	1459	1480	1501	1522	1543	1564	1585	1607	1629	1651	1673	1696	1719	1742	1765	1788	1811	1835	1859	1883	1908	1932	1957	1982	2007	2032	2058	2084	2109
½	1461	1481	1502	1523	1544	1565	1586	1608	1630	1652	1674	1696	1719	1742	1765	1788	1811	1835	1859	1883	1907	1932	1956	1981	2006	2031	2056	2082	2108	2134
39	1483	1503	1524	1545	1566	1587	1609	1631	1653	1675	1697	1719	1742	1765	1788	1811	1835	1859	1883	1907	1931	1956	1980	2005	2030	2056	2081	2107	2133	2159
½	1505	1525	1546	1567	1588	1610	1632	1654	1676	1698	1720	1742	1765	1788	1811	1835	1859	1883	1907	1931	1955	1980	2005	2030	2055	2081	2106	2132	2158	2184
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½	1550	1571	1592	1613	1634	1656	1678	1700	1722	1744	1767	1790	1813	1836	1859	1883	1907	1931	1955	1980	2004	2029	2054	2079	2105	2131	2156	2182	2208	2235
41	1573	1594	1615	1636	1657	1679	1701	1723	1745	1768	1791	1814	1837	1860	1884	1908	1932	1956	1980	2005	2029	2054	2079	2105	2130	2156	2182	2208	2234	2261
½	1596	1617	1638	1659	1681	1703	1725	1747	1769	1792	1815	1838	1861	1884	1908	1932	1956	1980	2005	2030	2054	2079	2104	2130	2156	2181	2207	2233	2260	2287
42	1619	1640	1661	1683	1705	1727	1749	1771	1793	1816	1839	1862	1885	1909	1933	1957	1981	2005	2030	2055	2079	2105	2130	2156	2181	2207	2233	2260	2286	2313
½	1642	1664	1685	1707	1729	1751	1773	1795	1818	1840	1863	1887	1910	1934	1958	1982	2006	2030	2055	2080	2105	2130	2156	2181	2206	2233	2260	2286	2313	2339
43	1666	1688	1709	1731	1753	1775	1797	1820	1842	1865	1888	1912	1935	1959	1983	2007	2031	2056	2081	2106	2131	2156	2181	2207	2233	2260	2286	2313	2339	2366
½	1690	1712	1733	1755	1777	1799	1822	1844	1867	1890	1913	1937	1960	1984	2008	2032	2056	2081	2106	2131	2156	2182	2207	2233	2260	2286	2312	2339	2366	2393
44	1714	1736	1757	1779	1801	1824	1846	1869	1892	1915	1938	1962	1985	2009	2033	2058	2082	2107	2132	2157	2182	2208	2233	2260	2286	2313	2339	2366	2393	2420
½	1738	1760	1782	1804	1826	1848	1871	1894	1917	1940	1963	1987	2011	2035	2059	2084	2108	2133	2158	2183	2208	2234	2260	2286	2313	2339	2366	2393	2420	2447
45	1763	1785	1807	1829	1851	1873	1896	1919	1942	1965	1989	2013	2037	2061	2085	2109	2134	2159	2184	2210	2235	2261	2287	2313	2339	2366	2393	2420	2447	2475
½	1787	1809	1831	1854	1876	1898	1921	1944	1967	1991	2014	2038	2062	2087	2111	2136	2160	2185	2210	2236	2262	2288	2314	2340	2367	2393	2420	2447	2475	2502
46	1812	1834	1856	1879	1901	1924	1947	1970	1993	2017	2040	2064	2089	2113	2137	2162	2187	2212	2237	2263	2289	2315	2341	2368	2394	2421	2448	2475	2502	2530
½	1838	1859	1882	1904	1927	1950	1972	1996	2019	2043	2066	2091	2115	2139	2164	2189	2214	2239	2264	2290	2316	2342	2368	2395	2422	2448	2475	2503	2530	2558
47	1863	1885	1907	1930	1953	1975	1998	2022	2045	2069	2093	2117	2141	2166	2191	2216	2241	2266	2291	2317	2343	2369	2396	2423	2449	2476	2503	2531	2558	2586
½	1888	1910	1933	1956	1978	2001	2024	2048	2071	2095	2119	2143	2168	2193	2218	2243	2268	2293	2319	2344	2370	2397	2424	2450	2477	2504	2531	2559	2587	2614
48	1914	1936	1959	1981	2004	2027	2050	2074	2098	2122	2146	2170	2195	2220	2245	2270	2295	2321	2346	2372	2398	2425	2451	2478	2505	2533	2560	2588	2615	2643
½	1939	1962	1985	2007	2030	2053	2077	2101	2125	2149	2173	2197	2222	2247	2272	2297	2323	2348	2374	2400	2426	2453	2479	2506	2534	2561	2588	2616	2644	2672
49	1965	1988	2011	2034	2057	2080	2104	2128	2152	2176	2200	2225	2249	2274	2299	2325	2350	2376	2402	2428	2454	2481	2508	2535	2562	2590	2617	2645	2673	2701
½	1991	2014	2037	2060	2083	2107	2131	2155	2179	2203	2227	2252	2277	2302	2327	2353	2378	2404	2430	2456	2482	2509	2536	2563	2591	2618	2646	2674	2702	2730
50	2018	2041	2064	2087	2110	2134	2158	2182	2206	2230	2255	2280	2305	2330	2355	2381	2406	2432	2458	2484	2511	2538	2565	2592	2619	2647	2675	2703	2731	2760

	½	46	½	47	½	48	½	49	½	50
0										
½										
1	861	881	900	919	939	958	978	998	1018	1039
½	872	891	910	929	949	969	988	1008	1029	1050
2	883	901	920	940	959	979	999	1019	1040	1061
½	892	911	930	949	970	990	1010	1030	1050	1072
3	902	922	941	961	981	1001	1021	1041	1062	1083
½	913	932	952	972	992	1012	1032	1052	1073	1094
4	924	943	963	983	1003	1023	1043	1064	1085	1106
½	935	954	974	994	1014	1034	1055	1076	1097	1118
5	946	966	986	1006	1026	1046	1067	1088	1109	1130
½	957	977	997	1017	1037	1058	1079	1100	1121	1142
6	969	989	1009	1029	1049	1070	1091	1112	1133	1155
½	981	1001	1021	1041	1061	1082	1103	1125	1146	1168
7	993	1013	1033	1054	1074	1095	1116	1138	1159	1181
½	1005	1025	1045	1066	1087	1108	1129	1151	1172	1194
8	1017	1038	1058	1079	1100	1121	1142	1164	1185	1207
½	1030	1050	1071	1092	1113	1134	1155	1177	1199	1221
9	1043	1063	1084	1105	1126	1147	1169	1191	1213	1235
½	1056	1076	1097	1118	1139	1161	1182	1204	1226	1249
10	1069	1090	1111	1132	1153	1175	1196	1218	1239	1263
½	1082	1103	1124	1146	1167	1189	1210	1232	1254	1277
11	1096	1117	1138	1160	1181	1203	1225	1247	1269	1292
½	1109	1131	1152	1174	1195	1217	1239	1261	1283	1306
12	1124	1145	1166	1188	1210	1232	1254	1276	1298	1321
½	1138	1159	1180	1202	1224	1246	1269	1291	1313	1336
13	1153	1174	1195	1217	1239	1261	1283	1306	1329	1352
½	1168	1189	1210	1232	1254	1276	1298	1321	1344	1367
14	1182	1204	1226	1248	1270	1292	1314	1337	1360	1383
½	1197	1219	1241	1263	1285	1307	1330	1353	1376	1399
15	1213	1235	1257	1279	1301	1323	1346	1369	1392	1415
½	1228	1250	1272	1294	1317	1339	1362	1385	1408	1431
16	1244	1266	1288	1310	1333	1356	1379	1402	1425	1448
½	1260	1282	1304	1326	1349	1372	1395	1418	1441	1465
17	1276	1298	1320	1342	1365	1388	1411	1435	1458	1482
½	1292	1314	1336	1359	1382	1405	1428	1452	1475	1499
18	1309	1331	1353	1376	1399	1422	1445	1469	1493	1517
½	1325	1348	1370	1393	1416	1439	1462	1486	1510	1534
19	1342	1365	1388	1411	1434	1457	1480	1504	1528	1552
½	1359	1382	1405	1428	1451	1474	1498	1522	1546	1570
20	1377	1400	1423	1446	1469	1492	1516	1540	1564	1589
½	1394	1417	1440	1463	1487	1510	1534	1558	1582	1607
21	1412	1435	1458	1481	1505	1529	1553	1577	1601	1626
½	1430	1453	1476	1499	1523	1547	1571	1595	1620	1645
22	1448	1471	1494	1518	1542	1566	1590	1614	1639	1664
½	1466	1489	1513	1537	1561	1585	1609	1633	1658	1683
23	1485	1508	1532	1556	1580	1604	1628	1653	1677	1702
½	1503	1527	1551	1575	1599	1623	1647	1672	1697	1722
24	1522	1546	1570	1594	1618	1642	1667	1692	1717	1742
½	1541	1565	1589	1613	1637	1662	1687	1712	1737	1762
25	1561	1585	1609	1633	1657	1682	1707	1732	1757	1782
½	1581	1604	1628	1652	1677	1702	1727	1752	1777	1802
26	1600	1624	1648	1673	1697	1722	1747	1772	1797	1823
½	1620	1644	1668	1693	1717	1742	1767	1793	1818	1844
27	1641	1665	1689	1714	1738	1763	1788	1814	1839	1865
½	1661	1685	1709	1734	1759	1784	1809	1835	1860	1886
28	1681	1706	1730	1755	1780	1805	1830	1856	1882	1908
½	1702	1727	1751	1776	1801	1826	1851	1877	1903	1930
29	1723	1748	1773	1798	1823	1848	1873	1899	1925	1952
½	1744	1769	1794	1819	1844	1870	1895	1921	1947	1974
30	1766	1791	1816	1841	1866	1892	1917	1943	1969	1996
½	1787	1812	1838	1863	1888	1914	1939	1965	1991	2018
31	1809	1834	1859	1885	1910	1936	1962	1988	2014	2041
½	1831	1856	1881	1907	1933	1959	1985	2011	2037	2064
32	1854	1879	1904	1930	1956	1981	2007	2034	2060	2087
½	1876	1901	1926	1952	1978	2004	2030	2057	2083	2110
33	1898	1924	1949	1975	2001	2027	2053	2080	2107	2134
½	1921	1947	1972	1998	2024	2050	2077	2104	2131	2158
34	1944	1970	1996	2022	2048	2074	2101	2128	2155	2182
½	1967	1993	2019	2045	2071	2098	2125	2152	2179	2206
35	1991	2017	2043	2069	2095	2122	2149	2176	2203	2230
½	2014	2040	2066	2093	2119	2146	2173	2200	2227	2255
36	2038	2064	2090	2117	2143	2170	2197	2225	2252	2280
½	2062	2088	2114	2141	2168	2195	2222	2249	2277	2305
37	2087	2113	2139	2166	2193	2220	2247	2274	2302	2330
½	2111	2137	2164	2191	2218	2245	2272	2299	2327	2355
38	2136	2162	2189	2216	2243	2270	2297	2325	2353	2381
½	2160	2186	2214	2241	2268	2295	2322	2350	2378	2406
39	2185	2212	2239	2266	2293	2321	2348	2376	2404	2432
½	2210	2237	2264	2291	2318	2346	2374	2402	2430	2458
40	2236	2263	2290	2317	2344	2372	2400	2428	2456	2485
½	2262	2289	2316	2343	2370	2398	2426	2454	2482	2511
41	2288	2315	2342	2370	2397	2425	2453	2481	2509	2538
½	2314	2341	2368	2396	2424	2451	2479	2508	2536	2565
42	2340	2368	2395	2423	2450	2478	2506	2535	2563	2592
½	2367	2394	2422	2449	2477	2505	2534	2562	2591	2619
43	2393	2421	2448	2476	2504	2533	2561	2590	2618	2647
½	2420	2448	2475	2503	2531	2560	2588	2617	2646	2675
44	2447	2475	2503	2531	2559	2588	2616	2645	2674	2703
½	2475	2502	2530	2558	2587	2615	2644	2673	2702	2731
45	2502	2530	2558	2586	2614	2643	2672	2701	2730	2760
½	2530	2558	2586	2614	2642	2671	2700	2729	2758	2788
46	2558	2586	2614	2643	2671	2700	2729	2758	2787	2817
½	2586	2614	2642	2671	2700	2728	2758	2787	2816	2846
47	2614	2643	2671	2700	2728	2757	2786	2816	2846	2876
½	2642	2671	2700	2729	2758	2786	2816	2845	2875	2905
48	2671	2700	2728	2757	2786	2816	2845	2875	2905	2935
½	2700	2729	2758	2786	2816	2845	2874	2904	2934	2965
49	2729	2758	2787	2816	2845	2875	2904	2934	2964	2995
½	2758	2787	2816	2846	2875	2905	2934	2964	2995	3025
50	2788	2817	2846	2876	2905	2935	2964	2995	3025	3055

	½	51	½	52	½	53	½	54	½	55
0	1039	1059	1080	1101	1122	1144	1166	1188	1210	1232
½	1049	1070	1091	1112	1133	1155	1177	1199	1221	1243
1	1060	1081	1102	1123	1144	1166	1188	1210	1232	1255
½	1070	1092	1113	1134	1155	1177	1199	1221	1244	1267
2	1082	1103	1124	1145	1167	1189	1211	1233	1256	1279
½	1093	1114	1135	1157	1179	1201	1223	1245	1268	1291
3	1104	1125	1147	1169	1191	1213	1235	1257	1280	1303
½	1115	1137	1159	1181	1203	1225	1247	1269	1292	1315
4	1127	1149	1171	1193	1215	1237	1259	1282	1305	1328
½	1139	1161	1183	1205	1227	1249	1272	1295	1318	1341
5	1151	1173	1195	1217	1239	1261	1285	1308	1331	1354
½	1163	1186	1208	1230	1252	1275	1298	1321	1344	1367
6	1176	1199	1221	1243	1265	1288	1311	1334	1357	1381
½	1190	1212	1234	1256	1278	1301	1324	1348	1371	1395
7	1203	1225	1247	1270	1292	1315	1338	1362	1385	1409
½	1216	1238	1261	1283	1306	1329	1352	1376	1399	1423
8	1229	1252	1274	1297	1320	1343	1366	1390	1413	1437
½	1243	1265	1288	1311	1334	1357	1380	1404	1428	1452
9	1257	1279	1302	1325	1348	1371	1395	1419	1443	1467
½	1271	1293	1316	1339	1362	1386	1409	1433	1457	1482
10	1285	1308	1331	1354	1377	1401	1424	1448	1472	1497
½	1300	1322	1345	1369	1392	1416	1439	1463	1487	1512
11	1314	1337	1360	1384	1407	1431	1455	1479	1503	1528
½	1329	1352	1375	1399	1422	1446	1470	1494	1519	1544
12	1344	1367	1390	1414	1438	1462	1486	1510	1535	1560
½	1359	1382	1406	1430	1454	1478	1502	1526	1551	1576
13	1374	1398	1422	1446	1470	1494	1518	1543	1567	1592
½	1390	1414	1438	1462	1486	1510	1534	1559	1584	1609
14	1406	1430	1454	1478	1502	1526	1551	1576	1601	1626
½	1422	1446	1470	1494	1518	1543	1567	1592	1617	1643
15	1438	1463	1487	1511	1535	1560	1584	1609	1634	1660
½	1454	1479	1503	1528	1552	1577	1601	1626	1651	1677
16	1472	1496	1520	1545	1569	1594	1619	1644	1669	1695
½	1489	1513	1537	1562	1586	1611	1636	1661	1687	1713
17	1506	1530	1554	1579	1604	1629	1654	1679	1705	1731
½	1523	1547	1572	1597	1622	1647	1672	1697	1723	1749
18	1540	1565	1590	1615	1640	1665	1690	1716	1741	1767
½	1558	1583	1608	1633	1658	1683	1708	1734	1760	1786
19	1576	1601	1626	1651	1676	1701	1727	1753	1779	1805
½	1594	1619	1644	1669	1694	1720	1746	1772	1798	1824
20	1613	1638	1663	1688	1713	1739	1765	1791	1817	1843
½	1632	1656	1681	1707	1732	1758	1784	1810	1836	1862
21	1650	1675	1700	1726	1751	1777	1803	1829	1855	1882
½	1669	1694	1719	1745	1770	1796	1822	1849	1875	1902
22	1688	1714	1739	1765	1790	1816	1842	1869	1895	1922
½	1709	1733	1759	1784	1810	1836	1862	1889	1915	1942
23	1727	1753	1778	1804	1830	1856	1882	1909	1936	1963
½	1747	1773	1798	1824	1850	1876	1902	1929	1956	1984
24	1768	1793	1818	1844	1870	1897	1923	1950	1977	2005
½	1788	1813	1839	1865	1891	1918	1944	1971	1998	2026
25	1808	1833	1859	1886	1912	1939	1965	1992	2019	2047
½	1827	1854	1880	1907	1933	1960	1986	2013	2040	2068
26	1849	1875	1901	1928	1954	1981	2008	2035	2062	2090
½	1870	1896	1922	1949	1975	2002	2029	2057	2084	2112
27	1891	1917	1944	1970	1997	2024	2051	2079	2106	2134
½	1912	1939	1965	1992	2019	2046	2073	2101	2128	2156
28	1934	1961	1987	2014	2041	2068	2095	2123	2151	2179
½	1957	1983	2009	2036	2063	2090	2118	2146	2174	2202
29	1979	2005	2031	2058	2085	2113	2141	2169	2197	2225
½	2001	2027	2053	2081	2108	2136	2164	2191	2219	2248
30	2023	2049	2076	2104	2131	2159	2186	2214	2242	2271
½	2045	2072	2099	2127	2154	2182	2209	2237	2265	2294
31	2068	2095	2122	2150	2177	2205	2232	2261	2289	2318
½	2091	2118	2145	2173	2201	2228	2256	2285	2313	2342
32	2114	2141	2169	2197	2224	2252	2280	2309	2337	2366
½	2137	2165	2193	2220	2248	2276	2304	2333	2361	2390
33	2161	2189	2216	2244	2272	2300	2328	2357	2386	2415
½	2185	2213	2240	2268	2296	2324	2353	2382	2411	2440
34	2210	2237	2264	2293	2321	2349	2378	2407	2436	2465
½	2233	2261	2289	2317	2345	2374	2403	2432	2461	2490
35	2258	2286	2314	2342	2370	2399	2428	2457	2486	2515
½	2283	2310	2338	2367	2395	2424	2453	2482	2511	2541
36	2307	2335	2363	2392	2420	2449	2478	2508	2537	2567
½	2332	2360	2389	2417	2446	2475	2504	2533	2563	2593
37	2357	2386	2414	2443	2472	2501	2530	2559	2589	2619
½	2383	2411	2440	2469	2498	2527	2556	2585	2615	2645
38	2408	2437	2466	2495	2524	2553	2582	2612	2642	2672
½	2434	2463	2492	2521	2550	2579	2609	2638	2668	2699
39	2460	2489	2518	2547	2576	2606	2635	2665	2695	2726
½	2486	2515	2545	2574	2604	2633	2662	2692	2723	2753
40	2512	2542	2571	2601	2630	2660	2690	2720	2750	2780
½	2539	2569	2598	2628	2657	2687	2717	2747	2777	2808
41	2567	2596	2625	2655	2684	2714	2744	2775	2805	2836
½	2593	2623	2653	2682	2712	2742	2772	2802	2833	2864
42	2621	2651	2680	2710	2740	2770	2800	2830	2861	2892
½	2649	2678	2708	2738	2768	2798	2828	2858	2889	2920
43	2676	2706	2736	2766	2796	2826	2856	2887	2918	2949
½	2704	2734	2764	2794	2824	2854	2885	2915	2946	2978
44	2732	2762	2792	2822	2853	2883	2913	2944	2975	3007
½	2760	2790	2821	2852	2882	2912	2942	2973	3005	3036
45	2788	2819	2850	2880	2910	2941	2972	3003	3034	3065
½	2817	2848	2879	2909	2939	2970	3001	3032	3063	3095
46	2846	2877	2907	2938	2968	2999	3030	3062	3093	3125
½	2876	2906	2937	2967	2998	3029	3060	3092	3123	3155
47	2905	2936	2966	2997	3028	3059	3090	3122	3153	3185
½	2935	2965	2996	3027	3058	3089	3120	3152	3184	3215
48	2965	2995	3026	3057	3088	3119	3150	3182	3214	3246
½	2995	3025	3057	3087	3118	3149	3181	3213	3245	3277
49	3025	3056	3087	3118	3149	3180	3212	3244	3276	3308
½	3055	3086	3118	3148	3179	3211	3243	3275	3307	3339
50	3085	3117	3148	3179	3210	3242	3274	3306	3338	3371

	½	56	½	57	½	58	½	59	½	60
0	1254	1277	1300	1323	1346	1370	1394	1418	1442	1466
½	1266	1289	1312	1335	1358	1382	1406	1430	1454	1478
1	1278	1301	1324	1347	1370	1394	1418	1442	1466	1491
½	1290	1313	1336	1359	1382	1406	1430	1455	1479	1504
2	1302	1325	1348	1371	1395	1419	1443	1468	1492	1517
½	1314	1337	1360	1384	1408	1432	1456	1481	1505	1530
3	1326	1349	1373	1397	1421	1445	1469	1494	1518	1543
½	1338	1362	1386	1410	1434	1458	1482	1507	1532	1557
4	1351	1375	1399	1423	1447	1471	1496	1521	1546	1571
½	1364	1388	1412	1436	1460	1485	1510	1534	1559	1585
5	1378	1402	1426	1450	1474	1499	1523	1548	1573	1599
½	1391	1415	1439	1463	1488	1513	1537	1562	1588	1613
6	1405	1429	1453	1477	1502	1527	1552	1577	1602	1628
½	1419	1443	1467	1491	1516	1541	1566	1591	1617	1642
7	1433	1457	1481	1506	1531	1556	1580	1606	1631	1657
½	1447	1471	1496	1520	1545	1570	1596	1621	1646	1671
8	1461	1486	1510	1535	1560	1585	1611	1636	1662	1686
½	1476	1501	1525	1550	1575	1600	1626	1651	1677	1703
9	1491	1516	1540	1565	1590	1616	1641	1667	1693	1719
½	1506	1531	1555	1580	1606	1631	1657	1683	1709	1735
10	1521	1546	1571	1596	1621	1647	1673	1699	1725	1752
½	1537	1562	1587	1612	1637	1663	1689	1715	1742	1768
11	1553	1578	1603	1628	1653	1679	1705	1732	1758	1785
½	1569	1594	1619	1644	1670	1695	1722	1748	1775	1801
12	1585	1610	1635	1661	1686	1712	1738	1765	1791	1818
½	1601	1626	1651	1677	1703	1729	1755	1782	1808	1835
13	1617	1643	1668	1694	1720	1746	1772	1799	1826	1853
½	1634	1660	1685	1711	1737	1763	1789	1816	1843	1870
14	1651	1677	1702	1728	1754	1781	1807	1834	1861	1888
½	1668	1694	1719	1745	1772	1798	1825	1852	1879	1906
15	1685	1711	1737	1763	1789	1816	1843	1870	1897	1925
½	1703	1729	1755	1781	1807	1834	1861	1888	1916	1943
16	1721	1747	1773	1799	1826	1853	1880	1907	1934	1962
½	1739	1765	1791	1817	1844	1871	1898	1925	1953	1981
17	1757	1783	1809	1836	1863	1890	1917	1944	1972	2000
½	1775	1801	1828	1854	1881	1909	1936	1963	1991	2019
18	1793	1820	1846	1873	1901	1928	1955	1983	2010	2038
½	1812	1839	1865	1893	1920	1947	1974	2002	2030	2058
19	1831	1858	1885	1912	1939	1966	1994	2022	2050	2078
½	1850	1877	1904	1931	1958	1986	2014	2042	2070	2098
20	1870	1897	1924	1951	1978	2006	2034	2062	2090	2118
½	1889	1916	1943	1971	1998	2026	2054	2082	2110	2138
21	1909	1936	1963	1991	2018	2046	2074	2102	2130	2159
½	1929	1956	1983	2011	2038	2066	2094	2123	2151	2180
22	1949	1976	2003	2031	2059	2087	2115	2144	2172	2201
½	1969	1997	2024	2052	2080	2108	2136	2165	2193	2222
23	1990	2018	2045	2073	2101	2129	2157	2186	2215	2244
½	2011	2039	2066	2094	2122	2150	2178	2207	2236	2266
24	2032	2060	2087	2115	2143	2172	2200	2229	2258	2288
½	2053	2081	2109	2137	2165	2194	2222	2251	2280	2310
25	2074	2102	2130	2159	2187	2216	2244	2273	2302	2332
½	2096	2124	2152	2181	2209	2238	2266	2295	2324	2354
26	2118	2146	2174	2203	2231	2260	2289	2318	2347	2377
½	2140	2168	2196	2225	2253	2282	2311	2341	2370	2400
27	2162	2190	2219	2247	2276	2305	2334	2364	2393	2423
½	2184	2213	2241	2270	2299	2328	2357	2387	2416	2446
28	2207	2236	2264	2293	2322	2351	2380	2410	2440	2470
½	2230	2259	2287	2316	2345	2374	2404	2434	2464	2494
29	2253	2282	2310	2339	2368	2398	2428	2458	2488	2518
½	2276	2305	2334	2363	2392	2422	2452	2482	2512	2542
30	2299	2328	2357	2387	2416	2446	2476	2506	2536	2566
½	2323	2352	2381	2411	2440	2470	2500	2530	2560	2591
31	2347	2376	2405	2435	2464	2494	2524	2555	2585	2616
½	2371	2400	2430	2459	2489	2519	2549	2579	2610	2641
32	2395	2425	2454	2484	2514	2544	2574	2604	2635	2666
½	2420	2449	2478	2508	2538	2569	2599	2629	2660	2691
33	2444	2474	2503	2533	2563	2594	2624	2655	2686	2717
½	2469	2499	2528	2558	2588	2619	2649	2680	2711	2742
34	2494	2524	2554	2584	2614	2644	2675	2706	2737	2768
½	2519	2549	2579	2609	2639	2670	2701	2732	2763	2794
35	2545	2575	2605	2635	2665	2696	2727	2758	2789	2821
½	2571	2601	2631	2661	2692	2722	2753	2784	2816	2847
36	2597	2627	2657	2687	2718	2749	2780	2811	2842	2874
½	2623	2653	2683	2713	2744	2775	2806	2838	2869	2901
37	2649	2679	2709	2740	2771	2802	2833	2865	2897	2929
½	2675	2706	2736	2767	2798	2829	2860	2892	2924	2956
38	2702	2733	2763	2794	2825	2856	2888	2920	2952	2984
½	2729	2760	2790	2821	2852	2883	2915	2947	2979	3011
39	2756	2787	2818	2849	2879	2911	2943	2975	3007	3039
½	2783	2814	2845	2876	2907	2939	2971	3003	3035	3067
40	2811	2842	2873	2904	2935	2967	2999	3031	3063	3096
½	2839	2870	2901	2932	2963	2995	3027	3059	3092	3124
41	2867	2898	2929	2960	2992	3024	3056	3088	3120	3153
½	2895	2926	2957	2988	3020	3052	3084	3117	3149	3182
42	2923	2954	2985	3017	3049	3081	3113	3146	3179	3211
½	2951	2983	3015	3046	3078	3110	3143	3175	3208	3241
43	2980	3012	3043	3075	3107	3140	3172	3205	3238	3271
½	3009	3041	3072	3104	3137	3169	3202	3234	3268	3301
44	3038	3070	3102	3134	3166	3199	3231	3264	3298	3331
½	3067	3099	3131	3163	3196	3229	3261	3294	3328	3361
45	3097	3129	3161	3193	3226	3259	3292	3325	3358	3391
½	3127	3159	3191	3223	3257	3289	3322	3355	3388	3422
46	3157	3189	3221	3254	3286	3319	3352	3386	3419	3453
½	3187	3219	3252	3284	3317	3350	3383	3417	3450	3484
47	3217	3250	3282	3315	3348	3381	3414	3448	3481	3515
½	3248	3280	3313	3346	3379	3412	3445	3479	3512	3546
48	3279	3311	3344	3377	3410	3443	3476	3510	3544	3578
½	3310	3342	3375	3408	3441	3474	3508	3542	3576	3610
49	3340	3373	3406	3439	3472	3506	3540	3574	3608	3642
½	3372	3405	3438	3471	3504	3538	3572	3606	3640	3674
50	3404	3437	3470	3503	3536	3570	3604	3638	3672	3707

ON THE APPLICATION OF SCULPTURE AND SCULPTURED ORNAMENT TO ARCHITECTURE.

By H. B. Garling.

At a meeting of the Royal Institute of British Architects, held on the 29th of May, the following paper was read :—"*Essay on the Application of Sculpture and Sculptured Ornament to Architecture, and the Principles which should regulate their introduction into Buildings generally, both with regard to Beauty of Embellishment and Propriety of Style.*" By Mr. H. B. Garling; for which the Silver Medal of the Institute was awarded.

If from the study of some individual branch of fine art, we proceed to consider how to combine any two or more of them in the same composition with the greatest effect,—in investigating the relation they bear to each other, the means by which the impressions conveyed by the one are influenced by its connection with the other, and the sources from whence our ideas of beauty or grandeur in each department result, we cannot fail to remark the close and striking analogy which exists between all the various branches into which fine art is divided, whether by the impressions they produce upon the mind, or the means by which those impressions are effected. We shall find that though varying in the organ by which they address the imagination, or the vehicle by which they convey their impressions to the mind, they influence the same feelings, strike as it were the same chords, and depend upon causes varying in form only, to produce effects substantially the same.

Whether it be architecture or sculpture, painting, music, or poetry that engages our attention, it is but the expression of one and the same sentiment—the collecting and arranging in the most effective manner, the giving form and substance, as it were, to those ideas and images, from which result our impressions of the sublime and beautiful.

Though we may discover in all, this common origin and aim, yet between some the connection is obvious; and the assistance they afford to each other, when skilfully combined, more natural and effective.

Thus, if to the symmetry and proportion of architecture we add the graceful terminations and flowing lines of sculpture, or the relief and rich variety of pictorial embellishments, we enhance the value of each by placing it in its most effective position, and surrounding it with suitable and appropriate accessories.

To the artist it is, therefore, an important as well as an interesting investigation to consider how the architect and sculptor may unite their labours with the most successful result; and what rules we must observe in the treatment of each department to produce a harmonious and effective combination.

If we commence our investigation by tracing the distinguishing features of the various styles of art as each rose in succession from the materials bequeathed by its predecessor, the first that engages our attention is the collossal architecture of the Egyptians. The distinguishing features of these extraordinary edifices are so well known as scarcely to need description: interesting as they may be to antiquarian research, and rich in matter for reflection and speculation on other points, to the artist they afford but scanty materials for study, and still less for imitation and example. That the germs of beauty and proportion may be traced in a certain propriety of decoration and regular disposition of parts may not, perhaps, be denied; as also that a certain effect of grandeur has been attained; the results of collossal size both in the general mass, and also in the details of the composition. Yet they exhibit a style of art so circumscribed in its object, so limited in its resources, and so much fettered by conventional ideas and principles, as to limit its advancement beyond a certain point—forming, in fact, a perfect reflection of the social condition of the people with whom it originated.

If from Egypt we turn to Greece (where exquisite refinement of taste and feeling were combined with a social condition more favourable to progress than in the former country), we shall find the powers of the artist rapidly increasing with the demand for their employment, and the scope afforded for their exercise. Aiming at the attainment of beauty by nicely-adjusted proportions and propriety of decoration, and attaining grandeur and dignity of effect, not by actual size, but by simplicity of parts and regularity of design, we observe even in their earliest efforts the germs of that perfect mastery of all the resources of art, which subsequently ripened and expanded into the inimitable productions of the age of Pericles.

Apart from the merits of each in its particular department, the principles they observed in combining architecture and sculpture in one composition claim our most careful attention. Whether forming the graceful terminations of the acroteria, or filling up the voids of the pediments, or metopes of the Doric entablature, or decorating the walls in long continuous friezes of elaborate design, we observe how admirably the sculptural accessories complete the general outline of the masses, fill up every void space with rich and appropriate decoration, and relieve the more regular forms of the architecture with the most pleasing variety of lines; imparting poetry of feeling to the whole composition, and assisting in a most important degree the character aimed at by the architect.

The rules observed in the treatment and distribution of sculpture by the artists of Greece, obtained throughout the whole of the best period of classic art.

The triumphal and monumental buildings of antiquity are particularly interesting, as exemplifying the views and ideas of artists of the most acknowledged skill and judgment. The mausolea of Halicarnassus, of Hadrian, and of Augustus, the Antonine and Trajan columns, the triumphal arches on the Via Sacra, the commemorative monuments in short of every class, when carefully considered, will be found to possess a character admirably adapted to the purposes of their erection: but in the application of these ideas to our own times, we must ever keep carefully in view the particular circumstances which guided them in the forms and arrangement they adopted. As art degenerated towards the decline of the Roman empire, the abandonment of true principles became apparent in all its departments—in none more so than in the treatment of sculptural accessories,—their meretricious character and the profusion of ornament (often exceedingly coarse and inelegant) destroying that repose and chaste simplicity, so essential to true dignity of style and so happily attained in the works of a better period. Of these abuses the latter examples of Roman architecture, particularly the baths and even to a greater degree the gorgeous remains at Balbec and Palmyra, afford remarkable instances.

The political convulsions which for centuries distracted the world, so completely buried in barbarism and ignorance every class of literature and every vestige of art, that scarcely any production worthy of the name can be recorded. This destruction of art seems to have been completed at a period when the true principles of taste being abandoned, and its most essential rules being completely lost sight of, all hope of further progress was stayed; and thus, though for a time its extinction was most complete, this very circumstance may be said to have paved the way for its regeneration on better principles, at a subsequent period. By it was annihilated all mere conventional rules, and by it was destroyed every false standard of excellence; and the absence of precedent compelled the artist to go back to the study of nature, the only source from which, in early ages, he can, and in all ages, he should, derive his ideas, however he may seek to form his taste, mature his judgment, or collect experience from the works of others: and from this constant reference to nature alone, we must trace that freshness of feeling and vigour of conception with which the early productions of art and literature teem, and which we strive in vain to catch when the feelings of society have become more refined and enervated, and its structure more artificial and complicated. Art will invariably take its tone and expression from the character of the age in which it is produced; it is an influence the artist cannot resist; it forms the very atmosphere he breathes; and from it the constitution of his mind takes its tone: the experience of the past offers no exception, the character of art at the present day confirms it.

As the arts gradually emerged from the obscurity in which they were buried (fostered by a patronage peculiarly favourable for the development of their loftiest powers), they began to assert their true position and exercise their legitimate influence on society; and while the monuments of classic art were rapidly falling to decay, another style of architecture arose, based on principles of construction and of composition almost as diametrically opposite to those of classic art as the source from whence it sprung, the purposes to which it was dedicated, and the character of the age and people amongst whom it originated. The sculptural accessories are no less different in character than the architecture with which they are associated. These sculptural accessories (often vigorous in design and well conceived, consisting principally of isolated figures, stiff and constrained, distributed and arranged rather by conventional and prescribed ideas of symbolism than by rules of artistic composition), convey ideas more by symbolical arrangement than by a combination of action and expression; of this perhaps the fronts of Wells and Exeter Cathedrals may be adduced as the most striking examples. Thus in the sculptural decoration of mediæval architecture we observe a style of art too subordinate in its character, too circumscribed in its views, and too much fettered by conventional forms to expand and assert an independent position; aiming solely at the expression of devotional feeling by the adoption of the most simple forms. These remarks do not apply to the artists of the revival in Italy; who, forming their taste on the model of the antique, united to these sentiments the lofty expression of intellect and ideal perfection; and thus produced a distinguishing merit and charm in their works. In the revival of the classic styles in Italy, we, in the treatment of the two arts of architecture and sculpture, meet with the observance of the same principles which guided the artists of classic times; but not, however, carried out with the same refinement of feeling and correctness of taste. The vigorous and fertile imagination of the great Italian masters (though it enabled them to trace out their own path, and to imitate the example and catch the feeling without tamely copying their model) often betrayed them into irregularity, which marred the effect of their most successful works; while by artists of inferior talent, exaggerated action and expression, eccentricity, and extravagant conceits, were too often confounded with the bold originality and vigorous conceptions of true genius. Of these defects the palaces and churches of Italy afford innumerable instances, which will immediately occur to those acquainted with the works of these masters. It cannot, indeed, be denied, that the peculiar character of the Italian style admitted a freedom of treatment in the sculptural accessories which would be offensive and inadmissible in more correct and regular compositions; but at the same time it will be obvious that there is a limit to these irregularities, which can only be assigned by good taste and discriminating judgment on the part of the artist himself.

The first and most important point is to observe a perfect accordance in style and character with that of the building to which we apply it, that it not only should illustrate its object and purpose, by intelligible and appropriate allegory, but convey it also with congruity of feeling and sentiment, even to the minutiæ of execution, (for the skilful architect not only adapts the main features of his building to the purpose for which it is designed, but also expresses it in every member, and moulds every detail in exact accordance). But to produce that harmony and propriety (which is the source of our most agreeable sensations in contemplating the productions of art), we must in addition, distribute it so judiciously through the composition, and so nicely adjust it in proportion and position, that it shall appear an integral portion of the design,—the work as it were of one hand, and so completely the expression of one idea, that a chasm and void would be created by its removal: that neither by disproportionate size, nor too prominent a position, it should obtrude offensively on the eye; nor by the opposite extreme, appear to retire too much and lose its legitimate effect and place in the composition. The regulation and nice adjustment of these points cannot, however, be determined by rule, since every individual case will require a different treatment, but it must altogether be attained by that refinement and correctness of taste on the part of the artist which can only result from a careful and accurate study of the best models, united with the greatest judgment and discrimination.

As a subordinate and purely decorative feature, it will be of the utmost importance that the outline of the sculpture should be regulated by, and accord most accurately with, that of the architecture; and that it fill up with precision those circumscribing lines within which it is placed; that there be no protuberance, undue projection, or ungraceful deflection in the contour, either in itself, or in combination; and that it do not interfere with, or break off those main lines which indicate the constructive features of the building, or the continuity of which expresses the arrangement and proportions of the composition.

It will also be found a point of considerable importance, in combining sculpture with architecture, to adopt a sober and subdued style of composition in the position and arrangement, and particularly in the treatment, of the draperies and accessories, not only in isolated figures and in those which form the terminations and crowning members, but also in the composition of the friezes and pediments. The confusion produced by exaggerated action or intricate grouping will be immediately detected by its discomposing and harshly contrasting, without relieving the lines of the architecture; though on the other hand must be avoided a meagre and straggling arrangement, and the stiff effect arising from perpendicular and horizontal lines. The value of sculpture as a decoration (independent of the sentiment it conveys) consists much in the relief it affords by carrying up the eye with its graceful terminations; filling up what would otherwise be void and blank, with varied and undulating lines and forms of the most exquisite beauty. The success with which the artists of Greece moulded and adapted these requirements will prove that, when properly treated, they tend neither to cramp the ideas nor to shackle the invention of the artist.

If it be necessary to observe these rules in the treatment of groups, it will be found still more so in the case of isolated figures; and the infringement of them produces still more ungraceful effects. On the revival of art in Italy, distortion and exaggerated action and expression were too frequently confounded with originality and vigour of execution; and we are continually meeting in their works with the most striking instances both of the infringement of these rules and the ungraceful effects resulting therefrom.

In placing sculpture in juxta-position with architecture, it is obviously a point of no small importance to consider the scale thereby imparted to the composition. It will hardly be necessary to demonstrate with argument, that with which every artist must be acquainted; viz., that magnitude is relative rather than actual, and that by skilfully proportioning details, or by placing in juxta-position features, with the size of which, by habit, experience, or instinct, we are acquainted, with those of which we have no other data for determining the magnitude, he can impart a fictitious scale to his composition; or that by diminishing one feature and exaggerating another, he can, by this comparison, produce an idea of magnitude which the actual size does not possess. In practice, this, nevertheless, has but too frequently been lost sight of; and in many instances, where circumstances institute the comparison, it has been rather the result of accident than design. Perhaps this remark might be more justly restricted to the revival and later productions of art; since, in the works of the antique, we continually observe not only its application, but the success with which it has been attended. The principle must, however, obviously become of peculiar importance in the case of sculpture, since the proportion of the human figure is that with which we are most naturally and necessarily acquainted, and one which we perhaps more readily apply than any other (adjusting everything to this scale instinctively), and although, to a certain extent, the scale of the sculptural accessories, particularly the isolated figures, will be indicated by various circumstances in the proportions of the architecture, it is not absolutely or invariably so, and the advantage to be gained by skilfully adjusting this scale must never be lost sight of. When, by being in due proportion to the members of the architecture, it would become too colossal, it might be preferable to adopt a different species of decoration; since, where the ordinary features of the composition are merely increased in actual size, and the same relative proportions observed, the scale by which we measure is increased in nearly the same ratio. We may also observe, that the undue exaggeration of the human figure beyond its natural proportions, so far from invariably producing an effect of grandeur, is sometimes productive of impressions akin to those resulting from actual deformity; the proportioning these parts is, however, a point which must depend solely upon the judgment of the artist, and one for which no rule can be laid down: a careful study of the best models and an accurate observation of works already executed, will form the best and perhaps the only guide.

When we observe how necessary to produce a pleasing and harmonious effect (even in isolated works, which are to be considered as complete in themselves and not affected by external circumstances) are the duly balancing the corresponding parts of the composition; the skilfully contrasting and combining forms and lines of varying contour; the duly filling-in and adjusting every part so as to give one outline to the mass, however varied in detail,—it is obvious, that in combination with architecture, the slightest discrepancy or failing in this respect will be exaggerated, by contrast with the regularity of the lines and masses with which it is associated; and to this point, therefore, the artist must direct his most diligent attention.

In designing groups and figures which crown and form the termination of the composition, it will be found of the greatest importance that the figures in every aspect appear in perfect equilibrium, and firmly planted and balanced on the pedestal on which they stand, devoid of any protuberance or projection, either in limb or drapery, which may appear to throw the mass more on one side than on the other. It will for this purpose be found necessary carefully to study the work from every possible point of sight from which it can be seen; since we have continually to observe that though perfect when viewed in some positions, this due equilibrium of the mass is disturbed when seen in others, and that even, when, in reality and mechanically speaking, it is duly poised.

Of the ill effects resulting from an imperfect or partial study of this important point, the works of the artists of the revival above alluded to (though masters of perspective and perspective effects) afford innumerable instances; while of consummate skill and science in meeting these requirements, the inimitable productions of the Grecian chisel afford at once a most striking example, and to the artist an invaluable model for study.

An important part of the subject of the application of sculpture to architecture is the employment of caryatides in the place of the column to support the entablature of the orders. Whether the origin of this feature be that related by Vitruvius, or whether it resulted merely in the fertile and lively imagination of the artist adopting this form for variety only, it will hardly be worth our while to consider; though the employment of the human figure combined with massive columns, but not aiding in the support of the mass above, occurring in the Egyptian temples, might induce the belief that the idea has been already suggested by precedent, aud that the character it assumed in Grecian architecture was merely the result of the more refined taste of the artist. The instances in which they were employed, and the manner in which they have been treated, has been already considered, as also that of the same feature by the artists of the revival in Italy. It has elsewhere been but very sparingly adopted. Jean Goujon has left us some admirable specimens of his taste and skill in the Louvre at Paris, which exhibit all the chaste and refined feeling of the antique combined with the freedom of the revival. Inigo Jones's circular court of caryatides, in the Palace at Whitehall, though not executed, yet forms so beautiful a feature in the design that we must not omit to notice it, and to observe with what peculiar judgment the architect has treated this feature of his design: by applying it to an interior court, a perfectly unique effect is preserved, undisturbed by comparison in size with the columnar arrangement.

It is obvious that, in a great measure, the same rules will regulate the treatment of caryatides which govern the application of sculpture generally to architecture; viz., a general sobriety of treatment; the avoiding all strained and unnatural positions of the limbs; no flutter or discomposure of the drapery; the figure balancing itself most accurately, and appearing in every position in the most perfect equilibrium; the outline of the limbs being clearly developed through the folds of the drapery; and, lastly, the absence of the idea of forced and laborious exertion on the one hand, and of positive inaction on the other, that the figure appear easily and naturally to support its superincumbent members, and that they be so treated that the same outline and position do not recur too often. If engaged with the wall, as is frequently the case, a greater freedom of treatment may undoubtedly be adopted, since the outline of the figure will not vary much in different points from which it can be seen.

It might at first be supposed that the study and practice of two arts, so intimately connected with each other, and so naturally and readily combined, might have been united with advantage in the same artist. If, however, we look back upon the history of art, more particularly to the era of the revival in Italy, at which time they were not uncommonly united in the same individual, we cannot but observe that the abuses and deformities are principally to be met with in the works of the architect-sculptors; and that in artistic effect and arrangement, as well as in appropriate and characteristic detail, they were surpassed by their brethren, the architect-painters of the same period. However, they both fall short of those whose whole attention was devoted to architecture alone; showing, more conclusively than argument, that the rules of the artist must, in these points, be his *non imperitus;* that to compass more than one to its fullest extent—to attain to or approach perfection, where the attention is divided upontwo objects of equal importance and scope,—is beyond the grasp of the most powerful intellect, and that the attempt can only be attended with failure in one, or mediocrity in both. There may be quoted a few brilliant exceptions; yet, if these even be fairly balanced upon their own merits, irrespective of the authority of great names, the observation may apply to them.

In conclusion, although it might seem that the rules to be observed in applying sculpture to architecture are rigid, and calculated to trammel the artist with restrictions incompatible with the free exercise of his genius, there is, in reality, perhaps no point on which the invention of the artist is less fettered, or on which so wide a field is left for the exercise of his own discretion, since they determine no fixed proportions, prescribe no particular form, arrangement, or detail, and their very application must depend on the artist's discernment and taste. How little these rules are calculated to induce poverty and tameness of design, or confine the free exercise of the imagination, the example of the gifted artists of Greece will sufficiently prove. The rules of art, so called, are not arbitrary restriction founded on the caprice of fashion, the authority of precedent, or the practice of approved masters,—but those immutable laws, upon the observance of which beauty, grandeur, and harmony most depend (which admit of no exception), apply to every variation of circumstances; are ascertained by an accurate observation of the effects of certain combinations; and are as inseparably connected with the productions of certain results as cause and effect in mechanical appliances in the physical world. It is the attribute and characteristic of true genius intuitively to know, and instinctively to apply them, however necessary experience, careful observation, and diligent study may be to mature the judgment and refine the taste. To conform to them will exercise its ingenuity rather than restrict its powers, while their due observance will give force and precision to its efforts, by directing them in the right channel, and by preserving it from those irregularities which mar the productions of genius unaided by experience and education.

RESISTANCES TO RAILWAY TRAINS.

EXPERIMENTS DOWN INCLINED PLANES BY GRAVITY.

Some experiments have recently been made on the retardation of trains on inclined planes; and as the subject has been much debated, a brief analysis of the results may be acceptable,—an account of the experiments themselves will be found at the end of this paper. It is to be observed, that the circumstances under which they appear to have been conducted, render uniformity and certainty in the conclusions from them very difficult, or rather absolutely impossible.

In the first place, to get a *general law* of resistance by experiments on inclined planes, it is absolutely requisite that the line should be straight, the air calm, and the distance traversed considerable. Of the resistance of curves, and wind in motion, nothing can be known till the resistance in more simple cases be ascertained. To begin with the more complex enquiry is to entangle the subject with phenomena, respecting which ignorance virtually is confessed, by the very circumstance of making the experiment.

Again, it is imperatively necessary that the distance traversed should be considerable—and we urge this point the more strongly, because it applies, not only to the present experiment, but also to former experiments on the narrow-gauge railways. The report to the British Association on Railway Resistances (1837) contains the following important remark on this head:—

> "In every case hitherto examined, the uniform velocity which may appear to have been attained under such circumstances, is somewhat less than that attained on the same plane, when the train has commenced the descent at a considerable velocity; it may therefore be doubted, if trains which may appear to have attained an uniform velocity after starting from a state of rest (on planes on which the experiments have been made), may not really be travelling at a very slowly accelerating velocity, and as the lengths of such planes of one inclination do not enable this to be ascertained with certainty, it has been deemed better to exclude such results. The same rule has been followed for similar reasons in analysing the other series of experiments on inclined planes referred to in this paper."

This remark appears to apply to the experiments before us, and also to those undertaken by Mr. Wyndham Harding, on the Croydon Atmospheric Railway. Of course, it is only where the mass of the train is small, that the resistance soon begins to *tell;* the effect of the inertia of large trains travelling at high velocities, is best seen by considering the distance they will move when subject to the enormous pressure of the break.

The present experiments being subject to these various sources of error, exhibit discrepancies which greatly diminish the value of the conclusions indicated. For instance, in each of the first nine experiments (except the 6th and 8th, which may be altogether disregarded on account of the disadvantageous circumstances under which they were conducted), there occurs a sudden and unexplained increase of velocity at the distance 85½. This may, perhaps, be attributable to local circumstances; but what is more important, is the fact that the alteration of the gradient from $\frac{1}{100}$ to $\frac{1}{330}$, makes no perceptible alteration of the speed in five out of the seven trustworthy experiments on those gradients. This consideration furnishes a convincing proof of the danger of drawing deductions from the *apparent* uniformity of motion for short distances. If the resistance in pounds per ton for a given velocity be deduced from the apparently unaltered motion on *both* gradients, we arrive at the absurdity of giving the resistance two different values, of which one is between six and seven times as great as the other.

To exhibit more clearly the very great effect of the inertia of trains in maintaining their velocity, we will calculate the motion on level ground, at a uniform resistance of 20 lb. per ton, when the train is started at a velocity of 80 feet per second (or rather more than 54 miles an hour). By the principle of Conservation of *Vis Viva*—

$$\tfrac{1}{32} W (V^2 - v^2) = 2 R x;$$

where R is the uniform resistance, V the initial velocity in feet per second, v the velocity at a subsequent time when the train has travelled x feet, W the weight, and therefore $\frac{1}{32}$W the mass (putting 32 feet for the measure of gravity): or *one thirty-second part of the weight* × *by the difference between the squares of the initial and subsequent velocity, is equal to twice the corresponding distance traversed* × *by the uniform resistance.* This is a simple arithmetical rule for calculating *all* cases of the rectilineal motion of a body started with a given initial velocity, and then abandoned to the influence of a constant retarding force.

To suit the present case, we put V = 80, and the resistance = 20 pounds per ton, and multiply the weight of the train by 2240, to express it in pounds; and the above formula becomes

$$\frac{2240}{32} (V^2 - v^2) = 40\,x; \text{ or, } 11{,}200 - \frac{7}{4} v^2 = x,$$

to find the distance in feet corresponding to any subsequent velocity. Putting $v = 0$, we find that *the train moves* 2·12 *miles before it comes to rest;* and putting $v = 70$, we find that *the train moves* 2,925 *feet, or more than half a mile, before its velocity is reduced from* 80 *to* 70 *feet per second.* If, instead of making the resistance uniform, we supposed it to decrease gradually, as it does on railway, the distances above calculated would be increased.

These considerations show the absolute necessity of using long distances in performing experiments on the retardation of trains. But though they throw a doubt on the experiments before us, it would be too much to say that they render them absolutely worthless. On the contrary, with some exceptions, the conclusions display a certain degree of consistency which adds to their weight. Of course, the testimony inferred from this consistency would be much greater if we were informed that these experiments are *all* that have been undertaken, and that none other inconsistent with them have been performed.

Now, of the experiments on the $\frac{1}{100}$ gradient, the 2nd, 3rd, and 5th, with an initial velocity of 50 to 52 miles an hour, exhibit tolerably uniform velocities. This would indicate that at 50 to 52 miles an hour, the resistance is $\frac{1}{100}$ the weight, or 22·4 lb. per ton. Experiments 1, 4, and 7, show retarding velocities, indicating that at 54 to 58 miles an hour, the resistance exceeds 22·4 lb. per ton. Again, in the 13th experiment, on a gradient of about $\frac{1}{83}$, the speed is tolerably uniform; in the 11th, on the same gradient, it is accelerated. In both experiments on a gradient of $\frac{1}{120}$, the speed is accelerated. Reasoning as before, we have—on the assumption that the above form of the data is accurate—the following general conclusions, in three pairs, corresponding with the three gradients:—

	miles per hour.		lb. per ton.
When velocity is	50 — 2	Resistance equals	22
	54 — 8	exceeds	
	55	equals	26
	43	less than	
	36	less than	19
	37	less than	

These results agree very well with those obtained in 1846, by Mr. W. Harding, by the dynamometer, on the South Eastern narrow-gauge railway, and reported in his paper presented to the Institution of Civil Engineers:—

	miles per hour.		lb. per ton.
Velocity	29	Resistance	16·5
	37		18·3
	45		21·7
	46		21·3

To complete the comparison, we select those of the experiments of the British Association which were made at velocities above 30 miles an hour, on inclined planes on narrow-gauge lines:—

	miles per hour.		lb. per ton.
Velocity	31	Resistance	23·4
	34		23·4
	37		25
	32		22·5

It is to be observed, that these rates of resistance considerably exceed the former.

We do not bring into the comparison the experiments of the Gauge Commission, in which the resistance is derived from the consumption of water by such an arbitrary and dangerous process, that we feel justified in rejecting that evidence entirely. Neither can Mr. Wyndham Harding's experiments on the Croydon Atmospheric Railway, by the difference of barometric pressures, be admitted into the comparison. *His case for the rapid increase of resistance with increase of speed, rests almost entirely on these experiments,* and therefore, as we think, on an insufficient foundation. The following results are obtained from several distinct experiments:—

	miles per hour.		lb. per ton.
Velocity	61	Resistance	52·6
	53		41·7
	55		36
	50		32·9
	47		33·7

In the first place, the results obtained by the barometer are inconsistent with themselves: the resistance at 55 miles an hour is fifteen per cent. *more* than at a *less* velocity of 53 miles. The only experiment at upwards of 60 miles an hour, shows an increase of resistance so disproportionate, as naturally to induce suspicion;—at all events, a *single* result, so inconsistent with all previous observation, ought not of itself to be sufficient evidence of a general law. Moreover, this very experiment was conducted under circumstances most unfavourable to a general conclusion. The distance traversed was 3¼ miles, the time of transit four minutes and a half, and the recorded velocity fluctuated from 32 to 61 miles. And yet this SINGLE trial is the mainstay of the theory of high resistances at high velocities! We have already shown the great effect of the inertia of trains at high velocities, and the extreme uncertainty of any conclusions from the *apparent* uniformity of motion;—that the uniformity is apparent only and not absolutely certain, the brief duration of the experiment and its great fluctuations are sufficient testimony.

It is important to observe, in confirmation of this view of the subject, that the barometric method of calculating resistances, always gives results which, as far as they can be compared, exceed those obtained by any other method.

On the whole, we are inclined to an opinion, from the insufficient evidence before us, that the resistance does not increase so much with the velocity as has sometimes been contended; and that the resistances per ton, do not differ widely on the broad and narrow gauge. The advantage, if any, belongs to the former; principally, we imagine, on account of the comparative smoothness of motion over longitudinal sleepers. There can be no reasonable doubt, that comparing the longitudinal and transverse sleepers, when both are in perfect order, the former, by giving more perfect support to the rails, render them less liable to vibration and concussion. It may be laid down, as a general rule, that whatever increases the regularity of motion, diminishes the resistance. One of the consequences of this rule is, that the resistance of trains is diminished by diminishing their lateral oscillation. On this subject we have not space to speak at length; it is sufficient to observe, that the tendency to oscillate depends on what is known in mathematics as the *radius of gyration*, and is therefore diminished by diminishing the weight projecting beyond the wheels outside, and by reducing the proportion of the height of the centre of gravity to the distance between the points of support.

[*Abbreviated from the "Morning Herald."*]

We return to the consideration of this interesting and important practical railway investigation. As we have previously stated, the question of the "resistances to railway trains at certain velocities," is not a mere scientific question, but one in which the convenience and accommodation of the public are very materially involved. The establishment of the truth of the "*formula*" which makes the resistance, at 60 miles per hour, some 40 lb. per ton, or 50 per cent. higher than we shall presently show it to be, would present a strong *economical* argument either *against* express travelling, or *for* the restriction of the accommodation of quick transit to first-class passengers at high fares.

In the observations made by us a few days since, in reference to the extraordinary differences of opinion existing on the subject between practical engineers, we noticed the singular fact that while a uniform velocity of not more than 36 miles per hour has ever been maintained with narrow-gauge trains, by the force of gravity, down an incline of 1 in 100, a uniform velocity of upwards of 53 miles per hour had been maintained with broad-gauge trains by gravity down an equal incline. We then stated that we had ourselves gone done the Box Tunnel incline (1 in 100) at a greater uniform velocity than 53 miles per hour. We have since made a series of experiments down the Wootton Bassett incline, stated to be 1 in 100, but some portion of which is 1 in 110 only; and down other inclines on the Bristol and Exeter Railway; and from the details given below, it will be seen that a much greater uniform velocity than 53 miles per hour, even under *very unfavourable circumstances*, can be obtained down 1 in 100, by gravity; and that consequently the foundation on which many railway engineers have rested the very pillar of their theory of high rates of resistance at high velocities, is utterly without substantiality,—that, indeed, it is a mere fallacy, which will hereafter be numbered amongst the delusions and visions of practical men.

The whole of the following experiments were made with ordinary working trains, and the object was not to collect minute data from which any scientific results might be deduced, but simply to prove—exclusive of the results of experiments made by either broad or narrow gauge engineers—that what has long been considered an "*established fact*" in reference to the resistance to railway trains descending inclined planes by force of gravity, is a mere "circumstance," which, although applicable to narrow-gauge trains, is utterly inapplicable to broad-gauge trains. The diversities in the rates of speed shown in the workings given below arose, no doubt, from a great variety of causes. Nearly the whole of the portions of the line over which the experiments were made consists of a series of curves, and of cuttings and embankments. The carriages were of different weights, and may occasionally have been well or badly coupled. One day the weather was calm, the next it was unsettled; in some of the experiments there was a slight head wind, in others a moderate side wind from the right, or a moderate side wind from the left prevailed, and during three of the experiments there was a brisk side wind. The speed, too, at which the trains were running when the steam was shut off would, in relation to the weights of the carriages, as well as to the direction of the wind, enter into the causes of these diversities of speed. We shall, however, not hazard a single opinion on these matters, but confine ourselves to demonstrations that the "*formula*" of high resistances at high velocities is worthless in respect of the resistance sdue to broad-gauge trains descending inclined planes by their own gravity.

In the experiments made down the Wootton Bassett incline with the dynamometer carriage, constructed under the directions of Mr. Brunel, the carriages were weighed to 10 tons each. In no one of the experiments given below, which were made with the ordinary passenger trains, did any of the carriages amount to this weight—that is, they were not full of passengers. The engines employed belong to an old class, and weigh, road-worthy, about 23 or 24 tons.

It has been objected against the experiments made down the Wootton Bassett incline with the dynamometer carriage, that the distance over which a uniform or increasing velocity was attained, viz., 10 or 11-16ths of a mile, is too short to produce a useful practical result. To meet this objection we took the rates of speed not only down the mile and one-eighth of the fall of 1 in 100, but down the next seven-eighths* of a mile, which are on a fall of 1 in 660 only. The fall of 1 in 100 commences a few chains beyond the 85th mile-post, and terminates a few furlongs† beyond the 86¼th mile-post. Thence to the 86¾th mile-post, the fall is 1 in 660.

The *first* experiment was made with a train consisting of four passenger-carriages, three horse-boxes, and one luggage van, weighing about 60 tons. The engine was the "Orion." The table gives the working for the quarter mile immediately preceding the 85th mile-post, as well as from the 85th to the 86¾th mile-post. The rails were dry, and very little wind was stirring.

It will be seen that the speed for upwards of half-a-mile down 1 in 660 is very little below the uniform velocity down nearly three-quarters of a mile of 1 in 100. We merely record the fact, leaving those who have more time at their command than we have ourselves to explain or suggest the causes.

The *second* trip was with a train of four passenger-carriages and a horse-box, weighing about 41 or 42 tons, and was attached to the "Mars" engine—rails dry and weather calm.

The *third* trip was with the same engine, with three passenger-carriages, one luggage-van, and two horse-boxes, weighing about 45 or 46 tons.

The *fourth* experiment was made with the "Firebrand" engine. The train consisted of three passenger-carriages and a luggage-van, weighing about 36 tons. The carriages were well filled with passengers.

The *fifth* experiment was with the "Orion," with four passenger-carriages, three horse-boxes, and a luggage-van, weighing about 59 or 60 tons. The steam was not shut off in this case until the engine was within a few chains of the 85¼th mile-post.

The *sixth* experiment was with the "Load Star." The train consisted of four passenger-carriages and a luggage-van, weighing about 41 or 42 tons. A brisk side wind was blowing. It will be observed that the rates of speed alternate over the whole extent of the 2¼ miles.

The *seventh* trip was with the "Arab," with a train consisting of three passenger-carriages and a luggage-van, weight about 38 or 40 tons—carriages well filled. In this trip we obtained the greatest uniform velocity—rails dry; weather calm.

The *eighth* experiment was with the "Bellona," with four passenger-carriages and a luggage-van, weighing about 41 or 42 tons.

A brisk side wind prevailed on this occasion, and the same result was produced as in the previous experiment, where a side wind affected the train, viz., alternating rates of speed.

The *ninth* experiment was with the "Firebrand," with a train of four carriages and a luggage-van, weighing about 45 or 46 tons—rails dry; slight side wind.

* Qy. seven-sixteenths. † Qy. chains.

The *tenth* experiment was upon the Bristol and Exeter line from the 174th to the 176¼th mile-post. This portion of the line is on a fall of 45·75 feet per mile, or about 1 in 120. The engine employed was the "Load Star," and the train consisted of four passenger-carriages and a luggage-van, weight about 41 or 42 tons. The descent was commenced at a speed of about 36 miles per hour—rails dry, and slight head wind.

In this experiment the velocity down an incline, less by 20 feet per mile than that down which the narrow-gauge trains have never yet maintained a uniform velocity of more than 36 miles per hour, increased from 36·3 to 42·4 or 6·1 miles per hour. And yet we have little doubt we shall still find *practical* men contending for the high rates of resistances which some of the narrow-gauge party pertinaciously assume to be due to *all* railway trains travelling at high velocities.

The *eleventh* experiment was from the 172¾ to the 170¾—viz., two miles. The engine employed was the "Saturn," and the train consisted of five passenger-carriages and a luggage-van, weighing about 56 or 57 tons. For about two-thirds of a mile the fall is 1 in 82; this is followed by a fall of about 6 chains of 1 in 90, and another fall of about 7 or 8 chains of 1 in 82. The rest of the distance is on a fall of 1 in 90. The average velocity of the train through the White Ball Tunnel, 49 chains in length, and which immediately precedes the inclines over which we took the working of the train, was 42·5 miles per hour. It will be seen that this speed was increased to 50 miles an hour at the 170¾th mile-post.

The *twelfth* experiment was a second run down the 1 in 120, between the 174th to the 176¼th mile-post. The engine employed was the "Firebrand," and the train consisted of four carriages and a luggage-van, weighing about 44 or 45 tons—rails dry, and moderate side wind.

The *thirteenth* and last experiment was with the "Milo," and a train of three passenger-carriages and a luggage-van. Weight, about 34 or 35 tons. A brisk side wide prevailed.

In this experiment the steam was shut off at the 172¾ mile-post, which is in the White Ball Tunnel.

Tables of Experiments.

Gradient.	Mile Posts.	Velocity in Miles per Hour.								
		1st Experimnt.	2nd Experimnt	3rd Experimnt	4th Experimnt	5th Experim	6th Experimnt	7th Experimnt	8th Experiment	9th Experimnt
	84¾	58·1	50	52·2	54·5	51·4	56·3	58·1	56·3	58·8
$\frac{1}{100}$	85	60	50	53·7	54·5	51·4	58·1	58·1	56·3	54·5
	85¼	58·1	50	50·7	51·4	52·9	57·1	57·1	53·7	54·5
	85½	59	52·2	54·5	52·9	52·2	56·3	59	55·4	52·9
	85¾	54·5	50·7	52·2	51·4	53·7	52·9	57·1	52·9	50·7
	86	54·5	50·7	52·2	51·4	52·9	53·7	57·1	53·7	50·7
	86¼	54·5	50·7	52·2	51·4	52·9	59·9	57·1	52·9	50·7
$\frac{1}{660}$	86½	53·7	50·7	51·4	51·4	52·2	54·5	56·3	53·7	50·7
	86¾	52·9	50	50	51·4	52·2	52·9	56·3	53·7	50

Gradient.	Mile Posts.	Velocity in Miles per Hour.		Gradient.	Mile Posts.	Velocity in Miles per Hour.	
		11th Experiment	13th Experiment			10th Experiment	12th Experiment
$\frac{1}{82}$	172¾	43·9	55·4	$\frac{1}{120}$	174¼	36·3	37·5
	172½	44·5	55·4		174½	38·3	37·9
	172	45	56·3		174¾	38·3	37·9
					175	39·6	38·3
$\frac{1}{90}$	171¾	46·2	55·4		175¼	40	38·3
	171½	47·4	54·5		175½	40·9	39·1
	171¼	48·6	56·3		175¾	41·4	38·7
	171	49·3	56·3		176	41·9	39·1
	170¾	50	56·3		176¼	42·4	40

REVIEWS.

Account of the Skerryvore Lighthouse, with notes on the Illumination of Lighthouses. By ALAN STEVENSON, LL.B., F.R.S.E., M.I.C.E., Engineer to the Northern Lighthouse Board. Edinburgh: Adam and Charles Black, 1848.

[SECOND NOTICE.]

What Mr. Stevenson calls "Notes on the Illumination of Lighthouses," may more rightly be called another work, and one not less important nor valuable than the account of the Skerryvore Lighthouse. Indeed, he calls the former Part II. He begins it by a short history of lighthouses, in which he shows a great deal of learning; and as by the former part every one will see that he is a hard-working man, so by this they will see that a man may be able to understand Homer in Greek, and yet be a good engineer.

We think both of those are wrong, those who wish to make the engineer a man of book-learning only, and those who want to make him a boor under the name of a working-man. Brunel, Robert Stephenson, Locke, the Rennies, Walker, and many more, have shown that to be a great engineer, and to make great works, there is no harm in a man being well-taught. We would always put the two together if we could,—we would have the man of learning and the working-man.

Mr. Stevenson's way of commenting on the classics is rather a new one,—rather unlike the Byzantine school, Scaliger, and the Revival critics, or the great High Dutch lights of this day. Some of these who went before Mr. Stevenson have put forth the bold thought, that the Cyclops were the keepers of lighthouses; some bolder still, that by the Cyclops was shadowed forth the lighthouse itself. Mr. Stevenson's answer is, that in the ninth book of the Odyssey, and at the 146th line, Homer tells us that in the darkness of the night, the fleet of Ulysses went ashore on the Cyclopean island. Mr. Stevenson looks at it with a workman's eye, and he says if there had been a lighthouse, the ships would not have struck in the dark. The words he brings forward show that it was pitch dark, and give no hint of a lighthouse; and therefore we think Mr. Stevenson right, in the teeth of the commentators. He has not, however, taken the trouble to set his Greek into English, so that his working readers may understand it.

What Mr. Stevenson says of the lighthouses of our days is the more worthy of being read, as he has seen many of them himself, and looked at them with the eye of a master.

Speaking upon lighting, Mr. Stevenson says, that down to a very late time, the only way was to burn wood or coal in chafing dishes on the tops of high towers or hills. Many now living know that the Isle of May light was of that kind, before it came under the care of the Board of Northern Lights in 1786. For forty years after the time of Smeaton, the fine tower of the Eddystone was lighted only with tallow candles. These lights were therefore very weak, and there were no means of knowing one light from another, so that the seaman might shape his way. Even now, it too often happens that seamen mistake lights, and by going inside, instead of outside or otherwise, they go aground and are wrecked. The old lighthouses were of little more good than to give warning that land was near; so that ships might, if they could, lie by or put out to sea until daylight.

Mr Stevenson now speaks of flame. He says:—

"Solid substances which remain so throughout their combustion, are only luminous at their own surface, and exhibit phenomena, such as the dull red heat of iron, or of most kinds of pit-coal, and are therefore more suited for the purpose of producing heat than light. But by using substances which are formed into inflammable vapours, at a temperature below that which is required for the ignition of the substances themselves, gas is obtained and *flame* is produced. Much light is thus evolved at a comparatively low temperature. The gas necessarily rises *above* the combustible substance from which it is evolved, owing to its being formed at a temperature considerably higher than that of the surrounding air, than which it is necessarily rarer. Of this description are the flames obtained by the burning of the various oils, which are generally employed in the illumination of lighthouses. In the combustion of oil, wicks of some fibrous substance, such as cotton, are used, into which the oil ascends by capillary action, and being supplied in very thin films, is easily volatilized into vapour or gas by the heat of the burning wick. The gas of pit-coal has been occasionally used in lighthouses; it is conveyed in tubes to the burners, in the same manner as when employed for domestic purposes. There are certain advantages, more especially in dioptric lights, where there is only one large central flame, which would render the use of gas desirable. The form of the flame, which is an object of considerable importance, would thus be rendered less variable, and could be more easily regulated, and the inconvenience of the clock-work of the lamp would be wholly avoided. But it is obvious, that gas is by no means suitable for the majority of lighthouses, their distant situation and generally difficult access rendering the transport of large quantities of coal expensive and uncertain; whilst in many of them there is no means of erecting the apparatus necessary for manufacturing gas. There are other considerations which must induce us to pause before adopting gas as the fuel of lighthouses; for, however much the risk of accident may be diminished in the present day, it still forms a question, which ought not to be hastily decided, how far we should be justified in running even the most remote risk of explosion in establishments such as lighthouses, whose sudden failure might involve consequences of the most fatal description, and whose situation is often such, that their re-establishment must be a work of great expense and time. Gas is, besides, far from being suitable in catoptric lights, to which, in many cases (especially when the frame is moveable, as in revolving lights), it could not be easily applied. The oil most generally employed in the lighthouses of England is the sperm oil of commerce, which is obtained from the South Sea whale (*Physeter macrocephalus*). In France, the colza oil, which is expressed from the seed of a species of wild cabbage (*Brassica oleracea colza*), and the olive oil are chiefly used; and a species of the former has lately been successfully introduced into the lighthouses of Great Britain."

Sperm oil is that which has been hitherto most burned; but colza oil will, it is thought, be found much better, and that a saving of one-half can be made. It was Mr. Joseph Hume, when chairman of a committee of the House of Commons on Lighthouses, who showed that colza oil was cheaper. Since then, Mr. Stevenson has tried it, and has told the Northern Lighthouse Board that it will give a saving of £3,266 yearly; but since that, colza oil is worth more, and Mr. Stevenson is not so strong in his feeling about it.

Of the Drummond and Voltaic lights, the writer says:—

"The application of the *Drummond* and *Voltaic lights* to lighthouse purposes is, owing to their prodigious intensity, a very desirable consummation; but it is surrounded by so many practical difficulties that, in the present state of our knowledge, it may safely be pronounced unattainable. The uncertainty which attends the exhibition of both these lights, is of itself a sufficient reason for coming to this conclusion. But other reasons unhappily are not wanting. The smallness of the flame renders them wholly inapplicable to dioptric instruments which require a great body of flame in order to produce a degree of divergence sufficient to render the duration of the flash in revolving lights long enough to answer the purpose of the mariner. M. Fresnel made some experiments on the application of the Drummond light to dioptric instruments, which completely demonstrate their unfitness for this combination. He found that the light obtained by placing it in the focus of a great annular lens was much more intense than that produced by the great lamp and lens; but the divergence did not exceed 30′; so that, in a revolution like that of the Corduan light, the flashes would last only 1½ second, and would not, therefore, be seen in such a manner as to suit the practical purposes of a revolving light. The great cylindric refractor used in fixed lights of the first order, was also tried with the Drummond light in its focus; but it gave coloured spectra at the top and bottom, and only a small bar of white light was transmitted from the centre of the instrument. The same deficiency of divergence completely unfits the combination of the Drummond light with the reflector for the purposes of a fixed light, and even if this cause did not operate against its application in revolving lights on the catoptric plan, the supply of the gases, which is attended with almost insurmountable difficulties, would, in any case, render the maintenance of the light precarious and uncertain in the last degree.

The Drummond light is produced by the ignition or combustion of a ball of lime (¾ inch diameter) in the united flames of hydrogen and oxygen gases, and is equal to about 264 flames of an ordinary Argand lamp with the best spermaceti oil. It derives its name from the late Lieut. Drummond, R. E., who first applied it in the focus of a paraboloïd for geodetical purposes, and afterwards proposed it for lighthouses. (See his account of the light in the Phil. Trans. for 1826, p. 324, and for 1830, p. 383.) The Voltaic light is obtained by passing a stream of Voltaic electricity from a powerful battery between two *charcoal points*, the distance between which requires great nicety of adjustment, and is the chief circumstance which influence the stability and the permanency of the light. The Voltaic light greatly exceeds the Drummond light in intensity, as ascertained by actual comparison of their effects; but the ratio of their power has not been accurately determined. It was first exhibited in the focus of a reflector by Mr. James Gardner, formerly engaged in the Ordnance Survey of Great Britain."

After speaking of what Argand did, and of the burner he made, which was such a great step, Mr. Stevenson comes to the reflector:

"The name of the inventor of paraboloïdal mirrors and the date of their first application to lighthouses, have not been accurately ascertained. The earliest notice which I have been able to find, is that by Mr. William Hutchinson, the pious and intelligent author of a quarto volume on 'Practical Seamanship' (published at Liverpool in 1791), who notices (at p. 93) the erection of the four lights at Bidstone and Hoylake, in the year 1763, and describes large parabolic moulds, fashioned of wood and lined with mirror-glass, and smaller ones of polished tin-plate, as in use in those lighthouses. Mr. Hutchinson seems to have understood the nature, properties, and defects of the instruments which he describes, and has shown a good acquaintance with many of the most important circumstances to be attended to in the illumination of lighthouses. Many claims to inventions rest on more slender grounds than might be found in Mr. Hutchinson's book for concluding him to have first invented the paraboloïdal mirror and applied it to use in a lighthouse; but, in the absence of any statement as to the date when the mirrors were really adopted, the merit of the improvement must, in justice, be awarded to others.

M. Teulere, a member of the Royal Corps of Engineers of Bridges and Roads in France, is, by some, considered the first who hinted at the advantages of paraboloïdal reflectors; and he is said, in a memoir dated the 26th June 1783, to have proposed their combination with Argand lamps, ranged on a revolving frame, for the Corduan lighthouse. Whatever foundation there may be for the claim of M. Teulere, certain it is that this plan was actually carried into effect at Corduan, under the directions of the Chevalier Borda; and to him is generally awarded the merit of having conceived the idea of applying paraboloïdal mirrors to lighthouses. These were most important steps in the improvement of lighthouses, as not only the power of the lights was thus greatly increased, but the introduction of a revolving frame proved a valuable source of differences in the appearance of lights, and, in this way, has since been the means of greatly extending their utility. The exact date of the change on the light of the Corduan is not known; but as it was made by Lenoir, the same young artist to whom Borda, about the year 1780, entrusted the construction of his reflecting circle, it has been conjectured by some that the improvement of the light was made about the same time. The reflectors were formed of sheet-copper, plated with silver, and had a double ordinate of 31 French inches. It was not long before these improvements were adopted in England, by the Trinity House of London, who sent a deputation to France to inquire into their nature. In Scotland, one of the first acts of the Northern Lights Board in 1786, was to substitute reflectors in the room of the coal-light then in use at the Isle of May in the Frith of Forth, which, along with the light on the Cambrae Isle in the Frith of Clyde, had, till that period, been the only beacons on the Scotch coast. The first reflectors employed in Scotland were formed of *facets* of mirror-glass, placed in hollow paraboloïdal moulds of plaster, according to the designs of the late Mr. Thomas Smith, the Engineer of the Board, who (as appears from the article *Reflector*, in the Supplement to the third edition of the 'Encyclopædia Britannica') was not aware of what had been done in France, and had himself conceived the idea of this combination. The same system was also adopted in Ireland; and in time, variously modified, it became general wherever lighthouses are known."

The reflectors used in the best lighthouses are made, says the writer,

"Of sheet-copper plated in the proportion of six ounces of silver to sixteen ounces of copper. They are moulded to the paraboloïdal form, by a delicate and laborious process of beating with mallets and hammers of various forms and materials, and are frequently tested during the operation by the application of a mould carefully formed. After being brought to the curve, they are stiffened round the edge by means of a strong bizzle, and a strap of brass which is attached to it for the purpose of preventing an accidental alteration of the figure of the reflector. Polishing powders are then applied, and the instrument receives its last finish."

"The flame generally used in reflectors, is from an Argand fountain-lamp, whose wick is an inch in diameter. Much care is bestowed upon the manufacture of the lamps for the Northern lighthouses, which sometimes have their burners tipped with silver to prevent wasting by the great heat which is evolved. The burners are also fitted with a sliding apparatus, accurately formed, by which they may be removed from the interior of the mirror at the time of cleaning them, and returned exactly to the same place, and locked by means of a key. This arrangement, as shown in figs. 1 and 2,

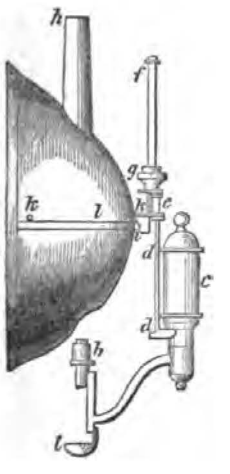

Fig. 2.

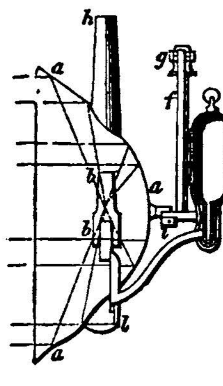

Fig. 1.

is very important, as it insures the burner always being in the focus, and does not require that the reflector be lifted out of its place every time it is cleaned; so that, when once carefully set and screwed down to the frame, it is never altered."

It will please our readers very much to find in Mr. Stevenson's book, the many clever tools which are used, and care which is taken to make the lamps and lights as good as may be. He has written a good deal about feeding the lamps with oil, and indeed everywhere he has shown that he is master of his work, even in the smallest things. It was said of the Duke of Wellington, that even to the horses' shoes he knew everything in his army, and that he thought nothing beneath him which had to do with the welfare of his men: and so should it be with the engineer; and this is the way in which he can truly become a working-man. Mr. Stevenson may not perhaps have put on a fustian coat, nor spent his time in filing, rasping, and fitting; but an engineer may be a working-man without that.

Lights are found by seamen so useful, that they are always calling out for more; but when put up, it becomes very troublesome to know one from another. A light ought to make known to the benighted mariner the land he has made, as the sight of a hill or tower would have shown him in the day; therefore, it becomes needful that each should be readily known, so as not to be mistaken.

"Catoptric lights are susceptible of nine separate distinctions, which are called *fixed, revolving white, revolving red and white, revolving red with two whites, revolving white with two reds, flashing, intermittent, double fixed lights*, and *double revolving white lights*. The first exhibits a steady and uniform appearance, which is not subject to any change; and the reflectors used for it (as already noticed) are of smaller dimensions than those employed in revolving lights. This is necessary in order to permit them to be ranged round the circular frame, with their axes inclined at such an angle, as shall enable them to illuminate every point of the horizon. The revolving light is produced by the revolution of a frame with three or four sides, having reflectors of a larger size grouped on each side, with their axes parallel; and as the revolution exhibits once in two minutes, or once in a minute, as may be required, a light gradually increasing to *full strength*, and in the same gradual manner decreasing to total darkness, its appearance is extremely well marked. The succession of *red* and *white* lights is caused by the revolution of a frame whose different sides present red and white lights; and these, as already mentioned, afford three separate distinctions, namely, alternate red and white; the succession of two white lights after one red, and the succession of two red lights after one white light. The *flashing* light is produced in the same manner as the *revolving* light; but owing to a different construction of the frame, the reflectors on each of eight sides are arranged with their rims or faces in one vertical plane, and their axes in a line inclined to the perpendicular, a disposition of the mirrors which, together with the greater quickness of the revolution, which shows a flash once in five seconds of time, produces a very striking effect, totally different from that of a revolving light, and presenting the appearance of the flash alternately rising and sinking. The brightest and darkest periods being but momentary, this light is farther characterised by a rapid succession of bright flashes, from which it gets its name. The *intermittent* light is distinguished by bursting suddenly into view and continuing steady for a short time, after which it is suddenly eclipsed for half a minute. Its striking appearance is produced by the perpendicular motion of circular shades in front of the reflectors, by which the light is alternately hid and displayed. This distinction, as well as that called the *flashing light*, is peculiar to the Scotch coast, having been first introduced by the late Engineer of the Northern Lights Board. The double lights (which are seldom used except where there is a necessity for a *leading* line, as a guide for taking some channel or avoiding some danger) are generally exhibited from two towers, one of which is higher than the other. At the Calf of Man, a striking variety has been introduced into the character of leading lights, by substituting, for two *fixed* lights, two lights which revolve in the same periods, and exhibit their flashes at the same instant; and these lights are, of course, susceptible of the other variety enumerated above, that of two revolving red and white lights, or flashing lights, coming into view at equal intervals of time. The utility of all these distinctions is to be valued with reference to their property of at once striking the eye of an observer, and being instantaneously obvious to strangers."

Although colour is needful, it is in itself a very great evil, for the coloured screens stop much of the light. Several colours have been tried, but red, blue, and green have alone been found useful; and the two latter only at such short lengths, that they are altogether unfit for sea-lights. Even the red lights take up from four-sevenths to five-sixths of the whole light, which is a very great loss; and the deeper the red, the greater the loss of light,—while the less red there is, the less can it be seen by the seaman. Red lights ought, therefore, to be used as little as may be. In Scotland, instead of a red screen or disc, a chimney of red glass is used.

We now come to the use of lenses, upon which the writer says:—

"One of the earliest notices of the application of lenses to lighthouses is that recorded by Smeaton in his 'Narrative of the Eddystone Lighthouse,' where he mentions a London optician, who, in 1759, proposed grinding the glass of the lantern to a radius of seven feet six inches; but the description is too vague to admit of even a conjecture regarding the proposed arrangement of the apparatus. About the middle of the last century, however, lenses were actually tried in several lighthouses in the south of England, and in particular at the South Foreland in the year 1752; but their imperfect figure and the quantity of light absorbed by the glass, which was of impure quality and of considerable thickness, rendered their effect so much inferior to that of the parabolic reflectors then in use, that after trying some strange combinations of lenses and reflectors, the former were finally abandoned. Lenses were also tried at the lights of Portland, Hill of Howth, and Waterford, by Mr. Thomas Rogers, a glass manufacturer in London; who possessed, it is said, the art of blowing mirrors of glass, 'and by a new method silvered over the convex side without quicksilver.'

"The merit of having first suggested the building of lenses in separate pieces, seems to be due to Condorcet, who in his *Eloge de Buffon*, published so far back as 1773, enumerates the advantages to be derived from this method. Sir David Brewster also described this mode of building lenses in 1811, in the *Edinburgh Encyclopædia;* and in 1822, the late eminent Fresnel, unacquainted with the suggestions of Condorcet or the description by Sir David Brewster, explained, with many ingenious and interesting details, the same mode of constructing those instruments. To Fresnel belongs the additional merit of having first followed up his invention, by the construction of a lens and, in conjunction with MM. Arago and Mathieu, of placing a powerful lamp in its focus, and indeed of finally applying it to the practical purposes of a lighthouse."

To show Fresnel's system fully would take more room than we can give, and many wood-cuts, and we are sorry that we must leave it alone, and send our readers to Mr. Stevenson's book, where everything is given in full,—Fresnel's brother having put his papers in Mr. Stevenson's hands.

One of Mr. Stevenson's own works was with the Isle of May light.

"Having been directed by the commissioners of the Northern lighthouses to convert the fixed catoptric light of the Isle of May, into a dioptric light of the first order, I proposed that an attempt should be made to form a true cylindric, instead of a polygonal belt for the refracting part of the apparatus; and this task was successfully completed by Messrs. Cookson of Newcastle in the year 1836. The disadvantage of the polygon lies in the excess of the radius of the circumscribing circle over that of the inscribed circle, which occasions an unequal distribution of light between its angles and the centre of each of its sides; and this fault can only be fully remedied by constructing a cylindric belt whose generating line is the middle mixtilinear section of an *annular* lens, revolving about a vertical axis passing through its principal focus. This is, in fact, the only form which can possibly produce an equal diffusion of the incident light over every part of the horizon.

"I at first imagined that the whole hoop of refractors might be built between two metallic rings, connecting them to each other solely by the means employed in cementing the pieces of the annular lenses; but a little consideration convinced me that this construction would make it necessary to build the zone at the lighthouse itself, and would thus greatly increase the risk of fracture. I was therefore reluctantly induced to divide the whole cylinder into ten arcs, each of which being set in a metallic frame, might be capable of being moved separately. The chance of any error in the figure of the instrument has thus a probability of being confined within narrower limits; whilst the rectification of any defective part becomes at the same time more easy. One other variation from the mode of construction at first contemplated for the Isle of May refractors, was forced upon me by the repeated failures which occurred in attempting to form the middle zone in one piece; and it was at length found necessary to divide this belt by a line passing through the horizontal plane of the focus. Such a division of the central zone, however, was not attended with any appreciable loss of light, as the entire coincidence of the junction of the two pieces with the horizontal plane of the focus, confines the interception of the light to the fine joint at which they are cemented. With the exception of those trifling changes, the idea at first entertained of the construction of the instrument was fully realised at the manufactory of Messrs. Cookson."

Speaking of Fresnel's lamp, used in the French lighthouses, Mr. Stevenson writes:—

"The only risk in using this lamp arises from the liability to occasional derangements of its leathern valves that force the oil by means of clockwork; and several of the lights on the French coast, and more especially the Corduan, have been extinguished by the failure of the lamp for a few minutes, an accident which has never happened, and scarcely can occur with the fountain lamps which illuminate the reflectors. To prevent the occurrence of such accidents, and to render their consequences less serious, various precautions have been resorted to. Amongst others, an alarum is attached to the lamp, consisting of a small cup pierced in the bottom, which receives part of the overflowing oil from the wicks, and is capable, when full, of balancing a weight placed at the opposite end of a lever. The moment the machinery stops, the cup ceases to receive the supply of oil, and, the remainder running out at the bottom, the equilibrium of the lever is destroyed, so that it falls and disengages a spring which rings a bell sufficiently loud to waken the keeper should he chance to be asleep. It may justly be questioned whether this alarum would not prove a temptation to the keepers to relax in their watchfulness and fall asleep; and I have, in all the lamps of the dioptric lights on the Scotch coast, adopted the converse mode of causing the bell to cease when the clockwork stops. There is another precaution of more importance, which consists of having always at hand in the light-room a spare lamp, trimmed and adjusted to the height for the focus, which may be substituted for the other in case of accident."

In the French lights, "these distinctions depend upon the periods of revolution, rather than upon the *characteristic appearance* of the light; and therefore seem less calculated to strike the eye of a seaman, than those employed on the coasts of Great Britain and Ireland. In conformity with this system, and in consideration of the great loss of light which results from the application of coloured media, all distinctions based upon colour have been discarded in French lights.

"The distinctions are, in fact, only *four* in number, viz.: fixed; fixed varied by flashes; revolving, with flashes once a minute; and revolving with flashes every half minute. To those might be added, revolving, with bright periods once in two minutes, and perhaps *flushing* once in *five seconds* (as introduced by me at the Little Ross, but I cannot say with such complete success as would induce me to recommend its general adoption). My own experience would also lead me to reject the distinction called 'fixed, varied by flashes,' which I do not consider as possessing a marked or efficient character."

For putting lights on a shore, Mr. Stevenson lays down a few laws for the engineer, which will be found very useful for those of our readers who may have to build lighthouses in our settlements abroad:—

"1. The most prominent points of a line of coast, or those first made on *over-sea* voyages, should be first lighted; and the most powerful lights should be adapted to them, so that they may be discovered by the mariner as long as possible before his reaching land.

2. So far as is consistent with a due attention to distinction, revolving lights of some description, which are necessarily more powerful than fixed lights, should be employed at the outposts on a line of coast.

3. Lights of precisely identical character and appearance should not, if possible, occur within a less distance than 100 miles of each other on the same line of coast, which is made by over-sea vessels.

4. In all cases, the distinction of colour should never be adopted except from absolute necessity.

5. Fixed lights and others of less power, may be more readily adopted in narrow seas, because the *range* of the lights in such situations is generally less than that of open sea-lights.

6. In narrow seas also, the distance between lights of the same appearance may often be safely reduced within much lower limits than is desirable for the greater sea-light; and there are many instances in which the distance separating lights of the same character need not exceed 50 miles, and there are peculiar cases in which even a much less separation between similar lights may be sufficient.

7. Lights intended to guard vessels from reefs, shoals, or other dangers, should in every case be placed, where practicable, to the seaward of the danger itself, as it is desirable that seamen be enabled to make the lights with confidence.

8. Views of economy in the first cost of a lighthouse should never be permitted to interfere with placing it in the best possible position; and, when funds are deficient, it will generally be found that the wisest course is to delay the work until a sum shall have been obtained sufficient for the erection of the lighthouse on the best site.

9 The elevation of the lantern above the sea should not, if possible, for sea-lights, exceed 200 feet; and about 150 feet is sufficient, under almost any circumstances, to give the range which is required. Lights placed on high headlands are subject frequently to be wrapped in fog, and are often thereby rendered useless, at times when lights on a lower level might be perfectly efficient. But this rule must not, and indeed cannot, be strictly followed, especially on the British coast, where there are so many projecting cliffs, which, while they subject the lights placed on them to occasional obstruction by fog, would also entirely and permanently hide from view lights placed on the lower land adjoining them. In such cases, all that can be done is carefully to weigh all the circumstances of the locality, and choose that site for the lighthouse which seems to afford the greatest balance of advantage to navigation. As might be expected, in questions of this kind, the opinions of the most experienced persons are often very conflicting, according to the value which is set on the various elements which enter into the inquiry.

10. The best position for a sea-light ought rarely to be neglected for the sake of some neighbouring port, however important or influential; and the interests of navigation, as well as the true welfare of the port itself, will generally be much better served by placing the sea-light *where it ought to be*, and adding, on a smaller scale, such subsidiary lights as the channel leading to the entrance of the port may require.

11. It may be held as a general maxim, that the fewer lights that can be employed in the illumination of a coast the better, not only on the score of economy, but also of real efficiency. Every light needlessly erected may, in certain circumstances, become a source of confusion to the mariner, and, in the event of another light being required in the neighbourhood, it becomes a *deduction* from the means of distinguishing it from the lights which existed previous to its establishment. By the needless erection of a new lighthouse, therefore, we not only expend public treasure, but waste the means of distinction among the neighbouring lights.

12. Distinctions of lights, founded upon the minute estimation of intervals of time between flashes, and especially on the measurement of the duration of light and dark periods, are less satisfactory to the great majority of coasting seamen, and are more liable to derangement by atmospheric changes, than those distinctions which are founded on what may more properly be called the *characteristic appearance* of the lights, in which the times for the recurrence of certain appearances differ so widely from each other as not to require for their detection any very minute observation in a stormy night. Thus, for example, flashing lights of five seconds interval, and revolving lights of half a minute, one minute, and two minutes, are much more characteristic than those which are distinguished from each other by intervals varying according to a slower series of 5″, 10″, 20″, 40″, &c.

13. Harbour and local lights, which have a circumscribed range, should generally be fixed instead of revolving; and may often, for the same

reason, be safely distinguished by coloured media. In many cases also, where the purpose of guiding into a narrow channel is to be gained, the leading lights which are used, should, at the same time, be so arranged as to serve for a distinction from any neighbouring lights.

14. Floating lights, which are very expensive and more or less uncertain from their liability to drift from their mooring, as well as defective in power, should never be employed to indicate a turning point in a navigation in any situation where the conjunction of lights on the shore can be applied at any reasonable expense."

The building of the lantern is a work of great care, and in which our writer has very cleverly made an improvement:—

"A considerable practical defect in all the lighthouse lanterns which I have ever seen, with the exception of those recently constructed for the Scotch lighthouses, consists in the vertical direction of the astragals, which, of course, tend to intercept the whole or a great part of the light in the azimuth which they subtend. The consideration of the improvement which I had effected in giving a diagonal direction to the joints of the fixed refractors, first led me to adopt a diagonal arrangement of the framework which carries the cupola of zones, and afterwards for the astragals of the lantern. Not only is this *direction* of the astragals more advantageous for equalising the effect of the light; but the greater stiffness and strength which this arrangement gives to the frame-work of the lantern make it safe to use more slender bars, and thus also absolutely *less* light is intercepted. The panes of glass at the same time become triangular, and are necessarily stronger than rectangular panes of equal surface. This form of lantern is extremely light and elegant. To avoid the necessity of painting, which, in situations so exposed as those which lighthouses generally occupy, is attended with many inconveniences and no small risk, the framework of the lantern is now formed of gun-metal and the dome is of copper; so that a first-order lantern of 12 feet diameter and 10 feet height of glass costs, when glazed, about £1260. In order to give the lightkeepers free access to cleanse and wash the upper panes of the lantern (an operation which in snowy weather must sometimes be frequently repeated during the night), a narrow gangway, on which they may safely stand, is placed on the level of the top of the lower panes, and at the top of the second panes, rings are provided of which the lightkeepers may lay hold for security in stormy weather. A light trap-ladder is also attached to the outside of the lantern, by means of which there is an easy access to the ventilator on the dome.

Great care is bestowed on the glazing of the lantern, in order that it may be quite impervious to water, even during the heaviest gales. When iron is used for the frames, they are carefully and frequently painted; but gun-metal, as just noticed, is now generally used in the Scotch lighthouses. There is great risk of the glass plates being broken by the shaking of the lantern during high winds; and as much as possible to prevent this, various precautions are adopted. The arris of each plate is always carefully rounded by grinding; and grooves about half an inch wide, capable of holding a good thickness of putty, are provided in the astragals for receiving the glass, which is a quarter of an inch thick. Small pieces of lead or wood are inserted between the frames and the plates of glass against which they may press, and by which they are completely separated from the more unyielding material of which the lantern-frames are composed. Panes glazed in frames padded with cushions, and capable of being temporarily fixed in a few minutes, in the room of a broken plate, are kept ready for use in the store-room. Those framed plates are called *storm-panes*, and have been found very useful on several occasions, when the glass has been shattered by large sea-birds coming against it in a stormy night, or by small stones violently driven against the lantern by the force of the wind.

The ventilation of the lanterns forms a most important element in the preservation of a good and efficient light. An ill-ventilated lantern has its sides continually covered with water of condensation, which is produced by the contact of the ascending current of heated air; and the glass thus obstructs the passage of the rays, and diminishes the power of the light."

We must now shut up Mr. Stevenson's book, though we could very well take more from it, for it is full of new and useful matter. We cannot, however, do so without giving our thanks to the Board of Northern Lights for publishing this book, as they before did the elder Stevenson's book on the Bell-rock lighthouse. In our last number we called strongly on the engineers to write books on their works; but, perhaps, we should have done better if we had called on the railway and other undertakings to find the money for it, as the Board of Northern Lights have done. There is something wrong now, and we cannot help thinking that the engineers are those most to blame. If Mr. Robert Stephenson would take under his care a book on the London and Birmingham Railway, we do believe that the shareholders would not grudge the money, as each of them could have a book. They have not grudged money for Wolverton, and we do not think they would for this, if it were fairly put before them by their engineer. The shareholders would never miss the money, while they would do a great deal of good. If the engineers do not stir, we hope the shareholders will; and that we shall have books on our great railway works, which may keep up their name and the honour of England.

Mathematics for Practical Men, being a common-place book of Pure and Mixed Mathematics, designed chiefly for the use of Civil Engineers, Architects, and Surveyors; by Olinthus Gregory, LL.D., F.R.A.S. Third Edition, Revised and Enlarged. By Henry Law, civil engineer. London: Weale, 1848. 8vo. pp. 510.

This is a new edition of a very well known book. An editor who undertakes the revision of the scientific labours of another writer, undertakes an onerous and difficult task. If he alter and interpolate freely, he may be charged with disrespect towards his author: if, on the other hand, he adhere too faithfully to the text, he becomes responsible for the original errors, as well as for all which he himself may happen to commit.

Dr. Olinthus Gregory, of the Woolwich Military Academy, published the first edition of his "Mechanics for Practical Men," in 1825; and eight years after, a subsequent edition, in which he says, "I have corrected a few errors which had escaped my notice in the former impression." The work commences with an elementary treatise on arithmetic and algebra, and the remainder is devoted to geometry and the mechanical sciences. This part of the work is, in his own phraseology, "synoptical." "The definitions and principles are exhibited in an orderly series, but investigations and demonstrations are only sparingly introduced." So much the greater, then, the importance of accuracy. Where results only are given, the reader must trust entirely to the authority of the writer: the process of investigation being omitted, there are no possible means of ascertaining the accuracy of the conclusions. They must be taken on trust. Like bank-notes, they may or may not represent sterling value; but in the absence of direct information, their circulation depends entirely on the credit of the issuer.

Engineers at the present day are pretty well agreed, that the accuracy of formulæ is something more than a matter of mere speculative interest—that, on the contrary, it has a real and tangible importance, quite apart from theoretical considerations. It was at one time thought that mathematical investigations of questions of engineering were matters of mere curiosity—learned pastimes. Now it is found, that if a bridge be constructed according to insufficient formulæ, it not only *ought* theoretically to fall down, but practically *will* do so. And if the duty of a steam-engine for a given quantity of fuel be inaccurately computed, not only are the laws of science infringed—but the pocket of the owner of the engine suffers also. In this way, scientific accuracy comes to have a practical importance, a real money value: and those who prided themselves that they were "practical men," and thanked heaven that they never troubled themselves about scientific theories, —which were all very well for college-students, and people who have nothing else to do,—discern faintly that their self-congratulation is premature.

These considerations render us very anxious that the theoretical science should not suffer discredit, nor practical engineering injury by misplaced confidence: and with this object in view, we proceed to the more particular examination of the work under review,—premising that, as far as we have compared it with the preceding edition, most of the errors appear to be Dr. Gregory's originally, and Mr. Law's by imputation only; and it is nothing but fair to suppose that the latter was actuated by a feeling of deference towards his author.

We pass over the treatises on arithmetic and algebra without examination; being altogether elementary, they may be presumed to be correct. Our criticism commences with the definitions of Curves.

"A *cycloid* or *trochoid* is an elegant mechanical curve, first noticed by Descartes, and an account of which was published by Mersenne in 1615. It is in fact the curve described by a nail in the rim of a carriage-wheel while it makes one revolution on a flat horizontal plane."

Cycloids "*or*" trochoids are used as synonymous words! They are names of curves essentially different: for the former, the tracing point is on the circumference of the generating circle—for the latter, the tracing point is within or beyond that circumference.

"If the generating circle, instead of rolling along a straight line, is made to roll upon the circumference of another circle, the curve described by any point in its circumference is called an *epicycloid*."

It is *not* called an epicycloid except when the generating circle is equal to the fixed circle, and rolls on the exterior of it. In the other cases, the curve generated is either a Hypotrochoid, Epitrochoid, or Hypocycloid. In the figure illustrating the definition of an epicycloid, this mistake is aggravated, by representing the rolling curve as much larger than the fixed curve.

It is of the very essence of mathematical definitions that they should be precise and comprehensive; and in no part of mathematics is this exactness of definition more necessary than in mechanics. What will our mathematical readers say of such a definition as the following?

"When the forces that act upon a body, destroy or annihilate each other's operation, so that the body remains quiescent, they are said to be in *equilibrium*, and are then called *pressures*."

This is clumsy and incomplete, to say the least. It is assumed, that when two forces "annihilate each other's operations," the body is at rest,—the case of uniform motion is overlooked. Besides, the word *pressure* is restricted to statical forces, whereas it is properly applied to dynamical forces also.

"*Vis viva*, or living force, a term used by Leibnitz to denote the force or power of a body in motion; or the force which would be required to bring it to rest."

Leibnitz never did anything half so absurd as is here said of him. *Vis viva* is not a force (or *power*,—for Dr. Gregory previously states that the words force and power are synonymous). *Vis viva* is a mere technical phrase—signifying, simply, mass multiplied by the square of velocity—which Dr. Gregory and his editor are determined to distort into something very complicated and abstruse. So far from *vis viva* being a force, it is not even *measured* by force alone—another element being the distance through which the force acts. When a body is acted upon by only one uniform force, the *vis viva* generated is equal to *twice* the force multiplied by the distance described in the direction of the force.

In the second problem of the chapter on Statics, the calculation respecting the strain on tie-beams and struts is totally erroneous. It is not worth while to state the problem here, as we could not make it intelligible without the diagrams. To the reader who has the work before him, it will be sufficient to state that the error arises from considering the forces at one end of the strut and tie-beam, and neglecting the forces at the other end of each. The conclusion is manifestly erroneous, for when the tie-beam became indefinitely long, it would be vertical, and the tension equal to the weight suspended; the strain on the strut at the same time becoming zero.

"If the particles or bodies of any system be moving uniformly and rectilineally, with any velocities and direction, the centre of gravity is either at rest, or moves uniformly in a right line."

This is not true. Does the author mean to assert, that if two bodies be moving with different velocities in straight lines perpendicular to each other, the common centre of gravity moves in a straight line?

In discussing the pressure of earth against walls, *the line of rupture* and the *natural slope* are said to be synonymous—they are entirely different things; the line of rupture being that which defines what is technically termed the wedge of maximum pressure. In the next paragraph is discussed the pressure exerted against the wall by the prism resting on the natural slope; whereas, by the very definition of natural slope, that prism exerts no such pressure, the friction being of the exact amount necessary to sustain the weight.

The section on the stability of the arch discusses the conditions for a case of rupture which is mechanically and geometrically impossible—that where there are only two joints of rupture, equidistant from the crown, the loading symmetrical, and the piers incapable of sliding. In the last of the formulæ in this section, the right-hand side of the equation has double it proper value.

The preliminary part of the chapter on Dynamics has been re-written,—not however, as we think, with great success. The confusion of ideas respecting *vis viva* is really marvellous, considering how simple the real signification of the phrase is. Mr. Law says, first, "Mechanical effect is measured by the product of the mass or weight of the body into the space over which it has moved." Then he defines the *vis viva* of a moving body as "the whole mechanical effect which it will produce in being brought to a state of rest." This definition is by no means satisfactory. First, the mass or weight are spoken of as convertible terms. Next, coupling the two definitions, the *vis viva* is said to "produce" the mass or weight multiplied by the distance. This is a strange expression: however, if we leave out the word "mass," and for "distance" read "twice the distance," the idea intended to be conveyed is tolerably correct, where the motion is vertical and the only force is that of uniform gravity. For bodies acted on by variable force, and for curvilinear motion, the definition is totally inapplicable.

In place of an enunciation of the three laws of motion, we have the following *experiments* as the foundation of dynamics.

"From carefully conducted and often-repeated experiments, the following results with regard to bodies in motion have been obtained:—

"I. If a body of a certain weight, and moving with a given velocity, meet another body of double that weight, and moving with half the velocity, the two bodies will destroy each other's motion, and *both* will be brought to a *state of rest*.

"II. A body of a certain weight and moving with a given velocity, being subject to a uniformly retarding force (*i. e.* a uniform force acting constantly in a contrary direction to the body's motion), will move over a certain space in being brought to rest, and will occupy a certain time in doing so; then another body of the same weight, but moving with *half* the velocity of the former, being subject to the same uniformly retarding force, will move over *one quarter* of the space moved over by the former, in being brought to a state of rest, and will occupy in doing so *half* the time. And another body of the same weight, but moving with *one-third* of the velocity of the first, will move over *one-ninth* of the space, and occupy *one-third* the time of the first, in being brought to a state of rest."

The second experiment would be analogous to that of trying whether all points in the circumference of a circle possess the property of equidistance from the centre! It is a matter of definition that they should do so. In the same way, the mere definition of uniformly retarding force leads to the inference here indicated as the result of numberless experiments. The conclusion depends on mere geometry, not on any law of mechanics. If a horse set off at a constantly diminishing speed—50 feet the first second, 49 feet the next, 48 feet the next, and so on—it requires no knowledge of mechanics, but a simple arithmetical computation, to ascertain how far he has gone, and the time which has elapsed, when his velocity is reduced to 20 feet a second. In the same way, if a body be acted upon by a uniformly retarding force—that is, one which diminishes the velocity at an assigned uniform rate—the law of motion is assigned *à priori*, and it requires no experiment to determine the distances corresponding to subsequent rates of velocity. The rule that the distance traversed before the body comes to rest is proportional to the square of the velocity destroyed, depends on purely geometrical computation.

In the section on Motion on Inclined Planes, we find the following:—

"Each particle of matter in a rolling body resists motion in proportion to the square of its distance from the axis of motion."

There is no such resistance, either in proportion to the square of the distance from the axis of motion, nor in any other proportion. It is incorrect to say that matter resists motion; it neither resists nor assists it, but is perfectly impassive and inert. The *force of inertia*, as M. Poisson observes, is an incorrect phrase, arising from inaccurate notions of the properties of matter—it, in fact, implies an idea that matter has some inherent property of altering its own motion.

In the section treating of Pendulums, it is asserted, that if a body suspended from a fixed point by a flexible string be made to vibrate, it will always rise the same vertical distance as it has descended. This is of course true when the motion is not disturbed; but it is added, that if the motion of the string be intercepted by a projecting peg, so as to shorten the radius of the arc in which the body moves, the same property holds. That this is not generally true is obvious, from the consideration that the peg may be so near the vibrating body, that the radius becomes too short to allow the body to regain its original height. Moreover, the string receives a jerk; and therefore, unless it be perfectly elastic, there is a loss of *vis viva*.

After a confused and inaccurate definition and table of values of the radius of gyration for several bodies, we have the following lucid explanation of the principles of rotation:—

"If the matter in any gyrating body were actually to be placed as if in the centre of gyration, it ought either to be disposed in the circumference of a circle whose radius is R, or at two points R, R′, diametrically opposite, and each at a distance R from the centre."

All that can be made out of this is, that if the body be in one place, it "ought to be" in another. The only inference from such a statement is a querulous determination on the part of the writer to be dissatisfied with the position of the body under all circumstances. The feeling is that of the wolf toward the lamb in the fable—a general disinclination that the body should have *any* position. Several preceding sentences gave rise to the suspicion that the author did not clearly understand the subject on which he was writing—the sentence just quoted converts suspicion into certainty.

The following are the definitions at the commencement of a chapter on Central Forces:—

"(1.) *Centripetal force* is a force which tends constantly to solicit or to impel a body towards a certain fixed point or centre. (2.) *Centrifugal force* is that by which it would recede from such a centre, were it not prevented by the centripetal force. (3.) These two forces are, jointly, called *central forces*."

Centrifugal force is not, as here stated, directed towards a fixed centre. It is normal to the path of motion; and, therefore, there is only one particular case—that of circular motion—in which the above definition is satisfied. In elliptical and other kinds of motion it is violated at every instant. This consideration is of itself sufficient to show that the third definition is also incorrect. Central forces are always taken by mathematicians to be forces directed from or towards a *fixed* centre—which centrifugal force is not.

The laws of motion about centres of attraction are applied to cases to which they have no relation. The following problem is an instance :—

"If a fly, 2 tons weight and 16 feet diameter, is sufficient to regulate an engine when it revolves in 4 seconds; what must be the weight of another fly of 12 feet diameter revolving in 2 seconds, so that it may have the same power upon the engine?"

It seems scarcely credible that the solution of this problem is derived from the law of motion of a free body in a circle about a central force—that "the forces are as the distances or radii of the circles directly, and the forces inversely." Could it be believed, that a student who had read mathematics for six months, would apply a law, which is wholly independent of the mass acted upon, to a problem in which the mass is the most essential particular? By such logic, the following relation between the weights of the two fly wheels is established:—

$$\frac{W\,D}{T^2} = \frac{w\,d}{t^2};$$

where W, w, are the weights; D, d, the diameters of the wheels; and T, t, the times occupied in revolution. Now, to show the absurdity of all this, we have only to express the times in terms of the linear velocities, V, and v, and the above equation becomes

$$\frac{W\,V^2}{D} = \frac{w\,v^2}{d};$$

which leads to the conclusion, that for two fly wheels of equal weight, that having the greatest velocity must also have the greatest diameter!—a conclusion to which our practical readers would probably demur.

It would take up too much space to explain all that appears objectionable in the work before us. Mr. Law certainly has the credit of rendering the new edition somewhat better than the preceding, by introducing De Pambour's investigations of the power of the steam-engine, and by several improvements of arrangement.

In the paper on the Strength of Materials, which is almost entirely re-written, Mr. Law gives some valuable views of the subject, which cause us to regret that he has not exercised keener criticism in other parts of the work. In estimating the tranverse strength of materials, an ingenious theory is proposed, for representing the total forces of extension and compression in any section of a girder by solids, of which lines proportional to those forces are the horizontal ordinates. Unfortunately, he overlooks the fact that the total forces of longitudinal compression and tension are equal and opposite. He assumes also that their moments are equal—which is incorrect. This error vitiates equation (I), page 373, and all that depends on it.

Our review must close here, not from want of subjects for further comment, but because of the space which they would occupy. We have done little more than point out, in the briefest possible manner, a few errors here and there; and have avoided general observations, lest our criticism should appear unduly severe.

The High-Pressure Steam-Engine; an exposition of its Comparative Merits, and an essay towards an Improved System of Construction. By Dr. Ernst Alban, practical machine maker, Plau, Mecklenberg. Translated from the German, with notes, by William Pole, C.E. London: Weale, 1848. 8vo. pp. 150.

This is the conclusion of a work of which the first portion was reviewed *ante*, vol. X., p. 45. It will be remembered, that the distinguishing feature of Dr. Alban's subject is an earnest advocacy of the merits of the high-pressure steam-engine, which, he contends, is for all purposes and under all circumstances, superior to the low-pressure engine. He proposes to increase the steam-pressure greatly beyond the limits now usually assigned to it; and as his observations are the result of long practical experience in the manufacture of engines, and in superintending their working, they are at least deserving of consideration. His arguments are those of a careful and judicious observer, and the details of his experience prove that he has pursued his profession with no ordinary amount of energy and ability.

In the present portion of the treatise, our author describes the form of the boiler and furnace adopted by himself, and which he recommends as models for general adoption. We must demur, however, to the notion of a *model engine*, and to any one routine of construction prescribed for universal practice. The steam-engine would lose much of its value if the arrangement of its parts were immutable. The diversity of forms which may be given to it, and the facility of adapting them to local exigences, render the steam-engine the most convenient, as it is the most economical, of motive agents.

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The principle which characterises Dr. Alban's boiler, is the circulation of hot water through the tubes, and the return to the boiler of the water which has been carried upwards in a liquid form with the current of steam. The dots in the diagram will sufficiently explain the relative position of the tubes. c, d, are two capacious vessels above them. The ends of all of them communicate with c, the "separator," into which, therefore, the steam generated, and the water mechanically mixed with it, are carried. At that end of this vessel where steam and water are admitted, violent ebullition goes on; but as the capacity of the boiler is large, the water and steam become more and more separated as they progress to the further end, whence they pass quietly by their respective pipes to the receiver d, in which an undisturbed water-level is maintained. From d, the steam passes off to the engine, and the water is returned to renew its labyrinthine course through the tubes of the boiler.

Our author assures us that he has determined the efficiency and economy of this invention, by actual and careful experience. The advantage which he claims is, chiefly, that of having a tube surface, subject to the direct action of the furnace, and yet not liable to excessive ebullition or boiling dry. The tubes are of small diameter; consequently, their heating surface bears a higher proportion to the volume of water in them, than would be the case with tubes of a larger diameter. This circumstance, Dr. Alban insists upon as most important for the economical generation of steam. At the same time, the tubes lie so far below the water-level, that a want of water in them is scarcely likely to occur: and if it did, it would take place first in the higher tubes, which are the least exposed to heat.

It will strike some of our practical readers, that this mode of construction, and the smallness of the tubes, must render them exceedingly liable to be impaired by the accumulation of deposit. We are told, however, that this is by no means so formidable a difficulty as it may at first sight appear, as the stony concretion is confined to the upper tiers of tubes, and the arrangement affords easy access to them. It is however allowed, that tubes of so small size as those here described would not be applicable to marine boilers, in which a great deposit from salt water takes place.

After a minute description of the boiler, the writer proceeds to an examination of improvements of the furnace. He does not deem of much importance the "smoke nuisance," as it is emphatically termed in England, and decries the legal restrictions to which engine owners are subjected in Germany, to prevent them from forcing the bituminous vapour and soot of their furnaces down their neighbours' throats. "The English," says he, "continue to live well among their smoke, and find themselves well off on it; they neither turn up their noses nor get asthma, but they live, and live long." We, however, who live in England, are not easily to be persuaded that the vitiation of the air by smoke is a slight evil. The pollution of the air in London and the manufacturing districts, inflicts mischief of which the magnitude can only be appreciated by actual observation. The cities of the continent, by the limits of their size, and the comparative insignificance of the manufactures carried on in them, are so little subjected to the injury in question, that it is not surprising that a foreign writer should speak slightingly of it. But the thousands who annually fall victims to the chimney-polluted atmosphere of this metropolis, give mournful proof that it is no false sentimentality—no popular prejudice, that have at length rendered the sanitary regulation of manufactures an irresistible obligation on the legislature. Dr. Alban considers all the self-acting contrivances for consumption of smoke useless; and deems it vain to expect that any future inventions for the purpose will succeed. It is sincerely to be hoped, however, that an object of such paramount importance will not be given up in despair. There can be no question that much improvement has already been effected, and that the combustion of fuel is conducted in a more complete and perfect manner now than it was a few years ago. When the necessity of further exertions becomes apparent, that parent of invention will stimulate our mechanicians to greater efforts and to the discovery of methods which, we are convinced, have not yet been attained, because the inquiry has been partially or feebly conducted.

The subject next considered is the engine itself, in which several improvements are proposed. According to our author's principle of confining himself to one exclusive model for every part of the steam-engine, he here selects the oscillating-cylinder for universal adoption. The history of these cylinders as given by the translator is curious, and affords interesting testimony that a discovery, after being abandoned by the original inventor as useless, may be taken up by others with complete success. In 1802, Trevethick took out a patent for an engine, in which cylinder, boiler, and furnace *all swung together;* and adds, that if it be desirable, *all the other parts may be fixed except the cylinder, which may be suspended on trunnions or pivots perforated for the admission of steam.* Other patents were also taken out for moveable cylinders; but the first oscillating-engines actually made, were those of Mr. Aaron Manby, and his son, the present able secretary of the Institution of Civil Engineers. The important addition of the slide-valve was patented by Joseph Maudslay, in 1827; who, by combining the D valve with eccentric gearing, made an important step in perfecting these engines.

Dr. Alban proceeds to discuss the several objections usually urged against the the oscillating-cylinder, and to explain its advantages. To the objection, that injurious lateral strains are produced every time the motion is reversed and the momentum arrested, he replies, that in steam-engines of ordinary construction, the parts subjected to reciprocating motion (the beam or side-levers) are usually heavier than the cylinder, and vibrate through a much greater arc. Though this be true, we must remark that the arrangement of the oscillating-engine renders it mechanically, or rather geometrically, impossible that its motion can be so even and regular as that of the beam-engine. By the arrangement of the ordinary crank, the motion of the beam is slowest at the two limits of its motion: it comes gradually to rest at the extremity of the arc of vibration, so that every thing like concussion is avoided: and that this advantage is attainable in the most perfect degree, is proved by the fact that in properly constructed engines, the most ponderous beams move without producing a jar or concussion. In the oscillating-engine, however, there is a peculiarity in the arrangement which precludes uniformity of motion. The arc through which the crank revolves while the cylinder oscillates in one direction, is less than a semicircle—and greater than a semicircle while the cylinder oscillates in the contrary direction. Hence, if the motion of the crank be uniform, the cylinder oscillates from right to left, and from left to right, in unequal times. If, on the contrary, the oscillations of the cylinder be regular, the crank moves faster when it is near the cylinder than when at its greatest distance from it. In practice, these two variations are compounded—or, if the phrase be allowable, the irregularity of motion is *shared* between the crank and the cylinder. Of course, the motion of the piston and other parts is affected by it. The actual amount of it depends on the relation between the length of the crank and connecting-rod, and the distance of the trunnions of the cylinder from the centre of the crank; and, *cæteris paribus*, the uniformity is increased by increasing the distance of the swing centre from the crank-shaft: but perfect regularity is unattainable.

To the objection, that the cylinders are unequally worn by the piston pressing first on one side and then on the other, the author replies, that this objection can only apply with much force where the pistons are large and heavy, and that the hemp packing (which he always prefers to metallic packing) almost entirely remedies the evil.

The disadvantage arising from the friction of the trunnions on which the cylinders swing, and which are usually perforated for the admission and eduction of the steam, is remedied by the author by suspending the cylinders—not on the gudgeons through which the steam passes—but on a separate frame, having no communication with them. After enlarging on the great increase of friction resulting from the heat of the metal, he shows that by keeping the actual bearings on which the weight of the cylinder is supported, separate from the steam passages, the heat of the rubbing parts is comparatively trifling, and that a great amount of friction is consequently avoided.

The fourth objection considered is, that "when the distance of the trunnion-axis from the crank-shaft is too small, the vibrations are unequal, as is also the force transmitted to the engine." To this remark the translator briefly replies, in a note, that "the objection has no weight at all." With great deference to Mr. Pole's authority, there is considerable weight in the objection. He has not appended to his *dictum* any reasons in defence of it, and there is therefore hardly any other way of meeting him than by counter-assertion. Does he mean to assert that the vibrations are performed in equal times? If so, it is quite clear, from the geometry of the case, that the crank moves at variable rates; and this is sufficient proof that the force is not uniformly transmitted to the working parts. If, on the other hand, the motion of the crank and the transmission of force be uniform, the oscillations of the cylinder take place in unequal times. There is no escaping from one or other of the horns of the dilemma. We do not insist on the disadvantage as necessarily serious; but that it exists, and is unavoidable, is obvious from mere inspection of a diagram showing the relative positions of the cylinder and crank.

The advantages of the oscillating-cylinder on which our author earnestly enlarges, are—1st, its simplicity, arising from the omission of the beam, parallel motion, and other parts; 2nd, the facility of construction, the fitting being in a great measure effected by the lathe; 3rd, compactness, and consequently suitability for steam-vessels; 4th, comparative lightness; 5th, the consequent portability; 6th, diminution of prime cost; 7th, the simplicity of working management; 8th, the diminution of friction; 9th, the saving of grease for lubrication; 10th, the little repair required; 11th, the facility of discovering and rectifying any error of adjustment; 12th, the omission of guides for the piston-rods; and lastly, the direct and advantageous transmission of force.

There is one remark to be made on this enumeration of the advantages of the oscillating-engine, which, though simple, deducts greatly from its claims to pre-eminence.—The greater part of the merits claimed for it do not belong to it exclusively, but are common to all kinds of direct-action engines.

Among the prominent features of Dr. Alban's views, is the preference which he tells us that long experience has induced him to assign to hemp packing for the piston. Contrary to the opinion of many practical men, who believe the metallic packing absolutely indispensable for high-pressure engines, he considers that method fraught with inconvenience. It may however be observed, that many of the disadvantages (those arising from imperfect workmanship) are more likely to arise in Germany than in England, where we may justly pride ourselves on the marvellous perfection which has been obtained in the manufacture of the details of the steam-engine.

Other objections to metallic packing are not to be thus disposed of. The cylinder and the piston are frequently of different metals, and therefore liable to different rates of expansion; consequently, the adjustment of the packing, though perfectly accurate when the metals are cold, becomes untrue after they are heated. Dr. Alban denies that the packing grinds itself steam-tight by working; on the contrary, he believes that if any imperfection exist originally, it is aggravated by use. We are however inclined to believe that he speaks on this point from limited experience, for while the elasticity remains unimpaired, it presses against the cylinder any irregular protuberances which may exist, and the adjacent parts are protected from attrition till these be worn down to an even surface. Of course, if the elasticity of the packing be unequally distributed, those parts most forcibly pressed against the cylinder will wear thin and be destroyed before the portions of the packing subjected to less pressure.

The liability of the packing to lose its expansive power, either by the component parts cohering and losing their mobility, or by the heat destroying the elasticity of the springs, is strongly insisted upon. It is also asserted that the complexity and number of the parts render them liable to get out of repair, and that they can never fit so closely as to be perfectly steam-tight. Hemp packing is preferred on account of its simplicity; and the author states, as the result of his experience, that a packing of rope, of loose unspun fibres, thoroughly lubricated, works well and remains steam tight under high pressures. We will not absolutely assert that there are not any circumstances under which this kind of packing may be used with advantage, but many of Dr. Alban's prejudices must have arisen from observing the working of metallic packing of inferior construction; and probably, if he were acquainted with the great improvements which have been effected in England in this part of the steam-engine, he might be induced to modify his opinions.

There are many other topics of the treatise before us deserving attention, but we must content ourselves with remarking, generally, that the very original views taken by the author are not those of an ingenious schemer merely, but of one who combines originality of invention with practical knowledge, and enhances both by the power of logical induction exhibited in the methodic arrangement of his arguments, and the distinct statement of the results of his experience.

The Assistant Engineer's Railway Guide. By W. Davis Haskoll, C.E. Part II. London: John Williams and Co., 1848.

Many excellent works on subjects connected with the profession of the civil engineer have at various times been published. But while the wants of the more advanced portion of the profession have been comparatively well supplied, the junior members have been left, at their entrance on the practical duties of their calling, almost without any guide to assist them. The need of a book, treating in a practical manner of the minor, though most important, operations which form the principal duties of the assistant engineer, has long been felt; and we are glad to find that this requirement has been satisfied by Mr. Haskoll, in the work before us.

In the first part, published in 1846, the subjects of setting-out the centre line, taking the permanent section, boring, and the other operations preliminary to breaking ground, were discussed; in the second part, the author has devoted his attention to the setting-out of works, the subject of earthwork, the formation of the permanent way, and the many operations necessary while the railway is in progress of construction. These various topics are treated in a clear and practical manner: every variety of work, whether on the skew or square, on a straight line or curve, is considered; and the methods of setting-out, and the precautions necessary during the construction are shown. The author is no advocate for the "rough-and-ready" system, but inculcates a careful attention to accuracy in every particular. Were this course more commonly adhered to, we should not so often hear of failure in works, causing often loss of life, and always profuse expenditure of capital. The following passage will illustrate the author's views on this subject:—

"Let me persuade the young practitioner, that the gratification he will feel at finding the string-courses of his bridges and viaducts at their true height and gradient, or the formation of a tunnel at the intended levels, will alone amply reward him for his trouble, independently of a reputation for accuracy, which he will not fail to obtain in the opinion of a judicious chief, as also in the estimation of directors. Let him beware of the vaunts of 'rough-and-ready' men (*rough* work and *readiness* to blunder), who disguise their incapacity and ignorance, by pleading the impossibility in practice to obtain truly correct levels; for if there be any truth, rationally speaking, in this excuse, the greater should be the engineer's care to avoid errors, and not to do his work in a slovenly manner, whereby he may double and treble his '*mistake;*' and he will find that contractors, masons, bricklayers, &c., will be careful and attentive, exactly in proportion to the care and attention which he himself bestows on the works. This observation applies exactly in the same sense, and to the same extent, in setting-out works. He will, moreover, have the satisfaction of knowing, that his mind on this subject will be at ease as the works proceed, and that no reproach can be made to him; on the contrary, an error of this kind carried out can be considered little better than wilful neglect of duty."

After giving an example of a section book, containing columns for the half-widths, distance, total rise, finished levels, excavation, and embankment, on one side,—with a sketch of the surface, and notes of the position and particulars of bridges, culverts, &c., on the other,—the author adds the following hints:—

"The pocket section being prepared so far, we should, as soon as the works of construction are determined on, insert notes from the working drawings, or otherwise, of the angles of skew at which the line crosses roads, canals, &c.; the spans of arches on the square and skew, the rise of the arch, the depth of arch-stones, of puddle, if any; also, if the works be on an inclined plane, the rise or fall from centre to centre of piers; memoranda also, of nearly similar nature, should be made of girder bridges, culverts, drains, and other works occurring along the line. These remarks are more than necessary; because, when on the works, the drawings, when required, are often mislaid, or partially defaced or destroyed. It must be added, however reluctantly, that the tracings with which contractors and sub-contractors are supplied, are often wrongly figured; and the site of construction, amidst the moving to-and-fro of masons, labourers, and 'navvies,' is not the place where such errors may be most readily detected and corrected."

The second chapter is devoted to earthwork; and here the author shows a practical acquaintance with the numerous considerations that determine the course to be taken in the treatment of this most important feature of the works of a line of railway. We subjoin a few extracts on cutting and embankment:—

"The determination of slopes for earthwork is one of the most uncertain subjects the engineer has to contend with, if he be anxious to reduce as much as possible the quantity of excavation, and that of land to be purchased—both formidable items of expense: but this reduction is attended with one great danger—namely, a 'slip,' which will often, for a considerable length, occasion a double and treble quantity of excavation, and the purchase of a corresponding quantity of land. * * * The slopes of cuttings in gravel will stand at almost any depth at 1¼ to 1, and at depths of 10 feet and 15 feet at 1 to 1;—chalk is more uncertain; in solid rocky masses, it will stand perpendicular; friable, it may require slopes of 1 to 1;—shale will stand at a ½ to 1, if the stratification be horizontal and dry, but when wet and soapy, there will be great uncertainty;—clay, however, is by far the most uncertain and treacherous earth to be met with in excavating; we have known it for many months to stand perpendicular for a depth of 40 feet, and suddenly slip off, determining a slope of 3 to 1; there is no doubt, that one of the most dangerous practices of excavators is to allow a gullet of this depth and nature to stand for a great length of time without lightening the sides, nor should it under any circumstances be allowed. A thin bed of clay will very often occasion the slip of material of a better nature. * * * When a slip has once fully declared itself, there is little left but to submit to the circumstance, and to form the slope to the extent determined by the slip; except, indeed, in the case of buildings, or gardens, &c., when we must have recourse to retaining walls and long counterforts, with a good system of drainage, which will always be found indispensable; so much so, that no good results can be expected from the best built and thickest walls without it."

"The best materials for the formation of embankments are gravel and sand, both from the facilities they offer for drainage, and their more rapid final consolidation;—*soft*, shaly earths are unfavourable, but if hard and dry they form good embankments, and settle well at slopes of 1 to 1;—vegetable earths, or what is termed soil, must be entirely rejected for the embankment, from their being so easily converted into soft mud; landowners, however, are always ready to carry these away, but care should be taken to preserve a sufficient quantity for soiling slopes, as when a good depth of soil has once produced a strong vegetation, it forms one of the best safeguards to slopes;—clays mixed with a quantity of stones, are by no means a bad material, and if dry, will form a sound embankment, though rather long in consolidating;—wet clay is as bad as peat, if not worse; it should never be allowed to be used under any circumstance whatever; a few wagons of wet clay, tipped in a deep embankment, will do more mischief by its slipping, and saturating all other materials laid on it, than one or even two thousand of good stuff will rectify, besides becoming for many years a continual source of settlement, and perhaps of danger, on that portion of the line. Where the less favourable materials must be employed for forming embankments, it is as well to make an exception to the general rule, of forming at once an embankment to its full height and width, and to leave a few feet in height to be raised up with drier materials, *if conveniently at hand;* isolated masses of this description are often found in excavations, otherwise of very inferior materials, which may be successfully employed for this purpose."

Two tables are given at the end of this chapter, which will prove of great assistance in estimating earthwork. The chapter on setting out of works goes very completely into the whole subject, and will render most valuable assistance to the young beginner; indeed, the information therein contained can be found in no other book than the one before us. After tables of experiments, by George Rennie, Esq., on the strength and other properties of various materials, now for the first time published, are given the specification and drawings of a very elegant and scientifically, designed laminated arch, over the river Ouse, on the East Anglian Railway, designed by J. S. Valentine, Esq.; and at the end of the book are placed many tables of a useful character.

Facts and Evidence Identifying the Authorship of the Letters of Junius. By John Britton, F.S.A.

Mr. Britton, who takes in a wide range of subjects in his antiquarian ken, has added a new book to the many on the *vexata questio* of the authorship of "Junius." He favours Colonel Barré. This discussion does not come within our scope,—but it does to record the labours of one who has contributed so much to architectural literature.

Irish Wants and Practical Remedies; an Investigation on Practical and Economical Grounds, as to the Application of a Government System of Railways in Ireland. By Humphrey Brown, Esq., M.P. London: Barnett, 1848.

Many of our readers will care very little about a system of railways for Ireland, though this little work deserves attention for what it says on that subject; but it requires notice as being the only attempt yet made to apply statistically to a given case the doctrine that railways can be made by means of existing resources, and that they are of a reproductive character. An additional value is given to it, that it contains the latest statistics on railway subjects, and many novel applications of them.

Among the chief points discussed, are the number of persons temporarily employed and permanently employed; the saving and reproduction on agricultural resources; the effect of extending the area of supply by extending the radius of communication; the average contribution and mileage of each head of traffic; the pecuniary or capital resources of Ireland; the correspondence between traffic estimates and traffic returns; and the existing traffic on Irish lines of road.

The following is a curious illustration of railway economics, and supplies evidence on a question which has been often mooted:—

"Mr. Porter, in the new edition of his work on the Progress of the Nation, p. 30, has given a table of the estimate of traffic given to parliament by several railways, and by appending to them the actual traffic from the returns made in 1845, we shall be able to see how far the estimates have been borne out.

The estimates for the railways constituting the Midland Railway, are as follows:—

	Passengers.	Cattle.	Sheep.	Merchandise by Land. Tons.	Coals by Water Tons.
Birmingham and Derby	145,747	7254	27,105	14,547	—
North Midland	149,812	—	—	124,350	—
Midland Counties	255,424	—	—	12.948	285,000
Total estimated	550,985	7254	27,105	151,855	285,000
Midland Railway, 1845	1,809,145	30,000	120,000	371,154	313,854

The Midland Railway traffic included, likewise, 30,000 pigs, and 56,290 tons of lime. The merchandise carried by water was estimated at 255,738 tons, and this, and a great quantity of coals, are still carried by water, so that the railway has, as it were, created an amount of traffic.

The estimates and returns for the Manchester and Leeds Railway stand thus:—

		Merchandise by Land. Tons.	Total Goods by Land and Water. Tons.
Estimates	207,588	106,486	358,958
Returns	1,674,946	507,852	—

Thus the traffic on the railway is greater than all that previously moving by land and water, although the canal traffic is as great as before.

The estimates and returns of the York and North Midland Railway stand thus:—

	Passengers.	Merchandise by Land. Tons.	Merchandise by Water. Tons.	Coal by Water. Tons.	Cattle.	Sheep.
Estimates	185,660	5547	95,100	98,000	53,000	110,600
Returns	461,755	351,022	—	—	15,364	87,639

The traffic in this case resembles that of the Manchester and Leeds in its results.

The following are the estimates and returns of various other railways:—

		Passengers.	Merchandise. by Land. Tons.
London and Brighton	Estimates	226,444	43,765
	Returns	788,386	65,747
South Eastern (1847)	Estimates	317,259	63,079
	Returns	1,477,802	204,100
Great North of England	Estimates	75,158	32,136
	Returns	196,729	234,198
Great Western and Bristol and Exeter (1847)	Estimates	821,145	150,719
	Returns	3,876,222	371,326
Lancaster and Preston	Estimates	106,957	——
	Returns	135,344	26,099
Glasgow and Ayr	Estimates	597,470	121,027
	Returns	834,078	168,370

This will be found useful as a book of reference, on account of the facts and figures it contains, and the mode in which they are applied, as it is the only work which has yet embraced the subject of railway traffic in a practical and comprehensive manner.

REGISTER OF NEW PATENTS.

REDUCTION OF COPPER ORES.

Charles Low, of Roseberry-place, Dalston, Middlesex, gentleman, for "*Improvements in the manufacture of zinc, copper, tin, and other metals.*"—Granted November 4, 1847; Enrolled May 4, 1848

The title of this patent is more comprehensive than the specification, as the patentee disclaims all parts of the title, excepting that relating to copper. The object of the improvements is to quicken the manufacture of copper from its ores, and to diminish the loss of metal. In reducing the ores a compound is employed, consisting of oxide of manganese, plumbago, nitrate of potash, nitrate of soda, or lime, and carbon. The proportions of these materials the patentee states to be, oxide of manganese forty-two parts, plumbago eight parts, nitrate of potash, nitrate of soda, or lime, two parts, and carbon fourteen parts; the carbon to be used, the patentee prefers to be either anthracite coal or wood charcoal. The mode of operation is as follows: the ore is roasted in the usual manner and then melted; and when in this state, the composition of the four materials named is introduced into the furnace and well mixed with the melted ore. The composition is introduced in the proportion of twenty-five pounds weight to one ton of ore operated upon, and acts as a flux. The slag rises more rapidly than ordinary to the surface of the melted mass, and is then to be skimmed off. When the workman perceives the metal is in a sufficiently forward state of manufacture, a second quantity of the composition in equal proportions is added, and the mass is again stirred and skimmed. Additions of the composition are repeated if necessary, until the copper is in a sufficient state to be removed and operated upon in the usual manner. Should it be considered desirable, the composition may be introduced at any of the subsequent meltings of the ores, either in addition to, or without being introduced at, the first melting. The patentee does not confine himself to the precise proportions specified of the materials, nor to the precise mode of operation described, but claims the employment of the compound of oxide of manganese, plumbago, nitrate of potash, nitrate of soda, or lime, and carbon.

DRESSING ORES OR MINERALS.

William Brunton, jun., of Poole, Cornwall, civil engineer, for "*certain apparatus for dressing ores or minerals.*"—Granted November 16, 1847; Enrolled May 16, 1848.

This invention consists in the application of centrifugal force combined with the upward impulse of water in the dressing of small ores. The first part of the apparatus consists of a tank from five to six feet square; within this is fitted a sieve, having a wove wire or perforated metal bottom, the apertures being adapted in size to the ore about to be dressed. This sieve is fixed upon an upright shaft or spindle, revolving in a bearing at the bottom, and having a turned journal at its upper end. The depth of the annular margin or sides of the sieve is about eight inches. Immediately under the bottom of the sieve a partition, enclosing about one-third of its area, crosses the tank, and having communication with the discharge pipe of a force-pump. On the opposite side of the tank is a receptacle for the ore, and this is supplied by an instrument termed a "skimmer;" its lower end forming a mouth, and equal in breadth to the semi-diameter of the sieve; the stem being hollow, and bent at a certain portion of its length (turning downwards), so that anything passing through it will be deposited in the receptacle attached to the tank. A rotating motion being given to the sieve by means of wheels and pulleys fixed upon the upper end of the upright spindle, and the sieve being charged with ore or mineral by means of a hopper placed above it, the mouth of the skimmer is so regulated that, as the whole revolves, the water is forced upwards through the sieve by the action of the force-pump. The ore, by excess of weight, falls through the bottom of the sieve into the tank, and the waste is carried into the mouth of the skimmer, in consequence of the rotating force, and passes thence through the pipe or stem into the adjoining receptacle. The stream of water which is carried with the waste returns into the tank, and is sufficiently clean to be used again. The area of the piston of the pump should not be less than one-third the area of the sieve, and from 60 to 100 impulsions should be given by the pump before the skimmer is set to work; by this means the particles are raised, separated, and adjusted according to their specific gravity and bulk. Should the "orey" stuff be larger than the apertures of the sieve, the feed from the hopper is shut off by a little door that closes its mouth, and a shoot being placed on or under the lower end of the stem of the skimmer which is lowered to take up the ore, it then passes through the stem into any receptacle placed to receive it. By another arrangement of the machine the skimmer revolves instead of being fixed, and traverses the ore at a regulated depth from the surface, and the waste is carried by the rotating force and the stream of water into the skimmer, and from thence into the central compartment, from whence it passes down the hollow shaft into the receptacle appointed to receive it. The second part of the invention relates to a method of dressing small ore and sleines of ore. A hollow frame or trunk, has for its section the exterior form of a cone, which converges to its centre from the extremes of its base, and terminates in an aperture having a cock. To this centre is fixed an iron arm or step, upon which the whole apparatus revolves. The apex is formed like a goblet, for the purpose of a funnel, into which the small ores are poured. On each side or limb of this trunk or hollow frame are attached three receptacles, the first opening from the trunk into the uppermost one, being about one-third from the apex or funnel; the second communicating with the middle one, at about two-thirds from the apex; and the third at the angle or extremities of the base. A pulley is fixed to the under side of the funnel, by which a rotating motion is imparted to the whole of the hollow frame, and the small ores in a moistened state are poured into the funnel, and pass down the hollow trunk. The centrifugal force of the revolving trunk causes the heaviest of the ores to be discharged at the upper opening into the adjoining receptacle; the next less in size into the middle one, and the least, or sleines, into the lower one. The water which passes into the trunk with the small ore or sleines of ore, is discharged by means of the cock at the base, immediately above the step upon which the whole revolves. When the receptacles are full, the small doors in front of each are removed, and the ores are taken out and placed in the usual bins, according to their various sizes. The patentee claims—first, the conveying the ores and waste into another receptacle over the annular margin of the sieve, by means of a skimmer-pipe and stream of water; secondly, the application of the force-pump; and thirdly, the application of centrifugal force for producing artificial gravitation.

MANUFACTURE OF PIGMENTS.

William Edward Newton, of Chancery-lane, for "*Improvements in the mode or modes of manufacturing or preparing certain matters to be employed as pigments.*" (A communication.)—Granted November 16, 1847; Enrolled May 16, 1848.

This invention relates to the manufacture of zinc-white, zinc-yellow, and zinc-green, though it is principally directed to the formation of zinc-white, the other pigments having been the subjects of a former patent. The processes are described at great length in the specification, but the claims of the patentee will sufficiently explain the nature of the proposed improvements. He claims—First, the distillation of metallic zinc, of oxide of zinc, or zinc ore, by one of several means mentioned. Second, the application of furnaces similar to glass furnaces and coke ovens, and the modification of them respectively in order to fit them for the purpose of manufacturing zinc-white. Third, the construction of furnace, formed of two cylindrical tubes placed side by side with furnaces or fire-places formed in the lower part of the brick-work. Fourth, the isolating the retorts from each other and also cutting off the communication between the retorts and the oxidizing chamber when required. Fifth, the employment of suitable apparatus for cleansing the mouths of the retorts without being obliged to enter the oxidizing chamber. Sixth, the arrangement of apparatus by which the retorts may be charged, cleansed, and replaced, or submitted to any operation required, without interfering with the oxidizing chamber. Seventh, the application or employment of blast furnaces for the production or manufacture of zinc-white or oxide of zinc, whether such furnaces are circular or of any other suitable form, and whether they are constructed and arranged in a vertical, inclined, or horizontal position. Eighth, the employment or introduction of currents of air into an oxidizing or other chamber, for the purpose of converting the metallic vapours of zinc into zinc-white or oxide of zinc; also the employment of an exhaustion-tube or blowing-apparatus for conducting the metallic vapours to the oxidizing chamber. The patentee claims also the employment of wire-gauze or sieves for sifting the products; also the arrangement of vessels for receiving the heaviest portions of products. Ninth, the arrangement of the oxidizing chambers so as to allow of the products being collected without the necessity of entering them. Having described all that appertains to the manufacture and manner of collecting zinc-white, the patentee next proceeds to an explanation of that part of the invention which relates to the yellow of zinc and green zinc. As the manufacture of zinc-yellow forms the subject of a previous patent, he merely remarks that hydrochloric acid may be used instead of sulphuric acid. To form zinc-green, yellow (having been produced by the patented process,) is diluted with a suitable quantity of water, and mixed with a certain quantity of prussian blue (previously mixed with a suitable quantity of water, oil, or other appropriate liquid), either in a hot or a cold state. Green of zinc will thus be formed, the colour of which will be as durable as the blue itself. These pigments may be employed for painting of any kind.

SMELTING COPPER ORES.

William Birkmyre, of Southdown, Cornwall, for "*Improvements in smelting copper and other ores.*"—Granted November 16, 1847; Enrolled May 16, 1848.

The chief object of this invention is to remove the nuisance arising from the sulphuric and sulphurous acid vapours, and from the vapours of arsenic, during the smelting of copper ores. The process is thus described:—A double iron pyrites kiln is constructed upon the usual principles, the ash-pits being furnished with a leaden cistern, filled with water, to abate the nuisance arising from the sulphurous and arsenious acids, when drawing out the mundic ashes. Over the charging-door for the mundic, is an air-hole, provided with a damper, to regulate the passage of the oxygen necessary for combustion. The size of the double iron pyrites kiln should be 13 feet long, 7 feet 4 inches wide, and 8 feet high, and each furnace should be 5 feet in diameter, and of an octagonal form, lined with fire-bricks. Above the charging-door for the mundic, resting on two or three bars, is a tray, made of iron or copper, 4 feet 6 inches long, 3 feet 6 inches wide, and having a rim round it three or four inches deep. This is so placed as to enable the air and acids to pass freely out of the top of the furnace into a vitriol chamber, which is placed over the kilns. The vitriol chamber should be 150 feet 6 inches long, 11 feet 3 inches wide, and 9 feet deep, divided into three compartments, technically called "bottoms." The acid in that compartment nearest to the kiln being impure, should be kept apart, but the acid in the second and third compartments will be found to contain good vitriol. These pair of kilns will be found capable of producing two tons of copper per diem, by means of mundic, and, at the same time, of three tons of vitriol of a specific gravity of 1·847. The copper ore being broken into pieces, about the size of walnuts, is put into the tray by means of a shovel or hopper (the furnace being charged with iron pyrites and previously kindled). After a lapse of six hours the other kiln is to be charged in like manner, and so on alternately. For every 8 cwt. of mundic ashes withdrawn, add a charge of 10 cwt. of mundic containing 40 per cent. of sulphur, as for every 32 parts of sulphur it loses, it gains only 12 parts of oxygen; but in copper ores, if the process is carefully completed, it gains as much in oxygen as it loses in sulphur; some copper ores it is stated will gain as much as four per cent. About 1½ cwt. of ore should be placed in the tray, and the charge should be spread out into a body of from one to two inches thick, which should be turned over now and then, in order that every part of it should be exposed. After being submitted to the process for one hour, it is to be turned into a leaden cistern, supplied with hot water from the cooling cisterns underneath the kilns, to undergo the process of lixiviation. The tray is then again charged with ore, and the process is continued. It requires two roastings and lixiviation by the electro-metallurgic process to obtain the pure copper. Another method of calcination is, when the pulverized copper pyrites are exposed in the tray, pour upon them a hot solution of nine parts of saltpetre, and eight parts of cubic nitre, or 16 per cent. of saltpetre and 10 per cent. of vitriol, or equal quantities of saltpetre and vitriol to half the quantity of the ore. By this system, the deutoxide of nitrogen, necessary for making vitriol on a large scale, is separated, and the oxidation of the ores accomplished. The patentee claims—First, the roasting separately common ores of copper and other metals, by exposing them in an open vessel in a mundic-kiln, so that the vapours shall freely mix with the vapours of combustion of the iron pyrites, and be condensed at the same time in the vitriol chamber. Secondly, the separating simultaneously the deutoxide of nitrogen, for the vitriol chamber, with the oxidation of the ores, by saltpetre or cubic nitre. Thirdly, the supplying the vitriol chamber with steam, by using saltpetre or cubic nitre; and, fourthly, the action of sulphuric acid upon the ores, either before or after they have been freed from the sulphate and arsenic of potash and soda.

ROTARY ENGINES.

Israel Kinsman, of Ludgate-hill, London, merchant, for "*Improvements in the construction of rotary engines, to be worked by steam, air, or other elastic fluid.*" (A communication.)—Granted November 11, 1847; Enrolled May 11, 1848.

The principal feature in this form of rotary engine is a "piston wheel," provided with any desired number of pistons upon its periphery. The pistons are formed radially from the centre of the piston-wheel, and bear and work against the interior of a stationary cylinder. From the curved periphery of the piston-wheel to the interior of the stationary cylinder, there are stops which pass into the cylinder, the ends of which bear against the periphery of the piston-wheel or the pistons, and thereby render that portion steam-tight. The peculiar form of the pistons enables the stops gradually to recede from the interior of the cylinder until they become flush with the interior surface of the cylinder, and thereby allow the pistons to pass them without obstruction. Immediately that a piston has passed a stop, the stop is again projected into the cylinder to act as a surface, against which the steam acts to propel the piston-wheel forward. The patentee claims—first, the employment of the piston-wheel, upon which the number of pistons shall always be one more than the number of steam-stops on the cylinder, there being one steam-port and one exhaust-port to each steam-stop; the steam acting upon one or more pistons at the same time. Secondly, the mode of moving the slides or steam-stops by a cam or cams, corresponding in form to the periphery of the piston. Thirdly, the connecting all the steam-ports with the steam-pipe, so that steam shall have access to the cylinder at the same time, by the pistons passing the ports. Fourthly, the connecting all the exhaust-ports with the main exhaust-pipe, so that steam may be exhausted from all the ports of the cylinder at the same time by the pistons passing the ports. Fifthly, the connecting all the ports with the steam-pipe, by a branch-pipe provided with a suitable shut-off valve, and also connecting all the exhaust-ports with an exhaust-pipe, by a branch-pipe, also provided with a suitable shut-off valve. Sixthly, the mode of packing the pistons by means of a central metal-piece acting against two side pieces, having bevelled edges.

COMBUSTION OF FUEL.

Richard Coad, of Kennington, Surrey, chemist, for "*Improvements in the combustion of fuel and in applying the heat so obtained.*" Granted November 25, 1847; Enrolled May 25, 1848.

The object of the first part of this invention is to divide the gases and the smoke resulting from the combustion of fuel in the furnace into numerous small streams, by causing them to pass through apertures in the heated fire-bricks or lumps before they pass into the chimney. The great heat of the fire-bricks thus effectually ignites the unconsumed gases and smoke. The fire-lumps enclose the fire-place at the sides, the end, and at the top, through the whole of which are made the apertures or openings which open to the general flue common to all. There is also an aperture over the fire-door to be regulated at pleasure, for the purpose of admitting a supply of atmospheric air in a heated or other state above the fire-bars for assisting the combustion of the fuel and the gaseous products. The second part of the specification relates to reverberatory furnaces, and consists in supplying through numerous apertures in the sides and the ends of such furnaces above the fire-bars, any requisite supply of atmospheric air in a heated or other state, for the purpose of more effectually accomplishing the combustion of the fuel in the fire-place,—the mode of construction described by the patentee being to form a passage or channel around three sides of the furnace, the fourth being open to the hearth of the furnace; this passage or channel is formed within the brickwork of the furnace. The portion between the fire-place and the passage being of fire-bricks or lumps, it is through these fire-bricks or lumps that the apertures are made through which the supply of air is admitted from the passage to the fire-place above the fire-bars. The patentee states he is perfectly aware that atmospheric air has before been admitted into various descriptions of furnaces above the fire-bars; but it has not hitherto been so employed and admitted with respect to reverberatory furnaces. The third improvement noticed in the specification relates to a more effectual and more economical arrangement of apparatus for the heating of water, and for the warming of rooms or buildings. This improvement consists in the mode of arranging the bars at the back of the grate or fire-place to prevent the fire from lying immediately against the tubes containing the water. There are a top and a bottom vessel connected together by these rows of vertical pipes or tubes, through the interior of which there is a communication between the vessels. From these vessels pipes communicate to warm apartments, buildings, or to other similar apparatus. The rows of vertical pipes or tubes connecting the vessels are placed immediately at the back of the fire-place, the flame and heated air passing amongst them in its way to the chimney in front of the rows of pipes; and between the fire-place and the pipes are bars for the purpose of preventing the fire from acting immediately against them. These bars are placed in vertical positions; the horizontal section being convex in front against the fire and angular behind next to the pipes, they prevent the contact of the fire with the pipes; these bars may be composed of fire-clay or of metal, but the patentee prefers the former. Above the fire-place, the front of the flue or chimney is perforated or pierced with a number of small apertures, for the purpose of admitting air to assist the action of the apparatus.

MANUFACTURE AND PRESERVATION OF TUBES.

Pierre Armand le Comte de Fontainemoreau, of South-street, Finsbury, for "*certain Improvements in the process and machinery for making, uniting, and preserving metallic and other tubes or pipes.*" Granted November 18, 1847; Enrolled May 18, 1848.

The specification of this invention is extremely minute in describing the different processes of manufacturing and preserving pipes, and the patentee claims seven distinct improvements, the enumeration of which claims will give a general idea of their character. The invention consists, first, in making and uniting metallic pipes simultaneously, by acting over the top or head of the rivet. Secondly, soldering, laterally, galvanised iron, leaden, and tinned pipes, (either riveted or clasped,) by means of a long thread or fillet of solder. Thirdly, uniting metallic pipes by means of a certain improved clasp. Fourthly, uniting metallic pipes by inserting in the clasps employed for the purpose certain compressible substances for preventing the escape of gas and fluids. Fifthly, uniting metallic pipes, by using a helix for elbowing without flattening the leaden elbow. Sixthly, preserving metallic and non-metallic pipes by the application of resinous matters, fatty bodies, and chalk. Seventhly, in the process of preserving iron and cast-iron pipes from oxidation by means of galvanic action.

CASTING WROUHT-IRON.

William Rocke, of Dudley, Worcestershire, for "*a new mode of treating and applying wrought-iron.*"—Granted November 18, 1847; Enrolled May 18, 1848.

The object of this invention is to obtain the form required which the facility of casting affords, retaining at the same the qualities of wrought-iron. Having previously prepared the moulds in a similar manner to that adopted in the moulding articles when made of cast-iron, the melted wrought-iron is to be run into the mould. The articles are then of a brittle nature, and deficient of malleable properties, to impart which the patentee next proceeds to treat or anneal them in an annealing furnace. For this purpose the articles are piled in an iron box lined with fire-bricks, leaving sufficient room to surround the articles with a quantity of Cumberland red ore, or other iron ore, or charcoal reduced to a fine powder, the articles being so completely covered as to prevent all admission of the air. In this state they are to be subjected to the required heat for a sufficient length of time to give the required malleability, in which great care must be observed by the workman, and until he has sufficient practice to perform it without, it is advisable to employ a small bar or trial-rod composed of the same metal, which may be withdrawn from time to time, to ascertain the state of the iron and detect the completion of the process, when the articles may be removed. When the density and close compactness of texture obtained by the use of wrought-iron is not required, he mixes a proportion of cast-iron therewith, according to the quality or texture of metal necessary for the article proposed, but in no case to exceed the weight of wrought-iron used; and when it is necessary to impart to the articles manufactured the nature and temper of steel, he mixes with the wrought-iron a portion of cast-steel, but in no case to exceed the weight of wrought-iron employed. These mixtures of wrought and cast iron, or wrought-iron and cast-steel, being melted, are to be cast in moulds, and treated or annealed in the same manner as that described for the manufacture of articles entirely of wrought-iron, when they will be found to have acquired the malleable properties required. The patentee does not claim as of his invention the melting of wrought-iron, this having been practised already to a limited extent; but he claims the treating and applying wrought-iron by melting the same by itself, or with a mixture of cast-iron or steel, and the reproducing malleability in the castings of the molten iron by annealing them in the manner described.

INLAYING METALS.

Cyprien Marie Tessie Du Motay, of Paris, for "*Improvements in inlaying and coating metals with various substances.*"—Granted November 4, 1847; Enrolled May 4, 1848.

The specification of this patent is exceedingly verbose, and it consists of fifteen articles, showing different modes in which the invention may be applied. The object of the invention is to produce ornamental designs on various articles, by depositing metal thereon after the articles have been properly prepared by marking or cutting out the intended design; and which articles, when finished, have the appearance of being richly ornamented with inlaid work. This method of ornamenting, by inlaying in metal, is known in France as "*damasquinerie.*"

The work produced by this invention is very durable, and not liable to be worn away by cleaning or friction; it being quite equal in solidity to the inlaid work produced by the ordinary means, and even superior in point of finish.

Before depositing the metals intended to form the design, the patentee commences by producing designs, either in intaglio or in relief, upon the body of the article to be ornamented, those parts where no metal is to be deposited being coated with a varnish.

When an inlaying of one metal only is required, the patentee proceeds as follows:—The metal is first cleansed, and then immersed in a bath of the metal, to be deposited by the galvanic current. When the metal has been deposited to a thickness equal to the depth of the hollow parts of the design, it is withdrawn from the solution and washed in water, and dried with sawdust, or by any other convenient means, and the damaskened surfaces are laid bare, by means of freestone, or by filing, scraping, or by any other means which will remove the layer of superfluous metal, in order to uncover the inlaid or damaskened work.

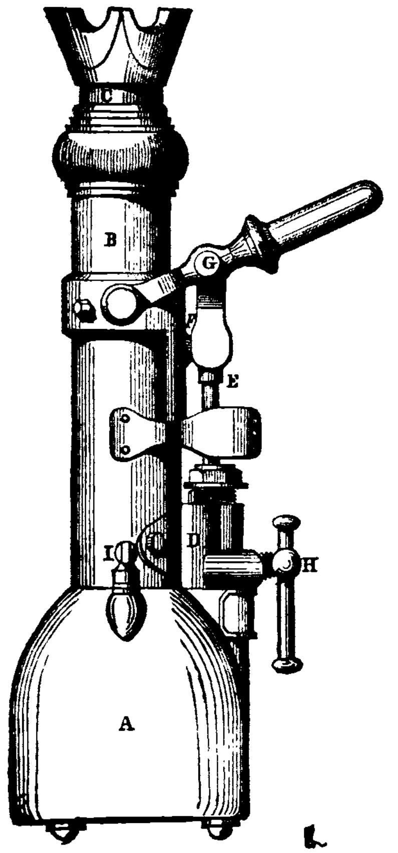
Damaskenes or inlaying in several metals may also be produced by means of pressure. For this purpose, a piece of metal, with an even surface, is covered without soldering, either by immersion or by electro-deposition, with several coats of different metals; each of these layers is of a certain thickness, according to the depth of the parts of the die which are in relief. The last coating being deposited, the piece is to be withdrawn from the last solution, washed, and wiped dry. When dry, it is to be submitted to the action of pressure or stamping by means of dies or matrices, the intaglio parts of which are of equal depth and the reliefs of different heights, or reliefs of equal heights and intaglios of various depths. These must be calculated in such a manner, that, by reason of the penetration of the projecting parts of the die to a greater or less depth, the layers of metal (being, in certain parts, thereby driven to greater or less depths) may, on the surface being laid bare, be of the same level as the inlaid surface.

In order to produce devices or ornaments to be inlaid in wood, marble, &c., by the ordinary means, the patentee proceeds as follows:—He takes a plate or sheet of any metal, and coats it, first, with a layer of copper, of suitable thickness; then with a coating of zinc; and upon that another of copper: and so on until the desired thickness is obtained. As the successive coats of metal entirely cover the tin core, parallel layers of metal are thus obtained, which differ from each other, both as regards the different kinds of metal and their various thicknesses. On cutting the sheet thus produced into thin strips, in the direction of its thickness, designs will be produced consisting of parallel lines of tin, copper, and zinc. With regard to other devices or ornaments, such as roses, stars, circles, &c., these can be produced by taking a metal core, of a certain length, either solid or hollow, and of the form desired to be produced, and coating it with successive and alternate layers of different metals; and when these deposits have been made to the required thickness, they are cut into thin discs. If the core, of whatever form, or metal, be solid, the parallel layers of metal will only be on its outside; but if it be hollow, they will also be inside, as the metal will be deposited on both sides.

HYDRAULIC LIFTING-JACK.

Registered by Mr. Simmons, *and Manufactured by* Messrs. Thornton and Sons, *of Birmingham.*

Under the head of the proceedings of the Institution of Mechanical Engineers at Birmingham, in the *Journal* for March last (page 87), we gave a short account of this jack, and now are enabled to give an engraving of it, which better explains its use. It is stated by the inventor, that one man with the jack can lift from 15 to 20 tons.



Scale, 2 inches to 1 foot.

A is a hollow vessel forming the base of the jack, and also a reservoir for the water. B, the cylinder; C, the ram; D, the pump; E, the plunger; F, the slide; G, the pump-levers; H conical pointed pin; I, a small air-tap. Before using the jack, tighten the pin H, and open the air-tap I. When it is requisite to lower the weight, slacken the pin H. When the jack is not in use, close the air-tap I. Should the water get too low, take out the tap I, and fill the cistern when the ram is down. The ram can be pressed down by hand when the pin H is slack.

For the purpose of increasing the leverage of the pump-lever G, an iron bar about 3 feet long, with a socket at one end, is fitted on to the lever G.

Mr. WHISHAW'S TELEGRAPHIC INVENTIONS.

We were present in the course of last week at a private view of the numerous contrivances invented by Mr. Whishaw for telegraphic communications. A great part of these inventions apply only to the communications at short distances, and of these an improved speaking tube is the most readily available. The improvements consist in using gutta-percha tubes of various diameters, and in applying removable whistles at each end, to afford a convenient means of calling attention when a communication is to be made. In a tube, two hundred feet long, coiled round so that the two extremities were near each other, the facility with which sound is transmitted was very strikingly exemplified. The slightest effort of the breath sounded a whistle instantaneously, and by blowing at one end, a musical instrument was played at the other as readily as if it had been applied to the mouth.

The chief peculiarity of the telegraphs exhibited, is the application of moveable "codes" to the face of the same instrument; each code consisting of all conceivable questions and answers on any given subject. The fixed dial contains the letters of the alphabet, the titles of the codes to be referred to, and several questions and answers of common occurrence, or most likely to facilitate the communications. The index of the dial may be moved by electrical agency or, for short distances, by mechanism, to be worked by the hand; and when the subject matter contained in any of the codes is to be communicated, the operator causes the index to point to that code marked on the dial. The codes are printed on large card-boards, and have circular apertures in the centre, through which the index and dial can be seen when placed on the instrument. The questions and answers are printed radially, so that a great number are contained within the range of the index in its circuit; and as it stops at any one, a whole sentence may be at once indicated. Should any word not on the code be required, the index is made to point to the word "spell," and afterwards it indicates the letters of the alphabet that form the word to be communicated. One plan of operating is by water-level indicators, the water in two vertical tubes being elevated or depressed till it stops at the signal wanted. Another telegraph, which however requires great delicacy in the manipulation, consists of two chronometers, each of which has a long second hand pointing to radially-placed words and sentences on the dial. It is essential to the accuracy of the working, that the two chronometers should move synchronously, for if there be the least deviation, it would transmit incorrectly. Supposing that the hands on the two dials at a distance from each other, are always pointing to the same words, in their revolutions,—whenever the transmitting instrument points to the sentence required, the operator is instantly to sound a bell at the distant station by means of electricity; and the observer there must notice at what sentence the hand is pointing when the bell sounds. If both operators be not very prompt in making and observing the signals, a wrong message would be communicated. This difficulty, however, Mr. Whishaw thinks may be overcome, and he has had much practical acquaintance with the difficulties in working telegraphs during a connection of some duration with the Electric Telegraph Company.

THE "ART-JOURNAL" *versus* ARCHITECTURE.

Not content with excluding architecture, and all notice of it from his columns, although he brings mere industrial art, as it is called, prominently forward, showing numerous specimens of it in every number of his publication, the majority of which are calculated to diffuse exceedingly bad taste among the public,—the editor of the *Art-Journal* appears anxious to get architecture thrust out of the Royal Academy. Some short time ago, he protested against architects being elected members of that body; and he now tells us that architectural drawings have "no business" to be in its exhibitions. This is very much like saying that there ought to be no exhibitions anywhere of such productions—the Academy's being the only one where they are admitted. It is to be hoped, however, that this marked insult will now arouse architects, more especially the leaders in the profession, and those who are members of the Academy, to a sense of their duty, and of what they owe, if not to themselves personally, at least to their brethren. Should it not do so, they must be lethargic indeed; and will fully justify at least one-half of the *Art-Journal's* opinion, by showing that at all events *they* have "no business" in the Academy.

What is the Professor of Architecture about, that he can patiently put up with the present state of matters with regard to architecture at the Academy? Hardly can he be ignorant of it, or not perceive how greatly it calls for correction; nevertheless, he makes no effort at all to correct it. Had he bestirred himself at all, we should of course have heard of it; moreover, if he had, and had done so ineffectually, we should have heard of his resignation,—which would be far more honourable to him than is the making himself a cypher,—not only without influence, but without even so much as a tongue or a voice.

Whatever—if any at all—the emoluments attached to the Professorship of Architecture may be, they cannot be such as to be of any moment to Mr. Cockerell. So long as the situation confers honour on him who holds it, it is worth having, whether any emolument at all be attached to it or not. But rather quite the reverse of honour attends it, when he who holds it is expected to sit by very tamely, and see all kinds of slights and affronts put upon architecture, without so much as attempting to check them.

There is, indeed, no danger of either the Professor or the Academy being called to account for the dereliction of their duty in regard to architecture, by the public press—that is, the newspapers; architecture being the very last thing of all to excite their attention or engage their sympathies. Yet if they, therefore, think that they are released from all responsibility to public opinion, and that their conduct excites no animadversion in other quarters, they are very much mistaken.

As to the editor of the *Art-Journal*, he ought to be hanged—in effigy, at least—by the architects. But, somehow or other, architects invariably show themselves to be the most pluckless race imaginable. Whenever their own personal interests are touched, or at all endangered, they are generally sensitive enough; but when it is only the credit of their art and their profession that is concerned, they show themselves to be the most torpid and sluggish of mortals.

ZERO.

THE DISPUTED INVENTION OF TUBULAR BRIDGES.

We regret to perceive, now success has attended the bold experiment of constructing tubular bridges, that attempts are being made to deprive Mr. Robert Stephenson of the merit so justly his due, as the original designer of the plan, and the superintender of its execution. Mr. Fairbairn, who, with Mr. Eaton Hodgkinson, assisted Mr. Stephenson in working out the design, claims to have the merit of all but the "original idea;" and he maintains that the working out of the idea and the development of the principle, as well as the greater portion of the construction, are the results of his labours. He states, also, that the original idea of Mr. Stephenson was a cylindrical tube, to be supported by chains; which plan, he says, can be proved would never have succeeded; and that it was only by a long series of inductive reasoning, founded on experimental research, of which he claims the exclusive merit, that the present strength and form of the Conway and Britannia tubular bridges were established.

It is of great importance not only to Mr. Stephenson, but to civil engineers and inventors in general, that these claims of Mr. Fairbairn should be estimated at their proper value. The original idea of overcoming the difficulty of taking the railway across the Menai Straits, by the construction of a tubular bridge, is admitted to be due exclusively to Mr. Stephenson. Mr. Fairbairn and Mr. Eaton Hodgkinson were employed by him to assist in its construction, and to make the experiments necessary to determine the best form for obtaining the requisite strength. He must, of course, have expected, from their known skill and experience in the strength of materials, that they would be able to afford important assistance in devising the means adapted to overcome the difficulties which such a novel structure necessarily presented. The experiments they made were subject to Mr. Stephenson's approval, and may be said to have been conducted under his superintendence. The mode of making them would however, for the most part, be necessarily entrusted to Mr. Fairbairn and Mr. Hodgkinson; who were not employed as mere mechanical agents, to act strictly under directions, but as practical men of science,—expected to bring their skill, ingenuity, and mathematical knowledge to bear on the important work entrusted to them, and to arrange the details by which Mr. Stephenson's invention could be best carried into effect. That Mr. Fairbairn has amply fulfilled what was expected from him, and has, under Mr. Stephenson's superintendence, completed the task ably, skilfully, and successfully, is a great merit, of which he may well be proud. Beyond this, he ought not to wish to carry his claims. Not only the original idea of tubular bridges, but a mode of carrying it into effect, unquestionably belong to Mr. Stephenson. Whether that was the best mode, was to be determined by experimental researches; and the result led to an improvement in the means first devised. This is the general and almost necessary course in the perfection of any invention; and whether the inventor carry on the experiments entirely by himself, or whether he obtain the assistance of others in perfecting his invention, does not affect his claim as the original inventor. It appears to us that a machinist or a draughtsman might, with nearly equal pretension, claim to be the inventor of an apparatus, or the architect of a [illegible] —because he had *succeeded in* making the machin[illegible] completing designs from outline plans,—as Mr. Fairb[illegible] to be the inventor of tubular bridges. We trust [illegible] sake of his own reputation will be satisfied wi[illegible] acknowledged to be his persist in claiming [illegible]

Floating Tunnel ac[illegible] submitted for approv[illegible] Ferdinand, engineer, [illegible] to Dover, for the wir[illegible] traversed by small b[illegible] was referred to one [illegible]

ON CHEMICAL AND ELECTRICAL FORCES.

By Professor Faraday.

Professor Faraday has this season delivered a course of seven lectures at the Royal Institution, "*On the Allied Phenomena of the Chemical and Electrical Forces.*" The last lecture of the course was given on Saturday, the 17th ult, and we now subjoin a brief sketch of the whole, showing the mode in which the subject was treated, and describing the principal experiments by which it was illustrated.

The *first lecture* was devoted entirely to explanations of the character and illustrations of the nature of chemical force, commencing with its simplest forms. In the first place, Professor Faraday explained the difference between mechanical force, or the force of gravitation, which produces molecular action and aggregation of masses, and the action of chemical force, which takes place among the particles of matter. At the same time as he entertains the opinion that all forces are closely allied, if not identical, he showed several experiments in which chemical action is effected by mechanical force, of which the explosion of fulminating powder by percussion afforded an example. The illustrations of chemical action in its feeblest form, he showed to be closely allied to mechanical force, as the aggregation of the particles of water, he said, depends on the same force as the most energetic chemical action; the difference between them being only in degree. As an illustration that chemical action takes place during the mixing of fluids, he poured some spirits of wine gently on to the top of water in a glass vessel, into which a long tube was inserted. The vessel and the tube being quite filled, he inverted the apparatus, to mix the spirits of wine with the water, when contraction in the volume of fluid was manifest by the tube being no longer full. Among other exemplifications of chemical action, were the solidification of two gases (muriatic acid gas and ammoniacal gas) on being mixed, and the conversion of two limpid liquids (carbonate of potass and muriate of lime) into a white solid mass. The results of chemical action, Professor Faraday observed, are the production of compounds distinct from, and frequently quite dissimilar to, the original substances that enter into combination. To show in a striking manner the difference between a mixture and a compound, he mixed together some copper and iron filings, and then separated the iron from the copper by means of a magnet; whereas in a chemical compound, no mechanical force can separate the combined particles, and they can only be resolved into their original elements by the chemical action of some more energetic agent. Though the original substances that enter into chemical combination seem to be entirely lost in the resulting compound, yet there is no destruction nor any alteration in the elements, nor is there any creation or destruction of power produced by the combination. Professor Faraday illustrated the reproduction of the elementary substance of a compound after it had been apparently destroyed, in the following manner. He put some iodine into a glass flask, which, on being heated, emitted the purple or violet-coloured fumes peculiar to that substance. He then added zinc and water to the iodine, when a combination took place, in which the properties of the iodine were apparently lost, and by no application of heat could the violet fumes be produced. On the addition of sulphuric acid, however, the iodine was set free from its combination with the zinc, and its fumes were again perceptible. That there is no destruction or change in the particles of matter produced by chemical action is generally admitted, but the Professor observed, that some philosophers still cling to the notion that there is a creation of power, as exhibited in electricity; but this opinion, he maintained, is not founded on fact, for there can be no creation of power without the creation of matter.

In the *second lecture* the consideration of the different actions of chemical force was resumed in the commencement, and then its gradual transition into electrical force was developed. In the first place, the Professor pointed out the difference that exists between the force of gravitation and chemical force in the relative constancy of their actions; for whilst gravitation never ceases to act at any moment, chemical affinity, on the contrary, often lies dormant for ages, until circumstances arise that bring it into action. Several experiments were performed to illustrate this, and also to show that the results of chemical action may be reversed by varying the temperature and the other conditions under which it takes place. A mixture of nitrous and oxygen gases, for example, produces no change on either litmus or turmeric paper, but when a stream of those mixed gases issues into the atmosphere at the ordinary temperature, a piece of moistened litmus paper exposed to the current is reddened, thus proving the presence of an acid. When the same stream of mixed gases is heated, the previously reddened litmus paper is restored to its original blue colour, and turmeric paper is turned brown, showing that the directly opposite property has been given to the gases, which then become alkaline instead of acid. When approaching to those chemical actions which are accompanied by the development of electricity, Professor Faraday first exhibited the solution of copper by an acid, and its reproduction in a metallic form on pieces of iron and zinc, which metals having a greater attraction for the acid that held the copper in solution than the copper itself, entered into combination with the acid and liberated the copper. He afterwards exhibited the action of oxygen and zinc, by first pouring some diluted sulphuric acid on a piece of that metal, which decomposed the water by attracting its oxygen, with which it entered into combination, and liberated the hydrogen as gas. On introducing a few shillings into the glass, the vigour of the action increased, and the decomposing power of the zinc seemed to be transferred to the silver, from which metal copious streams of hydrogen gas arose. A more obvious exhibition of the extension and transfer of chemical action from one metal to another was effected by the deposition of copper on silver from a solution of the sulphate of copper. When a piece of silver is immersed alone in a solution of sulphate of copper, no action whatever takes place, and it might so remain for any length of time without sensibly decomposing the solution; but as soon as a piece of zinc or iron is brought in contact with the silver in the solution, the copper is deposited on the silver as readily as on the zinc; and when the latter is amalgamated with quicksilver, the effects of decomposition are transferred entirely to the silver, and none of the copper is deposited on the amalgamated zinc. This effect is equally produced, whether the two metals are brought into contact in the solution, or whether connection between them is made by a wire, through which the action is readily transmitted. A new class of phenomena is brought into play by this exhibition of chemical force in dissimilar metals. When the wire that connects the two pieces of metal is made to pass over a suspended magnetic needle, the needle is deflected on one side, and by expanding the surfaces of the metals sufficient power is obtained to make a wire red hot. The deflection of the needle at any part of the connecting wire where it may be placed, shows that the action occurs along the whole course of the wire, and exemplifies one of the positions which the Professor wished to establish, viz., that the distant and local actions are identical. This new class of phenomena, Professor Faraday said, was, in his opinion, attributable merely to another exhibition of chemical force, but he should, in deference to received usage, denominate it electrical force.

The greater portion of the *third lecture* was occupied with the consideration of the decomposing power of electricity, in which respect its action seems the reverse of that of chemical force. The latter power acts by the affinities of the particles of one substance for those of another, and the results of its action are the formation of new compounds; electrical force, on the contrary, resolves compound bodies into their elements, and may act at a distance from its exciting cause. Numerous illustrations of the decomposing power of the voltaic battery were afforded, one of the most curious of which was the decomposition of muriatic acid by the following arrangement:—A glass vessel was divided into three compartments by diaphragms of blotting-paper, and filled with diluted muriatic acid,—the acid in the two end compartments being coloured with indigo. When the wires from the negative and positive poles of the battery were inserted in the two coloured divisions of the vessel, the muriatic acid became decomposed, the chlorine passing to one end, and the hydrogen to the other; which effect was rendered visible by the bleaching of the liquor in the end to which the chlorine was determined, whilst the middle compartment, through which the current force must have passed, remained unchanged. The decomposition of iodide of potassium afforded a striking example of the rapidity with which decomposition takes place under the influence of electricity. Across a piece of paper, wetted with a saturated solution of iodide of potassium, Professor Faraday drew rapidly one of the wires from the battery, when a strong brown mark was left, showing that the iodide had been decomposed. By pressing a coin on paper similarly prepared, and then touching it instantaneously with the wire of the battery, an impression of the coin was left on the paper, caused by the decomposition of the iodide where the parts most in relief had touched the paper. The amount of decomposition is, in all cases, proportionate to the current force; and though chemical decomposition does not take place excepting when the current is interrupted, yet the power is always active in its circuit through the connecting wires. The deflection of a magnetic needle, when placed parallel to the conducting wire, was adduced as a proof that the power exerts an influence at every part of the circuit, and the plates of the voltaic battery were shown to have the same power as the conducting wire, in deflecting the suspended needle from its ordinary position of north and south. This current of force throughout was noticed by Professor Faraday as one of the many instances in which electrical force differs in its action from chemical force, which is always local, though the two forces are really identical. The constant evolution of electricity, when we least suspect the presence of such an agent, was curiously exemplified by cutting a raw beef-steak with a steel knife and a silver fork, the knife and fork being connected by wires with a voltameter. As soon as the knife touched the meat, a current of electricity was evolved sufficient to deflect the needle of the voltameter. A cooked steak, peppered and salted, produced a still more powerful effect on the needle.

In the *fourth lecture* the alliance between the chemical and electrical forces exhibited in the evolution of light and heat, formed the principal point to which the Professor directed attention, and he illustrated the subject by numerous brilliant experiments. The light and heat produced by violent chemical action, of which a burning candle is a good example, form no essential part of the action that takes place among the combining particles, but are merely transient phenomena resulting from the activity of the combination. In the same manner, the light and heat evolved during combustion of substances by the voltaic battery, are the results of the combination of the zinc plate with the oxygen of the exciting liquid. To exhibit the voltaic light the lecture-room was darkened, and then pieces of charcoal were exposed to the action of the battery. The intensity of the light thus evolved was contrasted with the flame of an argand lamp, which was scarcely perceptible in the overpowering splendour of the voltaic spark. The combustion of silver-leaf, of iron-wire, of platinum, and of mercury, formed other dazzling exhibitions of the heat and light evolved by the voltaic battery, when the two poles were brought into contact with the metals. The heat thus generated is owing, Professor Faraday observed, to the passage of electricity through the substances acted on, and to the resistance they offer to its passage, for when the conductors are sufficiently large and perfect to afford a free passage to the electricity, no effect of heat is observable. A very curious experiment in illustration of this property of electricity was exhibited. In a glass vessel full of distilled water the charcoal points from the opposite poles of the battery were introduced, and when they were brought near to each other a most brilliant light was evolved under the water, dimmed only by the bubbles of steam generated by the heat. The water being an imperfect conductor of electricity, offered sufficient resistance to its passage to bring into action the heating and light-giving powers of the voltaic battery; but when it was afterwards made a better conductor, by mixing sulphuric acid with it, the effect was greatly diminished. In the preceding lecture, Professor Faraday showed that wires proceeding from the opposite ends of a voltaic battery possess different powers in the decomposition of compound substances, and he now showed that their heating powers also differ; for the copper wires from the two poles, on being held close to each other within a short distance of the ends, the one became much hotter than the other. The quantity of heat evolved by the action of the voltaic battery is in proportion to the amount of zinc oxidized, and Professor Faraday remarked there is good ground for supposing that the heat evolved is equal to that produced by the combustion of the same weight of zinc. Though the intensity of the light varies in the phenomena of voltaic electricity, just as it varies in different circumstances during ordinary combustion, yet the heat remains the same in both cases. As an illustration of this position, the Professor directed his breath against a gas light so as to greatly diminish the brightness of the flame, yet in both circumstances, he said the heat of the burning gas was the same. The latter part of the lecture was occupied with the consideration of the effects of electricity on the sensitive system of animals, and it was illustrated by several curious experiments. The original experiment of Galvani with the hind legs of a frog was very successful; for when the legs were placed on a sheet of platinum, and connection was made between that metal and a piece of zinc that touched the nerves, the muscular contractions of the limbs made them jump as far as the animal could have done when alive. A large live eel, in a glass jar, plunged about violently when the electric current from the battery was passed through the water, thus showing, that without any direct connection with the battery, the electric shock is felt by fishes when the water they swim in is made part of the circuit. Professor Faraday alluded to the experiment made with the *gymnotus electricus* at the Polytechnic Institution, from which he had obtained all the effects of an ordinary voltaic battery. The eel itself does not feel the shock it communicates to the fishes within its influence, though when an electric current from a voltaic battery is passed through the water, it exhibits as much annoyance as any other fish. The Professor observed that the effects of electricity on the nerves of animals, give an insight into the phenomena of life, since they seem to prove that nervous trritability, on which the action of the muscles depend, is caused by elecrical influence, though by what means the electricity is generated remains unknown.

The commencement of the *fifth lecture* was occupied with exhibition of the phenomena of electricity, when the circuit is not interrupted. The simplest evidence, that a constant action is going on in the conducting wire, is afforded by the deflection of a magnetic needle, when a wire that connects the two poles of a battery is held over it, parallel to the direction of the needle. Small pieces of bent iron, resting on the wire, became magnetic when the electric circuit was completed, and when the wire was twisted several times round a thick piece of iron, to increase the effect, the magnetic power became so strong, that it lifted an anvil of at least fifty pounds weight. The heating power of the voltaic battery, when the current is passing uninterruptedly along the wires, was shown by its making charcoal, and various thin wires red hot, in which state they would have remained as long as the battery continued in vigorous action. The conducting power of gold being greater than that of platinum, a fine wire of gold became a much brighter red by the passage of electricity through it, than one of platinum; and yet, when the two wires were joined together, the platinum wire became red hot, whilst the gold was not perceptibly heated. This anomaly Professor Faraday explained, by stating that the platinum wire obstructed the passage of the electricity, consequently the gold wire, which was capable of conducting a larger quantity, did not become sensibly affected by the small quantity which the platinum allowed to pass. The increase of heat diminishes the conducting power of metals, and several experiments were shown, for the purpose of illustrating this peculiar property, the red heat of one part of a fine communicating wire being brightened when another part of the wire was cooled; and the contrary effect being produced when the wire was heated by a spirit lamp. A great part of the lecture was occupied in explaining the two most popular theories respecting the nature of electricity, neither of which, however, Professor Faraday is inclined to adopt. One supposition is, that electricity is an ethereal imponderable body, distinct from the substances in which it is excited, and that it is transmitted along wires, in like manner to the rushing of fluids through tubes; the other, and as he observed, the more beautiful theory, is, that the phenomena of electricity are produced like sound, by vibrations. The Professor performed several experiments, for the purpose of showing the facts adduced in support of each of these theories. One of the difficulties to be overcome in any theory that purports to explain the nature of electricity, is to account for the instantaneous transmission of the power, which has been ascertained to exceed the rate of five thousand miles in a second. In support of the first theory, it is urged that as there is an immense difference in the rapidity with which different fluids pass along tubes—water, for example, flowing slowly in comparison with hydrogen gas—so it is asserted that the assumed imponderable fluid may pass with a rapidity vastly greater than hydrogen gas. The vibrations of sound, however, present much greater similarity to the transmission of electricity. Though sound passes in air at the rate of only thirteen miles a minute, it passes through water four times as quickly, and through glass sixteen times faster than through air. There is this resemblance also between the passage of sound and the transmission of electricity, that sound may be transmitted sensibly through solid bodies and become audible at the end. Two curious experiments were performed to illustrate this property of sound. A thin strip of deal was suspended from one end of the lecture-room to the other, and at the farther end it bore against a box. A tuning-fork, when struck and applied to one end of the strip of wood, caused the box at the other extremity to emit a loud musical sound, though the tuning-fork itself could scarcely be heard. In the other experiment a rod of metal passed through the floor of the lecture-room, and was placed in connection with a pianoforte in a room beneath. When the instrument was played, scarcely any sound was heard, until a guitar-case was placed on the rod, and then the notes were distinct and loud, as if proceeding from the guitar-case. There is a similarity also between vibrations and electrical shocks, as may be proved by striking a bar of iron when holding it near one of the points of vibration, the jarring sensation bearing a close resemblance to an electric shock. This vibratory sensation is felt yet more strongly when a wet string is fastened round the waist, and some one pulls the end of it through the fingers.

In commencing his *sixth lecture*, Professor Faraday said he was about to direct the attention of his auditors to a different condition of the electric force from that in which he had hitherto considered it, wherein the phenomena not only differ from, but are in many respects directly opposed to, those exhibited by chemical action and voltaic electricity; and yet the forces are the same. In the first place, he exhibited voltaic electricity in a higher state of tension than he had before done, by employing a water-battery, consisting of a great number of pairs of plates, by which arrangement a small quantity of electricity in a high state of concentration was excited. In this condition voltaic electricity nearly resembles the electricity excited by rubbing a stick of sealing-wax or a rod of glass. In the ordinary development of voltaic electricity, the effect is produced only when the current is passing, and ceases when it is broken; but in frictional electricity the power may be exerted when there is no current, and when the source of power is withdrawn. In this respect, indeed, the water-battery evolves electricity resembling that of the electrical machine, and forms the connecting link between frictional and chemically-excited electricity, serving to prove that they are identical. In the first place, Professor Faraday showed that by touching an electroscope with only one of the wires of the battery, the gold leaves diverged, and continued divergent when the wire was removed, thus exhibiting the development and the retention of the power when there was no current passing. When the wire from the opposite pole of the water-battery was brought in contact with the electroscope, the gold leaves collapsed. To show the identity of the electricity thus evolved by the battery with the electricity excited by friction, Professor Faraday caused the gold leaves of the electroscope, when diverged by the battery, to be collapsed when an excited rod of glass was brought near, and to be made more divergent by an excited rod of gutta percha, or by a rod of shellac. The different means by which the effect is produced affords no ground for supposing the electricity of the battery and that excited by friction to be distinct, for what is termed frictional electricity may be excited in varieties of ways, and is, in fact, continually being called into action, without our being sensible of its presence. The mere act of dusting a piece of metal with flannel was shown to excite electricity by its causing the leaves of the electroscope to diverge. We can scarcely touch anything without exciting this power, which, however minute and imperceptible in its development in these instances, is precisely the same force which produces the grandest phenomena of nature—thunder and lightning. Having given illustrations of the similarity of the forces developed by chemical agency and by friction, the Professor dwelt on the apparent differences between them. One remarkable difference is, that the substances by which frictional electricity is excited undergo no change, the metals and the glass remaining just the same after having developed the power as before; whereas voltaic electricity cannot be excited without chemical action, and an apparent destruction of the zinc. Another variation in the phenomena of voltaic and of frictional electricity is exhibited in their conduction through various substances. Water, for instance, which is so imperfect a conductor of voltaic electricity, will readily conduct the whole quantity excited by a powerful electrical machine, through the moisture contained in a wetted silk thread. Frictional electricity is spread over the surfaces of bodies, and does not enter them. This property was exhibited by several experiments, the most remarkable of which were the following:—A small metal ice-pail was placed on an insulated stand, and then a metal ball, suspended by a silk string, and charged with electricity, was lowered into the pail. The electricity instantly diffused itself on the outside of the ice-pail, and there was none within; for when the ball was again lowered into the pail and withdrawn, it produced no effect on the electroscope, but when the ball touched the outside the instrument was strongly affected. In the other experiment a wire-gauze vase was substituted for the ice-pail, with exactly similar results. When an electrical machine is excited, every person within sight of it is more or less affected by its influence, and a condition of electricty is induced in that part of their bodies towards the machine of a different kind from that developed by the conductor; and on the opposite side, or that farthest from the machine, electricity of the contrary kind is induced. This induction of positive and negative electricity on distant bodies, leads, as Professor Faraday observed, to important practical consequences. He had, he said, been often consulted by Government as to the propriety of having metal roofs on the powder-mills at Waltham Abbey, and he had always objected to them as dangerous, because a thunder-cloud might induce in the extended metal surface, an amount of electricity capable of discharging itself to the earth. In illustration of this, a large insulated metal ball, placed at a distance of two feet from the conductor of the machine, was brought near a jet of gas, which became ignited by the induced electricity passing off in a spark to the metal gas-pipe, though the ball was far too distant from the conductor for any spark to pass between them. This experiment was repeated several times, and each time with the same success.

The chief point to which Professor Faraday directed attention in the *seventh* and concluding lecture was, the cause of the difference between the phenomena of voltaic and of frictional elecricity, his object being to prove that they are really identical. The marked difference between frictional and voltaic electricity, which were dwelt upon so much in the preceding lecture, are caused entirely by the different degrees of intensity in which the force is developed, and Professor Faraday showed, in the concluding lecture, that, by diminishing the intensity of frictional electricity, the phenomena may be rendered similar; the great difficulty in showing these effects being caused by the very small quantity of electricity that can be evolved in a given time even by the most powerful electrical machine when compared with the amount evolved by the voltaic battery. Though the machine employed was a plate of glass, about four feet in diameter, which yielded a rapid succession of strong sparks five inches long, it would require about five million turns of the plate to produce a quantity of electricity equal to that evolved by a grain of water in the voltaic battery. The different appearances of the sparks emitted in the highest state of intensity by the electrical machine from those produced by the discharge of electricity accumulated in the Leyden jar, and the alterations the light and the length of the sparks may undergo by being transmitted through various media, were shown in numerous experiments. Though the rapidity of the electric spark is evidently very great, it far exceeds, in reality, the appearance to the eye, for the duration of the impression on the retina after the light is extinct occasions a prolongation of the effect. It has been ascertained by Mr. Wheatstone, that the duration of the light of the spark is less than the millionth part of a second, and Professor Faraday exhibited the mode by which this fact had been established. A concave mirror, placed horizontally, was made to revolve with great rapidity by multiplying-wheels, and when in action a bright light from the combustion of lime was reflected to a focus on the ceiling. The rapidity of the motion caused the light to form a circle, in the same manner as the turning rapidly round of a lighted stick or of any other bright object seems to form a circle, in consequence of the impression on the retina remaining until the effect is renewed by the return of the light to its former place. When an electric spark was substituted for the permanent light, each spark was seen separately, and no circle or prolongation of the light was produced. The velocity of the mirror and the number of successive sparks being known, an approximation can be obtained to the duration of the light. It is in consequence of this instantaneous duration of electrical discharges that they fail to produce many of the effects of voltaic electricity, and if the continuous action of the latter during a second could be concentrated one million times its effects would be tremendous. By diminishing the intensity of frictional electricity whilst retaining its quantity, Professor Faraday ignited gunpowder, which was blown away without ignition by the undiluted discharge. The following experiment afforded a good illustration of the different actions of frictional and voltaic electricities caused by the concentration of force in the former. A gold thread twisted with silk was deflagrated by a discharge from an electrical battery without injuring the silk, the action having been so instantaneous that there was not time to burn the silk, though the metal was destroyed by the heat evolved. When similar gold thread was exposed to the action of the voltaic battery, the silk was instantly consumed by the wire being made red hot, whilst the metal remained. The statical character of frictional electricity, Professor Faraday said, may be rendered current by applying a conducting substance to draw it off from the machine as quickly as it is excited, and the imperceptible effects of such a current prove how small the quantity of electricity excited really is, and it is only by allowing it to accumulate that we become sensible of its presence. The phenomena of lightning and thunder are owing to the facility with which Franklinic electricity can be accumulated, and thus reserved in store for an instantaneous discharge. Some specimens of the effects of lightning were exhibited on the lecture-table. A number of splinters from a riven oak, a branch from a mulberry tree, the rent and shivered handle of a hay-fork, and the partially-melted iron cable of a ship were displayed. The latter is such an extraordinary exhibition of electrical power, that Professor Faraday said nothing but the strongest evidence could have induced him to believe it; the ship was stated to have been struck with lightning during an earthquake at Callao. This rending power of frictional electricity cannot be imitated by the voltaic battery, but all other phenomena of the one kind can be produced by the other. The decomposition of chemical compounds by the discharge of the Leyden jar was shown by the decomposition of iodide of potassium, small indeed in effect, but corresponding with the quantity of electricity which the electrical machine evolves. The alliance of the phenomena of the two electricities had been shown in the course of these lectures, Professor Faraday observed, by their physical effects in communicating shocks, by the equal rapidity of their transmission, by their decomposing and heating powers, and by the communication of magnetism. The difference between the two consists solely in the degree of intensity, the electricity of the machine exciting a small quantity in a high state of intensity, whilst the voltaic battery evolves a much larger quantity in a low state of tension. Professor Faraday, taking a small flock of gun-cotton and exploding it in the flame of a candle, observed that the chemical force thus instantaneously called into action was equal to the production of an amount of electricity greater than would be contained in 500,000 charges of the powerful battery of Leyden jars which he had employed to deflagrate metal wires and gold leaf; and the important problem now remaining to be solved was, the conversion of such rapid chemical actions into current forces. Chemical decomposition, he said, when taking place less energetically, had been shown to evolve electricity, which became manifest and available as a current force by the voltaic battery, and it was quite within the reach of scientific discovery to render the most energetic phenomena of chemical force sources of continuous power.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

May 29.—AMBROSE POYNTER, Esq., V.P., in the Chair.

A paper was read "*On the Application of Sculpture and Sculptured Ornament to Architecture.*" By H. B. GARLING, Associate. Being the Essay to which the Medal of the Institute was awarded on 21st February, 1848; and which is given in full in our present Number (p. 201).

June 12.—SIDNEY SMYRKE, Esq., V.P., in the Chair.

A paper was read "*On the Theatres and Porticoes of Ancient Rome.*" By the Rev. RICHARD BURGESS, B.D.

June 26.—A paper was read "*On the Triforium of the Mediæval Churches.*" By the Rev. R. WILLIS, M.A.

This evening's meeting closed the session.

Next month we will endeavour to give an abstract of both the above papers.

INSTITUTION OF CIVIL ENGINEERS.

May 30.—Mr. FIELD, the President's Conversazione.

The accustomed annual conversazione of the President, which was heretofore held at the residence of the President, was this year held at the House of the Institution in Great George-street, a change we do not approve of; as also the one limiting the conversazione to one evening, which led to the rooms being most inconveniently crowded—so much so, that many of the numerous models and works of art could not be seen.

On the walls of the theatre we observed three faithful portraits, by Lucas, of Mr. George Stephenson, Mr. Robert Stephenson, M.P., and Mr. Bidder; they were contributed by Messrs. Graves, for whom they are about being engraved. The Electric Telegraph Company—Mr. Bain, Mr. Brett, and Mr. Reid—contributed instruments exhibiting their various systems of telegraphic communication, electric clocks, and electric printing. Mr. Rand's fly press, for raising at one blow the collapsible tubes or capsules. Mr. Whitworth's beautiful machine for knitting stockings was worked by a young girl sent up from the factory of Messrs. Ransome and May, of Ipswich, and formed an attractive object. The models of greater interest were those of Mr. Stephenson's wrought-iron tubular bridge erected at Conway; with that of his wrought-iron tubular girders for large spans. Mr. Fowler's steamboat floating landing stage, with its long approach over the mud banks, all to be supported upon Mitchell's screw piles, for the Humber Ferry. Mr. Brunel's excellent truss, of 110 feet span, used by him in the Somerset Bridge, on the Bristol and Exeter Railway. Mr. Fowler's plan for opening or shutting simultaneously four gates for a level crossing on the line of the Manchester, Sheffield, and Lincolnshire Railway. Messrs. Taylor, Williams, and Jordan's model of their machine for carving by machinery ornamental objects, figures or groups, such as we have previously noticed. This machine, by means of a tracer which guides the cutting tools, is enabled to perform the most delicate and elaborate work with great speed and at a cheap rate. Messrs. Seaward and Capel contributed a large collection of models of paddle-wheels and screw-propellers. Messrs. Maudslay and Field also contributed an interesting series of models of steam-engines, screw-propellers, and paddle-wheels; as did also Mr. Penn, of his horizontal trunk steam-engine. Mr. Clarke exhibited a beautiful model of the *Great Britain* steamer, full-rigged, and containing *fac-similes* of the engines, with the screw-propeller complete, and working by means of condensed air, the whole only weighing 1 oz.

Among the remaining models, we observed Messrs. Blake and Varley's atmospheric pile-driving machine,—Mr. Varley's rotating air-pump,—Mr. S. P. Bidder's simple and effective coal-drops,—Mr. Dodd's rail-straightening machine,—Mr. Southam's wedge and screw fix,—Mr. Thornton's improved hydraulic lifting-jack,—Mr. Wetherall's iron-twister,—Mr. Chrime's patent fire-plug valve,—Mr. Beattie's new wooden railway, with the drawing of the system of manufacturing it,—a model of a folding boat, of which each side was made of two thicknesses of water-proof cloth, filled in on Capt. Light's principle with very buoyant reeds, rendered non-absorbent, and consequently rendering the boat incapable of sinking, even when full of water, and even when partially torn by accident. The expedition in search of Sir John Franklin has been furnished with boats of this description, in order that they may be easily transported across the ice, and may bear injuries which would destroy a wooden boat. The Gutta-Percha Company sent a selection of their products from the rough material throughout all its stages of manufacture to the finished articles. Mr. Chubb's safety chest and locks and keys,—Mr. De la Fon's ingenious locks and bolts,—Mr. Defrie's improved dry gas-meter,—the new Aneroid barometers,—and numerous other interesting models and specimens.

June 20.—Joshua Field, Esq., President, in the Chair.

"*On Harbours of Refuge.*" By the Right Hon. the Earl of Lovelace.

The paper consisted chiefly in a succinct review of the Reports of the Commissioners on Shipwrecks and on Harbours of Refuge; giving the opinions of the naval officers and civil engineers on the necessity for harbours, in certain situations, and the naval qualities possessed by those positions—the possibility of constructing harbours in them, and the nature of the structures. The necessity for harbours on our coasts, capable of sheltering fleets from storms in peace, and the enemy during war, appeared to be admitted, particularly at the present moment, when the disturbed state of the continent and the restless character of our near neighbours were considered. It was stated, that, of various situations pointed out, that of Dover was the only one yet decided upon, although great works are contemplated at Portland, where, from Mr. Rendel's designs, a system of construction would be adopted, which would be both economical and stable, and, at the same time, would afford employment to a class of persons whose labour it had been difficult hitherto to use efficiently. The various projects of floating breakwaters, and other artificial shelter for vessels, were then examined, and were generally condemned, as entirely inefficient for the objects proposed.

The questions relative to the movement of sand, the drifting of the shingle, and the deposit of silt in Dover Bay, and other places, were treated at great length, and reasons given for the various forms of construction, and of the projects for meeting the difficulties induced by these circumstances.

The next question was the place of the harbour, and the mode of construction of the works. After quoting all the authorities on both sides, including the naval officers, the commissioners, the civil engineers, and the scientific writers, the preference was given to a large harbour, with two entrances, so placed as to allow a sufficient run of the tide through it, to prevent any very considerable deposit of silt, but so constructed as to afford shelter to the vessels within. The pier walls inclosing the harbour to be built vertically up from the bottom, or with a very slight inclination in their height, instead of throwing in masses of rubble stone, to find its own angle of repose, which, it was shown, was not less than four or five to one, and that it only attained solidity after a lapse of many years, even with a due admixture of small materials to fill up the interstices, and after constant supplies of stone, to replace that which the seas had removed. The reports of Capt. Washington were quoted, to prove the failures that had occurred at certain harbours in Ireland, where it was stated that the long slopes had been destroyed by the sea, and had ruined the harbours they were intended to protect. The proceedings at Cherbourg and Plymouth were followed in great detail, with a view to deducing arguments against the long slopes, and in favour of vertical sea-walls.

The protest, by Sir Howard Douglas, in favour of long slopes, was examined at great length, and the arguments used on both sides were analysed with skill and candour.

Colonel Emy's theory of the effects of the "*flot du fond*," was carefully examined; and, without going to the entire length that he did, it was admitted, in many cases, the effects produced were as he described them, and that the subject, as he had brought it forward, was well worthy the attention of civil engineers.

The placing a vertical wall upon a substratum of rubble, in the form of a long slope, was shown to be pregnant with mischief, and had never been successful; and that the adoption of that system at Cherbourg had been a matter of necessity rather than of choice.

Mr. Alan Stevenson's clever experiments, on the force of waves striking opposing bodies, were given; and it was urged, that the force shown to be developed by a breaking wave could not act upon a vertical wall, up and down which it would merely oscillate; whereas it might fall, with all its accumulated force upon a slope, upon which it would naturally break. In conclusion, it was urged that, although for Dover, which was the spot whereon to mount guard over the channel, in order not only to prevent invasion, but to maintain our present naval supremacy, it might be permitted to expend a large sum of money; yet it would not do *to have several Dovers*; and, therefore, it behoved the authorities to consider carefully the site, the plan, and the method of construction, before commencing works, in which, in the present state of engineering science, the experience of the past should be used to avoid the errors that had occurred in former and similar works.

In the discussion which ensued, and in which the principal civil engineers engaged on great hydraulic works took part, after justly complimenting the Earl of Lovelace, for the very able and impartial analysis he had made of the evidence contained in the Government reports, and the documents in his possession, the speakers explained most satisfactorily the actual circumstances and conditions of the works which had been instanced as failures; and it was shown, that far from being expensive or useless works, they had been completed within the original estimates; and that wherever the construction had required restoration, or addition, it had arisen from the use of defective materials, which, being on the spot, it had been obligatory to employ, and not from the use of the long slope, which, as compared to vertical walls in similar situations, was shown to be more durable, and to have been, in many instances, successfully substituted for vertical walls, after they had succumbed to the assaults of the raging billows.

INSTITUTION OF MECHANICAL ENGINEERS.

June 13.—J. E. M'Connell, V.P., in the Chair.

ON THE BALANCING OF WHEELS.

Mr. M'Connell read the following interesting paper on the above subject:—The paper treated on the balancing of wheels as a very important matter, as most of the accidents from carriages jumping off the line, had arisen from the balance in the wheels of the engine. The first who made this matter of practical observation was Mr. George Heaton, of Birmingham, on examining a lathe in the turning-rooms of Earl Craven, the pulley of which he found to be out of balance. This he remedied, and the lathe worked well again. Mr. M'Connell instanced several railway accidents of late, which had arisen from a want of proper balance in the wheels of the engine. He then proceeded to illustrate the usual method of balancing the wheels of locomotive engines, which he considered an improper one, and, on reference to experiments with another model, pointed out the desirability of obtaining an accurate balance in the piston and piston-rod.

In the course of the paper, Mr. M'Connell exhibited various experiments with a model railway carriage, explanatory and illustrative of the statements advanced in the above paper. The first experiment was made with wheels in balance, the motion to which was given by a spring, and the sustained regularity of the motion was unexceptionable. In the second experiment, a small piece of iron was inserted in the wheels, and the balance consequently destroyed—the natural tendency being to cause a jumping and jerking motion, to obviate which was the object sought in this contrivance. Similar experiments were made, to show the necessity of adopting a similar system of balancing the piston and piston-rods, in order to obviate this same jumping motion.

In explanation, Mr. M'Connell said, that the wheels could be properly balanced together. First, one wheel was balanced, and then they put the other wheel on upon the other side of the engine, and balanced it in the same manner. When the matter was first placed before Mr. Robert Stephenson, that gentleman considered it of no service, and it met with much opposition; but since that time Mr. Stephenson, and many other gentlemen, had adopted a plan of balancing their wheels, which, in his (Mr. M'Connell's) opinion, was not the correct one. When a locomotive-engine was connected, and the driving-wheels and working part attached, it was lifted up upon centres, and set slowly in motion, balance-weights being added until it moved at a certain speed without oscillating, and it became perfectly settled on its centres. That plan might answer tolerably well, but it was the really true mode of balancing wheels. He considered that great evil resulted from the piston and piston-rod not being in balance; it had been the cause of accidents in several cases where the engine did not leave the rails when the wheels were in balance. If the engine attained a certain velocity—the piston-rod moving 1,000 feet a minute—this momentum became so great, that the engine must jump; and the front wheels were, in some instances, clear of the road, and they could see between the wheel and the rail. They had an engine at Wolverton, fitted up with those correcting-weights, and it had been tried, for the first time, that morning on blocks. The engine at a certain speed on the blocks, threw itself down, and they were not able to run it so fast as might be wished; but, on attaching the balance-weight, the motion of the engine was completely neutralised.

Mr. Middleton said, that this appeared to be the system of balancing wheels, which had been introduced to the notice of the North-Western Railway, some years ago, by Mr. George Heaton, and against which hitherto there had been much prejudice. He felt convinced that it was one of the best methods ever suggested for securing the safety of the public, when travelling on railways, and a great many accidents might be obviated by the adoption of this, or some similar plan of balancing the wheels of engines and carriages. It was supposed that the North-Western line had disapproved of Mr. Heaton's plan, but he was happy to find that there was now some probability of Mr. Heaton reaping the reward of his industry by the use of his patent.

Mr. Cowper said, that a system of balancing wheels was used by the

Eastern Counties Company eleven years ago; but this was decidedly a superior plan to any he had ever witnessed, and in many respects superior to the plan he had seen of Mr. Heaton's.

Mr. M'Connell said, that Mr. Robert Stephenson had expressed his entire approval of the utility of the proposed mode of balancing wheels, and had already given orders for it to be attached to an engine he was now constructing.

LIGHT ENGINES—LIGHT TRAINS.*

The Secretary read the following paper on the above subject, by Mr. Samuel, engineer of the Eastern Counties Railway:—"The small locomotive, lately introduced on the Eastern Counties Railway, having attracted some considerable attention, has induced me to present to your notice a short description of it; and, at the same time, to offer a few observations on the practicability of the principle to the conveyance of passengers. This carriage was constructed under my superintendence, for the purpose of conveying myself and inspectors on the lines of the Eastern Counties Railway, and thereby avoiding the great expense of special engines. The total length of the carriage is 12 ft. 6 in., and includes machinery, water-tank, and seats for seven passengers, on one frame, which is hung below the axles, and is carried on four wheels, of 3 ft. 4 in. in diameter, the floor being within nine inches of the level of the rails. It is propelled by two cylinders, 3½ inches in diameter, with a 6-inch stroke, placed on each side of the boiler, and acting on a crank axle. The boiler is cylindrical, placed vertically, and is 1 ft. 7 in. in diameter, by 4 ft. 3 in. in height; containing a fire-box, 16 inches diameter, by 14 inches high; and 35 tubes, 3 ft. 6 in. long, by 1¼ inches diameter: giving 5½ feet heating surface on the fire-box, and 38 feet on the tubes. The engine is fitted complete, with link-motion, feed-pumps, &c. The water-tank is placed under the seats, and will contain 40 gallons. This carriage is capable of conveying seven persons, at the rate of 30 miles an hour. It has, at times, attained a speed of 44 miles. The consumption of coke is only 2½ lb. per mile; and the weight of the whole machine does not exceed 25 cwt., including coke and water. The result of observations, which I have for a considerable time been making, on the Branch Passenger Traffic of Railways, has been to convince me that, on the whole, it is not remunerative, and, in some cases, is even worked at a loss. I have been, therefore, led to consider whether the expenses might not be reduced, by the introduction of a system of steam-carriages more suitable to the amount of traffic to be conveyed. It is evident, that the more we can reduce the dead weight of the trains and engines, in proportion to the number of passengers, the less will be the expense of repairs, both of the carrying stock and engines, and of the way and works of the line. The average weight of a train, on the branch lines of the leading railways, is 56 tons; the number of passengers, conveyed by each train, not exceeding 25 to 40 on many of the branch railways in England. Supposing each passenger, with luggage, to weigh 1½ cwt., the total weight of passengers conveyed is about 3 tons; or, in other words, for every ton of paying load we are now carrying by the present system of locomotion, we have from 18 to 20 tons of dead weight. It is, therefore, in a commercial point of view, of the greatest importance, not only to railway companies, but to the public generally, that some less expensive, and, at the same time, equally safe, means of transit be adopted. It is, therefore, proposed to substitute steam-carriages for locomotives on branch railways, similar in construction to the drawings herewith produced. These drawings represent a patent steam-carriage, now in course of construction, under my direction, by Mr. W. B. Adams, the patentee, for the Eastern Counties Railway Company. The following are a few of the principal dimensions:—Diameter of cylinders, 7 inches; length of stroke, 12 inches; diameter of driving-wheels, 5 feet; distance between centres, 20 feet; width of framing, 8 ft. 6 in. The boiler is of the ordinary locomotive construction; 5 feet long, by 2 ft. 6 in. in diameter. The fire-box is 2 ft. 10½ in. by 2 ft. 6 in. There are to be 115 tubes, of 1½ inch in diameter, and 5 ft. 3 in. in length, giving 210 feet of heating surface in the tubes. The area of the fire-box is 25 square feet, giving a total of 235 feet of heating surface on the boiler. The consumption of coke I have estimated at 7 lb. per mile, at a velocity of 40 miles per hour. The total weight of the steam-carriage, with its coke and water, will not exceed 10 tons, and it will be capable of conveying about 42 passengers, at a speed of 40 miles per hour. The water is to be carried below the floor of the carriage, in wrought-iron tubes, of 12 inches diameter, and 12 feet long. One great object attained in this machine, is the reduction of the centre of gravity, and the consequent absence of lateral oscillation. This carriage is intended for the Enfield and Edmonton branch of the Eastern Counties Railway, and is expected to be at work in about three months from this date. When its practical utility and economy has been proved, I shall be glad to submit the result to the Institution at a future meeting; as I feel convinced that the subject is one deserving the attention of the members, and of all parties interested in the profitable working of railways. I may also add, that were the system of light steam-carriages adopted, branch railways might be constructed at a very small cost indeed, compared with the present outlay (which is unavoidable so long as the present system of heavy engines is continued); and the advantages of railway accommodation might be extended to those districts, which can never hope to enjoy them, if the construction of railways continue to require such large outlay of capital."

* This paper fully supports our remarks in the "Journal" for December last (vol. ix., p. 385.)

Mr. M'Connell also read a communication on the same subject. He had declined giving any opinion, wishing to take the sense of the Institution upon the merits of the engine in question.

Mr. Samuel considered that his engine would save a considerable sum in the wear and tear of the rails, if not in coke, in consequence of the great reduction in the weight of the engine. He estimated the wear and tear of rails at £80 per annum, independent of the loss in the tyres of driving-wheels, which was a large source of outlay. He suggested the running of a number of small trains on a light description of rails, which would reduce the cost of branch railways, and, at the same time, be adequate to all the local traffic.

A Member inquired, how the projector would be enabled to convey heavy castings upon such a line?

Mr. Samuel said, that might be obviated by distributing the weight over several trucks, as was sometimes found necessary upon the lines now in use; and, in case of holiday excursions, he proposed running a number of these small trains, instead of the present heavy ones.

Mr. M'Connell said, that he presumed it would be desirable to have the rails sufficiently heavy to allow an ordinary locomotive to travel over them, in case additional carriages had to be taken on at certain points of the line, for extra traffic arising from holidays, races, &c.

Mr. Samuel said, it would be desirable that such should be the case, where it could be done. It was proposed to construct these rails on longitudinal bearings of timber—therefore, a comparatively heavy engine might traverse it without danger. In reply to further questions, Mr. Samuel said, that the pressure usually used in this engine was 120 lb.; but it was not proposed to work those branch engines at a pressure of more than 80 lb.

Mr. M'Connell and Mr. Cowper considered this engine peculiarly calculated to be worked with economy on the branch lines, as it would tend very much to make them pay, by economising the locomotive expenditure.

Mr. Buckle inquired, how the distance of the wheels would suit the present turn-tables?

Mr. Samuel said, it was usual, at every terminus, to have a large turn-table, suited for engine and tender; and, where there was not such a contrivance, they could make a triangle, which would be as good. The increased speed obtained on these trains would obviate the necessity of frequent changes of carriages; and he estimated the average cost of conveying the passengers would not exceed one-fifth of a penny per mile. Many of the branch lines did not pay, and some economising principle was needed to effect that object. In answer to further questions Mr. Samuel said, that he proposed to work the goods traffic in a similar manner.

Mr. M'Connell still thought that the rails should be equal on these branch lines, to bear the ordinary engines now in use on the main lines, in case they went over them; the wear and tear would also be less upon strong rails.

Mr. Cowper considered the ordinary rails in use were much too light, and, at the present price of iron, he thought it bad policy to lay down a light rail.

The meeting expressed their entire approval of the engine for all the purposes of the ordinary branch lines of railway.

NOTES OF THE MONTH.

Daguerreotype Plates.—The plates prepared by depositing silver by electrical agency have been found far superior to the ordinarily-prepared plates. The mode adopted by Mr. Kilburn to test the superiority of the electro-plated metal is to deposit silver, by a Smee's battery, on one-half of a regularly-prepared plate, and then to apply the sensitive coating, and to go through the usual process of taking a picture. He says that the lights and shadows on the half that has been electro-plated will be much more clear and distinct, and that in comparison with that portion of the plate, the other will appear greasy. The requisite time of exposure also is found to be reduced about one-third.

Aerial Navigation.—Mr. Pitter, of Launton, Oxfordshire, has published plans and descriptions of an "improved Archimedian Balloon," whereby it is proposed to move through the air by paddle-wheels, set in motion by a steam-engine. This aerostatic machine will indeed be a "monster balloon," as it is proposed to give it buoyancy sufficient to raise thirteen tons; and it is to be 120 feet long, exclusive of hemispherical ends. Mr. Pitter conceives there will be little difficulty in steering this aerial ship, but he seems altogether to overlook the absence of a guiding resistance, for though he may be able to turn the machine round, that would be of no avail in steering, unless there be some resisting force superior to that of the wind.

Railways Opened.—One of the lines of rails of the Bolton, Blackburn, and West Yorkshire has been opened. The Tiverton branch of the Bristol and Exeter line was opened on the 12th June.

Compromise of the Gauge Question.—It has been decided by a committee of the House of Commons, "that the double gauge shall be laid down from Fenny Compton to Wolverhampton, the mode of laying down to be such as the Railway Commissioners may approve." "By this decision," says the *Railway Chronicle*, "the settlement of the gauge question, to attain which a commission was appointed in 1845 and legislation took place in 1846, is sent to the wind."... "Thus, diversity of gauge is being allowed to take root in the most pernicious form which it could adopt—namely, the double gauge system."

New Atmospheric Railway.—A working model of Messrs. Harlow and Young's atmospheric railway has been recently exhibiting, and it works very satisfactorily on a length of 150 feet, with a four-inch tube. The peculiarity of the invention depends on the formation of the valve. The tube is cast with a longitudinal opening, similar to Clegg's; but, instead of a flap-valve, the action is precisely similar to the slide-valve of a steam-engine. The sides of the opening are so cast, that one side presents a horizontal groove, and the other a tabular face, both planed perfectly true. On the tabular face the slide-valve rests, when forced out of the groove by the passage of the coulter, consisting of bars of iron, in a full-size working tube, proposed to be 4 or 5 feet in length. At each end of these bars a semicircular opening is turned through about half their thickness, forming, when two abut against each other, a circular slot, in which is placed a disc of iron, ground perfectly true with the under surface of the bars, and thus presenting a sort of rule joint without any fixed axis, and forming collectively a loose chain which slides over the opening, and renders it air-tight. To each of these bars, or links, is placed a steel spring, in the shape of a carriage-spring, merely of sufficient power to press the valve into its place, after the passage of the coulter. The whole is covered by a top plate, to keep out grit, wet, snow, &c., with the exception of a small space to allow the coulter to pass, which is not much thicker than a saw blade, and which connects the leading carriage with the piston in the usual manner.

Preservation of Wood for Railway Sleepers.—Messrs. Hutin and Bontigny have obtained a patent in France, for the preservation of wood intended for railway sleepers; the process of which depends on filling the pores at each end with a bituminous cement, after the ends have been previously charred. The process is thus described: "Immerse the ends of a piece of wood in some liquid carburetted hydrogen, such, for instance, as the oil of schist, which penetrates quickly some distance into the wood. 2. Set this carburetted hydrogen on fire, and at the moment the flame has burnt out, plunge the wood to the height of a few inches into a hot mixture of pitch, tar, and shellac, which will be slightly drawn up between the fibres, and form at each extremity of the wood a kind of hermetical seal, unalterable by moisture and air. 3. Coat the wood with tar over its whole surface by the ordinary methods."—A process nearly similar was not long since communicated to the Paris Academy of Sciences, by M. Gemini, In his plan, tar is used for the purpose of filling the pores of the wood, without the addition of any substance. He encloses the wood in a cylinder, wherein it is dessicated by high-pressure steam. A vacuum is then produced, and additional force is given to the tar in its penetration of the fibres of the wood by a force-pump. M. Gemini observes that a separation takes place between the solid portion of the tar (the pitch) and the oily portion; and that the first penetrates only an inch, whilst the oily matter will penetrate throughout the whole substance of the wood.

The "Divining Rod."—It is a practice not uncommon in the mining districts of Cornwall, to search for veins of ore by the "divining rod," which is supposed to be attracted towards the metal on walking over the surface of the ground. The following letter, in the *Mining Journal*, signed "H. F. Penny, Notting-hill," thus describes the *modus operandi*, as having been successfully practised in his presence. If Mr. Penny be neither deceiving nor deceived, this is one of the things that philosophy cannot account for:—"I have witnessed the operation of the divining rod, in a manner most conclusive and satisfactory to my own mind. I went, accompanied by Mr. H., first to Wheal Jane, the underground captain of which is what they call a douser. He ordered one of the men to cut half-a-dozen withes, of the requisite shape, from a neighbouring hedge, and we then proceeded to a field, across which the lode lay. We each held a rod, and walked abreast, the captain in the middle. Upon crossing the lode his rod bent downwards, and, to my surprise and delight, I felt, at the same time, mine pressing against the flesh of the finger, when it went down gradually from being perpendicular to horizontal, but would not go lower. Mr. H.'s remained perfectly stationary! We tried it again and again with the same result—the captain's, however, going lower and more freely than mine. We then went to another mine beyond Perran, and sent for a labouring miner from underground, who is a celebrated douser. We had another gentleman, a Mr. C., with us, an old farmer, a clerk of this mine, and myself—thus making six, all armed with rods. On crossing the lode, the dowser's rod went down like a shot, completely inverted! Mine went down gradually, but its pressure was quite perceptible, until one of the limbs of the rod, close to my fist, actually broke off, from the mysterious force in operation. Now, holding my hands perfectly still, and grasping each limb of the rod, it is impossible to move it downwards by any voluntary motion, much less to break it. Mr. H.'s remained as usual, quite stationary, as also the clerk's; the farmer's and Mr. C.'s acted nearly as powerfully as mine, very much to the astonishment of the latter, who was an unbeliever. I may mention, that it will not act with one person out of 50, or, perhaps, out of 100."

The Magnetic Telegraph.—Mr. Nathaniel Holmes, who is in the employment of the Electric Telegraph Company, has made an improvement in the magnetic telegraph which promises to be of great utility. The inven thus described by himself in a letter to the *Athenæum*:—"It may uninteresting to record the recent improvement I have made in reduc expenditure of battery power to one-tenth of the amount required b so that now, instead of working on the long circuit (a distance of abo miles), with an equivalent of 240 pairs of plates, 24 pairs do duty, much more effective result—the reduced intensity not suffering so mu the effect of bad insulation. The most important point, however, economy of power when it is applied to the numerous stations thro the kingdom, and the increased facility of working through a much amount of circuit resistance. The addition consists in the substitutio single small steel lozenge, three quarters of an inch long, for th 5-inch astatic magnetic needles, and placed between two small coils, culiar shape. This form has the advantage, besides those already men of giving a signal free from that constant vibration of the needle, which so much has been said—the pendulous action of gravity bein limited, from its better adapted form."

Telegraph Profits.—The profits of the New York and Washington graph Company are reported to amount to 1,000 dollars per month. Western Telegraph Company is, however, said to be doing a better bu than that.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM MAY 30, TO JUNE 16, 1848.

Six Months allowed for Enrolment, unless otherwise expressed.

William Wood, of Cranmer-place, Waterloo-road, Surrey, carpet manufactu "Improvements in weaving carpets, and in printing carpets and other fabrics."—May 30.

William Seaton, of Camden Town, Middlesex, gentleman, for "Improvem closing tubes, and in preventing and removing the incrustation in boilers."—May

Jasper Wheeler Rogers, of Nottingham-street, Dublin, civil engineer, for " Improved methods and machinery for the preparation of peat as a fuel, and in co tion with certain substances as a compost or manure."—June 1.

Richard Christopher Mansell, of Grange-road, Surrey, gentleman, for "certa provements in the construction of vehicles used on railways or on common ro June 1.

Thomas Hunt Barber, of King-street, Cheapside, for "Improvements in machi sawing wood." (A communication.)—June 1.

James Barham, of Stratford, Essex, manufacturer, for "Improvements in the facture of mats."—June 1.

Thomas Burdett Turton, of Sheffield-street, manufacturer, for "certain Improv in machinery for bending and fitting plates or bars of steel, iron, and other mater be used for locomotive engine and carriage springs, and other purposes."—June 1.

Henry Adcock, of Moorgate-street, London, civil engineer, for "certain Improv in furnaces and fire-places."—June 3.

William Brindley, of Birmingham, manufacturer, for "Improvements in the facture of articles of papier-mache."—June 6.

Richard Barnes, of Wigan, Lancaster, gas engineer, for "certain Improved app for manufacturing gas for illumination, part of which improvements is applica retorts for distilling, pyroligneous, and other similar purposes."—June 6.

Benjamin Lathrop, Esq., of King-street, Cheapside, London, for "an Improved for railway purposes."—June 6.

Joseph Foot, of Spital-square, Middlesex, silk manufacturer, for "Improveme making skeins of silk."—June 8.

Joshua Procter Westhead, of Manchester, manufacturer, for "Improveme manufacturing fur into fabrics."—June 8.

Thomas Dalton, of Coventry, silk dyer, for "Improvements in the manufac fringes, gimps, and bullions."—June 8.

Paul Marie Darlu, of Paris, in the Republic of France, for "Improvements in ob motive power."—June 8.

Richard Want and George Vernum, both of Enfield, Middlesex, engineers, fo improved steam-engine, which may be also worked by air and other fluids."—June

John Miller, of Henrietta-street, Covent Garden, gentleman, for "a new sys accelerated menatrite locomotion, even by animal impulsion, for every species of tra machines acting by means of wheels, whether on land or water." (A communicati June 13.

Charles Henry Capper, of Edgbaston, Warwick, gentleman, for a method of pr and cleansing minerals and other substances."—June 13.

Joshua Taylor Beale, of East Greenwich, Kent, civil engineer, for "Improveme the construction and arrangement of engines and machinery for propelling bo vessels on water, with a means of preventing incrustation in the boilers, parts of improvements are applicable to land purposes."—June 13.

William Hunt, of Dodder Hill, Worcester, chemist, for "Improved apparatu used in processes connected with the manufacture of certain metals and salts."—Ju

Sir Henry Hart, Commissioner of Greenwich Hospital, Rear-Admiral in the Nav "Improvements in apparatus for preventing what are called 'smoky chimneys.'"—13.

William Chamberlin, jun., of St. Leonard's-on-the-Sea, Sussex, gentleman, for provements in apparatus for recording votes at elections."—June 13.

James Roose, of Darlaston, Stafford, tube manufacturer, and William Haden Ri son the younger, of the same place, for "Improvements in the manufacture of tu —June 15.

George Emmott, of Oldham, in the county of Lancaster, civil engineer, for "c Improvements in the manufacture of fuel, and in the construction and arrangem furnaces, flues, boilers, ovens, and retorts, having for their object the economical ap tion of caloric, the manufacture of gas for illumination, and the consumption of s and other gaseous products."—June 16.

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THE JACQUARD PUNCHING MACHINE.

(With two Engravings, Plates X. and XI.)*

Patent Machine for Perforating Metal Plates, such as are used Steam-Boilers, &c.; and employed for Punching the Plates of the ular Bridge at Conway; made at the Globe Works, Manchester, Messrs. Roberts, Fothergill, and Co.

Mr. Roberts, the patentee, has most liberally, at our particular quest, furnished us with all the detailed drawings of this very portant machine; for which we are sure all our mechanical ders will join with us in awarding thanks for his liberality.

Fig. 1 (Plate X.) represents a sectional elevation of the machine; 2, an elevation of the back of the machine; fig. 3, a plan-view of apparatus for putting the punches out of action without ping the fly-wheel; and fig. 4, a plan-view of a few of the uard plates. Fig. 5 (Plate XI.) represents a front elevation; , a side elevation; and fig. 7, a horizontal section, taken through otted line A¹, A¹, in figs. 1 and 2. Fig. 8 is a detached view he traverse-apparatus; and fig. 9, a detached view of the ing-down or stripping apparatus. A, A, the standards. B, ed, through which there is an opening for the punchings, or punched out of the plate, to fall through; this bed is in-d into the standards. C, a stretcher-bar, to connect the top he standards. D, fulcrum of the levers *q*, *q*, which withdraw punches, and of the lever *w*, which traverses the plate. E, a rum-shaft, to which the levers *j*, *j*, and *k*, *k*, are keyed. F, the n or eccentric shaft, working in bushes in the standards. G, ar-wheel, keyed on the eccentric-shaft. H, a pinion, working the wheel G. I, the fly-wheel shaft, on which are the fast loose pulleys K, and L, the pinion H, and the fly-wheel J. M, connecting-rods, fitted to the eccentric necks of the shaft N, N, caps of the connecting-rods M, M. O, O, guide-plates the punch-rams P, P. Q, the cam-shaft. R, a spur-wheel, e on the cam-shaft, and having on one side two projections, ween which there is an opening. R*, a locking-disc or plate, ed on the shaft Q, having upon it a spring catch 38, which es into the opening between the projections on the wheel R, and R*, are seen detached in fig. 5, and the dotted lines on R* resent a weight to counterbalance the levers *k*. S, a toothed-eel, keyed on the main-shaft F. T, the punch-ram-depressor, ured to the connecting-rods M, M, by knuckle-joints at the er end of the connecting-rods. U, a slide-bar, on which the me traverses, which carries the plate to be punched. V, V, two rt slide-bars, to carry one side of the traverse-frame. W, a ck of iron, fastened with short wedges to the bed B, to carry die-plate X, into which the dies *d*, are inserted, and prevented m rising by a collar at the lower end of each, as seen in fig. 11. a square shaft, carrying the holding-down levers, or stripping-pers, *o*, *o*. Z, Z, levers on each end of the shaft Y. *a*, *a*, the nches let into the punch-holders *b*, *b*, bolted to the rams P, as n in the detached view, fig. 5. *c*, *c*, pieces bolted to the bed to carry the adjusting slide-bars V, V. *d*, dies inserted into holder X. *e*, *e*, (fig. 1), are the selecting slide-bars, which, en allowed to pass through the card-plate, enter the card-roller *f*, thout being pushed backward by them; the card-roller has in s case six sides, and the belt of Jacquard plates, after passing er it in the usual manner, passes over a round roller suspended a swing-frame, at such an angle as shall keep the belt oderately tight, whilst the roller *f* advances towards and recedes m the selectors *e*. *g*, *g*, brackets projecting from the depressor , and carried up and down with it. *h*, *h*, sliding-blocks, in which he journals of the card-roller turn. To an upright cast on each of hese blocks, is fitted a rod of round iron, thus, *, with a flat foot, ong enough to extend over two of the six pins in the ends of the ard-roller, against which the flat foot of the rods is made to press, by spiral-springs coiled around them in the usual manner employed in the Jacquard-loom, which is generally known, and need not be further described. *i*, *i*, (fig. 1), are two sets of guide-blocks, for the selectors *e*, one on each side of the depressor, adjustable laterally by set-screws on flat bars, extending across the machine; the use of these blocks is to carry the selecting-bars *e*, which are round at the end that enters the cards, and flat at the other end, to keep them in their proper positions; the centre portion of each selecting-bar is a solid piece of iron, projecting as much below the round stem as will, when the selecting-bar is driven backwards by a card-plate, permit the depressor T to complete its downward stroke without the selecting-bar touching the ram P, under it. *j*, *j*, are levers keyed on the shaft E, and connected at their lower end by links to the slide-blocks *h*, *h*. *k*, *k*, are levers also keyed on the shaft E, and having each a friction-roller at its lower extremity. On the shaft Q, are two cams, one of which works a lever *k*, on one side of the shaft, and the other cam works the other lever *k*, on the opposite side. One of the cams, through the medium of the levers *j*, *j*, and the links before referred to, causes the roller *f* to approach the selecting-bars *e*, and the other cam causes the roller to recede from them, until by a catch employed in the ordinary way in the Jacquard looms, the roller *f* is made to turn through one-sixth of a revolution, and is then retained in that position by the pressure of the spiral spring and flat foot above referred to. *l*, *l*, are brackets attached to the depressor T, at the back of the machine, seen best in fig. 1. *m*, a bar resting on the brackets *l*, *l*, and connected by rods with the sliding-blocks *h*, *h*, which, on receding, cause the bar *m* to bring all the selecting-bars *e* into the position for depressing the rams, as seen in fig. 11. *n*, *n*, are levers having their fulcra on studs screwed into the standards; one end of these levers is connected by a rod *p*, with the levers Z, Z; the other end is furnished with a roller which is acted upon by a cam *u*, on the shaft Q, (see fig 8). *o*, *o*, are the holding-down levers, adjustable laterally on the shaft Y, so as to admit of one of them being placed on each side of every punch. *p*, *p*, are rods connecting the levers *n*, and Z. By adjusting the length of these rods, the levers *o*, *o*, are made to press upon plates of different thicknesses, so as to hold the plates down while the punches are being withdrawn. *q*, *q*, levers turning on the fulcrum-bar D, for withdrawing the punches by means of the cams *r*, *r*, that actuate levers *q*, *q*. *s*, a broad but rather thin bar, extending through the series of punch-rams P, shown by dotted lines in figs. 7, and 2. The punch-rams P, are made with slots, through which the bar *s* passes, and these slots must be about two inches longer than the width of the bar *s*, in order to allow the punch-rams to be forced down when the bar is at the bottom of its stroke. *t*, *t*, are links connecting the bar *s* with the levers *q*, *q*. *u*, *u*, are cams which depress the holding-down levers *o*, *o*, through the medium of the levers *n*, *n*, rods *p*, *p*, and levers Z, Z, and hold down the plate while the punches are being withdrawn. *v*, a cam for the traversing-rack 5. *w*, a lever turning on the fulcrum-bar D, and worked by the cam *v*. *x*, the cam for lifting the rack 5. *y*, a lever turning on a stud in the standard, and worked by the cam *x*, for lifting the traversing-rack 5. *z*, a rod connecting the lever *y* with the lever 8, seen best in fig. 10. 1, is a lever on the traverse-shaft 2. 3, another lever on the shaft 2. 4, a link connecting the lever 3 with the rack 5. 6, a rod connecting the lever *w* with the lever 1, for traversing the rack 5. 7, a shaft for carrying the levers 8, 9, and 10. 11, a link connecting the levers 10 and 12. 13, a shaft carrying the levers 12 and 14. 15, and 16, are links connecting the rack 5 with the levers 9 and 14. 17, the upper or retaining rack. 18, a stud carrying the elbow-lever 19, which is provided with a handle. 20, another stud carrying the elbow-lever 21, which is connected by a link 22 with the lever 19. The rack 17 is carried on studs in the horizontal arm of the levers 19 and 21. 23, division-studs in the bar 24 of the traversing-frame.

The plate to be punched is put into a traversing-frame formed of two side-bars, 24 and 25, and two stretcher-bars secured by cottars to the side-bars, which are rabbeted to support the plate, and, when required, furnished with clamps to hold the plate down. 24 represents one of the sides of the traversing-frame, in which there is a groove to fit on the slide-bar U; into the outer side of the bar 24, is screwed a series of studs 23, represented in the engravings as being 12 inches from centre to centre apart from each other. The side 25 of the frame slides on the bars V, V. When the plates to be punched are very long, rollers may be used to carry the projecting ends of the traversing-frame. In fig. 9 is shown part of a frame, with a plate partly perforated. The racks 5, and 17, (fig. 10,) are drawn with three teeth in the length of a foot, which will divide plates to a four-inch pitch; but it will be obvious, that for a different pitch the racks must be changed; and it may, in some (cases such as when the pitch required is not an aliquot part of a foot) be necessary to alter the distance between the studs 23. Fig. 10 represents the traverse-apparatus, in the position it will be in when the retaining-rack is down, and the punches in the act of passing through the plate, and the traversing-rack having completed its return-stroke.

When the punches are being raised, the traversing-rack will rise also; and by the side-piece 26 (which is attached to it) acting against the roller 27, on a stud in the rack 17, will raise it also, and set the frame at liberty to be advanced by the cam *x*, through the mechanical means already described. In fig. 1, this traverse-apparatus is shown in the position it assumes when the plate is ad-

* In consequence of the elaborate character of the two engravings, we are obliged to postpone giving one of the plates until next month; but when the volume is bound up, the two plates will appear together.

vancing. The spiral-spring 28, acts on the lever 21, and forces the rack 17 down on to the pins 23. For every hole required to be punched in line with the width of the plate under operation, a corresponding hole must be made in a plate of the Jacquard, and an additional hole, marked 30, (see fig. 9), is also made, into which the stopping-bar 31 enters at every stroke until the punching be completed, at which time the Jacquard plate 32, which is left blank, will push all the selecting-bars *e* beyond the rams P, and at the same time, by pushing the bar 31, disengage the cam-shaft Q, by the mechanism to be hereafter explained, at the point where the punches and the levers *o*, are held up, and thus will allow the perforated plate to be taken out of the machine, and another plate to be put into it. The stopping-bar 31, is provided with a projection on its lower surface, which depresses the click-lever 39, when the bar is pushed back; the lever 33 is keyed on a shaft 34, moving in bearings at the back of the depressor; on the other end of the shaft 34, is keyed the lever 35, to the upper end of which is attached the link 36, connecting it with the elbow-lever 37; theend of the other arm of this lever is inclined, for the purpose of unlocking the plate R*, and is provided with a stud, on which is a latch 38, the tail of which comes in contact with the incline on the elbow-lever 37, when it is in the position shown in dotted lines in fig. 3; and as the wheel R revolves, the latch becomes disengaged from the opening between the two projections cast on the said wheel, at which time the cam-shaft Q, ceases to revolve. When the stopping-bar 31 has been pushed back, it depresses the lever 39, and liberates the lever 33 from behind the projection on the lever 39, when the spring 40 will pull the elbow-lever 37 into the position shown in dotted lines. To the blocks *h*, a small shaft is attached, on which are two levers, suspending by links a plate of metal similar to a blank card-plate, except that the holes for the guide-pins are cut at the bottom edge. At each end of the same shaft is a lever-handle, held up or down by a side-spring in the ordinary way. The use of this apparatus is as follows:—Should it be required to stop the machine before the plate is finished, by raising the lever here referred to, the blank plate will come in front of the roller, and will act the part of a blank Jacquard plate, and stop the machine.

Having now described the principal parts of the machine, we shall proceed to explain the manner of its working. The plate to be punched having been placed in the traversing-frame, on the sides U, and V, is then pushed forward. In its progress, the first pin of the series 23, passes under the inclined end of the rack 17, until the first notch in the rack falls upon the pin. The driving-strap being now on the fast pulley K, the machine is set to work by pulling down the handle 42, keyed on the shaft 34, until the lever 33 is latched by the click-lever 39; the elbow-lever 37 is then, by the spiral-spring 40, brought into the position shown in fig. 3. The latch 38 being now liberated, will, by the action of the spring 41, (see fig. 1,) drop into the notch in the wheel R, the first time it comes round; the cam-shaft Q will now revolve at the same speed as the shaft F, and the Jacquard-roller *f*, will be drawn back and made to perform one-sixth of a revolution on its centres; after which it will be advanced, and the first card of the series will remove those selecting-bars for which there are no holes in the Jacquard plate; the other selecting-bars will remain over their respective rams P, which will then force down the punches through the plate, by the descent of the depressor T. A little before the punches have gone through the plate under operation, the levers *o*, are made to press upon it, and are held there while the punches are being withdrawn by the bar *s*, which rises simultaneously with the depressor T, during one-half of its ascent.

Whilst the depressor is continuing its ascent and descent through the other half of the stroke, the roller *f* recedes, and draws with it the bar *m*, which brings all the selectors again over the punch-rams P. The roller *f*, while receding, having performed another sixth of a revolution, will, on advancing, bring another of the Jacquard plates against the selectors, and the operation will be repeated until all the holes are punched in the plate under operation.

Iron Vessels.—Mr. Fowles of North Shields, suggests the following improvements in the construction of iron vessels, by forming the keel and kelson of plate or bar-iron in one or two breadths, from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in thickness, and from 20 to 24 inches deep, and then to form the floors of angle-iron in two lengths, and turn the ends of each up the side of the kelson, and connect them together by rivets through the kelson from side to side. The floor plates also to be in two lengths, which being rivetted to the floors, the two sides of the ship will be connected together.

CANDIDUS'S NOTE-BOOK, FASCICULUS LXXXIV.

> "I must have liberty
> Withal, as large a charter as the winds,
> To blow on whom I please."

I. In that very amusing, but slovenly and in parts rather dull congeries of gossip, entitled "Nollekens and his Times," *Museum* Smith speaks of a certain "*happy possessor* of some of the *worst fragments of the antique in this kingdom*, who employs a mere mason to put them together, and is perfectly satisfied though a right foot has been most ingeniously placed upon a left leg!" Who the "happy possessor" alluded to was, I know not, but I do know that, *mutatis mutandis*, the satire applies as forcibly, or in general far more forcibly, to the stupid, and tasteless, and bungling, botchings-up of architectural odds and ends—whether antique or mediæval, classical or ecclesiastical—into a design intended to pass as an unexceptionable specimen of the particular style which is professedly imitated, but generally caricatured more or less when so treated,—*secundum artem*, but contrary to all artistic principle, and not unfrequently contrary to meaning and purpose also. Would that in architecture no greater blunders were ever committed than that of sticking "a right foot on a left leg,"—in which case the *artist* might fairly have excused himself by swearing point blank that it was not the *right* foot.—Our being imitators at the present day might be forgiven; but we are not so much imitators, as mere *copyists*, incapable of entering into the spirit or meaning of our models,—which are to us little better than blind guides, simply because we ourselves follow them blindly, and without the least regard to widely-altered circumstances. What more may, under present circumstances, be made of a style, is what we never consider. Yet if we really studied our models, we should find—at least, in all those most deserving of being studied—every part well *motived* and adapted to the express occasion. How far we in that respect imitate those who have gone before us, I leave it to the impartial reader to determine for himself.

II. In his above-mentioned book, Smith is pleased to say: "Men of true taste visit a mansion only upon the report of its statues, busts, and pictures. The architecture of a house unadorned by such productions of art, would not induce the general traveller to drive twenty miles out of his road, nor even five. How few allurements, indeed, would the Marquis of Lansdown's, Lord Pembroke's, Lord Egremont's, Lord Farnborough's, Sir Abraham Hume's, Mr. Peel's, (now Sir Robert), and many other noble mansions have, if totally destitute of their fine collections of statues and pictures!"—No doubt such would be the case, but why?—first, because there is nothing whatever of architectural interest in the "noble mansions" themselves; and, secondly, because if there were, your "general travellers" have very little, if any taste at all for architecture. I was the other day in a house here in town,—one that I may fairly call an "architectural house," which although totally "destitute of pictures and statues," with the exception of a *basso-relievo* by Lough, over a chimney-piece in one of the rooms, is in itself all *picture*—as superior to Peel's as a pine-apple is to a pippin. For my own part, whenever I go over a house for the first time, I have neither eyes nor thought—nor if I had, I have not time—for anything but the architecture itself. As to pictures and statues, any dowdy house may be bedizened out with them, and still be, as a house, as dowdy as ever,—a perfect cluster of C's: very convenient, very comfortable, very commodious, very correct, very *comme-il-faut*, and very (most of all) common-place.

III. In his anecdotes relative to Cosway, Nollekens' biographer says that, after quitting Pall-Mall, "he (Cosway) fitted up his new residence (No. 20, Stratford-place) in so picturesque, and indeed so princely a style, that I regret drawings were not made of the general appearance of each apartment; for many of the rooms were more like scenes of enchantment pencilled by a poet's fancy than any thing, perhaps, before displayed in a domestic habitation." If such really was the case, they certainly were worthy of being delineated; yet we may be allowed to entertain some misgivings—first, because such a character of the house partakes too much of the "*glamour* might" of some of George Robins's advertisements; and, secondly, nothing is said to corroborate it, or to give us any idea whatever of those "scenes of enchantment," notwithstanding that the writer could at least have done that,—have spoken of "the general appearance of each apartment," and have so far rescued them from complete oblivion. Instead of which, he merely goes on to astound us by enumerating some of the costly articles of furniture and certi which were displayed in the habitation of that once fashionable and now forgotten painter:—to wit, "ancient chairs, couches, and conversation stools, elaborately carved and gilt, and covered with the most costly Genoa velvets; escritoires of ebony inlaid with mother-of-pearl; rich caskets for antique gems exquisitely enamelled, and adorned with onyxes, opals, rubies, and emeralds (!). There were also cabinets of ivory, curiously wrought; mosaic tables set with jasper, blood-stone, and lapis-lazuli." Suffice it to say, that there were besides, among a variety of other things, "massive musical clocks, ottomans superbly damasked, Persian carpets, chimney-pieces carved by Banks, bronzes, models in wax and terracotta, crystal cups adorned with the York and Lancaster roses, &c. &c." To meet with such prodigal sumptuousness in the house of a painter must have been astonishing enough—almost incredible when contrasted with the scrubby, though never scrubbed, dog-hole rooms in which old "Nolly" and his amiable spouse *thrived* so well; or the wretched, but richly cobwebbed, garret in which Barry entertained Burke with a beef-steak and a pot of porter.—Still, I am quite at a loss to make out, from all that Smith says of Cosway's house, aught that warrants the expression of the rooms being so many *scenes* of enchantment, there being not a syllable even with regard to any of their decorations, or to indicate any particular fancy, or *recherché* taste, or well-studied effects in the rooms themselves. Sumptuous furniture and almost priceless works of art may be put into a very common-place room; but in such case, the latter is merely the receptacle of the other objects,—stripped of which, it would not be worth looking at; whereas—in a first-rate mansion, at least—every part of it, except the entirely private and domestic rooms, should be laid out with studied regard to effect, and to variety of effects—without, however, departing from consistency as to general character. Each apartment should be itself a picture,—strikingly beautiful in itself, charming, captivating, before it receives its finishing touches in the way of furniture and other accessories. At present, as they are left by architects, rooms (even those in the best houses) are little better than blanks, —large four-sided boxes for the cabinet-maker and upholsterer to fill; in doing which, they may chance to empty your purse before you are aware of it,—or if they do not actually do that, they are likely to disgrace your taste by cramming your rooms with a medley of ill-assorted articles, agreeing only in being all alike very expensive ones.

IV. In anecdotizing some of the former residents in St. Martin's-lane, Smith notices No. 60, as the house once occupied by Chippendale, "the most famous upholsterer and cabinet-maker of his day, to whose folio work on household furniture the trade formerly made constant reference. It contains, in many instances, specimens of the style of furniture so much in vogue in France in the reign of Louis XIV, but which, for many years past, has been discontinued in England. However,"—I entreat my reader to mark this—"as most fashions come round again, I should not wonder, notwithstanding the beautifully classic change brought in by Thomas Hope, Esq., if we were to see the unmeaning scroll and shell-work with which the furniture of Louis' reign was so profusely encumbered, revive; when Chippendale's book will again be sought after with redoubled avidity, and as many of the copies must have been sold as *waste-paper*, the few remaining will probably bear a high price." Smith's apprehension is already to a considerable extent verified; and that same Louis Quatorze taste, which, although dignified by such title, is essentially both puerile and barbarous, corrupt and *unprincipled*—quite contrary to every sound principle of sound art, seems to be now spreading through all branches of decorative design and ornamental manufactures; some recent specimens of which, though cried up by those who professing to guide public taste ought to know better, are chiefly remarkable not for elegance or beauty of form and combination in any respect, but rather for quite the reverse, and for what has been quaintly termed "*the depravity of elegance*;" which singular perversity of taste is the more unaccountable, as well as lamentable, now that we have Government Schools of Design. Really, if such institutions produce no better fruits than the specimens alluded to, the sooner they are broken up altogether, the better. The instruction there given, no more qualifies for producing artistic design, than learning to read and write qualify for a literary career. Were things left to take their natural and healthy course, very few except those who really possessed talent—or what is next to it, a decided relish for art—would think of applying to it. Where talent really exists, such institutions are no doubt highly beneficial, by enabling it to develope itself; but then, on the other hand, they are mischievous, inasmuch as they turn out upon the world a great many more who are quite talentless, though furnished with a certain degree of manual proficiency; and as such talentless creatures "must live," and cannot possibly be interdicted from exercising *pro malo publico* what they are pleased to call their "talent," the ultimate injury to art and to public taste is greater than the benefit. I remember a priggish young Oxford student boasting in company of the many eminent men who had been educated in *his* college, when he was cut short by some one calling out to him—"But you don't say a word of the thousands and tens of thousands of blockheads which it has also turned out," adding, *sotto voce*, "and I take you to be one of them."

V. In a letter on the subject of the the Architectural Publication Society, a correspondent of the *Athenæum* says, after quoting what is stated in that Society's prospectus, as to the paucity of architectural works in this country: "Surely the thumb-screw must have been applied to extort this confession!" When a remark to the same effect—that is, animadverting upon the paucity of English architectural publications, was made some short time ago in the *Westminster Review*, a gentleman who now figures among the "Promoters" of the above-mentioned Society, thought proper to contradict it publicly at one of the meetings of the Institute; nevertheless, what was then deemed an injurious calumny, is now proclaimed to be the fact. Indeed, it is wonderful that any one should have had sufficient hardihood to dispute it. For a certain class of architectural books, there has been a considerable demand and corresponding degree of supply, of late years; but they are merely elementary ones, and besides, almost exclusively confined to the Gothic style and to ecclesiastical architecture. Even graphic publications, such as those by Haghe, J. Nash, Richardson, and others, have been entirely mediæval—at least, of the "olden times" in subjects, and some of them altogether continental in their subjects also. We possess no satisfactory illustrations of contemporary English buildings, either in collections containing examples by different architects, or in works brought out by the respective architects themselves. Sir Jeffrey Wyatville's "Windsor Castle," is the last and almost the only English publication of the kind that has appeared in the present century; and that was by no means so satisfactory and interesting as it might have been, it doing only half its work, owing to the entire omission of sections, notwithstanding that they were indispensably requisite for much important information that is not to be obtained at all, except by means of such drawings. To whatever it may be ascribed, this falling-off in architectural publications is all the more surprising, when we consider how very much has been done in architecture during the last thirty years. Some few years ago, Mr. Weale, as will very well be recollected, made an offer to the Institute to bring out annually a volume of designs of the best buildings executed by living architects; but instead of such liberal offer being thankfully accepted, it was rejected not only once, but twice—for some time after the first rejection, it was repeated, and rejected moreover in the most sulky and ungracious manner. Yet now, these same people—for many, if not most of the "Promoters" belong to the Institute—come forward and whine out, that in architectural publications we are far behind all our continental neighbours, and "our deficiencies are very great, as a comparison of catalogues will show"! It would seem, then, that something like shame is at length felt. Let it be disguised as it may, the fact is, architectural works of a higher class (consequently expensive ones), similar to those which have appeared on the continent during the last thirty or forty years, are not saleable—that is, do not obtain a remunerating sale. There is no encouragement for bringing them out; wherefore, all enterprise of the kind is checked by certainty of loss. There are no publishers of them, for a plain and unanswerable reason—viz., there are no purchasers of them. It is not indeed to be supposed, that every copy would remain unsold, but the purchasers are so exceedingly few, that works of the kind could not be provided for them, except by putting an enormous price upon the books. Why all this should be the case, it is more easy to guess than it would be flattering to say. According to all appearances, the demand for them ought to be far greater than ever. The architectural profession has surprisingly increased in numbers; then we have a Royal and chartered Institute, which of course exerts itself most laudably in promoting and diffusing on all sides a taste for architectural studies; then, again, we have a Fine Art Commission, under whose cognizance architecture comes very prominently forward——pity, let me observe, *par parenthèse*, that said Commission did not take under their cognizance also Mr. Blore's additions to Buckingham Palace!——and as the Commissioners are selected from the aristocratic classes, the very natural presumption is, that Architecture, as well as the other Fine Arts, is studied among our aristocracy and the higher ranks of society. We have *blue-books* on matters of art, architecture included; *item*, architectural societies almost innumerable;—nevertheless and notwithstanding all these favourable symptoms, architectural study—at any rate, architectural publishing, is now at the lowest ebb. Yet, hardly is it because we in this country are so poor that we cannot afford to indulge in those book-luxuries, which our certainly not wealthier continental neighbours do. The plain truth is, that notwithstanding all our present chattering about art, we know nothing about it, and care less:—now, if any one calls that a *bull*, I return the compliment, by calling him a great *calf*.

VI. If architectural works, corresponding in character with those which used at one time to be published in this country, and which up to the present time have continued to be brought out upon the continent, are no longer engaged in by us, it is to be attributed, some will perhaps say, to their being supplied to us by the continent itself. That such publications as those of Schinkel, Kleuze, Gärtner, Famin, Gauthier, Letarouilly, Cicognara, Canina, Cassina, Diedo, Runge, Gladbach, Tietz, Joly (Chambre des Deputés), Calliat, (Hotel de Ville de Paris), and a great many others, are known here, there can be no doubt. One or two of them are stock-books with English booksellers. Yet, whether they have been imported to such extent as to render all home-production of the same sort quite unnecessary, may very well be doubted. Granting, however, such to be the fact, the consequence is, the continent gets nothing of a similar kind from us in return; wherefore, foreign architects, who would probably be benefitted by some exchange of ideas with us, are left to suppose that English ones produce nothing worthy of being shown, or that will bear the test of examination when fully exposed by being delineated in all its parts. We can very well afford, it may be said, to let other countries entertain whatever opinions they please of us, in the matter of architecture and art. Very true; why, then, are some among us so sore, so piqued, and so touchy, whenever it happens to be intimated that we lag far behind foreigners in regard to architectural publishing, "as any comparison of catalogues will show"—a confession now paraded before the public with the consent and under the auspices of several of our leading architects? If we have acted right of late years in entirely abstaining from producing architectural publications that might proudly rank with the best foreign ones of the kind, there is nothing at all to be angry or to blush at, whenever as much is stated. Rather ought we to congratulate ourselves upon our superior prudence and discretion. Why should "any comparison of catalogues" disturb us, or discompose the serenity of our tempers? On the other hand, if it be now considered desirable to show rivalry with the continent, in respect of architectural publications, what is contemplated by the "Architectural Publication Society" will go but a very little way indeed towards accomplishing such object.

VII. It might very naturally be imagined that architecture is pretty generally studied by our higher and middling classes, and that there would accordingly be a considerable and constant demand for books relating to it, it being from those classes that those who sit in committee and in judgment upon designs sent in at competitions are selected, or else elect themselves. They are of course all "highly respectable" and "honourable" persons, and so forth; yet that avails nothing, if they possess not at the same time some intelligence of architecture itself, which certainly does not come all at once by intuition, just when there happens to be occasion for exercising it, nor is it to be acquired without considerable study and application. Possibly, it may be that those who enter committees of the kind are so exceedingly ignorant, as not to be at all aware of the responsibility they take upon themselves, or their own utter unfitness for the office they assume. The consequence is, that although by undertaking it they are dignified—at least, fancy themselves to be so—art is damned. According to the present precious system of managing such matters, the sending in a carefully-studied design is no better than casting pearls before swine. A production of the kind elicits nothing better than a grunt, and the decision is made in favour of swill and Sansovino. Now, if gentlemen like to call for a bottle of genuine old Sansovino, they are welcome to do so; but it is, as my Lord Liverpool would have said, "really too bad" to cause other people to send in a hundred samples of various sorts, when the said Sansovino alone was wanted. Alas! for both the *nous* and the honour of the Army and Navy,—at least, for those of the Army and Navy Club, who, after taxing in no ordinary degree (owing to the limited space of the first sight) the ingenuity of between sixty and seventy architects, decided in favour of a prosaic affair vamped-up after Sansovino. That busy-body prig, Count d'Orsay, deserves to be well ducked in a 'Orse-pond, for leading the Army and Navy—our British Army and Navy, or their Club at least—by the nose. Rather ought the "club" to have been so wielded as to knock his Countship down, and send him to grope in the abyss of his coxcombical conceit. However, if English architects like to be kicked by French counts, without attempting to resent it, so be it. They may be both kicked and spit upon for aught that I care, if they are too cowardly to protect themselves.

VIII. In what he says of the Royal Exchange, the writer in the current number of the "*Westminster*" makes no objection to that edifice being so greatly disfigured by the shops. It is also somewhat strange, that while he so vehemently condemns the excess to which decoration has been carried at the Houses of Parliament, he is quite silent with regard to what persons less critical will be likely to consider the greatest fault of all—namely, the enormous cost so incurred. Mr. Hume's words, when he said (in 1836) he firmly believed that the expense of Mr. Barry's plan would be double the estimate, have already been verified. Mr. Mackinnon went even further, and declared that "Two Millions will not cover the expense." Let us then "firmly believe" that Three Millions will do so.

ARCHITECTURE AT THE ROYAL ACADEMY.

[THIRD NOTICE.]

Owing to the Exhibition's terminating this season somewhat earlier than usual, and to our not knowing that it was about to close until just a day or two before, when we were prevented from re-visiting it, we must now trust to our memory and a few slight notes previously taken down by us, for such further account as our readers must now be content with. Of the one hundred and sixty drawings in the Architectural Room, forty-six may very well be said to have "no business" there, they being not original architectural productions—not designs and compositions by the respective exhibitors, but merely views and other portraitures of different buildings, or bits of buildings. Now, in our opinion, subjects of that kind are at the best somewhat out of place in an architectural exhibition, if only because an annual exhibition is, unless otherwise expressed, expected to show us the performances of contemporary talent. Were the Architectural Room three or four times larger than it is,—or, what would be better still, were there two sufficiently spacious rooms, one of which might be set apart for what is mere architectural portraiture, there would be no objection to productions of the latter description being admitted, provided they were worthy of being so, either on account of intrinsic interest or freshness of subject, or superior ability and charm as regards artistic execution. Unfortunately, the reverse of this is the case: buildings that have become quite hackney and stale (having been shown again and again both in book-engravings and drawings, and also in copies from them, till we almost sicken at the bare mention of their names) are allowed to find admission at the Academy, in hundreth-edition representations of them. And not only are such things admitted, while original architectural productions are turned away, but many of them—and perhaps some of the stalest or else most trivial in subject, are allowed to occupy better places than drawings which show us, or rather would show us what we have not before seen, were they not hung where they cannot be seen themselves. As we have already observed, this is the unhappy case of No. 1095, the new Coffee Room of the Carlton Club-house; while, as if on purpose to render that case a still more scandalous one several large frames, which contain only very uninteresting views of architectural ruins, are placed very conspicuously nearly upon the "*line*." Had No. 1095 been differently described—had it passed, as it very fairly might have done, under the name of Mr Sydney Smirke, with the information that the encaustic embellishments were by Mr. Sang, it would, we suspect, have been very differently treated. Well, let us hope that it will be admitted again next season, for it certainly cannot be rejected as having been "already publicly exhibited," unless being publicly put out of sight is just the same as being "publicly exhibited." The *hangers* seem to think that they are at liberty to do just as they please in the Architectural Room, and commit all sorts of absurdities there without incurring the slightest censure. They know well enough that the architectural drawings are never spoken of by the newspapers press; the *hangmen*, however, are merely the executioners: they are not responsible for judicial blunders and want of judgment in the *judges* themselves, who not content with condemning this year many meritorious architectural performances, by rejecting them, have, by admitting them signified their approbation of a great many others which, whatever some among them may be as drawings, are below mediocrity as designs. If it be the policy of the Academy to bring architecture—that is, architectural drawings, into still further discredit and disfavour with the public, as a step towards such works being excluded altogether, after its being voted to be beneath the *dignity* of a Royal Academy to admit them into its exhibitions, much as we may admire the astuteness of such policy, we must reprobate its treacherousness.

To begin—as it is now high time for us to do, our notices of such drawings as we can now speak to, we will first of all mention those which belong to what is invariably the most scanty, though assuredly not the least interesting or least important class of subjects, we mean Interiors. One of them, whose title excites curiosity the most, is, as has already been stated, put quite out of sight. The next, No. 1117, "The Drawing Room and Corridor of the Army and Navy Club-house," *Messrs. Allom and Cross*, fares very little better, it consisting of two small drawings in the same frame, which being only slightly tinted in sepia, and hung up considerably above the eye, are hardly observable.* Of these two subjects we prefer the "Corridor" one, as manifesting, besides taste and considerable novelty also, more judgment with regard to due gradation of effect than the usual mistakenly ambitious practice of making the approach to the apartments in a club-house or private mansion far more impressive and important—architecturally speaking—than the rooms themselves,—pompous prefaces to what is, if not actually paltry, more or less common-place. We question whether the actual Club-house now in progress will be able to show anything half so full of effect—so scenic, yet not at all extravagantly or forcedly so, but rather quite the reverse—as this portion of Messrs. A. and C.'s design would have been. At the same time, we think there was more than one other design offered that was upon the whole still better than theirs. However, the Club, or perhaps the Count—the Hercules who wields that *club*, and against whom all the arguments of criticism *count* for nothing, has decided differently. We find that we have passed over in its numerical order, an interior placed conspicuously enough, therefore not at all likely to be passed by unnoticed on the wall, viz., No. 104, "Design for the Interior of a Room, decorated with Illustrations of the Coldstream Guards," *H. Shaw*. This design is about as odd as its title is oddly worded. The drawing is a large and pains-takingly laboured one; the "interior" of the room shows what is meant for florid Tudor Gothic in all its floridness, in which flags and heraldic embellishments bear a prominent part; still it is not by any means to our taste, and we therefore consign it over to the "illustrated" if not illustrious Coldstream Guards, for their especial admiration. As No. 1299, "Drawing of an Ancient State Pall belonging to the Company of Fishmongers," is by the same exhibitor, it may properly enough come in for notice immediately after the preceding. Its title shows it to be an exceedingly antiquarian affair—far more antiquarian than at all architectural. It is, in fact, little more than a highly-laboured drawing of a more curious than tasteful needle-work relic. What business it has to be here in one of the very best situations, we do not understand; on the contrary, marvel much at finding it here at all, knowing, as we happen to do, some of the architectual *designs* which were turned away in order to make way for such a very *old-ladyish* affair as this. Perhaps it took the fancy of the old ladies in the Academy.

No. 1200, "Entrance Hall and Staircase of the British Museum," as decorated by *L. W. Collman*, is a large and most captivating drawing, and strange perhaps to say tolerably well-placed. As to its subject, it is not so acceptable as one less known would have been, the Museum being freely open to every one; and so far, we could wish that Mr. C.'s drawing had changed places with Mr. Sang's,—the interiors of club-houses being not made of "penetrable stuff," but their beauties as carefully secluded from gaze profane and critic's eye, as are those of an eastern harem. In itself, the Museum staircase is not particularly striking—striking only by comparison with the plainness and bareness of the other parts of the building—the King's Library alone excepted. Faithful, too, as is Mr. C.'s representation, it is a flattering one, because of the hall itself it shows nothing more than what serves as fore-ground to the staircase, which is seen directly in front. All disturbing circumstances—all that detracts from or interferes with the scenic effect, as the staircase is thus shown, is kept out of sight. You are at liberty to fancy that it displays itself thus on first entering, or that if not at one extremity of the hall, it comes in at least at the centre of one side of it.—No. 1224 gives another staircase—viz., that at "Beaumanor Park, Leicestershire," *W. Railton*; in favour of which very little can be said, either as regards the design itself, or the manner in which the view is taken. The style adopted is the heavy, cumbrous Elizabethan, whose quaint carved-work is far more costly than elegant, although it costs an architect nothing—no study or thought, if he be content merely to copy without studying how to refine upon such style, and bring it into keeping with modern taste and notions as displayed in all respects throughout a modern residence.—No. 1288, "Design for an Entrance Saloon, adapted to the English climate," *W. Papworth*, puzzles us exceedingly. In what particular respect it is more adapted to our climate than any other room, we are unable to guess; unless it be that its excessive gaudiness and flutter of colours is intended to counteract the chilling influence of an English sky. Nor is the architecture at all better than the taste shown in embellishment as regards colour. The room has the look of a tawdry tavern "saloon."

We have got to the end of "Interiors," for we do not comprehend under that designation those of churches, both old and new; the former of which are of course mere views, not the designs of those who here exhibit them; while the latter, which might else be made to afford some exercise for inventive power and imagination, are, thanks to our modern ecclesiologists, their pedantry and their prudery, strictly bound to imitate, and as far as possible facsimilize, the old ones;—wherefore, to ecclesiologists and to Mr. Urban, we leave them. The only design of that class which struck us at the time, or which we can now call to mind with any distinctness, is 1183, "Highbury New Church, now erecting" by *T. Allom*. That this is a very charming drawing—one distinguished by its artistic treatment, we hardly need say, its author's name being a sufficient guarantee for such merit; but it has also great merit in other respects. The architecture itself is treated artistically;—all the spirit and better qualities of the style—Gothic or mediæval, as now matter of course, are preserved. The view here given of the church is, however, so exceedingly picturesque and *episodical*, that we cannot judge from it what the structure is or will be, upon the whole. Having mentioned this subject, we may be allowed to turn at once to another and quite different one, by the same architect—viz., No. 1229: "Continuation of a Design for Improving the Property on the Banks of the Thames, &c." This we take to be altogether "a castle in the air"—too gigantic a scheme; not, indeed, an impracticable one, but one which has not the slightest chance of being realised, or even seriously thought of at all in our time, or Mr. Allom's. When he conceived it and was at work upon his drawing, Louis Philippe was upon his throne: that Louis is so no longer; neither is Ludwig. *Tempora mutantur;* all Europe has received a shock—but we are getting prosy. To speak more architecturally and critically, we may observe, that for "improving property on the banks of the Thames," we should read "on the *north bank* of the Thames," because, like every other which has had a similar object in view, Mr. Allom's scheme provides no improvement whatever for the south or opposite bank of the river, the meanness and deformities of whose buildings would become more offensive than ever, were they to be confronted by, and looked at from terraces and quays on the north side, flanked by such façades as are represented in this design.

There is more than one good drawing and very fair design for houses in the Elizabethan style—shall we ever get to a Victorian style?—which we are unable now to particularise, but among which, if our memory deceives us not, as for reason explained it may do—is No. 1115, "A House now erecting at Southend, Sydenham," *H. E. Cox* and *E. Goodwin*. There is another drawing apparently by the same hand, but of a design by a different exhibitor, though in the same style, and similar also in many other respects; yet which it is we cannot undertake to say, the pencil notes in our marked catalogue being nearly effaced. To confess the truth we must now hurry on to *Finis*, and content ourselves with merely naming some of the few things that deserve to be rescued from the imputation of dulness and mediocrity, or even worse, with which the architectural part of this year's Exhibition is chargeable.—No. 1112, "The Stoke Station, now erecting from the designs, and under the superintendence of H. A. Hunt," *G. Buckler*, has considerable merit in parts, but is very unequal, and therefore unsatisfactory as a whole. Here again the style is Elizabethan; and did the drawing represent a *bonâ fide* production and monument of that age, it would be interesting enough; but as a design at the present day, it partakes too strongly of the fidelity of the Chinese tailor who copied all the holes in the coat which was sent to him as a pattern of an English one. Considerable praise is due to No. 1211, "Court-yard of a Gentleman's Farm-house, lately erected;" and No. 1213, "Design for a Chapel at Edmonton," both by *F. W. Ordish;* also to No. 1270, "Additions to Frankleigh House, Wilts," *H. Clutton*. Although there is too much of the aforesaid Chinese tailor in it, we confess to relishing Mr. Harkwick's design for a "House about to be erected at Aldermaston, Berks," No. 1217. Pity that it is of the "olden time" and not of our own; for if we

* Although the Exhibition is closed, we speak as usual in the present tense.

continue to go on thus, the nineteenth century will be positively a blank in the history of architecture, and, unlike that of Elizabeth, the reign of Victoria an absolute nullity. With No. 1201, "New Buildings in the Temple," *S. Smirke*, we are by no means so well satisfied. Not only are they more continental than English in physiognomy, but they do not at all accord with any thing near them; on the contrary, are quite a patch stuck upon that range of buildings which they are intended to carry on and complete. While others are effacing and defacing Soane's works, Mr. Smirke seems to be anxious to undo or else go quite counter to Sir Robert's doings.

ON TRIGONOMETRICAL FORMULÆ FOR FINDING THE LEVEL OF TWO DISTANT OBJECTS.

By R. G. Clark, C.E.

The object of this communication is to exhibit some simple formulæ, that may at one operation serve to determine the levels of distant objects with respect to the station from which the angles are taken. The subject may be considered thus: we have on a vertical plane H A D B, the given angles H A C, H A D, from H A the sensible horizon, and the given height C D, to determine the level of D at the base with respect to B, the base of the station A. (*see* fig. 1.)

There are two cases: first, when the vertex A of the station is above the level of the summit of the object C D; and, secondly, when the vertex A is below the level of C.

1st. Let the given angle of depression H A C $= \beta$; also the angle H A D $= \theta$; the given height of the object C D $= h$; and H D $= y$. Then by the triangle C A D we have

$$\sin(\theta - \beta) : h :: \sin(90^\circ - \theta) \text{ or } \cos\theta : \frac{h \cos\theta}{\sin(\theta - \beta)} = \text{A C}.$$

By the right-angled triangle A H C, we have

$$\sin\beta : y - h :: 1 : \frac{y-h}{\sin\beta} = \text{A C}.$$

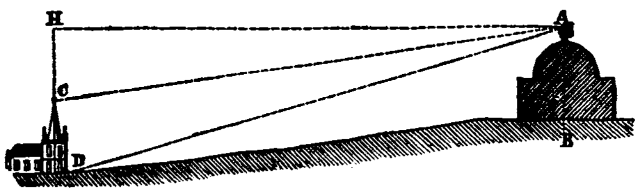


Fig. 1.

Equating the above values of A C,

$$\frac{h \cdot \cos\theta}{(\theta \sin - \beta)} = \frac{y-h}{\sin\beta}.$$

Therefore, $h \cdot \cos\theta \cdot \sin\beta = (y-h) \cdot \sin(\theta - \beta)$
$= (y-h)(\sin\theta \cdot \cos\beta - \cos\theta \cdot \sin\beta)$
$= y \cdot \sin\theta \cdot \cos\beta - y\cos\theta \cdot \sin\beta - h \cdot \sin\theta \cdot \cos\beta + h \cdot \cos\theta \cdot \sin\beta$; by transposing, $y(\sin\theta \cdot \cos\beta - \cos\theta \cdot \sin\beta) = h \cdot \sin\theta \cdot \cos\beta$ ....(1.)

Hence $y = \dfrac{h \cdot \sin\theta \cdot \cos\beta}{\sin(\theta - \beta)}$, or $y = h \cdot \sin\theta \cdot \cos\beta \cdot \text{cosec} \cdot (\theta - \beta)$ (2)

Dividing each side of (1) by $\sin\theta \cdot \cos\theta$, we have

$$y = \frac{h}{1 - \cot\theta \cdot \tan\beta}; \text{ but } \tan\beta = \frac{1}{\cot\beta}; \text{ therefore,}$$

$$y = \frac{h \cdot \cot\beta}{\cot\beta - \cot\theta} \text{ .... (3.)}$$

The formula (2) may be adapted for logarithmic computation, thus—

$\text{Log } y = \log\sin\theta + \log\cos\beta + \log\text{cosec}(\theta - \beta) + \log h - 30.$

The equation (3) can be effected by natural co-tangents, to be found in Hutton's "Mathematical Tables." An example is subjoined to elucidate the equation (2).

Ex. It being required to determine the level of two objects by angles of depression from the sensible horizon, taken at the summit of an edifice, as St. Paul's, the height being 404 (*see* fig. 1); the angle H A C $= 3^\circ\ 20'$; the angle H A D $= 8^\circ\ 30'$; and the height C D $= 300$ feet.

Here $\theta = 8^\circ\ 30'$; $\beta = 3^\circ\ 20'$; $\theta - \beta = 5^\circ\ 10'$; and $h = 300$.

By formula (2) we have

Log sin 8° 30'	... ...	9·169702
Log cos . 3° 20'	... ...	9·999265
Log cosec . 5° 10	...	11·045501
Log 300	... ...	2·477121

2·691589 = log H D = log 491·7.

Therefore 491·7 — 404 = 87·7 feet.

Hence B is 87·7 feet above the level of D.

2nd. When the summit of the station A is below the level of the vertex C of the object C D, fig. 2.

Let H D $= y'$; D C $= h'$; the angle H A D $= \theta$; and the angle H A C $= \beta$; and proceeding exactly the same manner as before, we have

$$y' = \frac{h' \cdot \sin\theta \cdot \cos\beta}{\sin(\theta + \beta)}, \text{ or } = h \cdot \sin\theta \cdot \cos\beta \cdot \text{cosec}(\theta + \beta) \text{......(4.)}$$

$$\text{And } y = \frac{h \cdot \cot\beta}{\cot\beta + \cot\theta} \text{ .... (5.)}$$

The only difference being in the signs.

Hence D C — A B = height of one object above the level of the other.

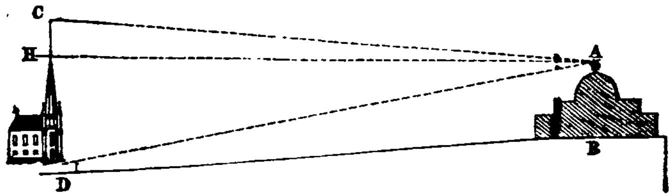


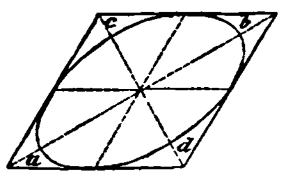
Fig. 2.

Remark. When the angles are taken to seconds, it is more advantageous to use (2) and (4), as the case may be, to ensure greater accuracy. To solve the foregoing question by the First Case of Plane Trigonometry would require thereby more than two operations: hence the manifest value of the above formulæ.

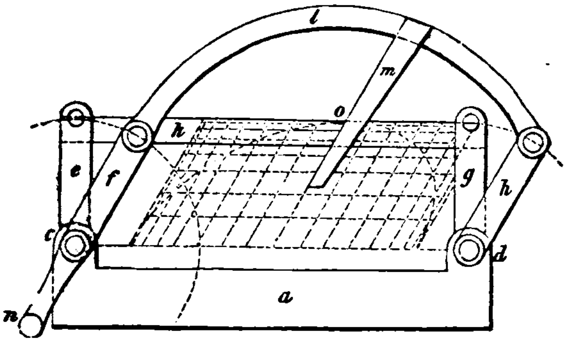
The subject is a valuable exercise to the young student in surveying, as giving him proper ideas of the utility of trigonometrical formulæ for the means of rendering operations more simple for computation.

ISOMETRICAL PERSPECTIVE.

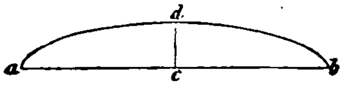
It is to be regretted that isometrical perspective is not in more general use amongst engineers and architects; but the infrequency of its application to designs of machinery and buildings, arises in a great measure, perhaps, from the difficulty usually experienced in properly representing curved lines. In this kind of perspective, we know that a circle inscribed within a square is represented by an ellipse touching the centre of each side of an oblique parallelogram, as in the annexed figure. Now, there is no instrument which can be set to describe such an ellipse, unless we first discover the transverse and conjugate diameters *a*, *b*, and *c*, *d*,—a somewhat troublesome preliminary. It is, therefore, much to be desired that an instrument could be contrived, whereby the draughtsman would be enabled to produce the ellipse with no more trouble than the simple measurement of the radius of the circle to be represented. Perhaps the following suggestion may supply that desideratum:—



To a block of metal *a*, let there be two projecting pieces, *c* and *d*, each one carrying a pair of radius-bars *e*, *f*, and *g*, *h*; let those bars exactly agree in length, and let each pair be so united by a pin passing loosely through the projecting piece, that their centre lines form an angle of 30°. Then, if *e* and *g* be made to carry a straight bar *k*, and *f* and *h* an arch *l*, having a tongue or blade *m*, which bears upon *k*, we shall have an instrument by means of which we can describe an isometrical ellipse; and the mode of using it will be to press upon *a*, with the thumb of the left hand, and with the fingers of the same hand turn the arm *m*, and thereby the two pairs of radius-bars—while at the same time the right hand holds a pencil point in the corner *o*, at the crossing of *m* and *k*. The pencil will thus be made to describe half the isometrical representation of a circle, whose radius is equal to that of the arms *e, f, g, h*; and by turning the instrument or the paper round, the other half may be drawn with equal facility.



By constructing the instrument so that the arms could be adjusted to any radius at pleasure, we should then be enabled to represent a circle of any diameter within its range. Ellipses, also, could be represented in this kind of perspective, by its means. If it were required to show the semi-ellipse *a, b, c, d*, the only adjustment necessary would be to set the radius of *f* and *h* to the line *a, b*, and that of *e* and *g* to the line *b, d*,—and the curve produced would be the true figure, according to the rules of the art. Moreover if the angles formed by the arms could be altered at pleasure, we should have at command an infinite variety of simple curves, embracing all that are derived from the isometrical projection of regular figures in any plane.



The form of the instrument may differ materially from that represented here—it may be made to describe the whole figure without being moved from its first position; but our sketch and description will, no doubt, be sufficiently suggestive of all that is required to render it efficient.

R. B. C.

PORTABLE COFFERDAM,*

SPECIALLY ADAPTED FOR HARBOUR AND OTHER MARINE WORKS.

By Thomas Stevenson, F.R.S.E., Civil Engineer, Edinburgh.

(Read before the Royal Scottish Society of Arts, January 10, 1848.)

When it is necessary, in the execution of marine works, to carry on founding or excavation in exposed situations within the high-water mark, cofferdams of the common description are not found to be answerable. Many circumstances conspire in rendering such erections inapplicable in situations where they are required to stand for several tides. The waves occasioned by a very moderate breeze of wind will, in many cases even in the course of a few hours, either entirely break up a well-constructed cofferdam, or render it leaky and unserviceable. Again, where there happens to be a covering of a few feet of sand above a rocky bottom, the piles will be found, even where there is shelter from the waves, to have no stability, and to fall inwards as the sand is removed from the interior, although every care be taken to support them with *shores* or struts.

The temporary dams which are generally employed in the execution of tide-works are of a very simple construction, and are intended to be serviceable during only one or two tides. They consist of a row of short piles which are driven in the line of a runner or waling-piece, and as the excavation proceeds, the piles are from time to time driven farther down. But this kind of erection is very unsatisfactory, and in many situations, and for a variety of purposes, it is in fact quite useless; for I have always found that it was impossible with this dam to drive the piles straight, from there being only one waling-piece to direct them. But even although they could be driven, a farther source of inconvenience still remains, for, as the stuff is removed from the interior, there is nothing left but the single waling to resist the pressure from the outside, and the bottoms of the piles being speedily forced inwards, all attempts to carry the excavation farther must necessarily be abandoned.

* An abstract of this paper was given in the Journal of February last, p. 63.

At Hynish harbour, Argyllshire, in 1843, I had a talus-wall to found on sand, which covered a rocky beach to the depth of from two to three feet. At another place, the rock was not only to be bared, but a navigable channel, twenty feet wide, and in some places as deep as eight feet in the rock, together with a small tide-basin, were to be excavated to the level of the low-water springs. The shores also were frequently subject, even during the summer months, to a very heavy surf.

The excavation of the tide-basin, which formed the landward part of the work, was effected by means of a series of dams, consisting of walls, built of pozzolano rubble. These were found to be quite water-tight, and to answer remarkably well in every respect; but they required, for their protection against the waves, a considerable bulwark or breakwater of *Pierres perdues* to shelter them from the waves.

In the excavation, however, which had to be undertaken seaward of the breakwater of *Pierres perdues*, any attempt to exclude the water during the whole of the tide, was what I never considered practicable. A trial was accordingly made to effect the excavation by means of a low wall, composed of a clay-rubble, resembling in its object those low dams consisting of logs of wood bedded in clay, which are often adopted in harbour-works, and which are only intended to keep out the tide during the first part of the flood, and to be pumped dry before the operations of the next tide are begun. But after many attempts with this clay-wall, it became quite evident that it would not be possible, with its assistance, to carry the excavations to near the level of low-water springs, which was due principally to two causes. First, because sand and shingle were, during almost every tide, washed in large quantities over the top of the wall into our excavation pit; and, secondly, because the waves washed out the clay from among the stones, so as to render the barrier no longer water-tight.

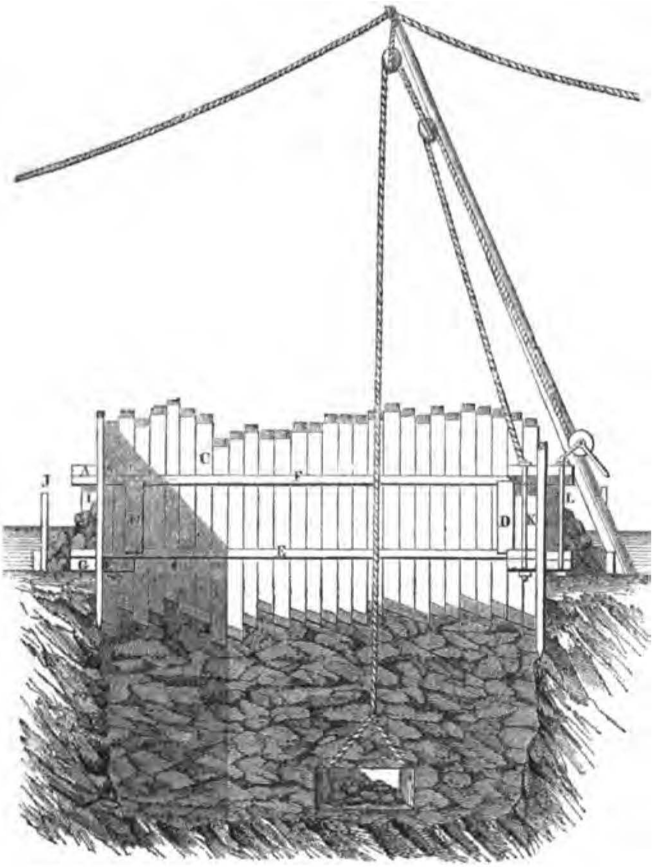
Being now compelled to set about some other way of carrying on the work, I had recourse to the simple method shortly to be explained, and which more than realised my expectations. Before giving a description of this method, however, it will be interesting, as well as still farther explanatory of the required objects, to quote a few lines relating to somewhat similar difficulties, from a Report upon the Harbour of Peterhead, which was drawn up in the year 1806 by the late Mr. John Rennie:—"The next material object of consideration," says the Report, "is that of deepening the harbour, which at present cannot well accommodate vessels drawing more than 12 feet of water in the spring-tides, but in neaps is not sufficient. To render this harbour more extensively useful, it would be advisable to have 17 or 18 feet of water over the greatest part of its bottom, and particularly along the west quay. The mode of performing this kind of work will be different, according to the difference of situation. Those places where the tide ebbs from the surface, and continues so for some time, may be done by blasting, or by loosening the stones with quarrying tools in the usual manner; but *in those parts where the tide seldom leaves the bottom, and in others but for a short time, different methods must be resorted to.* The best of all would be enclosing large spaces by cofferdams, and working at all times of tide by quarrying tools or blasting, as might best suit; but in some situations this would be inconvenient, as the dams would be in the way of vessels going into and coming out of the harbour. In such situations perhaps the simplest and most expeditious mode would be to use cast-iron cylinders of 7 or 8 feet diameter, having strong canvas fixed to the lower flanch, which might be kept to the bottom by bags of sand in places where there was but little agitation; but where there is much, an outer cylinder might be sunk thereon, to keep them in their situations."

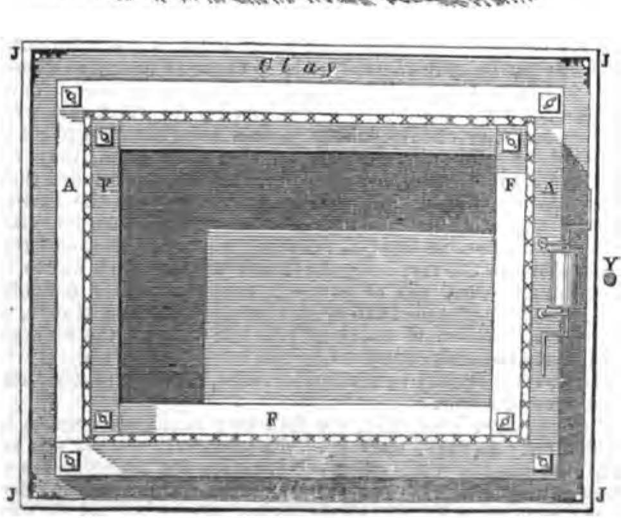
The cylinders proposed by Mr. Rennie were, no doubt, quite adequate to the special purpose and locality for which they were designed, and they unquestionably possess some advantages not to be gained by other means; but, on the other hand, they are attended with difficulties and disadvantages which precluded their adoption in the present case. Those objections were the limited area, the weight and unwieldiness of such cylinders, their inflexible nature and unalterable form, as affording no means in themselves of adaptation to the very irregular rocky bottom which was to be excavated, and what was of as much consequence, the difficulty which must have attended the removal of the *partitions* of rock, or those parts which would necessarily be left between the different compartments of the cutting. The last two objections, it may be remarked, refer equally to wooden caissons, or other contrivances on the same principle.

In the present case, then, the following requisites were to be provided for. In the founding of the talus-wall, all that was required was some method which would enable the found-stones to be laid as deep in the sand as possible, for which purpose the dam did not require to be absolutely water-tight, provided it were capable of excluding from the inside the sand which was so liable to replace what was removed from the interior. For the excavation of the rock, on the other hand, it was necessary that the dam should be water-tight, and suitable for taking out all the partitions; and both situations required piles for fitting close to the irregular bottom, and those piles needed some support other than the soil into which they were to be driven.

To effect such objects, it was clear that the means to be adopted must be at once easily managed and efficient. For although, where there is time for their employment, many complicated and troublesome refinements of construction are forced to answer purposes which might have been attained by simpler means, or by less cumbrous arrangements, yet I was well aware that in the hurry and bustle attending tidal operations and night-work, nothing can be tolerated but what is in every respect easily managed and truly efficient.

In the accompanying diagrams, A G represents a frame of double waling-pieces connected at the angles by the uprights I I, and bound together by the long bolts L, with forelocks





and washers, while E F shows similar double-framed walings for the inside of the dam, and of smaller dimensions, with their uprights D, and connecting bolts K. These frames being placed in the required position, the one frame inside of the other, the piles C, are driven down between them with heavy malls.

The dam was 12 feet long by 10 feet broad inside, so that five men were able to work in the interior.* If it was to be fixed within low-water mark, the two frames being placed in the water, were guided to the spot by the men in charge, and whenever they were in the desired position, the men at once moored or fixed the frames to the bottom, by driving down a pile at each corner. After this was done, all the piles were placed between the frames and driven down, and keyed up by the small piles called "closers." Four iron jumpers J, were then driven down to their proper places outside of the frames, and edge planks for retaining the clay were slipped down upon the jumpers through iron staples, which were fixed to the planks. After this, good clay (which should have some gravel mixed with it, to protect it from the wash of the sea) was *punned* hard between the planks and the cofferdam, after which the mast N was erected, and the water taken out by means of the iron scoop shown in the drawing, which not only was used in taking out the stuff, but proved far more efficacious than any pump we ever had. Indeed, to get the dam pumped dry was for long the greatest difficulty we had to contend with. But Mr. William Downie, to whom I gave the charge, soon removed this difficulty, by using the scoop instead of a pump. The capacity of the scoop was about 37 gallons, and they generally made nine deliveries a minute, so that we found this method greatly more expeditious than any other.

As the excavation proceeded, the piles were from time to time driven down; and when the rising tide began to come over the pile-heads, or to rise above the clay, the men, before leaving their work, placed the flooring or "*deck*," as it was called, within the piling, with the ends of the planks resting upon the top of the inner frame. On this deck, ballast (consisting of stones of a convenient size) was deposited to prevent the whole frame from being floated up,—the quantity so deposited varying with the height of tide, or appearance of the weather. As each compartment of the excavation was completed, and before the dam was removed, the rock below the two rows of piles which adjoined the next cuttings was completely taken out, and the piles driven down to the bottom of the excavated pit, and left standing.† When the dam was taken up, the frames were, for the next compartment of cutting, again superimposed upon one of the rows which had been left standing in the last pit. In this way no rock could possibly escape being removed; and when the frames were to be put down anew, there was no difficulty (although the pit was entirely covered with sand) in knowing exactly the position which they were to occupy, as the piles which had been left standing were an infallible guide.

The advantages peculiar to this description of dam are its cheapness,—its portability,—its ready adaptation to a sloping, or even to a very irregular bottom,—the ease and certainty with which the partitions between the different pits are removed,—and the double-framed walings that support and direct the driving of the piles. Wherever excavations require to be made in a rocky beach, covered by a stratum of sand, however thin, there need not be any hesitation in adopting this form of dam, as there is no kind of lateral support, such as stays or shores wanted, the structure containing within itself the elements necessary for its stability. It possesses, indeed, all the properties of a caisson, and has the further advantage of accommodating itself to an irregular bottom.‡

I may observe, in conclusion, that although this form of construction is specially adapted to marine works, in the execution of which it has proved a most valuable auxiliary, the same principle might also be carried to a greater extent, and be rendered fit, with little trouble, to answer for a variety of works,—such as under-footing quay walls, founding bridges, and in removing fords or other obstructions from the beds of rivers. The application of a *double-framed waling* I have also found in itself a very useful application in several situations, and for a variety of purposes.

* Since this paper was printed, a cofferdam on the same principle and thirty-five feet square, has been made for the Forth Navigation works, Stirling, where, in the removal of the "fords," under my direction, much difficulty has hitherto been experienced, from the constant flow of the river.

† Before lifting the cofferdam, the pit was filled with sand, to support the piles that were to remain, which, when the works were done, was cleared out by means of a water-scour, provided for the purpose of keeping permanently open the navigable tract.

‡ In situations also, where there is a considerable depth of water, and where, consequently, the frames must be made so as to stand high above the ground, it will be found of great advantage to plank the outside of the frames between A and G. This will not only make the dam more water-tight, but have the effect of binding and strengthening the framework.

THE THEATRES AND PORTICOS OF ANCIENT ROME.

Paper read at a meeting of the Royal Institute of British Architects, June 12th. By the Rev. RICHARD BURGESS, B.D.

In looking among my antiquarian and literary stores to prepare a subject for the Institute, I again found that it was not necessary for me to go out of old Rome, for although in a series of papers spread over some twelve years, I have led you "o'er steps of broken thrones and temples," and placed you in forums, baths, or halls, I have never yet described to you the theatres and porticoes which formed so important a feature in the architectural beauties of Rome.

The amphitheatre was an edifice unknown to the Greeks, the theatre was hardly ever naturalized among the Romans, and with the exception of some tragedies, ascribed to Seneca, which are lost, it does not appear that a single Roman tragedy was ever composed upon a Roman subject. Porticoes, which were generally in the vicinity of theatres and circuses at Rome, are the natural growth of a climate subject to great heat and sudden rains: we lose in these northern regions that great ornament of a city, the portico. Our admiration is limited to arcades and covered markets, which it must be confessed are more for use than ornament. But I return to the theatre. The ancient and modern drama differ as widely as the buildings in which they were respectively acted, and I shall hardly succeed in making my Roman theatre intelligible, unless I first indicate a few of the leading features which run through the Greek drama and its Roman descendant. The subject is by far too vast and intricate for me to attempt anything like an essay upon the Greek stage, and therefore I must limit my observations to what is strictly necessary for explaining the internal arrangements of the edifice. The Greek drama dealt more in set speeches than in broken dialogues, and did not admit more than three interlocutors at once: the action or event represented was brought within the space of time in which it might in reality have been accomplished. As a general rule, there was no change of scene during the piece. In every tragedy there was a body called a *chorus*, who took no part in the action of the piece, but reflected upon what was going on, and generally expressed what might be supposed to be the sense of the audience. The chorus did not come upon the stage, but occupied the orchestra, varying the dialogue which they sometimes held with the actors by choral songs and dancing. These terms of *stage* and *orchestra* I shall shortly have to explain.

Dramatic entertainments, both in Greece and Rome, formed part of the public expenditure, or they were exhibited gratuitously by some wealthy or ambitious citizen. The theatres, therefore, were of immense size, for they were meant to contain (in Greece, at least) the whole male population of great cities. The performance usually took place also in an uncovered theatre in Greece; but Roman luxury, at a later period, invented the awning. I once described to you, when I read a paper on the Colosseum, how this awning was contrived to cover such an immense space; and I must be allowed to suppose that you have not entirely forgotten that description. If any of you are desirous of satisfying your curiosity upon the Greek stage, I must refer you to "Butenger de Theatro," for I now hasten to the buildings themselves, which it is the principal object of this paper to describe. The origin of the theatre is rather ignoble;—it was originally a wagon, in which Thespis conveyed his actors about, with their faces besmeared with lees of wine, and from which they spoke their parts to the crowd assembled around them. To the ambulatory wagon of Thespis succeeded a moveable wooden structure, which was set up and taken down at pleasure, and it was in consequence of one of these structures having given way under an unusual crowd, that the first stone theatre was erected in Greece, by Themistocles, not long after the defeat of Xerxes. From this they began to increase in number, and we have the remains of several yet existing, both in Greece and in that part of Italy which was Greek in language and customs long after it came under the Roman dominion. We have also those remains of Greek theatres in Rome, to which I shall shortly direct your attention. A theatre became so necessary an appendage to a town, that Vitruvius gives systematic directions concerning the selection of a site. In his fifth book, cap. 3, we have the following:—"When the forum is finished, a healthy situation must be sought for, wherein the theatre may be erected, to exhibit sports on the festival days of the immortal gods, for the spectators are detained in their seats by the entertainment of the games, and remaining quiet for a long time, their pores are opened and imbibe the draughts of air, which, if they come from marshy or otherwise unhealthy places, will pour injurious humour into the body. Neither must it front the south, for when the sun fills the concavity, the enclosed air, unable to escape or circulate, is heated, and then extracts and dries up the juice of the body. It is also to be carefully observed that the place be not dull, but one in which the voice may expand as clearly as possible." One cannot let pass this quotation from the great architect of the Augustan age, without remarking that the selection of a site for an important public building was considered by Vitruvius as falling within the province of the architect. A healthy place for the theatre selected, we come next to consider its shape and disposition.

The form of the Greek theatre originated, as is thought, in the natural recess of a hill-side, and most of the theatres whose vestiges I have visited in Greece, occupy that position. Mantenia, built in a marshy place, offers an exception, and I believe there is another exception in Asia Minor; but it was evidently the practice to lighten the labour of erecting such buildings by making use of a ravine, or locality adapted to the purpose. At Megalopolis I was able to trace the whole *cavea* or hollow of the theatre, partly cut out of a hill; but the seats are overgrown with thick brushwood. The same economy is observed in most of the Greek *stadia* also, and even the council of Areopagus sat on seats, cut out of, or inserted into Mars' Hill. At Nicopolis, near Prevesa, the form of the theatre on the hill-side is preserved, and much of the proscenium. At Smyrna I was able to trace the *cavea* in a similar position, and also at Ephesus we get to the slope of Mount Prion, which overlooked the Temple of Diana, in the plain of the Cayster, before we find the theatre. Whilst the Greeks, however, hewed seats out of the rock, or excavated to a depth suitable to their purpose, as the nature of the ground allowed, the Romans usually built their theatres upon arches, and massive walls rose (as we see the theatre of Marcellus still existing at Rome), with two or three orders, like the Colosseum. The hollow which perhaps originally was adjusted according to the nature of the ground, in no definite curve, ended in a perfect semicircle. This was called in Greek "κοιλον," and in Latin *cavea*, and was the part for the audience. The other part was devoted to the business of the play, and thus we arrive at the two principal parts or divisions of the theatre. The κοιλον, or *cavea*, is easily described; it was bounded by the segments of two concentric circles, the inner arc separating it from the orchestra; in the Roman theatre it seldom exceeded a semicircle, but sometimes the extremities of the semicircular arc were prolonged by straight lines; the Greeks took more of the circumference of the circle, and cut the κοιλον by lines drawn from its extremities converging towards the centre of the circle, by which arrangement more space was made in width for the *scena* or stage. The *cavea* was fitted up with rows of seats rising in succession, so as to afford each tier an uninterrupted view: the whole was divided, as in the amphitheatre, into flights by διαζωματα or *præcinctiones*, which is the Vitruvian term for our landing-place. The *præcinctio* ran round the whole, and afforded an access from one flight to another. The entire arc was again cut into sub-divisions, called κερκιδες, in Latin, *cunei*, from being formed like wedges: the lines which effected those sub-divisions were called κλιμακες, or *scalæ;* these (which in the Roman circus were called *viæ*) led from the bottom to the top of the theatre, and they all converged to the centre of the orchestra. The lowest seats were considered the best, and were, in fact, the reserved seats for the magistrates and persons of office. As the audience rose in height, it descended in quality, until it reached the open portico at the very top, which has its counterpart in our shilling or sixpenny gallery. This portico, however, in an uncovered building was of some use, in confining the sound and giving shelter to the spectators from a passing storm. A κοιλον, or *cavea*, such as I have now described, would contain, in some of the largest theatres, as many as 30,000 to 40,000 spectators, which is about the capacity of those whose remains are yet to be seen in Rome. I now come to the other part of the theatre, which is more complicated and more difficult to describe. In Greek we have to deal with the three terms of ορκηστρα, σκηνη, and παρασκηνια. In the Roman language, we have the three corresponding terms of *orchestra*, *pulpitum* or *scena*, and *postscenium*, to which we are to add the *porticus*. I shall content myself with describing the Roman arrangements, and simply pointing out where the Greek theatre differed. Taking the *cavea* to be a semicircle, the concentric arc which separates the audience was also a semicircle, and this space, bounded by the diameter, was the *orchestra*,—not so called from anything relating to music, but because it was the place for the dancers. In the Greek theatre the segment was less than a semicircle; but if the circle be completed and a square inscribed in it, whose sides are parallel to the diameter, the side farthest from the *cavea* fixes the front of the stage; but in the Roman theatre the diameter itself determines the front of the stage, or *pulpitum*. The stage, therefore, in the Roman theatre, is brought nearer to the audience, and made deeper. The length of the stage was two diameters of the orchestra. The increased depth was rendered necessary on account of the greater number of persons assembled upon it; for the Romans put both the chorus and the musicians upon their stage. The points from whence the several staircases began to ascend the *cavea* were fixed by the vertices of four equilateral triangles, inscribed within the circle (when completed) of the orchestra. In the Roman theatre, as we have already observed, the front of the stage was called the *pulpitum;* and it was from that part that the interlocutors spoke. Some think that the *pulpitum* was a little elevated above the level of the stage; but at all events, the word has passed into use for designating a place to speak from in our sacred edifices. The lowest range of seats was raised above the area of the orchestra (one-sixth of its diameter), and the seats themselves did not exceed 1 ft. 4 in. in height. The stage in the Roman theatre was only elevated 5 feet above the seats in the orchestra: in the Greek theatre it was double that height. I have only hinted at the geometrical precision with which all these things were defined, and I shall relieve you from such dry details by a reference to the drawings behind me. The *postscenium* speaks for itself: it was a long narrow gallery behind the *scena*, where the actors retired, and where apartments or compartments were provided for them. From the *postscenium* were passages into the porticoes or gardens, which generally surrounded the theatres: but to these I shall have occasion to refer when I have finished the history and description of the theatres at Rome, to which I now come.

I have already remarked, that the earliest theatres at Rome, as well as at Athens, were but temporary erections of wood. The Romans were satisfied with standing-room for 200 years, and no seats were allowed; "lest," as Tacitus says, "if the people sat, whole days might be spent in idleness." Notwithstanding this prohibition to build permanent theatres, the temporary edifices were constructed with a magnificence which surpasses all belief. The wealth which supplied those theatrical exhibitions was generally the plunder of rich provinces: easily earned, and as easily dissipated, merely to obtain favour with the people, and procure still more lucrative appointments. All the bribery and corruption that ever came before a committee of an English House of Commons sink into insignificance compared with those times "when Rome was free." The treating of our "worthy and independent electors" at the open house of the candidate, was economy and parsimony compared with the lavish expenditure of a candidate for the honours and emoluments of a Roman governorship; and we cannot doubt, that whilst those worthy citizens were feasting for whole days at the expense of a Scaurus or a Curio, they would be loud in the praises of liberty; and had they known how to put their exclamations into the polite language of modern Europe, the air would have resounded in the midst of those entertainments with "*Vive la République!*" It was not until the year of the city 699 (that is, within 53 years of the Christian era), that a theatre of solid materials was built at Rome, and this was constructed by Pompey on his return from Asia, at the close of the Mithridatic war; but even Pompey found it expedient to pay a deference to the popular feeling. "Therefore," says Tertullian, "Pompey the Great, less great by his theatre only, when he erected that stronghold of wickedness, dreading lest the rebuke of the Censor might injure his memory, he built a temple to Venus on the top of it, and when he invited the people to come to the dedication, he did not call it a theatre, but the Temple of Venus, to which, he said, 'we have subjoined seats for seeing shows.'" The seats were therefore considered as the steps by which to ascend to the temple. We may call this either a pious fraud or a legal fiction. A piece of marble was found, in 1525, near the site of Pompey's theatre, on which Marliano read the words, "*Veneris Victricis.*" This building was erected in the third consulate of Pompey, and when the inscription came to be placed on the frieze, a dispute arose whether it should be *cos. tertio* or *tertium*. The matter was referred to Cicero, who advised the disputants to settle the controversy by writing *cos. tert.*

At the dedication of his famous theatre, Pompey produced twenty elephants; and when he was accused in the senate of introducing too much luxury into the city, he convinced the conscript fathers that it was an economy to build a solid theatre at once instead of raising a temporary structure on every occasion of giving shows. The Temple of Venus served very well as a pretext for making seats, *gradus spectaculorum;* but it could not equally be alleged for erecting a solid stage. It was not until the reign of Tiberius that this part of the theatre was added, and finally completed by Caligula. It was dedicated anew by the Emperor Claudius, who restored it after a fire, and it reached its greatest splendour in the time of Nero. Two vanquished chiefs, who came from the north of Germany to render submission to the emperor, were taken to Pompey's theatre in order that they might see the greatness of the people. It contained, according to Pliny, 40,000 spectators; and when Tiridates, king of Armenia, came to Rome, Nero caused the whole to be gilded, to show off the magnificence of the Romans to the vanquished Asiatic. It passed through a succession of events until Theodorus commissioned Symmachus to rebuild it; but not long after it shared the fate of the rest of the splendid edifices of Rome, and finally came into possession of the Ursini family, who occupied that quarter of the city in the wars of the middle ages. In the fifteenth century, an inscription, found with the name of Pompey, directed the antiquary to find out its site. Another indication of the place where this theatre stood was given in the finding of the famous statue which is now in the Palazzo Spada. That statue was found under the partition wall of a house, and lying across in such a way as to give two proprietors of the house a claim to the treasure: not able to agree about dividing the spoil, they came to the resolution of cutting Pompey in two, and each man taking his own half. The matter having reached the ears of Cardinal Capodifezzo, he hastened to Pope Julius III. to inform him of the judgment that had been pronounced upon the statue. The astonished pope dispatched a messenger with all haste, and sent 500 scudi to be divided between the litigants, instead of Pompey. Flaminius Vacca, who relates this anecdote, says the statue was found near the Palazzo della Cancelleria, in the Vicolo dei Scutari. The statue did not stand in the theatre, but in the Curia which Pompey built as an appendage to it; and the belief still obtains that it is the statue at the feet of which Cæsar fell. Being thus directed to the site of this famous building, we find ourselves in the immediate neighbourhood of the Church of St. Andrea della Valle. From near that church to the Palazzo Pio, the site is marked by a gradual rising of the ground, but no vestiges meet the eye. In order to see the remains of Pompey's theatre, we enter the court-yard of the Palazzo Pio, and descending into the vaults upon which the Palazzo is built, we find ourselves, at the depth of 40 Roman palms, among the foundation arches. These have been originally hollowed out of the natural rock, and they are pointed at the angles with large blocks of peperine stone. One of the *cunei* or sections of the *cavea* belonging to the lowest tier, may be perfectly traced; and after ascending to the court-yard again, and upon entering the stables, we see a second story of arches for supporting the seats, the construction of which is remarkable for its solidity; and it would not be difficult to trace, among the modern buildings and in the cellars of the Palazzo, at least one-half, perhaps two-thirds, of the whole *cavea*. I will not stay to describe to you the blocks of peperine and *opus reticulatum*, for the great point gained by tracing the *cunea* is the fixing of the position of the *scena* or stage. This appears to have reached very near the present site of the church of St. Andrea. But the most remarkable circumstance attending an investigation of the buildings erected by Pompey in this part of Rome, is the being able to present a ground-plan of them, although they have almost all vanished from off the face of the earth. In the sixteenth century there was found behind the church of SS. Cosma and Damiano a plan of ancient Rome, done in marble, and which had served to encrust the walls of the Temple (it is supposed) of Romulus and Remus. This marble map, where the ground-plan of all the public buildings was laid down, was found broken into fragments; some of them irrecoverable; others, gathered up with care and put together, presented an idea of a building. They now encrust the walls of the staircase of the Capitoline Museum, and are known under the designation of the Pianta Capitolina.* The two fragments most perfect happen to represent the Theatre of Pompey and the Portico of Octavia. By a reference to that fragment of the Pianta, you will not only see the ground-plan of the theatre, but also of some other buildings which were attached to it. Vitruvius cites the Porticus Pompeiana as an example of what a portico should be, when attached to a theatre for the convenience of the actors, or for the people to take shelter in, in case of rain. We know, from Martial, that Pompey's Portico had a hundred columns. Eusebius calls it, in consequence, "Hecatonstylon." The Pianta Capitolina exhibits some of those columns, but the fragment is imperfect. This celebrated portico was painted by artists of renown—Antiphilus, Pausias, and Nicias—the subjects being suited to the atmosphere which Ovid's lovers breathed. About the portico were rows of plane trees,

* These fragments were first engraved and illustrated by Bellario, and are reproduced at the end of tom. iv. of the "Grævius' Roman Antiquities."

interspersed with stone statues of beasts; and a fountain threw up, or poured out, its sparkling waters. The Pianta Capitolina exhibits two rows of columns, running in a direction towards the river, and not unlikely conducting to a grove along the banks of the Tiber. Besides these appendages to the theatre, there was the Curia, or senate-house, which is, no doubt, identical with the "Regia Theatri" of Suetonius: but I must forbear to expatiate beyond the proper limits of my subject. A careful inspection of that part of Rome where all those buildings stood, with the aid of the Pianta Capitolina and the antiquarian notices which I have cited, might still furnish a fine subject for the genius of a restoring architect; and when we consider that those extensive and magnificent buildings (whose very remains, at the end of nineteen centuries, excite our wonder) were erected out of the private resources of a single individual, it will be long before we find in another republic a popular favourite, who may vie in wealth, taste, and splendour, with citizen Pompey.

I shall pass quickly over the next theatre, which time and floods have not spared. It was erected in the twelfth year of the Christian era, by Cornelius Balbus, in compliment to Augustus, and was capable of containing 33,000 spectators. I am not aware that a vestige of this theatre remains, but Piranesi took considerable pains to ascertain the site, and found some remains of one of the *cunei*. The Palazzo, and Monte Cenci, now point to where it stood, and Camucci, one of the oldest of Roman antiquaries, who probably saw some remains of it in his time, states that from its vicinity to the Tiber, it frequently suffered from inundations. We are not aware of any portico attached to this theatre, but there was a *crypta Balbi*, which stood near it, and of this there are some remains.

The third theatre which adorned imperial Rome was that of Marcellus, and along with it I take the portico of Octavia: when I have given you some account and description of these two objects, I shall relieve you from this tedious *conversazione*.

The remains of the theatre of Marcellus are worthy of the architect's admiration. Eleven arches of both orders, and part of a twelfth, are conspicuous, though mutilated and disfigured by the dusky habitations into which they have been metamorphosed. The first order is nearly half interred, but the capitals of the Doric columns, as well as the entablature, are well preserved in several places. The second story exhibits a specimen of the Ionic order, as it was brought to perfection in the age of Augustus. Within those arches which formed the *ambulacra*, as in the amphitheatre, the *gradus spectaculorum* rose, and some of the *cunei* may be traced to the stables of the Osteria della Campana. The materials are tufo, mingled with brickwork, resembling those in Pompey's theatre, and one may perceive by a solitary column in the Via Savelli, standing at an angle with a piece of wall running in the direction of the *scena*, that the stage and its outworks must have touched the very banks of the river. The Palazzo Orsini, formerly Savelli, is built upon the ruins of the stage. Piranesi has calculated the capacity of this theatre to contain 25,000 persons: it was therefore the smallest of the three. Julius Cæsar, perhaps, laid the foundation of this edifice; but it was left for Augustus to complete it, and he dedicated it with the name of the Young Marcellus. On the feast of the dedication it is said that 700 wild beasts from Africa were consumed, and then, for the first time in Rome, there was seen a tamed tiger. We have an account of a fire having partly destroyed this theatre, but we hear very little of its history until Pierleone, in the twelfth century, made it a fortress. It passed successively into the possession of the Savelli and Orsini families, and there is no reason to suppose it has existed for several centuries otherwise than it now presents itself: in "Carnucci's Antiquities," we have a drawing of it, bearing date 1565, and it is there exhibited just as we see it at the present time. I may mention that its exterior walls are of travertine stone. The 25,000 spectators are now replaced by some workers in charcoal, and some mules, the former occupying the places reserved for the magistrates, and the mules having taken possession of what was the orchestra. Near to the theatre of Marcellus stood the famous Portico of Octavia, to which I have finally to call your attention. And although we must penetrate into the filthiest habitations in Rome, among stinking fish, in order to see the remains of this splendid work, it will amply repay us for our excursion, and stamp indelibly upon our memories the flavour of the Pescheria and the conservative habits of the Jews who live within the Portico of Octavia.

The first marble building ever erected at Rome was a portico which stood on this self-same site. It was built by Metellus Macedonicus: two temples were comprised within it. The architects were two Spartans, whose names were Sauros and Batrachus. They not only contributed their skill, but, as they were rich men, they employed their wealth also in the undertaking. The only reward for their services which they asked of the Romans was that their names might be mentioned in an inscription on the temples; but this honour being refused, they contrived to introduce their names allegorically: Sauros meaning a lizard, and Batrachus a frog—those animals were introduced into the capitals of the columns. The architects of the Portico of Octavia were also Spartans, and they respected the works of their distinguished countrymen. The new portico comprised in its circuit the two temples, made more magnificent and probably much enlarged: the fragment of the Pianta Capitolina, with the mutilated inscription "CVS OCTAVIÆ," gives us the plan of those splendid works. Bellori, in his illustration, computes about 270 columns. I confess I cannot make out that number with the utmost stretch of my feeble imagination, but I can present you with a plan made on the authority of the fragment and the ruins which still exist, adjusted on the dark tints, which show them in their proper places. By this plan it will be seen that the principal remains consist in six large columns of the vestibule or entrance (and who that has seen Rome has not admired the magnitude and elegance of those Corinthian columns), eight more columns of the exterior row of the peristyle, which are only to be seen by contending with the fish-stalls made out of the spoils of the portico; and there are also further remains of one of the temples to be seen in a Vicolo behind the church of St. Angelo: three columns standing at an angle indicate the position of the prostyle of the Temple of Juno; the other was dedicated to Jupiter. I must now leave you to raise up from this ground-plan, and from the splendid vestiges which remain, the elevations and architectural views of the portico and its temples; but even your ingenuity would not be able to restore to their proper niches, or affix on their respective walls, the works of art which once adorned the Portico of Octavia. In the Temple of Juno was her statue, made by Dionysius and Polycles; and a Venus by Philiscus of Rhodes. In the corresponding Temple of Jupiter was the much admired statue of the god, which was equally well executed by those sons of Timarchus. There was a group representing Pan and Olympius wrestling together, the work of Heliodorus; and perhaps the Venus of exquisite beauty which Pliny tells us adorned this portico (the work of Phidias) may be the very Venus de Medici which Santo Bartoli declares was found here in the Pescheria. In a part of the building called the Schola Octaviæ was the famous Cupid of Praxiteles, which called forth the eulogia of Cicero, Strabo, and Pausanias. It is more than probable that several of those statues perished in the fire which took place in the reign of Titus, and still more might be lost in that which happened under Sep. Severus. The paintings which adorned the walls and vaults were not less celebrated. There was the famous work of Artemon representing Hercules ascending from Mount Œta to Olympus, having put off his mortality with the consent of the gods; there was the painting by Antiphilus, where four figures of satyrs were grouped around the noble Hesion; and Alexander and Philip, with Minerva. You may exhibit to us an elevation restored; a few columns will direct you to complete the portico, and a medal will give you a finish for the pediment. You may square us off the basements, and crown the balustrade with colossal statues and urns; and you may festoon or triglyph the entablature;—but you cannot paint afresh the works of Artemon and Antiphilus, nor mould again the forms which the innate flash of the mind of a Phidias or a Praxiteles could produce. You must therefore be content with the bare recital, and inscribe upon the very best edifice I can describe, "*Stat nominis umbra.*" But you will remark in the enumeration of the names of those celebrated artists, that they were all foreigners, and Rome owed her most splendid works of art—I may say all of them—to the Greeks; and they owed much of their theatrical amusements to the Syrians and Egyptians. It is, in fact, a mistake to attempt to nationalise either art or science. If there be such a thing as communism in the world, it exists in the realms of genius, and no petty jealousy should ever attempt to exclude the foreigner who brings his originality of thought and genius to adorn a country of which he is not a native. It was written over the tomb of Ludlow, in Switzerland, "*Omne solum fortipatria;*" and the same may be said of the man of true genius—he belongs to every country: and I should say it generally betrays a sense of inferiority wherever there is an attempt to exclude from fair competition the genius which comes from a foreign shore. The Romans did not this, even in the histrionic art; they excelled in gladiators, but they were inferior in sculpture, and painting, and architecture: by admitting foreigners they ended by taking the lead in architecture, at least; and perhaps the studio of Emilius might have furnished a work worthy of the best Greek sculptor. And let me remark, that there are some things which no patriotism or spirit of nationality will accomplish. It will never make a man of taste admire an ordinary painting or an ungraceful statue; it will never reconcile him to a meagre elevation of an ill-designed public building.

I have generally attempted, in my papers which I have had the honour to read at the Institute, to show the influence which the public institutions under consideration might have upon the character and destiny of the Romans; and perhaps there is much more connection than at first sight appears between the works of the architect and the national character of the people. The architect is called upon to create only those works which are suitable to the habits of the people, and his object should be to study to do these well; and I, for one, do not regret that he is now compelled to study the construction of churches and schools, rather than that of theatres and porticoes. I am more than satisfied with the unarchitectural erections of Covent-Garden and Drury-Lane for theatres; and for porticoes and groves Vauxhal and the Surrey Zoological Gardens.

I am still compelled to speak only of the comparative innocence of our places of public resort; they are immeasurably inferior in architectural beauty, but they are a great improvement upon the moral aspect, and the restraints and the reflective influence of Christianity have even reached our public amusements. We cannot wonder at the indignation with which the early Christian writers viewed the theatres and places of public entertainment among the Romans, where every brutal passion or lascivious desire was gratified, and where vice in every form was enthroned by universal suffrage. We can excuse these holy men applying to these rendezvous of iniquity the title of "Devil's houses," for which I would hope no member of this Institute will ever have to give a plan. It is to my mind a happy circumstance that the *cavea* is now transferred to the lecture-room, the *orchestra* transformed into an Exeter-hall platform, the *stage* to the floor of the House of Commons, where sometimes members offer to die, and the *pulpitum* to the place from which the people are instructed in the truths and duties of Christianity. You will excuse me, then, if I rather rejoice over the ground you have lost in modern times for the exercise of your beautiful art; and that *my* profession has so amply supplied, by the sacred edifice, the field that is gone from you in the profane. I rejoice, not because either you or I have a stage more or less for our exertion, but because I think that the best interests of mankind and the happiness of the human race are more likely to be promoted by a church than by a theatre; and if we compare the national tastes of two neighbouring and rival countries in this respect, we at least shall be satisfied with the results;—and although I am loath to end this paper with a sentiment that may sound harsh to some, I cannot but be of opinion, that as the influence of Christianity prevails, and sober-minded pursuits follow as a matter of course in its train, theatrical representations, except for children, will give place: meanwhile, whatever tends to purify our places of public resort, and make them really places of recreation, is a benefit conferred on the morals of the rising generation.

THEORY OF STEAM-ENGINES.

Account of the experiments undertaken by order of the Minister of Public Works, France, upon the recommendation of the Central Committee upon Steam-Engines, to determine the principal laws and numerical data which enter into the calculation of Steam-Engines. By M. V. Regnault.*

Introduction.—The theoretic calculation of the work done by steam-engines is founded upon some incontestable principles of general mechanics, and upon several physical laws which are far from having been, up to this time, established upon certain bases. The authors who have written upon the theory of these machines, have been obliged to admit as the basis of their calculations, laws which ought only to be considered as hypotheses to which physical philosophers have been led, most frequently, by extending to vapours, laws which are not even rigorously exact for permanent gases. Thus, when the work really done by a machine is compared with that deduced from the theory, we always find, even in the best machines, a considerable deficit. A great part of this deficit may be attributed to the disturbances produced in the physical conditions, by the very motion of the apparatus; it is due to the loss of active force (*force vive*) occasioned by the cooling of the steam; to the resistance which is developed during its course through tubes of irregular forms, and in its passage through openings, more or less contracted. Finally, there are losses of active force produced by the friction and vibration of the different pieces of which the machine is composed. But a great part of the difference may well be occasioned by the inaccuracy of the fundamental laws which have been admitted into the calculation.

* We are indebted to the "Franklin Journal" for the translation.

Mechanics have, for a long time, greatly desired a general investigation for the purpose of establishing these fundamental laws upon a series of direct experiments executed with the means of precision which physical sciences now present. I had for some time formed the determination of devoting myself to this work, and had several times tried some introductory experiments, which however served only to show me that precise results could only be obtained by means of large apparatus, whose expense of construction far surpassed the very narrow means which we have at our disposition in our physical laboratories, and I should have been completely stopped in the execution of my projects, if the Minister of Public Works (upon the suggestion of M. Legrand, under Secretary of State), had not, with a kindness which will be appreciated by all the friends of science, placed at my disposal the funds necessary for the execution of this long and laborious work.

In order to show clearly what are the principal laws upon which the theory of steam-engines rests, it appears to me necessary to explain, in a few words, the principles of this theory. All known systems of steam-engines may be divided into four classes:

1. Engines without expansion, and without condensation.
2. Engines with expansion, and without condensation.
3. Engines without expansion, but with condensation.
4. Engines with both expansion and condensation.

The first three classes, may, in a theoretic point of view, be considered as particular cases of the fourth class, which presents the most complex case; the only one to which it is necessary for us to pay attention. We shall suppose an imaginary engine, which is not subjected to any external cause of cooling, nor to any loss of active force by friction, contractions of orifices, &c, &c. We shall suppose the boiler to be of very great capacity in comparison with the cylinder, so that the pressure of the steam may be considered as absolutely constant in the boiler during the motion of the machine; the heat of the furnace reproducing, constantly, the quantity of steam consumed by the machine.

Let ω be the surface of the piston expressed in square metres*.

x, the space described by the piston from the instant of the arrival of the steam in the cylinder, with the tension which it has in the boiler, until the moment at which we are examining it.

P, the constant pressure of the steam in the boiler, expressed in kilogrammes and referred to a square metre of surface.

T, the temperature of the steam.

v, the capacity, in cubic metres, of the part of the cylinders described by the piston from its starting point to the height, x.

V, the total capacity of the cylinder.

I. A first law, which it is important for us to know, is *the law which connects the elastic forces with the temperatures.*

We will distinguish two periods during the stroke of the piston: during the first of these the cylinder communicates freely with the boiler; the total pressure of the steam upon the surface of the piston is $P\omega$.

If the piston advances by a quantity dx, the element of work produced wil be $P\omega\, d\,x = P\, d\, v$.

The whole quantity of work produced during the first period, that is, from the beginning of the motion of the piston until the introduction of the steam is stopped (corresponding to a capacity V, described by the piston in the cylinder), is P V.

During the second period, which is that of the expansion, no more steam comes from the boiler, but the steam contained in the cylinder continues to press upon the piston; as this rises, the steam occupies a larger space, its elastic force diminishes, and its temperature is lowered by the absorption of latent heat during its dilatation.

Experiment has not decided what are the laws which govern these variations; but one of the following cases must happen:

First case.—The quantity of heat absorbed by a kilogramme of liquid water at 0° (32° Fahrenheit) in passing into vapour (which, for the sake of simplicity, we shall call *the total heat of the steam*), is the same, whatever may be the pressure, provided the vapour be at its maximum of density. If this law be exact, the steam will

* In the following translation we have preserved the French units of length, weight, and temperature. The metre is 39·371 inches. The kilogramme 2·205 lb., av.
The degree of the Centigrade thermometer, 1·8 degrees Fahrenheit.
To reduce Centigrade to Fahrenheit degrees, multiply them by 9, divide the product by 5, and add 32 degrees.

always remain in a state of saturation during the whole period of the expansion; the pressures of the steam will vary in the inverse ratio of its volumes, and they will constantly present the relations to the temperatures, which connect the temperatures of saturated steam with its elastic forces.

Second case.—The total heat of the steam increases in proportion as its elastic force is greater. As we suppose that the steam is not subjected to any external cooling influence, it is evident that, in proportion as the steam dilates into a larger space, it will require a smaller quantity of total heat to keep it in the state of vapour. Consequently, during the dilatation, there will be a disengagement of a certain quantity of latent heat, which will become sensible to the thermometer, and will raise the temperature of the steam above the point which corresponds to its saturation. The temperature of the steam will then be more slowly reduced than in the former case; the steam will be found overheated during the expansion, and the pressure of the steam upon the piston will diminish more slowly than it would according to the law of Mariotte.

Third case.—The total heat of steam is less in proportion as its elastic force is greater. If this law were true, there would be a precipitation of liquid water during the expansion, the steam would remain constantly saturated, but the elastic force would decrease more rapidly than according to the law of Mariotte.

In the absence of decisive experiments to show the accuracy of one of these three hypotheses, mechanicians have generally adopted the first, which is at the same time the most simple and the most precise. This hypothesis assimilates the expansion of steam to that of a permanent gas, dilating in a variable space, whose walls constantly restore to the gas the quantity of heat which is absorbed in the latent state during its expansion, so that its temperature remains invariable.

The work developed during the expansion is then calculated in the following manner:—Let v be the volume of the steam, and p its pressure at a given moment; dx the space described by the piston while the volume becomes $v + dv$; the element of work produced will be $p \omega dx = p dv$. At the commencement of the expansion, the volume is V, and the pressure P, and as we admit the law of Mariotte between the volume of the steam and its elastic force during expansion, we shall have

$$p = \frac{PV}{v}, = p dv = P V \frac{dv}{v};$$

and the whole work produced, while the volume of the vapour passes from V to V′, is $\int_{V}^{V'} P V \frac{dv}{v} = P V \log. \frac{V'}{V} = P V \log. \frac{P}{P'}$

This is the expression for the work produced during the period of the expansion. The total quantity produced during a complete stroke of the piston, is then

$$P V \left(1 + \log. \frac{P}{P'}\right).$$

We have heretofore attended only to the pressure which is exerted upon one of the faces of the piston, but the other face is constantly submitted to the pressure which exists in the condenser. We will suppose this latter pressure to be constant during the stroke of the piston, and represent it by f. The amount of resistance which it will have produced during the stroke of the piston, will be $f V_1 = f \frac{VP}{P_1}$. So that the moving power will be expressed by $P V \left(1 + \log. \frac{P}{P_1} - \frac{f}{P_1}\right)$.

If n represents the number of strokes of the piston per minute, the power developed during this unit of time, will be expressed by

$$n P V \left(1 + \log. \frac{P}{P_1} - \frac{f}{P_1}\right).$$

But the accuracy of the formula depends upon the accuracy of the hypothesis which we have admitted, and it is necessary to determine by direct experiments—

II. *The quantities of heat which must be given to a kilogramme of water, at 0°, to vapourize it, under different pressures.*

These quantities of heat are composed of two distinct parts—the heat necessary to raise the temperature of the liquid water from 0° to the point at which the change of state takes place, and the latent heat of vaporization. If we wish to distinguish these two parts of the total heat of steam, we must determine by experiment—

III. *The capacity for heat of water at different temperatures.*

Finally, if the total heat of steam is not constant under all pressures, in order to calculate the effect of expansion, we must still learn—

IV. *The specific heat of the vapour of water in different states of density, and at different temperatures.*

The theoretic power of a steam-engine may be estimated, by stating the amount of power which it is capable of giving for each kilogramme of steam consumed.

To do this, let ω be the weight of a cubic metre of steam under the pressure P, and at the temperature T; π the weight of steam consumed by the machine in one minute. We shall have $n V = \frac{\pi}{\omega}$, and consequently the power given by the machine, from a kilogramme of steam, will be expressed by

$$P \frac{\pi}{\omega} \left(1 + \log. \frac{P}{P_1} - \frac{f}{P_1}\right)$$

But in order to calculate, under all circumstances, the value of ω, we must know—

V. *The law according to which the density of saturated vapour of water varies under different pressures.*

VI. *The co-efficient of dilatation of the vapour of water, in its different states of density.*

Mechanical philosophers generally admit that the weight (ω) of a cubic metre of steam, under the pressure P, and at the temperature T, may be calculated by applying to saturated steam the law of Mariotte, and the law of the uniform dilatation of gases. Now, these laws are not even rigorously exact for the permanent gases, and it is to be feared that they are completely false for saturated vapours. Finally, the method most generally adopted to compare steam-engines, consists in stating the work which they perform for each kilogramme of fuel consumed. To do this, we must know the weight (K) of steam under the pressure P, which a kilogramme of fuel can develope under the circumstances in which it is employed; and we then have, for the work performed by a kilogramme of fuel, $P_1 K \frac{\pi}{\omega} \left(1 + \log. \frac{P}{P_1} - \frac{f}{P_1}\right)$.

The quantity K, depends upon a variety of circumstances which we cannot now discuss, such as the quality of the fuel, the nature of the furnace, the arrangements of the boiler, &c.

To sum up then, the theoretic calculation of steam-engines requires the knowledge of the following laws and data:—

I. The law which connects the temperatures and elastic forces of saturated steam.

II. The quantities of heat which one kilogramme of liquid water at 0° absorbs, in being converted into saturated steam, under different pressures.

III. The quantities of heat which one kilogramme of liquid water at 0° requires to elevate its temperature to that at which it assumes the state of steam, under different pressures.

IV. The specific heat of aqueous vapour, in different states of density, and at different temperatures.

V. The law according to which the density of saturated steam varies, under different pressures.

VI. The co-efficients of dilatation of steam, at different densities.

Before commencing the search for these different laws, it was necessary to treat several preliminary questions, so as to fix with certainty the indispensable auxiliary data, and, above all, to define clearly the conditions which must be fulfilled by the thermometers, by means of which we measure the temperatures, in order that these instruments may be rigorously comparable.

These preliminary researches obliged me to undertake successively, long series of experiments, the necessity of which I was far from foreseeing when I undertook the work. I was in fact obliged to undertake the re-determination of a great number of data, which, for the most part, appeared to be fixed with complete certainty by the researches of my predecessors, and as to which physical philosophers entertained no doubts whatever.

The whole of these researches will be published in a series of detached memoirs. I intend, at the end of my labours, to sum them up in a report, which will be addressed to the Minister of Public Works, in which the results will be presented under a form suitable to the especial view with which the work was undertaken—that is, the theoretic calculation of steam-engines.

My experiments frequently required the assistance of a great number of observers. I was frequently obliged to avail myself of the kindness of several of my students, among whom it gratifies me to cite especially MM. Bertin, Grassi, Bertrand, Lissajoux, and Silberman. Let me be permitted to return to them, thus publicly, my thanks.

But I must, in a very especial manner, testify my gratitude to my friend M. Izarn, for the zeal and complete devotion with which he has aided me in this long series of labours, some of which were not without danger, and all were very troublesome, as well as in the long and tedious numerical calculations which were the consequence of them. By the aid of his active co-operation, I have been able to terminate these labours in much less time than it would have been possible for me to have done it if I had been reduced to my own personal efforts alone.

FIRST MEMOIR.—ON THE DILATATION OF ELASTIC FLUIDS.

PART I.—*Dilatation of Atmospheric Air, under the ordinary Pressure of the Atmosphere.*

M. Regnault commences his memoir, by remarking that there is, in physical science, no numerical element which has been submitted to a greater number of experimental determinations than the co-efficient of dilatation of atmospheric air, and that nevertheless we cannot yet say that this co-efficient is known to us with sufficient precision. The experiments of the elder physical philosophers gave numbers so different from each other that no use can be made of them. The greater part of the circumstances which influenced the phenomenon were unknown to them.

The experiments of M. Gay Lussac (Annales de Chimie, 1st Series, tom. xliii., p. 137. Biot. Traité de Physique, tom. i., p. 182), seemed to have settled the question finally. He showed by a great number of experiments that between 0° and 100° (32° to 212° Fahrenheit) the co-efficient of dilatation was the same for all gases, and for vapours, when they were at some distance from their point of condensation, and that its value was 0·375.*

This co-efficient was adopted by all physical philosophers, and employed in calculations, until in these latter years a Swedish philosopher, M. Rudberg, cast a doubt upon its exactness. By a series of experiments made with care, M. Rudberg endeavoured to show that the co-efficient of M. Gay Lussac was much too large, and that its true value was comprehended between 0·364 and 0·365.

The experiments of M. Rudberg are then described at length, by M. Regnault. These experiments were originally published in two memoirs contained in Poggendorff's Annals, vols. xli. and xliv., and the English reader will find them in the valuable Scientific Memoirs, edited by Richard Taylor, vol. i., pages 507 and 514.

Rudberg terminates his second memoir by an important remark, which had already been made in 1803, by Gilbert (Gilbert's Annals, vol. xiv., page 267), but had been entirely forgotten, viz: that the experiments of Messrs. Dalton and Gay Lussac, which had been regarded as having given almost identical results, differed, on the contrary, very much. In fact, in the memoir of Dalton (Memoirs Soc. Manchester, 1st Ser., Vol. v., Part 2, p. 598), he says:—

"I have repeatedly found that 1000 parts of common air, of the temperature 55°, and common pressure, expand to 1,321 parts of the thermometer; to which, adding four parts for the corresponding expansion of glass, we have 325 parts increase upon 1000 from 55° to 212°, or from 157 of the thermometer scale *(Fahrenheit)*." It is evident that the volume of air here assumed as the unit, is that of air at 55° Fahrenheit, or 12·78 cent. If, on the contrary, we take for unit the volume of air at 0° (32° Fahrenheit), and put the dilatation between 0° and 100° $= 100a$, the results of Dalton give

$1 + 12{\cdot}78a : 1 + 100a :: 1000 : 1325$; whence $100a = 0{\cdot}392$.

This, then, is Dalton's true result. In truth, Dalton himself does not appear to have observed the error which had slipped into his calculations, for he says in his new system of chemical philosophy:—"The volume of air, according to the experiments of M. Gay Lussac and Minè, being 1000 at 32° Fahrenheit, becomes 1376 at 212° Fahrenheit."

In a note M. Regnault notices a series of experiments upon the same subject, made about the same time with his own, by Professor Magnus of Berlin. An extract from Professor Magnus' memoir will be found in the Annales de Chimie et de Physique, 3rd Ser. tom. iv., page 330; and a second memoir upon the same subject, tom. vi., page 353.

M. Regnault then proceeds to give his own method of experimenting, and the details of his experiments.

These methods were five in number. In the first four, the dilatation of the air was deduced from the observed changes in its elastic force at the temperatures of 0° and 100° cent., assuming as true the law of Mariotte, that the elastic force of a gas varies inversely as its volume, when the temperature remains the same. The fifth method was an attempt to measure directly the augmentation of volume due to the change of temperature.

The first method was similar to that used by Rudberg, in his first series of experiments, and by Dulong and Petit, in their comparison of mercurial and air thermometers.

The apparatus consisted of a glass cylindrical reservoir, from 25 to 30 millimetres in diameter, and about 110 millimetres long, containing from 800 to 1,000 grammes of mercury. To this was soldered a capillary stem, of which the diameter varied in the different experiments, from ½ to 2 millimetres. This was bent at right angles, at some distance above the reservoir, and drawn out to a fine point. The reservoir and the greater part of the stem were immersed in a vessel of water boiling under the usual atmospheric pressure, and filled with perfectly dry air, by exhausting it from 25 to 30 times, by means of a small pump, and re-filling it each time with air which had passed through two tubes, each one metre in length, filled with pumice-stone, saturated with concentrated sulphuric acid. This being done, the apparatus was suffered to stand from half an hour to an hour, the water being maintained in full ebullition; the end of the capillary stem was then closed by the blow-pipe, and the height of the barometer noted. The reservoir, with its stem, was then inverted upon a stand, so that the point of the stem dipped to some distance in a cup of mercury, the cup was broken off under the mercury, and the reservoir surrounded with pounded ice, and left in its condition for an hour or more, until the whole of the air (now contracted so as to fill only a portion of the reservoir) was reduced to the temperature 0°. The end of the stem was then again closed by a little wax, the barometer again noted, the position of the surface of the mercury in the cup marked by a point adjusted by a screw—the cup removed, and the reservoir and its contents suffered to take the temperature of the surrounding air. The height of the mercurial column above the level of the mercury in the cup was then measured by the cathetometer. The reservoir and its contents were then weighed, entirely filled with mercury, first boiled to free it from air and moisture, the point again immersed in mercury, and the reservoir surrounded with ice. At the end of one or two hours, when it was satisfactorily ascertained that the whole apparatus had taken the temperature 0°, the ice was removed, the mercury which was discharged by the rise of temperature was received in a capsule, and the apparatus placed in a boiler, as at first, and brought to 100°. The mercury expelled was collected in the capsule, and the height of the barometer at the moment of ebullition noted. By this means, all the data necessary to calculate both the dilatation of the air, and that of the glass vessel which contained it, were given.

In performing these experiments, M. Regnault observed a serious cause of error. When the point of the stem was broken under the mercury, he observed that a small quantity of air leaked into the reservoir, even when the point was plunged to the depth of $\frac{1}{10}$ metre under the mercury. This air was a portion of that which remained in contact with the glass tube, which not being wetted by the mercury, allowed, as it were, a tube of air from the point to the surface. This difficulty was obviated by attaching to the glass stem, plates of well-cleaned brass, to which the mercury adhered, and thus the entrance of air was prevented. In addition to this, a layer of sulphuric acid was sometimes poured upon the surface of the mercury, before the point was broken, and was carefully removed before the point was again closed. Equal care was taken to prevent the air enfilming the pincers used to break the point, from getting access to the interior. In this method fourteen experiments were tried, the mean of which gives for the volume of 1,000 measures of air, at the temperature of 0°, when heated to 100°, 1·36623.

The highest number obtained in any experiment, was	1·36689
The lowest	1·36549
The difference is	0·00140

or about $\frac{1}{976}$ of the mean.

The lowest number was above the mean result obtained by Rudberg. M. Regnault believes that this may probably be due to the phenomenon of the entrance of the air upon breaking the point having taken place in the experiments of the Swedish professor, and he remarks that the error would be greater in proportion as the quantity of air operated on was less. He also states that he believes the first experiments of his own series were affected by this phenomenon, and as an evidence of this states, that from the moment that he succeeded in preventing it entirely, no experiment gave a number below 1·3659.

* The results arrived at by Mr. Dalton, about the same time (Memoirs Lit. and Phil. Soc. of Manchester, 1st. Ser., Vol. v., part 2, p. 598), appeared to give a co-efficient, identical, or nearly so, with that of Gay Lussac, (0·[illegible]720), and confirmed his assertion as to the equal dilatation of different gases, so that Mr. Dalton himself adopted the co-efficient found by M. Gay Lussac.

The second series of experiments was tried with an apparatus differing but little from the one just described. The reservoir was a glass globe of from 350 to 400 cubic centimetres, soldered to a thermometer stem, about 38 centimetres long; upon this thermometer-tube was soldered, at the distance of 11 centimetres from the bulb, a piece of tube very regular in its diameter, about 50 millimetres long, and of a diameter sufficiently large to present but feeble capillary action. The thermometer-tube was bent at right angles, and drawn out to a point. The first operation was to gauge the apparatus carefully, and to ascertain its co-efficient of dilatation. This was done by filling it with mercury at the temperature 0°, then submitting it to a temperature of 100° collecting the mercury expelled, and weighing this, and the quantity which remained in the bulb.

The dilatation of the air was then determined very much as before. Eighteen experiments were tried in this way, the mean of all of which was 1·36633; the maximum, 1·36708; minimum, 1·36585; the difference, 0·00123, or $\frac{1}{1111}$ of the mean.

The third series of experiments was performed with an apparatus imitated from that described by Rudberg in his second memoir. Upon a shelf within a copper alembic, the cover of which is firmly fixed upon an appropriate support, is placed a glass cylindrical reservoir, 35 millimetres in diameter and 170 millimetres long; to its upper extremity is soldered a thermometer-tube, which passes through a tubulure in the cover, and bending twice at right angles, is soldered to a larger tube, which dips down into a cistern of mercury, passing air-tight through a tubulure in its cover. On the same shelf is placed a precisely similar reservoir, terminating in a straight thermometer-tube, which passes through another tubulure in the cover, and this apparatus being properly filled with mercury, furnishes a delicate thermometer for noting the temperatures in the alembic. The mercurial cistern is furnished, in its lower part, with a piston, moveable by a screw. Through a second tubulure in the cover of the cistern, passes a straight gauge-tube, open above, and dipping into the mercury below, and of the same diameter as the tube which terminates the thermometer-stem. The capacity of this apparatus having been gauged, and the co-efficient of dilatation determined by a previous experiment, the reservoir is filled with dry air, and the alembic filled with ice, so as to reduce the temperature to 0°; the piston in the mercurial cistern is then raised or lowered, until the mercury in the tube communicating with the reservoir, stands exactly at a mark previously made upon it, and the difference between this point and the top of the column of mercury in the gauge tube, is measured. The ice is then removed from the alembic, and replaced by water, which is boiled, and the temperature of the reservoir being thus brought to 100°, the piston is again adjusted, so as to bring the mercury to the same height as before in the tube communicating with the reservoir, and the differences of its height in this tube and the gauge-tube again read. These two readings of course give the elastic force of the air at these temperatures, and from these the co-efficient of dilatation is deduced. The experiments tried with this apparatus, give a mean of 1·36679—the difference between the maximum, 1·36747, and the minimum, 1·36612, being $\frac{1}{1012}$ of the mean. M. Regnault does not believe this method susceptible of the same accuracy as the other, on account of the irregular action of capillarity in the tubes, although purposely taken of equal diameters. He also remarks that the results obtained by him are larger than those got by Rudberg from a somewhat similar apparatus, which he believes may be attributed to the latter having made his mark upon a capillary tube, and to his neglecting the small quantity of air contained in the thermometer-tube, which is not heated to 100°. As however, unfortunately, M. Rüdberg has not stated the dimensions of his apparatus, it cannot be ascertained what influence this had upon his results.

For the fourth series of experiments a form of apparatus was devised similar in principle to that just described, but free from its objections. This consisted essentially of a glass globe, of a capacity of from 800 to 2,000 cubic centimetres, to which was added a capillary stem about 20 centimetres long. The globe was placed in an appropriate metallic vessel, so that it could be alternately heated to 100°, and cooled to 0°; the tube passing out of a lateral opening terminated in a small copper pipe which had two other openings—one of these was for the moment closed, the other communicated with the apparatus for drying the air, by whose means the globe and tube were filled with dry air with the usual precautions. Another glass tube of 16 or 17 millimetres internal diameter was cemented at its lower end into an iron cap terminated below by a stop-cock, and carrying a lateral branch bent parallel to the axis of the tube; into this lateral branch was cemented a second tube, which was for a certain distance of the same diameter as the first, and terminated above by a capillary tube, a part of that which formed the neck of the globe, which was bent at right angles. This system of tubes being firmly and carefully adjusted in a vertical position, the second tube with its attached capillary branch was carefully dried and filled with boiled mercury, and the upper part of the capillary tube, which was of course horizontal, was then fitted into the third opening of the small copper tube, so as to be in immediate communication with the neck of the globe. When firmly fixed, the stop-cock at the bottom of the compound tube was opened, and the mercury flowing slowly out was replaced by air drawn through the drying apparatus, and the apparatus filled with air to a certain mark *a*, placed upon the vertical tube, where it was of greatest diameter, the glass globe being all the time immersed in boiling water: the drying apparatus was then removed, and the branch of the copper tube with which it communicated hermetically sealed, and the height of the barometer noted. The hot water was then discharged from around the globe, and replaced first by cold water and afterwards by pounded ice, the level of the mercury being kept at *a*, by suffering it to flow off when necessary by the stop-cock. When the globe has certainly reached the temperature of the ice, the barometer is read, and the difference of the heights of the mercury in the two communicating vertical tubes is measured. We have thus all the data for calculating the co-efficient of dilatation of the air, but another observation may be had by reversing the experiment. To do this, re-connect the drying apparatus with the copper tube, the mercury will fall in the vertical tube in connection with the globe, but must be kept at *a* by pouring mercury into the other vertical tube: when equilibrium has been attained, remove the drying apparatus, and close its branch of the copper tube, then replace the ice by boiling water, and repress the dilatation of the air by pouring more mercury into the vertical tube; when you are satisfied that the air has taken the temperature of boiling water, read the barometer, and measure the difference of the heights of the mercury in the two vertical tubes.

The mean of six experiments tried in this way gave 1·3665 for the co-efficient of dilatation: the maximum result being 1·36710; the minimum 1·36580; difference $\frac{1}{1031}$ of the mean.

By this method the dilatation of the air is determined under very different pressures; in fact, during the first period of every experiment, the air is under the atmospheric pressure 0·760 metre when at 100°, and only under the pressure of 0·550 metre when at 0°. In the second period, the air at 0°, is under the atmospheric pressure 0·760m., and when heated to 100° under the pressure of about 1·040. It is even easy to arrange the apparatus so that the experiment may be tried under still greater differences of pressure. As the experiments showed no difference in the numbers obtained during these periods (1·36655 during the first, and 1·36645 during the second period,) we must conclude that within these limits of pressure, the co-efficient of dilatation of air is sensibly constant.

Fifth series of experiments.—In all the experiments hitherto described, the dilatation of the gas was determined indirectly from a direct measurement of the augmentation of its elastic fôrce when brought to a constant volume at a higher temperature, assuming the truth of the law of Mariotte. In order to get the dilatation directly, the gas enclosed in an eminently elastic envelope should dilate freely without changing its elastic force, and the augmentation of volume must be carefully measured, the gas being all at the same temperature. It is difficult to see how these conditions can be realised in practice, but it may be done approximately by following the method adopted by M. Pouillet in his air pyrometer. (Traitè de Physique, 4me edit. tome 1, p. 255.) In this way the elastic force of the gas remains sensibly the same, but a very notable portion in the reservoir of dilatation is at a temperature but slightly differing from that of the surrounding air.

The apparatus used by M. Regnault was to a great extent similar to that just described, but the iron cap into which the two vertical tubes were cemented was differently adjusted. It had two stopcocks, by one of which the barometric tube could be made to communicate at pleasure with the exterior, while the other, which was placed under the tube in communication with the globe, was so bored that it might make a communication either between the two tubes or between this second vertical tube and the external air. These two tubes were placed in a glass vessel which could be filled with water so that they could be maintained at any and a uniform temperature. The experiment was conducted as follows: The globe being surrounded with ice, and the communication with the drying apparatus opened, the level of the mercury was brought to the mark *a* on the vertical tube; the communication between the two tubes being open, the mercury would of course be at the same height in both tubes; the communication with the drying apparatus was closed, the barometer and the temperature of the water around the tubes noted. The globe was then brought to 100°, the mercury in the vertical tube was of course depressed, and in order to keep that in the barometric tube at about the same level with it, its stop-cock had to be opened and the mercury suffered to flow out; the two columns were thus kept nearly at the same height, that in the tube in which the air was dilating, being brought to a second mark β, and the exact difference in the heights of the two columns was carefully noted, as well as the height of the barometer, and the temperature of the water in the surrounding vessel. In order from this experiment to determine the dilatation of the air, it is only necessary to know the capacity of the globe, and of its stem as far as the mark α, and that of the vertical tube between α and β; these are all easily determined by the weight of pure mercury necessary to fill them.

Four experiments tried in this way gave a mean dilatation of 1·36706: the maximum being 1·36718; the minimum 1·36693; difference $\frac{1}{5468}$ of the mean. The co-efficient of dilatation given by this fifth method is sensibly greater than that got from the others. This circumstance is not accidental, as in the second part of the memoir similar differences are shown for other gases, and in certain cases these differences are very considerable.*

M. Regnault then proceeds to the discussion of his formulæ, for the purpose of determining the probable error in his results, and he shows that in the first three series—principally owing to the uncertainty of the readings of the barometer within $\frac{1}{10}$ millimetre, the maximum probable error is about $\frac{1}{1000}$, which is about the greatest difference between the maximum and minimum results in any one series. The two last series include the same source of error, and another arising from the uncertainty of the temperature of the air in the capillary tube, which, however, he believes may be altogether neglected in his experiments, the apparatus having been carefully arranged so as to make this a very small fraction of the whole volume of air under experiment.

He finally assumes 0·003665 as the mean co-efficient of dilatation of dry atmospheric air as determined by the first four series of experiments, and remarks that the number 0·00367 given by the fifth series must be adopted in experiments where the gas dilates freely and preserves its original elastic force. He also gives as a fraction easily recollected, the remark of M. Babinet that 0·00366666 should be expressed by $\frac{11}{3000}$.

Part II.—*On the Dilatation of some other Gases under Pressures near that of the Atmosphere.*

Physical philosophers admitted that all gases had the same co-efficient of dilatation, but since so serious an error in the numerical value of this co-efficient had been shown, it was necessary to submit this law also to verification, the result of which was to show its incorrectness. The experiments were tried chiefly by the methods I. and IV. under constant volumes, and V. under constant pressure. It is not necessary to describe them in detail, as M. Regnault has done, nor to give the methods by which the gases were purified; suffice it to say that all necessary precautions were taken, and the general results were as follows:—

	Co-efficient of Dilatation from 0° to 100°. Under constant volume.	Under constant pressure.
Hydrogen,	0·3667	0·3661
Atmospheric Air,	0·3665	0·3670
Nitrogen,	0·3668	"
Oxide of Carbon,	0·3667	0·3669
Carbonic Acid,	0·3688	0·3710
Nitrous Oxide,	0·3676	0·3719
Sulphurous Acid,	0·3845	0·3903
Cyanogen,	0·3829	0·3877

He also describes an apparatus, an easily-imagined modification of method IV., by which the difference in the co-efficient of dilatation of any two gases may be at once shown.

Part III.—*On the Dilatation of Gases under Different Pressures.*

It has been generally admitted that the dilatation of gases is constant between the same limits of temperature, no matter to what pressure they may be submitted; consequently, that it is altogether independent of their initial density. But it is difficult to cite conclusive experiments upon which this law is founded. Several observers having obtained the same value for the co-efficient of dilatation of air, under different barometric pressures, concluded that the co-efficient of dilatation of gases was constant under all pressures; but the barometric variations in any place are not sufficiently extensive to permit so general a conclusion to be thus deduced.

Sir Humphrey Davy is the only philosopher who has studied the dilatation of gases under very different pressures. (Phil. Trans. 1823, vol. ii, p. 204.)

He states that he found the same dilatation for air taken with the densities ⅛, ¼, ½, 1, and 2; but his experiments were not made by a sufficiently delicate method to allow his results to be considered exact.

The experiments of M. Regnault upon this subject were tried with apparatus of the same character as those before described, as methods IV. and V., with such modifications as the peculiar circumstances of the experiments rendered necessary: and the conclusion at which he arrived was that "*the air dilates, within the same limits of temperature, by quantities which are greater in proportion as the density of the gas is greater: that is, in proportion as its molecules are brought nearer to each other.*"

The following tables exhibit the results of his experiments upon air, carbonic acid, and sulphurous acid:

Dilatation of Gases under different Pressures, determined by the method of Constant Volumes. (II. and IV.)

ATMOSPHERIC AIR.

Pressure at 0°. Millimetres.	Pressure at 100°. Millimetres.	Density of the air at 0°, that of air at 0°, under a pressure of 760 millimetres = 1.	Volume of the air at 100°, that at 0° = 1.
109·72	149·31	0·1444	1·36482
174·36	237·17	0·2294	1·36513
266·08	395·07	0·3501	1·36542
374·67	510·25	0·4930	1·36587
375·23	510·97	0·4937	1·36572
760·00	—	1·0000	1·36650
1678·40	2286·09	2·2084	1·36760
1692·53	2306·23	2·2270	1·36800
2144·18	2924·04	2·8213	1·36894
3655·56	4992·09	4·8100	1·37091

CARBONIC ACID.

Pressure at 0°. Millimetres.	Pressure at 100°. Millimetres.	Density	Volume at 100°
758·47	1034·54	1·0000	1·36856
901·09	1230·37	1·1879	1·36943
1742·73	2387·72	2·2976	1·37523
3589·07	4759·03	4·7318	1·38598

Dilatation of Gases under different Pressures, determined by the method of Constant Pressures. (V.)

Atmospheric Air.		Carbonic Acid.		Hydrogen.		Sulphurous Acid.		
Pressure Milli.	Volume at 100°.	Pressure Milli.	Volume at 100°.	Pressure Milli.	Volume at 100°.	Pressure at 0°.	Pressure at 100°.	Volume at 100°.
760	1·36706	760	1·37099	760	1·36613	760·00	760·00	1·39030
2525	1·36944	2520	1·38455	2545	1·36616	982·73	987·64	1·39804
2620	1·36964	—	—	—	—	—	—	—

The general conclusions of this memoir are as follows:—

1st. The co-efficient of dilatation of air, 0·375, heretofore admitted by philosophers from the experiments of M. Gay Lussac, is much too great for dry air under the ordinary atmospheric pressure. The co-efficient 0·3645, which is the mean of the experiments published by M. Rudberg, is too small. When the co-efficient of dilatation of air is deduced by calculation, from the changes of elastic force which the same volume of gas undergoes when carried from 0° to 100°, its value is 0·3665. But when this co-efficient is deduced from the changes of volume of the same mass of gas in passing from 0° to 100°, its elastic force remaining constant, we find a value rather higher: that is—0·3670.

2nd. The co-efficients of dilatation of the different gases are not equal, as has been hitherto admitted; they present on the contrary, notable differences, as may be seen by the numbers before cited. There is often obtained for the same gas, very different values for its co-efficient of dilatation, according as this is deduced immediately from the observation of the change of volume which the same mass of gas undergoes between 0° and 100°, its elastic force remaining the same, or calculated from the variation in the elastic force of the gas between 0° and 100°, its volume remaining constant.

3rd. The air and all other gases, except hydrogen, have greater co-efficients of dilatation in proportion as their density increases.

4th. The co-efficients of dilatation of the different gases approach nearer equality as their pressures are lighter; so that the law which is thus expressed, "*all gases have the same co-efficient dilatation,*" may be considered as a limiting law which is applicable to gases in a state of extreme dilatation; but which is farther from the truth in proportion as the gases are more compressed, or, in other words, as their molecules are brought nearer together.

(To be continued.)

* M. Regnault describes in a note an independent series of experiments tried by him according to the method of M. Gay Lussac—that is, by observing the dilatations of a quantity of dry air contained in a true thermometer and separated from the external atmosphere by a small index of mercury. (Biot. Traité de Phys. tom. 1, p. 182.) The results obtained did not agree at all, and were all feebler than by any of the other methods; the highest result recorded was 1·3647.

CONTRIBUTIONS TO RAILWAY STATISTICS,

In 1846, 1847, and 1848.—By Hyde Clarke, Esq.

No. I.—PASSENGERS AND FARES.

Having published an analysis of the Railway Returns for 1845, I have taken the earliest opportunity after the appearance of those for 1846 and 1847, of giving a similar analysis of them, under the same title of "Contributions to Railway Statistics," which I hope may prove equally acceptable to practical men as the former series.

The following are the totals of each class of passengers in the years ending 30th June:—

	1844.	1845.	1846.	1847.
1st class,	4,875,332½	5,474,163	6,160,354½	6,572,714
2nd class,	12,235,686	14,325,825	16,931,065¾	18,699,288½
3rd class,	8,583,085½	13,135,820	18,506,527½	22,850,803½
Mixed	2,069,498½	855,445½	2,193,126	3,229,357
Altogether,	27,763,602½	33,791,253½	43,790,983¾	51,352,163

The amount received for each class, in each year, was as follows:—

	1844.	1845.	1846.	1847.
1st class,	£1,432 688	£1,516,805	£1,661,898	£1,675,759
2nd class,	1,375,679	1,598,115	1,937,946	2,048,080
3rd class,	483,069	651,903	1,032,206	1,286,710
Mixed,	147,858	209,518	93,164	146,733
Altogether,	£3,439,294	£3,976,341	£4,725,215	£5,148,002

The yearly increase in numbers on each class of passengers is as follows:—

	1845.	1846.	1847.
1st class,	12 per cent.	12 per cent.	7 per cent.
2nd class,	17 „	18 „	10 „
3rd class,	50 „	41 „	23 „
Altogether,	21 „	24 „	17 „

The yearly increase in money on each class of passengers is as follows:—

	1845.	1846.	1847.
1st class,	6 per cent.	9 per cent.	— per cent.
2nd class,	16 „	21 „	6 „
3rd class,	34 „	58 „	24 „
Altogether,	16 „	18 „	9 „

It is to be observed that no deductions can be drawn from these figures, as the Railway Department returns are defective and informal.

The gross returns in each year from passengers, goods, &c., were as follows:—

1842-3,	£4,535,189
1843-4,	5,074,674
1844-5,	6,209,714
1845-6,	7,565,569
1846-7,	8,510,886

According to Mr. Hackett, in Herapath's *Railway Journal*, the receipts for the years ending 31st December, have been as follows:

1842,	£4,341,781
1843,	4,827,655
1844,	5,584,982
1845,	6,649,224
1846,	7,664,874
1847,	8,949,681
For the year ending June 30, 1848,	9,423,963

Mr. Hackett's totals are taken from the traffic returns published in Herapath's *Journal*, and do not include many small companies which make returns to the Railway Department.

The following will show the totals of the Railway Department and of Mr. Hackett for the same period:—

	Railway Department.	Mr. Hackett.
1842-3,	£4,341,781	£4,530,401
1843-4,	5,074,674	5,114,575
1844-5,	6,209,714	6,065,956
1845-6,	7,565,569	7,159,562
1846-7,	8,510,886	8,194,767
1847-8,	——	9,423,963

Except in the first two years, it will be seen that Mr. Hackett's totals are below those of the Railway Department, for the reason already given.

1844-5,	£142,858
1845-6,	406,007
1846-7,	316,119

These figures show that any error in Mr. Hackett's figures must be on the safe side; and if we take the difference for the year 1847-8 at 300,000*l.*, this will give as the gross yearly traffic for the year ending 30th June last, 9,700,000*l.*, or nearly ten millions sterling.

The increase of passenger receipts in each year is as follows:—

1844-5	£537,047
1845-6	748,874
1846-7	422,787

The increase in the number of passengers in each year stands thus:—

1844-5	£6,027,651
1845-6	9,999,730
1846-7	7,561,180

The gross increase of revenue in each year stands thus:—

1844-5	£1,135,040
1845-6	1,355,855
1846-7	945,317
1847-8	1,200,000

Mr. Hackett has shown (Herapath's *Journal*, 3rd series, vol. X., p. 33), that the number of miles of railway on which his figures are taken, and the average traffic per mile, are as follows:—

	Miles.	Miles opened.	Traffic per mile.
1842,	1532	—	£3,036
1843,	1586	59	3,081
1844,	1780	194	3,283
1845,	2043	263	3,500
1846,	2610	593	3,288
1847,	3449	839	2,862
1847-8, (Half-year.)	3830	381	2,719

The last line has been made up from other data.

The capital expended on railways has been likewise given by Mr. Hackett, from which we can learn the amount expended in each year.

1842,	£52,380,100	whole capital,	——	expended.
1843,	57,635,100	„	£5,255,000	„
1844,	63,489,100	„	6,844,000	„
1845,	71,646,100	„	8,157,000	„
1846,	83,165,100	„	12,519,000	„
1847,	109,528,800	„	26,363,700	„

The total amount of railway expenditure from 1842 to the end of 1847 was 57,548,700*l.*

The total amount of railway income in those years has been—

1842,	£4,341,781
1843,	4,827,655
1844,	5,584,982
1845,	6,649,224
1846,	7,664,874
1847,	8,949,681
Add from Railway Returns	865,984
Altogether,	£38,884,181

Of course the whole of this income cannot be treated as real capital, no more can the whole of the expenditure; but it is a significant fact, that while the whole expenditure has been 57,548,700*l.*, the whole income has been 38,884,181*l.*, or more than two-thirds of that amount. This is deserving the attention of those who direct their attention towards the subject of railway capital.

It may be noted upon the decrease in the mileage receipts, that it is to be accounted for from the greater economy in working expenses allowing of lower fares, and from the progress of railway improvement allowing lines to be more cheaply constructed. It will be found that the net return is not less in 1847 than in 1842.

In "Irish Wants and Practical Remedies," by Humphrey Brown, Esq., M. P., (p. 63), is given a table of the estimated passenger and goods traffic of several English lines, as given before the House of Commons. This I have extended as follows:—

Name.	Length in Miles.	Passengers.	Goods. Tons.
Midland, ...	163¾	550,985	151,845
Lancashire and Yorkshire, ..	79	207,688	109,486
York and North Midland, ..	27½	185,660	5,547
London and Brighton, ..	50	226,444	43,765
London and South Eastern, ..	67	317,252	63,079
Great North of England, ..	45	75,158	32,136
Great Western, and Bristol and Exeter,	231	821,145	209,563
Lancaster and Preston, ..	20	106,957	——
Glasgow and Ayr, ..	18¾	597,470	121,027
Hull and Selby, ...	31	19,562	93,873
London and Cambridge, ..	57½	591,344	72,214
Dundee and Arbroath, ..	16½	200,727	51,899
Sheffield and Manchester, ..	44½	335,444	84,050
Altogether, ..	851½	4,135,836	1,038,504

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The traffic realised on the above lines in 1845 was as follows:—

Name.	Passengers.	Goods. Tons.
Midland, ...	1,809,145	715,272
Lancashire and Yorkshire, ...	1,674,946	507,859
York and North Midland, ...	464,755	351,022
London and Brighton, ...	788,386	65,747
London and South Eastern, ...	728,896	87,119
Great North of England, ...	196,722	234,198
Great Western, and Bristol and Exeter, ..	1,993,088	209,563
Lancaster and Preston, ...	135,344	26,099
Glasgow and Ayr, ...	843,078	168,376
Hull and Selby, ...	263,402	227,869
London and Cambridge*	534,206	44,572
Dundee and Arbroath, ...	269,187	81,484
Sheffield and Manchester,*	1,168,448	32,000
Altogether, ..	10,868,503	2,751,180

* Partially opened.

The results are as follows:—

	Passengers.	Goods. Tons.
Estimated traffic on 851 miles,	4,135,836	1,038,504
Realised traffic, 1845, ..	10,868,503	2,751,180
Excess over estimates, ..	6,732,667	1,712,676
Increase per cent. ..	160	170

In Mr. Brown's book on a length of 702 miles the same increase of per centage is shown, namely, 160 per cent. on passengers, and 170 on goods.

The whole traffic in 1845 was 33,791,253½ passengers, and of goods, &c. 11,600,000 tons. Supposing the proportions to be the same, the number of passengers carried in 1845 more than was provided with means of conveyance before the existence of railways was 20,800,000, and the number of tons of goods conveyed was 7,200,000. Thus the railways not only accommodated the full number of passengers for whom conveyances already existed, but carried the above enormous number in addition, besides a great quantity of goods. It will be found that this calculation is, however, far from representing the amount of accommodation now afforded.

Taking the later returns, where they are available, we shall find the increase still greater, as in 1846 for instance:—

Name.	Passengers.	Goods. Tons.
Midland, ...	2,468,110	900,895
Manchester and Leeds, ...	2,157,173	522,177
York and North Midland, and Hull and Selby,	933,514	370,414
London and Brighton, ...	971,081	93,407
London and South Eastern, ..	1,074,730	116,385
Great North of England, ..	239,587	433,867
Great Western, &c.	2,757,193	300,000
Lancaster and Preston, ...	162,012	25,585
Glasgow and Ayr, ...	1,091,371	293,304
London and Cambridge, ...	922,413	110,348
Dundee and Arbroath, ...	317,092	21,059
Sheffield and Manchester, ..	1,604,227	135,000
	13,718,503	3,530,441

In 1847 there were separate returns from some of these lines, as the following:—

Name.	Passengers.	Goods. Tons.
Great Western, &c.	2,876,222	371,326
Glasgow and Ayr, ...	992,096	397,515
Lancaster and Preston, ...	106,475	22,054
Dundee and Arbroath, ...	360,194	22,354
Sheffield and Manchester, ..	1,569,707	218,740
South Eastern, ...	1,477,892	204,100

The increase over the estimates on the traffic of 1846 is still greater than on 1845.

	Passengers.	Goods. Tons.
Estimated traffic, ..	4,135,836	1,038,504
Realised traffic, 1846, ..	13,718,503	3,530,441
Excess over estimates, ..	9,572,667	2,492,937
Increase per cent., ..	230	250

The traffic on these lines stands as follows:—

	Passengers.	Goods. Tons.
Estimated	4,135,836	1,038,504
Realised, 1845, ..	10,868,503	2,751,180
" 1846, ..	14,078,697	3,530,441

The lines for which there are separate returns in 1847 are as follows:—

Great Western, &c.,	231 miles.
Glasgow and Ayr,	18¾ "
Lancaster and Preston,	20 "
Dundee and Arbroath,	16½ "
Sheffield and Manchester,	44½ "
South Eastern,	67 "
	297¾ miles.

The traffic stands thus—

	Passengers.	Goods. Tons.
Estimated	2,378,995	529,618
Realised 1845, ...	5,138,041	604,641
" 1846, ...	7,006,625	891,333
" 1847, ...	7,382,586	1,236,081

The actual increase of traffic depends upon the length of time given for its development, beginning at 160 per cent. and going up to 230 per cent., and in the case of the selected railways even more. Taking the increased accommodation to passengers at 160 per cent., this would give the following as the increased number of travellers provided with travelling accommodation in each year:—

1844, ..	17,400,000
1845, ..	20,800,000
1846, ..	27,000,000
1847, ..	30,000,000

If the proportion be taken at 200 per cent., the number accommodated by railway for whom no accommodation was before provided, would be 34,000,000.

The following shows the proportion of traffic on railways in each year for which accommodation by coach, &c. was provided, and for which no accommodation by coach, &c. was provided:—

	Travellers from old coaches, &c.	New Travellers.
1844,	10,300,000	17,400,000
1845,	12,900,000	20,800,000
1846,	16,000,000	27,000,000
1847,	21,000,000	30,000,000

Reckoning that each passenger is on the average carried 20 miles, each male adult in this country will be carried that distance six times in the year,—an extent of accommodation which must have a great effect on trade and on the distribution of labour.

It appears from the averages given in the returns of the Railway Department, that there has been a still further reduction in fares on most of the lines, and an increase in the average speed per mile.

The total increase on each class of passengers is as follows:—

	1845.	1846.	1847.
1st class,	599,831	686,191	412,460
2nd class,	2,190,139	2,615,240	1,768,223
3rd class,	5,552,735	5,471,707	4,344,376
Altogether,	6,028,651	9,999,730	7,561,180

It is to be observed that these figures cannot be absolutely relied on, as the proportions of each class cannot be fully shown, on account of the confused state of the returns published by the Railway Department.

The total increase on each class of passengers between 1844 and 1847 has been as follows:—

1st class,	1,697,382
2nd class,	6,463,602
3rd class,	14,267,718
Altogether,	23,588,561

This is probably more than the whole traffic of the country in 1825, and it shows at any rate that there has been a great increase in the accommodation given to the working classes.

The number of first, second, and third class passengers in 1847 on the leading lines was:—

Name.	1st.	2nd.	3rd.	Total.
London and North Western,	1,112,970	3,323,380	2,163,285	6,599,736
South Eastern, ..	657,380	1,493,142	2,008,230	4,420,759
Midland, ..	445,260	1,260,312	2,571,836	4,277,419
London and Blackwall,	858,201	2,279,166	———	3,137,767
Lancashire and Yorkshire,	216,791	581,790	2,090,624	2,689,206
Great Western, ..	459,734	1,996,824	419,663	2,876,222
London and Brighton,	425,948	699,898	1,489,985	2,615,832
Dublin and Kingstown,	154,889	1,269,092	814,969	2,238,950
Eastern Counties, ..	287,526	741,486	1,044,168	2,074,170
South Western, ..	399,776	1,095,050	472,482	1,967,308
Manchester and Sheffield,	82,201	151,606	1,335,900	1,569,707
York and Newcastle, ..	152,083	753,927	643,203	1,553,213
York and North Midland,	163,837	309,782	731,207	1,204,826
Newcastle and Berwick,	67,734	174,890	944,891	1,187,515
Edinburgh and Glasgow,	105,373	206,485	836,025	1,147,883

On the London and North Western, Great Western, South Western, and York and Newcastle, the proportion of third-class passengers is much below the regular proportion.

The largest receipts from passengers in 1847 are—

London and North Western,	£1,173,798
Great Western, ..	674,241
Midland, ..	567,126
South Eastern,	335,764
Brighton, ..	314,493
Eastern Counties, ..	296,393
South Western, ..	286,273
Lancashire and Yorkshire,	184,762
York and North Midland,	165,434
York and Newcastle,	147,252
Edinburgh and Glasgow,	112,582

The largest amounts received for first-class passengers are—

London and North Western,	£513,795
Great Western, ..	232 854
Midland, ..	178,424
Brighton, ..	124,220
South Eastern, ..	117,659
South Western, ..	97,689
Eastern Counties, ..	93,304

The largest amounts received from third-class passengers are—

London and North Western,	£209,890
Midland, ..	153,354
Lancashire and Yorkshire	90,286
South Eastern, ..	85,403
Great Western, ..	77,129
Eastern Counties, ..	74,234
York and North Midland,	65,507

No. II.—CATTLE TRAFFIC.

The last parliamentary returns are still more defective than their predecessors, so that it is necessary to estimate some of the numbers.

The following shows the number of cattle carried in the year ending 1st July, 1846 :—

Name.	Cattle.	Sheep.	Swine.
Ardrossan, ..	467	3,826	306
Chester and Birkenhead,	7,508	5,461	740
Dublin and Drogheda,	429	1,186	3,636
Dundee and Arbroath ..	351	58	86
Eastern Counties: Cambridge,	36,238	106,055	2,618
„ Colchester,	17,134	89,211	11,190
Glasgow and Greenock,	640	1,492	——
Glasgow and Ayr, ..	2,136	6,567	1,424
Great North of England,	27,625	32,466	5,305
Great Western, ..	20,389	165,860	53,702
London and Birmingham	55,017	232,058	120,461
Grand Junction, ..	41,595	45,742	337,626
London and Brighton,	1,079	16,785	962
London and South Western,	6,390	62,454	5,412
Manchester and Leeds,	10,448	66,029	40,346
Maryport and Carlisle,	239	575	609
Midland, (*Estimated*),	22,000	15,000	129,000
Birmingham and Bristol,	2,641	5,274	26 044
Newcastle and Carlisle,	11,009	49,263	8,291
Newcastle and Darlington,	16,521	36,505	3,276
Newcastle and North Shields,	2,874	30,894	599
North Union ..	5,996	25,679	7,796
Norfolk ..	24,432	21,509	627
Preston and Wyre, ..	962	3,726	13,899
Manchester and Sheffield,	416	30,030	6,240
South Eastern, ..	3,892	48,344	5,224
Stockton and Darlington,	1,316	2,649	390
Stockton and Hartlepool,	302	860	420
Ulster, ..	999	878	27,388
Whitehaven, ..	15	19	——
York and North Midland,	37,657	62,249	4,944
Hull and Selby, ..	2,662	49,734	1,311
Total ..	360,314	1,209,447	813,967

As the returns are incomplete, this does not show the whole number of cattle, which will be as follows :—

Cattle,	370,000
Sheep,	1,2[illegible]0,000
Swine,	850,000
Total,	2,470,000

This shows an increase of 25 per cent. over the number of animals carried in 1845.

The number of calves carried in 1846 was as follows :—

Chester and Birkenhead,	6,288
Maryport and Carlisle,	1,372
North Union,	106

In other returns they are not distinguished.

The amount of revenue derived from cattle traffic was in 1846 as follows :—

	Cattle, £	Sheep, £	Swine £	Total £
Ardrossan, ..	30	20	6	56
Chester and Birkenhead,	237	45	12	294
Dublin and Drogheda,	95	57	180	332
Dundee and Arbroath,	28	1	1	30
Eastern Counties : Cambridge	9,864	3,693	178	13,735
„ Colchester,	2,997	2,454	239	5,690
Glasgow and Greenock,	98	24	——	122
Glasgow and Ayr,	213	135	14	362
Great North of England,	——	——	——	4 591
Great Western,	7,106	7,460	2,965	17,531
London and Birmingham,	11,715	8,817	6,161	26,693
Grand Junction,	9,126	4,000	22,365	35,491
Manchester and Birmingham	——	——	——	636
London and Brighton,	302	584	100	986
London and South Western,	1,251	2,083	479	3,813
Manchester and Leeds,	750	1,159	1,630	3,739
Maryport and Carlisle,	20	10	10	41
Midland, ..	——	——	——	8,960
Birmingham and Bristol,	352	161	906	1,420
Newcastle and Carlisle,	1,158	1,101	230	2,489
Newcastle and Darlington,	——	——	——	2,339
Newcastle and North Shields,	107	193	7	307
North Union, ..	——	——	——	20,919
Norfolk, ..	3,072	458	16	3,556
Preston and Wyre,	74	26	86	186
Manchester and Sheffield,	——	——	——	1,420
South Eastern ..	——	——	——	3,079
Stockton and Darlington,	87	32	4	123
Stockton and Hartlepool,	16	8	4	28
Ulster, ..	131	21	448	600
York and North Midland,	2,360	1,708	240	4,308
Hull and Selby, ..	793	1,491	32	2,226
Total ..				£167,201

On account of the very imperfect state of the returns, it is impossible to give the proportion paid in 1846 under each head of cattle traffic. In 1845 the proportions were—

Cattle,	£30,000
Sheep,	26,000
Swine,	30,000

The proportion for cattle must now be larger, and that for swine smaller.

In 1847 the number of cattle carried by each company was as follows :—

Name.	Cattle.	Sheep.	Swine.
Ardrossan, ..	820	332	760
Chester and Birkenhead,	1,688	6,582	1,065
Dublin and Drogheda,	680	1,794	4,388
Dundee and Arbroath,	325	32	6
Eastern Counties : Cambridge,	14,792	252,680	10,480
„ Colchester,	20,722	107,693	26,076
Eastern Union, ..	6,681	19,151	2,420
Ipswich and Bury, ..	1,408	4,848	749
East Lancashire, ..	287	1,290	40
Furness ..	3	42	——
Glasgow and Greenock	698	497	——
Glasgow and Ayr, ..	1,759	5,137	332
Great Southern and Western,	5,053	14,830	15,846
Great Western, ..	28,231	201,833	14,360
Kendal and Windermere,	108	1,814	73
Lancashire and Yorkshire, (M.&L.)	22,449	75,011	20,733
London and North Western,	161,171	399,998	150,674
London and Brighton,	2,617	28,858	3,018
Londonderry and Enniskillen,	28	108	47
London and South Western,	13,565	75,365	3,462
Manchester and Sheffield,*	6,000	5,000	10,000
Maryport and Carlisle,	924	615	2,282
Midland,* ..	30,000	150,000	39,000
Bristol and Birmingham,	3,526	12,771	10,684
Middlesborough and Redcar,	251	525	7
Newcastle and Carlisle,	14,599	66,628	9,759
Newcastle and Berwick,	1,908	32,224	597
North Union, ..	6,998	31,185	7,411
Norfolk, ..	38,888	85,349	8,634
Preston and Wyre, ..	2,245	3,788	6,169
South Eastern, ..	7,096	47,167	2,537
Stockton and Darlington,	1,878,	2,121	258

* Estimated amount.

Shrewsbury and Chester,	336	1,269	66
South Devon, ..	222	109	6
Stockton and Hartlepool	698	2,367	592
Ulster, ..	1,273	3,313	13,360
Whitehaven, ..	34	85	——
York and Newcastle,	41,399	88,287	9,142
York and North Midland,	41,931	84,656	7,014
Total ..	483,291	1,995,354	372,967

The whole number of cattle in 1847 will therefore be as follows, allowing for the incompleteness of the returns:—

Cattle,	500,000
Sheep,	2,000,000
Swine,	390,000
Total,	2,890,000

Making nearly three million head of stock. The falling-off in swine arose from the Irish famine.

The number of calves carried in 1847 was as follows:—

Chester and Birkenhead, ..	6,534
London and South Western	9,222
Maryport and Carlisle, ..	65
South Eastern, ..	1,062
South Devon, ..	217

The amount of revenue derived from cattle traffic was in 1847 as follows:—

Name.	Cattle.	Sheep.	Swine.	Total.
Ardrossan, ..	£ 6	£ 1	£ 2	£ 9
Chester and Birkenhead,	257	54	20	331
Dublin and Drogheda,	132	65	123	317
Dundee and Arbroath,	28	——	——	29
Eastern Counties, Cambridge,	15,112	9,656	296	25,064
" Colchester,	2,949	2,710	434	6,093
Eastern Union, ..	444	158	30	632
Ipswich and Bury	102	46	15	163
East Lancashire,	11	13	1	25
Glasgow and Greenock	92	21	——	113
Glasgow and Ayr,	223	128	22	373
Great Southern and Western,	764	584	455	1,803
Great Western, ..	7,864	9,021	776	17,661
Kendal and Windermere,	1	5	——	6
Lancaster and Carlisle,	595	875	——	1,470
Lancashire and Yorkshire,	2,192	1,276	844	5,312
London and North Western,	25,435	16,622	17,223	59,280
London and Brighton,	657	880	200	1,737
London and South Western,	1,808	2,204	138	4,150
Londonderry and Enniskillen,	3	2	1	6
Manchester and Sheffield,	——	——	——	3,036
Maryport and Carlisle,	71	10	25	106
Midland, ..	——	——	——	10,270
Bristol and Birmingham,	437	380	390	1,243
Middlesborough and Redcar	9	3	——	12
Newcastle and Carlisle,	1,323	1,306	273	2,902
Newcastle and Berwick,	71	204	9	284
North Union, ..	——	——	——	15,531
Norfolk, ..	——	——	——	6,508
North British, ..	——	——	——	757
Preston and Wyre,	170	38	42	250
South Eastern, ..	——	——	——	3,334
Stockton and Darlington,	129	31	3	163
Shrewsbury and Chester,	19	20	1	40
South Devon, ..	11	2	——	13
Stockton and Hartlepool,	31	25	6	62
Ulster, ..	172	92	237	501
Whitehaven, ..	2	——	——	2
York and Newcastle,	4,255	3,925	286	8,466
York and North Midland,	2,320	2,068	1,068	5,456
		Total	..	£183,400

The total receipts for cattle traffic in each year were as follows:

1845,	£102,000
1846,	167,200
1847,	183,400

The great advance in cattle traffic was made in 1846; but the progress was not so great in 1847, as there was a positive falling-off in the number of swine carried. The greatest increase is in the conveyance of fat stock and sheep.

The following are the proportions of cattle carried in each year:—

	Cattle.	Sheep.	Swine.
1845,	236,000	1,200,000	550,000
1846,	370,000	1.250,000	850,000
1847,	500,000	2,000,000	390,000

The cattle carried to the London market in 1847, may be reckoned as follows:—

	Cattle.	Sheep.	Swine.
London and North Western,	65,000	200,000	55,000
Great Western, ..	20,000	150,000	10,000
South Western, ..	13,000	75,000	3,000
South Eastern, ..	7,000	40,000	2.500
Eastern Counties: Cambridge,	10,000	200,000	10,000
" Colchester,	15,000	75,000	20 000
Brighton, ..	2,500	25,000	3,000
Total,	132,500	765,000	103,600

The number of cattle sold in Smithfield in 1846 was 213,525, and of sheep 1,527,220, so that the railways must have engrossed a considerable part of the cattle traffic. For the conveyance of cattle to the London market the railway companies receive at least £75,000.

Great reductions have been made in the charges for the conveyance of cattle since 1845. The charges are as follows:—

		Cattle.	Sheep.	Swine.
		d.	d.	d.
London and North Western,	1845,	1·020	·160	·160
"	1847,	·626	·135	·145
Eastern Counties: Cambridge,	1845,	·980	·200	·400
"	1847,	·943	·143	·107
Eastern Counties: Colchester,	1845,	·980	·200	·400
"	1847,	·890	·153	·173
Great Western, ..	1845,	1·530	·156	·188
"	1847,	·819	·156	·188
York and North Midland,	1845,	·500	·200	·500
"	1847,	·500	·200	·500
Lancashire and Yorkshire,	1845,	·870	·250	·250
"	1847,	·766	·177	·373
London and South Western,	1845,	1·750	·200	·500
"	1847,	1·460	·160	·190

No reduction has taken place on the York and North Midland Railway, because the rates were already low.

The largest cattle traffics in 1846 were as follow:—

	Cattle.	Sheep.	Swine.
London and North Western,	96,612	277,800	358,087
Eastern Counties: Norfolk and Eastern Union, ..	77,804	216,775	14 430
Great Western, ..	20,889	165,860	53,702
York and North Midland, and Hull and Selby ..	40,319	109,992	5,225
Great North of England,	27,625	32,466	3 300
Lancashire and Yorkshire,	10,448	66,029	40,346
South Western, ..	6.390	62,454	5,412
North Union, ..	5,996	25,679	7,796
Newcastle and Carlisle	11,009	49,263	8.291
South Eastern, ..	3,892	48,344	5,224
Newcastle and Darlington,	16,521	36,505	3,376
Manchester and Sheffield,	416	30,030	6,240

The gross amounts received in 1846 for cattle traffic range as follows:—

London and North Western,	£62,820
Eastern Counties, &c.,	28,971
North Union ..	20,919
Great Western, ..	17,531
Midland, ..	8,960
York and North Midland, &c.	6,534
Great North of England,	4,591
London and South Western,	3,813
Lancashire and Yorkshire,	3,739
South Eastern, ..	3,079

The largest cattle traffics in 1847 were as follows:—

	Cattle.	Sheep.	Swine.
London and North Western,	161,171	399,998	150,674
Eastern Counties, ..	82,491	469,721	48,359
Great Western, ..	28,231	201,901	14.360
York and North Midland	41,931	84,656	7,014
York and Newcastle, ..	41,399	88,287	9,142
Lancashire and Yorkshire (M & L)	22,449	75,011	20,723
South Western, ..	13,565	75,365	3,462
Newcastle and Carlisle ..	14,599	66,628	9,759
North Union, ..	5,996	25,679	7,796
South Eastern, ..	3,592	48,344	5,224
London and Brighton, ..	2,617	28,858	3,018
Newcastle and Berwick,	1,908	32,224	597

The following will show the progress of the cattle traffic of the principal companies:—

London and North Western,	Cattle.	Sheep.	Swine.
1845,	61,466	229,245	315,969
1846,	96,612	277,800	358,087
1847,	161,171	399,998	150,674

Eastern Counties,	Cattle.	Sheep.	Swine.
1845,	20,661	125,564	4,228
1846,	77,804	216,775	14,430
1847,	82,491	469,721	48,359
Great Western,	Cattle.	Sheep.	Swine.
1845,	14,058	172,264	52,443
1846,	20,389	165,860	53,702
1847,	28,231	201,901	14,360
York and North Midland,	Cattle.	Sheep.	Swine.
1845,	15,364	88,143	31,708
1846,	40,319	109,992	5,265
1847,	41,981	84,656	7,014
York and Newcastle,	Cattle.	Sheep.	Swine.
1845,	19,685	20 000	5,000
1846,	44,146	68,971	5,331
1847,	41,399	88,287	9,142
Lancashire and Yorkshire,	Cattle	Sheep.	Swine.
1845,	9,686	149,022	27,485
1846,	10,448	66,029	40,346
1847,	22,449	75,011	20,733
South Western,	Cattle.	Sheep.	Swine.
1845,	2,763	53,441	3,080
1846,	6,390	62,454	5,412
1847,	13,565	75,365	3,462
Newcastle and Carlisle,	Cattle.	Sheep.	Swine.
1845,	3,782	37,525	5,116
1846,	11,009	49,263	8,291
1847,	14,599	66,628	9,759

The Belgian cattle traffic from the returns was as follows:—

	Cattle.	Sheep & Swine.
1843,	8 609	33,562
1844,	12,691	39,056
1845,	7,597	29,704

Taking the saving by conveyance of cattle on railways at 10 lb. per quarter, 2 lb. for sheep, and 5 lb. for swine; or 40 lb. per beast, 8 lb. for sheep, and 20 lb. for swine, the gross saving in 1846 will be—

On	370,000 cattle,	14,800,000 lb.
	1,250,000 sheep,	10,000 000
	850,000 swine,	17,000,000
	Total,	41,800,000 lb.

The gross saving of animal food on the cattle conveyed by railway in 1847 was as follows:—

On	500,000 cattle,	20,000,000 lb.
	2,000,000 sheep,	16,000,000
	390,000 swine,	7,800,000
	Total,	43,800,000 lb.

In the late report on Smithfield market, some evidence is given bearing on the question of the conveyance of cattle by railway:—

Mr. R. Healy said that there is a much greater quantity of dead meat brought to the London markets in consequence of railway communication. By means of the railways, great quantities of hind-quarters of mutton are sent up from the country, as the butchers there kill large quantities of sheep and sell the fore-quarters at home amongst the population there, and send the hind quarters by railway to London.

Mr. Langham, a butcher, said that country-killed meat is better than town-killed meat, and that it comes in excellent condition from Scotland. It is the general opinion of butchers that this is the case.

Mr. Hicks, the salesman, said that he has a very large quantity of meat sent up from the country by railway, and that it is not damaged by the journey even in hot weather. He has used the electric telegraph to obtain a supply of meat from the country. A communication was sent the same night by the country grazier that he would send up 600 or 700 stone of meat by the next morning's train. At 1 o'clock in the morning it started from Ipswich, and before 5 o'clock it was in his premises in Newgate market on sale, having been alive the day before. Mr. Hicks has sometimes 300 carcases on a Monday.

Mr. Langham likewise stated, that since the railways have been opened a country trade in meat has been growing up. Beasts have been sent from Smithfield to Liverpool, and he has seen immense quantities of meat going down to Birmingham. The south country also is supplied from the London market with beef—Brighton in particular. The Brighton butchers are frequently seen in Smithfield purchasing cattle, which they take down with them the same day. Sometimes as many as 300 or 400 beasts have gone down by the Birmingham railway on a Monday.

These facts will show the nature of cattle traffic on railways.

THE "WESTMINSTER REVIEW," No. XCVII.:

THE NEW HOUSES OF PARLIAMENT.

Although political topics and subjects of a grave utilitarian cast form the staple of this periodical, with only occasionally an article of a lighter cast, the "*Westminster*" has in its time, and especially under its present editor, contributed more largely to architectural information and criticism than either of its rivals. In fact, the "*Edinburgh*" has scarcely once, during the whole of its long career, touched upon aught connected with architecture. One prevalent fault in *Review* articles of the kind, is the dull and impertinent prosing with which they are eked out, in order to fill up a printed sheet, or as much more as may be the space allowed, although all that the writer has to communicate would perhaps occupy not more than a couple of pages. In the present instance, we have no such complaint to make: the writer comes at once to the point, and criticises in succession (besides the New Houses of Parliament) the New Treasury Buildings, Buckingham Palace as altered by Mr. Blore, the British Museum, and the Royal Exchange; and his remarks are upon the whole so good, as far as they go, although we do not subscribe our own opinion to every one of them, that we wish he had entered more into particulars with regard to the three last-mentioned structures. How they and the "Houses" themselves are spoken of, except as regards ability on the part of the writer, we have not yet said. With respect to the Palace, indeed, it may be taken for granted that his opinion is anything but favourable, that unhappy building being abandoned to universal derision; but the writer is severe upon the others also—and not least of all, or rather more especially so, upon the Houses of Parliament, which proves that he does not take his cue from the vulgar flatteries of the public press, heaped upon Mr. Barry and his "great work." In short, he expresses himself exceedingly dissatisfied with that edifice; nor is he by many the only one who is so, for even among our own acquaintance—those, too, whose judgment in matters of architecture is entitled to some deference—we have heard opinions equally strong in disfavour of it. One serious complaint alleged against it is, that however well the florid and exuberant embellishment bestowed on the river-front may shine or sound in description, or show itself in an elevation drawing, it is all but entirely lost in the building itself;—that there is abundant sculptural decoration of some sort or other may be seen, but it cannot be at all made out. The decoration is, besides, not only too minute, considering the vast extent of the river-front, and the distance of the nearest accessible point from which it can be seen by the public, but is also so profuse, as quite to destroy "repose." While this is to be regretted for artistic reasons, it is also to be condemned for financial ones; an immense expenditure having being incurred for mere ornament, to scarcely any purpose at all. Surely the water-side of the building might very properly have been made some degrees less ornate than the other fronts, and still have been sufficiently finished-up, and sufficiently dignified and imposing,—nay, even more effective in its *ensemble* than it now is. Hitherto, stingy parsimoniousness has been allowed to betray itself more or less in nearly all our public buildings, where the effect of what is perhaps a handsome façade in itself is sadly marred by the meanness of plain brick walls, shabby chimneys, and other eye-sores that come into sight in every angular view of the building,—as is most offensively the case in the new façade of the British Museum, notwithstanding that it is decked-out in Ionic pomp, or what is meant for such. In the Houses of Parliament, the architect has fallen into the contrary extreme of error; and anxious to avoid the reproach of parsimoniousness, has incurred that of extravagance.

Besides wasteful excess of decoration, the writer in the "*Westminster*" urges against the "Houses" what he considers two capital and now irremediable defects; one of them being the want of greater loftiness in the river-front, more especially as the situation itself is very low; the other, the position of the Victoria Tower. No doubt, when all the towers in the rear of the river-front shall come to be completed, and the sheds, coffer-dam and other obstructions are cleared away, some expression of loftiness, as well as variety of outline, will be imparted to the general *ensemble*; but then that will again be counteracted by the much greater loftiness and bulk of the Victoria Tower. If exigences of plan required that the royal entrance should be just at the south-west corner of the pile,—if it was impossible to bring in that entrance as the central feature of the west side—or perhaps the east one, by forming a commodious carriage approach to it along the terrace—there was at all events no imperious necessity for carrying up such an enormous tower over it as is now intended to be done. It is true, in many mediæval edifices which have grown up by degrees, and consist of parts added to the original plan at long intervals of time, very great incongruities and discordant contrasts may be found, and may be pleaded by some as sufficient *precedent*. But the "Houses" will have been erected from one comprehensive original plan, laid down by the architect from the very outset; and so far from aiming at variety and contrasts in his elevations, Mr. Barry has most studiously attended to perfect regularity of composition and uniformity of features,—at least, such is the case with regard to the river-front, which, although a secondary one in regard to its situation, will hardly be secondary in regard to display. Nevertheless, so lofty a structure raised at one corner of the general mass as the Victoria Tower will be, must inevitably show itself as a striking irregularity,—an architectural excrescence, and apparently an after-thought—at least to those who may not happen to know that it was so planned from the very first.

With regard to the river-front, the question now is: How can it be rendered accessible to the public, so that its elaborate ornamentation can be fairly seen and enjoyed? At no very great distance of time, perhaps, and owing to the very insecure condition in which it now is, Westminster Bridge will be taken down, and either considerably lowered or rebuilt further off from the Houses of Parliament; in which case, Bridge-street will be converted into a *cul-de-sac*, similarly to the streets which run from the south-side of the Strand down to the river; consequently, the "Houses" will no longer be looked down upon from the bridge—but then how is their river-front to be looked at at all, except from a boat on the river itself? The only way of enabling the public to contemplate that façade, will be to form a second terrace or quay for foot passengers, advanced about fifty feet into the river, and perhaps about a couple of feet lower than the terrace between the advanced extremities of the building itself. Unless something of that kind were to be done, quite as much would be lost as gained by the removal of the present bridge; to say nothing of the great inconvenience attending the disturbing such a long-established line of communication and traffic.

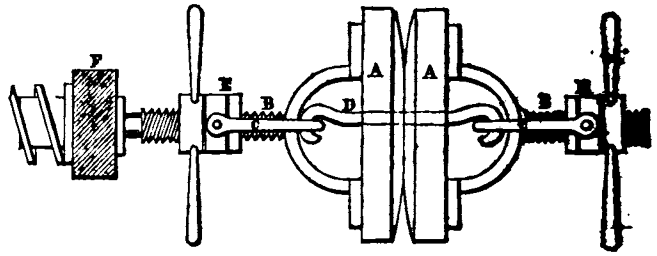
That we agree with the *Westminster*" in much or most of what it says, both in regard to the Houses of Parliament and the other structures which it notices, we freely admit. And it is pleasant to us to find opinions that are upon the whole in accordance with our own entertained by others. Speaking of Buckingham Palace, the "*Westminster*" observes that the Marble Arch "might have been advantageously incorporated with the design by an artist of resource and genius;" and again, of the British Museum, that the central portico or octastyle ought to have been loftier than the other colonnades, both which ideas have been brought forward in sketches in this very *Journal*. Although we should not have been displeased at his noticing that circumstance, supposing him to have been aware of it, we do not accuse the writer of making use of "our thunder;" on the contrary, we are right glad to meet with the coincidence of opinion, and to find that we are not altogethe solitary in our own. Here we will conclude, by earnestly recommending a perusal of the article in the "*Westminster*" to our readers. It certainly bears rather severely upon Mr. Barry, but he, if any one at all, can very well bear on his part to hear unpalatable truths. Of flattery and adulation he gets enough, or more than enough—more than may be altogether wholesome for him. An occasional draught of "bitters" will therefore do him no harm.

REGISTER OF NEW PATENTS.

RAILWAY LOCOMOTION.

Richard Wrighton, of Lower Brook-street, Grosvenor-square, for "*Improvements in apparatus to be applied to railway carriages and engines.*"—Granted December 22, 1847; Enrolled June 22, 1848.

The apparatus consists of five distinct applications to railway carriages and engines for different purposes. The first part consists in the construction of apparatus attached to the breaks of railway carriages; the actuating force upon the breaks being that of steam. The patentee claims under this head of his specification, the combination and arrangement of apparatus, whereby the piston of a steam-cylinder may be made to act upon central traction-rods or shafts, for the purpose of working the breaks of carriages and causing them to act simultaneously upon the wheels throughout the whole train; also the construction of box-coupling for connecting the shafts, and the power to the breaks.—The second improvement consists in the employment, in railway carriages, of one central buffer in lieu of the two side ones, as hitherto used; this the patentee constructs in combination with the draw-link. The annexed diagram represents this arrangement. A, A, are the buffer-plates of adjoining carriages; they are attached to



the buffer-rods B, B, the ends of which are made of the looped form shown, for the purpose of admitting the loop of the connecting-links C, C. The buffer-plates A, A, are made with holes through their centres, through which are passed the double-ended hooks D, when the carriages are required to be connected, which are hooked to the links C, C, upon the buffer-rods B, B. Immediately behind the loop are cut threads, upon which work the nuts, E, E, upon which are loose collars, that do not revolve with the nuts. To the loose collars are attached by studs the links C, C; When it is required to connect two carriages, the buffer-plates are brought together, the two nuts are turned up to the looped ends of the buffer-rods, and the double hook inserted and hooked on to the links; the nuts are then to be turned back until the links and the hooks become tight. Instead of passing the traction-rods entirely through the carriage as hitherto, the patentee passes the rod B, only through the end-frames F, F, of the carriage, where the helical spring G, is placed upon the rods, and acts as the buffing-spring.—The patentee claims as his third improvement, the employment of helical springs or other elastic substance, in combination with adjusting-screws, for making the couplings of railway carriages; also the combination of a double-joint with the adjusting-screws.—The patentee's fourth improvement consists in constructing the axle-box and the axle in such manner that the lubricating material employed shall be retained in contact with the journal and the bearing, and thereby prevent a considerable portion of the waste which has hitherto taken place with axle-boxes as usually constructed. He constructs the axle of one piece or of two pieces, as in the usual way; the brass forming the bearing is properly fitted in, and the end of the axle is inserted into the axle-box from the back; the axle inside against the journal is turned with a flat or taper shoulder, against which is fitted and placed a metal ring; between the ring and the back of the axle-box is inserted a ring of vulcanized india-rubber, or other similar substance, thereby preventing the escape from the axle-box of any considerable portion of the lubricating material employed.—The fifth improvement consists of a means of enabling any of the passengers in railway carriages of a train to signal and communicate with the engine-driver or guard, by the aid of electricity. To the middle partition of each railway carriage, near the roof, is fixed a small voltaic battery, by means of which the passengers are enabled to bring into action an electro-magnet, that explodes a percussion-cap or rings a bell.

COKE OVENS.

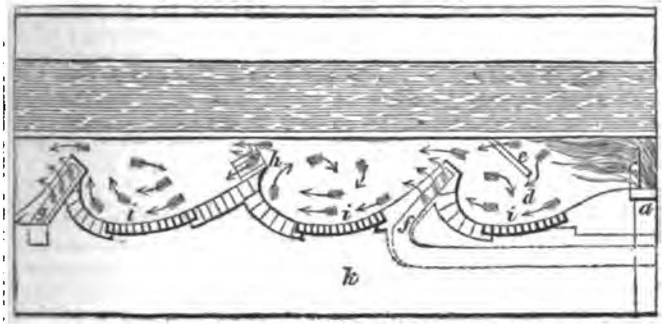
George Ambroise Michaut, of Epieds, France, for "*Improvements in the production and application of heat, and in the manufacture of coke.*"—Granted December 15, 1847; Enrolled June 15, 1848.

The application of the heat evolved during the formation of coke is the object of this invention. Several ovens are combined together, which are provided with fire-bars that occupy only a small portion of the area of the bottom. The ovens are separated from each other by partitions, and in the upper parts there are openings to permit the flame and products of combustion to pass from one oven to another; and there are openings in the top of each oven, through which the flame and heated gases ascend, in order to heat gas-retorts, lime-kilns, steam or other boilers, or other apparatus, situated above the coke-ovens. The patentee states, that by means of this invention the heat may be more advantageously obtained and applied than before. When the ovens are at work, the charges of coal are introduced in succession, in such manner that the charge in two out of three may be in a high state of ignition when fresh coal is put into the other. The operator will know when to withdraw a charge, by the flame ceasing on the surface; as soon as this is the case, the charge is to be withdrawn and cooled with water; a fresh charge of coal is then to be put into the oven, and, the fire-door being closed, the charge will soon be ignited by the heat of that oven and the flame from the other ovens. The ash-pit doors are to be kept closed at all times, except it be found requisite to introduce air to expedite combustion; and the ash-pit door of the oven, into which the air is to be admitted, is opened.

STEAM-BOILER FURNACES.

Henry F. Baker, of Boston, United States of America, for a "*certain new and useful improvement in steam-boiler furnaces.*"—Granted December 22, 1847; Enrolled June 22, 1848.

The annexed diagram represents a longitudinal vertical section of the furnace, as applied to the cylindrical boiler of a high-pressure engine. The fire-box *a*, is placed at one end of the boiler. At the end of the fire-bars there is placed a vertical grate *c*, which reaches nearly to the bottom of the boiler, for the purpose



of preventing ashes from being carried into the reverberatory chambers; in the addition of which, the peculiarity of the invention consists. The bottoms of these chambers are placed below the level of the fire-bars, and the number of them may be four or more as required. They are of a parabolic form, for giving a revolving motion to the gases and other inflammable matters, thereby retaining them till consumed; *e* is a plate of iron placed in an inclined position, whereby it receives the direct force of the entire flame from the furnace, part of which is deflected against the bottom of the boiler, while the remainder is turned downwards, and caused to circulate in the chamber below. Openings are left at the upper part of the plate *e*, between it and the bottom of the boiler, which allows the flame to pass along; *f* and *g* are air-channels, for the admission of atmospheric air or oxygen, in order to ensure the perfect combustion of the gases. These channels are carried into the brickwork at the side of the boiler, through which they may be conducted, and furnished with valves, if necessary, for regulating the quantity of air; *h*, *h*, are curved plates, which extend across the furnace, the openings in which are so arranged that, while part of the heat and flame passes along immediately in contact with the boiler, part also is deflected against the bottom of the boiler, and the remainder is directed down into the hollow bottoms of the reverberatory chambers. Gratings *i*, *i*, *i*, are placed in the bottom of each of the reverberatory chambers, to allow any small particles of incombustible material to escape, that may be carried over by the draught. These gratings open into a pit *k*, below, which must be kept closed. The fire having been ignited, the flame and gases evolved will be carried over and through the vertical bars *c*, and will come in contact with the plate *e*, by which they will be deflected against the boiler, and also turned downwards into the hollow bottom of the first chamber *d*, causing them to revolve and be retained a short time, to further the combustion. They then pass over the upper part of the air-distributing box, on the further side of which are numbers of small openings, whence the atmospheric air issues, as indicated by the arrows, the current of air or oxygen causing the unconsumed volatile product to be converted into flame, which, by the force of the current, impinges on the bottom of the boiler. The gases are also in this next chamber caused to revolve by the curved shape; and they are disturbed by the plate *h*, in the next chamber, where they are again retained a short time, the revolving in these chambers causing the heated particles to be brought in contact with the boiler, the last reverberatory chamber being also furnished with an air-distributing box *g*, which is supplied by channels through the brickwork. From the fourth chamber the incombustible product is conducted by a flue at the bottom of the boiler to the chimney.

AXLE GUARDS AND BUFFERS.

Charles de Bergue, of Arthur-street West, City, engineer, for "*Improvements in carriages used on railways.*"—Granted January 5; Enrolled July 5, 1848.

These improvements in railway carriages relate only to the axle-guards and boxes, and to buffers. The patentee constructs his axle-guards in such a manner, that a wooden surface shall be presented as a guard for the axle-box (which is of cast-iron) to rub against. For this purpose he secures two uprights to the main framing of the carriage, at a distance from each other suitable for receiving the axle-box, which has a flange, its whole depth on each side embracing both sides of the uprights. These wood uprights forming the guard, are strengthened by plates of iron, placed on each side, the width of such plates being less by the breadth of flange on the axle-box, than the wood against which they are bolted; thus the face of the axle-box slides flush with the face of the axle-guard. The upper parts of these plates are carried up the side of the frame, to which they are secured. The springs are of the kind previously patented, and consist of a series of india-rubber rings, separated by plates of metal. This spring is placed between the uprights of the axle-guard, the bottom plate being supported by a vertical rod resting in a step on the axle-box, immediately above the centre of the bearing, being within the grease-box, which forms part of, and is cast in one piece with, the axle-box. The wood faces of the axle-guards and the chase in the sides of the axle-boxes must be rendered particularly smooth, in order to prevent abrasion of the surface of the wood. The second improvement consists of a mode of making the conical centres of plates used for separating the rings of india-rubber in the buffer and other springs. In making these plates the patentee forms a thin disc of metal of the required diameter, having a hole in the centre larger than is necessary, to go over the buffer-rod; he then incloses this plate in a suitable mould, in which is poured a quantity of soft metal, such as zinc and tin, in order to form the conical centre of such separating-plates. The soft metal mould, being larger in diameter than the hole in the centre of the plate, it consequently becomes securely imbedded in the soft metal centre, which is cast with an opening suitable to receive the buffer-rod or other spindle, according to the purpose it may be intended for. The third part of this invention relates to what the patentee denominates a long-range buffing apparatus, which is applied to a van or truck placed between the engine and tender and the train of carriages, in order to protect the train as much as possible from violent concussion. The range of resistance in this apparatus is to the extent of several yards, and, unlike other buffers, it is not attended by any recoil. The resistance is produced by the friction of straps passing over a drum, which straps are so arranged in connection with levers and a train of wheels, that as the force of the collision increases, the straps are tightened and the resistance is augmented.

SCREW PROPELLERS AND PUMPS.

Edward Humphreys, of Holland-street, Surrey, engineer, for "*certain improvements in steam-engines, and in engines or apparatus for raising, exhausting, and forcing liquids.*"—Granted January 4; Enrolled July 4, 1848.

The improvements in steam-engines have reference solely to the mode of driving the screw propellers of steam-boats. The apparatus and the driving multiple wheels are so arranged, that the cranks usually employed are dispensed with, the place being supplied by the driving spur-wheels themselves. The pins to which the connecting-rods are attached, and which have hitherto been fixed to the cranks upon the ends of the shaft, are, by the patentee's arrangement, now fixed to the bosses of the driving-wheels, which take the places of the cranks. The second part of the invention consists in the construction of the valves for pumps for raising or lifting or forcing water, as applied to an air-pump. The patentee proposes to form the passages through the bucket, radiating from the centre; the passages being in pairs, having a thin partition of metal between them, each pair of the passages being covered by a valve, which is composed of a thin piece of steel or other flexible metal, one end of which is firmly secured to the inner part of the bucket, while the other part rises from its seat, when required to allow the flow of water. The patentee claims in respect to the first part of his invention—First, the placing the direct-acting marine steam-engines between a line drawn through the centre of the piston-rod, and a parallel line drawn through the adjoining bearing, or in the spaces usually occupied by the crank in ordinary engines; also the connecting the piston-rods to the driving-wheels, without the aid of cranks.

LAP-WELDED IRON TUBES.

Job Cutler, of Birmingham, civil engineer, for "*certain improvements in welded iron pipes or tubes to be used as the flues of steam-boilers.*"—Granted January 13; Enrolled July 13, 1848.

The object of the patentee is to produce lap-welded iron tubes or pipes, so formed as to give increased strength to those parts which are exposed to wear, without additional weight to the entire length of the tube, and thereby to obviate the evils to which boiler tubes are at present exposed. He makes the internal diameter of the tube greater at one end than at the other, instead of its being the same, or uniform throughout, as has hitherto been the case; the external diameter remaining, however, the same, and uniform throughout the entire length of the tube. The tube will, of course, be cylindrical upon the exterior, and conical upon the interior surface. The increased thickness of metal at the one end is to be drawn from the remaining portion of the entire length of the tube. And further, the operation is effected at one heat, so that the ductility of the iron of which the tubes are composed shall remain unimpaired.

The *modus operandi* is as follows:—The patentee employs a series of grooved rolls, moved by suitable toothed wheels and a mandril, with a conical bulb or head, the stem of which is of increasing diameter towards the opposite end. The skelp, after being properly prepared, as is usual in the manufacture of lap-welded iron tubes, is heated and passed between the first of the series of rolls. It is then welded over the conical bulb, and forced, at the same time, over the stem of the mandril. This mandril is held by a grip, attached by a hinge thereto in a stop, so as to allow of its being lowered and passed, after the conical bulb has been removed between the second series of rolls, the diameter of the groove of which is smaller than that of the first series. The tube, with the mandril still inside, is then passed through the third series of rolls, the groove of which is smaller than that of the second series. The object of these successive rollings, after the skelp has been welded on the mandril, is to remove any irregularities upon either of the surfaces, and to make the edges of the tube perfectly smooth and uniform. The tube is then taken to the drawing bench, in front of which is a stop, and against which the pipe rests. The stop is furnished with a hole to allow of the passage of the grip of the mandril, which is held by a pair of pliers; and, the bench being made to move while the pipe remains stationary, the mandril is withdrawn. When it happens that the mandril adheres too tightly to the tube, it is proposed to heat it in a muffle or furnace, then to cool the end which rests against the stop, and repeat the above operation, or to roll it cold between three rollers, as is usually done in straightening shafting.

ATMOSPHERIC RAILWAY.

William Froude, of Darlington, Devon, civil engineer, for "*Improvements in the valves used in closing the tubes of atmospheric railways.*"—Granted January 5; Enrolled July 5, 1848.

The material which is employed in this invention for closing the slit in the tube, is vulcanized india-rubber; and the advantage proposed to be gained is the dispensing with any unctious substance for keeping the valve air-tight. Flat valve-seats are formed on each side of the slit, both of which are bounded by vertical flanges; the right-angles formed by the vertical flanges and the valve-seats, being rounded off, and the valve-seats slightly recessed by shallow circular recesses, which thereby form the hinges or centres of motion of the valves. There are two valves employed, the lower portion is composed of plates of iron, of about eight inches in length each plate, the shape of the lower surface of which agrees in contour with the seat upon which it is placed; the one edge of the plates forming, with the shallow circular recess in the seat, the hinge or centre of motion. The other edge of the plates is nearly over the centre of the line of opening, thereby nearly meeting the edge of the opposite plate upon the other valve-seat. The under side of the plates over the aperture, is formed of the same curvature as the inside of the tube. The upper surfaces of these plates are flat, except that part over the aperture immediately adjoining the edge, where it is lower than the part over the seat. Upon these plates are placed a continued sheet of vulcanized india-rubber which extends from beyond the centre of the line of opening or aperture over the whole surface of the plates up the inner side, and also on the top of the vertical flange. The portion of the vulcanized india-rubber sheets which are over the line of opening, are increased in thickness and fill the whole of the depressed part of the plates, thereby forming at that part a thick pad. The upper surface of the vulcanized india-rubber is covered with canvas. Above the vulcanized india-rubber sheets are placed flat plates of iron, of similar length to those beneath and lying over them; they are securely rivetted together, thereby holding firmly between them the vulcanized india-rubber. The vulcanized india-rubber is secured to the side and top of the vertical flange by means of a series of iron bars, which are bolted to the flange, and which are to be about 15 feet long, which secures that edge of the valve air-tight, or nearly so. When the valves are firmly pressed upon their seats, the edges of the vulcanized india-rubber pads in contact are below a line drawn between the centres of motion of the two valves, whereby the tendency of the elasticity of the pads will be to further press the valves upon the seat instead of raising them therefrom. The patentee proposes to employ, for the purpose of opening the valves for the passage of the bar connecting the piston apparatus with the carriages, a series of not less than five wheels placed in advance of the connecting-bar; the first of these wheels being placed at about nine feet before the bar, and the other at intervals of about two feet from centre to centre. After the passing of the connecting-arm, the valves are lowered and closed over the opening by a wheel attached to the upper part of the connecting-bar, or to the carriage, in such manner as to run over the valves, and thereby press them down upon their seats, where they are securely retained, and effect an air-tight, or nearly air-tight, joint.

MINING APPARATUS.

Pierre Augustus Puis, of Paris, for "*Improvements in apparatus for raising and lowering heavy bodies in mines.*"—Granted December 22, 1847; Enrolled June 22, 1848.

The principal feature in this invention is the application of atmospheric pressure to the raising of weights, and to the draining of mines. The first plan by which the patentee proposes to raise bodies is by having a vertical air-tight tube in which there is a solid piston, to the under part of which the weights to be raised are to be attached; and the upper part of the tube being exhausted, the atmospheric pressure below will force up the piston and its load. In the drawings attached to the specification, two pistons are represented, the one following the other in the ascent. When the upper one reaches the top it is relieved of its load by means of a slide, which passes in below it, cutting off communication with the rest of the tube, and the weight is removed by a door in the side of the tube; the upper piston is then carried by exhaustion in a continuation of the tube above the shaft. The next one is then brought up and unloaded in a similar manner. The bottom of the tube is closed after the weights are introduced, the air being admitted by a small tube proceeding from the top of the mine, by which the admission of the air to the underside of the pistons is regulated. In another method of applying the atmospheric tube, instead of raising the weights within the tube, they are elevated on the outside, by means of arms projecting through a continuous slit. For the purpose of raising water in mines, the apparatus consists of a series of air-cylinders, which are placed at regular intervals down the shaft. Each of these is in communication with an exhaust tube. The lower pump draws the first lift by suction, the water then passes through the bucket, and is forced up a step higher to a small reservoir placed for the purpose. The next pump above repeats the operation, drawing the water from the reservoir, to which it has been previously raised by the pump below, and so on till the water arrives at the top. The action of the pumps is produced by alternately exhausting and admitting the air from, and to, the cylinders, on the upper side of the pistons. Another part of this invention relates to the raising weights in mines by a series of vertical rods, which are attached to each other, forming one continuous rod to the bottom of the pit. Two of these combined rods are placed side by side, and suspended at the top by two chains, attached to, and passing round, wheels supported over the mouth of the shaft. These wheels have a semi-rotary movement imparted to them from a steam-engine, by which means a continual reciprocating motion of the two rods is kept up. Hooks or notches are formed on the vertical rods at regular distances, corresponding with the height the rod is lifted at each movement. Each bucket to be raised by these rods is furnished with two spring-hooks, which take into the notches on the rods and suspend them while ascending; the bucket being suspended from the lowest notch, is elevated by the first movement, till the spring-hook slips into the second notch on the other rod. The rod by which it has been previously lifted, descends, thereby transferring the whole weight to the other rod, which immediately raises it another step, the changes being performed alternately in this way until the bucket reaches the top.

STEAM-ENGINES.

Charles William Siemens, of Manchester, for "*Improvements in engines to be worked by steam and other fluids.*"—Granted December 22, 1847; Enrolled June 22, 1848.

The chief object of this invention is the saving of fuel by a means proposed for regenerating the steam and for condensing it by successive exposures to water of different temperatures. There is no regular boiler employed, but the steam is generated in the first instance in a small flat chamber, placed close to the cylinder; the direct action of the fire being against a cast-iron chamber containing the bottom of the cylinder, and having considerable space between the two, which is filled with lead. The flues are continued twice round the cylinder, and then carried under the steam-generating chamber. The cylinder is fitted with a jacket, through which the steam has access to both sides of the piston, the area of the upper side of which being diminished one-half by a trunk which works through a stuffing-box in the top, and admits of the connecting-rod passing down to the piston, the difference of the area causing the piston to ascend. The steam having been thus admitted to the cylinder, is suffered to escape by a series of double-beat valves, which are lifted by a series of cams on the main shaft; the steam is thus admitted successively into eight different regenerating-chambers, which are placed immediately under the generator. The steam, as admitted to the upper chamber, will be of the greatest pressure, and the valve is suffered to remain open a very short time, the next in succession opening immediately, the duration of which will be somewhat longer, which goes on increasing, the pressure of the steam being also gradually reduced; the ninth valve opens to the atmosphere or to the condenser, and remains open till the engine is past the centre. These several chambers are each fitted with shallow horizontal trays, into which water escapes from the generator above, passing from one to the other. The heat thus communicated to these chambers regenerates the steam, which is again admitted to the same cylinder, or to another cylinder, should it be a double-cylinder engine, by the same set of valves, which are opened by another set of cams on the opposite side of the shaft, in the inverse order to that before explained, the lowest pressure being allowed to act first. The heat communicated by the fire to the cylinder also assists in the regeneration of the steam. The next part of the invention relates to the condensation of steam in ordinary condensing-engines. The condenser is subdivided by horizontal partitions, into four or five separate compartments, the steam being admitted by a cock having a hollow plug, which is opened to the cylinders. This plug opening to the separate compartments of the condenser in succession, beginning at the lowest, the injection water is admitted to the uppermost, where it completes the condensation of the steam, and from which the air-pump exhausts a portion of the injection; and the condensed water instead of being carried off by the air-pump, is received between two pistons working in a barrel between the upper and second chamber, by reason of the upper piston being above the top of the cylinder or barrel. This water is by the down stroke of the air-pump admitted to the chamber immediately below the injection chamber, and in which a portion of the steam is suffered to escape. Each of the partitions is fitted with similar apparatus for transmitting the condensed water from one chamber to the other, till it reaches the lowest, where the steam is first admitted. A portion of the steam on entering that chamber will be condensed by the water, and after having passed through all the separate chambers, and having the heat derived from several successive charges of steam from the cylinder, it will have attained a great heat, and may be introduced to the boiler. The quantity of water required for injection will thus be materially reduced, and may render it applicable to locomotives for condensing the atmosphere of the steam which remains in the cylinder after its high-pressure effect is spent through the blast-pipe in the chimney. The last part of the invention relates to an improvement in the chronometric governor, patented by Mr. Siemens, in December, 1845. The improvement consists in the adaptation of an expanding fly-wheel to the governor, instead of the pendulum-ball with which it was originally constructed. This fly-wheel is formed in four segments, and by centrifugal action they are caused to expand or recede from the centre. When any excess of the centrifugal force takes place, by reason of the increased velocity, bell-crank levers are actuated by the segments, so as to force a conical friction-break against a cone fixed to the frame-work. The friction caused by this break tends to retard the velocity of the shaft and segments, and the power which is exerted to drive the shaft being constant and independent of the velocity of the prime mover, limits the velocity of the expanding-wheel, causing nearly a uniformity of motion, if sufficient power be at all times transmitted to the shaft.

REPLY TO THE REVIEW OF DR. GREGORY'S "MATHEMATICS FOR PRACTICAL MEN."

Sir—In the criticism upon the new edition of Dr. Gregory's "Mathematics for Practical Men," which appeared in the last number of your *Journal*, the writer has in such positive terms denounced as incorrect certain portions of that work, involving principles not however peculiar to itself, but which have originated with, or been demonstrated by, all the principal mathematical writers, that I think myself called upon to offer the following remarks, to prevent your readers being misled upon the subject.

Your reviewer commences his criticism by expressing his surprise at my using the words *cycloid* and *trochoid* synonymously; I am not, however, the only person who has done so, for

Dr. Hutton says: "Trochoid is the same curve as what is more usually called the cycloid."[1]

Professor Barlow says: "Trochoid is the same as cycloid, that term being derived in a similar manner from χυχλος, a *circle*. It is, however, by *some* authors, used to denote exclusively the prolate cycloid."[2]

Your reviewer then proceeds to find fault with my definition of an epicycloid, which is as follows:—

"If the generating circle, instead of rolling along a straight line, is made to roll upon the circumference of another circle, the curve described by any point in its circumference is called an *epicycloid*." p. 179. Dr. Hutton says: "But if, instead of the right line, the circle roll along the circumference of another circle, *either equal to the former or not*, then the curve described by any point in its circumference is what is called the *epicycloid*."[3]	Your reviewer says: "It is *not* called an epicycloid, except when the generating circle is equal to the fixed circle, and rolls on the exterior of it."

Now, Professor Barlow[4] gives the properties of epicycloids when the generating and quiescent circles are not *commensurable*, which they always would be if equal and Dr. Young,[5] in an "Essay on Cycloids" (the attentive perusal of which I would recommend to your reviewer), speaks of epicycloids in which, while one circle remains constant, the other becomes either infinite or evanescent. If, then, your reviewer is *right*, it follows that Dr. Hutton, Professor Barlow, Dr. Young, and many others (whom I have not space to quote), are *wrong*.

He then goes on to say, that I have aggravated the mistake "by representing the rolling curve as much *larger* than the fixed curve," whereas it is really much *smaller* in both my figures (157 and 158); from which it is very evident that he has mistaken the fixed for the rolling circle.

Your reviewer next finds fault with one of my definitions, as being "clumsy and incomplete, at the least;" and asks, "What will our mathematical readers say of such a definition?" Now, one of our most justly-esteemed mechanical writers, Professor Moseley, has given a definition so precisely synonymous, that I transcribe both his and my own for the purpose of comparison:—

Professor Moseley's Definition.	*Definition Criticised.*
"When more forces than one are applied to a body, and their respective tendencies to communicate motion to it *counteract one another, so that the body remains at rest*, these forces are said to be in *equilibrium*, and are then called pressures."[6]	"When the forces that act upon a body, *destroy or annihilate each other's operation, so that the body remains quiescent*, they are said to be in *equilibrium*, and are then called *pressures*." p. 187.

Your reviewer objects to the sense in which I here use the word

[1] Phil. and Math. Dictionary, vol. 2 p. 541.
[2] New Math. and Phil. Dictionary,—Art. "Trochoid."
[3] Phil. and Math. Dictionary, vol. 1, p. 475.
[4] New Math. and Phil. Dictionary,—Art. "Epicycloid."
[5] A course of Lectures on Nat. Phil., vol. 2, p. 556.
[6] Mechanical Principles of Engineering and Arch., p. 1.

"*pressures*;" for which, however, in addition to that of Professor Moseley, I have the authority of Dr. Whewell,[7] who says, "*Statical* forces are called *pressures*;" and Dr. Young,[8] who says, "A *pressure* is a force *counteracted by another force, so that no motion is produced.*" If, then, your reviewer is *correct*, it follows that Professor Moseley, Dr. Whewell, and Dr. Young are *wrong*.

Your reviewer next takes up the subject of *vis viva*, on which I say,—

"*Vis viva*, or living force, a term *used by Leibnitz* to denote the *force* or power of a body in motion; or the force which would be required to bring it to a state of rest." p. 108

Professor Barlow says: "*Vis viva*, or living force, is *used by the same author* [Leibnitz] to denote the *force* or power of a body in motion."[9]

Dr. Hutton says: "*Vis mortua*, and *Vis viva*, are terms *used by Leibnitz* and his followers for *force*; understanding by the latter, that *force* or power of acting which resides in a body in motion."[10]

Notwithstanding, however, the united testimony of Professor Barlow, Dr. Gregory, and Dr. Hutton, that Leibnitz used the term *vis viva* as here stated, your reviewer is perfectly sceptical upon the point, and boldly asserts "that Leibnitz never did anything *half so absurd* as is here said of him;" that he did do so, is however a matter of *fact*, for here are his own words:—

"Hinc *Vis* quoque duplex: alia elementaris, quio et *mortuam* apello, quia in ea nondum existit motus, sed tantùm sollicitatis ad motum, qualis est globi in tubo, aut lapidis in funda, etiam dum adhuc vinculo tenetur; alia verò vis ordinaria est, cum motn actuali conjuncta, quam voco *vivam*. Et vis mortuæ quidem exemplum est ipsa vis centrifuga, itemque vis gravitatis, seu centripeta; vis etiam qua elastrum tensum se restitnere incipit. Sed in percussione, quæ nascitur a gravi jam aliquamdiu cadente, aut ab arcu se aliquamdiu restituente, aut a simili causa vis est viva, ex infinitis vis mortuæ impressionibus continuatis nata. Et hoc est quod *Galilæus* voluit, cum ænigmatica loqnendi ratione percussionis vim infinitam dixit, scilicit, si cum simplice gravitatis nisu comparetur. Etsi autem impetus cum vi viva semper sit conjunctus, differre tamen hœc duo, infra ostendetur."[11]

Not content, however, with denying that Leibnitz said that, which his own works prove that he did say, your reviewer denies that *vis viva* is a force at all, and says that it is a mere technical term; Dr. Whewell,[12] however, says, "The *vis viva* of a body in motion *is a force*;" and Professor Moseley,[13] "That the difference between the aggregate work of the accelerating *forces* of the system, and that of the *retarding forces*, is equal to one-half the *vis viva* accumulated or lost in the system." Therefore, either your reviewer is wrong, or else both Dr. Whewell and Professor Moseley.

He next states that, "in the second problem of the chapter on Statics, the calculation respecting the strain on tie-beams and struts is totally erroneous;" to which I answer that the calculation *is correct*, and that your reviewer *is wrong*; as he will find if he refers either to Tredgold,[14] Dr. Whewell,[15] Professor Moseley,[16] or Professor Wallace,[17] *(who quotes from Dr. Gregory the very problem denounced as incorrect)*.

Your reviewer then extracts the following proposition relating to the centre of gravity:—

"If the particles or bodies of any system be moving uniformly and rectilineally, with any velocities and directions whatever, the centre of gravity is either at rest, or moves uniformly in a right line" p. 193

Emerson says: "If two or more bodies move uniformly in any given directions, their common centre of gravity will either be at rest, or move uniformly in a right line."[18]

Dr. Whewell says: "If there be several bodies, which either all attract and are attracted by a single body, or all attract each other, these also will move in such a manner that the common centre of gravity will either remain at rest, or move uniformly in a straight line."[19]

Your reviewer merely says: "This is not true."

He then asks a question; "Does the author mean to assert, that if two bodies be moving with different [uniform] velocities in straight lines perpendicular to each other, the common centre of gravity moves in a straight line?" To which I answer very decidedly, "Yes, I do; and if you are at all sceptical upon the point, if you refer to Emerson's 'Principles of Mechanics,' p. 67, you will find the truth of my answer *demonstrated*."

The next objection of your reviewer is to my use of the term, line of rupture; which, however, I prefer to apply to the actual case of rupture of the ground, which takes place when the wall falls, and which is then obviously the same as the *natural slope*: the line determining the wedge of maximum pressure is only an imaginary line, and not that on which the ground would really separate.

Your reviewer has quite misunderstood Dr. Gregory, when he asserts, that the conditions upon which he examines the stability of an arch, are "that there are only two joints of rupture, equidistant from the crown, the loading symmetrical, and the piers incapable of sliding," no such conditions being assumed, or indeed necessary.

The next paragraph of your reviewer requires no comment from me; the obvious mis-quotation of my words does as much violence to common-sense and grammatical construction, as it exhibits the desire to pervert the meaning of what I actually say.

He then states that I have given certain experiments (which he extracts) "as the foundation of dynamics" and "in place of an enunciation of the three laws of motion," *which is not the fact:* I have merely employed them to illustrate the necessity of regarding time in estimating the forces of moving bodies: see Atwood,[20] Barlow,[21] and Hutton.[22]

Your reviewer next finds fault with my using the expression, "Each particle of matter *resists motion*; is he aware that Dr. Whewell[23] repeatedly uses a similar expression—"the inertia of the particles to *resist the communication of motion*;" and that M. Poncelet, in the introduction to his *Mécanique Industrielle*, has revived the term *vis inertiæ*, and has associated with it the definitive idea "of a force of resistance opposed to the acceleration or the retardation of a body's motion."

Your reviewer next takes objection to the assertion, that (neglecting the effects of friction) if a body suspended from a fixed point by a flexible string, have its path altered by a projecting pin, it will rise to the same height as it would have done if not so interfered with; Dr. Young, however, speaking on this subject says: "We may alter the form of the path in which it descends, by placing pins at different points, so as to interfere with the thread that supports the ball, and to form in succession temporary centres of motion; *and we shall find in all cases, that the body ascends to a height equal to that from which it descended, with a small deduction on account of friction.*"[24]

After stating that Dr. Gregory's definition of the centre of gyration is "confused and inaccurate," although identical (as he will find by reference) with that given by Dr. Hutton,[25] by Emerson,[26] and by Professor Barlow,[27] he proceeds to show by reference *to the "fable of the wolf and the lamb,"* that one of the propositions relating to the centre of gyration cannot be correct, and arrives at the *certain* conclusion that the author (as also Emerson, from whom the same proposition is taken) did not clearly understand the subject on which he wrote:—

Emerson's Proposition.	*Proposition Criticised.*
"If the matter of any gyrating body were actually to be placed in its centre of gyration, it ought either to be disposed of in the circumference of a circle, whose radius is S O, or else into two points, diametrically opposite, equal and equidistant from S."[28]	"If the matter in any gyrating body were actually to be placed as if in the centre of gyration, it ought either to be disposed in the circumference of a circle whose radius is R, or at two points R, R,' diametrically opposite, and each at the distance R from the centre." p. 230.

Your reviewer next informs us that centrifugal force is not always "directed towards a fixed centre," in which I perfectly agree with him, and am not aware that any person has stated the contrary.

He then points out an error of Dr. Gregory's, relating to fly-wheels, which had escaped my observation, and one of my own, in equation (I) page 373, which should read $\frac{1}{4}LP_s = E(\delta + \Delta)$; but which fortunately does not affect any other part of the subject. He then states that the total forces of longitudinal compression and tension are equal and opposite; this is, however, only the case when the applied forces are perpendicular to the beam, for when

7 Elementary Treatise on Mechanics, p. 6.
8 A course of Lectures on Nat. Phil., vol. 2, p. 37.
9 New Math. and Phil. Dictionary,—Art. "Vis."
10 Phil. and Math. Dictionary, vol. 2, p. 568.
11 G. G. Leibnitzii, Opera Omnia, tom. 3, p. 318.
12 Mechanics of Engineering, p. 132.
13 Mech. Prin. of Engineering and Arch., p. 133.
14 Elementary Principles of Carpentry. p. 9.
15 Elementary Treatise on Mechanics., p. 34.
16 Mech Prin. of Engineering and Arch., p. 494.
17 Practical Engineer's Pocket Guide, p. 17.
18 Princ'ples of Mechanics, p. 66.
19 On the Free Motion of Points, p. 96.

20 A Treatise on the Rectilinear Motion and Rotation of Bodies, p. 35.
21 New Math. and Phil. Dictionary,—Art. "Force."
22 Phil. and Math. Dictionary, vol. 1, p. 535.
23 Mechanics of Engineering, p. 133.
24 A course of Lectures on Nat. Phil., vol. 1, p. 43.
25 Phil. and Math. Dictionary, vol. 1, p. 297.
26 Principles of Mechanics. p. 81.
27 New Math. and Phil. Dictionary,—Art. "Centre of Gyration;" and Encyclopædia Met.,—Art. "Mechanics," vol. 3, p. 134.
28 Principles of Mechanics, p. 83.

inclined at any angle, Professor Moseley has shown that the *difference* of the forces of compression and tension is equal to the resultant of the applied forces multiplied by the sine of the angle which it makes with the normal to the neutral line at the point of rupture.[29]

In conclusion, if your reviewer is right, it follows that Dr. Hutton, Dr. Young, Professor Barlow, Dr. Whewell, Professor Moseley, Professor Wallace, Emerson, and Tredgold, one and all of them, *must be wrong;* but I think that any reasoning man will require something more, to convince him that the *laboured demonstration* of these men, who have hitherto justly been regarded as high authorities on the subject, are false, than the mere *denial* of an individual writer. Considering, then, with whom it is that your reviewer is at issue,—not with Dr. Gregory and me, but with all the first mechanical and mathematical writers who have lived,—would it not have been wiser, had he assumed a little less positive tone in his attempts to lay down the law?

I remain, &c.,

London, July 15, 1848. HENRY LAW.

*** Mr. Law cannot accuse us of want of good nature, for we print his letter at full length. We had no original prejudice against Dr. Gregory's book. The author has a kind of celebrity from his position at Woolwich, and from having written copiously, which, though he has not made a single step in the advancement of science, led us to imagine him capable of compiling a book like the present without gross and systematic blundering. The first two or three mistakes occasioned a little surprise, but were charitably attributed to inadvertance. It was only slowly and reluctantly that we yielded to the conviction, that the book was radically and essentially erroneous, and that a real mathematician could not by any chance have written it.

Still, we clung to the hope that Mr. Law was guiltless of the various delinquencies to which he had given his editorial sanction. It was, at least, a good-natured excuse—a pious fraud, to delude ourselves and readers with—that he had uttered false coin, *not* well knowing it to be spurious. Alas! even this pleasing self-delusion is destroyed.

The various subjects of discussion are not questions of authority, but of reason. If Newton, Lagrange, and Laplace were to arise from the dead, and assure us that they had discovered the ordinary multiplication table to be incorrect, not even their united testimony would produce conviction in our minds. We may as well set out by avowing, that if those illustrious names were quoted in support of Dr. Hutton and Mr. Law, even they would not produce the slightest change in our convictions. We should feel perfectly certain that their words were misquoted, or strained beyond their intended signification, or—(out it must come) that they had lost their wits!

Our task is a very simple one as regards the definitions; it is to refer Mr. Law to books in which he will find them correctly laid down. That Barlow, Hutton, and Young, have fallen into the same mistakes as Dr. Gregory, only corroborates an opinion independently arrived at—that they were just the men to do so. The distinctions between the cycloid and the trochoid are given correctly, and in exact accordance with our criticism, in Hall's "Differential Calculus, and in page 137 of the "Examples on the Differential Calculus," by the late D. F. Gregory, fellow of Trinity College, Cambridge, one of the most profound analysts in Europe—and therefore a very different mathematician to Dr. Gregory of Woolwich.

Professor Peacock, in his collection of Examples on the Calculus, distinguishes in a similar manner, between the cycloid and trochoid. The other curves in question are thus defined by him, page 192:—

"If one circle revolve upon another as its base, and in the same plane with it, it is called the *Epitrochoid*, which becomes the *Epicycloid* when the describing point is in the circumference of the revolving circle. If a circle revolve in a similar manner upon the concave part of the circumference of another circle, the curve described by a point in its plane is called the *Hypotrochoid*, which becomes the *Hypocycloid* when that point is in the circumference."

The definition of equilibrium criticised by us, begins "When forces that act upon a body destroy or annihilate each other's operation, so THAT the body remains quiescent" &c. If the words "so that" have the meaning generally adopted by persons who speak and write the English language, it is here asserted that if the forces acting on a body destroy each other's operation, the body must be at rest. It is wearying to have to repeat the correction of so obvious a blunder, but we have again to tell Mr. Law, that the case of uniform motion has been carelessly overlooked by his author. On Dr. Whewell's authority, it is declared that statical forces are called pressures; but he does not deny what we asserted, that dynamical forces are called pressures also; repeated instances of such a use of the expression, may be found in his works.

Dr. Gregory's assertion as to the manner in which Leibnitz used the term *vis viva*, is said to be confirmed by Barlow and Hutton. However, we need not inquire at second-hand what Leibnitz said, or did not say, because his very words are quoted at length. Now, does Mr. Law really mean to assert that in the Latin quotation *vis viva* is called a force? If so, all we can reply is, that he displays considerable fortitude under trying circumstances.

The Latin quotation first specifies the cases in which the two things called *vis mortua* and *vis viva* respectively exist—the former where there is no motion, and the latter where there is motion. Then it is added, that "where a body has been some time falling, or a bow has been some time unbending itself, or in any similar case, there is *vis viva*, generated from the continued infinite impressions of *vis mortua*,"—a perfectly distinct recognition of the truth which we asserted, that *vis viva* is not force, but something generated by it. Of course, the true interpretation of the phrase must be obtained from the context—not from an arbitrary translation of the word *vis*, which has a great diversity of meanings.

Professor Moseley's statement of the principle of *vis viva* is so clear, that it is really marvellous that Mr. Law did not perceive that he quoted an authority decisive against him. He says *vis viva* is a force; Moseley, that it is equal to a certain amount of *work of forces:* "work" being previously explained to be the product of force and distance. It is also important to remark, that *vis viva* is not said *to be* work, but *to be equal* to work. Twenty shillings are equivalent to a sovereign, but they *are* not a sovereign, but differ from it in weight, size, colour, and almost every other particular, except current value.

We will follow the example of printing the contradictory statements side by side. The case then between the authority last quoted and our present correspondent, stands thus:—

Mr. Law.	*Professor Moseley.*
Vis viva of a body "is THE WHOLE mechanical effect which it will produce in being brought to a state of rest."	"The difference between the aggregate work of the accelerating forces of the system and that of the retarding forces is equal to ONE-HALF the *vis viva* accumulated or lost in the system."

The discrepancy between "the whole" in the one quotation, and the "one-half" in the other, would be a fatal objection to Mr. Law's views if no other existed.

The following definitions, in which, be it observed, "force" is not even mentioned, are conclusive as to the use of the phrase *vis viva* among modern mathematicians:—

"The *vis viva* of a particle is the product of its mass and the square of its velocity."—Earnshaw's Dynamics, page 177.

"Since the publication of D'Alembert's work, the term *vis viva* has been used to signify merely the algebraical product of the mass of a moving body and the square of its velocity."—Walton's Mechanical Problems, page 387.

"The sum of all the bodies of a system each multiplied into the square of its velocity is called the *vis viva* of the system."—Whewell's Elementary Treatise on Mechanics, page 292.

"The term *vis viva* is still used to express the product of the mass and the square of the velocity."—Pratt's Mechanical Philosophy, page 202.

"On appelle *force vive* d'un point matériel, ou, plus généralement, d'un corps dont tous les points ont les meme vitesse, le produit de son masse par le carré de cette vitesse."—Poisson Traité de Mécanique, tom. ii., page 29.

The proposition respecting tie-beams was condemned by us because some of the forces acting on the beam and strut are neglected; and we showed as corroboratory proof of the incorrectness of the solution, that it led to an absurdity. Of all this our correspondent takes no notice; but refers us to Professors Moseley and Whewell. If both these references were relevant, which they certainly are not, they would not justify a palpable and obvious error; and we must tell Mr. Law plainly, that we should have had far more respect for him as an opponent, if he had made the necessary correction, instead of endeavouring to transfer the blame to authorities so way involved in it. As for Professor Wallace's adoption of the problem, we can only say that in this instance he has made an unfortunate selection.

By inserting the word "uniform," in quoting our remarks upon page 193 of the "Mathematics for Practical Men," Mr. Law makes us talk nonsense. However, we freely admit that we have

[29] Mech. Prin. of Engineering and Arch., p. 49?.

inadvertently mistook the purport of one of Dr. Gregory's sentences, and though what we said was true, omitting the word which Mr. Law forces upon us, Dr. Gregory's sentence *with* that word is perfectly correct also. Mr. Law unnecessarily injures his case by a quotation from Dr. Whewell, which has not the remotest connection with the subject. Dr. Whewell speaks of accelerated velocities in the several bodies: Emerson and Gregory, of uniform velocities only. The law stated by the two latter depends for its proof on wholly different principles to that enunciated by the former. The connection between them which Mr. Law attempts to establish, is of that kind which exists between the 1st of March and the foot of London-bridge. We have not the slightest objection to let the whole dispute between us and our correspondent rest on the reply of *any* real mathematician to this question:—Does not this attempt to confound two principles essentially different display either the most profound ignorance or the most hopeless confusion of thought respecting the science of exact mechanics? If Mr. Law can get *one* competent umpire to answer that question in his favour, we will give up the whole controversy.

The idea respecting the *natural slope* has the merit of originality. Mr. Law "*prefers*" giving it a meaning which it has not hitherto received. He says, the natural slope is the slope along which rupture would take place if the revetement wall were removed. Now, the definition of natural slope, as ordinarily used, is that it is the *very slope* along which rupture cannot take place—its friction being just capable of sustaining the superincumbent mass *without* the assistance of the wall.

We are next said to have misunderstood Dr. Gregory respecting the conditions on which he discusses one of the cases of the equilibrium of arches. This is mere assertion. We repeat the counter-assertion, that in the case referred to, conditions are assumed which, quite independently of all statical considerations, render it impossible that the arch from its mere *form* could be overturned. Mr. Law says that "no such conditions are assumed, or indeed necessary." Not necessary, indeed! Why, they make Gregory's lucubrations nonsense. Does Mr. Law mean to infer, that *sometimes* it is necessary that Gregory should talk nonsense?

Then follows an accusation against us, of having maliciously misquoted and perverted the words of the book under review. The best answer to personality is silence.

With regard to the "careful and often-repeated experiments" which Mr. Law asserts to have been repeatedly made, we have already explained, as clearly as we could, the confusion here made between mechanical experiment and pure geometrical measurement of distances. The words, "uniformly retarding force," involve the very conclusion which is declared to be the result of numerous trials; just in the same way that the first proposition in Euclid is a pure deduction from his definitions. *Experiment* would be as preposterous in the one case as the other.

The following quotations, the former from Moseley's Principles of Engineering, the latter translated literally from Poisson's Traité de Mécanique, are offered in a faint hope of clearing Mr. Law's ideas respecting the resistance of inertia:—

"So many difficulties, however, oppose themselves to the introduction of the term *vis inertiæ*, associated with the definitive idea of an opposing force, into the discussion of questions of mechanics, that it has appeared to the author of this work desirable to avoid it."—Principles of Engineering, page viii.

"It is important to rectify an inexact expression, which is often employed and tends to a confusion of ideas. Imagine that a body is placed on a horizontal plane, and that it is not retained by any friction. If I wish to make it slide on this plane, it is nevertheless necessary, on account of the inertia of the matter, that I exert some effort; if to this body be added a second, then a third, &c., it is necessary that I employ, to produce the same degree of motion, a force more and more considerable. I shall in each case experience a sensation of the effort which I shall be obliged to exert: but I must not thence conclude that the matter opposes any resistance to this effort, and that there exists in the bodies what is very improperly termed *resistance of inertia*. When any one expresses himself in this manner, he confounds the sensation which he has experienced, and which results from the effort which he has made, with the sensation of a resistance which does not exist."—Traité de Mécanique, No. 120.

Respecting the problem of the weight oscillating at the extremity of a flexible string, Mr. Law himself shall be umpire, if he will promise to make the following experiment:—Let the oscillating weight descend a vertical distance of one foot, and let the peg interfere with the string at a distance of one inch from the weight. If, then, he find the string so accommodating as to stretch itself out the odd eleven inches, necessary to permit the weight to rise to the former height, we will acknowledge ourselves beaten.

The propositions printed side by side after the next paragraph, amount to this: If a body be in one place, quoth Emerson, it ought to be somewhere else. To which Dr. Gregory responds, Amen.

From the manner in which Mr. Law meets our criticism upon his author's erroneous definition of centrifugal forces, we infer that he finds there is no tenable defence. He also candidly acknowledges two other mistakes, and therefore we have nothing further to say of them. Our remark on the equality of the total forces of compression and tension in a beam, were manifestly restricted to the particular case under examination—that where there are not appreciable horizontal forces acting externally on the beam.

It is important to observe, that throughout Mr. Law's letter, he never discusses any question on *its own merits*. He contents himself with appealing to authorities. This course is at least dexterous, for with the unlearned an array of imposing names is but too apt to carry conviction. The authorities quoted are, however, easily disposed of: several of them are of little weight when opposed, as we have shown them in several instances to be, to the most profound continental writers. The rest of the citations are either irrelevant, or make directly against Mr. Law's tenets. Had he suffered the controversy to rest on its own abstract merits, our task would have been more easy to ourselves, and more satisfactory to the cause of truth. It would be an insult to his understanding, to suppose that he did not perceive that many of the errors which he defends by quotations were, in reality, indefensible in any other way. Casuistry and perverse ingenuity, however well suited for mere disputation, are never the weapons of a man of science.

Mr. Law seems very fond of appealing to Woolwich Professors. Why did he not quote Mr. Davies or Mr. Rutherford—gentlemen who have acquired for themselves reputations not confined to the regions of Woolwich? It is very unfortunate, that the only two works written by Woolwich mathematicians which we have lately had to review, have been anything but very creditable to the scientific character of that institution; and this is the more to be regretted, since, as we have already hinted, inaccuracy in conceiving physical ideas, and clumsiness in developing them analytically, are not common to all the Professors—at least to all the *Teachers*—of the Royal Academy.

SANITARY LAWS AT HOME AND ABROAD.

The most destructive scourges of the human race are the epidemics and contagious diseases produced by a polluted atmosphere, and the congregation of men in crowded cities. Famine and the sword slay their thousands—the pestilence that walketh at noonday and in darkness its tens of thousands. The ravages of war and want are, partially at least, within human control; but when the destroying angel comes, borne on the breath of "quick pestilence," human skill and energy are all but powerless against him This sudden destruction, moreover, is not all that is caused by the infected air and artificial habits of populous places. The maladies indirectly induced, the remote consequences of a morbid habit of body which renders it a kindly soil for the future seeds of death, the degeneracy of sickly offspring who reap in a later generation the bitter fruit sown by their parents—these are among the penalties which the denizens of large towns too often pay for inhaling the hot vapours of the foundry or furnace, or breathing the stagnant air of crowded courts and lanes, where overhanging house-tops shut out the pure breath of heaven.

Prevention is almost the sole defence against these evils; for when once developed, they are either too sudden or too deeply rooted to admit of effectual remedy. A curious chapter in the history of the internal economy of states is that which the various sanitary provisions adopted under different forms of government. Nations working for the same end, the public health, seek it by entirely different means. On the Continent, where the rights and liberties of individuals seldom constitute a serious obstacle to State purposes, the most stringent sanitary regulations have long existed and the surveillance of police, which is almost unknown in England, constitutes the principal means of effecting them. Here, the public jealousy of state interference, and a sensative regard for the rights of property, have long prevented the institution of a general organised sanitary system. The Public Health Act, which will soon be the law of the land, makes the first provision for such a system in England; and it becomes, therefore, interesting to compare it with the machinery adopted for the same purpose by our continental neighbours.

The Public Health Act comprises two parts, the construction of a new *Central Board* of Health to put it in motion, and of *Local Boards*, for the purpose of carrying its details into effect. As the functions of these former and latter are entirely distinct, they may be stated separately.

The Central Board of Health consists of three commissioners, and the President is the first Commissioner of the Woods and Forests for the time being. These commissioners, upon the petition of one-tenth of the rated inhabitants of any town, may direct an examination as to its sewerage, drainage, supply of water, &c.; and after hearing the representations of parties locally interested, may report to her Majesty. *An order in Privy Council* may then be made, directing the application of the Act in cases where existing local Acts are not infringed upon, and the local boundaries are intended to remain unaltered. This order simply directs that the Act, or any part thereof, is to be put in operation.

Where, however, it appears necessary to alter the constituted local boundaries for the purposes of the Act, or to apply it in cases where local improvement acts already exist, the order in council is not made; but the General Board of Health have power to make such a *provisional order* for the application and execution of the Act as they may deem fit. This provisional order cannot be carried into effect until it have been sanctioned by Parliament. The orders issuing either from the Privy Council, or from the General Board of Health may, from time to time, be amended or extended, after due notice to persons locally interested.

The only other functions of the General Board are to determine appeals from certain decisions of local general boards, and to regulate intra-mural interments, by certifying upon the representation of the local boards, that certain places of interment are dangerous to health, and appointing a time after which it ceases to be lawful to bury in such places.

The Local Boards have much more diversified duties. When the whole of a district formed under this act is within a corporate borough, the corporation constitutes the local board. In other cases, it is selected by rate-payers. The offices assigned to it are principally these—to appoint inspectors of nuisances and officers of health—to prepare maps exhibiting a system of sewerage—to assume the control of public sewers, and purchase private sewers—to alter, extend, and cleanse the same—to cleanse and water public streets—to provide public necessaries—to register or provide and regulate slaughter-houses—to prevent (subject to an appeal to the general board) the establishment of noxious manufactures, and the erection of churches, hospitals, factories, or any other large building, without proper means of ventilation—to register, and if necessary, cleanse, or disinfect common lodging-houses—to restrict the use of under-ground cellars as dwelling-rooms—to level and pave streets—to move water or gas pipes, provided that their use and efficiency be unaffected—to prevent (subject to appeal to the General Board) the laying out new streets of objectionable width and level—to purchase premises for the purpose of widening streets—to provide public walks and pleasure-grounds—to construct water-works—to compel occupiers of houses to receive a proper supply of water—to supply cisterns and conduits for gratuitous use—and to levy rates for the purposes of this act. In cases of damage by the acts of the Local Board, compensation is to be made; and if its amount be disputed, it is to be settled by arbitration. The bye laws of the local boards are to be submitted to the Secretary of State for the Home Department for his approval.

It will be seen that in the actual administration of the act, little or nothing is assigned to the Central Board. The power is almost entirely in the hands of the Local Board, which is not amenable to the General Board for acts of omission or commission, except in one or two instances above referred to, in which appeal may be made. And as the Local Boards are popularly selected, the power of putting the act in force ultimately belongs to the great body of inhabitants of the districts affected. There seems, therefore, little reason to fear that people will be compelled to be clean, and drink wholesome water, and breathe fresh air, against their own free-will and consent.

On the Continent, however, the popular voice is not heard on these questions; and the power of enforcing measures for public health, is vested almost exclusively in central or government boards. It must be acknowledged that, notwithstanding the greater stringency of sanitary regulations with France and Germany, the practical effects of them have been even more imperfect than in England. In Paris and Vienna, the sewerage, drainage, paving, lighting and cleansing of streets, are far less complete than in London. On the other hand, our neighbours have local advantages wanting here. The boulevards, and other public walks of Paris, are far more extensive in relation to the number of the population, than the parks of London; and are also more easily accessible on account of the less size of the former city. There are no cattle markets within Paris, and the slaughter-houses are removed to the suburbs. Vitriol manufactories, and similar abominations, are not suffered to pour their pestilential vapours into the very heart of the city, nor consume human life and vegetation as they do in the close vicinity of this metropolis. Intramural burials have long been prohibited in Paris, and are of very rare occurrence.

The sanitary state of the capitals of France, Austria, and England, is partially indicated by the rate of annual mortality. It appears from the returns of the Registrar-General, published in 1845, that the average annual mortality for every hundred inhabitants of

Vienna, is about	4·898 per cent.
Paris (department of the Seine) ...	3·038
London	2·392

But, of course, the rate of mortality is influenced by many other considerations besides sanitary regulations; the vicissitudes of climate and the habits of the people having important effects on the duration of life.

It is comparatively recently, that Paris assumed the appearance of a well-lighted and well-paved city. The idea of paving it is said by Fœderé, a copious writer on the hygiene of France, to have originated with Philip Augustus, who, looking out of his palace windows one rainy morning, and surveying the marshes in which his capital was built, conceived the brilliant idea that it would be a convenience to himself and subjects to walk upon dry ground. So early as 1486 an ordonnance of the *Prevot* of Paris prohibits the erection of noxious and offensive manufactories within the town; and the records of French municipal law refer to many subsequent regulations of a similar kind. No very effectual or important measures seem, however, to have been taken till after the great revolution; and to Napoleon, the most uncompromising of reformers, is due the credit of founding the present system of law regarding public health. His attention having been directed to the insufficiency of the existing laws on the subject, the Academy of Sciences was consulted, and the class of physical and mathematical science reported to the Government, on the effects of various manufactures on the health of the people. On this report was founded an imperial decree of 1810, subsequently confirmed by a royal ordonnance of 1815, which, with some modifications suggested by subsequent experience, constitutes the modern sanitary code of Paris. For an account of it we have consulted, amongst other works, that of Fœderé, last cited; *Trebuchet's Code Administratif des Establissemens dangereuses et insalubres* (8vo., Paris, 1832); *Parent Duchatelet's Prostitution dans le Ville de Paris* (8vo., Paris, 1836); and the *Hygiène Publique*, of the same author.

The principal feature of the decree of 1810 was the division of noxious and offensive trades and manufactures into three classes, the first consisting of those so prejudicial to life and vegetation as to be required to be moved to a distance from human habitations; the second and third of those noxious in the less degrees. The distinctions between these three classes are carefully defined, and the exactness of the definition is practically of great importance, as the mode of applying for licenses for their establishment are different for each. The formalities necessary previous to the erection of a manufacture of the first or most dangerous class are very numerous and stringent. After notice publicly advertised of the intended application for license, the Mayor of the commune (or in Paris the Commissary of Police), reports on the nature of the localities infected, the distance of habitations, and the character of the processes to be employed. This investigation is technically termed the inquiry *de commodo et incommodo*. His report is referred to the *Conseil de Salubrité*, a body which takes cognizance of the establishment of all manufactures, which are "classified," or included in either of the classes above-mentioned. The *Conseil de Salubrité* delegates a sub-commission of its own members, to examine the locality of the proposed manufacture, in company with the Mayor, and to report upon the nature and importance of the manufacture, its salubrity, or inconvenience, the rate of flow of water required in its processes, the sufficiency of the apparatus, the merits of the principles on which it is constructed and applied, and lastly, on the admissibility of the application, and the conditions on which license should be granted. This report of the sub-commission is presented to, and discussed by, the general board. Among the other functions of the *Conseil de Salubrité* included the inspection of barracks, prisons, markets, and other public buildings. Besides the *Conseil de Salubrité* at Paris there are similar bodies at Marseilles, Lille, Bordeaux, and other large towns.

The *Architect-Commissary* is another public officer who discharges most important and valuable duties. A detailed *plan* of the proposed manufactory is submitted to him before the commencement of the building, and on its completion, he inspects the details of the workshops, furnaces, chimneys, and other parts, and determines whether the laws and prescribed conditions have been strictly observed in their construction. He must also also assure himself, as far as possible, of the stability and security of the buildings, both internally and externally, and ascertain whether the arrangements and situation agree with those indicated upon the plan previously deposited with him. M. Trebuchet, who speaks from practical experience as chief of the office in the Prefecture of Police which takes cognizance of establishments affecting public health, remarks, that this verification by the plan would be greatly facilitated if all plans were required to be laid down to the same scale; for instance, five millimetres to the metre. The Architect-Commissary has another very important duty. Whenever it becomes necessary to classify an altogether new manufactory, he is consulted as to the class in which it is to be placed. Upon all complaints against existing manufactories, his opinion is also required.

The actual execution of the laws respecting manufactories is assigned to the Mayor of the commune. His vigilance must be exercised to see that they are never infringed or evaded; and it is his especial office to maintain a surveillance, so that no manufactory be established without the requisite license.

To the Prefecture of Police the supreme municipal power belongs. The Prefecture institutes periodical inspections of authorised manufactures, and on its authority the execution of all official acts depends.

Steam-engines are put under a peculiar system of regulation as the ordinary laws respecting classified manufactures are not entirely applicable to them. As a general rule, stationary engines are ranked in the third class of manufactories. The rules for high-pressure steam-engines have been so greatly altered from time to time, that it is scarcely worth while to refer to more than one or two of the most important. All high-pressure engines are, or used to be, tested hydrostatically to triple their intended working pressure which is then marked upon them by a government stamp. Every new steam-boat is inspected by a commission of engineers appointed by the prefecture of police, and is required to have on board a person duly qualified to superintend the machinery, and see that it is in proper working order. Captains of steam-vessels are compelled to register the limit of their numbers of passengers, and are made personally liable for accidents arising from overcrowding or excessive speed.

The sewerage of Paris has been made the subject of that scientific and systematic inquiry which characterises the public administration in France of all matters relating to the acts. It appears from the *Hygiène Publique* of Parent Duchatelet, published in 1836, that the total length of sewers in Paris, was

Before	1830	...	...	43,340 yards.
From	1830 to 1834		...	23,790
In	1835	...	...	5,460
In	1836	...	...	4,040
				76,630

Some of these sewers are of great size, and have been excavated at great expense. That of the Rue Rivoli was excavated at an expense of £32,000, and with a solidity and excellence of workmanship which appears extravagant. Another of the largest sewers, that under the Rues St. Denis and Du Poncean, contains the pipes of pure water which supply the fountain of the Place des Innocens. Napoleon took great interest in this work, on account of the novelty of the application of the sewer to the purpose of conveying water, and examined it in all its details.

Paris stands on a gravelly alluvial soil; and the level above the bed of the Seine, is so small as to render inundations of frequent occurrence. This circumstance increases the difficulties of emptying the sewers of which the river is the general receptacle. The impetuosity of the current during winter has, however, the effect of preventing a permanent accumulation of impurities in its channel.

In supplying Paris with water, the conduits from the great aqueduct pass through the sewers. The practicability of rendering the sewerage serviceable for the purposes of agriculture, is recommended in a memoir presented to the prefect of police in 1835, by a sub-commission of the *Conseil de Salubrité*. It appears from the same authority, that the quantity of fœcal matter deposited in the Seine, is so small as to have no appreciable influence on the purity of its waters; and in a report of the *Academy of Sciences*, it is stated that the volume of water supplied by the flowing of the Seine, in a given time, is 9,600 times that of the utmost amount of impure substances which can be deposited in it during the period.

In Austria the sanitary institutions of the whole empire are placed under one general system, which appears to be carried out in an effectual manner. The laws relating to public health belong to the best part of the imperial code; and there are few countries in the world of which the medical institutions are conducted on such a magnificent scale. The administration of them is entrusted by the Austrian Government to a duly qualified corps of officers, at the head of whom, in every province, is a chief officer, called the *Proto-Medicus;* and in every circuit there are sub-officers, who constitute boards of health for their own districts. The functions of the *Proto-Medicus* are to inspect medical institutions, hospitals, lunatic asylums, and prisons, to regulate the medical police, and report on epidemics. The poor-law system of Austria provides for the gratuitous supply of medicine to the poor, and the attendance upon them by the district medical officers.

The Austrian police inspect all food exposed for sale, and have the power of examining houses and lodgings to ascertain that they are in good and healthy condition. All burial grounds are required to be at a distance from towns, and the instances in which burial in family vaults is permitted are exceedingly rare.

The vicinity of Turkey renders the quarantine laws of Austria very strict. A military cordon of 4,200 men is always maintained on the Turkish frontier, and the number can be increased to ten thousand on occasions of danger. Owing to the vigilance thus exercised, it is asserted that the plague has not crossed the frontier for upwards of a century.

On the whole review of the Continental and English sanitary systems, the essential distinctions between them appear to be that the former are administered by central, the latter by real, government; the former makes public health a matter of state policy, the latter of popular discretion. Our own system has the advantage of pleasing the governing power in the hands of those whose personal observation renders them the best judges of local wants, and generally the most sealous protectors of local interests. The question whether they will prove also the most strenuous promoters of sanitary improvements, must be determined by experience alone. In numerous cases, the intelligence of the beople will dictate, that public health be regarded as the paramount object. Other local bodies, from motives of false economy, may refuse to tax themselves for providing the means of health, or from apathy, may decline to exercise vigorously the powers of the most confided to them. Yet, these cases will be exceptioned; for the most prejudiced and the most indifferent must learn, sooner or later, that sordid neglect is never cheap. Health is wealth; for health gives energy and hope; and these beget industry and frugality, which are the sources of all wealth. But squalor and disorder are life-consuming, and the very canker-worms of social existence: they beget sloth and indifference—and these are spendthrift: they beget crime and disease—and these destroy.

WATERLOO EXTENSION OF THE LONDON AND SOUTH-WESTERN RAILWAY.

The extension of the London and South-Western Railway from Nine-Elms to Waterloo-bridge-road, was opened on the 11th ultimo. It appears to us that it would have been far better if the Waterloo Station had been made on the vacant ground adjoining, north of the present Waterloo terminus, and the principal entrance in York-road. The entrance to the railway would then have been as near to Westminster and Hungerford-bridges as it is now to Waterloo-bridge, without increasing the distance to the latter place, or the length of the railway. This alteration might now be easily made; it would save nearly half-a-mile, and eight minutes' walk, to foot passengers from Westminster and Charing-cross; the present approaches might be retained for a goods depôt—and if a steam-boat pier were made adjoining to the Surrey approach of Hungerford-bridge, and arrangements made with the steam boats to come direct from London-bridge to the pier, the extension of the railway to London-bridge might be abandoned, and thereby nearly a million sterling saved. This would, we are sure, enhance the value of the shares, and give confidence to those capitalists in the city who are now alarmed at the apparent reckless manner in which funds are being expended by railways on branches and extensions.

"The works of this undertaking were commenced in July 1846, by Messrs. Lee, the contractors, who engaged to complete the works by the 1st July, 1848. Mr. Thompson acted as the superintenden to the contractors, and Mr. Curlieu on behalf of Mr. Locke, the en gineer. The length of the new line is nearly 2¼ miles. The first quarter of a mile is carried over an embankment; then succeeds a viaduct, consisting of six massive iron girder bridges, and 300 arches (exclusive of those forming the present station in the Waterloo-road). These arches, which are expected to form a very considerable item in the receipts of the company, have been so carefully constructed, as to be easily applicable to various purposes, and their perpetual dryness has been insured by the application of the Seyssel asphalte, which has rendered them impervious to wet. There are four distinct lines of rail, and the quantity of iron alone consumed in laying down what is technically called the 'metals,' is at least 1200 tons, independently of about 800 tons weight consumed in the erection of the bridges. In the construction of the viaduct and station of the Waterloo-road, upwards of 80,000,000 of bricks have been consumed; and the present terminus, which is all on arches, covers a space of three-quarters of an acre of ground, its width being 260 feet. The major part of the present terminus has been coated with Claridge's asphalte, so that the arches on which it rests may with safety be made use of as storehouses, &c. To the present terminus in the Waterloo-road there are no less than four approaches for carriages and foot-passengers, the pedestrians having in each approach footpaths 8 feet in width. The stations at both Waterloo-road and Vauxhall are only temporary. The fares on the main line are increased as follows:—First class, 6d.; second class, 4d.; third class, 2d. The Nine Elms station is now closed entirely to passenger traffic."

STEAM-ENGINE GOVERNORS.

We give the following extract of the *Daily News*, from the police reports of the Mansion-House of the 22nd ultimo, as some allusion is made to our *Journal*, and to state that we were much surprised, after the exposure of the letters therein given, that Mr. Cousens should have had the audaciousness to send us the paper for publication. Immediately after its receipt we returned it to the author, and ordered to be cancelled an introductory paper on Steam-Engine Governors, which Mr. Cousens sent us previously to the appearance of the police report. We trust that Mr. Woods' praiseworthy resolution may deter others from attempting a similar proceeding. It is fortunate for Mr. Cousens that he had such a lenient magistrate to hear the case.

Mansion-House, July 22, 1849.—Alleged Attempted Extortion of Money.—Mr. R. B. Cousens, of No. 4, Bedford-place, Old Kent-road, appeared to answer a charge of having offered to prevent the printing and publishing of certain matters touching the complainant with intent to extort money. The charge was brought upon the 6 and 7 Vic., cap. 96, sec. 3, and it was stated, for the prosecution, that the defendant had by means of the following letter endeavoured to accomplish his purpose:—

"4, Bedford-place, Old Kent-road, July 8, 1848.—Sir,—I have written for publication a small treatise on the cause of the inefficiency of steam-engine governors; and in investigating the principles of the chronometric governor, of which you are the patentee, I find myself compelled to speak of it in a way which may, perhaps, lessen its value as a commercial speculation. Now, as I write only for pecuniary profit, I am willing to withhold the paper from the public eye, if, after perusing the accompanying copy of that part of it which concerns the chronometric governor, you feel disposed to purchase it at a fair remuneration. It is quite immaterial to me whether it be read by many or by one, whether it be preserved in the pages of a scientific periodical or destroyed, if I profit by it. It is unnecessary to say more in explanation of my object in transmitting to you the MS. copy. I shall merely add in conclusion, that after Wednesday, the 12th instant, I shall feel at liberty to forward the original to the publisher, unless I am previously favoured with some communication inducing me to withhold it.—Robert B. Cousens.—To Joseph Woods, Esq."

Upon the receipt of that communication Mr. Woods sent to the writer a note, to which the following answer was returned by that gentleman:—

"Bedford-place, July 10.—Messrs. J. Woods and Co.—Gentlemen,—In obedience to your request I have to acquaint you that my paper on 'governors,' if published in one of the periodicals, will most likely appear in the 'Civil Engineer and Architect's Journal;' but that I am yet undecided as to whether it shall appear in a periodical or form part of a separate pamphlet on that and another part of the steam-engine. In all probability I should pursue the latter course, as being the more remunerative.—Robert B. Cousens."

After he had received the second letter Mr. Woods resolved not to submit to be victimised, and, having it in his power to produce witnesses in support of the charge, was dvised to represent the case at the Mansion-House.—It was now urged for the defence that the case was one in which the magistrate had no jurisdiction, as the act of parliament directed that, in case of a libel, the person accused should be proceeded against by indictment. The offer made could not, it was said, be construed into an offer to refrain from publishing a libel upon the patentee.—Alderman Gibbs said it was undeniable that the letter was written for the purpose of raising money.—Mr. Humphreys contended against Mr. Hobler's view of the case that the magistrate had the power to compel the defendant to appear to answer an indictment as upon a charge of felony or misdemeanor of an ordinary description made before him. The charge against the defendant was clearly misdemeanor, as declared by the statute, and indictable at the sessions, and he submitted that the magistrate had full jurisdiction as to holding the defendant to bail.—Mr. Hobler said if Mr. Woods considered that an offence had been committed he had his remedy. He could go to the grand jury with his indictment, and if they found a true bill, he could bring the matter to trial; and if the defendant was found guilty, punishment would be inflicted; but it would be a very difficult matter to show his client's liability under such circumstances.—Mr. Humphreys: The charge against him is that he has attempted to extort money by means of threats.—Mr. Hobler said that if Mr. Cousens used threats, those threats were by no means conveyed in language of which cognisance could be taken.—Alderman Gibbs said he could not see that the letter was a libel upon Mr. Woods, or that it contained matter of which he could take any notice, whatever tendency and intention it might have had to extort money. He should therefore dismiss the case.

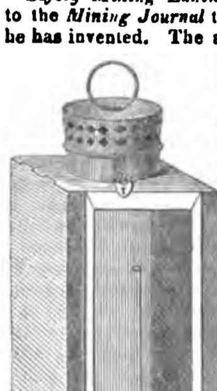
NOTES OF THE MONTH.

The Athenæum and the Engineers.—The *Athenæum* of the 15th ult. contains some remarks in reply to our's of last month, with regard to Mr. Chadwick, the Military Engineers, and the Metropolitan Survey. The *Athenæum* has replied to our remarks, as if we advocated the employment of the Surveyor's Association; whereas, we did not advocate the employment of that association, or of any particular individual or individuals. We objected to the employment of the military engineers, and named several civil engineers, who were quite competent "to conduct a trigonometrical survey, which involves the nicest points of astronomy, and requires all the resources of mathematical analysis." We again refer to the minutes of proceedings of the Institution of Civil Engineers, in the columns of our contemporary, as giving evidence of the attainments of the members in all respects, as exemplified in the discussions on atmospheric resistances, the atmospheric railway system, and the many mathematical debates which have occupied the Institution of late years. We now refer our contemporary to the account of the Ordnance survey of Liverpool, given in a report lately issued by the borough engineer, and which we shall publish next month.

South Hackney Church.—This has been three years under construction by Mr. Hakewill, and was consecrated on the 20th of July. It is in the Early English style, and in the shape of a cross, and is executed with great care and solidity. The cost was £15,700, besides land. The length inside is 172 feet; outside, 192 feet; width across the nave and aisles 61 feet, and transepts, 92 feet; height inside to roof, 60 feet, outside to top of spire, 187 feet. There are eight bells, and several painted windows, and a large sum was laid out in decoration. This is a building which possesses considerable merit; for too much has not been attempted, and a good effect has been produced. The proportions are well kept, and an air of grandeur and chasteness preserved.

Independent Chapels.—We are glad to see that such an advance is being made by the Independents in ecclesiastical architecture. Mr. Edward Walters, an architect of ability at Manchester, has been employed in erecting a chapel in Cavendish-street, in that city. It is in the mediæval style, with a tower and spire rising to the total height of 171 feet from the ground, and cost £24,000; so that it will be seen that it is an important building, as it is one likewise highly ornamental and artistic. Another chapel, erected by Mr. Walters, at Darwen, cost £5,000. A peculiarity in this building is a kind of screen raised above the roof; which, though of beautiful design, having no idea of usefulness attached to it, conveys to the mind an impression of superfluity.

Safety Mining Lanthorn.—Mr. Crane, of Birmingham, has forwarded to the *Mining Journal* the following description of a mining lanthorn that he has invented. The annexed drawing is a representation of the safety-lanthorn:—It is adapted to burn composition candles that require no snuffing. The same principles can, however, be applied to oil lamps, if any party prefer oil to candles. The front is made of strong glass; the back of polished tin—the two sides of wire gauze, soldered to the framing, having 900 apertures in a square inch of surface. It will do coarser: but the size stated is safest. Over the wire gauze sides are fixed covers of tin, hinged to the top of the lanthorn, which entirely cover the sides, and are kept fast by a small hasp at the bottom. The lower edge of each tin coverside is bent inwards to rest against the framing—so that the tin plate may be kept at a distance of ⅜ inch from the wire gauze. Sufficient space is thus provided to allow of the passage of air for the supply of the light.—These tin coversides are useful to protect the wire gauze from injury and dirt, as well as to stop any current, or "blower," of gas from blowing out the light. No direct current of wind can have any effect upon the light, because there is no admission into the lanthorn but obliquely at each corner. The candle is held between four short wires, soldered in the dish of a moveable socket, which fits into a socket soldered to the bottom; this candle socket is useful for retaining any waste fat that may run down; it can be lifted out by the wire handle, and cleaned, when necessary. The inside of the lanthorn is thus kept quite clean. The candle is put in through the neck on the top of the lanthorn, upon which a hinged lid fits down tightly. The lid is pierced with two rows of holes, through which the heated air and smoke escape; and to the top is fixed a large ring, by which the lanthorn is carried and hung up. This ring is kept cool by a simple, but effective, contrivance. A piece of tin, bent into the form of an inverted cone, is soldered inside the lid, which causes the hot ascending air to flow towards the sides, where it immediately escapes through the openings. To prevent any inflammable gas entering through the lid, a circular disc of wire gauze is soldered inside the rim of the lid—so that no gas can enter but through the wire gauze; this wire gauze will never become red-hot, so that no explosion can possibly occur. The size of lanthorns made is about 5 inches square, and 12 inches high; other parts in proportion. The inside of the tin coversides, and the outside of the lanthorn, are japanned of any dark colour.



The Soap Plant.—In California this plant is used by the people for washing every description of clothing in cold running water. In using it as soap, the women cut the roots from the bulbs, and rub them on the clothes, when a rich and strong lather is formed, which cleanses most thoroughly. To propagate the plant the bulbs are set in a rich soil, and grow luxuriantly in the soft bottoms of valleys or bordering running streams.

Copper Sheathing.—A correspondent of the *Mining Journal* states, as the consequence of his experience, that, in the treatment of the sulphurets of copper, there should be one calcining, one roasting, one smelting, and one refining—four operations in all; and that care be taken that no iron tools be used, except the ladles for the refining process. The carbonates of copper require only two operations—smelting and refining; but if copper pyrites be mixed with the carbonate, it will require three operations instead of two. By attention to these operations all foreign matter will be disengaged. The production of good malleable and pure copper depends on the refiner; the copper is brittle before, and should be stirred with a wooden rod. It requires considerable care to keep the metal to a proper heat until the moulding is finished, to give it due ductility, and make it suitable for the demands of commerce. In general, most operators go too far in the refinery, which renders the metal fibrous, and the result is serious lamination on one side of the sheet. If the copper ore is properly treated in the above operations, this metal is decidedly the best for ships' bottoms. The per centage of copper is also much increased by careful treatment, and the scoria comes out cleaner.

Method of Welding Iron, Steel, and Sheet-Iron.—In an earthen vessel melt borax, and add to it $\frac{1}{10}$th of sal-ammoniac. When these ingredients are properly fused and mixed, pour them out upon an iron plate, and let them cool. There is thus obtained a glassy matter, to which is to be added an equal quantity of quicklime. The iron and steel which are to be soldered, are first heated to redness; then this compound, first reduced to powder, is laid upon them—the composition melts and runs like sealing-wax; the pieces are then replaced in the fire, taking care to heat them at a temperature far below that usually employed in welding: they are then withdrawn and hammered, and the surfaces will be found to be thus perfectly united. The author asserts that this process, which may be applied to welding sheet-iron tubes, never fails.—*Rec. de la Soc. Polytech.*

Dotting Electric Telegraph.—A patent has been recently granted in this country to M. Dujardin, of Lille, for a new kind of electric telegraph in which the signals consist of dots made on paper. The telegraphic pen is fixed to a magnet, and it marks dots on a revolving traversing cylinder. The dots, by a previous alphabetic arrangement, are made to signify letters, each letter being characterised by a certain group of dots. The process is complicated, and must necessarily be a slow one; nor does the inventor, who is a physician, seem to have been aware of the invention of Mr. Morse, which accomplishes the same object more efficaciously, and with a much less complicated mechanism; Mr. Morse's alphabet consisting of short and long strokes, by which means the letters of the alphabet may be indicated by a smaller number of marks than by dots of the same size.

Time Signals.—Mr. Torrop, of Edinburgh, has patented an apparatus for giving notice of the approaching departure of railway trains, so as to supersede the use of bells or whistles. The apparatus consists of a hollow pole erected vertically at any convenient part of the station where it may be most advantageously seen both by those at the station itself, as also by those hastening towards the station. Upon the outside of this pole is placed a large ball, the pole passing through a hole through the centre of the ball, sufficiently large to allow free motion up and down the pole. The ball is suspended by cords, attached at the bottom of the pole to a clockwork movement, having a pendulum, the vibrations of which regulate the descent of the ball upon the pole. When the spring of the clockwork is wound up, the ball is raised to the top of the pole, which then begins to descend to the bottom of the pole, being regulated in its velocity by the clockwork and pendulum. The time of its descent will therefore be regularly the same each time the ball is raised to the top and then allowed to descend. The ball being raised to the top of the pole at the adjusted period of time (say ten minutes before the departure of each train), and then allowed to descend, the position of the ball upon the pole during its descent will give notice of the length of time to elapse before the departure of the train. During the night a lamp is to take the place of the ball.

A few Degrees of Difference.—In an action recently tried in the Court of Queen's Bench, the question was raised whether the variation of three degrees in the inclination of a wood pavement constituted an infringement of the patent right. The defendants (Esdaile and Co.) were licensees under Rankin's patent for wood pavement, and the plaintiffs (Hulse and Co.), entered into a covenant with them to pay certain royalties if they infringed upon the principle of Parkyn's patent. The principle was the inclination of the fibre of the wood to the horizon; and that was described to be from 40 degrees to 70 degrees. The defendants laid down pavement in Cornhill and at a bridge at Chalk-farm; and the blocks they laid down were at an inclination of 73 degrees. The contention for the plaintiffs was, that although the inclination was not within the precise words used in the deed, still that for all practical purposes there was not the slightest difference between 73 degrees and 70 degrees.—Mr. Justice Wightman, in summing up, observed, that if parties chose to bargain in specific terms they must abide by their bargain, and though in practice the two inclinations mentioned could make no difference, still the terms of the covenant were express; therefore, unless the inclination adopted by the defendants was within that limit, the plaintiffs on that ground were not entitled to recover. The jury therefore gave a verdict for the defendant, the plaintiffs having liberty to move to enter a verdict of 50*l.* 1*s.*

College for Civil Engineers.—On Tuesday the 18th ult., the yearly examination of the students of the College for Civil Engineers was held at Putney, and was attended by H.R.H. the Duke of Cambridge, and many of the aristocracy. The college seems to be advancing in public opinion. We inspected the drawings, models, workshops, and other practical departments, which we are happy to say show considerable advancement in the knowledge of engineering. We were sorry on such an occasion, and in an Institution so promising, to see year after year, in the workshops, such schemes as the locomotive air-engine, and the imitation of Hero's rotary-engine; for in an establishment like the college, it is better to be too far behind-hand, than to be suspected of running after what savours of visionary projects.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM JUNE 24, TO JULY 18, 1848.

Six Months allowed for Enrolment, unless otherwise expressed.

Deane Samuel Walker, of London-bridge, merchant, for "Improvements in the manufacture of bands or straps for hats, caps, shoes, and stocks."—Sealed June 24.

Henry Archer, of Shaftesbury-crescent, Pimlico, Middlesex, gentleman, for "Improvements in matches, and in the production of light, and in the apparatus to be used therewith."—June 24.

William Hunt, of Dodder-hill, Worcester, chemist, for "Improvements in obtaining certain metals from certain compounds containing these metals, and in obtaining other products, by the use of certain compounds containing metals."—June 24.

Richard Clark, of the Strand, Westminster, lamp manufacturer, for "certain Improvements in gas burners, and in candle lamps and other lamps."—June 26.

Frederick William Mowbray, of Leicester, paper-dealer, for "Improvements in the manufacture of looped fabrics."—June 27.

John McIntosh, of Glasgow, gentleman, for "Improvements in obtaining motive power."—June 28.

Joseph Skertchly, of Anstey, Leicestershire, gentleman, for "Improvements in bricks, and in the manufacture of tobacco-pipes, and other like articles."—June 30.

Elizabeth Dakin, of No. 1, St. Paul's Church yard, London; widow, for "Improvements in cleaning and roasting coffee, in the apparatus and machinery to be used therein, and also in the apparatus for making infusions and decoctions of coffee."—July 3.

Nathaniel Beardmore, of 13, Great College-street, Westminster, for "certain Improvements in founding and constructing walls, piers, and breakwaters, parts of which improvements are applicable to other structures."—July 3.

John Martin, of Killyleagh Mills, Down, Ireland, manufacturer, for "Improvements in preparing and dressing flax, tow, and other fibrous substances, and doubling, drawing, and twisting flax, tow, and other fibrous substances, and in the machinery to be used for such purposes."—July 6.

Joseph Clinton Robertson, of Fleet-street, London, civil engineer, for "Improvements in the manufacture of gas." (A communication.)—July 6.

George Beattie, of Edinburgh, builder, for "an Improved air-spring and atmospheric resisting power."—July 6.

Anthony Lorimier, of Bell's-buildings, Salisbury-square, City, book-binder, for "Improvements in combining gutta percha and caoutchouc with other materials."—July 6.

William Edward Newton, of Chancery-lane, Middlesex, for "Improvements in the construction of stoves, grates, furnace or fire-places for various useful purposes."—July 6.

William Swain, of Pembroke, Hereford, brick-maker, for "certain Improvements in the construction of kilns for the drying and burning of bricks, tiles, and other earthen substances, and for the consumption of smoke and other noxious gases arising therefrom, and which latter improvements may be applied to all chimneys."—July 6.

Enoch Steel, and William Britter, of Lambeth, Surrey, manufacturers, for "Improvements in the manufacture of tobacco-pipes."—July 6.

Walter Orbel Palmer, of Southacre, near Swaffham, Norfolk, for "Improvements in machinery for thrashing and dressing corn."—July 10.

Richard Roberts, of Globe Works, Manchester, engineer, for "certain Improvements in, and application to, clocks and other time-keepers, in machinery or apparatus for winding clocks and hoisting weights, and for effecting telegraphic communication between distant clocks and places otherwise than by electro-magnetism."—July 11.

Leon Castelain, of Poulton-square, Middlesex, chemist, for "Improvements in the manufacture of soap."—July 11.

Felix Alexander Testud de Beauregard, of Paris, engineer, for "Improvements in generating steam, and in the means of obtaining power from steam-engines."—July 11.

Mathew Kirtley, of Derby, engineer, for "Improvements in the manufacture of railway-wheels."—July 11.

Jesse Ross, of Leicester, agent, for "Improvements in apparatus for dibbling and other agricultural puposes, part of which improvements is applicable to propelling vessels."—July 11.

William Edwards Staite, of Lombard-street, City, gentleman, for "Improvements in the construction of galvanic batteries, in the formation of magnets, and in the application of electricity and magnetism for the purpose of lighting and signalizing, as also a mode or modes of employing the said galvanic batteries or some of them, for the purpose of obtaining chemical products." (Partly a communication.)—July 12.

William Swain, of Pembridge, Hereford, brick-maker, for "certain Improvements in kilns for burning bricks, tiles, and other earthen substances."—July 18.

Jean Louis Lamenude, of 30, Passage Touffroy, Paris, Jeweller, for "a new process of applying or fixing letters of metal upon glass, marble, wood, and other substances."—July 18.

Charles Purnell, of Liverpool, dock-master, for "certain Improved apparatus to be applied to timber-loaded and other vessels laden with materials the specific gravity of which is lighter than water, preventing the necessity of abandoning them at sea by ridding them of the superincumbent water, and enabling them thereby to carry sail."—July 18.

William Edward Newton, of Chancery-lane, Middlesex, for "certain Improvements in machinery for letter-press printing."—July 18.

Joseph Stenson, of Northampton, engineer, for "Improvements in steam-engines and boilers, parts of which improvements are also applicable to other motive machinery."—July 18.

Johann Arnold Steinkamp, of Leicester-street, Leicester-square, Middlesex, gentleman, for "Improvements in the manufacture of sugar from the cane."—July 18.

CANDIDUS'S NOTE-BOOK, FASCICULUS LXXXV.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. Architects are apt to pay by far too little attention to locality, aspect, and other circumstances which influence the effect of buildings;—such, for instance, as distance—too little space for obtaining a satisfactory view from any point, or so much that it looks diminutive in comparison with what the design, whether shown in a model or a drawing of it (that is, an elevation), promises. Neither the model nor the elevation conveys, or can convey, the slightest idea of locality; and even if recourse be had to perspective and pictorial representation, the probability is, that there is a vast deal of imposition passed off under the plausible and innocent name of artistic liberties. Liberties of the kind are, however, sometimes carried so far as to amount to downright *lies*—an ugly word, it must be confessed; but the imposition so practised is a far more ugly thing. And surely it amounts to nothing less than a lie, although not a spoken one, to represent a front that will always be in shadow throughout the whole day, kindled-up and *illustrated* by sunshine, with all its details sparklingly touched and brilliantly brought out. In Mr. Blore's view of the new building at Buckingham Palace, the sun is made to shine from the north-east; which, not to call it a miracle, is at any rate a piece of great complaisance on the part of that luminary—a direct testimony to the all-commanding talent of that Mr. B. Such deceptions are, it would seem, not lies, but merely poetical and graphic fictions; and we ought to congratulate ourselves upon getting anything poetical at all, where the design itself is so terribly prosaic.

II. Locality has so very much to do with the actual appearance which a building makes, that unless some information be afforded in regard to it, we may be totally ignorant and unsuspicious of many circumstances that require to be understood. If a building has been seen, it is of course known how it is situated with respect to other buildings; whether in an open space or in a street; and if a street, whether it is a wide one or a narrow one; or if an open space, whether it is a regular or irregular one. It is desirable also to know what is its aspect, for it makes a very considerable difference whether a portico or colonnade faces the north or the south—the east or the west. Therefore, if a building is known to us only by means of plans and other drawings of that kind, confined to the edifice itself, we may form very erroneous ideas. Of course, such drawings acquaint us with its actual dimensions, but leave us in entire ignorance as to its relative size in comparison with adjoining or neighbouring buildings. It may chance, for instance, to be so greatly over-topped by them, that instead of answering to the prepossessing appearance which it makes when shown apart from other objects, as to make but a rather insignificant appearance in reality; consequently, much as the design may be admired, the structure disappoints when seen, —at least, at first, though it may recover our first good opinion afterwards. The reader knows the story of the lady who fell in love with a portrait, but was cured of her passion on finding that her Adonis wore a wooden leg. In order to judge what figure a building actually cuts, it is necessary to know something more about it than elevations, &c. show. The "*about it*" is here to be understood literally; since, with regard to effect, much depends upon accidents of site and locality—upon aspect, point of view, and various other circumstances, any one of which may be more or less influential, even taken by itself singly; therefore, when combined, must be so in a high degree, either favourably or the reverse.

III. In some stringent remarks that have just appeared upon the "Houses of Parliament," in another publication, it is hinted that it would not have been amiss had the excessive decoration of the river-front been considerably moderated, and the saving so effected been applied to the finishing-up another public and national edifice—namely, the pile of buildings which are termed collectively Somerset-place, whose now exposed west, or rather south-west side, makes a most mean, though not exactly beggarly, appearance—yet beggarly as manifesting the pinching poverty of a government which cannot afford to get rid of such an unseemly public exhibition of architectural *sans culottism*. It is no reproach to Chambers that he did not provide against an event which he could not possibly foresee. He would have been regarded as a madman, had he advised that the terrace-front should be returned and continued northward, in order to form a west façade that might possibly some time or other be exposed to view, on the side most of all favoured by aspect. He could no more have any idea that Waterloo-bridge would be erected, than that such architecture as King's College would be brought so closely into contact, as to be made to appear part of his design. The bridge has certainly rendered one service to Somerset-place, since it enables us to obtain a view of the river-front and its terrace. But the formation of the street leading to the bridge has laid open to sight what was never meant to be seen at all, and therefore now detracts sadly from the grandeur of the façade which is beheld in connection with it. The disparity between the two is nothing less than offensive. The feeling it produces is akin to that which we should experience on beholding a costly sideboard and a kitchen-dresser cheek-by-jowl in a dining-room. The juxta-position which here presents itself is not like that of "pearls upon an Æthiop's arm," but of a blooming face upon the shoulders of a Blackamoor,—the head of Hebe upon the shrivelled carcase of a hag;—in short, we perceive Chambers and Pecksniff arm-in-arm together: no disrespect is intended to the former, he being sufficiently excused by what has been stated above. Still, that is no excuse for our neglecting to do what the greatly-altered locality of the building renders so highly desirable. If it is not worth while, merely for appearance-sake, to bestow a decent architectural exterior on the exceedingly unsightly and disfiguring range of building alluded to, how can we reconcile ourselves to the enormous outlay for mere embellishment in the river-front of the Houses of Parliament; and which, after all, does not produce any corresponding degree of effect? Either the "Houses" accuse us of the most niggardly meanness for allowing Somerset-place to remain in the disgraceful and unfinished state which it is; or Somerset-place accuses us of absurdly wanton extravagance, for crowding such a profusion of minute details and carved-work into that front of the "Houses" where they are quite lost, and where a few boldly-touched finishings would have told quite as well—perhaps even very much better. The west wing of Somerset-place, on the contrary, though at present a most offensive eye-sore—and perhaps doomed to remain so—is most admirably situated for architectural display. There is not any spot in the whole metropolis which affords so many of the requisites for a fine architectural scene. That side of the buildings of Somerset-place is favoured, not only by aspect, but by due space before it—neither so great as to take off from the size of the building, nor insufficient for viewing it as a whole. To these advantages, other peculiar and accidental ones may be added: the building descends so much below the level of Wellington-street, or the roadway leading to the bridge, that the street becomes as it were a terrace or elevated staging, from which it shows—that is, would show itself, most picturesquely, were it a worthy piece of architecture, instead of being the abomination it now is. When looked down upon from the parapet of the road, it would be seen rising statelily from a deep substructure. And that west front and the river-front—which latter shows at present only as a mere mask—seen together, would produce a fine palatial mass, and in combination with Waterloo-bridge, a most striking and noble group of architecture. The river-front itself, which now looks only like the fragment of an unfinished design, would gain in importance by becoming a portion of one consistently grand design. Besides all which—but let us have done with "besides's." We have "Marble Arches," and "Nelson Columns," and "Wellington Statues," and a good many other things that shall be nameless, to show how freely tens-of-thousands have been flung away on very futile if not absurd objects. Let us then have at least one public edifice that will serve as a monument of our notable economy and frugality. Therefore, since so it must be, let it even be Somerset-place. Let the foreigner who gazes with astonishment at such an achievement by individuals as Waterloo-bridge, look with astonishment of a different kind—with scornful wonder at the paltriness that is allowed to disfigure and disgrace a government building which might, with comparatively little cost, be rendered a uniformly noble pile.

IV. My good friends, the architects,—the friendship between us is not, perhaps, of the most cordial kind, my own share being marked more by boisterous freedom than by compliments and courtesy—still I say my very good friends, the architects, may be said to have contrived to outwit and enslave themselves. So long have they gone on preaching up the accursed and superstitious doctrine of its being unlawful to deviate from established forms and proportions, or from the precise letter of mechanic-enacted rules, that even those who could do so successfully, dare not even attempt it, so greatly do they stand in awe of the sneers of the whole tribe of

Incapables, who scout the idea that it is possible for any other than hackneyed forms to be beautiful, and who flatly deny it to be in the power of artistic conception to produce what, though different in character, should be equally beautiful in its peculiar way. Unhappy architects! ye have locked yourselves in, and flung away the key that would open the door and send you forth—the worthy and really gifted among you rejoicing once more in liberty and light. Unhappy architects!—unhappy architecture, also! for thou art now fettered, and delivered over to the tender charge of thy jailor, PRECEDENT!

V. Precedent is adhered to even for that lawless, hybrid style which we denominate Elizabethan. No one, indeed, has yet attempted to draw up a formal code of rules and regulations for it—perhaps, because it would be a task of very great labour to attempt to systematize so chaotic a mass as the various examples of it constitute; any one of which, however eccentric and exceptional, may now be quoted as sufficiently valid authority. This must be allowed to have its convenience; no more being required than to follow Precedent merely piece-meal, and patch up a design out of odds-and-ends, taken at random, and put together without any regard even to general consistency of composition. The name "Elizabethan," at once sanctifies all absurdities and all crudities: it operates as a talisman and an ægis against the shafts of criticism. It is in vain to object to that offensive inequality of design which results from plainness and coarseness in some features, and studied ornateness, perhaps finicality, in others. The greater the incongruity, the greater, it would seem, is the *Elizabethan-ness*. The utmost and most convenient latitude is freely allowed: forms and features strongly partaking of the latest-expiring Tudor style may be mixed up *ad libitum* with ultra-Italianized ones; no matter how incoherently, when incoherence is thought to belong to, if not actually to be the very genius of the style itself. Although for a very different reason, Elizabethan possesses one great recommendation in common with the pure Grecian style. What it is you shall learn by-and-by—that is, in my next Fasciculus; till which appears, I leave you to cogitate upon the matter, and solve the riddle, if riddle it be, for yourselves. Or, should your curiosity evaporate in the interim, it will not greatly matter. Putting, like a frugal hostess, that dainty bit "by for supper-time," what I now say is, that we do not at all avail ourselves as we might do of the opportunity which Elizabethan architecture holds out to us,—of the convenient pretext which it affords us for working out a style founded upon the *Italianism* or early *Cinque-cento* ideas which, although they show themselves only here and there partially, and more or less imperfectly, strongly mark those examples in which they occur to any extent. In reverting to Elizabethan, we have considered it rather as being the latest stage of expiring Gothic, than as the incipient one of a quite different architectural system; which, had it been allowed to proceed as it originated, and to develope itself freely and naturally out of its first rudimentary shoots, instead of being put into the hot-house of Palladio and Jones, would doubtless have produced other blossoms and fruits than those which have attended such "forcing" system. When Elizabethan was recommended as the style most of all suitable for the new Houses of Parliament, people—and architects among the rest, were puzzled to know what was to be understood by such name. Was it to be interpreted literally or liberally? If the former, it of course excluded every style that had been used before or up to the period of Elizabeth's reign, unless Elizabethan and Ante-Elizabethan mean one and the same thing, and unless Elizabeth reigned before she was born—a mystery I willingly leave to wiser heads than mine. On the other hand, if Elizabethan was to be interpreted liberally and latitudinarially, it would seem to imply that the style to be adopted might be either that which was actually employed during the latter half the 16th century, or which afterwards came up in the earlier part of the following one; and the way for which had been opened by the influences and tastes of the previous Elizabethan period. It is perhaps just as well that the taste of Elizabeth's grandfather—at least, that of his age—was preferred to that of her own. Nearly all the competitors for the "Houses" eschewed Elizabethan, and no doubt very prudently; for it would, perhaps, have occupied them till now to elaborate out of it aught that would have been both worthy of and suitable for the occasion.

VI. Some are so very sensitive and captious about terms and names, that I wonder they do not affect to be scandalized at that of the "Lancet style." It cannot, indeed, be said to be a very blunt one; on the contrary, it is sharp enough—so sharp as to pierce an ear that is at all refined. It must surely have been invented by Dr. Sangrado, or other practitioner of phlebotomy. Or it must have originated with the Company of Barber-Surgeons, so truly *barberous* is it in sound. If not so, it must have been applied in sneering derision by some such critics as those who make themselves merry with Nash's *extinguisher* in Langham-place, and Barry's *dumb-waiters* in Trafalgar-square. Lancet-style!—horrible name; suggesting ideas of bloodshed, at least of blood-letting! Let it be reformed by all means; more especially as people are now endeavouring to substitute more appropriate terms for those introduced by Rickman, notwithstanding that they have obtained general currency among as. If "Perpendicular" is to be transformed into "Rectangular" style, surely "Lancet" will no longer be tolerated by "ears polite," or ears archæological. Let a General Council of Archæologists be held forthwith; let the Institute assemble in solemn or somnolent conclave, to devise some less odiously vulgar name for what is now called the Lancet style. Should they not be able to think of one, still, they might possibly *dream* of one; or else they go to sleep to very little purpose indeed.

VII. Plans, elevations, and sections of Stowe, would just now possess considerable interest, even for those who would not care for them at any other time. None, however, are in existence,—at least, no published ones. There is no work which so describes that princely mansion;—no plates of it in any of the several collections which assume the title of "Vitruvius Britannicus," although they all contain subjects of far inferior note, and inferior merit also, and more than one which has nothing whatever to recommend it. Almost all that is known of the architectural authorship of Stowe is, that the original house is said to have been designed by Viscount Cobham, and the additions, comprising the stately south front, by the first Lord Camelford (about the year 1775). Vanbrugh and Kent designed some of the garden-buildings; but of the professional architects employed upon the mansion itself, the only names which appear to be known are those of Borra and Valdrè, both foreigners. Stowe is infinitely too modern to excite any sympathy among the admirers of ruins and rubbish. When it becomes an antiquity, and thereby entitled to the epithet of "venerable," it may acquire that value in the eyes of posterity which it has not in our own. And let us hope that it will be permitted to remain; and not doomed to be taken down and sold piecemeal, as were both Wanstead and Worksop. We can ill-afford to spare such an example of a palatial English residence, now that nothing else of the same class and character is erected. Scarcely a mansion of any architectural note at all has been erected for many years. What few large country-houses have been built, mostly affect antiquity, without either the charm or the merit of it. The tide now runs in favour of Model Lodging-houses and Buckingham Palaces,—of Baths and Washing-houses: but Greenwich Hospitals, and Blenheims and Stowes, are quite beyond our mark. Neither the aristocracy of rank nor the aristocracy of wealth patronise such architectural grandeur as marks the last-mentioned piles. Let it not be supposed from this, that unqualified praise of either Blenheim or Stowe is intended. In both of them there is much to censure—a great deal that might be many degrees better: still, there is the magnificent and the noble—which, as things now go, is a very great deal indeed. As to the *grandiose*, where will you now find it? Go and look for it in the façades of the British Museum or Buckingham Palace; and if you can discover it there, you may congratulate yourself as being able to discover the longitude also.

NOTES ON ENGINEERING.—No. X.

By HOMERSHAM COX, B.A.

The Dynamical Deflection and Strain of Railway Girders.

There is no subject in practical science which has been more elaborately investigated than the theory of the statical transverse strength of beams. It has fortunately happened that two different classes of investigators—mathematicians and experimentalists—have cooperated in the research: and the result of their united labours has been a valuable and comprehensive system of knowledge.

But the DYNAMICAL strength of beams, or their capability of sustaining weights moving rapidly over them, has never been satisfactorily discussed. There does not appear to be extant a single theoretical investigation of this subject—and the deficiency is due to two causes: it occurs partly because the subject has but comparatively recently grown into importance; partly because of its excessive and insuperable difficulties when investigated by the exact methods of theoretical mechanics. The following paper is a contribution to a more accurate knowledge of this important question, which has at length attracted the attention due to its influence on the security of railway traffic. The necessity of further inquiry seems to be generally acknowledged among engineers; and by the recommendation of the Commissioners of Railways, in a published minute of the 29th of June 1847, a government commission has been appointed for the very purpose. The minute expresses a doubt "whether the experimental data and the theoretical principles at present known are adequate" for the "designing iron bridges, when these are to be traversed by loads of extraordinary weight at great velocities."

There seems to exist great discrepancy of opinion as to the effect of the velocity of transit. Some have imagined that it may become a source of safety, by causing the railway train to pass over before the girder has had time to yield. Others, again, have estimated the effect of the moving load as highly as six or seven times that of the same load at rest. In the following investigation, both these opinions will be shown to be incorrect: they are here cited merely as indications of the extreme uncertainty prevalent on the subject.

The method of inquiry about to be explained consists, not in determining the dynamical strain absolutely, but by comparison with the corresponding statical strain. The results will consequently be much simpler than they would be if the dynamical strain were estimated independently. The deflection which a given load *at rest* upon a girder produces, will be always taken as one of the known data of the problem. The determination of this statical deflection, as it forms the basis of all the remaining calculations, is the first point of inquiry.

When a beam is not affected by a permanent set or defect of elasticity, it appears, both from theory and actual experiment, that the deflection by a weight resting at its centre is very nearly proportional to that weight—that is, if a given number of tons deflect it one inch, double the number of tons will deflect it two inches. This result is arrived at by Professor Moseley in his "Mechanical Principles of Engineering," and M. Navier in his "Resumè de Leçons de Construction," by independent methods. Its near accordance with practical truth has been abundantly confirmed by experiment, as may be verified by reference to numerous published accounts of actual observations on the subject, and especially to Mr. Hodgkinson's invaluable "Experimental Researches on the Strength of Cast-Iron." This work gives the results of an exceedingly large number of experiments, made by the author and others, on the transverse strength of beams loaded at their centres; and although these beams were of very different forms and dimensions, the law indicated is nearly observed in all of them. Whether the section of the beam be rectangular, triangular, or T-shaped, with the vertical rib either upwards or downwards, the constant ratio, in each beam, of each deflection to the corresponding load is nearly maintained: and the same remark applies to beams of the form most useful for railway purposes—that of an upper and lower flange connected by a vertical rib.

It will be found, however, by reference to the tables in Mr. Hodgkinson's work, that the actual deflections are somewhat more than the theoretical law would make them. This discrepancy may be accounted for by attributing it to the defect of elasticity, which the ordinary theory of beams does not consider. As this defect is not generally very great, it will here in the first instance be neglected: the deflections will primarily be estimated as if the elasticity were perfect; and subsequently the modifications due to defect of elasticity will be taken into consideration.

Work Done on the Deflection of a Beam.

The "work done" by a moving force may be defined to be the product of that force into the distance through which it acts. A familiar instance of the use of this measure is the Steam-Engine; where the work done receives the particular name of Horse-Power. If the pressure on the piston were uniform, that pressure (in pounds) multiplied by the distance through which it is exerted (in feet) would, if divided by 33,000, give the horse-power. But in the steam-engine, and all other practical instances, where the pressure is not uniform, but varying, it is impossible to calculate the work done by this direct multiplication. Where the value of the moving force is constantly altering, we may resort to either of the following methods of ascertaining the work done by it,—we may multiply its *average* value by the distance through which it acts; or, when that average cannot be ascertained, we may consider the whole distance divided into elementary portions, so small that it may be supposed without sensible error—that the pressure is at least uniform while it acts through each portion in succession. The aggregate work done, is the sum of the work done on each of these portions—that is, it is the sum of the products of each portion of the distance and the corresponding pressure.

This process of summation, when carried out with the greatest possible accuracy, is equivalent to that of mathematical integration; in which case, the work done by a varying pressure may be defined, in mathematical language, to be the integral of the product of the pressure, and its "virtual velocity." The work done in deflecting a beam by pressure at its centre is easily ascertained, if that pressure be assumed proportional to the deflection. Calling the deflection x, and therefore the pressure $a\,x$ (where a is a constant depending on the dimensions &c. of the beam) we have—

$$\text{work done} = \int_0^x a\,x\,d\,x = \frac{a\,x^2}{2} = \frac{a\,x}{2}\,.\,x.$$

Now $\frac{a\,x}{2}$ is the pressure or weight which would statically maintain half the deflection x. Hence, *the work done in producing a given deflection is equal to the weight which would statically maintain half the deflection, multiplied by the whole distance of deflection.*

The value of this rule will appear hereafter.

Distinction of Gradual and Instantaneous Loading.

When experiments are made on the strength and deflection of beams, they are generally loaded very gradually at their centres. Each addition to the load is allowed to produce its full effect before more be imposed. Consequently, at every stage of the experiment, the beam is in a state of statical equilibrium: the pressure of the load on the beam is always just equal to its weight, and is never increased by any momentum arising from downward velocity.

But if the whole load be suddenly and at once placed on the beam, while it is as yet undeflected, the effects are entirely altered. The deflection is greater than the same load would produce if gradually applied: for when the beam has reached the point of statical deflection, the momentum acquired by the downward motion urges it further; and the descent of load continues till it be *brought up* (so to speak) by the increased resistance of the beam. Afterwards, the beam and load rise again, as the deflection has been carried beyond the degree at which it can be statically maintained.

In the case here supposed of instantaneous loading, nothing like impact or sudden collision occurs. The pressure at the centre of the beam is finite and continuous. The load does not *fall* upon the beam—it is merely supposed to be placed originally in close contact with the beam, and then suffered to instantaneously rest upon it.

For the sake of elucidation, one or two instances of analogous action may be cited. If a common balance have its fulcrum above the points of suspension of the scales, and a weight suddenly rest in one of the scales, the lever will turn through a much greater angle than if the same weight were applied in small successive portions.

If an elastic string suspend vertically a weight from one end of it, the string will be more stretched if the whole weight be suffered to act at once, than if applied in small portions. It will be found, that if the extension of the string be proportional to the stretching force, the extension produced by the descending weight will be *twice* that due to the gradual effect of the same weight.

A light cylinder of wood, loaded at its lower end, and floating vertically in water, furnishes another illustration. If the cylinder be raised a little above its position of equilibrium and then let go, it will sink twice the distance it has been raised, if the motion be so small that the resistance is equal to the hydrostatical pressure.

In the same way, in a perfectly elastic horizontal beam, loaded at its centre, the effect of instantaneous loading is double that of gradual loading. For, by a known principle of mechanics, when a material system moves from one position of rest to another position of rest, the work done by the retarding forces is equal to the work done by the accelerating forces. For any small deflection of a beam by instantaneous loading, its position of ultimate deflection is one of instantaneous rest, for immediately before it arrives at that position, all the parts of the beam descend, and immediately after, ascend. Also, the work done by the accelerating force is the weight actually resting on the beam, multiplied by the space of deflection: and the work done by the retarding forces is, by what has been said above, "equal to the weight which would statically maintain half the deflection, multiplied by the whole distance of deflection." Therefore, putting the two amounts of work done equal to one another, we see that the weight actually upon the beam is that which would statically maintain half the deflection. In other words, *the deflection is doubled by instantaneous loading.*

Transit of a Single Weight.

We now proceed to examine the effect of the transit of a single weight *along* the girder, and first of all to show that its effect cannot exceed that which it has just been estimated to produce, if stationed at the centre of the girder and allowed to descend freely from the undeflected position—in other words, it will be proved that at whatever rate the weight may travel over the girder, its ultimate strain and deflection cannot be more than double the corresponding statical effects produced when it *rests* at the centre of the girder.

There is a general rule of constant use in engineering which, expressed in practical language, states that power is never gained, but only modified, by the intervention of machinery. This rule may be more scientifically expressed and extended by tracing it to its origin—it is a particular case of the principle known in theoretical mechanics, as the Conservation of *Vis Viva*. This principle may be very conveniently enunciated by employing the term "work done," as defined above: and it then assumes this form of enunciation—that the *vis viva* gained or lost by a system in moving from one position to another, is equal to twice the difference between the work done by the accelerating, and that done by the retarding, forces in the same interval.

From this it follows, that where there is *no* gain or loss of *vis viva*, there is *no* difference between the work done by the accelerating and retarding forces respectively. Hence, if the parts of the system be moving at the same velocity in the second position as in the first—or if both positions be positions of rest—the aggregate work done in the interval by the retarding forces is equal to that done by the accelerating forces.

A very simple case will illustrate this theorem. If a locomotive-engine travel a mile along a railway, and its velocity at the end of the mile be the same as at the beginning of the mile, the work done by all the forces which have resisted its motion is in the aggregate just equal to the horse-power developed in the steam-cylinders. And this equality holds good, however the engine have moved in the interval—whether on a straight level road, or on severe curves and gradients—whether the speed were uniform or very irregular—whether the steam were on the whole time, or the engine during large parts of the journey moved by its momentum only. The intermission of the moving force and all other irregularities disappear in the result. To establish equality between the work done in moving, and that done in retarding, the engine, all that is necessary is that the engine be moving neither faster nor slower at the end of the mile, than at the beginning of it.

Another illustration will serve to show the extreme generality of the principle in question. If a certain quantity of water have to be raised a certain height, the amount of work actually requisite for effecting the object is in all cases equal to the weight of water multiplied by the vertical height. This amount of necessary power or work is incapable of being diminished by any mechanical or hydraulic contrivance. The water may be contained in a vessel which is drawn up perpendicularly, as from a well, or which is drawn up an inclined plane or by a spiral path; or the water may be raised by an Archimedian screw, or by buckets attached to the periphery of a revolving wheel, or by a hydraulic-ram, or by a force-pump; or lastly, it may be thrown up in a jet, as from a fountain or fire-engine. But it is physically impossible, by these or any other methods, to diminish the requisite amount of labour. It is, of course, easy to increase the amount by a waste or unprofitable expenditure of labour, such as is caused by friction of the machinery, or the mutual action of the particles of water among themselves. But supposing no waste of force to occur—supposing all the power usefully employed in simply raising the water without doing anything else; then the amount of that power is in all cases just what has been stated—the weight of water multiplied by the vertical distance through which it is raised.

The rule is of universal application, and there is no other principle of dynamics of such great and constant utility in practical science; for it embraces all those cases of motion with which the engineer happens to be concerned—cases where the motion either ceases, or has the same values, at regularly-recurring intervals.

The case before us, of the transit of a weight along a girder, is a striking exemplification of this Principle of the Conservation of Work. For this principle enables us immediately to compare the effect of a weight moving along the girder, and that of the same weight stationed at its centre, and descending. If the deflection be the same in both cases, the work done by the descent of the load in both cases is the same—namely, the weight multiplied by the vertical descent: and this is true, whatever be the path of descent. Now, it has already been shown, that in the case of instantaneous loading, the work done by the descent of the weight is equal to that necessary to produce in the beam the deflection which twice the weight would statically maintain. Hence, the travelling weight can do no more.

The value of this conclusion appears the greater, when it is considered that it avoids all hazardous hypotheses as to the forms assumed by the beam during the transit. However the beam may be bent—whatever may be the nature of its vibrations and internal action, this is certain,—that when its elasticity is unimpaired, a weight travelling along it cannot, under any circumstances whatever, more than double its corresponding statical deflection. To suppose it capable of doing more, is to suppose the physical impossibility of a gain of power.

But though the travelling weight cannot, under any circumstances, produce *more* than double the statical deflection, it is quite possible that it may do *less*. A large portion of the work done by the weight may be absorbed in producing lateral vibrations and other irregularities of motion in the beam. All these concomitant operations act by way of diminution, and tend to make the dynamical deflection *less than* double the statical central deflection.

In determining the actual amount of this diminution, the velocity of transit must be taken into account. For that there is some particular velocity for which the deflection is a maximum, is obvious from this simple consideration—that when the weight travels exceedingly slowly along the beam, it always exerts a statical pressure, and does not tend to increase by momentum the deflection beyond its statical amount;—and, on the other hand, when the weight travels with excessive rapidity, it may not have time during the transit, to sink even the distance of statical deflection. To take the limiting case, when the velocity is indefinitely great, the descent of the weight must be indefinitely small; for even if it fell freely, and there were no beam to support it, the distance of descent in an indefinitely short time is inappreciable.

Effect of the Inertia of the Beam.

There is, then, between the exceedingly high and the exceedingly low velocity, some particular intermediate speed which produces the greatest possible deflection. Before, however, considering what that velocity is, or endeavouring to establish a direct relation between the velocity and the deflection, it is necessary to examine more particularly the case just referred to—where the velocity of transit is so great, that the weight has not *time* to sink beyond a certain degree.

Now, there are two ways in which this consideration of time might be supposed to affect the amount of deflection. The first is that already stated, where the period of transit is so short, that even if the weight descended freely, without support from the beam, its descent would be inconsiderable. This case may, however, be at once excluded, when it is considered that at all practicable railway velocities, the time of transit over a long girder (50 to 80 feet) could not be much less than one second, that a body would fall freely upwards of 16 feet in that time, and that its actual descent (equal to the deflection of the girder) is only a few inches.

But there is another way in which the consideration of time might be supposed to affect the deflection: there might not be time enough to overcome the inertia of the beam. This case requires more particular examination.

A person skating over a weak piece of ice may sometimes, by moving rapidly, glide over it safely before it have *time* to break—that is, before the pressure of his body have impressed on the ice the downward motion sufficient for it to attain the point of fracture while he is passing over it. Now, by the general principles of mechanics, the same pressure which, acting for a given time, would produce a great velocity in a small mass, will produce proportionably little velocity in a large mass. In order then that the inertia of the ice may, in the case supposed, be a cause of safety, it must be large in comparison with the pressure acting on it; that is, the mass of ice acted upon must greatly exceed the mass of the man's body.

In the same way, in order that the inertia of a girder might be a cause of security, the mass of the girder must be very much greater than that of the train passing over. But it will be shown that the mass of the former does not, for heavy loads, exceed that of the latter so greatly as to perceptibly diminish the deflection. It has sometimes been found useful to add to the inertia of the girder by laying on it heavy ballast, and by this means the structure is rendered *steadier*,—that is, the slight lateral oscillations and other irregularities of motion are reduced. But it is only these smaller or subsidiary movements that can be diminished by adding to the weight of the girder. Its mass, and that of the permanent load upon it, is not in generalso large as to materially influence the main, or vertical, deflection, when produced by nearly as heavy a load as it will safely bear.

When the train passes over the girder, the centre of gravity of the whole system sinks, the impressed moving force downwards being the weight of the train, and the motion of the centre of gravity being retarded by the elastic force of the girder.

To take a case every way unfavourable to the conclusion which we wish to establish, let the greatest deflection be 3 inches, and the velocity of the transit so great that the weight passes over the girder in a second of time. This would be the time of transit over a girder 88 feet long, at the rate of a mile a-minute. Now, the extreme deflection may be supposed to be accomplished in half the time of transit, or the centre of the girder sinks 3 inches in half a second. The centre of gravity of the whole system at no time sinks so much as the centre of the beam sinks, for its two ends do not sink at all. On the whole, it seems an ample allowance to suppose the maximum vertical descent of the centre of gravity of the beam $1\frac{1}{2}$ inch. Now, to find the work which would *alone* produce this velocity, we must have an equation of *vis viva*, excluding the retarding force.

By the ordinary rules for calculating the rectilineal motion of bodies, if a given mass M originally at rest be acted upon at its centre of gravity by one uniform force f moving through a space s in the time t,

$$2\,M\,s = f\,t^2.$$

Suppose the force to be that of a small weight. The mass of this weight will be found (on substituting numerical values and putting gravity $= 32$) to be only the 32d part of M, if the latter move through $1\frac{1}{2}$ inch in half a second.

The beam is usually constructed to bear a pressure considerably exceeding its own weight. In that case *less* then one 32d of the work actually exerted by the travelling weight would suffice for the mere acceleration of the beam: and we come to the conclusion, that even at the highest practicable velocity, the power required to set the beam in motion subtracts very little of the power producing deflection. In other words, when the mass of the load is not small compared with that of the beam, the deflection is never materially influenced by the inertia of the beam.

Influence of the Velocity of Transit on the Deflection in the case of a Single Weight.

Having arrived at the important conclusion that when the travelling weight is large, the inertia of the beam is an immaterial consideration, or that the effective moving forces are inconsiderable compared with the impressed forces, we might suppose the mutual pressure between the beam and the weight statically equal to the force which the former by its elasticity exerts in an upward direction to resist deflection.

But, in fact, the mutual pressure between the beam and the weight is an unknown force, not generally susceptible of exact determination. During the first part of the motion, the weight does not, so to speak, exert its full pressure on the beam, for the surface yields and recedes before it. During the latter part of the descent, on the contrary, the pressure in question exerts a superior power, to destroy the momentum previously acquired by the descending weight. The weight then moves downwards, first with an accelerated, and subsequently with a retarded, velocity: or the pressure on its under side is in the former stage of motion, less, and in the latter stage greater, than the effect of gravity.

The path of the weight is likewise unknown, for the motion is made up of two parts—the motion along the beam, and the motion of the beam itself. If, indeed, it be assumed that the motion is always along the beam, or that at every instant the curvature of the beam has, at the point of mutual contact, the same tangent as the path of the weight, the problem would be capable of solution. The investigations of Professor Moseley and M. Navier have determined the curvature of the beam sufficiently to afford means of tracing the curve described by the moving weight; and therefore its pressure, which is equal to its centrifugal force + the effect of gravity, might be ascertained.

The hypothesis which would lead to these results is, however, arbitrary and unsafe: and besides, the curvature of the beam as mathematically determined, is not exactly that which occurs in actual practice, where the elasticity is always more or less imperfect. The difficulty is however of no great importance, because, as will be presently shown, it does not occur where the moving body is not a single weight, but a long train. And the subject is here referred to, merely to show the almost insuperable difficulties of determining the motion of a single weight along an elastic beam.

Uniformly Distributed Load.

We have hitherto considered the effect of a single weight pressing only at one point of the girder. The more important practical case, where the pressure is applied to a considerable surface, remains to be examined.

In entering upon this inquiry, the consideration of horizontal motion will be in the first instance excluded. The distinction between the effects of gradual and instantaneous loading has been already pointed out, in reference to a single weight; and the comparison may now be extended to the case of an uniformly distributed load. If this load be gradually laid on, it produces less deflection than when laid on all at once. A series of weights applied simultaneously all along the undeflected girder, will move vertically downwards, and acquire momentum which has to be destroyed by an increased exertion of the elastic forces of the girder. In this case, as in that of a single weight, the ultimate deflection and pressure will be doubled, as will be demonstrated by analogous principles.

The beam being, as before, supposed to be perfectly elastic, the central deflection is proportional to the weight of the uniformly distributed load. If a be the length of the beam, x the central deflection, u the weight of a unit of length of the load, we may put $u\,a = \alpha\,x$, where α is a determinate constant.

Let x', y' be co-ordinates of any point in the surface of the beam, which is supposed to have the same curvature as its neutral axis. Then as the curvature is always exceedingly small, $u\,dy'$ is the weight of an element of the load, and $u\,dy'\,dx'$ represents the product of this weight and its virtual velocity, when the centre of the beam is displaced through a small vertical distance dx. The product of all the pressures and the corresponding virtual velocities is equivalent to

$$\int u\,dx'\,dy',$$

taking y' between the limits 0 and a. It may mathematically be shown that this integral is equal to $u\,a\;d\bar{x}$, where $\bar{x}$ is the vertical ordinate of the centre of gravity of the load. Also, from the equations given by Professor Moseley, in his "Principles of Engineering," Art. 374, it may be shown by a simple process, which is here omitted for the sake of brevity, that $\bar{x}$ is proportional to x, and may therefore be put $= \beta\,x$, where β is a determinate constant.

Hence, $u\,a\;d\bar{x} = \alpha\,\beta\,x\;dx$.

The integral of this, between limits 0 and x, is the total work done in producing the central deflection. This integral is equal to

$$\alpha\,\beta\,\frac{x^2}{2} = \frac{\alpha\,x}{2}.\bar{x}.$$

Or the "work done" is equivalent to that produced by a weight which would statically maintain half the deflection, moving through the whole space which the centre of gravity actually described. Hence, by the same reasoning as applied to the case of a single weight, *the statical deflection and pressure are doubled by instantaneous loading.*

Transit of a Continuous Load.

By combining the conclusion just arrived at with the principle which has here been termed the Principle of the Conservation of Work, it is readily seen that the statical strain and deflection cannot be more than doubled by the transit, at any horizontal velocity, of a uniform load of the same length as the girder. Indeed, the dynamical will in general be considerably less than double the corresponding statical effects.

It has been shown that where the weight of the load sustained is nearly as great or greater than that of the beam, the force required to produce motion in the beam is inconsiderable compared with the actual deflecting forces. The beam itself, therefore, is then always nearly in a state of equilibrium, and its form nearly the same as that which would be statically produced by the external pressures. If this be assumed to be strictly true, it follows that the curve of deflection is concave in every part, and therefore that no part of the beam sinks while another part is rising—that *all* the parts sink together, and all rise together. The vertical motion is so extremely small and gradual, that there can be no danger in assuming that all the parts arrive at their lowest positions at the same instant. It follows then, as previously to that instant the motion was downwards, and subsequently upwards, the beam in its lowest position is at rest, either instantaneously or for a definite period.

In this position of rest, the pressures on the surface of the beam are in statical equilibrium with its internal forces. At the same time, the pressure produced by the travelling load is the same as if the curve of deflection were a *fixed* curve.

Effect of Centrifugal Force.

When a body, moving along a fixed curve, is acted upon by no forces but the pressure of the curve and its own weight, the pressure on the curve (by the known principles of mechanics) is equal to the centrifugal force, plus the normal component of the weight. The curvature of a deflected girder is in general so exceedingly small, that it will be quite safe to assume the pressure equal to the centrifugal force, plus the weight itself. The curve assumed by the surface of the beam depends on the forces acting on it; and we here suppose the beam to be at *rest*, although the load upon it is in motion. Hence, the elastic forces of the beam are in *statical* equilibrium with the pressures on the curve.

The origin of co-ordinates being at one end of the beam, and the axis of x, measured vertically downwards, at any point (x, y) of the curve, the tangent of the angle of horizontal inclination is $\frac{dx}{dy}$, which is always very small. Hence, neglecting the square of that quantity as inconsiderable compared with unity, we may put the inverse of the radius of curvature at the point $(x, y) = -\frac{d^2x}{dy^2}$. (The sign never changes, as the curve is everywhere concave upwards.)

From the theory of perfectly elastic beams, it appears that $\frac{d^2x}{dy^2}$ is, at every part of the beam, proportional to the moment about (x, y) of all the pressure acting between that point and either extremity of the beam. Here, the pressures between (x, y) and the origin are the centrifugal forces and the weights acting downwards, and the pressure of the abutment acting upwards. The moment of all the centrifugal forces may be first ascertained.

Each small portion of the load may be supposed to act independently of the rest, or to press on the curve with its own weight and its own centrifugal force. Let m be the unit of mass; and therefore, at any point $(x'\ y')$ intermediate between (x, y) and the end of the beam, $m\,dy'$ the mass of an element of the load. Calling V its linear velocity, it appears from what has been already said about the radius of curvature, that $V^2 \frac{d^2x'}{dy'^2} m\,dy'$ is the centrifugal force of that element. The moment of this centrifugal force is $-V^2 \frac{d^2x'}{dy'^2} \cdot (y-y')\,m\,dy'$.

The moment of all the centrifugal forces about point (x, y) will be found by integrating this expression between the limits $y' = 0$ and $y' = y$. So it may be ascertained that the moment of these forces is

$$m\,V^2\,(y \tan\beta - x),$$

where β is the horizontal inclination of the curve at the origin. $y \tan\beta - x$ is the length of a vertical line drawn downwards from the point (x, y) to meet the tangent drawn from the origin; and is very small.

The weight of the portion of the load upon the horizontal length of the beam y, is $m g y$; and its moment about the point (x, y) is the same as if the weight were collected at a point half way between (x, y) and the origin, and therefore equals $\frac{m g y^2}{2}$.

Also, if P be the pressure of the abutment, Py is its moment; and representing the constant, by which the radius of the curvature has to be multiplied to render it equal to the sum of the moments, by E I, we have—

$$\mathrm{E\,I}\frac{d^2x}{dy^2} = m g\,\frac{y^2}{2} - \mathrm{P}\,y + m\,V^2\,(y \tan\beta - x).$$

This equation is integrable in its present form; but as the last term of it is very small, we may make an alteration which will tend very much to the simplicity of the results. The centrifugal pressures cannot under any circumstances be great compared with the other forces, as may readily be foreseen by considering that in all cases of actual practice, the curvature is very small on account of the very small proportion which the central deflection bears to the length of the beam. *For any central deflection previously assigned*, the curve would be very little altered if the centrifugal pressure were uniformly distributed. Therefore, in the above equation, the small term $m\,V^2\,(y \tan\beta - x)$ is neglected in estimating the radius of the curvature merely. Now, it appears from the "Mechanical Principles of Engineering," Art. 374, that when the beam is subject to any uniformly distributed pressures whatever,

$$\frac{d^2x}{dy^2} = \frac{24\,\mathrm{D}}{5\,a^4}\,(\tfrac{1}{2}\,y^2 - a\,y),$$

where a is half the length of the beam, and D is its central deflection. The curvature of the beam, when it assumes its permanent form under the influence of a passing load, will not greatly differ from that which this equation indicates. Of course, this hypothesis does not suppose the distribution of the centrifugal pressures to be actually uniform—it merely presumes that the curvature of the beam, *for a given deflection*, is nearly the same as if the pressures were so distributed.

From the equation last given, the value of $\frac{d^2x}{dy^2}$ at the centre, is $-\frac{24\,\mathrm{D}}{10\,a^2}$. Therefore, at the centre, a weight moving with velocity V, has a centrifugal pressure $= V^2 \cdot \frac{24\,\mathrm{D}}{10\,a^2}$ times its mass.

To ascertain the whole effect of centrifugal pressure, we have evidently the expression

$$-\int m\,V^2\,\frac{d^2x}{dy^2}\,dy = -m\,V^2\,\frac{24\,\mathrm{D}}{5\,a^4}\int(\tfrac{1}{2}y^2 - a\,y)\,dy,$$

integrating between limits $y = 0$ and $y = 2a$.

From this, it appears that the total centrifugal pressure

$$= \frac{32}{m}\,\frac{\mathrm{D}}{V^2}\,10\ \ a, \text{ which becomes } m g a \frac{1}{10}\,\frac{V^2}{a^2}\,\mathrm{D}, \text{ if } g = 32$$

Now, if T be the number of seconds in which either end of the load traverses the beam, $\frac{V}{T} = 2a$, and $\frac{V^2}{a^2} = \frac{4}{T}$. Substituting this value, and remembering that the total weight on the beam is $2\,m g a$, we find ultimately,

$$\textit{Centrifugal pressure on whole beam} = \frac{1}{5}\,\frac{\mathrm{D}}{\mathrm{T}^2} \times \textit{the weight}.$$

What very strongly confirms this conclusion, and shows that no materially great error is contained in it, is the consideration that if the curve had been supposed to be a *circular* arc passing through the middle and two ends of the curve, the effect of centrifugal pressure would be almost the same as the above formula gives it. The only difference (as will be seen hereafter) would be, that in the formula we must substitute $\frac{1}{4}$ for $\frac{1}{5}$. When it is considered how exceedingly small the curvature of the beam must necessarily be in all practical cases, it becomes clear that a circular arc of large radius would represent the curve with at least tolerable accuracy. At all events, that assumption furnishes a safe test of the foregoing conclusions.

Rule for Calculating the Pressure.

The formula then gives all the information that can be generally required, respecting the influence of the velocity of the train, or its pressure on the deflected girder, when the mass of the former is not small compared with that of the latter. Put into ordinary language, the formula amounts to this—that *when a long uniform load moves over a girder which is perfectly elastic, originally horizontal, the greatest pressure on the girder is that of the weight on it at any time + a small fraction of that weight, which fraction is found by dividing one-fifth the deflection (in parts of a foot) by the square of the number of seconds in which either end of the load traverses the girder.*

In order to give a clear idea of the value of the formula, and to show how small the influence of velocity generally is, one or two practical applications may be given.

A heavy train moves over a girder 88 feet long, at the rate of a mile a minute, and the observed deflection is one-third of a foot. To find the pressure on the girder.

In this case, either end of the train moves over the girder in one second. The square of the number of seconds is therefore 1. The deflection is $\frac{1}{3}$. Therefore, the fraction of the weight is $\frac{1}{15}$. Or the extreme pressure on the girder is one-fifteenth more than the weight on it at any time.

A train moves off a girder in three-fourths of a second, and the observed deflection is one-fourth of a foot.

Here the square of $\frac{3}{4}$ is $\frac{9}{16}$. One-fifth the deflection is $\frac{1}{20}$; and $\frac{1}{20}$ divided by $\frac{9}{16}$ gives $\frac{4}{45}$; or the pressure is not quite one-twelfth more than the weight at any time on the girder.

These instances give the dynamical pressure as large as it is ever likely to be with a properly-constructed girder-bridge. They consequently show that the dynamical pressure of heavy loads, even at high velocities, very little exceeds the statical; and at low velocities, differs from it only in an inappreciable degree.

It will be observed, that if the velocity be indefinitely increased, or T in the formula indefinitely diminished, the dynamical pressure is indefinitely increased. But the formula virtually excludes these hypothetical cases; for the investigation proceeded on the assumption that the centrifugal pressures are comparatively small, and that the whole pressure produces but a small deflection.

Defect of Elasticity.

It now remains that something be said of the defect of elasticity, and the modifications of the above results when applied to jointed or compound structures. The ordinary mathematical theory of the girder is based on the law of perfect elasticity, known as Hooke's law—namely, that the elastic force is proportional to the extension or compression.

It appears from experimental inquiries, subsequent to, and more extensive than, Dr. Hooke's, that this law is not quite true. The elastic force is in reality less than the law would assign it to be. Mr. Hodgkinson, in his recently published "Researches on Cast-Iron," Art. 106, seems inclined to think that the elastic force may be expressed by $a\,x - b\,x^2$, where x is the measure of compression or extension, and a and b constant empirical co-efficients. That this hypothesis is near the truth may be inferred from the consideration, that if the elastic force be expressed by a series in ascending powers of x, all terms involving high powers must be very small, as the elastic force is always nearly equal to the first term, and x is very small. It may, however, be worth while to remark, that if $a\,x - b\,x^2$ be taken to express correctly the elastic force, the same value of x, which reckoned positively gives the tension, will not, when reckoned negatively, give the same value for the pressure. In order that this may be the case, only uneven powers of x must be involved.

But whatever law of elasticity be assumed, this is easily ascertained—that where the elasticity is imperfect (that is, where it is less than in proportion to the extension or compression), the deflecting pressure of a girder will be less than in proportion to the deflection. In cast-iron girders, cast in one piece and in metal of good quality, the defect of elasticity is small; and consequently the deflection is pretty nearly proportional to the pressure. But in jointed structures, compounded of several parts connected by rivets or bolts, this is by no means the case. In them, the defect of elasticity must be great; and the deflection will therefore increase at a considerably higher rate than in proportion to the external pressure. If a load of 200 tons produce in a compound girder 2 inches deflection, 300 tons will produce considerably more than 3 inches deflection. Or, if 300 tons produce 3 inches deflection, 400 tons will produce considerably more than 4 inches deflection. *How* much more can be ascertained only from actual experiment.

It is very important that this distinction between simple and compound girders should be always taken into consideration, for the neglect of it would lead to very erroneous conclusions respecting the strength of structures of the latter kind. As cases in point, may be instanced calculations respecting the strength of girders formed in three pieces and supported by tension-rods. Formulæ which determine the strength of simple, unjointed girders, are inapplicable to these structures, and are not likely to give even an approximation to the amount of their real strength.

Where, however, the compound-girder is so well constructed, that its curvature, when deflected, is regular and free from sudden inflections, the formula given above for the dynamical pressure of long trains on perfectly elastic beams, will apply with considerable accuracy. For the deflection being previously assigned, is a safeguard against any very great error. That deflection being small, the curvature will also be small; only, on account of the defect of elasticity, it increases *cœteris paribus* more rapidly towards the centre of the beam, than it would if the beam were perfectly elastic. Consequently, the pressure towards the centre is comparatively greater in the compound, than in the simple girder: and pressure towards the centre is more effectual in producing deflection than pressure near the ends of the girder.

Consequently, there are two reasons why velocity increases the deflection of a compound, more than that of a simple, girder. In the first place, on account of the defect of elasticity in the jointed structure, its deflection increases in a higher degree than in proportion to the external pressure. Secondly, that external pressure is of necessity greater for the jointed than for the simple girder, because in the former the curve is sharper towards its centre. Velocity of transit has therefore much greater influence on the security of girders of the former, than of the latter kind.

It would have been satisfactory to have been able to confirm the results of these investigations, by reference to actual experiments. Unfortunately, however, there are at present but very scanty data for the purpose. An account of two experiments made on the Dee-bridge, of the Holyhead Railway, is all that can be cited. These experiments are described in a Report to the Commissioners of Railways, 15th June, 1847. An engine and tender, about 30 tons weight, passing over the bridge at 15 miles an hour, produced "a deflection nearly the same as with the engine at rest—viz., from $\frac{5}{8}$ to $1\frac{1}{16}$ of an inch." In another experiment, "an engine and train of 48 tons, at rest, gave a deflection of 2·4 inches; while the deflection caused by the same train at a speed of 15 to 20 miles an hour, was only $1\frac{3}{8}$ of an inch."

These accounts do not however furnish much information suited to our present purpose. In the first place, the experiments were made on a jointed structure of a complex nature, and of which the deflection appears, even from this brief account, to have followed no simple law. Moreover, in the first experiment, the deflection is not actually determined: it is merely said to have been from $\frac{5}{8}$ of an inch to three-sixteenths more; and in both, the mass of the girder greatly exceeded the mass sustained. All the inference that can be drawn is, that velocity did not very materially influence the deflection, but that the deflection was diminished at the highest velocity, the load sustained being comparatively light.

Means of Diminishing the Dynamical Pressure.

When a ball moves along a perfectly horizontal surface, the pressure on its under side is just equal to its weight, for this simple reason—that if the pressure were greater, the ball would rise; if less, sink.

In the same way, if a train moved along the surface of a girder which remained perfectly horizontal during the transit, its pressure would be just equal to its weight. But the train generally sinks a little, and acquires a momentum downwards, which has to be destroyed by increased pressure. The simplest precaution against this effect is—not to remedy it—but to prevent its existence. Suppose it be found that, when a certain weight travels along a certain girder which is originally perfectly horizontal, it produces a deflection of three inches at its centre: then, if the rails had a rise given them of three inches towards the centre, it is clear, that when the same weight travelled over them, it would be no lower when at the centre, than when at either end, of the beam.

Suppose now the reverse case—that there is a hollow or depression originally in the beam. Then, when the weight passes over the beam, it sinks the distance of this original depression, in addition to the deflection produced by pressure. Hence, the downward momentum is materially greater than if the beam had been perfectly horizontal originally. Or, to take another view of the question, the original hollow or depression, added to the deflection, increases the curvature of the beam, and therefore the centrifugal pressure of the load. Either way, then, of viewing the effect of the hollow, either in increasing the momentum downwards, or in increasing the centrifugal pressure, leads to the same result—that the pressure is increased. Mathematically, these two views of the case coincide.

It is seen, then, how extremely important it is that there should be no original hollow in the beam. On the contrary, it is advantageous that its surface should be convex, instead of concave—or should have a *camber*. In this case, the centrifugal pressure would act upwards instead of downwards; so that the pressure, instead of being greater than the weight, would be less at high speeds.

There is a very simple way of calculating this diminution, or of estimating the centrifugal force. And it may be remarked, parenthetically, that the method about to be given is useful for many purposes besides that to which we are to apply it. For example, it furnishes most simple and ready means of ascertaining the horizontal pressure on the flanges of the wheels of carriages going round railway curves.

If a be the length of the chord of a circular arc, which is of large radius, and x its lineal versed-sine, or the length of the perpendicular drawn from the centre of the arc to the chord, it will be found that the radius nearly equals $\frac{a^2}{8x}$.

Now, if V be the velocity of a mass m, moving round this curve, its centrifugal force becomes $m\,V^2\,\frac{8\,x}{a^2}$; and if T be the number of seconds in which any part of the mass describes the distance a, $\frac{V^2}{a^2} = \frac{1}{T^2}$. Substituting this value, and putting $g = 32$, the centrifugal force is equal to $\frac{x}{4T^2}\times$ the weight. This formula applies to horizontal railway curves, as well as to the vertical curves of a beam. Confining attention however to this application of it, we see that a very considerable reduction of the pressure of the weight may be effected by curving the upper surface of the beam. Suppose, for instance, that the time of transit were one second ($T = 1$), and that it were practicable to give the rails such a convexity that the rise at the centre was one foot ($x = 1$). Then, from the formula, it appears that the centrifugal pressure would be one-fourth the weight, or that only three-fourths the weight pressed on the beam.

It may be remarked that this law has most important effects on such stupendous structures as the tubular bridges for the Chester and Holyhead Railway. The Conway-bridge, after it was constructed, sank eight inches at the centre by its own weight; this depression was anticipated and corrected by a previous upward convexity of the tube. But in this, and all analogous cases, a rise or convexity, considerably *exceeding* the natural depression, would tend greatly to security: because, the curve being convex, an increase of the velocity would diminish, instead of increasing, the pressure of a given load. It may therefore be safely asserted, that *it contributes to the security of girders to give their upper surfaces as great a convexity as is consistent with other practical requirements.*

General Conclusions.

At the close of these investigations, it may be convenient to recapitulate the general conclusions derived from them. They comprehend the following laws for the motion of very heavy loads at practical velocities over horizontal girders.

1. If the girder be perfectly elastic, the pressure exceeds the weight on the girder by a fraction of the weight, not more than one-fifth the actual deflection (in parts of a foot), divided by the square of the number of seconds in which either end of the load traverses the girder.

2. In compound and imperfectly elastic girders this fraction is increased.

3. The influence of the inertia of the beam on its deflection is inconsiderable.

4. In all girders, a convexity of their upper surface, or rise of the rails from end to centre, may be made to materially diminish the pressure.

These conclusions will, it is believed, furnish a tolerably accurate idea of the influence of moving loads upon railway girders. The only subject on which no definite investigation has been here attempted, is the defect of elasticity in jointed girders. The modes of construction of compound girders are so numerous, that to establish any general law respecting them is obviously impossible—no accurate knowledge can be derived of the law of elasticity or deflection in these cases, but by direct experiment.

No pains have been spared to render the views here expressed, correct. They have occupied many months of reflection, and have been subjected to the careful revision of the author's mathematical friends. As the great object has been to exclude all operose mathematical investigations, it will be readily understood that the subject, by constant corrections and simplifications, has assumed an entirely different shape to that originally given to it,

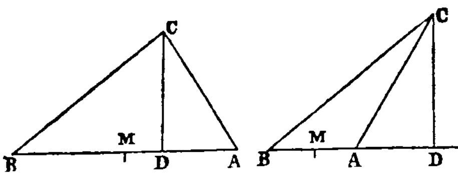
ON MR. CLARKE'S SURVEYING PROBLEM.

The problem proposed and solved by Mr. Clarke, in last month's *Journal*, p. 230, is by no means so new as he appears to think. The form under which the problem is most usually presented, is:—

Given the base and the angles at the base; to find the perpendicular, and the segments into which it divides the base.

Mr. Clarke's angles β and θ are the complements of the angles at the base of the triangle C A D, as is obvious. (*See* his figure, p. 230.)

The following investigation of the question is taken, almost literally, from the 12th edition of "Hutton's Course"; and it will be at once perceived to be more brief and simple than Mr. Clarke's.



Let C D be the perpendicular from the vertex to the base, and denote the angles of the triangle, as usual, by A, B, C, respectively. Then, by right-angled triangles, we have—

$$\mathrm{C\,D} \cot \mathrm{B} \pm \mathrm{C\,D} \cot \mathrm{A} = c, \text{ or}$$

$$\mathrm{C\,D} = \frac{c}{\cot \mathrm{B} \pm \cot \mathrm{A}} = \frac{c \sin \mathrm{A} \sin \mathrm{B}}{\sin (\mathrm{A} \pm \mathrm{B})} = \frac{c \sin \mathrm{A} \sin \mathrm{B}}{\sin \mathrm{C}}.$$

This value of C D is often required in problems of this class, giving (in Mr. Clarke's illustrative example) the *horizontal* distance of the point of observation from the observed object. It likewise as frequently occurs in determining the height of an object, as a hill, upon a horizontal plane.

From substituting the above value of C D in the equations, A D = C D cot A, and B D = C D cot B, we obtain

$$\mathrm{A\,D} = \frac{c \cos \mathrm{A} \sin \mathrm{B}}{\sin \mathrm{C}}, \text{ and } \mathrm{B\,D} = \frac{c \sin \mathrm{A} \cos \mathrm{B}}{\sin \mathrm{C}}.$$

I have left these expressions in sines and cosines, instead of changing the denominator into the factor cosec C. There is no doubt that the better form of working, *when* C *does not contain seconds* (with the ordinary tables I mean, for surveyors seldom use tables to seconds), is the form which Mr. Clarke has adopted: but in the other case it is somewhat questionable.

As, however, this is a mere question of experience—perhaps, too, of habit—every one should adopt the plan he can most easily use.

This mode of treating such problems is, in fact, the same with finding the co-ordinates of the point of observation, referred to the horizon and the vertical object observed. I have often been led to think, that if the greater part of the problems (if not all) which occur in surveying were systematically treated, according to the calculus appropriate to the co-ordinate system, the processes of computation would be considerably improved. Even were the actual work not materially lessened, the *systematising* of the entire class of problems would be in itself a great practical advantage.

When, however, we confine ourselves, as Mr. Clarke has done, to finding the difference of levels, a still shorter method of operating may be used, for it requires one reference less to the tables. It may be thus investigated.

Let M be the middle of A B; denote A B by $2a$, and M D by x.

Then (fig. 2) A D $= x - a$, and B D $= x + a$; whence

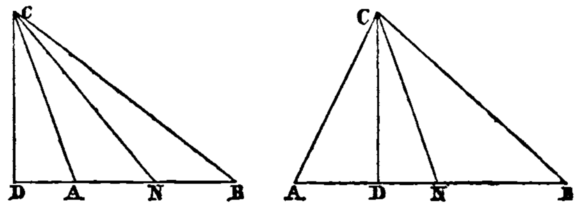
$$\mathrm{A\,D} \tan \mathrm{A} = \mathrm{C\,D} = \mathrm{B\,D} \tan \mathrm{B}, \text{ becomes}$$

$$(x - a) \tan \mathrm{A} = (x + a) \tan \mathrm{B}, \text{ or}$$

$$\frac{x - a}{x + a} = \frac{\tan \mathrm{B}}{\tan \mathrm{A}}; \text{ or again, } x = \frac{a \sin (\mathrm{A} + \mathrm{B})}{\sin (\mathrm{A} - \mathrm{B})}.$$

A corresponding form, adapted to the case represented in fig. 1, is deducible in the same way; but further notice of it here is unnecessary. A formula so simple, and so easily derived, can scarcely be new. Still, I do not recollect to have noticed it elsewhere.

Another variation of the same general problem is often useful. It is, *where the segments of the base* A B, *and the angle* C, *are given, to find the perpendicular* C D.



Put DA $= a$; D B $= b$; AC B $= 2\gamma$; let C D bisect BCA; and denote N C D by θ, and C D by x. Then we have

$$\mathrm{B\,C\,D} = \theta + \gamma, \text{ and } \mathrm{A\,C\,D} = \pm (\theta - \gamma);$$

$$\text{and } a = \pm x \tan (\theta - \gamma); \; b = x \tan (\theta + \gamma).$$

Wherefore,

$$\frac{a}{b} = \frac{\pm \tan (\theta - \gamma)}{\tan (\theta + \gamma)} = \pm \frac{\sin (\theta - \gamma) \cos (\theta + \gamma)}{\cos (\theta + \gamma) \sin (\theta - \gamma)} = \pm \frac{\sin 2\theta - \sin 2\gamma}{\sin 2\theta + \sin 2\gamma}$$

$$\text{and hence, } \sin 2\theta = \pm \frac{a - b}{a + b} \sin 2\gamma.$$

Whence the angle θ becomes known, and is very easily computed; and hence the perpendicular C D is obtained from either of the preceding equations,

$$x = \pm a \cot (\theta - \gamma), \quad x = b \cot (\theta + \gamma).$$

—But I need not further dilate on so simple a subject.

UBIQUE.

5th August, 1848.

THEORY OF STEAM-ENGINES.

Account of the experiments to determine the principal laws and numerical data which enter into the calculation of Steam-Engines. By M. V. Regnault.

(*Continued from page* 240.)

Second Memoir.—The determination of the density of gases.

The common method of determining the density of a gas consists in weighing a glass globe of great size:—

1st. When the globe contains perfectly dry air of a known temperature, and under a known atmospheric pressure:

2nd. After having exhausted it by means of the air-pump, so that the inclosed air exerts only a very feeble pressure, which, as well as the corresponding temperature, is noted:

3rd. After having filled the globe with the gas perfectly purified, the atmospheric pressure and temperature being again noted:

4th. After having again exhausted the globe, noting, as before, the pressure and temperature.

By which four weighings, and their accompanying observations of pressures and temperatures, all the data necessary for determining the density of the gas are given. But this method requires the exact knowledge of several elements, the determinations of which present generally great uncertainty.

In the first place, the temperatures which the air and the gas present at the moments of closing the globe, must be very exactly known; but the method generally used of having a thermometer placed near the globe is very defective: the temperature indicated by the thermometer may be totally different from that of the air in which it is bathed, and still more so from that of the gas which fills the globe.

MM. Dumas and Boussingault, who have lately (*Ann. de Chim. et de Phys.*, 3d *série, tome* III., *p.* 270) very successfully endeavoured to determine the densities of certain gases, place the thermometer intended to indicate the temperatures of the gases in the very centre of the globe; and for more security, they cause that temperature to be almost constant, by placing the globe in an inclosure formed by a large cylindrical vessel of zinc with double walls. The annular space left between the walls is filled with water, at a temperature differing but little from that of the surrounding air. With this arrangement, we may admit that the temperature of the gas is known with sufficient accuracy.

But the greatest uncertainties exist in the weighings of the globe; for we must weigh the globe in the air, and, to have its true weight, we must add to its apparent weight that of the air which it displaces. And, in certain cases, this latter weight is greater than that of the gas which fills the globe, so that it must be known with at least equal exactness. We are, up to a certain point, masters of the gas which we pass into the globe. We may prepare it so as to be sure of its purity; but it is not so with the external atmosphere; we are obliged to take it as it is. In a close chamber the air may change its composition very perceptibly; its temperature, and the quantity of moisture which it contains, very incessantly. MM. Dumas and Boussingault thought that they had completely avoided the errors arising from this source, by placing below their balance a large chest lined with lead, in which the globe suspended from one of the scales of the balance floats. A very sensitive thermometer is placed in this chest, and gives the temperature of the air. This arrangement is certainly far preferable to allowing the globe to hang freely in the air of the room; the globe suspended in the chest is kept from the currents of air, which render the weighings very uncertain, and the temperature of the air in which it is placed changes but slowly; but it does not do away with the errors arising from the changes in the composition of the air, and these are by no means negligible, especially when we are working with very light gases—such, for instance, as hydrogen.

At the same time that MM. Dumas and Boussingault were weighing gases, M. Regnault was also engaged in the determination of the density of steam under different pressures, and especially under very feeble pressures. He was struck with the uncertainties which the ordinary methods of weighing gases present, especially owing to the alteration of the density of the surrounding air, which seems to have attracted but little attention from men of science, and he was led to a method which presents a degree of certainty and precision which those heretofore used do not offer.

He avoids completely, and by a very simple artifice, the uncertainties which arise from the changes in the air in which the globe is weighed. In place of equipoising it by means of weights on the opposite scale, he balances it by means of a second hermetically-sealed globe of the same kind of glass, hung from the opposite scale. All the variations which take place in the air then affect the two globes in the same way, whether they arise from changes of temperature, barometric pressure, or composition of the atmosphere. It is not, therefore, required at the moment of weighing to watch the thermometer, barometer, and hydrometer; it is sufficient to wait until the two globes are in equilibrium of temperature, and when this is the case, it continues indefinitely. We have, in consequence, a very definite character by which to know when to read the weighings. This method presents also another advantage, that is, of avoiding the error arising from the different amount of moisture deposited upon the globe during different weighings. As the globes are made of the same glass, and equally dried before the commencement of the experiments, they may be assumed to condense the same amount of moisture when bathed in the same air, and consequently will remain in equilibrium.

The globes had a capacity of about 10 litres (2·2 gallons). The globe in which the gas is to be weighed has a stop-cock adjusted to it, so that it may be exposed to the temperature of boiling water without leakage. It is weighed when full of water, first in the air, and afterwards in water of the same temperature as that which it contains; thus is obtained the weight of water displaced by the globe.

The balancing globe is so selected that the weight of water displaced by it is rather less than that of the first, even after the addition of its metallic mounting by which it is hermetically sealed, and hung from the opposite balance scale; there is then added to it a glass tube of such capacity as that the weight of water displaced by it shall just make up the difference.

Before closing the second globe, a quantity of mercury was introduced into it so as to render it about 10 grammes (154·38 grains troy) heavier than the other. The two globes thus adjusted were submitted to several tests, in order to be sure that they satisfied the required conditions; they were left hanging for fifteen days under the balance scales, and the equilibrium was rigorously maintained all this time, although in the interval the temperature of the air had changed from 0° to 17°, (32° to 62·5° Fahr.,) and the barometric pressure from 741 to 771 millimetres (29·6 to 30·8 inches.) The general mode of operating was as follows:—A vacuum as complete as possible being made in the globe, it is placed in communication with the apparatus for producing the gas whose density is to be determined, and the stop-cock is opened in such a way that the gas in the apparatus preserves a slight excess of pressure. When the globe is filled with gas, it is again placed in communication with the air-pump, a very perfect vacuum made, and it filled a second time with the gas. In order to avoid any correction for temperature—a correction which would require the knowledge of the co-efficient of dilatation of the gas, and that of the globe—the globe is placed in a zinc cover and completely enveloped in melting ice. Before closing the globe, it is placed in direct communication with the atmosphere, so that the gas may place itself in equilibrium with the exterior pressure.

The globe taken out of the ice is carefully washed and dried, and hung from the scale of the balance. It requires a long time (often more than two hours) for the globe to take exactly the temperature of the surrounding air, and for its surface to cover itself with its normal amount of moisture. The balance used was able to appreciate with certainty a half milligramme when charged with one killogramme upon each scale.* It was placed over a large chest, such as used by MM. Dumas and Boussingault. At the end of the weighing, the observer did not approach the balance, but observed the oscillations of the index at a distance, with a telescope.

M. Regnault then notices the electric effects produced by wiping the globes, and the effects upon the weighings; he avoided it by wiping the globes with a napkin dipped in distilled water, and tested them by the gold-leaf electrometer. The pressures were measured by an apparatus which he describes under the name of a barometric-manometer. It consists of two tubes, one of which is an ordinary barometer of 20 millim. (0·8 in. diameter,) made very carefully; the other is a glass tube of the same diameter, which may, by a lead tube, be connected with the vessel in which pressures less than that of an atmosphere are to be measured; they plunge below into a cistern of mercury having a partition, so that the two instruments may be separated at pleasure by drawing off the mercury in the cistern of the manometer below the top of the

* That is, sensible to one four-millionth of the total load. Quere, whether this sensibility was determined after the globes had been hanging from the scales, and the balance in action for fifteen days?

partition; this is necessary during the exhaustion of the globe, and the re-admission of the gas, for these operations produce such great oscillations in the barometer as to introduce small quantities of air into the instrument, and thus vitiate the vacuum. The exhausted globe is weighed with the precautions that have been indicated. If P represent the weight of the gas when the barometer stands at H, and p that weight when the elastic force in the globe corresponds to a barometric height h, the weight of the gas at 0°, and under the normal pressure of 760 mil., is $(P-p)\frac{760}{H-h}$

To obtain a new weighing of the same gas, the exhausted globe, enveloped in ice, is placed in connection with the apparatus for generating the gas, and the series of operations which have been pointed out, repeated. The gas thus becomes purer at each operation. M. Regnault found that it is only from the fourth filling that the gas presents rigorously the same weight. It is desirable to satisfy one's self whether the gas upon which we are operating follows the law of Mariotte, at pressures below those of the atmosphere: this verification is absolutely necessary if the density of the gas is to serve for the determination of atomic weights. For the law of the volumes of gases, and the simple ratios which exist between their densities and atomic weights, exist rigorously only *at the limit*—that is, in a state of extreme dilatation; we must therefore see whether the anomoly in these laws does not commence already near the atmospheric pressure.

This is done by measuring the weight of the gas, with great care, at different degrees of elastic force, as marked by the comparison of the manometer and barometer.

Finally, by this means we may determine the weight of the gas which fills the globe at the temperature of 100° and under atmospheric pressure, and thus determine the density of the gas when compared with air at 100°. This new density must be exactly the same as that calculated for 0°, in order that it may serve in the calculation of the atomic weights; for it is necessary for this purpose that the gas should have the same co-efficient of dilatation as the atmospheric air; at all events the weight of the gas which fills the vessel at 100° compared with that which fills it at 0°, permits us to calculate the *co-efficient of the dilatation of the gas*.*

Again, in order to determine whether the gas follows the law of Mariotte, at the temperature of 100°, we have only to repeat the former experiments, filling the globe at this temperature, instead of at 0°.

M. Regnault then recapitulates the advantages of this method, which are,—that it gives the density of the gases with more precision, and far less trouble, than the methods formerly used; it gives these densities at identical temperatures at 0° and 100°, that is, at the fixed points of the thermometer, and consequently gives immediately the co-efficient of dilatation of the gas; and, finally, it permits us to determine with great exactness, whether the gas follows the law of Mariotte, at the temperatures of melting ice, and boiling water.

He then proceeds to give the detail of all his experiments, without a single exception, in order to allow the reader to judge of the degree of precision obtained by this method. It is not necessary that we should give these details—or those of the processes by which M. Regnault purified his gases; they were such as might be expected from one so familiar with all the minutiæ of physical science.

He first determined by nine experiments the weight of pure atmospheric air, freed from carbonic acid and watery vapour, which filled his globe at the temperature of 0°, and under the barometric pressure of 760 millim. (29·944 inches). The mean of these experiments was 12·7781 gr. The minimum, 12·7744. The maximum, 12·7809. The difference, 0·0065 or $\frac{1}{1977}$, very nearly $\frac{1}{2000}$ of the mean; and he remarks that it is probable that a great part of this error is due to the variations which occur in the composition of the atmosphere. He regards it as unfortunate that men of science should have selected the atmospheric air, whose constitution is known to vary, as the standard of densities for gases, in place of some gas which could always be obtained perfectly pure, such for instance as oxygen, which would be the more convenient since this gas is already chosen as the basis of the tables (adopted by continental chemists) of chemical equivalents.

Founded upon this determination of the weight of a given volume of air, he proceeds to determine the densities of different gases, and his results are as follows:—

* This is the only direct method which can be used for this determination, in gases which attack mercury.

	Tem. at 0° Bar. 760 m.	Minimum.	Maximum.	Difference.
Nitrogen, mean of 6 Experiments,	0·97137	0 97108	0·97155	$\frac{1}{2000}$
Hydrogen, „ 3 „	0·06926	0·06923	0·06932	$\frac{1}{770}$
Oxygen, „ 3 „	1·10563	1·10561	1·10565	$\frac{1}{3000}$
Carbonic Acid, 5 „	1·52910	1·52900	1·52916	$\frac{1}{1020}$
„ at 0° and 374·13 millim.	1·52366			
„ „ 224·17 „	1·52145			
„ 100° 760 00 „	1·52418			
„ „ 883·39 „	1 52410			

Densities determined by Dumas and Boussingault.

Nitrogen, from	..	0 970	to	0 974
Hydrogen, „	..	0·0691	„	0·0695
Oxygen, „	..	1·1055	„	1·0158

If we calculate the theoretic density of carbonic acid gas, admitting for the atomic weight of carbon 75, (oxygen = 100, or 6 if hydrogen = 1,) lately found by M. Dumas, we get the number 1·52024, which approaches the density found for this gas under the pressure of 224·17 millim. (less than nine inches.)

The density found at the temperature 0° and normal atmospheric pressure leads to an atomic weight for carbon 76·6 which approaches very nearly the number 76·44 (6·1152, if hydrogen = 1) which chemists for a long time admitted from the experiments of M. Berzelius.*

We see, by this example, how much circumspection is necessary in deducing the value of the atomic weight of a gas from its density.

Three experiments to determine the co-efficient of dilatation of the air between 0° and 100°, gave as the result 0·03663, which differs but little from the value obtained in the First Memoir.

An attempt to verify the law of Mariotte showed slight differences, in which the weights by experiments were always a little lower than those got by calculating the density by means of Mariotte's law from the observed elastic force; but these differences were always within the limits of the errors of observation.

The co-efficient of dilatation of carbonic acid gas between 0° and 100° was determined to be 0·003719. (In the First Memoir, the determination by the method V., in which the gas preserved the same elastic force at 0° and 100°, as in the present case, was 0·0037099.)

The experiments to determine whether carbonic acid gas obeys the law of Mariotte at pressures less than that of the atmosphere, gave the following results:—

			By experiment.	Calculated by Mariotte's law.
Weight of the gas at	0°,	and with an elastic force 224·17 mil.,	5·7345 gr.,	5·7634 gr.
„	„	„ 374·13 „	9·5845 „	9·6628 „
„	101·01°	„ 338·39 „	6·8549 „	6·3545 „

so that it appears that carbonic acid gas deviates notably from the law of Mariotte at ordinary temperatures, but conforms to it with the limits of experimental errors at 100°.

THIRD MEMOIR.—DETERMINATION OF THE WEIGHT OF THE LITRE† OF AIR AND OF THE DENSITY OF MERCURY.

In the preceding memoir, the densities of the different gases were determined, referring them to that of air assumed as the unit; but in a great number of circumstances, it is required to know the absolute weight of these gases: this is easily obtained when we know the absolute weight of air under the normal conditions, that is at a temperature of 0°, and under a pressure of 760 millimetres of mercury.

The weight of the litre of dry air under the normal conditions was determined by MM. Biot and Arago, with all the care which they could take—they found that at Paris this weight was 1·299541 gr. (*Memoirs of the Academy of Sciences for* 1806. *Biot Traité de Physique, tom.* 1, *p.* 387.) This number has been generally adopted.

But if we reflect upon the imperfections which the theory of gases and vapours still presented at that time, and the great number of uncertain corrections which they were obliged to introduce into their calculations; and if we note that they operated upon air charged with aqueous vapour, for which they endeavoured to allow by a correction; and that, in spite of the most minute precautions, this circumstance must necessarily introduce great disturbances into their experiments, we shall understand how absolutely necessary it was to make new determinations of this important doctrine, which will be frequently used in the following investigations.

In the preceding memoir, the weight of dry air which filled the globe at 0°, and under a pressure of 760 mil., was determined with great care; it will be enough then to find the capacity of this globe

* Berzelius himself now acknowledges the error of his former determination, and fixes the atomic weight of carbon at 75·12 or 6·01 (H = 1), which amounts to an admission of Dumas's determination. (Berzelius Traité de Chimie, Seconde Edition Française, 1845, tom. 1, p. 263.)

† The French litre is equal to 0·22 of the imperial gallon.

at 0°, to determine immediately the weight of the litre of air. Now, according to the principle upon which the French system of measures was established, the kilogramme is the weight of a litre of distilled water, freed from air, at the temperature of its maximum density, which is about 4° (39·2 Fahr.); it will suffice then to determine the weight of water at 4° which fills the capacity which the globe presents at 0°.

To do this M. Regnault operated in the following way:—

The open globe was weighed upon a good balance; its weight was found to be 1258·55 gr., the surrounding temperature being 4·2°, and the height of the barometer reduced to 0°, 757·89 mil.

A small quantity of water was introduced into the globe, and the globe exhausted by means of the air-pump, and at the same time heated. In this way the atmospheric air was completely expelled by means of the vapour of water which was constantly developed. The stop-cock of the globe was then closed.

On the other hand, perfectly pure distilled water was boiled in a large globe to free it completely from the air which it always holds in solution at ordinary temperatures. Upon the tubulure of the first globe was fixed by caoutchouc a glass tube, twice bent, one of whose branches descended to the bottom of the vessel in which the water was kept boiling. On opening the stop-cock of the globe, the boiling water entered it slowly, without coming in contact with air; it was consequently perfectly free from that gas.

The globe being completely filled, the recurved tube was removed, and replaced by a tube having a bulb which was kept filled with the boiling water, and furnished the quantity of water necessary to keep the globe filled as its temperature lowered.

When the globe, filled with water, had come down to the surrounding temperature, it was placed in a zinc vessel, and completely surrounded with melting ice, care being taken to pack the ice in proportion as it melted, upon the walls of the globe.

The globe was left in the ice for a time varying from 6 to 18 hours; the stop-cock was then closed, the bulbed tube detached, and the tubulure above the stop-cock carefully wiped.

The globe was placed in a large vessel filled with water at a temperature a little above that of the chamber in which the balance was; it was left for two hours, so that it should take nearly the temperature of the chamber. As the water contracts in proportion as its temperature rises from 0° (to 4°), the globe could be kept closed without danger of breaking. When the globe had acquired the temperature of the chamber, it was weighed, and this weighing (the temperature of the room and the height of the barometer being noted) gives the means of calculating the weight of water at 4°, which fills the capacity which the globe presents at 0°.

According to the experiments of M. Pierre (*Annales de Chimie et de Physique, 3d série, tome* xv., *p.* 348), if the density of water at 0° be taken as 1, at 4° it is $\frac{1}{0{\cdot}999881}$.

Whence we can calculate the weight of the water at 4° (its maximum density), which fills the capacity which the globe presents at 0°. Three experiments give the following results:—

I. 9881·060 grammes.
II. 9881·113 „
III. 9881·299 „

The third weighing gave a number probably a little too high, because the globe was intentionally left but a little time in the ice, in order to see what influence this circumstance would have upon the result. On this account, M. Regnault adopts the mean of the former experiments, viz.: 9881·086.

Desiring to ascertain whether the correction made to reduce the weight of water from 0° to 4° was sufficiently exact, M. Regnault made two direct experiments, which gave a mean differing only 0·152 or $\frac{16}{100{,}000}$ from the result of the calculation. The capacity of the globe at 0° was therefore 9·881086 lit., and since (*see* Second Memoir) the weight of air which filled it at 0°, under a pressure of 760 mil., was 12·7781 gr.; the weight of the litre of air, under these normal circumstances is $\frac{12{\cdot}7781}{9{\cdot}881086}$ gr. $=$ 1·293187 gr. a value notably less than that which was heretofore admitted from the experiments of MM. Biot and Arago* (1·299541).

From this and the numbers obtained in the preceding memoir for the densities of the gases we deduce, that at Paris

The litre of Atmospheric Air weighs 1·293187 grammes.
„ „ Nitrogen „ 1·256167 „
„ „ Oxygen „ 1·429802 „
„ „ Hydrogen „ 0·089578 „
„ „ Carbonic Acid „ 1·977414 „

Strictly considered, these values are only correct for the locality in which the experiments were made—that is, for a latitude of 48° 50′ 14″, and a height of about 60 metres above the level of the sea.

M. Regnault finds the weight of the litre of air, under the parallel of latitude 45°, and at the same distance from the centre of the earth as that at which his experiments were tried, = 1·292697.

And assuming this as the standard number, he deduces for any other latitude, and any other distance from the centre of the earth, the formula

$$w = 1{\cdot}292697 \text{ gr. } (1{\cdot}00001885)\,\frac{1}{1+\frac{2h}{R}}\,(1-0{\cdot}002837, \cos 2\lambda).$$

Or, more simply

$$w = 1{\cdot}292673 \text{ gr. } \frac{1}{1+\frac{2h}{R}}\,(1-0{\cdot}002837, \cos 2\lambda);$$ in which w is the weight of the litre of air (the litre is 61·09908 cubic inches); R, the mean radius of the earth = 6,366,198 metres; h, the height of the place of observation above this mean radius, expressed in metres; and λ, the latitude of the place.

Applying this formula to the level of the sea, in the latitude of Philadelphia (39° 56′ 51·5″), and assuming the radius of the earth at this point 6,367,653 metres:

The weight of the litre of air will be 1·2914392 grammes.

And assuming the litre as 61·09908 cubic inches, and the gramme as 15·433159 grains troy:

The weight of a cubic inch of air will be 0·32621 grains troy.

Or, (assuming Mr. Hassler's determination of the weight of a cubic inch of water, 252·6934 gr.) water is 774·63 times heavier than air.

Density of Mercury.

The density of mercury has been determined several times by M. Regnault, and with the greatest care; as he wished to satisfy himself whether this liquid, purified by the means employed ordinarily in the laboratories, presented a constant density.

A glass globe, of a capacity of from 250 to 300 cubic centimetres, was filled with mercury. The globe terminated in a capillary tube of about 2 mil. diameter, upon which a mark was made, and this tube was surrounded by a larger one which was used as a funnel. The funnel could be hermetically closed by a ground glass stopper. The globe being filled with mercury, this liquid was boiled, and suffered to cool. The globe was then placed in ice for several hours, and the level of the mercury brought exactly to the mark. As soon as it was satisfactorily ascertained that the level of the mercury did not change, the mercury was suffered to take the temperature of the air, and its weight determined. The same globe was then filled with distilled water, first boiled to deprive it of air. It was suffered to cool, the funnel being kept full of boiled water, and closed with its stopper. The globe was then surrounded with ice, and when the water had taken exactly the temperature 0°, the water level was brought to the mark, and the sides of the funnel wiped with filtering paper. The closed globe was then placed in water having nearly the temperature of the surrounding air, so as to bring it more quickly to the temperature of the air in which it was to be weighed.

The three determinations of the density of mercury, which are reported, were made at very different times, upon specimens from different sources, and in three different globes:—

I. The first specimen was mercury designed for the construction of a standard barometer for the observatory of Paris. This mercury came directly from the mine; it had been twice distilled in an iron vessel. It was then suffered to stand for several days under weak nitric acid, to dissolve the oxide of mercury which always forms during distillation. The metal was then washed with much water, and dried in the air-pump. The density of the mercury at 0°, compared with that of water at 4°, was 13·59599.

II. In the second experiment, the mercury employed was that used by M. Regnault, in the construction of his manometer. This mercury was distilled several years ago, in an iron retort, and has

* M. Regnault remarks, in a note, that all the numerical corrections made by MM Biot and Arago, for the purpose of reducing the weight of air to 0°, and to absolute dryness, contributed to render the number which they adopted too high. Another circumstance may have produced a similar effect. These experimenters exhausted the globe several times with a very good air-pump, and they supposed that the slight tension which remained in their globe was produced by the vapour of water which the walls of the globe abandoned in vacuo, which they re-condensed when the air entered again. It is, in fact, probable that this was the case; but it seems to be also very probable that when the globe was filled with air very nearly saturated with moisture, it gave a new portion of water to the glass. This portion, which was not taken into account, was considered as making a part of the weight of the air, and necessarily made that weight too great.—(See Biot's "Traité de Physique," tome 1, p. 367.)

been kept in glass vessels. It was frequently purified by shaking it in flasks with concentrated sulphuric acid, then washing with much water. Its density at 0°, compared with that of water at 4°, was 13·59578.

III. Recently, M. Regnault has determined the density of mercury prepared with the greatest care by M. Millon, by the calcination of crystallized nitrate of mercury in a porcelain retort. The metal was then shaken up with concentrated sulphuric acid, to dissolve the oxide. Density of the mercury, 13·59602.

Thus we find for the densities of these three specimens of mercury :—

$$\left.\begin{array}{r} \text{I. } 13{\cdot}59599 \\ \text{II. } 13{\cdot}59578 \\ \text{III. } 13{\cdot}59602 \end{array}\right\} 13{\cdot}59593.$$

These densities may be considered as identical.

MM. Biot and Arago found the density of mercury, 13·588595.

This density differs but little from those which we have found. The little difference ought probably to be attributed to the uncertainty of the corrections which these illustrious physical philosophers were obliged to make in their method of operating.

It is often necessary, as in measuring heights by the barometer, to know the ratio of the density of mercury to that of air.

Now 1 lit. of air at 0°, under a pressure of 760 mil., weighs 1·293187 gr.
„ water at its maximum density weighs 1000·000000 „
„ mercury at 0° „ 13595·93 „

The ratio of the densities of mercury and air at the temperature 0°, and under the pressure of 760 mil. observed at Paris, is then 10513·5. At the level of the sea, and in latitude 45°, it becomes 10517·3; and at the level of the sea, at Philadelphia, 10527·735.

(To be continued.)

CONTRIBUTIONS TO RAILWAY STATISTICS,

IN 1846, 1847, AND 1848.—By HYDE CLARKE, Esq.

(Continued from page 245.)

No. III.—COAL TRAFFIC.

Coal traffic is one of the largest and most important items of railway transit; but here, as elsewhere, the returns published by the Railway Department are insufficient to show the whole amount. This is the more to be regretted, as the great reduction in the price of coal by railways has largely increased the demand for household use, as well as for manufacturing purposes. The monopolies of the canal proprietors, and of the wharfingers connected with them, have been broken up, and each year some new operation throws open a fresh district.

Coal traffic is of three kinds: from the colliery inland; from the colliery to the sea; and from the sea-shore inland.

The following shows the gross tonnage of coals, coke, and culm on the undermentioned lines for the years ending 30th June, 1846 and 1847.

Name.	1846. Tons.	1847. Tons.
Arbroath and Forfar, ..	12,012	14,025
Ardrossan, ...	66,782	70,090†
Ballochney, ...	139,206	185,969
Bodmin and Wadebridge, ..	5,123	5,129
Caledonian (Glasgow and Garnkirk)	227,183	335,319
Dunfermline and Charlestown,	28,654	27,626
Dundee and Arbroath, ..	19,000	500†
Dundee and Newtyle, ..	10,000*	10,000
Durham and Sunderland, ..	394,974	——
Eastern Counties: Cambridge,	15,000*	15,000*
„ Colchester,	26,976	20,000*
„ Ipswich and Bury,	——	15,749†
„ Eastern Union,	——	18,744†
„ Norfolk,	6,000	15,000*
Edinburgh and Dalkeith,	95,571	——
East Lancashire, ..	——	1,181†
Furness, ...	——	2,748
Glasgow and Greenock, ..	28,429	30,387
Glasgow and Ayr, ..	180,130	242,443
Great North of England, ..	251,484	——
Hartlepool, ..	893,701	789,673
Hull and Selby, ..	40,000*	——
Kendal and Windermere,	——	100†
Lancaster and Carlisle, ..	——	6,886
Lancaster and Preston, ..	10,000*	——
Lancashire and Yorkshire	59,919	66,175
„ Preston and Wyre,	29,390	33,978
„ Manchester and Bolton,	49,255	27,469†
Llanelly and Llandilo, ..	97,017	84,150
London and North Western (Birmingh.)	37,889	440,000*
„ (Grand Junction)	323,905	——
„ (Manchester and Birm.)	119,774	——
London and Brighton: Brighton,	80,000*	40,000*
„ „ Croydon,	9,118	——
London and South Western, ..	18,830	31,659
Manchester and Bolton, ..	172,230	——
Manchester and Sheffield, ..	30,569	82,008
Maryport and Carlisle, ..	135,106	179 748
Midland, ...	305,904	370,787
„ (Bristol and Birmingham)	89,421	110,557
Middlesborough and Redcar, ..	——	4,894
Monkland and Kirkintilloch	400,000*	400,000*
Newcastle and Carlisle, ..	190,068	236,649
Newcastle and Darlington, ..	689,892	——
Newcastle and Berwick (North Shields)	29,345	33,866
North Union, ..	395,021	233,137
North British, ...	——	15,756
Preston and Longridge, ..	——	248†
Pontop and South Shields, ..	596,369	——
Slamannan	——	78,888
South Eastern, ...	45,350	71,723
Scottish Midland, ...	——	5,124
Stockton and Darlington, ..	904,358	911,645
Stockton and Hartlepool, ..	24,408	7,165
„ „ (Clarence)	497,100	537,333
Shrewsbury and Chester, ..	——	1,115
St. Helen's, ...	245,573	247,734
Taff Vale, ...	284,066	314,621
Ulster, ...	3,379	2,716
West Cornwall, (Hayle) ..	24,942	28,416
Wishaw and Coltness, ..	434,365	678,239
Wilsontown, ...	500	4,244
Whitehaven, ...	514	7,000†
York and North Midland, ..	159,608	185,982
York and Newcastle, ..	——	1,620,163

* Supposed amount. † Imperfect return.

The quantity enumerated amounts to about 8,900,000, or nearly 9,000,000; the number enumerated in 1845 being 7,000,000 tons.

The amounts received for the carriage of coals in the years ending June 30, 1846 and 1847, were as follows:—

Name.	1846. £.	1847. £.
Arbroath and Forfar, ..	1,749	2,012
Ardrossan, ...	2,339	3,200†
Ballochney, ...	3,765	7,091
Bodmin and Wadebridge, ..	616	628
Caledonian (Glasgow and Garnkirk)	5,123	17,535
Chester and Birkenhead, ..	——	120†
Cockermouth and Workington,	——	105†
Dunfermline and Charlestown,	3,078	2,910
Dundee and Arbroath, ..	4,000	28†
Durham and Sunderland, ..	20,604	——
Eastern Counties: Cambridge,	22,796	5,158
„ Colchester,	7,274	——
„ Eastern Union,	——	200†
„ Ipswich and Bury,	——	1,264
„ Norfolk,	700	2,000*
East Lancashire, ..	——	51†
Edinburgh and Dalkeith, ..	4,160	——
Glasgow and Greenock, ..	2,917	3,323
Great North of England, ..	20,978	——
Hartlepool, ..	35,958	31,477
Lancaster and Carlisle, ..	——	929†
Lancashire and Yorkshire, ..	2,257	4,840
„ Preston and Wyre,	3,172	2,821
„ Manchester and Bolton,	3,043	1,142
Llanelly and Llandilo, ..	6,579	5,284
London and North Western (Birmingham)	4,633	36,657
„ (Grand Junction)	17,807	——
„ (Manchester and Birm.)	5,470	——
London and Brighton (Brighton)	2,000*	——
„ „ (Croydon)	683	——
Manchester and Sheffield, ..	1,933	5,564
Maryport and Carlisle, ..	10,513	13,962
Midland, ...	63,183	56,590
„ Bristol and Birmingham,	8,668	7,660
Middlesborough and Redcar,	——	325
Newcastle and Carlisle, ..	18,259	23,944
Newcastle and Berwick (North Shields)	1,314	1,474
Newcastle and Darlington, ..	31,679	——

North Union,	..	20,000*	20,000*
North British,	..	——	1,571
Preston and Longridge,	..		16†
Pontop and South Shields,	..	46,283	——
Stockton and Darlington,	..	65,736	71,842
Stockton and Hartlepool,	..	782	247
„ „ (Clarence)		30,261	33,472
Slamannan,	..	——	2,325
South Eastern,	..	——	9,554
Scottish Midland,	..	——	349
Shrewsbury and Chester,	..	——	86
St. Helen's,	..	10,671	10,469
Taff Vale,	..	24,447	28,620
Ulster,	..	406	376
West Cornwall (Hayle)	..	3,220	3,667
Wishaw and Coltness,	..	13,623	19,184
Whitehaven,	..	14	350†
Wilsontown,	..	36	233†
York and Newcastle,	..	——	111,384
York and North Midland,	..	16,179	19,637

* Estimated amount. † Imperfect return.

This constitutes a total of nearly £550,000, so that the gross total is most probably nearly £700,000, being the sum received by railways on account of the conveyance of coal. Among the lines omitted are the following:—

Great Western,
Edinburgh and Glasgow,
Glasgow and Ayr,
London and South Western,
Eastern Counties: Colchester,
Monkland and Kirkintilloch.

The rates of charge vary much on the several lines, depending on many circumstances, so that it is impossible to institute an accurate comparison. In some cases, the coal-owners supply their own locomotives and wagons, and are charged with toll only. In others, they supply wagons only. In others, they are charged with an additional rent for wagons. In many cases the company hauls and supplies wagons.

Rate per ton per mile for toll only, and for total charges—

		Toll. d.	Total charges. d.
West Cornwall,	..	—	5·82
Dunfermline and Charlestown,		—	4·29
Bodmin and Wadebridge,		—	4·
Newcastle and Berwick (North Shields)		—	3·50
Arbroath and Forfar,	..	2	3·30
Cockermouth,	..	—	3·11
Scotch Midland,	..	—	3·07
Kendal and Windermere,		—	3·
Ballochney,	..	—	3·
Preston and Longridge,		—	2·66
Furness,	..	—	2·50
Maryport and Carlisle,	..	1·30	2·47
Londonderry and Enniskillen,		—	2·10
Wishaw and Coltness,		1·60	2·03
Brighton,	..	0·25	2·00
Slamannan,	..	—	1·88
East Lancashire,	..	—	1·85
London and South Western,		—	1·77
Lancaster and Carlisle,		—	1·75
Whitehaven,	..	—	1·60
Edinburgh and Glasgow,	..	—	1·50
Caledonian,	..	—	1·43
St. Helen's,	..	0·70	1·40
Llanelly,	..	—	1·35
Ipswich and Bury,	..	—	1·34
Shrewsbury and Chester,		—	1·33
Bristol and Birmingham,		—	1·32
Eastern Union,	..	—	1·26
York and Newcastle,	..	—	1·25
Newcastle and Carlisle,	..	—	1·25
Glasgow and Greenock,	..	0·81	1·25
Hartlepool,	..	0·75	1·25
Taff Vale,	..	0·66	1·16
Stockton and Hartlepool,		—	1·06
Lancashire and Yorkshire,		—	1·01
North British,	..	—	1·
Preston and Wyre,	..	—	1·
Eastern Counties (Cambridge)		—	1·
Clarence,	..	—	0·89
York and North Midland,		—	0·75

On the whole, the rates for the carriage of coal are lower than they were in 1845; only a small quantity of coal is carried on the higher priced lines.

The following shows the quantity of coal carried in the year ending June 30, 1847, at each rate of charge:—

3*d.* and upwards,	302,126 tons.
2*d.* and upwards,	198,252 „
1*d.* and upwards,	3,930,795 „
Under 1*d.*	629,416 „

Of the 3,930,795 tons carried at prices between 1*d.* and 2*d.*, 3,812,725 tons were carried at rates less than 1½*d.* per ton per mile. It will be seen that nearly all the coal carried by railway is carried for less than 1½*d.* per ton per mile.

The maximum charge for carrying coal is now 5·82*d.* per ton per mile, being on the West Cornwall or Hayle railway. In 1845 the maximum charge was 6*d.* per ton per mile, being on the Canterbury and Whitstable railway.

Many of the companies make no return of their charges for carrying coal, which is the more to be regretted, as the amalgamations have caused great alterations in the carrying rates.

The chief coal lines are the following:—

		1844-5. Tons.	1845-6. Tons.	1846-7. Tons.
York and Newcastle,		1,616,555	1,962,334	1,654,029
Stockton and Darlington,		900,000	904,358	911,645
Hartlepool,	..	796,486	893,701	789,673
Stockton and Hartlepool,		300,000	521,508	544,498
Midland,	..	492,420	395,325	481,344
London and North Western,		——	481,568	440,000
Caledonian,	..	——	227,183	335,319
Taff Vale,	..	125,066	284,066	314,621
St. Helen's,	..	229,775	245,573	247,734
Glasgow and Ayr,	..	120,000	180,130	242,443
Newcastle and Carlisle,		205,500	190,068	236,649
North Union,	..	321,923	395,021	233,137

The Ballochney, Monkland, and other railways in the neighbourhood, have a vast coal traffic; but from the state of the returns, no calculations can be made as to its extent.

The following shows the lines on which the largest receipts for coal have been obtained in each of the years ending June 30, 1845, 1846, and 1847:—

		1845. £.	1846. £.	1847. £.
York and Newcastle,		115,000*	123,050	112,858
Stockton and Darlington,		80,000*	65,736	71,842
Midland,	..	45,000*	71,851	64,250
London and North Western,		——	25,910	36,657
Stockton and Hartlepool,		——	31,043	33,558
Hartlepool,	..	32,627	35,958	31,477
Taff Vale,	..	19,939	24,447	28,620
Newcastle and Carlisle,		19,476	18,259	23,944
North Union,	..	——	20,000	20,000
Caledonian,	..	7,600	2,917	17,535

* Estimated amount.

It cannot be said that the coal traffic greatly advanced in the year ending June 30, 1847. Though a great advance was made in the previous year, there seem to be in 1847 symptoms of the effects of the commercial crisis. A decline took place in the receipts of the York and Newcastle, and Midland, though an increase took place on the Stockton and Darlington, and Newcastle and Carlisle.

The coals conveyed by railway from the several fields are as follows:—

		1845. Tons.	1846. Tons.	1847. Tons.
Northumberland and Durham,		3,850,000	4,500,000	4,250,000
Cumberland,	..	200,000	135,000	190,000
Leicester, Nottingham & Derby,		300,000	300,000	370,000
Lancashire,	..	900,000	1,270,000	1,000,000
Yorkshire,	..	——	240,000	190,000
Bristol,	..	50,000	90,000	100,000
South Wales,	..	220,000	380,000	400,000
Scotland,	..	760,000	1,650,000	2,100,000

It is impossible to separate the returns accurately, but it may be assumed that the quantity of coal carried by railway has increased in the Scotch and Cumberland fields. The produce of the Staffordshire fields cannot be separated.

The following shows the quantity of coals carried inland from the sea in each year:—

		1845. Tons.	1846. Tons.	1847. Tons.
Eastern Counties:	Cambridge,	——	15,000	15,000
„	Colchester,	20,000	26,976	20,000
„	Eastern Union	——	——	16,000
„	Ipswich and Bury,	——	——	19,000
„	Norfolk,	——	6,000	15,000

South Eastern, ..	35,519	45,350	71,723
Brighton, ..	36,000	40,000	40,000
South Western, ..	4,000	18,830	31,659
London and North Western,	10,000	10,000	10,000
Cornwall, ..	28,000	30,065	33,545

The quantity of coal carried inland by means of railways has increased.

The saving in coal supplied to the city of York, in consequence of Mr. Hudson's railway measures, is not less than £30,000 yearly.

In the south-east of England, which is supplied mostly from the Northumberland and Durham coal-fields, the quantity carried up-land by railway may be reckoned as follows:—

1845, 120,000 tons.
1846, 162,000 „
1847, 240,000 „

How trivial this is, may be seen from the quantity of coals imported into London, which is thus shown.

1825, 1,921,091 tons.
1835, 2,299,816 „
1845, 3,461,199 „

It will be seen that in the supply of the inland districts the railways have proved very effective; but they have as yet done very little for those districts which are supplied from the sea. This must be attributed to the inability of the railway companies to give their attention at present to this branch of traffic; but when they do, a complete revolution must be effected in the supply of coals. The only lines from which we have detailed returns are the South Eastern and South Western, which show a great increase in the quantity of coal carried. There is every reason to believe that a great traffic is growing up in the Eastern Counties district—not less than 85,000 tons: but the returns do not show this fully.

No. IV.—COKE TRAFFIC.

The traffic in coke must be considerable in some districts, but there is a want of detailed returns. It is a lucrative branch of revenue to the Midland Railway Company.

The following shows the traffic in coke in each year on the under-mentioned lines:—

	1844. Tons.	1845. Tons.	1846. Tons.	1847. Tons.
Midland, ..	26,826	29,767	57,015	78,246
Manchester and Bolton,	——	——	2,200	——
Newcastle and Carlisle,	3,504	8,333	3,312	8,221
York and North Midland,	——	16,013	50,785	93,899

The following shows the receipts for coke:—

	1846.	1847.
Midland, ..	£20,210	£24,198
Manchester and Bolton,	16	——
Newcastle and Carlisle,	391	457
York and North Midland,	4,772	7,792

No. V.—IRONSTONE AND IRON TRAFFIC.

These form great branches of mineral traffic, but the extent of them is very imperfectly expressed in the returns.

The traffic in ironstone on the following railways in the years ending June 30, 1845, 1846, and 1847, is shown below in tons.

	1845. Tons.	1846. Tons.	1847. Tons.
Ballochney, ..	239,010	190,352	229,362
Monkland, ..	——	200,000*	200,000*
Newcastle and Carlisle,	——	7,000†	7,000*
Taff Vale, ..	58,850	49,231	54,614
Ditto, Aberdare,	——	——	4,546
Furness, ..	——	——	106,301
Whitehaven, ..	——	406	140‡
Wishaw and Coltness,	32,240	42,231	27,000§

* Estimated amount. † Half-year, 3,381 tons. ‡ Half-year, 72. § Half-year, 18,976.

The returns for the Ballochney railway include iron likewise.

The amount received in each of those years was as follows:—

	1845.	1846.	1847.
Ballochney, ..	£6,931	£5,353	£8,901
Furness, ..	——	——	7,221
Newcastle and Carlisle,	——	2,700*	——
Taff Vale, ..	6,786	5,907	6,457
Ditto, Aberdare,	——	——	170
Whitehaven, ..	——	11	——
Wishaw and Coltness,	191	526	500*

* Estimated amount.

The rates charged for the conveyance of ironstone and iron-ore are as follows:—

	Per ton per mile.
Ballochney, ..	2·25*d.*
Newcastle and Carlisle,	1·37
Taff Vale, ..	1·16
Whitehaven, ..	1·25
Wishaw and Coltness,	2·23

The traffic in iron for the three years is as follows:—

	1845. Tons.	1846 Tons.	1847. Tons.
Ardrossan, ..	7,881	14,065	40,000†
Glasgow and Ayr,	25,000	39,679	56,825
Lancashire and Yorkshire,	——	9,000*	15,001
Maryport and Carlisle,	——	2,937	1,652
Shrewsbury and Chester,	——	——	9,488
Slamannan ..	——	——	881
Taff Vale, ..	88,493	61,996	67,039
Whitehaven, ..	——	1,233	1,200‡
Wishaw and Coltness,	73,429	77,826	80,000§

* Half-year, 4,470. † Half-year, 19,738. ‡ Half-year, 636. § Half-year, 44,030.

The amounts received are as follows:—

	1845.	1846.	1847.
Ardrossan, ..	£ 305	£ 556	£ 781*
Glasgow and Ayr,	2,400	——	——
Lancashire and Yorkshire,	——	1,011*	3,705
Maryport and Carlisle,	——	557	297
Shrewsbury and Chester,	——	——	851*
Slamannan, ..	——	——	78
Taff Vale, ..	4,901	6,974	7,770
Whitehaven, ..	——	52	37*
Wishaw and Coltness,	2,006	3,371	1,441*

* Imperfect returns.

The iron carried is mostly pig-iron.

The rates for the carriage of iron are as follows:—

	Bar-Iron, Per mile per ton.	Pig-Iron, Per mile per ton.
Ballochney, ..	3*d.*	1·66*d.*
Lancashire and Yorkshire,	2 25	——
Maryport and Carlisle,	——	1·80
Taff Vale, ..	——	1·00
Wishaw and Coltness,	——	1·84
Whitehaven, ..	——	1·83

A considerable quantity of dross and slag are carried, but there are only returns on the Wishaw and Coltness railway:—

Dross.

	1846. Tons.	1847. Tons.	1846. £	1847. £
Wishaw and Coltness,	110,084	90,000*	1,968	2,000
Slag and Char.				
Wishaw and Coltness,	882	1,000†	9	30

* Half-year, 45,261 tons, 1,002*l.* † Half-year, 544 tons, 17*l.*

The rates for carrying dross are 1·12*d.* per mile per ton, and for carrying slag 1·35*d.* per mile per ton.

The traffic of the Glasgow iron district in coals, limestone, ironstone, iron dross, and slag carried by railway was in 1846 and 1847 as follows:—

	1846.	1847.
Tons,	2,500,000	2,900,000

The traffic of the Welsh iron district in coals, limestone, ironstone, and iron, stands as follows:—

	1844.	1845.	1846.	1847.
Tons,	242,000	323,000	396,000	441,000

The traffic of the Furness iron district consists solely in the shipment of ironstone to South Wales, to the extent of 106,301 tons in 1847.

No. VI.—COPPER AND TIN TRAFFIC.

The traffic in copper and tin ores is confined to the Cornish lines. There are no data now to show this. In 1845 I estimated it as follows:—

	Tons.	£	Rate.
Bodmin and Wadebridge,	3,000	290	3·00*d.*
Hayle, ..	20,000	4,000	4·20

No. VII.—LIMESTONE AND LIME.

The following shows the quantity of lime carried in the years ending June 30, 1846 and 1847:—

	1846. Tons.	1847. Tons.
Arbroath and Forfar,	1,000	——
Middlesborough and Redcar,	——	808
Maryport and Carlisle,	2,549	2,844
Leicester and Swannington,	2,727	——
Newcastle and Carlisle,	2,032*	——
Slamannan, ..	4,000	——
York and North Midland,	——	4,669

* Imperfect return.

The following shows the amounts received for the carriage of lime:—

	1846.	1847.
Leicester and Swannington,	£ 199	£ ——
Maryport and Carlisle,	108	122
Middlesborough and Redcar,	——	25
Newcastle and Carlisle,	89	——
York and North Midland,	——	830

The following shows the quantity of limestone and lime carried in the years ending June 30, 1844, 1845, 1846, and 1847:—

	1844. Tons.	1845. Tons.	1846. Tons.	1847. Tons.
Arbroath and Forfar,	——	——	1,000	——
Ballochney, ..	——	——	——	2,441†
Furness, ..	——	——	——	579
Great North of England,	2,500*	——	——	——
Llanelly and Llandilo,	338	294	——	——
Maryport and Carlisle,	821	2,261	2,549	2,844
Midland, ..	35,575*	56,290	73,776	56,677
Ditto (Leicester and Swannington)	2,848*	4,800	2,727	——
Middlesborough and Redcar,	——	——	——	818
Newcastle and Carlisle,	19,072*	40,260	——	——
Slamannan, ..	——	——	9,291	7,292
Wishaw and Coltness,	10,604	13,482	18,618	13,000‡
York and North Midland,	8,554	8,998	14,324	——
Ditto (Whitby and Pickering)	1,362	1,659	——	——

* Lime only. † Half-year, 1,257 tons. ‡ Half-year, 6,773 tons.

The traffic in limestone and lime in 1847, so far as details exist, may be calculated as follows:—

Arbroath and Forfar,	1,000 tons.
Ballochney, ..	5,000 „
Furness, ..	579 „
Llanelly and Llandilo,	2,500 „
Maryport and Carlisle,	2,844 „
Midland, ..	56,677 „
Middlesborough and Redcar,	808 „
Newcastle and Carlisle,	40,000 „
Slamannan, ..	7,292 „
Wishaw and Coltness,	18,000 „
York and North Midland,	14,000 „
York and Newcastle,	2,500 „
Total enumerated,	146,000 tons.

The total enumerated in 1845 was 132,544 tons.

Much of this is used for agricultural purposes; some for building; and some in the iron-works. The quantity carried for agricultural purposes may be reckoned thus:—

District.	Tons.
Scotland,	40,000
Northern,	50,000
Yorkshire,	25,000
Lancashire,	25,000
Midland,	50,000
Southern,	20,000
Total,	210,000

The amounts received for the carriage of limestone and lime in 1845, 1846, and 1847, were as follows:—

	1845.	1846.	1847.
Arbroath and Forfar,	£ 300	£ ——	£ ——
Ballochney, ..	——	——	66*
Furness, ..	——	——	2
Llanelly and Llandilo,	12	——	——
Maryport and Carlisle,	82	108	122
Midland, ..	6,020	9,622	5,369
Middlesborough and Redcar,	——	——	25
Newcastle and Carlisle,	3,774	——	——
Slamannan, ..	——	276	386
Wishaw and Coltness,	124	323	——
York and North Midland,	929	1,175	830*

* Lime only.

The total receipts for the carriage of limestone and lime in 1847 were not less than £11,000, but there has been a falling-off in the Midland traffic.

The rates for the carriage of a ton of limestone and lime per mile are as follows:—

	Lime.	Limestone.
Arbroath and Forfar,	2·5*d.*	——*d.*
Llanelly and Llandilo,	——	1·00
Maryport and Carlisle,	1·50	1·30
Lancashire and Yorkshire,	1·33	——
Newcastle and Carlisle,	1·25	1·25
Slamannan, ..	1·9	——
Wishaw and Coltness,	——	1·35
York and North Midland,	1·50	1·50

The greatest traffic in limestone and lime is carried on by the following companies:—

	Tons.	£
Midland, ..	56,677	5,369
Newcastle and Carlisle,	40,260	3,774
York and North Midland,	14,000	830
Wishaw and Coltness,	13,000	323

The limestone traffic on the Midland is on the old North Midland line.

No. VIII.—STONE TRAFFIC.

The number of tons of building and paving stone carried in the years ending June 30, 1845, 1846, and 1847, distinguished in the returns, is as follows:—

	1845. Tons.	1846. Tons.	1847. Tons.
Arbroath and Forfar, ..	20,000	14,239	11,711
Chester and Birkenhead, ..	——	——	478
Maryport and Carlisle, ..	2,381	3,075	3,637
Midland (Leicester and Swannington)	10,412	8,203	——
Lancashire and Yorkshire (Preston and Wyre)	852	——	——
Preston and Longridge, ..	——	——	37,000†
St. Helen's and Runcorn,	17,169	——	——
Stockton and Darlington,	20,930	55,907	89,540
Stockton and Hartlepool,	——	18,249	7,388
„ „ (Clarence)	——	26,977	13,857
Wishaw and Coltness, ..	6,492	4,466	11,000‡
York and North Midland,	——	100,000*	91,349
Ditto (Whitby and Pickering)	30,465	——	——
York and Newcastle (Great North of England)	4,000	——	——
„ (North Shields Branch)	——	9,484	7,000§
Total enumerated,	112,000	266,000	404,000

* Half-year, 51,030 tons. ‡ Half-year, 5,291 tons.
† Half-year, 18,071 tons. § Half-year, 3,465 tons.

The figures above given by no means represent the gross traffic in building and paving stones for each year. From an examination of the detailed figures, there seems to have been a falling-off in the the use of building and limestones in 1847, although the gross quantity carried on railways increased.

The total quantity of building and paving stones, limestones, and lime carried on railways in 1847 was as follows, according to the enumerated returns:—

Building stones,	404,000 tons.
Limestones and lime,	146,000 „
	550,000 tons.

The enumerated traffic gives the enormous quantity of 550,000 tons of stones carried, but the whole quantity carried must be nearer 1,000,000 tons.

The amounts received for the carriage of building and paving stones stand thus:—

	1845. £	1846. £	1847. £
Arbroath and Forfar, ..	1,100	945	740
Chester and Birkenhead, ..	——	——	70†
Maryport and Carlisle, ..	——	183	162
Midland (Leicester and Swannington)	269	211	——
Lancashire and Yorkshire (Preston and Wyre)	91	——	——
Preston and Longridge, ..	——	——	2 400‡
St. Helen's and Runcorn, ..	674	——	——
Stockton and Darlington, ..	——	2,023	3,030
Stockton and Hartlepool, ..	——	304	123
„ „ (Clarence)	——	780	436
Wishaw and Coltness ..	151	88	170§
York and North Midland, ..	——	7,000*	9,453
Ditto (Whitby and Pickering)	1,110	——	——
York and Newcastle (Great North of England)	800	——	——
„ (North Shields Branch)	——	473	700‖

* Half-year, 3,925*l.* † Half-year, 38*l.* ‡ Half-year, 1,208*l.*
§ Half-year, 86*l.* ‖ Half-year, 392*l.*

The total receipts enumerated in 1847 were about £18,000, and those for limestone and lime £11,000; making about £30,000 enumerated.

The rates for the conveyance of building and paving stones are as follows:—

	Per mile per ton.
Arbroath and Forfar,	2·50d.
Maryport and Carlisle,	2·64
Lancashire and Yorkshire,	1·33
London and South Western,	2·50
Preston and Longridge,	3·00
St. Helen's and Runcorn,	1·12
Wishaw and Coltness,	2·50
York and North Midland,	1·00

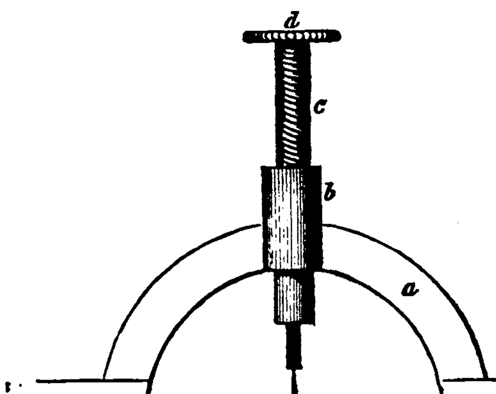
The greatest traffic in building, paving, and limestones, and in lime, is carried on by the following companies:—

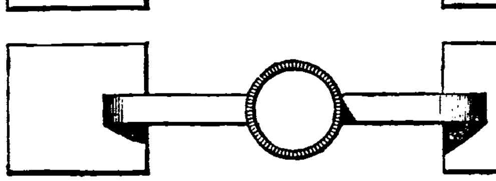
	Tons.	£
York and North Midland,	105,000	10,300
Midland ..	60,000	5,369
Newcastle and Carlisle,	40,000	3 800
Stockton and Darlington,	89,510	3,030
Preston and Longridge,	37,000	2,400
Stockton and Hartlepool,	21,245	560
Wishaw and Coltness,	24,000	500

PLAN-PRICKING INSTRUMENT.

Sir—Amongst other duties, I am engaged in making a most extensive and minute survey of a large city, showing every house and all the drainage throughout, the scale being very large—1 inch to 100 feet; and I am preparing duplicate fair copies of each sheet, which is being done by pricking through all the sheets at once, the original working drawing being placed uppermost. In doing this with the common pricker, I found that the draughtsman did not hold the pricker perpendicular; consequently, the lower sheets could not be accurate copies of the original. To obviate this, I have contrived an instrument, by which any attention on the part of the draughtsman in keeping it perpendicular is not required: all he has to do is to be careful that he pricks through the proper points of the plan correctly; the holes are then sure to be vertically under one another, let the sheets of paper be ever so numerous.

Elevation.





Plan.

The engraving is a plan and elevation of the instrument, the full size. The arch *a*, is of brass, with a cylindrical crown *b*, in which a piston *c*, works. At the lower end of the piston the needle-point is fixed; the arch is moved over the paper until the needle-point is precisely over the spot to be pricked through; the finger then presses on *d*, the top of the piston, which effects the puncture; and upon relieving it of the pressure, the spiral spring wound round the piston immediately raises it, and withdraws the needle-point from the paper;—in this way the work is done both correctly and rapidly.

To prevent the needle passing far through the paper and making a large hole, or sticking into the drawing-board, I have had a sheet of zinc to cover the board, and fastened down to it. This zinc sheet being a little less in size than the drawing-paper, admits of the latter being all (one upon the other) pinned down to the board round their edges, which overlap the edges of the zinc. I find the zinc to be very advantageous in use, as it causes the needle to make no other than extremely fine holes.

* * *

STREET PAVING.

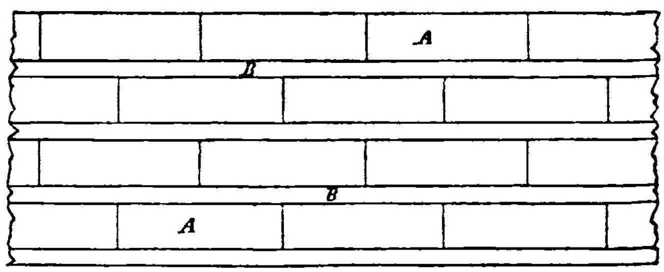
Sir—It is not necessary at this time to revive the controversy formerly raised between the respective advocates of wood and stone paving; experience or experiment—that great test of truth—will, ere this, have determined the opinions of most persons, as to the relative value or conditions of applicability of the two systems. It may not, however, have been considered how far combinations of the two might be made with advantage—adapted especially to certain cases.

The repairing of Holborn-hill, consequent on the recent removal of the houses on the north side of Holborn-bridge, brings to consideration the inconveniences—nay, dangers, occurring to the carriage traffic on declivities such as this, with any mode of paving hitherto adopted.

The placing of the granite stones obliquely to the line of surface, whereby the edges of the stones formed a series of sharp angles or steps (thus giving a rough surface and good foot-hold for horses drawing up, and obstructions to the too rapid sliding of wheels down the hill), appeared a vast improvement—and truly would be so, if the uneven surface thus obtained were not rapidly worn off by the continued traffic, and especially by the action of the drags on the wheels of carriages descending the hill. Thus the surface soon becomes smooth and slippery, whatever be the material used or form of laying, whenever the material is of one and the same kind, and consequently of equal wear throughout.

If, however, we employed materials, in conjunction, of different characters and rates of wear, we should then maintain inequalities of surface, affording continuous foot-hold for horses, and obviating existing defects.

Suppose that between each course of granite paving there were placed a thin course of wood, then the difference in the wear of the two would give the effect desired.



The annexed sketch shows the arrangement. A course of granite stones, A, to be laid in the usual way across the road, being about three inches in thickness; following this with a plank of wood, B, one inch thick, and of the depth of the granites; then following on with stones and planks in alternate courses.

Let us not stand arguing doubts and probabilities, but put the question to the true test—experiment. This can be done within a small space, and at little cost.

J. L.

Hampstead, August 8, 1848.

[A plan something similar to the above has been tried in Cheapside and in Piccadilly, but neither was of wood, they both produced a very disagreeable rattling and jolting in the carriage.]

EXPERIMENTS ON COALS.

Report on the Coals Suited to the Steam Navy. By Sir Henry de la Beche and Dr. Lyon Playfair.

Experiments necessary to ascertain the true practical value of coal involve a very large series of observations, extended over a considerable period, and directed to special objects of inquiry. The qualities for which particular kinds of fuel are pre-eminent being so varied, it is impossible to deduce general results from a limited series of observations. Even in the economical application of coals, their evaporative value, or their power of forming steam, one variety of coal which may be admirably adapted from its quick action for raising steam in a short period, may be far exceeded by another variety, inferior in this respect, but capable of converting a much larger quantity of water into steam, and therefore more valuable in the production of force. A coal uniting these two qualities in a high degree might still be useless for naval purposes, on account of its mechanical structure. If the cohesion of its particles be small, the effect of transport or the attrition of one coal against another by the motion of a vessel might so far pulverise it as materially to reduce its value. Even supposing the three qualities united, rapidity and duration of action with considerable resistance to breakage, there are many other properties which should receive attention in the selection of a fuel without the combination of which it might be valueless for our steam navy.

There is an important difference existing between varieties of coals in the bulk or space occupied by a certain weight. For the purposes of stowage-room this cannot be ascertained by specific gravity alone, because the mechanical formation of the fragments of coal may enable one of less density to take up a smaller space than that occupied by another of a higher gravity. This is far from an imaginary difference, being sometimes as great as 60 per cent., and not unfrequently 40 per cent. The mere theoretical determination of the density of coals would, therefore, give results useless for practice. The space occupied between two varieties of coals, often equally good as regards their evaporative value, differs occasionally 20 per cent.—that is, where 80 tons of one coal could be stowed, 100 tons of another of equal evaporative value might be placed, by selecting it with attention to its mechanical structure.

These facts are mentioned merely to show that a hasty generalization should not be made, and to account for our drawing attention to these various points as a means of preventing the selection of a fuel from any one quality. We do not, in the present stage of this inquiry, consider it proper to offer any recommendation of our own as to particular kinds of fuel, leaving the experimental facts to decide for themselves.

After preliminary experiments had proved that no practical result could be attained by mere laboratory research, it was determined to test each variety of coal on a scale of sufficient magnitude to check the theoretical views by the practical results. As it was impossible for either of us to devote our whole time to this inquiry, our services being required by other official duties, we appointed assistants* to superintend its special parts, under our general direction.

It will be obvious that there are several circumstances which must receive attention before the true evaporative value of a fuel can be obtained. Thus, the water in the tanks has a varying temperature during the day, dependent on atmospheric changes, and is always different from that in the boiler. The temperature of water in the boiler also varies with the external temperature, and the circumstances under which the experiments are made. The shape of a Cornish boiler favours an inequality in the temperature of the water in its various parts, the colder and denser water sinking to the bottom, and having a tendency to remain there; so that the temperature of water at the surface is far from being the mean temperature of water in the boiler, the difference between the surface and bottom water being, on an average, 70°. Other circumstances naturally affect the evaporative powers of the coal, as for example the fact that all the water exposed to the action of the fire in the boiler is not converted into steam, and that wood is used to light the fire. Another circumstance of considerable importance, is the expansion or contraction of the boiler from an increase or diminution of the temperature. In the early stage of the experiments, those conducted by Messrs. Wilson and Kingsbury, it was thought unnecessary to make a correction for this variation in conditions; but on ascertaining experimentally that the difference was as much as 69·625 lb. of water in the contents of the boiler, between the temperature 150° and 212°, it became desirable to make an allowance for it, even when the difference between the initial and final temperature was not greater than 10°. Other circumstances of less importance, but influencing the results, have been neglected, because the application of such corrections would have only complicated the results, and would have had little practical value when the errors of observation in such approximative experiments remain so large. Among these may be mentioned the quantity of gases evolved during combustion, the elevation in temperature of the air entering the fire-place, the barometrical and hygrometric conditions of the atmosphere, the radiation from the boiler (very small in amount, owing to its brick covering), the hygrometric state of the fuel, or the heat necessary for obtaining mechanical draught in the chimney. In most of these cases the necessary observations have been made, to enable the corrections to be applied, should it afterwards appear desirable.

In making the calculation for the evaporative value of a fuel, the quantity consumed was divided into two portions, the first being that necessary to raise the whole mass of water exposed to the fire from the *mean temperature* to 212°, the second portion being that required to evaporate the water taken from the tanks from a temperature of 212°. To enable this to be done, the mean temperature of the whole mass of the water is ascertained—that is, the temperature of the water in the boiler at its initial temperature after being mixed with the tank-water at its average temperature. The average of the latter was the mean of several observations taken during the day, and is designated by t'.

Let w be the weight of water from the tanks at temperature t';

W the weight of water in the boiler at temperature t'', this being obtained from surface temperature corrected by experiment;

t, temperature after mixture.

$$\text{Then } t = \frac{W\,t'' + w\,t'}{W + w}.$$

The correction for the wood was made from data procured by Messrs. Wilson and Kingsbury, but it can only be employed for the particular wood used, as in subsequent experiments the evaporative value was found very different from another quality obtained. The co-efficient of the evaporative power of the wood may be deduced from experiment, in which a certain weight of water was raised from a known temperature to the boiling point, and then a certain portion of it evaporated. The following formulæ have been used by Mr. Kingsbury for the calculation:—

N is the total weight of wood used in raising $(W + w)$ (the weight of water in the boiler, and of that let down from the tanks during the experiment) from the mean temperature t to 212°; then it is necessary to find the weight N′ necessary to evaporate w from 212°.

$$\text{Then } \frac{w}{N'} = e, \text{ the evaporating power.}$$

Let m be the weight of wood required to raise $W + w$ from t to 212°, the number 1000 being assumed as the latent heat of steam.

N to evaporate $W + w$ from 212°

N′ to evaporate $W + w$ from 212°

$$\text{Then } m + N' = N. \qquad \text{Now } \frac{l}{212 - t} = \frac{n}{m}.$$

$$\text{But } \frac{n}{N'} = \frac{W + w}{w}; \quad \therefore N' = n\,\frac{w}{W + w};$$

$$l\,(N - N') = (212 - t)\,n = (212 - t)\,N'\left(\frac{W + w}{w}\right);$$

$$N\,l = N'\left\{\frac{W + w}{w}(212 - t) + l\right\}$$

$$= \frac{N'}{w}\left\{(212 - t)(W + w) + l\right\};$$

$$\therefore \frac{w}{N'} = \frac{(212 - t)(W + w) + l\,w}{N\,l} = e$$

or, introducing the value of t as given by the first formula,

$$\frac{(l + 212 - t')\,w + (212 - t'')\,W}{N\,l} = e.$$

If q be the quantity of wood used in lighting the fire, eq will be the weight of water evaporated from 212° by the wood, and must be deducted from the weight of water evaporated in calculating the work done by the coal.

The co-efficient of the evaporating power of the coals, or the

* The assistants employed were Mr. Wilson, Principal of the Royal Agricultural College, Mr. Kingsbury, Mr. J. Arthur Phillips, and Mr. Hutchinson. Mr. Wrightson, a pupil of Liebig, was entrusted with the analyses of the coal, Mr. Galloway analysed the gases, and Mr. Howe also assisted in the analyses.

number of lbs. of water which one lb. of coal will evaporate from 212°, may be calculated as follows:—

Let P be the total quantity of coal consumed, then the work done by P will be to raise $W + w$ of water from t to 212°, and to evaporate $w - eq$ from 212°.

Let m be the weight of coal required to raise $W + w$ to 212°, from t
p „ „ evaporate $w - eq$ from 212°
n „ „ „ $W + w$ from 212°

$$\text{Then } \frac{w - eq}{p} = \text{E, the evaporating power.}$$

$$\text{Now } P = m + p; \quad \frac{212 - t}{l} = \frac{m}{n}.$$

$$\text{But } \frac{p}{n} = \frac{w - eq}{W + w}; \quad \therefore l\left(\frac{w - eq}{W + w}\right) = p\,\frac{212 - t}{P - p}.$$

$$\frac{(W + w)(212 - t) + (w - eq)\,l}{P\,l} = \frac{w - eq}{p} = E.$$

Introducing the values from which the mean temperature t was obtained (first formula), we have eventually—

$$\frac{(l + 212 - t')\,w + (212 - t'')\,W - l\,e\,q}{P\,l} = E$$

in which W is the weight of water in the boiler;
w the weight of water drawn from the tanks;
t' the mean temperature of water in the tanks;
t'' the corrected initial temperature of water in the boiler.

In the preceding formulæ, the latent heat of steam has been taken at 1000, the number generally used in this country; but after all the calculations had been made on this subject from the experiments by Messrs. Wilson and Kingsbury, and the results sent in to the Admiralty, Regnault's excellent memoir on the "Latent Heat of Steam" was published. It became necessary, therefore, to use these new results in the future experiments. These, so far as they apply to the present inquiry, are reduced in the following table.

TABLE I.—*Showing the Specific and Latent Heat of Water and Steam.*

Air Thermometer Centigrade.	Mercurial Centigrade.	Number of Unities of Heat abandoned by one kilo. of water in descending from T to 0°.	Air Thermometer Fahrenheit.	Mercurial Fahrenheit.	Number of Unities of Heat contained in one pound of water at T°.	Mean Specific Heat of Water between 0° and T cent. or between 32° and T Fahr.	Specific Heat of Water from T to T + dT.	Latent Heat of Steam saturated to the temperature T. Centigrade.	Latent Heat of Steam saturated to the temperature T. Fahrenheit.
°	°		°	°					
0	..	0·000	32	..	32·000	..	1·0000	606·5	1091 7
10	..	10·002	50	..	50·003	1·0002	1·0005	599 5	1079·1
20	..	20·010	68	..	68·018	1·0005	1·0012	592 6	1066·7
30	..	30·026	86	..	86 046	1·0009	1·0020	585·7	1054·2
40	..	40·051	104	..	104·091	1·0013	1·0030	578·7	1041·6
50	50·2	50·087	122	122·36	122 156	1·0017	1·0042	571·6	1028·9
60	..	60·137	140	..	140·246	1·0023	1·0056	564·7	1016·4
70	..	70·210	158	..	158·381	1·0030	1·0072	557·6	1003 7
80	..	80·282	176	..	176·507	1·0036	1·0089	550·6	991·1
90	..	90·381	194	..	194 685	1 0042	1 0109	543·5	978·3
100	100·0	100·500	212	212·0	212·900	1·0050	1·0130	536·5	965 7
110	..	110·641	230	..	231·153	1·0058	1·0153	529·4	952 9
120	..	120·806	248	..	249·450	1·0067	1·0177	522·8	940·1
130	..	130·997	266	..	267·794	1·0076	1·0204	515·1	927·2
140	..	141·215	284	..	286·187	1·0087	1·0232	508·0	914·4
150	150·0	151·462	302	302·0	304·632	1·0097	1·0262	500·7	901·2
160	..	161·741	320	..	323·133	1·0109	1·0294	493 6	888·6
170	..	172·052	338	..	341·693	1·0121	1·0328	486·2	875·1
180	..	182·398	356	..	360·316	1·0133	1·0364	479 0	862 2
190	..	192·779	374	..	379·002	1·0146	1·0401	471·6	848·9
200	200·0	203 200	392	392 0	397·760	1·0160	1·0440	464·3	835·7
210	..	213 660	410	..	416·588	1 0174	1·0481	456·8	822·2
220	..	224·162	428	..	435·480	1 0189	1·0524	449·4	808·9
230	..	234 708	446	..	454·474	1·0204	1·0568	441·9	795·4

It also became desirable to introduce new corrections, which the progress of the inquiry showed to be needful. Thus, Mr. Phillips's careful experiments determined the alteration in the capacity of the boiler at different temperatures, and correction was in future made for this difference. The alteration in the capacity of the measuring tanks was also estimated, whenever the temperature differed 2° from that at which they were gauged. Another cause of error, for which allowance should be made, is any difference which may exist between the initial and final temperature at the beginning and close of the experiment. This difference being known by observation, the correction may be applied from the table of expansion of the water in the boiler, given. Introducing these new corrections into the experiments for ascertaining the co-efficient of the heating power of the wood, the following are the formulæ used by Mr. Phillips:—

$$\frac{(W + w - w')(l + t) + w\,t' + (w' - w)\,t''}{P\,l} = E.$$

In which W is the water let down from the tanks during the experiment.

w = The weight of water found in the boilers at commencement of experiment.

w' = The weight of water in boiler at close of experiment.

l = Co-efficient of the latent heat of steam.

t = Quantity of heat necessary to raise the water in tanks from its mean temperature to that at which it is evaporated.

t' = Quantity of heat necessary to raise the water in the boiler from the initial to the final temperature.

t'' = Quantity of heat necessary to raise water at the temperature of tanks to the final temperature of water in the boiler.

P = Weight of combustibles consumed during experiment.

E = The co-efficient of the heating powers of wood.

But when the initial is lower than the final temperature, the formula becomes—

$$\frac{(W + w - w')\,l + Wt + wt' + (w' - w)\,t'''}{P\,l} = E.$$

All the terms retaining their original value except the last, in which t'' is replaced by t''' (or the heat necessary to raise the final temperature to that at which the water was expanded), and must be regarded as having a negative value, while t' becomes positive. If now q is the weight of wood used in lighting the fire, the formula for estimating the evaporative power of the coal will be

$$\frac{(W - Eq + w - w')\,l + (W + w - w')\,t + wt' + (w' - w)\,t''}{P\,l} = E'$$

$$\text{And } \frac{(W - Eq + w - w')\,t + Wt + wt' + (w' - w)\,t'''}{P\,l} = E'.$$

As the experiments are strictly comparative, and under like conditions, the want of the other corrections, to which we have alluded above, will not be felt in examining the results; while their execution would have introduced a refinement into the experiments which never could be obtained in practice, and which, in fact, would be useless and unwarrantable while, as previously remarked, the errors of observation in all such approximative experiments remain so large.

The only omitted correction which in appearance might be supposed necessary for practical purposes, is that for the hygroscopic condition of the fuel. Had wood been employed, this must have been done; but the hygroscopic nature of coal is very much less than that of wood. The latter contains ¼ its own weight of hygroscopic water; and the heat necessary for the evaporation of this quantity might be shown by a simple calculation to be nearly equal to 22 per cent. of the total heat obtained by the combustion of the wood. The hygroscopic water in coal is however very small, as will be seen by the following determinations of some of the Welsh specimens experimented upon:—

			Hygroscopic water.
Graigola Coal	..	..	1·06 per cent.
Anthracite	..	..	2·44 „
Oldcastle	..	..	0·74 „
Ward's Fiery Vein	..	..	1·27 „
Mynydd Newydd	..	..	0·67 „
Pentrepoth	..	..	0·78 „
Pentrefelin	..	..	0·70

Had we introduced corrections for these small quantities, practice would have been misled; because the coals will rarely reach a vessel in the dry state that they did in the present case, when they were packed in hogsheads and kept under cover.—It was found unnecessary to correct for any inflammable gases flying up the chimney, because repeated analyses of the chimney gases proved them not to contain any combustible constituent; the only products ever found being carbonic acid, sulphurous acid, oxygen, and nitrogen. The quantity of free oxygen in the chimney varied from ½ to ¼ of the oxygen which combined with the fuel; in other words, nearly twice the quantity of air passes through the fire than that which is strictly necessary by theory.

With regard to the selection of the coals for trial, we have to refer to Mr. Wilson's letter. This letter gives the information obtained in a tour made by Professor Wilson for the purpose of ascertaining the best coals fitted for trial in the South Wales coal district, and the ports from which they can conveniently be shipped. This district was selected because the varying character of the coals, from the bituminous to the anthracitic, offered those which were most likely to combine the qualities desired for naval purposes. It was intended, as being most convenient for the inquiry, to have adhered strictly to districts. In the experiments this has hitherto been done, except in special cases at the request of the Admiralty.

The following table (Table II.,) contains an abstract of the results, so far as regards the evaporative value of the fuel. This table relates only to the economical value of the coals examined, and to the steam generated by a unit of the respective coals, without however implying a unit of time. The details with reference to time, which forms a most important element in the value of the respective fuels, will be given hereafter.

TABLE II.—*Showing the Economic Values of the Coals.*

Names of Coals employed in the Experiments.	Economic evaporating power, or number of pounds of Water evaporated from 212° by 1 lb. of Coal.	Weight of 1 cubic foot of the Coal as used for fuel.	Weight of 1 cubic foot as calculated from the density.	Ratio of B. to C., or of the economical to the theoretical weight.	Difference per cent. between theoretical and economical weights.	Space occupied by 1 ton in cubic feet (economic weight).	Results of experiments on cohesive power of Coals per centage of large Coals.	Evaporating power of the Coal after deducting for the combustible matter in the residue.	Weight of Water evaporated from 212° by 1 cubic foot of Coal.	Rate of evaporation, or number of lbs. of Water evaporated per Hour.
	A.	B.	C.	D.	E.	F.	G.	H.	I.	Mean.
WELSH COALS.		lb.	lb.							
Graigola	9·35	60·166	81 107	·742	34·8	37·23	49·3	9 66	581·20	441·48
Anthracite, Jones	9·46	58·25	85·786	·679	47·26	38·45	68 5	9·7	565·02	409·37
Oldcastle Vein..	8 94	50·916	80·42	·633	57·946	43·99	57·7	..	455·18	464 30
Ward's fiery vein	9·40	57·433	83·85	·685	46·	39·	46·5	10 6	606·78	529·90
Binea	9 94	57·08	81·357	·702	42·63	39·24	51·2	10·3	587·92	486·95
Llangennech ..	8·86	56·93	81·85	·695	43·76	39·34	53·5	9·2	523·75	373·22
Pentrepoth ..	8·72	57 72	81·73	·705	40·17	38·80	46·5	8·98	518·32	381·50
Pentrefelin ..	6·36	66·166	84·726	·781	28 051	33·85	52·7	7·4	489 62	247·24
Duffryn	10·14	53·22	82·72	·643	55·43	42·09	56·2	11·80	540·12	409·32
Mynydd Newydd	9·52	56·33	81·73	·689	45·09	39·76	52·7	10·59	536·26	470 69
Three-quarter Rock Vein ..	8·84	56·888	83·60	.674	48·26	39·72	52·7	..	498 46	486·86
Cwm Frood Rock	8·70	55·277	78·299	·706	41·648	40·52	72·5	9·35	480·90	379·80
Cwm Nanty-gros	8·42	56·0	79 859	·701	42·60	40·90	55·7	8·82	471·52	404 16
Resolven	9 53	58·66	82·354	·712	40·39	38·19	35·0	10·44	559·02	390·25
Pontypool.. ..	7·47	55·7	82·35	·676	47·845	40·216	57·5	8·04	416·07	250·40
Bedwas	9 79	50·5	82·6	·611	63 565	44·32	54·0	9·99	494 39	476·96
Ebbw Vale ..	10·21	53·3	78·81	·676	45·98	42·26	45·0	10·64	544·19	460·22
Porthmawr ..	7·53	53·3	86·722	·614	62·7	42·02	62 0	7·75	401·34	347 44
Coleshill	8·0	53·0	80·483	·658	51·85	42·26	62·	8·34	424·0	406·41
SCOTCH COALS.										
Dalkeith Jewel	7·08	49·8	79·672	·625	59·984	44·98	85·7	7·10	352·58	355·18
„ Coronation	7·71	51 66	78·611	·657	52·17	43·36	85·2	7·86	398·29	370·08
Wallsend Elgin	8·46	54·6	78·611	·694	43·78	41·02	64·	8·67	460·82	435·77
Fordel Splint ..	7·56	55·0	78·611	·699	4 ·92	40·72	63·	7·69	415·80	464·98
Grangemouth ..	7·40	54·25	80·48	·674	48 35	40·13	69·7	7·91	401·45	380·40
ENGLISH COALS.										
Broomhill ..	7·3	52·5	77·988	·673	48·55	42·67	65·7	7·66	383·25	397·78
Lydney ..	8·52	54·444	80 046	·68	47·02	41·14	55·0	8·98	463·86	487·19
IRISH.										
Slievardagh ..	9·85	62·8	99·57	·630	58·55	35·66	74·	10·49	618·58	473·18
PATENT FUEL.										
Wylam's	8·92	65·08	68·629	·948	5·45	34·41	..	9·74	430·51	418·89
Bell's	8 53	65·3	71·124	·918	8 91	34·30	..	8 65	557·0	549·11
Warlich's.. ..	10·36	69·05	72 284	·955	4·49	32·44	..	10·60	715·36	457·84

The economical results obtained by evaporation in the best-applied practice are ascertained to be only a small part of the theoretical result following from the actual quantity of heat capable of being generated. Still, as a comparative statement, it is necessary to contrast the economical heat given out by a coal with the theoretical quantity. The cause of the difference between the applied and theoretical quantities is, at least in a great degree, obvious, and does not by the apparent difference prove the fallacy of calculation. Before the comparison can be made, it is necessary to have a knowledge of the composition of the respective coals: of this we subjoin a table.—(*See* Table III.)

Chemists differ as to the mode of calculating the theoretical heating values of coals, but, as an approximative rule, without insisting on its absolute accuracy, their calorific values are found to stand in relation to the quantity of oxygen required for their complete combustion. This may be estimated experimentally by heating the coal with an excess of litharge; or it may be determined by calculation from the known equivalents of the combustible ingredients of the coal. From the quantity of lead reduced by the coal, the oxygen employed in its combustion may be estimated, and the calorific values stand in direct relation to this quantity. The amount of oxygen necessary to consume the combustible constituents may more accurately be determined by elementary analysis; and thus calculated, the results are gene-

TABLE III.—*Showing the Mean Composition of average samples of the Coals.*

Locality or name of Coal.	Specific Gravity.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Per centage of Coke left by each Coal.
WELSH COALS.								
Graigola	1·30	84·87	3·84	0·41	0·45	7·19	3·24	85·5
Anthracite	1·375	91·44	3·46	0·21	0·79	2·58	1·52	92·9
Oldcastle Fiery Vein	1·289	87·68	4·89	1·31	0·09	3·39	2·64	79·8
Ward's Fiery Vein	1·344	87·87	3·93	2·02	0·83	*	7·04	..
Binea	1·304	88·66	4·63	1·43	0·33	1·03	3·96	88·10
Llangennech	1·312	85·46	4·20	1·07	0·29	2·41	6·54	83·69
Pentrepoth	1·31	88·72	4·50	0·18	..	3·24	3·36	82·5
Pentrefelin	1·358	85·52	3·72	Trace.	0·12	4·55	6·09	85·0
Duffryn	1·326	88·26	4·66	1·45	1·77	0·60	3·26	84·3
Mynydd Newydd	1·31	84·71	5·76	1·56	1·21	3·52	3·24	74·8
Three-quarter Rock Vein	1·34	75·15	4·93	1·07	2·85	5·04	10·96	62·5
Cwm Frood Rock Vein	1·255	82·25	5·84	1·11	1·22	3·58	6·00	68·8
Cwm Nanty-gros	1·28	78·36	5·59	1·86	3·01	5·58	5·60	65·6
Resolven	1·32	79·33	4·75	1·33	5·07	*	9·41	88·9
Ponty Pool	1·32	80·70	5·66	1·35	2·39	4·38	5·52	64·8
Bedwas	1·32	80·61	6·01	1·44	3·50	1·50	6·94	71·7
Ebbw Vale	1·275	89·78	5·15	2·16	1·02	0·39	1·50	77·5
Porthmawr Rock Vein	1·39	74·70	4·79	1·28	0·91	3·60	14·72	63·1
Coleshill	1·29	73·84	5·14	1·47	2·34	8·29	8·92	56·0
SCOTCH COALS.								
Dalkeith Jewel Seam	1·277	74·55	5·14	0·10	0·33	15·51	4·37	49·8
Dalkeith Coronation Seam ..	1·316	76·94	5·20	Trace.	0·38	14·37	3·10	53·5
Wallsend Elgin	1·29	76·09	5·22	1·41	1·53	5·05	10·70	58·45
Fordel Splint	1·25	79·58	5·50	1·18	1·46	8·33	4·00	52·03
Grangemouth	1·20	79·85	5·28	1·35	1·42	8·58	3·52	56·6
ENGLISH COALS.								
Broomhill	1·25	81·70	6·17	1·84	2·85	4·37	3·07	59·2
Park End, Lydney	1·283	73·52	5·69	2·04	2·27	6·48	10·00	57·8
Slievardagh (Irish)	1·59	80·03	2·30	0·23	6·76	*	10·80	90·1
FOREIGN COALS.								
Formosa Island	1·24	78·26	5·70	0·64	0·49	10·95	3·96	..
Borneo (Labuan kind)	1·28	64·52	4·74	0·80	1·45	20·75	7·74	..
„ 3 feet seam	1·37	54·31	5·03	0·98	1·14	24·22	14·32	..
„ 11 feet seam	1·21	70·23	5·41	0·67	1·17	19·19	3·23	..
PATENT FUEL.								
Wylam's	1·10	79·91	5·69	1·68	1·25	6·63	4·84	65·8
Bell's	1·14	87·88	5·22	0·81	0·71	0·42	4·96	71·7
Warlich's	1·15	90·02	5·56	Trace.	1·62	*	2·91	85·1

* Included in the Ash.

rally found to be about ⅛ greater than those indicated by experiment with the litharge. The calculation from the elementary analysis depends upon the circumstance, that 6 parts, or one equivalent, of carbon requires 16 parts, or two equivalents, of oxygen for combustion, while 1 part of hydrogen requires 8 parts of oxygen; it is only necessary, therefore, to subtract from the hydrogen a quantity corresponding to the oxygen contained in the coal to enable the calculation to be made on these principles.

As the calorific values are only relative, it is useful to refer them to the heating power of pure carbon, one part of which requires 2·666 parts of oxygen for combustion, and is capable, according to Despretz, of heating 78·15 parts of water from its freezing to its boiling point. The calculation may be simplified by multiplying each part of lead obtained by 2·265, which gives at once the weight of water capable of being heated between these temperatures by a unit of the coal used in reducing the litharge. On these principles the following table is constructed.—(*See* Table IV.

With regard to the practical application of fuel, such a table could not supersede experiment, as the economical values of the coal depend also on adventitious circumstances connected with their physical as well as their chemical condition. This table, while on the whole it agrees with and confirms the practical results of experiments, still differs in a marked degree in one or two instances: this difference arising as much from the chemical as from the physical differences of the coals. Thus, if by destructive distillation, which occurs in furnaces before combustion, a large quantity of the constituents of the coal are rendered gaseous, so much heat is expended in this act that the heat developed by their after-combustion is frequently not greater than that abstracted during their formation, in which case a thermo-neutrality occurs. To ascertain the proportion of fixed and volatile products in the various coals, a very difficult and elaborate process was adopted; but the tediousness and chances of failure in this kind of analysis have induced us to include only a limited number of coals (those given in Table V.), especially as for steam purposes it was sufficient to determine the per centage of coke, as stated in Table II.

TABLE IV.—*Showing the Calorific Values of the Coals.*

Locality or Name of Coal employed in the Experiments.	Quantity of Lead reduced by one part of Coal.	Oxygen removed from Litharge by one part of Coal.	Quantity of Oxygen theoretically required by Carbon and Hydrogen.	Quantity of Oxygen required by Carbon alone.	Relative calorific values, Carbon taken as 100, calculated from A. and B.	Number of lbs. of Water which 1 lb. of Coal can raise from 32° Faht. to 212° Faht., calculated from A.
WELSH COALS.	A.	B.	C.	D.	E.	F.
Graigola	32·08	2·49	2·49	2·26	93·4	72·66
Anthracite (Jones and Co.) ..	33·48	2·60	2·69	2·43	97·5	75·73
Oldcastle Fiery Vein	31·42	2·44	2·71	2·34	91·5	71·16
Ward's Fiery Vein	31·46	2·44	2·65	2·34	91·5	71·25
Binea	31·64	2·46	2·72	2·36	92·2	71·66
Llangenneck	32·66	2·53	2·59	2·28	94·9	73·97
Pentrepoth	31·16	2·39	2·69	2·36	89·6	70·57
Pentrefelin	30·52	2·37	2·53	2·28	89·2	69·13
Powel's Duffryn	30·00	2·33	2·71	2·35	87·7	67·95
Mynydd Newydd	30·34	2·35	2·67	2·25	88·5	68·72
Three-quarter Rock Vein ..	26·62	2·06	2·34	2·00	77·2	60·29
Cwm Frood Rock Vein ..	28·30	2·19	2·62	2·19	82·5	64·10
Cwm Nanty-Gros	29·64	2·28	2·47	2·08	85·5	67·13
Resolven	32·16	2·50	2·49	2·11	93·7	72·84
Pontypool	27·46	2·13	2·55	2·15	80·2	62·19
Bedwas	28·20	2·19	2·60	2·15	82·1	63·87
Ebbw Vale	32·00	2·48	2·80	2·39	93·0	72·48
Porthmawr Rock Vein	24·78	1·92	2·33	1·99	72·0	56·12
Coleshill	26·14	2·03	2·28	1·96	76·1	59·21
SCOTCH COALS.						
Dalkeith Jewel Seam	26·42	2·05	2·24	1·98	76·8	59·84
,, Coronation Seam ..	24·56	1·96	2·32	2·05	73·5	55·63
Elgin Wallsend	29·06	2·25	2·38	2·02	84·7	65·82
Fordel Splint	29·00	2·25	2·47	2·12	84·7	65·68
Grangemouth	28·48	2·20	2·46	2·13	82·8	64·51
Broomhill (English)	25·32	1·96	2·63	2·18	73·5	57·35
Slievardagh (Irish)	30·10	2·33	2·31	2·13	87·7	70·44
PATENT FUEL.						
Wylam's	28·32	2·23	2·52	2·13	84·0	65·27
Bell's	28·52	2·21	2·75	2·34	83·2	64·59
Warlich's	31·50	2·44	2·84	2·40	91·5	71·35

TABLE V.—*Showing the Amount of Various Substances produced by the destructive Distillation of certain Welsh Coals.*

Name.	Coke.	Tar.	Water.	Ammonia.	Carbonic Acid.	Sulph. Hydrogen.	Olefiant Gas and Hydro-Carbon.	Other Gases Inflammable.
Graigola	85·5	1·2	3·1	0·17	2·79	Traces.	0·23	7·01
Anthracite . ..	92·9	None.	2·87	0·20	0·06	0·04	?	3·93
Oldcastle fiery vein	79·8	5·86	3·39	0·35	0·44	0·12	0·27	9·77
Ward's fiery vein	..	1·80	3·01	0·24	1·80	0·21	0·21	..
Binea	88·10	2·08	3·58	0·08	1·68	0·09	0·31	4·08
Llangenneck ..	83·69	1·22	4·07	0·08	3·21	0·02	0·43	7·23

It has been for some time asserted, that the evaporative value of a bituminous coal is expressed by the evaporative value of its coke, the heat of combustion of its volatile products proving in practice little more than that necessary to volatilise them. If this supposition were even near the truth, the most useful practical results might follow from it. By a larger and better applied system of gas manufacture, the volatile products of distillation might be made useful not only for the purposes of illumination, but also for domestic heat, and the residual coke might be used with an equal economy in our manufactures*; thus preventing the emission of that smoke which at present is so destructive to the comfort of our large cities. It is easy from analysis to examine whether the duty performed by the coal is to be attributed to its fixed ingredients or coke, by estimating the work which the latter is capable of performing. This may be done by subtracting the amount of ashes in the coal from its amount of coke (Table III.) and estimating the remainder as carbon. This carbon multiplied by its heating power, 13268, and divided by 965·7 or the latent heat of steam, indicates the number of pounds of water which the coke by itself could evaporate, without the aid of the combustible volatile ingredients of the coal. These results are placed in column B, of Table VI., in juxta-position with the actual work done by the [illegible], and it will be seen, that notwithstanding several striking exceptions, which might have been expected, they on the whole show that the work capable of being performed by the coke alone, is actually greater than that obtained by experiments with the original coal.

The whole system of manufacturing coke is at present very imperfect. Besides losing the volatile combustible substances, which under new adjustments might be made of much value, an immense quantity of ammonia is lost by being thrown into the atmosphere. Ammonia and its salts are daily becoming more valuable to agriculture, and it is their comparative high price alone which prevents their universal use to all kinds of cereal cultivation. By a construction of the most simple kind, the coke ovens now in use might be made to economise much of the nitrogen which invariably escapes in the form of ammonia. As an inducement to this economy, we have appended to Table VI two columns (H. and I.), showing the quantity of ammonia (NH_3), and its corresponding quantity of commercial sulphate (NH_4O, SO_3), which each 100 lb. of the respective coals may be made to produce. When it is remembered, that the price of sulphate of ammonia is about £13 per ton, or that 100 tons in coking is capable of producing, on an average, about 6 tons of this salt, its neglect is highly reprehensible.

By the preceding data, the actual value of the coals will be contrasted with that which is theoretically possible, supposing their combustion proceeded under circumstances which prevented any loss of heat. The actual duty obtained by a pound of coal from the boiler employed may be easily expressed by the number of pounds raised to the height of one foot. This result may readily be obtained by the simple formula—

$$W\eta \times 965{\cdot}7 \times 782 = x,$$

W representing water, of which η pounds are evaporated by a pound of coal. This formula is deduced from the fact that η pounds of water multiplied by 965·7,* or the co-efficient for the latent heat of steam at 212°, indicates the number of pounds of water which would be raised 1° Fahrenheit; and the number 782 arises from experiment on the mechanical force denoted by the elevation of a pound of water 1° Fahrenheit; that force being equal to 712 lb., raised to the height of one foot, according to the careful experiments of M. Joule, on the friction of oil, water, and mercury.

The theoretical value of the coals, with reference to the number of pounds of water which one pound of fuel will convert into steam, is obtained by the formula—

$$\left(\frac{C \times 13268}{965{\cdot}7}\right) + \left(\frac{H - h \times 62470}{965{\cdot}7}\right) = x;$$

in which C is the quantity of carbon, H the quantity of hydrogen in a unit of fuel, and h the quantity of hydrogen corresponding to the oxygen contained in the coal. These multiplied by their heating powers, according to the results of Dulong, and divided by the latent heat of steam, indicate the number of pounds of water that can be converted into the latter by a pound of coal. The numbers thus obtained can be changed into the expression of mechanical force, by the previous formulæ.

The result of these calculations are thrown into Table VI.

The best Cornish engines are stated to raise 1,000,000 lb. to the height of one foot, by every pound of coal consumed; so that only about $\frac{1}{8}$ of the *actual* force generated becomes available, or only $\frac{1}{11}$ or $\frac{1}{12}$ of the force theoretically possible, is applied in practice. The various experiments made on boilers, with regard to the evaporative power of coal, have not given very uniform results. Smeaton, in 1772, with one pound of Newcastle coal, evaporated 7·88 lb. of water from 212°; Watt, in 1788, came to the conclusion that 8·62 lb. of water might be evaporated by the same quantity of coal; and later (in 1840), Wicksteed found that 1 lb. of Merthyr coal could be made to evaporate 9·493 lb. of water from 80°, which is equal to 10·746 lb. from 212°. In some experiments made on the boiler of the Loam's engine, at the United mines, in Cornwall, each pound of coal was found, by a trial of six months, to evaporate 10·29 lb. of water from 212°, this being the reduction of the result given, viz., that 234,210 cubic feet of water at 120° were evaporated by 700 tons of coal. Statements have indeed been made that 14 lb. of water have been evaporated by 1 lb. of coal burned in Cornish boilers; but as this is the utmost quantity theoretically possible, it is difficult to conceive that it has been realised in practice, even in the best-constructed steam-engines.

* In [illegible] it would not be necessary to carry on the process of distillation so far as at p[illegible] the residual coke would be more combustible and the gases purer.

* The co-efficient for the latent heat of steam at 212° is generally taken at 1000°, but the above number is from the recent experiments of Regnault on this subject, as given in Table I.

TABLE VI.—*Showing the Actual Duty, and that which is theoretically possible, of the Coals examined.*

Name or Locality of Coal employed in the Experiments.	Actual number of lbs. of Water converted into steam by 1 lb. of Coal.*	Number of lbs. of Water convertible into Steam by the Coke left by the Coal.†	Number of lbs. of Water convertible into Steam by the Carbon of the Coal.†	Number of lbs. of Water convertible into Steam by the Hydrogen of the Coal.†	Total number of lbs. of Water convertible into Steam by 1 lb. of Coal.†	Actual force generated, or the number of lbs. which 1 lb. of Coal could raise to the height of 1 foot.‡	Force capable of being generated, or number of lbs. which could be raised to the height of 1 foot by 1 lb. of Coal.†	Amount of Ammonia corresponding to the Nitrogen contained in Coal.	Amount of Sulphate of Ammonia corresponding to the Nitrogen contained in Coal.
	A.	B.	C.	D.	E.	F.	G.	H.	I.
Graigola	9·35	11·301	11·660	1·903	13·563	7,060,908	10,242,471	0·497	1·932
Anthracite ..	9·46	12·554	11·563	2·030	14·593	7,143,978	11,020,308	0·225	0·990
Oldcastle Fiery Vein	8·94	10·601	12·046	2·890	14·936	6,751,285	11,279,329	1·590	6·175
Ward's Fiery Vein	9·40	..	12·072	2·542	14·614	7,098,667	11,036,162	1·238	4·808
Bines	9·94	11·560	12·181	2·912	15·093	7,506,463	11,397,892	1·586	6·741
Llangenneck	8·86	10·599	11·741	2·519	14·260	6,690,871	10,768,829	1·299	5·044
Pentrepoth ..	8·72	10·873	12·189	2·649	14·838	6,585,146	11,205,322	0·218	0·848
Pentrefelin ..	6·36	10·841	11·749	2·038	13·787	4,802,923	10,411,630	Trace.	..
Powell's Duffryn	10·149	11·134	12·126	2·966	15·092	7,664,295	11,397,137	1·76	6·835
Mynydd Newydd	9·52	9·831	11·463	3·441	14·904	7,189,288	11,255,163	1·808	7·340
Three-quarter Rock	8·84	7·081	10·325	2·781	13·106	6,675,768	9,897,355	1·209	5·044
Cwm Frood Rock	8·70	8·628	11·300	3·488	14·788	6,570,043	11,167,563	1·347	5·232
Cwm Nanty-Gros	8·42	8·243	10·767	3·165	13·932	6,358,593	10,521,131	1·919	7·448
Resolven ..	9·53	10·234	10·899	3·072	13·971	7,106,840	10,550,583	1·675	6·505
Pontypool ..	7·47	8·144	11·088	3·207	14·295	5,641,175	10,795,260	1·639	6·364
Bedwas ..	9·79	8·897	11·075	3·766	14·841	7,393,186	11,207,587	1·748	6·788
Ebbw Vale ..	10·21	10·441	12·335	3·300	15·635	7,710,361	11,025,198	2·622	10·182
Porthmawr Rock	7·53	6·647	10·263	2·548	12·811	5,686,485	9,674,577	1·554	6·033
Coleshill ..	8·0	6·468	10·145	2·654	12·799	6,041,419	9,665,515	1·785	6·930
Dalkeith Jewel ..	7·08	6·239	10·242	2·071	12·313	5,346,655	9,298,499	1·214	0·471
Dalkeith Coronation	7.71	6·924	10·570	2·202	12·772	5,822,417	9,645,135	Trace.	..
Wallsend Elgin	8·46	6·560	10·454	2·968	13·422	6,388,800	10,135,991	1·712	6·647
Fordel Splint	7·56	6·560	10·933	2·884	13·817	5,709,141	10,434,286	1·372	5·327
Grangemouth	7·40	7·292	10·970	2·722	13·692	5,588,312	10,339,888	1·639	6·364
Broomhill ..	7·30	7·711	11·225	3·638	14·863	5,512,795	11,224,201	2·234	8·674
Park End, Lydney	8·52	6·567	10·101	3·156	13·257	6,434,111	10,011,886	1·477	9·617
Slievardagh (Irish)	9·85	10·895	10·995	1·487	12·482	7,438,497	9,426,124	0·279	1·084
Formosa Island	..	..	10·752	2·801	13·533	..	10,234,919	0·777	3·017
Borneo (Labuan)	..	..	8·864	1·388	10·252	..	7,742,078	0·977	3·771
„ 3 feet seam	..	..	7·461	1·295	8·756	..	6,612,333	1·132	4·620
„ 11 „	..	..	9·652	1·948	11·600	..	8,760,057	0·813	3·158
Wylam's Pt. Fuel	8·02	8·378	11·186	3·145	14·331	6,736,182	10,822,447	2·040	7·920
Warlich's ..	10·36	11·292	12·368	3·596	15·964	7,823,637	12,055,652	Trace.	..
Bell's ..	8·53	9·168	12·074	3·343	15·417	6,441,663	11,642,569	0·983	3·818

* Practical. † Theoretical. ‡ Calculated from heat obtained.

To ascertain how far our boiler was inferior to Cornish boilers, as principally from its size and less efficient coating it was likely to prove, we requested Mr. Phillips to make some experiments on one of the best engines in Cornwall. It was found by these experiments, that 11·42 lb. of water were evaporated by every pound of Welsh coal corresponding in composition to that of Mynydd Newydd; or, in other words, that improved Cornish boilers on a large scale may be assumed to have a superiority of nearly 20 per cent. over that used in these experiments. As the results stated in this Report are only relative, the comparison is not affected by this difference.

We have anxiously looked to the application of these experiments to the different varieties of patent fuel, but we have not been able to carry our observations in this direction to the extent we could have desired, from our inability to procure patent fuels in sufficient number, although our applications to the patentees have been numerous. Three varieties have been already examined, viz., those manufactured under the patents of Messrs. Wylam, Warlich, and Bell, and the results are given in the tables. The varieties of patent fuel are generally made up in the shape of bricks, and are therefore well adapted for stowage; so that, though the specific gravity of patent fuels is lower than that of ordinary coals, from their shape and mechanical structure there are very few coals which could be stowed in a smaller space per ton. While we look to the different varieties of patent fuel as of the highest importance, and, from their facility of stowage, as being peculiarly adapted for naval purposes, and perhaps even destined to supersede ordinary coal, at the same time, the greater part do not appear to be manufactured with a proper regard to the conditions required for war steamers. It is usual to mix bituminous or tarry matter with bituminous coal, and from this compound to make the fuel. An assimilation to the best steam coal would indicate, however, the very reverse process, and point to the mixture of a more anthracitic coal with the bituminous cement. As the greater part is at present made, it is almost impossible to prevent the emission of dense opaque smoke, a circumstance extremely inconvenient to ships of war, as betraying their position at a distance at times when it is desirable to conceal it. Besides this and other inconveniences, the very bituminous varieties are not well suited to hot climates, and are as liable to spontaneous combustion as certain kinds of coal. To avoid these inconveniences, some kinds of patent fuels have been subjected to a sort of coking, and thus, in a great measure, obtain the desired conditions. There is little doubt, however, that notwithstanding the large number of patents in operation for the manufacture of fuel, its value for the purposes of war steamers might be much enhanced by its preparation being specially directed to this object. It will be seen, by reference to Table II., that the three patent fuels examined rank among the highest results obtained. Should it be desirable to continue this inquiry, we conceive that it would be advantageous to pay special attention to this subject, by experimenting upon proper mixtures of different coals. Even anthracite may be introduced into such mixtures with advantage.

It is of much importance in an economical inquiry on coals, to obtain exact information as to the effects likely to be produced upon them by stowage and continued exposure to high temperature, not only as regards their deterioration, but also as to the emission of dangerous gases by their progressive changes.

The retention of coal in iron bunkers, if these are likely to be influenced by moisture, and especially when by any accident wetted with sea-water, will cause a speedy corrosion of the iron, with a rapidity proportionate to its more or less efficient protection from corroding influences. This corrosion seems due to the action of carbon or coal forming with the iron a voltaic couple, and thus promoting oxidation. The action is similar to that of the tubercular concretions which appear on the inside of iron water-pipes, when a piece of carbon, not chemically combined with the metal, and in contact with saline waters, produces a speedy corrosion. Where the "make" of iron shows it to be liable to be thus corroded, a mechanical protection is generally found sufficient. This is sometimes given by Roman cement, by a lining of wood, or by a drying oil driven into the pores of the iron under great pressure.

Recent researches on the gases evolved from coal, prove that carbonic acid and nitrogen are constantly mixed with the inflammable portion, showing that the coal must still be uniting with the oxygen of the atmosphere, and entering into further decay.

Decay is merely a combustion proceeding without flame, and is always attended with the production of heat. The gas evolved during the progress of decay, in free air, consists principally of carbonic acid, a gas very injurious to animal life. It is well known that this change in coal proceeds more rapidly at an elevated temperature, and therefore is liable to take place in hot climates. Dryness is unfavourable to the change, while moisture causes it to proceed with rapidity. When sulphur or iron pyrites (a compound of sulphur and iron) is present in considerable quantity in a coal still changing under the action of the atmosphere, a second powerful heating cause is introduced, and both acting together, may produce what is termed *spontaneous combustion*. The latter cause is in itself sufficient, if there be an unusual proportion of sulphur or iron pyrites present.

The best method of prevention, in all such cases, is to ensure perfect dryness in the coals when they are stowed away, and to select a variety of fuel not liable to the progressive decomposition to which allusion has been made. This is, however, a subject of so much importance to the steam navy, that it continues to receive our careful attention; and, beyond these general recommendations, it would be premature to offer any decided course for adoption, from the present limited series of observations.

Several varieties of coal were transmitted from Formosa and from Borneo, for analysis, the results of which are contained in the accompanying table. The quantity of each kind was so small, that no experiments could be made on their evaporative value. We extract from the preceding table the following results:—

Name.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ashes.	Specific Gravity.
Formosa Island ..	78·26	5·70	0·64	0·49	10·95	3·96	1·24
Borneo, Labuan kind	64·52	4·74	0·80	1·45	20·75	7·74	1·28
„ 3 feet seam	54·31	5·03	0·98	1·14	24·22	14·32	1·37
„ 11 feet seam	70·33	5·41	0·67	1·17	19·19	3·23	1·21

THE HOUSES OF PARLIAMENT.

That so important an edifice and national work as the "Houses" should be a frequent subject of discussion, both in parliamentary debate and out-of-door criticism, is only natural, especially as opinion is divided, some speaking in terms of unqualified admiration, while others see much cause for dissatisfaction, and express it accordingly; and some of the rudest critics of all whom Mr. Barry and his building have had to encounter, are among the members of the "House" itself—to wit, Messrs. Urquhart, Osborne, and Hume, and Sir D. Norreys, whose unfavourable opinions gain formidableness because they go forth to every nook in the kingdom where a newspaper finds its way. Last month we spoke of an article on the "Houses of Parliament," which had just before appeared in the "*Westminster Review*,"—and which, by-the-by, is now known to proceed from the pen of Earl Lovelace; and in the interval another has appeared in the "*Mechanic's Magazine*," of similar tendency. Whether this latter will call forth any remonstrance against it from the "*Builder*," remains to be seen; for at the present time of our writing, opportunity for reply to it has not arrived. The "*Magazine*" takes up the "*Builder*" pretty sharply upon two points. The first of them is the attempt on the part of the last-mentioned publication to set aside Lord Lovelace's objections to the position of the Victoria Tower at a corner, and the most remote corner, of the building, by remarking that such position for it was dictated by the plan adopted by Mr. Barry; whereupon the "*Magazine*" is somewhat sarcastic, and to say the truth, Mr. Barry has no cause to feel particularly grateful towards a defender who exculpates him, by removing the fault from him and throwing it upon—his design: as if defects of arrangement were to be attributed to the plan itself, and not to the architect. If the internal arrangement which first presented itself to the architect occasioned what is an incongruity in the exterior, the very natural question is: Why did he not, instead of adopting it, deviate from it so as to bring in the Royal entrance porch in some less objectionable situation?—and objectionable it seems to be, for even his champion, as the "*Mechanic's Magazine*" calls the "*Builder*," does not pretend to say that it is not so, but merely that it is to be excused by being attributed to—the plan!

The second point upon which the "*Mechanic's Magazine*" is rather strong and severe with the "*Builder*," is the unguarded assertion that, although it is so now, it does not follow that the Victoria Tower will always be at the extreme corner of the edifice. The actual possibility of extending the buildings and carrying them on farther southward, by pulling down the houses on the east side of Abingdon-street as far as might be required, is not to be disputed. The probability is a very different matter,—more than can now be foreseen, and is, besides, what Mr. Barry himself neither does nor ever has contemplated; the Victoria Tower being the conclusion and *finis* of his plan, southwards. As the "*Mechanic's Magazine*" remarks, the south-west is now finished, at least in its lower part, so as to render it impossible to prolong the building, and thereby remove that Tower from its position as an extreme point in it. Done it could be, but only by undoing what is equally beautiful and costly—namely, the south side of the Royal porch, which would have to be blocked-up and built up against.

The Royal entrance is now fixed beyond the possibility of change for it. Yet, it is not even now too late to re-consider some other points in the design. For instance, although the position of that important entrance may be justified by necessities of internal arrangement, and although it is very properly made a striking feature in the design, the necessity for erecting over it a tower of very unusual magnitude, and thereby proclaiming afar off the "eccentricity," as the "*Mechanic's Magazine*" terms it, of that porch, is not at all apparent; more especially, as that lofty superstructure will be more for sight than for any real service. We incline, therefore, to the opinion of the "*Athenæum*," that it would be more adviseable now to abandon the idea of that ambitious Tower, and terminate the Porch a little above its present height. Either some curtailment, we fancy, of Mr. Barry's plans must take place, or the ultimate completion of them must not be looked for by the present generation.

Could the Tower in question have been introduced in the centre of the general plan, it would have given not only pyramidal grouping to the whole pile, but harmonious contrast in its lines to the composition. Marked verticality of lines in such an imposing feature, so placed, would have been opposed to horizontality of lines in the principal front. The lofty upright mass and the horizontally-extended façade would have balanced each other, and mutually set each other off. Other towers there now will be, rising up behind the river-front; but how far they will agree with it, and with the larger tower also, is doubtful. If we mistake not, they are intended to be tapering and spiry in outline—consequently of quite a different character from the compact solidity which marks the Victoria one; therefore somewhat at variance with the character of the front also. At least, there is reason for apprehending that the arrangement of the several towers will appear very irregular, if not confused, and occasion an unpleasant discord with the studied regularity and uniformity of the principal front—principal at least in extent, though both its situation and its aspect render it in some degree a merely secondary one. If there must be a tower that shall, by its superior bulk, greatly predominate over all the others, it surely ought to show itself in some central situation,—central as regards one of the fronts, if not central as regards the entire plan; otherwise, it will appear to have been left to chance to determine and "dictate" the respective situations of those features, instead of their being arranged with some regard to that symmetry which is observed in the main, as far as it was possible to do, and which at present stamps the whole of the east side of the edifice.

It will perhaps be said that the position of the Victoria Tower was known from the very first: it has been shown again and again in the various engravings and cuts innumerable, copied or made up from the view of the future building given by the architect himself; its grandeur has been admired, without exception being taken at its situation. Yet, though no objection has been made all along, now comes Earl Lovelace with a very strong protest against that *Tower*. Wherefore was his Lordship so tardy with his remonstrances? or how happens it that no one else could perceive, or perceiving, cared to object to what is now alleged to be a most serious defect in the general design? The position of the Tower could hardly have been overlooked by, or indeed have failed to strike, the most careless observer who glanced at any of the published views. Very true; but merely seeing with the eyes, is quite a different matter from seeing with artistic vision. It is not every one who can see, in the latter sense of the word, what is actually before their eyes. Many, again, don't care to see, even if they can do so. Others, though they may be somewhat dim-sighted, have very convenient spectacles of criticism through which they gaze, and perceive either only all beauty or all deformity—either transcendant excellence, or ridiculous monstrosity.

The many, who have no opinion of their own, are overawed by this kind of dictatorial, one-sided stuff which calls itself criticism, and is presented to them in the imposing form of type and printed paper. While those who are capable of judging for themselves either do not care to raise a dissentient voice amidst the general hubbub of applause, or condemnation, as the case may be; or else have not the opportunity of doing so. With respect to the "Houses," both the "*Westminster Review*" and the "*Mechanic's Magazine*" have ventured to dissent from the acclamations of praise bestowed upon them in other quarters. It must be allowed that both those articles dwell almost exclusively upon defects, or what their writers consider such: yet surely there is nothing particularly strange in that, the object of both being to open people's eyes to many circumstances that have all along been kept out of sight. If to point out only faults and objections be invidious, by the same rule, to pass them entirely over, and point out only merits and beauties—would that all of them were where they could be seen!—may be called sycophantic: so that between the two we may arrive at a tolerably correct and sober judgment.

BOROUGH OF LIVERPOOL.

Report to the Health Committee of the Borough of Liverpool, on the Sewerage and other works under the Sanitary Act, by the Borough Engineer, (JAMES NEWLANDS.)

The facts detailed in the Report of the engineer of the Liverpool corporation afford a strong commentary on the claims of the military engineers. We have heard a great deal about the irresponsibility of the Associated Surveyors, and the superior responsibility and guarantee of the military engineers; and Mr. Chadwick rests the defence of his job on this plea. We have always held the contrary view, from our experience of the two classes, and this Liverpool affair comes in confirmation. The fact is, the military engineers are virtually irresponsible—they cannot be made to perform their work properly or punctually; while the civil engineer, at Liverpool for instance, is responsible in his professional character and capacity, and liable to be dismissed by his employer if he do not give satisfaction. From the misconduct of the Ordnance functionaries, the corporation of Liverpool are put to the trouble, expense, and delay of a second survey—and, to make it worse, they have no remedy. Whether the metropolitan survey will turn out better we have our doubts: but it remains to be seen. At all events, the Treasury will have to make good any short-comings of the Ordnance surveyors.

If the Ordnance have been unable to do their work properly and in time at Liverpool, what security have we against delay in the general and metropolitan surveys? To the great disgrace of the government, engineers have long had to use the northern sheets of Mr. Cary's survey; and now this dilatory body, having proved itself incompetent in its past duties, is to have more thrust upon it. Why do not the Associated Surveyors get Mr. Wyld to move for a parliamentary committee of inquiry into the general management of the surveys carried on by the Ordnance?

This Report is a sufficient specimen to show that civil engineers are not incompetent for sanitary duties, and we hope it will not be forgotten, for doubtless Mr. Chadwick will next propose that military engineers should be chosen to lay down the lines of drainage, and carry out the details under the "Health of Towns" Act.

The Report may be divided into the following parts:—

Sewage and drainage, what are the necessary conditions to produce a perfect system.

Description of the borough of Liverpool in relation to the river Mersey and the docks—the effects of discharging the sewage into the docks and river.

Schemes for constructing a new sewage.

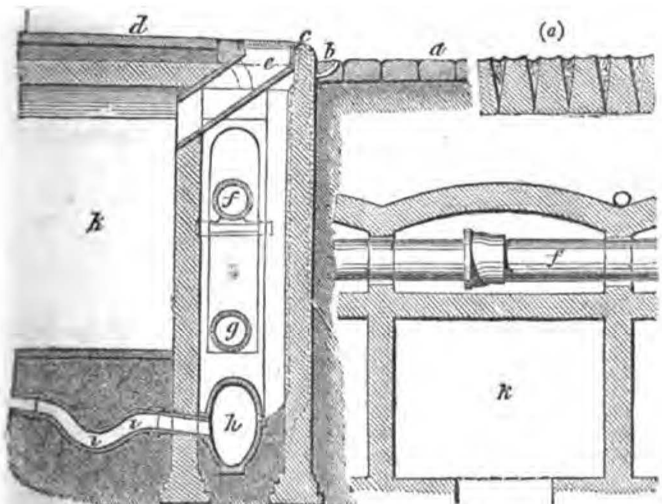
Lists of all the existing sewers, showing their size and length—of new sewers required.

Estimates for forming the new system of sewage.

On the application of the sewage water for fertilizing the soil.

On the form and size of sewers and drains. From this part of the report we make the following extracts:—

Sewers and Drains.—The proper size and forms of sewers and drains is a subject which of late has excited much controversy. In so far as the house drainage is concerned, the question lies within narrow limits; for if all the liquid refuse of a house passes through a soil-pipe of 2½ or 3 inches diameter, there is surely no need of the drain which receives it being made much larger. If more than one pipe enters a drain, the question is still a simple one; and although, by calculation, the corresponding increase of capacity for every additional pipe which enters the drain could be readily determined, practice will hardly admit of the refinement which would so nicely adjust the increments; and it is easy so to proportion the drain pipe in each case with the materials in practice at our disposal, that it shall be no larger than the quantity of water available under the particular circumstances of the case shall thoroughly flush. Pipes of from three to six inches internal diameter, are amply sufficient for service drains, as one of six inches, with a fall at the rate of one in forty will, according to the ordinary formula, discharge, in half-a-minute, as much water as is due to a family of six individuals for a whole day, even on the liberal scale of five cubic feet per head.



a, Carriage Pavement; *b*, Channel Stone; *c*, Curb; *d*, Foot-Paving; *e*, Coal-Vault Shoot; *f*, Gas-Pipe; *g*, Water-Pipe; *h*, Sewer; *i*, Syphon Trap; *j*, Tube; *k*, Coal-Vault.

The drains of streets should, in my opinion, be double in all the streets above twelve yards wide; and in such cases I would construct them in the bottom of the side trenches for the water and gas pipes, as shown in the annexed engraving. By this arrangement are insured diminished capacity and direct communication, and the other advantages connected with the paving, elsewhere insisted on. The first cost of the double sewer is nearly balanced by the saving in the service drains; and in regard to the paving, it is impossible sufficiently to estimate the saving, if, in connection with these side trenches, the more durable manner of paving recommended be introduced. The sewer proposed to be used in this case consists of a semi-oval underpart, formed of stone ware, or some of the other materials which will afterwards be noticed, and a semicircular cover, as shown in the above engraving. The joinings I propose to form with the pitch of coal-tar, in rather a soft state; and when any part of the drain requires to be inspected, a hot iron or a little blazing straw will soften the cement so much as to admit of the cover being removed. Service drains are connected with the side drains by means of sockets formed in the latter.

The report proceeds to denote the different forms of sewers and their connections, which are something similar to those described in the *Journal* for March last, p. 77. It then gives the area of land drained into each of the main sewers.

From observations made while Beacon's Gutter sewer (6ft. by 4 ft. 6 in.) was opened at its outlet, for the admission of the new sewer in Great Howard-street, it was found that the water was only 20¾ inches deep, after twelve hours of heavy rain.

The extent of drainage into that sewer is 983·3 acres; of which about one-fourth is built, and three-fourths unbuilt. Now, by the formula most approved, the diameter of sewer necessary for this drainage, with the given fall, would be ten feet, while the actual diameter of the sewer at its largest part is only 4 ft. 6 in., and the depth of water in it was somewhat less than a third of its longest axis, even after the continuance of heavy rain for twelve hours, when it may be reasonably supposed the whole earth would be saturated, and every drop of rain would flow into the sewer. All calculations for the capacity of sewers proceed on the assumption, that it is necessary to provide for the contingency of a rain flood, estimated at the enormous fall of five-eighths of an inch in half-an-hour. Now, that such a flood may occur is possible; but it would be easy to show, that if it did occur, it could not get into the sewer, and therefore there is no necessity to make provision for it; and it requires merely a glance at the streets of a town built on sloping ground like Liverpool, during even a moderately heavy rain, to be convinced, that a great part of the rain drains directly by the surface of the street into the river, and never enters the sewers. As all formulæ then, are founded on imperfect experiments, and give results so far above what experience shows to be necessary, they are obviously uncertain guides, and it is better to trust to the observations of what actually takes place. This, in fact, is experimenting on the largest and most proper scale.

The Report afterwards makes some observations on surface drainage and paving. If the streets of a town be unevenly paved, putrid exhalations will constantly arise. A smooth, non-absorbent, hard surface, without hollows or joints, is what health demands. Macadamised streets are the worst: the absorbent material soaks up the liquid filth, which, putrifying, sends its noxious exhalations into the atmosphere; and the road wears fast under great traffic—in wet weather it is covered with mud, and in dry weather the air is loaded with dust. It is the most expensive to keep in repair, and costs four times as much to cleanse as a paved road. Boulder paving is the next lowest in the scale of roads. Streets formed with stones dressed in regular courses are the best: where the road is steep the courses should be of stone 3 inches wide, with joints 1½ inch wide, filled up with cementitious substance, impervious to water. In streets less steep, the stones may be increased and the joints decreased. On a level, the stones may be increased to 5 inches in width.

To insure stability, the courses should be made nearly wedge-form. They should be in contact at their base and for about one-third of their height, and the width of the joint should be obtained by diminishing the width of the upper surface of the courses. The joints should be rammed hard with macadam or clean shingle, and then filled with a coarse kind of asphalte, composed of the pitch of gas-tar and small gravel. The joint should not be filled quite flush with the surface of the stones, but left slightly hollow, as in the figure (*a*). If the expense of the asphalte be objected to, lime grout may be used to fill the joints. The lime should, for this purpose, be such as will set under water.

For the foot-pavement, Caithness stone, 1½ inch thick, with sawn joints, is recommended in preference to Yorkshire stone 3 inches thick.

A good foundation to a road is no less essential than a good surface; hardness in the latter cannot be insured without firmness in the former. Softness or elasticity in a foundation will permit the surface to yield under the wheels of a carriage. The rise and fall forms a new obstacle to be overcome, and causes an increased amount of friction to be opposed to the moving power. Besides, by the sinking of the paving material, the soft earth is forced up between the stones, and covers the road with mud. It is worth while, then, to be at a little extra cost in the preparation of the foundation, when so much depends upon it; and I think the following plan the best adapted to secure perfect firmness. A level bed is prepared for the materials, and on this a pavement of common soft rock is laid by hand. The deepest stones are used for the centre, and the size is diminished towards the side, so as to bring the top line nearly to the intended transverse section of the road. The stones are all laid on their broadest edges lengthways across the road, and the thickness of the upper edge should not exceed four inches. When the setting is completed, the irregularities are broken off by hammers, and the interstices filled in with the chips. On the foundation so prepared, a three-inch stratum of small broken stones is to be laid, and on this, where the case will afford it, a coating of clean gravel should be spread, and the whole rolled with a heavy roller until consolidated, when it is in a condition to receive the covering of paving stones. The under pavement would be still farther improved by running the joints with good lime grout before laying on the ballasting; and in the case of macadam roads, the previous ballasting is not required, the macadam being laid directly on the pavement.

The objection to a street formed and paved in a manner so permanent as that described, is, that it requires to be frequently broken up for laying or repairing water and gas pipes and making branch sewers, and cannot be reinstated in so perfect a manner. But water and gas pipes should not be laid in the carriage way, but in trenches formed along the sides of the streets, as shown in the foregoing engraving, and the sewers should be double and laid in the bottom of these trenches. The advantages of this mode of forming streets I have before pointed out, and shall now merely exhibit a statement of the comparative cost of the two modes. The calculation is made for a street fifteen yards wide, and the actual cost of both modes is given:—

Estimated cost of side-trenches for gas and water pipes, and sewers.

6 Yards Brickwork, in one lineal yard, at 3s. 6d. per yard superficial			..	£1	1	0
10 Yards Brickwork do. do, at 2s. 0d.	„	cube	..	1	0	0
Cast Iron Bearers do. do. at 5s. 6d.	„	..	..	0	5	6
Side Entrances (every 40 yards) at 1s. 6d.	„	..	..	0	1	6
		Total, ..	..	£2	8	0

Estimated saving in the cost of laying down gas and water pipes, and excavating for sewers by using side-trenches.

In the Lineal Yard.

Main Sewer, 10 yards excavating, say one-half, at	1s. 0d.	£0	10	0			
Gas Pipes do.	2s. 8d.	0	3	3			
Water Pipes do.	2s. 3d.	0	3	3			
House Drains do. and Pipes	9s. 0d.	0	9	0			
Branch Pipes (Gas and Water) do.	2s. 6d.	0	2	6	£1	8	0
The difference of expense	..				£1	0	0

The excess of the cost of the trenches is £1 per lineal yard of street; but to counterbalance that cost, there is the saving in keeping the street in repair and cleansing it—the convenience and the non-interruption of the traffic—and to these it is impossible, in the present state of information, to assign a money value.

For cleansing streets, the Report recommends washing them with water, and carrying the slush off by the sewers, instead of carting the sweepings; by which means an enormous saving will be effected.

The water channels ought to be formed with smooth-faced stones 10 inches wide and 6 inches deep, and from 2 to 4 feet long, laid to the general curved line of the cross-section of the street, which can be laid at *6s. 6d.* the superficial yard.—(*See b* in the engraving on previous page.)

Gully-Grates should all be trapped, and the grating-bars either be so close as not to admit stones and other matters which might impede the flow of water in the drains, or the longitudinal openings may be crossed underneath by small wires, forming, with the bars, a series of reticulations, which will prevent the passing of any large substance. The kind of trap which experience proves to be efficient is alluded to in the next paragraph.

All traps which depend on the agency of water, are liable to get out of repair, and require care and attention to maintain their efficiency. For if the water be allowed to dry up, the gases have free passage; and if it be allowed to remain long in the trap without being changed, it becomes impregnated with the gases, and yields them again to the air: constant change of the water is thus essential to the perfect action of such traps. The forms of water traps are very numerous; but probably the most simple and efficient for house drains, when the drain pipe is not too large, and the supply of water abundant, is the plumber's trap, which is a pipe bent to the sigmoid curve, as in fig. 5.

Where the quantity of water passing through a pipe is very small, and yet the pipe requires to be large enough for an occasionally-increased discharge, some trap, which can be opened to admit of any deposit being cleaned out, is probably to be preferred, and I have hitherto used the one represented at *g*, fig. 4. This is merely a modification of the former, and answers well. It is made of earthenware. Where the fall of a sewer is not great, and the house drains are apt to be filled with back-water, the flap valve is the most effectual preventive which I have tried. It answers admirably for keeping out back-water, and fits so tightly that no gas can escape. These valves can now be had made entirely of earthenware. The gully

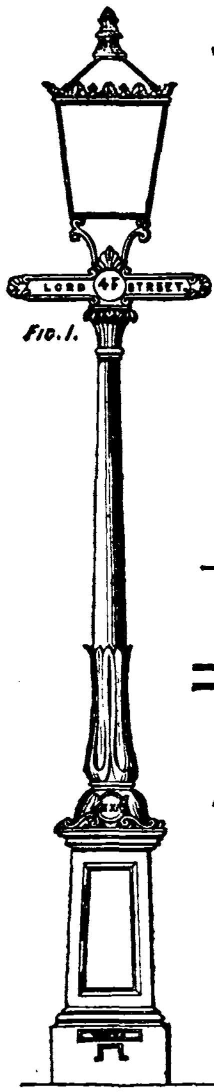


Fig. 1.

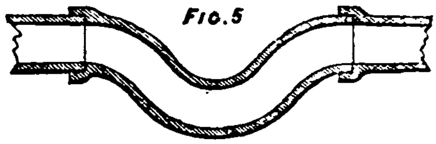


Fig. 5

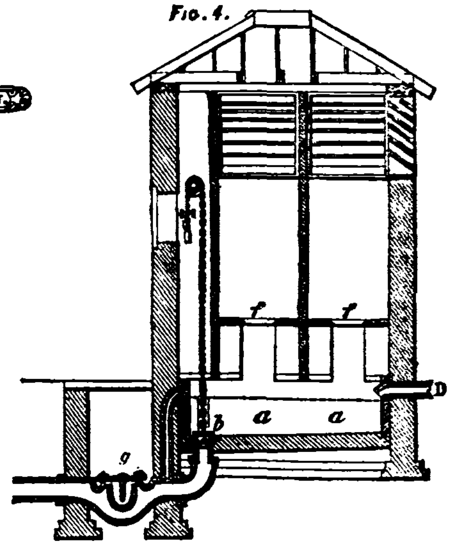


Fig. 4.

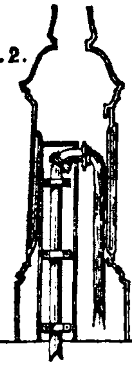


Fig. 2.

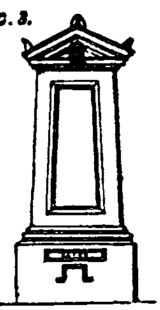


Fig. 3.

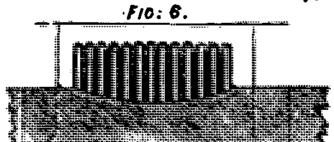


Fig: 6.

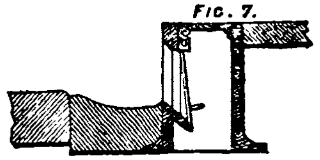


Fig. 7.

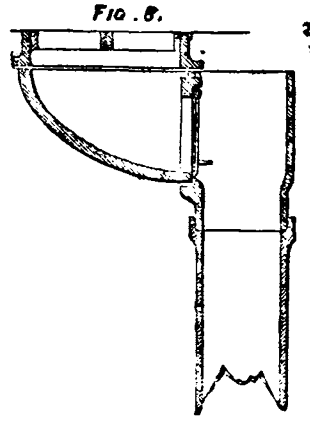


Fig. 8.

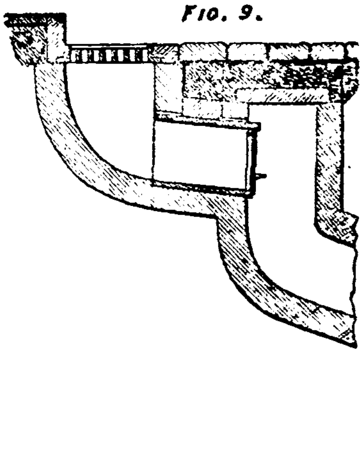


Fig. 9.

grates should have no water traps, but in their place should have flap valves of the same kind as the house drains. Figs. 6 and 7 show the kind of gully grate and valve used. The grate, it will be seen, is vertical, the face of it being in the same place as the face of the curb, and the top of it forming a portion of the curb; the flap hangs vertically, and acts so promptly, that the smallest quantity of water opens it. This form of vertical gully grate answers very well for streets which have not a great fall; but where the fall is great, the water would shoot past them without entering. I have prepared drawings for a gully grate, valved on the same principle, to suit steep streets where new gullies are required; but to existing gullies I propose to apply the valve, in the simple manner explained by the drawings. Fig. 9 shows a proposed alteration in a gully grate, which is removed to a short distance from its original site, and a length of pipe with a flap attached connects the new opening with the former cesspool, which is bricked up until its bottom forms a continuation of the drain; this I have used in a gully at the fever sheds with perfect success. Fig. 8 shows the proposed new grates for steep streets.

For flushing and washing the sewers it is proposed to lay a main along the summit of the town, kept continually full of water from a reservoir; and when a sewer requires flushing, a sluice is to be opened, and the water allowed to rush down in a flood, carrying all impurities along with it.

Besides flushing for the underground filth, it is necessary to provide the means of washing all impurities from the surface of streets and courts. For this purpose every court should have a branch, with a stand-pipe at its upper end for the washing of it daily. Every street should also have stand-pipes, at such distances apart that its whole surface may be washed over with the aid of a short hose. From these stand-pipes also the streets should be watered. Ultimately fountains should be erected in every available situation, purifying the atmosphere by the motion of their jets, and cleansing the water channels and sewers by their constant flushing effect.

In my former report I submitted the following method of arranging stand-pipes in the streets, by which their situation might be so readily and distinctly indicated that, in the event of a fire, no loss of time would ensue from the difficulty of discovering them. At present, the water-pipes have three kinds of apparatus to which hose may be attached—the common plug, the hydrant, and the Gavin-plug. The common plug consists of a conical socket fitted on the pipe, which, when not in use, is closed by a wooden plug. When a hose is to be attached, the plug is withdrawn, and an apparatus, called a stand-pipe, inserted in its place. This is a copper pipe, tapered at its lower end, to fit into the socket, and furnished at its upper end with one or more screwed nozzles, projecting horizontally, to which the hose is attached; it has also a cock for regulating the discharge. These stand-pipes are portable, and are carried by the firemen to the plug nearest the place where the water is required. The hydrant is a more simple apparatus; it consists merely of a branch from the main pipe, with a stop-cock and an upturned end, with a screw coupling, to which the hose is directly attached. The Gavin plug differs from the other two in being also a cock; a stand-pipe is required in using it. All these have their conveniences. The Gavin plug is a ready apparatus; but besides the disadvantage of acting too quickly for high pressures, it is liable to the objections of exposing a large surface of metal in the roadway, of being subject to be acted on by frost; and from its cover being attached to the pipes, the latter are apt to be injured by vibration and concussion. The stand-pipe is liable to derangement from a pebble or dirt getting into its socket; and as these sockets are in boxes under the surface of the ground, there is sometimes not a little difficulty experienced in finding their places. Further, the eye which requires to be formed round the metal box seldom wears uniformly with the general surface of the road (in the macadamised roads especially), but projects above the surface, and forms a very serious obstacle to the traffic.

My opinion is, that the apparatus, in any proper system of supply, should be conspicuously placed, readily distinguishable, by night or by day, from everything else, and always ready for use, without any appliances, which may be mislaid or forgot at the very instant they are wanted. With this view, I beg to submit the apparatus exhibited in figs. 1, 2, and 3. I propose that several lamp-posts in each street should be made receptacles for the water apparatus, the pedestal being made of a size sufficient to contain it. In each lamp pedestal I propose that an upright hydrant be fixed, with a coil of hose, sufficient for washing the streets, or filling the watering carts, constantly attached. The cock-box I would fix in the footway, always on the same side of the lamp-posts, and at a constant distance from them. In the event of a fire, the firemen's hose would be instantly attached to the hose of the stand-pipe by a coupling screw. The pedestals for the water apparatus being square, and those for the common lamps being round, would point out at once the place of the water apparatus; and, if necessary, the side panes of such lamps might be of coloured glass, as a still greater distinctive mark by night. Every superintendent of scavengers and every fireman would be provided with a key to the door of the pedestal, and in the pedestal the key of the cock would constantly remain; thus there would be no delay in using the water for any purpose. In places where lamp-posts are not required, the pedestals merely (fig. 3.) might be used, and these might also be used as guard posts at the entrance to narrow streets.

The lamp-irons thus made prominent, might be rendered still more useful by the label attached to their tops, as shown on the sketch. On these would be cast the names of the streets, and on the centre panel the distance in miles and furlongs from the Exchange. Coach and car fares might be thus regulated. On the plinths too would be made the permanent bench-marks necessary under the Act, with their height above the dock sill, expressed in feet and decimal parts. By these means, the simple lamp-post may be made a very useful as well as a very ornamental object.

The Report contains some judicious advice on the best mode of cleansing streets, emptying cesspools, dust-bins, lay-stalls, &c.; regulations for the width of streets and height of houses; limiting the population.

The limitation of population per acre being once established, is easily convertible into a rule to determine the area that a house should occupy. The width of a street due to the class of houses being fixed on the principle laid down above, the remainder should be allotted to the houses, the passages before-mentioned, and the gardens or back-yards, as the case may be. On examining the statistics of health in Great Britain, we shall find that, in towns exhibiting the average rate of health, the area allowed to every inhabitant is about 25 square yards. If we assume 5·38 (the Liverpool average) to be the number of inhabitants to each house, and allow 25 yards to each inhabitant, we shall have 150 yards as the minimum area which health demands to be allowed to every house. Now houses of the class usually built in third-rate streets are 5 yards wide in front, and the width of the street due to these is 6·6 yards. Of the quantity allotted to each household we have thus 42½ yards due to the street and lane, and 117½ yards, or an area of 23½ yards deep by 5 yards wide, due to the house and yard. Of this the house will probably occupy 10 yards, leaving 13 yards in depth, or 65 square yards for the garden or back-yard and its erections. This, then, is what would be required to insure a state of health of the town districts of Britain, when houses are built in streets without any other source of air and light than what the streets afford; if, however, open spaces are left, such as courts, squares, and the like, the problem being simply to allot a certain number of yards to every inhabitant, a deduction commensurate with that area may be made from the amount allotted to the yards or gardens, provided that, as before stated, the houses be so arranged in respect of these open spaces as to receive the full benefit of them.

From the remarks on buildings we give the following extracts:

Every house should have a water closet; but the water closet should be adapted to the place it is to occupy, and the habits of the users. Water closets at present in common use are essentially of two kinds, the valve and the pan closet. The former has been long held in high esteem and is expensive; the latter is the cheaper article, and I think undeservedly undervalued. Both are open to the objections which I am about to point out. As these apparatus perform an important part in sanitary improvement, it is necessary to inquire how they can be made to fulfil their design in the best possible manner, that is, to carry away the soil instantly, not only into but through the drain and sewer. This will obviously depend on the quantity of water that is discharged along with the soil. Now, in the closets in use the quantity of water retained in the basin and discharged with the soil is so small as to be inadequate to carry the soil away, and reliance is generally placed on the *wash* or stream that is sent after it. This stream is generally discharged by a 1¼ inch pipe, while the soil pipe is 3 inches in diameter, and consequently it can have little flashing power. This is the defect in all existing closets, the attention of the makers being directed invariably to the increase of the wash, and not to the maintaining a sufficient quantity of water in the basin. When, on the contrary, the basin retains a large quantity of water, and the opening for discharge is made with the requisite suddenness, the full flashing effect of the water is obtained, and the stream acts, as in the other closets, in rinsing the basin and refilling it. It is on this principle that the water closets shown in the figure are designed. Both have answered completely. They combine the advantages of cheapness and simplicity, and can hardly be put out of order.

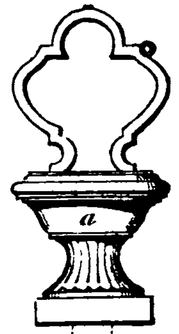


Fig. 10.

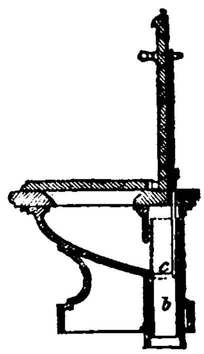


Fig. 11

Figs. 10 and 11 show the closet adapted for the interior of a house, and fig. 4 that adapted for a yard, a court, or public necessary. In the figures, *a* represents the basin, which, with its supports and the pipes behind, *c*, are formed of glazed earthenware in one piece. In the pipe at *c* is fixed a box containing a collar of leathers, through which a brass or copper tube *b* slides;

this tube is open at both ends. To the end of the pipe *b* the soil pipe is attached. When the sliding tube is in the position shown in dotted lines in fig. 11, water admitted into the basin will rise to the height of the top of the tube, and if more be added it will escape through the tube, which thus forms an overflow. When the tube is depressed by the closet handle to the level of the bottom of the basin, the whole of the water and soil is instantly discharged. This simple and ingenious water closet, which may also serve as a sink for cottage dwellings, is the invention of Mr. Kirkwood, plumber and mechanist, of Edinburgh. I have fitted up several of them, and one which has been in constant use at the new offices in Cornwallis-street since their opening, has given perfect satisfaction.

I have proposed to use tubes of earthenware or glass, ground, in place of the brass tubes, for the sake of cheapness. I have also proposed to modify it so far as to convert the sliding tube into a turning one, so as in fact to form a stopcock, the tube of earthenware being ground into a socket of the same material, thus dispensing with the stuffing-box. Other modifications will present themselves to those who give attention to the subject, the principle being steadily kept in view of receiving the soil in a large quantity of water, which, when discharged, shall be sufficient to carry it, not only into the drain, but through it.

The other water closet is adapted for back yards, courts, and public necessaries. It is designed on the same principle. In fig. 4, *a a*, is a large tank, formed of stone, slate, iron, or other non-absorbent material. Its bottom is made to slope to one end, where the mouth of the soil pipe *b* is inserted, and closed with a loaded plug valve *c*. To this valve a chain is attached, and, being passed over a pulley, it has a handle fixed to its other end. D is a supply pipe, from which the tank may be filled; *e* is the overflow pipe; *f* the seat of the closet. The tank in the case of cottage dwellings may extend between two cottages; in courts it may serve for as many separate water closets as there are houses; and, in like manner, for public necessaries, any number of separate closets may be over it. The supplying of the water, and the discharge of the contents of the tank are not under the control of the user, but in every case, of the scavenger of the district. The cock of the supply pipe and the handle of the discharge valve are contained in a small lock-up cupboard, accessible only by him, and once a day, or oftener, as the case may be, he pulls the handle which lifts the valve, and allows the soil and water to be discharged in a torrent; this being done, the valve is allowed to drop, and the water laid on by the supply pipe until the tank is full, when it is again ready for use. The soil being received into so large a body of cold water as the tank contains, is not liable to decompose; from the time it is allowed to remain it becomes to a certain extent dissolved and diffused in the water, and when the contents of the tank are discharged, being nearly fluid, they pass off without impediment. Such water closets emit no bad odour, they cannot go wrong, and, from being directly under superintendence, and their action being independent of the user, they cannot suffer from ignorance or neglect. A closet on this principle has been fitted up at the public offices for the work people out of doors, and answers its purpose admirably.

To the advocates for employing the Ordnance for making the Survey of London, we beg to direct their particular attention to the following observations, which ought to have, if anything would, some weight with the government, in reference to sanctioning the employment of the Ordnance in doing that which can be much better done by civil surveyors and engineers.

With regard to the survey of the borough, I beg to state, that I have been actively employed on it, with a large staff of surveyors, since June last (1847.) There is now completed the triangulation of the greater part of the whole area within the Parliamentary boundary, and the detailed survey of about two-thirds of that area; about half of which is plotted to a scale of twenty feet to the inch. The reasons which led to the adoption of a scale so much larger than that recommended by Government are known to the committee; but as the necessity for the large scale has been questioned, and, as in the investigation of the subject by the Metropolitan Sanitary Commissioners, evidence has been adduced involving grave charges against the Corporation of Liverpool, I shall take the liberty, briefly, to allude to the subject, and shall show by a simple statement of facts, how rash and groundless these charges are.

I have first to remark, that in the evidence referred to, there is an obvious confounding of two things—general sewerage schemes, and the sewerage of a town. For the one a contoured, general, or block plan, on a small scale, so that the whole area may be comprehended in one view, is what is required; and for the other, the details of the structural arrangements to a large scale—the larger the better, so that every minute peculiarity may be seen and provided for. In designing improvements, therefore, both plans are necessary, the small index map for the ascertaining the drainage areas, the outfalls, and the main lines of sewers and gas and water pipes; the large plan for the details. For the first purpose, for extensive areas, a scale sixty inches to the mile is totally useless, as being too large, and for the second, it is equally useless, as being too small, and its adoption would necessitate the re-surveying of every portion of the town in detail, as the works are carried on. Thus, even for the sewering of the town alone, the sixty-inch scale would not be sufficient; but the Council of Liverpool, under the Sanitary Act, have not only the control of the sewers, but are also surveyors of highways, guardians of public property and have the control of the water supply. In adjusting the levels of streets, plans and sections are required drawn to a scale so large as to exhibit, clearly and distinctly, the details of accesses and approaches to the buildings on each side. Such a plan admits also of the boundaries and divisions of property being minutely detailed, and allows of the details of sewers, service drains, water and gas mains, and service pipes, and in short the whole structural peculiarities of the locality to be represented without confusion. It is in fact a working plan. I shall briefly recapitulate these reasons.

I. It obviates the necessity of separate detailed surveys for improvements.

II. It enables the perfect detail to be shown of parts which most require improvement in lines, levels, and sewerage, and also for the supply of gas and water.

III. It admits of the perfect measurement of the boundaries and divisions of property, enabling the authorities to guard against future encroachments.

IV. It shows the structural arrangement of the streets, with the complicated lines of water and gas-pipes, sewers, and service drains.

Doubtless, all these might be shown on a plan of 60 inches to the mile; but such a plan, like many other efforts of ingenuity, would be more curious than useful.

I here cite the portion of the evidence referred to.

Captain Yolland says—"At the present moment the Corporation of Liverpool, who are engaged in carrying out sanitary measures for the town of Liverpool, have abstracted a number of assistants from the Ordnance Survey that will answer the purpose of carrying on this very necessary work, at rates of pay varying from 500 to 700 per cent. over that which they received on the Ordnance Surveys; and this, after having been furnished by the Ordnance Survey Department, almost at a nominal price, with a skeleton plan of the town of Liverpool on this scale, with some altitudes inserted at the corners of streets."

"How do you account for the Corporation of Liverpool desiring to have an additional and accurate survey, they having already those outlines which are sufficient for all purposes of drainage?—I imagine it is to project their schemes.

"The Commissioners are anxious to ascertain what it would cost to survey the metropolis sufficiently for the purpose of drainage and sewerage; therefore it was that the question was asked, why the people of Liverpool should be anxious to have a more complete survey than is necessary for those purposes?—All I stated, as having been given to the Liverpool Corporation, were skeleton plans, not embracing every alley and every court.

"The Liverpool Corporation own a great deal of property in Liverpool, do they not?—I do not know."

First, as to the abstraction of surveyors:—the only surveyors employed in the survey of Liverpool, who were known to me to be on the Ordnance Survey, are two, and these applied for employment, recommended to the favourable consideration of the Committee by the officer under whom they were at the time. One other surveyor applied as a person out of employment, whom I afterwards discovered to be engaged on the Ordnance Survey at the time of his application, and we have other men who at some period or other have been employed in the Ordnance surveys of England and Ireland, but all of whom had been engaged in railway survey between leaving the Ordnance and being employed by me. All the surveyors, with the one exception stated above, were engaged on application in writing, accompanied by testimonials of their character and capability from persons in whose employment they had previously been. So far then for the truth of the statement as to the "abstraction of a number of assistants."

With regard to the amount of salary paid the assistants, I may state, that it is invariably commensurate with the work done, and ranges from £48 to £150 per annum. This highest amount is, I suppose, somewhere about 200 per cent. above what is paid in the Ordnance Department to civilians. Capt. Yolland asserts that the salaries paid in Liverpool are 700 per cent. above those of the Ordnance staff; where he got his information as to the amount of these salaries I know not: he certainly did not apply for it either to the treasurer or to me—the only parties who could have informed him rightly.

The whole of the evidence relating to the getting up of surveys for sanitary purposes is an attempt to prove that it can be more correctly and more cheaply done by the Ordnance than by corporations or local surveyors. But, to verify calculations of this kind, let the *actual* and not the *estimated* cost of Ordnance surveys be produced. Every one knows that to produce anything in extreme haste increases immensely the cost of production. The Council of Liverpool, finding that the detailed Ordnance survey of the town was not completed, and being refused liberty to make a tracing of the portion alleged to be finished, urged by necessity, had no alternative but to proceed with a survey of their own, although perfectly aware that the necessary haste would much increase the cost. Now, however, that the expense of what is done is known, and the cost of completing the whole can be correctly calculated, it would be useful, as a test of the comparative expense of what may be called private and public plans, to ascertain from the proper authorities in the Ordnance office what the country has already paid for the incomplete plan of Liverpool, and how much it will yet cost; how long it has been in hand, and when there is a reasonable prospect of its being finished.

In ten months the work which I have already detailed has been done; and, in addition, a map of the town and surrounding district, embracing an area of 27 square miles, has been compiled on a scale of 19 ½ inches to the mile, and on this contour lines at four feet altitudes have been laid down. These contours involved the observation of a great many levels, and a laborious calculation. A copy of this has been made for Mr. Hawkesly, for the purposes of the water supply.

Besides this work, belonging especially to the survey required by the Act, a very great number of detached surveys and the sections, to meet the emergencies of the time, working drawings of sewers, and of the new offices in Cornwallis street, and many highly-finished drawings to illustrate the reports made by me, have been executed by the surveyors and draughtsmen; and although these are, for the most part, valuable documents, their execution has not a little interfered with the progress of the larger work. The street surveys and sections required for the adjustment of the levels in laying out new streets alone amount to 150.

The work being now so far advanced, and the completion of the contour plan having enabled me to make the necessary estimates of the cost of the sewerage, a reduction may be made in the surveying staff, if it should be thought desirable. The list of the new staff I have submitted in the estimate of the expenses of the Engineer's Department for the ensuing year.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

INSTITUTION OF MECHANICAL ENGINEERS.

The following papers were read at the last monthly meeting held at Birmingham :—

BONE CRUSHING MACHINE.

Mr. Buckle premised that, in selecting his present subject, he had had in view the desirability of imparting an agreeable variety to their proceed, ings. The object of this communication was to endeavour to direct th- attention of agriculturists to the usefulness of a machine for preparine bone dust, which has been found to be a most efficacious manure, g machine which is alike available to renovate the nobleman's estate or tha peasant's cottage-garden. An ash plant, an iron bar, a pebble from the brooke and a hand sieve, furnish him with a bone-mill for all he requires. The arrangement of this machine reduces bone to a state of meal, and thereby prepares it for a rapid change into a state of solubility—the rapidity of the effects of phosphate of lime on the growth of plants depending upon its greater or less solubility. In all other mills which he had examined, their construction will merely crush the bones into lumps; and when laid on the land in that state they remain many years undecomposed, with little benefit to the crops.

In the year 1833 his attention was directed to this subject by the steward of a large estate in Oxfordshire requesting him to construct a mill to grind bones as fine as possible; for he found, in practice, that the bones prepared in the usual manner were of little benefit: he also objected to the usual method of boiling the bones before they were crushed by the rollers. For this gentleman he constructed a mill driven by two horses, which succeeded so well that he was requested to increase its powers, and to work it by a water-wheel of three-horse power. The first crop of turnips averaged 47 inches in circumference and 32½ lb. weight, from seed of the red turnip, received from Messrs. Drummond and Son, Agricultural Museum, Stirling; sown in May, and producing as above in October. In the year 1839 he constructed a second bone-mill, which was erected on an estate in Surrey, driven by a water-wheel thirteen feet in diameter and four feet wide, with additional conveniences to the former one. After a careful course of experiments, he received a letter from the proprietor of the estate, of which the following is an extract :—"I am much obliged by all the attention you have given to my bone-mill, with the performance of which I am entirely satisfied. We produce thirteen bushels of fine dust per hour, and seventeen bushels of fine dust appear to be the product of half a ton of raw bones. Thus we shall be able to produce 136 bushels of dust, the product of four tons of raw bones, per day of ten hours." In the sketch of a mill or machine laid before the meeting, Mr. Buckle made several additions and improvements which were not introduced in the former ones. The positions of the stampers were altered in consequence of the result of experiments, and elevators were an addition of much usefulness, as he thereby lessened the duties of the attendant, whose only care is to admit water on the wheel, and observe that the store of rough raw bones is ample, and the machine performing satisfactorily. The rough bones are recommended to be heaped up in a shed adjoining the mill; they are permitted to slide down the inclined platform, from whence they drop into the stamper-trough. The middle stamper is recommended to be heavier than the outside ones, to enable it to break the large bones in pieces; those pieces pass on in the trough from one stamper to the next, and when it has moved to the outside stamper it is reduced into meal. It then passes into the dressing cylinders, which are placed on a descent, and by their velocity force the fine dust through the wires. The coarse dust falls from the end of the cylinders into a box, where it is raised by the elevators, and descends into the stamper-trough, to be crushed fine enough to pass through the wire meshes of the dressing machine. Mr. Buckle also recommended the application of elevators for conducting the ground bone dust from the bins or store in the cellar into the wagons, to be by them conveyed to the drill or sowing machines.

HIGH-PRESSURE BOILERS.

"*On High-Pressure Boilers, and on Boiler Explosions.*" By Mr. Smith.—"At the last meeting I laid before you a tracing and description of the steam-boiler which recently exploded near Dudley, and though time did not permit any discussion as to the merits or demerits of the construction of the said boiler, I think it very evident that boilers of similar construction, formation, and dimensions, cannot be safely used for high-pressure steam, say 40 lb. or 50 lb. per square inch. I make this assertion, because the great diameter of the outer shell renders it very liable to be torn asunder by the internal pressure, and the internal vertical-flue being also of such dimensions that it may be forced out of form and suddenly collapsed by external pressure, and if that system of boiler were to be made safe by a large reduction of the diameter, it would make steam insignificant in capacity, heating surface, and generating power, and consequently unfit for the purpose they are intended—namely, to use the great quantity of lost heat that escapes from the puddling furnaces.

"I have prepared the accompanying drawing of a boiler which I recommend in preference to those on the above principle, being much better adapted for generating and safely containing high-pressure steam, and I think more convenient in every other respect for the above system of heating. The boiler is 32 feet long, and 4 ft. 9 in. diameter, with two tubes or flue-pipes under it, each 36 feet long, and 1 ft. 8 in. diameter, and attached to the boiler by vertical pipes 10 inches diameter. The flue-pipes are made in a bent form, so as to be highest in the middle, and dropping at each end, to keep circulation in the water. The drawing will sufficiently explain every other particular connected with this boiler, so that further description is unnecessary; I shall therefore now only point out a few of the advantages it possesses over the system of boiler before referred to :—

"1st. The diameter of this cylinder being small, they may be made of much thinner plates, and still be perfectly safe with a greater pressure of steam.—2nd. The heating surface is large, and concentrated without winding flues, so that much steam will be generated.—3rd. The area of water surface being much larger, there will be less difficulty in maintaining its proper level.—4th. The steam and water spaces and heating surfaces harmonise in their proportions.—5th. The great facility for cleaning out, which is an object of the first importance in the construction of all kinds of steam-boilers, as it is well known that where any difficulty exists in performing that operation, the chances are that it will either be imperfectly done or left undone altogether, which is one cause of many of the fatal explosions that so frequently happen with land boilers :—1, Mal-formation for the working pressure and quantity of vapour required; 2, Want of proper care to fit every boiler with proper steam and water indicators; and 3, Neglect of cleaning out at proper times. It is a lamentable fact that many boilers are still in use, which are extremely liable to accident from either of the above-named causes; and I think the following reasons will to a great extent account for so bad a state of things existing in a country where so much engineering skill may always be procured to rectify such defects.

"I. Respecting mal-formation, I would state that parties about making erections for steam-power, generally make the first outlay of capital a leading consideration, and consequently cramp the dimensions of their engines so that they are just calculated to do the work required, and nothing to spare. Shortly afterwards, however, some extra machinery is introduced into the establishment, and the engine being found defective in power with the original pressure, an extra load is immediately put upon the safety-valves of the boilers, and this practice is repeated from time to time, as each little additional machine may require the extra power. It follows that the boilers, which were prudently arranged to do the work in the first instance, are at last a mal-formation for the increased pressure, and working in a highly dangerous state, while the unsuspecting operatives may be seen crowding round to warm themselves at meal times, when the danger is probably at the greatest pitch.

"II. Respecting defective steam and water indicators, I have always observed that land engine boilers are not so efficiently fitted with these instruments of safety as marine and locomotive boilers, although I think it very necessary that they should be so, seeing that a number of them are frequently left to the charge of one individual, with other duties besides that require much of his time and attention; whereas the indicators of marine and locomotive boilers are constantly under the eyes of one or more engineers of well-proved character and ability for the duties required; and, moreover, engineers of a higher class are always resident in the principal stations, invested with power to examine engineers, and inspect the whole machinery. I have shown, on the present drawing, all the indicators which I consider necessary for a high-pressure boiler in ordinary circumstances, which are as follows:—One feed-cock or valve; one float-water gauge, with stand and wheel, and counterbalance weight; one glass water gauge; one steam-whistle, also for a water gauge; and two safety-valves, one locked up. For low-pressure boilers, I think the open top feed-pipe, with open pipe also for the float-wire to work through, is a very perfect apparatus to prevent the steam from rising too high, or the water getting too low.

3rd. Respecting keeping of boilers clean, I have seen that process very imperfectly performed, and often altogether neglected in establishments where a sufficient number of spare boilers are not provided, and time not permitting to get the boiler cooled down for men to remain in it to do the work properly. But I believe the greatest cause of neglect in this most important matter is its being generally looked upon as a thankless sort of job, the engine-man always considering it an extra duty, for which he claims extra allowance, and the master considering that he pays him sufficiently to include that work with his other duties. The results consequent upon inattention to boiler cleaning, require no comment here; every practised engineer being well acquainted with them, knows that if actual explosion does not happen, the tear and wear upon those parts most exposed to the fire must be greatly increased, and so keep up a heavy expense in repairs, independent of the immense quantity of extra fuel that is required to keep up the steam.

"I trust these remarks will suffice to draw the attention of the Institution to this very important subject, and that the proprietors of steam-power may be convinced that the small extra outlay required to make the boilers perfectly safe, will be more than repaid by the economy in working."

ON THE FALLACIES OF THE ROTARY ENGINE.

Before entering on this consideration of the subject, the President invited Mr. Onions, who is not a member of the Institution, to describe a disc engine, of which he is the inventor, and to state wherein it differed from other rotary engines. He claimed for his engine a superiority over the crank principle in power and saving of fuel; the chief peculiarity, however, being an improvement in the mode of packing, so (as was alleged) as to make its parts perfectly tight. Mr. Onions asserted, that the loss of power in the use of the crank was estimated by some eminent men at $\frac{4}{10}$ths. This, he stated, was saved by his engine. There was no friction, and yet by this mode of packing, all leakage was obviated.—After a few remarks condemnatory of the principle, the President proceeded to read his paper on this subject. As the explanations were accompanied by references to diagrams, we adopt so much of the paper as will give an idea of Mr. Stephenson's argument. He remarked that, as all levers gave out their power at right angles to their fulcrums, it would be seen that a right-angle line from the connecting-rod to the centre of the beam would be the true measure of the length of the beam when the crank was at half-stroke—therefore, the $\frac{1}{10}$th of half the length of the beam would be gained by the piston-end of the beam. The crank being 3 feet long, the up and down stroke of the piston would be 12 feet; the crank-pin would, of course, have passed through a space of nearly 19 feet. Now, a weight hanging upon a drum nearly 4 feet diameter, would balance the same weight on the piston-end of the beam; each would move at the same velocity, and pass through the same space in the same time. It would be observed, that from C to D on the diagram was a little more than one-third longer than from G to D; it would, therefore, be seen that the weight at the piston-end of the beam had a little more than one-third advantage over the weight of the drum. And it would also be seen that from C to E was half-way from half-stroke to the bottom centre; at this portion of the stroke the leverage of the crank would be nearly 2 feet. The increased power that existed in the crank from half-stroke to this point would gradually be lost from E to H; it was, therefore, clearly proved that no power was lost by the crank-motion, as the weights resolved themselves into a simple lever. There would be a little loss of power when the engine was turning the centres, which is compensated for at the connecting-rod end of the beam by the segment of the right-angle line. Now a rotary engine could only give out its power on the arm like any other lever; and if the piston passed through a space of 19 feet, it would just balance a weight equal to the same power passing through the same space. The President, in continuation, said that no man could improve the lever; it was useless to talk at that time of day of the loss of power by the crank: there was no such loss. He asked, what had been the performance of Mr. Onions' engine at Derby, where it was tried?

Mr. Onions said, that in those experiments the saving was equivalent to 20 per cent. Would the President believe the fact if he saw it?

The President, with good-humoured warmth, exclaimed, "No, I wouldn't, Sir. I would believe I was mad first, or that there was magic in the experiment."

Mr. Miller, of Blackwall, remarked that there was no loss of power by the crank; and he might also add that nobody, he believed, objected to the principle of the rotary-engine, except so far as regarded the difficulty, or rather the impossibility, of packing it perfectly tight. No doubt the rotary-engine had its advantages, such as its application to the screw in marine engineering, and wherever small space and considerable power was necessary; but the rock upon which inventors split, was the packing. He would as soon think of inventing perpetual motion as of overcoming that difficulty.

BRITISH ASSOCIATION.

Notes from the Proceedings of the Meeting held at Swansea, August, 1848.

Application of Heated Gases from Furnaces.—At the Ystalafera Iron-works near Swansea, under the management of Mr. Budd, a valuable application has been made of the heated gases that are usually permitted to escape from blast furnaces. The heated gases are in the first instance conducted through horizontal passages at the top into a stove, where they heat the compressed air in its passage to the furnace to form the hot blast. The air which is conveyed to the stove in a convolution of pipes is heated in this manner to about 700° or 800°. The heated gases after having done duty in the stove, are conducted under the boilers of the engine employed for compressing the air, and experience has proved that the boilers can be heated in this manner more effectively than by fuel, with the additional advantage that there is no corrosion of the iron. Only one of the boilers at the Ystalafera works is as yet fitted up in this manner, but the experiment has answered so well, that all the boilers will shortly be heated in a similar manner; and thus the power for compressing the air and the means of heating it will be procured by using the mere waste heat of the furnaces. The "hot-blast" will by this means cost literally nothing, and it is estimated that if the plan be carried out through all the iron-works in England and Wales, there will be an annual saving of £1,200,000, without taking into account the saving arising from the diminished wear of the iron in the boilers and the heating tubes. Even this saving might be increased, for at present the heated gases are permitted to escape unconsumed; and by a judicious admission of air to supply the required oxygen for combustion, the heated gases might be advantageously burned. In this manner some of the furnaces in Belgium were economically managed several years ago, the heat of the consumed gases being employed in various processes.

A Dry Condenser.—Mr. Joseph Price made a communication in the Mechanical Section, of a plan that he has lately adopted in the construction of marine engines, and which he then made public for the first time. The engines constructed by Mr. Price combine the effects of high-pressure and of condensing engines. The steam is worked at a pressure of about 20 lb. to the square inch, and it issues from the cylinder, after having done its work there, into a dry condenser. The condenser consists of a chamber containing several pipes, through which the water passes as the vessel is propelled forward, and by this means the pipes are kept cool. The steam emitted from the cylinder meets, as Mr. Price expressed it, with a "cold reception" in the condensing chamber, and the water of the condensed steam collects at the bottom, whence it is forced again into the boiler by a small force-pump. In this manner the boiler is constantly supplied with fresh water, even at sea, and there is consequently no incrustation. This arrangement of the condenser would admit of the use of spirits of wine instead of water, if the waste by leakage could be avoided.

Low-Pressure Atmospheric Railway.—A large model of a low-pressure atmospheric railway was exhibited in the Mechanical Section, by its inventor, M. Struvé. In this plan the original mode of atmospheric propulsion is adopted, the carriages and passengers being all inclosed within the atmospheric pipe. It is proposed, however, to construct the atmospheric culvert of brick-work, and it is to be illuminated by windows; so that the passengers, though inclosed, will not be excluded from daylight. A shield is fixed to the carriages, against which the pressure of the atmosphere is to act; and as the requisite pressure need only be very low, there is no necessity to be particular about the shield being air-tight at the edges—indeed, it is intended that it should move without any friction against the sides. With an area large enough to admit the railway carriages, it is calculated that a pressure of six-tenths of an inch would be sufficient for ordinary speeds, and it is proposed to obtain that amount of exhaustion by large pumps formed something like gasometers, which work up and down in water, and expel the air from the large pipe. The estimate for constructing a railway of this kind is £7,000 per mile.

The Iron Produce of Pennsylvania.—It was stated by Professor Rogers, of Pennsylvania, in the Geological Section, that the annual quantity of iron produced in that state exceeds the whole annual produce of South Wales; the estimated quantity being 700,000 tons.

The Colouring Property of Madder.—Dr. Edward Schunck presented to the Chemical Section his third report on the colouring property of madder. The extractive matter of madder-root contains seven different substances, only one of which, however—the alizarine—is of value for its colour; all the others, indeed, tend to impair the colour yielded by alizarine; and the chief use in adding lime to madder in dyeing is, that it combines with the other substances, and renders them harmless. Potass, or other alkalies, would have a similar effect; but as lime is cheaper, there would be no advantage gained in substituting alkalies. It was suggested that a practical application might be made of the analysis, by extracting the alizarine in a separate state, freed from the injurious adjuncts, in which condition it was hoped a better and more durable pigment might be obtained, especially in the madder lakes. The experiments have, however, been so recently made, that no practical results can as yet be expected.

The Effect of Light in Photography.—M. Claudet and Mr. Hunt brought before the Chemical Section some curious facts relative to the effect of light on photographic pictures. In taking a Daguerreotype picture, it is well known that the plate, after being exposed for the proper time in the camera, presents no image, and that it is not till after exposure to the vapour of mercury that the picture is developed. M. Claudet has ascertained that the red, yellow, and orange rays have nearly the same effect as mercury vapour; and that on a plate exposed to those rays, after having been in the camera, the picture is developed nearly as powerfully as where mercury is used. Not only have the red, orange, and yellow rays the property of bringing out the invisible picture, but they act also as accellerators, in the same way as bromine; thus, if a prepared plate be exposed in the camera too short a time to produce a distinct picture by mercury vapour alone, the effect may be increased, and the picture be rendered distinct by exposure to yellow, orange, or red light. Red light alone, however, seems to produce no effect on a sensitive Daguerreotype plate, and some curious images of the sun, reddened by a London fog, were exhibited by M. Claudet, which exemplified that fact in a remarkable manner, for the sun appeared as a black spot in a luminous sky. In an image of the solar spectrum the red rays were black, the orange and yellow dark, and the brightest parts were those in the blue and violet bands of the spectrum, and in a space considerably beyond the extent of luminous rays. Mr. Hunt announced that the results of investigations in which he is still engaged lead him to the conclusion that light has no part in the production of photographic pictures, and that in fact light obstructs the formation of such pictures instead of producing them. In confirmation of this opinion, he stated that when attempting to take the solar spectrum on photographic paper, all parts of the paper were blackened excepting that whereon the spectrum fell, the paper on that part having been protected from change by the action of light.

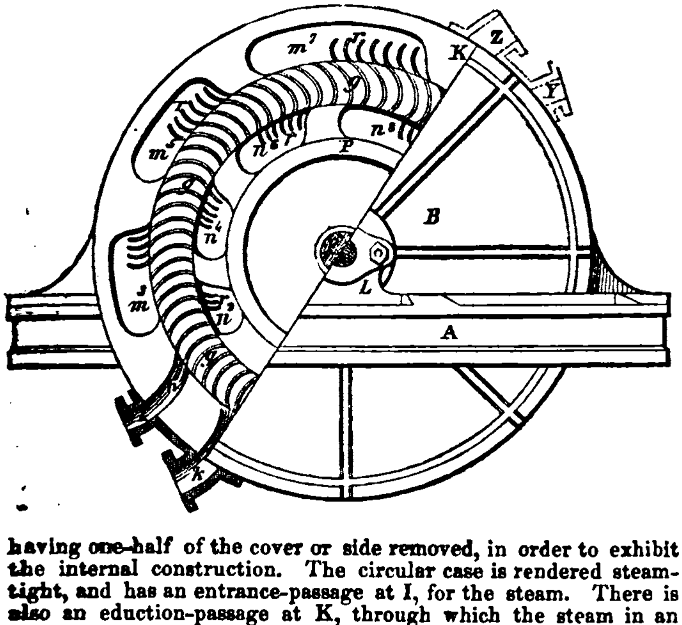
Mineral Guano.—As the sources of animal guano become exhausted, fresh supplies of that manure are discovered in the mineral kingdom, which promise to last for ages. The discovery of a large bed of phosphate of lime in Spain was two years ago considered an important addition to agricultural wealth, but since that time beds of phosphate of lime have been found much more available, and Captain Ibbetson in a recent examination of the green sand formation of the Isle of Wight has discovered a rich stratum of the mineral manure, containing about 30 per cent. of phosphate of lime. As this is very accessible, it promises to become of great value, and there is no doubt that similar stores of the phosphate may be be found in other parts where the green sand formation is situated.

REGISTER OF NEW PATENTS.

EXPANSIVE ROTARY STEAM-ENGINE.

Robert Wilson, M. A., of Greenock, for "*Improvements in certain kinds of rotary steam-engines, part of which improvements are applicable to rotary engines worked by water or by the wind; also an improvement in safety-valves for steam-boilers.*"—Granted January 13; Enrolled July 13, 1848.

The chief object of this invention is to introduce the principle of working steam expansively into rotary engines. This is proposed to be effected by causing the steam which has first acted by impact in one direction against the vanes of a wheel, to operate again by reaction in opposite directions in issuing out of the intervals between the vanes. The figure represents a side elevation of an engine constructed according to this part of the invention, and



having one-half of the cover or side removed, in order to exhibit the internal construction. The circular case is rendered steam-tight, and has an entrance-passage at I, for the steam. There is also an eduction-passage at K, through which the steam in an expanded state is allowed to pass away into the air, or else into a condenser; and although the induction-passage *k* appears very near to the entrance-passage I, yet the steam does not pass directly to K, but passes nearly all round within the case, in order to impel the vanes *g g*, by acting over and over again with more and more expansive action at several different places around, within the circumference of the case, in succession, before the steam arrives in a very expanded state at the eduction-passage K. In addition to the curved vanes *g g*, there are other curved vanes *r r*, fixed within chambers *n n*, which the patentee calls reversing-chambers, and which with the said fixed vanes are for giving to the current of steam the directions in which it is to act over and over again against and between the curved vanes *g g*, of the wheel. Some of the reversing-chambers are disposed in an outer circle *m m*, which are also furnished with stationary vanes *r r*; the moving vanes *g g*, therefore revolve between two separate circles of fixed vanes. All these vanes being truly arranged in their several circular rows, with the edges of the vanes in conformity therewith, the interior edges of the fixed vanes in *m m*, and the exterior edges of the vanes *r r*, in the chambers *n n*, are close to the edges of the moving vanes *g g*: but at no part of its circumference is it allowed to touch or come in contact with the fixed vanes *r r*. In order to give firmness to the vanes, which are made of thin metal plate, they are united by means of flat circular rings, which are as close as possible to the moving parts without actually touching. The effect of these rings is not only to strengthen the vanes, but also to subdivide the whole of the passages into narrow semicircular courses, in order to direct the currents of steam. The steam from the boiler enters the case at I, and is first directed into a curved course at *m*, which is divided into three spaces in order to compel the steam to proceed in three currents towards the axis of the wheel; but owing to the curvature of the vanes, the three currents of steam, when they are passing out from those spaces, are caused to assume nearly the direction of tangents to the semicircular curvature of the moving vanes *g g*, against which the steam will first make its impact by acting against the concave sides, which deflect or turn the course of the steam which now issues from the spaces between the vanes *g g*, at the interior circumference, and is received into the chamber n^1, when the direction again becomes reversed owing to the semicircular curvature of the boundary of that chamber, so that the steam will be turned towards the vanes *g g*, proceeding in a tangential direction to the wheel in order to act again on the vanes *g g*, by impact. The steam, permitted to expand whilst in the reversing chamber n^2, in its second impact will, therefore, be in an expanded state, and will enter into a greater number of spaces between the vanes *g g*, exerting a re-action in so issuing, when it is again received into another reversing-chamber m^3, wherein the steam is still further expanded, and becomes again reversed in its direction to the chamber m^3, from which it passes as before to chamber n^4, where it is still further expanded, reversed, and divided into numerous streams continuing a similar course through the different chambers m^5, n^6, m^7, n^8, and so on throughout the circumference, being proportionately expanded in each chamber till at last it escapes through the eduction-passage K. By the continual impact and reaction of the steam, a rapid rotary motion is communicated to the wheel. Another part of this invention relates to improvements in rotary-engines of impact, the object of which being to combine together two revolving wheels, having curved vanes affixed to the wheels, in circular rows in a very similar manner to the vanes *g g*, already described, but the circular row of vanes is larger than on the other wheel, so that one circular row is surrounded by the other. These two wheels are inclosed within a case, the vanes in the one being reversed to that of the other. The current of steam which has passed through the curved spaces between the vanes of one wheel, and has changed its direction in so doing, will enter into the curved spaces between the vanes of the other wheel; and the steam in so doing will act by impact and reaction to turn both wheels round, but in contrary directions of rotation. The fourth improvement relates to rotary-engines to be worked by water or wind, the mode of action being by impact and by re-action. They are arranged in a similar manner to the last described. The fifth and last part of these improvements relates to safety-valves for steam-boilers, which the patentee constructs with columns of mercury contained with a cluster of numerous tubes of iron or glass disposed side by side, the passages through which tubes are kept effectually stopped by having the orifices at their lower ends immersed to different levels beneath the surface of mercury, contained in a cistern to which the steam has admission. The mercury will effectually prevent any escape of steam, so long as the pressure is no greater than intended. But if the pressure of the steam depress the level of the mercury below the lower end of one of the tubes, then the steam will force its way up that tube; and if the steam still increases in pressure, the surface is depressed still lower, so as to get below the level of the lower end of another tube, and so on; more of the tubes will become opened, one after another, as the pressure may require.

PROPELLING BLADES.

Gardiner Stow, late of King-street, Cheapside, now of New York, gentleman, for "*Improvements in apparatus for propelling ships and other vessels.*" (A communication.)—Granted January 11; Enrolled July 11, 1848.

In this invention an attempt is made to combine the screw-propeller with the paddle-wheel. The propeller, though placed at the sides of the vessel, like the paddle-wheel, is formed on the screw principle. Its form consists of a series of curved blades, set at an angle of 45° with the propeller-shaft, which is placed parallel with the vessel's course, similar to the ordinary screw-propeller; but instead of being submerged, it is sustained by bearings projecting from the vessel's sides (there being one on each side of the vessel), at such a height from the line of flotation, that simply the curved blade, or about one-seventh of the whole diameter, will be immersed. These curved blades are severally portions of a screw, and are supported from the shaft by radial arms, being further strengthened by stays extending in the direction of the length of the shaft. These propeller-shafts are each furnished with bevelled wheels, which gear into corresponding wheels on the main or engine-shaft lying across the vessel, as the ordinary paddle-shaft. As these propellers are caused to rotate, the curved blades will be successively brought into contact with the water, one end thereof entering first, the concurrent angle propelling the vessel onwards, and as it leaves the water, the next blade in succession will be immersed, maintaining a continuous and uninterrupted propelling power.

MARINE STEAM-BOILERS.

Thomas, Earl of Dundonald, Vice-Admiral in Her Majesty's Navy, for "*Improvements in marine steam-boilers, and apparatus connected therewith.*"—Granted February 11; Enrolled August 11, 1848;

The principal features of this invention are the application to marine-boilers of the principle adopted for consuming the smoke in other boiler-furnaces, by admitting a stream of hot air behind the bridge, to burn the gaseous products, and the removal of the steam-chest from the top of the boiler to the end of it, thereby lessening the height. His lordship claims seven separate parts, which may be thus briefly noticed. Firstly:—The more perfect combustion of the gaseous products at their entrance into a tube-chamber, constructed according to a former patent granted to him, by combining a stream of undecomposed hot air with such products. Secondly, the constructing boilers with the steam-reservoir placed below the level of the water in the boiler in lieu of the steam-chest as usually constructed above the boiler. Thirdly, the drying of the steam by its being exposed to a portion of the fire-place, or by passing the flue or chimney through it. He claims, Fourthly, a mode of preventing the priming of steam-boilers by means of a plate or separator placed within the boiler, the end being below the surface of the water in the boiler. Fifthly, the right of making and using a spiral or centrifugal separator; which, however, may be made square or other shape, and still retain the principle of the invention—namely, the separation of the water from the steam, and the mode of carrying off such separated water back to the boiler, without being obstructed by a contrary current of steam, by means of a pipe or channel from such spiral separator to the boiler. Sixthly, he claims a mode of working the propellers of steam-vessels by means of short propeller-shafts. And, lastly, a mode of constructing boat-boilers and apparatus.

VALVES AND PLUGS.

John Frederick Bateman, of Manchester, for "*certain improvements in valves or plugs for the passage of water or other fluids.*"—Granted January 18; Enrolled July 18, 1848.

The chief object of this invention is to make a valve suitable for the water-pipes, the valve being made of smaller specific gravity than water, and being opened by being forced down by a plug. The claims of the patentee will sufficiently explain the structure of the valve. He claims, first, the application for the passage of water and other liquids, of a globular valve, of a lighter specific gravity than water, constructed of a coating of vulcanised india-rubber, gutta percha, or other suitable elastic substance, so that the valve shall be closed by the pressure of the liquid. Secondly, the use and application of a globular valve of the same or a greater specific gravity than the fluid, constructed with a coating of vulcanised india-rubber or other elastic substance, so that the valve shall be closed without the aid of machinery, by the pressure of the liquid. Thirdly, the opening of the valve against the pressure of the liquid, by means of a plug or key, through which the liquid will flow from the valve, the plug or key being attached to the fixed part, without the aid of any screw or thread.

PREPARATION OF BAR-IRON.

William Russell, of Lydbrook, Gloucestershire, iron-master, for "*an improvement in the preparation of such bar-iron as is used in the manufacture of certain kinds of rod-iron.*"—Granted January 29; Enrolled July 29, 1848.

This invention may be very briefly described. The object is to remove from the surface of ordinary bar-iron the spill or scale, which is found to be very injurious in making the billets from which wire-rod-iron and horse-shoe-nail rod-iron are manufactured. The scale is removed by passing the bar-iron through a kind of draw-plate called a "cleanser," composed of grooves formed in the shape of the letter "V." In conducting the operation, the iron is first made into lumps of about one hundredweight and a quarter. It is then removed to the hammer, where it is reduced by hammering to short bars of five or six inches square. It is next passed through the rolls in the usual manner, and reduced to bars of about one inch and a quarter square. In passing through the two last and finishing grooves in the rolls, opposite which the cleanser is placed, the lower half is slightly lowered in order to admit of the entrance of the bar to the rolls which draw the bar through. During this finishing operation, pressure is exerted to bring up the cleanser by means of the lever and shaft, thereby scraping the iron on all its four sides, and effectually removing all the spill and scale from the surface. The bar is then passed over the upper roll, and is introduced through a smaller groove in the rolls, when the operation of scraping is repeated, as before.

THE GRESHAM PROFESSORSHIP.

We have seen with great regret the decision as to the Professorship of Geometry in Gresham College, because it is an indication of a return to the old system, which it was held forth should be abandoned, and the College restored to its former efficiency and rank in the scientific world. A decision more lamentable than that now made could hardly have been come to, for it is a total abnegation of scientific attainment and exertion as a qualification for the Professorship.

Among the candidates were Professor Moseley, the Rev. Morgan Cowie, Mr. Potts, the Rev. Pelham Dale, and Mr. Edkin.

Professor Moseley took high honours in mathematics at Cambridge, is the author of a work on the "Mechanical Principles of Engineering," and is a professor in King's College, London.

The Rev. Morgan Cowie took higher honours, and was the senior wrangler of his year. He was afterwards elected Fellow of St. John's College, and Moderator of the Examinations in the University of Cambridge. He now holds the appointment of Principal in the College for Civil Engineers.

Mr. Potts and the Rev. Pelham Dale have devoted themselves to mathematical studies, and have published papers on scientific subjects.

Mr. Edkin took a law degree at Cambridge, and has since been a teacher in the City of London School.

The Gresham Committee have appointed Mr. Edkin to the vacant Professorship.

It is not attempted to be put forward that Mr. Edkin is entitled on the ground of his scientific superiority, but he is said to have given satisfaction as a master in the School. It may be added, that he is related to an influential member of the Common-Council

It may happen, albeit Mr. Edkin has as yet given no proof of his competency, that he may make as good a professor as Mr. Moseley or Mr. Cowie; but whether he do or not, the appointment is equally unjustifiable.

These professorships are not simply appointments of men competent to discharge the duties, but they are rewards for previous exertion; and when properly awarded, their beneficial influence is great, because, as all candidates must comply with the condition of having given practical and public proofs of competency and distinction, a powerful stimulus is given to the industry of those who are enterprising, and there is a curb on the indolent.

In University College, the way in which the appointments are made is very simple. A committee is appointed, not of members of the Council, but of the professors of the faculty in question, who draw up a report, stating the education of the candidate, the honours he has taken, the appointments he has held, the works he has published and the character of them, and the unpublished MSS., illustrative of his studies and researches, which he has submitted to them. Thus all the materials for coming to an impartial decision as to the merits of the candidates are laid before the Council, and their appointment is made in accordance with the report. There can, therefore, by this system, be no canvassing and no jobbery.

The Trustees of Gresham College have not adopted any such course, and they have not even the poor and usual plea of favouring a member of their own College, because their College has no *alumni*.

The appointment resolves itself into the gross breach of a public trust, and it is necessary that measures should be taken to prevent its recurrence. The University of London has no legal jurisdiction in this case, but it has a moral interest in seeing justice done; and we recommend that a memorial should be addressed to the senate, and another to the Committee of Council on Education, praying that they will take measures to obtain relief. These memorials should be signed numerously by literary, scientific, and professional men, and by citizens of London, and they may result in some better system for the future. It will be easy for the University of London to provide for the examination of future candidates, leaving the appointments to the Trustees, who will thus be put under a moral and public responsibility, to which they are not now subjected.

If Gresham College were properly administered, how useful might it be to the younger professional men and mechanics of the metropolis. The Chair of Geometry, once held by Briggs and Wren, ought not to be without a competent successor; and by giving an evening course of proper lectures, great benefits would be conferred, and the very serious want of mathematical instruction in some degree be supplied. Those who know the good that has been done by Lord Brougham's Evening Classes for Schoolmasters, at University College, would earnestly wish the system of cheap evening instruction to be extended. As a recent example of the way in which these classes work, we may mention that a school has been opened in the Mechanic's Institution, under the direction of one of these graduates, and in which the children of members are taught at fourpence per week.

Those who advocate literary institutions for the working-classes have been seriously impressed by the evident consequences of giving desultory instruction, which prevails in such places, and which has the tendency of unsettling rather than of strengthening the minds of young men; but no measures have been taken to establish colleges or institutions in which, for a guinea a-year, one or two lectures shall be given, in regular courses, on the higher branches of education in the faculties usually known as wits and philosophy. This can be done and ought to be done.

NOTES OF THE MONTH.

The Ordnance Maps are now undergoing the process of being electrotyped; they are to be sold at the low price of 2s. per sheet, or 6d. per quarter-sheet, and are to be issued as they are electrotyped, quarterly. The first series has just been published, and comprises part of Middlesex, Kent Surrey, Sussex, Lancashire, and Cheshire.

The Metropolitan Sewers Act has passed the House of Commons, and is now in the Lords. The purport of the Act is to embrace into one Commission all the Commissions in Middlesex, Surrey, and Kent, excepting the City and the Regent's-park Commission;—why the latter is to be omitted, we are at a loss to conceive. The measure, which we long ago advocated, will be incomplete if that division be not included, as the district runs right through and bisects the Westminster division. It has a sewer of ample capacity and depth to drain all the upper division of the old Westminster Commission. It commences near Primrose-hill, passes through the vicinity of Regent's-park, Portland-place, Regent-street, and Charing-cross, and discharges its contents in the Thames near Whitehall and Scotland-yard. If transverse sewers be formed in the New-road, Oxford-street, and Piccadilly, nearly the whole of the Borough of Marylebone and Westminster may be drained into it, without any great expense being incurred. We trust it is not too late to introduce that Commission into the Act. The district of the new Commission is to extend to the distance of 12 miles in a straight line from St. Paul's Cathedral. We do not like the idea of the Commission being empowered to make their own bye-laws as to penalties—this is very objectionable, to say the least of it.

Payne's Process for rendering Wood Fireproof.—On Wednesday, August 2, an experiment was exhibited at Whitehall-wharf, Westminster, for testing Mr. Payne's patent process for rendering wood fireproof, and for showing that his wood-preserving process is as effectual for the preservation of wood from destruction by fire as from the ravages of insects, dry-rot, &c. Two small houses were constructed, one of ordinary deals well dried, and the other of deals prepared by Mr. Payne's process, and each filled with fire-wood and shavings. Both were kindled at the same time. The house composed of the unprotected wood caught fire very soon, and in about half an hour was completely consumed; while the Payneized house remained standing nearly as perfect as ever,—the fire in it having gone out of itself, and left only some slight marks of charring on the inside of the boards. The liquid employed by Mr. Payne (by preference) is sulphuret of barium or calcium.

The Conversion of Diamond into Coke.—Professor Faraday lately gave a lecture on this subject at the Royal Institution, in consequence of M. Jacquelain having, in the course of last year, succeeded in converting diamond into a substance possessing the appearance, physical character, and electrical properties of coke by the following process:—Having attached a piece of hard gas-retort carbon to the positive wire of Bunsen's battery of 100 elements, he placed on it a small piece of diamond. He then armed the negative wire with a cone of the same carbon, and, by dexterous manipulation, enveloped the diamond with electric flame. After a short interval, the diamond underwent a sort of ebullition, became disintegrated, softened, and was actual coke. (*Comptes Rendus*, June 14, 1847; *An. de Chimie*, tom. xx., p. 459).—On this experiment Prof. Faraday made the following observations. 1. *As to the property possessed by certain substances to assume totally different forms without undergoing any chemical change.* The Professor adverted to the case of sulphur, which becomes brittle when suddenly cooled from its first state of fusion, but is soft and pliable when similarly cooled from its second state of fusion.—2. *As to the source of heat employed.* Professor Faraday dwelt on the beauty and power of the voltaic arc as a furnace, showing by experiment that diamond could be burned into carbonic acid gas by means of a current of oxygen gas directed on it when highly heated. The Professor stated that neither this heat nor any short of that of the voltaic battery, except that of the solar lens, was sufficient to convert diamond into coke. The fusion of rock crystal by a current of oxygen sent through an ether flame was noticed; and it was shown that this powerful heat was inferior in intensity to that of the battery.—3. *The condition of the diamond when thus converted into coke.* It becomes absolutely lighter. The spec. gr. of ordinary diamond is 3·368;—when changed into coke its spec. gr. is 2·679. It loses its insulating power. Professor Faraday here alluded to some experiments by M. Karsten *Archives des Sciences*, 1847), proving that certain compound bodies were conductors or not according to their preparation. He stated that this was the only case analogous to carbon.—4. *As to the philosophy of the change of the diamond's structure.* Referring to M. Gassiot's demonstration that the heat is greatest at the positive pole of the battery, Professor Faraday suggested the possibility that the particles of diamond might, under the influence of the intense heat, tend to form vapour having a sensible and assisting expansive force, and that in their axial position as regarded the enveloping discharge they might assume a state having relation to a diamagnetic condition. He requested to be understood, however, as offering this idea merely as a philosophical conjecture. Finally, he referred to Graham's supposition, that the difference between diamond and coke might depend on their known difference of specific heat.——In reference to the above experiments of M. Jacquelain, on the conversion of diamond into coke, Mr. Nasmyth states, in a communication to the *Mining Journal*, that he "had long since discovered that *coke was diamond*, in as far as that coke is possessed of one of the most *useful* and remarkable properties of diamond in respect to its power of *cutting* glass—owing, doubtless, to the extreme hardness of its ultimate particles, or minute crystals of which a mass of coke is formed. We are apt to consider coke as a soft substance, because we can crush it, and pulverise it with facility; but if we examine into the actual hardness of the minute, plate-formed crystals, which compose a mass of that substance, we shall find that they are possessed of a most remarkable degree of hardness, and can *cut* glass with that clean-looking cut which is so peculiar to the diamond." He feels certain, that when the extreme diamond-like hardness of coke is made known, that the fact will be laid hold of, and turned to good account as a most cheap material for all grinding purposes, such as required for many processes in the arts—to say nothing of its useful application to the sharpening of a razor, as a very superior strop powder; for which purpose, however, the coke must be reduced by *evigation* to the most minute and impalpable powder.

Dover Refuge Harbour.—This great national work is progressing with much spirit, and begins to show what it will be. The first portion, 800 feet of a massive sea-wall, has been contracted for by Messrs. Lee of London; and the works are carried on under the superintendence of their agent, Mr. Scott. The plan is that of Mr. James Walker, the eminent engineer; and the execution of the engineering department also devolves on him and his partner, Mr. Burgess. The works now extend 130 feet into the sea, and the curve to the eastward has been commenced. One diving-bell was lately put into requisition in the process of levelling the rocks for the foundation, and another will be speedily brought into use. Of the immense quantity of stone (8,500 tons) which has been landed here within a few months, nearly one-half has already been put down. The blocks are uniformly of large dimensions, some exceeding 10 tons weight.

Sunderland Docks.—The extensive works now in progress for the formation of the new docks at Sunderland are proceeding in the most rapid and successful manner. The sea has been most effectively banked out of the tidal basin, and nearly the whole length of the large dock; and there is the fullest confidence that this gigantic undertaking will be brought to a successful completion within the time fixed; and, what is still more unusual, there is a well-grounded expectation that it will be finished considerably within the estimated cost. The works begin to have a noble appearance, and when finished will be a magnificent undertaking. A dock of this magnitude, gained from the sea within the range of the tides, is an enterprise now proved to be practicable, and a safe undertaking.

Blasting Rocks.—The *Plymouth Times* observes: "The vast improvement effected in the mode of blasting limestone rock in this port, within the last 37 years, is almost surpassing belief. Last week, with a charge of 1 cwt. of powder, placed in a hole in the rock, 18 feet deep, no less than 1,000 tons of limestone rock were blasted at one blast, and that, too, without any accident occurring to the man engaged in firing the rock. He was six hours engaged in the operation, and was seven times pulled up from the side of the hole to the top of the quarries, before the fire took effect, and this huge blast was made."

Opening of Railways.—The Chester and Holyhead Railway was, with the exception of 3½ miles adjoining the Menai Straits, opened on Tuesday, August 1st., throughout, for goods and passenger traffic.—The Leeds, Dewsbury, and Manchester Railway, lessening the distance between the former and latter town 10 miles, was opened for public traffic on the 4th of August.—The opening of the Rouen and Dieppe line took place on Saturday, July 29.—The Castlecary branch of the Caledonian Railway was opened for public traffic on Monday, August 7, thus completing the direct line between London, Perth, Dundee, Arbroath, and Montrose. The express train from Dundee arrived at the Euston-square terminus in 15 hours, and from Arbroath in 15¾ hours.

A New Turn-Table has been invented by Mr. Turiff, of the Vulcan Foundry, Paisley. An engine and tender, weighing 36 tons, placed on one of the turn-tables, can be turned by two men by means of two wheel-pulleys, with comparative ease, in about a minute and a half, without any jar. The great advantage of this invention of Mr. Turiff's is, that with former turn-tables there were two frictions, while with this table there is only one; it is relieved by a powerful weight resting on the centre, which contains four large bolts, that lift the table from the side rails beneath. The machinery is very simple, composed of massive beams of iron, and can be worked by circular rollers, in cases of emergency. The turn-table itself is 36 feet in diameter, weighs 25 tons, and sustains 51 tons revolving weight.

Indurated Gypsum.—It is known that calcined gypsum, after being moistened with a solution of alum and again burnt, acquires much greater hardness and solidity. M. Kreating recommends for the same purpose a solution of 1 lb. of borax in 9 lb. of water, which is poured over the calcined fragments of gypsum. They are then kept at a strong red heat for six hours, ground to a powder and worked. The effect is said to be still better if a pound of tartar and twice the quantity of water are added to the solution.—*Liebig's Annalen.*

Suspension-bridge at Niagara Falls.—The *Albany Journal* states that the foot-bridge at the Falls was to be ready for crossing on the 4th of July:—"It consists of 16 cables; the number of strands in each cable, 600; ultimate tension, 6,500 tons; capacity of the bridge, 500 tons; number of strands in the ferry cable, 37; diameter of the cable, ⅞ths of an inch; height of stone tower, 68 ft. 1 in.; height of wood tower for ferry, 50 feet; base of tower, 20 square feet; size at the top, 11 square feet; span of the bridge, 800 feet; whole weight of the bridge, 650 tons; height from the water, 230 feet; depth of water under the bridge, 250 feet. This suspension-bridge is the most sublime work of art on the continent. It makes the head dizzy to look at it, and yet it is traversed with as much security as any other bridge of the same width. We were present while the workmen were engaged in hanging the planks over the fearful chasm. It looked like a work of peril, but it was prosecuted with entire safety. Not an accident has happened since the first cord was carried across the river at the tail of a kite. It is impossible to give the reader a clear idea of the grandeur of the work. Imagine a foot-bridge 800 feet in length, hung in the air, at the height of 230 feet, over a vast body of water rushing through a narrow gorge at the rate of 30 miles an hour. If you are below it, it looks like a strip of paper suspended by a cobweb."

Nature's Gas Works.—"An immense volume of natural gas, sufficient for the supply of a city, was discovered a few days since, near Detroit, Michigan, by the Messrs. Granger, while boring a 4-inch shaft for water. At a depth of 70 feet they struck a vein or cavity, from which issued a violent current of air, which threw up stones as large as hens' eggs, 10 or 15 feet high, accompanied by a volume of water, rising 10 or 12 feet. On applying a light to the air, it burnt furiously, the flame rising 20 feet. It is proposed to conduct this gas in pipes to Detroit, and light that city with it."—*New York Sun.* [Very much like a romance.]

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM JULY 20, TO AUGUST 22, 1848.

Six Months allowed for Enrolment, unless otherwise expressed.

Chevalier Alexandre Edouard le Molt, of Conduit-street, Middlesex, for certain "Improvements in apparatus for lighting by electricity, parts of which may be made use of in other applications of electricity."—Sealed July 20.

David Napier, and James Murdoch Napier, of York-road, Lambeth, engineers, for "Improvements in mariner's compasses, also in barometers, and in certain other measuring instruments."—July 20.

William Thomas, of Cheapside, London, merchant, for "Improvements in the manufacture of stays, boots, and shoes, also in fastening and connecting fabrics and garments."—July 26.

John King, foreman to Messrs. Shears and Sons, Bankside, and Henry Medhurst, operative engineer to the said Messrs. Shears and Sons, for "Improvements in gas meters."—July 26.

Charles Hancock, of Brompton, Middlesex, gentleman, for "Improvements in apparatus or machinery for giving shape and configuration to plastic substances."—July 29.

John Grist, of the New North-road, Middlesex, engineer, for "Improvements in furnaces and fire-places."—July 29.

James Robertson, of Great Howard-street, Liverpool, Lancashire, cooper, for "Improvements in the manufacture of casks and other wooden vessels, and in machinery for cutting wood for those purposes."—July 29.

George Walter Pratt, of the city of Rochester, state of New York, in the United States of America, gentleman, for "Improvements in the manufacture of printing-ink."—July 29.

Richard Abbey, of Slough, Buckingham, brewer, for "Improvements in preserving fermented and other liquids and matters in vessels."—July 29.

Edward Gribben Wilson, of Bury, Lancashire, tin-plate worker, for "certain Improvements in the construction of tin drums or rollers used in the machinery for drawing, spinning, dowling, twisting, and throwing cotton, wool, silk, flax, and other fibrous substances."—August 1.

Duncan Mackenzie, of Goodman's Fields, manufacturer, for "certain Improvements in Jacquard machinery for figuring fabrics and tissues generally, and apparatus for transmission of designs to said Jacquard machinery, parts of which are applicable to playing musical instruments, composing printing types, and other like purposes." (A communication.)—August 5.

David Newton, of Macclesfield, Chester, merchant, for "certain Improvements in the application of glass and glazed surfaces to nautical, architectural, and other similar purposes."—August 7.

Samuel Thornton, of Birmingham, merchant, and James Edward M'Connell, of Wolverton, Buckinghamshire, engineer, for "Improvements in steam-engines, and in the means of retarding engines and carriages on railways, and in connecting railway carriages or wagons together; also improvements in effecting a communication between one part of a railway train and another, by signals or otherwise."—August 7.

John Medcalfe, of Little Bolton, Lancaster, machine maker, and Robert Halliwell, of the same place, mechanic, for "certain machinery or apparatus for preparing and spinning cotton and other fibrous substances."—August 8.

Moses Poole, of London, gentleman, for "Improvements in the manufacture of casks and other similar vessels of wood." (A communication.)—August 8.

Samuel Lees, of the firm of Hannah Lees and Sons, of Park-bridge, Lancaster, iron-manufacturer, for "certain Improvements in the manufacture of malleable iron."—August 8.

Joshua Couch, of Harleston, Northamptonshire, agricultural implement maker, for "Improvements in sackholders."—August 10.

William Thomas Henley, of Clerkenwell, philosophical instrument-maker, and David George Foster, of Clerkenwell, aforesaid, metal merchant, for "certain Improvements in telegraphic communication, and in apparatus connected therewith, parts of which improvements are also applicable to the moving of other machines and machinery."—August 10.

Samuel George Hewitt, of Buchanan-street, Glasgow, N.B., engineer, for "Improvements in the construction of certain parts of railways."—August 11.

John Varley, of Bury, Lancaster, engineer, for "certain Improvements in steam-engines."—August 14.

James Henderson, of Surrey Canal Dock, millwright, for "Improvements in machinery for cleansing and polishing rice, pearl barley, and other grain and seed."—August 14.

Joseph Simpson, of Manchester, civil engineer, and James Alfred Shipton, of the same place, engineer, for "certain improvements in steam-engines."—August 14.

Edwin Thomas Truman, of the Haymarket, London, dentist, for an "Improved method or methods of constructing and fixing artificial teeth and gums; and of supplying deficiencies in the mouth."—August 15.

James Warren, of Montague-terrace, Mile-end-road, Middlesex, gentleman, and Willoughby Theobald Monzani, of St. James's-terrace, Blue Anchor-road, Bermondsey, gentleman, for "Improvements in the construction of bridges, aqueducts, and roofings."—August 15.

Thomas Delarue, of Bunhill-row, Middlesex, manufacturer, for "Improvements in producing ornamental surfaces to paper and other substances."—August 15.

William Galloway and John Galloway, of Knott-Mill Iron-Works, Hulme, in the borough of Manchester, and county of Lancashire, engineers, for "certain Improvements in steam-engines."—August 17.

Moses Haym Picciotto, of Finsbury-square, London, merchant, for "a method or methods of purifying and decolorising certain gums."—August 17.

Thomas Richardson, of Newcastle-upon-Tyne, chemist, for "Improvements in the condensation of metallic fumes, and in the manufacture of white lead."—August 21.

William Young, of Queen-street, Cheapside, lamp manufacturer, for "Improvements in closing spirit and other cans or vessels."—August 21.

Isaac Taylor, of Stanford Rivers, Essex, gentleman, for "Improvements in preparing and engraving surfaces, also in the construction of cylinders adapted for engraving, and also in machinery for printing and ornamenting surfaces."—August 21.

Richard Shaw, of Gold's Green, West Bromwich, in the county of Stafford, railway-bar finisher, for "Improvements in the manufacture of iron into tyre-bars, round-bars, square-bars, and flat-bars, T-iron, angle-iron, and trough-iron."—August 21.

John Bethell, of Parliament-street, Westminster, gentleman, for "Improvements in preserving animal and vegetable substances, and also stone, chalk, and plaster, from decay."—August 21.

Alexander Angus Croll, of the Gas works, Tottenham, for "Improvements in the manufacture of gas, and in apparatus to be used in transmitting gas."—August 22.

Alonzo Buonaparte Woodcock, of Manchester, for "Improvements in steam-engines, and in apparatus for raising, forcing, and conveying water and other fluids."—August 22.

whic . . . , the platform and saws; and figs. 6 and 7, enlarged views of the steam-cylinder and driving-hammer.

The apparatus and machinery consist of the following parts :—

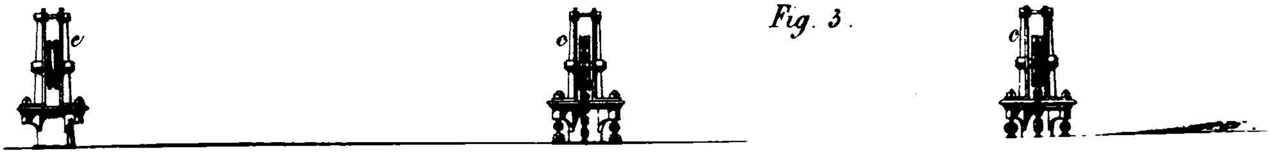
Firstly, the steam-boiler, A, similar to a locomotive-boiler, with steam-chest on the top. This boiler stands upon a platform B,

tempts of the ordinary pile-driving machines at utter defiance.

It may be proper to observe, that notwithstanding the energetic blows which this machine showers down on the heads of the piles, in consequence of these blows being given by so massive a hammer as 35 cwt., and at the moderate velocity acquired by a fall of only

PLATE XII

Fig. 3.



proposed to cond... o Detroit, and light that city with
"—*New York S*... a romance.]

decay."—August 21.

Alexander Angus Croll, of the Gas works, Tottenham, for "Improvements in the manufacture of gas, and in apparatus to be used in transmitting gas."—August 22.

Alonzo Buonaparte Woodcock, of Manchester, for "Improvements in steam-engines, and in apparatus for raising, forcing, and conveying water and other fluids."—August 22.

STEAM PILE-DRIVER.

(With an Engraving, Plate XII.)

Patented by Mr. James Nasmyth, *and Manufactured by* Messrs. Nasmyth, Gaskell, and Co, *of the Bridgewater Foundry, Patricroft, near Manchester.*

Public works are acquiring such magnitude even in their details, and their several parts are so numerous, that they are constantly making greater requirements on the resources of mechanical engineering. It has been a matter of dispute frequently whether a particular class of works belonged to the architect or the civil engineer; and Professor Hosking goes the length of claiming the whole domain of civil engineering as belonging to architecture. Others may now come forward and claim many of these works as the province of mechanical engineering. Thus, a still greater tendency to the separation of the professions of the architect and engineer is created. The tubular bridges over the Conway and the Menai, the High Level Bridge at Newcastle, iron and screw pile lighthouses, and suspension-bridges, are more the production of the mechanical engineer than of the architect. As a specimen, we gave in our August number an account of the ingenious patent Jacquard machine, invented by Mr. Roberts, for punching the plates of the tubular bridge at Conway, for the purpose of saving time and labour; and in our present number we publish the engravings of another powerful machine, invented by Mr. James Nasmyth, for driving piles by the aid of steam, and which has been used with great success in the construction of the High Level Bridge at Newcastle, the Docks at Plymouth, and other works of magnitude. It is gratifying to see this mutual aid of civil and mechanical engineering, for it is this combination of talent which is best calculated to elevate the character of both branches of the profession, and to extend their application. Whatever mechanical processes diminish the cost of production, whether of a railway or of a pin, contribute to increased use; and we look forward to a great reduction in railway expenditure from the progress of improvement, and consequently to an extension of the system under circumstances where, from considerations of economy, its application is not now contemplated.

Any consideration of the great works of civil engineering, even in such a case as the Eddystone Lighthouse, will show how much depends on overcoming the mechanical obstacles which stand in the way. Time is money, and money again often saves time; and a due attention to these points enables an engineer to execute his works cheaply and well. At the present time, a great deal depends upon the rapid and economical prosecution of works, and it becomes doubly important to call in the aid of mechanical science wherever, as in the cases already named, it promises to do the work more efficiently and more economically.

The merits of the steam pile-driver now before us consist, in the first place, in the direct manner in which the elastic force of steam is employed as the agent by which the "monkey" (or block of iron which strikes the head of the pile) is lifted to the height requisite for that purpose. Secondly, in the very peculiar and original manner in which the pile itself is made to act as the only support for the active or blow-giving portion of the apparatus; by which arrangement, the entire dead weight of the apparatus in question is turned to most important account as a "*persuader*," to assist the pile in sinking into the ground when in the act of being driven: this dead weight also acting very importantly as an anti-recoil agent, so far as its entire weight (three tons) can accomplish that object.—Thirdly, in the peculiar manner in which the pile-driving part of the apparatus is permitted to sink down along with the pile, and guide it in its descent, so as to remove all chance of the pile twisting, or in any respect swerving from the true position given to it at the commencement of the operation of driving.—Fourthly, in the peculiar manner in which a vast increased degree of energy is given to the blows of the monkey beyond that which is due to the height through which it falls.

The engraving exhibits an arrangement of the "Patent Steam Pile-Driver," for driving two piles in two continuous lines, without the necessity of a previously-existing gangway, the machine making its own way as it is moved forward. Fig. 1 is a side elevation; fig. 2, a section on a b; fig. 3, front elevation; fig. 4 a plan, showing the engine and platform; fig. 5, a plan of the timbers which carry the platform and saws; and figs. 6 and 7, enlarged views of the steam-cylinder and driving-hammer.

The apparatus and machinery consist of the following parts:—

Firstly, the steam-boiler, A, similar to a locomotive-boiler, with steam-chest on the top. This boiler stands upon a platform B, supported on iron wheels b, running on iron rails b^1, placed on balks of timber b^2, fixed on to the top of the piles as they are driven; and vertical guide-posts C C, with pulleys, $c\,c$, $c^1\,c^1$, on the top.

Secondly, a small steam-engine D, placed horizontally in the centre of the platform, with connecting-rod d, driving a crank d^1, and pinion d^2, on the crank-shaft, that takes into a cog-wheel e, fixed on one end of a shaft E, with pinion e^1 on the other end that takes into another cog-wheel f, fixed on the long shaft F, upon which are fixed two pinion-wheels f^1, f^1, that take into cog-wheels f^2 f^2, fixed on the axles of two spiral-fluted barrels f^3 f^3, upon which are coiled the chains f^4 f^4, for lifting the steam-pile, driving-cylinder, and hammer. Upon the ends of the shaft D, are two smaller barrels G, for the ropes or chains g^1 to lift the piles into their places.

Thirdly, the pile-driving apparatus, consisting of a cylinder H, with its piston-rod passing out at the bottom, and directly attached to a block of iron or monkey I (weighing about 35 cwt.), placed inside of a square wrought-iron case J, which acts as a guide to the hammer in its rising or falling, and rests upon the shoulder of the pile K at $j\,j$; and at the same time, grasps the neck and shoulders of the pile with great tightness, so that it cannot twist or swerve from the position which the vertical guide-posts C give to the case J, and which is clamped to the posts by the sliding-clamps j^1 j^1. L, L, are steam-pipes from the top of the boiler A, to the pile-driving cylinder H, jointed together by swivel joints of cast-iron.

Fourthly, horizontal saws M, M, fixed on to the underside of the platform, for cutting off, to a level surface, the heads of the piles as they are driven. The saws are worked by the bevel gearing m, fixed on to the middle shaft, E.

With respect to the action of this machine, in order to describe it with clearness, we shall suppose that the pile-driving part of the apparatus seen in fig. 1, and enlarged view figs. 6 and 7, marked H, I, J, has been wound up by the small engine D, and the gearing F, and let down upon the shoulders of the pile K, and the steam admitted under the piston in the cylinder H, by means of the jointed wrought-iron pipes L, L, L, which serve to convey the steam from the boiler A to the cylinder H, at whatsoever height the cylinder may be at in respect to the boiler. The steam being let in under the piston, the steam-hammer action is commenced, and the 35-cwt. block I, is made to give 75 to 80 blows per minute with a fall of 3 feet, upon the head of the pile, with such earnest energy as to cause the pile to sink into the soil at an average rate of from 5 to 10 feet per minute (according to the nature of the soil). As each blow is given, the apparatus H, I, J, follows down along with the pile, as the shoulders of the pile are the only means of support to H, I, J, and they are therefore free to slide down the face of the vertical pole C, the instant a blow is given to the pile-head and drives it down; and this action is so rapid, that the eye can scarcely appreciate the interval. The jointed steam-pipe at the same time accomodates itself to every new position which the sinking pile causes the driving-apparatus to assume. For the purpose of opening and closing the steam-valve, there is a small inclined plane on the hammer-block, inside the case, which coming in contact with the end of a small lever passing through an opening in the side of the case J, shown in figs. 6 and 7, causes the valve in the valve-box (cast on the steam-cylinder H) to open and shut. When the steam has raised the piston to its proper height, the steam-valve, by the action of this lever, is closed, and an outlet-valve opened, which allows the steam to blow out into the air and the hammer-block to descend.

As soon as the pile is driven to the required depth, the apparatus is again wound up by the small engine D; and the next following pile K^1, which may have been in the mean time hoisted by the engine D and gearing G, ready for driving (as seen in fig. 1), is then "pitched" or placed in its proper situation. The locomotive gear is then put in motion, and the apparatus lowered down on to the shoulders of the pile in question. The hoisting-chain f^4, is then let free, so that the apparatus may be free to rest on the shoulders of the pile, and follow down along with it as before. The steam is now again let into the cylinder H, and the driving proceeded with as before. The ease and dispatch with which the entire process is proceed with requires to be seen to be duly appreciated. Piles have been driven by this machine into descriptions of soils and under circumstanceu which would have put all the attempts of the ordinary pile-driving machines at utter defiance.

It may be proper to observe, that notwithstanding the energetic blows which this maehine showers down on the heads of the piles, in consequence of these blows being given by so massive a hammer as 35 cwt., and at the moderate velocity acquired by a fall of only

3 feet, they do not the slightest damage to the pile-head: so much is this the case, that the pile-heads have actually a neater appearance *after* being driven than before.

In respect to the means employed for giving to the blow of the monkey a greater degree of energy than such as would be due to its fall through 3 feet, this object is accomplished by having the top of the cylinder H made air-tight, and by having a set of openings at *h*. The instant the piston passes these openings in its upward action, all further motion in that direction is terminated by the compression of the air then confined in the space between the top of the piston and under-side of the cylinder cover; which compressed air, on recoiling, adds to the force of the blow all the energy it would have acquired by falling from the height to which the monkey would have been carried by the momentum given to it in the upward direction by the lifting action of the steam acting on the under-side of the piston.

We have much pleasure in appending to our description a copy of a certificate by Mr. Stephenson.

"Nasmyth's Steam Pile-Driving Machine has for some time past been employed in piling the foundations of the High Level Bridge at Newcastle-upon-Tyne, and at the Viaduct over the river Tweed, near Berwick. Its operation has been triumphantly successful. Piles have been driven with great economy and remarkable dispatch, where the ordinary methods would have entirely failed.

"I consider this machine to be one of the most valuable and important auxiliaries which have recently been invented for the construction of engineering works.

ROBERT STEPHENSON.

24, *Great George-street*, *Westminster*,
May 2, 1848."

CANDIDUS'S NOTE-BOOK, FASCICULUS LXXXVI.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. The lately-opened Catholic Cathedral of St. George's does not say very much for Mr. Pugin's artistic talent and taste. Satisfactory as are many of the separate parts and ornaments when considered merely by themselves, just as articles of furniture are looked at and examined in a show-room where they are exposed for sale,—they are there brought together without any regard to artistic keeping and effect. The consequence of which is, they do not serve to set each other off to advantage; but, on the contrary, there is much that is quite at variance with all the rest. We see a collection of studies of various ornamental details, and other mere *matérial* of design, but we miss a well-studied and consistent whole. The most opposite and conflicting sorts of architectural character are brought into contact with each other. Barn and ball-room are strangely mixed-up together. In the chancel, and the two chapels at that end of the church, decoration is not only carried to such extent as to cause all the rest to look unusually cold and bare, but fails to produce the amount of richness aimed at. When added up, the total does not answer to the value of the several items as taken by themselves.

II. In architecture, incapacity for producing new ideas shelters itself under the plausible pretence of a reverential regard for old ones. Because excellent ideas have been produced before our time, we are told that we have no occasion for any of our own. Aught that partakes of innovation is set down as both unorthodox and dangerous; which is assuredly most comfortable doctrine—highly convenient, and therefore comfortable, because merely to copy is easy and safe; whereas, to attempt to emulate is a difficult as well as a doubtful matter. We do well, therefore, to protest against innovation—that is, for ourselves, since those whom we profess to look up to and admire, were in their day very gross innovators: by gross, I mean wholesale innovators. The history of the art shows a series of innovations from first to last; that "last"—finale and conclusion of it as a creative art, seems to have been already reached; and all that is now left for us is merely to repeat, perchance to mimic, what has been done before. Whatever may be the case with the twentieth, the nineteenth century will not shine in the history of architecture; or if it is to do so, it must now set about it in earnest, for half its time is already gone. Bad or good, the Elizabethan period had a distinct architectural character of its own; whereas, the present Victorian one has none, but is "everything by turns," of most chamelion quality, but without any distinct, self-acquired, character. The present age is content with merely making use of those hoards of art which its more industrious predecessors wrought out and accumulated. Satisfied with being able to live upon the interest, we do not seek to improve the capital. In fact, to such a pass has architecture been brought, that further progress for it in any direction is impossible, so long as we persist in our present perverse views of it—of its nature and powers as a fine art. No matter what style we take up, we treat and are expected to treat it literally—to adhere to it servilely, instead of being allowed to infuse any fresh ideas into it, or even, by varying its *tournure*, to adapt it to greatly-altered purposes and occasions. Provided the separate features and details be but correctly copied from those in former buildings, we are quite satisfied, though the structure so compounded be full of incongruities as a whole,—prosaic and unartistic.

III. One consequence of the present rage for the merest copyism is, that we ourselves produce no structures that will deserve to be studied hereafter as original models and architectural records of the age in which they were erected. Even our most monumental edifices will not be monuments of our own time,—of our own ideas moulding and organising the fabrics we rear. Future antiquaries will be greatly puzzled some centuries hence, to determine dates from the styles which buildings exhibit. At any rate, they will set down this nineteenth century as that in which architectural talent displayed itself chiefly in mimicry and masquerade. This is what is not particularly pleasant to contemplate, though it is what we have to thank the present race of antiquaries for, and others whose opinions and influence as employers control the free-agency of architects, who, whatever they might have done by timely resistance to such domineering dictation, can hardly help themselves now. They have suffered their necks to be put into the yoke; so, however hard it may be to bear, they must now endure it with what patience they can. All that we can look forward to, is to its being shaken off by some bold and independent spirit, gifted not with genius only, but with the opportunity of manifesting it decidedly, however it may run counter to the minikin theory and doctrine of established rules. But as miracles are not to be looked for and calculated upon like the return of comets, we cannot with any sort of reason look forward to such event. Nay, instead of being looked forward to with anxious hope, even the possibility of its occurring is contemplated with real apprehension by many, who accordingly deprecate most earnestly what they are pleased to call "tampering" with existing styles. Incapable of forming a valid judgment, they take refuge in prejudice. By their croaking cry of "rash"—"absurd"—"extravagant"—"chimerical!" they endeavour to intimidate; and by denouncing before-hand all aim at originality, and every deviation from ordinary custom and rule, seek to insure the accomplishment of their ill-omened predictions. The merely aiming at it does not insure success in achieving originality; but if, instead of being aimed at, it is sedulously shunned, it will never be achieved by any one; and were there no possibility of failing, there would be no particular honour gained by succeeding. Many act most discreetly in not attempting to signalise themselves and their works at all by any unborrowed ideas—by which are to be understood not mere fancies for which they can assign no sufficient reason even to themselves, much less to any one else, but ideas that have germinated, have been meditated upon and matured, in their own minds. In not attempting or affecting to do what they are conscious lies far beyond their power of reach, such persons manifest their prudence; it is, on the contrary, only dogmatical presumption, when measuring the powers and abilities of others by their own, they pronounce that which is to themselves impossible to be equally impossible to every one and all. Rather ought they, if at all sincere in the regard they profess for the interests of architecture and its advancement, to welcome the doctrine of its being possible to enlarge the present boundaries of the art almost indefinitely. How far he as an individual can contribute to such progress and amplification, must be left to each individual to decide for himself. Those who feel no impulse from within, may be left to jog on as they can *secundum artem*—that is, ploddingly and mechanically: but they have no right to prescribe the same limits to others. As matters are managed at present, a prohibition is actually laid upon original genius, it being demanded of it that it should forego its very nature, and exercise itself only in the same track of ideas as has been previously trodden: in other words, it must conform to routine. A good deal has been argued about the Emancipation of Woman; I wish somebody besides myself, and of far greater authority and influence, would stand up boldly for the Emancipation of the Architect, who is at present fettered by prejudices—in reality the merest cobwebs, but twisted together till they become as bulky as cables. If my views and opinions are erroneous, let them be opposed; yet no one it seems cares either to oppose or to second me. Well! if I am not flattered, even by contradiction, neither am I discouraged. Happy are those who expect nothing, for they shall not be disappointed; and that state of beatitude is mine.

II. As it is now too late to protest against the barbarism of stripping the Quadrant of its colonnades—and they have assuredly contributed not a little to the architectural character of Regent-street, the Quadrant being by far the most scenic part of the whole line,—let us hope that the columns themselves will be preserved, that is, re-erected, so as to form some ornamental structure elsewhere,—on some spot where they will not give any *umbrage* to shops and shop-keepers—and the latter show themselves to be somewhat unreasonable, because it was they who came to the colonnades, and not the colonnades to them. Their removal would be less matter of regret, were we but assured that the columns would now be so applied, that ample amends would be made to us for what we shall lose in Regent-street. If no better and more utilitarian purpose can be suggested for them, they might be employed to form an open screen of two lines of columns, inclosing the court-yard in front of the British Museum. Sir Robert Smirke's building itself would gain materially thereby, inasmuch as it would be seen from the street very picturesquely through the range of Doric columns in front, which being, besides, on a lesser scale, would serve to give greater importance to the Ionic colonnades behind. To the very excellent suggestion here volunteered, it will be objected—and objections are always as cheap as suggestions themselves—that the Quadrant columns are only Roman-Doric, while the façade of the Museum is pure Greek-Ionic. That ultra-Grecianism is affected for it, is not to be denied; but there is even now a great deal in the general design that is anything but pure Greek in physiognomy. Neither the wings, with their homely and ordinary house look, nor the two little bits between them and the main building, would be able to reproach the Quadrant columns with being too undignified and unclassical to bear them company. Still, one thing may be confidently predicted: I therefore prophecy that my idea will not be adopted, nor even so much as taken into consideration. Happy the prophet whose predictions are sure to be verified, and such state of beatitude, I repeat, is mine.

THE NATIONAL GALLERY.

Whatever general truth there may be in the paragraph which appeared in last month's *Art-Journal*, informing us that the present National Gallery is to undergo extensive alteration by Mr. Barry, its correctness as to particulars may be questioned. What seems to vouch for such piece of intelligence being more than a mere vague, unauthorised report, is the express statement of the sum to be expended—viz. £50,000; to which the architect is to be limited. And for that the entire façade is to be altered, and another story added to the building. How the latter can be accomplished without destroying the lantern lights in all the rooms now constituting the upper-floor, puzzles both ourselves and others to conceive. There appears to be no other alternative or mode of alteration in that case, than that of lighting the present rooms from their sides, or rather their two ends, in the front and back of the building; which would hardly be any improvement as far as they are concerned, nor perhaps much, if any at all, to the exterior.

It has all along been the *fashion*—we can call it nothing else—to decry and abuse the National Gallery, more especially its façade, as if that were not merely the chief, but the sole disfigurement of Trafalgar-square,—as if St. Martin's Church, and the other buildings on the east and west sides of the "Square," were absolute paragons of architectural taste and excellence. Even those who affect excessive admiration for the "Church," affect to be scandalised at Wilkins's façade of the "Gallery." Ask them, *why*? and they soar upwards—fly into a towering passion,—and from that altitude, look down upon you with scorn most supreme. Even that lump of architectural cockneyism and dulness, the "College of Physicians and Union Club-house," if it does not obtain admiration, at least escapes censure, which is levelled exclusively against that scape-goat of Trafalgar-square, the National Gallery. However, the latter is to become a "Deformed Transformed;" and poor St. Martin will need the whole of his cloak to spread over and shelter the insignificance of his Church.

As to one material point connected with the purposed alteration we are left in entire doubt, not being informed whether the whole of the additional story is to be appropriated to the "Gallery," or the portion of it at the east-end of the plan, bestowed upon the Royal Academy.

Whatever may be done to it, the building can never, in our opinion, be rendered adequate to the now greatly-increased, and henceforth likely to become still greater, requirements for the national collection of pictures, unless the whole of it be given up to the "Gallery," and the Academy turned out to provide for itself elsewhere. For exhibition rooms, the Academy needs only longitudinal extent of plan at the rear of a very moderate-sized front towards the street, for the walls being invariably covered from top to bottom with pictures, the rooms themselves might be of the very plainest description,—both in construction and appearance not at all superior to ordinary show-rooms, auction-rooms, and similar places. Therefore, if the space now required for the "Gallery" demands it, we should say, turn the Academy adrift to shift for itself. It does not throw open its doors gratuitously to the public: why then should it expect to be in any way supported by the public,—or, what is just the same thing, by government? At any rate, there is no necessity for the Academy's continuing to occupy so considerable a portion as it does of the building in Trafalgar-square, now that the whole of it is required for the national collection of pictures.

The paragraph in the *Art-Journal* does not speak at all doubtingly, as of rumour that requires confirmation; therefore, unless it should be contradicted, we may presume that there really exists a definite intention of enlarging and otherwise altering Wilkins's edifice; and that, consequently, government do not entertain any idea of erecting a new National Gallery, as has been talked of by many, and by some fully expected. There have been various rumours on the subject, one of them being that a structure for the pupose was to be built upon the inclosed area in Leicester-square. In what is now stated, there is far more of probability and likelihood, although the *Art-Journal* speaks only upon a "we understand." Let it be based upon what it may, that "understanding" assumes some degree of shape and colour, several particulars being distinctly touched upon. Mr. Barry's design has been "submitted to the proper authorities," and not only approved of, but, as it would seem, actually determined upon before the public were aware that anything of the kind was in contemplation. It is not, indeed, very easy to reconcile this with what is said in another page of the same publication, where we are told that Mr. Pennethorne being directed to examine the lower rooms of the present Gallery, with a view to the Vernon Collection being deposited there, reported their total unfitness for such purpose, and recommended that a plain temporary building, calculated to last about a dozen years, should be erected, and that in the interim parliament should make an annual grant of from £15,000 to £20,000 for a permanent edifice. One tale contradicts the other: either Mr. Barry's design, or Mr. Pennethorne's suggestion, is thrown out. If there is to be a new building in some other situation, the present Gallery will remain untouched; and *vice versâ*, if the latter is to be greatly enlarged, and to have £50,000 expended upon it, another structure will not be erected. Between the two schemes lies doubt: error there is as to one of them, and error there may be as to both. Still, something appears to be in agitation or contemplation; therefore, it is not at all amiss that public attention should be directed to it at an early stage of proceedings.

Most may be of opinion, and some are or have been in full expectation, that let be done whatever might—whether a new National Gallery is to be built, or the present building enlarged, the work would, like the "Houses of Parliament," be made the subject of competition. The occasion itself is a public one, and of a kind to exercise talent in no ordinary degree; a structure for the purpose being something altogether *sui generis*. Of almost every other kind of buildings the examples and instances are so numerous, that general conventional ideas may be taken from them; but with respect to Picture Galleries the case is quite different. For them there are no models; neither have any studies been provided, or aught of any moment on the subject been written and published. Some of the most celebrated public collections of pictures in Europe are in buildings which, besides being tasteless or in exceedingly bad taste themselves, are so badly arranged and devoid of all contrivance, that they do not seem to have ever been intended for the purpose to which they are applied. Besides accommodation with regard to actual space, effective lighting the rooms, and other obvious matters of that kind, the providing for a judicious arrangement of the pictures is what requires considerable study and foresight. In temporary exhibitions, pictures must be hung up as well as they can be. The disposing them on the walls is of necessity a work of such hurry, that it is little to be wondered at if it is frequently attended with awkward mistakes, such as putting a good painting nearly out of sight, and an inferior one just upon the line. Even if it be detected, there is no time for correcting the error, because to do so might render it necessary to alter the situations of a score of other pictures.

In a permanent gallery, on the contrary, more especially one claiming to be considered a public museum of art, where nothing, it is to presumed, is admitted but what is worthy of being studied —at least, of being noticed as a work of art,—the utmost attention ought to be given before-hand to what is required by the collection itself. Should this last be already fully formed, to provide properly for it becomes a comparatively easy task; whereas, for one that is increasing, regard should be had to future growth. When Mr. Wilkins—or rather, perhaps, those who employed him—took measure of it, our national collection was merely in its infancy. Thanks to Mr. Vernon, the child has nearly all at once started up into a tall stripling,—has quite outgrown his former "fit," which suit suits him no longer; so Mr. Barry is now it seems to enlarge it, and convert it as well as he can into a becoming *toga virilis*. If he can do so without reclaiming from the Academy the piece of stuff they have got possession of, he must have far more talent in point of contrivance than most of his professional brethren.

After all, we may possibly have been put quite on a wrong scent. Should which turn out to be the case, all we can say is, that the mistake does not lie at our door. We leave those from whom we got it to trace out the author of it; nor should we be greatly surprised to find it traced home—if mistake it really be—to that confounded, universal mischief-maker, Mr. Nobody!

COLLISION OF TRAINS.—No. II.

In our last paper (p. 197), we considered the law and amount of collision in a train of carriages of equal weights, and provided with a single engine in front. We now propose to examine the effect of an engine behind, the other circumstances of the problem remaining the same.

As a first and introductory example, let us suppose a single carriage, weight 4 tons, having a pair of buffers in front, with a foot play to each, and each with an extreme strength of 4 tons (the law of resistance of the buffers being assumed to vary as their compression), to impinge on a fixed obstacle with a velocity of 60 feet per second. Let us now determine how much of this velocity will be destroyed by the time the buffers have ceased to act.

Let m be the mass of the carriage; p, the pressure on the head of either buffer when it is compressed to an extent x; v, the velocity, in seconds, of the carriage;—then, the mass of the buffer being neglected as small in comparison with the mass of the carriage,

$$m v \frac{dv}{dx} = -2p.$$

Now, 4 tons is the value of p when $x = 1$; and since p has been assumed to vary as x

$$p = 4x; \quad \therefore m v \frac{dv}{dx} = -8x; \quad \therefore m v^2 = c - 8x^2.$$

If the accelerating force of gravity be taken at 32 feet per second,

$$m = \frac{4}{32} = \frac{1}{8}; \quad \frac{v^2}{8} = c - 8x^2; \quad v^2 = 8c - 64x^2.$$

$$\text{When } x = 0,\ v = 60; \quad \therefore 8c = 3600.$$

When $x = 1$, the buffers cease to act, and $v^2 = 3600 - 64$; or, $v = 59\frac{1}{2}$ nearly; consequently, only half-a-foot of velocity is destroyed.

Let us next consider the case of a train of n carriages, each provided with a pair of buffers before and behind; and with an engine, weight r tons, attached to the last carriage; and let us suppose this train to impinge on a fixed obstacle at the rate of V feet per second; and from these data seek approximately the amount of velocity destroyed in the rearward engine by the time all the buffers are used up.

In order to make the problem general, we will assume the weight of the carriages each $= w$, and the extreme strength of the buffers μh tons; also their extreme play h feet. By the time the engine behind has moved forward a space x, after collision has commenced, let $2p$ be the pressure on the buffers of the rearward engine. We shall now show that p is always less than $\frac{P}{n'}$, where n' is the number of pairs of buffers, and P the pressure on any buffer compressed to an extent x. For let x_1, x_2, x_3, &c., be the extent to which the buffers are simultaneously compressed, reckoning from the carriage which first sustains the shock; μx_1, μx_2, μx_3, &c., the pressures of the buffer-heads corresponding to the compressions x_1, x_2, x_3, &c. Now we have shown in our last paper that the pressures of the buffers, and therefore x_1, x_2, x_3, &c., decrease as we recede from the end of the train nearest collision.

$$\therefore x_1 \text{ is } > x_2; \quad x_2 \text{ is } > x_3; \quad \text{\&c. is } > \text{\&c.}$$

$$p = \mu x_{n'}; \quad p \text{ is } < \mu x_{n'-1}; \quad p \text{ is } < \mu x_{n'-2}; \quad \text{\&c. is } < \text{\&c.}$$

$$\therefore n'p \text{ is } < \mu(x_{n'} + x_{n'-1} + \text{\&c.}) \text{ is } < \mu x \text{ is } < \mathrm{P};$$

$$\therefore p \text{ is } < \frac{\mathrm{P}}{n'}.$$

$$\therefore \int_{n'h}^{0} p\,dx \text{ is } < \int_{n'h}^{0} \frac{\mathrm{P}}{n'} dx \text{ is } < \int_{n'h}^{0} \frac{\mu x\,dx}{n'} \text{ is } < \frac{\mu n' h^2}{2}.$$

Therefore, if v be the velocity of the rearward engine, by the time the buffers are all used up,

$$\frac{r}{32}(\mathrm{V}^2 - v^2) \text{ is } < 2\mu n' h^2.$$

As an example, let $h = 1$, as before; $n = 19$; $\therefore n' = 40$ (including buffers of engines before and behind); $r = 20$; $\mathrm{V} = 60$; $\mu = 4$.

$$\therefore \mathrm{V}^2 - v^2 \text{ is } < \frac{32}{20} \times 320 \text{ is } < 32 \times 16 \text{ is } < 512.$$

If $\mathrm{V} = 60$, $\therefore v^2$ is > 3088; $\therefore v$ is > 55. Or, the velocity of the rearward engine has been diminished by less than 5 feet a second.

If V had been put $= 30$, which is equivalent to about 20 miles an hour, still v would have had a value of 20 feet a second, or twelve miles an hour. In either case, it is clear that the shock of the engine behind would have been most destructive—in the first case frightfully so.

To recapitulate the results of our investigation, it appears, first, that when a train with a single engine is violently checked, the first carriage will sustain the greatest damage, and the effect of the buffers will be to increase the number of blows on the first and succeeding carriages, but to diminish their intensity. Secondly, that when an engine is attached behind; the last carriage after all the buffers are used up—having first to sustain the shock of the rearward engine proceeding with a diminished but still considerable velocity, if the original velocity of the train had been great,—will probably be the most seriously injured of all the carriages. A double shock will in this case have passed along the train—at first, by the sudden stoppage of the first carriages *before all* the buffers are used up; and then from the blow from the rearward engine *after all* the buffers are used up.

Since writing the former paper on this subject, we have seen a model of a break, by Mr. Bishop, which by an ingenious and simple contrivance is capable of being applied to all the carriages simultaneously, and almost instantaneously. We earnestly recommend the adoption of some such method of suddenly occasioning a powerful retarding force, as a most efficient means of avoiding casualties and coroners' inquests.

J. H. R.

NOTES ON ENGINEERING.—No. XI.

By Homersham Cox, B.A.

The Strength of Hungerford Bridge.

The security of a Suspension Bridge erected in the very centre of the metropolis, and liable to sustain the weight of a very large number of persons, is a subject possessing a scientific interest commensurate with its practical importance. The moment of the question has been greatly increased by two independent circumstances—first, that it has been the subject of serious doubt and scientific discussion; and secondly, that the traffic of the bridge has recently received an important accession by the opening of a railway terminus in its immediate vicinity.

There are some parts of the theory of suspension bridges exceedingly complicated and difficult, and others perfectly simple. Among the latter is the estimation of the statical strain to which a chain is subjected when its weight and all its dimensions are known. This particular branch of the question may be set at rest without much difficulty. The object of the present paper is to do this by methods distinct from those which have been adopted in the previous discussions of the question.

Sir Howard Douglas, who first publicly moved the subject of the sufficiency of Hungerford Bridge, has ably calculated the strength of the chains, on the assumption that the form of them is the "common catenary:" this method, the most scientific and exact of any, involves however considerable mathematical skill in its application. The mode about to be employed may be readily used in general practice, as it does not require a knowledge of mathematics; and the agreement of its result with that obtained by the process referred to, tends to their mutual confirmation.

In suspension bridges, the central deflection is always small compared with the span between the points of suspension. It follows that the curvature of the chain is very small; and whether it be considered a catenary, a parabola, or even the arc of a circle, the deviation from the real form will not be considerable. It is very usual, for the sake of simplicity, to assume the curve to be a parabola, and that assumption will be here adopted after a few remarks tending to prove its accuracy.

If the horizontal distribution of the weight of the chain and its load were uniform, the curve would be *exactly* a parabola, as may be easily ascertained by reference to any standard treatise on mechanics which refers to the subject. Now, when the bridge is crowded, the load on the platform *is* uniformly distributed horizontally. This is also the case with the weights of the platform and the parapet, which are considerable. The only mass not so distributed is that of the chains themselves, of which the links are horizontal at the centre, and inclined more and more up to the points of suspension. But practically this inclination is never large; for instance, in Hungerford Bridge at the points of suspension, as will be presently shown, the tangent of the angle of inclination is about $\frac{6}{17}$. This gives the cosine of the angle less than $\frac{18}{17}$; or 18 feet measured along the chain there, nearly corresponds with 17 feet measured horizontally. This shows that the hypothesis of horizontal distribution, even for the chain alone, does not involve any considerable error; and when the additional effect of the mass of the load and platform, which is really so distributed, is taken with it, the deviation from the truth must be inconsiderable.

On this assumption, then, the vertical line through the centre of gravity of half the chain and its load is situated midway between the centre of the chain and the extremity of the platform; or the horizontal distance of this centre of gravity from the abutment is equal to one-fourth the span. Therefore, the moment about the point of suspension of the weight of half the chain and load, is the product of that weight and one-fourth the span.

At the centre of the chain the tension is horizontal: its vertical distance below the point of suspension is equal to the deflection of the chain. Therefore, the moment of this tension about the point of suspension is the product of the tension and the deflection.

The moments just determined are equal, the total effect to turn the half-chain about the point of suspension being produced by the weight, and this effect being resisted by the effect of the horizontal tension. (The platform not being rigid, contributes nothing to the ultimate support of the load.) Also, in Hungerford Suspension Bridge, the deflection is 50 feet, and the quarter-span 169 feet. Consequently,

Horizontal tension × 50 = *weight of half-span* × 169.

Hence the weight of the half-span is $\frac{50}{169}$, or very nearly five-seventeenths of the tension at the centre of the chain.

On the authority of Mr. Cowper, who is believed to have obtained authentic and accurate information, it is stated, in Part 93 of this *Journal* (June, 1845), that the total sectional area of the chains at their centre is 296 square inches. The Bridge is supported by four chains, two on each side of the platform, and the above is the sum of the sectional area of all four together. The horizontal tension is supposed to be uniformly distributed over these 296 inches.

Wrought-iron bars become sensibly stretched and impaired when subject to a tension of 17 tons per square inch. They will not bear that strain permanently; and in practice it is not considered safe to subject them to a greater tensile force than 9 tons per square inch. Taking the latter measure, the greatest horizontal tension which the four chains together can safely bear is 296 × 9 = 2664 tons; and the greatest weight of the half-span must, by what has already been said, be $\frac{50}{169}$ths of this, or very nearly 788 tons. Consequently, for the whole-span,

The greatest total load = 1576 *tons.*

This is, in fact, nearly the load to which the bridge is actually liable to be subjected. The weight of the chains (715 tons) added to that of the platform, parapet, rods, &c., and a crowd covering the platform with a weight of 100 lb. to the square foot, gives, according to Mr. Cowper, the maximum load at about fifteen hundred tons. We come to the conclusion, then, that when the bridge has its full load, the statical tension at its centre is nine tons to the square inch.

The following method was adopted to test the accuracy of the hypothesis on which this conclusion is founded. By a known principle which applies to catenaries of every form, the tangents at any two points of the curve meet in the vertical line through the centre of gravity of the intervening portion of the chain. Consequently, if the assumption be true that the vertical through the centre of gravity of the half-chain bisects the half-span, the tangent at the point of suspension ought, if produced, to meet the platform midway between its centre and extremity. The observation of this fact would be a *crucial* test of the above conclusions. This test was satisfactorily performed in the following manner. The inclination of the chain at its summit was observed with a telescope from various positions on the Bridge, and that position was noted in which the inclination of the chain at its highest point coincided with the axis of the telescope. That position of the observer's eye for which one end of the highest link *covered* the link, was of course in the line of that link produced. By these means (applied for the sake of mutual confirmation to the points of suspension at both towers), it was ascertained that the centre of gravity of each half-chain was about six feet nearer the end, than the centre, of the platform. The advantage of this method of observation was, that it did not require particular accuracy: an error of 10 or even 20 feet would not have made a considerable difference in the result, while the errors of observation were certainly far within those limits.

It is important to observe, that if the Bridge were loaded with its full weight, the actual position of the centre of gravity would coincide with that above assumed, even more closely than it did at the time of the observation.

To ascertain the tension at the points of suspension, we have the following rule, applicable to catenaries of every form. Add the squares of the horizontal tension and of the weight on the half-span: the square root of this sum is the tension at the summits of the chain—which, therefore, in the case before us, is

$$= \sqrt{\{(2664)^2 + (778)^2\}} \text{ tons.}$$

After obtaining this square root, divide it by 9, and the result is 308, for the number of square inches over which the tension at the summit must be distributed if the tension be 9 tons per square inch. The actual sectional area of the chain at the points in question is very near this—namely, 312 square inches.

In the above caculations, the structure has been supposed to be in a state of equilibrium. The vibrations of the several parts of the chain, arising from the rapid motion of traffic, or the action of the wind, would certainly increase the strains greatly, though no means of calculating that increase have been yet ascertained. The foregoing method shows, with all the precision requisite for practical purposes, that both at the centre and extremities of the chain the tension of the metal is 9 tons per square inch, when the bridge is fully loaded. The fairest way of stating the conclusion from these investigations appears to be this:—If the permanent tenacity of the metal be so great that it may be safely subjected to a greater strain than 9 tons per square inch, then the excess is a provision against accidental disturbances. If, however, 9 tons per square inch be the utmost strain which the metal will safely bear, no margin is left for security against the effects of rapid motion.

THE WATER-GAS.

Some time has elapsed since a patent was obtained for a process of making illuminating gas from water; but the plan was not carried into practical effect, and dropped out of public notice. The invention has once more been brought before the public, and in a manner calculated to attract attention, by being made the subject of lectures delivered by Mr. Ryan at the Polytechnic Institution. The process itself is a very curious one; and though the expense may probably render it a less economical mode of supplying gas than coals, where they are to be purchased at a cheap rate, yet, in many parts of the country, it is probable that the water-gas may be the cheaper of the two; and as its purity and illuminating power exceed those of the carburetted hydrogen obtained from coals, it is well that the mode of making it should be generally known.

To those who are unacquainted with the chemical composition of water, it may seem strange that water should be rendered the source of fire; but to most of our readers it must be well known that water is composed of hydrogen, the most inflammable of bodies, and of oxygen, which, when in the form of gas, is the most active supporter of combustion. A plan of obtaining hydrogen gas from water, by passing steam through a hot tube containing iron has been long known. The *rationale* of that process is, that the steam when in contact with heated iron becomes decomposed, the oxygen uniting with the iron to form an oxide of that metal, and the hydrogen is liberated in the form of gas. This, indeed, is the best mode of obtaining hydrogen gas in a state of purity; but for the purpose of illumination, such gas is of no value. The flame, though emitting great heat, is scarcely visible. The illuminating power of coal-gas depends on the carbon it contains; and the more carbon is contained in carburetted hydrogen, the greater is its illuminating power. It is owing to the great proportion of carbon in turpentine, that it affords such a brilliant light in the "camphine" lamps, the only difficulty in the burning of that substance being to produce perfect combustion; otherwise the abundance of carbon causes volumes of dense smoke. To render the water-gas illuminating, it is necessary, therefore, to combine with it a portion of carbon; and it is this part of the process in which the principal novelty of the invention consists. The apparatus employed in the manufacture of the gas is exhibited at work at the Polytechnic Institution. It consists of a furnace, in which are three long iron retorts placed perpendicularly. Two of these are nearly filled with coke and old iron chains, or pieces of iron. Water is admitted into the first of these, and being converted into steam, it is then decomposed by the iron, and the hydrogen gas which is liberated, absorbs at the same time some portion of carbon from the heated coke. The gas and residual steam are then passed into the second retort, where a similar process of decomposition and of further carbonization takes place; and it then issues into the third retort, where it is brought into contact with heated tar, and absorbs from it a large portion of carbon. The carburetted gas is then forced through some vertical tubes, to permit the deposition of superfluous tar, and is conducted into the gasometer ready for use. The illuminating power of this gas is estimated to exceed that of ordinary coal-gas, 25 per cent.; and its freedom from sulphur and other impurities renders it far preferable to coal-gas. Respecting the economy of the process, Dr. Ryan says nothing; and we believe that it was on this point that the invention failed to be practically useful when first introduced. The cost of the fuel to heat the retorts, of the iron to decompose the steam, and of the tar to carbonise the gas would, we fear, amount to more than the cost of coal, in most parts of England, for making the ordinary kind of coal-gas. In many circumstances, however, we conceive this mode of generating illuminating gas may be advantageous, especially when the purity of the gas consumed is an object of importance.

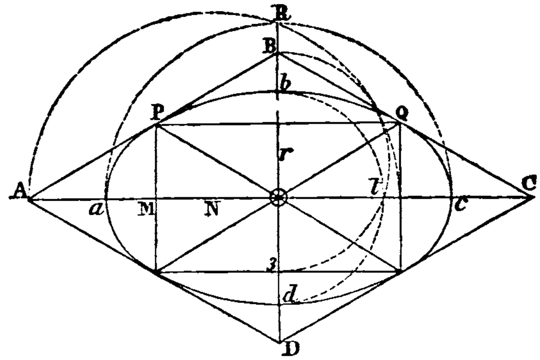
ON ISOMETRICAL PERSPECTIVE.

By R. G. Clark.

The object of this article is to communicate an easy method, by construction, for determining the transverse and conjugate diameters of an ellipse touching the sides of an oblique parallelogram, being the isometrical projection of a circle inscribed in a square.

Draw the isometrical parallelogram A B C D, and its two diagonals A C, and B D; bisect O C in *m*, also bisect A *m* in N, and then with the radius A N and centre N, describe a semicircle cutting O B, produced in R. Again, with centre O, radius O R, describe a semicircle *a* R *c* cutting A C in *a* and *c*; then will *a c* be the transverse diameter required of the ellipse. In like manner, bisect O D in *s*, and B *s* in *r*, and with the centre *r*, and radius *r* B, describe a semicircle cutting O C in *t*; again, with centre O and radius O *t*, describe an arc cutting D B in *b* and *d*, then will *b d* be the conjugate diameter required.

The above may be demonstrated thus:—Because the sides of the oblique parallelogram respectively touch the curve, they are tangents to it. By the properties of the Conic Sections (see Dr. Hymer's elegant treatise), we have, $AO \times MO = aO^2$; but $MO = mO$, therefore $aO^2 = AO \times mO$. Also, by the property of the Circle, we have $aO^2 = OR^2$. A similar mode of proof applies to the conjugate diameter. After the diameters are thus determined, the curve can be easily trammelled in the usual way. It would also be well to state an easy rule, by calculation, founded on the above construction.



Rule.—Multiply the diameter of the circle by 1·224 for the transverse diameter, and by ·707 for the conjugate diameter.

Ex.—Given the diameter of a circular turn-table = 14′ 5″, to find the transverse and conjugate diameters of its isometrical representation.

Here, by the rule, $14{\cdot}5 \times 1{\cdot}224 = 17{\cdot}748$ transverse diameter.
$14{\cdot}5 \times {\cdot}707 = 10{\cdot}25$ conjugate diameter.

The previous method of construction, however simple, I have not before met with in any work on isometrical perspective. The rule by calculation is easily deduced from the construction, making the isometrical diameter, or the given diameter, of the circle equal to unity: Thus, because the isometrical angle $OAB = 30°$, therefore $BO = \frac{1}{4}AC$. Hence $OA = \sqrt{(1{\cdot} - {\cdot}25)} = {\cdot}866$; therefore, $aO^2 = AO \times MO = {\cdot}866 \times {\cdot}433 = {\cdot}3749$. By extracting the square root of each side, we have $aO = {\cdot}612$; consequently, the transverse diameter $ac = 1{\cdot}224$. Also, $BO = \frac{1}{4}BC = {\cdot}5$; therefore, $BO \times \frac{1}{4}BO = bO^2$; hence $bO = {\cdot}3535$; consequently, the conjugate diameter $bd = {\cdot}707$. These are the numbers as given in the rule. I have not seen this rule in Jopling's treatise, but there is a table given of diameters, with the same figures to the Diameter 1. It will be observed, that all the lines that are in the figure are not required in the construction, but only the two diagonals: the other lines are only drawn to assist in the demonstration. The method given by Professor Farish in his paper on *Isometrical Perspective*, in Gregory's "Mathematics for Practical Men," is very tedious, both by construction and calculation.

EXPERIMENTS ON CEMENT.

A good deal of attention has recently been directed to the merits of a cement called "Portland" cement, manufactured by Messrs. Aspden and Robins, of Northfleet; and on Monday, the 18th ult., a numerous body of architects, builders, &c., assembled at the town premises of these gentlemen, in Great Scotland-yard, to witness a number of experiments with the cement, both alone and in combination with sand, in different proportions; the following are some of the trials made:—

Best Stock Bricks Cemented against the Wall.

Experiment 1.—17 stock bricks were cemented together with *roman cement* (all cement) and projected before the face of a wall, as fig. 1. They broke down with 7 lb. placed on the end.

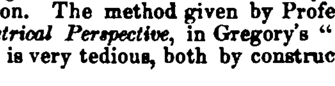


Fig. 1.

Experiment 2.—11 stock bricks, cemented together with 1 sand and 1 roman cement, broke down with 7 lb. placed on the end.

Experiment 3.—38 bricks, cemented with neat, patent *portland cement*, broke down with 14 lb. placed on the end.

Experiment 4.—30 bricks, cemented together with 1 portland cement and 1 sand, broke down with 15 lb. at end.

Experiment 5.—22 bricks cemented together with 1 portland cement and 2 sand, broke down with 168 lb. at end.

Experiment 6.—25 bricks, with 1 portland cement and 4 sand, broke down with 56 lb. at end.

Experiment 7.—26 bricks, with 1 portland cement and 5 sand, broke down with 74 lb. at end.

Experiment 8.—14 bricks, all portland cement, with a wheel of 9 cwt. in the centre, broke down with 17 lb. at end.

Experiment 9.—16 bricks, cemented together with 1 portland cement and 1 sand, and suspended at both ends, broke down with 15 cwt. placed in a scale suspended on the centre. (*See* fig. 2).

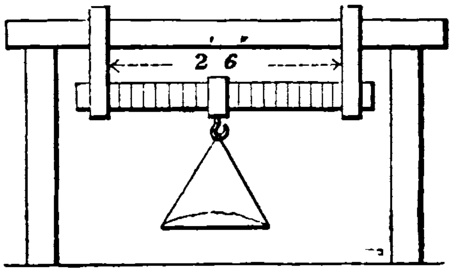


Fig. 2.

Experiment 10.—A block of portland stone, 2 ft. 11 in. long, and 9 by 9 inches, broke with a weight of 38 cwt. (*See* fig. 3.)

Note.—A block, cemented with roman cement, would not bear the weight of the stone, in a similar position.

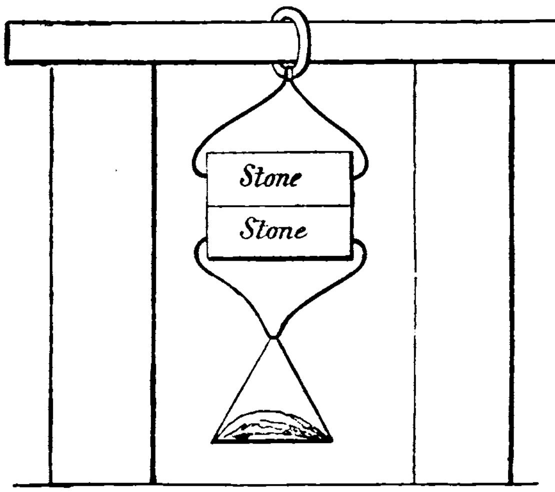


Fig. 3.

Trials in a Hydraulic Press.

Experiment 11.—A block, all portland cement, 18 inches high and 9 × 9 inches, bore a pressure equal to 108½ tons on the square foot.

Expt. 12.—A mixture, 1 sand and 1 cement, ... 80 tons sq. foot.

Expt. 13.—A mixture, 4 „ 1 „ ... 80 „ „

Expt. 14.—A mixture, 7 „ 1 „ ... 44½ „ „

Experiment 15.—A block, all roman cement, broke at 22½ tons.

Experiment 16.—A mixture, 4 parts sand and 1 roman cement, would not bear any pressure.

Experiment 17.—A block of portland stone, 1½ in. × 1 in., broke up at 23 cwt.

Experiment 18.—A block of the portland cement, the same dimensions, broke with 18 tons.

New Screw-Cutting Machine.—A plan of cutting iron screws is stated to have been invented by Mr. P. H. Gates, of Chicago, Illinois, by which the power of one man will cut per day, 700 half-inch, 500 three-quarter inch, 400 one inch, and 300 one-and-a-half inch bolts. The advantages claimed for this plan over the common die are, its dispatch in doing work; its durability, having cut over 4,000 bolts with one die, without any repairs; instead of jambing or driving the thread into shape it cuts it out, the same as in a lathe, leaving the thread of solid iron, which cannot be stripped off as is usual with those cut by the common die, and it will do the work by once passing along the bolt, making the thread perfect. The die, it is said, can be made by ordinary workmen, with far less expense than the common die, and when made, is not at all liable to get out of repair.

REVIEWS.

The Palace of Westminster. Imperial quarto, Part I. London: Warrington and Son, 1848.

At present, we can hardly pretend to give an opinion as to the merits of a series of architectural illustrations from the three engravings in this first Part; nor are we able even so much as to say to what extent it is intended to carry the publication, and what will be the entire number of plates, there being neither prospectus nor advertisement on the wrapper to afford that somewhat desirable information. What strikes at the very first as objectionable is, not that the plates are published miscellaneously while the work is coming out, but that it seems they are intended to be bound up so, instead of being duly arranged according to some sort of order and sequence. The subjects contained in this Part I. are: Plan of the Principal Floor, the Royal Court (a perspective view), and an Elevation of the lower part of the Victoria Tower, which are designated in the heading of the descriptive letter-press accompanying each of them, as Plate I., II., III., respectively. Wherefore, although the descriptive letter-press itself is not paged—which looks as if it had been intended to leave it to purchasers to arrange the subjects ultimately to their own fancy—such accommodation is now frustrated by the plates being numbered in the letter-press, and in our opinion quite uselessly, there being no corresponding numbers on the plates themselves, so that the binder can be guided only by their titles. We almost fancy that the "numbering" must have occurred through mere oversight; and if so, now that the very great inconvenience attending it is pointed out, it ought to be abandoned at once,—should which be done, cancels ought to be given of the descriptions already published.

As matters have been managed, Plate I. is a Plan of the Principal Floor; but surely that will not be the only illustration of the kind, or else the work will be singularly defective and unsatisfactory. Hardly can we believe that it is not intended to give some other plans—at any rate that of the ground-floor, it being quite indispensable for properly understanding the structure. The floor immediately above the principal one ought also to be shown. Besides which, there are many portions of the Principal Floor itself which require to be exhibited upon a larger scale, and much more in detail; the scale of the general plan being no more than that of an inch to 120 feet, which is so small that it is imposible to measure from it with any sort of accuracy some of the lesser rooms;—wherefore it would not have been amiss had the respective dimensions, according to actual measurement, been inserted in the "Key to the Plan." With regard to the plan itself, it does not extend beyond Westminster Hall; consequently, it does not show what is to be done on the west side of the Hall, along Margaret-street and New Palace-yard. Nor is the plan quite so distinct as it might be, owing to all the parts that are under roof being shaded, and only the open courts and areas left plain or white. So far indeed distinction is made between the covered and uncovered parts of the plan, but there might just as well have been greater distinctness also produced by making the walls considerably darker than the rest. In our opinion, shading of the kind might have been dispensed with altogether in what is an upper-floor plan, it being quite sufficient to treat the ground-floor one in that manner. Or—for the disagreeable doubt now comes across us—is this plan to be the only illustration of the kind? We will not believe that it is until we can no longer disbelieve it. Even a ground-floor plan will not be quite satisfactory unless it be made to show—except that be done in a separate situation's-plan, on a lesser scale—the relative position of Westminster Bridge, Henry VII.'s Chapel, and other circumstances of the peculiar locality. Else, how are those who are quite unacquainted with that locality, to form any notion of it? A publication like the present, more especially its subject being taken into account, is not likely to be confined to this country, but will be eagerly turned to abroad, wherever the fame of the Palace of Westminster and its architect has reached; and how are those who possess no other information than what they can derive from plans, to understand the difficulties imposed upon the architect by the site, and make due allowance for what must strike them as being defective and unsatisfactory in the disposition of the west or principal land-side of the edifice? For our part we should say, that besides a general situation's-plan, there ought also to be a plan of all the buildings as they existed before the fire. And undoubtedly a plan of the kind ought to be inserted in this publication, if only as a historical document.

Plate II. shows, in a perspective view, a part of what is called the Royal Court, it being that into which the state carriage and other royal equipages drive and turn round when the sovereign goes to parliament. Here we see on the east side, the large bay window and range of upper windows of the Royal Gallery, and part of the south side of the court, where the windows on the principal floor belong to the office of the Lord Great Chamberlain. The archway through which the carriages pass from the porch beneath the Victoria Tower is quite in a corner, at the south-west angle of the court. The architecture of the court is good, but not at all remarkable, except on the west or gallery-side of it, where the two archways below (one of them leading into the Chancellor's Court) the small octagonal staircase turret, the oriel window with solid wall in the compartment between the buttresses on each side of it, broken only by arched and splayed panels, containing royal armonial bearings, form, together with the range of lofty windows above (those in the upper part of that side of the gallery), form a sufficiently picturesque and piquant combination,—such as can hardly fail to captivate the admirers of the olden time. What the other elevations of the court, which are not shown in the view, may be, the description does not inform us. To say the truth, the descriptive letter-press is exceedingly meagre, dry, and bald; and has, besides, the disadvantage of consisting only of detached scraps.

Plate III., the elevation of the royal portal or entrance-porch in the lower part of the Victoria Tower, exhibits, on a tolerably adequate scale, the exceedingly rich details of that part of the structure; in the character of whose open arch we fancy we recognise a resemblance to that of the beautiful Erpingham Gate at Norwich. Satisfactory as it is in other respects, the print hardly does justice to the structure itself; for it conveys no idea of the strikingly-fine effect produced by an open arch of such magnitude (50 feet high to its apex), on the exterior of a building. The plate being a mere outline one, the picturesque contrast of light and shade is quite lost; therefore, although it is not likely that any one will actually make such a mistake as to suppose that the arch itself is filled-up by the lesser arch and gate seen on the further plane of the elevation, it would have been better had that plane been entirely, though slightly, shaded—because then the opening of the arch would have been distinctly defined. There will, we hope, be a section of this porch drawn to the same scale as the elevation; and we also desiderate a fully detailed plan, to show the groining of its vault.

However interesting and excellent the materials for it furnished by Mr. Barry may be, the publication does not seem to have been planned with much judgment or foresight. The separate "History" of the Palace of Westminster is by Mr. H. T. Ryde; but who is the general editor, or who writes the descriptive portion of the letter-press is not said,—it is certainly nothing to boast of. As to what calls itself "Introduction," that might, in our opinion, very well have been spared, for it strikes us as being in wretchedly bad taste—a tissue of vulgar bombastic commonplace, and puff.

Since the above was put into the printer's hands, we have seen Part II., which came out only a very few days after Part I., and which gives us three more plates. The first of them exhibits to us in perspective a portion of the exterior—viz., the "South-Wing Towers" of the principal or east front; yet, although carefully done by a very competent architectural draughtsman (Mr. J. Johnson), and although we cannot but commend the diligence bestowed upon the drawing, the engraving is not altogether satisfactory. What has been alleged by some against the building itself, makes itself here felt; for the multiplicity of the details and enrichment spread over every part, is such as to occasion no small degree of confusion and indistinctness. This is especially the case with regard to the upper part—the towers and the roof, where the different forms and surfaces do not define themselves at all clearly. More decided general effect as to light and shade, and greater vigour of touch, are required. In fact, the ordinary mode of lithography—that here employed—is hardly capable of doing justice to such a subject, for it shows poor and flat in comparison with that improved method in which the *whites*, as they are technically termed, are printed; therefore, after being now accustomed to that more energetic and pictorial mode of lithography, we feel dissatisfied with the one here practised. With the next plate—the Interior of the Royal Porch—we are made to feel very much so; for whether it be that the impression we have got is a defective one, it is particularly feeble and tame, and most of all so in those parts which require some of the deepest touches of shadow. While there is little or no truth as to the general effect of light in such a situation, the shafts and mouldings of the second or smaller, immediately inclosing the third and smallest arch, are scarcely defined at all below, on the side which is in the shadow. It may also be objected that this subject shows us very little more than what is seen in Plate III. beyond the open arch in the elevation of the exterior of the porch, the view being confined merely to that east side, without showing anything of the vaulted roof, or of the flight of steps on the north side leading up to the royal entrance into the building; which is consequently not even so much as indicated, although it might very easily have been so by just reducing the scale a trifle, and bringing a little more of the interior into view. This plate moreover confirms what we have said as to the injudiciousness of numbering the subjects according to the order in which they happen to be published, since this view is partly identical in subject with Plate III., accordingly ought to have immediately followed it; instead of which, Plate IV. is altogether different in subject—one, besides, which interrupts the natural sequence of the subjects, for all the respective views of the exterior ought to come together, and follow each other in some regular order; yet no such arrangement can now be adopted, except by disregarding the numerical order of the plates, and thereby giving the letter-press the appearance of being strangely shuffled-up. Plate VI., however, does really follow Plate V. with great propriety; it showing on a larger scale the statues of the three popular Saints, Andrew, George, and Patrick, in the niches over the gate leading to the royal court. Whether they are worthy of having a plate devoted to them is a different matter: as mere architectural accessories, they may be privileged to pass muster without criticism; but if they challenge admiration on their own account as works of art, they are not likely to obtain it—at least, not as here represented, which is but in a very so-so-ish manner.

A General Sheet Table for Facilitating the Calculation of Earthworks for Railways, Canals, &c. By Francis Bashforth, M.A., Fellow of St. John's College, Cambridge.—Chain of 100 Feet.

Mr. Bashforth's previously-published table of earthworks was calculated to a chain of 66 feet. He has now extended the utility of his labours by calculating the present table for a chain of 100 feet: the method of applying the figures remaining the same as before. As we have already reviewed at length Mr. Bashforth's system, which is distinctly and peculiarly his own, and have had occasion to decry an attempt to rob him of his indefeisible right and property in his own labours, it is not necessary now to speak further, either in the way of explanation or commendation. In the present table the proportional parts, instead of being contained on a separate card, are printed beside the integral numbers. By this arrangement space and trouble are saved, and all the information which is usually requisite is condensed and presented at one view. We are afraid to say much in praise of the improvements which the author has effected in the calculation of earthworks, lest our observations should provoke the cupidity of some literary burglar: property in tables of earthworks is found to be so insecure, that the only safe way of retaining it seems to be by concealing it.

Incitements to Studies of Steam and the Steam-Engine; or, Practical Facts relative thereto Properly Appropriated. By W. Templeton, R.N. Woolwich. London: John Williams, 1848.

The object of this little book is to diffuse information on marine engineering, particularly to enable persons to prepare for the examinations for engineers in the navy. Of course, such a work will be equally useful for engineers in the commercial steam service. We think it likely to be very serviceable for those classes to whom it is addressed, and we therefore recommend it to our readers who feel an interest in the subjects to which it refers.

Mr. Templeton suggests as one of the uses of this little book, that although it is not professedly instructive for the higher branches of the profession, it may be found available as a ready prompter, for refreshing the memory on points of practice. By keeping up the standard of attainments among working-men, we think Mr. Templeton will do some good.

GEORGE STEPHENSON.

On the death of a great man it is a good time to think of what he has done. We are struck by the loss: the thought comes gloomily that he who so lately stood among us, whose smile still beams upon us, whose sayings are fresh in our ears, and whose looks have not faded from our sight, has ended his days here and sought another world. We begin to tell over his words and deeds, the great and good things he has done, his strength and his failings, his sorrows and his joys;—we hasten to snatch a last look before the bright remembrance is dimmed.

George Stephenson was so lately amidst us, in strength of body and mind unbroken, that it is hard to believe he lies in the cold grave; and the more so while his works speak so loudly of him. In mind he is among us, if not in body—indeed, his remembrance cannot so soon leave. The last duties have been paid—the earth has been laid upon him, his name is written on his coffin, and the newspapers have told of his birth and his death: but his brethren have yet much to think over. He has given the engineers of England a European name; he has opened for them a new field of employment at home, a wider field of honour and of wealth abroad, and they owe him heartfelt thanks.

When we look to the man, our hearts are stirred within us. We begin with his lowly birth, we witness his great rise, his wonderful works, but still more his kindly feelings; we wonder how he did so much from small beginnings, and every young man burns to follow in the footsteps of one so truly great and good. We have thought, therefore, a few words may be in good time now, gathered from the several books and papers in which they lie scattered, and which may perhaps be a spur to those able to do something worthier of the man.

His life is none the less useful as being that of a working-man, who by his own straight-forwardness raised himself to the topmost height; and as he began without school-learning, and in a private way, it opens many of those questions which have been much written upon of late years as to the teaching of engineers, and how far they should be under the sway of a government. Inasmuch, too, as, unlike many men of learning, he was most happy in earning wealth, and in keeping it, in a good name, and in the love of his household, it may be worth while to ask why he should have had a better lot than other men, and what share an upright and manly mind had in helping on a quick and ready wit. Many, indeed, think that a clever man may do as he likes, and that he need put no bridle on his wishes, nor trouble himself whether his deeds be right or wrong, but may be a good and successful engineer notwithstanding. Stephenson's life will tell us something on all these heads.

I. BOYHOOD.

George Stephenson was born in 1760, at a small and lone cottage between Close-House and Wylam, in Northumberland, and within nine miles of Newcastle, in the colliery district. He was one of several children, the son of poor people, who had long dwelt in the same neighbourhood, and who were very respectable. The elder Stephenson is said to have been a collier, but by other more likely accounts[1] an engine tenter at a colliery. That the parents were people of high character is best proved by the early life of the son, but most by his behaviour towards them.

Schooling they were ill able to give him, and it is not certain that he learned to read before he began to labour; but he had that best kind of teaching which comes from the heart. An open and upright mind was the true groundwork on which his greatness was built, and he owed it to the humble home in which he was brought up. We pride ourselves now-a-days that we have spread national schools over the land, and that we have taken care for the right bringing up of youth; and we think it much better that all can now learn to read and write. It may however well be asked, how far this alone is good; for we have struck a blow at that home-schooling, under which for so many hundred years Englishmen have been bred. Formerly, the cotter had the whole care of his children; the father and the mother were held answerable for their offspring, and if these ended ill, the shame was a by-word among the neighbours. Now, the child is handed over to the schoolmaster, without whose teaching life is held as nought, and whose reading and writing are to breathe worth into the boyish mind. It is no longer said learning is better than house or land, but that it stands in the stead of everything, and is worth itself. The work of father and mother is now at an end; and if any ill befall, they answer they sent the child to school, and if any be in the wrong it must be the schoolmaster. This is telling more than is believed, and is one of those things which is sapping England. How often must it be said that reading and writing are not to bring a child up, while its body and its soul are untaught? and better is it to have the homely English breeding of George Stephenson than the mock useful-knowledge-schooling of Dr. Bell or the Prussians.

If not taught to write, George Stephenson was taught to be a good son, and an upright man; and thus in after-time to find in his own son a true helpmate, and one who fondly loved him. It is not likely that the lad felt any repining, but earnestly took up—what should be the lot in life of all—to work for his bread by the sweat of his brow. He never looked for anything else,—he had no yearning for idleness, and his mind never gave way under the burthen which was laid upon him in after-life. In common with his brothers he was early set to work to earn his share of the household food—so early, that his first earnings were only two-pence a day. He led the horse at the plough when almost too young to stride across the furrow;[2] riding him to his work betimes in the morning, when many children were still asleep, and had not begun their boyish play.

So lowly were his first endeavours, that they were given to the ploughshare or the coal-heap. Sometimes he wrought at picking bats and dross from the coal; and he was so young, and so young-looking, that he had often to hide himself when the overseer went round, lest he should be thought too little to earn his small living.[3] From twopence a day he rose to fourpence, and at length to sixpence a day,—as great a rise, and perhaps as fraught with brightest hopes and swelling pride, as when in after-years his locomotives moved from miles to scores, and when the maker of a short tramway became the undertaker of iron roads between London and the millions of the north, and kings and statesmen smiled on the wonders he had wrought.

In his boyhood he was most marked among the playmates of the hamlet as foremost in their sports and pastimes,—and indeed we need not wish for more. His mind was not tasked beyond its strength, nor made to yield unripe fruit. The healthy growth of his body enabled him to work out whatever his powerful mind spurred him to do; and for twenty years of his life (from forty to sixty), he never flagged in tasks which the unbroken strength of youth can seldom master.

It is said that he early showed a mechanical turn, and that he mended the clocks and watches of the pitmen, and even made their shoes,[4] to eke out his boyish earnings; but it seems more likely that the watch and clock mending belonged to a later time of his life, for had he shown such a happy knowledge, it is hardly likely that his skill should have been so little thought of, as until his manhood it seems to have been.

Shortly after he had come into his teens, he worked as breaksman for Waterrow pit, on the tramway between Wylam and Newburn. By this time his father had moved from Wylam to Walbottle. The lad now set up his first servant, which was no other than a great dog, whom he taught to bring his dinner daily from Walbottle colliery to the tramway.[5]

He is said even at this time to have helped in keeping his father and mother,[6]—a homely deed, but one of which he had a greater right to be proud than of any engineering undertaking. A right English feeling in his love of kindred was always lively in his mind, and it showed itself in his fondness for his father, his son, and the children of his brothers, and in every deed of his life. While earnest to make his own way, he was no less so that those about him should get forward—nay, if it might be, even before him; and while his mind was still unbroken, he left his son to carry out alone the great works in which they had begun together.

II. KILLINGWORTH.

The Stephensons went to Willington and Killingworth, at which latter is a colliery belonging to Lord Ravensworth and his partners. Young George was now put to be stoker to a colliery engine, at one shilling a-day, and as he himself told—"In my younger days I worked at an engine in a coal-pit. I had then to work early and late, often rising to my labour at one and two o'clock in the morning."[7] It was at Killingworth, however, that his lot in the world was settled, for there he made his beginning as an engineer.

As his strength grew so did his work, and he went on until he became an engineman at 12*s.* a-week. This was a great step, as he never forgot, for some months ago being at Newcastle, he sent for an old fellow-workman to dine with him at the Queen's-Head hotel, and talk over old times.—"Do you remember, George," asked his friend after dinner, "when you got your wages raised?" "Well," said Stephenson, "what about that?" "You came out

1 Derby Reporter, August, 1848.

2 Derby Reporter.
3 Derbyshire Courier, August 19, 1848.
4 Leicestershire Mercury.
5 Gateshead Observer, August 19, 1848.
6 Derbyshire Courier.
7 Speech at Newcastle, June 18, 1844.

of the office all smiles, and told us you'd got your wages raised to 12s. a-week, and you were a man for life. Now, you would find it hard to tell what you have a-week." "Yes," answered he, laughing, "I dare say I should."[8]

It was, however, a great step, for it had a share in his teaching. He was at home with the steam-engine, and with his searching mind he was storing up that knowledge which was to be most useful to him. It was a good working-school for a great engineer—as good as Brindley's in a mill, or Watt's in his workshop at Glasgow. His mind was awakened: he did not stand listlessly by to feed the fires,—but the engine lay before him as a book wherein to read its workings, to master its powers, to know its weaknesses, to task its cunning. There is something in the steam-engine which is a spell and a charm to the beholder,—something more and something else than the love of the sailor for his ship; such as the weaver feels not at his loom, nor the smith before his anvil. The smith or the weaver is the maker—the hammer or the shuttle works as his hand lists; but the steam-engine stands as with life and breath within it—working of itself, earnestly, steadily, and manfully; by day and by night, in its youth and in its elder years, when scores of men who wrought with it have sickened and breathed their last. To the working-man it is a thing of care and love, and its sight seems to give might to those who behold it, and to teach them the cunning which is in its own make. Thus, boys who watched strengthened it with cords and rods of iron;—thus, a toy in the hands of Watt, it claimed his life for its care, and grew to unwonted growth;—thus, time after time, have master and workman nursed its childhood, and helped it onwards to its mightiest strength—and Stephenson has not been among the least of these. The weaver does not better the loom; but day-by-day some lowly workman gives his small meed of help to the steam-engine.

The next step that we know of in Stephenson's onward path was his getting seventeen shillings a-week.[9] Whether this was at Willington or Killingworth is not settled; but soon afterwards he was at Killingworth, with a shilling a-week more, and sometimes putting to his slender earnings a little for his over-time or for piece-work.

He had now grown up to manhood, and to a good name among his neighbours, being, as those who now live remember, a hard-working and upright man, having the trust of his masters and of his fellow workmen.

One of the first deeds in which he is said to have shown his skill was at Killingworth. The sheaves over which the ropes work at the pit were much fretted as they were then made, and the ropes wore quickly away. Indeed, the ropes which elsewhere lasted three months, wore out at that pit in a month. This was a heavy outlay to the owners, and much trouble to the work-people. Many ways were tried, but fruitlessly; and at length they gave up all hope of a cure. Seeing the evil was great, Stephenson gave his mind to find out whence it arose; and having done so, he set to work and put the sheaves to rights, so that a rope was saved in two or three months.[10]

By this time he began to feel his own worth, and to yearn after something better than his then way of living; but he thought that to better his means, no other way was so good as to learn more, and fit himself for higher tasks. He had it in hand moreover to go to New England, whither the stream of settlers did not flow so fast as it does now, and where therefore greater hopes were held out to the skilful workman who chose to leave the Old World so far behind. In the beginning of this age, it was a greater task to go to America than it now is to go to New Zealand; and it shows young Stephenson's boldness that he undertook it. Nevertheless, it is not likely that it was his own thought, but that of one of the two men who were to be his fellows in the undertaking. One of these, named Wood, gave Stephenson a knowledge of writing and of numbers, which it therefore seems he did not learn until his manhood. It was the wish of Wood and Stephenson to try their hands in the New World at mechanics and farming, for which latter he had at all times a love.[11] If we remember that in those days the trip to America was costly, and that no one could go free, we may see that Stephenson must have had some thrift, when he was able from his slight earnings to save wealth enough for such a task. It shows, too, that he was not given to drinking or to waste, but had steered free of that shoal on which too many working-men are wrecked—the pot-house, in which their wages are swallowed up, their minds blasted, and their health worn out. We know, indeed, there were few evenings of George Stephenson's early life which were idly spent. First, he was kept late at his engine; afterwards his nights were spent in learning; by-and-by in earning the means for his son's schooling, and afterwards in working and learning by his side.

Beyond the prompting of Wood or his other mate, there was much in the times to work upon the mind of any thoughtful man in the lower walks of life. In 1800, a fearful dearth spread throughout Europe, and the want of bread was sorely felt among us. The war, too, had full sway—wages were low, food dear, and what was worse, the lot of the working-man was cast under the bitterest thraldom which ever befell Englishmen. George Stephenson, in common with every poor and friendless man in every hamlet throughout the land, might have been torn from his home and kindred at any hour by a press-gang; hurried off to sea, and kept in bondage, as many good tradesmen now in London have been, for ten long years or more without setting foot on English ground. He was open to the lot of the militia and the local militia, and could only find some one in his stead at a very great outlay. In many townships, wages were made up by the parish-board, and the hard-working man was made a beggar against his will. Such was the lot of the working-man, were he even husband or father: his life was not his own; his freedom hung by a thread, at the breath and will of others. George Stephenson, too, might have been pressed, as others were. These were the good old times—gone, it is to be hoped, never to come again; now almost forgotten, and even when read here it will hardly be believed that in boasting England such things were.

It could hardly be otherwise than that the manly English mind of George Stephenson should spurn the lot in which he seemed to be cast, and yearn for the freedom which was held out to him among our brethren on the other side of the great sea; and had he gone, we should have lost him as we have so many other men of great mind—lost to England, and gone to swell the wealth and fame of America, and keep up the race of life against us. Those who know our best working-men, are well aware how wistfully they look to those lands where they can share in the birthright of their fathers, and how often they give up a good livelihood at home for the love of that freedom which is withheld from them in England by the working of the laws. Irishmen go to Canada or New Brunswick; but the Englishman who leaves home, goes not to our settlements, but to the United States—for he seeks more than bread. If, too, a man of quick mind, he is not shut out by burthensome patent-laws from reaping the fruits of his skill; and the best wealth he takes with him is often some bright thought, which ripens in the new land he has chosen. We may follow in our mind's eye George Stephenson across the seas, and behold him building at Philadelphia the engines and railways of which he has here made us proud. These are things little thought of—but still worth thinking about, for they come home to the bosom of every free-minded working-man among us.

It was unwillingly, and with sorrow, Stephenson thought of leaving his kindred and his best beloved, his homestead and the land of his birth, of his boyish games and of his early manhood. It went against his heart; but he felt upon him the strong call to free himself from the thraldom which beset him round. Thus he told afterwards to one who knew him: he said, "You know the road from my house at Killingworth to such a spot.—When I left home and came down that road, I wept, for I knew not where my lot would be cast."[12] How bitter must have been the thought to one who felt so deeply.

It was not, however, to be so—we were not to lose him. While his lot hung by a thread, and day by day the time for leaving drew nearer, he had every morning as he went to his work to pass a newly-sunk pit, whence they were endeavouring to draw the water; and time after time did he see the pit overseers and engineers striving bootlessly to get through their work. In one of his walks he stopped to look, and could not help saying to some of those around, that if they would let him, he could, to use his own words, "set them to the bottom." He was at first laughed at, but at length they left him to have his way; and he went through with it so as fully to answer to what he had held forth.[13]

This gave him a name among the neighbours as a skilful man; and he was no less happy with an engine which had been put up to pump water at a pit, but would not do its work, for it could not be made to pump. As is said at all such times, the skill of the whole neighbourhood was overcome, and Stephenson came in as the last doctor, to make the cure, and make it more wonderful. He said he could make the engines pump in a few hours; and though not believed, he did so, to the delight of the overseers.[14] Whether this was the same work as that already named we cannot say, for by some it is told as two things. One writer[15] says it was a large

8 Gateshead Observer. 9 Derbyshire Courier.
10 Derby Reporter—Derbyshire Courier. 11 Derby Reporter.
12 Derby Reporter. 13 Derbyshire Courier.
14 Derbyshire Courier—Derby Reporter. 15 Gateshead Observer.

condensing-engine, made to draw water from the pit, and which had gone wrong. After several fruitless trials to mend it, Stephenson had the rashness to undertake the job, which he did fully —and moreover made some improvements in the engine. Stephenson himself said[16] that he had made some improvements in engine work. This, however, is sure—that he had got the trust of the pit-owners; and, having a better hope of livelihood, he gave up the thought of settlement abroad, and made Killingworth his home for some time.

When he was twenty-two years old, he wedded a young woman of the neighbourhood; and in 1803, his son Robert was born; but he had no other child. In the life of another man, the birth of a child would not be worth naming; but with his fatherly fondness, the child became the apple of his life, until he grew up to be his fellow-workman, to earn a great name, and to hold that standing among the mighty of the land which the father would not take. All went so happily with George Stephenson, that everything seemed to fit him. He was able to give his only son that breeding and that schooling, which, if he had had many children, would perhaps have been beyond his reach—though it is hard to spell what never happened. This, however, we may say—that Robert Stephenson owes his greatness to the unshared care of his father, who shaped his mind from earliest years to the full strength of manhood. Paintings have been drawn of the fondness felt by a mother in watching the growth of an only son; but there is something dearer in the father, like George Stephenson, who, in the son of his youth, not only sees, but shares, in the growth of a great and manly mind. The mother can but be as a looker-on, and cannot feel his deeds to the full; but the father, while watching with the eye of a master, takes share and part in the toil. To few men this happens; for, in the common way of things, a man weds late in life, and the son comes upon the world only as the father is leaving it, and before the strength of manhood has ripened to its full.

The engineman had now become a stripling engineer, and began to look out for a wider field. He seems to have tried his hand on most kinds of colliery work. It is said that he laid down some tramways, or wagon-ways as they are named in the north, and made some improvements in them.[17]

He was now getting a good name among the neighbouring land and coal owners, and had got on the high-road to engineering. Instead of being pinned to the stake, as a workman by the day or week, it was open to him to rise as others had done around him, and to make his way as a mining engineer. The colliery school was a better one for breeding great engineers than even that of Cornwall; for it had all that Cornwall had, and more too. The Cornishman could learn the steam-engine, pump-work, and mine surveying; he saw enough of sinking, and driving, and draining. The Northumbrian, however, while he had all these to learn by, having a greater bulk to move, had to look more to the roads and ways on which so many thousand chaldrons were borne to the ship-side. Hence, in Northumberland, many men had turned their skill towards the roads and wagon-ways, to the rails and sleepers, and to the works and bridges by which they were borne over the rivers and hollows. Both had the same school in the works of the millwright and the iron-founder, but the Northumbrian was better off; because, instead of the outaway, small towns of Truro, Redruth, and Camborne, he had near him Newcastle, on the high road from London to Scotland; and having its booksellers, schools, and men of learning. He was much nearer to the world than his Cornish brother, truly at the Land's-End. The north, therefore, has given us more civil engineers than the west, though the latter has its Trevithick and its Woolf.

By Lord Ravensworth, and others, Stephenson was employed in putting up steam-engines, and sloping planes under-ground; and in one pit, two or three engines were made to do the work of nearly 100 horses.[18]

We have seen that Stephenson had a love of knowledge, by what he had learned with Wood; and we know that he must have schooled himself much at this time, from what he soon afterwards did. It is true, he was not fond of reading, but he always liked to know everything thoroughly; and he did not leave out anything whereby what he undertook could be well done. It was always his wish to go to the ground-work, and to build steadily up; and he had a great dislike for those engineers who undertake anything carelessly or rashly. As he himself said,[19] he had too "frequently noticed the miscalculations of hundreds of engineers, for want of studying the laws of mechanics, and knowing that a pound could only weigh a pound." It was on that sound knowledge that his trust in himself in after-life was built, and that he was able fearlessly to stand up before the House of Commons and the people, in his great struggle for the locomotive against the lights of the day.

III. THE LOCOMOTIVE.

Stephenson was now getting beyond his thirtieth year, his mind strengthened by knowledge, and by the trust that what he might do would reap its full reward. His child was growing up to boyhood, while his earnings were still so slender that he could do but little for his schooling. He had at this time felt bitterly his own want of learning, and he made up his mind that he would put his son to a good school, and give him good breeding. "I was, however," said he afterwards at a meeting at Newcastle,[20] "a poor man; and how do you think I did?—I betook myself to mending my neighbours' clocks and watches at night, after my day's work was done; and thus I got the means of bringing up my son." This he might well say with boasting, for it is one of the bright lights in his life.

The great draught of coal on the tramways, and the heavy trains which went forth from the pits, had set the minds of many at work to use steam instead of horses to draw the loads. The stationary engine worked well on the incline, but the steam-horse was called for to run throughout from the pit's-mouth to the ship's-side. In 1758 or 1759, Dr. Robison, then a young man, had hinted to Watt to put steam to work wheel-carriages.[21] Watt, however, had other things on his mind, though he named it in his patents of 1769 and 1784; but as Watt had a dislike for high-pressure steam, that may be one cause why he never made a locomotive.[22]

About 1763, John Theophilus Cugnot, a Lorrainer, showed a model of a steam-carriage to the Count de Saxe. He afterwards went to Paris, and got the help of the Duke de Choiseul. In 1769 he built an engine at the cost of the king, and it was tried in 1770. It moved with such strength, that it knocked down part of a wall which stood in its way; therefore some thought that the power was too strong to be kept within bounds, and not fit for common use.[23] It is said the engine was given up and put in the Arsenal Museum, and is now kept in the Conservatoire des Arts et Métiers. It would be worth while for any engineer who may be in Paris to look after it.

In 1782 or 1792, Murdoch made a model of a steam-carriage at Redruth. This was perhaps the beginning of Trevithick's, who is said to have been brought up under Murdoch, and who knew him well.

In 1786, Oliver Evans laid a plan for steam-wagons before the commonwealths of Pennsylvania and Maryland, and the latter gave him a privilege for fourteen years—yet he was never able to get money enough to build a wagon. All that he did was in 1804 to put wheels on a steam dredging-machine he had made for cleansing docks, and which he made to move slowly, though in a cumbersome way.[24]

On March 24, 1802, Trevithick and Andrew Vivian took out a patent,[25] which among other things was for the use of high-pressure steam for carriages, and by which the weight of the engine was brought very low. A carriage was made and run in Cornwall, and afterwards in London. Another was made in 1804 in South Wales, which was worked on the Merthyr Tydvil Railway, and "drew after it as many carriages as carried ten tons of bar-iron, from a distance of nine miles, which it performed without any supply of water to that contained in the boiler at the time of setting out; travelling at the rate of five miles an hour."[26] The engine had an eight-inch cylinder, and the piston a four-feet six-inches stroke.[27]

These engines fell into dislike, from the one on the Merthyr Tydvil railway blowing up,[28] having been made (against Trevithick's orders) without a safety-valve, and likewise from the wrong belief which got about that the wheels had no bite on the rails, and could not work up a slope.[29]

One of Trevithick's engines was sent, singularly enough, to George Stephenson's birth-place, to Mr. Blackett, of Wylam; and thus it came within his sight. This happened most strangely, and most luckily, for the mind of Stephenson was now brought to bear on the great work of his life. The finding of Trevithick's model by Uvillé was strange, and most fruitful in the deeds it brought about; but perhaps we owe more to the Wylam engine. On some ground or other, the engine does not seem to have been put to work on the tramway, but was used to blow a cupola in an iron-foundry at Newcastle.[31] This engine had one cylinder only, and a

16 Trent Valley Meeting.
17 Gateshead Observer.
18 Derby Reporter.
19 Trent Valley Opening.

20 Newcastle and Darlington Opening.
21 Robison's Mechanical Philosophy.
22 Penny Cyclopædia.—Art. "Steam-Carriage."
23 Stuart's "Steam-Engine."
24 Mechanics' Magazine, No. 372.
25 Repertory of Arts, 2nd ser., vol. iv., p. 241.
26 Wood on Railroads, 1st edition, p. 127.
27 Stuart's Steam-Engine, p. 460.
28 Railway Register, vol. v.
29 Lardner on the Steam-Engine, 1840, p. 336.
30 Stuart's Anecdotes of the Steam-Engine.—Civil Engineer's Journal, "Life of Trevithick."—Railway Register, vol. v.
31 Wood on Railroads, 1st, 2nd, and 3rd edition,—2nd edition, p. 129.

fly-wheel to secure a rotatory motion in the crank at the end of each stroke. If Mr. Blackett did not however work this engine, he had another of the same kind made and set upon his tramway at Wylam; and in 1813 it worked by the adhesion of its wheels on the rails, thus upsetting the belief that the engine could not so work.

On the 30th December, 1812, William and Edward Chapman took out a patent for an engine, with additional wheels to work upon a chain stretched along the middle of the railway the whole length. This engine was tried on the Heaton tramway, near Newcastle, but given up.

On the 22nd May, 1813, William Brunton, of Butterley, took out a patent for a locomotive with legs. This was tried and worked. In 1811, Mr. Blenkinsop had hit upon the plan of having a cog-wheel and cog-rail to overcome the adhesion.

At this time, Mr. Blackett was fully at work experimenting on the Wylam railway with an ill-made engine of Trevithick's, which was found to be very troublesome, as the irregular action of the single cylinder made jerks in the machinery, so as to shake it in pieces. Still, the whole of the coals were taken down the tramway by this kind of engine.[32]

By this time George Stephenson was likewise at work; and Lord Ravensworth and the Killingworth owners had such trust in him, that they gave him the money to make an engine in the opening of 1814, and on the 25th or 27th July, 1814,[33] it was tried on the tramway. As Stephenson said Lord Ravensworth and his partners were the first to intrust him with money to make a locomotive engine, "We called it *My Lord*. I said to my friends, there is no bound to the speed of such an engine, if the works can be made to stand it."[34]

The engine had two cylinders, each eight inches diameter and two feet stroke; the boiler was cylindrical, eight feet long and thirty-four inches diameter; the tube twenty inches diameter, passing through the boiler. The cylinders worked two pairs of wheels by cranks placed at right angles, so that when the one was in full operation, the other was at its dead points,—by which means the propelling power was always in action. The cranks were held in this position by an endless chain, which passed round two cogged wheels placed under the engine, and which were fixed on the same axles on which the wheels were placed. The wheels in this case were fixed on the axles and turned with them.[35]

The trial was made on a piece of road laid with the edge-rail, rising about one in four hundred and forty, and was found to drag after it, besides its own weight, eight laden wagons, weighing altogether about thirty tons, at the rate of four miles; and after that time it kept steadily at work. The application of the two cylinders made the working of the engine regular, and secured the steady progressive motion which was wanted in the Wylam engine, there being only the single cylinder and fly-wheel.[36]

It was not till the next year that Stephenson took out a patent for his locomotive, and here we find the bad working of the patent laws as bearing upon our poor workmen. Had it not been that his first engine was not perfect, he could have had no patent, and would have reaped no fruit from his days and nights of toil, as he could not raise the money to pay the heavy fees which are drawn from the patentee. Even for his first trial he wanted money, and for which he was beholden to the kindly feeling of Lord Ravensworth: much happier than Oliver Evans, who fruitlessly sought in America and England for the means wherewith to start his steam-wagon.

Here we may rest for a time, and think a little as to what led Stephenson on in the world. No man could be worse off for money or means: he had no powerful kinsmen, no wealth left him by a father; his earnings were barely enough for the wants of himself and his son; his standing was lowly; he had no rich schoolfellows or friends who had known him from childhood. Within twenty years from this time he had, however, got together houses and land, and at his death left behind him wealth which he never durst have hoped for. Brindley was not so happy in the end, neither was Trevithick, nor Dodd. Watt began in a small shop—but he belonged to the middle classes, and had not the hard task of working himself up from the lowest depths of life. If, however, he gathered riches, he owed it to the fostering care of Boulton, without whom he would have spent his income in undertakings which had not within them the seeds of wealth, whatever else could be said for them. He would have made the finest machinery for copying statuary; he would have tried to the utmost cures for illnesses of the lungs by breathing gases,—but he would have died worth not one halfpenny.

Fulton wandered through the Old World and the New, begging kings and commonwealths to give him the means of building steam-ships. We have seen that the utmost luck of Oliver Evans with his steam-wagon was to get rights which were of no use to him, and to turn the wheels of a ballast-engine. Dodd, after planning two of the greatest bridges on the Thames, and spending thousands in bringing steamboats into use, died unhappily.

Trevithick, after trying one thing after another, and finding friend after friend to help him, did, two years after Stephenson's beginning at Killingworth, leave England for the West Indies; whence he did not come back, and that penniless, until Stephenson had laid down the Stockton and Darlington Railway. Trevithick was taken up by Mr. Blackett, a bold and daring man, and sent a locomotive to Wylam, which, like most things in which he had a hand, was so wretchedly made that it was put to other uses. Mr. Blackett made another, and Stephenson had it as a model to shape something better. Trevithick began better than Stephenson: he had friends in Cornwall and in London; and he ought not to have left to Stephenson to work out the locomotive engine and the railway. Trevithick was always unhappy and always unlucky; always beginning something new, and never ending what he had in hand. The world ever went wrong with him, as he said,—but in truth, he always went wrong with the world. The world had done enough for him, had he known or had he chosen to make a right use of any one thing. He found a partner for his high-pressure engine,—he built a locomotive,—he had orders for others for Merthyr Tydvil and for Wylam,—he set his ballast-engine to work,—and he drove his tunnel under the Thames for a thousand feet;—but no one thing did well: all were afraid, and at length no one would have anything to do with him. It was not that his mind was more fruitful than that of Stephenson, who in this short time had made improvements in pit-work and railways, built a locomotive, and found out the safety-lamp, and who throughout his life was ever working out something new. What it was, was this—Stephenson never lost a friend, and Trevithick never kept one. To the day of his death, Stephenson had among his friends those who had given him a helping hand in early life; and from year to year he went on strengthening the bonds of friendship with them and their sons, and the younger men who grew up around him. The Ravensworths, the Peases, the Brandreths, Matthew Bell, the Meynells, and others of his earlier friends, will be found with him throughout, standing by him as directors in his great railway undertakings, as they had befriended him in his small beginnings. This was a great strength to him, and though poor he had a mine of wealth in the purses of his friends. A manly and upright Englishman, open in speech, steady, straight-forward, and hard-working, he earned their friendship and never lost their trust; and if to others he was known as a great engineer, to them he was better known as an upright man. This made the poor working-man the rich manufacturer and great mine-owner. This gave him the means of doing what Trevithick and Evans could only talk of.

(To be continued.)

WROUGHT-IRON BOWSTRING GIRDERS FOR BRIDGES.

Some experiments have been lately made at the establishment of Messrs. Fox, Henderson, and Co., at Smethwick, near Birmingham, on a wrought-iron Bowstring Tubular Girder Bridge, of a similar construction to the one designed by Mr. Harrison, and given in our *Journal* in January last.

The experiments were made on a wrought-iron rib or girder, 120 feet clear span, in the presence of the Government Inspectors of Railways, and Government Board of Commissioners for inquiring into the Strength of Iron. The girder is constructed entirely of wrought-iron, and consists of an arch of boiler-plates and angle-iron, tied across at the ends by horizontal bars; and the tie-bars are connected with the arch by vertical standards, and by a double system of diagonals, which have the effect of distributing over the whole curve of the arch the action of weights placed on, or pass-

32 Wood on Railroads, 2nd edition, p. 184.

33 Wood on Railroads, 2nd edition, pages 134 and 136, where different dates are given. In the report of Stephenson's speech at Newcastle in 1844, he is made to say that the date was 32 years before, which would be in 1812. This is a mistake.

34 Speech at the Newcastle and Darlington Opening.

35 Lardner on the Steam-Engine, p. 340.

36 Wood on Railroads, 2nd edition, p. 136.

ing over, any point of the bridge. The proof was applied by loading the bridge rib with 240 tons of rails, bars, &c.; and it produced the following satisfactory results, as the weight was applied:—

Weight in tons of rails, &c., placed on the cross-girders.	Extreme amount of deflection produced at centre of arch
34¼ tons	0 1-16th inches.
69½ „	0 5-8ths „
102¾ „	1 5-16ths „
137 „	2 1 8th „
171¼ „	2 3 4ths „
205½ „	3 5-16ths „
240 „	3 11-16ths „

The proof weight was fixed at 240 tons, as being double the greatest load which the bridge can by any possibility be ever required to bear. A heavy goods' train weighs less than half a ton per foot lineal; a train, consisting entirely of locomotive engines (which would be heaviest of all possible trains) would only weigh one ton per foot lineal, and, consequently, would place a load of not more than 120 tons on a bridge of 120 feet span. The new bowstring bridge has, therefore, been proved to twice the weight which ever can be placed upon it, and to four times the weight which it is ever likely to have to bear. It is scarcely necessary to add, that the trial gave great satisfaction to all parties. These ribs are adapted for large spans, in cases where either headway is of importance, or where sufficient abutment cannot be obtained without very heavy expense. Bridges constructed of these ribs may be employed with perfect safety for very large spans, in precisely the same manner as ordinary girders are used for small ones. The strength of the bridge depends upon the rib or arch, and on the tie-bars by which the extremities are held together. The vertical standards are introduced, partly to suspend the load from the arch, and partly to obtain longitudinal and transverse firmness; they also support the tie-bars. The diagonals are employed for the purpose of preventing undue deflection in the rib, when the bridge is unequally loaded. The rib itself is constructed of boiler-plates and angle-iron, rivetted up in the form of a square hollow trunk; it is strongly tied together, so that the full section of the plates and angle-iron may be depended upon to resist the crushing strain. In order to give this trunk additional lateral stiffness, the side-plates, which form the top, overhang, and are strengthened on the edges by angle-iron, &c. The tie-bars measure about 8 inches, by 1 inch each, and are introduced in sufficient number to take the whole strain. The ribs are supported at each end on cast-iron shoes, fixed at one end to the piers, and mounted at the other on sliding-frames and rollers. This arrangement provides, not only for expansion and contraction, but also for motion under a very heavy load. The action of these parts under proof has been found to be perfect. Cross-girders, constructed entirely of wrought-iron, are suspended between the ribs.

Besides the above experiments on the Blackwall Extension bridge, the two ribs for a bridge, 130 feet span, have been proved with a weight of 260 tons—that is, 2 tons per foot lineal each, put on in dead weight, by suspending cast-iron cross-girders underneath the points where the wrought-iron girders are intended to be attached, and by placing thereon 260 tons of rails, pigs, bars, &c. In proving, the load was first put on two points at one end, then on the next two points, and so on, in order to produce as nearly as possible the same effect as the passage of a heavily-loaded train. In the case of one rib, the load was allowed to remain several days, and then removed. After the lapse of a few days, the same load was replaced, and again allowed to remain some days. The results were satisfactory.

During the process of proving, observations were taken with a level, placed at a distance; and the sinking of the bearing-plates in the ground was observed and noted. The bridges being now constructed, are intended to carry a double line of rails; and the test applied is, therefore, equal to 2 tons to each foot lineal of single line of way. This test was fixed upon in the belief that the greatest possible load which can in working be placed upon each line of rails is about 1 ton per foot lineal; and that, to provide for the additional strain caused by the rapid motion, &c., of the practical load of trains passing, the proof weight ought to be fixed at double the greatest possible load. In very large spans, (say 400 feet, and upwards), it would be necessary, on many accounts, to use four ribs, instead of two, and to brace all the four ribs together overhead, so as to obtain additional transverse stiffness.

We understand that several girder-bridges of the above construction are to be erected on the Blackwall Extension Railway, under the superintendence of Joseph Locke, Esq.

DRAINING MARSHES BY STEAM.

The following paper, "*On the application of Steam-power to the Drainage of Marshes and Fen Lands*," was read at the recent meeting of the British Association, by Mr. Glyn.

The number of districts in which I have successfully applied the steam-engine to drainage is fifteen, and the quantity of land so drained amounts to more than 125,000 acres; the engines employed being 17 in number, and their aggregate power 870 horses, the size of the engines varying from 20 to 80 horse-power. I was also engaged in draining the Hammerbruk District, close by the city of Hamburg; and in another district near to Rotterdam, an engine and machinery with the requisite buildings were erected from my plans by the Chevalier Conrad. In many of the swampy levels of Lincolnshire and Cambridgeshire much had been done to carry off the water by natural means; and many large cuts had been made and embankments formed—especially in the Bedford-level, which alone contains about 300,000 acres of fen land; and the great level of the Fens contains about 680,000 acres, now rich in corn and cattle. The Dutch engineers who had been engaged in these works had erected a number of windmills to throw off the water when the sluices could not carry it away. By the aid of these machines the land was so far reclaimed as to be brought into pasture and cultivation, producing occasional crops of wheat. The waters from the uplands and higher levels were intercepted by catch-water drains, which carried away as far as might be practicable the highland waters, and prevented them from running down upon the fen; but as it often happened, when there was most rain there was least wind, and the wind-engines were useless when their help was most needed, and the crops were lost.

In this state was the fen country when the steam-engine was introduced; and by its aid the farmer may venture to sow wheat upon these rich levels with as much confidence and even more than upon higher ground; for not only can he throw off at pleasure the superfluous water, but in dry weather a supply can be admitted from the rivers—so that farming in such cases is rendered less precarious than in situations originally more favoured by nature. It is, however, to be remarked that the quantity of rain which falls in these levels on the eastern side of England being much below the general average of the kingdom, the power required to throw off the superfluous water is small compared with the breadth of land to be drained; the proportion seldom being greater than 10-horse power to 1,000 acres, and in some cases considerably less.

The general plan is to carry away the water coming off the higher grounds, and as far as may be practicable prevent it from running down into the marsh by means of the catch-water drains before-mentioned, leaving the rain water alone to be dealt with by mechanical power. As the quantity of rain falling in the great level of the Fens seldom exceeds twenty-six inches, and about two-thirds of this quantity is carried off by evaporation and absorption, or the growth of plants, it is only in extreme cases that two inches in depth require to be thrown off by the engines in any one month—which amounts to 1½ cubic foot upon every square yard of land, or 7,260 cubic feet to the acre. The standard and accepted measure of a horse's power is 33,000 lb. raised one foot in a minute, or 3,300 lb. raised ten feet in the same time; and as a cubic foot of water weighs 62½ lb. and a gallon of water 10 lb., so a horse's power will raise and discharge at a height of ten feet 330 gallons, or 52·8 cubic feet of water in a minute. Consequently this assumed excess of 7,260 cubic feet of water fallen upon an acre of land will be raised and discharged at an elevation of 10 feet in about two hours and ten minutes.

If the quantity of land be 1,000 acres of fen or marsh, with the upland waters all banked out, the excess of rain, according to the above estimate, will amount to 7,620,000 cubic feet. A steam-engine of 10-horse power will throw off this water in 232 hours, or in less than 20 days, working 12 hours a day; and I have found this calculation fully supported in practice.

Although the rain due to any given month may fall in a few days, yet in such a case the ground will absorb a good deal of it, and the drains must be made of a capacity large enough to receive and contain the rain as it falls;—besides, in cases of necessity, the engine may be made to work 20 hours a day instead of 12, until the danger is past. I have generally caused the main drains to be cut 7½ feet deep, and of width sufficient to give them the required capacity to receive the rain water as it falls and bring it down to the engine. In some instances—where the districts are extensive and their length great—it has been found requisite to make them somewhat deeper.

In all cases where I have found it necessary to use steam-power, I have applied scoop-wheels to raise the water. These scoop-wheels somewhat resemble the undershot-wheel of a water-mill; but instead of being turned by the impulse of the water, they are used to lift it, and are kept in motion by steam-power. The float-boards or ladle-boards of the wheels are made of wood, and fitted to work in a trough or track of masonry; and they are generally made 5 feet in length—that is to say, they are immersed 5 feet in the water—and their width or horizontal dimension varies, with the power of the engine and the head of water to be overcome, from 20 inches to 5 feet. The wheel-track at the lower end communicates with the main drain, and the higher end with the river, the water in the river being kept out by a pair of pointing doors, like the lock gates of a canal, which close when the engine ceases to work. The wheels themselves are made of cast-iron, formed in parts, for convenience of transport. The float-boats are connected with the cast-iron part of the wheel by means of oak starts, which are stepped into sockets cast in the circumference of the wheel to receive them. There are cast-iron toothed segments fitted to the wheel, into which works a pinion upon the crank-shaft of the engine.

When the head of water in the river or delivering drain does not vary much, it is sufficient to have one speed for the wheel; but when the tide rises in the river, it is desirable to have two speeds or powers of wheel-work—the one to be used at low-water, and the other more powerful combination to act against the rising tide. But, in most cases, it is not requisite to raise the water more than three or four feet higher than the surface of the land intended to be drained—and even that is only necessary when the rivers are full between their banks, from a continuance of wet weather or from upland floods. In some instances, the height of the water in the river being affected by the tide, the drainage by natural outfall can take place only during the ebb; and here, in case of long-continuing rains, the natural drainage requires the assistance of mechanical power.

I have stated that the main drains have generally been made 7½ feet deep, or more in larger districts—so that the water may never rise higher than within 18 inches or 2 feet of the surface of the ground, and the ladle or float-board dip 5 feet below the water, leaving a foot below the dip of the wheel, so that the water may run freely to it, and to allow for the casual obstruction of weeds in the main drain—which if it be sufficiently capacious and well-formed, will bring down the water to the engine with a descent of 3 inches in a mile. Suppose, then, that the wheel dip 5 feet below the surface of the water in the main drain, and that the water in the river into which this water must be raised and discharged has its level 5 feet above that in the drain, the wheel in such case will be said to have 10 feet head and dip, and ought to be made 28 or 30 feet in diameter. I have found it practicable to throw out the water against a head of 10 feet, with a dip of 5 feet,—that is to say, 15 feet head and dip with a wheel 35 feet in diameter; but in another engine more recently erected I have made the wheel 40 feet in diameter. The engine that drives that wheel is of 80-horse power, and is situated on the ten-mile bank near Littleport, in the Isle of Ely.

The largest quantity of water delivered by one engine is from Deeping Fen, near Spalding. This fen contains 25,000 acres, and is drained by two steam-engines—one of 80 and one of 60-horse power. The 80-horse engine has a wheel of 28 feet in diameter, with float-boards or ladles measuring 5½ by 5 feet, and moving with a mean velocity of 6 feet per second. So that the section of the stream, when the engine has its full dip, is 27½ feet, and the quantity discharged per second is 165 cubic feet—equal to more than 4½ tons of water in a second, or about 16,200 tons of water in an hour. It was in the year 1825 that these two engines were erected, and at that time the district was kept in a half-cultivated state by the help of 44 windmills—the land at times being wholly under water. It now grows excellent wheat—producing from 4 to 6 quarters to the acre. In many districts land has been purchased at from 10*l.* to 20*l.* an acre by persons who foresaw the consequences of these improvements, and which they could now sell at from 50*l.* to 70*l.* an acre. This increase in value has arisen not only from the land being cleared from the injurious effects of the water upon it, but from the improved system of cultivation which it has enabled the farmers to adopt.

The fen lands in Cambridgeshire and in part of the neighbouring counties are formed of a rich black earth, consisting of decomposed vegetable matter, generally from 6 to 10 feet thick, although in some places much thicker, resting upon a bed of blue gault, containing clay, lime, and sand. When steam-drainage was first introduced, it was the practice to pare the land and burn it; then to sow rape-seed, and to feed sheep upon the green crop; after which wheat was sown. The wheat grown upon this land had a long weak straw, easily bent and broken, carrying ears of corn of small size, and having but a weak and uncertain hold by its root in the black soil. Latterly, however, chemistry having thrown greater light upon the operations of agriculture, it has been the practice to sink pits, at regular distances, through the black earth, and to bring up the blue gault, which is spread upon the surface as a manure. The straw—by this means taking up an additional quantity of silex—becomes firm, strong, and not so tall as formerly, carrying larger and heavier corn; and the mixture of clay gives a better hold to the roots, rendering the crops less liable to be laid by the wind and rain; whilst the produce is most luxuriant and abundant.

REGISTER OF NEW PATENTS.

THE STEAM HAMMER.

James Nasmyth, and Holbrook Gaskell, of Manchester, engineers, for "*certain improvements in machinery or apparatus for forging, stamping, and cutting iron and other substances.*"—Granted February 23; Enrolled August 23, 1848.

This patent is for improvements in the steam-hammer, for which invention patents were granted to the same parties in 1842, 1843, and 1844. The principal object of these improvements is to regulate the action of the hammer with greater facility, by working the lifting-cylinder by means of an additional small steam-cylinder. The general arrangement of the primary parts remain very similar to the hammers now in general use. As is well-understood, the hammer is lifted by admitting the steam below the piston in the cylinder, and, by allowing the steam to escape, the hammer, by its own gravity, falls and gives the required blow. In the present invention, the force of the blow is regulated more conveniently than before. For this purpose, there is a small steam-cylinder for working the main slide-valve. This cylinder is fitted with a piston, connected by means of a rod to the main slide, to which the steam is admitted from the boiler. The small cylinder is furnished with three steam-passages similar to ordinary high-pressure engines, admitting steam alternately above and below the piston, and regulated by the slide-valve. This valve is connected by a rod to the piston of another cylinder, which is subject to the pressure of the steam from the main cylinder on the under-side, and is depressed by steam entering from a tube communicating with the valve-jackets of the slides. Steam having been admitted to the working-cylinder, the piston is elevated, and to regulate the height of the fall, a cock or valve is opened, communicating with an opening in the cylinder. This permits a rush of steam to flow into a pipe, which conveys it thence below the piston, raising it by the pressure of the steam on the under surface. The effect of this movement is to produce the requisite change in the position of the valve, so as to suffer the steam which entered the small cylinder above the piston, to escape into the atmosphere; and by the entrance of steam below the piston, it elevates the valve, so as to cover the steam-passage to the cylinder and the eduction-port, thereby suffering the steam to escape from the main cylinder; consequently the hammer, by its own gravity, will fall from the height to which it has been raised. There are three passages, each furnished with a valve or stop-cock, the levers of which are connected by rods to hand-levers, by which they may be opened or shut at pleasure; therefore, if the hammer is not required to fall from a height greater than the first opening, the valve connected therewith must be closed and the one above it opened, when the same action will be produced whenever the piston is elevated above such opening by the escape of steam. Two other methods of regulating the action of the hammer are shown in the specification, but the one we have noticed is sufficient to show the nature of the invention.

The patentees claim:—First, the application and use of an additional slide-valve, piston, and cylinders, or any of these parts separately, for the purpose of working the piston of the larger cylinder, and thereby actuating the main slide, so as to produce the alternate admission and escape of steam to and from the main cylinder.—Secondly, the employment of apertures in the main cylinder, for the purpose of working the piston and main slide, thereby effecting the motion of the hammer and regulating the various heights to which is raised.—Thirdly, the use of a vessel, with its plug or cock, so as to regulate the interval of time required for the falling of the hammer from the various heights to which it is elevated.—Fourthly, the application of a valve, placed in the eduction-port of the main cylinder, for actuating the valve, so as to effect the required change of the piston, and with it the main slide-valve, thereby actuating the hammer, and also for the purpose of obtaining the lapse of the required interval of time for the fall of the hammer.—Fifthly, the application of a latch-lever motion to the moving of the small slide-valve in one direction.—Sixthly, the combination of the latch lever-motion with the arm, and other parts connected therewith, by which motion is also transmitted to the valve, in the reverse direction, instead of employing the small cylinder for that purpose.—Seventhly, the application of the screw, and parts connected therewith, for the purpose of regulating the height to which the hammer is elevated. —And, lastly, they claim the moving of the main slide-valve, direct from the piston, and also without the intervention of the main slide.

DECORATIVE ARTS.

Miss Elizabeth Wallace, of Laurel-lodge, Cheltenham, spinster, for "*Improvements in facing, figuring, designating, decorating, planning, and otherwise fitting up houses and buildings, parts of which are applicable to articles of furniture.*"—Granted February 28; Enrolled August 28, 1848.

The improvements in the decorative arts patented by Miss Wallace are divided in the specification into ten kinds, though the distinguishing feature in the invention is the production of the effects of marble, malachite, &c., by casting tablets of plaster of Paris on to glass, the glass or plaster being coloured or decorated to give the required effect. These tablets are intended to be applied both externally and internally, the internal decorations being of course more ornamental than the tablets used to imitate marble, &c., on the exteriors, and they are to be fixed to the walls by cement and long copper nails. Among other parts of the invention is a mode of producing the appearance of gold without employing any metal, and it is thus described:—"To make a flat tablet of this description, I take a plate of figured yellow glass (the nearer the colour of gold the better); to the back of this I attach a plate of plain yellow glass silvered; and I unite the two plates of glass by cementing them at the edges with gutta percha, or any other suitable cement. The result of the combination is, that the figured parts of the upper glass exhibit the appearance of deadened or frosted gold, with a groundwork of burnished gold, or *vice versâ*. Sometimes I substitute for the front plate of figured yellow glass, a plate of white glass, figured or ground (the whole of it, or parts only); and sometimes I also dispense with the second sheet of glass altogether, and apply the silvering at once to the back of the figured or ground front plate."

In another part of the specification is described the following process for giving additional brilliancy to painted glass:—"As regards stained, or painted, or other figured glass—I take a sheet of plain white glass, give it a coating of gum, then sprinkle over it a quantity of what are known in the glass trade by the name of 'frostings,' which are readily laid hold of by the gum; and the glass thus prepared I attach to the stained, or painted, or other figured glass on the inside, or that side which is next to the interior of the house or building, by means of gutta percha solution, or some other suitable cement, applied to the edges. The frostings have on the inside the effect of giving a beautiful lustre to all the lighter parts of the design on the stained, or painted, or other figured glass, without impairing in the least the strength of tone of the darker or coloured portions; while they impart to the glass, when viewed from the outside, much the same effect as if a flood of light were streaming through from within."

In all the other different modes proposed for decorating houses by the patentee, the plan of giving a glass surface is adopted so as to produce the effect of a most brilliant polish, and at the same time to serve as a protection against damp and atmospheric corrosion.

ECONOMY OF FUEL IN STEAM-FURNACES.

Felix Douche, of Rouen, France, merchant, for "*certain means, processes, and apparatus used for saving and applying the lost heat in general, and sometimes direct heat, to many useful purposes.*" (A communication.)—Granted February 10; Enrolled August 10, 1848.

This invention relates, first, to an improvement in the feeding apparatus for supplying the feed-water to steam-boilers, and is constructed as follows. A number of tubes or pipes are placed in a vertical position within a cylindrical vessel, the ends of the tubes being secured to two chambers, one at each of the ends of the tubes, the interior of the tubes forming a communication between the chambers, which have no communication with the exterior of the tubes; there are two communicating pipes from the cylindrical vessel, one at the top and the other at the bottom; there are also pipes of communication from the two chambers. The upper pipe of the cylindrical vessel communicates with the boiler, and the lower with the feed-pump; thus the supply of feed-water will pass through the cylindrical vessel amongst the tubes, and take up the heat given off by the waste steam, which is passed through the tubes and chambers for that purpose. The second improvement consists of a slight modification of the above, for the purpose of heating air by passing steam or fire through the tubes, the air being in contact with the exterior of the tubes; the patentee gives this apparatus the name of ærifor or caloridor. The third improvement relates to a stretching apparatus for stretching the tissues or fabrics as manufactured by machinery. The fourth improvement consists in allowing the waste steam to flow through a pipe into a large square receiver, where it is condensed. The fifth improvement consists in the application to external surfaces, for the purpose of retaining the heat therein, of envelopes or wrappers.

TURN-TABLES.

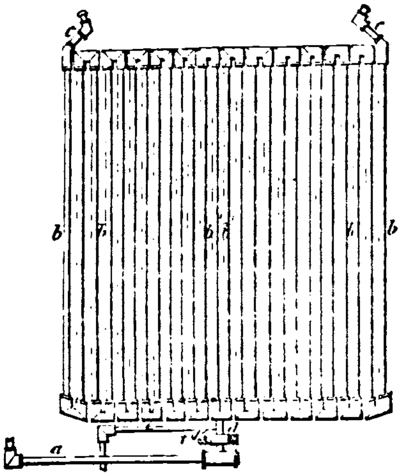
William Thorold, of Norwich, engineer, for "*Improvements in turn-tables.*"—Granted January 13; Enrolled July 13, 1848.

This specification is very voluminous, as the patentee claims eleven different improvements in the construction of turn-tables. The first relates to an improved centre-pin, which improvement consists in forming on it a projecting flange or collar, the upper surface of which is an incline or snail piece on which the centre of the table rests. The upper part of the pin has a ratchet-wheel attached, which is level with the surface of the table, and fitted with a click or pall attached to the table, which prevents it turning round without the table, while, at the same time, the ratchet and pin may be turned round by inserting a spanner in two holes in the upper side of the ratchet, the incline plane at the lower end raising the table when such elevation is required. Secondly, the patentee claims a mode of constructing the centre squares of the top frame, having the rails laid thereon, and independent of the other part of the frame-work. Thirdly, different modes of constructing and arranging the working rollers that form the support of the circumference of the turn-tables. Fourthly, a method of diverting the dust, rain, and all extraneous matters, and also for clearing away such extraneous matters from the circumference. Fifthly, a mode of constructing turn-tables without centre-pins, and, consequently, without the usual parts connected with centre-pins and other bearings. For this purpose he employs beams or girders of a stronger description than usual, for supporting the rails and platforms of tables of a corresponding size. These girders being attached at each end to the upper bearing-surface of the circumference, which is supported on rollers as usual from the under surface. The axes of these rollers instead of being attached to a separate frame revolving round the centre-pin, have their axes placed between two concentric belts or rings, which maintain the position of the rollers in a circle equal to the diameter of the bearing-surfaces. The under bearing-surface has its inner circumference rendered truly circular, and forms a surface on which horizontal guides or friction-rollers travel. These rollers are supported from axes pendent from the under-side of the table, and consequently maintain the position of the table concentric with the bearing-surfaces. The sixth improvement consists in a mode of constructing the top frame in several divisions or compartments, and of various kinds of material. The seventh claim is for the exclusive privilege of casting the bearings and all working parts of turn-tables on chills, the same never having been heretofore practised. Eighthly, the method of constructing single-line tables in such a manner as to render them more economical than such tables have hitherto been. Ninthly, the constructing larger kinds of turn-tables, with moveable joints in the beams or girders which support the rails; also for the more perfect mode of stopping such tables at the proper point for effecting a junction with the line of rails. Tenthly, a method of constructing the larger kinds of turn-tables, so that the power of a locomotive can be applied to the turning of such table when it is loaded with the engine and its tender, and when they require reversing on the line of rails. Lastly, the patentee claims a method of raising and locking the centre of turn-tables, when they require to be turned.

STEAM-BOILERS.

Horatio Black, of Nottingham, lace-maker, for "*improvements in evaporation.*"—Granted February 14; Enrolled August 14, 1848.

This invention relates to a mode of supplying water to steam and other boilers, by passing it through a succession of hollow fire-bars, of wrought-iron, brass, copper, or malleable cast-iron, previous to entering the boiler.



The annexed engraving is a plan of a set of fire-bars. *a* is the supply-pipe, through which the water is forced into the tubular fire-bars, *b b*: the water first enters the middle bars *b*' *b*', and, after circulating through the whole series of bars, passes, in a highly-heated state, through the pipes *c c*, into the boiler. It is not essential that the water should be divided into two streams, as the whole supply may enter into one bar, and circulate through the series of bars in the same direction; or more than two divisions of bars may be used in large furnaces. *d* is a cock on the supply-pipe, to regulate the quantity of water admitted. *e* is a pipe, furnished with a cock *f*, which is to be opened when the supply of water to the boiler is not going on; as otherwise the heat of the fire would tend to force the water out of the tubular bars; but by the cock *f* being opened sufficiently to permit the escape of a small quantity of water, such a circulation will be kept up as will prevent the water being driven out of the bars *b b*, when the supply of water to the boiler is stopped.

The above arrangement is suitable either for high or low pressure boilers; but, generally, for low-pressure, a rising pipe is attached, with a small cistern at the upper part, to the supply-pipe *a*, near the force-pump; and a valve is placed over the opening through which the water enters the cistern;—"the valve preventing the water from flowing from the cistern to the boiler, by the valve being weighted, causes a pressure sufficient to force the water into the pipe *a*, and thence through the hollow bars *b b*, into the boiler; the quantity admitted to the boiler being regulated by the cock on the pipe *a*." By means of this arrangement, the water, forced into the pipe *a*, will flow into the boiler so long as it is required; but any excess will pass up the rising-pipe into the cistern, which is provided with an overflow-pipe: the boiler will thus work, at all times, subject to the pressure of the column of water in the rising-pipe and cistern. It should be stated that there is a valve in the pipe *a*, between the rising-pipe and the force-pump; which valve opens towards the boiler, and permits the water to flow in that direction, but closes against any flow of water from the boiler.

REVERBERATORY FURNACES.

James Timmins Chance, and Edward Chance, of Birmingham, for "*Improvements in furnaces, and in the manufacture of glass.*" Granted February 14; Enrolled August 14, 1848.

This invention, as the title imports, relates to improvements in two distinct departments of the manufactures. The first, which refers to reverberatory furnaces, has for its object the greater economy of fuel, by re-conducting the heated gases to the furnace. In the usual construction of such furnaces, the heat from the fire, after striking against the arch above the furnace, and being reverberated downwards, passes off to the chimney. The patentees, instead of thus passing the heat direct into the chimney, render it further available to heating the furnace by returning the flue and carrying it back over the reverberating arch, and then downwards and to the chimney, whereby the heat in passing through the return-flue is reverberated downwards upon the top of the reverberating arch of the furnace itself, and thus assists in heating that portion of the furnace. The second part of the invention consists in a mode of passing sheets of glass into annealing furnaces or kilns. By the ordinary method the glass to be annealed is pushed into the kiln, and before this can be done the glass must lose a great portion of its heat, to enable it to possess sufficient firmness and solidity to bear the pushing strain to which it is subjected. The patentees make in the side wall of the furnace opposite to that where the entrance for the sheets of glass into the furnace is situated, a hole or opening through which the workman passes an instrument which, passing across the furnace and taking hold of the edge of the sheet of glass, pulls and draws it into the kiln; by this mode the temperature may not be so much reduced as when the old mode of pushing is adopted, inasmuch as the strain attending the pulling is considerably less than that of pushing.

RAILWAY-BREAKS.

Robert Heath, of Heathfield, Manchester, gentleman, for "*certain improvements in the method of applying and working friction breaks to engines and carriages used upon railways.*"—Granted January 13; Enrolled July 13, 1848.

The object of this invention is to bring a heavy weight, attached to a lever, to bear against the friction break, so as to render the action more certain and regular than when manual force alone is exerted. The lever is placed under the control of the guard, who, by turning a winch placed in the ordinary manner, may bring the weight to bear upon the peripheries of the wheels, or remove it, with very little effort.

Samuel Cunliffe Lister, of Manningham-hall, Bradford, gentleman, for "*improvements in stopping railway trains and other carriages, and generally where a lifting power or pressure is required.*" Granted January 18; Enrolled July 18, 1848.

In this railway-break the resisting force is atmospheric pressure, or the pressure of compressed air, bearing against the breaks, which, as usual, act on the circumferences of the wheels. The apparatus consists of an air-chamber, placed below the framing of the carriage. It is provided with a piston or pistons, to the rods of which are attached the blocks, bearing against the wheels. The air is condensed into the air-chamber by air-pumps, worked by the axles of the carriages; and, by means of the pistons and rods, the pressure is communicated to the wheels. The mode to be adopted when the breaks are required to be thrown into action, is for the guard, by means of suitable connecting apparatus, to open the valves, by which means the atmospheric air will be admitted to the pumps, a few strokes of which will then so compress the air within the receiver as to press the breaks against the wheels. Similar effects are produced by making the pumps act as exhausters, instead of compressers.

RAILWAY KEYS.

William Henry Barlow, of Derby, civil engineer, for "*Improvements in the manufacture of railway keys.*"—Granted January 27; Enrolled July 27, 1848.

In these improved wooden keys, the inconvenience arising from expansion and contraction is attempted to be obviated, by rendering the wood impervious to moisture. This is done by introducing into the pores of the wood, fatty or other matters that are insoluble in water. The patentee first prepares the keys of the requisite proportions, after which they are subjected to heat for the purpose of expelling the moisture. This he effects by placing them in an oven for 24 hours, which is maintained at a temperature of 212°, after which they are immersed in a solution by preference composed of four gallons of creosote, one gallon of naphtha, 24 lb. of pitch, and half a gallon of boiled linseed oil. The proportion of this mixture used to impregnate the wood is about one gallon to the cubic foot, and the keys should be immersed therein about 24 hours. They are then ready for use, unless it be deemed necessary to subject them to the process of compression. Instead of simple immersion in these insoluble matters, the process may be greatly facilitated by exhausting the air from the wood in a close vessel, and afterwards forcing the fat composition in under pressure.

IMPROVEMENTS IN MARINE ENGINES AND PROPELLERS.

JOSEPH MAUDSLAY, of the firm of Maudslay, Sons, and Field, of Lambeth, engineers, for "*Improvements in obtaining and applying motive power and in the machinery and apparatus employed therein.*"—Granted March 8; Enrolled September 8, 1848. [Reported in the *Mechanics' Magazine.*]

Fig. 1.

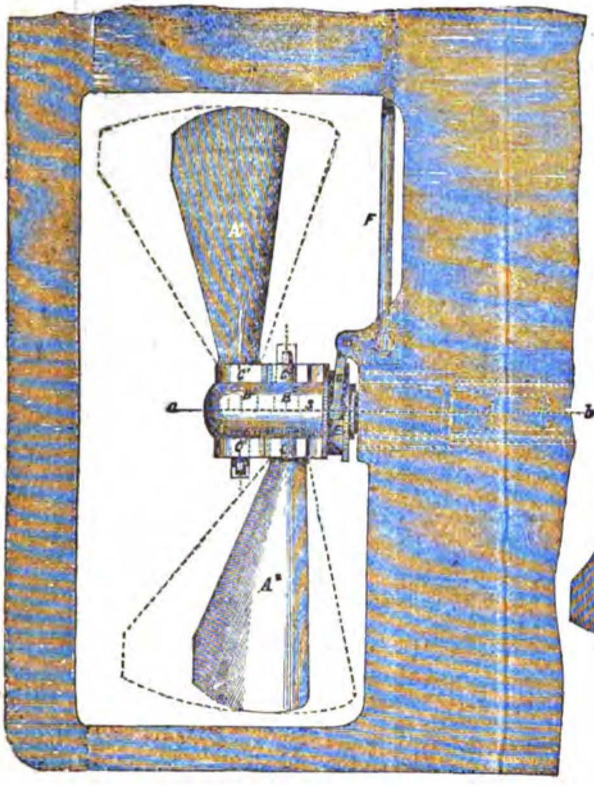


Fig. 2.

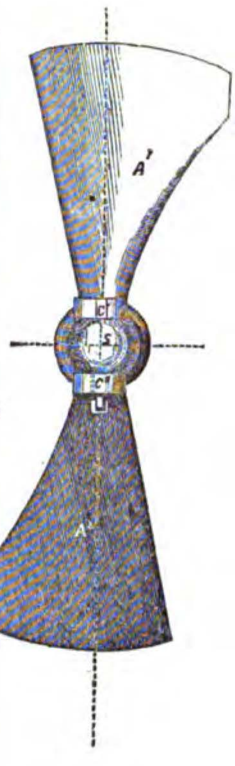


Fig. 3.

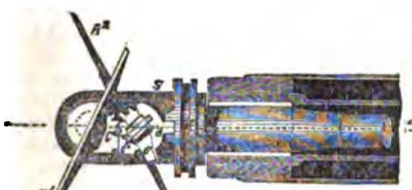
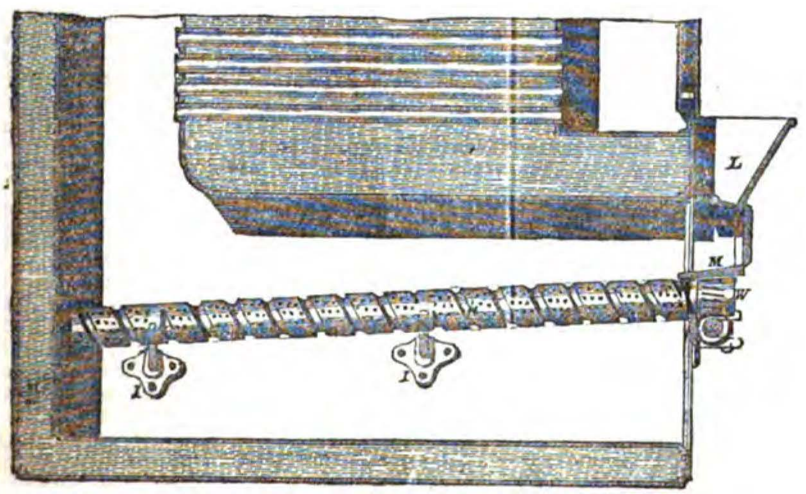


Fig. 4.

Fig. 5.



1. The new steam propeller which forms the leading subject of Mr. Maudslay's present patent, obviates one of the greatest obstacles that have hitherto stood in the way of steam propelling, whether by means of screw blades or flat blades, or blades of any other description; viz., the difficulty of shipping and unshipping the propeller. Mr. Maudslay affixes the blades of his propeller (which may, he says, be of "any approved or suitable form") in such a manner to the driving-shaft that the propeller assumes of itself, as it were, the proper angle for propulsion, the instant the driving-shaft is put in motion, and returns as instantly into a neutral or inoperative position when the driving-shaft ceases to rotate.

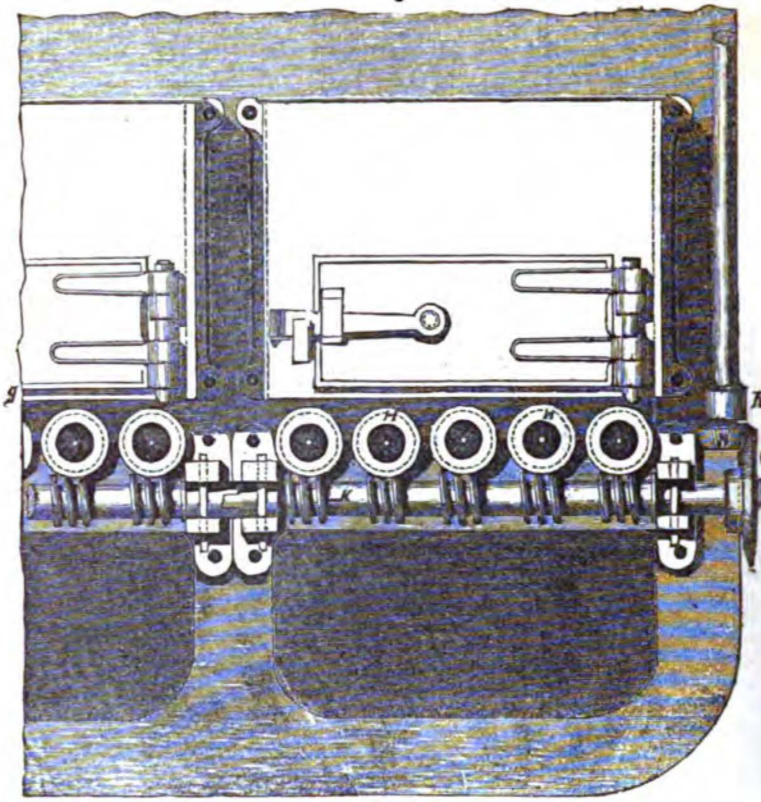
Fig. 1 represents part of the stern of a vessel fitted with this improved propeller; fig. 2, a front view of the instrument detached from its place in the vessel; and fig. 3, a sectional plan of the propeller, and its connections on the line *a b* of fig. 1.

"A^1 A^2 are the blades of the propeller, which are inserted at their inner or narrow ends into sockets B^1 B^2, in the end of the propeller-shaft S, in which sockets they are free to turn to the extent to be presently defined. To the shank of each propeller blade there are two toothed segments C^1 C^1, C^2 C^2, attached one at the top of each socket, and the other at the bottom of it; and the two sets of segments work the one into the other within the limits determined by the stops *f f*, so that the propeller-blades must always move in perfect unison, and can only turn round in their sockets to the extent allowed by the stops. E is a sliding clutch, affixed to the driving-shaft inside of the propeller-blades, which may be moved sternwards, so as to lay hold of either of two sets of pins, *d d* and *e e*, which project from the back of the wheels of the innermost propeller-blade A^2. F is a vertical rod, by means of which the clutch E, may be worked from the deck of the vessel; this rod terminating at bottom in a screw, which takes into a swivelled nut *n*, which is attached to one arm of a bell-crank G, the other arm of which is forked so as to embrace the clutch E, when brought down upon it. The mode in which the propeller, as thus fitted, acts, is as follows:—Supposing the clutch to be disengaged, and the driving-shaft to be put in motion, the blades are immediately thrown out into the angular positions proper for propelling, and they will continue in these positions as long as the shaft continues to rotate. Should occasion arise for backing the vessel, the blades are then secured in their extended positions by interlocking the clutch with the pins *d d*, at the back of the wheels of the innermost blade A^2, as represented in fig. 3. When the engine is stopped, and the driving-shaft ceases to rotate, and the clutch is withdrawn, the propeller-blades will, by the action of the water upon them, be turned round in their sockets until they come into a line with the course of the vessel, and present their sharp edges only to the water, as exemplified in fig. 4; and, for greater security, they may be made fast in this position by interlocking the clutch E, with the pins *e e*, at the back of the wheels of the innermost blade."

From the instantaneousness with which this peculiarly fixed screw propeller can be turned to account, from its never being required to be raised out of the water, and never offering, when in the water and at rest, any material obstruction to the steering or progression of the vessel, it seems to possess so far a great superiority over all the screw propellers hitherto in use; but it promises to be more especially advantageous in the case of vessels going long voyages, with small store of fuel, and employing steam as an auxiliary power only, when the wind is not fair for the use of sails. With a propeller of this description, not a minute need be lost in changing from sailing to steaming, or from steaming to sailing, and consequently, not a pound more of fuel need be expended than is absolutely required.

2. The peculiar feature of Mr. Maudslay's new furnace consists in the employment of rotating tubular screw bars, and hence the the name ("Archimedian") by which we (not Mr. Maudslay) have ventured to distinguish it. Fig. 5 is a longitudinal section of the furnace; and fig. 6 a front view.

Fig. 6.



H H, are the fire-bars, which, instead of being as usual solid fixtures, consist of a series of tubes which are free to revolve in their bearings, are open from end to end, screw-threaded on the outside, and perforated with numerous air-holes. On the front end of each bar there is a broad flange or shoulder *f*, which projects beyond the general line of the furnace, and has a worm-wheel W, formed upon it. An endless screw-shaft K, which passes across the front of the furnace, and is worked from the engine through the medium of the bevil-wheels N, O, takes into the whole series of worm-wheels W, and causes thereby the constant rotation of the fire-bars. L is a throttle-valve hopper by which the coals are supplied to the furnace. As the coals drop from the hopper they fall upon an inclined shoot M, which projects them upon the front end of the furnace bars, whence they are carried gradually forward to the back, by the rotation of the bars and the action of their screwed surfaces on the mass of fuel.

In consequence of the bars being in this constant state of rotation it is almost impossible that either clinkers or ashes should accumulate upon them.

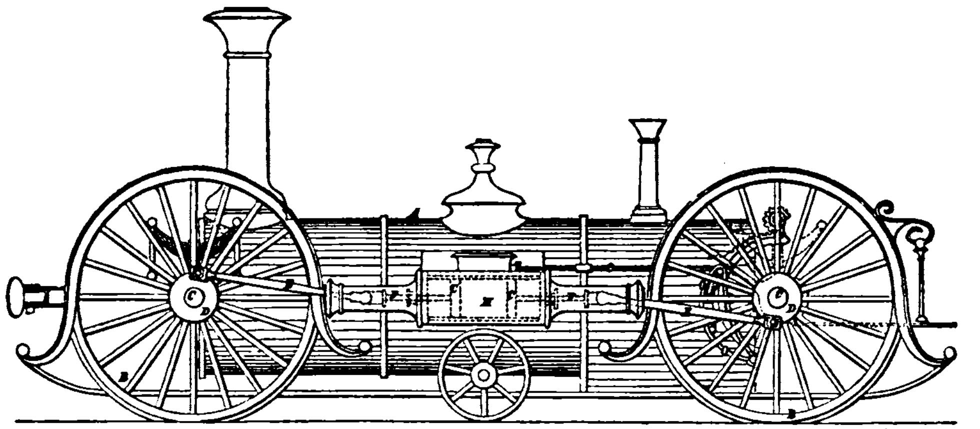
LOCOMOTIVE ENGINES.

Charles Ritchie, of Aberdeen, Scotland, engineer, for "*certain Improvements in locomotive engines.*"—Granted March 2; Enrolled September 2, 1848. [Reported in the *Mining Journal.*]

This invention consists in, and has reference to, certain improvements in locomotive and other engines, carried into practical effect by the means, or through the agency, of certain new or improved mechanical combinations and arrangements, having for their object the simplification of the construction, and the augmentation of the efficiency, of such engines.

The first part consists in the application of a cylinder, or cylinders, with two distinct and separate pistons in each cylinder, to which are affixed piston-rods, for imparting motion to the cranked-axles and driving-wheels fixed thereon, whereby the rocking, or oscillating, motion attending locomotive engines as hitherto constructed, is considerably diminished, and greater steadiness of motion obtained, as, by this arrangement, the momentum of one piston, together with its cranks, and other connections, is at all times exactly balanced, or nearly so, by that of the other, in consequence of the approaching or receding of the pistons to and from each other being always simultaneous. The second part relates to an improved mode of working the slide-valves of locomotive and other engines, by rendering the eccentric, which imparts motion thereto, available for the purpose of reversing the engine. The third part relates to an improved valve for regulating the admission of steam, or other motive power, to the working cylinders of locomotive and other engines, and to improvements in safety-valves, to be applied to the boilers of engines, or other reservoirs of power. The fourth part relates to an improved anti-primer, or steam-collector, to be applied to the boilers of steam-engines. The fifth part relates to an improved self-acting feeding apparatus, for supplying water to the boilers of steam-engines. And the sixth and last part consists in the application to the wheels of locomotive engines of an improved guard, or safety-break.

The drawing exhibits a side elevation of a locomotive engine, constructed according to this invention. A marks the boiler of the engine; B, the driving-wheels fixed upon the crank-axles, C; the boss, or nave, D, of each of such wheels serving as the crank, to which one end of the connecting-rod E, is attached by a crank-pin, or stud, *a*, secured to the said nave, and the opposite end of the rod E, is connected to the piston-rod F, in the usual way of forming such connections. G, G, two pistons, to which are attached the rods F, F—the said pistons working steam-tight in the cylinder H, by means of metallic, or other packing. The cylinders are fixed to each side of the boiler. Instead of having the fixed cylinder and connecting-rods, as above described, oscillating-cylinders may be used, with their piston-rods connected directly with the crank-axle; or where fixed cylinders are used, and space is an object, the connecting-rods E, E, may be dispensed with, by attaching to the piston-rods a cross frame, in which there is a slot formed, into which a crank-pin, or stud, takes. The outer end of the frame works through a guide-hole, fixed to the side of the engine, and thus the rectilinear motion of the piston-rods imparts rotary motion to the crank-axle and driving-wheels fixed thereon. The steam may be admitted through the ports, into the cylinder, by a common slide, in the following manner:—Upon the hindermost driving-axle is fixed an eccentric, upon which is a cam, of the following peculiar construction:—Two rods are fixed to, or formed upon, the said cam; or it may be composed of one double-gabbed rod, one gab being employed for effecting the backward, and the other the forward, motion of the slide-valve, through the intervention of a double lever, which has its fulcrum upon a stud, fixed to the side of the boiler, as shown by the drawing, and this lever is connected to the slide-valve by a rod *c*. The length of this lever, as also the angle of inclination of the parts O, O, should be in accordance with the lead of the valve—the one or other of the inclined parts O, being caused to act upon the lever by a hand lever, connected to the said cam in any convenient manner, so as to enable the engine-driver to start, reverse, and stop the engine readily, by the same eccentric which gives motion to the slide-valve. By making the end of the valve-rod moveable, as in a slot in the lever P, the steam may be worked expansively at pleasure. Improved spring safety-valves are exhibited by other drawings attached to this specification, from which it will appear there are two forms of construction, showing a valve with a conical-shaped seat, being a flat-valve, and constructed with a flange, which the inventor terms a compensation flange—such flange being let into the seat vertically, about one-sixth of the diameter of the steam-



way in the valve-seat. This valve is weighted by a helical spring, of sufficient power, according to the required pressure of the steam; and when it is intended to be used as a reserve safety-valve, the spring is to be placed around that part of the stem below the valve—that is to say, within the boiler. The advantage of this form of construction of valve over the ordinary valve is as follows:—As soon as the pressure of the steam raises the valve from its seat, the flange, being exposed to the pressure of the steam, presents an increased surface, which compensates for the increasing resistance of the helical sping, until the valve has been raised to a height equal to the area of the steam-way, when it allows the steam, or vapour, to escape freely. When not intended as a reserve safety-valve, this valve may have the spring placed above it. Another valve, which is called an indicator safety-valve, is exhibited, consisting of a piston, which is fitted into a tube, having a spring attached to it—lateral openings being made in the tube, to allow the steam to escape when the piston becomes raised above such openings; and by making the said tube moveable within another one, the "blowing-off" point may be varied at pleasure. An index, like that of a barometer, may then be attached to the stem, or rod, of the piston, and will indicate very slight variations of pressure. A regulating-valve is attached, the construction and arrangement of which is as follows:—There is a short socket-pipe, having two conical valve-seats formed therein, into which the valves fit—such valves being connected together, or formed upon one stem, into which one end of a rod is screwed, or otherwise made fast, and the opposite end of the said rod attached to an eccentric spindle, working through a stuffing-box, to which a hand-lever is fixed—such lever and rod being for the purpose of opening, or closing, the regulator-valve at pleasure.

The anti-primer before-mentioned is formed in the following manner:—Two distinct and separate plates of sheet metal, the outer edges of which are securely fixed to the inside of the boiler, by rivetting, or otherwise, the said plates being inclined towards the centre of the boiler, care being taken to leave a space between the inner edges of the two plates, so as to reserve a channel lengthwise of the boiler, for the passage of steam into the steam-chamber thus formed, and within, or in connection with which the regulating-valve, is situate the steam-pipes which lead to the cylinders being connected thereto. Instead of forming the anti-primer of two separate strips, or pieces, of metal, the same result may be obtained by forming it of one strip, or piece, of metal, of the shape shown—the said plate being pierced with an infinite number of small holes. The construction and arrangement of the feeding-apparatus are as follows:—There is a metal cylinder, which should be bored perfectly true and cylindrical, fitted with a piston, the rod of such piston forming the plunger, or ram, of the cold water pump, the barrel of which serves as a compound gland for the stuffing-box of the cylinder and pump-barrel. The slide-valve, which may be made to cover or uncover the ports, or passages, in the cylinder, by the opposite sides of the piston coming into contact with the levers, which are connected to the slide-valve by a rod or rods. There are spherical-valves (the seats of which are knife-edged), formed within the spherical flange pieces, which have openings for establishing a communication between the tender, the pump-barrel, and the steam-boiler, as exhibited. The *modus operandi* of this feeding-apparatus is as follows:—Upon steam being admitted from the boiler into the cylinder, through the steam-port, or passage, the piston will be acted upon, and the ram, or plunger, be withdrawn, the water from the tenders will raise the valve, and enter the barrel, to supply the space previously occupied by the plunger, or ram; by this time the piston will have acted upon the lever, so as to cause the slide-valve to uncover the port, or passage, and cover the port, or passage, P_1, thereby allowing the steam on the other side of the piston to escape through the exhaust-pipe; the piston will now be impelled in a contrary direction, and the plunger, or ram, entering the barrel, will cause the one valve to be closed, and the other to be opened by pressure of the water therein, which as the plunger, or ram, advances, will be forced into the boiler, to supply the deficiency of that water which has been converted into steam; R_1, R_1, mark wheel-guards, or safety-breaks, which are each composed of a strong band, or strap, of iron, placed like a splasher over the wheel to be protected; the inner surface of the said guard, or break, is formed of the converse shape to that of the tyre, and fixed securely to the framing, or boiler, or both, as near to the top of the wheel as the play of the bearing-springs will admit of, and as near to the back of each wheel as possible, without touching it.

To each side of the engine a bar of iron is placed, and securely fixed in a longitudinal direction—such arrangement being intended to preserve such wheels in a vertical position, and thereby support the engine, in the event of the axles breaking, and to operate at the same time as a break, to retard the motion of the engine, in the event of any such accident. Another improvement in locomotive engines consists in arranging that part of the boiler known as the fire-box, in such manner that the height of the water in this part of the boiler shall at all times be at a proper level, which is effected by what is called an anti-fluctuator, which is a separate partition-plate across the water space, or an extension of the plate to which the tubes are fixed as shown; and, by causing the water to be fed to the boiler at that part which surrounds the fire, it will appear evident that the barrel of the boiler can only receive its supply of water from that which overflows the said partition-plate. Having described the nature of his invention, the patentee remarks, that he does not claim the exclusive use of any of the separate parts above-mentioned and referred to, when considered *per se* and apart from the purposes of the said invention, as hereinbefore set forth and described.

Improvements in Perforating Glass for Ventilation. Patented by Mr. J. Lockhead, of Milton, Gravesend.—In forming plates, sheets, lenses, or other forms of glass, the glass, when in a semi-fluid state, is poured from the pot on to the casting-table—the stream being followed by a pressure-roller, for the purpose of flattening it; and, while the glass is in a plastic state, a metal mould, with teeth or projections on its under-side, according to the pattern required, is applied to the surface, forcibly pressed down, and left in that position until the glass has set; after which it is to be removed, and the glass will be found to be perforated, in corresponding shapes to the projections on the mould. To effect this in the most complete manner, a screw-press, made to the size of the casting-table, is used, very similar to a common copying-press, and different pattern-moulds being fixed to the lower end of the screw, and worked by a cross handle.

Improvements in obtaining Oxide of Zinc from the Ore. Patented by M. C. A. F. Rochaz, of Paris.—By this process, the employment of retorts, as by the old method, is dispensed with, the fuel and labour economised, the operation completely independent of the skill of the workman, and the loss of metal, incidental to the old method, prevented. Ores of lead and zinc may be operated on at once. The principal feature consists in the reduction of the native sulphuret of zinc (blende), and of the carbonates, oxides, and silicates of zinc, and sulphurets and oxides of lead, by the action of the reducing gases of a blast-furnace, by which the scoria, or slag, is fused, and the zinc volatilised; the vapours are then condensed, and conducted into a reservoir, situated over the mouth of the furnace, and heated by the gases therefrom. The furnace having been heated to the required temperature by the combustion of fuel alone, a charge of any kind of the above zinc ores, mixed with a suitable flux, is introduced into the charging aperture, and, by means of a cover above, and a sliding plate below, none of the gases are allowed to escape. The charge thus falls upon a layer of incandescent fuel; a layer of fuel is then poured upon the ore; then another charge of ore, until the furnace is full, and it is to be replenished as the charge sinks below a certain depth. The zinc is thus volatilised by the heat, and the scoria falls into the lower part of the furnace; the gases and volatilised zinc pass through proper openings through a hydraulic main, and there deposit any zinc carried with them.

BRITISH ASSOCIATION.

Reports read at the Meeting held at Swansea, August, 1848.

Railway Statistics.

"*Facts bearing on the Progress of the Railway System.*" By Mr. W. Harding.

The modern railway system of Europe may be said to date from 1830, when the construction, by Mr. G. Stephenson, of the Liverpool and Manchester Railway, with its locomotive engines, was completed. After that date we heard no more of such prophecies as the following (from the *Quarterly Review*, in 1825), which it is not useless to record as a lesson of caution to us for the future:—"As to those persons who speculate on making railways generally throughout the kingdom, and superseding all the canals, all the wagons, mails, and stage-coaches, post-chaises, and, in short, every other mode of conveyance by land and by water, we deem them and their visionary schemes unworthy of notice. What, for instance, can be more *palpably absurd and ridiculous* than the following paragraph,"—in which a prospect is held out of locomotives travelling twice as fast as stage-coaches. "We should as soon," adds the reviewer, "expect the people of Woolwich to suffer themselves to be fired off upon one of Congreve's ricochet rockets, as trust themselves to the mercy of such a machine, going at such a rate." The modern railway system has, however, not only done this, but it has given rise to new habits in the present generation, and has proved to be the great mechanical invention of the nineteenth century, as the steam-engine was of the eighteenth. As it is still in its infancy, it is especially the province of statistical inquiry to watch its growth, so that on the one hand timely remedies may be applied to its defects, and on the other free scope may be given to its beneficial tendencies. Valuable papers have been contributed by Messrs. Laing, Porter, Graham, and others, analysing the traffic on railways during the infancy of the system to the year 1843. Shortly before that period there had been a pause in railways. During two years, only five miles had been sanctioned, but the period which has since elapsed comprises the memorable mania years of 1845 and 1846. Under this excitement intelligence and emulation have been stimulated among the managers of railways to the utmost, and the system has rapidly advanced. The consolidation of lines under a few great companies, by the process styled amalgamation, has proceeded;—the atmospheric, an entirely new system of traction, has been brought forward;—the electric telegraph, conveying intelligence at the rate of 280,000 miles a second, has been widely introduced;—express trains, travelling at nearly the highest attainable speeds, have been established,—and the length of railways in operation has been doubled. It therefore becomes a matter of interest to inquire to what the results of so active a period point. Have low fares answered?—Has the third-class traffic, the most important to the bulk of the people, been encouraged, and has it been found wise, not only for the users but for the owners of railways, to encourage it or the reverse?—Has the increase of speed been successful, and are we likely to travel faster or slower hereafter?—How have the receipts kept up while the length of railway has been doubled?—Did the first 2,000 miles get the cream of the traffic, as has often been thought, and has the average receipt per mile consequently fallen off?—Should the experience of the past, in short, give us confidence in urging on the system at the extraordinary rate at which we are now doing it, or not? In the following investigation and collection of facts it has been attempted to throw some light upon these points;—the recent publication of the official railway returns for 1846 and 1847 affording peculiar facilities for the purpose. The following paper refers to English, Scotch, and Welsh lines only,—the Irish lines are excluded, the economical condition of Ireland being different from that of this country, and there being but few railways open in that country:—

Comparative Lengths of Railway open in 1843 & 1847 and Receipts thereon.

The lengths of English, Scotch, and Welsh railways open June 1843 were			1,990
Ditto, open at the commencement of 1848	..	..	3,597
The gross receipts returned for the year 1842 were	..	..	£4,740,000
Ditto, for the year ending June 30, 1847	..	..	8,366,772

After making the necessary corrections in the above figures, the average receipts per mile of railways in 1842 were 2,489*l.*; in 1847, 2,596*l.* We therefore arrive at the important fact that, although the mileage of our lines has been doubled, the receipts have been more than doubled. This must be regarded as a favourable general feature in the state of railways. There was much reason to fear that, as the first railways ran between the great towns or traversed the manufacturing districts, the railways which were next opened would show a great falling off in receipts. Hitherto, then, we find that this is not so,—a fact which may give us confidence as regards the great length of railway which has been sanctioned by parliament but which is not yet open.

Lines sanctioned but not open.—The length of railway sanctioned by parliament at the commencement of 1848, but not then open, was 7,150 miles. A considerable portion of this is in progress, more or less rapid. On the 1st of May 1847, 5,209 miles were returned as in progress, on which 218,792 persons were employed, or 42 per mile.* These new railways are principally designed for the accommodation of the agricultural parts of the country. We will presently refer to the prospects of railways in such districts. When the railways now in contemplation are completed, and it is probable that the greater portion will be so in the course of the next five years, we shall have upwards of 10,000 miles of railway open,—on which, judging from the numbers employed on lines now open, (viz., 14 per mile), 140,000 persons will be permanently employed, at good wages,—representing, at five to a family, three quarters of a million of the gross population. The importance of this addition to our internal communications will be appreciated when it is remembered that there are only about 4,000 miles of inland navigation and 30,000 miles of turnpike road open for traffic in the country.

Analysis of Traffic.—General Features.—The gross traffic for the year ending June 30, 1847, was, as we have seen, 8,366,000*l.* There were conveyed during that year, from the returns of the Board of Trade,† in round numbers, 7,000,000 tons of merchandise and goods, 8,000,000 tons of coal, 500,000 horned cattle, 1,500,000 sheep, and 100,000 horses.

Of the gross sum, 8,366,000*l.*, the passenger receipts were	..	£5,024,000
The receipts from all other sources—goods, cattle, carriages, parcels, mails, &c.	..	3,342,000
Total	..	£ 8,366,000

In every 100*l.* of receipts, the passenger traffic therefore forms 60 per cent., the traffic receipt from other sources 40. In 1842 these proportions were as 64 to 36. The proportions of traffic receipts from other sources than passengers (being principally goods and cattle traffic) have thus increased since 1842 as 40 to 36, or 11 per cent. The total number of passengers carried in the year (ending June 30) 1847 was 47,484,134, as compared with, in 1842, 22,403,478. The average distance travelled by each passenger was, in 1842, 13 miles; in 1847 it was 16 miles. The numbers and proportions of classes were

	In 1847.	In 1842.
First-class	14 2	20·2
Second-class	38·3	45·4
Third-class	47·5	34·4

Thus, the third-class passengers (which have increased in number since 1842, from 6,000,000 annually to 21,000,000,) now form nearly half of the whole number travelling, whereas in 1842 they formed only about one-third. Only one-third of the third-class passengers have availed themselves of the parliamentary trains, arbitrarily (and, as it appears to me, unfairly) imposed upon railway companies in 1844. The following table, comparing the fares of the metropolitan railways in the year ending June 1843, with those in the year ending June 1847, shows the great reduction which has taken place in fares during the last four years. To make the comparison more appreciable, the fares are taken as for 100 miles in pence.

Name of Railway.	Fare for 100 Miles.					
	1st Class.		2nd Class.		3rd Class.	
	1843.	1847.	1843.	1847.	1843.	1847.
London and North-Western ..	334·8	218·1	241·1	144·6	131·2	93 3
Great Western	303·1	274·4	208·5	187·8	118·8	100·0
London and South-Western ..	312·0	245·0	210·0	168·0	120·0	96·0
Eastern Counties	294·1	210·0	227·4	141·5	164·7	92·3
Northern and Eastern ..	217 4	—	165·	—	110·9	—
South-Eastern	227·0	214·0	150·0	152·0	87·5	90·0
London and Brighton ..	350·0	263·0	225·0	171·0	150·0	109·0
Average	303·5	237·4	210·3	160·8	128·6	96·7
Difference per cent. ..	—	21·8	—	23·8	—	25·0

This reduction in fares, coupled with the increase in the number of trains, and the speed of travelling, must be regarded as the principal cause of the great increase of the number of passengers since 1843.

We have already seen that the numbers in 1847 and 1843 are as 47,484,134 to 22,403,478. If we take into account the number of miles opened at those dates respectively, the annual number per mile was, in 1842, 11,772, and in 1847, 14,806.

* In this return the number of miles returned as in progress are more than those really in construction, the number of men employed per mile is less than the truth.

† These returns are not complete, and they require some correction, in respect of the same articles being sometimes conveyed over several different lines, and therefore counted over more than once.

The proportion of third-class passengers has, we have seen, thus satisfactorily increased between 1842 and 1847. The third-class traffic has, however, developed itself very differently on different lines; and it may be well to inquire into this. The statement subjoined shows the third-class traffic of two metropolitan companies (the Eastern Counties and the Great Western)—two North of England companies (the Lancashire and Yorkshire and the Newcastle and Berwick)—and two Scotch companies (the Edinburgh and Glasgow and the Glasgow and Greenock).

Year ending June 30, 1847.

Name of Railway.	Length in Miles.	Number of Third-class Passengers conveyed.	Proportion in every Hundred of Third-class Passengers.
Glasgow, Paisley, and Greenock ..	..	957,514	83·3
Newcastle and Berwick ..	65¼	944,891	79·5
Edinburgh and Glasgow ..	46	836,025	72·8
Lancashire and Yorkshire ..	109	2.090,624	72·3
Midland	285	2,366,892	65·4
Eastern Counties	177	1,044.158	50·3
Great Western	240¾	419,663	14·6

From this it appears that while the Great Western Company, on a line 241 miles long, have only carried 419,663, the Edinburgh and Glasgow Company, on a line 46 miles long, have carried 836,025; the Midland Company, 285 miles long, 2,366,892; and that while on the Great Western only 15 out of every 100 passengers conveyed are third-class, on the Eastern Counties 50 out of every 100, and on the Glasgow, Paisley, and Greenock, 83 out of every 100 are third-class passengers. Although it is true that the different character of the population and other circumstances will affect to some extent the relative number of third-class passengers on different lines, the disparity here is so great that we can come to no other conclusion than that the arrangements of such a line as the Great Western as to third-class passengers must be such as to preclude hundreds of thousands of third-class passengers yearly from using the railway who, with greater facilities, would be glad to use it. I say this with confidence, because as manager of the Glasgow and Greenock Railway, where the third-class system has been more developed than on any line in the country (and where we carried passengers at a profit for one farthing a mile), I had an opportunity of observing the real advantage and comfort which very cheap travelling is to the working class. As the results of the working of that line afforded a remarkable instance of the effects of low fares, I have thought that it might not be uninteresting to record them. The River Clyde runs beside the Glasgow, Paisley, and Greenock Railway, which is 23 miles long. The steamboats have long afforded an excellent mode of transport between Glasgow and Greenock, the fares by boat before the railway opened being from 1*s* to 2*s*., and the time occupied was about two hours. Glasgow, with a population of 274,000, was at one end of the line, Greenock, with a population of 36,000, at the other end of the line, and various summer watering places lie at the mouth of the Clyde, below Greenock. On the line were Paisley (population 60,000) and Port Glasgow (population 7,000). Between Glasgow and Paisley was a canal on which there were passenger-boats drawn by horses at a speed of 6 miles per hour. These facilities gave rise to a great traffic before the railway was opened,—the yearly number travelling along the course of the railway being 1,185,340, and the average fare 1*s*. 4*d*. Notwithstanding this, after the railway was opened (in 1843) the numbers travelling by all means of conveyance were found to exceed 2,000,000, or to have increased 100 per cent., the average fare having in the mean time fallen to 10*d*. This was the gross result; but the fares of the railway (originally 2*s*. 6*d*. first-class and 1*s*. 6*d*. second-class for 23 miles) were varied from time to time; and as I closely observed the effects of these variations, having caused an account to be taken of the number travelling by steamboat and canal as well as by railway, it may be well to state the results of these variations of fares.

First alteration.—In 1842, uncovered, open, third-class carriages, at a fare of 6*d*. for the 23 miles (or about ¼*d*. per mile), were introduced on the railway between Glasgow and Greenock, whereupon the annual number of railway passengers between those places increased 224,000, being an increase of 32 per cent. of the total number travelling (either by railway or steamboat). The number of first and second-class fell off at the same time 30 per cent., the passengers having transferred themselves from the higher class-carriages into the open third-class carriages, tempted by the difference of fares between ¼*d*. per mile and ½*d*. per mile. The gross receipts, however, increased simultaneously 15 per cent.; the working expenses on the other hand, did not appreciably increase, although the average number of passengers per train increased from 72 to 117.—*Second alteration.* The third-class fares were subsequently (in 1843) raised from 6*d*. to 1*s*. with the hope of increasing the revenue. The whole number travelling by railway and steamboat immediately fell off 18 per cent. The first and second class railway passengers increased by 10 per cent., but the gross receipts fell off more than 10 per cent. The effect was also tried of making the third-class carriages more comfortable by covering them in. This was found not to increase the number travelling, but it did reduce the number of first and second class passengers by 16 per cent., and therefore caused considerable loss to the company. The same experiment was repeated on the second-class carriages: they were made more comfortable by inserting glass windows instead of wooden shutters, and by carrying the interior partition higher. The number of first-class passengers shortly fell off by 12 per cent., but beyond this the second-class passengers did not appreciably increase; this experiment, therefore, also resulted in loss. The results of these experiments were then—1st. That a reduction of fares to ¼*d*. per mile even from so low a rate as ½*d*. per mile increased the number travelling by nearly a quarter of a million or by two-thirds of the whole population of the district. As these people were generally of the less affluent classes, it appears that they were actually drawn out of the noisome streets of Glasgow to the North of the Clyde by the temptation of a very low fare, and immediately that the fare was raised they were driven back again into the city. 2nd. That under the circumstances of the line in question, cheap and rapid travelling increased the number travelling; but improving the lower-priced carriages did not, however, appear to act in the same way, but merely tempted passengers from the higher class carriages—those from the second-class into the third-class carriages, and from the first to the second class:—of course it by no means follows that similar results would ensue on lines in other localities; each case must be determined by its peculiar conditions. 3rd. That no limit can be assigned to the number of travellers which cheapening and quickening the means of conveyance will create. The introduction of the railway, even where steamboats already afforded a most pleasant, rapid, and cheap communication, increased, we see, the number travelling from 110,000 to 2,000,000—2,000,000 being five times the whole population of the district. I doubt whether either at home or abroad so large a proportion of travellers to the whole population is to be found. The traffic between Glasgow and Paisley is probably the most remarkable instance on record of the increase of travelling caused by increased facilities. In 1814 there was only one coach a week between Glasgow and Paisley, conveying about 2,000 persons per annum; if we multiply this by 5 to allow for the greater number of gigs and private vehicles then in use, we only get 10,000 passengers per annum conveyed between the two places. In 1842 the numbers travelling by public conveyance between Glasgow and Paisley were upwards of 900,000. Now as the population between 1814 and 1842 had only about doubled itself, while the traffic, as we see, had multiplied itself ninety-fold, it follows that the increased facilities of transport had increased the number travelling relatively to the population 45 times: that is to say, that for every journey which an inhabitant of Glasgow or Paisley took in 1814 he took 45 journeys in 1843. These results, I conceive, place it beyond a doubt that we should spare no effort to make railway travelling cheap and within the reach of all classes.

Now, there is only one true way of encouraging cheap travelling, and that is by keeping down the original cost, and the annual expenses of railways. All the other contrivances which the public are inclined to trust, such as legislative restriction on profits, and so on, are mere quackery. Even competition is inapplicable to railways, and is not to be relied on.* Mr. R. Stephenson, the engineer, put the whole case into one sentence when he said, to "have combination is practicable—competition is impossible." The experience of all railway competition shows that this is true; when, therefore, under the plea of competition unnecessary outlay is being incurred, the public may rest assured that they will ultimately suffer for it in the charges they will have to pay.

Mr. Hill Williams, the actuary, has compiled some useful tables,† to show arithmetically "how far a remunerative charge for the conveyance of passengers and goods on railways is modified by the original cost" and other circumstances.

The following is an extract showing the effect of increased cost of construction.—

Total yearly traffic, number of passengers or tons of goods, 90,000.

	Original cost of Construction £15,000 per mile.	Original cost of Construction £20,000 per mile.	Original cost of Construction £25,000 per mile.	Original cost of Construction £30,000 per mile.
Fixed charge per mile on every passenger or ton of goods requisite in order to give common interest, 5 p. cent. on the outlay	d. 1·00	d. 1·33	d. 1·66	d. 2·00

We see from this that the fixed charge on every ton of goods or passenger must average 2*d*. per mile to return common interest on a railway costing 30,000*l*., whereas if the railway cost 20,000*l*. 1⅓*d*. per mile would be sufficient, and if it cost 15,000*l*. 1*d*. per mile would be sufficient.

After a series of similar observations, the author concludes as follows:—The result of the preceding inquiry is, it appears to me, on the whole satisfactory. The railway system has doubled itself in the last three years. Fares have been greatly reduced. Third-class passengers have largely increased. The importance and value of the traffic in goods and cattle relatively to the passenger traffic have become more apparent. The number of trains is greater and the speed of some of the trains has been accelerated; and all this has been effected without any falling off in the average receipts on each mile of railway in working, but with an increase probably sufficient to meet the increase of the working expenses attendant on the increased accommodation now afforded by railways: whatever falling off in dividends

* Evidence Select Committee on Railway Act Enactments, 1846.

† Appendix No. 7, Select Committee on Railway Act Enactments, 1846.

there may have been, is, therefore, to be attributed in a general view of the subject to the capitalisation of loans and the creation of fictitious capital by the purchase of railways at premiums, and, therefore, at sums beyond what they actually cost. These being profitable speculations when shares were high, were pushed to such an extent as now to press severely on the original share capital of railway companies. The great evil of the last three years is the extravagant outlay of money which has taken place; an outlay which, instead of being checked by the legislature, has been encouraged to the utmost by the mode of inquiry adopted. This has inflicted on the railway system a burden which it will never be able to throw off, and which the public will always have to bear with them in a higher rate of charge for conveyance than would with common prudence have been necessary. It only remains to stop the extravagance with a strong hand. The very existence of the railway companies depends on the economy they can practise in making and working their railways; and nothing which on the face of it involves increased outlay, be it diversity of gauge and its consequence the mixed gauge, or the more plausible plea of competition, should be countenanced either by railway companies or by the legislature, if we wish to secure for ourselves the full fruits of that admirable invention which England and English engineers who have followed in the steps of George Stephenson have given to the world.

Anemometry.

"*Report of further progress of Anemometrical Researches.*" By Professor Phillips.

Referring to the report on this subject presented to the Southampton Meeting, the author recapitulated the steps of the investigation by which he had been conducted to propose the evaporation of water as a measure of the velocity of air-movement. In the former researches, the conclusion which may be drawn *à priori* from Dr. Apjohn's formula for the relation of the temperature of the dew point to that of an evaporating surface was verified; and the *rate of cooling* of a wet bulb in the open air was found to be *cæt. par.* simply proportional to $t - t'$ (t being the temperature of the air, t' that of an evaporating surface). The air-movement was found to affect the rate of cooling nearly in proportion to the square root of the velocity; and thus by simply observing the rate of cooling of a wet bulb exposed to a current of air, and also the value of $t - t'$, the velocity of the air current becomes easily calculable. But this instrument is only an *anemoscope*, of extreme delicacy and various applicability indeed, but incapable of being converted to a self-registering *anemometer*.—It appeared to the author probable that the *rate of evaporation* followed nearly or exactly the same law as the rate of cooling,—the same reasoning in fact applying to each case. This was tested by experiment in a great variety of ways, with instruments of extremely various forms, and with velocities of air-movement from 400 yards to 27,000 yards in the hour. The velocities of the wind were measured by a very lightly-poised machine anemometer of Dr. Robinson's construction, but without any wheel-work, the revolutions being counted by the observer.—In the course of these experiments some apparently anomalous circumstances in the rate of evaporation occurred to the author; but these he hopes to be able to interpret by further careful research, and finally to present in the compass of a few cubic inches an anemometer specially suited to measure and record the low velocities of wind, and furnish a useful complement to the larger machines already esteemed to be so important in meteorology.

Height of Waves.

"*On the Velocity and Height of Waves,*" as observed by Capt. Stanley; being the result of experiments made on board H.M.S. *Rattlesnake.*

The method adopted for the determination of the length and speed of the sea was to veer a spar astern by the marked lead line, when the ship was going dead before the wind and sea, until the spar was on the crest of one wave, while the ship's stern was on the crest of the preceding one. After a few trials, it was found that when the sea was at all regular, this distance could be obtained within two or three fathoms, when the length of wave was 50. In order to ascertain the speed of the sea, the time was noted when the crest of the advancing wave passed the spar astern, and also the time when it reached the ship; and by taking a number of observations, there is every reason to believe results have been obtained not very far from the truth. The officer noting the time in all these observations having only to register the indications of the watch when the observer called "Stop," had no bias to induce him to make the differences more regular. For measuring the height of the waves, a plan recommended by Mrs. Somerville was adopted—which Capt. Stanley has tried for ten years with great success. When the ship is in the trough of the sea, the person observing ascends the rigging until he can just see the crest of the coming wave on with the horizon, and the height of his eye above the ship's water-line will give a very fair measure of the difference of level between the crest and hollow of a sea. Of course, in all these observations, the mean of a great many have been taken; for even when the sea is most regular, apparently there is a change in the height of the individual waves. In order to show how closely the different results came, observations on different days are given from which they were deduced,—

Experiment, No. 1.

Length of sea, 55 fathoms; speed of ship, 7·2 knots; height of wave, 22 feet; time the wave took in passing from spar to stern, 10 seconds; speed of sea deduced, 27′ per hour.

Experiment, No. 2.

Times observed of wave passing from spar to stern.	
Sec.	
8·7	
7·0	
9·2	Length of wave, 43 fathoms.
6·3	Average height, 20 feet.
7·0	Speed of ship, 6 knots.
8·6	Speed of wave deduced, 24·5 nautical miles per hour.
8·8	
8·4	
8/64·0	
8·0	Mean time of wave going from spar to stern.

Experiment, No. 3.

Sec.	
7·4	
13·0	Length of wave, 50 fathoms.
10·7	Height of wave, 20 feet.
10·0	Speed of ship, 6 knots.
10·2	Speed of wave deduced, 24 nautical miles per hour.
9·0	
6/60·3	
10·0	Mean time of wave passing from spar to stern.

Experiment, No. 4.

Sec.	
7·5	
7·0	
10·0	Length of wave, 30 to 60 fathoms.
9·0	Height of wave,—
9·0	Speed of ship, 5 knots.
10·0	Speed of wave deduced, 22·1 nautical miles per hour
9·0	
8·0	
9·5	
9/79·0	
7·8	Mean time of wave passing from spar to stern.

Experiment, No. 5.

Length of wave, 33 fathoms.
Speed of ship, 6 knots.
Speed of wave deduced, 22·1 nautical miles per hour.

Experiment, No. 6.

Sec.		
12·0		
9·0	Length of wave, 57 fathoms.	Sea irregular;
7·5	Height of wave, 22 feet.	observations
10·5	Speed of ship, 7 knots.	not very good.
10·5	Speed of wave deduced, 26·2 nautical miles per hour.	
13·0		
6/62·5		
10·4	Mean time of wave going from spar to stern.	

Experiment, No. 7.

Sec.	
9·5	
6·5	Length of wave, 35 fathoms.
8·0	Height of wave, 17 feet.
8·5	Speed of ship, 7·8 knots.
7·0	Speed of wave deduced, 22 nautical miles per hour.
12·5	
10·0	
7/62·0	
8·9	Mean time of sea passing from spar to stern.

Summary of Observations.

Date. 1847.	Number of Observations.	Force of Wind.	Speed of Ship.	Height of Wave.	Length of Wave.	Time of Wave passing from spar to stern.	Speed of Sea deduced.	Remarks.
April			Knots	Feet.	Fms.	Seconds	Knots	
21		5	7·2	22	55	10·0	27.	Ship before the Wind, with a heavy following Sea.
23	8	5	6·0	20	43	8·0	24·5	Ditto.
24	6	4	6·0	20	50	10·0	24·0	Ditto.
25	9	4	5·0		35 to 40	7·8	22·1	Sea irregular.
26		4	6·0		33	7·4	22·1	Heavy following Sea.
May 2	6	(4·5)	7·0	22	57	10·4	26·2	Sea irregular—observations not very good in consequence.
3	7	5	7·8	17	35	8·9	22·	Wind and Sea a little on port quarter.

Note.—The numbers denoting the strength of the wind are those used by Admiral Beaufort.

Atmospheric Waves.

"*Report on Atmospheric Waves.*" By Mr. Birt.

The report consists of three parts:—The first denoting the information we now possess relative to such waves as have been determined: the second treating of the barometric curves which result from the crossing of the north-westerly and south-westerly waves, the two principal systems common to Europe—the most prominent subject being that particular curve known as the "great symmetrical wave of November:" and the third embodying the results that have been obtained during the last year illustrative of the symmetry of the "great wave," more particularly the locality of greatest symmetry and the departure from symmetry in certain directions. Under the second head, the author has thrown together the result of his inquiries into the *forms* presented by the barometric curves at certain stations, and has devoted attention to the symmetrical curve of November as it has been observed at the Observatory at Greenwich in the years 1841 to 1845. In connection with this subject, the author remarked "it has been assumed that the symmetrical wave of November consists of *five* subordinate waves giving rise to the five maxima which characterise it, the central maximum forming the apex of the symmetrical curve, the remainder being subordinate thereto. ("Association Reports," 1846, p. 125.) Upon a close inspection of the curves of the "great wave" as laid down from the Greenwich observations, six subordinate maxima can be traced, three on each side the central apex, which in all the years is by far the most prominent. The mean curve leads to the conclusion that *Greenwich is not the point of greatest symmetry*, its closing portion being depressed more than two inches below the commencement. The next feature is the decided rise of the mercurial column during a period of sixty-eight hours preceding the transit of the crest: the value of this rise is ·7 inch or about ·010 inch per hour. The fall is not so precipitous; the barometer appears to be *kept up* in this locality by the *first subordinate maximum* succeeding the crest, so that at the epoch of sixty-eight hours after transit the value of the reading is more than 2 inches higher than at sixty-eight hours before transit. At eighty hours after transit a precipitous fall commences, which continues during the next twenty-four hours, the mercury sinking ·36 inch or about ·015 per hour. The fall afterwards continues with two slight interruptions, answering to the subordinate maxima, until the close of the wave 148 hours after transit." The peculiar features of the mean curve, especially the difference between the initial and terminal readings, ·241 inch, combined with certain features exhibited by the "great wave" at its last return, has suggested the possibility of expressing numerically the departure from symmetry for any station that may be selected. This departure from symmetry is strikingly manifested by the observations of 1846, especially as we proceed from Brussels, the European nodal point, towards Ireland and the north-west of Scotland, and is well seen in the series of curves illustrating the author's report in the last volume of the "Association Reports." Three principal maxima, characterise these curves on the 5th, the 9th, and the 12th of November; and the differences of altitude between those of the 5th and 12th have been employed to indicate the deviation from symmetry in the direction already alluded to. The discussion of these differences and the results deduced from them form the third part of the report. The author has laid down on a map of the British Isles these differences, and from them constructed a chart of the lines of equal deviation from symmetry: these lines range from ·100 inch—which passes north-west of the Channel Islands, proceeds towards the Isle of Wight, skirts the shores of Sussex and Kent, and passes through Ramsgate—to ·550 inch, which passes through Limerick, is slightly curved as it crosses Ireland, and proceeds nearly in a straight line across the Scottish Islands to the north-west of Great Britain. The values of these lines express the *depression* of the maximum of the 5th below that of the 12th. Among these lines the author regards the direction of that representing ·200 inch as the best determined. It appears to have passed near and to the west of Helstone, this station exhibiting a deviation of ·258 inch; it then proceeded along the coast of Cornwall and Devonshire, crossed the Bristol Channel, entered Wales, and continued its course across Glamorganshire towards Brecon, which it left to the north-west as it rather abruptly changed its direction and proceeded towards Gloucester, which it passed through. It appears to have undergone considerable inflection as it traversed the central parts of England, rising again towards Nottingham, which is removed ·025 inch from it to the west: it finally left the shores of England at the south-eastern angle of Yorkshire and entered on the German Ocean. The author solicited attention to a feature which characterises all these lines, especially the one just traced, viz., the decided inflection they undergo as they pass over the land. The chart exhibits *two* systems of inflection, one being peculiar to Ireland and England; the general direction of the lines undergoing a change as the line of greatest symmetry is approached, the inflection being governed apparently by the masses of land: and the other to Scotland, the inflection being very decided over the land northward of the Frith of Forth. From the *single* instance discussed by the author, the result appears to be that the symmetry of the barometric curve is departed from in a greater degree at *inland* stations, a greater difference between the points selected being exhibited at such stations than at the sea coast on either side. The report closed with some remarks on the non-persistency of the *direction* of these lines of deviation from symmetry, and on the high probability that they revolve about the nodal point of the two principal systems of atmospheric waves, Brussels.

Health of Towns.

"*Report on the Air and Water of Towns.*" By Dr. Smith.

In commencing his report the author says, it has long been believed that the air and the water have the most important influence on our own health, —and superstitions have therefore constantly attached themselves to receptacles of the one and emanations of the other. The town has always been found to differ from the country: this general feeling is a more decisive experiment than any that can be made in a laboratory. The author proceeds to examine all the sources from which the air or the water can be contaminated. The various manufactures of large towns, the necessary conditions to which the inhabitants are subjected, and the deteriorating influences of man himself are explained. If air be passed through water a certain amount of the organic matter poured off from the lungs is to be detected in it. By continuing this experiment for three months, Dr. Smith detected sulphuric acid, chlorine, and a substance resembling impure albumen. These substances are constantly being condensed upon cold bodies, and in a warm atmosphere the albuminous matter very soon putrifies and emits disagreeable odours. The change which this substance undergoes by oxidation, &c., is next examined,—and shown to give rise to carbonic acid, ammonia, sulphuretted hydrogen, and probably other gases.

The ammonia, generated fortunately from the same sources as the sulphuretted hydrogen, materially modifies its influences. The consequences of the varying pressure of the atmosphere have been observed; and it is shown that the exhalations of sewers, &c., are poured out in abundance from every outlet when the barometric pressure is lowered. By collecting the moisture of a crowded room by means of cold glasses and also dew in the open air, it was found that one was thick, oily, and smelling of perspiration, capable of decomposition and production of animalcules and confervæ,—but the dew beautifully clear and limpid. Large quantities of rain-water have frequently been collected and examined by Dr. Smith; and he says,—I am now satisfied that dust really comes down with the purest rain, and that it is simply coal ashes. No doubt this accounts for the quantity of sulphites and chlorides in the rain, and for the soot, which are the chief ingredients. The rain is also often alkaline,—arising probably from the ammonia of the burnt coal, which is no doubt a valuable agent for neutralising the sulphuric acid so often found. The rain-water of Manchester is about $2\frac{1}{2}^{\circ}$ of hardness,—harder, in fact, than the water from the neighbouring hills which the town intends to use. This can only arise from the ingredients obtained in the town atmosphere. But the most curious point is the fact that organic matter is never absent, although the rain be continued for whole days. The state of the air is closely connected with that of the water: what the air contains the water may absorb—what the water has dissolved or absorbed, it may give out to the air.

The enormous quantity of impure matter filtering from all parts of a large town into its many natural and artificial outlets, does at first view present us with a terrible picture of our underground sources of water. But when we examine the soil of a town we do not find the state of matters to present that exaggerated character which we might suppose. The sand at the Chelsea Waterworks contains only 1·43 per cent. of organic matter after being used for weeks. In 1827 Liebig found nitrates in twelve wells in Giessen, but none in wells two or three hundred yards from the town. Dr. Smith has examined thirty wells in Manchester, and he finds nitrates in them all. Many contained a surprising quantity and were very nauseous. The examination of various wells in the metropolis showed the constant formation of nitric acid; and in many wells an enormous quantity was detected. It was discovered that all organic matter, in filtrating through the soil, was very rapidly oxidized. The presence of the nitrates in the London water prevents the formation of any vegetable matter,—no vegetation can be detected, even by a microscope, after a long period. The Thames water has been examined from near its source to the metropolis, and an increasing amount of impurity detected.

In the summary to this report, Dr. Smith states that the pollution of air in crowded rooms is really owing to organic matter and not merely carbonic acid,—that all the water of great towns contains organic matter,—that water purifies itself from organic matter in various ways, but particularly by converting it into nitrates,—that water can never stand long with advantage unless on a large scale, and should be used when collected or as soon as filtered.

Steam Navigation.

"*On the Improvements which have been made in Steam Navigation.*" By Mr. Scott Russell.

The first great improvement that had been made was in the boilers. Formerly, the boiler-flues were constructed of great length, so that the smoke was kept winding round and round in the flues and at last was allowed to escape with difficulty. Now, however, they had adopted the plan of getting as much fire as possible in the shortest space of time,—and this had been accomplished by imitating as nearly as they could the locomotive engine boiler, by having tubes of thin metal which would evaporate a much greater quantity of water in the same time as flues of the usual thickness; now, also, instead of taking the smoke a long dance as in the old fashion, they used short flues of four to six feet in length, and by having a great many of as thin metal as possible they heated the greatest quantity of water, and had the additional advantage of keeping the metal cool,—in consequence of which a boiler of smaller extent and surface was of much greater efficiency with less weight of metal. The next point of improvement was in the engine; in the construction of which, however, there had been less change than in other matters. The former beam-engine had been changed for the direct-action engine, which was of various kinds; but the greatest change which had been made within the last ten years consisted in the employment of greater quantities of wrought-iron in the construction of the engines, instead of the mass of cast-iron formerly used. This was the only great change.—for the newest Halifax steamers were still fitted up with the old-fashioned or lever-engines. The next improvement consisted in working steam expansively to a much greater extent than heretofore. It was only within the last ten years that they had adopted this principle: the effect of which was that instead of completely filling the cylinder with steam, they filled only to the extent of one-fourth —a volume of steam not of course of equal density, but by which they got two-thirds of the work done and at one-fourth of the cost. The next improvement had been made in the paddle; not so much, perhaps, in the wheel itself—for he was still inclined in favour of the old paddle-wheel, although for short voyages be admitted the advantage of the feathering paddle-wheel which had been advocated by Mr. Price at their Meeting some years ago, and he had then opposed him:—but of this by-and-by. Another great improvement which had been made was the driving the paddle-wheels faster. They had an old maxim which was, whereas a good old horse going 2½ miles an hour could not draw advantageously at more than 220 feet per minute, and that as the steam-engine was only a substitute for horses, and reckoned as so much horse-power, it ought not to go faster than 2½ miles per hour—and this one thing had kept them back for half a century. He did not mean that the result should not be faster than 2½ miles per hour, but that the piston should not rise up and down in the cylinder faster than 2½ miles an hour, which was only four feet in a second, while the motion of steam of 15 lb. was 1,100 feet in a second. Fortunately, however, this old maxim had been abandoned, and the piston now moved from 250 or 270 to 300 feet in a minute. For this improvement they were indebted to no new principle, but to the application of mathematical principles of science. He now came to another great improvement, which was the change in the formation of steamboats, which had been radical—he meant the entire alteration of the form of the ships. A few years ago steam-vessels which would go ten or twelve miles an hour were deemed fast ships; now, however, we had attained a much higher rate of speed. Vessels were then built on the old-fashioned principle that the water-line should be nearly straight, and that the run of the vessel should be a fine line, and that there should never be a hollow line, except a little in the run of the ship, but that there most certainly should not be any hollow line in the bow, for there the water-line should be straight or a little convex. Researches and inquiries were, however, made by a Committee of the British Association as to the form which would enable the vessel to go fastest through the water. These inquiries lasted for years, and they established, by a series of experiments, a set of very curious facts. Formerly, every builder of ships had his notion of proportion; some that the length should be four times the breadth—others that it should be 4½ or 5, —and some went as far as to say that the length should be six times the breadth, but these were deemed innovations; so that although the proportions of width as compared with breadth were said to be fixed ones, yet strangely enough every one differed as to those proportions. Another question was what part of the vessel should have the greatest width, and it was generally thought that the greatest width should be nearest the bow. Some daring persons had, however, put it back as far as the centre of the ship. This was, however, the exception, and not the rule. Then there was another great principle, which was that the bow and stern should exactly balance each other,—that is, that the vessel should be equally balanced; but the new rules which the British Association had established were as follows:—They began by upsetting the old rule with respect to the proportions which the length should bear to the breadth, finding that the greater the speed required the greater should be the length, and that the vessel should be built merely of the breadth necessary to enable the engines to be put in, and to stow the requisite cargo. Then the second great improvement made by them was that the greatest width of water-line, instead of being before the middle, should be abaft the middle of the vessel, and in fact two-fifths from the stern, and three-fifths from the bow. The next great improvement was that, instead of having the bow broad and bluff, or a cod's-head bow, for the purpose of rising over the wave, you might have hollow water-lines, or what were called wave lines from their particular form, and with that form the vessel would be propelled with less power and greater velocity,—and also that instead of keeping to the old fine run abaft and cutting it away you might with great advantage have a fuller line abaft, provided it was fine under the water. Thus by these improvements the form of the old vessel was pretty nearly reversed, to the great annoyance of the old school, and the steamers were given large and commodious cabins and after-holds, instead of having cabins so pinched in that you could hardly stand in them. Another heresy introduced by the British Association was, that of the principle as to the balance of the stern and the bow upon which they now rested; but which was founded in a most singular error, for they left out something which was very material. They concluded that the wave acted equally on both ends of the vessel in striking it; but they did not take into consideration the impossibility of this when a vessel was moving, not having taken into calculation the velocity of the wave or of the vessel, and that from this circumstance the concussion from a wave striking the bow would be a most powerful one, while it could not be so with regard to the stern, because if the velocity of the wave meeting it was fifteen miles, the shock would be as of thirty miles; and, therefore, it became most plain that the bow would give the greatest resistance to the wave. He had examined all the fastest steamers which had accomplished from fifteen to seventeen miles an hour—and in smooth water eighteen miles an hour; and he would venture to state that there was not one of them which accomplished fifteen to seventeen miles an hour, which had not all these alterations in every particular, and that the wave form and wave principle were now adopted by all the great steam-ship builders, and that all the fast steamboats had what was called the wave-bow. Now, of the eight boats on the Holyhead and Dublin stations, if examined, it would be found that all of them were built on these principles, although in some of them there was still left a little of the old principle, some of the boats being made a little fuller and more straight; and if any one would look at one of these boats, it would be perceived that the moment they moved the very wave itself rebelled against them and broke against their bows,—and that consequently these were slower than any of the class; and he gave the details of their construction,—for which we have not space. All of them were examples of the value of the form and the principles which the British Association had advocated and introduced at a very early period in its history.

Mr. J. Taylor stated, that as Treasurer of the Association, he could bear witness to the value of the efforts of the Association in this direction; and he felt bound in justice to state that the credit Mr. Russell had given to the Association was chiefly due to himself, as the individual who, with the late Sir J. Robinson, had conducted the investigations on this subject.

"*On Common Salt as a Poison to Plants.*" By W. B. Randall.

The following notice is presented as being likely to afford a useful practical caution to those interested in the cultivation of plants. In the month of September last, three or four small plants in pots were shown to the writer, nearly or quite dead; and he was, at the same time, informed that their destruction was a complete mystery to the party to whom they belonged, and that Dr. Lindley had expressed his opinion, from the examination of a portion of one sent to him, that they were poisoned. Having searched in vain for any strong poison in the soil, and in the plants themselves, he inquired more minutely into the circumstances of the case, and found that these were only specimens of many hundreds of plants both in the open air and in green-houses (but all in pots) which exhibited, in a greater or less degree, the same characteristics. The roots were completely rotten, so as to be easily crumbled between the fingers; the stems, even in young plants, assumed the appearance of old wood; the leaves became brown, first at the point, then round the edge, and afterwards all over; while the whole plant drooped and died. At least, 2,000 cuttings in various stages of progress, and 1,000 strong, healthy plants had been reduced to this condition; including different varieties of the fir, cedar, geranium, fuchsia, rose, jasmine, and heath. The sight of this wholesale destruction, coupled with the fact that the whole were daily watered from one particular source, suggested the conclusion that the cause of the evil must reside in the water thus used; and this was accordingly examined. It yielded the following constituents, making in each imperial pint of 20 fluid ounces, nearly 9½ grains of solid matter entirely saline, without any organic admixture:—

Carbonate of lime	0·600
Sulphate of lime	0·462
Chloride of calcium	0·200
Chloride of magnesium	1·252
Chloride of sodium	6·906
	9·420

The mould around the plants and an effusion of the dead stems and leaves also afforded abundant evidence of the presence of much chloride of sodium. Further inquiry showed that the well from which the water was procured had an accidental communication, by means of a drain, with the sea; and had thus become mixed with the salt water from that source, and had been used in this state, for some weeks, probably from two to three months. From about that time the plants had been observed to droop; but it was not until nearly the whole of a valuable stock had been destroyed, that any extraordinary cause of the evil was suspected. To place it beyond doubt that the water was really the cause of the mischief, twelve healthy fuchsias were procured from a distance and divided into two parts; half being watered morning and evening with the water in question, and the others with rain water. In a week, the six plants watered from the well had turned brown, and ultimately died, while all the rest remained perfectly flourishing. Assuming from these facts, that the common salt in this water was the chief cause of the results described, it is proved that water containing about seven grains of salt in each pint is, in its continued use, an effectual poison to the weaker forms of vegetation; or that when a soil is continually watered with a weak solution of salt it gradually accumulates in it until the soil becomes sufficiently contaminated to be unfit to support vegetable life. In either case an interesting subject of inquiry is suggested—What is the weakest solution of salt which can produce in any measure this poisonous effect?—or, in other words, at what degree of dilution does the danger cease? For salt is an important natural constituent of much spring water, quite independent of any infiltration from the sea, as in this instance. Thus:—the water of the artesian well, Trafalgar-square, London, contains in each gallon about 20 grains: that at Combe and Delafield's Brewery, 12 7; that at Wolverhampton Railway Station 6; one lately sunk at Southampton, for supplying a private manufactory, 40. May it not be asked, whether the subject of the suitableness of waters in general for the various purposes to which they are applied—be it in manufactories or for steam-engines, domestic purposes or drinking—is not worthy of a greater share of scientific attention than it has hitherto commanded?

Geology of South Wales.

On the Geology of Portions of South Wales, Gloucestershire, and Somersetshire. By Sir H. T. De la Beche.

The rocks of this district have originated in several distinct ways: some have had a mechanical origin, and consist of the detritus of older rocks broken into fragments or reduced to powder, and brought down from the land by rivers, or worn by the breakers from the coast; others have been deposited from a state of chemical solution, like some of the limestones; and some have been formed almost entirely from the aggregation of organic remains. The materials obtained from the destruction of the older rocks have been employed over and over again in the formation of those of later date.

1. The most ancient strata of the district have been denominated Cambrian and Silurian: the former may be seen in Pembrokeshire, towards St. David's. They contain the earliest fossil remains which have been discovered. Numerous volcanoes appear to have been active at this period, ejecting quantities of ashes which, falling into the sea, entombed the animals living on its bed. Even at this early period there may be discovered indications of portions of the sea's bed having been upheaved so as to form dry land or islands. Subsequently a depression took place, and an accumulation of sand was spread over the whole, constituting what is called the Caradoc sandstone. After many thousands of feet of materials had thus been accumulated and become consolidated, another contortion and folding of the strata took place, followed by a change in the nature of the materials deposited in the sea.

2. The second series of deposits constitute the Old Red Sandstone, which consists mostly of detrital matter, but contains occasional beds of impure limestone (*cornstone*), and in its lower part there is a great thickness of marl, also coloured red by per-oxide of iron, and occasionally streaked with blue and green where the iron has been reduced to a lower state of oxidation by the presence of decomposing vegetable matter. The upper beds consist of coarse sand and gravel cemented together and forming a hard conglomerate; the multitude of quartz pebbles, derived from *veins*, indicates an immense destruction of older rocks. No fossils are found in this formation, because sands are always barren, and per-oxide of iron is fatal to animal life when it exists in excess; but in the *cornstones* a few remarkable fishes (*Cephalaspis, &c.*) have been obtained. These rocks appear to have been formed near a coast, whilst at a small distance in Cornwall and Devon the sea was depositing fine sediment, was free from the injurious per-oxide, and abounded in organic life. The Old Red Sandstone is sometimes conformable to the underlying Silurian rocks,—at others unconformable; and in the Valley of the Towy it begins to overlap the Upper Silurian and rest upon the Lower Silurian rocks; further west, it is itself overlapped by the coal-measures which there rest on the Silurians.

3. After this another great change took place, and the sea deposited carbonate of lime, forming the carboniferous limestone, well shown on the coast of Pembrokeshire. The lower part of this series consists of sandstones and shale, in which the remains of fishes occur in abundance. Mollusca also appear; and soon the abundance of organic remains becomes so great that whole strata are formed of their remains: indeed, the carbonate of lime seems to have been chiefly produced by the agency of animal life. This limestone, which is sometimes 2,000 feet thick, dwindles to 70 or 80 feet towards Haverfordwest, and does not appear to have extended far to the north. Here a change of mineral character takes place in the coal-measures, originally consisting of mud, sand, gravel, and accumulations of vegetable matter. The lowest division, millstone grit or farewell rock, is usually a white quartzose sand, but sometimes a calcareous mudstone with organic remains, the equivalent of the culm of Devon. Above this were formed beds of mud and sand, with occasional beds of vegetable matter and carbonate of iron; these beds diminish in thickness from Merthyr Tydvil to Pont-y-pool; and are wanting in Dean Forest, but exist in the Bristol field. With respect to the origin of the coal in this district, there is evidence that it originated in accumulations of vegetable matter which *grew on the spot*. The conditions under which the beds of coal occur have been described minutely by Mr. Logan; under each coal seam is a bed of sandy clay, full of the fossil plants known as *Stigmariæ*, and which Mr. Binney has shown to be the roots of another plant, the *Sigillaria*, equally abundant in the coal, which must have grown in swamps near the sea. After each great accumulation of vegetable matter, the land seems to have subsided, and the sea flowed in, bringing sand and mud and marine shells; again marshes were formed and fresh accumulation of peat and plants, to be in turn covered by silt from the sea. Evidence of the local origin of the coal is also afforded by the frequent occurrence of fossil trees with their trunks erect and their roots spreading out in the clay below; several of these trees, each 14 or 15 feet high, were discovered at the head of the Taw Valley; the outside of their trunks appears to have been originally hard and to have resisted the action of water for some time, but their interior was soft and soon became hollow and filled with mud, which is regularly stratified; the sandstone on the outside of the trees also bears traces of the rippling of the water around them. The iron ore of the district occurs in the form of nodules of argillaceous ironstone, lying in courses; the cracks in these nodules being filled with carbonate of iron just as those in the cement-stones (*septaria*) of the lias are filled with carbonate of lime. One of the phenomena of the coal district is the occurrence of cracks, attended with the displacement of the beds on either side; these *faults* are numerous, and amount in one instance to 2,400 feet; the cracks are sometimes wide, whilst at others the sides are in close contact. Many of the faults appear to have been formed before the deposit of the magnesian conglomerate; but others appear to have been formed at almost every subsequent period. In some instances beds of coal seem to have been partially washed away before the accumulation of the succeeding bed, giving rise to spurious faults, such as that called the "Horse" in the Forest of Dean.

4. At the conclusion of the coal period, all the existing rocks appear to have been squeezed and contorted not only in Britain, but over a great part of Europe, a new deposit of detrital matter began to be formed, similar to those before the coal period, and called by way of distinction the *New* Red Sandstone. Where this formation approaches the older rocks it puts on the appearance of a shingle bed, in which the detritus of the older rocks is cemented together by carbonate of lime and magnesia, hence termed the magnesian conglomerate. These fossil beaches are thickest on the south-west and west flanks of the Mendip and other hills, indicating an open ocean and prevalent winds in that directron. In the red sandstone and marls formed at the same time, but further from the coast, there are no traces of animal life; but as the red stain disappears from the rocks, towards the conclusion of the period, remains of fishes and shells appear.

5. Further subsidences took place; the sea, now freed from the per-oxide of iron, swarmed with animals of extraordinary form and structure. We still trace its boundaries in Glamorganshire and the Mendips by beds of rolled pebbles from the subjacent rocks, and close to these sheltering coasts the remains of marine saurians abound in the consolidated mud and limestone (*Lias*), along with the bones of the flying *Pterodactyle*. Somewhat later, great beds of oolitic limestone were accumulated in the sea, which now constitute the Cotteswold Hills and their extension to Bath and Dorsetshire.

6. No further history is afforded by this district until comparatively modern times, when we find evidence of subsidence beneath the sea and of agencies by which the present form of the surface was accomplished. The present land must have been at least 1,500 feet lower; and, therefore, nearly all under the sea. There is also evidence that the climate became cold, that there were glaciers in the mountains of North Wales and icebergs floating round the shores, carrying blocks of stone and gravel and presenting all the phenomena of polar regions. The sea also accumulated beds of clay, in which the few existing shells are of Arctic character. Still later, the land must have risen again above the sea to an elevation greater than it now has, for we find *submarine forests* fringing all the shores of Europe from Spain to Norway. Of this, one of the best examples occurs in Swansea Bay, where the stumps of oak and alder may be seen at low water, 20 or 30 feet lower than they could have grown.

"*On the Relative Position of the various Qualities of Coal in the South Wales Coal-field.*" By S. Benson, Esq.

The coal is of three kinds: 1. bituminous, the small of which will coke; 2. free-burning, the small of which will not coke, but which burns with great rapidity and a considerable volume of flame; 3. anthracite or stone coal. These three pass into one another imperceptibly; the same vein of coal changing gradually from bituminous to free-burning, and from this to anthracite.

1. The coal beds which crop out on the south side of the basin are highly bituminous, becoming less so towards the north. The five-foot vein, extensively worked near Swansea on the south rise, is highly bituminous,—on the north rise, within a distance of two miles, it becomes free-burning. The various beds also differ considerably in their bituminous qualities and commercial value.

2. The free-burning coals occupy a tract running north-east and south-west through the centre of the coal-field. Those which are intermediate between the free-burning and bituminous are perhaps better adapted than any for smelting purposes,—and in the neighbourhood of Merthyr form the chief supply for the blast furnace, being either used raw or the large only being coked in the open air. The pure free-burning coals are less adapted for smelting, but are preferred for steamers from their readiness of combustion and the absence of clinkers in the grate. Free-burning coals are admitted to government contracts from the following places: Llangennech, Camerons, Graigola, Brindowey, Resolven, and Aberdare.

3. The northern side of the basin is occupied by the anthracite, which graduates through the various "culms" into the free-burning coal. In Pembrokeshire the coal is all anthracite. Taking the area of the Glamorganshire coal-field at 750 square miles, it is estimated that $\frac{1}{12}$ths of this area is occupied by bituminous and free-burning coals, and the remainder by culm and anthracite. It appears that the beds of coal on the south crop lose their bituminous qualities gradually as they dip to the north; so that if on a section lines are drawn to show the boundaries of the qualities of coal

they will not be vertical but inclined to the north. If the change in the quality of the coal is attributed to the influence of subterranean heat, then the inclination of these lines will serve to point out the direction *from* which that heat acted, namely, from the north-west of the coal-field.

Mr. Booker, being called on by the President for some statistical information, stated that there were 159 blast furnaces in the district employed in smelting iron, and that 550,000 tons of iron were annually manufactured. The coal raised in the district was employed as follows:—

1,500,000	tons annually in the manufacture of iron.	
200,000	,, ,, ,, ,,	copper.
150,000	,, ,, ,, ,,	tin.
750,000	,, employed in domestic purposes and in agriculture.	
1,750,000	,, exported.	
4,350,000	tons per annum.	

At this rate, and supposing the coal to exist only over 100 square miles, there was sufficient for 1,400 years to come. The value of the exports from the district, consisting of iron, &c., in a state of rough manufacture, amounted to 4,000,000*l.* a year.

"*On the Submergence of Ancient Land in Wales; the Accumulation of newer Strata around and above it; and the Re-appearance of the same Land by Elevation and Denudation.*" By Professor A. C. Ramsay.

This communication was illustrated by a section, on a true scale, of the rocks near Builth, in Radnorshire, where the Wenlock shales rest unconformably on the Llandeilo flags. The lower rocks must have been elevated previously to the formation of the upper, and their upturned edges must have been worn away by the sea when the upper rocks were deposited or previously. No power is known to exist far below the level of the sea, by which this process could have been effected; it must have taken place at the sea's level. Throughout Wales the Lower Silurian rocks appear to have been disturbed at one particular period, to have been heaved above water and formed a coast, around which the succeeding rocks were accumulated. Near Bishop's Castle the upheaval of the Llandeilo flags was followed by the deposition of the Caradoc sandstone, which is full of pebbles of the older rocks. After this a subsidence appears to have taken place, the area of the sea was increased, and the Wenlock shale was deposited not only over the Caradoc sandstone, but beyond it, as at Builth, upon the Llandeilo flags; and in some places the shale rests on greenstone rocks and certain pebbles from it, being in fact a gravelly sea bottom. This depression of the bed of the sea continued also during the deposition of the Ludlow rocks, which are conformable to the Wenlock shale; and there is no marked alteration in the organic remains of the two rocks. The Wenlock shale is 1,500 feet thick, and the Ludlow rocks 3,500 feet; and as it is certain that their organic remains could not have existed at the depth of 5,000 feet, we must suppose a gradual subsidence of the area, such as is believed to be now taking place amongst some of the coral islands, until 5,000 feet of rocks was accumulated over what had been dry land. The old red sandstone, which has a maximum thickness of 8,000 feet, appears also to have extended over this country, judging by the outliers, at a considerable distance to the north and west. Subsequently, the whole of this series, from the Caradoc sandstone upwards, was removed, and the ancient Silurian strata became the surface of dry land as they had been so long before. It now became a question, what amount of alteration may the Silurian rocks have undergone during the time they were so covered up? If the same laws regulated the ascent of the internal temperature as at present, namely, 1° for every 54 feet, then the addition of 5,000 feet of rock would have raised the temperature by 92°, whilst 9,000 feet would have added 160°, and with 11,000 of superincumbent strata the Lower Silurian rocks must have endured an increased temperature of 212°. To influences of this kind may, perhaps, be attributed the crystalline or metamorphic condition of some of the more ancient rocks,—as suggested by Sir J. Herschel, in a paper communicated years ago to the Geological Society of London.

The Dean of Westminster referred to the Portland rock, in which a bed of vegetable soil occurs, full of trunks of trees, and cycadites; this bed rests on limestone containing ammonites, and is covered by similar marine deposits. Again in the Weald, fossil forests and beds of freshwater shells are found above marine accumulations, and followed by the greensand and chalk. At the present time we find peats, and antlers of the red deer, in the bed of the Channel, several miles off Swansea. On the Norfolk coast, and in the English Channel, are found the bones of the elephant, and fossil wood, disinterred from former cliffs by the action of the sea. These, with many other circumstances, were quoted as showing that whilst the sea-level was fixed, the land had suffered depressions and elevations at many periods of time.

Professor Phillips pointed out the extent of some of these subsidences of the land; for example, the old red sandstone, 8,000 feet thick, all formed in shallow water, and the coal measures 11,000 feet thick, and added under similar circumstances: and inquired what condition of the interior of the earth can have admitted of the gradual subsidence of such great masses of strata? According to Mr. Hopkins's statement, it was improbable that the interior would *now* admit of it. With respect to the augmentation of temperature which would follow on the addition of several thousand feet of strata, it should be remembered that the communication of heat from below, through such rocks, was remarkably slow; and the law of the distribution of internal temperature could not be assumed the same in ancient as in modern times. As to the level of the sea remaining unchanged, this was only assumed for security in geological reasoning; there was evidence in the Malverns of a sea-level 600 feet above the present, but it was impossible to say whether that ancient level was nearer the *centre of the earth* when formed than now.

Coast Levels.—Lieut.-Col. Portlock communicated some observations on apparent changes in the level of the coast near Portsmouth, and contended that, as these evidences of subsidence could be traced back to the most ancient times, so they had continued up to the present day, and expressed his conviction that a parallel might be found in existing nature to all the phenomena of ancient times. It appears that Fort Cumberland, near Portsmouth, stands on a bank of gravel and sand, and that owing to some new wall made to protect it from the sea, a fresh direction was given to the tide, and a portion of the bank undermined and washed away, in the course of which a thick plank with a bolt was discovered, showing that the basis of the fort had no great antiquity. An artesian well has also been made to supply Blockhouse Fort, which shows, for the first 60 feet nothing but clean shingle, and then a layer of sandy clay, full of common oyster-shells.

"*On the Chemical Character of Steel.*" By Mr. Nasmyth.

Were we to assume, as our standard of the importance of any investigation, the relation which the subject of it bears to the progress of civilization, there is no one which would reach higher than that which refers to the subject of steel: seeing that it is to our possession of the art of producing that inestimable material that we owe nearly the whole of the arts. I am desirous of contributing a few ideas on the subject, with a view to our arriving at more distinct knowledge as to what (in a chemical sense) steel is, and so lay the true basis for improvement in the process of its manufacture. It may be proper to name that steel is formed by surrounding bars of wrought iron with charcoal placed in fire-brick troughs, from which air is excluded, and keeping the iron bars and charcoal in contact, and at a full red heat for several days; at the end of which time the iron bars are found to be converted into steel. What is the nature of the change which the iron has undergone we have no certain knowledge; the ordinary explanation is, that the iron has absorbed and combined with a portion of the charcoal or carbon, and has in consequence been converted into a carburet of iron. But it has ever been a mystery that on analysis, so very minute and questionable a portion of carbon is exhibited. It appears that the grand error in the above view of the subject consists in our not duly understanding the nature of the change which carbon undergoes in its combination with iron in the formation of steel. Those who are familiar with the process of the conversion of iron into steel, must have observed the remarkable change in the outward aspect of the bars of iron, after their conversion—namely, that they are covered with blisters. These blisters indicate the evolution of a very elastic gas, which is set free from the carbon in the act of its combination with the iron. I have the strongest reasons to think that these blisters are the result of the decomposition of the carbon; whose metallic base enters into union with iron, and forms with it, *an alloy*, while the other component element of the carbon is given forth, and so produces in its escape the blisters in question. On this assumption we come to a very interesting question—What is the nature of this gas? In order to examine this, all that is requisite is to fill a wrought-iron retort with a mixture of pure carbon and iron filings, subject it to a long-continued red heat, and receive the evolved gas over mercury. Having obtained the gas in question in this manner, then permit a piece of polished steel to come in contact with this gas, and in all probability we shall then have *reproduced* on the surface of the steel a coat of carbon resulting from the re-union of its two elements, namely, that of the metallic base of the carbon then existing in the steel, with the, as yet, unknown gas; thus synthetically, as well as by analytic process, eliminating the true nature of steel, and that of the elements or components of carbon.

"*On Hydraulic Pressure Engines.*" By Mr. J. Glyn.

This paper described the mode of employing the power of waterfalls in a most useful and important manner—too long neglected in this country, considering the advantages it affords in hilly districts for the drainage of mines. Mr. Glyn brought under their notice the means of employing high falls of water to produce a reciprocating motion by means of a "pressure-engine." The pressure-engine acted by the power of a descending column of water upon the piston of a cylinder to give motion to pumps for raising water to a different level, or to produce a reciprocating motion for other purposes. The pressure-engine was calculated to give great mechanical effect in cases where waterfalls may be found of much too great a height and too small a quantity to be practically brought to bear in a sufficient degree on water-wheels within the ordinary limits of diameter. The author produced instances of the desired pressure-engine, one of which was constructed about forty years ago in Derbyshire—and which he believed was still at work in Alport Mines, to which it was removed from its original situation. The cylinder was, he believed, 30 inches in diameter. In 1841 Mr. John Taylor advised the application of another and more powerful engine at the Alport Mines, which was made under his (Mr. Glyn's) direction at the Butterley Ironworks in Derbyshire. This was the most powerful engine that had been made. The cylinder was 50 inches in diameter, and the stroke 10 feet. It was worked by a column of water of 132 feet in height, so that the proportion of power to act on it was as the area of a piston to that of the plunger—namely, 1,963 to 1,385, or fully 70 per cent. The superintendent of the machinery assured him that the engine had never cost them £12 a-year since it was erected. Its usual speed was about 5 strokes per minute; but it was capable of working at 7 strokes per minute without any concussion in the descending column, the duty actually done being equal to 163 horse-power:—Area of plunger 9·621 feet × 10 feet × 7 strokes = 673·41. 673·41 × 62·5 × 132 = $\frac{5555562}{33000}$ = 163 horse-power. The author concluded by remarking that, in this case as in all others when water acts by its gravity or pressure, those machines do the best work when the water enters the machine without shock or impulse and quits it without velocity. They thereby obtain all the available power that the water will yield with the least loss of effect; and this result is best accomplished by making the pipes and passages of sufficient and ample size to prevent acceleration of the hydrostatic column.

"*Analysis of Wrought-Iron produced by Cementation from Cast-Iron.*" By Professor MILLER.

It is to be noticed that considerable change in the specific gravity occurred in the iron after cementation: it was forged, and then found to have increased in density; the brittle iron had a specific gravity of 7·684, the malleable 7·718. The results of analysis were briefly these:—The quantity both of carbon and silicon are materially diminished by the cementation, though still the proportion of both is materially greater than in good bar-iron. It also appears that the portion of carbon which is insoluble in acids is partly the same both before and after the iron has been rendered malleable, the diminution being confined almost to that portion of carbon which was chemically combined with the metal, and which, therefore, would be in a state for propagation through the mass more readily by cementation.

"*On the Drainage of a Portion of Chat-Moss.*" By G. W. ORMEROD.

The *surface* of the moss varies from 80 feet to 100 feet above the sea level; its *bottom* at the deepest part is 100 feet below the sea line. Part of this moss is now being laid dry by means of open drains, under the directions of Mr. Ormerod. After cutting the drains, the level of the peat falls rapidly; near the main leader it sank perpendicularly 5 ft. 6 in. in nine months, and in one part 2 ft. 6 in. in a single week.

"*Extraction of Silver from some of its Ores by the Wet Way, with a Notice of a Process as a Substitute for that of Liquation.*" Communicated by Dr. PERCY.

This communication proposes to treat silver ores with hyposulphate of lime and chloride of lime; and from experiments detailed by Dr. Percy there appears every reason to believe that these substances may be employed economically, and both gold and silver extracted by an easy and effective method. A process as a substitute for that of liquation was also suggested. Mr. Hunt proposed, from the importance in a practical point of this communication, that it be printed entire in the volume of Transactions. Col. Yorke seconded this proposition; and it was adopted.

"*A new Hydrographic Map of the British Isles,*" by HERR PETERMANN, was exhibited.

On this map about 1,550 rivers are distinguished by names, 480 lakes and ponds, and 40 waterfalls; the canals with their altitude, as well as that of the rivers and lakes, and the great drains in the fen districts. It was stated that there were 20 rivers in England, 10 in Scotland, and 10 in Ireland, each draining 500 square miles and upwards. Of these—

18	drain an area each	—	500 to	1,000	square miles.
14	„	—	1,000 „	2,000	„
8	„	—	9,000 „	10,000	„

These last eight are—The

Humber (including Trent and Ouse) to Spurn Point	9,550
Severn (to Flat Holmes)	8,580
Shannon (to Loop Head and Kerry Head)	6,946
Thames (including Medway) to Nore Light	6,160
Barrow	3,410
Great Ouse	2,960
Bann	2,846
Tay, as far as Rhynd	2,250

The river Amazon drains a tract of 2,275,000 square miles.

"*On a New Element of Mechanism.*" By Mr. R. ROBERTS.

The writer explained the construction of a contrivance by which he effected in a very simple manner movements for which more complicated mechanism was frequently employed. The model consisted of a steel stock-shaft, on which were fitted two brass discs in such a way as to be kept steady. One of the discs had eleven teeth rounded at the top and bottom in its circumference, and was placed on the body of the shaft. The other disc, which was rather the larger, was in the eccentric position of the shaft, with its face to that of the toothed disc. The plain disc had four studs rivetted into it at equal distances from each other and at such distances as to admit of their being brought successively, by the revolution of the eccentric, to the bottom of the hollows in the toothed disc. The following movements may be effected by this model:—viz., if the shaft be held stationary and the discs be made to revolve upon it, one of the discs will make twelve revolutions whilst the other only makes eleven. Again, if the toothed disc be held whilst the shaft be made to revolve twelve times, the plain disc will revolve, in the same direction, one revolution only; and if the plain disc be held, the toothed disc will perform one revolution in the contrary direction, for eleven revolutions of the shaft. It would be evident that almost any other number of revolutions may be produced by employing a smaller number of studs, not fewer than three, which will not divide the number of teeth in that disc. The idea of this novel element in mechanics was suggested to Mr. Roberts by a dial movement in an American clock.

MINTS.*

The subject of mints is one on which there is little printed, but Major Smith, of Madras, has brought out a considerable book. This work is mostly directed to the subject of mint accounts, but with this object a close investigation is necessary into the processes affecting the condition of the precious metals in the operation of coining, and this may be found of interest. Major Smith's great purpose is to establish that no loss of *value* of gold or silver can or does take place in coining, and that there is therefore no difficulty, under a proper system of management, of providing an adequate check. He says—

We consider it beyond doubt, judging from the results of actual experience, that there ought to be no loss whatever by the process of conversion, in any of the Indian Mints; on the contrary, as we have elsewhere explained, there ought to be a small surplus in the out-turn. In the discussion, therefore, of the duties and responsibilities of the different officers of the establishment, we shall consider this as being admitted, because our object is to determine what the requisite checks are to insure the business being properly executed; not what may suffice if it be imperfectly done, or slurred over.

Before proceeding, however, it may be advisable that we should first notice and obviate a misconception which has been suggested to us in reference to the above assertion, as it strikes at the very root of all the benefit of the important principle involved in it. It has been said, that it may be very true there ought to be no waste, or even a slight surplus in the re-delivery of the precious metal entrusted to a Mint, provided it were possible to extract all the particles from the mass of refuse wherein they are buried; that by pushing the recoveries to an extreme length, in defiance of all real economy, it may be in fact possible to exhibit a trifling over-plus, though the cost of the extraction of the last particles may have far exceeded the value of the metal; but that unless this reckless contempt of true economy be systematically persevered in, as it is clear that a certain amount of bullion must, of necessity, be allowed to remain untouched, on account of the expense of extraction, a waste must be unavoidable; so that however true in theory, it must be a fallacy in practice to say, that there ought to be a nett surplus of delivery, and an actual *bonâ fide* excess. This argument is, however, based upon a misapprehension of the truth it is intended to oppose, for the assertion is not, that there should be no metal not recovered, but that there should be no metal lost whose existence could not be proved, and its value recovered, if necessary. Further, that as a matter of actual practice, there ought to be a nett surplus of delivery, including the particles in the drosses, whether they be recovered therefrom or whether they be not, which is totally immaterial to the question; to which it may be added, that this excess ought to be so much larger than the value of all the particles which are not extracted from the refuse, that even taking the matter in the sense in which it is viewed in the objection, the assertion still remains practically true.

The principle and the practice we contend for is, that the out-turn of a Mint in coins, bullion, and drosses, ought to be *exactly* estimated, and compared with its receipts; and we affirm that if this be correctly done, and the duties of the Mint have been strictly and faithfully performed throughout, the former ought to exceed the latter, whenever the bullion is debited at the "trade Assay." Which being the case, we are of opinion that, as a matter of system, the comparison ought to be made, and the check thereby established, in preference to the more lax proceeding of omitting the comparison, and writing off all deficiencies to profit and loss as "unavoidable waste in the operations of coinage." The extent to which the extraction of the bullion out of the drosses ought to be carried, is another and a very simple question; the answer to which obviously is, that it should be carried so far, and no farther, than it would be attended by a clear profit to do so. In this way it is that the business is carried on in Madras, the refuse, when no longer capable of being "recovered" on account of Government with profit, being sold, and the proceeds carried to account; and it is according to this scheme of practice, that the actual results which have been referred to have produced a nett surplus amounting to $\frac{1}{13}$ per mille.

If, however, there ought to be no deficiency of the precious metals, it does sometimes happen: it seems that coins are sent out of the mints too good. Thus it is said—

We have been informed, that in the year 1845, the coins issued by the

* "Observations on the Duties and Responsibilities involved in the Management of Mints; chiefly with reference to the Rules and Practice of those of India. With suggestions for their Improvement." By Major J. T. SMITH, H.E.I.C. Engineers, F.R.S., A.I.C.E., Master of the Madras Mint. Madras, 1848.

Bombay Mint were so much above Standard, that if they may be assumed as being fairly represented by 50 pyx assays made of them at the Royal Mint, and the value of the out-turn calculated thereby, they must have contained very nearly 36,000 rupees worth more pure silver than they ought to have done; a case in point showing the impossibility of the Mint officers guarding against loss, because if it be assumed that the merchants were *fully* paid for their bullion, the Mint must have suffered the loss of the above sum.

With regard to the probability of loss of metal, the author examines whether it could take place in the melting, and he mentions—

There is a greater probability in this process, that a real loss, an actual diminution of value should occur, than in any other. I have above stated that a change of value cannot possibly be effected, except by a literal abstraction of the precious metal, and we can easily understand why such is the case. If a pound of *pure* silver, for instance, were melted a thousand times, and if copper were added to and subtracted from it by successive portions: at every step of these processes, provided none of the particles of pure metal had been allowed to escape, the result of every true assay of the metal, whether in its coarse or fine condition, ought to be such as to make its value equal to that of a pound of pure silver. There is nothing in mere manipulation to alter value, unless some of the precious particles are dissipated; but we might be inclined to suspect that this might occur during fusion. It is not impossible, one would think, that silver might be volatilized, and thus the precious metal be diminished in quantity. It is certain that if any alloy be melted, its weight after fusion is considerably reduced; but it is also eqally certain that, practically, not a particle of silver escapes from the furnace.

This being the only point on which the smallest doubt could reasonably be entertained, I have given it the most attentive examination. When I was in Calcutta in January, 1842, and visited the Mint there, I made particular inquiries as to the volatilization of silver. The very idea of such a thing seemed to be considered absurd, and I was assured that no such thing as volatilization of silver had ever been experienced. It was not the custom to sweep out the chimneys, because the volatilization of silver was out of the question, but I was told that when that metal was adulterated with mercury there was a loss, and particles of the mercury might be evaporated. This is true also in regard to lead, fumes of which escape from silver very frequently. But neither of these would at all change the *value* of the mass in fusion.

The same question has also been practically tested at Madras—and though no such thing as sweeping the chimneys for the purpose of recovering volatilized silver had ever been heard of previously, I determined upon having it done, in order to obtain decisive evidence upon a point of so much importance. The result was, that in the chimney of a furnace which had been in constant daily use for about 15 years, and in which many crores of rupees worth of bullion must have been melted, there were collected particles of silver which altogether weighed about 70 *grains*. This experiment taken in connection with the experience of the Calcutta Mint, seems to my mind to be quite conclusive as to the fact that there is no real loss in melting, by any dissipation of the precious metal.

The following is a practical explanation of one of the causes of apparent loss:—

It is notorious, however, that when silver is melted for coinage, the weight after fusion is considerably less than before, even after making this recovery and every allowance. It is admitted also that the metal undergoes refinement, and consequently that it has become purer in quality than it was. All that I wish to add is, that its value after fusion ought to be precisely equal to what it was originally, and that there is no necessary cause for wastage or loss; and this, because it is simply copper, and nothing besides but copper, or base metal, which is injured by the heat, so as to be separated from the alloy and lost in the refuse, whence it is not worth while to recover it. It is owing to the absence of any means of recognising the minute changes of fineness in the silver alloy, and the consequent adoption of a system of account independent of them, that it has been impracticable to exhibit this truth, or to take advantage of it, in the manner indispensable to avoid waste; and the attention being therefore exclusively paid to that change in the metal which alone is palpable, viz., in its weight, is one of the great causes of the real loss which I inquired into. I propose hereafter to detail the means by which this evil has been rectified; in the mean time I must invite attention to another.

When the Mint receives bullion, it is supposed to receive nothing but solid metal, which is charged to it according to its weight and actual fineness, but I found that these supposed conditions did not always exist, and that the bullion was not always made over to the Mint in the solid state. In some cases coins were received, which were always more or less dirty, and these were calculated in the accounts by multiplying the gross weight of dirt and silver by the average fineness of a sample melted for assay. The consequence manifestly was an unavoidable loss, corresponding with the amount of dirt which had been reckoned as silver, and the remedy was plain, viz., taking care to melt the coins always in future. In this way one of the principal causes of the previous loss was got rid of.

Another case was more serious to the parties.

We may also cite a case which occurred in Bombay, where there was a deficiency between the produce and valuation of a particular parcel of bullion received into the Mint, to the amount of about 1,200 rupees. A committee being appointed to inquire into the deficiency, stated, that the discrepancy was apparent, but as it would never do to doubt the assays, they must conclude the fraud had been practised by the melters. The head melter was accordingly ordered to pay the money, and did so; but it was afterwards plainly shown that the valuation had been made without proper precautions against mistake, and that in so far as the evidence went, there was not the least reason to believe that the quantity of bullion for which the melter had been held accountable had ever been received by him.

In annealing, an apparent increase of weight takes place, which is thus explained.—

The process of annealing is for the purpose of softening the blanks, and making them more fit to receive the impression of the die. It also assists the operation of the acid in cleaning. The blanks are placed in a reverberatory furnace and brought to a red heat, after which they are cooled, either by immersion in water, or by exposure to the air. The effect of this process is a slight increase of weight, owing to the combination of oxygen with the alloy in the metal; and as it is entirely superficial, it varies in its proportion according to the form and superficial area of the pieces exposed to its action. We have not made any experiments with minute accuracy on this point, as the pieces after leaving the laminating and adjusting department are counted on transfer, and thus passed from hand to hand by tale, so that trifling variations in the gross weight cease to be of any importance; but from the experiments which we have made, the difference of weight in rupees has been shown to be about 3 annas 7½ pie per mille, or 4⅓ pie per cent. As this increase of weight is occasioned merely by the addition of a foreign substance (oxygen) to the metal, it cannot of course, by any possibility, be the cause of any loss of value.

In blanching, a slight difference in the apparent weight takes place, because in some mints grease and oil are used in laminates, which adheres to the metal and is removed by the acid.

Difference of *weight* may take place, but difference of *value* cannot; and it is by adopting this latter test that a proper system of accounts can alone be adopted. We may remark, in conclusion, that the author has laboured very hard and conscientiously in establishing the correctness of his views; and, which excites the more admiration, as having been done under the hot sun of Hindostan and in a state of ill-health.

THE PLATE-GLASS TRADE.

The statistics of the manufacture of plate-glass in England, just published in a tabular form, with a few remarks appended, on a folio sheet, by Mr. Henry Howard, of Plaistow, in Essex, are very instructive.

In 1819 the excise duty on plate-glass was 98*s.* per cwt.; none was made in England larger than 120 inches by 72, the quality was indifferent; the price when 12 inches square was 13*s.* 1*d.* per foot, when 120 inches by 72, it was 160*s.* per foot.

In 1827 the excise duty was 60*s.* per cwt.; plate-glass 144 inches by 75, was manufactured; the quality was considerably improved; the price of plate-glass, when 12 inches square, was 6*s.* 8*d.* per foot, when 114 inches by 75, it was 50*s.* per foot.

In 1847 there was no excise duty on plate-glass; plates 144 inches by 76 were manufactured; the quality was very much improved: the price of plates 12 inches square was 3*s.* 4*d.* per foot; plates 144 inches by 76, cost 35*s.* 6*d.* per foot.

In 1819, when the excise duty was 98*s.* per cwt., the quality of the glass was indifferent, the average price per foot 20*s.* to 25*s.*, the quantity sold per week about 3,000 feet, and the supply apparently equal to the demand.

In 1827, when the duty was 60*s.* per cwt., the quality was improved, the average price per foot 10*s.* to 12*s.*, the quantity sold per week about 5,000 feet, and the supply inadequate to the demand.

In 1847, when the excise duty had been taken off, the quality was very much improved, the average price per foot 4*s.* to 5*s.*, the quantity sold per week about 70,000 feet, and the supply very inadequate to the demand.

In 1836, when the excise duty was 60*s.* per cwt., the estimated number of hands directly and indirectly employed in the manufacture, was about 2,500, the capital invested in it about 250,000*l.*

In 1847, when the duty had been taken off, the number of hands was about 12,000, the capital about 1,000,000*l.*

No comment is required on the tendency of these facts to show how much the manufacture was benefitted by the reduction of excise duties; how much more it has been benefitted by entire emancipation from the trammels of the excise.

Since 1845 foreign plate-glass had been allowed to be imported free of duty. In July 1847, Lord George Bentinck undertook to prove (in Parliament) that the removal of the glass duties had been a failure. He stated that the declared value of glass exported in the first five months of 1845 was 215,630*l.*; in the first five months of 1846, only 131,739*l.* But his lordship omitted to state an important explanatory fact pointed out by Mr. Howard:—"It was in the first five months of 1845 that the duty was remitted, and during that particular period the makers and dealers exported enormous quantities of every description, not on account of increased demand from abroad, but for the express purpose of obtaining the large drawbacks (amounting to bounties) which were then, for the last time, allowed by the excise."

The fact is, that an official return, dated May 5, 1848, printed by order of the House of Commons, shows the total amount of foreign plate-glass, entered for consumption in England, to have been 99,841 feet. This is at the rate of 1,920 feet per week. The number of feet of English make sold per week during that time being 70,000, while in 1845 it was only 23,000. The importation, instead of causing a displacement of English labour, has, by stimulating competition, improved quality and lowered price, and by thus increasing consumption, caused more English labour to be employed.

The state of the exports, as shown by the return already referred to, is equally satisfactory. The exports of English glass in 1847 exceeded those of 1846, in flint-glass, by 20 per cent.; in common window-glass, by 42; in bottles, by 5; in looking-glasses, by 49; and in plate-glass, by 110 per cent. Well may Mr. Howard remark, "Looking at the unexampled commercial difficulties of 1847, this increase is almost incredible."

Two facts relative to the trade in plate-glass, stated by Mr. Howard, have a bearing upon these general results too important to be omitted. Of two agencies established here, exclusively for the sale of foreign plate-glass, one has been compelled to relinquish the sale of it, simply from inability to withstand British competition. There was no English plate-glass exported to the United States in 1846; while, in 1847, it equalled in amount the exports to all the world in 1846.

How, then, are we to account for complaints made both in and out of Parliament that British interests have suffered from the remission of the glass duties? Mr. Howard throws some light on this question:—"In 1845, when the excise duty was remitted, the English makers reduced the price of small plates (which foreigners could not afford to send here at all) to a fair and equitable scale, but the large plates (which, paradoxical as it may appear, cost less per foot than the small ones) were kept up at the unreasonable rates quoted above. Our neighbours, the French and Belgians, attracted and encouraged by the simplicity which thus invited them here, under cover of our excessive prices, accordingly brought over and sold their larger fabrics at enormous profits, whilst our manufacturers, realising still greater advantages, and supported by an immense demand, refused to modify this extraordinary tariff, although its manifest injustice to the public, and direct tendency to injure the very interest it was intended to promote, have been almost universally condemned as the climax of absurdity."

Labour forms directly and indirectly nearly 80 per cent. of the cost of plate-glass. The raw material is nearly all English produce. In short, it is a natural manufacture. As such it was depressed by heavy excise duties, and not relieved by protection from foreign competition. Since it has been emancipated both from the oppressive and the protective influences of fiscal regulations, it has daily grown in strength and prosperity, in defiance of competition. It is only under such a system that branches of industry, natural to a country, can flourish, and such branches of industry only are really advantageous to a nation.

THE GREAT VIADUCT ACROSS THE DEE, IN THE VALE OF LLANGOLLEN.

While the speed to be attained by mechanical ingenuity is being intensely considered, the architecture of our railways is not forgotten, and we feel pleased to have it in our power to notice one of the most daring and stupendous efforts of skill and art to which the railway has given rise. We refer to the great viaduct now in course of completion across the valley of the Dee, in the Vale of Llangollen—the dimensions of which surpass any thing of the kind in the world. While the tubular bridges across the Menai Straits and Conway River are, from their novelty, attracting much attention, the undertaking referred to has proceeded nearly to completion, without any considerable notice being taken of it. Its vastness of proportions may be better conceived, when it is stated that, in magnitude it far exceeds what is considered the greatest effort of human skill in connection with railway communication—the Stockport viaduct. The Dee viaduct (for this is the term given to the one at Llangollen) is upwards of 150 feet above the level of the river—being 30 feet higher than the Stockport viaduct, and 34 feet higher than Menai Bridge. It is supported by 19 arches of 90 feet span, and its length is upwards of 1530 feet, or nearly one-third of a mile. The outline of the structure is, perhaps, one of the handsomest that could have been conceived, both as regards its chaste style and attractive finish; and its general appearance is considerably enhanced by the roundness of the arches, which are enriched by massive quoins, and the curvilinear batter of the piers: this style of architecture imparts a grace and beauty to the structure without impairing its strength. The greatest attention seems to have been paid to the abutments—the only part of the erection, in reality, where any decorative display could be made. In the middle of both, on each side, there are beautifully executed niches in the Corinthian order, in addition to some highly-finished masonry. The piers are neatly wrought at the angles, and at the base of nearly each there is a bedding of upwards of 400 square feet of masonry. With the exception of the entradoes of the arches, which are composed of a blue sort of brick, the whole structure is built of beautiful stone—if not as durable, equal in richness and brilliance to Darlydale. The viaduct has an inclination from end to end of 40 feet, and connects that part of the Shrewsbury and Chester Railway between Rhos-y-Medre and Chirk. Viewed from beneath, the vast structure presents a noble and truly grand appearance, and its bold proportions, with its height, cannot fail to call forth admiration from the most indifferent beholder. While the view below developes what art can accomplish, that from the summit surpasses in richness and luxuriance of the picturesque any landscape in the kingdom. Situated in the middle of the far-famed Vale of Llangollen, there is all that nature and art can bestow to make the view charming and beautiful. On one side are bold and swelling hills, on the other a plain teeming with luxuriance far and wide. Within view are Castell Dinas Bran, or, as it is commonly called, "Crow Castle," which is situate on the crown of a conical hill—the glaciated rocks, Wynnstay, and Pont-y-Cyssyllte, or the Dee Aqueduct. This last structure, which conveys the Ellesmere Canal, is within a short distance from the viaduct, and, from its beauty and extent, imparts additional interest to the locality.

The viaduct has been erected by Messrs. Makin, Mackenzie, and Brassy, contractors, at a cost of upwards of 100,000*l.*, being upwards of 30,000*l.* more than the Stockport viaduct. The cost of the timber required to form the scaffolding, &c., for its erection was 15,000*l.*, and between 300 or 400 masons alone were employed during the whole time of construction. Within a few miles distance there is another viaduct in course of building across the valley of Ceiriog. This structure will be upwards of 120 feet high, and will have 10 arches, of 45 feet span, and one of 120 feet. The entire length will be at least 850 feet, and will cost, when completed, a large sum of money.

NOTES OF THE MONTH.

The Copying Electric Telegraph.—We mentioned in a former number (p. 191 *ante*) that an electric telegraph had been invented by Mr. Bakewell, by means of which a written communication could be copied at a distant town, so as to enable correspondents to recognise the handwriting of each other. This telegraph has, during the past month, had several trials between London and Slough, that line of wire being the only one that can be spared by the Electric Telegraph Company for experiments. The results of these trials have proved that the power transmitted along the wires is quite sufficient for the copying process, as only the same batteries were employed as are necessary to work the needle telegraph. We have seen several specimens of the writing copied along 40 miles of wire, which prove that when the instruments are accurately constructed, copies of any writing may be taken by means of this telegraph. With the model instruments and a single wire, the copying was, we understand, done twice as quickly as communications can be made by the needle with a single wire, and Mr. Bakewell expects to be able to increase the speed ten-fold with larger instruments. Independently of the gain of speed by this means, there would be greater confidence given to telegraphic communications, if the intelligence received were written in the handwriting of correspondents, since by the present mode of communicating there is no proof that the information received is authentic; and as the messages transmitted by the copying process are traced from the original writing, there can be no errors committed by the misunderstanding of signals.

The New Brazilian War-Steamer "Affonso."—The first pair of marine steam-engines built in Bolton, were constructed by Messrs. Benjamin Hick and Son, for the *Affonso*, Brazilian war-steamer, which has obtained such honourable notoriety by the services it rendered to the passengers and crew of the *Ocean Monarch*. These engines are made on the direct-acting principle, are 300-horse power, and several improvements have been introduced in their construction. The framing for supporting the paddles and intermediate shafts is made of forge or wrought-iron, and some idea may be formed of the value of this improvement, by comparing it with the ordinary cast-iron framing generally adopted. One of these pedestal blocks, of which there are four, when shaped and finished, weighed 28 cwt.; but if made of cast-iron, and equally strong, the weight would have been 80 cwt., and even then the liability to fracture would be more than trebly hazardous. There is, also, in the construction of these engines, a simple and improved arrangement of the eccentric and reversing motion, which enables the valves to be reversed for going ahead or astern with the greatest ease, and by which the labour of three men to each engine is saved when reversing. The mode of introducing the injection water is also new, simple, and effective. The *Affonso* was built for navigating the shallow rivers of the Brazils, and she is well armed for the protection of their trade, having a 64-pounder fore and aft, which swivel on carriages, and also four 34-pounders in her side ports. The vessel and engines were built under the orders and inspection of Admiral Grenfell, the Brazilian consul at Liverpool, and though from her construction she was not expected to sail more than 9 knots per hour, she accomplished 11½ on her trial trip.—*Liverpool Mercury*

The Britannia and Conway Bridges.—The report of Mr. Stephenson, presented to the meeting of the Chester and Holyhead Railway, on the 24th ult., stated that the construction of the second tube of the Conway-bridge is far advanced, and there is no doubt it will be ready for removal by the middle of October. The pontoons have been strengthened, the capstans re-erected, and every other arrangement in a forward state for its erection. About three-fourths of the masonry of the Britannia-bridge have been completed; and, taking the progress now making as a guide, it is calculated that the first tube will be ready for lifting to its place in the course of next March or April. The iron-work at the Britannia-bridge has progressed even more rapidly than was expected, and the four large tubes are just approaching completion. The whole of the central portion of the tubes is finished, and the castings at the ends are now being inserted. The scaffolding for the end tubes on the Anglesea side is complete, and a large proportion of the iron is already punched for their immediate commencement. The scaffolding necessary for the tubes on the Carnarvon side will be erected immediately, to open the line throughout as rapidly as possible. Every arrangement is being made for floating the tubes as soon as the masonry is ready. The works throughout the whole of the line are standing in the most satisfactory manner. The daily passage of heavy trains through the Conway tube for four months, together with a series of careful observations as to the effects produced, have completely established the correctness of the views upon which the designs for this and the Britannia were based. The cost of these structures has very much exceeded what was originally calculated upon; on re-considering, however, the whole subject, Mr. Stephenson is satisfied that the method which has been adopted is certainly the most eligible, if not the only practicable one.

Mode of Extinguishing Fires at Sea.—The following letter has been addressed by Dr. Reid to a daily morning paper:—"As the danger from fire at sea is attended with so many appalling circumstances (of which we have had a recent instance in the melancholy catastrophe of the *Ocean Monarch*), I beg to submit for the public consideration, and especially underwriters, the following plan, as a cheap, simple, and efficient method of preventing the occurrence of such accidents. Flame or combustion cannot go on where there is carbonic acid gas. This is one of the elementary principles of chemistry. It may be shown in various ways. A lighted taper plunged into a jar of carbonic acid gas is instantaneously extinguished; or, if we take the glass of a common argand burner, and close the upper end of it by a flat plate of glass, or even by a piece of card or pasteboard, firmly, so completely as to prevent any current of air through the tube, on introducing for about an inch or so the flame of a candle at the other extremity (the glass of the argand burner being held upright) it will, usually in the space of little more than a minute, be extinguished, merely by the accumulation of the carbonic acid gas produced by its own combustion. The production of carbonic acid gas is completely at our command, for on adding dilute sulphuric acid to chalk, we can set at liberty, in the space of two or three minutes, enormous volumes of this so-called fixed air. The cost of material for a ship of 1,000 tons would not exceed 15*l.* or 20*l.* sterling By means of tubes proceeding from the upper deck in connection with a cistern containing the dilute sulphuric acid, to the quarters below where there is most likelihood of danger from fire, or moveable hose (made of gutta percha), which can be introduced into any part of the vessel—the oil of vitriol, previously diluted with water, can be at once poured over the chalk (which is to be thrown down in the place where the fire rages), and immediately, the carbonic acid being set at liberty, the fire is extinguished; for combustion cannot go on in an atmosphere of carbonic acid gas. I have been much occupied experimenting on this subject, and find that from five tons of chalk, as much carbonic acid gas may be obtained as will be sufficient to completely fill a vessel of 1,000 tons burden. The expense of laying the tubes will not exceed 30*l.* or 40*l.*; and, once laid, there is no further trouble or expense. I may observe also (but experiments are at variance on this subject) that it is not requisite to have an atmosphere absolutely consisting of carbonic acid gas to extinguish flame, for some experiments show that a taper does not burn in an atmosphere of three parts atmospheric air and one part carbonic acid gas. Lightning-conductors are provided for ships—surgeons also to take care of the health of the crew—assuredly no expense (and it is but a trifle) would be grudged to secure a ship and its passengers from the contingency of such a melancholy mishap as that of fire. If this method will do—and there seems to be everything in its favour—all our emigrant ships, indeed every ship, ought to be secured against a calamity which really must be held as the most dreadful that can occur to a vessel at sea."

South-Eastern Railway.—The works at London Bridge for enlarging the station and widening the Greenwich Railway viaduct, suspended during the monetary panic of 1847, have been resumed. The bridge to cross Bermondsey-street is rapidly progressing. The Gravesend branch is also in a very forward state. It is expected to be opened for public traffic early in the spring.

Railway Signals.—Another of the many contrivances suggested for enabling passengers in railway trains to communicate with the engine-driver or guard, has been recently patented, though it differs little from several others of the same kind. The patentee is Mr. Richard Baird, of Dundee, and he claims the application of tubes to railway carriages, and the combination of cords, wires, or chains with the tubes, in such manner that either the passengers or guard may sound the steam-whistle. It is proposed to connect the cords passing through the tubes under each carriage by spring hooks.

Great Western Docks, Plymouth.—These docks are being proceeded with rapidly, and, when completed according to the design, will furnish accommodation superior to that afforded by any docks of similar extent. The inner basin, or floating dock, will be capable of containing and affording ample wharfage for 12 steamers of the largest size, a number, we believe, equal to that accommodated by the great basin at Portsmouth, recently opened. There will be two entrances to this basin; one will admit merchantmen of the largest size, and steamboats of ordinary dimensions, for two or three hours before and after high water—through the other the largest screw-steamer can pass at high water. The area of the outer basin will be nearly 30 acres. If this basin should be deepened to the extent proposed, vessels can enter and be afloat in it at all times of the tide without the delay of pasing through a lock. This is an advantage not possessed by Liverpool, and many other ports. The entire extent of wharfage will exceed a mile, and the area of ground for stores is adequate to the greatest possible trade.—*Devonport Chronicle.*

Birkenhead Docks.—It appears by the *Liverpool Times*, that the most active preparations are going on in the engineer's department of these works, in the preparation of working drawings, &c., for the recommencement of the construction of the docks forthwith. Arrangements, it is said, have been made for raising the requisite capital, and no doubt remains as to the successful accomplishment of the object of the new trust. An important trade is opening up in the exportation of coal from the Welsh mines, which can be brought, it is said, to Birkenhead docks, and put on board vessels at very considerably less cost, and with far greater facility, than from the Lancashire coal-field.

The Grimsby Docks.—These are mighty works, and are proceeding with most satisfactory rapidity, alike creditable to all concerned. The chief engineer, Mr. Rendell, is expected shortly; but the engineer, Mr. Adam Smith, who is very properly called the resident engineer, is always on the works. There is a defect, or rather a sinking, in one portion of the piles from the "blow sands"—a name upon which tradition has exhausted its ingenuity, and has summed up all by ascribing to demoniac agency the "fathomless pit." Shakspeare was right in putting into *Hamlet's* soliloquising thoughts, "Oh, what a mighty piece of work is man!" and had he lived to see the mighty pieces of work which man achieves, some other as appropriate exclamation would by him have been furnished. One hundred and fifty acres taken from the sea, and defences raised to prevent the mighty ocean claiming back "its own," and such defences as will resist its foaming rage, let its battering waves lash it as they may—borrowing from some of its sister land chalk as the means of defence, of which no less a quantity than 10,000 tons are every week conveyed on a road of iron. By October, it is expected all will be ready to receive his Royal Highness Prince Albert, to lay the first stone of the intended Royal Albert Grimsby Docks; and, within three years, a dock of 37 acres will be ready to receive vessels laden with foreign stores. So much progress could not have been made but for the perseverance of Mr. Adam Smith, and those under his directions.—*Nottinghamshire Journal.*

Clifton Suspension Bridge.—Upwards of £40,000 have already been expended upon this undertaking, and no more money being forthcoming the works are now at a stand-still.

Improvements in Bridge Building.—A fine wooden bridge has recently been erected by the Cambuslang-road trustees, across the river near Dalmarnock, to supply the place of the old one, which is now 30 years old, and very much decayed. The new bridge was commenced only five months ago, and was built from a design by Mr. Robson, C.E. The whole length of the bridge is 356 feet, and the width within the side-rails is 28 feet. There is a footpath on each side, covered with asphalte pavement, and the road-way is composed of a mixture of asphalte and whinstone metal, broken, 7 inches deep, and laid on the top of the planking, which had been previously well caulked with oakum, and coated with pitch and sand, for the purpose of making it water-tight.

Circular Sawing.—An experiment has been lately made at the Saw-mills, Woolwich-dockyard, with the view of testing the efficiency of circular saws in cutting through the centre of rough timber of a diameter nearly equal to that of the saw itself. An elm tree—one end of which was of the full diameter of the saw—was placed upon one of the circular sawing machines, having a saw 4 feet diameter, and a self-feeding motion, in the usual way. By this motion the tree was brought towards the saw, and passed over it; and by a reverse motion, it was turned back. The cut made in the tree, passing over the saw, was in dead wood all the way, and fully 20 inches deep. After the tree was run back, it was turned over, and adjusted for a second cut, to line with the first; and in this position it was brought forward, as before, and completely divided in two.

Method of Welding Iron, Steel, and Sheet-Iron.—In an earthern vessel melt borax, and add to it one-tenth of sal-ammoniac. When these ingredients are properly fused and mixed, pour them out upon an iron plate, and let them cool. There is thus obtained a glassy matter, to which is to be added an equal quantity of quicklime. The iron and steel which are to be soldered, are first heated to redness, then this compound, first reduced to powder, is laid upon them; the composition melts and runs like sealing-wax. The pieces are then replaced in the fire, taking care to heat them at a temperature far below that usually employed in welding; they are then withdrawn and hammered, and the surfaces will be found to be thus perfectly united. The author asserts that this process, which may be applied to welding sheet-iron tubes, never fails.—*Mechanics' Magazine.*

The South-Foreland Lighthouses.—These edifices are now completed, and their appearance reflects credit on all parties concerned in their erection. There are two—the one called the Upper, and the other the Lower South-Foreland Lighthouse. The headland on which they stand is the nearest point in England to the coast of France, the distance being barely 21 miles across the Channel. The upper lighthouse consists of a massive tower (externally octagon, internally circular), the lanthorn of which is about 375 feet above high-water mark, leaving a perpendicular height of the cliff on which it is situated of about 290 feet. The lanthorn is constructed on a novel principle. It is furnished with 264 mirrors, which are inclosed on the side opposite the sea by six lenses. These mirrors, casting a multitudinous reflection on each other, afford a stong and brilliant light, being clearly visible on the opposite coast, throughout the Downs, Ramsgate, and even Margate, and the greatest portion of the Isle of Thanet. The lamp, which is in the centre of the lanthorn, consists of one large socket, containing four burners; and it supplies itself with oil by means of a kind of clock-work machinery, which, while it pumps up the oil to the wick, also returns the surplus quantity to the reservoir; and in case of any defects, or want of supply, by a small hydraulic balance, strikes a sharp tinkling bell, as a warning to the keeper. The machinery is very simple, and at the same time curious. The lanthorn consists of a cupola, the roof and sides of which are composed of neatly wrought-iron frames, apparently light, but sufficiently strong to stand against the tempest. It is enclosed by 48 oblong panes of plate-glass, from 2½ to 4 feet long. Around the cupola, on the exterior, is a balcony, rendered safe by a castellated parapet, from which, in clear weather, a splendid view is obtained. Passing from the upper lighthouse, about a quarter of a mile easterly, is the lower one, standing on the verge of the cliff. The tower is not so high as the former, neither is it lighted on the same principle. Within the lanthorn are suspended from copper branches 15 Argand lamps, each having a burner of rather large dimensions with a concave reflector of the greatest brilliancy, and about 20 inches in diameter. It appears that it is yet a matter of doubt which system of lighting is preferable, but the Corporation of Trinity are giving each a fair trial.

The "New Star," Steamboat.—Some experiments were tried on this vessel, on the river Thames, on the 27th ult., preparatory to the building of a new iron steamer. The trials were highly satisfactory, an average speed being attained, after several trials at the mile distance at Northfleet, of 13 miles per hour in dead water. The engines and vessel were manufactured by Messrs. Miller and Ravenhill. Tonnage, 265; oscillating engines of 68-horse power; diameter of cylinders, 34 inches; length of stroke, 2·9; number of revolutions per minute, 48.

Launch of a Steam-vessel in the Thames for Service in Scotland.—A very handsome-built iron boat was launched, on Saturday, the 16th ult., from the building-yard of Miller, Ravenhill, and Co., Orchard-wharf, Blackwall. This is the third vessel turned out by the above firm for the Edinburgh and Northern Railway Company; the two former vessels being known as the *Auld Reekie*, and *Thane of Fife*. The new craft is expressly adapted for the passage across the Frith of Forth, and will have a speed superior to the former squadron. She was christened the *Express*, and will be furnished with a pair of oscillating engines of 120-horse power, a pair of feathering wheels, tubular boilers, &c., which are now erecting on board. Her length is 150 feet between her perpendiculars; breadth, 148 feet at load line; depth, 11 feet; draught of water, 6 feet.

Alleged Propulsion of a Vessel by Steam in the Year 1543.—M. Gonzales, director of the Royal Archives of Simancas in Spain, published in 1826 an account of an invention by Biasco de Garay, a naval captain, who, it is stated, exhibited in Spain, in 1543, an engine, by which ships of the largest size could be propelled in a calm without the aid of oars or sails. He made an experiment before commissioners, appointed for the purpose of examining his invention at Barcelona, on the 17th of June, 1543—the vessel used being a ship of 200 tons. Garay, we are informed, wished to keep his mechanism a secret; but it was observed to consist partly of a large cauldron, or vessel of boiling water, and of two moveable wheels, one on each side of the ship. The experiment succeeded so far, that the vessel was propelled at the rate of two leagues in three hours; and the inventor was rewarded by receiving a sum of 200,000 maravedis, besides having his expenses defrayed from the public treasury. It is added, that the invention would have been further encouraged had not State expeditions of great consequence claimed the immediate attention of the emperor. And it is important to mention, that the authenticity of the entire history of Garay's invention, as published by Gonzales, has been called into question, and that no practical results of any utility followed. *Frazer's Magazine.*

Gutta Percha Boats.—At Seacombe, a No. 1 pilot boat, built of gutta percha has been tested. It is 17½ feet long, and though nearly filled with water, and having four men on its gunwale, kept its buoyancy. It weighs 190 lb. and sustains a pressure of 15 cwt. It not only answers the purpose of a pilot-boat, but is also convertible into a life-boat. This substance must make an excellent life-boat; and before we saw the above account, we had thought of calling attention to the feasibility of this application. The toughness, elasticity, and lightness of this material, for the purpose of boat-building, is unquestionable. The price is one dollar per pound, and 30 pounds must make a boat of a moderate size. The old gutta percha can be sold at a reduced price.—*Scientific American.*

Indian Waterfall.—Among the cliffs of the Eastern Ghauts, about midway between Bombay and Cape Comorin, rises the river Shirawati, which falls into the Arabian Sea. The bed of the river is one-fourth of a mile in direct breadth; but the edge of the fall is elliptical, with a sweep of half a mile. This body of water rushes at first, for 300 feet, over a slope at an angle of 45°, in a sheet of white foam, and is then precipitated to the depth of 850 feet more into a black abyss, with a thundering noise. It has, therefore, the depth of 1,150 feet! In the rainy season the river appears to be about 30 feet in depth at the fall; in the dry season it is lower, and is divided into three cascades of varied beauty and astonishing grandeur. Join our fall of Genesee to that of the St. Lawrence, and then treble the two united, and we have the distance of the Shirawati cataract. While we allow to Niagara a vast superiority in bulk, yet in respect to distance of descent it is but a mountain rill compared with its Indian rival. —*Rochester Democrat.*

The American Lakes.—Professor Drake, of Cincinnati, has been making some observations upon these inland seas, and gives the results to the public. The chain of lakes extends over nearly eight and a half degrees of longitude in length. The extent of their surface is estimated at 93,000 square miles; and the area of country drained by them is computed at 400,000 square miles. Their relative sizes are as follows:—"Ontario, 5,300 square miles; Erie, 9,600; St. Clair, 360; Huron, 30,400; Superior, 22,000. The average depth of water in the different lakes is a question upon which there is no certain information. Authorities differ. Dr. Drake gives it as follows:—St. Clair, 20 feet; Erie, 84; Ontario, 500; Superior, 900; Huron, and Michigan, 1,000. In standard works, Lake Erie is usually stated to have a depth of 120 feet. The depest soundings have been made in Lake Huron. Off Saginaw Bay, 1,800 feet of line have been sent down without finding the bottom. The altitude of these lakes varies step by step from Ontario to Superior. Lake Ontario is 232 feet above the tide-water of the St. Lawrence. Erie is 333 feet above Ontario, and 565 feet above the tide-water at Albany. St. Clair is 6 feet higher than Erie; Huron and Michigan are 13 feet above St. Clair, and Superior lies 44 feet above them. This shows the curious fact that while the surface of Huron is 684 feet above the level of the ocean, its bottom, at Saginaw Bay, is more than 1,100 below the same level. The waters of these lakes, with the exception of Erie and St. Clair, are remarkable for their transparency and delicious flavour. Of Lake Huron, Professor Drake ascertained that the water at the surface, and 200 feet below the same place, indicated precisely the same temperature,—namely, 56°. His explanation of this fact is: the waters are so pure that the rays of the sun meet with no solid matter in suspension to arrest and retain the heat."

New Cement.—The *Buffalo Journal* describes a valuable cement, which was first discovered in Sharon, Medina county, Ohio, and, after undergoing the most thorough test, has been pronounced of great value for cementing roofs of buildings, steamboat decks, &c. The mine itself (says the *Cleveland Herald*) is one of the most singular depositories to be found. It seems as if poured into a large sand-stone basin, covering some four acres, is found at the depth of 20 feet, presents an even level surface, is about 5 feet thick, and when dug out is no harder than tallow, and is entirely free from dirt and other impurities. An exposure of two weeks to the air changes the cement to stone, so hard, that it is difficult to grind. In preparing it, the cement is first ground when green, and after it has been hardened, it is ground again, and remains in a powdered state until mixed with oil for use. When applied to roofs, it becomes hard and durable as slate, and is a certain fire-proof, and is in no way affected by the weather. We have been shown a specimen of the cement that has been on wood nine months, which adheres closely, is as hard as the slates used in schools, shows pencil marks equally as well, and has the grit of a fine hone. The cost is small, being 3 dollars per cwt., which, with the same amount of oil, is sufficient to cover 1,200 square feet.

A Portrait of Mr. T. Cubitt, by Pickersgill, has been subscribed for by the Builder's Society.

Salt.—A spring of brine has just been "tapped," by Mr. B. Smith, at Droitwich, Cheshire, at the depth of 217 feet—being a greater depth than any before discovered; the usual depth being 170 or 180 feet.

On the Occurrence of Vanadium in the Refinery Slag of Staffordshire.—Mr. Deck, in a communication to the *Chemical Gazette*, says—"Being commissioned by an eminent English railway engineer, who has directed much attention towards the qualities of iron employed in bridges, &c., to examine some refinery slag, which, without any assignable reason, had the property of imparting extraordinary ductility to the iron with which it was mixed, I have succeeded in discovering a large quantity of vanadium, existing as silicate of vanadic acid, combined with small portions of molybdena, chrome, and the usual quantities of phosphoric acid and silicates. The first metal being confined to few localities, has had its properties but little studied by English chemists, and has hitherto been found in no other slag than that from the Taberg mine in Sweden, the iron of which is remarkable for its ductility; and no mention is made of it in Dr. Percy's elaborate analyses of slags for the British Association. The quantity of slag at my command operated upon was very small; but the vanadium existed in a much larger proportion than in the Swedish slag, which I have since examined; and it is, doubtless, the cause of the superior ductility of both."

A New Method of Cutting Trenches for Drain Tiles has been invented by Mr. White, of Kennington-road; it is for the purpose of slicing-out the earth, of just sufficient width for the admission of the pipes, instead of the unnecessary and expensive plan at present (from necessity) in use, of digging a trench large enough for the men to work in, perhaps, 2 feet broad, when it may require only a 4 inch, or, at most, a 6-inch drain. The machine consists of two large wrought-iron wheels, of any required diameter, 1½ inch thick at the centre for 12 inches diameter, then tapering to a knife-edge, which is to be hardened steel. These are fitted in a frame, immediately behind each other, but sideways, such a distance apart as to suit the diameter of the pipe intended to be employed. They turn, however, rather closer at bottom than at the top, in order to render the cut of a tapering form smallest at bottom, for the more ready removal of the earth. The implement is drawn by horse-power backwards and forwards, in the direction of the cutting, until the necessary depth is required. As these knife-wheels would cut much better, by having a jet of water dripping upon the earth to be cut, a cistern is proposed to be carried upon the frame. To give increased—indeed, double—power to the horses, when the friction would be very great, a small anchor is to be fixed in the ground, at any distance, for a single piece of cutting—a rope from which would pass through a pulley on the machine, and the horses pull from that end of the rope; the earth is afterwards removed by a peculiar plough. Supposing the implement to travel at the rate of 1½ mile per hour, and that it had to pass over the ground three times to produce the required depth, and that the distance between the drains is 30 ft., in 10 hours it would cut 18 acres.

Smelting Copper.—A correspondent of the *Mining Journal* gives the following process as adopted at Toraas, in Norway:—The ore, which is the common copper pyrites, containing a large proportion of sulphur, when brought from the mine, is spalled to about the size of a walnut. A round kiln, built of dry stones, about 3 feet high, with apertures at short intervals, is constructed; two cubic fathoms of wood are laid in the bottom; on this the ore is placed; this quantity of wood, in general, is supposed to be sufficient for the calcination of 100 tons of ore. When lit, the mass generally burns for three weeks; towards the close of the operation, smalls are thrown on the pile, to prevent the too rapid calcination of the ore. As soon as the fire has ceased, the kiln is opened, and the ore is then wheeled to the smelting-works; if properly calcined, it has a dark red appearance, and is exceedingly friable; great care is required in this operation, as too much heat will cause the ore to melt, and a regulus will be formed. The ore is, in general, allowed to remain three or four days, previous to its being forwarded to the ulterior operations. It is then melted in a common blast-furnace, similar to those used in the Hartz, and other parts of Germany; it requires there about 70 cubic feet of charcoal to smelt 8 cubic feet of copper. The regulus produced from this operation is from 15 to 20 per cent. produce, has a coarse open grain, and, in general, a deep purple appearance. This is subsequently calcined six times; a semicircular kiln, about 6 feet long by 2 feet broad, with an aperture at the end, is built; 4 fms. of wood is in general required to the produce of 100 tons of ore; each calcination takes about 24 hours. After undergoing these calcinations, the regulus assumes, when broken, a white appearance, with a close grain, somewhat similar to white metal. From thence it is taken to the copper furnace, and after remaining there 12 hours, is tapped out in the form of rose copper (*gahn kobber*). The produce of this is about 94 per cent.

Wood Carbonised by High-Pressure Steam.—M. Violette, commissary of the government gunpowder works at Esqueros, has communicated to the Paris Academy of Sciences a process he had adopted for making charcoal suitable to the manufacture of the best kinds of gunpowde. He finds that at a temperature of 200° centigrade = to 392° Fah., wood does not carbonise; that at 250° centigrade = to 482° Fah., an imperfect charcoal alone is obtained, formerly called *brûlots*, or burnt wood; that at 300° centigrade = to 572° Fah., the red charcoal is produced; and that, at 350° centigrade = to 662° Fah., and above, the operation invariably furnishes the black or complete charcoal. The time necessary for carbonization, he found to vary from three hours to half an hour, and the products passed from red charcoal to black progressively. He also took account of the produce of the charcoal, and found it to diminish in quantity in proportion as the carbonization was carried to a more advanced stage. The quantity of wood usually operated upon by M. Violette was 25 kilog. = ½ cwt., and the wood employed, the blackthorn (*rhamnus frangula*).

Fossil Tree.—A few days since, the workmen employed in the railway-cutting near the Coalbourn Brook, Staffordshire, discovered a fossil tree, in a perpendicular position, in the lime and iron-stone formation called *clunch*. It was 20 inches in diameter, and the top as flat as if regularly sawn off, while, in weight and hardness, it resembled iron-stone. A piece, of 4 feet in length, has been sent to Enville-hall, to enrich the Earl of Stamford's museum; the lower part still remains, but its length has not yet ben ascertained.

A Coal Bed on Fire.—Under the village of Lower Haugh, near Rotherham, Yorkshire, an extensive bed of coal has been burning for twenty years, and threatens to destroy the village by undermining the foundations of the houses. The heat is very sensibly perceptible at the surface, and the inhabitants take advantage of it as a natural hot-bed for raising early vegetables. The sulphurous smell and smoke, however, form a great drawback to this privilege, and indeed render some of the houses scarcely habitable. The coal was ignited at a part where it "bassets out," by making a large fire there for the purpose of burning stones intended for road materials.

The "Great Britain" Steam-Ship.—This celebrated vessel, with her machinery, sails, anchors, cables, &c., was put up for sale by auction, at Liverpool, on Monday, the 18th ult., at which port she has been since September last. The "Great Britain" was built at Bristol, in 1844, by the Great Western Steam-Ship Company, for the New York trade: she was 3,442 tons, registered old measurement; her length of keel and fore-rake, 286 feet; ditto over all, 319 ft. 3 in.; beam, 50 ft. 4 in.; depth 32 feet. She was propelled by engines of nearly 1,000 horses'-power, and fitted with Woodcroft's patent screw propeller; and has accommodation for 250 cabin passengers, with stowage room for 800 tons cargo (measurement), and 1,200 tons coal. Her great strength enabled her to withstand the shocks of the heaviest seas, while stranded in Dundrum Bay, on the northern coast of Ireland, throughout a whole winter, without in the slightest degree altering her lines. The damage done to the engines and ship's bottom has been carefully estimated, after surveys by competent engineers and ship-builders, and, for a moderate sum, the whole ship and machinery might, it is stated, be restored to the original condition. With a smaller pair of engines, capable of propelling her at a slightly reduced speed, by which her coal stowage would be reduced one half, she would accommodate over 1,000 emigrants for a distant voyage. The spacious sale-rooms of Messrs. Tongue and Curry, were densely crowded with merchants from all parts of the kingdom—there being at least 300 gentlemen present. Mr. Curry said, he was instructed to put the vessel up at a certain price, for the parties by whom he was employed, but he should prefer an offer from the company present. Some time having elapsed, the auctioneer informed the company that 20,000*l*. were offered for her. Another pause then ensued, when he said he should take her in, on account of the owners, at 40,000*l*. During the progress of the sale, it was stated in the room, that if from 30,000*l*. to 35,000*l*. had been bid for the vessel, she would have been sold. She originally cost 125,000*l*.

The New Park at Battersea.—The new park at Battersea, which has been for some time in abeyance, will be commenced without delay, notices having been conveyed on the 16th ult. to all the residents on the spot, that they must quit possession, the intention being at once to remove the houses. The water works will remain. The park will extend the whole distance between Battersea Bridge and Nine Elms, and from the bank of the river to the public road across Battersea Fields, making the length of the park about two miles and a quarter, and its width a little more than a mile. A carriage-drive forty feet in breadth will be formed along the bank of the Thames, and a suspension-bridge will be thrown across the river to the spot where the Red House now stands. Towards the construction of this bridge the Marquis of Westminster has contributed the sum of 60,000*l*. At the south-western boundary of the park an elegant church has been erected, and will be ready for consecration in the course of the present autumn.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM AUGUST 22, TO SEPTEMBER 21, 1848.

Six Months allowed for Enrolment, unless otherwise expressed.

Hugh Lee Pattinson, of Washington-house, Gateshead, Durham, chemical manufacturer, for "Improvements in manufacturing a certain compound or certain compounds of lead, and the application of this and certain other compounds of lead to various useful purposes."—Sealed August 22.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for "certain Improvements in dressing or cleaning grain, and in separating extraneous matter therefrom." (A communication.)—August 22.

Edward Deuch, of Hurstperpoint, Sussex, hot-house builder, for "Improvements in the roofing conservatories, hot-houses, and other like structures."—August 26.

William Young, plumber, and Henry Burgess Young, engineer, both of Barnstaple, Devon, for "Improvements in smelting and refining lead ores."—August 28.

Charles Rowley, of Birmingham, Warwick, button-manufacturer, for "Improvements in the manufacture of buttons."—August 28

Elizabeth Chrees, of Homerton Castle, Homerton, Middlesex, for "Improvements in the manufacture of sealing wax."—August 29.

Peter Wright, of Dudley, Worcester, vice and anvil manufacturer, for "certain Improvements in the manufacture of vice-boxes, and in the machinery for effecting the same."—August 31.

George Nasmyth, of Ebury-street, Pimlico, Middlesex, civil engineer, for "certain Improvements in the construction of fire-proof flooring and roofing, which improvements are also applicable to the construction of viaducts, aqueducts, and culverts."—September 4.

William Wheldon, engineer to Messrs. John Warner and Sons, of Jewin-crescent, London, brass-founders and engineers, for "Improvements in pumps or machinery for raising or forcing fluids."—September 4

John Lewis Ricardo, of Lowndes-square, Middlesex, Esq., M.P., for "Improvements in electric telegraphs, and in apparatus connected therewith."—September 4.

William Edward Hollands, of 73, Regent-quadrant, Middlesex, dentist, and Nicholas Whitaker Green, of 15, Walton-place, Chelsea, gentleman, for "a new manufacture of artificial fuel in blocks or lumps."—September 4; four months.

William Losh, of Newcastle-upon-Tyne, for "Improvements in steam-engines."—September 4.

Henry Smith, of Vulcan-works, West Bromwich, for "Improvements in the manufacture of railway wheels."—September 5.

William Dickinson, of Blackburn, Lancaster, machine-maker, for "certain Improvements in, and applicable to, looms for weaving."—September 11.

Robert Walter Winfield, of Birmingham, merchant and manufacturer, and John Ward, of Birmingham, aforesaid, a workman in the employ of the said Robert Walter Winfield, for "certain Improvements in the manufacture of tubes and in the manufacture of certain articles made in part of tubes."—September 14.

William Sager, of Rochdale, Lancaster, wool-dealer, for "certain improved means and apparatus for effecting the transit or conveyance of goods, passengers, and correspondence, by land or water, and for other such purposes, part or parts of which means and apparatus constitute a new and improved method of generating steam, which improvement is applicable to other purposes to which steam is generally applied as a motive power."—September 15.

William Brown Roof, of Stanhope-street, Regent's-park, chemist, for "certain Improvements in the construction of respirators."—September 21.

Henry Wilson, foreman to Messrs. William Greaves and Son, of the Sheaf-works, Sheffield, for "Improvements in the manufacture of chisels and gouges."—September 21

Joseph Lillie, of Manchester, engineer, for "certain machinery or apparatus applicable for purifying and cooling liquids, and for purifying, condensing, and cooling gases."—September 21.

John Frearson, of Birmingham, machinist, for "Improvements in bending or shaping iron or steel, and other metals."—September 21.

CANDIDUS'S NOTE-BOOK, FASCICULUS LXXXVII.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. I lately called attention to a very feasible improvement, or rather, highly desirable completion, of an important public edifice —namely, Somerset-place; and my remarks appear to have been not entirely thrown away, since they have been noticed by others. I will now mention another building—a public one, of considerable importance, and admirably situated in many respects, it having among other advantages that of being placed directly at the extremity of a vista from one of the most frequented thoroughfares in the whole metropolis. Notwithstanding all which, it is in itself a most flagitious architectural monstrosity. Can any one, after this, be at a loss to guess what is the building which I allude to? I myself know of no other so situated, precisely at the end of a vista whose sides enclose it. After this, and my calling it a perfect monstrosity, can you possibly be any longer in doubt? Those who still are so, ought to be left sticking fast in it, and left to help themselves out of it as well as they can. Don't be in a hurry, good folks; take your time, or take a map of London, and examine it, and then—Oh! you have found it out, have you? you guess that I allude, after my own rigmarole fashion, to the front of Guildhall. Well! since there is no denying it, I confess it: it is the front of Guildhall that I mean,—and both mean and unmeaning enough it is in itself. Civic taste runs more in favour of turtle soup than architecture, or the citizens would abridge the number of their annual tureenfuls of that luxurious fare, in order to accumulate funds for a worthy exterior to their banqueting-hall. As far as it goes, their taste is unexceptionable, but it does not go far enough; it is very palatable, but not at all palatial,—at least, not externally, the exterior of their Hall of Guild being as tasteless as can well be conceived. Instead of turtle, venison, and champagne, it announces water-gruel and cag-mag; it being the most veritable architectural cag-mag ever produced. Some of the city folks must, I think, have longed to carry off the Victoria porch from the Palace of Westminster, and plant it as a portal before their Guildhall, with such addition as might be found requisite for filling up the entire frontage. What that last may be, I cannot undertake to say,—there being no published plan from which measurements can be ascertained. However, that we should there have a *fac simile* or duplicate of the Victoria porch at Westminster, is not at all to be desired. We might be very well content with something of similar character in regard to nobleness of idea and grandeur of design. Yet, so long as there is no absolute occasion for doing anything to the building, nothing is likely to be done; wherefore, one is almost tempted to regret that it was not burnt down by the fire that broke out close by it some time ago, and threatened to lay hold of it; but was, unfortunately, laid hold of itself, and arrested before it could perform the good office of ridding us of that scandal to City taste. Pity that that taste is more Apician than Vitruvian,—that it patronises turtle soup so much, as to have no patronage left for architecture.

II. There are buildings which seem to have been intended to exemplify errors and defects, and thereby deter from anything similar being attempted. Among such monitory and well-intentioned works, we may place the front of the Royal Institution, in Albemarle-street, which looks like a huge lodging-house, with as many eyes as Argus, peeping out from between the columns of a Corinthian temple,—perhaps that of Argus himself. Instructive it may fairly be called, inasmuch as it makes manifest at a glance the utter preposterousness of attempting to unite together, as is there done, two such irreconcileable systems of composition as are those of Columniation and Fenestration. Now, I am not quite so straight-laced in my opinions as to object to an order being employed as decoration, but then it should in every case accommodate itself to the structure which is so ornamented, instead of affecting to produce the same expression as a simple open colonnade, where the columns and their entablature alone constitute the exterior of the fabric. When first seen in such a foreshortened view of it that the windows within the intercolumns are concealed, the front of the Royal Institution suggests the idea of an open colonnade upon a noble scale; but the very next minute we are undeceived, disappointed,—even disgusted. Instead of finding anything like nobleness or grandeur, we are shocked at the positive littleness and meanness which prevail in everything but the columns themselves. Not only is there a most violent and offensive contradiction occasioned by the adoption of conflicting modes and ideas, but there is no sort of keeping whatever as to style. After the columns, there is nothing whatever of Corinthianism in the other features and details. We find the most florid order applied as decoration to what is itself kept most penuriously bare; so that richness and poverty of style—or, I might say, style and no-style—are coupled together. With such absence of all artistic feeling is that pretentious façade treated, that what is meant for its decoration, causes the building itself to appear most insignificant, or even worse. Although both the columns themselves and the front are large enough, the whole is a mass of littleness and prosaic sameness; for, as if there were rather a paucity than superabundance of windows, the very doors are made to resemble the windows as much as possible: therefore, so far, the design may be said to be all of a piece throughout—yet after so unlucky a fashion, that instead of being a merit, that circumstance becomes a defect.

III. Taste is subject, not only to wholesale revolutions, but to strange fluctuations and relapses. One day we are disposed to think that taste has taken a better direction than before, and is likely to advance in it if allowed to have its free course; when, the very next, perhaps, we are startled and shocked, puzzled and perplexed, by some architectural monstrosity which runs quite counter to, and upsets our calculations. Although such is the fact, it seems hardly credible that two structures which are almost within sight of each other, and erected in the very same year, should exhibit such diametrically opposite tastes as do Bridgewater-house and Mr. Hope's new mansion in Piccadilly. The latter is such a vile compound of uncouthness and deformity, as to be nothing less than marvellous. That precious sample of design is said to be by some foreign architect,—which is the only thing to console us; yet, let whoever may be responsible for the design itself, the discredit of adopting it falls upon no other than Mr. Hope himself. Had an ignorant employer—one compelled to trust entirely to the taste and judgment of others, been prevailed upon to make choice of such a piece of studied ugliness, he would have been to be pitied, and our astonishment would have been greatly diminished. But Mr. Hope is not the man to be so imposed upon; he has the reputation—the hereditary reputation at least, of being an authority in matters of art and taste, wherefore he is almost the very last person from whom so public a display of bad taste was to be apprehended. Besides marvelling much, there is also room for fearing that, through the influence of his name, his example may become contagious, and encourage others to perpetrate similar architectural enormities. One comfort is, the building seems to be universally disliked and condemned; while the evil else to be apprehended from such example will now be greatly counteracted by the very opposite one of Bridgewater-house. What is to be regretted is, that instead of occupying as public a situation as the other, the latter mansion is comparatively secluded from notice. Even its Park-front cannot be seen very satisfactorily, all the lower part being completely screened by the garden, with its fence and shrubbery; and of as much of it as is visible, the rich and delicate detail becomes almost lost, owing to the impossibility of approaching sufficiently close to inspect it as it deserves. And the other, or south-front, which is somewhat the longer of the two, is where it is almost concealed from public observation,—Cleveland-row being no thoroughfare into the Green-park, but a mere *cul-de-sac*.

IV. Bridgewater-house puts its neighbour, "Sutherland," quite out of countenance. The two buildings contrast very strikingly with each other, and afford a very good lesson, and make manifest that decided improvement upon the whole has taken place within the last five-and-twenty years. In point of architectural quality, Sutherland-house is a very ordinary production (by two of the Wyatts); *mesquin* in its *ensemble*, and insipid and flavourless at the best. There is nothing about it that can really be called style: it has none of the stamina of style, but merely feeble, *usé* mannerism, without a single touch of genuine artistic feeling or taste, or of *con amore* diligence. Undoubtedly there are many things quite as poor, or even very much worse; therefore, if it be any praise to say that of it, to such praise Sutherland-house is unequivocally entitled. Such praise, however, is only condemnation in a milder shape; and if the structure in question is not to be called a failure, it is only because nothing more than dull *routinier* mediocrity seems to have been aimed at—and it has been produced. Apsley-house is another piece of Wyattism, and is such as to make us hope that that *ism* is now departed from among us for ever. In those days, Sansovino seems to have been quite unknown here, or else must have been put into an *Index Expurgatorius*.

V. In the subjects generally proposed to architectural students in competition for academical medals or other premiums, no very great judgment is shown, they being almost invariably of a class altogether out of the sphere of usual practice. Such subjects as royal palaces, senate-houses, cathedrals, and others of a similarly ambitious kind, do not exercise those faculties and abilities which are most of all necessary, because the opportunities for exerting them are comparatively of every-day occurrence. He who can display talent, ingenuity, and taste, on occasions which seem to afford hardly any room for displaying them, will be at no loss for ideas on more important occasions that may require him to put forth his strength, at the same time that they afford great scope for his imagination. The converse does not hold good: the production of an extravagant chimerical *projet* as an academical theme, is no pledge for the sort of talent which is really wanted, any more than the obtaining a Gold Medal is any pledge for after-distinction. Subjects so rare and exceptional that they may be ranked among the phenomena of the art, are hardly the very best preparatory themes and exercises. Even granting that they tend to develope and confirm artistic talent of a higher grade, if the talent itself be of a kind that requires extraordinary emergencies and illimitable resources for exerting and displaying it, it becomes, in a manner, a superfluous one. Unless he at the same time has powers more generally available, the possessor of it is likely to prove in the condition of Hercules employed in spinning with a distaff, at which labour his gigantic thews and sinews could have been of little service to him. Of Hercules' handiwork of that sort, no "long yarns" have been preserved as relics; but no doubt they were rather clumsy ones—as clumsy as this fantastic comparison will perhaps be considered by many. So I drop it, and resume with a fresh paragraph.

VI. Such ambitious efforts in architectural design as those above alluded to, do not at all serve to call into play what is a most valuable species of ability, that which can accommodate itself to untoward circumstances, and overcome difficulties. Where a *carte blanche* is offered, all those thwarting and fettering conditions which the architect must expect to meet and contend with, are got rid of at once. Comparatively little exertion of thought is required where what may be called dreaming will suffice. Were *carte blanche* matter of course on all occasions, imagination might be left to run riot at will. Though as to imagination, it may be doubted whether even that is much exercised and disciplined by the kind of subjects proposed for *Grands Prix* and Gold Medals. They generally show more of high-flown but empty architectural *bombast*, than of fertile invention. When examined, they may be found to be made up out of the usual stock ideas—some of them rather worn out, or at least the worse for the wear. It requires no great exertion of imagination, or power of fancy, to draw out upon paper mile-long colonnades, or spires that shall pierce the clouds. Between such mere extravagance and the artistic and poetical, there is a wide difference. Moreover, it is very possible to be exceedingly extravagant and exceedingly dull at the same time. Some of Soane's architectural "visions," as it pleased him to call them, partook of that double quality. There was enough of them as to measure and quantity, but the stuff itself of which they were formed was very ordinary and homespun—far more prosaic than poetical in texture. Schemes of such magnitude have ere now been produced upon paper, that Barry's "Palace of Westminster" would shrink into insignificance in comparison with them; yet, though the things themselves have been of monster size, they have oftener than not been made up of rather dwarfish ideas. Even empty common-place may be inflated to such bulk, as to look not only large, but solid too. But as a monster *projet* proposed by an Academy is required for producing the inflation, the bladder empties itself, and falls to the ground again. Were colossal monumental edifices reared by us every day, there would be some reason in proposing them as subjects to students; although even then they ought to be accompanied by some sort of conditions, which would have to be observed; but as such is not the case, it would surely be better to direct study with more regard to the application of it on ordinary occasions. And the talent which can display itself upon such occasions,—which is capable of elevating what seems to be a common-place subject into the sphere of art, by happiness of treatment and skilful touches,—is, though it may seem a comparatively humble, an exceedingly rare one. It is one that demands artistic feeling, and a thorough knowledge of artistic character and effect. It works out, as it were intuitively, rules for itself, which unlike ordinary technical ones, do not admit of being formally and clearly expressed in words.

VII. Ordinary rules have, no doubt, their serviceableness, but it is rather of a negative sort: the observance of them will prevent faults, but will not ensure positive beauties, or other merits than those which partake of mere routine, and are therefore equally at every one's command—of the novice as well as of the master. Rules are indispensable, since they constitute the very grammar of the art; but from its grammar to its poetry the distance is prodigious—at least, so great that ninety-nine out of a hundred never advance beyond the former so as to reach the latter. What is done by mere rules and routine, can be accomplished by one man just as well as by another. It is the something more—the undefinable and individual *non so che*, which lying beyond the reach of rules, is not to be overtaken and caught by them. As far as this finer quality of art can be studied and learnt at all, it is what every one must study for himself; for it is not to be learnt from general precepts and rules, but from a careful and diligent examination of examples marked by such felicitous quality. Rules teach *much*, but they do not teach *all*. Yet, instead of being frankly acknowledged, this is a truth which is thrust aside and kept out of sight; whereas it is one that ought to be strongly impressed upon every student. Rules and the observance of precedent will suffice for mere mechanical copying, but if architecture need not, or cannot now advance beyond that, it ought to forfeit all pretension to the character and title of Fine Art. And why should it or its followers for it be ambitious of such title, if it cannot support it by acting up to it? If we are content with it in its present condition as a mechanical art, wherefore not confess as much by calling it so, instead of claiming for it an empty title, which only reminds us of what it no longer is? As a Fine Art, all its privileges seem to be gone; therefore, they and its power being gone, it would lose nothing by being deprived of its nominal rank. This will, no doubt, be considered very harsh and unwelcome advice. Well, then, if its rank must not be given up, let us endeavour to render it worthy of such rank, and to re-instate it in its quality of Fine Art, endowed with all those prerogatives and privileges of which in these latter days it has been despoiled and stripped, and forced to subsist upon the remnants of its former treasures.

VIII. Many, it might be supposed, would be really glad, were the idea of architecture being a Fine Art to be altogether renounced, since art does not seem to be at all their element. They are safer on *dry* land—on the honest *terra firma* of practical routine. Art is a treacherous element to those unprepared for and inexperienced in it. If, according to the opinion which, though not formally expressed, is to be gathered from the remarks of certain writers, we have no further occasion for artistic invention, or any actually operating and creative principle in architecture, but may get all the art that is required for it at second-hand, and would therefore do well to confine ourselves exclusively to traditional forms and ideas,—if such be the case, and we can now dispense with art itself, we can surely dispense with the name of it. Or, if we must call it art, let us call architecture the art of making new buildings by copying or hashing-up old ones. But to affect to consider and style it a fine art, when we make it in practice just the reverse, partakes too much of quackery. Architects are now such a numerous class, that it would be strange if there were not some among them who might fairly aspire to the honourable name of artists; but the majority have very questionable claim to it, and some none at all; nor even so much as any genuine relish for their "art": and the want of earnest affection for it, is of itself a proof of the want of the talent requisite for it.

IX. Those who admire one style of architecture, are apt to be not merely indifferent to, but intolerant of every other. The lover of pure Greek architecture sees only the corruption of it in the Roman style; and of this latter, the degradation in the Italian. His standard of excellence is the Parthenon; and by that standard he tries everything else, no matter how different may be the principles upon which it is constituted. He would have Greek-Doric temples spring up everywhere throughout the length and breadth of Europe, and of America also. He is willing to extend some degree of favour to Ionic, that being at all events Grecian; but Corinthian is Roman, and shows a sad falling-off from the manly simplicity of the earlier style. On the other hand, the lover of Roman and Italian design is equally strong both in his liking and his antipathy, holding Greek architecture to be frigidly severe and monotonous, exceedingly *borné* withal; and Gothic, together with all other mediæval styles, to exhibit only the barbarous conceits of the dark ages,—to be utterly devoid of "proportions," lawless, extravagant, and irreducible to "rules." Such at least used to be the case, for at the present day, such sweeping condemnation and insolent contempt of mediæval architecture cannot be expressed with impunity. *Tempora mutantur:* Gothic may be said to have now the ascendancy, and its admirers and devotees repay with compound interest the insults and indignities which it formerly received from the Italian school and its followers. Opposite as they are in their tastes, all these parties are alike in one respect, they being all alike one-sided, prejudiced, and intolerant in their antipathies, and cheating themselves out of much varied enjoyment by limiting the sphere of it to the compass of a single style of the art; instead of sympathising with the beautiful and intrinsically æsthetic in architecture, whatever may be the particular form under which it presents itself, or the name to which it answers.

STUDY OF MECHANICS.*

Mechanical science is certainly the most ancient branch of natural philosophy. The very commencement of existence is the exercise of force; and of all his physical powers, the first which man puts into operation is his strength: the whole business of his animal life consists in the exercise of it, and from the beginning of the world until now, every human being, from his cradle to his grave, has been making repeated experiments in that knowledge which only modern philosophers profess to teach with perfect accuracy.

Why has a study, of which the study has been universal and uninterrupted, advanced with such slow and uncertain steps? This tardy development is not the history of all other sciences. Geometry—the exact knowledge of forms and dimensions—though its applications to the purposes of life are much fewer, and much later required, became a methodic science, while mechanics still remained a crude collection of facts. So late as the end of the sixteenth century, the very simplest phenomena of falling bodies were in doubt. A heavy body falls to the ground more rapidly than a light body, said the opponents of Galileo.—The weight of the bodies makes no difference in their motion, was his counter-assertion. Now, here was a question which the world might be presumed to have settled for itself before it was five thousand six hundred years old. If there be any operation of nature more frequently observed than another, it is this very one of the descent to the ground of unsupported bodies. Yet, notwithstanding the incalculable number of previous observations, it was necessary that Galileo should appeal to direct experiment to support his views. He ascended to the top of the leaning tower of Pisa, with two balls differing very much in weight, yet both of such a density as not to be much affected by the action of the air. The balls were simultaneously dismissed from his hands, and reached the ground at the same moment, or at least without perceptible interval.

This was conclusive?—On the contrary, the discussion gained in vehemence what it lost in argumentative reasoning. Galileo's opponents were not convinced, but merely irritated. From time immemorial, it had been believed that the greater the mass of a body, the greater was the acceleration of gravity. Was it to be supposed—they asked—that they and all preceding philosophers, from the time of Aristotle, had been mistaken on this fundamental point? Rather than concede that, they chose to disbelieve the evidence of their own senses.

The momentum of mind operates as manifestly as that of matter. The difficulty which Galileo had to combat, arose not from the nature of his subject, but from the necessity of overcoming the previous tendency of men's minds, and moving them in a contrary direction. This difficulty has existed throughout the history of mechanical science: *now*, also, it is the greatest obstacle to the student's progress.

If there were no previous errors and prejudices to be overcome, no previous misconceptions to be unlearned, mechanics would be one of the most easily-acquired branches of human knowledge. If the brain were as an unwritten, unsullied scroll, ready to receive those fair characters which have been traced and perfected by the co-operation of the most stupendous efforts of human intellect—the liability to error and confusion would almost cease to exist. But this can never be the case. The student has been learning mechanics long before he commenced the study of its systematic laws. He has, as was before said, been experimenting on the subject from his infancy; and his experiments have been so crude and irregular, that almost every conclusion derived from them involves a certain amount of error.

Not until a very considerable progress be made in the study of mechanics, is the full extent of this disadvantage perceived. The science may be approached with a perfect willingness to acquiesce in its doctrines, but the perversion of undigested experience creates difficulties and prejudices which not the will merely, but great mental strength and long-continued mental habit also, are required to overcome. It becomes, then, a matter of great importance to the student to ascertain before-hand the precise nature of these prejudices and difficulties. They are manifold: and before they can be fully understood, some idea must be acquired of the character of the evidence on which the conclusions of the theory of mechanics are founded.

This evidence is of several kinds: that which will most influence the tyro—that which will always be most valid in popular estimation—is the *weight of authorities*. The testimony, however, of great names, high as it is in itself, is by far the lowest kind of evidence of the truths of mechanics. A sciolist will stop the mouths of those who know as little or less than himself, by quoting the authority of Newton, Leibnitz, Euler, the Bernouillis, Lagrange Laplace, or Poisson. The man of science cannot be so answered. To him—to no one else so much—the ideas of these master-minds are of the highest importance; but they do not work conviction. Between the effect of Newton's *dictum*, and of the greater part of Newton's *reasoning*, there exists that immeasurable difference which intervenes between a very high probability and absolute certainty In the absence of more exact information, the mere knowledge that a certain conclusion is supported by the opinion of one or more of the great founders of the science, will and ought of itself be a strong argument, but not an insuperable one. To assert that the authorities were fallible, is merely to assert that they were human, and that science is progressive.

Another, and a higher, though not the highest, evidence, is that derived from comparing the remote predictions of theory with actual observations. Let us cite an instance. Mathematicians infer from the law of gravitation, that the earth moves round the sun in an elliptic orbit, if the very small perturbations arising from the influence of other celestial bodies be neglected. This prediction as to the earth's course is so remote a consequence of theory, that it could not have been immediately foreseen—the theory could not have been shaped *merely* to meet this particular case. Now, the knowledge of the earth's actual course depends on the evidence of mere eye-sight, and may be ascertained, independently of all theory, by purely practical observations. How far, then, do these observed results verify the theoretical anticipations? "If we trace on paper," says Sir J. Herschel, "an ellipse, ten feet in diameter, to represent the orbit in which the earth is moving about the sun, and if we trace by its side the path actually described in its revolution around the sun, the difference between he original ellipse and the curve actually described is so excessively tminute, that the *nicest examination with microscopes* continued along the outlines of the two curves, would hardly detect any perceptible interval between them."

Again, it is known that the solar orbit slowly changes from age to age. The effect of this variation, Laplace showed to be that the moon moves more rapidly around the earth now than it did in remote times. This result of theory is exactly verified by observation. It has been ascertained, from the records of ancient lunar eclipses observed by the Chaldean astronomers, and subsequently by the Arabian astronomers in the eighth and ninth centuries, that the moon's mean motion is increasing by about eleven seconds in a century.

The action of pendulums, the most delicate and refined instruments used for scientific purposes, exemplifies, in a wonderful manner, the predictive power of mechanical philosophy. The earth's rotation causes bodies at the equator to be acted upon by a centrifugal force, in the contrary direction to their weight; it is clear, therefore, that their tendency towards the earth is diminished. The value of this diminution, as also of its effects on the vibration of pendulums, is determined by theoretical calculations, which take into account a large number of independent considerations—the earth's radius, spheroidal attraction, the inertia of the pendulum, the effects of thermometric expansion, the barometrical pressure, the resistance of the air; &c. By most elaborate processes, then, it is determined that the same pendulum which beats seconds in London (that is, vibrates 86,400 times in the twenty-four hours), ought to make fewer vibrations by about 140 at the equator. Also, the number of vibrations which this pendulum ought to make in various other latitudes, north and south of England, have been computed; and the results have been confirmed by observation, in a remarkable manner. Pendulums, constructed with the greatest care, have been carried from London to many places on the

* From the Introduction to Part I., just published, of the "Civil Engineer and Architect's Course of Mechanics, applicable to Structures and Machines." By Homersham Cox, B.A.

earth's surface, and their performances observed with extreme caution. The discrepancies observed between these results and those of theory are so minute, that no one but a mathematician would regard them; and he successfully ascertains that they arise from incidental circumstances, wholly independent of theoretical computations.

Such results are magnificent exhibitions of the powers of the mechanical sciences. The tests of their accuracy are immeasurably more varied, more numerous, and more minute, severer, longer continued, and executed on a grander scale, than those to which any other natural science is subjected. But the accuracy of a system is not absolutely proved by the circumstance that in any finite number of instances it leads to right conclusions. It is possible—though excessively improbable—that this accuracy is, in every case, merely the result of fortunate guesses. And this view of the subject is not so very unnatural, when it is remembered that such fortuitous anticipations, though very remarkable, are by no means uncommon, and that some of the most important laws of mechanics were wonderfully felicitous conjectures long before they were demonstrated truths.

The absolute certainty, then, of mechanical science must rest on yet higher grounds. Its supreme authority consists in this—that all its conclusions are rigorously logical inferences from indisputable elementary laws. The philosopher has a right to *demand* unreserved credence so far, and only so far, as he can establish such inferences. The demonstrative truth of his results depends on the answers to these two questions—Are the elementary laws indisputable?—Are the deductions from them rigorously logical? These are the two bases of the whole evipence. Let them be considered in their respective order, for the right comprehension of them will greatly facilitate the object proposed in the present inquiry—namely, to explain the preliminary difficulties of the study of mechanics.

First, as to the elementary laws: their peculiar characteristics constitute the very perfection of the science. In number they are so few, that *a priori* it seems impossible to build upon them any system of great extent: in nature they are so simple and apparent, that the mere enunciation of them necessarily carries with it immediate assent. These fundamental principles, regulating the minutest and the grandest phenomena of the material world, are yet detected at once on the most imperfect and careless observation of the operations of nature. They are inductions, either from the rudest, or from the most refined, experiments. Indeed, it is sometimes difficult to perceive that our knowledge of them is experimental at all, and not intuitive;—at this very moment, there are controversialists who believe them to be mere axioms or self-obvious truths, innately perceived in the mind, and not acquired from sources external to it.

And here it is necessary to establish a distinction between these fundamental laws and their ultimate causes. With the latter, the mechanical philosopher has no concern: he seeks only to ascertain and trace the *effects* of the rules by which material bodies are observed to operate on each other; but causation or speculation as to the *modus operandi*, forms no part of his inquiry. That heavy bodies are drawn towards the earth when unsupported, is a fact, of which, notwithstanding its constant occurrence, no explanation has ever yet been given. Were we not so familiar with this phenomenon, it would appear very wonderful, that one body should approach another without any communication between the two, or any visible cause of the motion. To say that it is due to the earth's attraction or gravity, is merely to give a name to, not an explanation of, the mystery. Again, who can tell what mighty, unseen chain binds this earth to move for ever in a certain orbit round a body ninety-five millions of miles distant? Planets and satellites, apparently isolated in space, separated from all other bodies by distances which the mind is utterly incapable of recognising, move on from age to age in their predestined courses; yet, so silently, that no mortal ear ever yet heard the sound of their mighty mechanism. Man, indeed, discerns its minutest operations, and from their regular recurrence learns to predict them with unfailing accuracy; but the secret agency which pervades and guides the whole system, remains an unsearched, an unsearchable, mystery for ever.

The harmonious concord of nature, however—her consistency and never-failing regularity—these are questions within the province of mathematical reasoning, and these are the questions upon which the evidences of mechanical science rest. Let it be ascertained that the laws of matter are unchangeable and universal, and a system may be founded on those laws, which can never be shaken by speculations as to their ultimate causes.

Such, then, are the *premises* from which the mechanical philosopher reasons. The only remaining question as to evidence is this—are the inferences from them rigorously logical?

The premises are obtained by induction, the inferences by deduction. The premises, as has just been said, are arrived at by comparing a great number of natural phenomena, and extracting the simple principles common to them all. This is the process of induction, which reasons by analogy from examples. All the physical sciences derive their origin from this source; for how are we to contrive a physical science—that is, how are we to reduce any class of natural phenomena to a regular system—unless by ascertaining, from nature herself, the primary laws by which she acts? It is clear, that if a man did not look out of himself, into the external world, for this elementary knowledge, his system would be nothing more than an ingenious figment of his own brain.

But the *application* of the primary laws depends on another kind of logic than that of induction. Now, we no longer reason by analogy—no longer refer to examples—no longer, indeed, draw knowledge from the external world. Nature has furnished the premises; the mind of man depends on itself alone for the inferences. These are deductive from that application of logical syllogisms to abstract propositions, which is no other than the process of *common-sense*—the very highest kind of reasoning of which the human mind is capable. It is not within our present scope to discuss the principle on which deductive reasoning depends, further than by explaining, that it may always be immediately referred, or ultimately reduced, to the Aristotelian dictum, *de omni et nullo*—what is universally true of a class of things, is true of anything in that class. It is not necessary, however, to examine minutely here this logical, or rather metaphysical, question: it is enough for our purpose that there are certain primary truths which the mind universally recognises, certain elementary methods of combining them, the validity of which is as certain to every man as his own consciousness,—and that on these primary truths and these elementary methods the inferences of mechanical science exclusively depend.

Of course, the full effect of these considerations can be perceived only in the actual study of the science itself. But we are now in position to explain the difficulties which originally retarded its progress, and which, even now, constitute the greatest obstacles to the student's progress. Geometry, it was mentioned, became a systematic science, while mechanics remained obscure and confused. If the preceding attempt to explain the foundations on which the latter science depends, have been at all successful, the reason of the earlier development of geometry will readily suggest itself. One of the elements of mechanical investigation—experimental induction—was wholly wanting in geometry. It is needless here to inquire whether any of the primary ideas of this science also be derived from experience: we may well be anxious to avoid a discussion of those essential affinities and distinctions between the objective sciences, respecting which such men as Bacon, D'Alembert, Diderot, Locke, Adam Smith, Dugald Stewart, Turgot, &c., have been unable to agree. But this is readily seen, and is of itself quite sufficient to explain the comparatively rapid development of geometry—that its progress was not impeded by difficulties incident to the advancement of mechanics—the necessity of making experiments, and of selecting, from an overwhelming abundance of results, those which, from their universality and precision, might be made the foundations of the new science.

The same difficulties occur to the student now. He approaches the study of geometry with an unprejudiced mind: whatever previous ideas of space, form, and distance he has acquired, may be confused and imperfect, but they cannot be positively erroneous. Geometry contains no secret principles, detected only by their effects; all its subjects are so obvious and palpable, that any direct mistake respecting them would be certain to soon detect itself. But of mechanics, almost every doctrine is unconsciously prejudicated before the commencement of its systematic study: here *is* a secret principle, undetected, except by its effects—an invisible agent, FORCE of which the existence is ascertained only by experience of its operations, and of which the ultimate nature is altogether unknown.

The great task, then, which the student of mechanics must perform, is to refer every problem to first principles: to refrain from appealing to his own physical notions, acquired accidentally and without method. Not that he is required to give up the right of private judgment, or subject it, unconvinced, to a fixed standard. Thus far only is he called upon to yield to the experience of his predecessors in the same pursuit—to give credence to their assertion that all the knowledge which he requires may be derived from the elementary principles which they lay down. The accuracy of those principles, and the legitimacy of the inferences from them, he must determine for himself by the effort of his own mind, independently of—if he please, in defiance of—the influence of standard authorities.

By adopting the method, here insisted upon as all-important, of referring every question to a few first principles, his science becomes a connected chain of reasoning, and acquires the two great advantages of method, certainty and facility—certainty of the accuracy of his knowledge, facility in applying it. This power, however, of tracing the mutual connection of the several parts of mechanics, and the ultimate dependence of each part upon elements common to them all, is to be acquired only by long-continued habit. There are certain practical difficulties however in the exercise of it, of which the student ought to be forewarned, and which act as snares upon his judgment; oftentimes inducing him to believe that he traces a logical consequence where none in reality exists.

Of these sources of error in the pursuit of mechanical science, the most important are included among Bacon's *idola fori*—idols or fallacies, of which the power arises in the forum or common intercourse of mankind—the defects of words—the names of non-existencies, or confused names of existencies. Language can never be so perfectly refined as to avoid entirely this disadvantage, for while the subtlety of nature is infinite, the subtlety of words is finite, and, in general, serves only to nominate general ideas, and not their minutest distinctions. In erecting the lofty edifice of science on so narrow a basis as a few elementary definitions and axioms, extreme exactness in the use of words is therefore requisite; and beautifully is it said, that when we attempt to rear a temple to heaven, we must not be unmindful of the confusion of languages.

Of no science have the principles been subject to more vehement and learned debate than mechanics; yet most of these debates have been ultimately discovered to be mere logomachies—disputes about words—which, it is therefore reasonable to suppose, would never have arisen had it been possible originally to give strict definitions of the terms involved. Perhaps the most instructive example of a learned controversy turning out to be a mere strife of words, is that respecting Vis Viva—a term retained in modern science as a mere technicality, of which the interpretation does not depend on any mechanical knowledge, but is purely conventional and arbitrary. The following account of the controversy is taken from Walton's "Mechanical Problems," a work, the value of which to the English student of the physical applications of mathematics, it would be difficult to over-estimate:—

"Leibnitz contended, in opposition to the received doctrines of the Cartesians, that the proper measure of the Vis Viva, or Moving Force of a body, is the product of the mass into the square of the velocity; the measure adopted by the disciples of Descartes having been the same as that of the Quantity of Motion—namely, the product of the mass and the first power of the velocity. This contrariety of opinion in respect to the estimation of Moving Force, gave rise to one of the most memorable controversies in the annals of philosophy; almost all the mathematicians of Europe ultimately arranging themselves as partisans, either of the Cartesian or Leibnitzian doctrine. Among the adherents of Leibnitz may be mentioned John and Daniel Bernouilli, Poleni, 'sGravesande, Camus, Muschenbroek, Papin, Hermann, Bulfinger, Kœnig, and eventually Madame du Châtelet; while in the opposite ranks may be named Maclaurin, Clarke, Stirling, Desaguliers, Catalan, Robins, Mairan, and Voltaire. * * * The memorable controversy of Vis Viva, after raging for the space of about thirty years, was finally set at rest by the luminous observations of D'Alembert, in the preface to his '*Dynamique*,' who declared the whole dispute to be a mere question of terms, and as having no possible connection with the fundamental principles of mechanics. Since the publication of D'Alembert's work, the term Vis Viva has been used to signify merely the algebraical product of the mass of a moving body and the square of its velocity; while the words Moving Force have been universally employed, agreeably to the definition given by Newton in the '*Principia*,' in the signification of the product of the mass of a body and the accelerating force to which it is conceived to be subject: no physical theory whatever, in regard to the absolute nature of the force, being supposed to be involved in these definitions."

Technicalities expressing the elementary ideas of mechanics are *idola fori* belonging to the commencement of the science: other and different difficulties of language occur in its ultimate conclusions. Among the remote results of elaborate investigation are certain general theorems, exceedingly extensive and useful in their application; but which, if inaccurately enunciated, may be made to include cases which do not belong to them, and exclude others legitimately within their province. These difficulties may be termed questions of jurisdictions. When the language of a general theorem does not indicate with precision its jurisdiction over any particular case, or its proper mode of application to it, the only legitimate mode of arriving at a decision is by tracing the processes by which the theorem itself has been arrived at, and considering whether the particular case in question was contemplated in *them*. The general mechanical theorems have so vast and varied applications, that the bare enunciation of them, however carefully expressed, is utterly insufficient to convey to the student's mind an idea of all their consequences. Their actual operation, and the boundaries which define their power, *quos ultra citraque nequit consistere rectum*, can be fully learned only by actual practice. In this respect, the science of jurisprudence presents a striking analogy. We are accustomed to reverence the common law of England as the accumulated wisdom of ages—the combination of the most subtle sagacity and the most extensive experience. But who does not know that a bare acquaintance with the general principles of law is practically insufficient for the solution of particular cases—that amidst the infinite variety of combinations to which the business of life gives rise, the abstract rule cannot be successfully applied without a certain intellectual dexterity, which long experience and constant practice alone confer?

The importance to the mechanical student of expertness similarly acquired, can scarcely be over-rated. His efforts should be incessantly exerted in the application of mechanical principles to the direct solution of problems; and it is scarcely too much to assert, that his knowledge of the science will be proportional to the number of problems which he solves. The most trivial incidents of his every-day life—every weight which he moves, every action of his muscles, suggest cases fruitful with instruction respecting the laws of force. There is not a single spot in the material world, free from the influence of force; and he has but to look around him, to discern innumerable instances in which the *rationale* of their action may be investigated, and the consequences of them predicted. This unintermitted habit of ransacking the stores of nature, of tracing the most trivial and the grandest of her operations to first principles, strengthens and confirms the power of investigation, and reduces those effects of the material laws which on a superficial view appear confused and disconnected, to one harmonious and simple system.

Another class of errors peculiarly incident to our science, is that arising from incorrectness of data—the neglect of operating causes, either from absolute oversight or from an impression that their effect is inconsiderable. The first of these mistakes will seldom be made, except by an inexperienced student; and may be altogether avoided by practice and care in conceiving the exact nature of the question before him. As a useful precaution against this difficulty, he should habituate himself to test the accuracy of his conclusions by particular instances, and by varying this test within the widest legitimate limits. If, in any one instance, his general investigations lead to an absurd consequence, they are themselves erroneous; and it will be necessary to re-examine them, and ascertain at what step the error arose.

There are more difficult cases, however, where the neglect of data arises, not from oversight, but from necessity—where the complexities of the question are such, as to render its solution impracticable without hypothetical simplifications. In all such instances, the investigator must remember that he is solving, not a question of real existence, but an artificial case—making the nearest approach to it which his powers of investigation permit. In practical mechanics, this consideration is especially important; and, as a general rule, no such hypothetical simplification should be admitted—or at least acted upon—without some estimate of the *limits of the error* which it may possibly induce.

Complicated mathematical formulæ are wholly unsuited for the practical application of mechanics, on account of the refinement and exactness of both workmanship and computation which they require. The only formulæ which the practical artisan or mechanic will *trust*, are those which he can readily apply, and which afford a margin for all the diversified circumstances of practice, unavoidable and unknown imperfections of materials, and other irregularities of detail. The method of determining results between certain limits, has the advantage of leaving such a margin, and will therefore be frequently employed in the following pages. Among its incidental recommendations is this,—that it generally gives great simplicity to formulæ which otherwise would be exceedingly complicated.

It is not within the compass of the present work, restricted in the use of mathematical language, to give a systematic development of the whole science of mechanics: its principal aim is to explain those parts of the science which are of the most direct economical importance, and to assume as little previous knowledge as possible on the part of the reader. He must be forewarned, however, that in solving mechanical problems, the difficulty does not wholly consist in determining the nature of the forces supposed to act—but, in a great degree, in ascertaining the position of the several parts of the system at which they are applied. This latter difficulty is, of course, only to be overcome by a competent knowledge of pure geometry. Galileo, the father of modern mechanical philosophy, has explained this point with like accuracy and eloquence. *La filosofia*—says he, in his Saggiatore—*è scritta in questo grandissimo libro, che continuamente ci sta aperto innanzi agli occhi, ma non si può intendere, se prima non s'impara a intender la lingua e conoscer i caratteri, ne' quali è scritto. Egli è scritto in lingua matematica, e i caratteri son triangoli, cerchi, ed altre figure geometriche: senza questo è un' aggirarsi vanamente per un oscuro labirinto.**

The Elements of Euclid are, and it may be safely assumed always will be, the best foundation of the study of geometry. Unrivalled simplicity and perspicuity recommend this work as an elementary treatise; its method and precision claim for it the highest position among works devoted to the exact sciences. The first four and the sixth books should be thoroughly mastered; and, above all, the intelligent student will endeavour to imbue himself with the *spirit* of Euclid,—to trace the uninterrupted current of his reasoning, from the fountain-head (the axioms and definition) to the final conclusions. It is the distinct dependence of inferences on their premises, which renders Euclid invaluable in disciplining the mind into a habit of logical and consecutive reasoning. The beginner will sometimes meet with propositions so simple and obvious, that it appears an idle waste of time to prove them—let *those* propositions be his especial study: when he has mastered their demonstrations, he will see that Euclid's intention was—not to explain trivial truths, but to show how they might be deduced as necessary consequences of *his* principles. The familiar study of this ancient work—it has stood its ground against all attempts at improvment for two thousand years—will gradually induce a mathematical habit of mind, and a right appreciation of the real nature of proof—of that which not merely does, but ought to, produce conviction.

As preliminary to the study of mechanics, some knowledge of the elements of trigonometry is requisite. The history of mechanical science will also affords important facilities for mastering its principles. The full value of a scientific theorem is not appreciated without some knowledge of the hard struggle by which—so to speak—it has been wrung from nature. The wanderings of the earlier mathematicians, their fruitless labours and controversies, their slow and gradual approximations to right results, reveal the subtle nature of physical truth, the narrow boundaries which separate it from error, and the necessity of maintaining those boundaries inviolate.

Dispute respecting the laws of mechanics is no longer possible. They are demonstrated; and to attempt to make them matters of controversy, is to exhibit ignorance of the processes by which they have been ascertained. "We have, therefore," it has well been said, "*no sects nor parties* in mathematics; but they abound in every other department of human opinion." And again, "In mathematical questions, where relations of quantity alone are concerned, a dispute can be completely terminated; because, from wrong premises, or false reasoning, a contradiction can be at least shown to result."

If, then, the labours which perfected the science of mechanics—for it is now perfect—have been great, if its study now task severely the highest efforts of the student's mind, are not the results commensurate? The revelations of pure truth in its most attractive forms—its manifestations in the grandest phenomena of nature, and the proudest achievements of art—these are the wages of philosophic toil. So vast are the domains of this science, that every year brings tidings of new and rich discoveries within it: while its applications to the practical wants of men are ever receiving fresh and more important developments—ever creating revolutions more extensive, more lasting, and more noble than those of politics or war.

* Philosophy is written in that greatest of books which stands continually open before the eyes of men [that is, the universe], but cannot be learned without previous preparation to understand the language and decipher the characters in which it is written. It is written in the language of mathematics, and its characters are triangles, circles, and other geometrical figures; without which, we should wander in vain, through mazes and obscurity.

ARE WE TO HAVE AN ARCHITECTURAL EXHIBITION?

Something of the kind seems to be dawning upon us: there is what just at present looks like the prospect of such exhibition, though it may after all turn out to have been a mere unsubstantial and deceitful *mirage*. In proportion as we are anxious that the vision should be realised, we feel apprehensive of its fading away into nothing. We learn from a contemporary, that the "Architectural Association" purpose to "get up an annual architectural exhibition." Between purposing and firmly determining upon a scheme, there is a good deal of difference, more especially when the purposed "getting up" is likely to prove very up-hill work. This remark is meant not to discourage so much as to stimulate. In order to overcome difficulties, it is necessary to look them boldly in the face at once, and be prepared to encounter them.

The "Architectural Association" is a junior society, which as yet hardly stands before the public at all,—certainly not in any imposing attitude. It has no royal standard to hoist in the form of a charter—the chief privilege conferred by which seems to be that of indulging in indolence and doing nothing. Yet, if it have no charter, a junior and youthful society has, or ought to have, something greatly in its favour; for it may be presumed that it possesses zeal and energy, of both which much will be required, in order to carry properly into effect the scheme they are said to meditate. One question for consideration is, how is it likely to be looked upon by the Institute? As to the Royal Academy, that body would, no doubt, be exceedingly well pleased at a separate exhibition for architectural drawings and models being established, since they would thereby be almost entirely relieved from works of that kind, which it is evident enough they take in very reluctantly, and treat very slightingly. That the Institute would not take umbrage at that being done by a junior society which they have left undone (although their means for effecting it are as great, or much greater), is not quite so certain. Apathetical as it is, the Institute might yet feel something like awkward compunction and shame, were others to bestir themselves diligently, and venture upon an experiment which, should it succeed, would place them before the public more prominently than the Institute itself can boast of being.

The success of the experiment, however, will depend very much upon the manner in which it shall be made. If it be made at all, it is to be hoped that it will not be timidly and feebly.—And it here strikes us that we have possibly fallen into a misconception, since what the "Architectural Association" contemplates may be something very far short of the kind of exhibition that is needed. If it is to be one confined to that society's own members, instead of being open to contributors generally, and be also upon such a footing as to admit architectural subjects without distinction as to the nature and mode of them—such technical illustrations as plans, sections, and details, as well as those more pictorial representations which are the only ones received by the Royal Academy—if, we say, it is not to do this, it will fall far short of supplying a main desideratum. Resting entirely upon the abilities of the members themselves, without aid from other quarters, the proposed exhibition could hardly have sufficient stamina and substance to come properly before the public, and so as to attract notice and claim support. Neither would anything at all be done towards affording the opportunity of exhibiting their productions, to the many who are excluded from the Academy on account of the exceedingly limited accommodation there for architectural designs and models. At present, there is only Hobson's choice for architectural exhibitors,—either the Royal Academy or nowhere. And the accommodation at the Academy for works of the kind is totally inadequate; for while only a comparatively small number of them can be hung up, not above a third of them can be hung so that they can really be looked at. Therefore, what with the chance of being turned away for want of room, or else of being thrust out of sight, it is not greatly to be wondered at if many are deterred from sending anything at all. To such, other opportunity of exhibiting would be welcome; and their contributions would, it may be presumed, be equally welcome and serviceable to the "Association." Without support of the kind from others, and the extended interest so created for the success of the undertaking, there might not be attraction sufficient to produce extraction—to wit, of shillings from the pockets of the lieges. We speak merely upon our own conjecture, but take for granted that the exhibition in question would require the usual shilling passport for admission to it; because otherwise, the public would be excluded, and the exhibition be merely a private one, open only to the members and their friends, so that any good result as to diffusing a taste for architecture as a branch of design would be frustrated.

What renders it so highly desirable that a special exhibition of architectural drawings and models of every class should be established is, that productions of the kind have no chance of obtaining any attention so long as paintings are to be seen at the same place. It would be almost unreasonable to expect that they should, especially at the Academy, where the pictures are so numerous that they alone afford quite occupation enough for several visits. There, the architectural subjects are scarcely looked at at all, except just by those who make them their chief object. Let it then be fairly tried, whether, when withdrawn from its eclipse at the Academy, and allowed to display itself in a different orbit, it has really no power of attraction for the many—we do not mean the mob, but those (and they are many) who, if they possess not, affect at least to have a taste for art generally.

Supposing that the "Association" now intend to bestir themselves in good earnest, one thing which they ought especially to consider beforehand is, that architectural drawings require proportionably a much greater space for exhibiting them than pictures of the usual kind do,—because they require to be inspected as closely as miniatures or engravings; consequently, little more than the direct *line* of wall on the level of the eye can be made available for the purpose. It is of no use—rather a mere mockery—to profess, as the Academy does, to exhibit productions of the kind, and then hang the majority of them where it is only by great effort that their subjects can be made out, and all detail is completely lost. Mr. Billings—who, by-the-by, at the opening meeting of the present season, signified the Association's intention to get up the exhibition in question,—observed that he himself had no right perhaps to grumble at the Academy, because, of eight drawings which he sent in this year, seven were hung up—but four near the ceiling, and three near the floor. Considering how many subjects of his were admitted, he had reason to look upon himself as highly favoured—if it be any favour or compliment at all to have drawings received merely because their frames happen to be just the size to fit in "very nicely" with others on the same part of the wall. Such must ever be the consequence of the abominable dove-tailing system in hanging pictures and drawings, which frequently renders it necessary to put a good subject or production in an unfavourable situation, or else an inferior one in a good situation, merely because no other places where they would so well fit in can be found for them. Possibly, however, our advice may be altogether superfluous, since it is possible that the purposed exhibition will turn out to have been a mere flash in the pan.

ON A READY METHOD OF DETERMINING THE WIDTHS OF LAND REQUIRED FOR THE FORMATION OF A RAILWAY.

We will suppose the centre line to be staked out, and the distance from the top of the peg to the intersection of the slopes to be given. Let A be a centre-stake, at which the half-widths are to be determined; B, the intersection of the slopes produced; and r to 1, their ratio. The level must be placed at some point D, and the line of collimation adjusted so as to describe a horizontal plane at a distance a B above the point B (fig. 1), for a cutting. $\mathrm{BA} = \mathrm{K}$; $\mathrm{A}a = h$; $ec' = ac = h'$, the reading of the staff when stationed at c'. Then we have,

$\mathrm{B}c = \mathrm{B}a - ac = \mathrm{BA} + \mathrm{A}a - ac = \mathrm{K} + h - h'$, and the length of the horizontal line through $c' = cc' = x = r \times \mathrm{B}c = r(\mathrm{K} + h - h') = r(\mathrm{K} + h) - rh' = aa' - rh'$............(1)

The horizontal distance of c' from a B, must also be measured with the chain, and this we will suppose to be y. It is evident, that at the point c', where the slope B a' meets the surface of the ground, the condition $y = x$ must be satisfied; and for no other point can it be satisfied. This point c' must be found by repeated trials.

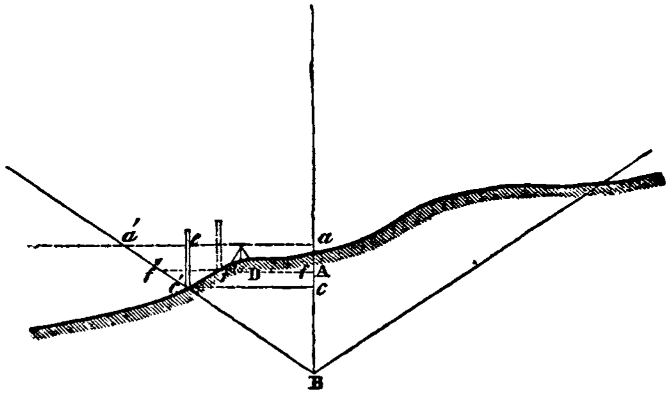


Fig. 1.—Cutting.

In the case of an embankment (fig. 2),

$$x = r \times \mathrm{B}c = r(\mathrm{K} - h + h') = r(\mathrm{K} - h) + rh' = r\mathrm{B}a + rh' = aa' + rh' \text{ .... } (2)$$

Hence, whether there be cutting or embankment, we must determine the half-width (aa') at the *level of the line of collimation;* and in making repeated trials, we have nothing more to do than multiply the reading of the level-staff (h') for the slope by r, and add the product to aa' for embankments, or subtract it for cuttings, to obtain the value of x, which must be compared with the horizontal distance (y), found by measurement with the chain. Repeated trials must be made until a point is discovered which satisfies the condition $y = x$.

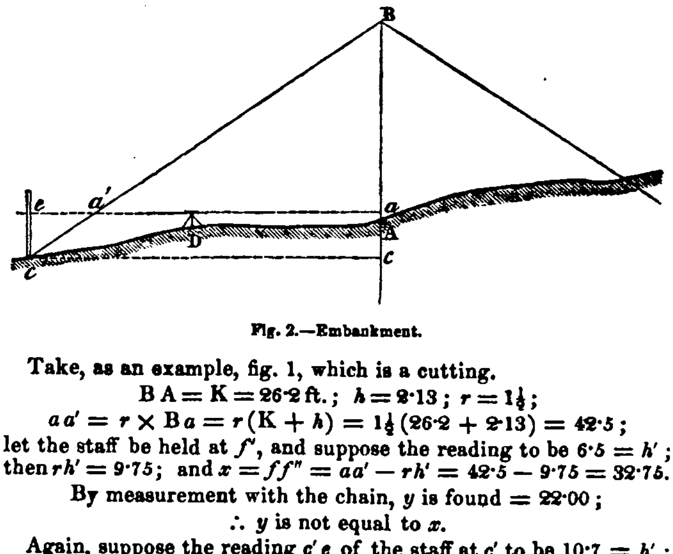


Fig. 2.—Embankment.

Take, as an example, fig. 1, which is a cutting.

$$\mathrm{BA} = \mathrm{K} = 26{\cdot}2 \text{ ft.}; \; h = 2{\cdot}13; \; r = 1\tfrac{1}{2};$$

$$aa' = r \times \mathrm{B}a = r(\mathrm{K} + h) = 1\tfrac{1}{2}(26{\cdot}2 + 2{\cdot}13) = 42{\cdot}5;$$

let the staff be held at f', and suppose the reading to be $6{\cdot}5 = h'$; then $rh' = 9{\cdot}75$; and $x = ff'' = aa' - rh' = 42{\cdot}5 - 9{\cdot}75 = 32{\cdot}75$.

By measurement with the chain, y is found $= 22{\cdot}00$;

$\therefore y$ is not equal to x.

Again, suppose the reading $c'e$ of the staff at c' to be $10{\cdot}7 = h'$; then $rh' = 16{\cdot}05$; and $x = 42{\cdot}5 - rh'$

$$\left.\begin{array}{r} = 42{\cdot}5 - 16{\cdot}05 = 26{\cdot}45 \\ \text{and } y \text{ is found by measurement to be } 26{\cdot}45 \end{array}\right\}$$

$\therefore y = x$; and c' is the point sought.

Example of an Embankment.—Slopes $1\frac{1}{2}$ to 1. Let $\mathrm{K} = 42{\cdot}36$; $h = 2{\cdot}43$. Then $(\mathrm{K} - h) = \mathrm{B}a = 42{\cdot}36 - 2{\cdot}43 = 39{\cdot}93$; and $aa' = r \times \mathrm{B}a = 1\frac{1}{2} \times 39{\cdot}93 = 59{\cdot}9$.

Suppose the reading $c'e$ of the staff at c' to be $10{\cdot}05 = h'$, then $rh' = 15{\cdot}07$;

$$\left.\begin{array}{r} x = aa' + rh' = 59{\cdot}9 + rh' = 59{\cdot}9 + 15{\cdot}07 = 74{\cdot}97 \\ \text{and suppose that } y, \text{ found by measurement, is } = 74{\cdot}97 \end{array}\right\}$$

then c' will be the required point.

These necessary calculations are very simple, but they are also very numerous, and I have found it advisable to substitute a kind of sliding rule, which at once performs the multiplication of r and h', and adds the product to, or subtracts it from, $a\,a'$. (*See* figs. 3 and 4.)

A long scale of equal parts (H) is formed at the edge of a groove, and another (V) slides in contact with this, as shown in the figures. H represents the horizontal measurements commonly taken with the chain, and should extend from 0 to about 150 feet.

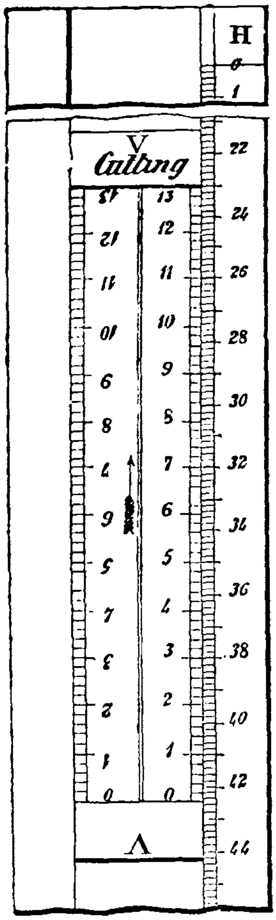


Fig. 3.
Slide arranged for determining the Width of a Cutting.

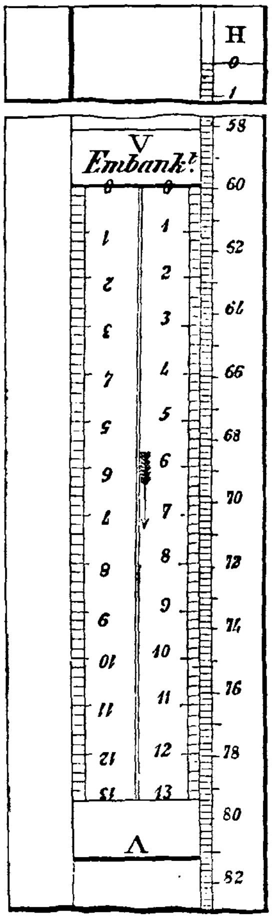


Fig. 4.
Slide arranged for determining the Width of an Embankment.

If the instrument be made of box, H may contain 10 feet to the inch, and each foot may be divided into 5 equal parts. The slide V corresponds to, and must at least contain as many feet as are marked on the levelling-staff. The scale on V, as shown in the figures, is for a slope of $1\frac{1}{2}$ to 1; for $1\frac{1}{2}$ foot on H is equal to 1 foot on V. Other slides will be required for other slopes.

In the example of a cutting previously calculated, we found that $a\,a' = 42{\cdot}5$ feet. Bring 0, on slide V, opposite 42·5 on H (fig. 3). The staff is set up at f', and the reading is found to be 6·5. Refer to V with 6·5, and opposite this point we find $x = 32{\cdot}8$ on H, without any calculation.

But the measured distance y is 22·00 ; $\therefore$ y is not $= x$.

Again, the staff is set up at other points, and the trial repeated till we come to the point c', where the reading of the staff (h') is 10·7 feet. Refer to V with 10·7, and opposite it we find 26·5 on H, which differs only by the $\frac{1}{20}$th of a foot from the result previously given by calculation.

As $r\,h'$ has to be *subtracted* from $a\,a'$ in *cuttings*, it is necessary for the scales V and H to be numbered in *opposite* directions, as in fig. 3. But in *embankments*, $r\,h$ must be *added* to $a\,a'$, and the scales V and H must increase in the *same* direction, as in fig. 4. This is the reason why the slide has two scales, differently numbered. Fig. 4 corresponds to the numerical example given above for an embankment: 0 on V being placed opposite 59·9 on H; and 10·05 on V falls opposite 75 on H.

We have hitherto supposed that zero on the scale V is placed opposite $a\,a'$, the horizontal width at the level of the line of collimation. Now, the value of $a\,a'$ is dependent on the accidental position of the level, and must be calculated in the field. Suppose, however, that the half-widths at the levels of the centre-pegs have been determined, and registered previously to commencing operations. In the example of a cutting (fig. 1), we supposed B A to be $= \mathrm{K} = 26{\cdot}2$; $\therefore$ the half-width, supposing the ground to be level, $= r\,\mathrm{K} = 1\frac{1}{2} \times 26{\cdot}2 = 39{\cdot}3$; and h was taken $= 2{\cdot}13$. And the result is the same,

whether we place 2·13 (or h) on V opposite 39·3 on H,
or 0 on V opposite 42·5 on H.

The first method will be found the best, because all the half-widths at the levels of the stakes may have been previously determined in the office. The same may be said of fig. 4.

It will be found convenient to have an index capable of sliding along H, independently of V, and capable of being fixed at pleasure. This may be formed partly of a piece of horn, or other transparent substance, having a line ruled parallel to the divisions of the scales. This will be of great service where the ground is very sloping, and it becomes inconvenient to hold the levelling-staff on every peg.

If, in figs. 1, and 2, the ground had been so low that the top of the staff $c'\,e$ fell below the line of collimation, it would have been necessary to have shifted the level, and $a\,a'$ would have taken a new position and value. It will, however, be found an easy matter to determine B a, and therefore also $a\,a'$, in all cases; and 0 on V must then be placed opposite this value of $a\,a'$ on H.

Or, calculation may be avoided even in this case. Fig. 1. Suppose the first reading at a to be 2·15, and the half-width at the level of A, 39·3 feet. Bring 2·15 on V opposite 39·3 on H. Let the staff be held at any point, and take the reading 9·55, suppose. Slide the *index* along H to point to 9·55 on V.

Remove the level to a new position D', and adjust it, and suppose the back sight taken in the ordinary way to be 3·2. Move the *scale* V, so that the index points to 3·2 on V; and the instrument is adjusted for the cross-section at A, so long as the level is not disturbed.

The index will be found very serviceable where it is not convenient to commence levelling from every centre-stake. Suppose the centre-pegs to be one chain apart, and that the gradient rises δ in every chain.

We have seen that the distance B a of the horizontal plane through $a\,a'$ from B is $= \overline{\mathrm{H} + h}$ (fig. 1), as the gradient is supposed to *rise* δ feet in a chain, at a point corresponding to B; but a chain from it, the new value of a B becomes $(\overline{\mathrm{K} + h - \delta})$;

and the new half-width $a\,a'$ becomes $r\,(\mathrm{K} + h) - r\,\delta$.

If we take an embankment (fig. 2), the new value of a B becomes $(\overline{\mathrm{K} - h + \delta})$ at the distance of one chain;

and the new value of the half-width $a\,a' = r\,(\mathrm{K} - h) + r\,\delta$.

Thus, in a *rising* gradient, δ for every chain, we must move the slide by *the scale* H, a distance $r\,\delta$ upwards for cuttings
and a distance $r\,\delta$ downwards for embankments }

But $r\,\delta$ on the scale H is the same in magnitude as δ on the scale V, and therefore it will be most convenient to employ the index in moving the slide V upwards or downwards, through a space δ for every chain.

It may be useful to remark that for *a rising* gradient the slide V has to be moved in that direction in which the numbers of the feet on V *increase*, as denoted by the arrows, whether the case be one of cutting or embankment. If there be a falling gradient, the slide V must be moved in the opposite direction.

It will be found convenient to be provided with the height of each stake above some common datum; the half-width, supposing the ground to be level; the numbers and distances of the stakes, with particulars respecting the gradients, slopes, &c. Also, vacant columns must be prepared to receive the half-widths on each side, as they are determined, and the corresponding reading of the level. The point on H to which the zero on V is opposite, ought also to be registered. This last is very useful where a number of consecutive side-stakes are determined without starting from the centre; and doubts might otherwise arise as to whether the proper correction had been made for the gradient in every case.

As this slide-rule has been used where the ground was remarkably uneven, both for determining the widths of cuttings and embankments, and the limits of embankments at the ends of viaducts, I can strongly recommend it to the attention of those practically engaged on such work, as it avoids much trouble and uncertainty, and the result is as accurate as can be desired by the most fastidious. An addition to the widths above found must be made to allow for the ditches and fences.

St. John's College, Cambridge, Francis Bashforth.
Oct. 21, 1848.

GEORGE STEPHENSON.

(Continued from page 300.)

[The above engraving is after a Portrait by Mr. Briggs, R.A.].

IV. THE SAFETY LAMP.

Fire-damp is one of the greatest evils happening to coal-mines, and one which is too well known to all having anything to do with them. Thirty or forty years ago, this was so strongly felt that many mines had reached their furthest workings, because the men had no good means of going on, for the least flame was enough to set the fire-damp burning, and the steel mill gave little light, and was unsafe.

In 1763, the Academy of Sciences were drawn to look into this matter, several coal-mines at Briançon, in Dauphiny, having fired. All that the Academy did was to recommend a better way of airing the mines.[1]

Above a hundred years ago, Sir James Lowther had seen that common fire-damp does not catch fire from sparks of flint and steel; and one of his overmen, said to be Mr. Spedding, made a mill for giving light by striking flint and steel.[2] This was worked by a boy, and was used in the English collieries. It is, however, known, that with the steel mill some mines have been set on fire.

In Hainault, amadou, or fungus tinder, was sometimes used; but it gives so little light, that the men could not work by it, and all that they could do was to find their way by it sometimes from one side of the pit to another, where fire-damp was blowing.

In 1796, Humboldt made a lamp[3] for giving light in mines where a common candle would not burn, or would set fire to the mine. It was founded on the plan of keeping the light away from the air, and could only burn a short time—that is, so long as the air within it lasted.

In 1813, Dr. Clanny made a lamp, to which he gave air from the mine, through water, by bellows. This lamp went out of itself in explosive mixtures. It was to be worked by hand or by machinery, but was too heavy to be moved about readily.

From what Dr. Clanny had done, and from a fearful loss of life in the Felling Colliery, whereby 101 men, women, and children died, the minds of many were turned to some way of lessening the fearful evil of fire-damp. At Sunderland a meeting was held, wherein Mr. Buddle, Mr. Dunn, Mr. Cuthbert Ellison, M.P., Bishop Gray, Dr. Clanny, and others, had a share, and who called upon Sir Humphrey Davy to search into the whole matter.[4]

1 Histoire de l'Academie Royale, 1763, p. 1, quoted by Davy.
2 Hutchinson's History of Cumberland, quoted by Davy.
3 Journal des Mines, viii. 839, quoted by Davy.
4 See Sir Humphrey Davy's several works in 1815, 1816, 1818, and 1825, but which are nearly the same. The one here quoted is that of 1818.

Sir Humphrey looked at Dr. Clanny's lamp, but he was told it was too heavy and too costly to be useful. He tried phosphorus and the electrical light; but at length he found out that a lamp could be made air-tight, and to which the air could be sent in through very small pipes or tubes, or from small openings in wire gauze put below the flame, and having a chimney at top of the same kind, for carrying off the foul air. This he afterwards brought to bear in the shape now so well known as the Davy Lamp, or Davy, in which he was greatly helped by Dr. Faraday.

Meanwhile, others were no less busy: Mr. R. W. Brandling, Dr. Murray, and Mr. John Murray made lamps, and so did George Stephenson; and at length there was very great strife between the friends of Davy and Stephenson, as to who was the first. We have here a small book, written by George Stephenson, in his own behalf, and which is the only work of his which is printed, other than reports. Here it is well to say, that it would be worth while to print the reports of George Stephenson, to bind with those of Smeaton, for they are written in a very clear, thoughtful, and business way; and are of great worth for the history of engineering, as Stephenson was called upon to fight for the locomotive engine and the railway in their childhood, against the world, having few to back him or help him in his hard struggle.

Stephenson's book is called "A Description of the Safety Lamp, invented by George Stephenson, and now in use in Killingworth Colliery; to which is added, an account of the Lamp constructed by Sir Humphrey Davy, with Engravings. London: Baldwin, Cradock, and Joy; Archibald Constable and Co., Edinburgh; and E. Charnley, Newcastle, 1817." It is only about sixteen sides, and was printed by S. Hodgson, of Newcastle, and has four engravings.

Another very interesting book is the "Report upon the Claims of Mr. George Stephenson relative to the Invention of his Safety Lamp. By the Committee appointed at a meeting holden in Newcastle on the 1st Nov., 1817, with an appendix containing the evidence." This was printed at Newcastle, and has three plates, which are the same as in Stephenson's book.

Stephenson says: "Several of my friends having expressed a wish that I would lay an engraved plan of my Safety Lamp before the public, with as correct an account of the dates of the invention as I am able, I have resolved to do so. I was, at the same time, advised to publish the steps by which I was led to this discovery, and the theory I had formed in my own mind upon the subject, which, with the facts from which I drew my conclusions, were freely communicated to several persons during the time I was engaged in the pursuit. With this I cannot persuade myself to comply; my habits, as a practical mechanic, make me afraid of publishing theories; and I am by no means satisfied that my own reasons, or any of those I have seen published, why hydrogen gas will not explode through small apertures, are the true ones. It is sufficient, for our present purpose, that that fact has been discovered, and that it has been successfully applied in the construction of a lamp that may be carried with perfect safety into the most explosive atmosphere."

"During the four years," Stephenson goes on to say, "that I have been employed to superintend the engines at Killingworth Colliery, one of the most extensive mines in Northumberland, where there is a considerable quantity of machinery underground, I have had frequent opportunities of employing my leisure hours in making experiments upon hydrogen gas. The result of those experiments has been the discovery of the fact above stated, and the consequent formation of a Safety Lamp, which has been, and is still used, in that concern, and which my friends consider (with what justice the public must decide) as precisely the same in principle with that subsequently presented to their notice by Sir Humphrey Davy."

The first thought of the safety lamp had been long in Stephenson's mind; and in August, 1815,[5] he made a drawing of it, which was shown to several people on the works—among others, to Mr. Nicholas Wood,[6] whose name is now, for the first time, seen along with that of Stephenson. He was then a viewer at Killingworth, and seems to have taken a great share and delight in all that Stephenson did, as is shown by the works of both. Stephenson told Wood that he thought a lamp might be made which would burn the fire-damp without blowing-up. The way was this,—to make a tube in the bottom of the lamp, and he thought the attraction of the flame upwards would be greater than the force downwards. Wood drew out the plan under Stephenson's eye, and in October, 1815, they went to Mr. Hogg, a tinman, at Newcastle, and had a lamp made, which a fortnight after was put into Stephenson's hands. When Stephenson first spoke about it, he asked

5 Stephenson, p. 7. 6 Report, p. 16.

that the tube might be made a quarter of an inch in diameter, but Mr. Hogg having suggested that it probably would not burn, it was made half an inch in diameter, and a slide attached to it in order to lessen it if need were.

This first lamp had an open top and conical shape, and was given to Stephenson on the 21st of October, 1815. This was on a Saturday, and in the dusk, Stephenson, Wood, and Mr. John Moodie, an under-viewer, went down to the A pit to try it. Stephenson lighted the lamp and went to a blower of fire-damp in the roof, going to it from the windward, and keeping the candle about twenty yards off. By some deals, they made a part of the mine foul, for the purpose of having a trial with the lamp[7]. About an hour afterwards, Moodie went into the part so made foul, and found by the smell, &c. (of which, from knowledge, he was a sound judge) that the air was in such a state, that if a candle had been taken in, the place would have caught fire, which would have been very fearful. Moodie told Stephenson it was foul, and hinted at the danger; nevertheless, Stephenson would try the lamp, trusting in its safety.

Stephenson took the lamp and went with it to the spot in which Moodie had been, and Nicholas Wood and Moodie, fearful, went further off. Stephenson tried the lamp, and it went out without making any explosion—on which, Stephenson again held forth the safety of his lamp. It has been said, before now, that there is as much bravery in the engineer as in the seaman or the warrior—aye, and as much call for it, too; and often in the common workman will there be as stout and bold a heart in the greatest straits, and in the utmost fear of life and limb, as there is in the leader who storms a breach, or heads the bloodiest fight. Stephenson was as fond a husband as a father, but he did not want daring when he thought the call was on him; and although death loomed before him, he did not turn back from what he felt to be his duty. Here we have the witness of those who were with him, and we may stand by him in this time of trial, and watch his every step.

"Stephenson," says Moodie, "again lighted the lamp, and Wood, who had now more trust in it, went with him to the former spot, and even held the lamp—they tried it again, and with the same end. When the lamp was put lighted in the gas, there was a great flame, the lamp was almost full of fire, and then it smothered out. Stephenson then said that he could so shift it, that he could make it burn better."

This first lamp was made with a slide, to regulate the opening of the pipe through which air was sent into the lamp. The slide was partly shut before the lamp was brought near the blast of the blower—indeed, it was so far shut, that the lamp burned but weakly in good air; and when the lamp was brought to the blower, the flame grew bigger, as already said, and then went out.[8] An explosion, indeed, took place within, but it did not pass outwards. The slide was several times shifted, and trials made afterwards with bladders filled with air from the blowers. The first trial was with the pipe quite open, and the explosion passed downwards. Trials were thereafter made with the slide so shifted, that at length the opening was so small, the explosion no longer passed downwards, and the lamp kept alight; but it was so weak, that it easily went out by being moved. It was therefore thought, that by making more pipes of this smallness, air enough for burning and for keeping up the light might be let in; and yet the holes or openings be so small, as still to stop the explosion from going downwards.[9]

The lamp was now sent to Matthews, a tinman, in Newcastle, and the three pipes put to it, but outside the burner. On Saturday, the 4th of November, this was tried in the pit, and found to burn better than the other, but still not well. Nevertheless, the explosion did not go downwards. A spot in the mine had been again made foul by Moodie, and Stephenson, Nicholas Wood, John Moodie, his son of the same name, an overman, and George Wailes, an overman, went down and made further trials, which, as they all thought, turned out better than the first. Moodie here says,[10] that three months before the first lamp was tried, Stephenson was often making trials with a candle near the blowers, for which Moodie, who was fearful, reproved him. Stephenson then told Moodie that he thought a lanthorn could be made so as to be taken in safely amongst the foul air; but Moodie did not think it could be done.[11]

After this, two lamps of the second pattern were made and given to the waistmen in Killingworth pit. A few days after—namely, on the 9th of November, a boy was killed in the A pit, at Killingworth, on the spot where the trials were made with the first lamp. Stephenson said, on that day, if the boy had had his lamp, he would not have been burned.[12]

John M'Crie, a sinker, tells the same tale. He says, that in the summer of 1815, Stephenson was setting up sloping planes underground, and often as he was coming out, he set the blower on fire, and by lighted candles put to windward, put the blower out. Stephenson said that he could make it useful to save men's lives. This he said, when M'Crie spoke against what he was doing as hurtful.

Up to this time, Stephenson knew nothing of what Sir Humphrey Davy had found out or done, or of what he had written to the coal trade thereupon. He now made his third lamp, which had more pipes, so as to get a better draught of air. He afterwards thought,[13] that if he cut off the middle of the pipes, or made holes in metal plates, set some way from each other, as far as the pipes, that the air would get in better, and that there would be the same safety against explosion. Another lamp was therefore made and tried.

This third lamp did so well, that it was long used in Killingworth pits, and workmen were bound to it under a fine of half-a-crown for using a candle. This lamp was tried alongside with Davy's, and found to do as well.

The first trimmer was a wire down the chimney of the lamp; but afterwards, Sir Humphrey Davy's trimmer was used. Nicholas Wood wrote on this in the *Tyne Mercury*.

On the 24th of November, 1815, Stephenson showed his lamp to Mr. Robert William Brandling, and to Mr. Murray of Sunderland, both well able to give a judgment upon it.

On Tuesday, the 5th of December, 1815, Stephenson's lamp was brought before the meeting of the Literary and Philosophical Society of Newcastle, the same evening that Dr. John Murray's paper about his own lamp was read. Trials were made of Stephenson's lamp with bladders, holding the fire-damp, put below, and the fire-damp let into the lamp.[14]

The difference between Stephenson's lamp and Sir Humphrey Davy's was, that Stephenson used a plate in which holes were cut, and Davy hit upon the happy thought of using a wire gauze screen; but Stephenson seems to have been the first who found that the explosion would not pass outwards, and upon this all depended,—for wire gauze instead of a metal plate was a mere change of shape, though for the better.

Whether Stephenson's lamp is still used, we do not know; but, as shown above, it was kept in use till 1818, and very likely till long after, for Stephenson's friends were so steadfast they would not give in to what they said was a copy of their lamp.

V. THE GIFT.

In 1816, those who had called in Sir Humphrey Davy, thought it time to give him some reward, and therefore called a meeting of coalowners, at Newcastle, on the 31st of October, when Mr. Nathaniel Clayton took the chair. The meeting was to reward Sir Humphrey Davy, "for the Invention of the Safety Lamp."[15] By this time, a paper war had arisen, and while Bishop Gray and Mr. Buddle felt called upon to stand by Sir Humphrey Davy, a great number held to George Stephenson, and much bitterness of feeling was shown. Neither were there wanting those who upheld Dr. Clanny, Dr. Murray of Edinburgh, Mr. John Murray of Hull, and Mr. Robert William Brandling. Dr. Clanny was the first—Sir Humphrey Davy and Stephenson acknowledged this; but the lamps of the two latter had been brought into work, and the struggle lay between them. Dr. Clanny helped Sir Humphrey Davy, and Mr. Brandling[16] sided with Stephenson. Davy was so much the stronger than Stephenson, that he was better known, and had all the men of learning on his side, while Stephenson was backed by the Killingworth men, and all those who thought highly of what the self-taught workman had done with the locomotive and the safety lamp. Sir Humphrey's friends were angry that one so lowly should be set up against him—Stephenson's, that one so lowly should be put down, and kept out of his fair share of the work, to bolster up a great name. Both sides went great lengths, both went too far, and now it is easy to do right by all.

Perhaps Watt took a part, for he was an early patron of Davy, who was employed in the Pneumatic Institution, at Bristol, under Dr. Beddoes, in which Watt took a great share.

So much was said and done by George Stephenson's friends, they fought so hard for him, and against Davy, that the meeting on the

[7] Report, Moodie's witness, p. 18.

[8] Stephenson, in the Report, p. 15.

[9] Wood's witness, in the Report, p. 17.

[10] Report, p. 19.

[11] Witness of Richard Thompson, an overman. Report, p. 21.

[12] Report, p. 21.

[13] Report, p. 16.

[14] Witness of Mr. Henry Edmonston, Secretary, and of Mr. Henry Atkinson and Mr. Anthony Clapham. Report, p. 22.

[15] The whole of this is well given in the Gateshead Observer, of August 19, 1848, from which the above is taken.

[16] Davy, on the Safety Lamp.

31st of August was held over till the 11th of October, when John George Lambton, the late Earl of Durham, took the chair. Mr. Brandling then moved that the meeting should be again put off, that inquiry might be made, whether "the merit of the invention of the Safety Lamp was due to Sir Humphrey Davy, or George Stephenson." Mr. Arthur Mowbray likewise stood up for this, but it was set aside by a great number of hands. A purse of one hundred guineas was however given to Stephenson.

Stephenson's friends were very wroth at being thus beaten, and Stephenson himself thought that the meeting had dealt very unfairly with him in awarding the meed to Davy. "Whether or not," says Stephenson, in a letter afterwards printed, "Mr. Brandling is justified in the opinion he has expressed [that Stephenson was the inventor], it appears to me may be easily decided; and I shall only add, that if it can be proved that I took advantage, in the formation of the safety lamp, of any suggestions, except the printed opinions of scientific men, I deserve to lose the confidence of my honourable employers, and the good opinion of my fellow-men, which I feel an honest pride in, and which even in my humble situation in life is of more value in my estimation than any reward that generous, but indiscriminating affluence can bestow."

Davy's friends thought they did not do enough in upholding him, but they must further pull down Stephenson; and instead of choosing the likely path, that both might have gone on without knowing each other, they openly said that Stephenson had taken or stolen the thought from Davy.[17] Here was the sting—and hence the manly and earnest speech of Stephenson, given above, which fully shows what his feelings were—his love of standing well with his fellow-men—his earnestness to be worthy of the trust bestowed upon him. From the time he first set foot in the great world, to the day of his death, these were his strong feelings; and as has been before shown, they give the key to his life, and lay open to us the springs of his well-doing.

He was quite right in thinking that the good-will of his neighbours, and the trust of his fellow-men, were worth more than any money which could be bestowed; for they were to him as the land which yields a yearly harvest, while the latter is but a crop which is once gathered in, and there is no more of it. The harvest may fall short sometimes, but there is the land to give a better crop in other years, and to give a good income for whatever is laid out upon it: so is it with a good name—it is a lasting mine of wealth to the owner, the yield of which is the greater the longer it is wrought.

The friends of Davy were none the less angry that a common workman was set up against one of his great name, as if it were likely that one of Davy's standing should be beholdened for anything to a lowly pitman. They were maddened at the thought of one of the greatest men of his day being so set down. How little did they think or dream that the drudge they then looked down upon was to shine upon the world as one no less great than Davy—as one of the brightest lights of his day—as one of whom even they now feel proud. Such is the worth of a name, such is it to weigh with an untrue beam, and to set down wrong weights. The great man of to-day soon sinks into the dust,—the lowly of yesterday is the mighty of the morrow; but let each be weighed by his deeds, and not by his name; by his own works, and not by the witness of his friends.

The writings which were put forth in Stephenson's name are by one hand; but though they breathe his thoughts, it does not seem likely that they are his. In that last given, the earnestness of thought is his, but it is not his speech. There is too much Latin—there are too many of the chosen words of the schoolman, and too much of his craft, to let us believe that they come from a free-spoken Englishman. In talking, Stephenson always had the homely speech of an Englishman, as indeed it now too often happens that among common men our mother tongue is best spoken. With them, the well of English is bright and strong; whereas bookmen, instead of speaking better English for their greater knowledge, only learn Latin and Greek to bring them into English, as if our English were a worse speech, and the others better; or, as if a word were the better understood by being swaddled in outlandish clothes. Stephenson most often had the pen of another, else we might have had from his hand something worthy of our best writers; for it has been often seen, that those have written the freest who have risen as he did, from among those who know no other tongue but their own. The cot is a better school for speech than the college—there is a greater freshness in its sayings: a strength and earnestness and heartiness which come home to our bosoms; something which breathes sweetly of our childhood, and takes us back beyond our school years. Whether in the Bible, in Shakspeare, our best-loved books and writers, those sayings always delight us most which are most homely; and yet, more care is given to eke out a book with big words, borrowed from every land but our own, than to write such things as every one may readily understand.

If Davy's friends spared nothing for him, Stephenson's were as steadfast; the war went on, and the Newcastle papers were full of writings, for and against. The Rev. John Hodgson, Mr. Buddle, Mr. Brandling, and the full number of "Friends to Justice," strove together; but neither side would give in, or own that it was in aught wrong: they were too busy in saddling things on each other to take off one bit from themselves. If Davy had the meeting of coalowners on his side, Stephenson was not to be left barren, and therefore his friends made up their minds that he should have a meeting of his own, and that plate should be given to him as a set-off against what had been done for Sir Humphrey Davy.

It should, however, be said that, having been beaten in getting an inquiry from the meeting of coalowners, they had a meeting of their own, to look into what Stephenson had done, and which ended in the Report, which has been already named. Stephenson, Nicholas Wood, and the others who had a hand in the business, were called together, and gave witness as to what they had seen or done. This was written down and printed at the end of the Report, and it showed the faith the meeting had in the goodness and rightfulness of the side they had taken up. The members were, the Earl of Strathmore, C. J. Brandling, Esq., C. W. Bigg, Esq., Matthew Bell, Esq., R. W. Grey, Esq., Arthur Mowbray, Esq., James Losh, Esq.,[18] T. H. Bigg, Esq., Dr. Headlam,[19] C. N. Wawn, Esq., Anthony Clapham, Esq., and G. Charnley, Esq. Richard Lambert, Esq., was the Treasurer, and Robert William Brandling, Esq., the Secretary.

On the 1st of November, 1817, the further step was taken, and a meeting was held in the Assembly-rooms, Newcastle; at which C. J. Brandling, Esq. took the chair, "for the purpose of remunerating Mr. George Stephenson, for the valuable service he had rendered to mankind by the invention of his Safety Lamp." The first resolution held forth, "that Mr. George Stephenson, having discovered the fact that explosion of hydrogen gas would not pass through tubes and apertures of small dimensions, and having been the first to apply that principle in the construction of a Safety Lamp, was entitled to a public reward." A committee, headed by the Earl of Strathmore, was named to carry this out.

Davy's friends were anew stirred up, and they sent to the newspapers a writing, signed by Sir Joseph Banks, President of the Royal Society, William Thomas Brande, Charles Hatchett, H. W. Wollaston, and Thomas Young, setting forth their conviction, "that Mr. Stephenson was not the author of the discovery of the fact in question, and was not the first to apply that principle in the construction of the Safety Lamp."

The other committee printed their report in answer, setting forth the whole truth, and ended by saying, "After a careful inquiry into the merits of the case, conducted, as they trusted, in a spirit of fairness and moderation, they could perceive no satisfactory reason for changing their opinion." The dead set made by the men of learning who stood by their friend, Davy, did not frighten the others, and did not put a stop to their work. Their minds were made up, and the subscriptions set afoot by them went on steadily. Lord Ravensworth (then Sir Thomas Henry Liddell, Bart.) and partners, gave one hundred guineas; C. J. Brandling, and partners, gave the like,[20] Matthew Bell,[21] and partners, gave fifty guineas; and John Brandling, and partners, gave the like. Thus, a goodly purse was filled; and the great gifts of the Liddells, and the other coalowners, are a very good earnest of how Stephenson was looked upon in his own neighbourhood, and the path which lay open before him. It was not hard to tell what he would do with his inborn skill.

In January, 1818, a dinner was given to George Stephenson, at

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17 Tyne Mercury, Nov. 25, 1817.—Newcastle Courant, Nov. 29, 1817.

18 Then partner with Stephenson in the patent for the rails and chairs.

19 Afterwards a director of the Newcastle and Carlisle Railway.

20 Robert William Brandling, Esq., is the son of the late Char'es Brandling, Esq. M.P., and connected with most of the leading coalowners [Railway Post-Office Directory, 1848], being brother-in-law of Rowland Burdon, Esq., uncle of Matthew Bell, Esq., M.P., and cousin of R. W. Grey, Esq., M.P. He was therefore well able to help George Stephenson, to whom he was a great friend. He is a barrister by profession, but has taken a great share in all undertakings in his neighbourhood; among other things, in the Brandling Junction Railway, and in the Safety Lamp.

21 The Bells were likewise great friends of Stephenson. Matthew Bell, Esq., of Woolsington, is the one named above. The son, born in 1793, is now M.P. for South Northumberland, and has been a director of the Newcastle and Carlisle Railway since 1829. [Railway Post-Office Directory, 1848.] In 1816, he had been High Sheriff of Northumberland.

the Assembly-rooms, Newcastle, when a silver tankard was put into his hands, together with one thousand guineas.

"I shall ever reflect with pride and gratitude," said he, "that my labours have been honoured with the approbation of such a distinguished meeting; and you may rest assured that my time, and any talent I may possess, shall hereafter be employed in such a manner as not to give you, gentlemen, any cause to regret the countenance and support you have so generously afforded me."

This pledge, as is well known, Stephenson fulfilled.

Of the feelings of the committee, the best earnest is the following words, given in their Report:—"When the friends of Mr. Stephenson remember the humble and laborious station in which he has been born and lived; when they consider the scanty means and opportunity which he has had for pursuing the researches of science; and look to the improvements and discoveries which, notwithstanding so many disadvantages, he has been enabled to make, by the judicious and unremitting exercise of the energy and acuteness of his natural understanding, they cannot persuade themselves that they have said anything more than every liberal and feeling mind will most willingly admit."

Thirty years afterwards, a third piece of plate was given to the "Inventor of the Safety Lamp," which this time was Dr. Clanny,[22] who has been already named.

Although so much noise was made at the time, and each said that the other had stolen the thought from him, it is not hard, now that angry feelings have softened down, to see the truth. It was held by them that one must be the first finder: but there is no need to believe anything of the kind, for two or three might as readily busy themselves with a safety lamp as one. Why, indeed, was Sir Humphrey Davy called in? Why did Stephenson give his mind to it but from the want of such a thing, the fearful loss of life which had followed from taking candles into fire-damp, and the little good of the steel mill? Many, therefore, set their wits to work to find out a safety lamp. We have named five, and it was in no way odd that two should hit upon the same thing.

Throughout the field of learning we have found this happen. Was there not the very same thing with Newton and Leibnitz about fluxions? Did not Watt, Cavendish, and Lavoisier each take a share in finding out the composition of water? At the same time, Fulton and Bell were at work on the steamboat,—Trevithick and Oliver Evans on the steam-wagon,—and in our days, there has been a struggle between Le Verrier and Adams, by which the learned world has been torn, as to who found out Neptune. There are several put forward as the first lighters of gas. Young and Champollion fight over the Rosetta stone; we have not yet awarded the meed to the man who first set railways going: James and Gray (though dead) are still in the field, with many more who strive to wrench from them the name of "Father of Railways." This will ever be, for where there is a want, the ready wit of many men will be ever ready to find out the right way. Is there anything new brought forward, straight every one rushes into that path. There is not much mistake in saying, that there were a thousand clever inventors who found out atmospheric railways. The heads of railways unhappily know how many makers there are of new buffers, breaks, links, wheels, rails, and chairs—each good, and each the best. The Gutta Percha Company have before them a list of two hundred hints for making everything of gutta percha, from ear-trumpets to horse-shoes. It is good that it should be so, rather than that we should lag behind, waiting for the slow work of a few minds, when we may bring to bear the fruitfulness of many.

Stephenson seems to have been the first to try a lamp with holes so small that explosion of fire-damp did not pass downwards; but Davy had nothing to do with him, and was not far behind, and he made a much better lamp by taking wire gauze instead of pipes or holes.

The following, from the 9th page of the Report of the Committee, shows what each did:—

1815.	MR. STEPHENSON.	SIR HUMPHREY DAVY.
Aug. to Oct.	Busy with those experiments upon blowers in Killingworth Colliery, which led to the construction of his lamps.	The subject occupied his attention, as an object of speculation.
Beginning of Oct.	Ordered his first lamp, which was tried in the colliery on the 21st of that month.	Commenced his experiments on fire-damp, and before the 18th of that month had discovered certain facts [the facts in question] respecting that inflammable substance, and states, in a letter dated Oct. 19, that if a lamp or lanthorn be made air-tight on the sides, and furnished with apertures to admit the air, it will not communicate flame to the outward atmosphere.
End of Oct.	Ordered his second lamp.	In a letter, dated Oct. 30, describes to Mr. Hodgson a lamp, in which he adopted *tubes and canals* above and below.
Nov. 4.	Tried his second lamp in Killingworth Colliery.	Mr. Butler noticed Sir Humphrey Davy's discoveries in an oration.
Nov. 9.		Read to the Royal Society a paper giving a detailed account of his experiments, and the various applications he had made of his discoveries, but without mentioning dates.
Nov. 19 or 20.	Ordered his third lamp.	
Nov. 30.	Tried his third lamp in the mine.	
Dec. 5.	Exhibited his third lamp to the Literary and Philosophical Society in Newcastle.	
Dec. 31.		*Before* this period "had presented to the miner the wire gauze lamp."[23]

What made the struggle was, that the meeting of coalowners had called in Sir Humphrey Davy, and while he was busy, George Stephenson, a common workman, of his own free will, stepped in between the meeting and Davy. The coalowners did not deal fairly with Stephenson, for after calling a meeting to thank Sir Humphrey Davy for "the Invention of *his* Safety Lamp," and throwing off Stephenson, on the ground that the meeting was to thank Davy only for what *he* had done, free from what any one else had done, they made it to thank Davy "for his invention of *the* Safety Lamp"—which was another thing altogether. Having done this, they gave, as a sop, the hundred guineas to Stephenson; but he and his friends would not stand still under this slight. They could have nothing to say as to what might be given to Davy, but they had when Stephenson was set aside.

VI. ENGINEERING.

In 1813, when he was thirty-three, Stephenson had been set, as we have seen, to overlook the engines at Killingworth, in which higher berth he brought out his locomotive engine and his safety lamp; so that Killingworth had its own works, as well as Wylam or any other colliery. His son was being brought up at Newcastle, and afterwards he sent him to Edinburgh, that he might be at its University—then at its height, and one of the greatest schools of its day.

In 1814 he brought out his first locomotive, and in 1815 he was busy with the safety lamp, and the second locomotive. He had likewise some work in laying down slopes and railways.

He had not been able, as we have seen, to take out a patent when he made his first engine, but he soon after became known to Mr. R. Dodd, and with him took out a patent on the 28th February, 1815, for a method of communicating power to the engine without the cog-wheels used in the first engine.[24]

The plan proposed was the application of a pin upon one of the spokes of the engine-wheels; the connecting-rod fixed to the cross-beam of the engine, and moving with the piston, being attached at the lower end to the spoke of the wheels, and working in a ball-and-socket joint. Thus the reciprocating motion of the piston was converted, by the pin acting as a crank, into a rotatory motion. To keep the cranks at right angles with each other, Stephenson used an endless chain of one broad and two narrow links, which lay upon a toothed wheel fixed to each axle. The teeth stood out about an inch from the wheel, and went in between the two narrow links, leaving a broad link between every two cogs, and resting on the rim of the wheel. Thus the chain moved round with the wheel, and one wheel could not be moved round without the other. This chain he afterwards gave up.

22 Gateshead Observer, August 19, 1848.

23 Morning Chronicle, Dec. 18, 1815.—Newcastle Chronicle, Dec. 23, 1815.

24 Lardner on the Steam-Engine; Ritchie on Railways, p. 222; Stuart's Anecdotes of the Steam Engine.

This engine was put to work on the Killingworth Railway.

In 1816, Trevithick left England for the West Indies, leaving the locomotive to look after itself, for what he knew. Stephenson, however, looked after it. In this year he took out a patent with Mr. William Losh, a great engineer of Wallsend and Newcastle. Among other improvements was that of "sustaining the weight, or a proportion of the weight, of the engine upon pistons, moveable within the cylinders, into which the steam or water of the boiler is allowed to enter, in order to press upon such pistons, and which pistons are, by the intervention of certain levers and connecting-rods, or by any other effective contrivance, made to bear upon the axles of the wheels of the carriage upon which the engine rests."

The cylinders were open at the bottom and screwed upon the frame of the engine. The piston, which was solid and packed in the common way, was furnished with an inverted rod, the lower end of which passed through a hole in the frame, and supported the engine, and pressed upon the chair, which rested on the axes of the wheels upon which the carriage moved. This chair had motion up and down the piston-rod. The pressure of the steam upon the piston transmitted the weight to the axle, and the re-action took an equal weight from the engine, and the steam served the purpose of an elastic spring.[25]

Mr. Ritchie objects to this invention, that it aimed at too much, was too complicated, and not precise enough to be of much use.

Messrs. Stephenson and Losh had their patent likewise for a cast-iron rail, which was held to be an improvement on the rails then used.[26] As railways were then laid, the wagon-wheels met with a hindrance at the joints, and a shock was given, and the rails put out and broken. Stephenson therefore wished to fix the rails fast in the chairs. His rails were made with a half-lap joint, having a pin or bolt, which fixed them, so that the end of one rail should not rise above the end of the next one, and so that the rails should not yield if the block sank.

We have seen that in 1817, Stephenson was busy in his struggle with Davy about the safety lamp. In the next year, the dinner was given to him, and he was laying down railway works and making engines.

In that year (1818), and in the next, he gave his time, as Nicholas Wood acknowledges,[27] to experiments with Wood on railways, which have been printed.

His son had now become an under-viewer, and was a helper to his father.

Perhaps about this time he first came up to London for the patents.

We have followed Stephenson so far until he is upon the eve of starting in a new path, and we find him in a new walk of life, and much better off. We have seen his beginning from his father's cot, his struggles as a workman, his care as a father, and the spreading of his name after making the locomotive and the safety lamp. He had begun to reap some reward from his toil, and instead of being poor and penniless, he had had eleven hundred guineas given to him beyond what he had earned. From being the man, he had become the master; from being the learner, he was to be henceforth a teacher. He had a share in two patents, and there was a call for his work, for besides his old masters at Killingworth, the neighbouring coalowners were now among his friends.

As his rise had been quick, and he was brought at once into the fellowship of the northern gentry, his honours came blushing thick upon him. He did not so fully feel his own weight, but having been kept down so long, he hailed willingly the hands which were stretched forth towards him; taking everything as a kindness held out to him, instead of looking upon it as a right. His greatness had not grown gradually upon him,—he did not settle slowly in his seat: he was marked as a new man, and always through life he had a quick feeling of his lowly beginning. It was better, perhaps, that it was so, for he kept up a kindly feeling with all around; whereas, had he taken on him the bearing of a great man, as many do, he might have lorded it over the world. but he would have missed what was dearer to him than this—the love of his fellow-men. He was thankful for everything, and therefore kindly to every one. As he did not look for much, or stand upon his rights, he was seldom wronged and always happy.

25 Ritchie on Railways, p. 226. 26 Ritchie on Railways, p. 31-37.
27 Wood on Railways.

CONTRIBUTIONS TO RAILWAY STATISTICS, IN 1846, 1847, AND 1848.—By Hyde Clarke, Esq.

(Continued from page 272.)

No. IX.—SAND TRAFFIC.

Sand is a large article of traffic. The amount detailed in each year ending June 30, stands thus—

Company.	Tons. 1845.	Tons. 1846.	Tons. 1847.
Arbroath and Forfar,	——	11,173	12,619
Bodmin and Wadebridge,	12,227	8,420	12,320
London and Croydon,	3,000	1,992	——
Leicester and Swannington,	——	31	——
West Cornwall (Hayle),	——	——	2,944
Wishaw and Coltness,	2,921	2,764	——

The receipts in each year stand thus—

Company.	1845.	1846.	1847.
Arbroath and Forfar,	£1,310	£414	£447
Bodmin and Wadebridge,	——	882	1,293
London and Croydon,	450	——	——
Leicester and Swannington,	——	5	——
West Cornwall (Hayle),	——	——	298
Wishaw and Coltness,	21	32	——

Some of the returns mix up gravel, ballast, and sand.

The sand on the Bodmin and Wadebridge, and Hayle Railways (15,264 tons in 1847), is sea-sand used as manure. Sand is used for building, agricultural, and domestic purposes. That carried on the Croydon is partly for sanding floors.

The rates are as follows:—

London and Croydon,	3·75d.	per ton	per mile.
Bodmin and Wadebridge,	3·00	"	"
Leicester and Swannington,	2·75	"	"
Wishaw and Coltness,	2·20	"	"
Arbroath and Forfar,	1·97	"	"
Lancashire and Yorkshire,	1·33	"	"

On the Durham and Sunderland Railway, ballast is carried for shipping purposes. The return stands thus—

1845.	1846.	1845.	1846.
30,356 tons.	36,567 tons.	£506	£609

No. X.—SLATE TRAFFIC.

There is little information as to the quantity of slate carried. In the year ending 1846, there were carried on the Wishaw and Coltness Railway 1,280 tons, for which £41 was received.

The rates for carrying slates per ton per mile are as follows:—

Ballochney, ..	3·0d.
Newcastle and Carlisle,	2·0d.
Wishaw and Coltness,	1·3d.

No. XI.—BRICKS AND TILES.

That railways cause a large saving in many places in the carriage of bricks is shown by the quantities carried. Many new brick-fields and tile-works have been opened to take advantage of these facilities, as well as of the cheap coal,—in the same manner as they are opened near canals.

The quantities detailed in each year ending June 30, are as follows:—

	Tons. 1845.	Tons. 1846.	Tons. 1847.
Lancashire and Yorkshire (Preston and Wyre),	——	——	1,000
Leicester and Swannington, ..	746	503	——
London and Croydon, ..	560	——	——
Maryport and Carlisle, ..	370	1,209	——
Wishaw and Coltness, ..	291	2,051	*1,541
Whitehaven, ...	——	44	*86

The amounts received were—

	1845.	1846.	1847.
Lancashire and Yorkshire (Preston and Wyre),	£ —	£ —	£ 117
Leicester and Swannington, ..	92	60	—
London and Croydon, ..	50	—	—
Maryport and Carlisle, ..	40	99	—
Wishaw and Coltness, ..	12	95	*46
Whitehaven, ...	—	2	*4

* For half year only.

The rates of carriage per mile per ton are as follows:—

Bodmin and Wadebridge,	4·00d.
Ballochney, ..	3·00
Leicester and Swannington,	3·00
London and Croydon, ..	3·00
London and South Western,	2·09
Maryport and Carlisle,	2·09
Wishaw and Coltness,	1·95
Whitehaven, ..	1·80

The only return of tiles carried for building or agricultural purposes is that of the Wishaw and Coltness Railway for the year ending June 30, 1846, 502 tons. Receipts £20.

The only return of clay carried for brick-making, pottery, or other purposes, is that of the Wishaw and Coltness Railway, 1846, 346 tons; and 1847, 475 tons. Receipts, 1846 £6, and 1847 £8.

The rates for the carriage of bricks are generally too high, and are exclusive of loading. Twopence per ton per mile would be enough.

The above returns give no means of calculating the quantity of bricks and tiles carried on the whole length of railway.

No. XII.—MISCELLANEOUS MINERAL TRAFFIC.

Besides the articles already enumerated are many others, as lead ores, copper, brass, lead and tin manufactured, salt, sulphur, roman cement, glass, pottery, fullers'-earth, &c., but as to which no information is to be got.

The rates for carrying salt are as follows, per ton per mile :—

Bodmin and Wadebridge,	4·00*d.*
Newcastle and Carlisle,	2·50
London and Brighton,	2·24
Lancashire and Yorkshire,	1·32

The rate for carrying fullers'-earth on the London and Brighton Railway is 2·24*d.* per ton per mile.

No. XIII.—MINERAL TRAFFIC.

The whole mineral traffic shows the following results in tons :—

	1845.	1846.	1847.
Coal and Coke,	7,000,000	8,900,000	8,900,000
Iron-stone,	400,000	500,000	600,000
Iron,	230,000	230,000	300,000
Dross,	——	110,000	110,000
Copper and Tin,	23,000	23,000	23,000
Limestone and Lime,	200,000	250.000	300,000
Building Stones,	200,000	400,000	600,000
Sand,	30,000	30.000	37,000
Ballast,	30,000	36,000	36,000
Bricks and Tiles,	2,000	5,000	5,000
Miscellaneous,	——	280,000	300,000

All these amounts, except for coal, are far below the mark; but they establish a total mineral traffic in 1847 of not less than 11,200,000 tons, besides unenumerated articles.

Besides the returns already given are the following miscellaneous returns, of Minerals and Stones (1); Stones and Timber (2); Stone and Coal (3); Stone and Bricks (4).

	Tons. 1846.	Tons. 1847.
(1) Brighton,	——	95,315
(1) Lancashire and Yorkshire,	*10,660	33,177
(1) Norfolk, ..	*5,800	11,659
(1) St. Helen's, ..	——	25,060
(2) Dublin and Drogheda.	9,686	3,745
(2) Great North of England,	8,298	——
(2) London and South Western,	*4,984	——
(2) Eastern Union, ..	——	*5,951
(3) London and Brighton,	55,747	——
(4) West Cornwall (Hayle),	42,795	——

The amounts received were as follows :—

Company.	1846.	1847.
(1) Brighton, ..	£——	£9,095
(1) Lancashire and Yorkshire,	*2,024	5,532
(1) Norfolk, ..	*716	1,184
(1) Saint Helen's, ..	——	1,002
(2) Dublin and Drogheda,	726	549
(2) Great North of England,	*2,720	——
(2) London and South Western,	*4,984	——
(2) Eastern Union, ..	——	*305
(3) London and Brighton,	4,287	——
(4) West Cornwall (Hayle)	6,304	——

No. XIV.—TIMBER TRAFFIC.

The quantity of timber carried in each year ending June 30, as detailed in the returns, is as follows :—

	Tons. 1845.	Tons. 1846.	Tons. 1847.
Great North of England,	1,000	——	——
Lancashire and Yorkshire,	——	*667	4,837
Maryport and Carlisle,	——	2,434	1,774
Whitby and Pickering,	911	——	——
Whitehaven,	——	*303	*198
Wishaw and Coltness,	148	1,435	*2,451

* Half-year.

The amounts received are as follows :—

Great North of England,	£160	£——	£——
Lancashire and Yorkshire,	——	*667	1,455
Maryport and Carlisle,	——	539	331
Whitby and Pickering,	506	*37	——
Whitehaven, ..	——	*20	*15
Wishaw and Coltness,	130	117	*81

The rates for the carriage of timber are as follows :—

Whitby and Pickering,	5·00*d.* per ton per mile.
Ballochney, ..	3·00 " "
Whitehaven, ..	3 00 " "
Bodmin and Wadebridge,	2·50 " "
London and South Western,	2·50 " "
Wishaw and Coltness,	2·35 " "
Maryport and Carlisle,	2·33 " "
Lancashire and Yorkshire,	2·24 " "

Timber is in some returns mixed up with stone traffic, as seen in No. XIII.

On the Cornish and Northern lines, timber is carried for mining purposes; in the agricultural districts, for hop-poles and fences; on all lines for building. Bark is carried on the Southern railways.

In 1845, I estimated the quantity of timber carried at 40,000 tons, and there seems no reason for doubting that this is a safe estimate.

No. XV.—BUILDING TRAFFIC.

On the whole, railways afford great accommodation to the building interests, though not to that extent which they may and will do when the traffic is more developed.

The following is an estimate of the traffic carried on for building purposes under each head :—

	Tons. 1845.	Tons. 1846.	Tons. 1847.
Stone,	200,000	400,000	600,000
Bricks and Tiles,	2,000	5,000	5.000
Timber,	40,000	40,000	50,000
Lime,	50,000	50,000	50,000
Sand,	10,000	10,000	10,000
Total,	300,000	400,000	715,000

The rates for the carriage of each of these articles, though below those on roads and canals, are still too high for the development of the traffic. It is a great disadvantage that most of these articles—stone, timber, and bricks—give much trouble in loading and unloading.

No. XVI.—FISH TRAFFIC.

This traffic is of the greater importance, as it gives a positive addition to the supply of food in the country, and is therefore of great national benefit. Railways stimulate the production, or economise the cost of production, of grain, meat, and other article of food; but all fish that can be carried inland, is so much added to the resources of the country. In this respect, railways have done much and can do more, both for the supply of food to the country, and the promotion of the fisheries.

In the beginning of last year, I laid before Mr. Hudson a suggestion for extending the carriage of fish, as a means of relieving the famine, and to which he gave his approval. In the last session, Mr. Wyld, M.P., called the attention of the House of Commons to my plan for increasing the consumption of fish, by adopting it as an article of occasional diet in workhouses and prisons. This would cause an increased consumption of at least 20,000 tons of fish. Sir George Grey said there was no objection to the adoption of this plan, provided enough fish were given.

In consequence of the progress of the railway traffic, there has been a great increase in the consumption of fish inland. A very strong proof of this is given in the case of Birmingham, where they find it necessary greatly to enlarge the fish market.

On the South-Western, Eastern Counties, and other metropolitan railways, great numbers of fish hawkers go down by the early trains.

It is very much to be regretted that there is a great dearth of information on this very important subject; and it is very desirable, in consequence of the absence of definite information, that a parliamentary return should be obtained of the quantities of fish carried by railway. This, however, can only be obtained by approximation, as all the fish is not carried in bulk, but very much is carried as parcel traffic, and some by passengers as luggage.

* Half-year.

The only returns are the following:—

Company.	Tons. 1844.	Tons. 1845.	Tons. 1846.	Tons. 1847.
Eastern Counties (Cambridge)	—	—	*5,100	—
Great North of England,	1,218	867	—	—
Norfolk, ..	—	—	†2,775	†7,102
Whitby and Pickering,	777	1,109	‡350	—

The receipts stand as follows:—

	1844.	1845.	1846.	1847.
Great North of England,	£1,378	£1,020	£—	£—
Norfolk, ..	—	—	†1,730	†3,895
Whitby and Pickering,	777	330	‡156	—

* Estimated. † Half-year. ‡ Two months.

The rates are high. The following are the rates per ton per mile.

London and Brighton,	5·69*d.*
Great North of England,	5·55
Whitby and Pickering,	5·00
Preston and Wyre,	4·00
London and South Western,	3·
Norfolk, ..	2·3

The Great Western are known to carry a great quantity of fish over the South Devon line. The receipts are said to be £250 per week.

The traffic of the lines given above may be estimated as follows:

Eastern Counties (Cambridge)	5,100 tons.
Great North of England,	1,000 „
Norfolk, ..	12,000 „
Whitby and Pickering,	1,100 „
Total,	19,200

This is nearly 20,000 tons on four lines of railway, and not including the Eastern Counties (Colchester), Brighton, South-Western, Great Western, South-Eastern, Hull and Selby, Liverpool and Manchester, and Preston and Wyre.

In 1845, I estimated the railway traffic in fish at 13,000 tons, which must have been much below the mark.

The following is an estimate of the amount now conveyed:—

Districts.	Tons.
Scotland,	2,000
Northern,	4,000
Midland,	2,000
Western,	2,000
South Western,	4,000
Southern,	4,000
Eastern,	25,000
Total,	43,000

This traffic is very remunerative, and does not bring less than 10*s.* per ton. If parcels were taken into the account, the gross tonnage of fish carried may be reckoned as 70,000 tons; or, on the lowest computation, the food of as many individuals.

No. XVII.—GRAIN TRAFFIC.

The conveyance of grain and flour is irregular; for though there is a fixed quantity carried to the local markets, the import of foreign corn is fluctuating.

The returns for the years ending June 30, are as follows:—

Company.	Tons. 1845.	Tons. 1846.	Tons. 1847.
Great North of England,	5,901	—	—
Lancashire and Yorkshire,	—	*39,682	117,312
London and Croydon,	45	—	—
Manchester and Bolton,	—	—	*4,351
Maryport and Carlisle,	229	2,434	120
Norfolk, ..	—	*8,796	*17,771
Slamannan, ..	—	—	2,624
Whitby and Pickering,	407	*89	—
Whitehaven, ..	—	27	*44
Wishaw and Coltness,	—	1,333	—

The amounts received in each of the years are as follows:—

Company.	1845.	1846.	1847.
Great North of England,	£1,284	£ —	£ —
Lancashire and Yorkshire,	—	*13,176	*36,260
London and Croydon,	5	—	—
Manchester and Bolton,	—	—	*415
Maryport and Carlisle,	81	97	13
Norfolk, ..	—	*1,091	*2,082
Slamannan ..	—	—	282
Whitby and Pickering,	142	4	—
Whitehaven, ..	—	2	*4
Wishaw and Coltness,	— —	48	—

* Return for the half-year of grain and provisions.

The rates are as follows, per ton per mile:—

Bodmin, ..	4·00*d.*
Maryport and Carlisle,	4·00
Whitby and Pickering,	4·00
Whitehaven, ..	3·10
Ballochney, ..	3·00
Wishaw and Coltness,	2·32
Lancashire and Yorkshire,	2·29
Arbroath and Forfar,	2·12
Norfolk, ..	1·25

The amount of grain and meal carried by railway is certainly not under a quarter of a million of tons, and most probably exceeds three hundred thousand tons.

Through the kindness of Mr. Waddington, I have been favoured with the following return of grain, flour, and seed, carried for the London markets by the Eastern Counties Railway.

Half-year ending	Flour. Sacks.	Malt. Qrs.	Wheat. Qrs.	Barley. Qrs.	Oats. Qrs.	Beans. Qrs.	Peas. Qrs.	Seed. Sacks.
June 26, 1847.	126,269	99,114	20,850	4,409	11,326	3,542	1,079	15,099
Dec. 25, 1847.	113,365	81,688	24,287	14,888	2,934	3,239	1,909	9,904
June 24, 1848, to	149,957	139,078	26,649	9,990	16,426	1,858	931	11,445
Aug. 12, 1848.	45,360	28,300	14,847	789	2,132	407	140	2,971

Not knowing the average weights of the above, they cannot be reduced into tons.

No. XVIII.—PROVISION TRAFFIC.

There are no means of estimating the provision traffic on railways; but such returns as there are, show that it is very great.

The following are returns of the number of tons of provisions carried in each of the years ending June 30. The Lancashire and Yorkshire, and Norfolk returns, already given, include corn; the Eastern Counties return is from Mr. Moseley, through Mr. Waddington, and includes fish.

Company.	Tons. 1845.	Tons. 1846.	Tons. 1847.
Eastern Counties, ..	—	—	30,000
Lancashire and Yorkshire, ..	—	†3,968	117,312
Lancashire and Yorkshire (Preston & Wyre),	8,521	8,412	5,220
London and Brighton, ..	—	3.632	—
London and South Western,	—	40,655	—
Norfolk, ..	—	†8,796	†17,771
South Eastern, ..	*10,000	—	—

* Fruit, meat, and vegetables, half-year, 3,583 tons, besides fish, bacon, hams, &c.
† Half-year.

The amounts received are as follows:—

	1845.	1846.	1847.
Lancashire and Yorkshire (Preston & Wyre),	£2,591	£2,815	£1.740
London and Brighton, ..	—	4,373	—

The rates charged are as follows per ton per mile:—

London and Brighton,	5·69*d.*
Preston and Wyre,	4·00
London and South Western,	2·57

Ale and beer are carried largely on the South Western, Newcastle and Carlisle, and other lines. The rates on the London and South Western are 2·09*d.* per ton per mile, and on the Durham and Sunderland, 2*d.*

To the tonnage of provisions must be added that of fish and grain, which gives the following returns for 1847:—

Fish.—	Great North of England,	1,000 tons.
	Norfolk, ..	12,000 „
	Whitby and Pickering,	1,100 „
Grain.—	Great North of England,	6,000 „
	Slamannan, ..	2,600 „
	Wishaw and Coltness,	1,300 „
Provisions.—	Eastern Counties,	30,000 „
	Lancashire and Yorkshire,	117,312 „
	„ Preston and Wyre,	5,220 „
	London and Brighton,	3,632 „
	London and South Western,	40,655 „
	Norfolk, ..	25,000 „
	South Eastern, ..	10,000 „

In 1845, I estimated the supply of provisions to the London markets by railway as follows, to which I subjoin a new estimate. This does not include cattle.

		Tons. 1845.	Tons. 1848.
South Eastern,	..	7,000	10.000
Brighton,	..	5,000	30 000
South Western,	..	20,000	20,000
Great Western,	..	30,000	40,000
London and North Western,		30 000	30 000
Eastern Counties,	..	15,000	100,000

Among these articles are fresh fish, meat, milk, butter, fruit, &c., which cannot be brought from great distances except by railway. Milk is now largely carried on the Eastern Counties and other railways, under arrangements by which the companies take back the empty cans.

The metropolis is now the seat of a considerable trade in provisions, supplying to the country towns, fish, prime beef, poultry, fruits, and articles of foreign provision.

The whole provision traffic of each district, including fish and grain, may be estimated as under.

District.	Tons.
Northern,	100,000
North Western,	200,000
Midland,	50,000
Western,	50,000
South Western,	30,000
Southern,	50,000
Eastern,	200,000

This estimate does not include Scotland. It is very vague and much under the mark.

No. XIX.—MANURE TRAFFIC.

This traffic is of great value to the agricultural interests, but there is a want of adequate information respecting it.

The following are returns of manures carried for the years ending June 30.

Company.	Tons. 1845.	Tons. 1846.	Tons. 1847.
Leicester and Swannington,	496	221	——
Wishaw and Coltness,	1,056	2,516	*1,727
York and North Midland,	——	*5,943	——

* Half-year.

The tonnage on the two former lines is chiefly guano. On the Wishaw and Coltness, 1,043 tons were carried in 1846.

The amounts received are trifling. They are as follows:—

Company.	1845.	1846.	1847.
Leicester and Swannington,	£ 49	£ 19	£——
Wishaw and Coltness,	27	149	*95
York and North Midland,	——	*445	

* Half-year.

The rates are as under, per ton per mile.

Newcastle and Carlisle (guano)	2·5 d.
London and Brighton,	2·24
Arbroath and Forfar,	2 12
Leicester and Swannington,	2·00
Lancashire and Yorkshire,	1·33
Wishaw and Coltness,	1·10
York and North Midland,	1·00

Lime and sand are likewise carried as manures.

It is much to be regretted that no adequate measures are taken for applying the manure of towns. In the metropolis alone, the waste cannot be less than what would be equivalent to raising food for a million of people.

The following is an estimate of the whole amount of manures carried.

Lime,	210,000 tons.
Sand,	30,000 „
Manure,	40,000 „

The whole quantity is perhaps about three hundred thousand tons, and it may be safely taken that there is a production of food for a hundred thousand individuals effected by means of railway transit.

Bones form a regular article of transit on some of the railways. The charge on the Arbroath and Forfar Railway is 2*d.* per ton per mile.

No. XX.—MISCELLANEOUS AGRICULTURAL TRAFFIC.

Many small articles are included under the head of agricultural traffic, as to which there are a few scattered details in the returns.

On the South-Eastern Railway hops are carried. This is a season traffic, carried on one-half year only. The number of tons in 1847 was 7,248, and the receipts £7,741.

The rate of charge on the London and Brighton is 2·5*d.* per ton per mile.

Malt is not carried so much by railway as might be expected, because the malt gets shaken up, and then measures less on delivery, because it cannot be so well heaped up. As the quality of the malt is not affected, this is only a temporary prejudice on the part of the dealers.

The charges for carrying malt are on the London and South Western Railway 3*d.* per ton per mile, and on the London and Brighton 2·68*d.*

Bark is carried on most of the Southern lines. The rates are on the London and Brighton, 2·68*d.*, and on the London and South Western, 2,57*d.*

Brooms are manufactured near the London and South Western Railway, and are carried at the rate of 2·09*d.* per ton per mile.

Hay is reckoned hazardous from its liability to catch fire from the engine sparks. The quantities carried and amounts received on the Newcastle and Carlisle Railway are—

1846.	1847.	1846.	1847.
968 tons.	1,003 tons.	£ 892	£ 879

The rate of carriage on the above railway is 5*d.* per ton per mile.

There are no details as to wool traffic, though wool of home and foreign growth is carried. The rate is 3*d.* per ton per mile.

There is a return of potatoes carried in 1846 on the Wishaw and Coltness Railway, 43 tons at 2·35*d.* per ton per mile, the receipts being £2 only.

The rates for hides are, on the London and South Western 2·5*d.* per ton per mile, and on the London and Brighton, 3·5*d.*

The following are mixed returns of agricultural produce for the years ending June 30.

Company.	Tons. 1846.	Tons. 1847.
Dublin and Drogheda,	5,324	6.054
Great North of England,	63 323	6,064
West Cornwall (Hayle),	1,398	——
London and Brighton,	26,804	——

The receipts were as follows:—

Dublin and Drogheda,	£1,867	£1,823
Great North of England,	4,718	——
West Cornwall (Hayle),	288	——
London and Brighton,	11,204	——

No. XXI.—AGRICULTURAL TRAFFIC.

The preceding sections show the services rendered to agriculture by railways. The accommodation may be classed under the following heads:—

Brought to the Farm.

		Tons.
Building materials, draining tiles, hop-poles, &c.,		350,000
Manures, lime, bones, sand, &c.,	..	300 000
Hay, turnips, oil-cake, &c., for feeding stock,		——
Clover and other seeds,	..	15 000
Salt, ..	..	——
Coals, ..	..	4 500,000
Lean stock, 100,000 cattle; 250,000 sheep,		
Implements and iron, ..	..	——
Fish, ..	..	10,000
Foreign provisions and groceries,	..	——

The whole weight carried by railway to the farms cannot be less than 6,000,000 tons, on which a very great saving has been effected.

Produce carried to Market.

	Head.	Tons.
Cattle,	400,000	——
Calves,	——	——
Sheep,	1,750,000	——
Swine,	100,000	——
Horses,	——	——
Provisions,	——	700,000
Grain,	——	——

Other produce, hides, hams, wool, hops, malt, ale, beer, cyder, perry, hay and animal food, timber, bark.

No. XXII.—PARCELS TRAFFIC.

This is a well-paying branch of revenue, connected with the passenger traffic, and has been latterly much improved. The subjoined accounts do not, however, show the full extent of the parcel traffic, as a great portion of it is still included in the general account for goods, the carriers making up parcels as goods. The results are therefore minimum results.

The following shows the number of parcels carried in each year ending June 30, so far as they are detailed in the returns :—

Company.	1845.	1846.	1847.
East Lancashire,	—	—	*23,733
Eastern Counties (Colchester)	184,545	133,953	—
Eastern Union,	—	—	60,808
" Ipswich and Bury,	—	—	*10,920
East Anglian,	—	—	2,783
Kendal and Windermere,	—	—	8,976
Lancaster and Preston,	32,000	—	—
Lancaster and Carlisle,	—	—	24,728
Llanelly and Llandillo,	5,597	6,199	—
Londonderry and Enniskillen,	—	—	*2,234
Lancashire and Yorkshire,	88,571	203,239	392,402
Newcastle and Carlisle,	36,835	40,962	38,817
Manchester and Sheffield,	—	—	*21,658
South Devon,	—	—	26,855

* Half-year.

The numbers for 1847 may be made out thus :—

East-Lancashire, ..	40,000
Eastern Counties : Colchester,	180,000
" Cambridge, ..	300,000
Eastern Union, ..	60,000
" Ipswich and Bury,	20,000
East Anglian, ..	2,783
Kendal and Windermere,	8,976
Lancaster and Preston, ..	30,000
Lancaster and Carlisle, ..	24,728
Llanelly, ..	6,000
Londonderry, ..	4,000
Lancashire and Yorkshire,	400,000
Newcastle and Carlisle,	38,817
Manchester and Sheffield,	40,000
South Devon, ..	26,855

The amounts received for the carriage of parcels in each year stand thus ; the amounts for 1845 being obtained by doubling the half-year ending June 30, 1845 :—

	1845.	1846.	1847.
Arbroath and Forfar,	£250	£326	£410
Ardrossan, ..	—	—	*38
Ballochney, ..	28	56	71
Chester and Birkenhead,	700	825	852
Caledonian (Garnkirk) ..	—	—	*20
Cockermouth and Workington,	—	—	*11
Dublin and Drogheda, ..	1,800	1,260	1,377
Dublin and Kingstown, ..	471	354	578
Dundee and Arbroath, ..	346	733	939
" Perth, ..	—	—	*48
" Newtyle, ..	36	52	61
Eastern Counties : Cambridge,	3,000	8,851	10,902
" Colchester,	6,984	5,444	5,767
Eastern Union, ..	—	—	1,100
" Ipswich and Bury,	—	—	*303
East Anglian, ..	—	—	131
East Lancashire, ..	—	—	1,140
Edinburgh and Glasgow,	—	3,174	2,715
" Dalkeith,	—	160	—
Furness, ..	—	—	*3
Glasgow and Greenock,	—	1,885	1,884
Great Southern and Western,	—	—	2,349
Great Western, ..	30,000	*14,983	34,155
Kendal and Windermere,	—	—	107
Lancaster and Preston,	1,200	1,370	† 454
Lancaster and Carlisle,	—	—	*241
Lancashire and Yorkshire,	4,074	4,309	5,225
" Manch. and Bolton,	860	1,021	—
" Preston and Wyre,	340	*253	700
Llanelly and Llandillo,	338	417	—
London and North Western,	56,000	60,427	104,748
" Grand Junction,	20,000	30,527	
" Manch. and Birm.		5,751	
London and Blackwall,	—	162	201
London and Brighton,	—	6,009	9,506
" Croydon,	280	*184	—
London and South Western,	—	10,678	10,629
Londonderry and Enniskillen,	—	—	*33
Manchester and Sheffield,	700	*878	1,079
Maryport and Carlisle,	158	306	344
Midland, ..	21,000	24,879	28,986
Newcastle and Carlisle,	1,261	1,389	1,307
North Union, ..	2,800	2,893	3,096
South Eastern, ..	6,400	7,035	8,445
" Greenwich, ..	11	142	334
" Gravesend and Rochester,	—	39	*14
Scotch Midland (Coupar and Angus),	—	127	390
Slamannan, ..	—	—	*14
Stockton and Darlington,	360	479	593
Stockton and Hartlepool,	172	*40	82
" Clarence,	—	*71	158
St. Helen's, ..	70	*54	110
Shrewsbury and Chester,	—	—	*312
South Devon, ..	—	*41	1,066
Whitehaven, ..	—	*26	*40
Wishaw and Coltness,	—	—	*30
West Cornwall (Hayle)	29	53	65
York and North Midland,	—	10,618	13,476
" Hull and Selby,	2,800	—	—
York and Newcastle,	2,800	—	8,256
Middlesborough, ..	—	—	114
North Shields, ..	1,346	1,495	*354
Durham and Sunderland,	220	186	—

* Half-years. † This seems to be erroneous.

The total receipts in each year are as follows :—

	1845.	1846.	1847.
Detailed returns,	£156,910	£208,952	£266,043
Add for half-years omitted,	—	16,500	1,100
Add for companies omitted,	40,000	8,000	2,400
Total,	£196,910	£233,452	£269,543

The returns of parcel traffic are the only returns which show any improvement; the others afford less information in each year.

From the above amounts a correction has to be made for passengers' luggage charged in excess, included in the parcels returns. This is usually about 6 per cent. of the gross returns; but as it is deducted in some cases, 5 per cent. is a sufficient compensation. It must be observed that in some cases parcels are included in the goods return.

The South Devon return includes receipts for telegraphic messages.

Making the above correction, the net receipts for parcels will be

1845.	1846.	1847.
£186,000	£222,000	£255,000

It is not necessary to give the detailed charges for parcels, as they include sometimes charges of booking and delivery.

In 1844-5 the number of parcels enumerated was 362,202, and the receipts £14,034, which gives an average rate of 9·29*d.*, or a little more than 9¼*d.* per parcel, or rather more than 28 parcels per pound. Taking this as the average, the total number of parcels carried in 1844-5 would be about 4,500,000.

In 1845-6 the number of parcels enumerated was 384,353, and the receipts £11,559, which gives an average rate of 7·2*d.*, or nearly 7¼*d.* per parcel, or more than 33 per pound. Taking this as the average, the total number of parcels carried in 1845-6 would be about 7,400,000.

In 1846-7 the number of parcels enumerated was 530,641, and the receipts £8,685, which gives an average of 3·9*d.*, or nearly 4*d.* per parcel.

It is questionable, however, whether the average is so low in any of the years, as the London and North Western, which has so large an amount of the parcels traffic, is not taken to form part of the average. It is, however, certain that the average rates for the conveyance of parcels have been much reduced. A fair average will be 18 parcels per pound for 1844-5, 19 for 1845-6, and 20 for 1846-7. This will give the whole number of parcels carried by railway in each year as under.

1845,	3,350,000.
1846,	4,200,000.
1847.	5,000,000.

The number of parcels carried both ways to each town may be reckoned thus :—

London,	1,500,000
Manchester,	300,000
Liverpool,	200,000
Leeds,	200,000
Birmingham,	200,000
Glasgow,	100 000
Bristol,	100,000
York,	100,000
Bath,	100,000
Cambridge,	100,000
Southampton,	100,000
Dover,	80,000
Brighton,	60,000
Sheffield,	60,000
Preston,	50,000
Edinburgh,	40,000

Hull,	30,000
Exeter,	20,000
Newcastle,	20,000
Carlisle,	20,000
Chester,	10,000
Dundee,	10,000
Ipswich,	10,000

In consequence of new arrangements made by the companies, a great increase of business has taken place in the carriage of booksellers' parcels. There is a great tendency in the parcels traffic to increase in consequence of the extension of the supply of the local grocers, linen-drapers, &c. from London and the great towns, for it is well known that instead of taking stock a few times yearly, they now receive frequent supplies.

The chief parcels traffic is on the following lines:—

	No. of Parcels.	Receipts.
London and North Western,	2,000,000	£104,738
Great Western,	700,000	34,155
Midland,	600,000	28,986
Eastern Counties,	480,000	16,669
Lancashire and Yorkshire,	400,000	5,225
York and North Midland,	300,000	13,476
York and Newcastle,	300,000	8,724
London and South Western,	200,000	10,629
London and Brighton,	200,000	9,596
South Eastern,	200,000	8,793

No. XXIII.—MAILS.

The receipts for mails in each of the years ending June 30, is as follows; the amount for 1845 being made up by doubling the return for the half-year ending June 30, 1845:—

Company.	1845.	1846.	1847.
Arbroath and Forfar,	£40	£40	£40
Ardrossan, ..	30	30	30
Caledonian (Garnkirk),	——	15	15
Chester and Birkenhead,	827	835	835
Dublin and Drogheda,	1,600	1,600	1,600
Dundee and Arbroath,	636	636	636
Eastern Counties: Cambridge,	150	4,688	5,092
" Colchester,	3,000	3,390	3,340
" Norfolk,	——	——	4,616
Eastern Union,	——	——	1,396
" Ipswich and Bury,	——	——	*54
East Lancashire,	——	——	*25
Edinburgh and Glasgow,	——	1,800	1,800
Glasgow and Greenock,	——	529	529
Glasgow and Ayr,	——	497	497
Kendal and Windermere,	——	——	*26
London and North Western,	15,000	15,832	38,492
" Grand Junction,	20,000	22,479	
" Liverpool & Manch.	1,000	——	
" Manch. and Birm.	——	45	
London and Blackwall,	62	62	62
London and Brighton,	260	337	607
London and South Western,	——	6,303	6,578
Lancaster and Preston,	4,600	——	——
Lancashire and Yorkshire,	2,200	2,379	2,533
" Manch. & Bolton,	101	101	——
" Preston and Wyre,	170	170	177
Manchester and Sheffield,	——	*54	256
Midland, ..	11,000	11,532	11,928
Newcastle and Carlisle,	4,766	766	766
North Union,	4,443	4,443	4,443
South Eastern, ..	7,200	7,359	7,100
" Greenwich,	50	50	50
Stockton and Darlington,	375	375	375
Stockton and Hartlepool,	——	——	89
" Clarence,	——	*22	36
Taff Vale, ..	——	——	205
York and North Midland,	——	4,266	5,111
York and Newcastle,	2,800	——	5,588
" North Shields,	50	50	50

* Half year.

The total receipt detailed in 1845 was £77,000, to which has to be added for omissions £23,000, making a gross total of £100,000.

The total receipt detailed in 1847 was £105,872, to which has to be added for omissions £25,000, making a gross total of £130,000.

THEORY OF STEAM-ENGINES.

Account of the experiments to determine the principal laws and numerical data which enter into the calculation of Steam-Engines. By M. V. REGNAULT.

(Continued from page 268.)

FOURTH MEMOIR.—ON THE MEASUREMENT OF TEMPERATURES.

We do not as yet possess any direct means of measuring the quantities of heat absorbed by a body under given circumstances, and we recognise this absorption of heat only by the changes which occur in the state of the body, or by its dilatation. The name *thermometer* is given to the instrument whose object is to indicate the variations in the quantities of heat in any medium. These instruments are generally founded upon the dilatation which bodies undergo by the action of heat, or upon the changes in elastic force which the same bulk of a gas experiences under the circumstances to which the medium is submitted.

A perfect thermometer would be one whose indications were always proportional to the quantity of heat which it had absorbed, or, in other words, one in which the addition of equal quantities of heat produced always equal dilatations. To fulfil this condition it is necessary, either that the capacity for heat, and the dilatation of the thermometric substance, should remain invariable during the experiment, or that these two elements should vary strictly inversely as each other.

Nor would the perfect thermometer yet indicate the quantity of heat absorbed by the medium under given circumstances, unless this medium presented the same advantages as the thermometric substance—that is, unless it absorbed equal quantities of heat for equal variations of temperature as noted by the thermometer.

But a comparative study of the dilatations of different substances under the same circumstances, quickly shows that they are far from following the same law; and if we compare together the quantities of heat absorbed by these different bodies when brought successively to different temperatures, measured by the dilatations of one of them, we see that these quantities are variable, and unequally variable in each one of them, without our having been able heretofore to show the relations which exist between these variations of capacity and the changes of bulk.

The great precision which can be obtained in the construction of the mercurial thermometer, the facility with which the thermometric liquid may be obtained of the same degree of purity, and the great extent of temperature through which this liquid preserves the same state, have given to the mercurial thermometer the preference over all other instruments of the same kind, and have caused its adoption almost exclusively for all precise experiments.

But there is an essential condition which every apparatus for measurement ought to satisfy; it is, that it should not only remain rigorously comparable with itself—that is, that it should always mark the same degree under the same circumstances,—but it is moreover necessary that we should be able to reproduce it at will, and obtain always instruments rigorously comparable.

Physical philosophers have thought that they had completely attained this end, by making the scales of the mercurial thermometers agree at certain normal temperatures which are easily reproduced and always perfectly identical; for this purpose, they have adopted the constant temperature at which ice melts, and that not less constant which saturated steam presents when it exerts an elastic force of 76 millimetres. But I have shown (*Annales de Chimie et de Physique, 3rd Série, tome* v., *pages* 100 *et seq.*,) that two mercurial thermometers, adjusted for the same fixed points of melting ice and boiling water under a pressure of 76 mm., may show very considerable differences in their movements beyond these fixed points, if they are not made of glass of the same nature. Even when the glasses of the reservoirs present the same chemical composition, there may still be very sensible differences in their indications according to the way in which the reservoirs have been worked in the glass-blower's lamp, the molecular state of the glass undergoing very notable alterations during this working.

The mercurial thermometer, then, as it has been constructed up to the present time, is defective in one of the most essential conditions which ought to be required of an apparatus for measurement—it cannot be always reproduced in the same state; and the different instruments of the same kind are rarely comparable with each other beyond the fixed points of their scales.

Physical philosophers thought that they had observed that all the gases dilate exactly the same fraction of their volume at 0°, when they are carried from the temperature 0° to that of 100° (32° to 212° Fahrenheit). This law, so remarkable for its simplicity, naturally led them to think that the dilatation of the gases ought to be in a more simple ratio to the quantities of heat than that of solids or liquids. Some, more bold, even concluded that the dilatation of gases must be rigorously proportioned to the quantity of heat, and that the gas thermometer was the true normal thermometer to which all the phenomena of heat ought to be referred.

We now know that this great simplicity in the law of the dilatation of the gases is far from existing. I have shown in the memoir upon the dilatation of gases that not only the different gases have not the same coefficient of dilatation, but that even for the same gas this coefficient varies with its density. The indications of gas thermometers then, can only be considered, like those of other thermometers, as functions more or less complicated of the quantities of heat.

But the gas thermometers present an advantage over the mercurial, and in general over all liquid or solid thermometers, an advantage which arises from the greatness of the dilatation of the thermometric substance. In any thermometer formed by a liquid or gaseous substance, the indications of the instrument depend upon the dilatation of this substance, and of that of the substance in which it is inclosed. Now, the dilatation of mercury is only about seven times greater than that of the glass which holds it; and the variations which we remark in the law of the dilatation of the different glasses, form very appreciable fractions of the apparent dilatation of the mercury, and consequently influence in a notable manner the indications of the instrument. In the gas thermometer, on the contrary, the dilatation of the gas being one hundred and sixty times greater than that of the glass, the variations of the law of dilatation of the different glasses no longer sensibly influence the indications of the apparatus, and do not prevent the instruments from being comparable.

If, then, we wish to profit by this important property, and adopt the gas thermometer as a standard, we must study several important questions, so as to fix the conditions under which the instrument will remain comparable.

The present memoir has for its object the study of the different methods which have been imagined for measuring temperatures in experiments which require great precision. I will divide it into three parts: in the first part, I will treat of the gas thermometer; in the second, of the mercurial thermometer; and in the third, of the measurement of temperatures by means of thermo-electric currents.

Part I.—*Of Gas Thermometers.*

When a gas enclosed in a mathematically-elastic envelope is submitted to an elevation of temperature, its volume increases, and the gas retains the same elastic force. But if we prevent this dilatation of the gas, by exerting a proper degree of pressure over the whole surface of the envelope, the gas retains the same volume, but its elastic force increases.

There are then two modes of employing a gas as a thermometric substance. The gas may be placed under circumstances such, that the pressure which retains it remains constant, and its increase of bulk be observed; or the gas may be compelled to keep the same bulk, and its increase of elastic force be examined.

First Method.—In order that a gas should realise the conditions prescribed by this method, which are very nearly those found in the mercurial thermometer, it would be requisite that the gas submitted always to the same pressure, should expand freely in a gauged reservoir, kept throughout at the same temperature. But these indications cannot be fulfilled in practice—at least, if the apparatus is to be submitted to high temperatures.

The thermometer must therefore be composed of a reservoir which is to be exposed to the temperature which it is desired to measure, and a gauged tube, united to the reservoir by a capillary tube, which removes the other from the place where the temperature is to be measured. This gauge tube fulfils the purpose of the graduated stem of the mercurial thermometer, and serves to collect the gas which the rising of the temperature drives out of the reservoir. This tube may also be kept at a constant temperature differing but little from that of the surrounding air. At any moment during the experiment, the gas is composed of two parts: the first, contained in the reservoir, is at the temperature to be found, the other in the tube is at the surrounding temperature. These two portions are at the same pressure, which may be brought as nearly as is desired of that of the atmosphere. The equations derived from these conditions permit us to calculate the required temperature.

This arrangement is the one adopted by M. Pouillet, in his air pyrometer, and M. Regnault himself employed it in his fifth series of experiments made to determine the dilatation of gases. It presents a very serious inconvenience when the apparatus is to be used for the measurement of high temperatures. In fact, it will easily be seen that in this case the far greater part of the air will already be in the gauged tube, and but little will remain in the reservoir, so that a further elevation of the temperature will cause but a very small portion to pass over into the tube, and this will with difficulty be measured with the proper degree of accuracy.

In fact it can be easily shown that, calling the temperature x, and the coefficient of dilatation of the gas a, the sensibility of the apparatus will vary very nearly inversely as $(1 + a x)^2$. This circumstance led M. Regnault to reject this arrangement for a gas thermometer.

Second Method.—In the second method the gas is kept constantly of the same volume, and the elastic force which it presents under different circumstances is measured; then from these, by the law of Marriotte, we may calculate the dilatations which the gas would have undergone if the pressure had been kept constant.

The apparatus founded upon this second method are much more easily managed, and give greater precision than those constructed according to the first method: they have moreover the advantage of presenting the same sensibility at high as at low temperatures. By placing in these apparatus air of atmospheric pressure when the reservoir is surrounded by melting ice, we are sure to have instruments rigorously comparable. Nevertheless, if we desire to measure very high temperatures—if for instance the instrument is to be used as an air pyrometer—it is to be feared that the elastic force of the gas within, becoming very considerable, the envelope may experience a permanent change of form under the great interior pressures. This inconvenience may be avoided by introducing into the apparatus, air under an initial pressure less than that of the atmosphere, when the reservoir is at 0°. In this way the elastic force may be kept within limits as low as may be desired, but it is evident that the apparatus becomes less sensitive in proportion as the elastic force of the gas at 0° is feebler; still, as the measurement of the elastic force may be made with extreme precision, the indications of the apparatus will be in the greater number of cases sufficiently exact, even though the initial pressure of the gas at 0° was but one-fourth of that of the atmosphere.

But here a very important question presents itself: *are air thermometers filled with air at very different densities comparable with each other?* That is, will such instruments agree at all temperatures when their scales have been made to accord at 0° and 100°? We have before seen (p. 240) that the absolute value of the coefficient of dilatation of a gas changes very notably with its density; it is required to know whether the changes of density will not produce besides, sensible differences in the law of dilatation. It is absolutely indispensable to decide this question in order to fix the conditions under which air thermometers shall be established in order to be comparable with each other. M. Regnault also proposed for himself a second question, which he thinks not less important than the first—viz., *do gas thermometers, filled with gases of different kinds accord with each other when they have been adjusted at 0° and 100°?*

The apparatus used in these investigations consisted essentially of two gas thermometers placed side by side in the same boiler.

Each of these thermometers was composed of a globe of flint glass (crystal), of from 700 to 800 cubic centimetres content, terminated by a re-curved capillary tube, and a manometric apparatus. The two globes were kept, by copper wires, side by side on a metallic support, consisting of two metallic plates of lozenge form placed, one below, the other above the globes, and united by iron rods which were permanently fixed to the cover of the boiler; the upper plate was pierced with two holes through which passed the stems of the air thermometers, and with two other holes, situated in a line at right angles to that joining the first, through which passed the stems of two mercurial thermometers.

The boiler-cover was permanently fixed to a solid partition, and the copper boiler was attached to it by screw bolts, so that it could be removed or replaced without disturbing the thermometers.

The manometric apparatus was composed of two glass tubes of 12 or 14 mm. interior diameter, cemented into an end piece of cast-iron provided with a stop-cock, so arranged, that by properly turning it, you could at pleasure either cause the two tubes to communicate together, or dicharge the mercury from either of them, or intercept the communication of the tubes with each other and with the open air. The manometers were fixed to the side of the partition opposite to the boiler.

The capillary tubes of the air reservoir were connected with the capillary tubes of the manometers, by bringing these tubes into exact contact at their ends, and cementing over them a brass tubulure, grooved to fit them outside. This brass tubulure had a rectangular tube opening into it, into which was cemented a capillary tube, by means of which communication was made with an air-pump, so as to dry the apparatus and introduce the gases to be operated on.

The boiler contained oil, which was constantly agitated so as to maintain an uniform temperature throughout the whole bath.

The method of operating is as follows :—

In the first place, to dry the apparatus, a little mercury is put into the inner manometer tube, and the stop-cock so placed as to cut off this tube from communication with the other and with the opening. The lateral tube of the tubulure is then put into communication with an air-pump furnished with several tubes filled with pumice soaked in concentrated sulphuric acid, which are intended to absorb the moisture. A vacuum is made a great number of times, and each time the air is allowed to enter very slowly. To be sure that the drying is complete, the globes are heated to 50° or 60° (122° to 140° Fahrenheit). The pump is then removed, but the tubes are left open in communication with the drying tubes. Suppose now that it is desired to compare the movement of a thermometer containing air whose elastic force at 0° is 76 mm., with that of another containing air of a less elastic force.

The two globes are surrounded with melting ice, and the stop-cock of the first manometer being so placed as to make a communication between the two manometer tubes, mercury is poured in so as to raise its level to a mark placed near the top of the inner tube (that is, the one communicating with the reservoir). The two mercurial columns will be necessarily at the same level, because the apparatus communicates freely with the air by the tubulure.

On the other hand, a partial vacuum is made in the second globe, and the rarefaction of the air in it is determined by the difference of height of its manometric columns; when a proper rarefaction has been attained, the apparatus is closed by hermetically sealing the lateral capillary tube of the tubulure, and mercury is then poured into the manometer until its surface stands at a mark made near the top of the inner manometer tube.

The elastic forces are measured by four properly-placed cathetometers, each one being so placed as to be able to follow the meniscus in one of the tubes.

The necessary observations of the height of the barometer, and the position of the meniscus of each of the manometer tubes being made, the lateral tube of the first reservoir is then hermetically closed, the ice removed and replaced by oil which is heated by a furnace placed under it. The oil bath is heated until the temperature at which the two instruments are to be compared is attained, the air-holes of the furnace are then more or less closed and the oil kept in constant agitation; and the thermometers are adjusted for observation by pouring mercury into the manometer tubes, so as to bring back the level of the columns in the inner tubes to the marks made upon them. The temperature then rising only very slowly, the movements of the four columns of mercury are simultaneously watched, and when they are perfectly stationary, at a signal given by one of the observers the barometer is read, and the temperatures of the air in the vicinity of the manometer tubes, and of the lateral tubes attached to the reservoirs, noted.

As it is essential in this mode of experimenting to keep the temperatures stationary as long as possible, they should be raised very slowly when approaching the maximum at which the observations are to be made, and by a little practice a series of observations may be got at temperatures not differing more than 1° from each other, and the observer be assured that one instrument is not behind the other in its indications. This precaution is above all indispensable when the air thermometer is compared with the numerical.

It is not necessary, and would be very difficult, to bring the mercury in the manometers exactly to the marks. It is sufficient to bring them nearly there, and as the observations give exactly their differences of level, the volumes can easily be calculated when the tubes have been gauged in the vicinity of the marks. The experiments upon thermometers filled with different gases are conducted exactly in the same way.

These globes were too thin to permit the experiments upon thermometers filled with air at a much higher pressure than 76 mm. to be tried with them; recourse was had to others similar, but having their walls 3 or 4 mm. thick. These globes were of rather less capacity than the former, holding only about 600 cubic centimetres.

A great number of experiments were made by M. Regnault with the apparatus in which air of ordinary density was compared with that of much less, and with that of much greater density, as well as with hydrogen gas, carbonic and sulphurous acid, and the principal conclusions which he draws from them are as follows:—

1. The atmospheric air follows the same law of dilatation from 0° to 350° (32° to 662° Fahrenheit) of temperature, even when its initial elastic force at 0° varies from 0·m4 to 1·m3, (1·33 to 4·25 ft.). So that in the construction of an air thermometer, no attention need be paid to the density of the air introduced,—the instruments will be comparable whatever may be the density.

2. Atmospheric air, hydrogen gas, and carbonic acid, follow between 0° and 350°, sensibly the same law of dilatation, although their coefficients of dilatation are sensibly different. So that the thermometers made with these different gases will accord, provided the temperatures are calculated from their proper coefficients. From this it follows that the coefficients of dilatation of these gases present sensibly the same ratio at every temperature.

3. Sulphurous acid gas departs notably from the law of dilatation which the preceding gases present. The coefficient of dilatation of sulphurous acid diminishes with the temperature as marked by an air thermometer.

It is important to remark that in these experiments the relative dilatations of the gases were not measured directly, but were deduced by calculation from the observation of the elastic forces which these gases present at the same temperatures, their volume remaining constant. It appears very probable that similar conclusions would be arrived at, by measuring directly the increase in bulk of the different gases for the same temperatures, their elastic force remaining constant, by a method analagous to that of the fifth series of experiments upon the dilatation of gases; but these experiments would not be susceptible of equal precision in the measurements, for reasons already given at the commencement of this memoir.

(To be continued.)

COPPER SMELTING FURNACE.

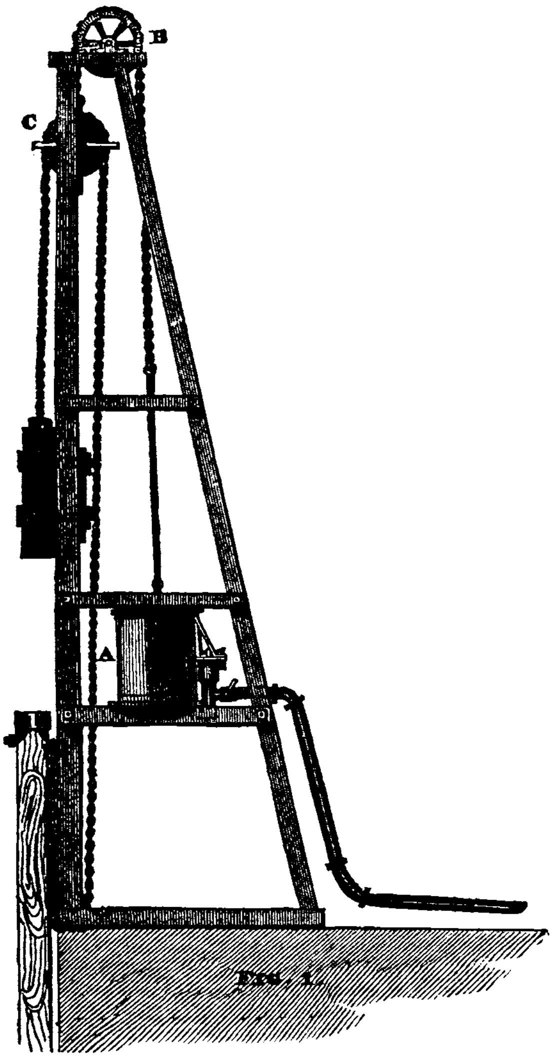
A correspondent of the *Mining Journal* gives the following estimate for the construction of a reverberatory furnace for smelting copper on the Swansea plan. The stack of the furnace was single, 40 feet high, and the furnaces 13 feet by 8. The following are the details:—

12,000 common bricks—at 80s. per mille ..	£18	0	0
12 barrels of lime—at 4s	2	8	0
5,000 Newcastle bricks—at 3*l*. 10s. per mille. ..	17	10	0
1,300 Dynas ditto—at 4*l*. 10s. per ditto ..	5	17	0
2,000 Stourbridge ditto—at 8*l*. „ ..	16	0	0
1½ ton cement clay—at 1*l*. 17s. ..	2	15	6
2 tons Dynas ditto—at 15s. ..	1	10	0
12 brown Flintshire bearers—at 10d. ..	0	10	0
2 Stourbridge ditto—at 1s. 1d. ..	0	2	2
6 slabs—at 7d.	0	3	6
23 cast-iron studs, 50 cwt.—at 7s. 6d. ..	18	15	0
2 wrought-iron ditto, 2½ sq., 3 cwt.—at 16s.	2	8	0
3 sleepers, cast-iron, 3 sq., 5 cwt.—at 7s. 6d.	1	17	6
Hopper and frame, round iron for cramps, square ⅝-iron for stack rocks, flat 1 × 14 for stack cramps, fire-bars and wedges, about 1 ton—at 10*l*. 10s. ..	10	10	0
Fore and concave and skimming plates ..	7	0	0
Contingencies	2	0	0
Making a total of	107	6	8

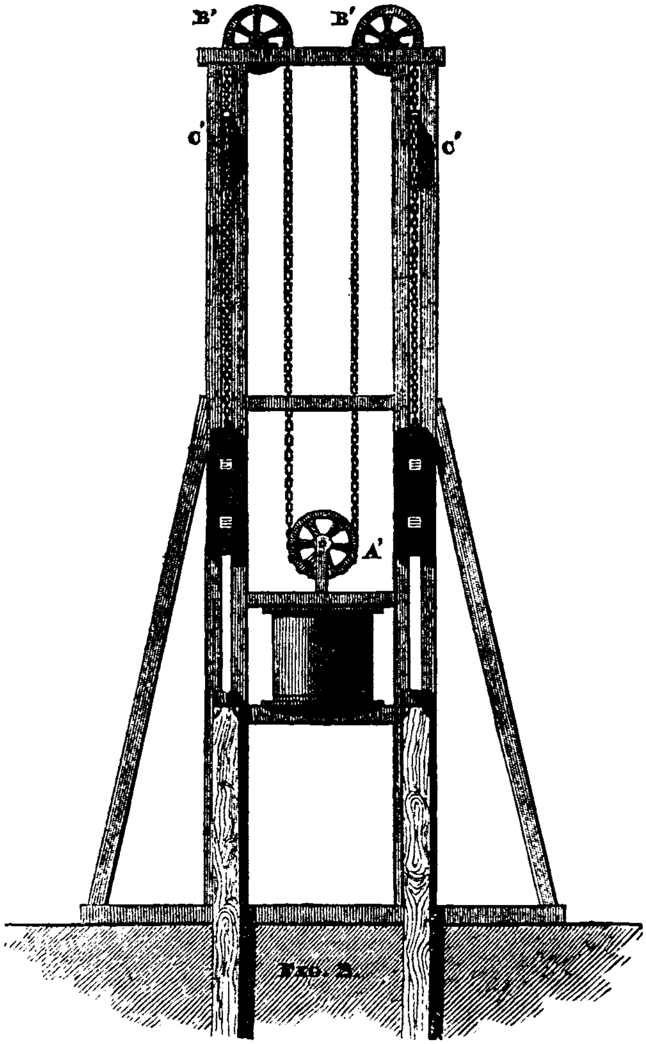
To this must be added, about 14*l*. for the masons' labour, and 2*l*. for that of the smiths', which, added to the cost of the furnace, 107*l*. 6*s*. 8*d*., will make a total cost of 123*l*. 6*s*. 8*d*. The prices given are those of the period when the furnace was constructed;—of course, at different times they will vary considerably; any one, however, will be able from them to calculate what the present outlay would amount to. By building two furnaces, with a double stack to serve both, and using clay in the sides, instead of bricks, a less consumption of materials would take place, which would necessarily be followed by a commensurate reduction in the expenditure, thereby enabling the contractor to construct his furnaces on a more economical principle than above detailed.

ATMOSPHERIC PILE-DRIVING MACHINE.

PATENTED BY CLARKE AND VARLEY.



Side Elevation of a Single Machine.



Front Elevation of a Double Machine.

This apparatus has been lately used for driving the piles of the cofferdam for Irongate, St. Katherine's Docks. The inventors state that by this machine, piles may be driven at half the expense of driving them by the ordinary machine worked by hand, and in about one-sixth of the time. Mr. Crate, the clerk of the works at the above docks, states that he drove forty-two piles, 18 feet deep, into a bed of very hard compact gravel, at the rate of three piles each tide of about 3¼ hours; and to drive one pile only, by the ordinary hand-engine, occupied five tides before it could be finished, and even then was left 2 feet above the height required to be driven. Mr. Harrison, the engineer, also certifies that the Atmospheric Pile-Driver gave him entire satisfaction.

This machine consists of a vacuum cylinder of wrought-iron (A), closed at the bottom and open at the top, having an air-tight piston, and self-acting slide-gear, fixed to any convenient part of the frame of a common pile-engine. The piston-rod is connected to a chain which passes over a fixed pulley (B) on the top of the engine; to the end of this chain is suspended a pulley (C); over this passes a second chain, one end of which is attached to the ram, and the other, passing down under the bottom of the frame, is brought up and affixed to the head of the pile. The power is derived from a small steam-engine, fixed at any convenient spot, which works an air-pump for producing the exhaustion. Communication is made between the air-pump and the Pile-driving Machine by small wrought-iron tubes, connected together by flexible joints of vulcanised india-rubber. *Thus the machine possesses the incalculable advantage of being worked at any required distance from the steam-engine, and moved about with as much facility as a common crab-engine.* The mode of action is as follows: the ram being supposed down on the pile-head, and the piston consequently at the top of the vacuum cylinder, communication is opened by the valve gear with the air-pump, exhaustion then takes place in the cylinder, the piston descends by the external pressure of the atmosphere, and raises the ram; when the piston arrives at the bottom of the cylinder, the valves reverse themselves, communication with the air-pump is then shut off, and the external air admitted under the piston; equilibrium being now restored, the ram falls with the full effect of gravity on the pile; the valves are again reversed, and the same operation is repeated. Thus a succession of short heavy blows is given, rapid of course in proportion to the power of the steam-engine; and, as by the arrangement of the pulleys, the distance between the pile-head and the face of the ram is always the same, a regularity of action is obtained, quite unknown to the old pile-driver, the injurious effect on the head of the pile, and rebound of the ram, consequent upon great height of fall, avoided; and the ram being permanently fastened to the chain, the whole time lost by the re-attachment after every blow is saved. *The machine is so constructed, that it may be fixed in a few hours to the frame of a common pile-engine.*

Fig. 2 shows an arrangement by which *one vacuum cylinder* can be made to work *two rams*, and, consequently, *drive two piles at the same time.* A pulley (A^1) is attached to the piston-rod of the vacuum cylinder; round this passes a chain which goes over the two pulleys (B^1 B^1), having the ends fastened to the two suspended pulleys (C^1 C^1). The arrangement of the second chain is similar to that of the single machine. The two rams, being exactly the same weight, will, of course, rise and fall at the same time with each stroke of the piston. If it should be found that one pile is driving faster than the other, and for this or any other reason it should be desirable to give a shorter blow to one pile than to the other, it can be done in the following simple manner: a small chain or rope is attached to each ram, hanging freely; the man in attendance can at any time, without stopping the machine, fasten the end of this chain or rope so as *to check the rise* of one ram to any extent—a very small force will do this, as the two rams exactly counterbalance one another; the other ram will, of course, then make a stroke *longer* in proportion to the *shortening* of this one. Or the working of one ram may, by the same means, be entirely stopped, the other then making a blow twice the length that it did when both were working equally.

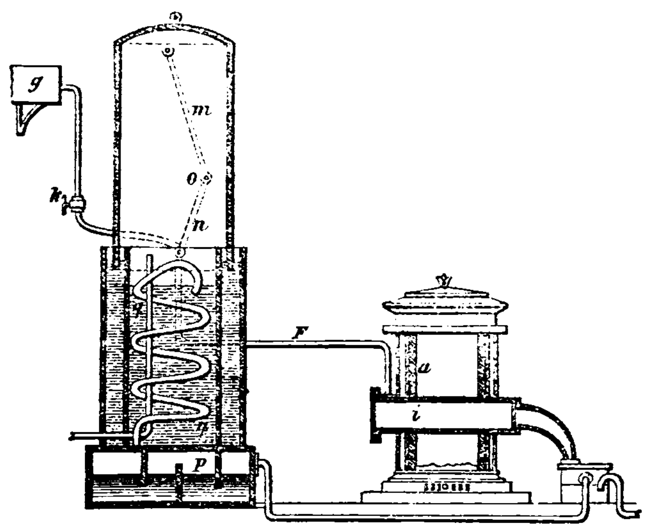
A working model of the machine may be seen at 31, Parliament-street, Westminster.

REGISTER OF NEW PATENTS.

SELF-ACTING GAS APPARATUS.

John Watson, merchant, and Edward Cart, gentleman, both of Hull, for "*improvements in the manufacture of gas.*"—Granted February 14; Enrolled August 14, 1848.

The patentees describe the object of this invention to be the combination of apparatus with an ordinary hot-air stove, for generating gas in proportion to the supply required, and so to arrange the parts that the supply of material to the retort will be cut off by the filling of the gas-holder, so that if the supply of gas from the retort be not consumed, the further feed to the retort will be cut off. The figure represents a section of the apparatus.



a, is an ordinary hot-air stove, with the retort set therein, or the retort may be set in brick-work or masonry, in lieu of the iron stove; F, feed-pipe, to conduct the liquid for gas manufacture from the holder *g*, to the retort *i*; *k*, tap opened and shut at the commencement and conclusion of the process; *l*, self-acting tap connected with the gas-holder by means of the two rods, *m* and *n*, and which are moved together at the joint *o*. The volume of gas required for combustion being supported by a quantity of the liquid flowing into the retort, the proportion is regulated by the tap *l*, in exact ratio with the current consumption, and whatever decrease or increase is made in the number of lights during the apparatus being in operation, causes the gas-holder to ascend or descend, until the self-acting tap *l*, admits only the quantity of liquid to the retort commensurate with the flames burning; *p*, washer or purifier; *q*, worm-pipe fixed in a cylindrical vessel containing cold water for condensation. The worm-pipe conveys the gas from the washer or purifier, and terminates with a bend which dips into the water contained in the cylindrical vessel; the gas having forced itself through the surface of this water, rises into the gas-holder, whose sides dip into water contained in the tank surrounding the cylindrical vessel wherein the worm-pipe is fixed; thus it will be perceived there are two cylindrical vessels, one the longer as a tank for the gas-holder, and another the smallest to contain water for condensation only.

The heat used in generating gas may be employed to the ordinary purpose of heating air, in addition to generating gas, or it may be applied to other uses.

STEAM-BOILERS AND ENGINES.

William Exall, of Reading, engineer, for "*certain improvements in thrashing machines, and in steam-boilers, engines, and other apparatus for driving the same, which apparatus is applicable to driving other machinery.*"—Granted March 8; Enrolled September 8, 1848.

This is a very comprehensive specification, and includes nine claims, the enumeration of which will sufficiently explain the nature of the improvements patented.—The first and second claims refer to thrashing machines, and to a mode of regulating the distance of the concave from the drum that carries the thrashers. In the third, the patentee claims the employment of two piston-rods to each piston in what are known as the Brunell engine, with a cranked cross-head, and the forming a recess in the top of the cylinders and pistons, thereby obtaining a greater descent of the cross-heads and their connecting-rods. Fourthly, the mode of adjusting the eccentrics which work the valves or slides (without stopping the engines) by means of a rack, acted upon by a pinion contained within the shaft, this giving motion to another pinion that gears into the toothed ring or arc on the side of the eccentric. Fifthly, in respect to "Hero's engine," he claims the introduction of the steam into the arms through a hollow neck of prepared india-rubber, with metal washers, employed to make the revolving joint steam-tight, together with the partial or total closing of the emission apertures, and the reversal of the motion of the engine, by means of valves or slides receiving motion through the hollow axle of the engine. Sixthly, the combining of a vertical cylindrical boiler and fire-box, having radiated horizontal flues, with a flue surrounding the boiler, which is bounded by the external casing of the boiler, and also the placing the surface of the fire-bars somewhat below the bottom of the boiler, for the admission of air on all sides of the fire. The seventh claim refers to an improved horse-gearing for driving machinery. Eighth, the application of compressed wood to the manufacture of the teeth of wheels, so that when the teeth are driven into the recesses or cavities of the periphery of the wheel, the subsequent expansion will retain them securely therein. Ninth, the forming of dove-tailed or other suitable shaped grooves extending across the face to receive teeth of a suitable shape formed of wood which has been previously compressed.

HIGH-PRESSURE AND EXPANSIVE STEAM-ENGINES.

John Lawes Cole, of Lucas-street, Middlesex, engineer, for "*certain improvements in steam-engines.*"—Granted March 22; Enrolled September 22, 1848.

This invention has for its object a better arrangement of parts in the combination of high-pressure and expansive steam-engines, wherein two cylinders are used. In the first proposed arrangement, the two cylinders are placed above one another, and the two pistons are fixed to the same piston-rod, the high-pressure cylinder being above, and the larger cylinder for the expanded steam being below. The piston-rod passes through a stuffing-box between the two cylinders which separates them from each other. This stuffing-box is packed by means of two horizontal openings in the plate forming the stuffing-box, opposite to each other, by which packing is introduced, the packing being forced into contact with the rod by blocks pressing behind by means of screws. In another arrangement, two piston-rods are employed to the piston in the expansive cylinder, unconnected with the piston-rod of the high-pressure cylinder. These two piston-rods pass up through the cover of the expansion-cylinder and on each side of the high-pressure cylinder to the cross-head or beam above, to which they as well as the piston-rod of the high-pressure cylinder are secured. The other parts of the engine are constructed in the usual manner, or so modified as to be suitable to the present arrangement of the cylinders. Another improvement is the adaptation to direct-acting steam-engines of high-pressure and expansion cylinders, which are placed side by side upon the sole plate, the two piston-rods of these being attached above to a cross-head, common to both; from the centre of the cross-head a connecting-rod passes down between the two cylinders to a crank placed upon the shaft below. To preserve the parallelism of the piston-rods, a system of levers is placed above, in connection with the cross-head. These levers and rods have also the effect of equalising the strain of the two pistons. Another part of the invention consists in the adaptation to double-acting air-pumps of slide-valves instead of the clack-valves, the slide-valves being worked by an eccentric or crank in the manner of the usual slide-valve of steam-cylinders. Expansive slide-valves are formed by placing on the cylinder-face loose blocks, which are connected to the valve itself by means of two rods, one on each side, upon which are placed nuts for the purpose of adjusting the distance of the blocks from the valve; and thus, by increasing or diminishing that distance, to vary the expansion of the steam in the cylinder. A further improvement consists in the construction of safety-valves for steam-boilers, by combining with the ordinary conical safety-valve, a piston within a cylinder so arranged that whenever, from its ceasing to act, the pressure of steam in the boiler increases beyond the required amount, the rise of the piston will open the valve and thus relieve the pressure.

FURNACES AND BLOWING MACHINES.

George Lloyd, of Stepney, Middlesex, iron-founder, for "*certain improvements in furnaces and blowing machines, and in engines and machinery for driving the same; which improvements are also applicable to other purposes where motive power is required.*"—Granted March 8; Enrolled September 8, 1848.

This is a multifarious specification, comprising so many separate "improvements," that it is difficult, without occupying more space than we are willing to bestow, to give any description of the whole; we must therefore confine our notice to a few of the leading points. The principal part of the invention relates to furnaces for heating steam-boilers. The furnace chamber does not pass under the boiler, but is at the extreme end. The fire-bars are placed in a vertical position, about the same situation as usually occupied by the fire-doors; while the fuel is inserted at a hopper-mouth at the end of the boiler, which, in this case, is represented as being flat, with the fuel chamber extending partly up the end. This chamber is about the usual width of furnaces; but in its length, it is confined to about the usual depth of fuel by means of a number of fire-brick lumps, extending from the hearth to the bottom of the boiler, and placed so as to present their edges to the fuel in the manner of bars. The fuel being ignited, is piled within the chamber till quite full, the only covering being the unconsumed fuel which extends in the hopper-mouth above the bars. The products of combustion pass between the fire-lumps, in contact with the bottom of the boiler, and break into a chamber immediately in front of the bridge, where a series of pipes are placed for the admission of air. The great heat attained by the fire-lumps, imparts a sufficient degree of heat to the gaseous products to cause them to flash into flame on being mixed with a due proportion of atmospheric air. This flame is conducted over the bridge and through the flues in the ordinary manner. In the construction of the blowing machines, the blades are tapered towards the points, and are placed at angles of 60 degrees backwards, by which means the inventor proposes to overcome the disadvantage which blowing machines usually possess of waste of power, by the fans striking the air within the case that is not expelled. The blades are confined at the sides by discs of metal extending to the point of the blade, and having an opening in the centre, of the same area as the openings in the sides of the case. The air driven off at the periphery is limited by the entire area between the blades being equal to the area of the side inlets, and at the same time attains a superior blast with less power, without that disagreeable beating noise, consequent on a rapid motion being given to the ordinary fanner. Another blowing machine, described in the specification, consists of a series of bellows placed within an octagonal case, each of the eight sides forming a base for one bellows. The other boards of the bellows are placed in a radial line, each of the upper or moving boards being attached to a crank in the centre of the case by a suitable connecting-rod; this crank being actuated by a shaft passing out at the sides of the case, which is closed quite air-tight. On motion being given to the shaft, the bellows will be successively acted upon, as the crank performs its revolution. The air entering from the outside by inlet valves, when the bellows are expanded and discharged inside the case, when collapsed by the motion of the crank, a uniform pressure of air is thus kept up, which may be conducted by suitable pipes or channels from the casing to the point required.

The following claims of the patentee set forth the various inventions included in this specification:—First, the construction of a steam-boiler furnace, in so far as regards the combination of vertical fire-bars made in two pieces, together with vertical fire-clay lumps behind the fuel-chamber, and vertical air-tubes behind the fire-lumps. Secondly, the employment in furnaces of every description of fire-bars made in two pieces. Thirdly, the mode of applying the vapours arising from the chimneys of cupolas for the heating of boilers. Fourthly, the construction and arrangement of the fan blowing-machine, in so far as regards the employment of an inner casing with openings of small area in its periphery. Fifthly, the general arrangement and combination of parts constituting the bellows blowing-machine. Sixthly, improvements in rotary steam-engines, in so far as regards the employment of two or more chambers, and two or more sets of arms and steam-jets or apertures in such arms of successively increasing area. Seventhly, an improved spindle or shaft-bearing in which the end or journal of the shaft works in a collar or socket of plumbago. Lastly, the construction of strap-riggers of a combination of iron and gutta percha.

ZINC ORES.

Charles André Felix Rochaz, of Paris, France, merchant, for "*certain improvements in treating zinc ores, and in manufacturing oxide of zinc.*"—Granted December 22, 1847; Enrolled June 22, 1848. [Reported in Newton's *London Journal.*]

This invention consists, firstly, in improvements in the treatment of zinc ores; and, secondly, in improvements in manufacturing oxide of zinc.

First, as regards the treatment of the ores of zinc:—This process has usually been effected by first converting them into the state of oxide, by roasting or calcination, and afterwards reducing and distilling the oxides, by mixing them with coal, and submitting them to great heat, in close vessels or retorts. This mode of operation is attended with great disadvantages, for, besides occasioning great consumption of fuel, and rapid destruction of the retorts, the product obtained is by no means proportionate to the richness of the ore.

By this improved process the employment of retorts is entirely dispensed with, and the fuel and labour are greatly economised; the operation is also completely independent of the skill of the workman or attendant; and, lastly, the loss of metal incidental to the ordinary method is prevented. Besides these advantages, the patentee observes, that ores of lead and zinc may both be operated upon at once by his improved method.

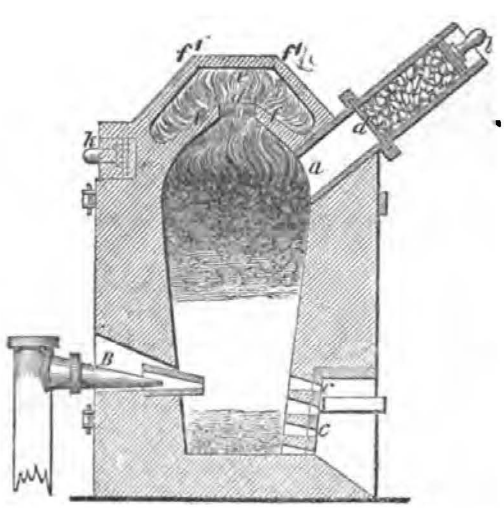


Fig. 1.

The principal feature of the invention consists in the reduction of roasted blend-ore (native sulphuret of zinc), and of the carbonates, oxides, or silicates of zinc, and also of the sulphurets and oxides of lead, by the action of the reducing gases of a blast furnace; by which the scoria or slag is fused, the reduced zinc volatilised, and the vapours condensed, and conducted into a receiver of a peculiar form, situated over the mouth of the furnace, and heated by the gases therefrom.

Fig. 1 represents a vertical section of the furnace, taken in a line with the tuyère holes; fig. 2 is an elevation of the same, on that side where the aperture for charging is situated, the condensers being shown in section; and fig. 3 is an elevation of the furnace, on the side where the tuyère pipes are situated. *a*, is the aperture or channel for charging; *a**, is a sliding partition; *b*, the outer door or cover for closing the charging channel; *c*, *c*, *c*, are apertures, through which the scoria runs; *d*, is an opening between the body of the furnace and the receiver *e*, the lower part of which is formed by the cover or partition *f*, at the top of the furnace; and the upper part by another cover f^1, larger than the lower one, forming a kind of channel, in which the zinc is condensed. *g*, *g*, (fig. 2) are openings for the escape of the gases; *h*, is an hydraulic main; B, is the tuyère or blast-pipe; and *k*, *k*, are openings for extracting the zinc and any extraneous matters; these openings are luted every time the metal, &c., is run off.

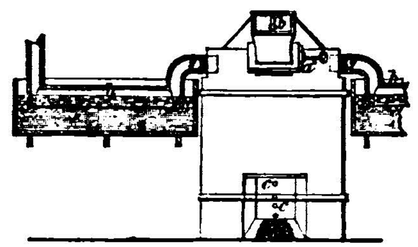


Fig. 2.

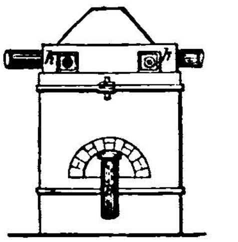
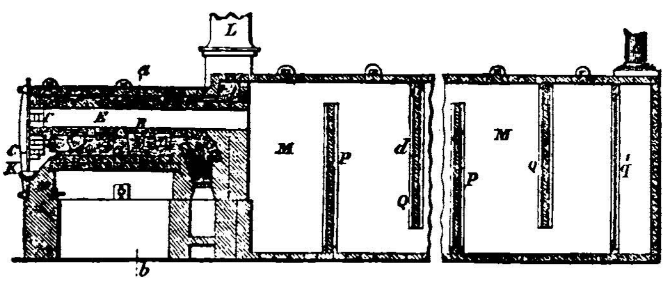


Fig. 3.

The mode of operation is as follows:—The furnace having been heated to the required temperature by the combustion of fuel alone, a charge of zinc ore, either in the state of oxide, carbonate, or silicate, mixed with any suitable flux, according to the nature of the ore, is introduced into the charging aperture *a*, between the sliding-plate *a**, and the door *b*; so that by drawing out the slide *a**, the charge will descend by its own gravity into the body of the furnace, without allowing the gases to escape through the charging aperture *b*. The charge thus falls upon a layer of incandescent fue, rising to a certain height above the tuyère B. A layer of fuel is then poured upon the ore, then another charge of ore, and so on alternately until the furnace is full; and it is to be

Fig. 4.



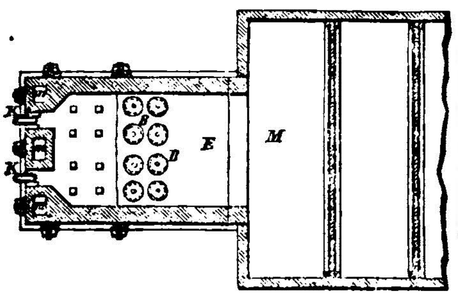


Fig. 5.

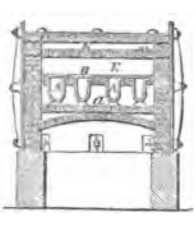


Fig. 6.

replenished in the same manner, when the charge sinks below a certain depth, which can be easily ascertained by experience.

The zinc is volatilised by the heat, and the scoria falls into the lower part of the furnace, and is run out at the apertures *c*, *c*, *c*. The volatilised zinc is carried off with the gases arising from combustion, and passes through the opening *d*, into the receiver *e*, above. The gases from the fire-place escape through the openings *g*; and as these latter might carry off particles of zinc with them, they are passed through an hydraulic main *h*, before being allowed to escape into the atmosphere. By this means all solid matters are retained, and the zinc, together with any dust or extraneous particles, is extracted through the openings *k*. When the ore to be operated upon is in a comminuted state, it is advisable to make it up into a paste, together with the flux, by the addition of water, so that it may be charged in pieces of such size as not to pass through the fuel. Zinc ore is often mixed with sulphuret of lead, and by this mode of operation the zinc is obtained by volatilization, and the lead by fusion (this latter running to the bottom of the furnace below the scoria), if, by previous roasting, a portion of the sulphur has been driven off from the ore.

The second part of the invention consists in a novel construction of apparatus for the manufacture of oxide of zinc. Fig. 4 is a vertical section of the furnace, and of the chamber for the reception of the oxide of zinc; fig. 5 is a horizontal section of the furnace, taken in the line *c*, *d*, of fig. 4; and fig. 6 is a vertical section, taken in the line *a*, *b*, of fig. 4. A, A, are the retorts or subliming-pots (of which there may be any convenient number), placed in the sole of the furnace; B, B, are the covers of the retorts, which are perforated; O, is the door of the oxidising-chamber; F, upper flue, through which the gases and other products of combustion pass from the fire-place to the chimney; K, K, are vessels for receiving the zinc, in case of rupture of the retorts or pots, in which case the liquid metal would run down on the floor *a*, *a*, and from thence into these vessels; L, is the flue or chimney of the furnace; *m*, *m*, fig. 6, are vertical flues in the wall, for the passage of the waste gases of combustion; N, is a top partition, dividing the oxidising-chamber E, from the horizontal flue F;—M, M, is a chamber for receiving the oxide of zinc; O, a chimney for creating a draught, and thus drawing the oxide of zinc, together with air and gases, through the chamber M, and alternately over and under the upper and lower partitions P, and Q. There may be any number of these partitions, according to the size of the apparatus, and the quantity of oxide to be manufactured. q^1, is a wire-cloth, or other suitable sifting partition, at the end of the chamber M, for retaining the oxide of zinc, and, at the same time, allowing the air and gases to pass through to the chimney O. It will be seen that the furnace is divided into three separate chambers or compartments; the lower one, which may properly be called the furnace or heating-flue, contains the retorts A, which are charged with the zinc to be operated upon. The volatilised zinc escapes through the orifices in the covers B, of the retorts, and enters the middle or oxidising-chamber E. The zinc vapour is oxidised and forced through the chamber M, either by means of a blower or by the draught created by the chimney O, at the end of the chamber M. The upper compartment F, is nothing more than a narrow channel or flue, for the passage of the smoke and gases from the fire-place to the chimney L. These gases heat the dome N, and thus keep the oxidising-chamber at a sufficiently high temperature to burn the zinc vapours with facility and rapidity. The partitions P, and Q, in the chamber M, are for the purpose of checking the power of the current and facilitating the deposit of the oxide in the chamber M, from whence it is withdrawn by means of openings at the sides.

The patentee, in conclusion, states that he is aware of oxide of zinc having been heretofore obtained by distillation, and bringing the volatilised metal into contact with atmospheric oxygen in an oxidising-chamber; he does not, therefore, intend to claim, generally, producing oxide of zinc in this manner; but he claims, firstly—obtaining metallic zinc in the manner and by means of the apparatus above set forth and described, or any mere modification thereof. And, secondly—producing oxide of zinc by distilling the metal, or matters containing metal, in subliming-pots or vessels, furnished with perforated covers, through which the volatilised metal may issue into an oxidising-chamber, where it is met or brought into contact with the oxygen of the atmosphere, and becomes converted into oxide of zinc.

COUNCIL OF HEALTH OF PARIS.

The most perfectly organised Municipal Board of Health hitherto established is that of the city of Paris. The comprehensive system of the Conseil de Salubrité of Paris, the scientific ability and energy of its members, and their fearlessness and devotion in invading the most dangerous and offensive hiding-places of disease, render invaluable the copious stores of sanitary knowledge contained in the long series of Reports of their researches.

Before the revolution, the administrative and judicial police of French towns was under the control of several authorities, and had not that unity of action so necessary in large cities. The Minister of the Interior, the Prefet of Police, and the Prévôt des Marchands had, each according to his jurisdiction, part of the surveillance required for the public health of the metropolis. Hence, the impossibility of instituting a complete system of regular jurisprudence, such as that which the Conseil de Salubrité established some years later. With the growth of the population, the multiplication of manufactures, and the general increase of commerce, the duties of sanitary surveillance became more and more important, at the same time that they became more and more difficult.

At the close of the last century, these duties were delegated by the Lieutenant of Police to two able physicians, M. Pia and M. Cadet a Vaux, to the latter of whom is due the merit of suppressing the Petit Châtelet, the amelioration of prison discipline, the suppression of cemeteries in the interior of Paris, and of sepulture in churches, in addition to many other salutary reforms.

The year 1802 was the epoch of the creation of the Conseil de Salubrité. Before that time, the Prefect, whenever he had to give a decision on a subject connected with the public health, took the advice of a physician, surgeon, agriculturist, chemist, or veterinary surgeon, according to the nature of the object which engaged his attention. The inconveniences of this method were such, that in July of the year above-mentioned, the Prefect Duboix instituted the Conseil, which he composed of four members, who were to examine the adulteration of liquids, diseases of animals, and noxious manufactures. In 1807, the powers of the Conseil were extended, and the number of members was increased to seven, who were required to meet regularly twice a month. To them was assigned the investigations respecting epidemics, the regulation of markets, rivers, cemeteries, slaughter-houses, sewerage, public baths, &c., medical statistics, and the tables of mortality, the cleansing of public places, the prevention and reparation of the effects of inundations, the repression of charlatanism, and the lighting of streets. The necessity of particlar attention to epidemics, induced the Prefect to add two physicians to the number of the members of the Council; other additions have been made from time to time. In order to add to the authority and importance of this body, it has from its origin had the nomination of its own president and secretary, and the privilege of recommending to the Prefect persons qualified to supply any vacancies which may occur in the Council.

Some idea of the importance and number of the investigations undertaken by the Conseil de Salubrité during the first quarter of a century after its establishment, may be obtained from the fact that the number of reports made from 1815 to 1829, was upwards of *four thousand three hundred and thirty*. The number of these reports averaged, annually, two hundred and twenty-five; and in the years 1818, 1819, and 1829, respectively, exceeded 340, 350, and 420. The beneficial effects which have resulted from the establishment of this institution, have led to the establishment of similar boards, under different names, in foreign countries; and in France, the Prefects of several departments have created provincial Councils of Health, which, but for the distraction of political events, would now probably exist in every important town in that country.

The functions of the Council are consultative, not administrative; but it assumes the responsibility of measures of government founded on its reports. It was re-organised in 1833, by an ordonnance of the Prefect, which directs the reduction of its number to 12 titulary members receiving stipends, and 6 additional non-stipendiary members. The Prefect of Police is president of the Council, and to him the Council addresses annual reports, which are printed.

The number of reports addressed to the government, from the year 1829 to 1839, was *four thousand four hundred and thirty-one*. During the succeeding six years, the number rose to *three thousand and eighty-seven*. The augmentation of the annual average is accounted for by the growth of the population, which in 1846 was 1,034,206, showing an increase of 100,000 on the return of the census five years previously. Another consideration, which indicates the importance and difficulty of the duties of the Council of Health of Paris, is, that the metropolis affords facilities for commencing many new manufactures long before they can be successfully introduced into the provinces. Paris is the centre of scientific associations and enterprise; and in directing the development of mechanical and chemical arts in the capital, the Council of Health does, in fact, solve problems which affect the health of the whole country.

In the present rapid survey of the recent reports of the association, their number and diversity render it necessary to confine the selection to a few of the more important subjects. The principal reports relate to the adulteration of food, the analysis of bread, the filtrage of water, the escape of waste liquids of manufactories, baths, and wash-houses, the refuse of slaughter-houses, tallow-melting, glue-making, &c., the smoke of kilns and cement-works, tanneries, and foundries, the cleansing of cesspools, methods of heating and ventilation, the regulation of baths, the purification of street gas, precautions in the manufacture and conveyance of chemical matches, fusees, and fulminating powders, steam-engines, the sale of arsenic, metal-gilding, distilleries, remedies against drowning and suffocation, epidemics, and a large number of questions respecting the medical police.

Salt.—In a single year the Council analysed nearly 5,000 samples of salt, which had been taken from different dealers by the police, and found 2,561 samples to be adulterated, the principal ingredients for the purpose being plaster and potash. After examining other samples taken directly from the salt-pits, the Council reported, that when white salt contains potash, calcareous matter, or sand, it is artificially adulterated; that grey salt appears to contain naturally a little potash or calcareous sulphate; but that the foreign substances always exist naturally in very minute quantities.

Water.—In 1841, the Council reported on the different systems of purifying the waters of the Seine; a matter of vast importance in Paris, where a large part of the population use water obtained from public conduits and fountains supplied from that river. Two public companies employed Smith's process, with filters of sand and charcoal in open vessels, and under a small pressure. The layer of charcoal is between two layers of sand, which again are between two beds of flints. A third company used the filters bearing the name of Fonvielle, which consist of several alternate layers of sponge, sand, and charcoal, contained in a closed vessel, subject to a pressure of one atmosphere, for the purpose of increasing the rapidity of filtration. Another process, most extensively used, is that of Souchon's, which consists in filtering the water through a number of layers of a woollen tissue, formed of wool clippings placed on the frames forming the bottom of the filter, and spread, by the action of the water itself, in a compact uniform layer. The water passes through five such layers, of which the two lowest are the thickest and remain unchanged for five or six days; the others are changed two or three times a-day. The public conduit of Notre Dame is supplied by five of the above described filters.

On a microscopic examination of water filtered by the three different processes, the Council of Health found the water containing the least impurity to be that filtered by the Fonvielle process; next to which came that of the Souchon filters. The purity of water depends, however, not entirely on the absence of matters held in suspension, but also of dissolved organic substances which after a time give a disagreeable taste to the best filtered water. In this respect, the water filtered by the process first described was found to be by far the best, as it remained a much longer time without alterations. This result is attributed to the use of charcoal, which is frequently renewed, washed, and dried. The quantity of water filtered daily by Souchon's process is stated at about 162,800 gallons; by Fonvielle's process at 88,000 to 110,500 gallons. The relative rapidity of the other methods is far slower.

Steam-Engines.—Numerous memorials have been addressed to the Council respecting the smoke, discharge of waste water, noise, and danger of explosions of steam-engines. With respect to the smoke, the Council have principally confined themselves to prescribing the use of fuel giving comparatively little smoke, such as semi-bituminous coal; the improved construction and regulation of furnaces, so as to insure as complete combustion as possible; and, lastly, increased elevation of the furnace chimneys.

Gilding on Metal.—In 1816, the munificent prize of 3,000f. (£120) was offered by a private individual, and awarded by the Academy of Sciences to M. D'Arcet, for a most successful method of removing the injuries to health produced by the operation of gilding with mercury. The principal sources of these injuries are the volatilisation of the mercury, the disengagement of hyponitric acid, and the contact of nitric, sulphuric, and hydrochloric acids, mercury, and nitrate of mercury, with the hands of the workman

The Council provide against the effect of pernicious vapours, by requiring (according to M. D'Arcet's system) the construction, for all the operations in which vapour is disengaged, of a flue having a strong upward draught, and an opening only just large enough to admit the execution of the work. Air-valves are to be used to prevent down-draught in the chimneys, which are coated with a mercurial soot, and often filled with acid or mercurial vapour; and the height of the chimney is required to be sufficient to prevent the deleterious effects of the vapours upon the inhabitants of the neighbourhood of the manufactory.

Street Gas.—The disagreeable odour of street gas is due to hydro-sulphuric acid, free or combined with ammonia or pyrogeneous products. When the sulphuretted hydrogen and hydro-sulphuret of ammonia reach the burner, the combustion converts the sulphur into sulphuric acid, which exercises a deleterious influence on health.

It is curious, that in this respect, the provincial towns of France exhibit an advantage over the capital. In many of the former, gas is delivered to the consumer free from sulphuretted hydrogen and ammoniacal gas. By proper management, the process of purification may be rendered complete, and will give, in place of a residue of valueless lime, a product valuable for chemical and agricultural purposes. A commission appointed to examine the process of M. Mallet, which has been successfully employed at Boulogne, Abbeville, and other towns, reports, that his method consists in passing the gas, before it reaches the lime, through chloride of manganese, or sulphate of iron, which rob it of the ammoniacal salts by a double decomposition; precipitating certain products, and leaving others in solution in the liquor in which the gas is washed. The separation of the sulphuric and free carbonic acids is subsequently effected by lime, of which a much smaller quantity is required than by the old method. M. Mallet's process has the advantage of utilising a substance otherwise valueless; for the salts of manganese which he requires are the refuse of numerous kinds of manufactures, where it has been hitherto a useless incumbrance. In localities however, where it cannot be procured, sulphate of iron, the product of alum-works, may be substituted. Moreover, either substance, after being used at the gas-works, furnishes a valuable chemical product—muriate of ammonia, or sulphate of ammonia.

Sanitary Police.—At the instance of the Minister of Agriculture and Commerce, the Prefect of Police submitted to the Council the important question whether the bodies of persons deceased in the colonies, of such diseases as plague, typhus, yellow fever, or cholera, could be conveyed to France with safety. The Council replied unanimously in the affirmative; pointing out, at the same time, certain measures of precaution, founded on a singular experiment made by some of its members who had been sent to Egypt upon a commission for the purpose of examining the nature of the plague. *All the persons on this commission wore next their skin, for a whole day, without inconvenience, clothes infected by the plague, and impregnated with pus,*—the only precaution taken being to soak (not wash) the clothes for a certain time in chloride of soda.

A Report on the effects of the Cholera Morbus in Paris was made by special commission, consisting principally of members of the Council of Health. From this document, published in 1834, and returns made to the commission, the following particulars are deduced:—The cholera appeared nearly simultaneously in Paris and the departments, and its duration was the same in both (March to August, 1832.) The mortality was greater among women than men. The ages which suffered least were those from 6 to 20 years. The total mortality in Paris due to cholera was 18,402 persons,* or 23·42 in a thousand; and the malady was most fatal during the month of July, and in localities where the population was poor and the air confined. The excesses to which the working population of Paris give themselves up on Sunday, appear to have produced an augmentation of 178 in the number of admissions into the hospitals on Monday. The military throughout the country suffered in the proportion 25·66 to a thousand, which exceeds the corresponding proportion (21·83) of the civil population. In some districts infected by putrid emanations, the disease was not more destructive than where the air was purer. Up to the 1st of August, the number of deaths was 17,076, or 1 in 46. In the Cité and the vicinity of the Hôtel de Ville the mortality was truly frightful, and may be readily traced to the filthy condition of those parts of Paris. In many of the houses, the walls were blackened by the damp exhalations of unclosed cesspools; the pipes from these were in other cases choked, and discharged their contents on the ruined staircases. In some cases these pollutions escaped into the living-rooms, and, in many, the only access of air and light was from a court, 3 feet in diameter, the bottom of which was used as a common receptacle. Added to this, a large part of the population of these quarters constitutes the very dregs of society, and subsists on the fruits of dishonesty or debauchery. The retribution which in the case of these persons followed the violation of the laws of society, may be estimated by the fact, that in the lodging-houses of the 7th, 9th, and 12th Arrondissements (the worst parts of Paris), the number of cases of cholera was 1 in 9, and the deaths 1 in 19.

* The total number of deaths in Paris, in 1832, was 44,119 of which 18,402 were due to cholera, leaving 25,717 arising from other causes.

The annual mortality for 10 years previously was 25,300; so that the mortality in 1832, *exclusive* of cases of cholera, exceeded the annual average. The total duration of the disease was 27 weeks, from the 26th of March to the 30th of September (from one equinox to the other).

The report from which the above particulars are taken, concludes with an earnest appeal on the part of the commission for those sanitary reforms of which their inquiries have revealed the necessity. The statical returns furnished them with appalling details respecting the filth, indigence, and neglect of a large part of the population. Among the measures specifically recommended are, that no new street should be built less than 40 feet wide (the present average is 25 feet); that the height of the houses should be limited; that public conveniences should be constructed; for open gutters, under-ground pipes communicating with the sewers should be substituted; that there should be an increased supply of water, which it stated to be supplied to the inhabitants of Paris at the rate of 7 litres for each person, the corresponding rate in London being 62 litres; and finally, that as far as possible the centre of Paris should be rendered more open, by new streets and public promenades, sufficiently spacious to be planted with trees.

The following summary of the proceedings of the Conseil in one particular class of their duties, will give some idea of the extent of their whole labours:—

Year.	Manufactories licensed.		Including steam engines.	Licenses refused.
1840	199	„	64	25
1841	194	„	68	22
1842	361	„	97	22
1843	402	„	95	17
1844	407	„	105	23
1845	397	„	90	20
1846	462	„	130	24

RAILWAY RESCUE.*

It is a gratifying proof of railway progress, that attention is now more strongly directed to the means of running light trains. It is true that in the beginning, in the Liverpool and Manchester Railway contest, lightness of the engine was considered the great essential; but for a long time, there was an exigency which demanded all the energies of engineers, and that was—increase of speed. When we recollect how very moderate were the expectations of most parties, as to the rate to be run by a locomotive; when we recollect that ten miles an hour was treated as an extravagance, and that superiority over good coaches was doubtful. When railways were started, twelve miles an hour was got by good coaches, and for posting a higher speed; and the locomotive engineer had to get such a velocity for the railway, as should give it a decided superiority over all rivals, and overcome by force the prejudices which were entertained against railway travelling altogether. The engineers put their strength in getting a higher speed, and it must be borne in mind that they were the more pressed to do so, as propositions were then put forward and experiments made, showing that a high speed for passenger travelling could be got on canals, and there were several plans for putting locomotives on the tow-paths of the canals. The steam-carriage was then on the road, and in better favour; and it was necessary to get on the railway a speed beyond that at which steam-carriages could safely be run on the turnpike roads.

Provided speed was got, whether by an increase of weight or expense, it mattered not: and it was got, and every year has added to the weight; but we are prepared thereby for a new era. By these great exertions, not merely the weight has been increased, but the working power, and the economy of working has been greatly promoted.

If the locomotive engineer had his attention absorbed and

* London. Effingham Wilson. 1848.

drawn in one direction, so it was with the railway manager. He had to provide for the traffic which first came in his way, and for the demands of the wealthy and commercial classes, far greater accommodation. As yet, this is all that has been done; and although some saving has been made, yet one of the original objects of the railway system—cheap transit—has not yet been accomplished.

A comparatively low speed is the most economical for passengers and goods, but railways have not yet been able to give the accommodation implied by this condition. To suit their general traffic, and to work with safety, they have been obliged to work at a nearly uniform speed—which has, of course, been a high one; but with the resources afforded by the electric telegraph, it now appears possible to introduce slow and cheap trains. We long since pointed out in this *Journal*, the plan of running trains at various speeds, which was some years after advocated by the *Railway Chronicle;* and we are glad to see that the principle of it has now been more fully acknowledged.

The pamphlet now before us advocates lighter engines, lighter stock, and lighter works; but it seems that this is to be accompanied by getting rid altogether of the present high speed. There can be no doubt that express trains damage the rails, points, and switches, most seriously; but we cannot now turn back.

The present pamphlet, although it is crude and short-sighted in some of its views, contains a great deal of valuable matter, and in the main point of lighter stock and cheaper trains, is calculated to do very much good. We, therefore, particularly recommend it to our engineering readers.

The following are the author's opinions as to the discrepancy between rolling stock and rails:—

If there be any doubt expressed as to the discrepancy of strength between the rolling stock and the rails, a very plain answer may be found in the fact of the general renewal of rails now required. If this be not enough, let the proportions of the periphery of a locomotive driving-wheel be compared with the rail beneath it. The former weighs upwards of 200 lb. per yard; the latter from 70 lb. to 80 lb. Yet the former is of an arch form, supported by the spokes at intervals of nine inches, while the latter is a simple straight beam, supported at intervals of fifteen feet, which invariably deflect beneath the passing load and destroy the continuity of support. To make a perfect railway, the rail-bar should be of sufficient vertical depth to resist all deflection, with the heaviest load passing over it. More than this, it should be sufficiently hard to prevent lamination. And the joints of the rails should be so re-inforced as to be equally inflexible with the solid part of the rail. None of these conditions are yet attained as regards the modern class of engines, and it is a problem whether they can be attained at all. Even as there is a limit to the height of architectural structures relatively to their base, by reason of the friability of the material, so there is a limit to the weight of engines, by reason of the compressibility of iron and the impossibility of increasing surface-bearing; for whether a driving-wheel be of three feet or eight feet in diameter, the contact with the rail can only be a point or that which geometers call a "flowing point," viz., a line. Iron, according to its density, will bear a given weight without compressing, the point of contact being a line. When iron has done its utmost, steel may be resorted to; and, possibly, a rail of 200 lb. per yard, of deep vertical section, with a surface of hard steel three inches in width and three quarters of an inch in depth, supported by cross sleepers at intervals of eighteen inches, might be available to construct a real "permanent way,"—for the modern engines. "Permanent way" is at present a *lucus a non lucendo.* "Permanent maintenance of way" is a practical fact, as shareholders pockets' can testify.

You, gentlemen, will doubtless be startled at the contemplation of the outlay of capital involved in the real permanent way before described. If you will not agree to this proposition, you must "try back." If you cannot suit the road to the wheel, you must suit the wheel to the road. Having the fear of "no dividends" before your eyes, you must turn to the practical maxim of the Manchester and Liverpool directors of old, gathered from the experience of the road, and keep down your weights. Light horses for the high speeds: brewers' horses for the drays. Small trains and frequent, with small station room, few police and porters, and fewer clerks, a slight increase of drivers and stokers, and a huge decrease of plate-layers, and a reduction in iron invoices, would do more for your dividends and the public accommodation than the present system of elephantine traction, with a yielding foothold—a power developed and wasted. For it must be obvious that if, after expending millions to secure "good gradients," a deflecting rail be laid down, it is equivalent to converting them into bad gradients. In water-transit a steamboat drives a greater or lesser wave of water before her bows. In rail-transit, a locomotive drives a wave of rail before her driving-wheels equivalent to ascending a constant incline, and demanding a far greater expenditure of steam-power to surmount it. The difference in the two cases is, that it is impossible wholly to surmount, though we modify, the difficulty, with the steamboat, whereas in the case of the rail it is practical to surmount the difficulty altogether by proportioning the load on the wheel to the strength of the rail.

The wave line of the rails might fairly be adopted as a standard in estimating the value of a railway; for in proportion to the depth of the wave will be, *cæteris paribus*, the power of steam and the cost of coke. You must be aware that, to ascend a constant hill, requires more horse-power than to travel along a level. Your horse-power is steam, and the railway oat is coke. If your drivers and ostlers and road trustees increase the consumption of oats, the coach will soon be run off the road.

But even wave lines vary. For example, rails laid on longitudinal timbers, as the Great Western, yield an equable wave line. Rails laid on chairs and transverse sleepers make unequal waves at their mid-length and at their joints. The result is concussion as well as sinking, and the loss of power is greater. Mechanical men having their living to get by the prevention of waste, and the economy of steam-power, readily apprehend all this, for they carry the safety-valve in their own breeches' pockets; but it does not so readily occur to railway directors. Let them maintain a standard gauge—the wave of the rails. Perhaps as an additional stimulant you will take into your thoughts the somewhat startling fact that a pair of the largest railway locomotives would furnish power enough to supply the largest pumping water-works in London. Another pair might achieve the tasks of delivering it into their attics instead of the ground-floors of the London dwellings. Another pair might pump up all the sewage water south of the Thames, as Mr. Chadwick will inform you.

SMELTING COPPER ORES.

Description of the process of M.M. Rivot and Phillips, *for smelling copper ores.* (From a paper read before the Society for the Encouragement of Arts and Manufactures, Paris.)

In a visit to England in 1845, one of us became acquainted with the experiments made in an English copper-works, to extract the metallic copper by means of the action of voltaic electricity, from previously roasted sulphur ores of copper. The information we obtained was the same as was laid before the Society as descriptive of the process employed by M Napier.

The sulphur ores were first well roasted, then smelted in a reverberatory furnace, and the copper brought to a metallic state by passing through the fused metallic silicute a very powerful voltaic current; the grafhite hearth of the furnace, and a plate of cast-iron kept at the upper part of the melted mass, forming the remaining part of the voltaic current.

Starting from these given points, we first tried to reduce by a voltaic current, not the silicate of copper, but the pure sulphuret of copper.

After several ineffectual attempts, we succeeded in passing during more than two hours, a constant current through a crucible containing sulphuret of copper at a red heat.

In a common Hessian crucible, we placed two small pieces of compact coke, kept at a little distance by well compressed luting; and in these we plunged two platinum wires communicating with the two poles of the battery. The platinum wires were preserved from the action of the sulphur by the pieces of coke and the luting. We found in these direct experiments, that coke is a good conductor at a red heat, and that the luting conducts but a very little at that temperature.

Tubes, fixed in two notches of the crucible, had for their object the prevention of contact between the charcoal and the platinum wires, a point of essential importance on two accounts:—First, the burning charcoal would have established a communication between the two poles of the battery outside the crucible, and consequently, a large portion, if not the whole of the current would have been deviated, and not have traversed the fused mass.—Secondly, the alkaline ashes of the wood charcoal would have rapidly attacked the platinum wires, and the current thus have been interrupted. The copper wires closing the circuit communicated with a galvanometer, the needle of which indicated by its deviation the energy of the current. We employed constant batteries with copper and zinc elements, and solutions of sulphate of copper and common salt, of six to twenty-four couples, and sometimes only one Bunsen battery of thirty elements. We always simultaneously made two comparative experiments, by placing in the furnace two crucibles exactly similar, the one traversed, and the other not traversed, by the current.

We found, after several experiments, that the sulphuret of copper not decomposed by the coke, is but very slightly decomposed by a constant current of twenty-four couples of the voltaic battery, producing a deviation of the needle of the galvanometer of 35 to 40 degrees.

By employing a Bunsen battery of thirty elements, producing a deviation of the needle of the galvanometer of 45 to 50 degrees, we have reduced a notable quantity of copper in a state of fusion; but the largest proportion of the sulphuret remained undecomposed.

These results convinced us that the action of the battery is feeble as regards sulphuret of copper, and that the very powerful voltaic current requisite for effecting the decomposition, as well as the difficulty of conveniently disposing the apparatus, would prevent the employment of this process for the treatment of sulphuret of copper, and *a portion* for that of pyritic copper, which is the most common ore of copper.

Experiments analogous to the preceding, in the which we replaced the two poles of coke by rods of iron, have indicated to us that the action of the battery renders more rapid, but not complete, the reduction of sulphuret of copper by the iron. It always forms a mass, rich in copper.

The action of the battery, aided by that of the iron, separates from the sulphuret of copper but a very small proportion of copper.

In analagous experiments made on galena (sulphuret of lead), this mineral presented the same characters as the sulphuret of copper. We also found always a great loss in the crucible traversed by the voltaic current, due to the volatilisation of the metal. These experiments clearly demonstrated to us that the action of the battery, aided even by that of iron, could not serve as a process for the direct treatment of the sulphurous ores of lead or of copper.

We then repeated the experiments of M. Napier, and endeavoured to reduce the fused silicate of copper and iron, by a current brought by two poles, the one of iron, the other of plumbago, in immediate contact with the fused mass. But we very soon convinced ourselves, that of the three agents employed for the reduction of the oxide of copper (the plumbago, the iron, and the current), the first two, especially the iron, were quite sufficient; and numerous experiments proved to us, that by the action of iron alone, a silicate of copper, containing besides oxides of copper, other bases, such as soda, lime, oxide of iron, &c., gave up in less than one hour's action of the fire, the whole of its copper united in a button of complete purity.

It is thus that we have been led to search in the action of iron, the principle of the reduction of oxide of copper. We first made several experiments in crucibles, in order to determine the circumstances most favourable to the action of iron. The following are the principal results which we obtained. In our crucible were arranged two or more iron rods, dipping almost to the bottom, and kept at the upper part by a bed of luting. The material employed was either roasted pyritous copper, or a mixture of oxide of copper, oxide of iron and sand; to these we added as fluxes, soda, or lime, or even chalk only. By employing soda as the flux, the reduction of the oxide of copper was complete in a very short time. At a quarter of an hour's fusion, the copper obtained was chemically pure. With chalk, the complete reduction required one hour's fusion. The copper produced contained much iron (often 15 per cent.) when the iron-rods dipped down to the bottom of the crucible; and, on the contrary, was always very pure when the rods reached but a little way above the bottom. The time necessary for the complete reduction of the oxide of copper, was more or less great in proportion to the number of iron rods employed.

Satisfied with these results, we constructed a reverberatory furnace capable of containing about 250 kilogrammes (5 cwt.) of fused metallic silicates, and presenting no other peculiarity of construction than having six grooves or vertical hollowed-out places in the wall opposite to the door of the furnace. Their use was to maintain in the fused mass six bars of iron of 6 to 8 centimetres (2¼ to 3¼ inches) wide, and 70 centimetres (28 inches) long. These bars thus acted on a large portion of the melted mass, were not in contact with the copper, were readily put in and removed, and we were able to stir the melted mass between the bars, in such a way as to render it homogeneous, and renew the parts in contact with the iron. We have treated in this furnace, more than three tons of the pyritic ores of Cornwall, Germany, and Spain, all previously carefully roasted. This complete rousting is easy enough when the ore is ground with fine sand; it is done with ordinary precaution, but should be finished with a brisk heat. In the first experiment, we commenced by fusing the roasted ore with lime and poor slag; and when the fusion was complete, we applied six bars of iron, which were allowed to remain during four hours. After this time, we removed the bars and ran out the metal. In operating thus, we always found the consumption of iron to be much greater than theory, pointed out as sufficient for the reduction of the oxide of copper. The slag retained from 2 to 3 per cent. of copper. We attempted to smelt this slag by itself, and acted upon it with bars of iron for four hours: the result was that we obtained new slag, equally rich in copper with the former; and this, notwithstanding that the bars lost several kilogrammes of weight. This oxidation of the bars of iron could not be attributed to the air of the furnace which had not served for combustion, since the bars were constantly and entirely plunged into the fused material, but was evidently due to the peroxide of iron contained in the metallic silicate, and which would be brought by the iron to the state of protoxide before the oxide of copper could be completely reduced by the iron. We then endeavoured to reduce the consumption of iron, and recover the copper lost in the slag, by adding to the action of the iron that of charcoal or coal. The carbonaceous material might be employed in two ways. First, mixed with the wasted ore; secondly, added after complete fusion, to the compound formed of the fused silicates. In operating in this last manner, we were soon convinced that the charcoal acted but slowly and feebly in the fused silicates, because it floated on the surface of the mass, and could not be kept within it. Nevertheless, its action is of some account; for, when we threw on the melted mass in the furnace a certain quantity of poor coal, we always observed a rapid augmentation of its fluidity, explained only by the reduction to the state of protoxide of iron, of a considerable quantity of the peroxide. The consumption of iron being still very great, we next proceeded to examine the action of the carbonaceous matter, when mixed with the roasted ore before charging the furnace. After several trials, we have adopted as the most convenient proportion of charcoal dust, or small poor coal, that which is required to produce one-half carbonic acid, and one-half carbonic oxide, in combining with the oxygen of the oxide of copper, and that combined with the protoxide of iron in the roasted ore. This proportion gave us, without employing the action of iron, a slag containing 2½ per cent. of copper. We have proved by several trials (1.) that this proportion of charcoal need not be rigorously adhered to; and that it may be either increased or diminished to some extent, without the slag being either poorer or richer in copper, or the quality of the copper altered. (2.) That in increasing much the proportion of charcoal mixed with the ore, and in raising the temperature of the furnace to a bright white heat, we could always bring the last slag (without the action of iron) to such a point, that it should not contain more than $\frac{11}{1000}$ of copper: but then the copper contained 8 to 10 per cent. of iron. By operating at a lower temperature to that strictly necessary for fusion, we obtained a slag rich enough in copper, and still containing 5 to 6 per cent. of iron. (3.) That the action of the bars of iron on the fused silicate, containing 2 to 3 per cent. of copper, is powerful and rapid; and that three hours are sufficient to bring the slag to such a state that it shall contain only $\frac{4}{1000}$ to $\frac{6}{1000}$ of copper, the copper obtained being at the same time free from iron. The following is the mode of operation, we were definitively led to adopt:—We charge the heated furnace with a mixture of roasted ore (3 to 3½ cwt.) and lime or sand, and the slag of a preceding operation, in quantity convenient for determining the fusion of the material, and charcoal or small coal in the proportion previously indicated. In reckoning only as bases in the charges, the protoxide of iron and the lime, we endeavour to produce a bisilicate, containing 12 to 15 per cent. of lime. Experience has pointed out, that a bisilicate of protoxide of iron, one base only, melts very quickly and acquires a great fluidity, but readily gives a copper containing much iron.

After charging the furnace, we throw on the surface of the mass one or two shovelsful of small coal, for the purpose of preserving the material from oxidation by the flames of the furnace. We stir the mass from time to time, in order to enable it to heat more uniformly, and melt quicker. We sometimes succeed in melting completely in four hours. As soon as the mass commences to agglomerate, the parts which attach themselves to the rakes contain a certain quantity of copper scales: when the fusion is complete, the rods plunged into the melted mass indicate the re-union of the copper at the lowest point of the hearth of the furnace near the discharge hole.

We have always examined the slag swimming on the copper at this moment of the operation, after having carefully stirred the mass so as to produce slag of a homogeneous quality, and found it to contain 2 to 3 per cent. of copper. When the whole is well melted, we place six bars of iron, weighing altogether from 36 to 45 kilogrammes (84 to 105 lb.), fixing their ends in the grooves in the side of the furnace opposite to the door, taking care to plunge them entirely into the melted mass. We then again throw on the surface of the slag a small quantity of coal, to prevent the peroxidation of the protoxide of iron of the slag by the flames; then, from half-hour to half-hour, we stir with a two-pronged rake (very convenient to clean) the surface of the iron-bars immersed in the slag. We also employ as a powerful means of producing the mixture, a wooden pole, which, plunged into the slag, gives a considerable disengagement of gas, and produces a strong frothing up. The appearance of the slag furnishes but little indication of the progress of the reduction of the metal; we have however, proved that trials made with a cold rake, plunged for a moment into the fused mass, always presents on contact with the iron, a reddish metallic tint, strongly marked where the slag was rather rich; a tint which, on the contrary, was scarcely discernable when the slag contained not more than $\frac{4}{1000}$ to $\frac{6}{1000}$ of copper.

We have always found that three to four hours are sufficient to remove the copper from the slag up to $\frac{4}{1000}$ to $\frac{6}{1000}$. After this interval of time we draw out the bars, and run off the metal. The duration of one entire operation is thus about eight hours, and three operations may be readily conducted in one day. The loss in weight of the iron bars varies in our experiments to from 1 to 6 kilogrammes (2¼ to 13 lb.), for quantities of copper of 12 to 42 kilogrammes (27 to 94 lb.) obtained from ores of various qualities. This loss is independent of the richness of the ore, and the consumption of the iron is proportionally less for the rich than the poor ores. For the pyritic ores of Spain, containing 21 per cent. of copper, we have consumed 11 parts of iron for 100 of copper obtained. The English ores which we have melted contained 7 per cent. of copper, 4 to 6 per cent. of arsenic, a small portion of antimony, and some traces of tin; from these we have obtained an impure black copper, containing 3 to 5 per cent. of arsenic, 2 to 3 per cent. of tin, and only a few thousandths of sulphur and iron. This result has not surprised us; the arsenic can only be completely driven away by a great number of successive operations and alternations of roasting and reduction. Thus, we do not propose the application of our process for the treatment of ores containing much arsenic or antimony—as, for example, the grey copper ores. With the pyritic ores not containing arsenic we have always obtained a very pure black copper, containing only from $\frac{2}{1000}$ to $\frac{5}{1000}$ of sulphur and iron.

The roasting has a certain influence on the quality of the copper, and on the consumption of iron. With well roasted ores we never had a deposit underneath the copper, which was the case with ores imperfectly roasted. The copper contained not the least iron, and less than $\frac{2}{1000}$ of sulphur. The consumption of iron was much less with well roasted ores, and the final slag less rich in copper. The temperature which we have adopted as the most convenient, is that which is strictly necessary for the fusion of the copper and the slag. Too high a temperature renders the action of the iron on the silicate of copper more rapid and energetic; but the coal reduces more easily a part of the oxide of iron combined with the silica. In operating in the same manner, on the same mineral, at a well-regulated temperature, and at a bright red heat, maintained from the commencement of the operation, we have obtained, in the former case, a copper of sufficient purity; in the latter case, a copper contaminated with 3 per cent. of iron.

The consumption of coal employed in our furnace will not give a great indication as to the quantity which would be required in a large reverberatory furnace kept in constant operation. We can, however, give a calculation of sufficient approximation from the consumption of the large copper furnaces in Wales.

The ores to which our process may be applied with the greatest advantage are the oxides or pyritic ores with a gangue of pyrites or oxide of iron; they render, by our mode of treatment, copper of excellent quality. These ores, as at present treated, yield a black copper containing much iron. Our process is also readily applicable to all the ores of copper which do not contain too much arsenic or antimony. The process which we have described offers several marked advantages over the methods ordinarily employed. It is rapid and economical, since by one single fusion we obtain a slag sufficiently poor to be rejected, and all the copper in a state of sufficient purity to be sold after one smelting, or at the most a short refining. It requires no difficult manipulation, and the workmen can readily understand the way of conducting the operations. The complete roasting of the ore is not a new operation in metallurgy; it is easily accomplished when the ore is ground with sand of sufficient fineness; it requires tact and attention on the part of the workmen, and should be finished by a good stroke of the fire, in order to decompose the sulphates formed at a lower temperature. We have previously pointed out that the principal inconvenience of an incomplete roasting is, in the smelting, a greater consumption of iron, and a less complete removal of the copper from the slag in a given time. A good roasting furnace should contain about 1½ ton of ground ore: the operation should be continued from 15 to 24 hours. For the smelting, the furnaces should be similar to the large reverberatory furnaces of Wales, and contain for a charge 24 cwt. of ore. There should be three smelting furnaces for four roasting furnaces, supposing that three operations may be conducted in each smelting furnace daily. The refining of copper of the first smelting may be done in a furnace containing four tons; an operation which does not require more than 12 hours. To give an idea of the principal *matériel* necessary for the production of a certain quantity of copper, we will suppose that we have to treat a pyritic ore of copper with a gangue of pyrites or quartz, containing at the most 15 per cent. of copper. To produce per annum 100 tons of copper, there will be required two pair of stamping mills, twelve roasting furnaces, eight smelting furnaces, and one copper refining furnace.

It will also be very advantageous to annex to the copper-works an iron-work, which would produce at a low price the iron necessary for the tools and implements employed, the bars, &c., and to use up the old bars which will no longer serve in the smelting furnaces. We have also applied the action of iron on the metallic silicates in fusion to the treatment of sulphate of lead, but less successfully than in the case of copper ores. These trials have been made on a large scale in a reverberatory furnace capable of containing 24 cwt. of materials.

To the dry sulphate of lead, we added sand, a little chalk, the slag of a preceding operation, and about three per cent. of charcoal. A larger proportion of charcoal always gave a little sulphuret of lead with the metallic lead. We charge the furnace, and heat it so as to effect an entire fusion for the space of five hours. We then throw into the fluid mass, at three or four times, iron turnings, which replace to great advantage the bars of iron. The proportion of cast-iron turnings necessary is about one-eighth of the weight of the dry sulphate of lead. We stir the mass very frequently, and after four or five hours' action of the iron, run off the metal. We have obtained, in this manner, 45 to 48 parts of lead from 100 of sulphate of lead. The loss, therefore, of metal was considerable, which was due in great part to the volatilization of the lead, the fumes of which were evident at the top of the chimney; this volatilization principally took place during the stirring and the charging. We notice this application of our process to the reduction of sulphate of lead, because that it proves that iron acts very rapidly on the silicate of lead, and that this action might be employed under certain circumstances.

To complete the description of the process for the metallurgical treatment which we propose, we now proceed to give an estimate of the probable cost of the treatment of copper ores. We base this estimate on the duration of the operations in the reverberatory furnaces in which we have treated the ores of copper and the sulphate of lead; on the consumption of coal in the large smelting furnaces in Wales; and on the consumption indicated from our own experiments.

To compare our process with that adopted in the greater number of copper-works in England, we have adopted the figures given by MM. Dufrenoy, Elie de Beaumont, Costa, and Perdonnet, in their "*Voyage Métallurgique en Angleterre.*" We will reckon the cost for 1 ton of pyritic ore having a gangue of quartz and iron pyrites. For the refining, we calculate the expense for one ton of copper.

RIVOT AND PHILLIPS' PROCESS.

First Operation.—Grinding of the ore.

For one ton, ... 1*fr.* 50*c.* = 1*s.* 3*d.*

Second Operation.—Roasting of the ore in furnaces containing 36 cwt. Duration of roasting process, 18 hours. (We may remark that for the roasting, the lost heat from the smelting furnaces may be very well employed, as is done in some English works.)

Labour, 1½ day @ 2 francs	3 *fr.*	
Coal, 6 cwt. @ 1 *fr.* ℔ 2 cwt.	3	
Total	6 *fr.*	= 5 *s.*

Third Operation—Smelting of the roasted ore. Furnaces containing 1½ ton of ore (weight of crude ore). Duration of operation, eight hours. Consumption of coal per hour, on an average, 120 kilo. = 2 cwt. 1 qr. 16 lb. The iron is put at 25 fr. the 100 kilo. = 20*s.* the 2 cwt.

	fr.	c.	
Labour, 0·87 day @ 2 fr.	1	74	
Coal, 640 kilogrammes @ 1 fr. ..	6	40	
Iron, &c.	9	00	
Special Expenses	17	14	= 13*s.* 8*d.*

This operation gives all the copper contained in the ore in the state of black copper, containing but a very little iron and sulphur.

The special expenses of the treatment of one ton of copper ore of ordinary quality, 6 to 30 per cent. according to our process,

	fr.	c.	
Grinding	1	50	
Roasting	6	00	
Smelting	17	14	
Total	24	64	= 19*s.* 9*d.*

Fourth Operation.—Refining of the black copper obtained by smelting. In a furnace containing 4 tons of copper. Duration of the operation, 12 hours. Mean consumption of coal per hour, 2 cwt.

For one ton of copper:—

	fr.	c.	s.	d.
Labour, 1 half-day @ 3 francs	1	50	1	3
Coal, 1½ cwt. @ 1 franc	1	50	1	3
Total	3	0	2	6

For an ore rendering 8 to 10 per cent. of copper, the refining will add about 30 per cent. to the expenses.

In adding to these expenses 3 francs (2*s.* 6*d.*) for repairs of implements, &c., we arrive at a sum of 27 *fr.* 94c. for the expenses of the treatment of one ton of ore, comprising the refining—say in round numbers, 28 francs (22*s.* 6*d.*) For a return of 8 to 10 per cent., the special expenses for 1 ton of refined copper will be 350 francs (14*l.*); for a return of 25 per cent., 112 francs (4*l.* 10*s.*)

WELSH PROCESS.

The special expense of the treatment of one ton of ore, containing or rendering 8 per cent. of copper, is as follows:—

Coal, 1,600 kilogrammes @ 1 franc	16 *fr.*	
Labour, &c. &c.	26	
Total	42 *fr.*	= 33*s.* 2*d.*

Difference in favour of our process, 14 francs (11*s.* 8*d.*)

For one ton of copper and for the ores ordinarily treated in Wales, the difference in the special expenses of the treatment is 175 francs (7*l.*)

The Society for the Encouragement of the Arts and Manufactures, and the Academy of Sciences, have both reported favourably on the process of MM. Rivot and Phillips.

FALL OF RAIN.

An Account of some Observations made on the Depth of Rain which falls in the same localities, at different altitudes, in the hilly districts of Lancashire, Cheshire, and Derbyshire. By S. C. HOMERSHAM, C.E.—(Read before the Royal Society of London, May 25, 1848).

Having been present at a meeting of the Royal Society of London on the evening of the 18th of May last, when a valuable and interesting paper was read, "On the Meteorology of the Lake Districts of Westmoreland and Cumberland," by J. F. Miller, Esq., of Whitehaven, in which paper the following remark occurred:—"It would be premature, from the scanty data before me, to draw any conclusion as to the gradation in the quantity of rain, at these great elevations above the sea. *But it seems probable that, in mountainous districts, the amount of rain increases from the valley upwards, to an altitude of about* 2,000 *feet, where it reaches a maximum;* and that above this elevation the quantity rapidly decreases. The table for 1846 exhibits the rain fall of the summer months only; but the additional returns of 1847, obtained in every variety of season, confirm the above deductions in every essential particular, so that we may fairly assume the combined results to be indicative of a physical law, so far at least as relates to the particular locality in question."

I am desirous of laying before the Royal Society certain observations made under my own direction, which lead me to differ from the author of that paper in the conclusion he has deduced from his facts.

Mr. Miller kindly furnished me some time since with many, if not the whole, of the results of his experiments in these districts up to the beginning of March last. I have been careful to ascertain whether Mr. Miller's own experiments fully bear out the conclusions suggested in the quotation above made, because this conclusion is in direct opposition to the recorded observations of the Honourable Daines Barrington, F.R.S., Dr. Dalton, Professor Daniell, Samuel Marshall, Esq., of Kendal, and John Fleming, Esq., of Manchester; and also to observations made in 1841 by Captain Lefroy, then Director of the Observatory at St. Helena; the results of which observations were published in 1847, by order of Her Majesty's Government, under the superintendence of Lieut. Col. Sabine, F.S.R.S., in a volume entitled "Observations made at the Magnetical and Meteorological Observatory of St. Helena."

The Honourable Daines Barrington, F.R.S., states in the "Philosophical Transactions" for 1771, page 294, that in 1770 he caused two rain gauges to be placed, one on Mount Rening, in Wales, 1,350 feet above the level of the sea, and the other upon the plain below. From July 6th in this year to October 29th, the gauge on the top of the mountain caught 8·165 inches of rain; the one at the bottom 8·766 inches, showing half an inch *more rain to have fallen at the bottom* than on the *top* of the mountain.

Dr. Dalton, in the "Memoirs of the Literary and Philosophical Society of Manchester," vol. v., New Series, p. 236, says:—"From the observations made in Great Britain, it appears to be an established fact, that more rain falls in the hilly part of the country than in the plain; *but it also appears that the quantity of rain in a low situation is greater than in an elevated situation in the vicinity.*"

Professor Daniell, in his "Elements of Meteorology," vol. i., p. 236, states, "It has been ascertained more rain falls at the bottom of a mountain than the top. Samuel Marshall, Esq., of Kendal, also states, in a communication published in 1839; in the Transactions of the Meteorological Society," vol. i., p. 115, that, "It is a fact sufficiently well established, that more rain falls in low situations than in more elevated ones, even when contiguous.

And more recently, John Fleming, Esq., states, in the "Memoirs of the Literary and Philosophical Society of Manchester," vol. v., Second Series, p. 252, that, "On the descent of the hill, and probably about the foot of it, the heaviest rain will fall." In the "Observations made at the Magnetical and Meteorological Observatory of St. Helena," before alluded to, it is stated at p. 102 of the index:—"In 1841, Captain Lefroy, then director of the observatory at St. Helena, established rain gauges at three other points of the island, for the purpose of ascertaining a comparative estimate of the quantity of rain. The stations were—1. Near the highest pinnacle of the island, on a very narrow ridge or rock; 2. lower down on the same ridge of hills; 3. Longwood observatory; 4. James Valley. The three first stations might be comprehended in a circle of one mile radius, and the fourth is but little more distant. The quantities of rain received at these stations, during nine months of 1841, were as follows:—

1. At 2644	feet of elevation,	22·68	inches.
2. At 1991	"	27·11	"
3. At 1782	"	43·42	"
4. At 414	"	7·63	"

This table shows that at 1782 feet elevation, much *more* rain fell in a given time than at *the higher* elevation of 1991 feet. The reason why so small a quantity as 7·63 inches only was recorded in the same time at 414 feet elevation, is not very apparent; but it would probably be found, upon examination, that this result is due to some local circumstance in the position of the gauge, and not to its elevation—a conclusion to which I am led by an examination of the localities, compared with the quantities of rain collected in Mr. Miller's experiments.

In a Report which I have recently published, "On the Supply of Surplus Water to Manchester, Salford, and Stockport," p. 70, I have shown that, during the past year of 1847, I had four rain gauges fixed, one at the bottom of Todd's Brook Valley, situated in Cheshire, near Whaley, 620 feet above the level of the sea; another at Brinks, the top of the hill bordering this valley, 1,500 feet above the level of the sea, and that 38·39 inches in depth was received at the bottom of the hill, and only 29·5 inches at the top of the hill. A third gauge was fixed at the bottom of the Comb's Brook Valley, situated in Derbyshire, near Chapel-en-le-Frith, 720 feet above the level of the sea, and that 51·30 inches in depth was caught at the bottom of the hill, and only 35·85 inches at the top of the hill.

Since the report just referred to was published, I have been favoured by Thomas Hawksley, Esq., C. E., with the results of some important unpublished experiments made by him for the Corporation of Liverpool, on the amount of the fall of rain at Rivington, and in the Valley of Roddlesworth, near Preston, in Lancashire. Six rain gauges, placed near the ground, were fixed in these localities at the beginning of January, 1847, three at Rivington, and three in the Valley of Roddlesworth.

The quantities falling per month are shown in the following table, and also the monthly fall for January, February, and March, 1848, all of which results prove the same general fact, that more rain falls at the bottom than the to of the hills in the same localities.

TABLE.—*Showing the quantities of rain fallen per month in three rain gauges, fixed near the ground, in the district of Rivington, and in the Roddlesworth Valley, Lancashire, during the year 1847 and three months of 1848, with their respective heights above the level of the sea.*

Rivington District.

Height above the level of the sea.	January and February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1847.												
No. ft.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
1.—410	5·60	1·47	2·69	6·22	4·22	1·30	2·91	6·28	5·69	5·07	7·88	48·83
2.—710	5·36	1·22	2·75	6·09	4·20	1·26	2·92	5·63	5·37	4·85	6·83	46·48
3.—750	5·51	1·25	2·69	6·04	3·79	1·11	2·78	5·59	5·27	4·75	7·18	45·96
1848.												
1.—410	3·13 7·93	3·81	..	..	..	..	..	..	..	..	..	14·78
2.—710	2·89 7·86	3·91	..	..	..	..	..	..	..	..	..	14·66
3.—750	2·88 8·00	3·77	..	..	..	..	..	..	..	..	..	14·65
1847.					Roddlesworth Valley.							
4.—550	6·42	1·33	2·31	5·69	4·52	1·05	3·72	5·86	6·25	5·53	7·54	50·22
5.—700	6·79	1·35	2·72	6·30	4·93	1·20	3·95	7·10	7·09	6·55	9·12	57·10
6.—900	6·46	1·28	2·80	6·59	4·48	1·50	3·21	6·60	6·39	5·99	7·28	52·53
1848.												
4.—550	2·70 8·61	3·64	..	..	..	..	..	..	..	..	..	14·95
5.—700	3·19 10·25	4·26	..	..	..	..	..	..	..	..	..	17·70
6.—900	2·90 8·36	3·21	..	..	..	..	..	..	..	..	..	14·47

The gauge at the lowest elevation in the Rivington district (410 feet) received 48·83 inches of rain during the year 1847; the gauge at 710 feet elevation 46·48 inches during the same time; and the gauge at 750 feet, the highest elevation, only 45·96 inches.

The gauge at the lowest elevation in the Roddlesworth locality (550 feet) received 50·22 inches of rain during the year 1847; the gauge at 700 feet elevation 57·10 inches during the same time; and the gauge at 900 feet, the highest elevation, 52·53 inches. Here it will be observed, that the gauge at 900 feet elevation received, as before, a considerable *less* amount of rain than the gauge at the lower elevation of 700 feet, but that the gauge at the lowest elevation of 550 feet forms an exception, as this gauge received abou 2½ inches less in depth during the same time than the gauge at 900 feet elevation, and nearly 7 inches less than the gauge at 700 feet elevation.

A personal knowledge of this locality, or a glance at the map, may serve to explain this departure from the general rule observed, for this gauge is placed at the bottom of a steep valley, bordered to the west by very precipitous and high land, and it is in this manner sheltered, to a considerable extent, from the prevailing rainy winds.

Two rain gauges which I have caused to be fixed, one in the neighbourhood of the Bosley Reservoir, situated near Congleton, Cheshire, 590 feet above the level of the sea, and the other at Bosley Minns, 1,265 feet above the level of the sea, in the same locality, show that, during the first four months, January, February, March and April of the present year, 11·75 inches fell on the bottom of the hill, and only 11·65 inches on the top of the hill.

The amount of rain received in the rain gauge placed near the bottom of a hill at Todd's Brook, (before referred to,) during this period, was 13·03 inches in depth, and at Brinks, the top of the same hill, only 11·51 inches.

The amount received in this time at Comb's gauge at the bottom of the hill, was 19·70 inches, and in the gauge at the top of the hill only 10·45 inches, as shown in the monthly report of the observations made with all these gauges which are given in the following table:—

TABLE *showing the quantities of rain fallen per month in certain funnel rain gauges, 9 inches diameter, and placed 2 feet 6 inches above the surface of the ground, at Todd's Brook, near Whaley, Cheshire; at Comb's Brook, near Chapel-en-le-Frith, Derbyshire; and Bosley, near Congleton, Cheshire, with their respective heights above the level of the sea.*

Situation and height above the level of the sea.	Jan.	Feb.	March.	April.	Totals.
	Ins.	Ins.	Ins.	Ins.	Ins.
Todd's Brook, Brinks, top of hill, 1,500 feet,	1·75	5·49	2·22	2·05	11·51
Todd's Brook Reservoir bottom of hill, 620 feet,	1·76	5·60	3·21	2·46	13·03
Comb's Ridge, top of hill, 1,670 feet, ..	1·56	4·86	2·39	1·64	10·45
Comb's Reservoir, bottom of hill, 720 feet* ..	2·60	9·20	4·60	3·30	19·70
Bosley Minns, top of hill, 1,265 feet, ..	1·90	4·75	2·75	2·25	11·65
Bosley Reservoir, bottom of hill, 590 feet, ..	2·38	4·21	3·29	1·87	11·75

A knowledge of the facts before mentioned induced me to examine Mr. Miller's experiments soon after receiving them, with a view to ascertain how far they confirmed or were in opposition to the recorded observations and facts stated by the many eminent meteorological authorities before quoted, for which purpose I procured the best map of the lake district I could obtain, and marked upon it the situation of Mr. Miller's rain gauges, and then compared together the results obtained by the rain gauges placed in the valleys or the bottom of the hills with the rain gauges placed upon the tops of *the same hills* or bordering *the same valleys*. By proceeding with reference to locality in this manner, it soon became apparent that the valuable and interesting facts collected and recorded by Mr. Miller, with very few exceptions, which it appears to me may be easily accounted for, agreed with the observations of other meteorological writers. Indeed, this could not fail to be the case, unless the generally received and admitted theory of the formation and distribution of rain, as laid down by Dr. Dalton, *was also disproved*.

* The gauge at Comb's Reservoir is a cylindrical gauge, 7 inches diameter, and 18 inches above the level of the ground, and has a float and staff to indicate the amount of rain falling: this gauge probably shows an excess of the amount of rain.

Upon examining Mr. Miller's facts, it will be found, from April to December, 1846, both inclusive, that at Whitehaven, 90 feet above the level of the sea, 38·063 inches fell; while at Round Close, 480 feet above the sea, and not far distant, only 36·195 inches fell in the same time; and during 1847, that 42·92 inches are recorded to have fallen at Whitehaven, and only 42·623 at Round Close.

On examining with reference to locality in a similar manner the rain gauges placed in the Valley of Borrowdale, or Derwent Water, in which vale the quantity of water received by four rain gauges at different altitudes are recorded by Mr. Miller, namely, one at Seathwaite, 242 feet above the sea; one at Sty Head, 1,290 feet high; one at Seatoller, 1,334 feet high; and one at Sparkling Tarn, 1,906, feet high; it will be found, as shown in the following table, which I have drawn up from a careful analysis of Mr. Miller's experiments as communicated to me by himself, taking the longest period during which he has registered experiments at each of the localities, that from June 1846, to November 1847 inclusive, 193·69 inches fell at a level of 242 feet above the sea; at the greater elevation of 1,290 feet a less quantity, or 164·12 inches, fell; at the greater elevation still of 1,334 feet, a yet smaller quantity, or 155·75 inches. The last example, however, at an elevation of 1,906 feet, shows that 183·47 inches fell in the same time, being, in this instance, less by 10 inches than the quantity which fell at the elevation of 242 feet, but much more than the quantities which fell at the elevations of 1,290 and 1,334 feet. This last fact I think may be accounted for by reference to the peculiar position of Sparkling Tarn (the mountain on which this last gauge is fixed). This mountain is only 1,906 feet high, but is in the *immediate* vicinity, that is, within a mile and a quarter to a mile and a half of the mountains Scawfell Pike and Bowfell to the south, and within a mile and a quarter of Great Gavel to the north. These mountains vary from 2,900 to 3,166 feet in height, the lowest of them being upwards of 1,000 feet higher than Sparkling Tarn, while Sparkling Tarn is fully exposed to the westerly winds; and the clouds being carried inland by this wind, between the gorge formed by these high mountains, it may be easily conceived that a large portion of rain in the transit of the clouds would be deposited on the top of Sparkling Tarn; so that the large amount of rain falling at this altitude in this locality would appear to be the exception and not the rule.

TABLE.—*Borrowdale, or Derwent Water.*

Months.	Seathwaite, 242 feet.	Sty Head 1,290 feet.	Seatoller, 1,834 feet.	Sparkling Tarn, 1,906 feet.
1846,	Ins.	Ins.	Ins.	Ins.
June, ..	6·42	6·26	5·70	6·55
July, ..	20·80	17·76	18·35	22·72
August, ..	10·58	11·03	8·15	12·03
September, ..	4·60	4·22	3·75	5·06
October, ..	25·43	15·35	17·42	20·35
November, ..				
December, ..				
1847.				
January, ..	41·06	32·52	27·51	31·82
February, ..				
March, ..				
April, ..				
May, ..	8·08	7·56	7·13	7·59
June, ..	7·27	7·12	5·71	8·13
July. ..	3·32	3·66	2·50	4·15
August, ..	10·48	10·22	10·38	12·00
September, ..	13·28	10·92	12·06	12·48
October, ..	20·52	17·50	19·02	18·0
November, ..	21·85	20·00	18 07	22·64
December, ..				
Totals, ..	193·69	164·12	155·75	183·47

In the valley of Wast Water, the amount of rain falling at Wastdale, 166 feet above the level of the sea, from March 1846, to November 1847, both inclusive, is shown to be 170·55 inches; and at Scawfell Pike, which borders this valley to the east, 3,166 feet high, only 128·15 inches fell in the same time. In the valley of Ennerdale, at Gillerthwaite, 286 feet above the sea, 133·86 inches fell; while at Great Gavel, 2,925 feet high, during the same time, only 124·68 inches fell.

All the valuable facts here alluded to, supplied by Mr. Miller with one exception only, prove that the greatest amount of rain falls in the same localities at or near the base of a hill, and not at so great an altitude as 2,000 feet above the sea; and the one exception, namely, that at Sparkling Tarn, 1,906 feet high, shows that from June 1846, to November 1847 (both inclusive), 183·47 inches fell; while at Seathwaite, the bottom of the valley, bounded by Sparkling Tarn, during the same time, as much as 193·69 inches fell, or 10 inches more at the lower than at the higher locality, thus confirming the conclusion arrived at by my observations, which also fully accord with the meteorological authorities I have quoted.

As the amount or depth of rain falling in a given time in Great Britain, in different localities and under different circumstances, is a matter of very great practical importance to civil engineers generally, and especially to those engaged in designing works to supply large towns with water, to regulate the flow of rivers, or to drain large tracts of land, independent of their importance in a philosophical point of view, I have been unwilling to allow the valuable facts collected by Mr. Miller, with such perseverance and industry, to pass without a few comments, which, as it appears to me, may tend to make them more generally useful, by explaining their supposed discrepancy with the generally received views, of such accurate observers as Dr. Dalton, Professor Daniell, Captain Lefroy, and the other authorities quoted in this paper, confirmed as the observations and recorded experiments of these last-named gentlemen are shown to be by the more recent experiments herein detailed.

NOTES OF THE MONTH.

New Steam or Hydraulic Wheel.—At a meeting of the Royal Cornwall Polytechnic Society, an invention by Mr. James Sims, of Redruth, was explained, the object of which was to carry out simplicity and portability to a greater extent than had hitherto been effected in such engines. It was intended to be worked either by steam or water-power. As a steam-wheel or rotary engine, he conceived it surpassed all former attempts at this principle, as the motive power is in the piston and cylinder of the ordinary construction of Boulton and Watt's engines, and the expansive principle of cutting off the steam is carried to a greater extent than in those engines—the motion of the piston being independent of the motion of the wheel, and almost instantaneous. In all the rotary or steam-wheels hitherto before the public, he was not aware that any of the inventors had availed themselves of the benefit of working with the ordinary cylinder and piston; they have, therefore, failed to carry out the expansive principle, and also to prevent the leakage of steam. In some, packing has been attempted, but here the friction is so great, and the wear so rapid, that not one on this plan has succeeded well. In this engine, on the revolution of the wheel, when the cylinder comes to a perpendicular position, the steam is admitted underneath the piston, at the same time it escapes from the top side, thereby shifting the weight to the top of the wheel, and causing it to revolve by its preponderance, the power of the engine being the amount of weight moved a certain number of feet in a given time. Regularity of motion being essential, it might be accomplished by a good governor. The blow against the buffers is in proportion to the extra quantity of steam admitted, and is on the same principle as the ordinary reciprocating or pumping engine. As an hydraulic engine, it is well adapted for situations where a good height of water can be obtained, but not sufficient for the ordinary water-wheels. The water might be conveyed in pipes, when a very small stream could be made available to an extent in proportion to its height and quantity. It would be admitted into the cylinder in the same way as steam, thereby shifting the weights, and making a very effective and economical water-wheel, as every pound of water would be used. The velocity of the wheel would be much superior to the ordinary water-wheel, being in proportion to the height and consequent pressure, and the quantity of water to be obtained. So also its velocity as a steam-wheel would depend on the pressure of steam, admitting the shifting of weights, however quick the passing of the aperture for the admission of the steam. The engine was at present in its infancy, and although it worked well, there was, no doubt, room for further improvement. The principle being good, as regards the application of steam and water-power, and its economy and portability being conspicuous, it should not be lost sight of; he should, therefore, proceed with his experiments, and hoped at the next meeting to report more fully of its advantages. Its application may be general, and he thought more advantageous than almost any other engine, as in the absence of the crank, each end of the shaft is at liberty for any attachment. The small amount of friction, consequent on its simplicity, is seen at once, as is also the small amount of liability to derangement.

The Conway Tubular Bridge.—The second great tube of the bridge over the Conway Straits was floated on the pontoons to the piers, on the 12th ult. The operation, combined with the stupendous machinery employed in the process, attracted large crowds from Conway and other parts of the principality. Everything favoured the lifting of the leviathan structure. At precisely 9 o'clock, or 50 minutes before high water, Captain Claxton, R.N., gave the signal to pipe all hands, and almost immediately the tremendous freight was seen creeping stealthily to its destination. Next him was Mr. R. Stephenson, M.P., the celebrated engineer, and designer of this new feature in engineering art; Mr. E. Clarke, C. E., his head assistant; Mr. A. M. Ross, C. E.; Mr. W. Evans, the contractor; Mr. F. Forster, C. E.; and Mr. Amos, of the firm of Easton and Amos, who constructed the lifting machinery; and near it Sir C. Smith, Bart.; Bishop of Bangor, Rev. Mr. Morgan, Mr. J. O. Burger, and a number of the gentry. The tube was lifted the height of 2 feet in about 60 minutes, and with its weight of 1,300 tons was got safely home at a few minutes past 10, amidst enthusiastic bursts from the bystanders, and a salvo of artillery from the castle walls. The entire operation was effected without the slightest accident.

Opening of the Shrewsbury and Chester Railway.—This line of railway, which is 41 miles in extent, was opened throughout on Thursday, 12th ult. The present line is an amalgamation of the North Wales Mineral, and the Shrewsbury, Oswestry, and Chester Junction Railways; 15 miles of the line—namely, from Chester to Ruabon, have been opened for nearly two years, and the receipts during that time have been about £40 per mile per week. The cost of the entire line has been about £17,000 per mile, and the working stock will be about £4,000 per mile more. The traffic on the line is chiefly mineral. In honour of the opening, the occasion was observed as a general holiday along the line, and several trains ran both ways, conveying the inhabitants gratis.

Ice.—The intrinsic value of ice, like that of metals, depends on the investigation of an assayer. That is to say, a cubic foot of Lower Canada ice, is infinitely more cold than a cubic foot of Upper Canada ice, which contains more cold than a cubic foot of Wenham ice, which contains infinitely more cold than a cubic foot of English ice; and thus, although each of those four cubic feet of ice has precisely the same shape, they each, as summer approaches, diminish in value—that is to say, they each gradually lose a portion of their cold, until, long before the Lower Canada ice has melted, the English ice has been converted into lukewarm water.—*Chambers' Edinburgh Journal.*

An Experimental Vessel.—There is now loading in the North Docks, Sunderland, an experimental vessel, named the *Mary Caroline*, built by Mr. Siddon, of Rochester, who is also the owner. She has no keel, but is flat bottomed, and built in the barge style. Neither is she caulked—the seams are lined with felt. She is 224 tons register, and carries 4,000 yards of canvas when in full sail; and when full laden with 20 keels of coals, she draws only 9½ feet of water. She is intended for the French trade. On the run down, with a N.N.W. wind, she outstripped 40 colliers.—*Durham Advertiser.*

Railway in Spain.—An experimental trip was made on the 8th of October, on the railway from Barcelona to Mataro, by the directors and their friends. The journey from Barcelona to Mataro was made in an hour, exclusive of stoppages, and the journey back in 50 minutes—the distance is five leagues. The *Barcelones* are very proud of Catalonia being the first in Spain to possess a railway. The line was to be opened to the public on the 15th.

The Railway Interest.—As there appears to be a good deal of misapprehension and misstatement afloat with reference to the object of the meetings of the three great railway companies, and their consequent negociations, we have endeavoured to ascertain the real facts, and we have reason to believe that they are as follows:—The distinct object of the conference is not to increase fares or arrange trains, but it is for effecting a complete union of capital of the three great companies—the North-Western, the South Western, and the Great Western, and the conversion of the three into one great company, under one controlling body, leaving the working details with the respective boards. The delegates consist of five directors from each company, headed by their respective chairmen. They have generally met twice a week at Mr. Glyn's house, adjoining the bank. We understand that some general principles of union have been affirmed, and the details left to the consideration of the solicitors of the respective companies, who will have to consider of the proper notices to Parliament; for, of course, nothing can be done without the consent of the proprietors of all the companies and legislative sanction. We have heard that some obstacles have arisen from the discussion introduced by that vexed question—the broad gauge and narrow gauge interests—but more particularly from the difficulty of ascertaining the relative values of the great interests which it is proposed should be united. We have, however good reason to hope that these difficulties will be surmounted.—*Morning Chronicle.*

Galvanised Wire and Hemp Ropes.—An experiment was lately tried in Woolwich Dockyard, to ascertain the comparative strength of wire and hemp ropes. A wire rope, 3 inches round, and a hemp rope of three strands, hawser laid, common make, 7 inches round, were spliced together, and placed in the testing machine, and on the hydraulic power being applied, the hemp rope broke in the middle on the strain reaching 11¾ tons, the wire rope remaining apparently as strong as when the experiment commenced. A wire rope, 3½ inches round, was then spliced with an 8-inch hemp shroud rope, and on the power being applied the hemp rope broke in the middle, with a strain of 10½ tons, the wire rope continuing apparently uninjured.

Steam Power of France.—According to a late statistical report, made to the government, the number of locomotive engines constructed in France, and employed by the country in 1842, equalled the number imported from abroad; in 1843, there were two more French than foreign engines; in 1844, the surplus was 44; in 1845, 76; in 1846, beyond which year the report did not go, this excess was 161. In 1846, there were 294 steamboats, belonging to private individuals and companies, navigating the rivers and seas. The numbers and force of the engines in use on land, and acting as locomotives in the steamers, were, in 1846, as follows—viz.: 4,395 engines at work on land, equalling 163,402-horse power; 461 locomotives, of 60-horse power each, upon the average amounting to 27,600-horse-power; 338 engines used in steam-ships and boats, amounting to 108,513-horse power. These, together give a force of 299,515-horse power. Comparing the strength of man to horse-power, it will be found that the steam-engines employed in France in 1846 were substitutes for 2,097,625 men.

Vegetable Wax.—M. Jules Rossignon submitted to the Academy of Sciences a specimen of vegetable wax, extracted from the berries of a common laurel grown on the mountains of Vera-Paz, in the Republic of Guatimala. The analysis of this wax gave, Carbon, 76·29; Hydrogen, 15·08; Oxygen, 8·63. It is of a green colour, and exhales a slightly aromatic odour when rubbed or melted. The candles which have been made with this wax give a beautifully clear light, and diffuse a pleasant aromatic odour. The laurel whose berries furnish this wax, has the character and leafage of *Laurus nobilis*; it forms numerous thick forests in the mountains of Vera-Paz, that is, throughout the whole of that part of the Guatimalian territory which commences at Rio Polochis, and spreads to the limits of Yuctan.

Geological Discovery.—A correspondent of the *Fife Herald* states that "a section of limestone rock has been lately laid open by the cutting of the Edinburgh and Northern Railway, at the Newburgh station, which belongs to the cornstone of the old red sandstone formation. The face exposed is about 100 feet in length, by upwards of 20 feet in thickness, and very distinctly stratified. The beds are broken near the centre, which causes their edges to slip down and dip in opposite directions, inclining on one side at an angle of 28° towards the north-east, and on the other approaching to nearly a vertical position towards the north-west. What adds to the geological importance of the discovery, is the fact that the grey sandstone, or Carmylie fossilliferous pavement stone, is found in the immediate vicinity of the calcareous deposit. The representative of the Cornstone in England, it is well known, is extremely rich in fossils, particularly of the genus *cephalaspis*, while not a fragment has as yet been detected in any of its numerous localities in Scotland. The colour of the limestone is that of a dark flinty grey, with innumerable white thread-like veins of carbonate of lime, both vertical and longitudinal, and which cause the rock to split up into thin bands of larger and smaller rhomboidal masses. The deposit is subcrystalline, of an extremely hard and cherty texture; it is not nodular or compound, as in so many other places, but of a close, uniform, homogeneous structure."

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM SEPTEMBER 28, TO OCTOBER 26, 1848.

Six Months allowed for Enrolment, unless otherwise expressed.

Robert Stirling Newall, Gateshead, Durham, for "Improvements in locks and springs, and in the means of fastening and setting up the rigging of ships."—Sealed Sept. 28.

Andrew Paton Halliday, Manchester, manufacturing chemist, for "certain Improvements in the manufacture of pyroligneous acid."—Sept. 28.

Fennell Allman, of Charles-street, Saint James's-square, Westminster, for "certain Improvements in apparatus for the production of light from electricity."—Sept. 28.

William Wilkinson Nicholson, of Acton-street, Gray's Inn-road, civil engineer, for "Improvements in machinery for compressing wood, and other materials requiring such a process."—Sept. 28.

Joseph Gillot and John Morrison, Birmingham, for "Improvements in ornamenting cylindrical and other surfaces of wood and other material."—Sept. 28.

Thomas Metcalf, High-street, Camden Town, Middlesex, gentleman, for "Improvements in the construction of chairs, sofas, and other articles of furniture for sitting and reclining on."—October 5.

Edward John Massey, Liverpool, for "Improvements in apparatus for measuring the speed of vessels and streams, and for ascertaining the depths of water."—October 5.

Joseph Sharp Bailey, Bradford, York, spinner, for "certain Improvements in preparing, combing, and drawing wool, alpaca, mohair, and other fibrous materials."—Oct. 5.

John Wright, Camberwell, Surrey, engineer, for "Improvements in generating steam and evaporating fluids."—Oct. 12.

Charles de Bergue, of Arthur-street, West, London, engineer, for "Improvements in bridges, girders, and beams."—Oct. 12.

Arthur Dunn, of Dalston, chemist, for "Improvements in ascertaining and indicating the temperature and pressure of fluids."—Oct. 12.

John Davie Morries Stirling, of Black Grange, N.B., Esq., for "Improvements in the manufacture of iron and metallic compounds."—Oct. 12.

Elias Robinson Handcock, of 16, Regent-street, London, and Rathmoyle-House, Queen's County, Ireland, Esq., for "certain Improvements in mechanism applicable to impelling and facilitating the propulsion of vessels in the water, which improvements are applicable to locomotive engines for railways, and other similar purposes."—Oct. 12.

John Ashby, of Carshalton, Surrey, miller, for "certain Improvements in machinery applicable to cleaning grain and dressing meal."—Oct. 12.

Daniel Watney, of Wandsworth, Surrey, distiller, and James John Wentworth, of the same place, for "Improvements in machinery for drilling metals and other substances." Oct. 12.

Samuel Cunliffe Lister, of Manningham, York, gentleman, for "Improvements in preparing, hackling, and combing wool, and other fibrous substances."—Oct. 19.

Frank Clarke Hills, of Deptford, Kent, manufacturing chemist, for "Improvements in treating certain salts and gasses, or vapours."—Oct. 19.

Robert Angus Smith, of Manchester, for "Improvements in the application and preparation of coal tar."—Oct. 19.

Robert William Sievier, of Upper Holloway, Middlesex, gentleman, for "Improvements in the means of warping and weaving plain and figured fabrics."—Oct. 19.

Joseph Eugene Asaert, of Lille, in the republic of France, machinist, for "Improved means of obtaining motive power."—Oct. 19.

William Brown, of Cambridge Heath, Middlesex, weaver, for "Improvements in manufacturing elastic stockings and other elastic bandages and fabrics."—Oct. 26.

Soren Hjorth, of Jewry-street, Aldgate, for "certain Improvements in the use of electro magnetism, and its application as a motive power, and also other improvements in its application generally, to engines, ships, and railways."—Oct. 26.

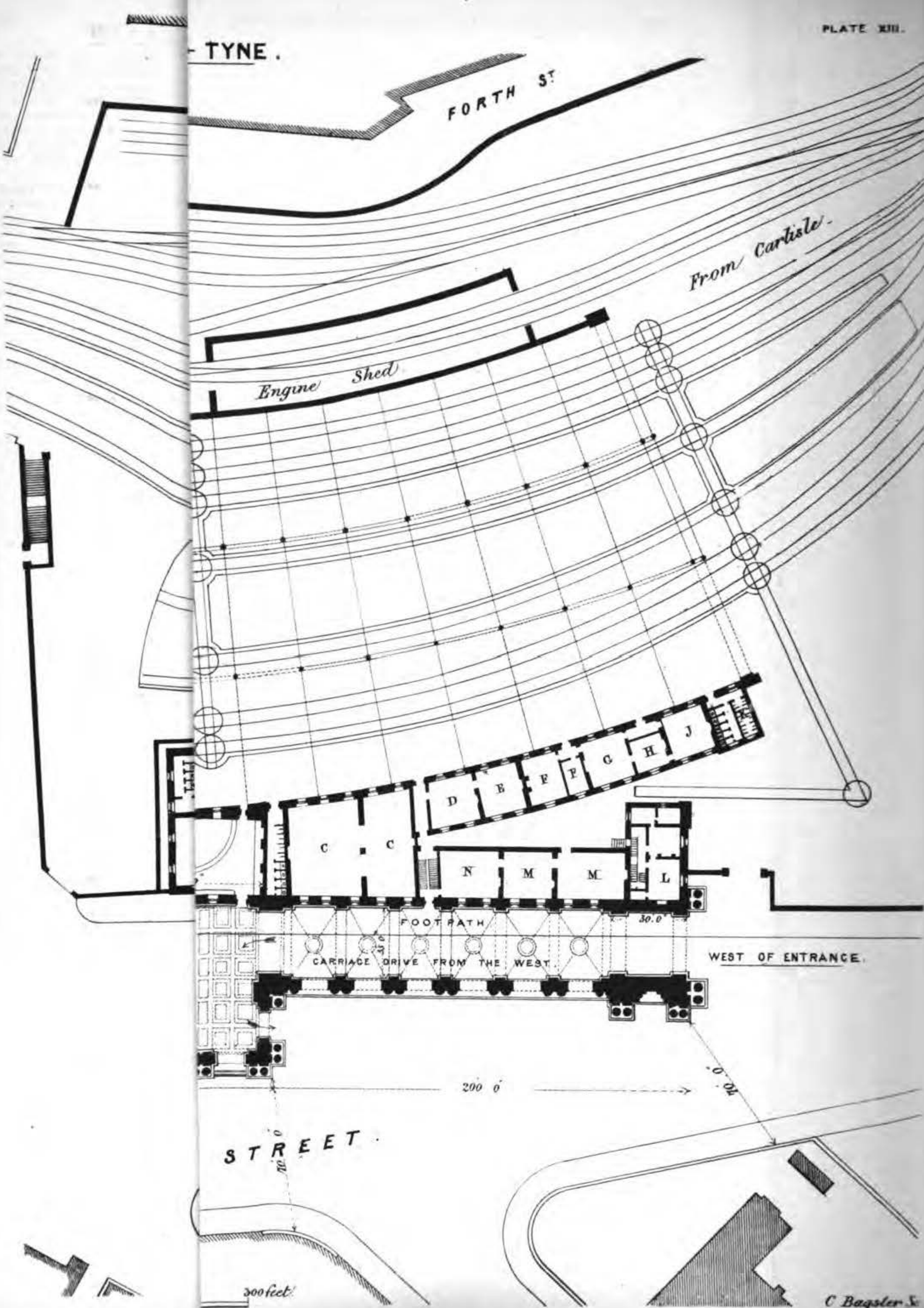
James Clark, of Glastonbury, Somerset, manufacturer, for "Improvements in the manufacture of boots, shoes, and clogs."—Oct. 26.

William Longmaid, of Beaumont square, Middlesex, gentleman, for "Improvements in treating the oxydes of iron, and in obtaining products therefrom."—Oct. 26.

William Church, civil engineer, and Thomas Lewis, woollen-draper, both of Birmingham, for "a certain Improvement or certain improvements in machinery, to be employed in making playing and other cards, and also other articles made wholly, or in part, of paper or pasteboard, part or parts of which said machinery may be applied to other purposes where pressure is required."—Oct. 26.

Peter Fairbairn, of Leeds, York, machine maker, for "Improvements in machinery, for hackling, carding, drawing, roving, and spinning flax, hemp, tow, silk, and other fibrous substances."—Oct. 26.

James Burrows, of Haigh, near Wigan, Lancashire, engineer and draughtsman, and George Holcroft, of Manchester, consulting engineer, for "certain Improvements, in and applicable to steam engines in the machinery or apparatus belonging thereto, in the construction and arrangements of boilers, for the generation of steam, and in the furnaces and flues used in connection therewith; parts of which improvements are also applicable to other similar purposes."—Oct. 26.



TYNE.
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THE CENTRAL RAILWAY STATION, NEWCASTLE-UPON-TYNE.

JOHN DOBSON, Esq., Architect.

(With an Engraving, Plate XIII.)

Railway buildings ought to do much for architecture: being quite a new class of structures, erected for purposes unknown until the present age, or, we may say, the present generation, they suggest, or ought to suggest, a character of their own, and fresh combinations in design; and being generally upon an extensive scale, they afford opportunities that have hitherto been of rare occurrence. They are, moreover, especially public works—structures constantly seen by thousands and tens of thousands of persons; and might, therefore, do much towards improving the taste of the public. That they have done so, or have been calculated to do so, cannot, we fear, be asserted of them generally. In more than one instance, expression has been falsified or forfeited by the adoption of some style intended to be reminiscent of mediævalism—of times whose spirit and whose institutions contrast very strongly with the present railway age, in which it is either our good luck or our misfortune to live. All the various modes of Gothic are very ill adapted to buildings totally different in purpose, and, therefore requiring to be differently constituted from those in which such modes are exemplified. Either violence—or what is likely to be thought such—must be done to the style itself, by deviating greatly from its traditional physiognomy, or mediæval physiognomy will be in contradiction to modern purpose. The character aimed at may be well kept up; but in proportion that it is so, it will be foreign from the express occasion—for what class of mediæval structures are there that have aught in common with railway stations and termini? Is it the castellated with its feudal fortresses?—or the ecclesiastical with its churches and conventual buildings, its priories and abbeys?—or the palatial, or the collegiate, or the domestic? Is there any one of those styles or classes which supplies what is required for railway structures as a specific class, that ought to carry with them a distinct and appropriate character of their own? The Gothic style does not readily provide open external halls or ambulatories, which, if not indispensably demanded, are highly desirable adjuncts to every principal railway station where there is a great confluence of passengers. It is only in the form of the cloister that Gothic examples supply any accommodation of that kind; and, besides that the cloister or arcade was hardly ever made an external feature, it is one that carries with it associations that, unless it were to be greatly modified, rather unfit than at all recommend it.

The accompanying engraving (Plate XIII.) is a plan of the magnificent Station that has lately been constructed at Newcastle-upon-Tyne (under the direction of Mr. John Dobson, architect of Newcastle), for the York, Newcastle, and Berwick Railway Company.

It will be in the recollection of our readers, that at Newcastle the great eastern trunk line of railway from London to Edinburgh is intersected by a main line of railway extending across the island, from sea to sea; that is to say, from Maryport, on the Irish Channel, to Tynemouth, on the German Ocean. The traffic of this cross line has lately been added to that of the original line from York to Berwick, by the leasing of the Newcastle and Carlisle, and Carlisle and Maryport Railways, to the York, Newcastle, and Berwick Company; and the local traffic of the great northern mining district gives employment to branches from Newcastle to North Shields and Tynemouth, to South Shields and to Sunderland. Thus, with the despatch of the through trains, at least 140 arrivals and departures of passenger trains will take place daily at the central station; and it is to provide for this immense accumulation of traffic that the present building is required. It will readily be imagined, therefore, that the sheds and erections must necessarily be upon a scale of no ordinary magnitude. In the infancy of the railway system, no one could have ventured to predict the extent to which the inland traffic has increased; and we have, therefore, seen the great expense which has been incurred by the London and North Western and other [illegible]ilway companies to obtain additional room for their principal sta[illegible] and the great sacrifice of valuable property which has in consequence taken place. The York, Newcastle, and Berwick Railway Company, however, having had the benefit of the experience of later years, have taken great pains to select a site where the necessary extent of ground can be obtained, with the most ready access to the centre of the town; and they have been fortunate enough to find a spot which, at a very reasonable cost, and with the destruction of very few buildings, combines both these advantages. The manner in which the junction of the northern and southern with the eastern and western lines has been effected,—and the great works required to complete the union of the whole, by means of the high level bridge over the Tyne viaduct, through Newcastle and Gateshead, from the designs of Mr. Robert Stephenson, and under the able management of Mr. Thomas Harrison,—form too extensive a subject to be treated of here, and will probably be the object of a separate notice.

The identity of the central points of the great railway system of this period with the central points of the military occupation of the country by the Normans, has been, in many instances, strikingly exemplified; and in none more so than at York, Newcastle, and Berwick, in each of which towns the railway station closely adjoins the Castle. The station at Newcastle extends from Westmoreland-place, the ancient town-house of the illustrious family of the Nevilles, Earls of Westmoreland, situate in Westgate-street; takes in the site of the convent and garden of the Carmelites or White Friars, known as the Spital, for many years occupied as the Royal Free Grammar School, the *alma mater* of Lord Stowell, Lord Eldon, and Lord Collingwood; crosses the town-wall and ditch at West Spital Tower, and terminates at the Forth, an open piece of ground formerly in the outskirts of the town, and which was bequeathed by some worthy of former days to the burgesses of Newcastle, "to walk abroad and recreate themselves," a circumstance which has hitherto prevented its being built upon.

The façade or principal front, exclusive of the hotel, is 600 feet in length. The style of the building is Roman, and the most striking feature in the design is the portico in the centre, 200 feet in length by 70 feet in width, flanked on each side by an arcade the same length, by 35 feet in width, allowing sufficient room for carriages to drive in at the end of each arcade, to turn, and go out at each end of the projecting part of the portico. The convenience of this plan in such a climate as ours, allowing passengers and luggage to be loaded and unloaded under cover, will at once be apparent: and the grandeur of the effect produced by an arcade and portico of this length will readily be comprehended, even by the general reader, although no drawing will convey an adequate idea of that effect.

The exterior front of the portico is composed of seven arches, each 14 feet in width by 32 feet in height, divided by coupled insulated Doric columns, 29 feet in height, elevated on a basement of 7½ feet, and supporting a broken entablature and attic of the same style. The arcades on each side are formed of arches, of the same width as the portico, divided by coupled inserted columns. These columns, with the key-stones of the arches, support a continued unbroken entablature, without an attic. The ends of the arcades terminate in front in a niche, having coupled insulated columns on each side, supporting an entablature and low attic. The entrance to the end of each arcade is by an arch 25 feet in width; and the arcades will be covered with groined ceilings of stone, with a circular light at each intersection.

The front of the station-house facing the platform is concave, forming the segment of a circle of 800 feet radius. This form was rendered necessary by the junction of the various lines of railway at this point; and the elevation is of rubble stone, from Prudham Quarry, of a plain and bold Roman character, the doors and windows having arched heads, with moulded imposts and archivolts; and the long-continued line of these circular arches, with their deep reveals, produces a striking effect.

The shed is 236 yards long, and 61 yards wide, covering an area of 14,426 yards, or about three acres. The roof is composed of iron, divided into three compartments, and supported by columns 33 feet apart, and 23 feet high from the platform to the springing of the roof. The various offices, waiting-rooms, and refreshment-rooms front the platform, with the exception of the booking-office and parcels-offices, which extend the full width of the building.

The entrance to the shed is, from the centre of the portico, 40 feet wide, with a stone vaulted ceiling, supported by two rows of columns, which leads direct to the centre of the platform, about 120 feet square. On the right hand is the booking-office, 70 feet long by 36 feet wide; adjoining which are the two parcels-offices, the telegraph-office, lamp-room, and other rooms and offices extending westward, for the engineers, guards, porters, and other officers of the company. A house for the station-master concludes the front range of buildings to the west.

On the left of the entrance is the station-master's office, first, second, and third class waiting-rooms, (containing separate apartments for ladies and gentlemen), washing-rooms, attendants' rooms, and other requisites. Adjoining this suite of rooms is the first-class refreshment-room, 66 feet long by 33 feet wide. At one end is a distinct refreshment-room for ladies, and at the other end a corresponding room for the bar, each 15 feet by 23 feet, divided from the large refreshment-room by columns only, and forming with it one large apartment, 96 feet in length. Adjoining the bar is the second-class refreshment-room, which terminates on the east the range of building facing the platform. The kitchens form the eastern end of the front building, immediately behind the refreshment-rooms, and adjoining the hotel; and are provided with larders, store-rooms, and servants' rooms, on the same floor, with sleeping apartments above.

In addition to the above extensive range of building, it is proposed to erect an hotel, communicating with the station, forming a separate range 190 feet in length by 66 feet in depth; to contain 70 bed-rooms, with a proportionate number of other apartments; and in the basement story, tap-rooms and refreshment-rooms for servants and other persons.

The construction of this building entirely of stone, would, in any other locality, be attended with enormous expense; but the county of Northumberland affords such an abundant supply of the finest freestone, that this material becomes there not only by far the most durable, but really the least expensive.

References to Plan, Plate XIII.

EAST OF ENTRANCE.

- B Station Master's Office.
- C Lost-Luggage Store.
- D Waterclosets and Urinals.
- E 2nd Class Gentlemen's Waiting Room.
- F 2nd Class Ladies' ditto ditto.
- G 1st Class Gentlemen's ditto.
- H 1st Class Ladies' ditto ditto.
- I 1st Class Ladies' Refreshment Room.
- J 1st Class General Refreshment Room.
- K Bar.
- L 2nd Class Refreshment Room.
- M Kitchen and Scullery.
- N Pastry and Store Room.
- O Bar Sitting Room.
- P Store Room.
- Q Waiters' Sitting Room.
- R Waiters' Bed Room.
- S Ladies' Attendants' Room.
- T Washing Room for 1st Class Ladies.
- U Waterclosets and Washing Room for 2nd Class Ladies.—Part of U is Waterclosets for 1st Class Ladies.

WEST OF ENTRANCE.

- A Entrance.
- B Booking Office.
- CC Parcels' Office.
- D Lamp Room.
- E Oil Room.
- F Porters' Room.
- G Engineer's Offices.
- H Engineer's Pay Office.
- J Clerks' Office.
- K Urinals and Waterclosets.
- L Station Master's House.
- M M Store Houses.
- N Telegraph Office.

[We had intended to have given a Perspective View of the building, but the Engraving, which was entrusted to an engraver at Newcastle, has turned out so very defective, that we have been obliged to postpone giving it for another opportunity, that we may do justice to the talents of the architect.—Ed. C.E. & A. Journal.]

CANDIDUS'S NOTE-BOOK, FASCICULUS LXXXVIII.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. The organ of *De-*, as well as that of *Con-*structiveness, appears to be possessed by Barry and some other architects. After being taken down and pulled to pieces by critics while living, Nash and Soane are now literally taken down and pulled to pieces by their successors,—by "literally," however, is not to be understood "personally." The "Board of Trade" of the one, and the Georgian palace of the other, have equally disappeared, although the latter is merely blurred or *blored* out. But then, poor Nash has been dismantled of his Quadrant colonnades, which served as a mantle that cloaked a good many of his architectural sins; besides which, his Brightonian Pavilion is now a wreck,—whether it is to grow interesting by growing into a ruin, remains to be seen. Nor does the work of destruction stop here, for we are now told by the newspapers that Dover-house is to be taken down, in order to make way for a new Colonial-office, to be erected on its site by Mr. Barry; so we must prepare to bid adieu to its charming screen façade—an architectural gem—not indeed of the first magnitude, but of the first "water,"—picturesque, classic, and elegant, although ignored by those who lavish their stale and second-hand extasies on St. Martin's Church. Most unfortunate Holland! thy Drury-lane Theatre expired, like Semele, in flames; thy splendid Carlton-house portico is demolished, and now thy exquisite little composition at Whitehall is doomed to destruction! Were there no other site to be had in the neighbourhood, necessity might excuse the act of Vandalism; but excuse for it there is none, while there is a "hoarded-up" gap just by, between Downing and Fludyer streets,—which gap is apparently not only hoarded-up, but treasured-up, as something infinitely too precious to be parted with. Therefore the gap is likely to remain, and Dover-house to be sacrificed to it,—which is only an exemplification of the feeling and *nous* bestowed by us upon architecture.

II. I am no bigotted admirer of Holland; if I think that he showed himself a classic and an artist in the portico of Carlton-house, the façade of the *ci-devant* York, now Dover-house, I freely admit that he showed himself to be no better than an arrant Pecksniff in what he did at the Pavilion at Brighton, before Nash took it in hand; as is shown in the design preserved, most unfortunately for his credit in the "New Vitruvius Britannicus." We look on it with a fit of shuddering, and shudder at the "princely" taste which could adopt anything so vulgar and plebeian,—and not only so vulgar, but so atrociously vile. But George was then "the Prince;" and had he taken a fancy to have columns turned upside-down, his taste would have been cried up by his flunky flatterers. That such a truly miserable design—if design it can be called—should have proceeded from the architect who, in the two other works here mentioned, gave evidence of more than ordinary gusto, is hardly credible,—at all events, quite unaccountable. It ought, however, to teach us something,—namely, to judge of works of art (be they buildings, pictures, or anything else) by their intrinsic merits,—according to what they are in themselves, and not according to extrinsic circumstances. The opinion that is influenced by the prestige of a name is cowardly and worthless. Even Homer sometimes nods, but we are not therefore to nod again when he does so, in affected approbation and delight. Even Raffaelle sometimes daubed—at least, what would else be called daubs, have been passed off under his name, and have, in consequence, been admired and extolled for excellences freely imputed to them by the imagination or else by the ears of spectators; whereas, daubs they would have been pronounced to be, had it been known that they proceeded from the *atelier* (*i.e.* garret) of some Jack Smith, who lives by manufacturing genuine specimens of the Old Masters. A hungry belly—that great *artis magister*, as we are assured by most classical authority it is, may be that same Jack's excuse for the deception. But what excuse is there for those who suffer themselves to be deceived, to be imposed upon and humbugged by names, and who affect transports which they do not feel? Give me the honest critic, him who is not at all biassed by names, but who would as freely condemn either Jones or Wren where they have shown themselves Pecksniffian in taste, as he would Pecksniff himself. "What a strange man you are, Mr. Candidus! And so you really think that both Jones and Wren were sometimes Pecksniffian in their taste." Even so: nothing would induce me to praise, or rather, not to condemn and turn away in disgust from some of their doings. Few will confess as much, because very few have the moral courage of Candidus, who is in that respect libertine in the extreme,—who is not only *nullius addictus jarare in verba magistri*, but would animadvert just as freely on a Palladio, a Jones, or a Wren, as on some poor devil of a "Jack Smith!" Let others affect milk-and-water modesty: I am content to be sincere in opinion, and fearless in the expression of it.

III. A most curious accident, and one recorded with singular *naïveté*, is that which happened to a certain architect in a book of designs published by him; it being expressly stated in the letter-press, that, in one of the elevations, the offices which ought to have been shown, were "omitted by accident." Very much nearer the mark would it have been to say, that the omission was occasioned by gross stupidity and unpardonable blundering. "By accident," forsooth! Would "accident" be received as an excuse for a painter sending home your portrait without a nose to your face, he having through sheer forgetfulness omitted that interesting, or at any rate indispensable, feature? Certain it is that, with regard to the unlucky elevation here alluded to, the omission was discovered before the plate was published, since otherwise, it would not have been apologised for; which being the case, why was not the error itself corrected? One, and indeed the only valid reason may have been, that the design looked all the better for the accident. If that was not the real reason, the only other imaginable one is, that the expense of altering the plate could not be afforded by the poor devil who published his designs. The reader will agree with this last hypothesis, when informed that the work here referred to was by Soane! That poor man seems to have been not merely the sport, but the very victim of "accidents;" for, on the very next page of that book, we read, "the arched recesses were semicircular in the drawing, but by a *mistake* of the engraver, are made considerably more!" Nor is that the *finis* with regard to mistakes, for the printer—or else Soane himself, committed many more, by "omitting by accident" the explanations of the letters of reference in some of the plans. And in their plans, or in what is dependent on and arises out of plans, the chief, or, to speak more correctly, the sole merit of that collection of Soanean designs consists; many of the elevations being little short of the downright ugly and hideous. Soane should have confined himself to plan and contrivance: they were his forte. His ground work was often truly admirable; his superstructure generally quite the reverse. The work of Soane's here referred to is remarkable of its kind; for, professing to show only "cottages, villas, and other useful buildings," it includes a design for what is neither a very cottage-like nor very utilitarian edifice, to wit, a National Mausoleum. Soane seems to have had a pious *penchant* for burying people: for the matter of that, he would not have scrupled to bury the whole nation alive, so that he had the erecting its mausoleum, or *mouse*oleum, as ——— terms it; which last, I suppose, means nothing more nor less than a mouse-trap.

IV. Pugin does not at all shine in the parliamentary "blne book" which shows his design for Maynooth College, and those by different architects of some other public buildings that are now in progress in Ireland. "Maynooth" would furnish an illustration for Mr. P.'s own work entitled "Contrasts," it being a sufficiently striking sample of pseudo-Gothic, *alias* modern Gothicising. It is only Pugin's professed admirers—those who make it a point of honour to admire whatever proceeds from him, who can look with complacency on such a dowdy and prosaic design, which possesses neither style, nor quality that atones for the dereliction of style. Still it may, on that very account, prove not a little satisfactory to some,—those, to wit, among his professional brethren who may have taken offence at Welby Pugin's supercilious tone towards them in his "Contrasts" and other writings. Perhaps they will retort upon him, and ask if Maynooth is to be regarded as an example of what can be achieved by those who boast of being inspired by "the faith of our forefathers."

V. *Place aux dames!* A lady-writer on architecture is so great a phenomenon—such a veritable *black swan* (applied to one of the *fair* sex the simile sounds somewhat antithetical), that Mrs. Tuthill deserves to have a separate article, or at least an entire Fasciculus devoted to her, more especially as she shows herself to be a reader of Candidus, and has paid him the compliment of transferring to her own pages one or two of his pithy paragraphs. Still I am not so much indebted to her for the compliment, as she is to me for those little bits of architectural philosophy which sparkle like gems amid the dulness of her book, since she has not had the grace to acknowledge to whom they belong. Inverted commas mark them for quotations, and that is all; except it be that they are jumbled up with extracts from other writers, without the difference of proprietorship being hinted at. *Suum cuique*, my good lady, is an honest maxim, and the best policy; for your own unscrupulousness now relieves me from all scruples and qualms of gallantry, and emboldens me to speak out somewhat freely. Privilege of sex cannot be allowed you: you are of the feminine gender,—and so are "man-of-war" ships;" so also are amazons, but their *she*-ship did not shield those belligerent ladies from wounds in the brunt of battle. I do not deny you the right of wielding that feminine implement the scissors; but I do disapprove of your making use of the paste-pot at the same time; and your book is a notable sample of that species of literary manufacture which goes by the name of "scissors-and-paste work." Perhaps you will say that it is genuine patch-work, and, as such, is a very suitable occupation for your sex. That a good deal has been ere now written upon architecture by women I do not dispute; but then, till now they have invariably been *old women*, and of the man-kind, whereas you are neither the one nor the other. "What then," you will say, "may not ladies, who are not old ones, turn their attention to architecture? Why should they be interdicted from cultivating a taste for that branch of fine art which has so much to do with taste generally?" Why, indeed, should they? Architecture has, as you observe, been strongly recommended in a paper in the "*Foreign Quarterly*," as a study particularly adapted to enter into the list of female accomplishments; and you might also have brought forward Wightwick's opinion to the same effect. Nor do I dissent from them: there certainly is nothing to hinder a woman from understanding architecture—that is, the æsthetics of building, just as well as a man, or indeed a great deal better than many men, since some of them mistake mere building for architecture. Proficiency in the study is quite irrespective of sex: it depends upon the intelligence, the application, and the relish brought to it. Sincerity of study, diligence of reflection, are the *sine qua non*: whereas you seem to have overlooked some of the most indispensable qualifications for the proper execution of the task which you undertook; and which, in the vastness of your ambition, you extended to every known style of the art, including some that no one knows anything about at all. You appear to have set up for a teacher, while you yourself were only a learner, and not very perfect in your lessons. You show that you have spoken by book and by rote, feeling secure in, and trusting to, the greater ignorance of your readers. Come, cheer up, my good Mrs. Tuthill: though you get no flattery from me, you may still get plenty of puff from other critics; therefore the acidity of my remarks may be useful to you, by correcting the fulsomeness of theirs. Considering—you must excuse the ungraciousness of that qualifying expression,—considering, I say, that it is the production of a female pen on a *masculine* subject, your book is not so very poor a book after all. At all events, it is something in the bodily shape of a book—a goodly-sized octavo volume, with your name on the title-page; which is far more than Candidus can boast of having ever sent forth to the public. Yours is, besides, a funny book—funnier perhaps than you intended it to be. One of its drolleries is that of omitting in the list of those who have distinguished themselves in architecture, such recent celebrities as Cagnola, Schinkel, Gärtner, and several others, and immortalising such *obscurities* as Joel Johnson, and John Linnell Bond. Oh! Mrs. Tuthill, Mrs. Tuthill, you are a very roguish creature! To think of your immortalising—and immortal they now will be in your book—such poor devils in all their littleness, is no doubt very laughable, but partakes too much of a *mauvaise plaisanterie*.

VI. Loudon's "Architectural Magazine," and others of his publications, have been very freely laid under contribution by Mrs. Tuthill, who has copied several woodcuts from them, but without any acknowledgment of their being copies, and without even mentioning the names of those by whom they were designed. At p. 307, for instance, she has re-produced from the Supplement to Loudon's "Encyclopædia," what she very justly calls "a beautiful English villa in the Elizabethan style," and recommends as a model for residences of that class in "the northern, middle, and western states;" but very ungraciously withholds from Mr. E. B. Lamb the credit of having designed it, although his name is attached to it in the publication from which she pirated—or, to speak more prettily—borrowed it. The suppression of its author's name is perhaps less unjust than it otherwise would be, because she exhibits a fac-simile of the original cut, with all the vexatious blunders which Mr. L. complained of and pointed out in the letterpress accompanying his design, observing, that owing to the ignorance of the engraver, "the parapet appears like a Grecian guilloche instead of Gothic perforated panelling; the arches do not present the easy curve of the Gothic four-centred arch; and the scroll label over the projecting bays assumes also a different character." Yet, notwithstanding that these provoking infidelities of delineation were plainly enough pointed out by the author of the design, they are not corrected, neither is there a syllable of caution against them; so that the serious solecisms and errors in the cut may unwittingly be copied together with the real merits of the design. Call you that honesty, Mrs. Tuthill,—or can you fairly call yourself an honest woman?

VII. "Simplicity of style in architecture," says Mrs. Tuthill—Mrs. Tuthill again!—"is in itself a beauty." The *dictum* requires, however, to be qualified by adding, provided the simplicity itself be æsthetic, and accompanied by other æsthetic qualities. "A Doric temple," she observes, "is perfectly simple; yet what object of art is more imposing and beautiful?" No doubt: the Greek Doric temple was worked by refined and truly artistic simplicity, and by perfect consistency and completeness of expression. The difficulty is to infuse an equivalent degree of similarly-refined simplicity into structures very differently constituted, and which, therefore, ought to be stamped by appropriate character of their own. Hardly can Mrs. T. mean to recommend the antique Doric temple as a model at the present day, it being one which it is utterly impossible to adhere to. In fact, Greek temples are the stumbling-block against which many American architects—of English ones I say nothing—have tripped themselves up. A mere portico has generally been made by them their Alpha and Omega of design. They have accordingly showed their classical taste and utter lack of invention by applying that convenient ready-made feature, the portico, and tacking it on to most Pecksniffian buildings, without the least suspicion that they were thereby out-Pecksniffizing Pecksniff himself. Mrs. T.'s own book gives us a sample of the kind at page 300, assuring us that "the beautiful portico is copied from the Erechtheum." All the more pity then that it should be stuck on to a little smug sash-windowed house. It seems, however, that "the front is of white marble." All the more pity again, that white marble should have been wasted upon a design for which lath and plaster would have been quite good enough. The turning Erechtheums and Parthenons into prose is a notable achievement, truly!

VIII. Although she indulges in a good deal of young-lady-like writing and feminine sentimentality, much ready-made enthusiasm (but of a rather threadbare sort) included, Mrs. T. is a very matter-of-fact sort of lady,—a mere *materialist* in criticism. Artistic idea and design, or the absence of them, are to her as nothing in comparison with the merit derived from such materials as white marble or granite. The adverting to the mere circumstance of material, when every other is passed over, does not bespeak much competency to the task in one who professes to instruct others in architecture, and direct their taste. Mrs. T.'s criticism never ventures beyond a poor, solitary, mateless, forlorn-old-bachelor, celibatarian epithet; and even that is not only exceedingly loose and vague, but sometimes quite misapplied also. If we may believe what she *says*, Yale College Library is a "beautiful edifice;" but if we are to believe what she *shows*, and to trust to our own eyes rather than to her words, it must be truly execrable in every respect. That building and Hartford Athenæum (of which a print is also given) are both by the same architect (H. Austin), and are both meant to be in the Gothic style—of the Strawberry Hill period, it may be presumed. Which is the most hideous of the two—to which of them the "*Detur Turpiori*" ought to be assigned, it would be difficult, perhaps impossible, to decide. Their similarity of merit—or demerit, is so great, that Mrs. T. herself has been forced to employ precisely the same terms for their characterization, calling the one and the other "a symmetrical and effective building,"—a proof that her stock of expressions is but a very scanty one. "Effective" enough they both are, no doubt, and so is—an emetic: and just like an emetic, it is, that they operate; at least, if they resemble the representations of them in the book. Some time ago, an American journal made mention of a fish without eyes; and it would seem that the Americans themselves are altogether without eyes (or eye) for Gothic architecture.

IX. It was to be supposed that Mrs. T. would avail herself largely of the opportunity of chronicling for fame some of her own countrymen, in her "Chronological Table of the Principal Architects;" instead of which, she does not there insert the name of a single one, assigning for the omission the following not very logical reason:—"It would be very desirable to add here a list of eminent American architects; but so many of the most distinguished are still living, that we must deny ourselves the pleasure!" Oh, Mrs. T.! Mrs. T.! What a woman's reason! You are woman all over!

"In reasoning weak, in captivation strong."

Dead worthies, it seems, are not to be spoken of, because the race is not extinct, and other worthies are still alive. Very easily might you have helped yourself to some notices of American architects, quite sufficient for your purpose, from Dunlop's "History of the Arts of Design in the United States"; but you scorn to borrow or pilfer from anybody.

X. At any rate, it cannot be said that Mrs. Tuthill has failed to enrich her volume with a glossary; and a particularly rich treat it is to the lovers of fun and laughter. I, for one, was certainly guilty of *man's-laughter*, when I read her definition of "vertical." I would take a thousand bets that no one would ever guess it. She does not indeed actually say that "vertical" means "horizontal;" but she says—never would you find it out of yourself—that it means "opposite;" which being the case, I am quite *vertical*—in opinion I mean, and in opinion only—to Mrs. T. How fortunate, or else how unfortunate, it is that the Atlantic is between us!

XI. Among those with whom Mrs. T. has got into debt by her literary borrowings from them, is Mrs. Jameson; of whose description of the Königsbau, at Munich, she has availed herself, without having the grace to acknowledge its authorship, or the policy to quote it in evidence of the competency of a female pen. However, if she has defrauded some of her literary creditors, she has paid off one of the smallest of them with usurious interest; namely, the gentleman to whom she has thought proper to apply the epithet "learned," as the most characteristic one which she could select,—or it was the one perhaps which was just then at the point of her pen,—styling him emphatically "the learned Briton"! Possibly, such epithet may, as a general one, be well merited by the what-shall-I-call-him to whom it is applied; yet hardly appropriate to the actual occasion, since the words she quotes are only a sample of what Sam Slick calls "soft sawder." Go to, Mrs. T.,—where you deserve to go to, I don't say; but go to, for a very quizzical and roguish woman.

OCCASIONAL NOTES UPON ART.

By Frederick Lush.

I. We admire true art, on account of its ennobling tendency. This has its origin in principles which, founded in the constitution of our nature, are the foundation of excellence. It would not be a difficult, though a very interesting task, from the varied and honoured labours of the artist, to show that success demands, upon his part, the exercise of the highest mental faculties. Real art is an evidence of these—a manifestation of skill and manly energy. It proclaims with eloquence its intrinsic dignity. How often, for instance, do the stately monuments which her genius has reared force themselves on our regard, rivetting our attention, and commanding our admiration, even when men are intently occupied in the bustling transactions and exciting pursuits of life! When the appeals of art are so powerful, it would be idle to say anything in vindication of its character, were it not that there are creatures upon whose minds they seem to make no impression, and who rudely pass them by, or only cast upon them a look of cold indifference. To write, however, on subjects of pure and sublime art, is to eulogise them, and at the same time, to give to the world a history of the good they have effected; but this has been felt and acknowledged, from time immemorial, by all persons who have claims to our respect for their quick sensibility to beauty and lofty elevation of intellect: for, to the poet they have ever afforded a congenial and favourite theme; to the wealthy an opportunity of gratifying their own taste in a judicious encouragement of talent; nor has posterity ever forgotten those artists whose services and beautiful emanations have thrown such a glory over their vocation, but have recorded their names on the roll of fame, as benefactors to their race. There is no reader of those remarkable poems, the Iliad and Odyssey, but must remember the frequent allusions which Homer makes to the works of the skilled Sidonian artists and cunning artificers; with what warm sympathy, but, at the same time, with what propriety he introduces descriptions of various instruments and accoutrements of war—royal and sacerdotal vestments curiously woven—the shield of the hero Achilles—with works of larger construction—architectural fabrics—such as in after ages were conceived by a Palladio, or by a Sir Christopher Wren. He considers all these as growing under the superintending eye and inspiration of personified Divinity—be it Pallas or other goddess, the beauty of their contrivance and the transcendancy of their invention being referred to a superior power, who strengthened the artists' energies. Moreover, he reminds us how the workmanship added immeasurably to the value of the material, by the superiority of mind over matter. Yet, whether it was the architect who built the lofty pile, or the potter who fashioned utensils of domestic use into forms of beauty, each, by the selection of the most durable materials, insured to his work the greatest permanence possible. The lower departments of art received a high degree of artistical effect from the refined feeling and knowledge of harmonious composition applied to them; it being an important aim in those decorative and ornamental arts which adorned the palace or the temple to cultivate beauty of design in the fullest extent; so Minerva is represented as watching over and herself occupied in the "illustrious labours of the loom;" but it was not the *stuff* of the tapestry, nor the precious stones that composed the floor of rich inlay, but the design that graced it, which was admired and commended. In works of fictile manufacture, where the finer and most delicate skill of the hands was visible, the splendid vase is praised, not because its material was costly, but because it was "figured with art that dignified the gold," and reflected the image of a master-mind. We witness, in all this, a most consummate taste and judgment. So Ovid, in the opening of his glowing description of Phæton:—

"Regia Solis erat sublimibus alta columnis,
Clara micante auro, flammasque imitante pyropo;
Cujus ebur nitidum fastigia summa tegebat:
Argenti bifores radiabant lumine valvæ,
Materiem superabat opus."

The bard of the Iliad says, the inventor of these elegant arts was

a wise man, and that he must have acted from precepts delivered to him by Minerva:—

"——— the work
'Twas a wise artist fram'd, his wisdom taught
By precepts from Minerva."

II. Lord Bacon's definition of art—namely, "a proper disposition of the things of nature, by human thought and experience, so as to answer the several purposes of mankind," clearly expresses that the success with which the mind achieves that desirable end, and the means it adopts for the production of the beautiful, depends upon such high attainments as can be expected only after a long course of observation and experience. Art will exert a beneficial influence upon society, and be a realisation of beauty, according to the wise and "proper disposition of the things of nature." Herein is pointed out the necessity of a knowledge of first principles, which, when systematised by reasoning and taste, form a sure foundation whereon the artist may securely rest in all his operations. The amassing together a variety of perceptions requires the perfection and activity of the organ of vision, and the power of combining and representing figures in their most natural and appropriate forms,—is acquired only after a repetition of manual efforts, aided by the co-operation of the mind, and added to much practical wisdom. Such representation of sensible objects—not, however, strictly copied as they are, but improved to what they should be—portrayed truly, yet poetically, demands a system of various and well-approved precepts, for instruction in which man must look with the cautious and careful eye of observation into the laws which have governed the works of the Divine artist. The words of Paley, when arguing the existence and attributes of God from his works,—"Contrivance proves design, and the predominant tendency of the contrivance indicates the disposition of the designer," apply equally to human productions; and we correctly infer from their elegant beauty or imposing grandeur, the artist's endowments.

III. The well-understanding of the sound principles of art (by which only it can be learnt and appreciated) prevents the commission of solecisms and barbarisms. Pursued on principles contrary to nature and just reasoning, its results are generally absurdities, and sometimes those one-sided, partial, and imperfect views, which are nothing less than proofs of insanity. Witness Borromini in architecture; or, who was worse, Father Guarini, the specimens of whose architectural achievements in Turin look more like the sugar-and-plaster compositions of a pastry-cook and confectioner; or Bernini, who in sculpture, imitated the style of Rubens; and surely nothing could be so bad in taste as to make the drapery of his sculpture resemble that of painting, or anything it in reality is not; for in the imitative arts, as in morality, the advice *esto quod esse videris*, should be recollected. These are examples of an individual caprice, of a love of extravagance, and of a spirit so opposed to all truth, that they deserve censure; and the more so, because they are apt to captivate the ignorant and unreflecting. So necessary is it that all should be under the guidance of reason and intention, that he who does not attend to what these governing faculties prescribe as binding and imperative, but acts only from impulse or chance, forfeits all right to the title of artist. But worthy of all admiration is he who exhibits a control over himself and his, perhaps, too ardent imagination; who regulates his enthusiasm by reason; who makes his genius conform to the rules of art; and rising above every particular and partial, represents only the universal truth. For in this, as most other pursuits, it will be best to preserve a medium. Extremes on either side are to be shunned.

"*Altiùs egressus, cœlestia tecta cremabis;*
Inferius, terras; medio tutissimus ibis."
OVID.

ON THE STABILITY OF FLOATING BODIES.

The doctrine of *stability* is of much greater importance in the constructive arts than is commonly imagined; it is, moreover, a difficult subject, and when considered in all its generality, it requires a much more extensive knowledge of mathematical investigations, than is possessed by the greater part of that class of individuals engaged in mechanical pursuits; hence the reason why the subject, notwithstanding its importance, is so little understood. But although the general investigation of the theory is attended with considerable difficulty, yet there are cases of a highly interesting and practical character, in which the difficulties are but slight, and which may consequently be understood by every person moderately acquainted with the elementary departments of science; and it is to those cases which, in the present instance, we intend the more especially to direct the attention of our readers. The following are the conditions on which the equilibrium of flotation depends. A solid body, floating on a fluid which is specifically heavier than itself, will remain in a state of equilibrium or balanced rest, when it has sunk so far below the surface, that the weight of the fluid displaced by the immersed portion of the body, is exactly equal to its whole weight, and when the centre of gravity of the whole floating mass, and that of the immersed portion of it, are situated in the same vertical line.

If the floating body be inclined from the position of equilibrium through a very small angle, by the action of some external force any how applied, the question of stability consists in determining whether the body, when left to itself under such conditions, will continually recede farther and farther from its position of equilibrium until it finally oversets, or whether it will librate about some axis, until it ultimately restores itself to the position which it occupied previously to the action of the disturbing force.

In the following inquiry we shall confine ourselves to that particular case of the problem, in which the first condition of equilibrium is supposed to be satisfied, in whatever position the floating body may be placed; that is, when the weight of the whole floating mass is exactly equal to the weight of the fluid displaced by the immersed portion of it.

Every solid which is generated by the revolution of some plane about a fixed axis, and in general, every solid body having an axis about which the opposite parts are symmetrically arranged, if it be specifically lighter than the fluid on which it floats, and if it be placed in the fluid with its axis perpendicular to the horizon, may sink to a position in the fluid, where it will remain in a state of quiescence or balanced rest. In all such bodies, there are two opposite positions in which the equilibrium obtains; but there is only one position in which a permanency of flotation can take place.

If the floating body be homogeneous, or uniform in density throughout the whole of the mass, the centre of gravity of the entire body will be situated above that of the part immersed, or, which is the same thing, that of the displaced fluid; but if the density of that part of the body which is below the *plane of flotation** be greater than that of the part above it, the centre of gravity of the whole floating mass may be lower than that of the immersed part, or of the displaced fluid. Indeed, the centre of gravity of the whole floating mass may always be placed below that of the immersed portion of it, by increasing the density of the lower, and diminishing that of the upper portions; and in this way may the stability be augmented in any ratio at pleasure.

If a floating body be any how cut by a plane, in respect of which the opposite parts are symmetrical, or similarly placed; then, any portion of the body cut off by a plane perpendicular to the former, will also be symmetrical in regard to the same plane; hence, we infer, that if a body, symmetrical with respect to a certain plane passing through it, be partially immersed in a fluid with the said plane vertical, the immersed portion of the body will also be symmetrical as regards that plane; and the centre of gravity of the whole floating body, and that of the part below the surface of the fluid will lie in that plane; consequently, for every such plane as that here specified, which can be taken in a floating body, there will be at least one position of equilibrium. These things being premised, we are now in a condition to investigate some of the simpler cases of *the stability of flotation*.

Problem.—If a uniform prismatic body, whose transverse section is a triangle, be made to float upon a fluid specifically heavier than itself in a given ratio, with one of its angles downwards, it is required to determine the different positions in which it will float in a state of quiescence.

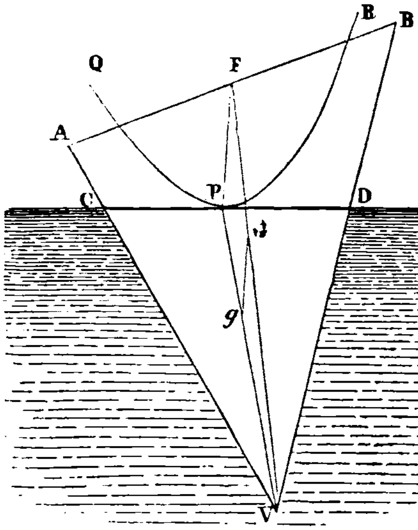
Let A B V, in the annexed engraving, be a transverse section of the prismatic body, floating on the fluid with the angle A V B downwards, and let the straight line C D be the line of common intersection of the plane of the triangle with the surface of the fluid, or that which, by the writers on mechanics, has been called *the water-line*.

Then, since the specific gravity of the fluid, as well as that of the floating body is known, the area of the triangle C D V is known, being to that of the triangle A B V, as the specific gravity of the floating body is to that of the fluid on which it floats.

Let the floating body be a prism of fir, of which the specific

* The plane of flotation, is the horizontal section of the body, coincident with the surface of the fluid; or it is that horizontal section which separates the immersed and emersed portions of the body.

gravity, as compared with that of water is, as 11 to 20; and let the sides of the transverse triangular section be respectively as follows:—viz., A B = 36·5 inches; A V = 44·2 inches; and B V = 53·1 inches.



Then, since the prism is uniform throughout the whole length, the weights and solidities of the floating body and the immersed part of it, will be truly represented by the areas of the triangles A B V and C D V. Now, by the rules of mensuration and by logarithms, the area of the triangle A B V is found as follows.

Side B V = 53·1 inches;
Side A V = 44·2 inches;
Side A B = 36·5 inches.

B V + A V + A B =	133·8, sum of the sides of the triangular section of the prism;		
½ (B V + A V + A B) =	66·9, half sum of the sides ..	log.	1·8254261
	13·8, half sum minus B V ..	log.	1·1398791
	22·7, half sum minus A V ..	log.	1·3560259
	30·4, half sum minus A B ..	log	1·4828736
		log.	5·8042047, Sum;
Area of the whole triangle A B V =	798·183 square inches,	½ log.	2·9021023, ½ Sum;

and, consequently, the area of the immersed triangle C D V, being to the whole area as 11 to 20, is

$$20 : 11 :: 798\cdot183 : 439\cdot00065 \text{ square inches.}$$

Bisect the sides of the triangles A B and C D, in the points at F and P; draw V F and V P, and from the vertex V, set off V G and V g respectively equal to two-thirds of V F and V P; then, by mechanics, G is the position of the centre of gravity of the triangle A B V, and g, that of the triangle C D V; join the centres G and g by the straight line Gg; then, according to the second condition of equilibrium, Gg is a vertical line.

Since the area of the triangle C D V is known, the horizontal line C D touches a given hyperbola described with the asymptoles A V and B V; and C D is bisected by that curve in P, the point of contact. Join P F, then P F is parallel to Gg, and because Gg is vertical, P F is also vertical, and consequently perpendicular to C D, which is horizontal; it is likewise perpendicular to the hyperbola Q P R which C D touches in P. Therefore, since the position of the point F is known, the position of the straight line P F can be found; and for each perpendicular that can be drawn to the curve of the hyperbola from the point F, there will be a position in which the prism, whose transverse section is the triangle A B V, can float in equilibrio with the vertex downwards; and the different positions of P F which satisfy the conditions of equilibrium, may be determined, either by the solution of an algebraic equation of the fourth degree; or geometrically, by the intersection of two hyperbolas, of which the elements of construction are known.

When a body, floating permanently on the surface of a fluid specifically heavier than itself, has its equilibrium of flotation disturbed by the action of some extraneous force—that is, when the centres of gravity of the whole floating mass, and of the immersed part, are not in the same vertical line; if a vertical plane be made to pass through those centres, the body will revolve upon an axis perpendicular to that plane, and passing through its centre of gravity; for when the impulse communicated to a body is in a line passing through its centre of gravity, all the parts of the body move forward with the same velocity, and in lines parallel to the direction of the impulse communicated. But when the direction of the impulse does not pass through the centre of gravity, as is the case in the present instance, the body acquires a rotation on an axis, and also a progressive motion, by which the centre of gravity is carried forward in the same straight line, and with the same velocity, as if the direction of the impulse communicated had actually passed through the centre of gravity; and it is a curious mechanical fact, that the rotatory and progressive motions thus communicated, are wholly independent of one another, each being the same in itself as if the other did not take place.

This follows from the general mechanical principle or law, that the quantity of motion in bodies estimated in a given direction, is not affected or changed by the action of the bodies on one another. The revolution of a body on its axis is produced by an action of this kind, and therefore it can neither increase nor diminish the progressive motion of the whole mass moved. When a single impulse only is communicated to the body, the axis on which it begins to revolve is a line drawn through its centre of gravity, and perpendicular to the plane which passes through that centre and the direction in which the impulse is communicated.

It is the nature of some floating bodies, when their equilibrium of flotation has been disturbed, to return to their original position, after making a few oscillations backwards and forwards, upon an axis similar to that above alluded to. But others, again, when their equilibrium of flotation is ever so little disturbed, do not resume their original position, but continue to revolve on an axis passing through their centres of gravity, until they attain another position, when they are again in equilibrio. In the former case, the equilibrium is s said to be *stable*, and in the latter it is *unstable*, and the body oversets.

When the floating body is made to revolve from the position of equilibrium, by the action of some external force; *if the line of support** move, so as to be on the same side of *the line of pressure*,† as that part of the body, which becomes depressed below the surface of the fluid in consequence of the inclination from the state of equilibrium; then, the equilibrium is stable, and the body will restore itself; that is, it will resume the position which it occupied before it was submitted to the action of the deflecting force. But if the line of buoyancy, or the line of support, be on the same side of the line of pressure, as the emersed or elevated part of the floating body, then the equilibrium is unstable, and the body will recede farther and farther from its original position, until it finally oversets.

When a body floats upon the surface of a fluid specifically heavier than itself, the force which tends to make the body revolve about its centre of gravity, is equal to the weight of the body, acting on a lever, the length of which is equal to the horizontal distance between the line of pressure and the line of buoyancy; and when this distance vanishes, that is, when the centres of gravity of the whole body and the immersed part of it are in the same vertical line, the force tending to cause the body to revolve is equal to nothing.

When the floating body is any how inclined or deflected from the position of equilibrium, and when the line of buoyancy falls on the same side of the centre of gravity of the whole floating mass, as that part of the body which becomes depressed below the surface of the fluid in consequence of the deflection, the lever by which the force acts is said to be affirmative, and the force tends to establish the equilibrium, or to restore the body to its original position. But on the other hand, when the line of buoyancy is on the same side of the centre of gravity of the whole body, as that part of it which becomes elevated above the surface of the fluid in consequence of the deflection, the lever by which the force acts, is said to be negative, and the force tends to overset the body.

These are the chief principles necessary to be known in taking a cursory view of the subject; and we shall now proceed to show in what manner the momentum of stability is to be calculated.

Let the vertical transverse section of the floating body be uniform, or the same from end to end; then put—

a = area of the transverse section of the immersed part of the body;
d = distance between centre of gravity of the whole and immersed part;
l = length of the water-line, or the base of the immersed section;
ϕ = small angle of inclination or deflection;
w = whole weight of the floating mass;
m = momentum of stability.

* The vertical line which passes through the centre of gravity of the immersed part of the floating body, is called "the line of buoyancy," or "the line of support."

† The vertical line which passes through the centre of gravity of the whole floating mass, is called "the line of pressure."

Then, on the supposition that the angle of deflection is very small, as it must be in all practical cases, the momentum of the force tending to restore the equilibrium of flotation is, by the principles of mechanics,—

$$m = \left(\frac{l^3}{12a} - d\right) w \sin \varphi.$$

This equation is general, whatever may be the form of the floating body; but the subsidiary calculations are more intricate in some cases than in others, and in consequence, the formula in those cases will be more difficult in its application, and the labour will be much more tedious and irksome.

By attentively examining the constitution of the above equation, there are certain inferences that offer themselves, which it may be useful to specify. They are as under:—

1. If the first term of the parenthetical expression $\frac{l^3}{12a}$ be greater than the second, d, the leverage is affirmative, and the force tends to restore the body to its original state.

2. When the two parenthetical terms are equal, there is no force tending either to restore or destroy the equilibrium; for, in that case, the momentum is nothing.

3. When the first of the parenthetical terms is less than the second, the leverage is negative, and the force tends to destroy the equilibrium and overset the body.

4. When the weight of the body remains constant, the stability is proportional to the expression $\left(\frac{l^3}{12a} - d\right) \sin \varphi$.

5. When the centre of gravity of the whole floating mass is lower than the centre of buoyancy, or that of the part immersed, the term d, or the distance between the centres of gravity, is negative, and the whole parenthetical quantity $\left(\frac{l^3}{12a} - d\right)$ becomes affirmative; a circumstance which greatly increases the stability of flotation, as we have already intimated.

If, in the vertical line passing through the centre of gravity of the whole body and that of the immersed portion, there be taken a point distant from the centre of buoyancy, by a quantity equal to $\frac{l^3}{12a}$, that point is called the *metacentre* by naval architects, because it must always be situated above the centre of gravity of the mass, in order that the body may float with stability. These things being premised, we shall now give an example of the method of calculating the momentum of stability, according to the above formula; and if the process be well considered in this particular case, there can be little difficulty in applying the same principles to similar cases, even when the section of the body is of a very different form.

Example.—In the prismatic body of fir formerly mentioned, and of which we have given a transverse section, the length of the water-line C D is 25·8 inches; the vertical distance G g, 8·5 inches, and the whole weight of the floating body 5,200 lb.; what is the momentum of stability, or with what force does the body endeavour to restore itself, when deflected from the equilibrium through an angle of 5 degrees.

By a previous calculation, we have found the area of the immersed triangular section to be 439 square inches, omitting the fraction; hence, by the formula, we have—

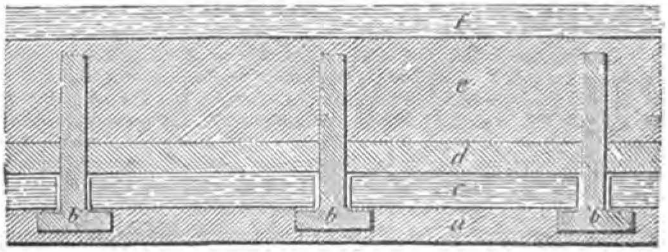
$$Momentum = \left(\frac{25{\cdot}8^3}{12 \times 439} - 8{\cdot}5\right) \times 5200 \times \sin 5°.$$

The length of the water-line is 25·8 in.	log.	1·4116197
		3
$25{\cdot}8^3 = 17173{\cdot}502$	log.	4·2348591
Area of the immersed section = 439 sq. in.	ar. co. log.	7·3575355
Constant number, 12	ar. co. log.	8·9208188
Natural number, 3·2599	log.	0·5132134

Consequently, we have $\frac{l^3}{12 \times a} = \frac{25{\cdot}8^3}{12 \times 439} = 3{\cdot}2599$; which, being less than the term $d = 8{\cdot}5$ inches, the third inference shows that the leverage at which the weight of the body acts is negative, and the force tends to overset it, the momentum of instability being $(-8{\cdot}5 + 3{\cdot}2599) \times 5200 \times 0{\cdot}08716 = -2374{\cdot}981$ pounds.

FIRE-PROOF BUILDINGS.

The advantages of building our dwellings fire-proof is so generally acknowledged, that it is needless to say a word in its favour; but the great difficulty in the way has been the expense in constructing the floors and ceilings. To Dr. Fox, of Bristol, are we indebted for the erection of buildings that are fire-proof, and at the same time quite as economical as the ordinary timber-built floors. About 15 years since, Dr. Fox built a private asylum at Northwoods, near Bristol, on a large scale, containing no less than 120 rooms. Externally, it is built in the ordinary way with brick-work, but the floors are constructed as shown in the annexed engraving; and in order to make our description practical, we shall describe the weight and size of the bearers as adapted to one of the rooms at Northwoods. The floor is 18 feet by 13 feet; the joists, which are placed lengthwise, are of cast-iron, of the ⊥-shape, and are 3 inches deep at the bearings, and 5½ inches deep in the middle; ¾ths of an inch thick at the bottom, and ⅝ inch at the top. The depth includes the flange at the bottom, which is 2½ inches wide, and ⅞ths of an inch thick, on the underside. Each joist weighs 15¼ lb. per foot, and they are placed 18 inches apart.



Upon the flanges are laid stout fillets of wood, about 1 inch square, clove out of short ends of deals, with a space of about half an inch between each slip. Upon these fillets is laid a thickness of coarse mortar, portions of which pass through the spaces, and form a key for the ceiling. Upon the coarse mortar is placed a layer of pugging or concrete, and finally a composition composed of lime, ashes, and sand, well beaten down, and trowelled on the face. After the whole has become tolerably dry, linseed oil is rubbed over the surface, which renders the floor perfectly non-absorbent of moisture. The ceiling is then put on below—first a coating of lime and hair, then a floating coat, and at the conclusion the setting coat. When the whole has stood for a few days, the floor forms a solid mass, and is very stiff and strong.

Models, showing the form of construction, may be seen at Messrs. Fox and Barrett's offices, 46, Leicester-square.

References to Engraving.

a, Plaster Ceiling, formed in the ordinary way.—*b, b, b*, Cast-iron Joists. *c*, Strips of Wood, Slate, or other material, with narrow spaces between each.—*d*, a coat of coarse Mortar, forming a bed for the concrete above, and a key for the ceiling below.—*e*, Layer of concrete or pugging.—*f*, a facing layer of composition, forming a floor of great hardness, toughness, and durability, and perfectly free from absorption.

Blast-Furnaces.—Remarkable Accident.—At one of our blast-furnaces, blown with heated air, while the blast was shut off for a few minutes, as is usual after casting, an explosion took place inside the pipes, which, from its effects, we consider extraordinary. In the pipes immediately outside one of the stoves for heating the blast, and at the end next the furnace, is a stop-valve—a circular disc of cast-iron, 1½ inch thick, and 12 inches diameter, cutting off the connection between a line of cold-blast pipes and the hot-air pipes. This valve, by the force of the explosion, was literally shattered. Several of the joints in the line of cold-blast pipes, with which the breaking of this valve opened a connection, were blown out, and another stop-valve, in the large main, at a distance of 20 yards, was also broken in pieces; there the explosive mixture escaped in flame at the waste. The furnace, at the same time, belched out a great quantity of the materials in front. Will any of your scientific correspondents have the kindness to explain the nature of the explosive compound likely to be formed in the hot-air pipes? It appears to have generated in the furnace, and fired by the pipes of the stove being red-hot, which they very soon become (if the fireman is at all careless) when the blast is not passing through them.—AN OLD SUBSCRIBER: *Merthyr Tydvil, Oct.* 31.—*Mechanics' Magazine.*

HIGH-PRESSURE STEAM GENERATOR.

Invented by J. A. Leon, C.E.

In the beginning of this century the tubular boilers of Woolf and Rumford were used for generating steam. Soon after Trevithick's flued-boilers were introduced, it was found that metallic flues surrounded with water were more effectual than tubes filled with water, and surrounded by the products of combustion. Since, the number of flues in a boiler increased successively until they formed the multiflux locomotive boiler.

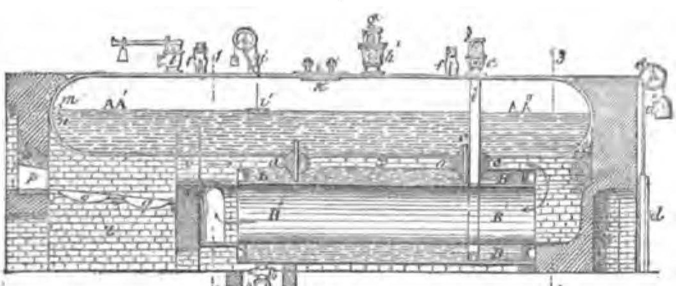
Flued boilers ought to be used only where they cannot be avoided, as on railways or for navigation. The space occupied by the flues reduces the size of the steam-chamber. The water at its maximum height covering these flues only a few inches, does not permit the use of the float-stone, the best water indicator on stationary boilers. The metallic flues are sometimes left dry, and burst. Boilers of that description are not easily cleaned, free access to the inside being almost impossible; the result of such neglect, if it causes no explosion, it increases greatly the tear and wear, and the expense of extra fuel is very considerable.

The common cylindrical horizontal boiler, being the simplest, the safest, and the most easily cleaned, ought to be preferred as a stationary generator. The only objection against its use was its small area of heating surface; but the greatest part of the wasted hot air leaving the boiler can be absorbed before reaching the chimney by an appendix vessel, containing water for feeding the boiler.

To obviate the defective method of cooling the cylinder by injecting cold water in it, Watt condensed the steam in a separate vessel. Here, in place of injecting cold water, mud and all, into the boiler, this compound is primitively received into the heater, where the water, before reaching the boiler, deposits its insoluble matter, and acquires an elevated temperature. The generator receiving by this process a constant supply of hot water, keeping the steam steady, no perturbation is felt, as when injecting cold water.

This heater requires no extra room: its place is below the boiler, and behind the fire-grate bridge, a space commonly filled with rubbish. A great advantage of this heater is, to keep the supply of water in almost a quiescent state, which gives the effectual means of obviating the evil of bad water. The sediment accumulates, in one or more heaps, in the front of the heater, where the water happens to be the least agitated. Those deposits are received in some recipients placed near the man-hole. The generator, fed with water almost clean, is no more liable to burn.

Fig. 1.



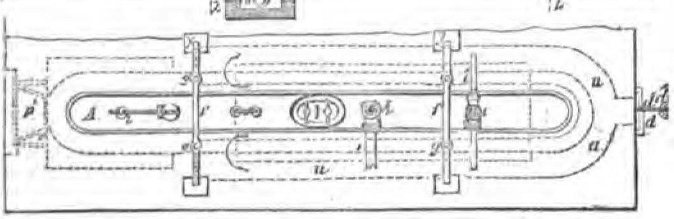


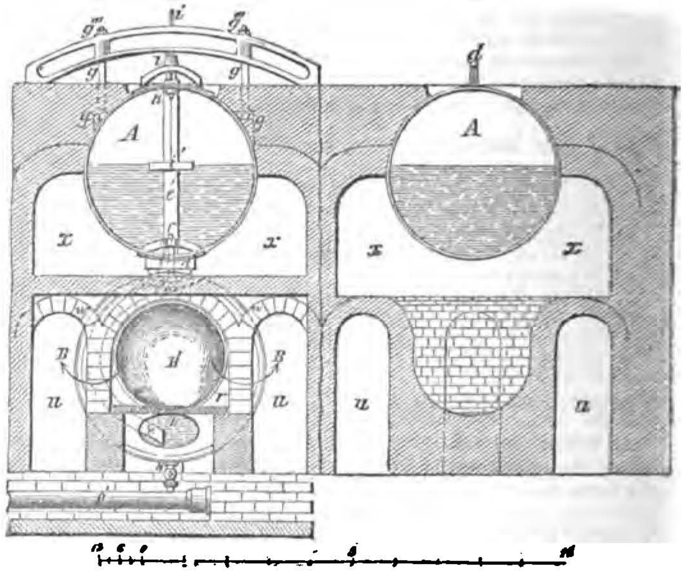
Fig. 2.

The heater is comparatively of a small size. In the engraving the generator's axis has 26 feet, its diameter 4 feet, while the length of its heater is only 14 feet, its diameter 4 ft. 6 in., and, notwithstanding this, its heating surface is twice as much as the heating surface of the boiler itself, which is here 150 square feet. In reducing the 300 square feet of the inner and outer surface of the heater to 120 square feet of effective heating surface, the whole apparatus has 150 and 120, or 270 square feet of heating surface. This divided by one square yard, or 9 square feet, per horse power, will prove a 30-horse power for the capability of the steam generator. The grate, 5 by 6 feet, or 30 square feet, harmonises perfectly with a 30-horse high-pressure boiler.

The upper and lower brick flues are very large, and answer for burning all kinds of combustible—vegetable, as well as mineral fuel.

The boiler and its heater are screwed and cemented together, when set on the furnace. If rivetted together, their transport by land and sea would not be so easy.

Fig. 3. Fig. 4.



*Reference to Engravings.**

Fig. 1, Longitudinal section.—Fig. 2, Top view of Furnace and Boiler.—Fig. 3, Vertical section through line 1—2, fig. 1.——Fig. 4, Vertical section through line 3—4, fig. 1.

A A′, Cylindrical boiler, with hemispherical ends, containing only the steam-chamber, and the water to generate steam.

B B′ Horizontal reservoir, composed of two concentrical cylinders, leaving an annular space filled with water, supplying the generator A A′, by means of the short vertical pipes *b b′*, set into the sockets *a a′*.

c c′, Joint bolts fastening A to B with curved cramp-irons. The annular space between *b b′* and *a a′* is filled on the spot with iron cement.

d, Damper, with pulley *d′* and weight *d″*.

e, Stop-valve betwixt the feed-pipe *e′* and the plunger-pipe *e″*.

f f′, Two erect cast-iron segments, resting upon cast-iron plates Y, on the top of the furnace. On those curved girders the boiler A A′ is suspended by its brackets *g*, with bolts, pegs, and nuts, *g′*, *g″*, *g‴*.

h h′, Main steam-pipe and stop-valve.

i, Whistle regulated by the float *i′*, to give the alarm when the water falls below its minimum level.

k k′, Man-holes to boiler A and to heater B.

l, Safety-valve.

m m′, Gauge-cock and pipe-indicator of maximum of steam.

n n′, Ditto, ditto, of minimum of water.

o o′, Discharge-cock and pipe for emptying the water from both vessels, A and B, and for filling them by means of a perpendicular pipe connecting *o′* with an elevated water-tank.

p, Passage from the furnace-door to the fire-grate *q*.

p′, Moveable fire-mouth, in the shape of an arched-top bayed window, placed in the fire doorway, its narrow part inside the furnace, for burning bundles of bagass, or dried squeezed sugar-cane; each bundle is pressed into the fire-mouth, and acts by turns as a furnace-door. This sort of hopper is removed when wood or coal is used.

q, Fire-grate.

r, Moveable plate, shifted when necessary to clean the flues.

s, Fire-bricks surrounding the sockets *a a′*, not shown in the engraving.

t, Two fire-brick lumps, on which rests the heater B.

u, Two return brick flues, joining before reaching the damper *d*.

v, Interverted arched bridge.

w, Partition between upper leading flue *x*, and lower return flues *u*.

y, Cast-iron plates, on which are placed the girders *f f′*.

z, Ash-pit.

* We are indebted for the drawings to a work that Mr. Leon is about publishing, on "Colonial Machinery for Manufacturing and Refining Sugar."

GEORGE STEPHENSON.

(Continued from page 333.)

(Continued from page 333.)

VII. STEPHENSON, GRAY, AND JAMES.

The share which Stephenson had in bringing railways to the height at which they now are has been much fought about. He has been named the "Father of Railways" by many of his friends; but there are others who are put forward. By what he did with the locomotive he had made a step onwards, and this he followed up by the Stockton and Darlington Railway. These were great works; but no one who fairly looks at it can believe that to George Stephenson only is owing our wide net-work of railways. At forty, Stephenson was hardly more than a working man, with little weight even among his own friends; and he had no means, had he had the wish of moving the world to the great step, whereby the bounds of neighbourhood were to be widened, the furthest shires of England and Scotland brought within a few hours reach, and the householders of London and of Paris, sundered from the beginning of the world, made to know each other as friends and as brothers. He had his share, and a great share, but no more, in this mighty stride towards the fellowship and brotherhood of all mankind, which the wise of old have sighed for and dreamed of, but which they durst never hope should be so nearly brought about.

The earth has this year taken to itself Thomas Gray, as well as Stephenson, so that each can be as fairly brought to doom. Had not the former come forward while living, perhaps his name would have never been heard, nor would he have been called the "Railway Pioneer." It seemed hard, however, that a grey-headed old man, who, in his youth, had seen so far beyond his fellows, should be left to starve in the sight of the wonders which he had foretold. There is always a feeling for the seer who is happy in his bodings; more, perhaps, than for the workman who has slowly wrought out the task with which he set forth. There is a feeling of kindness, too, for one who has wished to do well, and on whom good luck has not smiled. There was a forbearance, therefore, in searching into what Thomas Gray had done, and meting it out narrowly by the wand of truth, yet the utmost of what could be said of him was, that he was one of those who, like Sir Richard Phillips[1] and others, but later, had laid down what was within the bounds of skill to do. What Thomas Gray wrote and spoke in 1820, hundreds had said when Trevithick run his first steam-engine on the Merthyr Railway: to have seen his engine and the Croydon tramway was enough; any man of common daring would foretell the greater speed and might of the iron horse, which would grow with his growth. To map out the railways as Thomas Gray did needed no skill, for they must be made where the trade already flowed, and not over the highlands of Scotland, the wastes of Dartmoor, or the heights of Snowdon. That Gray did good in writing his book no one will gainsay, for it awakened others to the worth of railways, so far as it went; but others did the same work, and others did still more. Trevithick, Blenkinsop, Wm. Chapman, Blackett of Wylam, and George Stephenson, set the iron horse going, others laid down tramways: in 1818, R. Stevenson, of Edinburgh, wrote for a great railway from Edinburgh; and later, Wm. James brought forward his great railway undertakings.

On February 11, 1800, Mr. Thomas, of Denton, read before the Literary and Philosophical Society of Newcastle a paper, styled "Observations on the Propriety of introducing Roads on the Principle of the Coal Wagon-ways, for the General Carriage of Goods, &c." This is the first proposition that we know of for a general railway system, and nearly twenty years before Gray's.

In 1814, George Stephenson had in his mind's eye a better road, and a greater speed, and he soon brought them to bear; the others, each in their way, did something; but Thomas Gray only wrote, as Sir Richard Phillips had done. By writing, Gray might have done much, had he, without doing anything, only shown to others something new, which might be done: but this cannot be said for him; and he stands as a writer and talker, while the others were doers.

Not so, however, with William James, of Warwick. He not only saw what railways could do, but he set to work to make them. It is now almost forgotten that the busy time of 1825 teemed with railway undertakings, as much as 1835 or 1845. Then were laid down all the great works, which have since been made, and these, in a great way, through the earnestness of James. The Liverpool and Manchester Railway, and the London and Birmingham Railway, must be looked upon as his offspring; and had it not been for his unwearied earnestness, they might have been longer put off. As it is, we are now only doing in 1845 what might have been done in 1825; and in the outcry against railway calls and works, many railways, the want of which was seen in 1845, will not be made until 1855 or 1865. We hear a great talk about mad-brained undertakings; but the cool looker-on must weep to see how, by blindness, the works most needful for the good of England are hindered and kept back. How much better should we be now if the works laid down in 1825 had then been begun and set out! All that good to which we now own in better husbandry, cheaper coal, and quicker trade, would now have reached a greater height. Had Brindley or Stephenson been listened to when they first spoke of canals and railways, England would have been much more forward than she is, and still more a-head of other lands. We may still learn from what has gone by, but it does not seem as if we were willing to do so.

We are not called upon to search why James did not fully follow up his great railway undertakings, nor why he did not reap a better or greater reward. Too little is known about him; his life has yet to be written; and, until then, we cannot coolly settle whether he were the loser by the carelessness and unthankfulness of the world, or, like Trevithick, by his own want of steadiness. That to him very much is owing ought to be acknowledged; and now, that death does not hinder us from speaking freely, the works of James are likely to be set in a higher light. By George Stephenson and his son they were acknowledged; and the latter took the lead when a call was made on railway shareholders and engineers for the widow and children of James, who are left behind to witness his works, but without sharing in the wealth which they have yielded to others. The Stephensons, however, afterwards withdrew, and the subscription fell to the ground.

William James laid down the first railway of any length in England, the Stratford and Moreton Railway,[2] finished in 1821; the London and Brighton Railway, which he surveyed in 1812.[3] the Liverpool and Manchester Railway;[4] the London and Birmingham Railway;[5] and the Canterbury and Whitstable Railway.[6]

We may, without any very great wrong, believe that two such men as Ralph Dodd and William James must have done much in strengthening the mind, and awakening the hopes of George Stephenson. The former had a share in fostering the steam-boat, as well as the locomotive; his engineering works were daring. James drew the outlines of our great iron roads. The former was untimely in his end; both unhappy in their lives, and ever beset by ill-luck. With these two Stephenson was in fellowship; but happier in his lot, and happier than Trevithick, in whose path he followed, and carried out what the other had left undone. It is not needful now to say anything of the others' ill-luck; it is enough to say again, that the root of Stephenson's happiness lay within himself. He, too, had a struggle with the world. He had been in want of work and bread: he could not get a patent for his first engine; and for his next, he had no good partner in Dodd; and with his safety lamp he was overshadowed by the greater name of Davy, and reaped but a slender reward. He was laughed at by the mighty, and set down as a quack and a cheat; but he looked more to himself than the world, and he overcame it.

It must be borne in mind, that before James and he set about the Liverpool and Manchester Railway, Stephenson had set the locomotive going, and was busy on the Stockton and Darlington Railway. Stephenson was ready for his task; but the strong hand of a man who knew the world well must have been a great help to him, and the time was most smiling. It was when Prosperity Robinson had fanned the flame of greediness; and when the fulness of wealth sent a stream of English gold to the mines of Brazil, Mexico, and Peru. Ten years before, had there been such an opening, Stephenson would have been found unready for it: he had not got his engine in full work; he knew little of railways; and he had not put off his workman's apron. He had neither the strength nor trust within him; and though he and Dodd may have talked over what was to be thereafter, yet the mind of Dodd, daring as it was, does not seem to have been awakened fully to what was to do greater wonders, and bring greater wealth than even the steamboat. In taking a share with Stephenson in the patent for the locomotive, Dodd must have seen its worth, and may have looked forward to its becoming the iron horse, which it has been fondly named; but he did not feel the time come to ask for railways all over the land, as James did, who

[1] "Mechanics' Magazine," October 21, 1848, which quotes Sir Richard's "Morning Walk to Kew," published in 1813, and likewise quoted by the "Manchester Examiner." Sir Richard was an upholder of Blenkinsop's engine.

[2] Ritchie on Railways, p. 37.
[3] Weale's Ensamples of Railways, p. 4.
[4] Ritchie on Railways, p. 238.
[5] Ritchie on Railways, p. 238.
[6] Railways of Great Britain, by Francis Whishaw, C.E.,—Art. Canterbury and Whitstable.

was a busy railway engineer before he knew Stephenson, when he helped him to the partnership with Losh, and for which James had a fourth share of the patent.[7] In 1824, the fulness of time had come; there was the time, and there were the men, and the start was made. It is true, that all which might then have been done was not done—but there was a beginning: and in 1835 Stephenson had shown his skill, and had greater weight and name in the world, so that he could push railways on—or rather hinder them from being lost sight of, as they might have been even then; for there was no want of croakers—the backers of canals were loud and strong, and the fear of railways beset all the old women and womanish men throughout the land.

Of the two men who have been named with Stephenson—Trevithick and Dodd—it has never been shown what a strange likeness there was between them in many things. This went so far, that each had his tunnel under the Thames, Trevithick at Rotherhithe, Dodd at Gravesend; each had a patent for the locomotive engine; each left Stephenson to reap what good was to be got from it. Dodd well knew Trevithick's works; and, when Stephenson and he met in 1815, they must have talked about them; but Dodd did not feel strong enough to set up as a great railway-maker.

VIII. STOCKTON AND DARLINGTON RAILWAY.

The Stockton and Darlington railway was one of our first great railway works, but it is that as to which the least has been written. Very little can therefore be said as to George Stephenson's share in it; though it is much to be wished we knew more about it, that we might see the working of his mind in his early undertaking. Whatever Stephenson undertook was, so far as he could, thoroughly done; and he was always seeking for the best way. He therefore, in making the Stockton and Darlington Railway, brought into use many things which were quite new.

Nicholas Wood, who could best have done it, says nothing of the Stockton and Darlington Railway in his book.[8] Tredgold does not seem to have seen it, though he names it.[9] Francis Whishaw, in the "Analysis of Railways,"[10] often names the Stockton and Darlington Railway, and speaks about it at length in his "Railways of Great Britain."[11] This, however, does not show it as it first was; and an eye-witness like Nicholas Wood, could have done much for us.

We have sought in the British Museum, without finding them, Thomas Gray's "Observations on a General Iron Railway;" T. C. Cummings' "Account of Railways;" Charles Silvester's "Report;" and Joseph Sandars's "Report." Most of what was written between 1820 and 1830, on the Stockton and Darlington, and Liverpool and Manchester Railways, is not to be found in the British Museum, as such things were not thought of any worth: had they been a few sheets about a Greek play, they would have had a happier lot.

In this day we know nothing of the men to whom, less than thirty years ago, we were beholden for bringing forward our great railway works. Some, as Joseph Sandars, Robert William Brandling, and Henry Booth, still live; but many have sunk to the grave, unknown and unthanked. Two books are wanted before it is too late to learn all the truth,—the History of Railways, and the Lives of Engineers. There are lives of poets, painters, doctors, and lawyers, but not of engineers, beyond Smeaton, Brindley, Watt, and Telford. Stuart has done the most in his "Anecdotes of the Steam-engine." The Institution of Civil Engineers gives medals for the lives of Trevithick, and others; but no one asks for them. George Stephenson will not be forgotten by them; and, before the Institution of Mechanical Engineers, a life of him was read by John Scott Russell.

Stephenson was about forty when he was first called on to be engineer to the Stockton and Darlington Railway. This could hardly be named as more than a tramway; and, although travellers were carried by coach, it was only a coal line, made to draw the coals from the pits in South Durham. Some of these pits belonged to Messrs. Pease and Backhouse, members of the Society of Friends, and powerful bankers.

The Messrs. Pease were partners as bankers with the Liddells, the owners of Killingworth Pit; and this, perhaps, led to George Stephenson being named as engineer, so far away from his own neighbourhood. The Messrs. Pease thought so highly of Stephenson, that they afterwards found the money for a locomotive workshop, now known as that of Robert Stephenson and Co., of Newcastle. The brothers and their children henceforth took a great share in railways, not only in the north, but likewise in the midland, and they are still great holders in the northern lines. Joseph Pease was a very great holder in the London and Birmingham, in the Manchester and Leeds, and others of Stephenson's railways. Joseph Pease, his nephew, formerly M.P. for South Durham, is now treasurer and deputy-chairman of the Stockton and Darlington Railway, and treasurer of the Great North of England, the Wear Valley, and the Middlesborough and Redcar Railways.[12] Joseph Robinson Pease is deputy chairman of the Hull and Selby Railway. John Pease and Henry Pease are directors of the Stockton and Darlington and other neighbouring railways.

The Backhouses are no longer on the Board of the Stockton and Darlington Railway, but Edward Backhouse is a director of the Durham and Sunderland Railway; and John Church Backhouse of the Great North of England Railway.[13]

The Meynells, of Yarm, took likewise a busy share in the Stockton and Darlington Railway, as did the Hobarts of Etherly Pit. Both are still directors.

The main line was only twenty-two miles long, and was to ship coals from the dale of the Tees, between Darlington and Stockton. The money to be raised was only about a hundred thousand pounds, and the Act was got in 1821. The works most likely began in the next year. The first line was from from Witton-park colliery, to Stockton-on-Tees, and the money to be raised by shares was 82,000*l.*, and by loan, 20,000l. This was then thought a great deal to be raised by the Peases, Liddells, and Backhouses, who had it mostly on their own hands. In 1848,[14] the shares were 275,000*l.*, and the loans 170,000*l.*; and the shareholders leased at 6 per cent. the Wear Valley Railway, which cost 140,000*l.*; and the Middlesborough and Redcar, which cost 70,000*l.*. The earliest dividend on the shares of the Stockton and Darlington Railway was 4 per cent.; this rose to 11 per cent., and afterwards to 14 per cent.; but it was lowered to 10 per cent., and 4 per cent. put by as a sinking fund. These shares do not come into the market now, but have been sold for more than 260*l.* for a hundred pound share. They are now in a few hands; and Mr. Tuck says, "The directors refuse to publish any accounts whatever."

The gauge of this railway was 4 ft. 8½ in., what is now named the narrow or national gauge, which had been taken up as the common width of wagon-wheels. The rails were at first 28 lb. to the yard.[15] These were afterwards made 35 lb., and at length, 64 lb. They were fish-bellied,[16] on Jessop's plan, which was then held better than parallel rails. Stephenson was in favour of wrought-iron rails, and of Mr. Birkenshaw's system, as is shown by a well-written report given in Wood on Railroads,[17] and one of his earliest writings, printed after that on the safety lamp, heretofore named. In this,[18] he speaks of the non-rusting of wrought-iron rails when kept in work, and of the rusting of unused wrought-iron rails laid alongside; but he gives no good reason for this. He thinks that there is a change in the chemical condition of the surface of the rail. The rails were laid under the patent taken out with Mr. Losh, in 1816;[19] but Nicholas Wood thought that the chair might be so made as to get rid of the jolting where the chairs were pinned together. This was, in 1829, done under a patent of Messrs. Losh, Wilson, and Bell.

Part of the rails were laid down on square blocks of wood,[20] and part on stone blocks. Nicholas Wood[21] wrote recommending the latter. Stephenson, perhaps, wished to get a smoother road for the sake of his engines, which had been one of his ends in his patent with Losh. The old way of setting the blocks was by mallets and shovels, beating the blocks till they came to the right level; but Stephenson set up another way, which is that now followed. He had a portable lever, about twenty feet long, which lifted up the block by the short end, about a foot high; and by letting it fall several times upon the coating of the road in the intended seat, throwing at the same time gravel or fine sand under it, made a solid bed for it. It is then set to its right level, both lengthwise and crosswise, by squares and sights.[22]

The line was fenced with hedge-rows over a greater part, which was then rather a new kind of fencing.[23]

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7 Communicated by J. C. Robertson, Esq., of the Mechanics' Magazine.

8 Wood, on Railroads, 1825.

9 Tredgold, on Railroads, 1825, p. 20.

10 Analysis of Railways. London, 1837.

11 Railways of Great Britain, p. 430.

12 Post Office Railway Directory, 1848.

13 Post Office Railway Directory, 1847, 1848.

14 Tuck's Railway Shareholder's Manual, p. 230.

15 Railways of Great Britain, by F. Whishaw, p. 415.—Nicholas Wood, 1st edition, p. 70.—Ritchie, on Railways, p. 36.—The weight given in the Analysis of Railways, by F. Whishaw, p. 273, is, by error, stated as 35 lb.

16 Ritchie, on Railways, p. 36.

17 First edition, 1825

18 Wood on Railroads, 1st edition, p. 66.

19 Wood, 1st edition, pp. 36, 66.

20 Ritchie on Railroads, p. 57.

21 Wood on Railways, 1st edition.

22 Ritchie, on Railways, p. 60.—This way was first brought in by George Stephenson, but it is not sure whether on the Stockton and Darlington Railway, or afterwards.

23 Whishaw's Analysis of Railways, p. 275.

The engines are said, by Francis Whishaw, who had seen many of the old ones, to be "ponderous and clumsy, but still powerful."[24] Many of the old ones were on the line in 1837. The Lord Brougham was 16 feet long, with six wheels; each three being connected by cranks. The engine-driver rang a bell on coming near a station. About 1836, the steam-whistle came into use for the passenger-engines; but the bell was used for the coal-engines.[25] Whishaw thought that it was better to have several kinds of signals, rather than the steam-whistle only.

Level road-crossings were then thought to be without any harm; and therefore there were fifteen on the Stockton and Darlington line.[26] This kind of crossing was, as is known, afterwards put a stop to by law, but is now sometimes allowed. In 1839 there were no gates on the line, but merely signal-posts, with the word "Signal."

In 1823 and 1824, further acts of parliament were got; and the Company were allowed to run locomotives and carry passengers. On the 17th of September, 1825, the line was opened.[27] Stephenson now tried on a large scale, on the Hagger Leases branch of the Stockton and Darlington Railway, his locomotives, which were thought to be very successful. By this time, the Wylam, Killingworth, and Hetton tramways were worked by steam-power.

The gradients on the Stockton and Darlington Railway are mostly steep, 1 in 128, 204, 233, and 427. The line rises from Stockton; and was worked by stationary engines at the inclines, which are 1 in 30, 32, 33, and 104.[28] The length of the main line is 25 miles, but the whole length is now 55 miles 5 furlongs;[29] and there are eight passenger and goods stations. The whole cost per mile is now 9,000*l.* 1,064 persons are employed on the line.

Passengers were first carried in stage coaches, drawn by horses; and it was some time before the locomotive was brought into play, while the speed was low. In 1837, Whishaw found the speed of the passenger-trains only 12 miles per hour.[30] As this was mostly a coal line, it will be seen that the speed of the locomotive would never have been brought out here, although its power was fully tried by Stephenson and Nicholas Wood.

Whishaw does not think that the earthworks are heavy, nor does he name any great work. Some of the curves on the main line are sharp, being much under a radius of a quarter of a mile. There are thirteen bridges under, and eleven bridges over, the main line. The slopes of some of the embankments towards the top of the line are planted with firs.[31] The line is ballasted with small coal.

This is named as the first line on which houses for the workmen were built on the side of the railway,[32] and Whishaw foresaw that it would be followed elsewhere. The end for which these cots were built was to keep the waymen and other workmen near their work, and away from the ale-house.

In 1839, there were 5,000 coal-wagons at work on the line.[33] At that time, there were thirty engines, very few of which were by the Stephensons, some were by Timothy Hackworth, of Shildon, by the Kitchens of Darlington, now directors of the line, and the Hawthorns. The works of Timothy Hackworth are at Shildon, on the line; and thus he was stimulated to the Liverpool and Manchester struggle by seeing the engines of Stephenson running on the line before him. At Shildon are likewise the engine workshops of the Stockton and Darlington Railway.

The tenders were two waterbutts set on a wagon frame, and holding together 1,200 gallons of water. Beside them was the coke or coal for the engines. The whole mounted on four wheels.[34] This was the rough beginning of the tender. Coal was burned in the coal-engines, and coal and coke, mixed, in the passenger-engines. The coke was made at St. Helen's pit, on the line, and was coked for eight-and-forty hours. The cost was 10*s.* per ton.

In the year ending the 30th of June, 1847, the gross receipts were 113,922*l.* for the Stockton and Darlington, and Bishop Auckland and Weardale Railways.[35] Of this, 16,115*l.* was for passengers, 71,842*l.* for coals, 21,439*l.* for goods, and 3,030*l.* for lime and stone. The number of travellers was 428,514. Of these, it is said, 33,222 were by horse-coaches (showing that some still ran on the line), and 1,840 by coal-trains. Each passenger travels about 6½ miles, and pays about tenpence as a fare. 911,635 tons, or nearly a million of tons of coals are carried, showing how great is the yield of the coal field. The number of tons of goods is 125,883. It may safely be said, that no such number was carried before the railway was opened. The number of tons of lime and stone is 89,540, which likewise shows a great trade, and which is much beyond what it formerly was. The cattle carried are few; 1,878 beasts, 2,121 sheep, and 258 swine. 557*l.* is paid for parcels.

While the works were going on, Stephenson was beset in the "Newcastle Magazine,"[36] by Mr. B. Thompson, of Ayton Banks, who wished to show that locomotive-engines would never pay, and that Stephenson had reckoned wrongly. Thompson said that locomotives were not equal to horses.

He further said, that the breaking of rails at Killingworth was very great, and that horses were used to help the engines on. If steam were to be used, he thought stationary engines better than locomotives.

Mr. B. Thompson was the maker of a new kind of rail,[37] which was tried on the Brunton and Shields Railway, but was not found to answer. It was something like Stephenson's, but the rail was fastened to the chair by a screw bolt.

Nicholas Wood took the side of Stephenson,—said that Thompson's tale about the rails and horses was untrue, and gave other reckonings to show that Thompson had made the cost of the locomotives too much.

This Thompson answered; and a paper war went on, in which Thompson laid against Nicholas Wood, that he had made many mistakes as to horse-power and so forth. Wood seems to have had the better of the fight.

These were among the early writings of Nicholas Wood, and in all likelihood led to the work on railways, written by him in 1825, and in which, as is well known, he held forth that it was wrong to look for a speed of ten miles an hour. Wood does not seem to have had at first a very ready belief in Stephenson, either in this or in the Safety Lamp; but he has lived long enough to find Stephenson in the right, and to be himself the maker of the Brandling Junction Railway, which was mostly done by the means of Robert William Brandling, already named as an old friend of Stephenson, and likewise as the maker of a Safety Lamp. Another great work done by a single hand in the north, is Sunderland-bridge, built in 1790 by Rowland Burdon. This, and the Brandling Junction Railway, show the boldness of the Northumbrians.

Stephenson may be looked upon as one of the makers of Nicholas Wood's book on railways, for he made all that belongs to locomotive-engines, and on the Stockton and Darlington Railway, he had set forth the best way of making railways. This is the first great book on railways, and which set Tredgold writing. Wood gives a report by Stephenson, and acknowledges his help in the experiments to discover the precise amount of resistance opposed to the motion of carriages on railways, and the resistance to different forms of carriages.[38] These, undertaken seven years before, show how careful Wood had been in getting his book up. The book is worth the more, from George Stephenson's share in it.

Wood must have been of great help to Stephenson many other times besides this; and his reading and mathematical knowledge must have stood Stephenson in good stead. It is said[39] that the Rev. William Turner, of Newcastle, was a great helper of Stephenson with books, with instruments, and advice.

As an end to this long tale about the Stockton and Darlington Railway, it may be said that the manager is now Mr. George Stephenson, nephew of the engineer, so that the name is still kept up. It is hoped, however, that some more lasting remembrance of the great man will be set up on this first of his railway works. Mr. Meynell, of Yarm,[40] who laid the first rail at Stockton-on-Tees, is still a director, and should not let his old friend be forgotten.

IX. LOCOMOTIVE FACTORY.

Before 1825 Stephenson laid down the Stockton and Darlington, Hetton and Springwell Railways, and set the locomotive at work on them. He had now two learners under him, his son Robert, born in 1803, and brought up at Newcastle and Edinburgh; and Joseph Locke, born in 1805, at Attercliffe, near Sheffield, and brought up at Barnsley Grammar School. The latter laid out the Springwell tramway, from Springwell to Jarrow,[41] which is said to be a good work.

Both Robert Stephenson and Locke are now members of the House of Commons; the former a Knight of Leopold, and the latter of the Legion of Honour. These were the first offspring of what has since been found a great school of engineering. By

[24] Whishaw's Analysis, p. 280. [25] Whishaw's Analysis, 1837, p. 267.
[26] Whishaw's Railways of Great Britain, p. 415.
[27] Ritchie on Railways, p. 233. [28] Whishaw on Railways.—Ritchie on Railways.
[29] Tuck, Railway Shareholder's Manual, p. 243.
[30] Analysis of Railways, p. 292.—Quarterly Review, vol. 31.
[31] Whishaw on Railways, p. 413. [32] Whishaw on Railways, p. 416.
[33] Whishaw on Railways, p. 418. [34] Whishaw on Railways, p. 422.
[35] Parliamentary Returns, 1848.

[36] Newcastle Magazine. vol. 1.
[37] Ritchie, on Railways, p. 32, where there is a drawing.
[38] Wood, on Railroads, 1st edition, p. 175.
[39] Gateshead Observer. [40] Gateshead Observer, August 19, 1848.
[41] Gateshead Observer, Aug. 19, 1848.

George Stephenson were made the railways of the north-east, by Robert Stephenson those of the south-east, and by Locke those of the west, from Southampton to Glasgow, leaving only one great share for Brunel. Therefore, to the three named do we owe most of our railways. At Birmingham their works meet; and here, some day, will be a fitting seat for some remembrance of the three.

Locke was of great help to George Stephenson, and most in the answer to the report of Walker and Rastrick. After the Liverpool and Manchester was done, Locke undertook works of his own, which was not taken well by Stephenson.

In 1824 there were two great things in George Stephenson's life—the setting up of the Locomotive Factory, and his being named as engineer of the Liverpool and Manchester Railway.

It has been already seen how he became known to the Messrs. Pease, of Darlington; and they set up the factory at Newcastle, for the building of locomotive engines, of which there was now some want. Messrs. Murray, Fenton, and Wood, seem to have been builders of engines then.[42] Mr. Michael Longridge had a share in the new factory; and afterwards Robert Stephenson.[43] It was first known as the factory of George Stephenson and Co., and afterwards of Robert Stephenson and Co. It still flourishes, under the care of Mr. Hutchinson.

The first locomotive used on the Stockton and Darlington Railway was built by George Stephenson, and, we believe, at the Newcastle factory. This was the first locomotive used for drawing passengers on a railway, which it did in 1825, and is said to be still in being. In 1846 it was decked out, and brought forth to head the train at the opening of the Middlesborough and Redcar Railway, so that it has had a busy life for a locomotive. It is a shame to us that there is no English museum for such things, or it might be as proudly kept as we are told that of Cugnot is, in the *Conservatoire des Arts et Métiers*, at Paris.

From the Newcastle factory have been sent forth engines for the old world and the new; and there is hardly a land on the railways of which Stephenson's locomotives will not be found. From his great name, these locomotives were much sought for on the opening of railways abroad, and from them the French, Flemings, and High Dutch learned to make locomotives.

Up to 1840, above two hundred and fifty of these engines had been sent forth, and as the price was then high, it will be seen how much money must have come into the hands of the makers. Whether in railways or in the factory, the Messrs. Pease had no need to sorrow for anything they did with Stephenson; whereas few had anything to do with the other great lights of engineering without making up their minds never to see them again. The lovers of knowledge may overlook the wanderings of great men,—they may look to their heads, and not to their hearts; but when the trust of men of business has been once broken it can never be made whole. The earnings of a good undertaking are a fair ground for doing something greater,—they are looked upon as an earnest; even where there is a loss, it is fairly looked upon; but a breach of trust is never thought of but with sorrow.

The Rocket, the winner of the 500*l.* on the Liverpool and Manchester, was built at Newcastle, and gave a great name to the factory, so that orders poured in from abroad.

Stephenson most prided himself that Brunel had had to make use of his engines. If in anything Stephenson showed a littleness of feeling, it was about Brunel. He was too much given to do as others did about him, to look upon railways and engines as belonging to himself alone, and that no one else had a right to meddle with them. He had so often had to fight for his railways and engines, that he might well have a fondness for them, and think he was made up with them; having, from 1820 to 1830, to meet the utmost opposition, not only from such men as Mr. B. Thompson and Mr. Francis Giles,[44] but likewise of such as Mr. James Walker, and Mr. J. U. Rastrick. Forgetting that he himself was the follower of Trevithick, Jessop, and Chapman,—the helpmate of James, Birkenshaw, Booth, and others, he could not bear coolly anything which was not of his school. He never forgave Brunel for taking another gauge, although the narrow gauge was not set up by himself, but found by him already set up. In the speech at Tamworth this soreness breaks out strongly, and he gives way to very coarse words. He said of the atmospheric railway, that he had never been to look on it, "because I consider it humbug from beginning to end......But it is not the only humbug. The broad gauge is another misconception, as erroneous as the system of the atmospheric railway, only they have got my engines to carry them through." If we wished to draw George Stephenson as anything but what he was in truth, we should be very glad to leave out all this, for it shows an utter want of right feeling, and an utter forgetfulness of his own early life. The atmospheric railway or the broad gauge were as well worth trying as the two-cylinder locomotive or tubular boiler; they held forth something which might be done, and it is yet to be seen whether they are so far behind as Stephenson says. The locomotive was twenty years old before Stephenson got it to draw passengers on the Stockton and Darlington; and it has not yet received its full might, after four-and-forty years since it was first set going by Trevithick.

At the Trent Valley opening there was no call for this show of ill-feeling on the behalf of Stephenson, which makes it the worse. He goes on to say, "The Great Western Railway began with engines differing as much as possible from mine. They put the boiler on one carriage and the engine on another; they had the wheels ten feet in diameter, and were determined to go one hundred miles an hour; but what became of these engines? They required porters to help them out of the station, and they were obliged to call the North Star, which I had sent them from Newcastle, to carry on the train, and though it wanted rest, it was obliged to go out again, and do the duty for which Mr. Brunel's large engine was incapable."

George Stephenson had in all likelihood stood by the Wylam tramway when Trevithick's locomotive was helped on by men; and he might have owned, that if Brunel made up his mind to have a speed of one hundred miles an hour, he got it in the end. Whatever Stephenson might choose to say, England owes much to Brunel for spurring on Stephenson; for had it not been for the Great Western we should never have got the great speed which we now have. Brunel fought against the Stephensons, and they against him; and in the end, we have higher speed and cheaper working.

In "Whishaw's Railways of Great Britain" will be found a list of all the locomotives in 1839, and in it are many of Stephenson's, some as old as 1830, which were still at work. There was one on the Bolton and Leigh, and two on the Liverpool and Manchester. Of the year 1831, there was one on the Liverpool and Manchester, and some on American railways. Of 1832, three on the Liverpool and Manchester.

(To be continued.)

[42] Newcastle Magazine, Vol. I. [43] Gateshead Observer, Aug. 19, 1848.
[44] Whishaw's Railways of Great Britain.

THE STRENGTH OF HUNGERFORD BRIDGE.

The paper, by Mr. Homersham Cox, on the "Strength of Hungerford Bridge," which appeared in the part of the *Civil Engineer and Architect's Journal* for October (p. 292), has no doubt been read with interest and with pleasure. The neat application which he makes of the doctrine of moments to the statical conditions of the bridge, cannot fail to gratify every professional reader. He gives sound reasons, too, why the subject is at this moment of the highest practical importance. His calculations exhibit the power in the chains of the bridge to support a certain weight, with all necessary accuracy, it may be admitted;* but, as one part of the question—namely, the load which it is probable will ever be brought upon the structure—claims a wider consideration than he has given to it, and affects the conclusion he has drawn—that "if 9 tons per square inch be the utmost strain which the metal will safely bear, no margin is left for security against the effects of rapid motion"—it is hoped that some further inquiry into that part may result in advantage.

Mr. Cox computes the greatest gross load which the suspension chains can support, without exceeding a strain of 9 tons per square inch of iron, as equivalent to a weight of 1,576 tons uniformly distributed, and exerting a tension of 2,664 tons. He adds, that "this is in fact the load to which the bridge is actually liable to be subjected .... The weight of the chains (715 tons), added to that of the platform, parapet, rods, &c., and a crowd covering the platform with a weight of 100 lb. per square foot, gives, according to Mr. Cowper, the maximum load at about 1,500 tons."

The sentence quoted embraces the point which needs examination.

* In fact, the tension at the lowest point of a catenary is (Poisson, in "Barlow on Strength of Materials," p. 800) T = ½ *suspended weight* × cotan c; the chains, suspension rods, platform, and load making the weight, and c being the angle at the point of suspension, formed by the horizontal chord with the tangent to the curve.

If the curve is considered as a parabola, this becomes $T = \frac{Ws}{8d}$, s being the span or chord line, and d the deflection; an expression identical with that given by Mr. Cox. But the suspension chains do not form an exact curve; their figure is a polygon, of which the angles have their loci in a parabola, according to the conditions assumed; and a change in the form of calculation follows in consequence, without however any difference in the result which is worth notice here.

Referring to the *Journal* for June, 1845 (vol. VIII., p. 165), there would appear to be an accidental error, in calling the weight of the chains 715 tons: the links of those suspended between the piers, which alone enter into the calculation, are stated by Mr. Cooper to weigh only 352 tons. It is to be regretted, that in the extract given from that gentleman's paper, read before the Royal Institution, all mention of the remaining weights which constitute the permanent load, as well as the particulars which would facilitate an approximation, are omitted.

Mr. Cowper appears to exhibit the figures, 296 × 5 = 1480 tons; and these are cited by Mr. Cox, in round numbers, as "about 1,500 tons." But there is this very serious difference between what it seems probable the former meant to convey by them, and the interpretation given to them by the latter—that Mr. Cowper would appear to have calculated upon a tension of 5 tons per square inch as the greatest that could be thrown upon the chains by the heaviest possible accidental load of 100 lb. per square foot of platform, added to the permanent load of chains, rods, &c., which tension would amount in all to 1,480 tons;—whereas Mr. Cox has called this the value of the load itself from which the tension arises.

If Mr. Cox has misinterpreted Mr. Cowper, his conclusion as to the present critical state of Hungerford Bridge fails instantaneously. If Mr. Cowper's meaning has been mistaken here, what remains to be said will be less forcibly applicable to that great structure as maintaining its sufficiency of strength, but will remain to invite some notice as a general question.

No explanation is given in the *Journal* to show why Mr. Cowper adopted a tension of 5 tons per square inch, as the greatest that would probably arise; and it is desirable to analyse his process of calculation, as far as the imperfect data which are on the instant accessible will permit.

Such an amount of tension would be the effect of a gross load of 875 tons, uniformly distributed, and supported by the chains between the piers. It would be made up of

Weight of chains	... ...	352 tons
" load	... ...	398 "
Estimated weight of platform	... ...	100 "
" " suspension rods	...	25 "
Total	...	875 tons.

There may be inaccuracy in the estimate of the two last items: it cannot, however, be very material, and the meagre means at command admit of no more certain result.

The principal question now for investigation is, whether it be possible that the bridge is liable to a load of 100 lb. per square foot from the assembly of a crowd of persons on the platform.

This will be answered when we ascertain how many persons can be crowded into a given space, and what the aggregate weight of that number of persons may amount to.

It is well known to military men, that, taking the average of large bodies of infantry when close packed, each man covers with his own person a space of 20 × 15 = 300 square inches. We should therefore find 0·48 men in a square foot.

Mr. James Walker, who, by direction of government, investigated the circumstances connected with the fall of the suspension bridge at Yarmouth, in May, 1845, stated in evidence before the coroner, that he calculated the weight of people, "packed *en masse* upon the bridge," at six persons per square yard, consisting chiefly of women, and children under 14 years of age, each person being of the fair average weight of 7 stone; which, he adds, might be a *large* average, but one adopted by him, partly because it has been frequently employed before. This would give $\frac{2}{3}$ of an individual belonging to such a description of persons, as chiefly women, and children under 14 years of age, for each square foot; and, following Mr. Walker's average of weight, it would amount to 65 lb. per square foot.

Herr Von Mitis, who constructed the steel suspension bridge across the Danube at Vienna, computed its probable load as arising from the occupation of a square fathom (of Vienna) by 15 men, each weighing 115 Vienna pounds. Hence, per unit of one square foot English, we should have 0·39 men, and 54·9 lb.

Drury, in his work on Suspension Bridges, lays down an arbitrary standard of 2 square feet per man weighing 10 stone. This, per square foot, is equivalent to 0·5 men, and a weight of 70 lb.

It is familiar information, that in France the conditions imposed by government on the constructors of suspension bridges, require that, before the public is admitted to the use of any such bridge, the chains shall undergo the proof of carrying for 24 hours, an imposed load of 200 kilogrammes per square metre of platform in addition to the weight of chains, rods, platform, &c. This is equal to 41 lb. per square foot. The rigour of this condition is modified, too, in practice, by permitting the use of the bridge, subject to special police regulations, for six months after its completion, if proof to the extent of one-half this weight has been satisfactorily made; but at the end of that time, proof to the full weight of 200 kilogrammes per square metre must take place.

The *concessionnaire* is required also to maintain the bridge in good order, which shall be done by the authorities, at his expense, in case of neglect. Annual surveys of the works take place; and the Prefect may order a fresh proof to be made whenever any ground for fear arises, as to the stability of the bridge, or as to the safety of using it.

With respect to the average weight of a number of persons assembled accidentally, we may form some precise judgment, with assistance from the researches of Quetelet, published in his "Treatise on Man," in which he gives a table of the average weights and sizes of men and women at different periods of life,—sufficient for our purpose being found in the following extract.

Age. Years.	Males. Kilogrammes	Females. Kilogrammes		
5	15·77	14·36	means	Male, 61·53 lb. avoird.
10	24·52	23·52		Female, 57·50 "
15	43·63	40·37		
20	60·06	52·28	"	Male, 135·59 "
25	62·93	53·28		Female, 116·33 "
30	63·65	54·33	"	Male, 140·21 "
40	63·67	55·23		Female, 121·8 "
50	63·46	56·16		

To apply this table,—

From military experience, and assuming the age of soldiers to range between 20 and 50, we should get a weight per square foot, arising from a packed crowd, thus—

$$0{\cdot}48 \times 137{\cdot}9 = 66{\cdot}19 \text{ lb.}$$

According to Mr. Walker's estimate of the number of persons on the Yarmouth Bridge, there would be a weight per square foot of $\frac{2}{3} \times 89{\cdot}29 = 59{\cdot}53$ lb.

Taking the estimate of Herr Von Mitis, as to numbers, the weight per square foot would be $0{\cdot}39 \times 137{\cdot}9 = 53{\cdot}78$ lb.

And, upon the arbitrary standard of Mr. Drury, that weight would be $0{\cdot}5 \times 137{\cdot}9 = 68{\cdot}9$ lb.

By bringing all our results together, the conclusion to be derived from them will be more obvious:—

Mr. Walker's estimate of weight per square foot is		65 lb.
Herr Von Mitis "	"	55
Drury "	"	70
Proof load by French Government	"	41
A packed body of Infantry	"	66
From the numbers on Yarmouth Bridge		60
" " as per Von Mitis	"	54
" " as per Drury	"	69
The average of the whole would be	"	60

But suppose we adopt that number which is derived from facts apparently the best ascertained—viz., 66 lb. per square foot—does it not seem to be inadmissible that an increase of 50 per cent. should be made to it when we are about to calculate what margin may be left for contingencies, in the strength of a material member of a suspension bridge? If this be so, let us revise the estimate of strain when shorn of so considerable an excess.

The distance between centre and centre of piers being taken at 676½ feet, the length of platform supported by the chains would appear (from the application of a scale to the plates given in the *Journal* for June, 1845,) to be

$$676\tfrac{1}{2} - 29\tfrac{1}{2} - 13 = 634 \text{ feet.}$$

Hence, straining-weight of	platform would be	98	tons
" "	load "	261·5	"
" "	suspension rods	25	"
" "	chains would be	352	"
	Total ...	737	tons.

Equivalent to a tension of 4·2 tons per square inch on the lowest part of the suspension chains.

Before pronouncing any judgment on the sufficiency of the Hungerford Bridge, it would be requisite to know what weights the suspension rods, the timbers, and the planking of the platform are capable of sustaining. Indeed, it it not impossible that in the latter we might find a limit which would act as a safety-valve for other parts of the structure. At all events, we should not forget that dense crowds of persons generate a lateral pressure, such as the parapet railing of a suspension bridge is usually unequal to resist. And the inference might be fairly drawn, that indications of danger would be testified by less-important members of this bridge than its suspension chains, before fears need be entertained of their being unequal to their purpose.

The conclusions we arrive at are these:—

1st. That when the bridge is fully loaded, the strain on the suspension chains is $4\frac{1}{2}$ tons per square inch, or in the most extreme case 5 tons per square inch,—being one-half the strain under which iron is considered to be perfectly safe, and reserving one-half its power to meet contingencies.

2nd. That 66 lb. per square foot of platform is sufficient allowance in estimating the weight of an accidental crowd of persons upon suspension bridges.

October 30*th*, 1848. J. H.

[The above letter having been referred to the writer of the "Notes on Engineering," he appends the following note:—

The researches of "J. H." seem to prove satisfactorily that the weight of Hungerford Bridge has been over-estimated in the paper (*ante* p. 292, Oct. 1848) on the strength of that structure. In collecting the data of that paper, considerable pains were taken to reconcile the apparently contradictory accounts of the weight of the bridge, given in the extract (vol. VIII., p. 165.) from Mr. Cowper's paper, which contains the following words:—"We have therefore, for the weight the bridge will actually bear, $296 \times 17\frac{1}{2}$ tons = 5,180 tons, while 296×5 tons = 1,480 tons *is the greatest load that can be actually put upon it.*"—Was it not natural to infer from this, that Mr. Cowper had ascertained that the weight which the main chains would have to sustain was 1,480 tons?

However, the above letter shows that the words just quoted are not the statement of an ascertained fact, but probably the inference from some theoretical computations not given. The main chains of the central span consist of 1,280 links, of which each weighs $5\frac{1}{2}$ cwt., and therefore the whole together 352 tons. This item, however, does not include the weight of the coupling-bolts, pins, and suspension plates: with respect to these, and the weight of the platform and parapet, which are massive and strengthened by iron stays, we have no data. There are certainly no *authentic* grounds for objection to the estimate of "J. H.," but in the absence of more certain information, the following seems a legitimate mode of estimating the total weight of the structure. Mr. Cowper remarks, that "the entire weight of the chain, platform, and full load upon it would make a load of about 1,000 tons on each pier." This gives 2,000 tons total weight of the whole bridge; and as the centre span is one-half the total length of the structure, it appears safe to assume that the whole weight of the centre span, platform, and load is 1,000 tons. This would make the horizontal tension per square inch at the centre of the main chain = 6 tons.

It must be remarked, that the words, "the present critical state of Hungerford Bridge," are used by "J. H." on his own authority, and are *not* to be found in the "Notes of Engineering." It was not said, nor suggested in them, that Hungerford Bridge was in a "critical condition;" all that was asserted was that which admits of strict proof—that, assuming certain apparently accurate data for the weight and dimensions of the structure, the metal was subject to a tension of 9 tons per square inch. It now, however, appears that the data themselves were incorrect, and that the tension is consequently less; but even the greater amount would by some practical men be deemed within the limits of security. The error in question, which, respecting a point of fact, is not, however, to be regretted, as it has occasioned an inquiry and revision, of which the results are by their near agreement recommended to general confidence. Another benefit of the discussion has been, that it has elicited on one side a display of interesting and extensive research which, it is to be hoped, will be renewed in other investigations of that important class of which the above letter indicates the familiar study.]

The "Taman."—On Monday, the 13th ult., this iron steamer was launched from the works of Messrs. Robinson and Russell, at Millwall. She is 175 feet long, 26 feet beam, and is to have engines of 180-horse power. Her lines are by Mr. Ditchburn, and the hull is very smoothly finished. The *Taman* is built for the Russian government, to be employed on the Black Sea. She is to be handsomely fitted by Messrs. Paul. On the next slip is an iron steamer for the Nabob Nazim, one of the mediatized princes of India. She is to go fourteen miles an hour on the Ganges, and is to be used by the nabob in his hunting trips. This shows the progress of European luxury in the East, as the *Taman* proves that English skill is not yet surpassed on the freezing shores of the Black Sea. The nabob's steamer will make the seventh built by Messrs. Robinson for the Ganges. An iron steamboat for the Humber is to be laid down on the slip of the *Taman*.

CONTRIBUTIONS TO RAILWAY STATISTICS,

IN 1846, 1847, AND 1848.—By HYDE CLARKE, Esq.

(Concluded from page 338.)

(Concluded from page 338.)

No. XXIV.—MISCELLANEOUS GOODS.

Among other articles enumerated in the returns, are furniture and vitriol.

In the year ending 30th June, 1846, there was carried on the Manchester and Bolton, 256 tons of furniture; on the South-Western, 325 tons (half-year); and on the Brighton, 2,923 tons. The receipts were, Manchester and Bolton 128*l*.; and Brighton 4,687*l*.

In the year ending 30th June, 1847, there was carried on the Brighton Railway 4,669 tons, the receipts for which were 6,660*l*.

The carriage of furniture is now considerable, the railway being preferred to the canal for long distances. The rates per ton per mile are high. On the Manchester and Bolton the rate is 12*d*.; on the London and South-Western, 7·26*d*.; and on the London and Brighton, 7·49*d*.

Vitriol is carried on the Newcastle and Carlisle Railway. In the year ending 30th June, 1846, 17 tons, bringing 11*l*.; and in 1847, 62 tons, bringing 39*l*. Vitriol is classed as dangerous, and the rate for carrying it is $6\frac{3}{4}d$. per ton per mile.

No. XXV.—GOODS.

The gross tonnage of goods in the years ending 30th June, 1844, 1845, 1846, and 1847, is as follows, including every description of traffic:—

	1844 Tons.	1845 Tons.	1846 Tons.	1847 Tons.
Arbroath and Forfar	45,866	59,844	61,000	70,344
Ardrossan	45,678	67,385	118,642	*77,461
Ballochney	337,894	377,007	381,299	485,995
" Monkland	969,058	1,146,812	1,199,270	1,213,285
" Slamannan	60,705	64,236	77,301	97,057
Bodmin and Wadebridge	27,825	20,376	22,220	30,177
Caledonian (Garnkirk)	214,037	297,714	398,598	534,554
Chester and Birkenhead	3,842	6,912	7,060	11,198
Cockermouth and Workington ..	—	—	—	*2,633
Dublin and Drogheda	—	4,688	21,817	18,196
Dundee and Arbroath	16,484	21,484	21,059	22,355
" and Newtyle	29,715	34,743	47,654	31,282
Dunfermline and Charlestown ..	26,596	33,622	32,082	31,800
Eastern Counties (Cambridge) ..	28,866	44,572	110,349	236,463
" " (Colchester) ..	20,348	31,669	47,231	83,364
" " (Norfolk) .	—	5,009	*36,854	114,096
Eastern Union	—	—	—	28,632
" " (Ipswich and Bury) ..	—	—	—	*31,207
East Lancashire	—	—	—	*7,283
Edinburgh and Glasgow (Wilsontown)	—	—	54,653	62,818
Fleetwood and W. Riding (Longridge)	—	—	—	†36,000
Furness	—	—	—	110,095
Glasgow and Greenock	108,000	79,418	83,606	98,297
Glasgow and Ayr	86,253	168,376	293,304	397,615
Great Southern and Western ..	—	—	—	11,187
Great Western	129,283	209,563	†390,000	374,398
Kendal and Windermere	—	—	—	5,346
Leeds & Thirsk (Stockton & Hartlepool)	26,173	†50,000	51,036	23,542
" " (Clarence) ..	—	†300,000	551,513	566,699
Lancaster and Preston	22,222	26,099	25,585	49,054
" and Carlisle	—	—	—	*24,044
Lancashire and Yorkshire	379,934	503,618	522,177	597,262
" (Manchester and Bolton) ..	121,875	149,245	160,139	*85,754
" (Preston and Wyre) ..	—	43,060	64,749	†80,000
Llanelly and Llandilio	96,886	92,675	106,841	95,181
London and North-Western ..	—	—	—	—
" (London and Birmingham)	154,839	211,590	370,008	1,177,453
" (Grand Junction) ..	232,880	332,761	920,387	*233,527
" (Liverpool and Manchester)	300,043	349,633	—	—
" (Bolton and Leigh) ..	82,184	84,679	*43,854	—
" (Manchester and Birmingm.)	84,935	130,344	293,741	—
London and Blackwall	17,515	23,161	20,406	25,071
" and Brighton	41,652	65,747	93,407	186,930
" and Croydon	3,978	9,802	12,174	—
" and South-Western ..	71,153	93,525	110,640	148,415
Londonderry and Enniskillen ..	—	—	—	*1,352
Manchester and Sheffield	81,678	†82,000	†67,678	218,740
Maryport and Carlisle	106,885	128,731	167,046	204,678
Midland	131,916	715,267	909,895	1,196,177
" (Birmingham and Derby) ..	87,939	—	—	—
" (North Midland) ..	394,360	—	—	—
" (Leicester and Swannington)	154,788	197,447	213,329	—
" (Birmingham and Glo'ster)..	58,687	*59,963	—	—
" (Bristol and Glo'ster) ..	*9,016	—	—	—
" (Bristol and Birmingham) ..	—	97,702	210,404	254,038
Newcastle and Carlisle	†270,000	†280,000	†340,000	†390,000
North British (Edinburgh and Dalkeith)	106,534	109,828	105,351	64,978
North Union	261,928	413,256	490,460	548,813
" (Bolton and Preston) ..	*16,850	—	—	—
South-Eastern	†30,000	88,801	116,384	204,102
" (Canterbury and Whitstable)	30,000	36,000	—	—
Scotch Midland (Newtyle and C. Angus)	8,925	9,506	11,007	12,284
St. Helen's and Runcorn	219,738	257,816	284,060	292,505
Stockton and Darlington	†1,000,000	†1,000,000	1,044,070	1,127,058
Shrewsbury and Chester	—	—	—	*16,661
South Devon	—	—	—	*1,176
Taff Vale	254,472	442,991	426,357	479,189
Ulster	—	—	—	63,673
West Cornwall (Hayle)	—	66,871	69,530	78,004

	1844 Tons.	1845 Tons.	1846 Tons.	1847 Tons.
Whitehaven	——	——	*3,811	18,613
Wishaw and Coltness	428,777	610,136	697,472	924,424
York and North Midland	187,667	851,022	878,414	446,181
" " (Hull and Selby) ..	162,938	227,869	226,101	——
" " (Whitby and Pickering)	25,198	86,101	*9,378	——
York and Newcastle	——	——	——	1,847,689
" " (Gt. North of England)	180,156	234,198	433,867	——
" " (Newcastle & Darlington)	——	268,080	787,347	——
" " (Newcastle & N. Shields)	21,034	26,936	88,830	46,600
" " (Durham & Sunderland)	568,849	412,523	444,961	——
" " (Pontop & S. Shields)	625,651	719,733	818,378	——
" " (Hartlepool) ..	662,637	824,824	922,822	812,306

* Half-year. † Estimated Amount.

The total tonnage in each year was as follows:—

1844	1845	1846	1847
9,823,533	12,522,976	15,871,179	16,699,382

The following shows the distribution of the traffic in 1847, in tons:—

Coals and Coke	8,900,000
Ironstone	600,000
Iron	300,000
Iron Dross	110,000
Copper and Tin	23,000
Limestone and Lime ..	300,000
Building Stones	600,000
Sand	37,000
Ballast	36,000
Bricks and Tiles	5,000
Miscellaneous Minerals ..	300,000
Fish	43,000
Grain	300,000
Provisions	400,000
Manure	40,000
Goods, Timber, and Sundries ..	4,705,382
Total ..	16,699,382 tons

To show how small this traffic is relatively to the total carried, the following items in the consumption of the people of this island, in tons, may be noted:—

Corn	3,000,000
Potatoes	3,000,000
Sugar	300,000
Tea, Coffee, and Tobacco ..	50,000
Malt	400,000
Spirits	100,000
Paper	40,000
Soap	90,000
Candles	100,000
Cotton Goods	250,000
Woollens	100,000
Linens	100,000
Iron	1,600,000
Glass	40,000
Coals	30,000,000
Salt	650,000
Timber	2,000,000
Total ..	41,720,000 tons

This enumeration of 41,720,000 tons is under the mark, and only gives the total consumption of this island, reckoning the articles as only carried one way, and not including many articles of agricultural produce,—manures, leather (60,000), fish, stone, lead, copper, earthenware, oil (60,000), fruits, &c.; bark, 50,000; dye-stuffs, 70,000; hemp, 50,000; cabinet woods, 30,000; rice, 20,000; tar, 20,000; turpentine, 20,000; &c. The railways at present do not carry more than a fourth of the traffic of the country, if so much.

The largest tonnages in 1847 were the following:—

York and Newcastle ..	2,706,595
Ballochney	1,746,339
Midland	1,449,215
London and North-Western ..	1,411,080
Stockton and Darlington ..	1,127,058
Wishaw and Coltness ..	924,424
Lancashire and Yorkshire ..	763,016
Leeds and Thirsk	610,235
North Union	548,813

The total receipts for minerals and goods in 1847 were 2,600,000*l.*, of which for minerals 750,000*l.*

No. XXVI.—AVERAGE RATE AND MILEAGE.

It is of some importance for engineers to know the average distance that each class of produce is carried, and the average receipt, which are far below what is believed.

Passengers.—The average mileage of all the passengers in 1847 was 16 miles,* and the average receipt 2*s.* The average receipt on the London and North-Western is 4*s.*; Great Western, 4*s.* 9*d.*; Midland, 2*s.* 7*d.*; South-Eastern, 1*s.* 6*d.*; Brighton, 2*s.* 4*d.*; Eastern Counties, 3*s.*; South-Western, 3*s.*; and Lancashire and Yorkshire, 1*s.* 4*d.*

Beasts.—The average receipt for beasts on the London and North-Western is 42*d.*, miles 57; Eastern Counties, 68*d.*, miles 75; Great Western, 34*d.*, miles 45.

Sheep.—London and North-Western, 10*d.* 70 miles; Eastern Counties, 9*d.* 75 miles; Great Western, 10*d.* 66 miles.

Swine.—London and North-Western, 18*d.* 120 miles; Eastern Counties, 6*d.* 58 miles; Great Western, 12*d.* 75 miles.

Coals.—York and Newcastle, 16*d.*; Stockton and Darlington, 18*d.*; Midland, 27*d.*; London and North-Western, 20*d.*

Ironstone.—Ballochney, 9*d.*; Taff Vale, 28*d.*, 25 miles.

Limestone and Lime.—Midland, 22*d.*; Newcastle and Carlisle, 20*d.* 16 miles; York and North Midland, 14*d.* 9 miles.

Building Stone.—York and North Midland, 24*d.* 24 miles; Midland, 20*d.*; Newcastle and Carlisle, 22*d.*

Sand.—Bodmin and Wadebridge, 24*d.* 8 miles.

Fish.—York and Newcastle, 21*s.* 50 miles; Norfolk, 13*s.* 68 miles Whitby and Pickering, 9*s.* 25 miles.

Parcels.—Average of enumerated lines, 3·9*d.*

Horses.—Average of all lines, 16*s.*—*Carriages*, ditto, 25*s.*

No. XXVII.—HORSE TRAFFIC.

The total number of horses carried in 1847 was 99,405, and the total receipts 80,216*l.*

The greatest horse traffics are the following:—

	Horses.	£.
London and North-Western ..	27,715	22,890
Great Western	11,785	12,788
Midland	12,373	11,794
Eastern Counties	8,155	6,084
Brighton	6,558	4,901
York and North Midland ..	5,813	2,613
South-Western	5,447	4,335
South-Eastern	3,782	3,576
York and Newcastle ..	3,456	——

The charge for horses per mile is, London and North-Western, 3*d.*; Great Western, 5·4*d.*; Midland, 4·25*d.*; Eastern Counties, 3·6*d.*

Many day-tickets are taken out for horses on the London and North-Western and other lines, by persons going out hunting.

No. XXVIII.—CARRIAGE TRAFFIC.

The total number of carriages in 1847 was 41,135, and the total receipts 51,733*l.* The greatest traffics are as follows:—

	Carriages.	£.
London and North-Western ..	8,790	12,785
Great Western	5,842	9,452
Midland	4,775	6,892
Eastern Counties	3,266	3,747
Brighton	3,040	3,220
South-Western	2,904	3,285
South-Eastern	2,458	4,520

The average charge per mile is, on the London and North-Western, 4*d.*; on the Great Western and Midland, 6*d.*

No. XXIX.—DOG TRAFFIC.

Dogs are enumerated only in a few returns. The average rate per mile is ½*d.* The number carried in 1847 on the South Devon line was 1,086, 34*l.*; on the Maryport and Carlisle 336, 51*l.*; and on the Whitehaven, 230.

No. XXX.—CARRYING-STOCK.

The following is an enumeration of the carrying-stock of the London and North-Western Railway in 1848, suitable for special traffic:—Horse boxes, 210 (horses carried, 27,715); carriage trucks, 217 (carried 8,790); bullion vans, 9; post offices, 8; ditto tenders, 13; milk trucks (north division), 2; convict van, 1; cattle wagons, 495 (cattle, 161,171); sheep wagons, 117 (sheep carried, 399,998); coal wagons, 653 (440,000 tons); timber trucks, 12; powder magazines, 4; iron trolleys, 4.

No. XXXI.—MANCHESTER AND SHEFFIELD.

The following, communicated by the kindness of Mr. Meadows, secretary of the company, gives some particulars as to the traffic of the Manchester, Sheffield, and Lincolnshire Railway:—

* See a valuable paper by Mr. Wyndham Harding, read before the British Association, at Swansea, and since re-published.

Analysis of Merchandise Traffic.

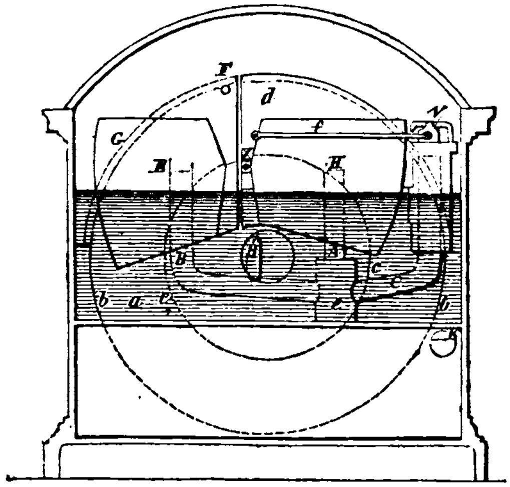
Date.	Coal.	Stone.	Sheffield Goods.	Flour and Grain.	General Goods.	Total.
1848.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
March	12,334	6,176	1,791	1,159	5,550	27,010
April	9,689	7,530	1,884	1,618	4,698	25,419
May	8,673	8,561	2,262	2,663	5,443	27,602
Total ..	30,696	22,267	5,937	5,440	15,691	80,031

REGISTER OF NEW PATENTS.

GAS-METERS.

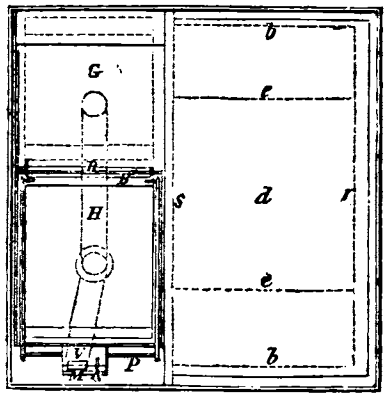
Samuel Clegg, of 24, Regent-square, London, civil engineer, for "*certain improvements in gas-meters.*"—Granted April 20; Enrolled October 20, 1848.

The patentee claims, in this invention, the dividing of the gas which passes through a meter into two or more portions, and ascertaining the whole quantity by measuring a part when under pressure, instead of measuring all the gas which passes through the meter. Another portion of the invention claimed as new, is the making of the inner circle of the drum of a water-meter water-tight, that being in water it may be buoyant, and prevent the weight of the drum from pressing upon the axis. The principle on which the first part of this invention depends, is the well known law, that the discharges of the same fluid through different openings at the same pressure are proportional to the areas of the openings. The arrangement of the apparatus is as follows:—The measuring-drum of a wet meter consists of a hollow concentric ring and cover.



The drum, revolving upon an axis in water, is divided into compartments so arranged that, as the gas enters, it shall in succession fill all the chambers, and be discharged measured. The inner circle *c*, *c*, of the drum is made water-tight, so that when the meter is filled to a certain level with water, the drum is buoyed up, and would nearly float if otherwise unsupported; consequently, there is little or no friction upon the axis. The gas from the service enters the meter-case through the pipe K, and after passing a valve,—which, when the meter is sufficiently filled with water, is opened by a float in the usual way,—is divided into two streams, and flows through the pipes C and B′, the latter stream being the one measured, and is discharged so measured from the drum-cover by the pipe P, through the opening N. Now this discharge being known, the quantity of gas that passes through the other opening M, is known also, and the sum of the two discharges is marked on the face of an index arranged in the usual way.

To equalise the pressure, the following apparatus is used: E and H, are two hollow vessels connected with one another at their lower parts, open at the bottom, sealed by water, and free to vibrate about a common centre X; V is a slide, covering the two openings M and N, attached to the hood H, in such a manner that, as it rises or falls, it shall move the slide V, and open or close these openings. The pipes A and B, lead into these vessels or hoods, and the gas discharged into them is of the same pressure as that which flows into the meter; so that, if the regulating-hoods were of the same weight, and at equal distances on each side of the centre X, they would balance each other. Over the hood E, is fixed immoveably another and larger vessel G, open at the bottom and sealed by water, having communication with the drum of the meter, or rather with the drum-cover at F. The openings M and N, adjusted by the movement of the hood H, are by its descent partially closed, and the pressure of the gas flowing through them is reduced by so much as exists between the gas flowing into the meter-drum through the pipe B′, or the initial pressure,—or that between the interior or exterior surfaces of the hood E, viz., one-tenth; so that the gas now flows through both openings, M and N, with the same relative velocities, the discharges being in proportion to their areas.



Supposing that the measuring-drum required a pressure of two-tenths head of water to work it, and that the initial pressure was four-tenths, the pressure in the cover of the drum and in the fixed hood G, will then be two-tenths. The gas will issue from the opening N, with a pressure also of two-tenths; and the differences of pressure between the interior of the hoods E and H, and the exterior of the hood E, being two-tenths, the hood H, will have a descending power of two-tenths, and thus the velocities with which the gas issues through M and N, will be equalised; and so for any other pressure. The same principle of measurement may be applied to dry meters.

TUBULAR FLUES.

Thomas Potts, of Birmingham, brass tube maker, for "*improvements in the manufacture of tubular flues of locomotive and other steam-boilers.*"—Granted April 10; Enrolled October 10, 1848.

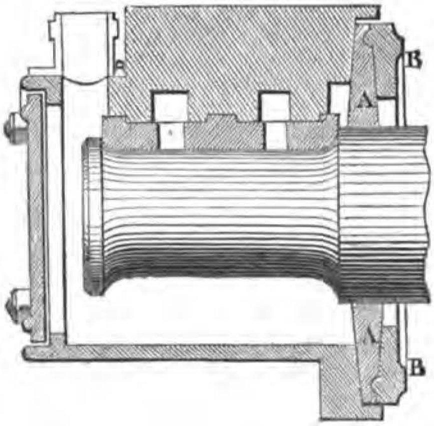
The object of this invention is to protect the flues of boilers, by lining them with a composition resembling that used for brazing. In forming this material, ten ounces of refined tin are added to a hundredweight of "bath metal," which is composed of two parts of foreign zinc and three parts of good copper. This compound metal is rolled and formed into a tubular shape of the size required; after which, the tubes are annealed and stretched, so as to straighten them and bring the edges correctly together. On each of these tubes is placed a tube formed of copper or an alloy of copper; and the compound tube is put on to a steel mandril, made with a taper of about one-sixteenth of an inch into its whole length, which not only facilitates the withdrawal of the mandril, but also gives additional thickness to that end of the tubular flue which is to be fixed to the fire-box of the steam-boiler. The compound tubes, each having a mandril within them, are then drawn through draw-plates. It is not necessary to solder together the edges of the inner tube, as it will be sufficiently strong without. The lining should be made twice as thick as the outer tube.

The patentee claims the use of a lining of such a preparation of metal, for lining tubular flues of copper and of copper alloyed; the object being to obtain a lining of metal which shall be less prejudicially acted on by the passage of sharp grit from the fire, than if the whole tube were made of copper or of copper alloyed.

AXLE-BOXES AND JOURNALS.

William John Normanville, of Park Village, Middlesex, gentleman, for "*certain improvements in railway or other carriages, partly consisting of new modes of constructing the axle-boxes and journals of wheels; also an improved method of lubricating the said journals or other portions of machinery, by the introduction of aqueous, alkaline, oleaginous, or saponaceous solutions.*"—Granted May 2; Enrolled November 2, 1848.

The claims of the patentee do not correspond in length with that of the title of the invention, as they are simply for a peculiar combination of various elastic and other materials with the axle-box and journal, for the purpose of rendering the lubrication of the journals of railway-wheels and other moving parts of machinery more perfect; and, secondly, for arrangements for enclosing the lubricator within a vessel, which shall contain it and exclude the dirt. In carrying into effect the first part of the invention, as regards the axle-boxes of railway-carriages, a shield or collar of vulcanised india-rubber, or other suitable elastic substance, is made of the form shown in the engraving, marked A, A, and attached to the axle-box at its outer edge. This shield is perforated in its centre; such perforation being cut to a perfectly smooth surface, to allow the passage of the journal through it. The perforation is made of less diameter than the diameter of the journal, and by the tendency of the material of which the shield is made to collapse, it presses so closely to the journal, that an air-tight joint is maintained.



The diameter of the perforation in the shield for a four-inch axle should be three inches and five-eighths, the outer diameter of the shield should be one-eighth of an inch less than the disc of the axle-box into which it is to fit, and it will then be found to completely fill it. After having been stretched over the axle, the shield tapers from its centre to its outer edge. For the protection of the elastic shield, and behind it, is placed a thin cast-iron or other metal shield B (secured to the axle-box by four bolts) which being more or less tightened, presses upon the outer periphery of the elastic shield and occasions pressure as required to maintain the joint upon the axle. In adjusting this box upon the journal, no more compression should be put upon the outer diameter of the elastic shield than is necessary to make an air-tight joint, otherwise there would be considerable risk of the shield firing, before it could become properly lubricated. When by continued wear the air-tight joint can be no longer maintained, a loose ring of india-rubber, of the same diameter as the axle, and about a quarter of an inch in thickness, may be placed upon the axle. The original shield, whose orifice has become enlarged by wear, is then stretched upon this ring, and by its contractile force clasps it so tightly, that a perfect joint is maintained between the two surfaces of the india-rubber, while the axle revolves within the inner or loose ring; and the operation of tightening by the means of the four bolts is repeated as required. Or by another modification of this arrangement, a metal ring is introduced in contact with the axle, using the contractile force of the india-rubber shield to keep the ring in close contact with the polished axle. These axle-boxes should be filled with a saponaceous grease in a semi-fluid state, so that it may flow towards the shield, and lubricate it without delay. The top of the axle is of a circular form, with a lid furnished with a small air-hole screwed thereon, and effectually closing the box. The grease is introduced through the aperture whenever required.

MANUFACTURE OF WHEELS.

John Ashbury, of Openshaw, near Manchester, for "*certain improvements in the construction and manufacture of wheels for use upon railways and common roads, and in the methods of preparing and constructing the tyres used thereon.*"—Granted March, 11; Enrolled September 11, 1848.

Fig. 1, in the annexed woodcuts is a side elevation and a longitudinal section, showing the first part of the patentee's invention.

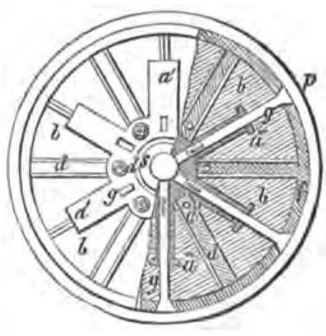


Fig. 1.

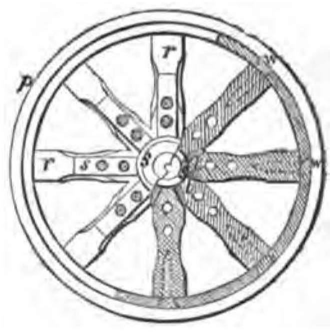


Fig. 2.

The nave *a* is made of cast-iron, and presents the same appearance on each side of the wheel, having six projecting-arms a^1, a^1, with sufficient space between them transversely to admit of the insertion of the wooden pieces *b*, *b*. They are also divided in the same direction by the radial plates a^2, a^2, while the circumferential portions a^3, a^3, are of equal breadth and extend transversely between them in the recess thus formed. On each side of the radial plates a^1, a^2, are placed one of the wooden pieces *b*, *b*, one side of each of which is prepared so as to abut upon the radial plates a^2, a^2, and being furnished with a notch, by which the projections of the circumferential plates a^3, a^3, are cleared, they impinge upon each other radially, till they reach the periphery of the wheel; all lateral action being prevented by dowels, inserted between them. The opposite sides of the pieces *b*, *b*, diverge slightly from the radial line; and between them the wooden wedges *d*, *d*, which are prepared to a corresponding angle, are inserted, and driven on towards the nave. The pieces *b*, *b*, are brought firmly into contact with the radial plates a^2, a^2, their escape outwardly being prevented by the plates a^3, a^3. When these wedges are driven up, they are secured to the nave by the bolts d^1, d^1, passing through them transversely, any lateral motion between them and the pieces *b*, *b*, being prevented by metal tongues. The wheel then appears like a disc of wood with an iron nave; and in this state it is placed in a lathe, and the periphery trimmed and turned to the required diameter. A wheel thus constructed, although without a tyre, could suffer no dismemberment until the removal of the bolts. The methods which the patentee employs for securing the tyres to the wheel, form the third and fourth series of improvements. The tyre *f* upon this wheel is slightly convex upon its inner circumference, and when it has been put upon the wheel in a heated state, and allowed to contract in cooling, this convexity enables it to assume and retain a more effectual hold upon the wooden portion of the periphery, than if its inner circumference were a flat surface of the ordinary kind. The tyre is secured to the nave *a* by means of the bolts *g*, *g*.

Fig. 2, is a front elevation and longitudinal section, illustrating the method of constructing the wheel according to another improvement. *p* is the tyre, furnished with two inner flanges p^1, p^2, the space between which is equal to the thickness of the spokes *r*, *r*, transversely: this tyre, it must be understood, is laid down cold, and the spokes are then arranged in order within it, their motion laterally being prevented by flanges at a short distance from the point of abutment of the spokes. Upon the nave *s* they converge on each side in lines radiating to the centre of the wheel, or to some centre determined by practice as the most suitable, but in either case sufficiently to admit of the insertion of the wedges *t*, *t*, between them. These wedges are driven up by a tapering mandril and by other mandrils of increasing diameter successively until the effectual contact of the spokes with the inner circumference of the tyre and with the wedges is effected. The wheel is then placed in a lathe, and the ends of the spokes and wedges prepared for the reception of the nave, which may be of cast or wrought-iron. The nave is made in two equal parts, consisting of as many arms s^1, s^1, as there are wooden spokes to the wheel; while the boss, or that part of each which is inserted in the wheel transversely, is made slightly tapering towards the other: the lugs or projections s°, s^{2}, which correspond with the number of wedges t, t, are made equally tapering, the heads of the wedges being cut away to receive them, and the recesses thus formed in the boss impinging upon the ends of the spokes. Whenever the bolts which secure the two portions of the nave with each other and to the spokes, are screwed up by the nuts, their action upon the surfaces of the boss of each portion of the nave causes the wedges to be driven up further between the spokes r, r, which are also brought into more effectual contact with the inner circumference of the tyre, as a small space is left between the two portions of the nave in the middle of the wheel. In this wheel the tyre is shown attached by jagged spikes, one of which is driven into each spoke.

The next improvement consists of a cast-iron wheel; the nave from which the arms radiate, and the inner or cast-iron tyre, is formed in the usual manner, the outer tyre being made of wrought-iron. The arms of the wheel have a hollow opening or slot, extending from the inner tyre to the nave; down this opening the bolts which secure the outer tyre to the wheel, pass, and are held by cotters driven transversely through the nave, under the first series of improvements. One great advantage of this method is, that as the outer tyre becomes loose by continual wear, it can be tightened and held fast to the wheel by merely driving up the cotters, without involving the necessity of re-tyring the wheel; and this applies equally to wooden as to iron wheels. The fifth part of the improvements refers to a method of preparing, dressing, and finishing the outer surface of tyres for railway wheels, by grinding them with hard stone, instead of dressing them in the lathe in the ordinary manner.

HEATING AND VENTILATION.

John Brittern, of Birmingham, machinist, for "*certain improvements in heating, lighting, ventilating, and closing and screwing the doors of apartments; also in lighting and ventilating carriages; parts of which improvements are applicable to other like purposes.*"—Granted April 20; Enrolled October 20, 1848.

This specification is so comprehensive, that we can only notice the principal objects which the invention is intended to accomplish. In the first place, the patentee claims a mode of closing fire-places or stoves with ground glass, introduced like panels into the iron frame. The door is placed in front of the fire, and is not hinged to the frame of the stove in the usual manner, but rests upon a sliding damper below the bottom of the fire; thus by withdrawing the damper, the door is also withdrawn at the same time for the admission of air to the fire. The door is kept close to the frame at the top by means of a weighted latch. The second part of the invention relates to the ventilating of apartments. This the patentee proposes to do by closing up the fire-place by a door, and supplying the fire with air by means of a pipe from the top of the room. The pipe conveying the air is divided into two branches, one of which delivers the air above the fire directly into the chimney, and the other delivers it below the fire to aid the combustion of the fuel: it is provided with a valve or damper, by which the intensity of the fire can be regulated as required. Another part of the invention consists of a candle-guard to prevent candles from guttering. It is formed by a cap, which is placed upon the top of the candle, the upper part of the cap forming a ring round the melted part of the tallow, and, as the candle burns away, the cap descends with it by its own weight. Improvements in the windows of carriages are comprised in this specification: the improvements proposed consisting in having the windows to open outwards with hinges, like French windows of houses; and a projecting roof to the carriage is proposed, for the purpose of avoiding drafts. The hinges and locks of doors come next within the scope of the patentee's improvements. Among other alterations, he proposes to place the common arm-spring on the opposite side of the door to that on which it is usually placed. The two last parts of the invention relate to the latches and locks of doors. The patentee describes a variety of methods of effecting the lifting of the latch or other fastenings of doors, by simply pulling the door-knob on one side of the door, or by pushing in on the other. The pin or rod connecting the two knobs is so connected by levers or other apparatus to the latch or bolt, that any motion given to it will lift the latch. The last part consists in a mode of locking locks without the aid of the opening key. It consists in forming the pins upon the tumblers bevelled on one side, so that by simply pushing forward the bolt, by means of a small lever attached to a handle, the pins will be raised from their respective notches by their peculiar shape, and thus allow the bolt to pass; but the vertical faces of the pins fully lock the bolt, and prevent its being forced back without the key.

ROTARY STEAM-ENGINE.

Isaiah Davies, of Birmingham, engineer, for "*improvements in steam-engines and locomotive-carriages; parts of which are also applicable to other machinery.*"—Granted May 2; Enrolled November 2, 1848.

The improvements in steam-engines comprised in this specification have chiefly reference to rotary-engines, and to a new kind of stuffing-box adapted to the shafts of such engines, for the purpose of keeping them steam-tight, where the shafts pass through the curves, with little friction. The patentee uses a metallic packing, which consists of several segments, the larger set of which are adapted to the size of the box, and are furnished with a flange piece projecting inwards so as to fit the shaft; while the inner set of segments are placed within, so as to rest on this flange piece: the whole are prevented turning by two fixed ribs running parallel with the shaft. These segments are cut so as to leave about one-eighth of an inch between the ends, and are placed so as to "break joint," as it is technically termed. The whole are forced up by spiral springs, placed in recesses cast in the box: the steam has access to the back, and also acts as a spring thereto. Metal discs are placed above and below this packing, and the whole is secured in the usual manner. Another improvement consists in fitting the piston of rotary-engines to the shaft, by means of three feathers let into the shaft, instead of keying it fast. This is to prevent the piston turning on the shaft, and at the same time to admit of any slight end-movement consequent on its application as a motive-power, without giving rise to a great amount of friction, which would otherwise be produced in the cylinder. Another part of the invention consists in working the expansive-valves of steam-engines by a double-acting cam, so that by moving a lever, which changes the position of the different connections, the steam is cut off at a different point of the stroke.

The mode of connecting the engine in locomotive-carriages to the driving-wheels forms another part of the patentee's claims. The engine is placed midway between the wheels, within the framing. The axle projecting through has a suitable crank affixed at each end; these being connected by the rods to similar cranks on the driving-axle, describing a circle of the proper radius from the centre. According to the ordinary method of constructing these carriages, (the engine being a fixture to the framing, and the driving-axle moving vertically in the axle-guards or gabs), the distance of the centres must be increased or diminished, as the points are nearer or farther from a straight line: to prevent which, the patentee constructs the axle-guards in portions of circles, struck from the centres of the engine-shaft and crank-pin; consequently the axle-boxes are kept at the same distance, whatever may be the rise and fall of the framing on the driving-axles.

LAYING-DOWN OF RAILS.

Lewis Dunbar Brodie Gordon, of Abingdon-street, Westminster, for "*an improvement or improvements in railways.*"—Granted May 9; Enrolled November 9, 1848.

The patentee puts in five claims for improvements in the construction of railways. The first is for forming the ends of rails in such manner that the end of one shall rest upon the end of the next. Second, the adaptation of thin malleable plate-iron to form the sleepers for supporting the rails, combined with a mode of fastening the chairs to the sleepers. Third, a mode of supporting the ends of adjoining rails by a trough or girder. Fourth, a mode of fastening the rails in the chairs. And lastly, a mode of preparing the keys of railway-chairs.

The first of these improvements consists in forming the ends of the abutting rails in such manner, that the end of one of them shall rest upon the other; the end of one rail being cut so that, when laid in the chair, it shall rest as well upon the end of the rail as upon the chair. In the second improvement, the patentee states his mode of forming the sleeper as follows. The chair is cast upon the sleeper. A plate of iron of about 15 or 16 inches in width, and of from one-sixth to one-fourth of an inch in thickness, is then to be bent in the direction of its breadth into a circular curve, having a radius of from about 30 to 36 inches as most desirable. The moulds for the chairs are placed in the fonndry in the exact relative position to each other that they should occupy when permanently laid, and upon them is placed the bent plate, with the convex side downwards to the moulds. The cast-iron is then run into the moulds, and in such manner as to imbed in the metal of the chair itself a portion of the curved plate; the cast metal being of about the thickness of half an inch upon the upper side of the plate. Thus will the chair be securely cast upon the curved plate, and firmly fixed without any bolts or pins. In carrying into effect the third improvement, upon the sides of the chairs are projecting pieces or ledges, upon which the girder is placed. The one shown by the patentee in his drawings, is of a trough-shape, that is, it passes along beneath the rail to be supported, and also along the sides, so as effectually to support the rail. The mode of fastening the rails to the chair is effected by means of a screwed bolt passing through one of the cheeks of the chairs, and through a nut; it is screwed through the nut, and not through the chair, the nut fitting into a recess on the inside of the cheek to receive it, and prevent it from turning when the pin is screwed up. In the fifth improvement, for the mode of preparing the wood keys, the patentee proceeds thus. He makes a varnish by combining with any of the drying oils red lead, in the proportion of about $\frac{1}{16}$ to $\frac{1}{20}$ of the latter: these are to be subjected to heat for several hours, and while at the temperature of about 450° Fahrenheit, the wood keys are immersed therein, and the wood becomes thoroughly impregnated, so as to withstand the tendency of the dryness or moisture of the atmosphere to effect its bulk.

MEASURING WATER.

Edward Haigh, of Wakefield, plumber, and manager of the Wakefield Waterworks Company, for "*an invention for measuring water or any other fluid.*"—Granted May 9; Enrolled November 9, 1848.

This invention for measuring water or other liquids, consists of a wheel or drum, divided vertically by a partition, which contains on each side three measuring chambers. Above the drum is a "preparatory cistern," into which the liquid flows from two feed-pipes, and which is divided into four parts. The water flows from this cistern in two streams into one of the measuring chambers on either side of the partition alternately; so that while one chamber is filling, the liquid flows through the machine: but the gauge-cocks and other parts of the machine being so nicely adjusted, and its being made to register twice as much as is actually measured, no error it is stated can occur. This drum is mounted on a horizontal spindle, and carries at one end a toothed wheel which gears into a toothed pinion, and communicates its revolving motion to an ordinary indicating apparatus as usual. On the periphery of the vertical partition are six projecting pins (equal to the number of measuring chambers), which catch against and rest upon the extremity of a tumbling lever, which is weighted at the other end by a ball; so that when the weight of the water in the measuring chamber exceeds that of the regulator, it gives way, allows the pin to fall, the chamber to turn, and the water consequently to flow out. The patentee claims—"An apparatus or machine consisting of a 'preparatory cistern' in connection with a drum or wheel containing two sets of measuring chambers, into which the water flows alternately from openings in the 'preparatory cistern,' and made to revolve by the liquid; and also the employment of the tumbling-lever, or regulator, as before described.

MANUFACTURE OF IRON.

Charles Attwood, of Wolsingham, Durham, Esq., for a "*certain improvement or improvements in the manufacture of iron.*"—Granted April 18; Enrolled October 18, 1848.

The object of this invention is to obtain a better reduction of small pieces of the ore which at present run through the coke, &c. to the bottom of the furnace, without having come sufficiently in contact with the limestone and other substances usually mixed with the ore in blast-furnaces. The small pieces of ore to be operated on are mixed with a bituminous coal, which will agglutinate in the process of coking, in the proportion of about one-fourth of the weight of the coal. The mass so mixed is afterwards coked in the ordinary way of coking coal for smelting purposes, and the ore becomes involved in the body of the coke, by which it is retained, till freed, by the subsequent process of smelting. Ore so combined cannot fall through the blast furnace faster than the coke with which it is combined; it will therefore have abundance of time to combine with carbon to the required extent, before it reaches the bottom of the furnace. With regard to the size of the particles of ore that will be benefited by such treatment, anything from the size of a hen's egg or large walnut, down to the smallest particles of dust, it will be proper to subject to such combination with coal previous to coking; but anything materially larger, it would be nnnecessary to subject to such treatment, as it becomes properly reduced in the ordinary method of smelting iron.

The patentee finds that coke formed of the kind of coal found in Durham and Northumberland will, after having been coked and combined with one quarter of its weight of ore, bear a burden of ore, in the ordinary manner of charging the blast furnace, equal to the same weight of coke without such combination of iron ore; it therefore becomes improved to a very considerable degree, independently of the advantage derived from a proper reduction of the smaller particles of ore effected by this process.

SELF-ACTING SAFETY-VALVE.

Edward Walmsley, of Heaton Norris, Lancashire, cotton spinner, for "*certain improved apparatus for preventing the explosion of steam-boilers.*"—Granted April 27; Enrolled October 27, 1848.

This invention is chiefly applicable to low-pressure boilers, the safety-valves of which are lifted, when the pressure becomes too great, by a weight of water forced out of the boiler and acting at the end of a lever.

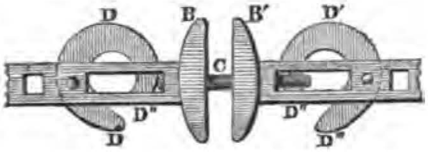
This apparatus consists of a vertical tube, containing a column of water, which may be the ordinary feed-head. In this the water is sustained at a certain height, according to the pressure of the steam. A little higher than the surface of the water is placed a horizontal branch-pipe, leading to a descending-tube, down which the water flows when forced over by any undue pressure in the boiler. Immediately under the descending pipe is placed a small circular pan with a bottom slightly conical, suspended on the end of a long lever. This lever forms a continuation of the safety-valve lever from the fulcrum in an opposite direction to the weighted end, and is so adjusted, that when the pressure of the steam is at the proper height, it will be nearly in equilibrium, the preponderance being slightly in favour of the weighted end of the lever. When the pressure becomes too high, the water column will be elevated so as to run down the pipe, and will be caught in the pan. This additional weight of water causes that end of the lever to preponderate, which will immediately descend, thereby raising the safety-valve. The pan is furnished with a small valve in the bottom, having a short stem projecting through, so that on completing its descent this pin comes in contact with the bottom of a receiver, thus raising the valve and allowing the water to flow out. The steam in the mean time having been reduced to its ordinary pressure, the whole assumes its original position.

A second improvement consists of an apparatus for opening a valve in a channel leading into the fire-place, directly above the dead plate. The cover of this channel is connected with the opposite end of a lever from which the float is suspended. In the event of the water falling below the proper level in the boiler, the float will consequently sink, thereby causing the opposite end of the lever to remove the cover from the air-channel, and allow a current of cold air to pass through the fire. The same principle is scarcely applicable to high-pressure boilers, because the column of water would require to be inconveniently high. To obviate this difficulty, the patentee employs only a short length of vertical tube, through which however the water does not rise until the safety-valve has been raised by the pressure of the steam; the weight of water being in this case only a supplemental assistant in opening the valve farther after it has been raised by the steam-pressure.

COUPLING IRONS.

Daniel Rice Pratt, of Worcester, United States of America, for "*machinery for connecting railway carriages.*"—Granted April 27; Enrolled October 27, 1848.

This specification describes a mode of constructing what the patentee calls a self-acting coupling, for connecting together railway carriages. The object to be effected by the use of it is, that when two carriages to which it is applied are brought together, end to end, the coupling connects and secures itself. It is formed of a moveable and peculiarly-shaped hook, to which the draw-link attaches itself. It is represented in the annexed figure,

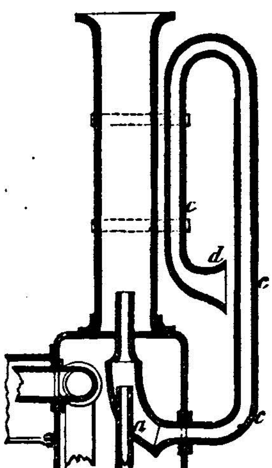


A, A′, being the two ends of the draw-bars of two separate carriages. The ends of the draw-bars are provided with the concave buffing-plate B, B′; a hole passes through the centre of each buffing-plate and into the ends of the draw-bars, through which passes the coupling-link C. Hooks D, D′, are jointed to the draw-bars by fulcrum-pins, upon which the hooks are at liberty to move. They are of the peculiar shape shown, and the ends so formed, that when the end of the coupling-link passes through the hole into the interior of the draw-bar, it comes against the end hook D″, and thereby raises it sufficiently to allow the end of the coupling-link to pass under the end of it; so soon, however, as the end of the link has thus passed, it comes in contact with the other end D‴ of the hook, and depresses it, and also the other end D″ takes hold of the link and retains it fast. The hook may be released by means of a cord or chain attached to the upper part of it being pulled, and thereby raised. The patentee states, his improvement may be attached to all descriptions of railway carriages, whether with or without spring-buffers and draw-rods; and he claims the hook, in conjunction with the coupling-link described.—*Patent Journal.*

THE BLAST OF ENGINE-FURNACES.

Eugene Ablon, of Panton-street, Haymarket, for "*improvements in increasing the draft in chimneys of locomotive and other engines.*"—Granted April 8; Enrolled October 8, 1848.

The object of this invention is to produce a steady draft or blast in the furnaces of locomotive engines more particularly, by causing a quantity of atmospheric air to be drawn into the chimney by the action of the escape-steam. In the annexed woodcut,

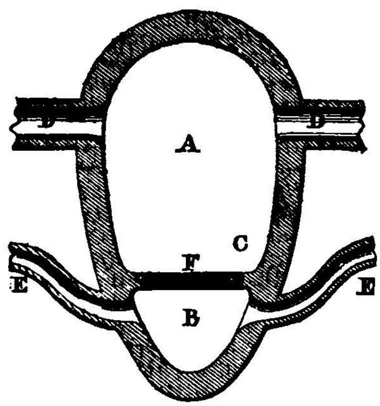


c c, c, represents the form of the pipe by which the air is admitted into the chimney, the mouth *d* being enlarged for the entrance of the air. The following are the proportions of the pipe, to which considerable importance is attached by the patentee:—The opening of the escape-pipe being circular, to ascertain its surface and its diameter it is necessary to measure the size of one of the cylinders of the engines of the locomotive in cubic inches, and by deducting the cube of the piston (measured in the same way) the number of cubical inches remaining being divided by three hundred and ninety-four, the quotient of that division will indicate the number of square inches that the opening of the escape-pipe should have. The diameter of the opening of the escape-pipe is to the diameter of the cylindrical part as four is to five. The height *b′, b″*, of that cylindrical part is equal to five times the diameter *b′, d″*. The diameter b^1, d^1, of the part H^a, is to the diameter of the part *e, e,* as five is to seven, and its height b, d^1, is equal to the diameter *b, b,* of the opening of the escape-pipe K. The locomotive-engine being put into motion, the steam from the boiler passes through the escape-pipe *a*, and produces in it a powerful suction of air, which flows into that pipe through its mouth *d*; and its acquired speed, it is stated, remains in it constant on account of its inertia, and although the action of the escape of steam be intermittent. Then a powerful current of air mixed with steam escapes in the chimney, and produces a powerful uninterrupted draft. The pipe through which the air passes may be arranged in any other form around the chimney, and may enter into the smoke-box by one of its lateral sides instead of entering by the front. The patentee claims the mode of arranging apparatus whereby currents of steam and air are brought to act together in the chimneys of locomotive and other engines, so as to accelerate the draft therein.

IMPROVEMENTS IN SEWERS.

Design for a Diaphragm Double Sewer, for separating or combining House-drainage and Surface-drainage.—Registered by W. B. Moffatt, Esq., of Spring-gardens.

The annexed engraving represents a design for a main sewer, the novelty of which consists in forming it in two separate chambers, the upper or larger portion A forming a subway for means of access to the lower sewer B, and house-drains E, E, and also for the passage of surface-water from inlets D, D. It may also be used for electric telegraph, gas, or water pipes, so as to prevent the breaking up of the pavement. A tube may also be inserted above the level of the inlet D, for placing service-water or gas-pipes to houses, &c.



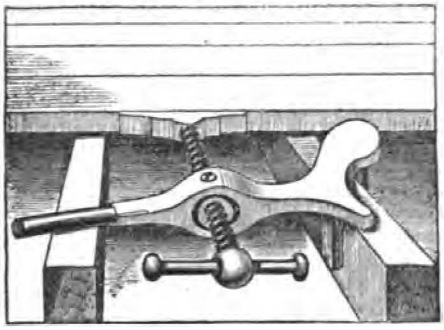
The engraving represents a transverse vertical section of a sewer constructed on the principle described, showing the diaphragm and trap.

A, the subway. B, the main sewer, which is separated by the diaphragm C. This diaphragm is continued throughout the entire length of the sewer, but has inserted at intervals a moveable trap F, which may be raised for cleaning the house-drains and main sewer, if required, and may be used for flushing with surface water. E, E, inlet for house-drainage. D, D, inlet for surface-drainage.

Protection has been obtained for the diaphragm C, and trap F, which, together with the separate passages A, B, are new, as applied in the manner herein shown.—*Patent Journal.*

JOINTING CLAMP.

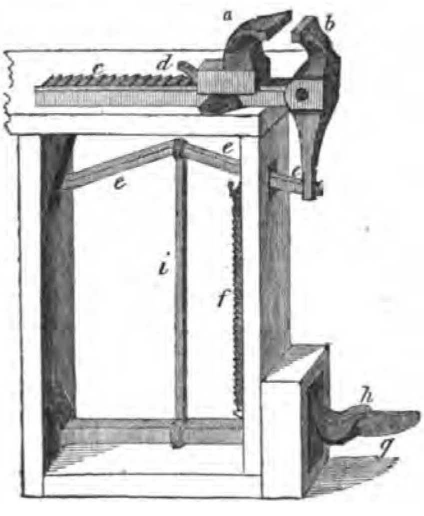
Jointing and Compressing Screw Cramp.—Patented by Mr. James Kimberley, of Inge-street, Birmingham.



The accompanying engraving fully explains the nature of an ingenious clamp, to be applied for jointing of floors, &c. Its construction is extremely simple, and its power great, and it can be easily fixed and removed. It is applicable in all cases where two bodies require a fixity and perfect union, and in the laying of floors it compresses the boards very gradually and truly together. It does not require the workman to rise off his knees when using it (as in all former ones) to effect a leverage, one progressive and uninterrupted motion only being wanted; moreover, it can be left, with its full pressure upon its work when necessary, unattended, and with perfect safety. Amongst builders, shipwrights, coachmakers, and others, a cramp to improve upon the ponderous and tedious action of the present kinds in use, has been an object long looked for, and the one described appears to be an invention which will prove a great auxiliary to the working department of every one engaged in the above pursuits,—as multiplying power, reducing labour, and increasing dispatch. It is contrived in but few parts, and breakage or derangement appears impossible. The cost of the instrument is two guineas.

NEW LEVER VICE.

The accompanying cut and description will explain the principle of a new lever vice, patented by Messrs. J. Peck and L. Pardee, of the United States. The following qualities, it is claimed, give it a decided superiority over all over vices:—



Greater strength than any other vice of equal weight possesses. Greater power, and so applied as to save, in work requiring frequent changes, at least one hour in ten, as it is worked entirely by the foot, without the necessity of laying down a file, or other tool, or without any use of the hand, whatever. It can be changed to receive work from one-sixteenth of an inch, to eight or ten inches in width, as easily and as quickly as any other vice can be moved one-fourth of an inch. And heavy work, requiring both hands to lift, can be easily placed in the vice, without calling the assistance of a second man; it will soon pay for itself in saving of time. It is much easier for the labourer, the strain upon the breast in turning up a screw is entirely avoided, and the vice can be closely approached without being obliged to bend the body over the end of the screw, as in other vices. When the vice is forced up, it becomes more firmly attached to the bench than any other vice can be, rendering the whole much more solid, which in chipping, and other heavy work, is very desirable.

a, sliding jaw. *b*, jointed, or swinging jaw. *c*, rail on which the sliding jaw moves. *d*, click which catches in ratchet on rail *c*, and holds the sliding jaw firmly where placed. *e*, jointed lever (elbow joint), which turns on pins *e e*, and is attached to prong of rail *c*, and the lower end of the swinging jaw. *g*, foot-lever with joint attached to leg of bench, and connected by rod *i* with jointed lever. *h*, click which catches in ratchet at the foot of the forward bench leg, and holds the jaws firmly as forced up by the combined levers; it is easily tripped with the foot. *f* is a spiral spring which lifts the foot-lever, and throws open the jaw.

THE GREAT AMALGAMATION.

The great amalgamation of the three companies, the London and North-Western Railway, the Great Western Railway, and the South-Western Railway, is attracting the attention not only of railway men, but of the public at large. Considered as an amalgamation of fifty millions of capital, it is certainly the largest financial operation of the kind yet effected. The capital of the Bank of England is not a third part of that of the Great Amalgamation; the union of the two East India Companies, which resulted in that which now exists, was not equal in importance; the South Sea Company did not propose to touch so large an amount of capital. Abroad no example is to be found of a private enterprise so great. Yet, considered in its individual features, the measure does not bear that unprecedented character. The annexation of the Great Western to the London and North-Western, is not greater than the annexation of the Grand Junction to the London and Birmingham; and the annexation of the South-Western is of still less importance. It is therefore the aggregate to be constituted which gives character to the measure.

To hold forth any certain views with regard to the course likely to be followed by the managers of this system of policy is in so far futile, as it is by no means sure that they have a design of ultimately carrying it out in good faith. When we consider what temporary objects the proposition of such a plan is calculated to serve, regardless of its execution, it is prudent to hesitate before we assume too hastily how it will be carried out. If we recollect that there is no compulsion on one of the chief members of the league (namely, the Great Western,) to amalgamate; if we recollect that a purposed contest has been long carried on, and has ended in the achievement of the objects by the party last-named; when we consider the ambition of their views, and the indisposition of the London and North-Western shareholders towards them, we must feel how uncertain is it, so far as the parties themselves are concerned, whether they will persevere,—and still more uncertain, whether they will be allowed by the legislature, in opposition to the public voice and interests, to carry out the measure in the form in which the several boards may settle it with each other.

It happens (not unexpectedly to those who know anything of the parties) that the avowed object of this league is to raise fares, and constitute a monopoly; and no time could be more unluckily chosen for the promotion of such designs. Three years ago, the high-fare party were beaten by the conclusive evidence of facts, and forced to give way to a policy which gained neither their conviction nor their sympathies. And as they have ever since been on the look-out for the opportunity of reverting to their old course, the moment a decline took place in railway dividends, it was instantly asserted that it was owing to the lower fares and increased accommodation: and the directors, seconded by the sympathies of shareholders of their own school, have lost no time in doing away with the day-tickets, raising the fares, and diminishing the number of trains,—and this is but the beginning.

It has not been asked, what were the reasons which led to the adoption of the low-fare system,—it is quite forgotten that it was the experience of its success which was the cause of its adoption; and some inquiry it would be thought might be made, before its abandonment was determined on. At any rate, while the country was in its ordinary state, the low-fare system was fully competent to give good dividends; and it is therefore quite groundless to assert that it has ceased to be able to do so, or that it is the cause of lower dividends. No one ever supposed or asserted that that system was competent to give a maximum dividend, irrespective of all other causes; and still less that the low-fare system, or the high-fare system, or any system, could give the same amount of dividend, in defiance of the depression resulting from the greatest financial and political crisis which the world has yet seen,—and (if we take into account the failure of the grain, potato, cotton, sugar, and other crops, and the prevalence of cholera, influenza) and the greatest physical crisis.

If we were to sit down and estimate before-hand what would be the results of such a crisis, we surely could not be surprised at a falling off of dividends from ten to seven per cent.; and if we had a fore-knowledge of such a crisis, we should be able to decide that there must be a falling-off in the business of the country, such as after-knowledge proves. This is a truism: and it is perfectly idle to charge the diminution of revenue on the fare system. That there has been a diminution consequent on the opening of a great number of branches, we believe; but that is to a great extent a necessary evil, and is temporary in its operation; at all events, the public are not to suffer. Those gentlemen who were very anxious for "calves" and new shares in 1845, and who pocketed the premiums upon them, are not to turn round in 1848, and make the public pay, because their branches are not yet yielding the full ten per cent. At the same time we believe, as said in some letters in the *Morning Herald* on "Railway Legislation and Railway Administration,"* that the uniform fares have pressed heavily on some of the branch lines; for with a new and undeveloped traffic, an absolutely low-fare is of no good; because it has no effect in diverting the old traffic on to the line of railway, and which time is the chief agent in effecting. A reduction in fares will stimulate a traffic already existing, but has not such great effect in diverting traffic from accustomed routes, and in overcoming the prejudices of old women and obstinate men. The remedy proposed for this is a practical one; and that is, to give the Railway Board the power of allowing alterations in the tariffs of fares beneficial to the companies and to the public. The writer just named has pointed out that, so far from fares being raised, they might, if the companies had the power, be beneficially lowered to many of the great towns and places of chief resort; whereby the revenues of the companies would be much increased. A Railway Board, to be good for anything, should have the power of mitigating those regulations which press harshly on the publicand the companies: and, as the writer in question has shown, there is great room for the exercise of such discretionary functions in the case of amalgamations, loans, new stations, fares, preference shares, and many minor arrangements for which the expense and delay of an act of parliament is now needlessly required.

If, every time there is a commercial panic, the business and energies of the country are to be still further depressed by the railways putting the screw on to the means of conveyance, the public will find the need of ridding themselves of such an oppression; and an additional argument will be furnished for taking railways into the hands of the government.

Altogether, the policy of abridging the public accommodation is as odious as it is unprofitable, but it is held by a certain school who are amongst the worst enemies the railway system has ever had. Mr. Glyn has always advocated monopoly, high fares, and government meddling; and his brother chairmen have much the same views. They have already met severe rebuffs in the narrow policy to which they are attached; but in the present instance failure is sure to attend them, whether successful or unsuccessful in carrying a bill through parliament. The public are fully aware of the motives on which it is founded; and either a bill will be granted, accompanied by such stipulations as permanently to reduce the income of the companies, or free competition in railways will be allowed, the result of which will be, at an early date, a cheap line betweeu London and Birmingham. One railway man already talks of a line at £5,000 per mile; and it is practicable. In either case the expectations of the shareholders will be greviously deceived; and therefore we say, failure must result.

Mr. Glyn is himself one of the authors of the present difficulties, for it was he who advocated the limitation of dividends to ten per cent., and its enactment by the legislature; a measure uncalled for and injudicious, for while it did not propitiate those who objected to railway profits, it trammelled the companies. While there are famines and panics, traffic must fluctuate,—and therefore profits must fluctuate. While the object is to declare a maximum dividend of ten per cent., there are no means of forming a reserve to equalize the dividends; but, were there no restriction, profits above ten per cent. would be reserved to keep up the dividends in unfavourable years. This is now rendered impossible, whereby very great hardships are inflicted on railway shareholders. The least that should have been given is an average ten per cent. from the time of opening.

The railway system is yet in its infancy; and nothing can be more unwise than the constant efforts to shackle it and to cramp it; and the more directors attempt to do so, the more they peril the existence of the undertakings to which they belong. Interested and prejudiced parties may choose to assert that nothing more can be done; but whoever looks at the history of the last twenty years will never dare to tie himself down to any such conditions. It is the very result of improvement, that it allows further improvements to be made. It would never answer to make a machine for half a dozen pins; but when thousands are wanted machines are set up. A great traffic makes expensive engines cheap; a high speed authorises those means which were before unthought of. After all, dare any one say that engines cannot be made lighter, rails cheaper, bridges and viaducts of readier construction, and gradients of greater inclination? The claimants to effect these things—nay, who are now doing them,—are already at the doors; the minds of thousands of ingenious men are at work in inventing new and cheaper modes of traction; the resources of science ared aily becoming greater; and, since light and electricity have been enlisted among the servants of man, a new impulse has been given to the applications of art.

The demand for a monopoly forcibly recalls all the evils of our present system of legislation on public works. The Morisonian and Doctrinaire calls out for a government system of railways, and relies on the Amalgamationists to prove his case: those who advocate freedom in public works equally profit by the same circumstances. Conviction is gaining ground, even among the railway press, who have hitherto been staunch advocates of the old companies, and opposed the introduction of new ones. *Herapath's Journal** very well points out, that in the district of the Great Amalgamation there is room for thrice or four-fold the number of railways. And urges that the monopolists will neither make them themselves nor allow others to make them. It should be added, neither will the government make them, should it get hold of the railways; and thus the progress of the country in its struggle with manufacturing and commercial rivals may be irretrievably impeded; for if we stand still, other countries will not; and as it is, we are already too much fettered. Nothing short of freedom in the construction of public works can secure us against high charges or inadequate accommodation; and let us have but that freedom, and the Great Amalgamation may be allowed to charge whatever fares they like. It is not true that competition in railways cannot exist: the question has never been carefully discussed; for the railway parties who have discussed it have thought themselves bound to monopoly. Till the poorer classes of this country can be conveyed on suitable terms, we shall not have reached the limits of fair accommodation; and we want thousands of miles of railway to do this. In another part of this journal it is shown that the traffic of the existing railways is but a fraction of the whole traffic of the country: indeed, the extension of the means of economical conveyance is most urgent.

When the Amalgamation Bill comes to be discussed in parliament, it is very likely its supporters may be little inclined to go on with it. Their strength in the House of Commons is great; but the exposure of the discussion will of itself be a severe shock, while the possible political operations are menacing. To a large party in the house a tempting opportunity is offered, of gratifying the people at the expense of the shareholders: cheap travelling will save the members from putting taxation on a fair basis, or giving the people a share in the government. The Cheap Travelling Bill will be the measure of the session; members may look their constituents in the face, and say they have done something; and the character of the Do-nothing Parliament will be retrieved. The temptation to the government is very sore: financial reforms deprive them of patronage in the customs, dockyards, and excise; and taking possession of the Great Railway Amalgamation will give them compensation, without alarming the opponents of patronage and prerogative, and to the gratification of those who think that the government should have legitimate means of securing a majority. Neither Whigs nor Tories can withstand such a chance, in which both have an interest,—one contingent, the other immediate.

* Letters by "Observer," Tewkesbury, October, 1848.

* Nov. 18.

The catastrophe of a government-purchase Mr. Glyn may anticipate, and may have laid this trap to effect, for he has always been a consistent supporter of such a course; but these are rather dangerous times in which to try such strokes of policy. If a sop must be given to the people, railways will be sacrificed here, as in France the provisional government proposed they should be, under the amiable desire to gratify the people at the expense of anybody. And English capitalists have already much suffered, although the whole measure has not been carried out.

The position of the Great Western Railway under its shrewd leader, Mr. Saunders, is the great element in the problem. He has succeeded in getting the means of coercing the London and North-Western after hard fighting; and he is not likely now to rate peace so highly as to give up for it the fruits of victory, which offer themselves to his hands. What, too, is to be done with the broad gauge? After all the service it has done to the public, is it to be set aside? What compensation are the Great Western to get for their varied claims? These are all questions to be solved, and to be solved satisfactorily in a pecuniary sense, or it is very certain amalgamation will not go on. Mr. Saunders has fought to get something, and he will have it.

Mr. Glyn's motives in bringing about the amalgamation are appreciable. He effected that with the Grand Junction—he stayed the dissension: and to carry out a further amalgamation, and to appease a most dangerous competition are still greater measures. Can he pay the price? His shareholders have for years been plied with the most rancorous insinuations by the narrow-gauge advocates; and will they in this day accede to those terms, without which the Great Western will not give up their vantage-ground. The South-Western directors and shareholders are glad to snap at anything; but the Old Grand Junction shareholders, and the shareholders in the Liverpool and Manchester Railways, (who have had their dividends cut down), are notlikely to hear calmly any proposition for giving high terms to a company which they have been taught to believe is overcharged with liabilities, paying dividends out of capital, and pursuing a ruinous system of management. These falsehoods have been widely propagated, and have been countenanced by those who ought to have known better. Now they will reap the fruits of falsehood. The narrow-gauge partisans, editors, and pamphleteers, will find it hard to make the shareholders believe a new tale, after what they have heard for years.

It seems to have been left out of account by most parties, that the amalgamation will result in an increase of income and economy of expenditure; affording a surplus fund which under a liberal system would go partly to extend public accommodation, but which in the present case will be divided between the three parties to the amalgamation. This is the point for negotiation. The Great Western may say, "Without us this amalgamation cannot be carried out, and therefore it is fair we should have the larger share;" and as this is true, they are not obliged to accede to a division in proportion to capital, and the greediness of the others must give way.

So far as we regard the public interests, we are most heartily glad that this measure has been proposed; for we are convinced that the ultimate result must be for the public benefit, notwithstanding what directors may believe. The latter may plume themselves that they have secured dear fares; but we do not fear that we shall have not only cheap fares, but cheaper fares and greater accommodation. Discussion must do good; and discussion will now take place on a wider and more liberal basis than it has heretofore done.

What the end of the bill will be no one can say; but meanwhile the shareholders will have something to think of, and something to talk of at the meetings; and the directors will have time to look about them. The *Times* and *Punch* have got a good cause; the public will get excited; and the bill may be postponed till another session,—or may get into parliament, and the whole basis of railway legislation be upset.

Ships without Keels.—Captain Jean Napoleon Zerman, of the French navy, has recently taken out a patent in this country for the construction of ships without keels. His ships are to be flat-bottomed; and through the vessel, from stem to stern, there is to be an opening or trough; the size being about the width of one-third the greatest breadth of beam of the vessel, and the height so much as just to be above the low-water line. The patentee states his object to be, in adopting this mode of construction, enabling the vessel to draw less water, and take a greater hold of the water. The vessels are so constructed as to go each way, and are to have a rudder at each end.

REVIEWS.

Theoretical and Practical Mechanics, designed principally for Practical Men. By James Hann, A.I.C.E., Mathematical Master of King's College School, London. Weale, 1848, 8vo.; pp. 324.

We are scarcely in the position to review a book written by Mr. Hann as impartial critics. A pre-disposition in favour of his new work, arising from a strong impression of the merits of those which preceded it, will be admitted by the reader to be, within certain limits, a fair ground of criticism. But we have other motives for a partial verdict, besides those patent to all who have read Mr. Hann's former publications. The extraordinary zeal which prompted him to the study of mechanical and mathematical science—the sacrifices which he has offered to his favourite science—these are considerations, derived from personal knowledge, which cause admiration, mingled with something like surprise. We are too much accustomed to think that academic discipline is almost indispensable for the attainment of that severe precision of thought and language which is pre-eminently required in mathematical studies. Here, however, those studies have been pursued in far other scenes than the seclusion of a college, and with far other means than the appliances of the professor's lecture, the tutor's private instruction, the discussion with contemporary students, and the powerful stimulus of a university examination.

In Mr. Hann's work we occasionally meet with definitions and expressions which seem to lack the precision of our accustomed class-books. Our author in these cases, is not always, as it appears to us, uninfluenced by impressions derived from the works of inferior writers,—men who address themselves to practical engineers, and have been too long deemed mathematicians because they use mathematical symbols. But if Mr. Hann and ourselves be at issue respecting the value of the class of authors referred to, this, at least, we concede—that if he sometimes borrow from such books their unscientific phrases, he does not borrow their blunders in the conception and application of principles. In turning over English books on engineering and analogous subjects, we usually adopt a rule, derived from vexatious experience, never to trust to the result of a single investigation till after having worked it over again for ourselves. In looking over the pages of *this* book we do nothing of the kind; we do *not* expect to find at every turn an error of principle. On the contrary, we have not yet found but one result which we are disposed to dispute: this occurs at page 205.

"Suppose, by measurement, it be found that a man-of-war, with its ordnance, rigging, and appointments, sink so deep as to displace 1,300 tons of sea-water,—what is the whole weight of the ship, supposing a cubic inch of sea-water to weigh ·5949 of an ounce avoirdupois?

"The weight of the water displaced is equal to the weight of the ship. 216 gallons = 1 ton. 1300 × 216 = 280,800 gallons; and if we take 277·2738 cubic inches to the gallon, then 280,800 × 277·2738 = 778,584; 83·04 cubic inches; and this multiplied by ·5949 gives 463,180, 11·5367 ounces = 1292·35 tons, the weight of the ship."

Surely there is an error in this passage. If the displacement of the ship be 1,300 tons, it will weigh 1,300 tons—not an ounce, not the millionth-part of a grain, more or less. Here, however, without any apparent reason, the displacement is reduced from tons to cubic inches, and then brought back again to tons; and the several multiplications with decimals account for the eight tons lost in this unnecessary process. The error is, however, evidently accidental.

About one-third of Mr. Hann's work is devoted to the theory of statics; and considering the class of readers for whom his work is intended, he has acted judiciously in avoiding, as far as possible, complicated mathematical operations. We wish that it could have been found practicable to substitute arithmetical methods for the somewhat difficult analysis which occurs in the subsequent pages. The chapter upon Revetements (p. 209-223), for example, consists almost entirely of mathematical symbols, and is not, therefore, likely to have much practical utility. Besides, we have strong doubts whether *any* system of theoretical computation will express even approximately the pressure of earth upon sustaining walls. Coulomb's idea of the wedge of maximum pressure is, in a scientific view, extremely beautiful; but in practice many things concur to vitiate all deductions from the theory. In railway cuttings, stratified formations which dip to the horizon will be liable to slide forward where the inclination is towards the face of the cutting; and when the inclination is in the reverse direction, the strata may sustain each other by their mutual action. In this way it will happen that, in a railway cutting through inclined strata, the right-hand bank may require the support of a strong revetement wall, while the left-hand bank is able to support itself. Again, the effects of ramming or binding the earth of an embankment, and of imperfect drainage, &c., altogether vitiate mathematical formulæ.

We do not insist upon this point to the disadvantage of Mr. Hann's book, but as a general truth. It might be extended to another important subject—the theory of the Arch. There also we are satisfied that practice and modern theory are widely at variance. Petit and Garidel's tables (p. 244-6) may be correct abstractedly; but we imagine that it would be difficult to point out one actually existing structure for which they would indicate even approximately correct results. There *do not exist* any of those "arches with parallel extrados," and "arches with horizontal extrados," for which the tables are computed. *Real* bridges and arches are not the homogeneous uniform structures here supposed: on the contrary, they are composed of materials of very variable specific gravities; the voussoirs may be of granite or Portland stone, the spandrils may be either filled in with solid rubble, or partly occupied by abutting or inverted arches, and the roadway and parapet may be composed of materials still more heterogenous. No general formulæ will meet such cases. If there be any instances where Petit and Garidel's tables (founded on the assumption that all the materials of the arch are homogeneous, and uniformly distributed) apply with anything like accuracy, we at least are not aware of their existence.

In the present treatise, the mathematical theories of the Arch and Revetements are presented with as much simplicity and analytical elegance as the subjects probably permit, but engineers never can, and never will, trust to long mathematical formulæ. In abstruse theoretical calculations, the errors arising from neglect of practical contingencies increase and multiply at every step of the investigation; so that the adoption in practice of *remote* results of theory is generally inadmissable, and always hazardous. The more value, therefore, attaches to the numerous simplifications effected in the present work. The mathematical science of engineering is daily becoming more simple and exact; and to Mr. Hann belongs a large share of the merit of these important improvements.

On the Importance of Studying Abstract Science, with a View to its Future Practical Applications—An Introductory Lecture, given at Putney College, Sept. 1848. By LYON PLAYFAIR, F.R.S., F.G.S.—[Printed for private circulation.]

This lecture of Dr. Playfair's is of more extensive use than it would appear to be from its title. There is a general disinclination on the part of practical men who have not been educated scientifically, to allow that such investigations as those which take place in the laboratory of the chemist, or the experimental philosopher, are practically useful. It may take more or less time to bring their discoveries into *use* for the benefit of man, but Dr. Playfair has shown that some of the least-promising discoveries have eventually been made extremely useful—polarization of light, for example, and galvanism. His text is the idea on which Boyle wrote:—"There is no one thing in nature the uses of which are thoroughly understood." Nothing about or around us but what may eventually be found to be of service to man in many ways, of which at present he is ignorant.

The certainty of this truth is undoubtedly a great incentive to all to persevere in acquiring a knowledge of the intimate constitution of bodies, and the developments of their known qualities. Dr. Playfair also gave excellent advice to the students he was addressing, on the necessity of intense application, and constant perseverance in studious and industrious habits. In the present day, the examples of fortunes rapidly made by men eminent in their profession, and sometimes even by less competent persons, have an injurious effect on the rising generation—making them expect to advance more rapidly than is either good for them or their employers. However well qualified to enter on the practice of their profession, no young men ought to look to securing, at starting in life, positions or emoluments which are the legitimate prize of lengthened services, and years of laborious assiduity.

To return to Dr. Playfair's lecture, which will be read with pleasure by all who take an interest in the practical applications of science, we would only further hint, that a little more care should be taken in correcting the press, even though the lecture is printed for "*private circulation only.*" Some sentences are ungrammatical, and some unintelligible; but we again must express our opinion, that the main idea of the lecture is excellent, and the advice given well deserving the careful attention of the students.

A very good illustration of the progress, from the discovery of an abstract philosophical theory to its practical application, is given in the following extracts:—

"It is but the overflowings of science which thus enter into and animate industry. In its study you are never sure that the morrow may not gladden the world with an application of a principle which to-day was abstract and appeared remote from practice. This is a truth that I wish most particularly to impress upon you who are to devote your lives to its practical applications. In your studies you will constantly meet with abstract truths which you might think it was unnecessary to acquire, because you did not see their practical tendency. This feeling in itself is wrong, education being a course of mental discipline fitted to frame the mind to habits of induction and investigation; and therefore, if it were thought necessary to teach you truths, which from their nature never could be practically applied, their use would still be great in expanding and tutoring your intellects, and enabling them to grasp difficulties when they present themselves."

"An officer of artillery, directing an optical instrument to the windows of Versailles, which were illumined by the sun, was struck with the fact that in one position they disappeared from his view. This was the first dawn of the discovery of polarised light,—of light which had suffered a change, similar to that which it experiences when it has passed through doubly refracting Iceland spar. When a ray of this light was passed through flat plates of certain crystalised substances, the most brilliant colours were observed. These phenomena were remarkable, and were well worthy of the attention of scientific observers. Nothing, however, could appear more remote from practice than the study of an altered beam of light. It was most interesting, indeed, that, as in the case of sound, where two sounds reaching the ear either exalt or destroy the effect, so in light, two rays interfering with each other may produce darkness. But who from this abstract observation would have dreamt that out of it would come useful applications? It was found that the light which reached reflecting surfaces at a particular angle was polarised in coming from them; that, for example, much of the light reflected from water is in this condition. Thus, suppose, you look with a Nichol's prism, the common polariser, at the shadow of a man on a smooth lake; by turning round the prism in a certain direction the shadow will disappear, because much of the light is polarised, while the man seen by common light will remain visible; thus realizing the German fable of the man without a shadow. This property of the polarising prism was after a time applied to the important purpose of detecting shoals and rocks at sea. It had been long the practice for mariners, when they suspected the existence of shoals, to send a man to the head of the mast to detect them; for the outlook viewing the water from a vertical position shut out much of the reflected light, which dazzled and obstructed his view. Now, as a great part of this reflected light is polarized, it was obvious that by looking through a polarizing prism from the deck, the depths of the ocean could be scanned without the interruption of the glare, which had formerly rendered this so difficult; and thus this abstract truth of the alteration of light by reflection became practically applied to the preservation of mariners from the hazards of the sea. Another useful application was now made to salmon fisheries, to enable the spearsmen to see the fish at considerable depths, where detection was before impossible. The singular insight which polarized light gave into the inner constitution of bodies, was usefully employed to discover the laws of tension in beams, thus showing that it might be made to aid in the promotion of mechanics. Under the hands of a Biot, a ray of polarised light performed with magical quickness the most refined but tedious operations of the analytical chemist, by enabling him to ascertain the amount of sugar in various saccharine substances. He was enabled to follow the increasing richness of sugar in the juices of various plants at different stages of their growth, so as to indicate when they are most fitted to be gathered in for the purposes of the sugar manufactures; and by the same ray silently performing its quick analysis, he was able to make improvements in the economy of labour. Thus, when beet is ready to be gathered, labour is in demand for the harvesting of other crops, and consequently is expensive. It would not do then to take another crop, such as parsnips, inferior in its amount of sugar, as the cost of production would outweigh the returns. But precisely at the time that horses and carts are disengaged, and labour is cheap, parsnips contain most of their saccharine ingredients, so that it is then useful to employ the idle mills in the production of sugar from this plant. Thus a ray of light has produced good also to the farmer, as well as to the seafaring man and the engineer. Or to take a case of the use of polarised light to science, who could have dreamt that the colours it exhibits in transparent substances would render it possible, by means of a mineral, to determine such questions as to whether the light of the sun proceeded from a solid mass or from a gaseous canopy, or whether the comets enjoyed light of their own, or only reflected the light from other bodies (Humboldt)?

There are other applications of polarised light to the telescope for measuring the size of distant objects; but to these I will not at present draw your attention, mentioning only one other instance, the recent beautiful discovery of Wheatstone, who has invented a simple means, far more accurate and useful than the sun-dial, of determining the apparent solar time by the diurnal changes of the plane of polarisation at the north pole of the sky. By availing himself of the fact that the planes of polarisation in the north pole of the sky change exactly as the position of the hour circle alters, Wheatstone has adapted a simple and ingenious apparatus, by which the true time may be told within three minutes. This elegant application of the laws of polarization is only one of others which we may expect from the same philosopher."

The following interests others besides students of the College for Civil Engineers, and in the present dearth of employment at home will meet with attention from many of our readers; and the more so, as it comes from one who has a practical knowledge of what he says:—

"It is scarcely necessary to urge on you the desirableness of a practical education, such as you will receive at this College. I have said enough to show you that it is indispensable in this country, if you wish to outstrip the competition which now, happily for the world, prevails in all departments of industry. If it be requisite here, it is far more necessary to the aspiring colonist abroad. The field open for well-educated men in the colonies is so great, that I doubt not there will be many of you who will try their fortunes in foreign lands. I myself, having been born in a colony, and all my relations having spent their lives and acquired their fortunes in colonies, I naturally know somewhat of the life and of the prospects of intelligent emigrants. This I can assure you, that I have never known an instance of failure, where a man went out with a well-grounded scientific knowledge, and with a power of applying it in a special direction. I have many friends in the colonies, who have gone out with no other recommendation than that—a very high one certainly—of being proficient in some one of the sciences. I recall to my mind at the present moment names of men who I am proud to call my friends—men who are now all in the enjoyment of lucrative posts abroad, from having gone out, some with a knowledge of geology, others of chemistry, and others of natural history. It is true that scientific men are rare in our colonies; and it is because practical scientific education is rare,—the more the chance for you who avail yourselves of your youth and your advantages. Look at the treasures opened in Australia by the discovery of coal and of valuable mineral ores. What a grand field for the mineralogist, the metallurgist, the geologist, chemist, and practical engineer! When we hear of men who have lately made large fortunes in the course of three years, by a happy development of formerly-neglected mineral wealth, is there not here encouragement to those who have a sound knowledge of the applied sciences to devote their lives to the development of our colonial industry? But in attempts to do so, there will be, of course, difficulties to overcome, such as cannot occur in this land, where all kinds of professional talent is available. It is for this that we give a general practical education such as we do. Are you to be a farmer in the colonies? Then learn before you go to understand the principles of machinery, so as to make and repair your implements; learn how to survey; how by geology and chemistry to choose your land; how to cultivate it when procured—learn to think how the resources of the country are to be economised. Recollect, that in boiling down whole flocks of sheep for their tallow only, in imitation of your brother farmers, you might at the same time make the most admirable and nutritious portable meat and soups for armies and navies—a process, if carried out, which is, I am sure, destined to become one of the most valuable, though yet untried manufactures of Australia—and why untried? Because there is no science to guide them in a manufactory involving a knowledge of animal chemistry, as well as of a wise adaptation of machinery, and an acquaintance with what has been done in the same way in other countries. And if you go out as a surveyor, how invaluable to gain the geological knowledge which you may also here acquire; how indescribably useful your chemical power of detecting and assaying valuable ores and minerals! Are you destined for the army abroad? The best way of getting staff-appointments or lucrative employment, is to have the power of making yourself useful with your scientific knowledge. I again say, that in this service in our colonies I have never known an instance where a really deserving scientific man failed in being speedily advanced to a useful and honourable position.

But do not think that in these days fortunes or honours are easily acquired. It is not mediocrity in your pursuits that will enable you to outrun the masses struggling to push forward. The age is an age of action; and if you are to succeed in future life, you must now brace and prepare yourself for the struggle. If you fall asleep now while you are young, in vigour, and able to prepare yourself for future life, the world will not know when you awake, and it will be a long and a sad struggle for you to overtake those who were active when you were passive. Recollect, that it is only by study, downright hard study, that you can acquire that mental strength and vigour that will enable you to overcome the increasing difficulties of progress in life."

History of Architecture from the Earliest Times; its Present Condition in Europe and the United States. By Mrs. L. C. Tuthill. Philadelphia: Lindsay and Blakiston, 1848.

As there are some remarks on this work in the *Fasciculus* of "Candidus," we shall not trouble our readers much further as to its critical merits. It was intended for a popular work in the United States, but, unhappily, it gives little definite information as to the buildings there, and is ten years behind hand as to those of Europe, the "Architectural Magazine" having been the chief authority.

It seems from the remarks of the authoress that Gothic and Elizabethan are now the fashion, instead of Greek, but there are few favourable American examples of any style given by the authoress, though there are many American buildings of great merit. We shall try and glean what we can as to buildings in the United States of which any particulars are given by the writer.

At Boston among the novelties are named—

"*Trinity Church*, in Summer-street, a Gothic edifice, of granite, built in 1829.

The Tremont House is a large and beautiful building, of granite, with a fine Doric portico in front. J. Rogers, architect.

Two beautiful Gothic churches, of freestone, were built in 1847. Billings, architect."

At New York—

"*The Church in Washington-square*, belonging to a congregation of the Dutch Reformed denomination, is said to be one of the most perfect Gothic structures in the United States. Le Fevre, architect.

Trinity Church was commenced in 1841, on the site of the old church in Broadway, and completed in 1846. It is built of a beautiful fine-grained freestone, in the Perpendicular Gothic style. It is 192 feet long, and 84 wide. Its graceful, symmetrical spire is 264 feet high. It is by many considered the finest specimen of ecclesiastical architecture in this country. Mr. Upjohn, architect.

Grace Church, on Broadway, is built in the form of a cross, in the Gothic style, and is of white marble. The windows are of stained glass, and the edifice cost 145,000 dollars (£30,000). It was completed in 1845. Mr. Renwick, architect.

The Custom House, in Wall-street, is a beautiful Doric building, 177 feet long, and 59 feet wide. The architects were Ithiel Town and Alexander J. Davis.

The Episcopal Church of the Holy Trinity, at Brooklyn, New York, is one of the finest specimens of Gothic architecture in this country. A citizen of Brooklyn, with a munificence above commendation, has erected this noble edifice, at a cost of about 150,000 dollars (£30,000). Lefevre, architect."

At Philadelphia—

The United States Bank, now the United States Custom House for the port of Philadelphia, is one of the most beautiful buildings in this country. It is closely copied from a perfect model, the Parthenon. Its length is 161 feet; its breadth 87 feet. The fine massive Doric columns of the portico stand upon a platform of white marble, the ascent to which is by a high flight of marble steps. Thus lifted up away from the street it has a very imposing appearance. The banking-room is 81 feet long and 48 feet wide.

The new Bank of Pennsylvania is copied from the Ionic Temple of the Muses, upon the Ilissus; it is built of marble, and is a large and handsome edifice.

The Girard College.—The main building, which is the subject of this description, is composed in the Corinthian order of Grecian architecture: it covers a space of 181 feet by 239½ feet, and consists of an octastyle peripteral superstructure, resting upon a basement of 8 feet in height, composed entirely of steps extending around the whole edifice; by which a pyramidical appearance is given to the substruction, and a means of approach afforded to the porticoes from every side. The dimensions of the stylobate (or platform on which the columns stand) are 159 feet on the fronts, by 217 feet on the flanks; and the cell, or body of the building, measures 111 feet, by 169 feet. The whole height, from the ground to the apex of the roof, is 100 feet.

The columns are 34 in number; the diameter of the shaft at the top of the base is 6 feet, and at the bottom of the capital, 5 feet; the height of the capitals, including the abacus, is 9 feet, and the width, from the extreme corners of the abacus, 10 feet; the whole height of the column, including capital and base, is 55 feet. The entablature is 16 feet 3 inches high, and the greatest projection of the cornice, from the face of the frieze, is 4 ft. 9 in.; the elevation of the pediment is 20 ft. 5 in., being one-ninth of the span. The capitals of the columns are proportioned from those of the monument of Lysicrates at Athens: they are of American marble, and were wrought upon the grounds of the college.

The building is three stories in height, each of which is 25 feet from floor to floor: there are four rooms of 50 feet square in each story. Those of the first and second story are vaulted with groin arches, and those of the third story with domes supported on pendentives, which spring from the corners of the rooms at the floor, and assume the form of a circle on the horizontal section, at the height of 19 feet. These rooms are lighted by means of skylights of 16 feet in diameter. All the domes are terminated below the plane of the roof, and the skylights project but one foot above it, so as not to interfere with the character of the architecture.

The roof is covered with marble tiles, so nicely overlapping each other as to defy the most beating storms.

Beside the main edifice, there are four other buildings belonging to the institution, each 52 feet wide, 125 feet long, and four stories high. Thomas U. Walter, architect."

At Washington, among other buildings, are—

"*The President's House*, of Potomac freestone. It has two fronts with porticoes, and is 180 feet in length by 85 feet in width.

The Patent Office is still unfinished; it is designed, when completed, to surround the square on which it stands. It is of the dark freestone of the Potomac. The building already completed has a superb portico of the Doric order.

The General Post Office, of white marble, is a magnificent building, ornamented with pilasters, and an entablature of the Corinthian order. The edifice already occupies the front and part of two other sides of a square. It is unfinished, but when completed will be one of the most splendid buildings in the United States.

The Capitol is finely situated, commanding a view of the city, with the surrounding country, and the river Potomac. It is 352 feet long in front, and its greatest height 145 feet. The Hall of the Representatives is of a half-circular form. The dome rises above an entablature, supported by 24 Corinthian columns of variegated marble (sometimes called pudding stone), from the banks of the Potomac."

At Baltimore we find—

"*The Roman Catholic Cathedral*, planned by Latrobe. It is of the Ionic order; 190 feet in length, 117 feet wide, and 127 feet high, to the top of the dome."

For want of something better we shall extract what is said of the public squares and walks of the United States, to which more attention is now paid, a gratifying proof of the progress of taste.

"The citizens of New York have at length become aware of the beauty and salubrity of public squares. St. John's-park, Washington-square, Union-square, and several others in recently-built parts of the city, are tastefully ornamented with trees and shrubbery, affording sweet green spots for the eye to rest upon, as a relief from the glare of brick walls and dirty pavements.

Every city should make ample provision for spacious public squares. Trees of every variety, shrubs, flowers, and evergreens, should decorate these grounds, and fountains throw up their sparkling waters, contrasting their pure white marble with the deep green foliage. Here, beneath the shaded walks, the inhabitants might enjoy the sweet air, the children sport upon the fresh grass, and all be refreshed and cheered by the sight of beautiful natural objects. Here the young and old might meet to 'drive dull care away,' and lose for a few brief moments the calculating money-making plans that almost constantly usurp American thought and feeling.

The Boston Common is the most spacious pleasure ground in the United States. Seventy five acres were appropriated by the early 'fathers of the town' for this purpose, on the condition that it should ever remain devoted in this way to public convenience and comfort. The same venerable elms which shaded the patriots of the revolution, still wave over the heads of their successors, and fresh young trees are planted from year to year by the side of the new gravelled walks, rendered necessary by the rapidly increasing population of the city. The undulating ground of the common gives it a pleasing diversity of hill and vale, and the little lake or pond near the centre adds to its picturesque beauty.

The New York Battery, though much smaller, is very delightful, affording a view of the magnificent harbour, gemmed with its beautiful islands. Convenient seats are placed about the battery, that its numerous visitors may quietly enjoy the cooling breezes from the ocean, beneath the grateful shade of the trees. It is one of the loveliest spots in the world.

The public squares of Philadelphia are incalculably important to the health of the city. Beneath the dense foliage of Washington-square, crowds of merry children enjoy, unmolested, their healthful sports. Within the inclosure of Independence-square was first promulgated the Declaration of Independence. Franklin-square has in the centre a fountain, falling into a handsome white marble basin. Penn, Logan, and Rittenhouse-squares are also ornamental to the city.

The New Haven-green has been justly celebrated as one of the most beautiful public squares in this country. Its elms are remarkably fine; it has recently been enclosed with a light and tasteful iron railing, which adds much to its beauty.

Many of our large cities are entirely destitute of such green retreats. Gardens and squares are so necessary to the health, as well as the enjoyment of those who are shut up in the close streets of a city, that it should be considered an imperative duty to provide them for all classes of the inhabitants."

The following shows the resources available to the architect in the United States:—

"*Granite*, a primary rock, may be called the *foundation-stone* of the earth. Its constituent parts are quartz, feldspar, and mica. It is a hard and brittle stone, but with much labour may be worked into capitals and other ornamental parts of a building. It abounds in the New England States, especially in New Hampshire and Massachusetts. A beautiful white granite is there quarried, and employed in building at home, and sent to distant parts of the Union. The United States Bank is of this white granite; the market-house at Boston, some fine dwelling-houses in New York, and many other edifices there and elsewhere.

Sienite is often called granite, from its resemblance to it; feldspar and hornblende predominate in its composition. It is even more difficult than granite to chisel into ornamental work. The fine quarry of this stone at Quincy, near Boston, has given it the name of Quincy stone, by which it is extensively known. The Astor House in New York is built entirely of sienite, and in Boston there are many structures which have now been standing for some years; showing that it bears exposure to the air, without injury to its appearance. The Bunker-hill Monument is of this stone.

Marble is one of the most durable of stones. The beautiful Pentelic marble of the Parthenon has stood the storms of more than 2,000 years, without injury. Happily for us, this fine material abounds in almost every part of the country. The black, gray, and white marble of Vermont are extensively known. Massachusetts furnishes specimens of various kinds. The splendid columns of the Girard College were brought from Sheffield, in Berkshire county, in that State. New Hampshire has several quarries. In Connecticut, near New Haven, green marble abounds, resembling the verde antique. Many specimens of this marble have been sent to Europe, and been much admired in the cabinets of the curious and scientific. Near the same place another quarry is found, in which yellow predominates. White marble abounds in Pennsylvania. In short, marble is so abundantly supplied, that taste and durability may be combined by the use of this material in elegant edifices.

The United States Mint, Custom-house, and Pennsylvania Bank in Philadelphia, are all of Pennsylvanian marble; the Washington Monument, Baltimore, is also of white marble.

Sandstone, usually called freestone, is found of variegated colours, from gray to red, and dark brown. It is easily wrought, and much used in building. Extensive quarries of red freestone are worked at Chatham, in Connecticut. The Potomac freestone is extensively used; the President's House, the Capitol at Washington, and St. Paul's Church, Boston, are built of it. Sometimes it is employed without smoothing, and is thus a durable and economical material for cottages, stables, &c. It is in general use for the basement, window-sills, and caps of brick buildings.

Gneiss, a stone containing a large proportion of mica, splits with ease, and affords a beautiful paving-stone.

Slate is found in great abundance in this country; it is used for covering roofs, and should be universally substituted in cities for shingles or other combustible materials.

No country in the world is more abundantly supplied with wood of every variety than the United States.

The *white oak* grows to a great height in the Middle States and in Virginia. It is strong and durable, and although sometimes employed in domestic architecture, is more generally used for ship building. The black oak rises to a still greater height, but is not so large in circumference. Several other kinds of oak abound, all of them durable, and some of them excellent for timber.

The *black walnut* is a beautiful wood for the interior, being susceptible of a fine polish, and not liable to warp, nor to split. In Ohio and Kentucky this wood is used for the shingling of houses, and occasionally for timbers. It is admirably adapted for doors and window-frames.

Maple, of several varieties, is also susceptible of a fine polish. The curled and bird's-eye maple are very handsome for interior finishing. Maples grow in almost every part of the Union; they are numerous and luxuriant in the Western States.

Pine is a soft wood, easily worked, and has for this reason been hitherto quite too much used for building. It is, however, a valuable wood, and will long continue to be used for the interior, after more durable materials are substituted for the exterior of buildings. From Maine to Florida pines of various kinds abound, and are exported in large quantities to Europe and the West Indies.

The *white ash* is a strong and durable wood, which sometimes grows to the height of 80 feet. It splits straight, and is not apt to shrink. It abounds most in the Northern States.

Birch is not much used in building, although it abounds in New England and the Middle States.

The *black birch* furnishes a hard, dark-coloured wood, that receives a fine polish, and is very handsome for interior finishing.

The *cypress* grows to a great size in the Southern States, and is frequently used for building.

The *white cedar* grows abundantly in the Middle and Southern States, and being a soft light wood is used for shingles and interior finishing. The *red cedar* is a durable wood, used for posts and fences."

It will be seen from the extracts we have given that some very respectable works have been lately executed, or are in progress, but there is no great architectural monument on hand.

Syllabus of Lectures on Civil Engineering, for the use of the Students at Putney College. By W. Ranger, C.E., lecturer on Civil Engineering and Architecture at Putney College, and on Civil Engineering to the H.E.I.C. Officers at the Royal Engineering Establishment, Chatham. London: Taylor, 1848.

This is nothing but what it purports to be—the syllabus of lectures; yet it may be very usefully referred to by the professional man. It seems very easy to put down the heads of lectures; but Mr. Ranger has shown in the arrangement the resources of a logical mind, and his intimate acquaintance with the subject which he teaches. It is in these qualities that consists the use for the professional man, who is able practically to supply the detailed information, and may refresh his memory by reading, under each head, the enumeration of the various resources applicable to the work intended.

HYDROGEN GAS AS A MOTIVE POWER.

Among the patents for new inventions in this country specified within the last month, is one (obtained by the widow of a French engineer, at the request of her late husband,) for employing the explosive force of hydrogen gas as a motive power. In the arrangements for effecting this object there is nothing deserving of special notice, the explosive force being made to act against pistons working in two cylinders, wherein the explosions of the gas mixed with atmospheric air take place alternately, either by the agency of electricity or by the flame of a gas-light. To what extent however such an explosive force would be available, supposing it could be regulated to act with uniform pressure, is a question deserving consideration, as the attempt has been previously made, and may be again and again repeated.

There is a peculiarity in the power generated by all explosions, which renders it almost impossible to employ it usefully in working machinery; inasmuch as the greatest part of the force exerted depends on the instantaneous or percussive action, which enables it to overcome resistances that would not yield to the same amount of force steadily applied. In the explosion of hydrogen gas there is the further peculiarity, that the resulting product occupies so much less space than the original gases as to result in a partial vacuum; and we have heard a popular lecturer when noticing this result assert, that in such explosions the force is directed altogether *inwards*, and that there is no external force whatever: this assertion, too, was made in defiance of the common experiment of the electrical pistol, with which he must have been familiar. The external force is indeed only momentary, and depends upon the instantaneous expansion of the gases by the heat caused by their ignition; consequently, the difficulty of regulating such a power is greatly increased; but that there is power exerted there can be no doubt, though the amount of it we believe to be too small to be ever practically available.

With a view to ascertain the amount of force generated by the explosion of hydrogen gas, we some years since made several experiments, which, if not strictly accurate, were sufficiently so to enable us to conclude that the force generated is much too small to be of use, and amounts only to the expansion of the gases employed into about eight times their original volume; or to the exertion of a momentary pressure of eight atmospheres. The experiments were arranged in two different ways, but the results nearly coincided. The first method adopted was, to ascertain the quantity of water displaced by the explosion of a given volume of hydrogen gas mixed with atmospheric air. A square tin vessel, open at the bottom, was made; to the top of which there was soldered a smaller tin vessel that held one cubic inch. This smaller vessel for holding the gas, was open entirely at the bottom, so as to form in fact only a projection from the top of the larger one. Insulated wires were introduced into the small gas-holder, for the purpose of causing explosion by means of an electric spark. The vessel having been filled with and inverted in water, a cubic inch of an explosive mixture of hydrogen gas and atmospheric air was passed up into the small reservoir. A small trough, into which the tin vessel was inverted, was then filled exactly to the brim; and the tin was held firmly on supports, which raised it several inches above the bottom of the trough. The electric spark was passed through the gas, and the explosion forced over a quantity of water into a receiver. By measuring the water thus displaced, the expansion of the gas by heat during the explosion was ascertained. This experiment was several times repeated with nearly corresponding results: the amount of water displaced being about eight times the volume of the mixed gas.

In the second method the experiments were made in the dry way. Under the impression that the explosive force was very great, a gun barrel was procured; and a piston, attached to a small rod, was loosely fitted into the barrel. The mixed gases were introduced from a bladder through a hole at the breach; the space occupied by the gases being measured by the height to which the piston was drawn up. The explosion of the gases was effected by an electric spark: and the space in the gun-barrel through which the piston was forced was ascertained by a narrow ribbon attached to the piston rod; the ribbon being drawn out with the rod during the explosion, and left loose afterwards. The loose part of the ribbon indicated the extent to which the piston had been forced from its first position, and by measuring and comparing it with the space occupied by the gas, the expansive force of the explosion was determined, and it nearly agreed with the results of the first set of experiments. In the course of these experiments the operator had, unexpectedly, personal experience of the force exerted by the explosion. The bladder containing the mixed gases, whilst held under his arm, was inadvertently brought near the flame of a candle, and the contents exploded with a loud report and concussion, that blew out the candles and left him in the dark, somewhat stunned, indeed, by the force, but without inflicting any injury.

Though these modes of experimenting were certainly not calculated to afford very accurate results, yet they proved that the expansive force of hydrogen gas is very much less than we had anticipated, and that consequently it was useless to pursue our attempts to render it available as a motive power. It is very probable that, by using other proportions of hydrogen gas and atmospheric air than we employed, greater force may be obtained; but it cannot, we feel convinced, be under any circumstances at all comparable to the explosive force of gunpowder. The terrific effects so frequently produced in coal mines by explosions of carburetted hydrogen gas, may probably lead to the supposition that the explosive force is immense; but if the large volumes of gas exploded in producing such disastrous results be taken into consideration, it will be found that the power exerted is insignificant, compared with the explosive force of other agents.

NEW ELECTRIC LIGHT.

An experiment was made on the Great Western Railway, on the 18th ult., to test the power of a new species of light produced by electricity, particularly with a view to its being used by railway trains. The light is produced by an apparatus invented by M. Le Mott, a French gentleman, who has been for several years employed in electrical experiments in Russia, and whose discoveries in that department are well known to the scientific world. At half-past six o'clock a truck, containing a square wooden box, about the size, though not the shape, of a sentry-box, and having a galvanic battery of some 60 or 70 small jars disposed around it, was attached to the last carriage of the train then about to proceed from Paddington. The light was produced inside the box, and the rays, condensed and heightened by a powerful reflector, were emitted by an aperture contrived for the purpose. The light was produced before the train left Paddington, when a dazzling blaze filled the whole of the spacious station, casting the numerous gas lamps there completely into the shade. As the train proceeded on its way, the reflection left a long track of clear bright light for the distance of a mile and more behind it, in such a manner as to render it utterly impossible that any train coming up behind should run into it, except as the effect of deliberate intention. The reflection, as seen from the carriage, was very beautiful, the prismatic colours being distinctly and vividly delineated along the outer edge of the circle of radiation; and as these fell upon the dense column of smoke ascending from the engine, the effect was singular and striking. The night was dark, but clear, and so far favourable to the experiment; and objects, such as a bridge, were rendered distinctly visible at the distance of about two miles. The experiment was made as far as Slough, on arriving at which station the truck was detached from the train, and continued there for about half-an-hour, till the up-train arrived, with which it returned to town. While at Slough, the light was turned in the direction of Windsor Castle, as it was the expectation of M. Le Mott, who accompanied the experiment, that it would be seen from thence. While there a gentleman stationed himself at the distance of 200 yards or so from the apparatus, and read a newspaper by the light produced, which he found he could do with perfect ease. The apparatus then returned to town in the same manner, the light being continuously intense during the whole of the journey and return; and we were informed by the ingenious inventor that there could be no difficulty in keeping it up for the whole night. The experiment afforded great satisfaction to all who witnessed it, the only drawback being, that the apparatus, having been in the first instance adapted for stationary experiments, suffered considerably from the jolting inseparable from railway motion—a defect which the inventor considered might be with ease overcome in any future experiment.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Nov. 20.—EARL DE GREY, President, in the Chair.

This was the opening meeting. The PRESIDENT, in presenting the Royal Medal which had been awarded to Mr. Cockerell by the Institute, in February last,—but which, in consequence of the time required to prepare the dies, made expressly for this purpose, had not been presented at the closing meeting of the last session—complimented that gentleman on his being the first individual selected by his professional brethren to receive the honour which the Sovereign had placed at the disposal of the Institute.

Prof. DONALDSON then gave a description of the Cathedral Church of St. Isaac, Petersburgh.

SOCIETY OF ARTS, LONDON.

Nov. 22.—J. WALKER, Esq., C.E., in the Chair.

A letter from the Royal Society of Edinburgh was read. It was accompanied by a medal bearing the effigy of Napier of Merchiston, and was offered as a mark of respect for the Society of Arts.

The SECRETARY read an address from the Council, which concluded as follows:—"It is proper, however, that the Council should direct special attention to a new feature in the exhibitions of the present session. It has been complained, that for a couple of years the Society has directed attention too exclusively to the Fine Arts, to the neglect of the Mechanical Arts and Manufactures. This may, perhaps, be in part true. But in reforming the operations of the Society, it was necessary to do one thing at a time. The Council have postponed the mechanics—not lost sight of them; and have availed themselves of the past vacation to prepare the large room on the ground floor for the reception at Christmas of an exhibition of the models of large inventions of recent date and of a mechanical nature. This they hope will afford the public the gratification of having laid systematically before them all that is most important in the records of modern invention."

"*On a plan for constructing a Malleable Iron Lever Bridge.*" By Mr. T. M. GLADSTONE.—The advantages which the author considers it to possess over other plans, are that of enabling bridges of any span to be built without a centering, whereby a saving is effected; also enabling a flatter roadway to be obtained while a higher waterway is insured than can be got by any plan in which the arch springing from the pier is made use of. The paper concluded with a detailed account of the comparative cost of constructing bridges on the various plans hitherto used, and also of the weights of metal employed.

INSTITUTION OF MECHANICAL ENGINEERS.

At the last quarterly meeting of the members of this institution, held at Birmingham, the recent death of George Stephenson, the lamented President of the Society, and the intimation that a paper relating to his character and life would be read at this meeting, invested the proceedings with an unusual degree of interest.

After the minutes had been read and confirmed, Mr. M'CONNELL, who occupied the chair, said that in consequence of the absence, from illness, of Mr. Scott Russell, the duty devolved upon him (the chairman) of reading the paper on the character of their late worthy and much-lamented President. They had met for the first time since the death of the great man who had lately presided over them—an event which the society greatly deplored, and their grief was shared by all who could appreciate honesty and genius. In his death the world had lost one of its brightest ornaments. He had risen by the force of his own talents from a humble rank in life. He was a kind friend, and not less distinguished as a man than as a great mechanical genius. As long as railways existed, the name of Stephenson would live with them.

The Chairman then proceeded to read Mr. Russell's memoir, the length of which precludes the possibility of insertion here.

At the conclusion of the paper, Mr. GEACH then said he rose under feelings of no ordinary kind to propose that the society should, at this the earliest possible moment, place on their minutes an expression of their deep regret at the loss of their much esteemed friend and President, Mr. George Stephenson. Really when they remembered his last appearance amongst them at their last meeting, in high spirits, good health, and indomitable strength and activity of mind, it was not easy to realise the full extent of the calamity that had befallen them, nor to speak of the bereavement without feelings of strong emotion. He (Mr. Geach) had not known their late President so long as many present; but the peculiarity of Mr. Stephenson's character was, that one did not require that time should elapse before he was known and loved. It was impossible for any one younger than him to regard him with any other feelings than those of deep affection. There was something in his manner, in the very tone of his voice, which endeared him to all. He was open, honest, manly, and straightforward in all his dealings; sometimes rough, but that peculiarity never could hide the inherent kindness of his disposition. Peculiarities he had, undoubtedly, but in his long battle with the world he had so often found himself right, that he was, as it were, privileged to speak authoritatively; and, moreover, what in other men would have been unpardonable, if, in him, noticed at all, only made him the better liked. There was another peculiarity that was remarkable: he was never ashamed—nay, he was proud of his early life. He never attempted to gloze over his struggles with an unfavourable position; and while he was the associate of peers of the realm, he looked back on his early associations with pleasure and pride. And this was almost the only pride he had, for his greatest delight was in meeting with the son of some early friend who had laboured alongside of him, and gladly acknowledging the claim such a man had upon his kindly aid. He (Mr. Geach) could not refrain from giving these feelings expression; and, in conclusion, he would propose the following resolution:—"That the members of this institution desire to express their deep regret at the decease of their late President, George Stephenson, whose early support of this institution has greatly contributed to bring it to its present state of success."

Mr. FOTHERGILL briefly seconded the motion, which was carried unanimously.

Mr. M'CONNELL remarked, that immediately after the death of Mr. Stephenson, the Council of the institution met at Manchester, and drew up and forwarded a letter of condolence to his widow for the great loss she had experienced. They at the same time thought that the best tribute they could pay to his memory, and the best service they could render the society, would be the selection of Mr. Robert Stephenson as a successor to his father. Accordingly, Mr. Fothergill and Mr. Buckle had put themselves into communication with that gentleman, and the result was, that he had consented to accept the office of President. The announcement was received with loud applause.

Mr. FOTHERGILL detailed the steps they had taken to bring about this desirable consummation.

Mr. M'CONNELL then formally proposed the election of Mr. Robert Stephenson. A better choice could not have been made, and the active connection of that gentleman with their society would give their proceedings additional lustre.

The motion was seconded by Mr. FOTHERGILL, and passed by acclamation.

"*On the Adaptation of the Cambrian Engine to Locomotive Purposes.*"—A paper on this subject, accompanied by drawings, contributed by Mr. John Jones, of Bristol, was then read by the Secretary. The advantages claimed for an engine constructed on this principle are the obtaining a long stroke in the crank, without the disadvantages of a long-stroked cylinder, where high velocities are required, the arrangement of the levers which balance the engine, the entire disappearance of any oscillating motion of the engine, and doing away with all centre pressure.—A somewhat lengthy and interesting discussion followed the reading of this paper, in which the Chairman, Mr. Cowper, Mr. Slate, Mr. Peacock, Mr. Crampton, Mr. Humphries, Mr. Beyer, and others, took part. Considerable difference of opinion existed as to the value of the engine described. The weight of the argument, which we have not space to follow, was against the presumption that the adaptation would be advantageous; but at the suggestion of the chairman it was proposed to reserve any decision on its merits until there was more information before the meeting.—This suggestion was adopted, and the discussion terminated.

"*On a Railway Elevator.*"—Mr. FOTHERGILL read a paper contributed by Mr. W. L. Kinmond, of Glasgow, on an elevator erected for the Glasgow and Ayr Railway Company. Several members stated that they had seen the machine at work, and it was an admirable piece of mechanism. It had been erected in 1840, and had never required repair, except in one instance some few years ago.

"*Brockedon's Patent India Rubber Joints.*"—Mr. COWPER brought this subject before the meeting in a brief explanation of the application of vulcanised India rubber to pipe joints, and their economy compared with those of lead, the cost being about half.—Mr. FOTHERGILL apprehended that the practical objection to the adoption of the joints would be the difficulty of repairing them.—Mr. RICHARDS, of Worcester, said he had had more than twelve months' experience of the joints, and he could speak in confident terms of the great value of the invention. They had withstood the influences of ammonia and other gases, and did not seem to be at all affected by the changes of temperature. He considered that the repairs could be done even more easily with joints such as those than with lead, for there was no use for the shoulders with which the spigot in the drawing before them was encumbered. He intended to adopt the joints extensively.—Mr. FOTHERGILL said that Mr. Richards's explanation had removed the objection stated.—After a few other commendatory remarks, in which the value of the adoption of India rubber was unanimously acknowledged, the CHAIRMAN remarked that they seemed to be agreed as to the usefulness of these joints, their durability being the only point on which the society could not give an opinion.

NOTES OF THE MONTH.

Branch Passenger Locomotives.—Several trips were made on Wednesday, 15th ult., on the West London Railway, with a little passenger-carriage engine, the *Fairfield*, which has been constructed for one of the branches of the Bristol and Exeter line. The engine, "tender," and carriage, which have been constructed by Mr. Adams, of Fairfield Works, Bow, are connected together upon one frame, and weigh, with coke and water, about 10 tons. The object sought is to economise the working expenses of branch lines, and to introduce light rails and light engines into various districts of the country, the passenger and goods traffic of which are not calculated to pay a dividend upon the ordinary outlay for laying down the present character of permanent way, and supplying the present locomotive and carriage stock. The engine and carriage run upon six wheels. The engine has but two wheels—viz.: the driving-wheels, which are in front. She is fastened to the carriage by longitudinal side-plates, which are screwed together, and also by bolts and screws through a transverse frame, so that when in working order the whole may be said to run upon one frame. The engine has an upright boiler similar to the little 22 cwt. express engine belonging to Mr. Samuel, the resident engineer of the Eastern Counties Railway. The boiler has 150 tubes of 1½ inch diameter outside, and 4 feet long. The fire-box is 2 feet 6 inches, by 2 feet. The diameter of the driving wheels, which have about 3 tons upon them, is 4 feet 6 inches; the cylinder 8 inches, and the stroke 12 inches. The engine is to be worked at about 100 lbs. pressure, and the consumption of coke is calculated at 10 lbs. per mile. In front of the driving wheels is the tank, which holds 220 gallons of water. The coke is carried in an iron box attached to the carriage. The carriage is a composite one, and will afford sitting-room for 16 first-class and 32 second-class passengers; but by a slight alteration the same compartments might be made to accommodate 60 persons. The cylinders of the engine communicate with the axle through an intermediate crank shaft. This is connected with the axle by side-rods. The trailing and centre-wheels run loose on their axles; the axles also run loose in their journals. The trips were run under great disadvantages. Being a new engine, her boiler is necessarily dirty, and she runs stiff. It was not till three or four journeys had been made that the priming could be kept down sufficiently to get anything like an effective working pressure in the cylinders. But, with these disadvantages, the little engine and carriage maintained a speed of 24 miles an hour up 1 in 100, and 41 miles per hour down the same incline. About 30 persons were in the carriage and upon the engine during these trips. Another of these carriage engines is in the course of construction for the Eastern Counties lines. The boiler is to be the common horizontal one. In a few days the *Fairfield* will, no doubt, be in pretty good working order. We shall then make a few more trips upon her, and be able to offer an opinion upon her speed and power.—*Herald.*

London and North-Western Railway—Deterioration of Permanent Way.—It is stated a committee has been appointed by the directors of the London and North-Western Railway Company, consisting of Mr. Dockray, the resident engineer; Mr. M'Connell, the locomotive superintendent; Mr. Madigan, the ballast-carrying contractor for the southern division of the line; and Mr. Crampton, C.E.; for the purpose of discussing by what means the comparative deterioration of the permanent way, caused by heavy engines of different classes, may be ascertained.

Certain Prevention of Explosions in Steam Engines.—It is impossible for the force of elastic steam to produce the breaking of engines and rending of boilers that so frequently occur, they are the work of the explosive principle, when disengaged from its combination with steam. Similar in its effects to lightning, it is identical with electricity in its distinctive properties; its velocities are in effect unlimited; it is devoid of weight, and not subject to the laws of gravitation, which are inherent in all matter that has weight, and it is hence evident that it may be conveyed away by similar conductors. It is absolutely certain that the explosive principle is disengaged from steam as it is let into the cavity of the nozzle, or valve chamber, on the opening of the steam valve; the pressure that kept them combined is then in great part taken off, until the cavity is filled with steam. There is no proper escape of the explosive element from the nozzle, which is heated, and in effect insulated, and the accumulation is highly dangerous; but it may be safely carried off by proper conductors—those most convenient are small copper tubes. One end of a tube of proper length is to be terminated in the best manner for the diffusion of the electric fluid—the other end to enter the cavity of the nozzle, and have over its orifice a slight valve, kept by a spring a little open, to allow the explosive element to pass off by the tubular conductor, the valve to close by the force of steam, as the cavity becomes filled therewith. The conductors of a condensing engine should be carried high enough above the water in which they terminate to preserve the vacuum. The security from explosions and breaking of engines must be complete, the cost and trouble only nominal.—J. Wilder: *N. Y. Tribune.*

Testing of Metal at Woolwich Dockyard.—The trial of the large guns supplied to the Board of Ordnance, which has been carried on during the last 18 months, for the purpose of ascertaining the best description of gun, and the best metal supplied by contractors, has just been concluded, and Colonel Dundas, C.B., and Mr. Monk, deserve great credit for the excellence of their models. The former 32-pounder gun, of 50 cwt., is now reduced on Colonel Dundas's principle of construction to 25 cwt., effecting a saving of 1¼ ton on each gun of that calibre—the average price of the metal being from 10*l.* to 12*l.* per ton. There is also a saving of 6 lb. of powder on each charge, the former charges being 10 lb., and the new pattern being found equally efficient with a charge of 4 lb. The guns cast at the Low Moor Foundry, in Yorkshire, have been found to stand the heaviest charges when fired, and will consequently receive the largest orders. The expense of the trials has been considerable; but the saving which will ultimately be effected, and the knowledge that no danger is now to be apprehended from the bursting of guns when placed on board of ships, or mounted for service in the garrisons, must give confidence in working them. A trial has also been made of a wrought-iron 9-pounder gun, submitted by Mr. Morgan, of Bristol, but it had been found inapplicable to the service, in consequence of the great recoil breaking the cap squares, or coverings, of the trunnions.

Marine Compass.—A new invention, by Captain Sir Samuel Brown, K.H., patentee of the chain cables, has been exhibited in the Portsmouth Dockyard. It is a compass in a glass box, sustained by a small pillar with telescope slides, by which it can be elevated or lowered to any desired height. It is designed to obviate the local attraction of the ships. The card is transparent, and the whole apparatus will supersede the use of the binnacle. There is a mirror attached to it, on which the helmsman will be able to see the reflection of the compass card. A lamp will be placed over it at night. The whole is a most ingenious contrivance, and, if successful, will effect a great desideratum for the nautical world.

Supply of Water from the New Red Sandstone.—We learn, from the *Manchester Guardian*, that the mayor of that town and several of the council, on the invitation of the directors of the Manchester and Salford Waterworks Company, proceeded lately to the works of the company at Gorton, to witness the success with which a shaft had been sunk into the new red sandstone. After inspecting the reservoir, they visited the chief object of attraction—the splendid new and powerful Cornish engine, which has just been put down by the company, and which was set to work to exhibit its great capabilities in pumping up a vast volume of the water obtained by sinking in the red sandstone to a depth of 70 yards. The water is stored by means of galleries from the main shaft, which serve as internal and subterranean reservoirs. The volume of water thus raised by this engine is estimated to be equal to about 2,000,000 of gallons per day, a quantity considerably exceeding the expectations of the company themselves.

A New Method of Extracting Pure Gold from Alloys and from Ores.—The following method of obtaining pure metallic gold in the form of a spongy mass, has been practised by me for several years, and no account of the process has, to my knowledge, heretofore been published. It is very useful to the chemist and to the manufacturer, and is more economical than any other method that I am acquainted with. After separating the gold from silver, by means of a mixture of nitric and hydrochloric acids, as is usually done, the solution containing gold and copper is to be evaporated to small bulk, and the excess of nitric acid is thus driven off. A little oxalic acid is added, and then a solution of carbonate of potash, sufficient to take up nearly all the gold in the state of aurite of potash is gradually added. A large quantity of chrystallised oxalic acid is now added, so as to be in great excess, and the whole is to be quickly boiled. All the gold is immediately precipitated in the form of a beautiful yellow sponge, which is absolutely pure metallic gold. All the copper is taken up by the excess of oxalic acid, and may be washed out. Boil the sponge in pure water so long as any trace of acidity remains, and the gold is then to be removed from the capsule, and dried on filtering-paper. It may be formed into rolls, bars, or thin sheets, by pressing it moderately in paper. I have made several useful applications of the gold sponge thus prepared, and had a tooth plugged with it in October, 1846, to which purpose it is well adapted. By moderate pressure the spongy gold becomes a solid mass, and burnishes quite brilliantly. The jeweller or goldsmith will find spongy gold to be quite convenient when he requires it for a solder, and it is a convenient form of the metal for making an amalgam for fine gilding. I have used it for some years in soldering platina, and prefer it to the filings of gold or foil for that purpose. This method of separating fine gold from coarse is very simple, and cheaper than the usual processes. It is applicable in the separation of gold from ores that may be treated by acids, and is vastly preferable to the method commonly used by chemists and assayers. When making oxide of gold for dentist's use, the chemist will find that oxalic acid, added to this potassic solution, will at once recover all the gold that is dissolved in an excess of the alkaline solution. Many other applications of this very simple method will occur to chemists and artisans.—C. T. Jackson: *Silliman's Journal.*

Extraordinary Block of Granite.—A block of granite, containing upwards of 12,000 cubic feet of stone, and exceeding in weight 850 tons was lately dislodged at the granite quarries of Messrs. Freeman and Co., at Maen. A hole 9 feet deep having been bored, 1½ pound of powder, with which it was charged, produced a slight crack; into this was thrown another charge of 35 lbs., which, on explosion, threw out this immense block several yards from its bed. Considering the largeness of some of the stones produced at these quarries, it is astonishing in how comparatively short a time they are prepared for exportation. A few days since, another large rock was unseated, measuring when wrought 150 feet, and in weight 11 tons; the preparing and working of which was performed by a couple of men in a week.

Safety Pressure-Gauge for Gas-Works.—In the manufacture of gas there are many circumstances under which accidents are very likely to occur; for instance, if the pipes which conduct the gas happen to become obstructed by deposits of crystalised napthaline, or carbonate, or hypo-sulphate of ammonia, there are great dangers of explosions. Any neglect in the complicated arrangements of the valves will form an obstruction, and by preventing the free flow of the gas generated in the retorts into the gasometers, an explosion is the result. The only means at present in general use to call attention to the state of the gas in the tubes is the ordinary pressure gauge, which is, under many circumstances, insufficient. M. Magnier communicated at the last sitting of the Paris Academy of Sciences, a plan for an apparatus for giving timely warning of any obstruction to the passage of the gas, which is simple and inexpensive. He terms it a "Safety Pressure-Gauge," which consists of a small bottle-shaped vessel, with two orifices, one of which is attached to the glass tube forming the ordinary pressure-gauge. To the other of these orifices is attached a whistle, in such manner, that whenever any obstruction or excess of pressure occurs, a loud warning is given. Water is introduced into the pressure gauge, which communicates with the gas apparatus, on which the pressure is reproduced, and all the variations of pressure, to several inches of water, can be traced; but if greater than ordinary, the water contained in the pressure-gauge is forced into the bottle, and the gas, in escaping through the orifice, acts on the whistle, producing a sound which gives notice of danger, and which sound becomes so much louder as the pressure increases, thus giving sufficient timely notice to avoid danger.

A Novel Steam Engine.—Practical Application of Water in the Spheroidal State.—It will be remembered by our readers, that at the meeting of the British Association at Cambridge, a considerable sensation was produced by M. Boutigny, who brought before the meeting a series of experiments on what he calls *the spheroidal state* of water, and the remarkable phenomenon of freezing water in red-hot crucibles, under the influence of this peculiar condition. At a recent meeting of the Academy of Sciences at Paris, M. Boutigny announced, that by the persevering efforts of a young engineer, M. Testud de Beauregard, a steam-engine had been constructed, which was moved by the vapour of water in its spheroidal state. This is a machine of one-horse power, the boiler of which is so small that it can be easily carried in the pocket. It was also stated, that two other machines were in progress, one of two, and the other of four-horse power; and that a third, of four hundred horse-power, was about to be made in England. From a communication to *La Presse*, we learn that the boiler is placed in a bath of melted lead, and water projected in small quantities at a time upon its heated surface. The spheroidal state is produced, and although the temperature of the water never rises above 190 degs., the elastic force of the vapour given off is found to be very far superior to that of steam in its ordinary conditions; and if we understand the somewhat obscure description given, a portion of the water is decomposed, as in Professor Grove's beautiful experiments; and the additional force of the gases is rendered available. We may briefly state, for the benefit of those who may not be familiar with Boutigny's experiments, that if water is projected upon a metal-plate heated to dull redness, it is not vaporised at once, but it forms itself into a sphere, and rolling with great rapidity over the heated surface, evaporates with comparative slowness. This is the spheroidal state—a remarkable physical condition is produced, in which even the ordinary powers of chemical affinity are suspended, but the vapour of which appears to obey other laws than those of steam. We may therefore hope that we are on the eve of a great improvement in the employment of heat as a motive power.—[The above *French invention* is not new in England. Patents have been taken out in this country by Smith, Howard, and others.—ED. C. E. & A. Journal.]

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM OCTOBER 26, TO NOVEMBER 23, 1848.

Six Months allowed for Enrolment, unless otherwise expressed.

Alfred Vincent Newton, of 66, Chancery-lane, mechanical draughtsman, for "certain Improvements in the manufacture of steel."—Sealed Nov. 2.

Charles William Kesselmeyer, of Manchester, warehouseman, and Thomas Mellowdew, of Oldham, for "certain Improvements in the manufacture of velvets, velveteens, and other similar fabrics."—Nov. 2.

Charles Dawson, of Hardinge-street, Islington, professor of music, for "certain Improvments in musical instruments, and in apparatus to be used in connection with musical instruments."—Nov. 2.

Robert Thomson Pattison, of Glasgow, printer, for "an Improved preparation or material for fixing paint, or pigment colours, on cotton, linen, woollen, silk, and other woven fabrics."—Nov. 2.

James Hart, of Bermondsey-square, engineer, for "Improvements in machinery for manufacturing brick, sand, and tiles, parts of which machinery are applicable to moulding other substances."—Nov. 2.

William Weild, of Manchester, mechanical draughtsman, for "certain Improvements in machinery for spinning cotton and other fibrous substances."—Nov. 2

Richard Bright, of Bruton-street, Middlesex, lamp manufacturer, for "Improvements in lamps, wicks, and covers for vessels for holding oil and other fluids."—Nov. 2.

Robert Walter Winfield, of Birmingham, manufacturer, for "certain Improvements in the construction and manufacture of metallic bedsteads, couches, and sofas."—Nov. 2.

John Harris, of Richard's-terrace, Rotherhithe, Surrey, engineer, for "a mode or modes of founding type, &c., and of casting in metal, plaster, and certain materials."—Nov. 2.

James Robertson, of Liverpool, cooper, for "a mode or modes of consuming smoke and other gaseous products arising from fuel and other substances."—Nov. 2.

Richard Archibald Brooman, of Fleet-street, London, gentleman, for "certain Improvements in the manufacture of hinges, and the machinery or apparatus used therein." Nov. 2.

William Bullock Tibbits, of Bramston, Northampton, gentleman, for "Improvements in obtaining, applying, and controlling motive power, parts of which improvements are applicable to the raising and forcing of liquids."—Nov. 2.

Francis Gybbon Spilsbury, of St. John's Wood, gentleman, for "Improvements in paints and pigments."—Nov. 2.

George Arthur Biddle, of Ipswich, engineer, for "Improvements applicable to gas burners."—Nov. 2

Meyer Jacobs, of Spitalfields, Middlesex, gentleman, for "certain Improvements in the manufacture, stamping, and treating generally, of woven fabrics of all kinds."—Nov. 2.

Thomas John Knowlys, of Heysham Tower, near Lancaster, gentleman, for "Improvements in the application, removal, and compression of atmospheric air."—Nov. 2.

George Henry Bachhoffner, of the Royal Polytechnic Institution, London, doctor of philosophy, professor of natural philosophy, for "Improved means of transmitting, communicating, or conveying intelligence."—Nov. 4.

Joseph Cooper, of Walworth, tailor, for "Improvements in fastenings for wearing apparel."—Nov. 4.

Charles Iles, of Birmingham, machinist, for "Improvements in the manufacture of certain descriptions of dress fastenings, and in the making up of dress fastenings and other articles for sale."—Nov. .

Henry Kempton, of Pentonville, Middlesex, gentleman, for "Improvements in reflectors and apparatus for artificial light."—Nov. 7.

Moses Poole, of the patent bill office, London, gentleman, for "certain Improvements in machinery for making nails." (A communication.)—Nov. 7.

James Napier, of Swansea, operative chemist, for "Improvements in the manufacture of copper and other metals, and alloys of metals."—Nov. 9.

Richard Coad, of Kennington, Surrey, chemist, for "Improvements in the construction of blast and other furnaces and fire-places."—Nov. 9.

James Anderson, of Abbotsford-place, Glasgow, starch manufacturer, for "a certain Improved mode of separating the different qualities of potatoes and other vegetables."—Nov. 11.

Alexander Parkes and Henry Parkes, of Birmingham, for "Improvements in the manufacture of metals and alloys of metals, and in the treatment of metallic matters, with various substances."—Nov. 11.

John Browne, of Osnaburgh-street, Middlesex, gentleman, for "Improvements in fire escapes, and in apparatus to facilitate persons employed in cleaning windows."—Nov. 11.

Alexander Balfour, of Dundee, Scotland, leather merchant and manufacturer, for "Improvements in apparatus for cutting metal washers and other articles, and in the construction of buffers."—Nov. 16.

Samuel Adams, of West Bromwich, Stafford, organist, for "Improvements in mills for grinding."—Nov. 16.

William Wilkinson, of Farrow, near Gateshead, Durham, coke manufacturer, for "certain Improvements in the construction of coke ovens, and in the machinery or apparatus to be connected therewith."—Nov. 16.

Thomas Masters, of Regent-street, for "certain Improvements in apparatus for making aerated waters, and in apparatus for charging bottles and other vessels with gaseous fluid; also improvements in bottles and other vessels, and in apparatus for drawing off liquids; in securing corks or stoppers in bottles or other vessels, and in taps and vent pegs."—Nov. 18.

Thomas Cullen, of the city of London, gentleman, for "Improvements in apparatus for steering ships and other vessels."—Nov. 18.

John Juckes, of Rosamond-cottage, Fulham, gentleman, for "Improvements in furnaces and fire-places."—Nov. 18.

Alexander McDougal, of Longsight, Manchester, chemist, and Henry Rawson, of Manchester, agent, for "Improvements in the manufacture of sulphuric acid, nitric acid, oxalic acid, chlorine, and sulphur."—Nov. 21.

John Oliver York, of 24, Rue de la Maldeleine, Paris, engraver, for "Improvements in the manufacture of metallic tubes."—Nov. 21.

William Hood Clement, of Philadelphia, for "certain Improvements in the manufacture of sugar, part of which improvements are applicable to evaporation generally; also Improved apparatus for preparing the cane trash to be used as fuel."—Nov. 21.

Henry Newson, of Smethwick, near Birmingham, for "Improvements in trusses."—Nov. 23.

Hugh Bell, of London, gentleman, for "certain Improvements in aerial machines, and machinery in connection with the buoyant power produced by gaseous matter."—Nov. 23

Christian Schiele, of Manchester, mechanician, for "certain Improvements in the construction of cocks or valves, which improvements are also applicable for reducing the friction of axles, journals, bearings, or other rubbing surfaces in machinery in general" Nov. 23.

Peter Llewellin, of Bristol, brass and copper manufacturer, and John Hammons, of the same place, brass-founder, for "Improvements in the manufacture of cocks or valves for drawing off liquids."—Nov. 23.

Henry Archer, of Great George-street, Westminster, gentleman, for "Improvements in facilitating the division of sheets or pieces of paper, parchment, or other similar substances."—Nov. 23.

Frederick Bramwell, of Mill-wall, Poplar, engineer, and Samuel Collet Homersham, of the Adelphi, gentleman, for "Improvements in feeding furnaces with fuel."—Nov. 23.

END OF VOLUME XI.