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Industrial Architecture in Concrete

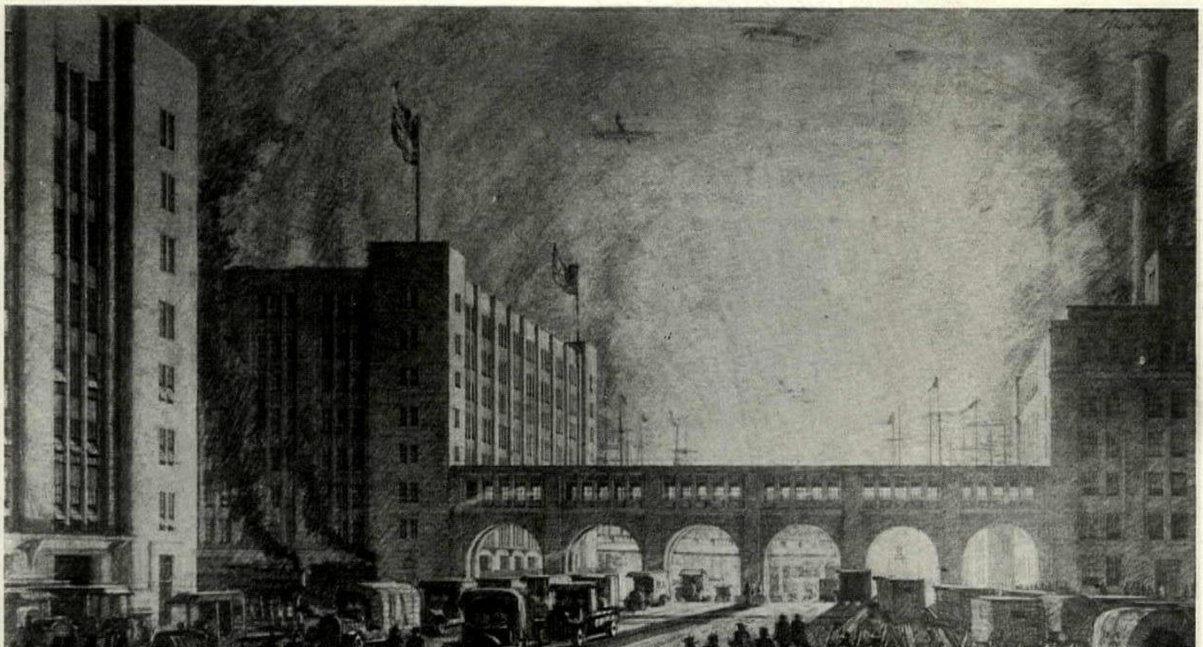
By CASS GILBERT

IT may be taken as an axiom in concrete construction that the simpler the form the better the design. The nature of the material dictates the form of all its parts, and assuming that the purpose of the structure is kept in mind, as it should be, this purpose is necessarily expressed in very simple terms.

I recall that Russell Sturgis once said to me about terra cotta that it should be used as a "plastic" material, that "it should be *poured* at the top of the building and allowed to run down until it covered the structure," and my answer was, "it won't 'pour' and it won't run down; it is plastic only until it is burned; it has to be designed with that in view." Concrete is not a plastic material. It is no more plastic than cast iron, and less so than terra cotta. Generalizations are well enough for purposes of conversation, and serve to accent a witty remark, but they are not a sure guide to the art of design in any of its myriad forms.

Granite in its formative stages was a liquid material, but no one will contend that it is so now, and whatever concrete may be in its initial stages, it certainly is not plastic when it becomes concrete. Concrete must therefore be treated in accordance with its own nature, and so treated it is a highly useful building material, with many yet undeveloped possibilities in design.

Many of the Roman domes and vaults of vast dimensions were of concrete of a sort, and a pretty good sort at that, and surely few nobler, grander structures have been erected by man than these. Concrete in architecture depends upon the "form" upon which, or into which, in its semi-liquid state it is poured. The Romans and Byzantines used brick and tile as well as lumber in constructing these



Crayon Drawing by Hugh Ferriss

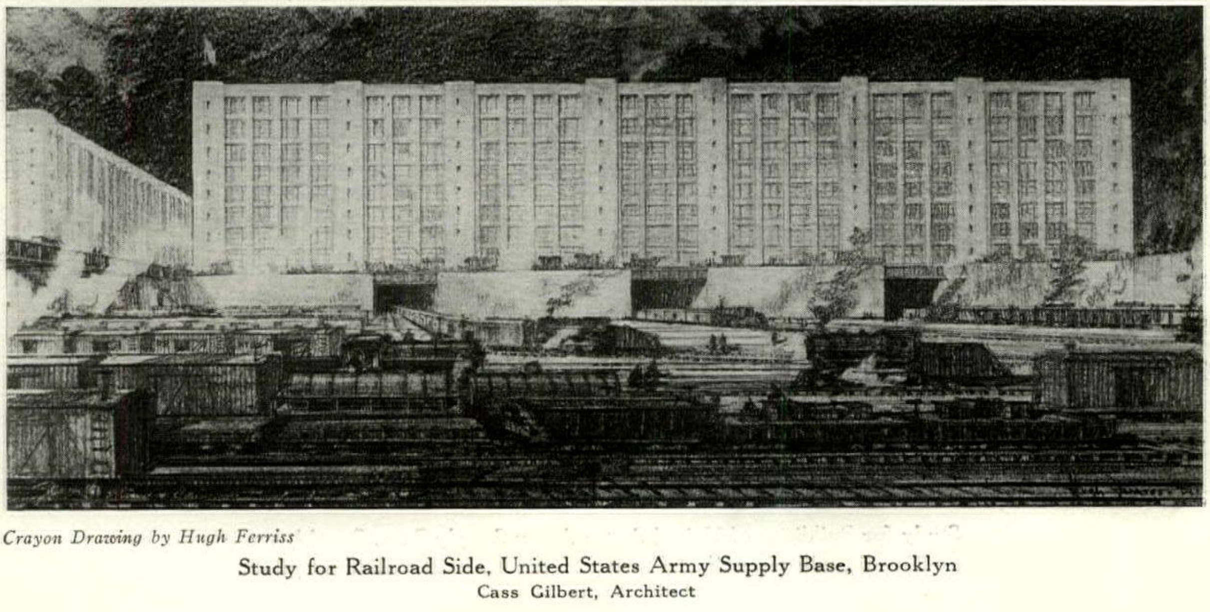
Study for Buildings of United States Army Supply Base, Brooklyn
Cass Gilbert, Architect

Detail of Concrete Viaduct, United States Army Supply Base, Brooklyn

"forms," hence curved surfaces such as domes and vaulting were of the very nature of their structural design. We use lumber, or occasionally sheet metal, for the "forms," and we have developed our concrete design accordingly. The ancients probably built empirically; we now, with greater knowledge of the strength of material, build scientifically. As we build with a primary view to low cost (a matter which concerned the ancients very little, as they had slave labor for their larger enterprises), we are forced to consider economy at every stage. Hence, as it is cheaper to build a lintel and a post than it is to build an arch and a pier, in proportion as it is cheaper to build in a straight line than in a curve, we follow the direction in which the finger of "economy" points and build columns and girders and flat surfaces rather than those in complex curves. It is cheaper because the "form" costs less. Therefore the "form" dominates the design, and economy has its innings. Still, is not this the problem that has had to be solved age after age as long as man has erected buildings, even though his work may have been done by slaves, a condition, by the way, which certainly does not exist today? The greater the difficulty, the greater the honor in surmounting it. If concrete, after full trial, proves to be the economical material for use, it will in time be well designed. One thing we may be sure of, and that is that for the present at least the evidence before us points toward simplicity as the basic principle of design in concrete, and that is a lesson much needed in this complex, restless age. Why not make simplicity, then, the keynote, and welcome it as a help and not an obstacle to good design? Why attempt to adorn this simplicity with trinkets and gewgaws and patterns and raw bits of colored tiles or panels of brick, or fictitious corbels, cornices, capitals or other details culled from traditional architecture constructed of other materials? In short, the logic forbids such intrusions.

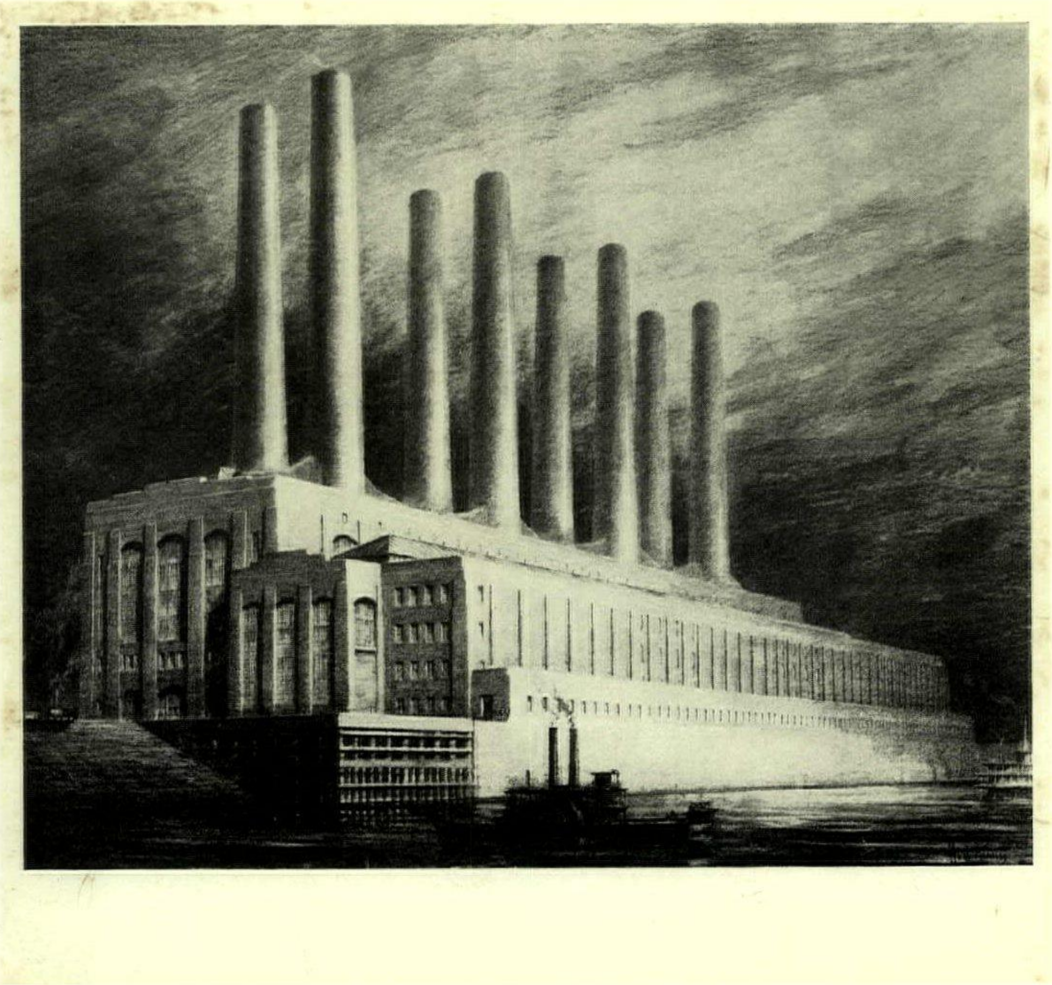
There are great possibilities of texture in concrete, as yet untried, and texture is needed to dispel a barrenness of effect in broad surfaces. In stone masonry or in brickwork the joints alone would give a certain quality of "texture" in the surface of a wall, but while there are no joints in concrete (except those widely spaced for expansion) there is no reason why the texture of the surface may not be made beautiful. It is not necessary to smear it with calcimine, as is so often done. I have seen a concrete bridge where the aggregate was of a trap rock or granite that gave a rich, warm color and a beautiful texture to the surface that could scarcely be rivaled by any other material.

There is something very fine about a great gray



Crayon Drawing by Hugh Ferriss

Study for Railroad Side, United States Army Supply Base, Brooklyn
Cass Gilbert, Architect

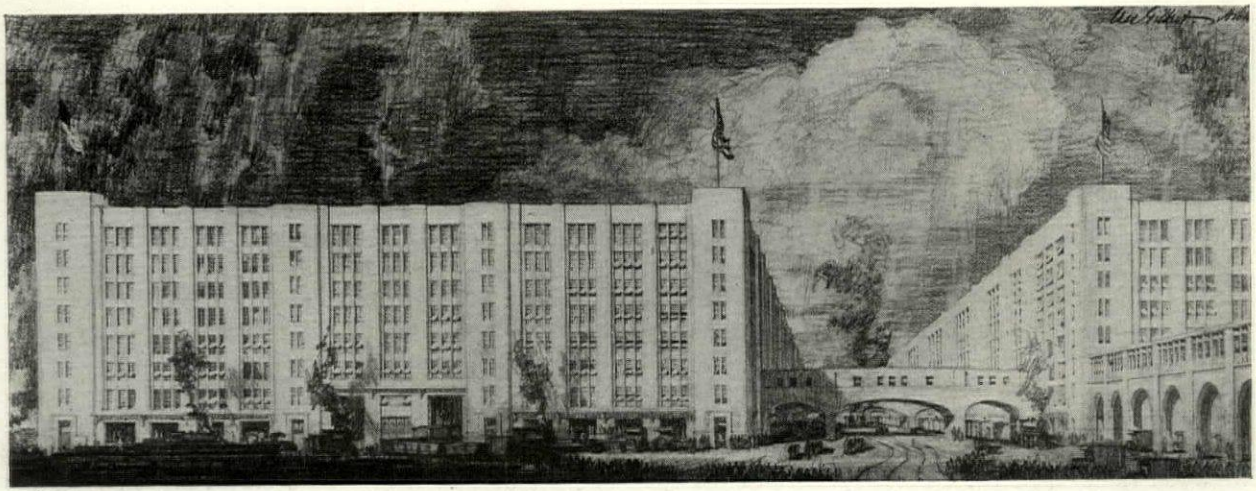


CAHOKIA POWER STATION
NEAR EAST ST. LOUIS, ILL.

McCLELLAN & JUNKERSFELD, INC.
Engineers and Constructors

MAURAN, RUSSELL & CROWELL
Consulting Architects

From Crayon Drawing by Hugh Ferriss

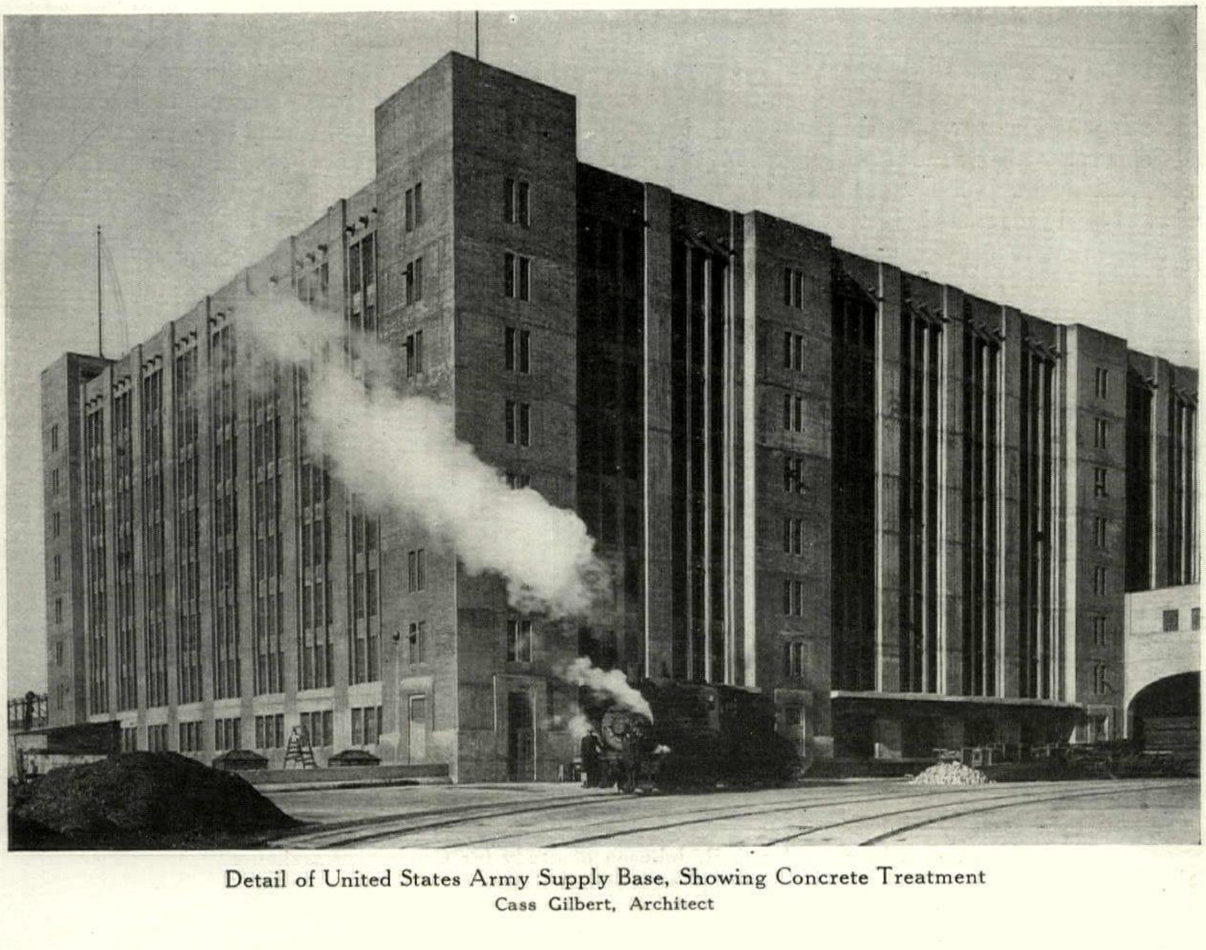


Crayon Drawing by Hugh Ferriss

Study for United States Army Supply Base, Brooklyn
Cass Gilbert, Architect

mass of building, all one color, all one tone, yet modified by the sunlight or shadow to pearly gray of wonderful delicacy. It is the big simplicity of the thing that counts, and if there may be projections for necessary fire towers or elevator shafts, or other salients, if there may be low roof structures for tank houses or machinery, and if the glass surfaces are kept in scale, there may be silhouette, and light and shade and shadow and reflected light that will make a picture not easily to be forgotten. Such effects may occasionally be seen in concrete industrial buildings. It was this sort of thing I sought to achieve in the Army Supply Base in Brooklyn, and these are among the considerations that dictated its design. If it has in any respect been successful as a work of architecture (aside from its practical efficiency), it is because of its manifest simplicity.

I have emphasized the importance of simplicity of outline and surface, and have decried the use of extraneous ornament, especially in industrial buildings, as out of character with the direct and practical purpose of such structures. There is no reason why concrete buildings for other purposes, with very simple outlines and broad surfaces, may not be richly adorned with color and inlays of mosaic



Detail of United States Army Supply Base, Showing Concrete Treatment
Cass Gilbert, Architect

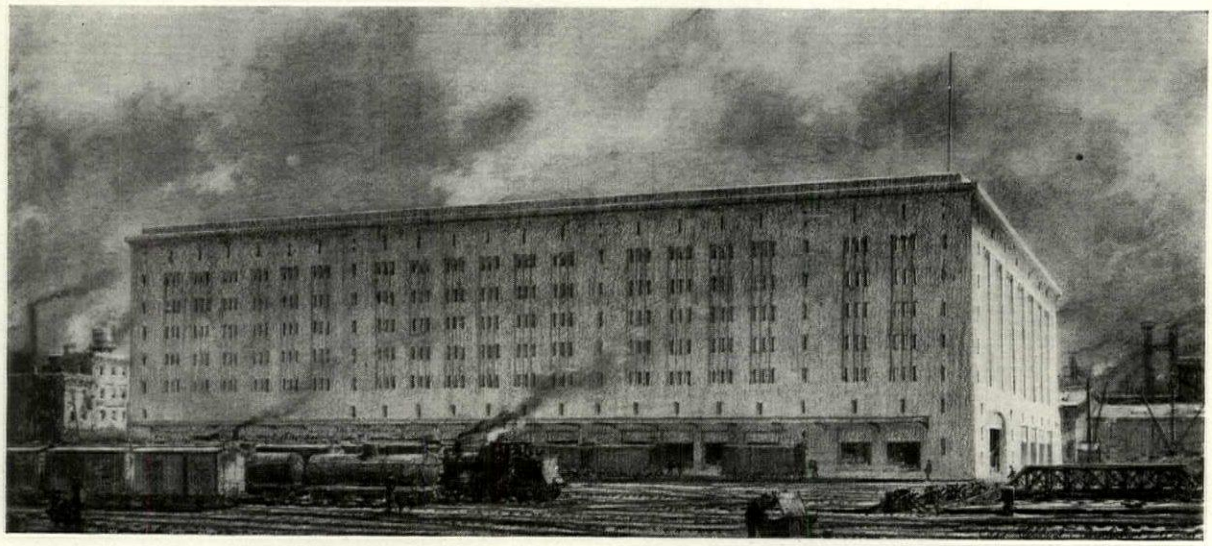
arabesques in bands or panels, and the reveals of the windows and the marginal lines of walls and openings all enriched in this manner. If the fundamental lines are simple and the surfaces such as are reasonable in concrete, the decoration may be as rich as you please, but if you are wise you will use such liberty with great restraint.

Concrete invites study. It is as individual as steel or stone or brick or wood, and while at first (as in the early development of all building material) forms consistent with other materials are commonly used, new forms adapted to the new material will be found, and a new architecture may result. Thus was the transition from the Attic shepherd's hut made to the Parthenon, until forms originally of wood came to be the classic contours of the age of Pericles. I anticipate no such triumphant result, for we are not the ancient Greeks, nor yet is concrete Pentelic marble.

"I hold no brief," as the phrase is, for concrete as against other useful materials. In other words, I do not prefer it above others, except in certain specific cases where the nature of the structure or economic reasons imply its use. It is not always the most economical material, though it frequently is so, and as a structural material it requires very expert handling. Bad concrete is not only worthless; it is dangerous, and concrete buildings should not be attempted by incompetent or negligent builders. I remember my old friend George B. Post's making a brief speech on the subject of reinforced concrete some years ago in London, in which he summarized the whole matter by saying: "Concrete is, as Sam Weller said of veal pies, 'weal pies is werry good things when you knows the lady as made 'em.' "

The temptation to reduce the thickness of walls and floors, particularly the former, and to make concrete construction as light as possible, is very great, and it should be resisted, just as one should resist the temptation to get the last ounce of theoretical strength out of a brick wall or pier. There should be something more than a "factor of safety." A building owes something to its neighbors as well as to itself, and it should not only be strong, but it should *look* strong. A very small percentage of increase in the cost will accomplish this. Any sensible architect, and most business men, would prefer to spend money on excess strength and the appearance of solidity to spending it on elaboration of ornament. There is no reason why our industrial buildings should be ugly. It is not necessary for a building to be ugly in order to be useful. That's why skillful architects should design these buildings. They are too often left to draftsmen in contractors' or engineers' offices who have not been trained in the art of design or whose only function is to lay out the work that will be cheapest for their employers to build—cheapest for their employers, but not cheapest or best for the owner of the building. In the fact that it is difficult to design an industrial building and make it look well, lies the very reason why a highly expert architect should be retained, and most of the best concrete construction contractors know this and prefer to work under, or with, such an architect.

When the architect, the engineer, the contractor and owner all unite in a joint effort, travel along the same road to the same destination, good design and good building are almost a foregone conclusion. This is so in all building work, but especially so in concrete, where the builder can show from his experience and special knowledge of the material, economic methods of using it, where the architect can guide the design (of which subject he is supposedly a master), and where the engineer can work out scientifically the structural problems encountered. But of all things, it is necessary to have a good "owner," for without a good client no good building can be built. Let us give chief praise to the owner, then, when a good building is built, and praise be, there are many such in this country.



Pencil Drawing by T. R. Johnson of Study for Concrete Warehouse
Cass Gilbert, Architect

The Choice of an Industrial Building Site

By MAURICE M. OSBORNE, M. E.

THE first step in the detailed planning and construction of an industrial building is the choice of its site. It is frequently argued that this is a matter lying between the owner and his real estate agents, and that there is no need for the services of the architect and the engineer in the transaction. In many cases, probably the majority, the choice of the architect for an industrial building project is deferred until the land has been selected and bought.

This undesirable state of affairs has been mainly brought about through the owner's lack of understanding of the architect's and engineer's full value, and conversely by the architect's and engineer's belief that this problem is a little beyond their province.

It is nevertheless true that the engagement of the services of the architect before the selection of the site should operate in every way to the advantage of the owner, and every architect will admit that the earlier he may be brought into a building problem as principal adviser the more valuable his services will be to his client.

Further, when it is known that a building project is under consideration, an early selection of the architect certainly shortens the misery of all of the aspirants for the commission, and wasting less of the time of the less fortunate many, conserves the nervous energy of the chosen individual or firm for the task to be accomplished.

It is proposed in this article to outline the various ways in which the architect and the engineer may be of service to the owner in the choice of his building site. Even though the owner may be equipped to make the necessary study and selection on his own behalf, a knowledge of these matters should be of value to the architect, both in relation to the problem later to be worked out, and as a means of keeping his present or future client interested in him through judicious conversations and discussions.

The selection of an industrial site is necessary when a new industry or business requires quarters for the first time, or an established business, through growth, obsolescence of plant, change of type of neighborhood, or expiration of lease, must shift to an economically sounder location.

Manufacturing plants present the most complex problem in location of industrial buildings and will be considered mainly in this discussion. Considerations governing location of warehouses, garages and other industrial and semi-industrial types, are included under the general principles applying to manufacturing plants.

It is not as yet usual for the architect or engineer to be entrusted with the study of the general location of a new plant serving a nation-wide business, but the principles followed should nevertheless be understood.

Industries have always shown a tendency to localization in centers producing a typical line of products. For example, the state of Connecticut has for many years been a great metal-working center, especially in brass products; the steel industry is concentrated in a corner of Pennsylvania.

This localization is the result of a number of influences, which must be understood before any intelligent general selection of plant location can be made. However, as a general rule, an industry would best be established where similar industries already have flourished.

As offsetting this is the tendency of certain industries to change their established centers, through change in centers of population, types of labor supply, or sales territory.

In the United States census of 1900 seven advantages were listed, which in varying combinations, tend to cause localization of industry.

These are:

1. Nearness to materials.
2. Nearness to markets.
3. Water power.
4. Favorable climate.
5. Supply of suitable labor.
6. Capital available for investment.
7. The momentum of an early start.

The more bulky and the cheaper the raw materials used in the projected plant, the nearer should the plant be to the source of such materials. As their bulk decreases and value increases, the further is it economically permissible to ship them for manufacture, all other considerations being equal.

The more centrally located a manufacturing plant may be with respect to the centers to which it must ship its product, the lower its shipping cost per unit and the more advantageous its situation. A study of markets, freight rates, railway lines, etc., is necessary before arriving at any conclusions on this point.

An industry requiring water power, or a large supply of pure or cold water, must be further influenced by that consideration. The advent of hydro-electric and steam power has made water power less of an influence than formerly in establishing the plant site.

Climate plays a part in textile and certain other industries, but less now than formerly.

In very large industries requiring much unskilled labor, labor will come to the location selected for other reasons than that of labor supply. As the industry requires more and more skilled and intelligent labor, the more it must seek localities where the required type of skill has been developed through training and heredity. Skilled labor is settled, it has a high standard of living, friends, social and family ties and traditions, and dislikes to migrate.

As to capital, a town or city looking for industries, ready to supply tax-free land for a period, with a Chamber of Commerce working to serve in every way to establish the new plant, and capital ready to be invested in it, naturally offers substantial attractions to the owner seeking a new site.

One of the best examples of the effect of the momentum of an early start is in the establishment of the textile industry in New Bedford, Mass., to supplant its former industry of whaling. When the heyday of the whaling industry had passed with the discovery of petroleum in Pennsylvania, the capitalists of New Bedford decided to manufacture textiles. All they had to their advantage were climate, capital, and an early start. They had no water power, were hundreds of miles from the source of raw materials, and not at all centrally situated as to markets. Yet New Bedford is today one of the great textile cities of the country.

Let us say that the owner and his engineer or architect have made a study of these considerations, and selected a general locality for the new plant.

The next step is a detailed examination of the locality for an actual lot of land.

Here the following major considerations govern in greater or less degree:

1. Transportation facilities:—by rail, water, and for labor to and from work.
2. Initial building requirements as to space, adaptability of space to buildings of minimum cost to fit the purpose, and as to future expansion.
3. Local labor supply and housing facilities.
4. Dependence on other industries.
5. Aid from the community, and water, gas, electric and other services.
6. Building restrictions and zoning laws.
7. Local markets.
8. Advertising value of site.
9. Cost of the land.

The architect and engineer, if commissioned early in the attack on the problem, should begin at once with the owner a study of the requirements of the business to be housed. From this study should proceed an ideal plan of the plant to be built. Any final plan will probably be a compromise between the ideal and that made necessary by actual conditions, but having the ideal plan at hand will aid greatly in the selection of a specific lot of land.

Once the requirements under the major considerations listed here have been determined, the real estate agent is brought into action. He submits various lots of land to the owner, which in his judgment most nearly meet the requirements. The architect and engineer may then examine these lots with the owner, as to the considerations numbered here, in particular:

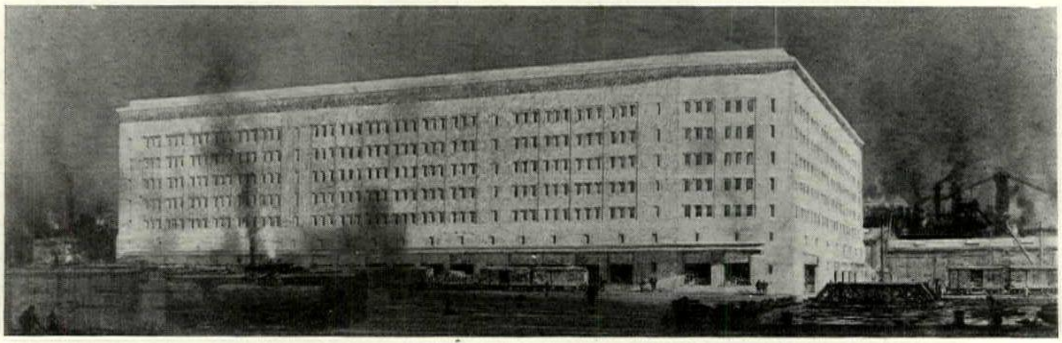
1. Transportation facilities.
2. Building requirements, future expansion and foundation conditions, which later greatly affect building costs, and which may be the worst on the cheapest land.
3. Water, gas, electric and other services.
4. Building restrictions and zoning laws.

Such examination will save much time and money for the owner, at very little greater expense for services than if the architect and engineer had been selected after deeds had been signed and titles recorded.

It is therefore clear that the architect and engineer may do much in connection with the selection of industrial building sites, and that their services should be valuable in that connection.

There is a further value to the architect and engineer in taking part in the solution of this problem. This is because of the contacts brought about with real estate agents, which frequently lead to information about other prospective commissions and to legitimate new business. Real estate agents and architects should have close relations for mutual prosperity.

Finally, let it be said that the discussion here applies primarily to that type of job so rare and dear to the heart of the industrial architect, in which the owner finds and furnishes all the cash himself. Advice as to the best action to be followed when the owner tries to get someone else to build for him would undoubtedly be superfluous, would take a book instead of a brief article to set forth, and would probably be wrong.



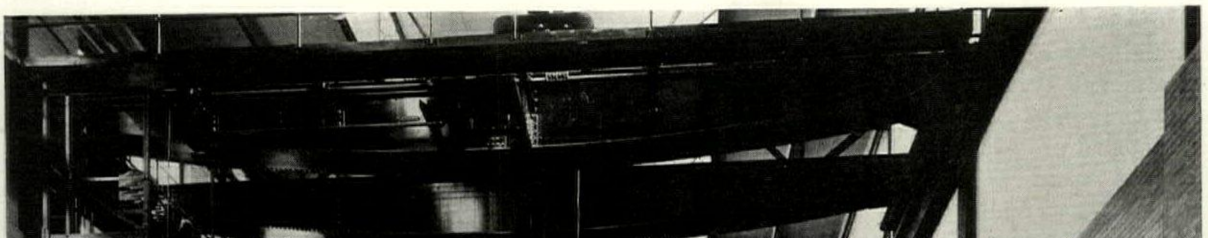
Pencil Drawing by T. R. Johnson of Study for Concrete Warehouse
Cass Gilbert, Architect

General Principles of Industrial Building Planning

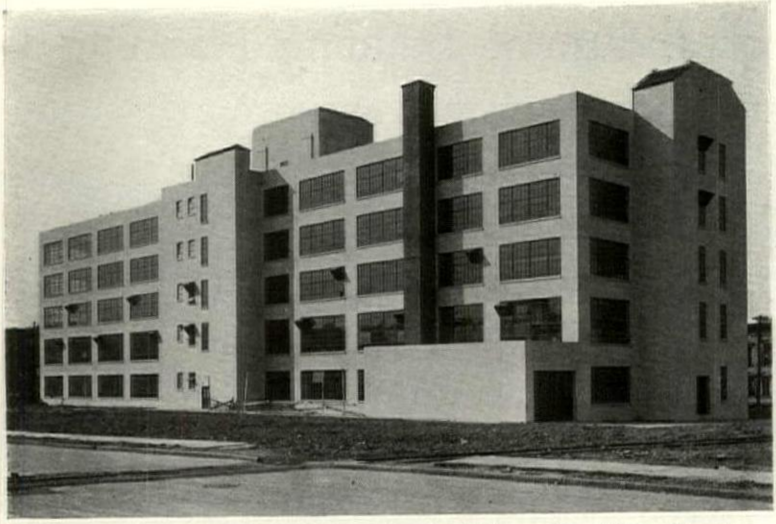
BASED ON INTERVIEWS WITH INDUSTRIAL ARCHITECTS

THE huge development of manufacturing in this country has produced industrial buildings of great magnitude, in the building of which the heads of large industries have in the majority of cases called upon all available sources of aid except that of architecture. There have, however, been a sufficient number of industrial plants erected from the designs of architects to point out the possibilities of improvement over the ordinary means of enclosing a given volume of space, not only from an æsthetic standpoint, but also from the economic viewpoint of the owner. From the purely architectural angle, the interest of the architect would seem to be in the treatment of the exterior of the building, but for two reasons his interest must and does exceed this scope. In the first place, plan is of equal or greater importance than exterior design, and while the elements of plan in an industrial project are simple, it is from their disposition that the architect receives the key to exterior design; secondly, the value of architectural planning is just as positive in industrial work as in the most complicated monumental structure. The natural faculties for securing logical and convenient arrangement of parts possessed by the architect guarantee to the owner a study of his requirements and a co-ordinated grouping of functions within the building that have a business value far in excess of the architectural fee incurred.

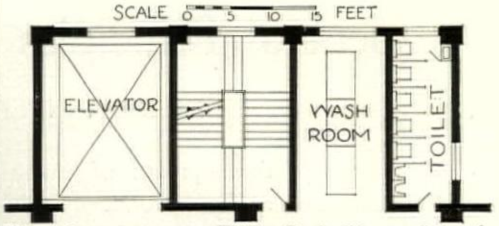
A statement recently made by J. P. H. Perry, Vice-president of the Turner Construction Company, which has had extensive experience in industrial building, bears out this contention. He said: "There is not much doubt but that the very finest industrial buildings which have been built in the last ten years in this country, the finest in general effectiveness as well as in appearance, have been produced under the direction of architects. A certain distinctive appearance, a certain completeness of design, a more perfect interior arrangement and a general suitability seem more likely to prevail when the bigger industrial buildings are handled through an architect's office than when an architect is not in the picture."



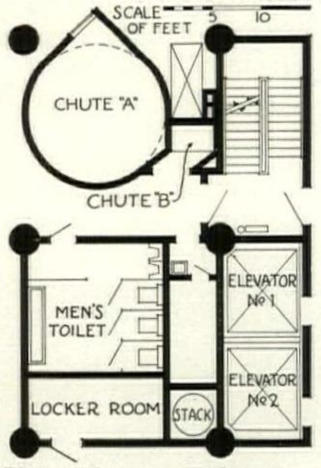
Interior of Power House, Victor Talking Machine Co., Camden, N. J.
Crane extends across width of building with monitor above. The monitor roof drains to the center to assist conducting warm air and gases out through the ventilating sash
The Ballinger Company, Architects and Engineers



Rear View of Mill Building of Kahn & Feldman, Brooklyn, showing extensions at ends and center for toilets, stairs and elevators
Buchman & Kahn, Architects



Plan of extensions in Fisher Body Plant. One of these provided for every 18,000 square feet



Plan of Interior Toilet Group
Western Electric Co. Warehouse, New York

It is therefore of definite interest to architects who would seek commissions in the industrial field to review the major principles of factory planning, based on data furnished by architects and engineers who have made a special study of this particular architectural problem. Modern manufacturing has been so intensified and speeded up because of keen business competition on the one hand and the shortening of working hours and higher rates of pay on the other, that no concern with an obsolete or poorly planned building can hope to carry on business successfully; the building must work to produce efficiency in as great a degree as the management personnel. Its plan has a direct relation to output.

The first requisite to good planning is a knowledge of the operations of the industry to be housed. Time spent in preliminary investigation of this character cannot be overvalued. In the instance of the Bunte Brothers' candy factory in Chicago, illustrated in this issue, two representatives from the architect's organization, one an architect and the other a mechanical engineer, spent two months in continuous study of plant operations and the movement of material. The engineer familiarized himself with the size, load and mechanical requirements of every machine used in the plant. This and other detailed data were collected, and formed the basis for the study of the general scheme of building arrangement which further permitted the definite location of every machine required in the new plant.

Detailed study of intricate manufacturing methods is not always necessary or possible; the success of a plan, however, demands a clear knowledge of the essential process and methods of handling material so that the most direct lines of travel may be determined in the first stage of planning. Many manufacturers are inclined to believe that they alone know enough about their businesses to design a plant because they alone understand their many secret formulæ; these are of little or no interest to the architect or engineer who knows that all manufacturing is a series of operations by various machines and appliances. The architect, however, should always co-operate with the owner or his managing expert who will, as a rule, select machinery and work out sequence of operations.

The first detail in developing an industrial building plan is the preparation of the site plan showing railroads, wharves (if any) and streets located and grades indicated; all underground water, electric and sewage lines should likewise be indicated. This, together with calculations of the quantities of raw materials used and the product turned out, is used to determine sizes and locations of buildings, locations and lengths of tracks, capacities of storage bins, yards or buildings, and warehouses and shipping buildings for the finished product. The location of these with respect to their uses and handling requires careful study to avoid unnecessary travel. Every industry has this problem, though perhaps none to a greater degree than large machine works, where for every ton of finished product at least three tons of raw material has to be handled.

Storage of coal and its delivery to the plant are matters of importance. The power plant can be located at the most convenient point for handling fuel and ashes, because transmission and underground pipe lines will carry light, heat and power to any desired point. By all means proper equipment for handling of coal and ashes as outlined in a later article should be incorporated. If an overhead bunker is not a part of the original contract it is well to make provisions for a future installation. Boiler and engine room likewise should be arranged for future extension. The expense of correcting oversights of this nature at a later time is tremendous, frequently involving entire rebuilding.

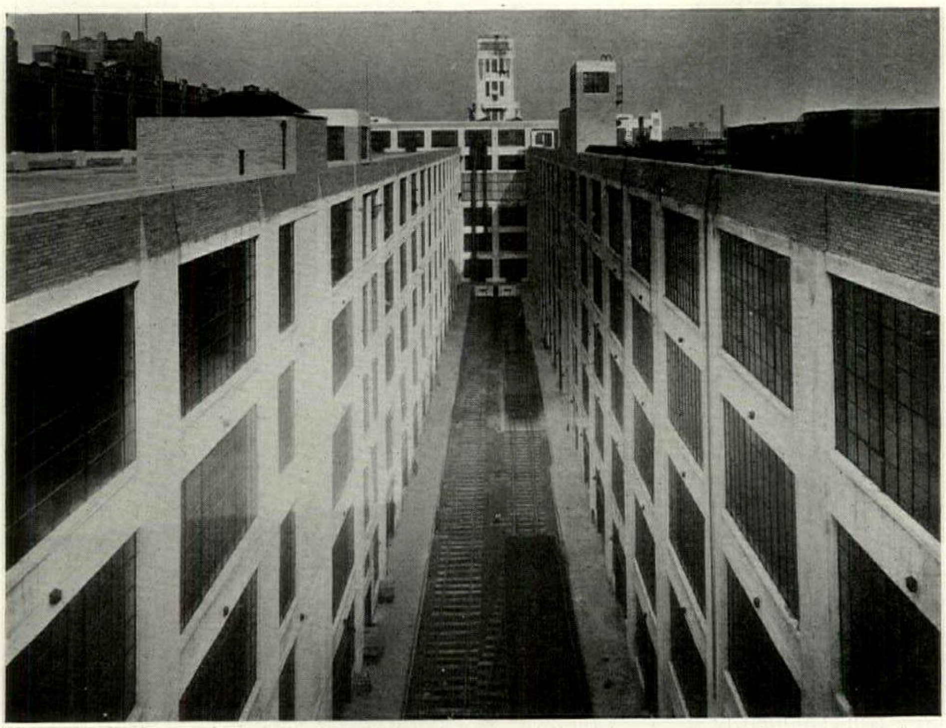
The types of buildings suitable for manufacturing purposes may be divided into three general classes: (1) the one-story, three-bay construction for foundries, forge and machine shops for medium and heavy work, requiring overhead cranes; (2) the one-story sawtooth or monitor lighted building for lighter work requiring no heavy cranes, which may be of any width and any number of bays, and (3) the multi-story building for all types of manufacturing purposes as well as storage except of the heaviest character.

The first type has generally a wide center bay served by one or more heavy traveling cranes and ranging in height from 30 to 60 feet to the roof with a narrower bay at each side for the lighter machine tools, etc. Foundries are similarly arranged with heavy moulding in the center bay, with melting furnaces, core shops and core ovens in one side bay and machine moulding, sand blasting, etc., in the other side bay. With the monitor form of roof the headroom may be less than in other types of wide building, because piping, ducts, etc., may be accommodated in the monitor, thereby reducing volume and cost. Shops using cranes, of course, require the high bay, and the side bays are frequently two stories high with a cantilevered balcony to serve as a receiving platform for the crane. The second type, usually with sawtooth roof, may be of any width, with columns spaced to suit the requirements of the industry. For spanning wide areas the sawtooth roof gives the best solution to the problem of lighting, and with recent developments in the design of trusses the possible objection to the rather numerous columns required in standard sawtooth construction is removed. The third type covers a great variety of buildings, including loft buildings and industrial terminals erected for several tenant manufacturers in which hundreds of employes are frequently accommodated. The major problem here, aside from arrangements dictated by manufacturing requirements, is the provision of adequate safe exits and ample elevator facilities for the handling of material and passengers. With the general adoption of the individual motor drive for machinery, the problem of power transmission has been greatly simplified and the old belt tower eliminated.

The width of multi-story buildings is determined by lighting conditions and manufacturing requirements. Shoe factories, as a rule, are rather narrow compared with other factories, usually about 45 feet with 50 feet as the maximum. Textile mills vary from 75 to 125 feet for all departments except weaving, which requires excellent light and for which the sawtooth weave shed is usually preferred.

The floor arrangement of tenant loft buildings is generally determined by economical column spacing; partitions are usually light and movable and can be placed to meet requirements of individual tenants. The standard and most economical bay is 16 by 25 feet; larger spacing necessitates more

Combined Shipping Court and Garage, Hydrox Co. Ice Cream Factory, Chicago
Electric trucks are used exclusively and connections for charging are provided overhead
Richard E. Schmidt, Garden & Martin, Architects



Interior Court of American Chicle Co. Plant, Long Island City, N. Y.
Provides center light in building 200 feet wide and space for 16 freight cars
Car scale at right under track. Court 40 feet wide

expensive construction, and except for special manufacturing reasons is not often warranted.

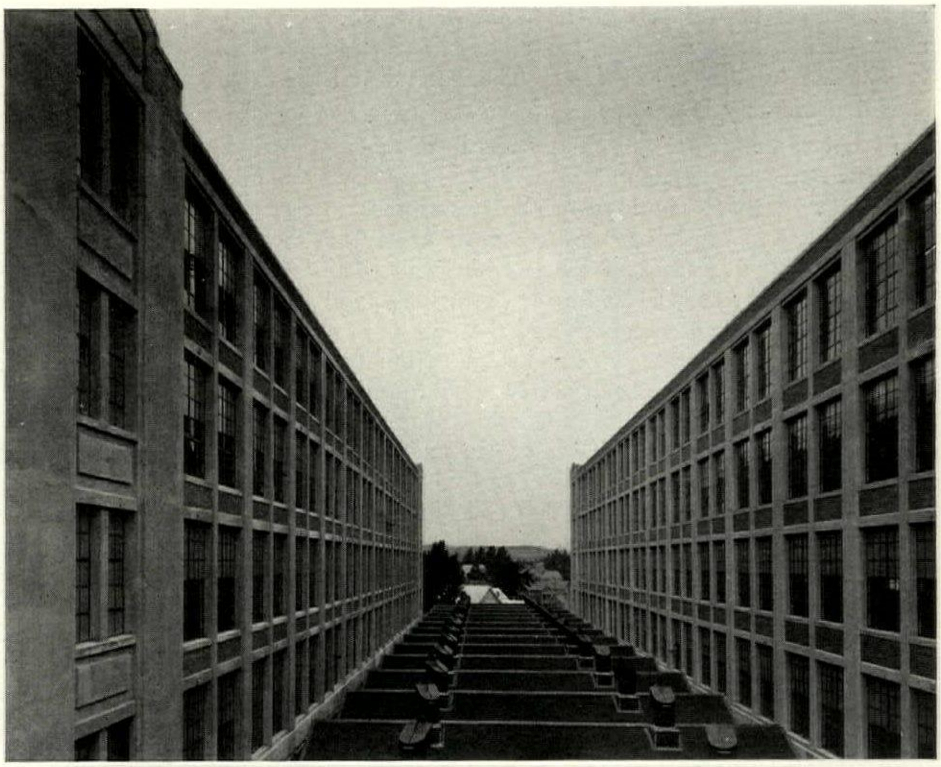
Natural lighting is of great importance. In general it may be said that all wall area not required for support should be glazed. In particular, if the light from the sky is unobstructed, 50 per cent of the wall should be glass and may well be as much as 80 per cent. If light is cut off by adjoining buildings, the glass area should be enlarged proportionately and may need to be the maximum. Consideration should also be given to possible future obstruction of light, and provisions made for contingencies.

In the multi-story building, if the width of the floor is greater than 40 or 50 feet, all available space should be glass. Greater widths than this are inconvenient because of fire hazard and difficulty in heating and ventilating. In buildings with windows on opposite sides and with the usual 12- to 14-foot ceiling heights, 60 feet is satisfactory for the floor width and permits good machine layouts. Greater width of course is possible, but the center of the floor would have to be used for storage or other purposes requiring little light. The windows in these wide buildings should reach from the ceiling to within 3 feet of the floor. In the Bridge & Beach Mfg. Co. plant, illustrated in this issue, the sash are carried to within 2 inches of the undersides of the concrete slabs, the spandrel beams being placed above the slabs to accomplish the result. This method prevents shadows on the ceilings and allows them to reflect light to the floors.

In flat slab buildings the outer bays may be extended in cantilever fashion 4 feet beyond the outside of the outer columns, permitting continuous sash and also continuous work benches. It is a universal experience that facing the source of light is fatiguing; work benches should therefore be arranged so that light will fall on them from the side rather than from front or back; a still better plan is to place them at an angle to the windows to permit momentary glances out the windows to relieve eye strain with the least effort and interruption to work.

Planning the layout of floors requires knowledge of manufacturing processes, and here the value of preliminary investigation is proved. From this data the machine positions are plotted and the lines of travel established, care being exercised to avoid conflict of travel in opposite directions; the means of transportation must be known and ample space provided for the easy passage of trucks in opposite directions when required. Otherwise, heated arguments between employes will cause confusion and loss of time. Planning for future extension should always be kept in mind. Any industrial plant should be arranged to permit extensions with the least possible expense and interruption to business. In fact, the ideal plant is designed at the start to cover the largest possible future growth, and at first only the needed number of units built. Modern handling of materials is designed to eliminate hand labor as much as possible. Conveyers should be installed wherever they will displace enough hand labor to pay for the investment. In a large brass foundry, for instance, a conveyer carries the metal from the basement to the charging floor; the moulten metal is conveyed by traveling cranes to the moulds. A conveyer belt under a grating in the floor returns all used moulding sand to the sand basement where it is mixed with new sand after screening and brought up by another elevator and conveyer and distributed to the moulding floor. Much of this work was previously done by trucks and wheelbarrows. In warehouses and tenant loft buildings, as in the case of the Gilbert Building, New York, a continuous spiral chute is installed to permit the easy handling of packages and small shipments from each floor to the shipping platform.

Many of the factors which improve factory buildings architecturally are dictated by legal regulations now generally in force for the safety and protection



Center Light Court, Spinning Mill, Goodall Worsted Co., Sanford, Maine
Lockwood, Greene & Co., Engineers

of employes. Yet these have not been standardized, and architects should familiarize themselves with emergency conditions that have arisen in factories and make provisions for meeting them. Ample and safe exits are foremost in importance; in a wooden floored building of any considerable height there should be not only fire escapes but ample fireproof stairways enclosed in fireproof walls.

The convenience of the workers should be a goal to strive for in planning; unnecessary traveling or the climbing of stairs to reach related departments of the work or the toilets and washrooms is annoying to the workmen and a direct cause of lowered efficiency. Stairs, elevators and toilets should be placed conveniently for all parts of the building, to interfere as little as possible with the lighting and to give the least possible obstruction to floor space. In buildings with party walls, the obvious and generally adopted plan is to locate them along such walls; in long, narrow buildings they are frequently incorporated in extensions at the ends or in the centers of the long sides. Exits should include at least one enclosed fireproof stairway, either exterior or interior, and from every floor there should be

Group of four standardized warehouses with shipping facilities and railroad sidings in basement. Flat slab reinforced concrete construction. Central Manufacturing District, Chicago
S. Scott Joy, Architect

not less than two exits with no point of the floor more distant than 100 feet from an exit, and in sprinklered buildings 150 feet. The second exit should preferably be another stairway.

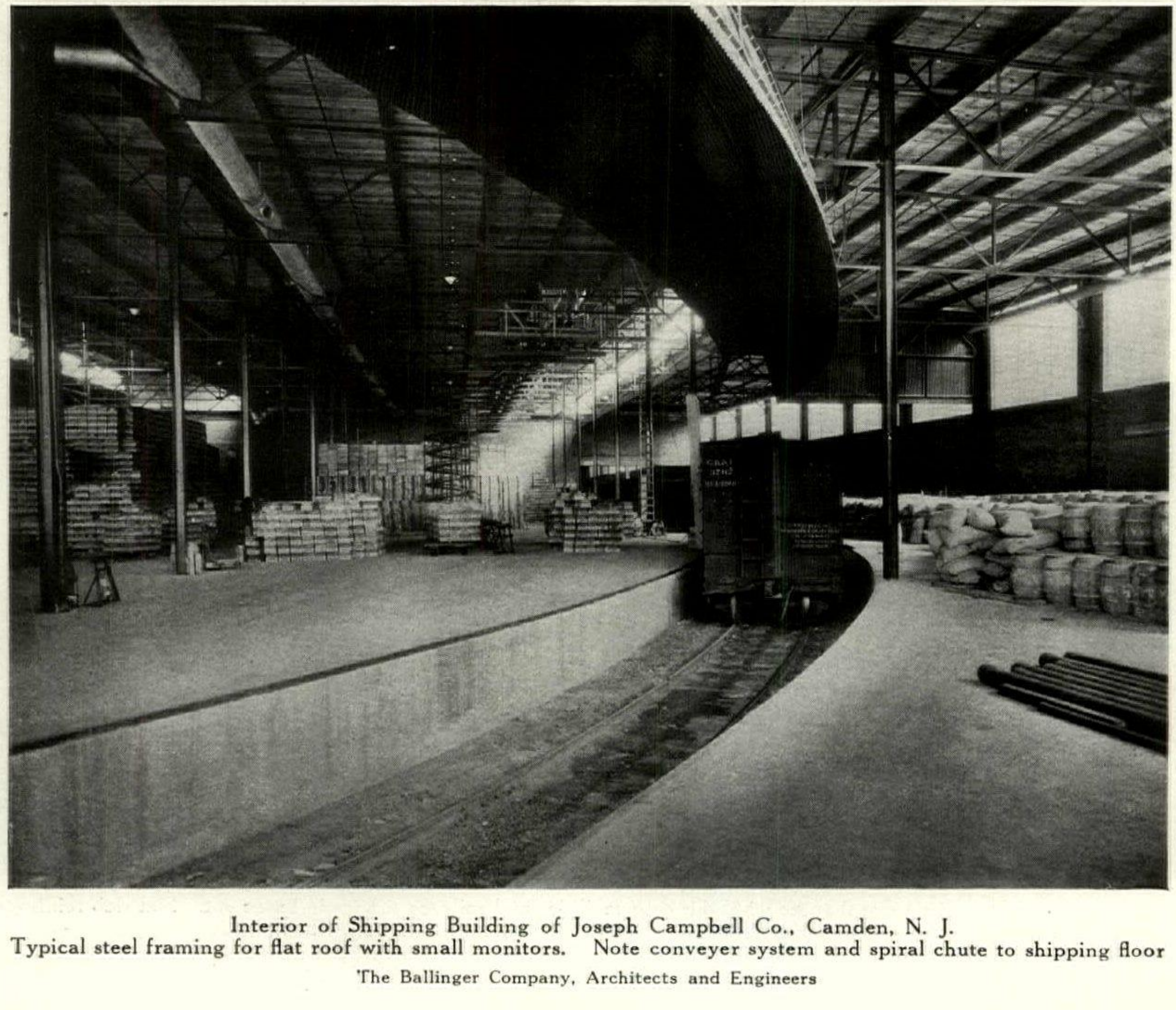
In determining sizes of stairways, it is recommended that the aggregate width of stairs in each story of a fireproof building shall be sufficient to accommodate at one time one person for each 150 square feet of floor area of the story served. The minimum unobstructed width of stairways and passages leading to them should be 44 inches.

All elevator and other shafts leading from one floor to another should be enclosed with fireproof material and have fireproof roofs and all openings provided with fire doors. Elevators in multi-story buildings are determined in size and number by the bulk of materials to be handled and the number of employes to be transported. The passenger elevators may be determined by rules similar to those applying to office buildings; in the large tenant manufacturing buildings in the Central Manufacturing District, Chicago, freight elevators are provided in the ratio of one to every 30,000 square feet of floor space. Similarly, trackage for one freight car is supplied for every 20,000 square feet of floor space.

In congested city districts it is good practice to limit undivided floor areas to 20,000 square feet when of fireproof construction and not sprinklered; with sprinklers the area may be increased to 50,000, and in buildings of one story these figures may be increased 50 per cent.

Certain standardization is possible in industrial buildings, and where large scaled operations are planned it is of definite value in speeding up construction; it likewise has an influence tending toward simplicity in plan. In the buildings of the Central Manufacturing District, Chicago, of which S. Scott Joy is the architect, two types of construction only are used, one mill construction, when small bays suffice, and reinforced concrete when larger bays are required. The mill construction bays are 16 x 16 for laminated flooring in buildings having long continuous runs of floor, thereby eliminating all cutting possible. Joists and heavy matched and dressed flooring are used when greater spans and lighter loads are required. Girders always run the short dimension of the building to permit the framing of the floor before the walls are brought up.

The flat slab bay 20 x 20 is the standard for reinforced concrete buildings. When larger bays than this are required, the live loads are decreased and the dimension of the bays increased in the direction which allows the most practical and economical use of lumber in mill buildings, and in concrete buildings the exterior bays are increased by a cantilever slab extending 4 feet beyond the outside columns.

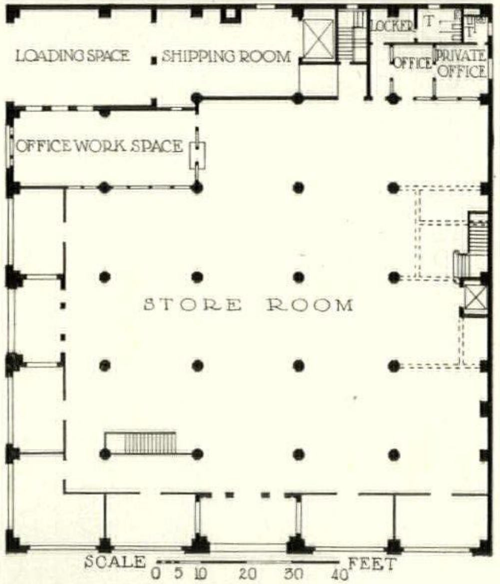


Interior of Shipping Building of Joseph Campbell Co., Camden, N. J.
Typical steel framing for flat roof with small monitors. Note conveyer system and spiral chute to shipping floor
The Ballinger Company, Architects and Engineers

General Exterior View

Interior of Second Floor

THIS building is used for furniture showrooms. Reinforced concrete with flat slab floors; floor loads, 150 pounds. Exterior faced with rough texture brick with cut stone trim and terra cotta cornice. Metal and plate glass show windows; other windows wood frame except those on exposures, which are fireproof. Low pressure gravity steam heat. Date of contract, January 24, 1922; total cost, $180,203; 14 cents per cubic foot.



First Floor Plan

CLEMONS BROTHERS BUILDING, CHATTANOOGA, TENN.
LOUIS H. BULL, ARCHITECT

Co-operation Between Architect and Builder

By HAROLD FIELD KELLOGG, *Architect*

ONE always feels that the art of the middle ages as expressed in architecture is the result, largely, of the guild system. How that differed from our trade unionism of today is not the argument here; that the work was done by close co-operation between the designer and the man, the guild or the union which actually executed the design, is a matter of history. Can this co-operation be renewed? If it can, our trade unions will have taken their place in the community by doing their share to express the civilization of our times. If the architect had to execute some of his designs, it is probable that they would be far different. To design a building which can be built with unskilled labor properly directed is an interesting problem.

Such an effort at co-operation has been attempted in the design and execution of the A. M. Creighton shoe factory, in Lynn, Massachusetts. Unlike some clients, the owner knew what he wanted and was willing to pay a fair price for it. He did not want to put up the cheapest building which would give the maximum of well lighted floor space for the minimum of cost. Dignified advertising, he felt, was legitimate, and a building just a little better than the uniform mercantile type he considered good advertising. The difference in cost, in this case, was estimated at 4 per cent.

The requirements of the factory were fixed by the methods of making, handling and selling shoes. The floor loads, beams and column centers were fixed by the trade, and the width of the building was fixed by the light efficiency at the machines. The size and height of the tower were fixed by the sprinkler tank, which usually presents an unsightly appearance on the roof. Here, then, was the skeleton, and it remained only to interpret these forms. Here was where the architect and the builder, representing the trades, could meet to mutual advantage.

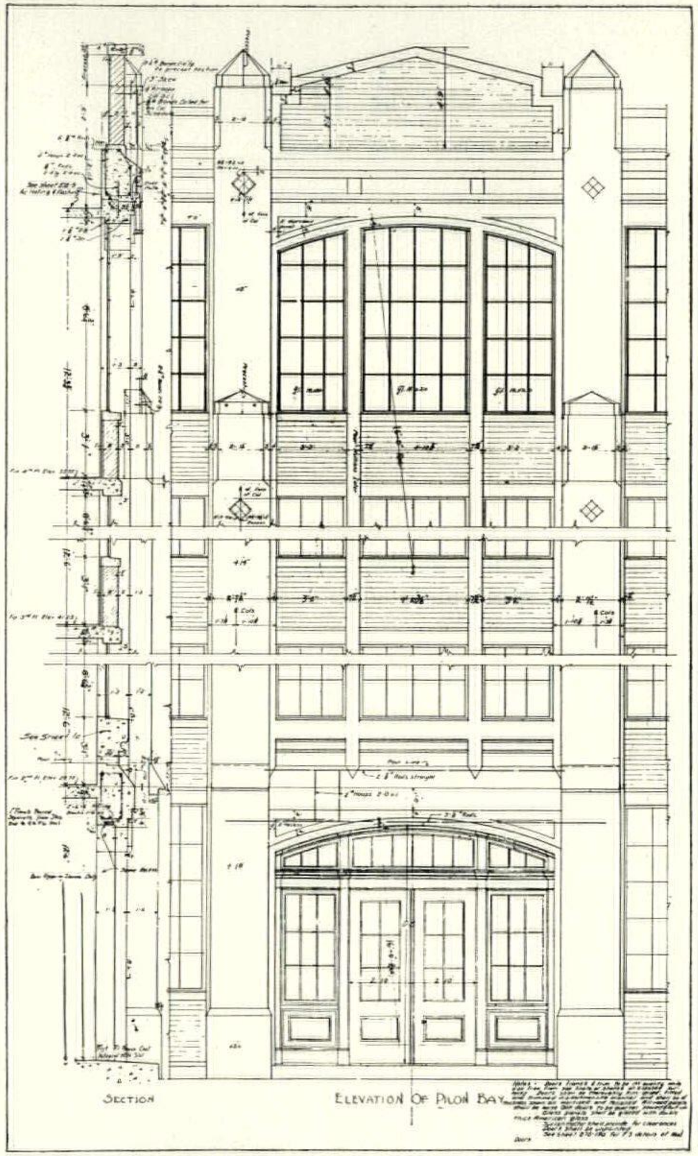
Before the design was fixed in any of its details, the "pour lines" or where the gang of laborers stopped pouring concrete at night, were determined. Relative to these "pour lines" all the details such as belt courses, cornices, buttress washes, etc., were designed. The amount of detail cast on the ground and raised in place was minimized. Only the washes of the buttresses and their crowning pyramids and the inserted tiles were cast at the site. Again, the design was dependent on the re-use of the same board forms. This, luckily, kept the imagination from inventing too many motifs which do not make for unity. Every insert was so designed that building the general concrete frame of the building could proceed, with openings left for the inserts. This was difficult in places on account of the steel reinforcement coming near the outside surface of the

GENERAL EXTERIOR VIEW

A. M. Creighton Building, Lynn, Mass.

Harold Field Kellogg, Architect

DETAIL OF LOWER PART OF PYLON BAY



ELEVATION OF PYLON BAY

A. M. CREIGHTON BUILDING, LYNN, MASS.
HAROLD FIELD KELLOGG, ARCHITECT

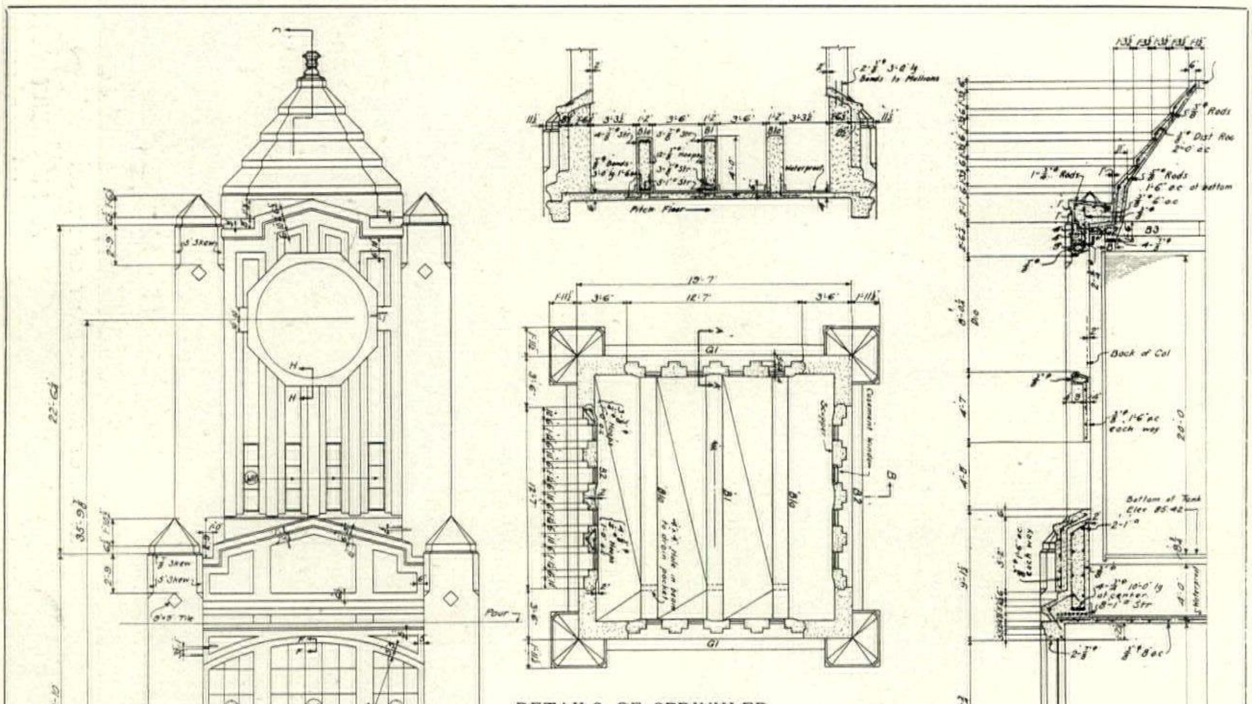
concrete. It was also impractical to leave wires or rods to tie these inserts to, so that each insert had to be in balance without being held in place.

The belt courses and cornices were designed so that the concrete frame could be built without waiting for them to be poured. If the horizontal detail members were poured integrally with the slabs and beams, it would mean that a form the whole length of the building would have to be made. By pouring only a relatively short length at one time, this form could be used over and over again, just as column forms are re-used vertically. This requirement did much to determine the form of the mouldings. All the details were so designed that the forms could be stripped without injury or taking the forms apart. Thus many conferences between the architect and the builder modified the design before construction began. The height and size of the tower were fixed as already said, by the sprinkler tank which it concealed. The added weight was expressed by the buttresses, much like the old cathedrals' multiplied buttresses around their towers.

Carving was, of course, impossible and not desirable in commercial work to any extent. The design, therefore, of the top of the buttresses, which in Gothic work was usually surmounted by a carved finial, was a point to be considered with great care. Here again what was the method of construction? Board forms were to be used and the concrete poured in. If each element required a special board form, the wood from the story below could not be re-used. It was, therefore, advisable to get the effect of a finial by placing something inside the old forms. There were triangular pieces of wood tacked in the corners, the pieces being no longer than a man could reach down from the top to nail in place. Every recess in panel buttresses or reveal was made of ⅞-inch boards as that was the thickness of the common lumber used.

With the circular clock it would seem to be necessary to depart from the straight line dictated by the method of construction, that is the use of board forms. Yet here the circle of the face was placed upon a hexagonal background of concrete which required no bent lumber to construct. The only details where the expression of lintel and column was not followed were the flat arches, really not a concrete form, yet used to attract the eye by a difference of line from the rigid vertical and horizontal. Inside, the building is simplicity itself, except for the owner's private office, the general offices and the waiting room. Here Gothic quartered oak paneling was used, with enough carving to give a domestic touch.

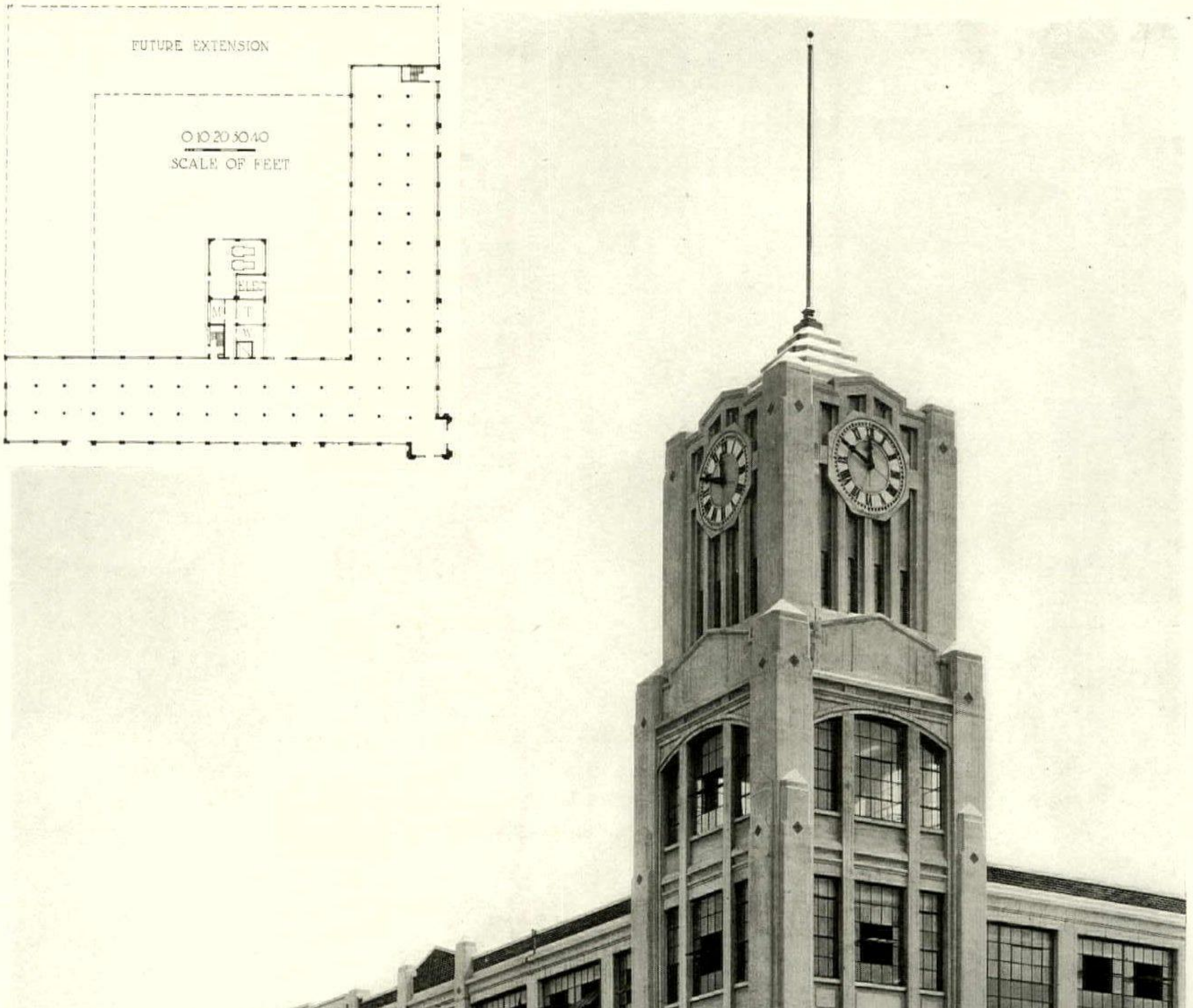
Throughout the progress of the work the architect and builders were in constant touch. Their one desire was to create, with the materials and labor commonly used, something neither commonplace nor yet elaborate. If this co-operation were in more constant practice the building trades would have a greater influence on the architecture of today.



DETAILS OF SPRINKLER TANK TOWER

A. M. CREIGHTON BUILDING, LYNN, MASS.

Harold Field Kellogg, Architect

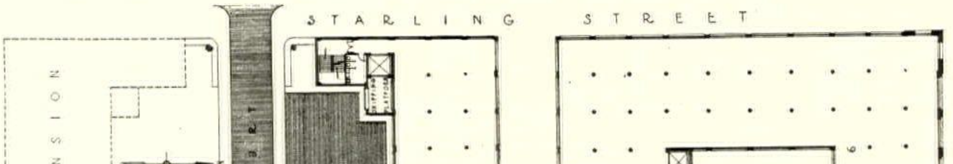


DETAIL OF TOWER AND TYPICAL FLOOR PLAN

A. M. CREIGHTON BUILDING, LYNN, MASS.

HAROLD FIELD KELLOGG, ARCHITECT

PERSPECTIVE VIEW OF COMPLETE GROUP OF BUILDINGS



FIRST FLOOR PLAN

Type of construction: Reinforced concrete flat-slab floors; solid slab and beams for roof where in Factory No. 1 a monitor runs through center bay. Building for manufacturing of shoes.

Exterior materials: Frontage faced with gray brick; Indiana limestone trim. Concrete exposed on other walls. Tar and gravel roof over concrete.

Interior materials: Floors in factory portions, factory maple; elsewhere, monolithic cement.

Heating: Vapor system from central plant. Exhaust fans in basement toilets; plenum system on third floor.

Windows: Side wall factory steel sash.

Date of general contract: March, 1922.

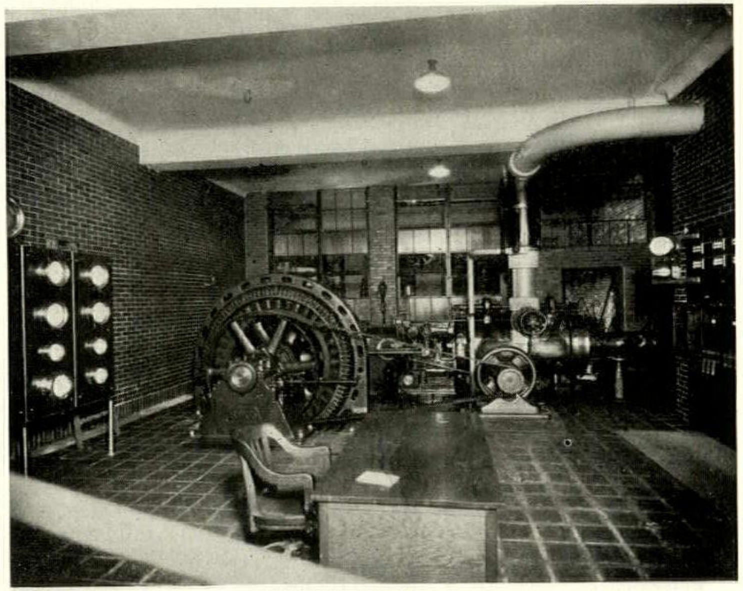
Cubic foot cost: 19 cents, exclusive of equipment; 2,560,420 cu. ft.; cost of power house with equipment, 72½ cents per cu. ft. Factory No. 1 and the power house are now completed.

H. C. GODMAN COMPANY FACTORY, COLUMBUS, OHIO

RICHARDS, McCARTY & BULFORD, ARCHITECTS

BELLE STREET FACADE OF FACTORY NO. 1

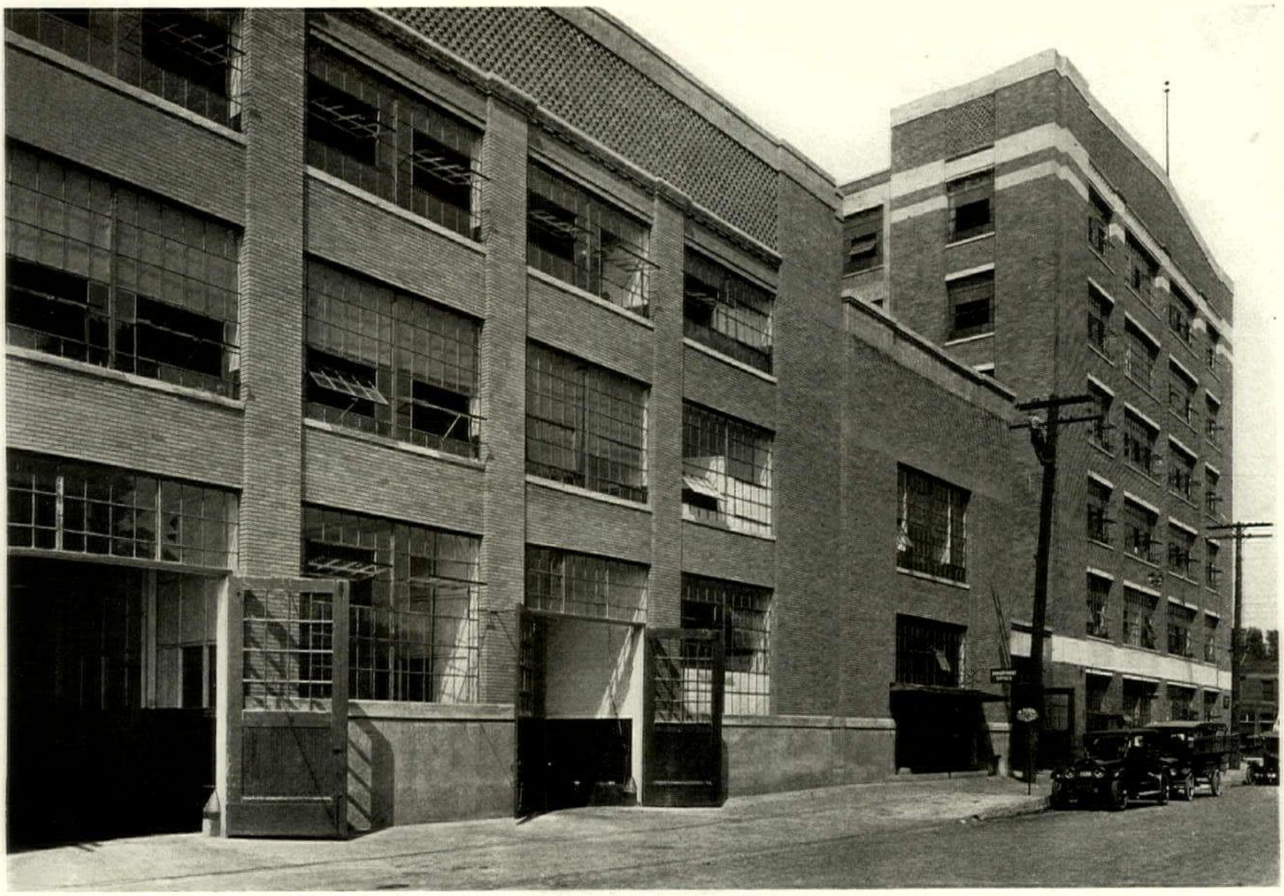
INTERIOR OF THIRD FLOOR



ENGINE ROOM

H. C. GODMAN COMPANY FACTORY, COLUMBUS, OHIO

RICHARDS, McCARTY & BULFORD, ARCHITECTS



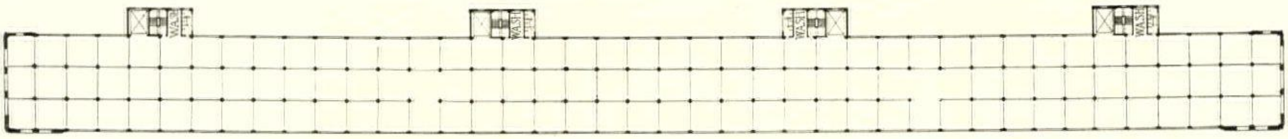
DETAIL OF END FACADE

EXTERIOR OF KILN AND MILL BUILDING

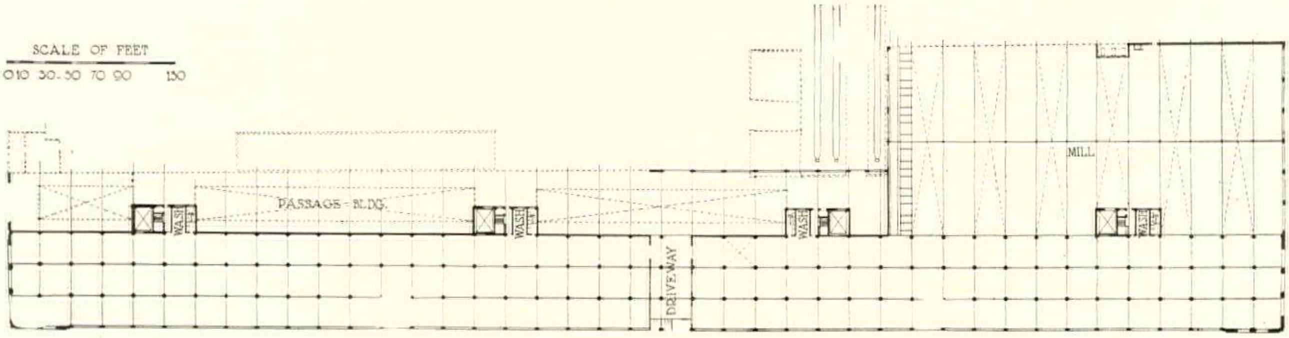
WEST END PLANT, FISHER BODY COMPANY, DETROIT

ALBERT KAHN, ARCHITECT

GENERAL VIEW OF EXTERIOR



TYPICAL FLOOR PLAN



FIRST FLOOR PLAN

Type of construction: Reinforced concrete skeleton. Building planned for live loads of 100 pounds per square foot for supported floors, and 30 pounds per square foot for roof slabs.

Exterior materials: Face brick.

Windows: Steel sash throughout.

Use: For the manufacture of automobile bodies.

WEST END PLANT, FISHER BODY COMPANY, DETROIT

ALBERT KAHN, ARCHITECT

Choice of Type of Construction

By JOHN R. NICHOLS
Consulting Engineer, Boston

WHEN the owner of a prospective factory, warehouse, mill, shop, foundry or other industrial building, or his professional adviser, faces the question "What kind of construction?" he has a choice of three generally recognized types, namely: (1) Mill Construction, (2) Steel Frame, and (3) Reinforced Concrete. Varied, indeed, are the circumstances and conditions that, having been given due consideration and weight, will determine the choice. And varied, too, are the modifications and partial combinations of the three types from which may be finally selected a design considered best suited to the situation in hand. It is the writer's purpose, without attempting to be exhaustive either of the subject, or, he hopes, of the reader, to discuss some of the characteristics of the types of construction available and to appraise their value in meeting requirements frequently imposed.

For many years the floors and roofs of industrial buildings have been framed out of wood. In the early part of the era of the power saw, when "two-by's" were the most familiar sizes used by the carpenter, framing consisted of joists or plank on edge, a few inches apart, overlaid with boards. This is termed "joisted" or "close-framed" construction, and is now used chiefly in dwellings. On account of the slender sizes of the members and their close spacing, fire, once started, consumes framing of this type rapidly, and because of the numerous recesses of the ceiling, is difficult to extinguish.

Walls of industrial buildings, too, used to be framed in wood, and to some extent are so framed at the present time. The value of masonry for walls, however, as a protection against the spread of fire, as well as for its durability when exposed to the weather, has long been recognized, and few buildings, other than dwellings and temporary sheds, are now constructed without the benefit of a masonry shell. Masonry walls in industrial buildings may almost be taken for granted.

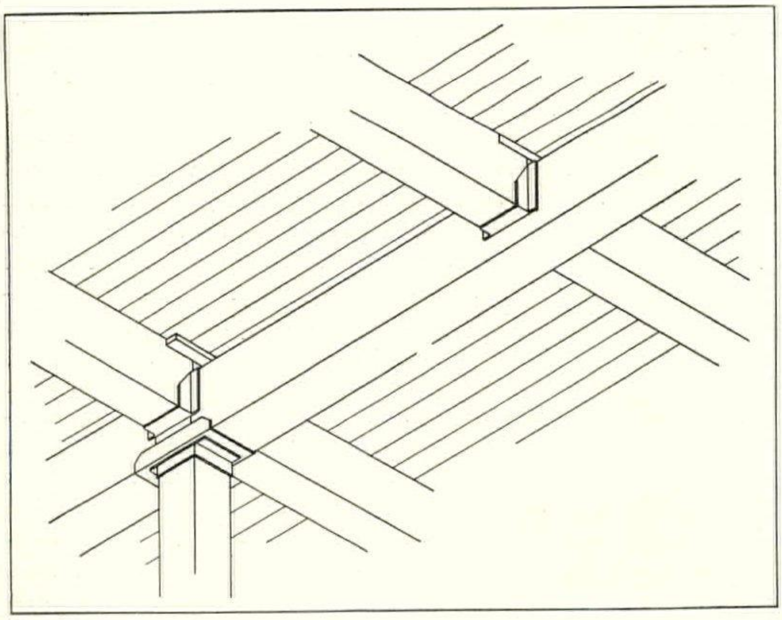
Some few years ago an endeavor originating in textile mills, to improve the fire-resistance of wooden-framed floors and roofs in buildings having masonry walls, resulted in what is known as "mill construction," sometimes called "slow-burning construction." The improved framing sought, by widened spaces between beams,—8 to 10 feet or more,—to bring all surfaces easily within reach of water from hose streams or sprinkler heads; by increasing the sizes of timbers,—no dimension less than 6 inches,—to lessen the combustible area exposed to fire, and to make possible a considerable depth of charring without endangering the load-carrying capacity; and by interposing thick floor planks between stories,—2, or better, 3 inches thick,—to provide a cut-off that would withstand fire and support floor loads for a longer time than the thin boards of joisted framing. The requirements of textile mills are well suited to the use of mill construction in its simplest and most economical form. Floor loads are light, 40 to 70 pounds per square foot, and close post spacing, transversely of 16 to 20 feet and longitudinally of 8 to 10 feet, is not objectionable. The floor beams, running transversely, rest directly on exterior masonry walls and interior posts, the plank spanning from beam to beam. No girders are required.

As mill construction was adopted for uses requiring wider post spacing, longitudinal girders became necessary, themselves resting on the posts and carrying the ends of intermediate floor beams. This is a modification of mill construction sometimes styled "intermediate framing." Although the term "mill construction" is held strictly to apply only to the original form with beams in but one direction, it has come in recent years to be used in the broader sense including all the modified forms of wooden floor and roof construction which embody in substantial degree the essentials mentioned.

Mill construction is not fireproof, even in the limited sense in which the term is properly used, for no construction is proof against all fire. In fact, the structure itself is fuel for the burning. But the heavy timbers resist fire and support their load longer than exposed steel, which gives way when heated, and the type well merits the term "slow-burning." Buildings of mill construction, equipped with automatic sprinklers, often carry a rate of insurance nearly or quite as low as would a fireproof building under the same circumstances.

Column spacing, for economy of construction, should generally be as short as the occupancy will permit. Rarely does this allow going beyond the point where added posts and foundations cost more than the saving in floor and roof framing. When, as in the case of general warehouses, columns interfere little with operation, it may become interesting to consider the purely economical spacing. This depends on so many varying factors that we cannot attempt here more than a generalization. Heavy floor loads, many stories, low story heights and good bearing soil favor close spacing, which will probably never be less than about 8 feet by 14. Conversely, light loads, few and high stories, difficult and costly foundations favor wider spacing.

The direction of beams and girders is determined by a number of considerations. If post spacing is wider in one direction than in the other, the girders, which are more heavily loaded, should be favored with the shorter span. This consideration is important when the use of structural steel for girders is



Isometric view of ceiling in a mill construction building, showing detail at column cap, and method of supporting beams at girders
The floor planking is raised 4 inches above girders

thus avoided. The direction of the boards in the finished flooring is another consideration. The distribution of light from the windows and its reflection from the ceiling are better when beams run across the building.

Yellow pine timbers, chiefly used in mill construction, are not readily available for depths greater than 16 inches. The larger sizes command a premium. Sixteen-inch beams loaded to capacity are subject to excessive deflection in spans of more than 20 feet. For longer spans, the deflection may be kept within bounds by reducing the allowable fiber stress, but the cost then mounts rapidly. For spans greater than 25 feet, steel becomes a close competitor, and considerations of delivery will usually dictate its use.

The girderless form of mill construction is economical for column spacing, at right angles to beams, up to the limit of span for 3-inch plank. This may be 8 to 12 feet, depending on load and allowable deflection. Wider spacing calls for girders to carry ends of beams intermediate between columns. The largest timbers available for girders are good for spans up to about 16 feet, depending on the floor load.

Beyond the limiting spans for timbers, recourse must be had to structural steel. This involves an appreciable increase in cost and, unless the steel is protected against fire at still further expense, a sacrifice of fire resistance. The only gain, aside from the wider column spacing, is increased stiffness. Timber combined with steel, as in trussed beams or flitch beams, had a vogue before the advent of cheap rolled steel, but is cumbersome and in view of the difficulty of joining the materials effectively is rarely found economical today.

Some attention should be given, in spacing of beams and columns, to layouts of the sprinkler system. The reasons for installing automatic sprinklers are first, to reduce the fire hazard and second, to reduce the insurance rate. Having the second object immediately in view as the best guide to attaining the first, the rules of the insurance underwriters are to be observed. In the case of joisted ceilings a sprinkler head is required for not exceeding 80 square feet. Symmetrical arrangement with respect to posts and beams, and extra heads at walls and partitions, will usually reduce the average area per head to about 60 square feet. When the spacing of beams is over 3 feet, the ceiling comes in the class of mill construction, and heads are arranged in relation to the beams, the maximum area per head being 100 square feet. The maximum spacing of heads is 12 feet. Having due regard to the length of bays, therefore, beam spacing of 8 to 12 feet is most easily susceptible of arrangement for minimum number of heads, with a line of sprinklers in the center of each bay. Beam spacing from 5 to 8 feet also calls for a line of heads in each bay, and results in decreased sprinkler spacing, and corresponding expense. For beam spacing between 3 and 5 feet, sprinkler heads are staggered in alternate lines, generally resulting in much less than 100 square feet per head.

It is possible, however, to attach too much importance to sprinkler arrangement. Allowing ten cents per square foot of floor space for sprinkler equipment, a choice of 7-foot instead of 8-foot spacing for beams requires 14 per cent more heads at an added cost of only 1.4 cents per square foot. This would be more than paid for if, for example, the thickness of floor planking could be reduced thereby.

When, for some reason incidental to the occupancy, wider spacing of beams is required than 4-inch plank is good for, either on account of stress or deflection, recourse is sometimes had to use of so-called laminated floors. This construction consists of laying small, square-edged joists on edge close together and spiked solidly through the sides. The only advantage in this over the usual grooved and splined plank lies in economy. The small joists used cost less per board foot than larger sizes, and the expense of grooving and of splines is saved. The object of grooving and splining is twofold: to give an individual plank subject to concentrated load the assistance of its neighbors, and to stop the passage of dirt through the floor. Included with the first is holding the planks to a smooth surface. Laminated floors accomplish the first object fairly, although the task of lining up warped and twisted two-by-sixes is by no means easy. In meeting the second object laminated flooring fails utterly, and it is hardly practicable in the ordinary course of construction work to keep all dirt and the necessary debris of masonry laying off the floor. Powdered mortar and other fine refuse is ground into cracks, later, when the wood shrinks, to fall from the ceiling below. When shrinkage occurs, some cracks open wide, making the ceiling unsightly. Where these results are not objectionable, of course, advantage may be taken of the possible economy of laminated construction.

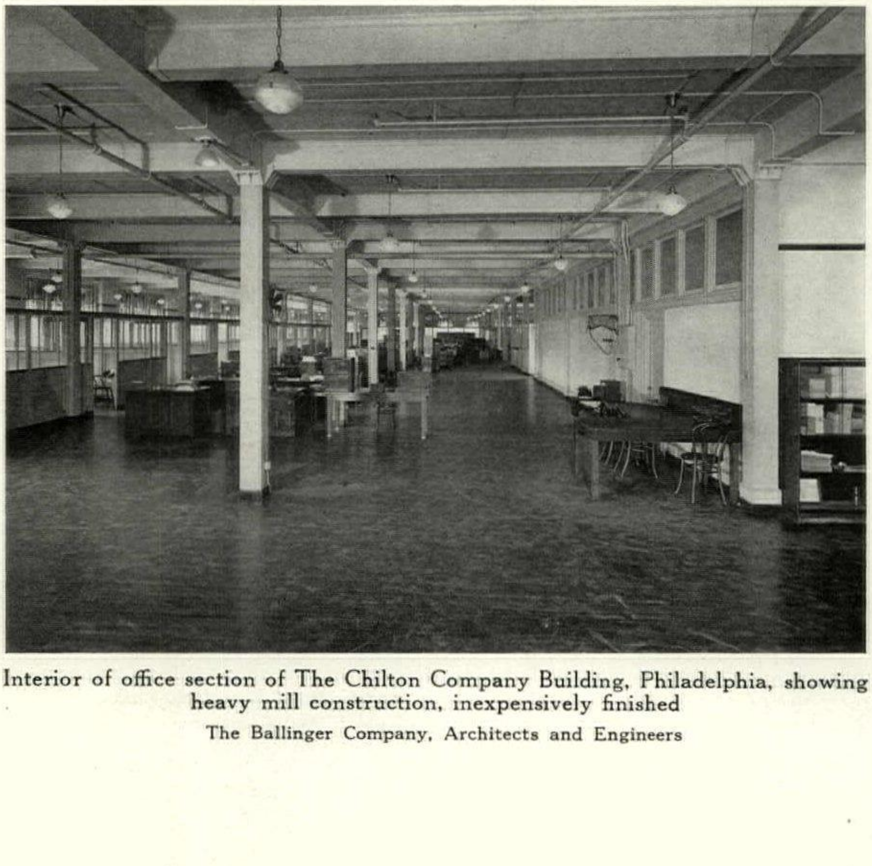
In laying laminated flooring the strongest and stiffest floor is obtained by making butt joints between ends of sticks as few as possible, and when they do occur by placing them at about one-fifth the span from the beams. They should always be staggered. The appearance of butt joints on the ceiling may be avoided by placing them over beams, but this reduces the strength and stiffness of the floor. A floor laid with random lengths is the cheapest and is stronger than when joints are over beams, but it lacks something in appearance.

Beams are supported on girders, either by resting on them or by being hung in iron stirrups or beam hangers. When the tops of the beams are level with the tops of the girders, it is called flush framing. Flush framing is objectionable either in floors or roofs, for the reason that when the beams shrink, the tops settle in relation to the girders, and a ridge is formed where planking is forced up along the line of the girders. Better practice is to hang the beams 3 or 4 inches above the girders, and to span across girders with 2-inch pieces resting in notches cut in the ends of the beams. The cost of this is not great, especially when iron dogs, otherwise required to tie together the ends of beams, are dispensed with. Space is thus conveniently provided for the passage of pipes, electrical conduits, wires, etc., on the ceiling.

Posts should not rest on the ends of wooden beams. Either they should be carried down between ends of beams to the column cap or base plate below, or metal pintles should be provided. The latter method has the advantage that the slender pintle permits ends of beams or girders to extend over the shaft of the column below. Its disadvantage is a lack of continuity of the column as a whole, which subtracts somewhat from its lateral stability. When the wooden column shaft itself extends down to the cap of a lower column, the beams and girders necessarily rest on brackets, usually a part of the cap, projecting beyond the face of the lower column. In such cases, cast iron for caps is to be avoided, as in case of fire the brittle metal is apt to crack off and drop the floor. Steel, though it may soften and sag, is more likely to hang on. Caps for top-story columns may be of wood, oak if necessary to avoid over-stressing in bearing across the grain at the column. Wooden columns in the lowest story should have metal base plates, which may be of cast iron, to intercept moisture brought up from the ground by capillary attraction.

Similarly, ends of beams in exterior masonry walls should have metal bearing plates. It has sometimes been the practice to brick in tightly the ends of beams in masonry walls. This frequently leads to rotting and is to be avoided. A space for circulation of air about the end of the beam is desirable, and to insure its thorough provision, sheet metal hoods are provided about ends of timber to keep back brick and mortar.

Wood kept dry lasts indefinitely, but where the moisture content exceeds a percentage, not accurately defined, for a long period, rot is apt to set in, and if allowed to persist will ultimately destroy timber for structural use. Thus in laundries, dye houses, and certain industries where a high humidity is maintained, rot (sometimes, when the moisture is not visible, called dry rot) has frequently caused serious damage to wooden framing. Floors constructed above the ground or over damp, unheated basements have suffered rapid deterioration from this cause. A number of preservatives have been developed which are more or less effective in retarding the growth and spread of rot, but permanence is not assured when dampness prevails.



Interior of office section of The Chilton Company Building, Philadelphia, showing heavy mill construction, inexpensively finished

The Ballinger Company, Architects and Engineers

In industries where arrangement of machinery is subject to frequent change, mill construction is found advantageous on account of the ease with which shafting is secured to the ceiling, machines bolted to the floor, openings cut for chutes, conveyers, etc., and the floors strengthened or reframed to meet changing conditions. Mill construction is rarely used in buildings more than six stories high. This is partly due to lack of lateral stability, which is chiefly dependent on the masonry, and the excessive size of posts and thickness of masonry in the lower stories, and partly to the restrictions imposed by building laws in cities, on account of the fire hazard.

The cheapening of steel manufacture that was brought about by the invention of the Bessemer process has made steel framing economical for buildings, under circumstances which favor its use. In steel framing, a framework of rolled structural steel members, which is entirely stable by itself, is erected on foundations, and the skeleton thus formed is clothed with walls, floors and roof. Members are assembled and joined one to another by means of rivets, although in unimportant structures bolts are used.

Two distinct types of steel-framed buildings are recognized. One follows the lines of mill construction with its beams, girders and interior columns, but with a steel frame taking the place of exterior masonry bearing walls. Buildings of the other type are known as "mill buildings," an unfortunate term, perhaps, which must not be confused with "mill construction." Mill buildings are long structures, usually one story in height, whose distinctive feature is their one or more broad bays free of posts. This type of building is used for heavy metal-working shops such as foundries, boiler shops, etc., where cranes are necessary for handling heavy or bulky work, and where large spaces clear of columns are required. For this type of building steel framing is practically a necessity. No other material is suited to the long spans and the high walls exposed to wind pressure and lateral forces from moving cranes. Sometimes, in temporary structures, timber trusses are used, but the difficulty of making suitable joints with wooden members, and the shrinkage of the wood, loosening the joints, are sources of continual trouble which are only completely avoided by using steel, the result generally justifying difference in cost.

Steel, although not fireproof, is incombustible, and when combined with incombustible materials in the finished structure at least affords no source of fire. In the metal-working trades, for which mill buildings are usually employed, fireproofing of such a structure and fire-protective equipment are superfluous. Corrugated sheet iron for roof and walls, and steel sash are commonly used when the building is not heated. Loss of heat through sheet iron is so great, however, that it pays to use concrete, gypsum, tile or other similar material for the roof, and masonry for the walls, when buildings are to be kept warm. In steel frame buildings which house quantities of combustible material, such as lumber, oil and inflammable chemicals, no advantage is gained by shunning timber for purlins and roof planking. Automatic sprinklers are then of great value. The choice between wood and masonry for walls of such buildings depends upon exposure to fire from nearby structures, or to the degree of permanence desired in the structure.

In other than mill buildings the use of steel for framing has been due to two reasons: First, to obtain structural members stronger than the largest available timber. Second, to employ a material which, when surrounded with a protective covering of concrete, tile or other suitable insulation, results in a fireproof structure, a structure much more resistant to fire than mill construction.

Steel is economical in fireproof construction, in high office buildings, hotels, apartments, etc., where the loads to be carried are light. Reinforced concrete, its chief competitor, is so heavy that the dead load of the structure becomes disproportionate when it is used in the frames of such buildings. For very high buildings, such as the "skyscraper" of New York,

Interior of heavy stamping mill showing typical steel "mill building" construction with craneway under monitor. Plant of Edw. G. Budd Mfg. Co., Philadelphia
The Ballinger Company, Architects and Engineers

steel is a necessity. The weight of reinforced concrete and the bulk of concrete columns in the lower stories, required to sustain it and occupying valuable space, are prohibitive.

Reinforced concrete has had its greatest development as a building material since 1900. The development has been so rapid, however, that today it is well recognized as one of the standard types of construction for industrial buildings. Concrete is an artificial stone and has the brittleness and lack of tensile strength characteristic of natural stone. High in compressive strength, however, it can be reinforced where it is subject to tensile stress by embedding steel rods in it when it is made. The combination of concrete, reinforced with steel properly placed and proportioned, is called reinforced concrete.

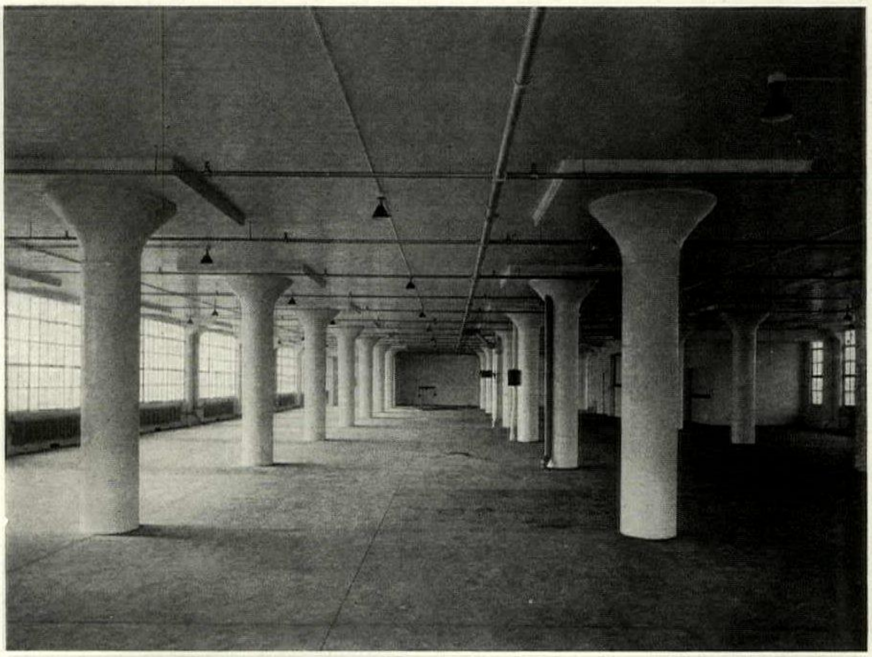
Reinforced concrete, properly designed and constructed, is classed as fireproof, and will withstand the destructive effects of fire as well as any of the commonly used building materials. Like all of them it suffers from long-continued exposure to a hot fire, but concrete structures subjected to fire are not usually damaged beyond repair, and are seldom if ever destroyed by it.

A structure of reinforced concrete is practically monolithic. Plastic when placed, successive days' work fits perfectly the concrete previously placed and hard. There is no looseness at joints, or play, affording opportunity for swaying. Concrete construction is therefore well suited for multi-storied buildings containing vibrating machines or machines having heavy reciprocating parts, such as printing presses.

Reinforced concrete in piers and exterior walls is stronger than masonry. Moreover, lateral stability is contributed by interior columns. Exterior columns or piers may therefore be more slender and more widely spaced than in mill construction, and correspondingly larger space is afforded for windows. The so-called "daylight factory" came into vogue with reinforced concrete. When floors are of the flat slab type, ceilings unbroken by beams and windows carried to the ceiling, the light distribution is unequaled. The use of rolled steel sash, with its slender members and large lights of glass, aids the natural illumination.

Reinforced concrete construction is best adapted to buildings having heavy floor loads. For loads in excess of 200 pounds per square foot it will frequently be found cheaper than mill construction. It is therefore well suited to warehouses. In high buildings, heavily loaded, the columns in the lower stories may become bulky and occupy too much valuable space. In this case, however, structural steel embedded in the concrete columns is successfully used to reduce their sizes. Reinforced concrete buildings are durable; sometimes too durable, when alterations are to be made or a building demolished. Cutting through floors is expensive and, if openings are numerous or large, may result in a weakening of the structure which is difficult to correct. Cutting the floor for small pipes, wires, etc., to bring water, steam, oil, compressed air or electric power to machines, wherever they may be placed, is sometimes facilitated by leaving wood blocks in the concrete at close intervals, covered over by the granolithic finish.

With reinforced concrete, as with mill construction, the closest column spacing permitted by the occupancy will be usually found economical. Bays 15 or 16 feet square are perhaps the minimum for economy in warehouses. Concrete, like steel, is a manufactured product, and is not subject to the limitation imposed, by the natural growth of trees, on mill construction. There is no well-defined upper limit on the size of bays. Flat slab, or girderless floor construction is particularly economical for small bays which are square or nearly square. For maximum economy the wall bays and end bays should be 10 per cent narrower than interior bays. Flat slab construction is used frequently up to 25 feet column spacing, and less often to 30 feet. For wide spacing it is very heavy, and the lighter construction of formed beams, girders and thin slabs saves enough concrete and steel to pay the extra cost of forming. Except in high, many-storied



Interior of typical flat slab concrete building, showing use of gloss white paint to increase effective illumination. Tiffin Building, Long Island City, N. Y.
The Ballinger Company, Architects and Engineers

buildings carrying light loads, reinforced concrete is almost always cheaper than fireproofed steel.

Where moist conditions do not prevail, hardwood flooring is probably the best and the cheapest satisfactory wearing surface for floors of factories, not laid on the ground. Matched flooring gives a more even surface, but where heavy trucking is done, square edged is more durable. In buildings of mill construction it is the obvious type of floor finish, nailed directly to the planking. Under wash bowls and isolated wet processes it may be desirable to lay cement, asphalt, mastic or other type of waterproof flooring, but this is always at added expense. Industries which are wet throughout should not use mill construction for floors.

In reinforced concrete and fireproofed steel frame construction, the laying of hardwood flooring is more expensive. A means for supporting the boards and securing them in place must be provided. The usual provision is wooden sleepers, bolted, wired or otherwise secured to the floor, filled between with cinder concrete. The sleepers must be carefully leveled, and to them the flooring is nailed. Hardwood flooring laid in such buildings costs 15 to 20 cents per square foot more than cement or granolithic floor finish laid directly on the structural floor. The requirement of hardwood flooring therefore favors economy of mill construction as compared with reinforced concrete.

For ordinary factory floor loads, when there is no special requirement for floor finish, mill construction costs about 10 per cent less than reinforced concrete, and steel frame, fireproofed, about 10 per cent more. Extraordinary opportunities to purchase lumber, cement or steel may affect the relative costs, even so far as to reverse their order, when other conditions favor, but usually the prices of these materials rise and fall together and proportionately. Subject to favoring conditions already touched upon, the relative costs have remained approximately as given since reinforced concrete came into general use.

Floor loads are usually determined by the building code in cities, and, where there is no code, by an estimate of the heaviest loads likely to come on the floor. Members of a frame which supports small floor areas should be adequate to carry possible heavy concentrations, or local loads more severe than the average. Girders supporting large areas, and posts may be designed for average loads 10 per cent to 25 per cent less than local loads. Columns carrying more than one floor may have the live loads still further reduced. The building codes of cities usually recognize the correctness of this principle and specify definite reductions. It is not applicable to warehouses and buildings which may be fully loaded in all stories.

For the structural floor and roof filling of a steel-framed building, a wide variety of materials and combinations are available. Where the structure is not fireproof, wooden plank may be used and is cheapest and lightest. For fireproof buildings, burned clay products were, until recently, used almost entirely. Brick arches with cinder or cinder concrete filling were common in warehouses and other heavily loaded buildings. Specially shaped skewbacks to rest on the lower flanges of beams and protect them from fire beneath the flanges were provided. Terra-cotta segmental arches were similar to those of brick, but lighter. These are rarely seen today in new construction. Where flat plastered ceilings are required, terra-cotta flat arches, with their skewbacks and flange protection, were used in office buildings, apartments and similar structures and are still used to some extent.

Reinforced concrete has very largely taken the place of brick and terra-cotta segmental arches, and is often used in such structures as office buildings. The slab is placed at the upper flange level, avoiding the expense of filling and its weight. The concrete protection is extended down the sides and beneath the beams. Plastered ceilings may be hung below.

In plastered buildings, flat ceilings with long spans may be obtained economically by using terra-cotta partition tile in combination with reinforced concrete. In this type of floor, the tiles, 12 inches wide and of the necessary depth, are laid on forms with spaces of 4 inches or more between rows, for concrete and steel reinforcing. Usually concrete is placed over the tiles. The terra-cotta is utilized as a permanent form for the concrete and a support for the plaster ceiling. Except that one wall of the tile, when so placed that joints are staggered, may be used to assist the concrete in shear, the terra-cotta serves no structural purpose. This type of floor construction is employed in spans up to 25 or 26 feet in schools, hospitals and other fireproof buildings where loads are comparatively light. The concrete ribs may run in one direction, when the openings in the partition tile are stopped only at the ends of the span, or they may run in two directions, the floor panel supported on four sides.

Gypsum, or plaster of Paris, treated to retard the set, and sometimes mixed with wood chips, has found use recently in the roofs and floors of steel-frame buildings. It is placed in forms and reinforced as is reinforced concrete, but having considerably less strength than concrete, must be thicker. Its advantage is that it weighs only about one-third as much as stone concrete and hardens much faster. In roofs, its property of heat insulation is sometimes of great value. It usually costs more than concrete, though the saving in steel, due to reduced dead weight, partly if not wholly compensates for the added cost of the floor itself. Both gypsum and concrete are made into slabs or tiles and sold by a number of concerns for roof and floor decking. They are useful in non-combustible buildings where the steel is not fireproofed. Cast and hardened before erection, they are placed rapidly, and time is saved by their use as compared with the use of reinforced concrete.

Fire Prevention and Protection for Industrial Buildings

By C. STANLEY TAYLOR

AMONG the more important elements which must be considered in the planning of factory and warehouse buildings are the structural and mechanical provisions for the protection of life and property against loss by fire. It is the purpose of this article to indicate the more important elements which receive consideration and the sources of information and technical service which the architect will find available in developing the various factors of fire protection for any building project which he may be planning. In another article in this issue of THE ARCHITECTURAL FORUM will be found a description of various organizations formed for the purpose of promoting a better knowledge of insurance engineering, together with a bibliography of important codes, standards and authoritative technical literature. The architect is advised to read the article as a source of reference to every problem involved under this consideration. Meanwhile, it is important to note that there are several sources from which dependable technical advice may be obtained without cost to the client, and which will result not only in greatly increasing the factor of safety but will probably bring about a drastic reduction in the insurance rating, for both the building and its contents.

Forms of Insurance

In general, there are two methods under which fire insurance is carried on an industrial building. The first of these is the regular fire insurance policy in an established fire insurance company (stock company), and the second type of insurance is carried in what is known as a "mutual" company, in which the rating is in accordance with experience, and is subject to rebate after losses have been paid for the year and the expense of administering the company's business has been met. The first point, therefore, is to determine with what fire insurance company or type of company the client intends to place his insurance. If the insurance is to be placed with a stock company, this will unquestionably be done through a large agent or insurance broker. Several such organizations maintain well organized insurance engineering departments, which will co-operate directly with the architect and the owner, usually with no charge except an agreement to place the insurance with the co-operating organization. When such arrangements are to be made, the architect will find it highly advantageous to call upon the engineering department of the owner's insurance representative to check over plans and specifications and to make suggestions tending to increase safety and reduce rates. If the insurance is to be placed through a mutual company, a similar service will be found available, as it is an important function of such an organization to reduce hazards wherever possible in risks carried by member manufacturers. In addition to these sources of advice, a number of the larger fire insurance companies maintain insurance engineering departments, and there are also such sources of information as local rating bureaus, the National Board of Fire Underwriters, and others mentioned in another article in this issue.

Rating Schedules as Guides

In the establishment of insurance rates, the rate of premium is standardized as the amount of money charged by the insurer for each $100 of the amount of insurance indemnity contracted for. This rate is in effect established by the amount of risks undertaken by the insurer as based on past experience and statistics gathered during years of painstaking research. Naturally, the greater the risk the higher the premium will be, and it is a policy of insurance interests to encourage all efforts on the part of the owner to safeguard his plant against losses. In establishing the rate of insurance the method commonly followed is known as schedule rating. A basic rate has been established for the class of risk, and a schedule established which adds to or subtracts from this rate in accordance with local hazards and structural and protective measures taken by the owner to guard against a fire loss. There are several rating schedules commonly used, including the Universal Mercantile Schedule, the Manufacturing Schedules, and the Dean Schedules, all somewhat similar in their methods of operation.

It has been said that a properly drawn rating schedule is a convenient and effective expression of the view of underwriters at large upon standards in materials, construction and protection, and is, therefore, a guide to architects and builders who desire to follow the best methods of fire prevention. It is also educational to the public, and has frequently to our knowledge influenced the adoption of better building laws, following the principles laid down in the schedule. It seems, therefore, that such a system should be considered a most important ally, and almost indispensable to the other and, perhaps, better known branches of scientific fire prevention, representing as it must the best thought of all who are interested in that subject, whatever may be their profession. It is obvious that these schedules include a large number of allowances and changes, and that with these as a guide the architect may incorporate in his plans and specifications many points which will be immediately recognized by the local rating bureau. Copies of such schedules are obtainable through insurance companies, agents and brokers or representatives of mutual fire insurance companies.

The Importance of Protective Measures

For full details of structural safeguards and fire protection equipment covering all types of buildings, architects are referred to two handbooks: "Fire Prevention and Fire Protection" (Freitag), and "The Crosby-Fiske-Forster Handbook of Fire Protection." Some of the more important problems affecting the planning and equipment of industrial buildings will be discussed here, but the architect on his individual project is advised to follow the clause already recorded, in asking the co-operation of insurance engineers and in obtaining information and data on his special problems directly from authoritative sources of information. The problem of fire protection in industrial plants divides itself naturally into four parts: First, preventing the origin of fire, and providing for extinguishing it at the point of origin. Second, to prevent the rapid spread of fire through large unprotected areas of floor space. Third, to prevent the spread of fire from floor to floor through unprotected vertical openings, such as stair and elevator shafts, conveyers, etc. Fourth, to prevent the entrance of fire into the building through exterior openings facing or over nearby buildings which constitute a menace as exterior exposure hazards.

Dividing Floor Areas for Safety

The National Board of Fire Underwriters has established a limit of areas which are to be enclosed within fire walls properly equipped with fire doors in order to check the rapid spread of fires. This subdivision of floor areas serves to hold the fire closely to the point of origin, prevents strong drafts, and aids materially in the work of extinguishing. In establishing these limitations of areas, which are sometimes required by local building codes and always by insurance interests, it is primarily a problem of the original design of the building and should be considered as one of the factors influencing the architect's work. The building code of the National Board of Fire Underwriters provides for allowable floor areas in accordance with the tabulations on this page covering various types of buildings:

Non-fireproof Construction—

(a) Tenement houses, 3000 square feet.

(b) All other ordinary non-fireproof buildings, height not exceeding 55 feet.

Fronting on	Without sprinklers	With sprinklers, increase of 66⅔ per cent.
One street	5,000 sq. ft.	8,333 sq. ft.
Two streets	6,000 " "	10,000 " "
Three or more streets	7,500 " "	12,500 " "

(c) Mill construction buildings, height limit 65 and 75 feet.

Fronting on	Without sprinklers	With sprinklers, increase of 100 per cent.
One street	6,500 sq. ft.	13,000 sq. ft.
Two streets	8,000 " "	16,000 " "
Three or more streets	10,000 " "	20,000 " "

Fireproof Construction—

(a) All buildings of Classes A, B, C and D
Light and power stations
Office buildings
} No restrictions as to area.

(b) All other buildings not exceeding 65 feet in height.

Fronting on	Without sprinklers	With sprinklers, increase of 66⅔ per cent.
One street	10,000 sq. ft.	16,666 sq. ft.
Two streets	12,000 " "	20,000 " "
Three or more streets	15,000 " "	25,000 " "

(c) Stores, warehouses, factories and workshops not exceeding 85 feet, and other buildings not exceeding 125 feet in height.

Fronting on	Without sprinklers	With sprinklers, increase of 50 per cent.
One street	7,500 sq. ft.	11,250 sq. ft.
Two streets	10,000 " "	15,000 " "
Three or more streets	12,500 " "	18,750 " "

(d) The first floor only of any fireproof building occupied as a store may have an area of 20,000 square feet, and if fully protected by approved automatic sprinklers may be increased 50 per cent, or have a maximum area of 30,000 square feet.

NOTE: Attention is directed to a document entitled "Allowable Heights and Areas for Factory Buildings," distributed by the National Board of Fire Underwriters.

Interesting extracts from the National Board Building Code relative to slow-burning construction specifications call for fire walls of brick, and brick laid in Portland cement mortar, or reinforced concrete. Non-bearing walls shall be not less than 16 inches thick in upper four stories or upper 50 feet, increasing 4 inches for each two stories or fraction thereof below. No such two-story increment shall exceed 30 feet in height. Parapets are to be full thickness of wall, extend at least 3 feet above the roof at all points, and to be coped with durable material. No timbers let in from opposite sides of wall are to have less than 8 inches of solid masonry separation. All openings in walls are to be protected with approved fire doors on each side of the wall. Mill construction building heights are limited to 65 feet from curb to roof. This same code provides vertical openings in brick or reinforced concrete shafts with minimum thickness of 12 inches and 8 inches respectively, parapeted 3 feet above the roof and with openings protected by fire doors.

The vertical openings in a factory which should receive primary consideration include elevator shafts, and emergency exits such as smokeproof towers. The smokeproof tower is a particularly favored means of egress in case of fire, and has the primary advantages of forming a cut-off fire and smokeproof stair shaft to which employes become accustomed by constant use as a means of floor to floor communication, and the use of which in case of fire does not develop that form of nervous panic which is customary where outside fire escapes are used. This shaft can also serve as a safe location for the standpipe of a private or public fire protection water supply and a factor of vital importance. In the construction of the smokeproof tower there are essential features of the specifications:

Classification of Available Approved Fire Doors and Shutters by Forms in Which Commonly Used and by Suitability to Different Situations

Column	1	2	3	4	5	6	7	8	9	10
		Fire Doors and Shutters Forms in which commonly used			Class A	Class B	Class B	Class C	Class D	Class E
Line	Type of Construction	Sliding	Swinging	Counterbalanced	Fire Walls	Elevator Shafts	Stair Enclosures	Corridors & Partitions	Severe Exterior Exposure	Moderate Exterior Exposure
1	Tin-clad, 3-ply	A,G,2	A,G,2	A,N	A,G,2	A,G	A,G	A,N	A,G	A,N
2	Tin-clad, 2-ply	A,G,4	A,G	A,N	U	A,G,2	A,G,3	A,G,3	A,G,1	A,G,3
3	Sheet metal	A,G,1	A,G,1	U	A,G,1	A,G,3	A,G	A,N	A,G,1	A,G,2*
4	Solid steel	A,G,3	A,G,3	U	A,G,3	A,G	A,G,2	A,N	A,G.2	A,G,3
5	Rolling steel	B	B	A,G	A,G	A,G,2	U	N	A,G.2	A,G,2*
6	Hollow steel	U	A,G,1	U	A,G,4	A,G	A,G,1	A,G,1	U	U
7	Counterbalanced Elevator	B	B	A,G	U	A,G,1	B	B	B	B
8	Metal-clad	U	A,G	U	U	A,G	A,G	A,G,2	U	U

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*Metal frame, wire glass window is first choice.

Walls: To be brick, concrete or tile, and to be self-supporting except in fire-resisting buildings. To have no openings except to outside of building.

Stairs and Landings: Preferably non-combustible. No winders to be installed. Stairs to be not less than 44 inches wide. Landings to be at least as deep as the stairs are wide, except at the door landings, where depth shall be 1 foot additional.

Doors: Doors to swing into shaft, except at point of exit where they should swing outward. Doors to be hinged upon the down side wall, so as to swing with the travel. No locks whatsoever shall be placed upon tower doors. Doors to vestibules or balconies may be locked by bolts on inside, so arranged as to be easily operated. No padlocks requiring keys to be allowed.

Balconies and Vestibules: Floors to be non-combustible and to be solid. Rails to be not less than 3 feet, 6 inches high. Width of platform to be at least 44 inches.

Illumination: A separate circuit from switchboard to supply each tower, and wires to be carried in conduit from switchboard to the tower. Lights to be provided in each story, and preferably so arranged that all lights can be turned on from switches placed in tower near doors, and in building near the doors at entrance to balconies or vestibules. The sign "Fire Escape Lights" should be painted on the wall near the switches in the building.

Where stairs are located in fireproof shafts directly connected to the building, it is quite possible they will be useless in case of fire above any point where a door may be left open. This form of exit is generally used, however, in factory buildings, and essential features to be considered for inside stairs of this nature include:

> Doors should swing with the travel or slide across it.
>
> Stairs should be broad, easy and free from winders.
>
> Continuous railings should be provided on both sides of stairs.
>
> Ventilator of liberal area should be placed on roof to carry off smoke which may enter the shaft.
>
> In many locations, stairs should be carried to roof.

In any case, stair enclosures should take the form of a shaft rather than be individual for each flight of stairs, as in this manner a fair means of escape will be provided. All elevator shafts should be constructed according to the best practice of fire protection, and should be arranged with solid walls and fire doors of a type which will be described in later paragraphs. If the elevator is operated by electric power, great care should be taken to safeguard the current supply against interruption in case of fire. (See N.F.P.A. publications for methods.)

For the protection of openings in fire walls many types of fire doors have been developed. The best practice for the architect is to obtain from the Underwriters' Laboratories a report of tests on various types of fire doors, which will indicate the margin of safety provided. The National Board of Fire Underwriters has a booklet entitled "Protection of Wall Openings," which deals with the installation of fire doors, shutters and wire glass windows, and explains the different types of door construction permitted in different situations. As a matter of reference the authors of the "Crosby-Fiske-Forster Handbook of Fire Protection" have originated a tabular form giving approved types of protective coverings for various situations and indicating their opinion of the range of good practice and of what is the best ordinary practice. This chart is printed herewith, and in this connection these lettered symbols may be noted:

A. Approved for use in situation shown.

B. Barred for use in situation shown, on account of design.

G. Good practice to use in situation shown.

N. Not good practice to use in situations shown.

U. Unapproved or unsuitable for use in situation shown.

This tabulation should be interpreted thus:

a. Classes A to E are those of the National Board of Fire Underwriters, appearing in the rules on "Protection of Wall Openings."

b. Types of construction of doors and shutters are those approved by the Underwriters' Laboratories.

c. Form in which commonly used indicates which types of construction are found in form of sliding, swinging, and counterbalanced doors. Except in the case of rolling shutters, all types of construction could be made in all three ways.

d. Through the medium of letters and figures, the authors have indicated what is approved, unapproved, and unsuitable for use, what constitutes good practice, and what, in the opinion of the authors, is the very best practice in each situation.

e. It is to be noted, of course, that in time changes may be made in practice, as, for example, hollow metal doors used in sliding and counterbalanced form. There may have been some instances of doors being used in forms not indicated in tabulation, but this tabulation is intended to show well established practice.

The term "counterbalanced" technically does not apply to a rolling shutter, although such shutter is counterbalanced by springs. Vertically counterbalanced doors (objectionable from an accident hazard and blocking exit standpoint) and elevator doors counterbalanced on each other are both included in the tabulation under the heading of "counterbalanced."

An important contributing element to the fire hazard in industrial buildings is the exposure hazard which involves protective measures against an immediately adjacent risk, a hazard which is considered in insurance rating and charged for in accordance with the protective measures employed. There is also to be considered protection against an extended conflagration, and finally there is the communication of flames from one floor to another through exterior openings.

Everett U. Crosby has summarized the possible causes of exposure fires thus: "Exposure and conflagration possibilities from grouped risks are due to fires extending from one building to others in view of the following cases: (a) fire in the individual risk passing beyond control; (b) effect of the size of the risk, viz., the amount of combustible material comprising the building and contents subject to burning at one time; (c) fire extending out through wall openings and through roofs; (d) fire entering through wall openings and through roofs; (e) fire spreading, due to the falling of burning rooms, floors, and contents; (f) fire spreading due to falling walls of a burning building; (g) influence of street widths and open areas; (h) influence of prevailing winds; (i) the 'range' of or territory affected by heat waves and fire brands; (j) adverse conditions of the weather or of the fire facilities."

If the proposed structure is located in an isolated position, the exposure hazard is naturally greatly decreased, and it is unnecessary to take most precautions in its regard. Otherwise, care should be taken to provide as few window or door openings as possible in close proximity to an exposure risk, and to protect these openings with wire glass, shutters and even sprinklers so that there will be little chance of fire passing into the building. In factory buildings it is important that all window frames and sash be of an incombustible matter which will serve to prevent the communication of exterior fire or fire passing from floor to floor. The most successful types of windows have frames, muntins and sash made of variously shaped rolled steel sections with patented methods of interlocking the vertical and horizontal muntins. Where there is any exposure hazard these windows are usually equipped with wired glass which serves an important purpose in retarding the entrance of flames. For additional protection it is customary to install fire-resisting shutters, of which there are several types, including tin-covered shutters for which standards have been developed by the National Board of Fire Underwriters and the Underwriters' Laboratories; sheet iron shutters, corrugated iron shutters and rolling steel shutters, of which the automatic type has been approved by the Underwriters' Laboratories. These rolling steel shutters are particularly valuable as they form a fireproof curtain which is automatically released in case of exposure fires and which have proved invaluable for this type of protection. Other types of window frames and sash which might be mentioned include hollow sheet metal windows and kalamein windows. Another possible method of protecting window openings is the use of double-glassed sash having an air space of at least 1 inch between the sash, and this type of sash is used where it is probable that inflammable contents of the building may be stored within 3 feet of a window, and serves to prevent the actual radiation of heat sufficient to ignite such stored material. In connection with all window and door openings and in the protection of vertical openings it is impossible to stress too greatly the importance of wired glass, which has the advantages of retaining its position under the effect of great heat and preventing rapid communication of fire and the opening up of channels and danger traps.

It is impossible to treat fully the importance of automatic sprinklers for use in reducing the fire hazards in industrial buildings. It is sufficient to say that practically all industrial buildings are equipped with automatic sprinklers, and that insurance rates are reduced to a comparative minimum in buildings which are completely sprinklered.

Of considerable importance in connection with the water supply for fire protection is the question of standpipes, hose racks and roof nozzles. According to Freitag, the possible great value of adequate standpipe installation and maintenance, especially in buildings of considerable height, is seldom fully appreciated by architect or owner. The provision of such protection is too often perfunctory, to cover some requirement in the local building laws or some regulations of the fire department rather than to provide and maintain suitably a fire protection auxiliary which is very likely to prove of the utmost importance. A proper and efficient standpipe equipment must satisfactorily cover many details which should not be relegated to any plumber in a haphazard fashion, but should be most carefully considered. Such details include location, capacity, water supply, valves and street connections, character of hose racks and hose, roof nozzles for particular use under conflagration conditions, or during fire in adjacent premises and, last but not least, some system of adequate inspection and maintenance.

The location of standpipes should be in or adjacent to stairway shafts, so that they may be readily found and used by either tenants or firemen, and they should invariably be located in some chase or flue which will protect them against possible injury by fire or falling debris. Details as to size and capacity of standpipes may be obtained from various sources already mentioned, as may also adequate information as to hose, hydrants and other equipment. The value of other pipe service, especially if equipped with roof nozzles, is important in connection with exposure fires. Many instances have been recalled where exposure fires have been prevented by the use of a roof nozzle. Full recommendations for this equipment may be obtained from the National Fire Protection Association.

Roof Types and Roof Surfaces

By WALTER F. BALLINGER

President, The Ballinger Company, Architects and Engineers, Philadelphia and New York

A THOROUGH treatment of the subject of roof types and roof surfaces would require the compilation of a vast amount of detail showing many ramifications of modern practice. To encompass this field in a brief space requires much elimination and a rather cursory treatment of the major problems involved in roof design. The principal points discussed are structural types, roof materials and surfaces, condensation, and the prevention of leaks.

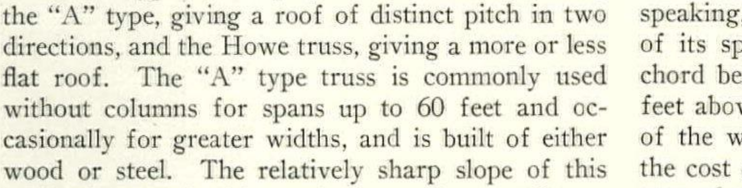
The simplest form of roof construction is a flat roof supported on beams, girders and columns. Either wood alone in heavy mill construction, or wood beams on steel girders and columns, or all-steel construction is used in this type. Wood plank generally forms the structural surface. Due to the many columns necessary to support an extensive roof of this kind, it is employed in industrial work mostly for small or temporary buildings or for warehouses in which the material to be stored does not require large, unobstructed floor areas. It is, however, frequently used in concrete construction of the beam and girder type. Flat slab concrete construction is essentially the same structurally.

To procure longer spans between columns, trusses of various types are employed, the commonest being the "A" type, giving a roof of distinct pitch in two directions, and the Howe truss, giving a more or less flat roof. The "A" type truss is commonly used without columns for spans up to 60 feet and occasionally for greater widths, and is built of either wood or steel. The relatively sharp slope of this roof, when used with monitors or other ventilators at the ridge, assists in ridding a building of heated air or obnoxious fumes that are lighter than air, as the gases rapidly seek the highest point and pass out through the openings provided.

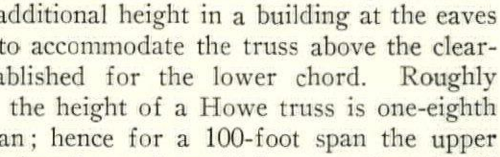
Where high humidity must be maintained within a building, as in many textile mills, and where condensation of the moisture with the resulting dripping must be avoided, it is important that there be no obstructions to the free passage of the air along the under side of the pitched roof from the low point to the ridge. Should the moisture-laden air be interrupted in its flow by a purlin placed horizontally, for example, the air caught by the pocket thus formed would tend to give up its moisture due to the prolonged contact with the cool roof. The water condensed at this point would drip from the roof and purlin, while the air after cooling would tend to descend out of the pocket to be replaced by more moisture-laden air, the process constantly repeating itself. By keeping the heated, moist air rapidly moving to the ridge and out of the ventilators, much of the condensation is avoided until the air is actually outside the building.

When a structure of considerable area is to be roofed, columns become necessary. To combine a series of "A" trusses would result in deep valleys over each row of columns. Consequently, where long spans are required with columns at relatively remote intervals and when ventilation is not a primary requirement, the Howe truss or some one of its related types is used. Clear spans up to 80 feet are common with this truss, and greater widths can be bridged if the cost is not too great a factor. A characteristic of this type of framing is that it requires additional height in a building at the eaves in order to accommodate the truss above the clearance established for the lower chord. Roughly speaking, the height of a Howe truss is one-eighth of its span; hence for a 100-foot span the upper chord bearing the roof would be approximately 12 feet above the lower chord. This adds to the cost of the wall construction, and it adds materially to the cost of heating and conditioning this extra volume of air, whenever such is necessary.

Both the "A" truss and the Howe truss are commonly surmounted by monitors which take various forms. The most frequently used monitor consists of two parallel rows of glass on either side of the ridge, with a pitched roof above them, the slopes of the monitor roof being approximately the same as for the main roof. Sometimes a straight roof, pitched to drain in one direction only, is employed on the monitor. A variation of this monitor consists in having its roof surfaces pitch downward to the center, forming a V, the bottom of which is

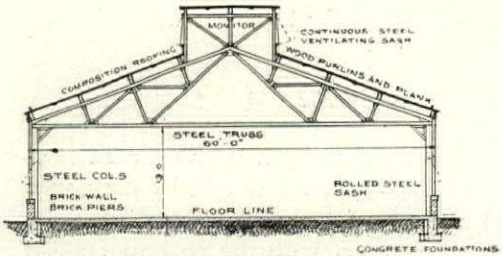


Standard Saw-Tooth Skylight Roof in Steel Construction

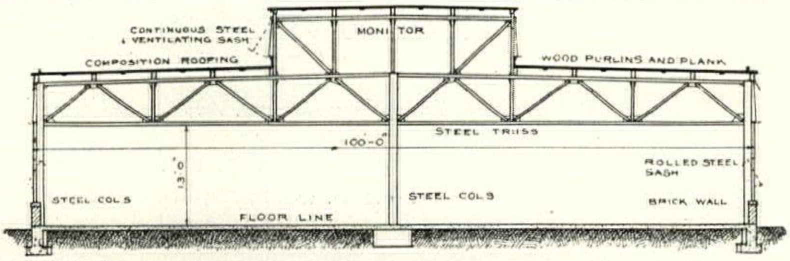


"Super-Span" Saw-Tooth Roof

Patented by The Ballinger Company, Architects and Engineers



Monitor Roof in Steel Construction, Giving Good Light and Ventilation



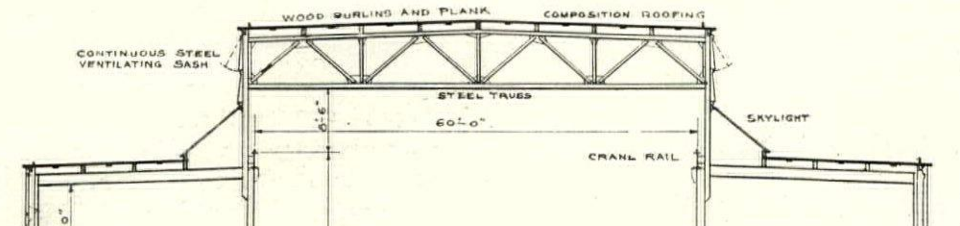
Wide Monitor Type, Providing Space Above Bottom Chord of Truss for Ducts and Piping

generally at the same level as the ridge of the main roof. The purpose of this reversed form is to eliminate any air pocket, and to assist in the complete removal of moist air or undesirable fumes. As will be noted, this kind of monitor places the windows at the highest point. A modification of this kind of monitor is formed by continuing one surface of a pitched roof beyond and above the ridge for a short distance, and connecting this false ridge with the other roof surface by means of glass sash set at a slope of approximately 3 inches to the foot away from the vertical. The resulting monitor is thus one-sided, combining the characteristics of a sawtooth roof with an "A" truss framing. The glass in these monitors is generally faced only to the north as in sawtooth buildings to eliminate sun glare and heat, but sometimes it is placed in alternating directions in every other bay without regard to compass points. In this case the function of the monitors is primarily that of ventilators.

The "high and low bay" roof is useful where long spans are desired with monitor lighting. In this type, the building is spanned crosswise with a series of flat or Howe trusses spaced at regular intervals. Beginning at one end of the building the roof is placed at the level of the bottom chords. The roof between the first and second truss is at the level of the top chords and rests upon them. The roof between the second and third truss is again placed down at the bottom chord, and so on down the length of the building. The vertical faces of each truss carry ventilating or rigid steel sash, so that every other pair of trusses constitutes a monitor with glass sides. By this simple scheme the depth of a Howe truss is utilized with a minimum of waste space requiring heating and air conditioning.

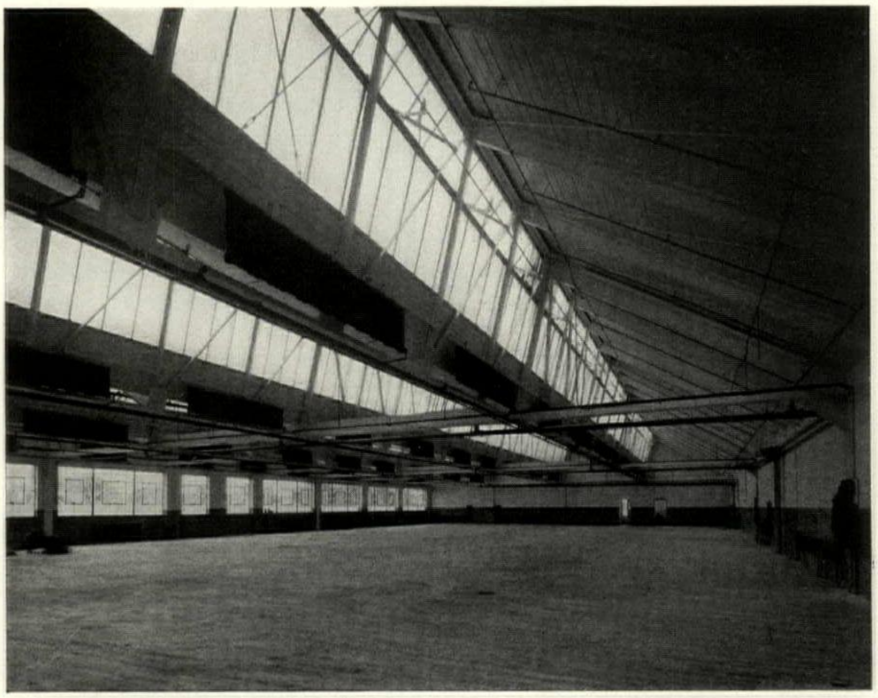
Monitors may function both as ventilators and skylights. Under certain conditions the admission of direct rays of the sun through monitors is objectionable because the illumination of the interior is very "contrasty," with bright, sunny spots and dark shadows. Furthermore, skylights admitting the sun's rays act as greenhouses; that is, the heat of the sun enters, which is often undesirable, especially in summer and in plants that are otherwise overheated. To overcome these objections, sawtooth roofs are used, consisting of a series of parallel skylights facing the north, and having the glass so placed as to receive none of the direct rays of the sun. The glass may be placed vertically, but a greater lighting efficiency results from sloping the glass to the angle corresponding to the deviation of the sun from the meridian at the summer solstice.

Sawtooth roofs are constructed entirely of wood or may be entirely framed with steel or concrete. Generally each valley is supported by a row of columns spaced from 16 to 25 feet apart, though greater spacing may be obtained with ordinary I-beams of sufficient depth. To get long spans several methods are employed. A Howe truss may be used in back of the glass in a perpendicular position from the peak of the skylight or sloped to correspond with the angle of the glass. Owing to the depth required for this truss it is practicable only up to 60 or 70 feet. The use of a Howe truss transversely to the sawteeth and beneath them permits of somewhat longer spans, but the cost is greatly increased. This is because the truss requires from 8 to 12 feet of extra height to the building, and from 8 to 12 cubic feet of wasted space to be heated and conditioned for every square foot of floor area.



Three-bay Monitor Type, with Crane Rail and Side Aisles and Balconies, for Forge Shops and Heavy Manufacturing

An economical method of framing sawtooth roofs without columns has been developed and patented by the writer and is called "Super-Span" construction. The system employs both longitudinal and transverse trusses. In back of the glass is an ordinary truss as just described, which supports the roof longitudinally for distances up to 60 or 65

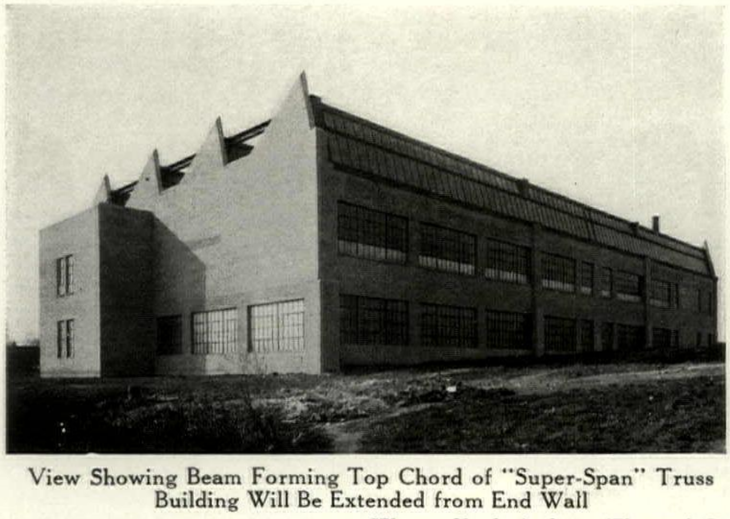


Interior of Ardross Worsted Co. Weave Shed, Philadelphia
"Super-Span" Saw-Tooth Roof, Spanning Room 88 by 168 Feet
Note Ventilating Sash and Operating Device

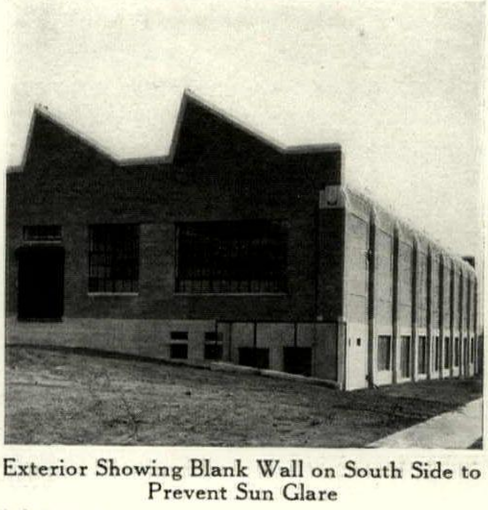
feet. These trusses in turn are supported (at 60-foot intervals) by a heavier transverse truss, whose bottom chord is at the same level as the valleys and whose top chord extends outside the "sawteeth" connecting their peaks one to the other, the structural members of the skylights becoming the struts and braces. It is somewhat like an ordinary bridge truss except that the angles of the web members are not equal in each pair. Reference to the accompanying illustration will clarify this point. With this system of framing, spans of 100 feet in width (transversely to the skylights) and of any length whatever are constructed at only slightly greater cost (for the building as a whole) than for a sawtooth roof supported on columns under each valley. If widths greater than 100 feet are to be roofed, a row of columns about 60 feet apart is required for each additional 100 feet, giving a column spacing of 60 x 100 feet.

A fourth kind of roof framing is the wood or steel truss of arch form, suitable for spans of considerable length where very light roof loads are to be carried. They are frequently used for garages or small armories, but when built of wood are not highly considered by fire protection engineers on account of the small dimension lumber used to build up their lattice webs and laminated chords. Two types may be distinguished, the first consisting of a curved truss built up of wood, in which the upper and lower chords are both arched and are nearly parallel to each other. The web members are placed much the same as in a Howe truss. A steel or iron rod in tension connects the ends of this truss like the string to a bow, and takes care of the thrust of the roof. The usual spans for this roof range from 60 to 100 feet. The second type, which is generally built up of laminated wood members, has an arched upper chord and a flat lower chord, the whole forming the segment of a circle. The latticed web members of this truss are arranged according to a rather complex system, and several effective methods of construction are controlled by patents. Spans as great as 100 feet have been bridged occasionally with these segmental trusses.

Skylights are used on all types of roofs, sometimes even in conjunction with monitors. There are two kinds—those that have their glass near to and parallel with the roof surface, called "flush" sky-



View Showing Beam Forming Top Chord of "Super-Span" Truss
Building Will Be Extended from End Wall



Exterior Showing Blank Wall on South Side to
Prevent Sun Glare

Weave Shed, Ardross Worsted Co., Philadelphia
The Ballinger Company, Architects and Engineers

Concrete Monitor Construction with Movable Steel Sash
Tiffin Building, Long Island City, N. Y.
The Ballinger Company, Architects and Engineers

lights, and those having their glass in various arrangements on frames extending well above the roof surface, called "standing" skylights. Flush skylights are used principally on pitched roofs of distinct slope where their shallow frames are not likely to be flooded, and function almost entirely as windows rather than as ventilators. Standing skylights take many forms, but very commonly have tops shaped like a hip roof with plain or ribbed glass held in light metal or wood framing. The sides of the skylight may be of glass or metal, but very frequently have ventilating sash like that used in monitors. When ventilating sash is not used other forms of ventilators are employed, as these skylights are mostly used over elevator and stair wells or light courts through which warm and foul air rises and is removed.

Turning now from roof structure to the materials of construction, we face an even broader field. First to be considered are the materials used for the structural roof itself—the substances used to span the spaces between trusses or purlins, on which the upper waterproof surface is placed. Wood plank is largely used because it is inexpensive and is a fairly good non-conductor of heat and therefore helps to reduce the heat loss from the building and to minimize condensation on the under surface. It is objectionable in several ways, however, the principal disadvantages being that it will rot, and that it is combustible. The tendency to decay may be counteracted by various chemical treatments, some of which are sufficiently inexpensive to warrant their use. Wood may be used in the presence of many chemical fumes that would destroy metal or masonry construction. Concrete is much used for structural roofs where the rest of the building is of concrete. It has many merits, particularly for roofs of flat pitch. Various systems of construction are used, employing gypsum tile, metal tile, burned clay tile and the like, or using ordinary beam and girder or flat-slab construction. Concrete requires some insulating layer to prevent excessive condensation under certain conditions. Gypsum in various forms is coming into wide use because it is a non-conductor of heat and therefore reduces condensation to a minimum. In this respect it is about as effective as wood. Gypsum is non-combustible, permanent, and of light weight, and is easily handled. Except under acid conditions, gypsum is generally preferable to wood plank and costs but little more.

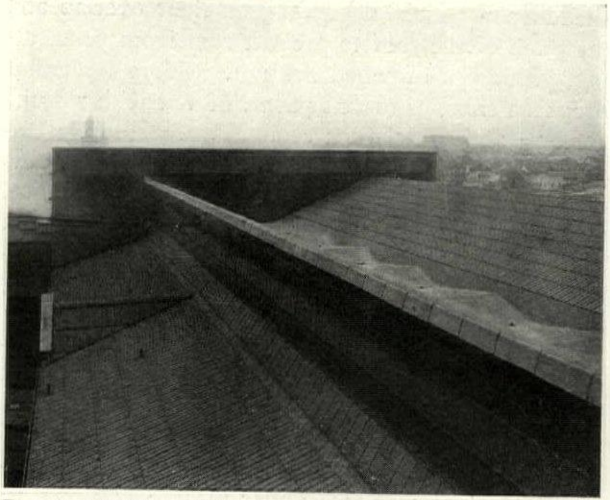
There are several methods of laying a gypsum roof. One method employs a roof tile or small slab set in angle irons or inverted T's. Another uses a much larger slab of gypsum containing suitable reinforcement. A third uses a stiff gypsum board resembling a prepared plaster board which is rested on iron framework of the type used to support gypsum slabs. Reinforcing steel is placed above this board, and then a gypsum cement is poured over the whole, the board acting as a form that is left in place. A similar method uses a temporary wood form as for flat-slab concrete work, with light I-beams at proper intervals. Gypsum cement is poured over wire reinforcing as in the last case.

There are a number of substances which not only form the structural roof surfaces but also have suitable weatherproof surfaces which are used without top membranes or other surface treatments. Commonest among these is corrugated galvanized iron, which is much used for low cost temporary structures. It is probably the lowest in first cost of any roofing material. Its use is limited by the fact that it will rust in time, that it is attacked by many gases and chemical fumes, and that it is an excellent conductor of heat. This last characteristic connotes that much heat is lost through the roof in winter and that it will be unduly hot in summer sunshine, and furthermore that under humid conditions moisture will rapidly condense on its under surface on cool days. To overcome the deterioration of galvanized iron and yet retain its relative economy and simplicity, it now comes with both surfaces (and even the edges) covered by one or more layers of asbestos paper firmly cemented to the metal. A great improvement in the life and usefulness of the material has been achieved by this process, although the conductivity has not been lessened sufficiently to eliminate this factor.

Corrugated asbestos or even plain asbestos sheets are used in much the same manner. This material is less subject to deterioration even when exposed to many chemical fumes. It has low heat conductivity and is therefore less liable to permit condensation, although the thinness of the sheets does not afford sufficient insulation when there is any very great difference in temperatures to be combated.

Corrugated zinc is now being placed on the market and offers certain merits useful in special cases. Zinc will not rust, and therefore a roof of this material will have a high salvage value, suggesting its use for buildings of only a semi-permanent nature. It has a low melting point and would be destroyed by a fire in close contact with it. It will resist corrosion of some fumes, but is readily attacked by other chemicals. Like iron roofing, it is highly conductive.

Corrugated wire glass is similar to the types of material just mentioned, having aside from its translucency the qualities of permanence and resistance to practically all forms of corrosion. If securing daylight were the prime requisite of a structure, there is no reason why the entire building might not be made of glass supported on a steel framework. The disadvantages of glass are its high conductivity, its weight, and its brittleness. Though wire glass will not shatter under an impact, the cracks that result will admit water unless cemented. The motion of a building, due to temperature changes, wind pressure, or internal stresses, requires a flexible setting for the glass, which is now entirely practicable.



Detail of V-Shaped Monitor Roof, Showing Drainage and Cement Tile Covering

Concrete tile of fairly large dimensions are now on the market and may be used alone directly on the steel channels whenever air leakage and condensation are not factors, as in boiler houses and foundries. They are adapted only to steep pitch roofs, but require no further surfacing. Wood, concrete, and gypsum roofs require the protection of a waterproof or rain-shedding surface material to give satisfactory results. On roofs of steep pitch, materials that will shed water are sufficient, while on flat or low pitch roofs a waterproof membrane must be constructed, on which water can stand.

Shingles, slate, and tile are the principal water-

Maxwell Motor Company Plant, Detroit
Saw-Tooth and Monitor Type Roofs Covered with Interlocking Cement Tile with Glass Insert Slabs

shedding materials, depending on their overlap and the pitch of the roof to prevent rain from penetrating. Shingles of wood are now seldom used, but prepared shingles of felt paper, of felt with a stone surface, and of asbestos cement are commonly employed in industrial construction. Choice depends on the factors of cost, permanence, fire resistance, and appearance pertaining to any given problem. Slate and tile are somewhat heavier materials, having similar qualities, with like factors governing their choice.

Metals are also used on roofs of steep pitch, copper, tin, and zinc being the materials most employed. The metal sheets are crimped together at the edges and are soldered at all flat seams. The vertical seams are frequently left standing. Copper possesses ideal permanence under most conditions, its use being restricted largely by the expense. Tin is the least expensive in first cost, but requires regular painting to protect it from corrosion. Zinc is quite new to this purpose, but it appears to have a place between copper and tin, and will doubtless prove satisfactory when its possibilities and limitations are thoroughly understood.

Flat roofs or roofs having valleys where water may collect, as in sawtooth buildings, require that the roof surfaces be made absolutely impervious to water. Pitch or asphalt with layers of paper or felt, and frequently with a surface of gravel or crushed slag, are the materials employed to form a watertight membrane. The process employed is well known, generally consisting of the application to the roof of a layer of hot pitch or asphalt, over which is a layer of paper or felt, then another layer of binder and another of felt until four or five layers of the tar and three or four layers of the webbing have been laid. All seams are overlapped as each layer is added. On the last coat of tar fine gravel or ground slag is spread to form a protective surface, keeping the sun from melting the binder.

The characteristics of the several materials employed vary slightly. Pitch has a lower melting point than asphalt, and will melt under a hot sun and gradually work down the slope of a roof unless protected by gravel or slag. Asphalt does not need this protection and may be left black, although this practice is not desirable on sawtooth roofs, as a light surface greatly increases the amount of light entering the adjacent skylights. The webbing may be of felt paper impregnated with pitch or asphalt or asbestos felt impregnated with asphalt. The only choice in the use of gravel or crushed slag is to get the cheapest, as either is satisfactory.

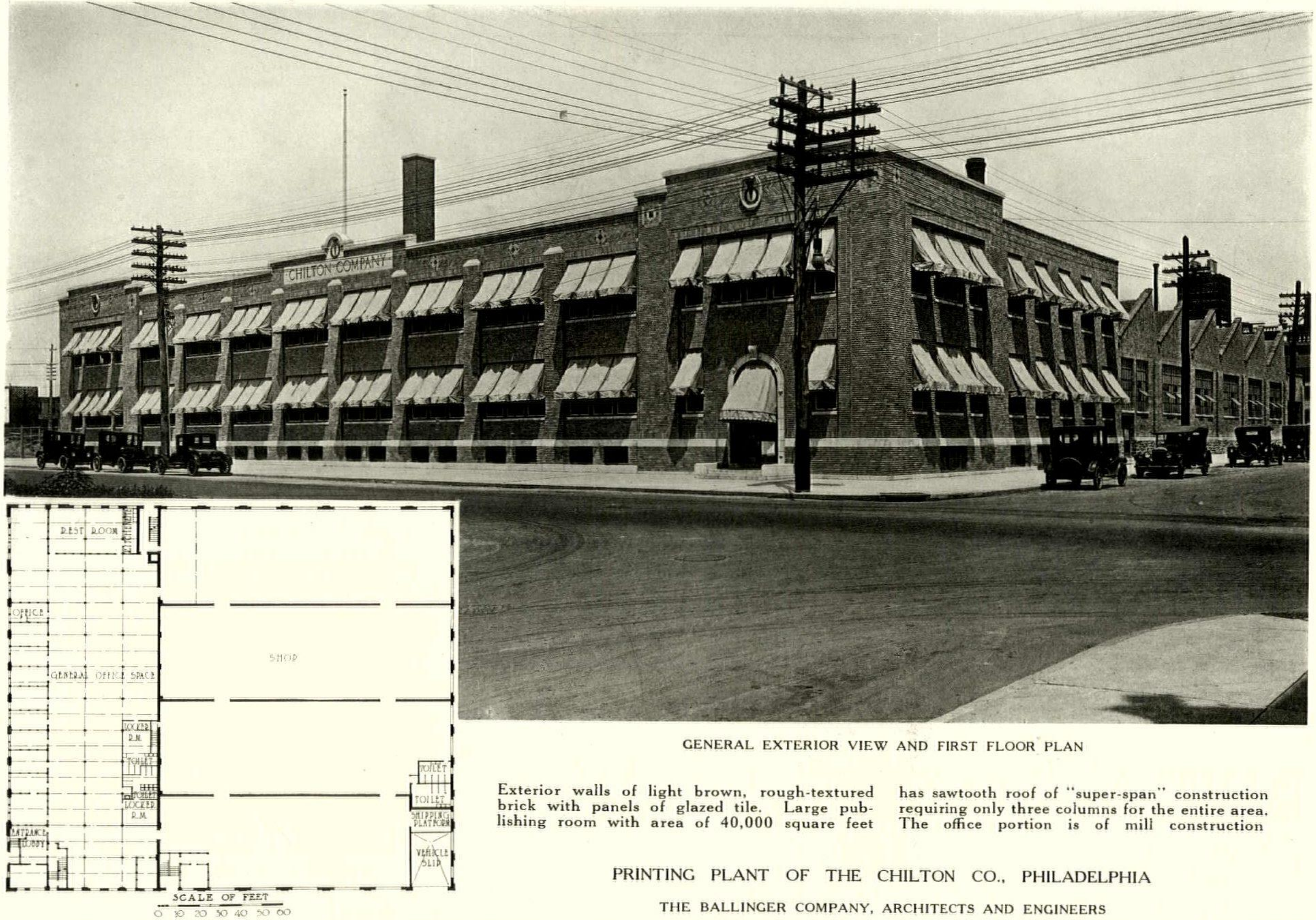
When flat roofs are used to walk upon, as for play areas or for promenades, it is best to provide a more durable wearing surface over the waterproof membrane. Concrete may be used for a low cost job, if expansion is provided for; otherwise quarry tile or small slates are set in asphalt.

For temporary buildings, and where first cost is an important consideration, prepared roofing made of layers of tar and paper or felt are on the market in great variety, many having a stone surface rolled on. They are laid with a cemented lap, and if properly laid are practically the same as a built-up roof of equal weight. However, the human factor counts in this work to such a degree that a more permanent roof generally results when there are three or four laps in the thickness of the roof than when there is only one; in other words, a built-up roof may have imperfect laps on one or two layers and still be tight, but a prepared roof depends entirely on the tightness of a single lap. On the other hand, roll roofing may be economically laid on sloping roofs where the tightness of the lap is of less importance. Vertical surfaces, such as the ends of monitors and sawtooth skylights, are generally covered with metal or with prepared roofing or shingles.

To eliminate the difficulties attending the loss of heat through roofs, with particular concern for minimizing condensation on the inner (and in some cases, upper) surface of roofs, it is occasionally necessary to interpose a layer of insulating material between the structural roof and the outer surfacing material. Several substances are prepared for this purpose, cork being very commonly utilized. Fibrous mattings or compressed boards are efficient in varying degree. If extreme conditions are being contended with, drip gutters must be placed beneath windows, under beams, and at all places where experience shows drops of water will collect. To avoid condensation on windows it is necessary to use double-glazed sash.

The prevention of leakage is simply a matter of using appropriate materials in a workmanlike manner. A leaky roof, in fact, is more frequently to be blamed on the architect for lax specifications and wrong choice of material or method, or upon the owner for parsimonious economy in first cost, than upon the roofing contractor. Sawtooth roofs are generally considered by laymen to be always leaking, due largely to this lack of good roof construction. A sawtooth roof, with its many valleys, may be as tight as any other roof. It is simply a matter of good flashings and of extra layers of felt and asphalt in the valleys to take the wear of persons walking along them to wash windows.

The final point in a satisfactory roof is the flashing at all interruptions in the plane of the roof. These points should be observed: First, the flashing should be of a permanent and non-corrosive material. Second, it should be set in a flexible manner, particularly with wood plank roofs so that the shrinkage of the wood will not tear the flashing. Third, flashings should be carried above the highest point to which water can collect before overflowing its barriers in case the drains are choked or are of insufficient capacity. This means that the flashings should extend at least as high as the "crown" of a flat roof, and preferably to the level of some emergency overflow, such as a series of "weep holes" extending through the parapet walls.

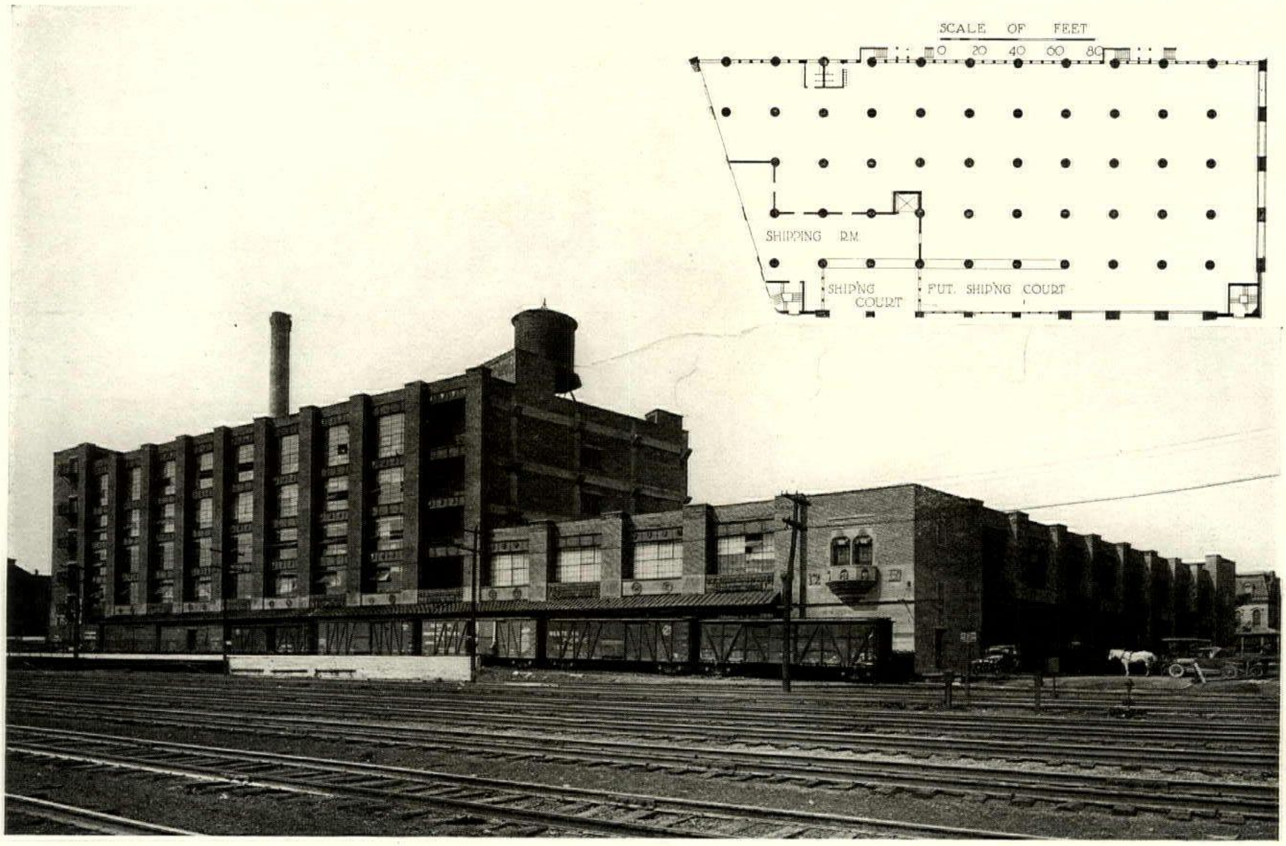


GENERAL EXTERIOR VIEW AND FIRST FLOOR PLAN

Exterior walls of light brown, rough-textured brick with panels of glazed tile. Large publishing room with area of 40,000 square feet has sawtooth roof of "super-span" construction requiring only three columns for the entire area. The office portion is of mill construction

PRINTING PLANT OF THE CHILTON CO., PHILADELPHIA

THE BALLINGER COMPANY, ARCHITECTS AND ENGINEERS



GENERAL VIEW FROM RAILROAD, AND PLAN OF TWO-STORY SECTION

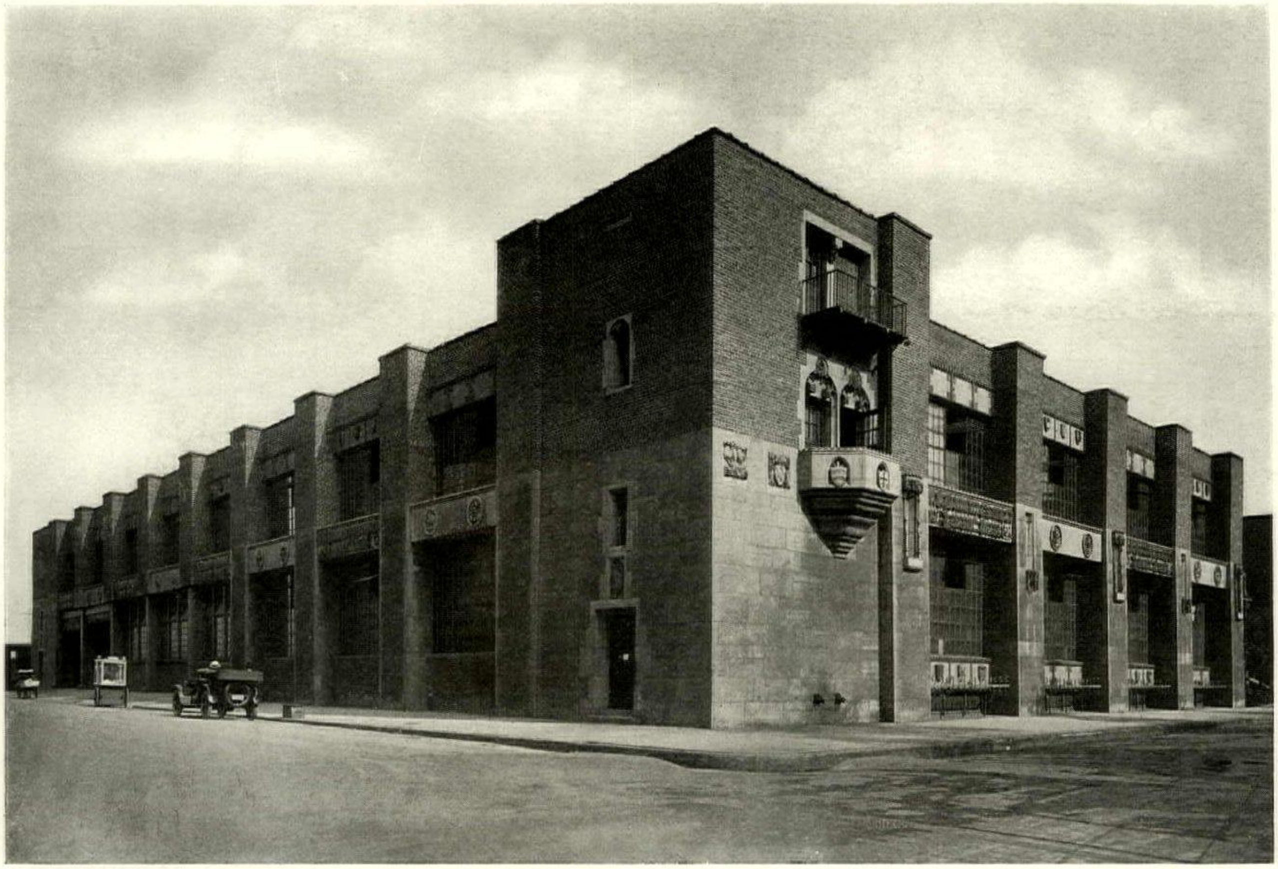
DETAIL OF FIVE-STORY SECTION

R. R. DONNELLEY & SONS CO. PRINTING PLANT, CHICAGO

HOWARD SHAW, ARCHITECT

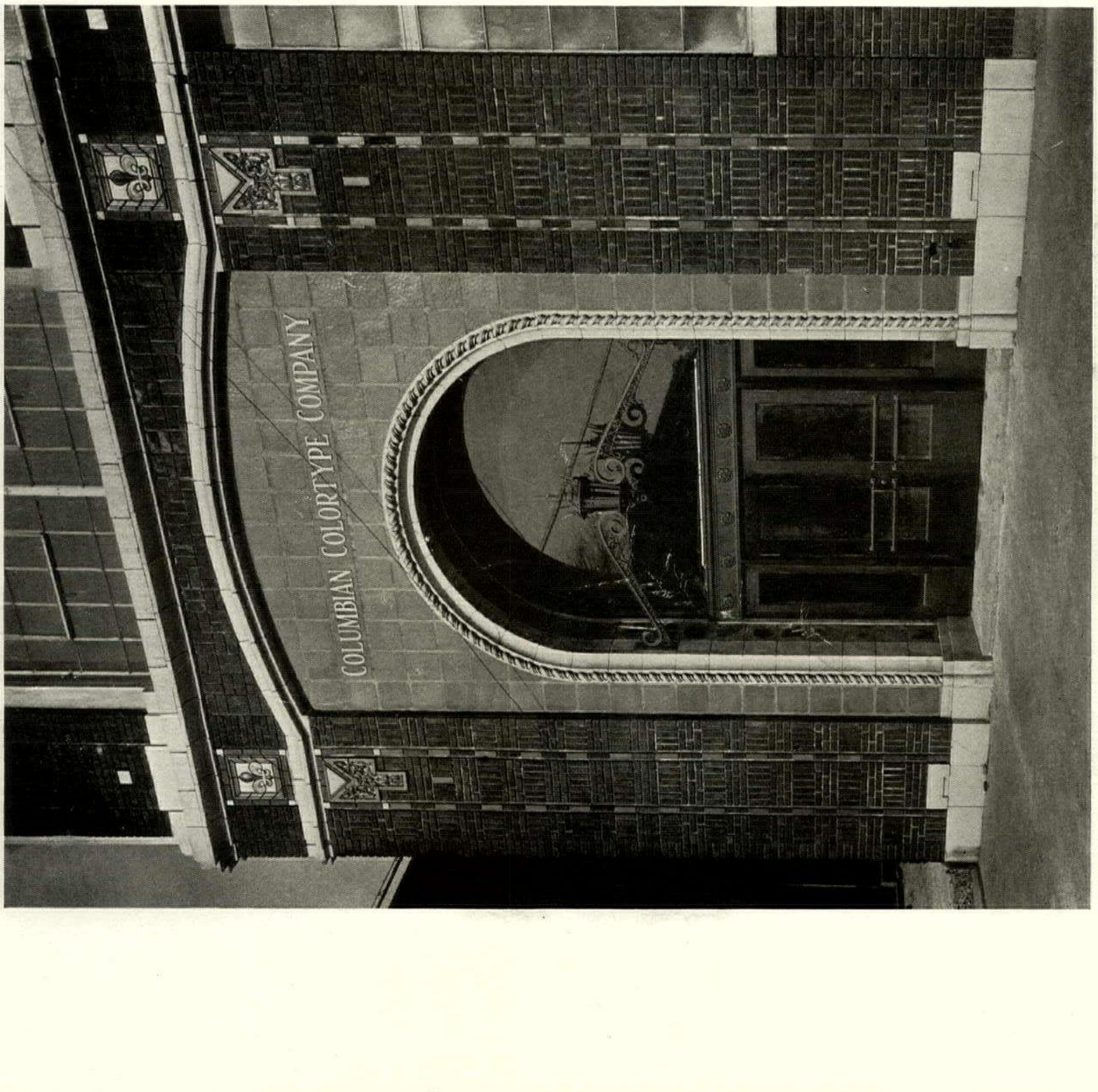
PERSPECTIVE VIEW OF COMPLETED MAIN BUILDING

This building for the Lakeside Press is of flat-slab reinforced concrete construction, the floors being designed for a live load of 300 pounds and columns spaced 25 feet on centers each way to accommodate large printing presses. Dark red brick and Indiana limestone are used for the exterior. Interior walls are of plaster, and ceilings are of concrete, painted; no wood trim is used. The floors are of concrete.

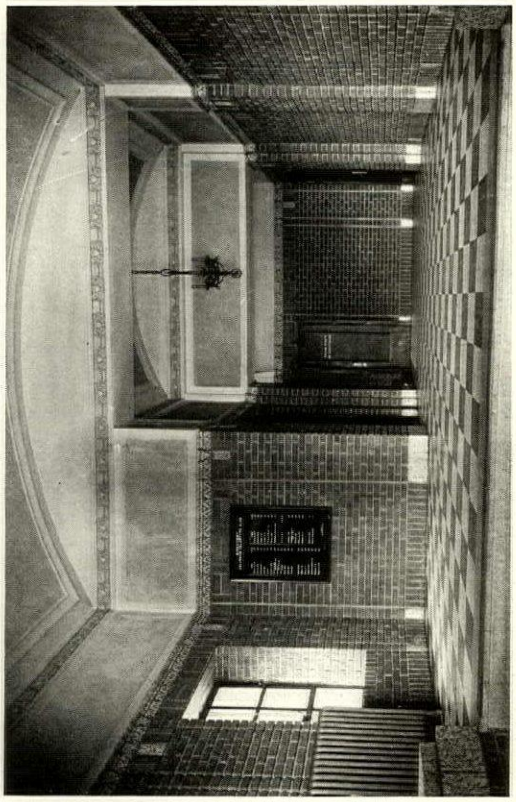


DETAIL OF LOWER STORIES OF MAIN BUILDING

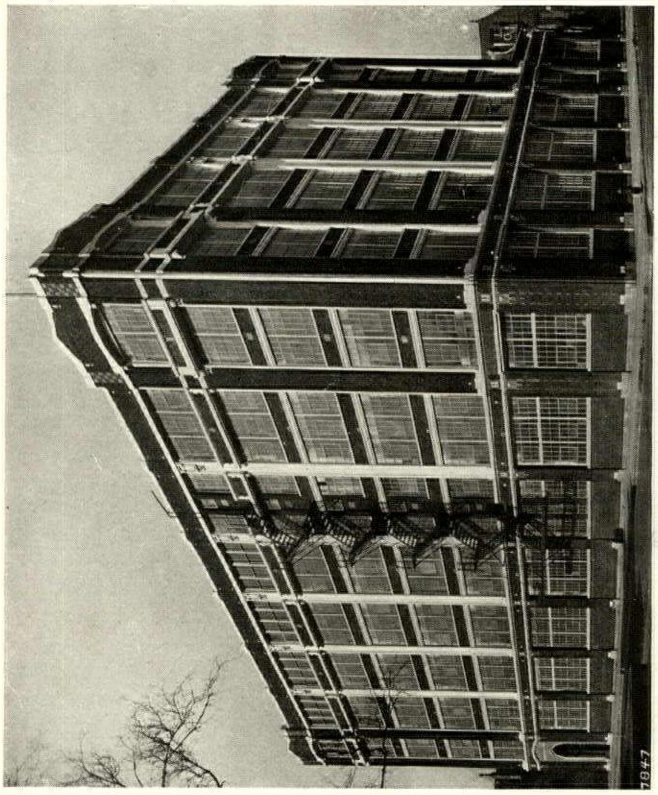
R. R. DONNELLEY & SONS CO. PRINTING PLANT, CHICAGO
HOWARD SHAW, ARCHITECT



DETAIL OF ENTRANCE



ENTRANCE LOBBY



GENERAL EXTERIOR VIEW

COLUMBIAN COLORTYPE CO. BUILDING, CHICAGO

ALFRED S. ALSCHULER, ARCHITECT

COLUMBIAN COLORTYPE CO. BUILDING, CHICAGO

Illustrations on Plate 41

Type of construction: Reinforced concrete. First floor on filled ground; 2nd, 3rd and 4th floors designed for live loads of 250 pounds; 5th and 6th floors 150 pounds per square foot.

Exterior materials: Rough textured brick with terra cotta trimming.

Interior materials: Plaster walls; wood trim.

Floors: For working spaces, finished with cement and treated with a floor hardener; for toilet rooms, composition; in other places, terrazzo.

Windows: Steel sash; large skylight in photograph gallery.

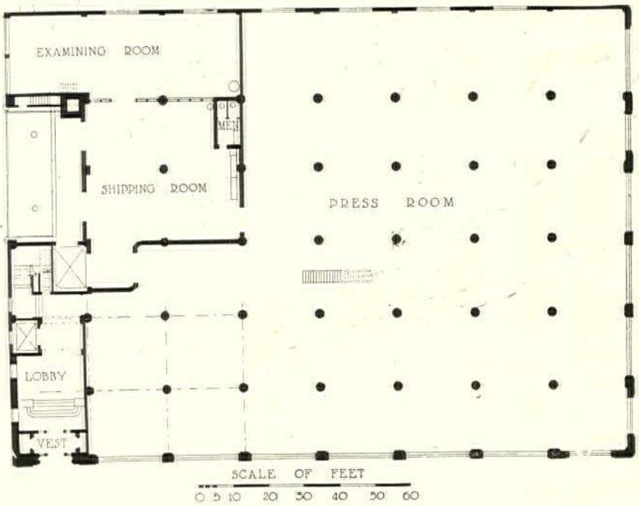
Lighting: Steel enameled reflectors over presses, composing tables, type racks, etc.; general illumination elsewhere. Many special provisions in art room and photograph department.

Heating: Direct vacuum steam radiation; electric vacuum pump to care for returns. Building heated by four cast iron sectional low pressure boilers.

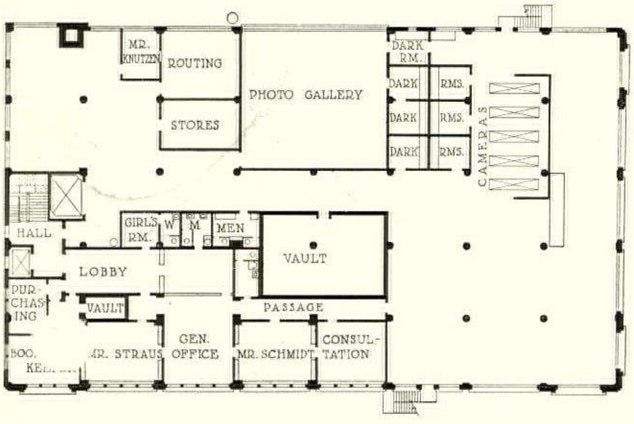
Date of general contract: April, 1920.

Total cost of building: $497,500.

Cubic foot cost: 28 cents.



FIRST FLOOR PLAN



SECOND FLOOR PLAN

DETAIL OF ENTRANCE TOWER

VIEW OF PLANT FROM APPROACH

TYPICAL INTERIOR VIEW

MANUFACTURING BUILDING, WHITIN MACHINE WORKS, WHITINSVILLE, MASS.

J. D. LELAND & COMPANY, ARCHITECTS

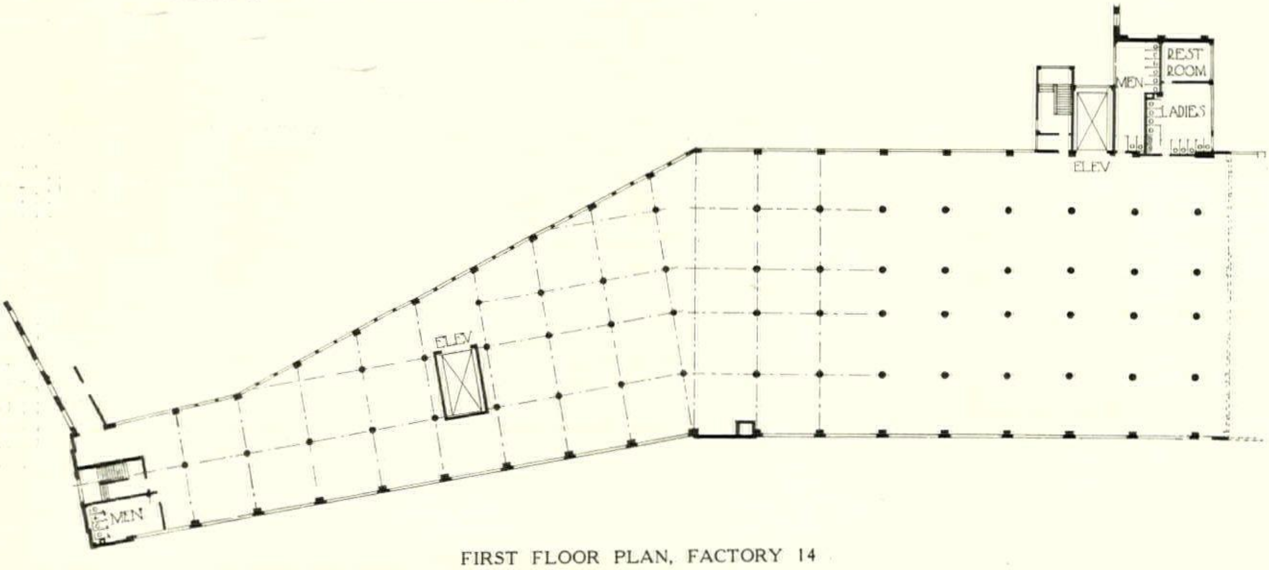
BUILDINGS FOR WHITIN MACHINE WORKS, WHITINSVILLE, MASS.

Illustrations on Plates 42-44

Factory 14: Reinforced concrete construction, mushroom type with brick veneer. Basement, first and mezzanine floors are designed for live loads of 550 pounds; other floors, 250 pounds. The windows are counter balanced, steel type. The stairways are reinforced concrete.

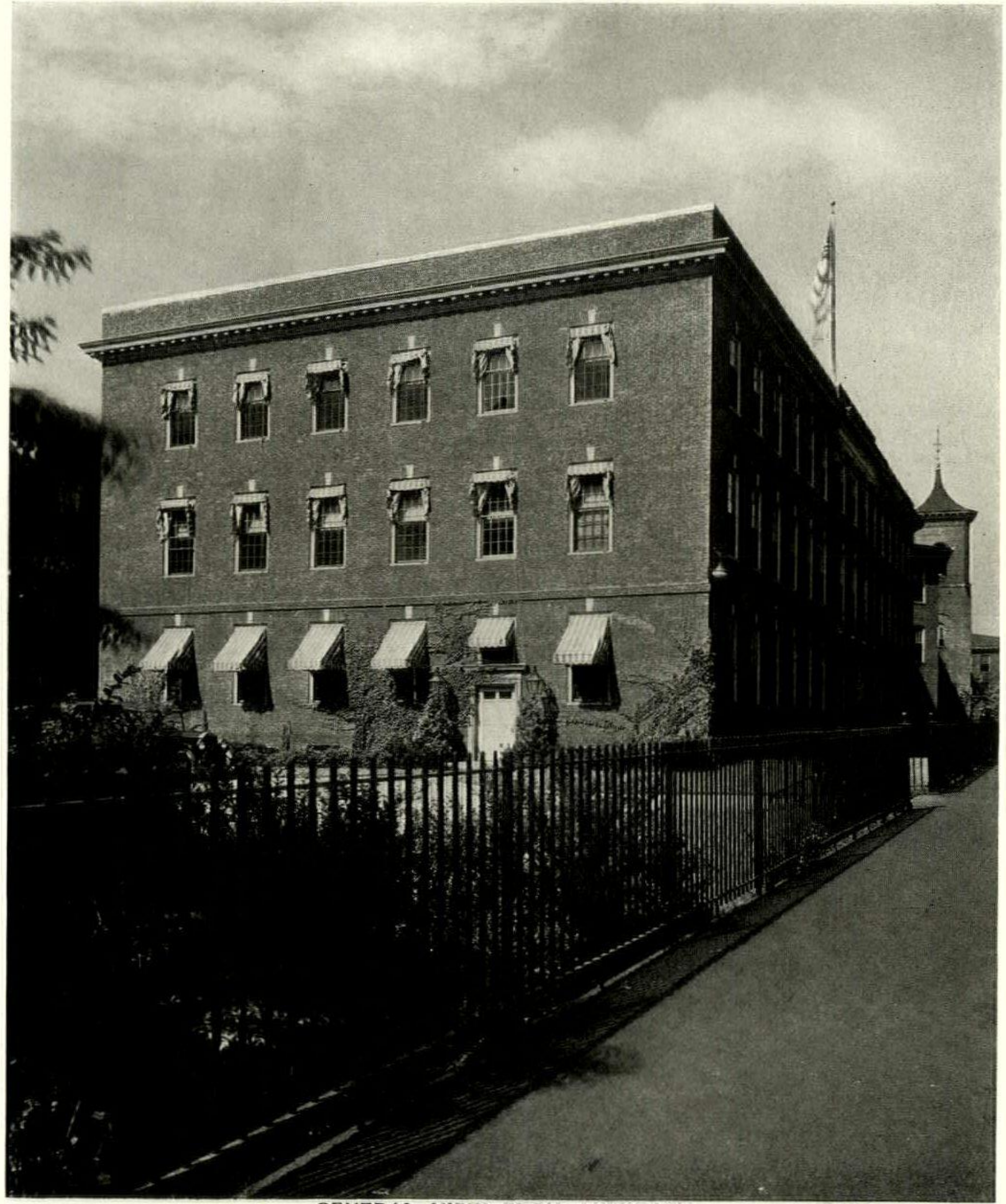
Administration building: Reinforced concrete construction with brick veneer, interior finish in ash, and the finished floors are linoleum. The stairways are iron and slate, and the exterior balconies of ornamental wrought iron; the windows are wood. The building is equipped with mechanical ventilation.

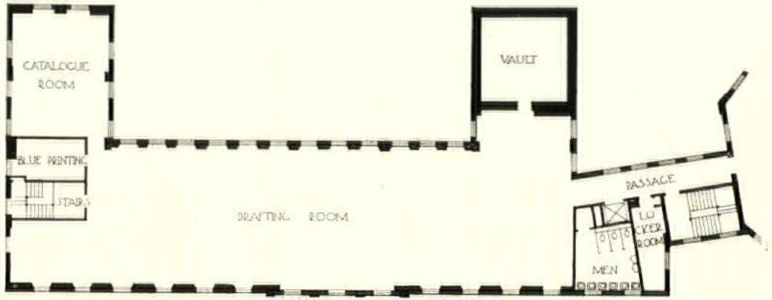
Garage: Reinforced concrete construction with concrete stairs; exterior of brick veneer; counter balanced steel sash. All buildings are equipped with electric elevators.



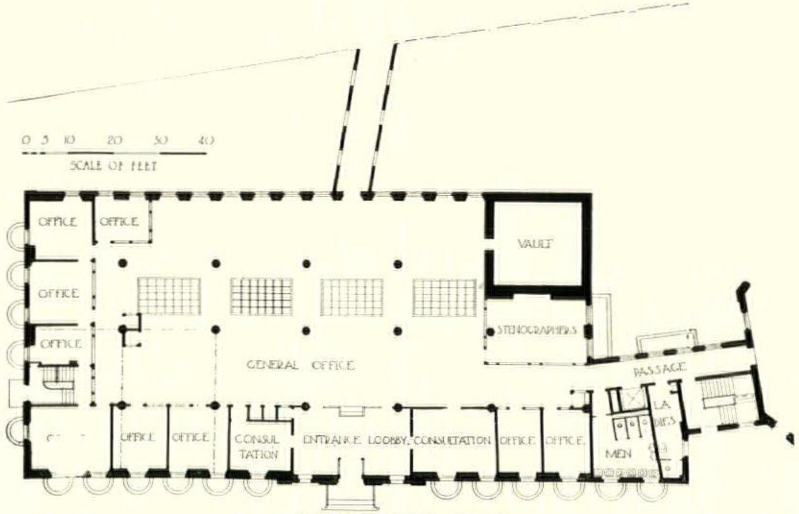
FIRST FLOOR PLAN, FACTORY 14

BASEMENT FLOOR PLAN, FACTORY 14

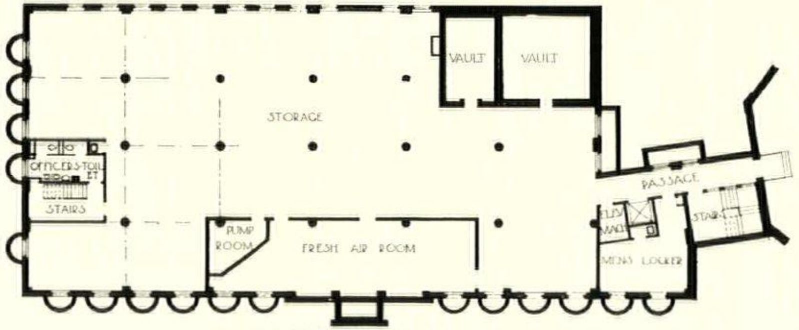




THIRD FLOOR PLAN



FIRST FLOOR PLAN



BASEMENT FLOOR PLAN

GENERAL VIEW FROM APPROACH

ADMINISTRATION BUILDING, WHITIN MACHINE WORKS, WHITINSVILLE, MASS.

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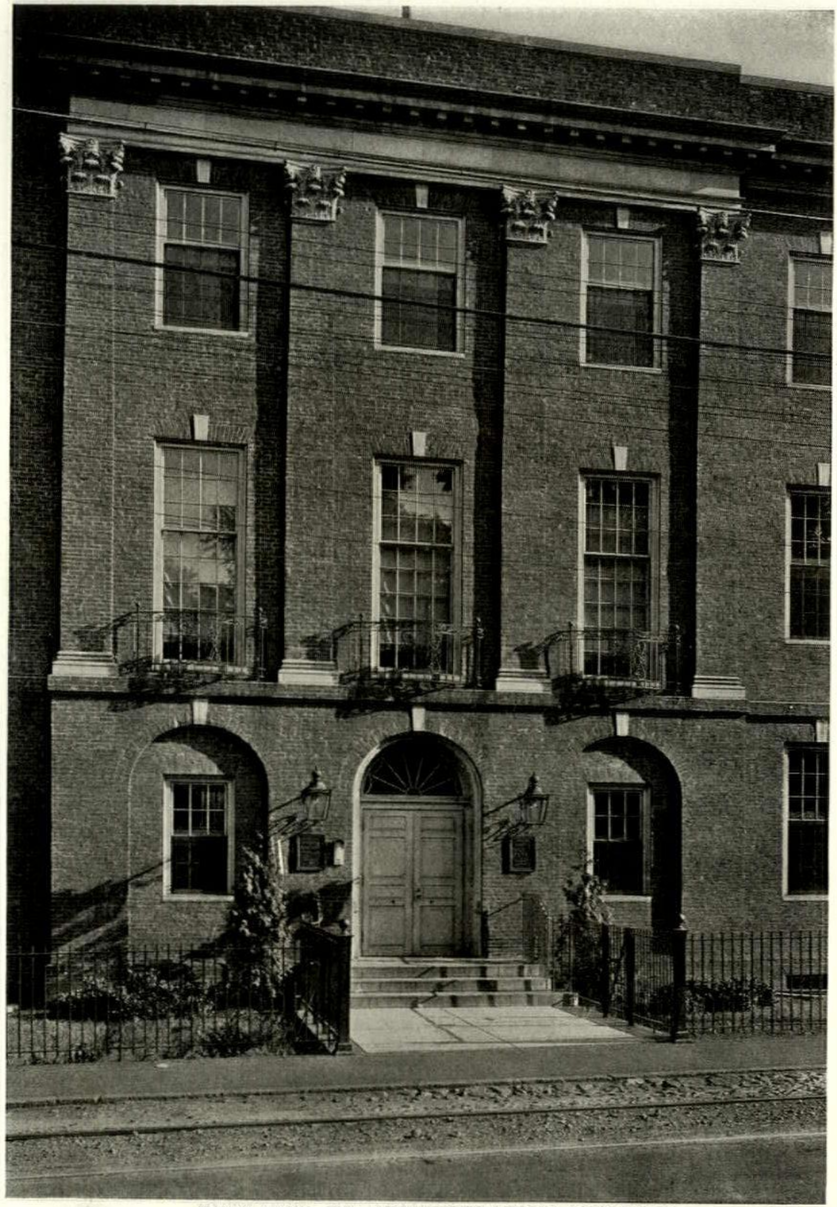
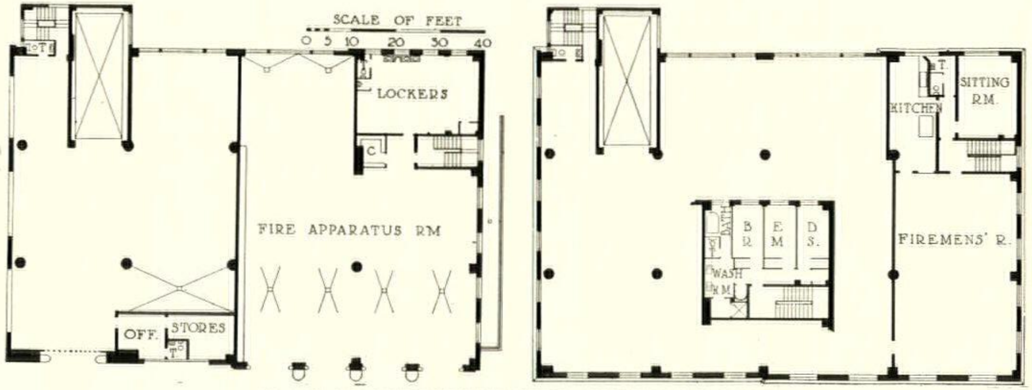


ENTRANCE TO ADMINISTRATION BUILDING

GENERAL VIEW OF FIRE HOUSE AND GARAGE



PLANS OF FIRE HOUSE WITH MEZZANINE INSET

BUILDINGS FOR WHITIN MACHINE WORKS, WHITINSVILLE, MASS.

J. D. LELAND & COMPANY, ARCHITECTS

Industrial Flooring Materials

By CHARLES A. WHITTEMORE

Of Blackall, Clapp & Whittemore, Architects, Boston

IN industrial buildings the problem of construction is complex. Foundations must support the buildings without undue settlement. Walls must support the superimposed loads without distortion. Floors must be sufficiently strong to carry the dead and live weights without deflection or vibration, and the surface must not disintegrate. In connection with this last condition the problem presents difficulties which are not easy of solution. There are so many different kinds of floor surfacings on the market that one could confer with a continuous stream of representatives, each with merit to his claim that his material will meet the requirements.

If it were possible to obtain the ideal floor surface it would be wearproof, dustproof, waterproof, and inert. These qualities are all important in industrial buildings, and in many cases the lack of these characteristics will mean losses in the manufacturing process. Wearing down of floors necessitates repairs; dusting ruins machinery; absorption destroys the strength of the floor, and "non-inert" floors by cracking, swelling or shrinking may affect the alignment of machines as well as causing unevenness in the surface. The floor treatment which meets all these conditions will be a wonderful discovery. Boiler plate is in many ways unsatisfactory. Marble wears out; wood rots, etc. It seems as though natural products would not be as satisfactory as manufactured floor materials might be.

In mill construction maple floors present a good wearing surface and have long been considered satisfactory for most places where wood may be used. There are now on the market wood flooring materials treated with preservatives for which much is claimed. There are also wood floorings in block form, some of them so arranged that the wear all comes on the end grain, and this grain arranged so as to vary its direction. Each serves its purpose and specific place, but none may be considered the ideal floor. There is no other natural flooring material which can be generally used. Expense or lack of durability prohibits. The net result of such a decision is that investigations must be conducted in the field of manufactured materials.

The broad divisions of manufactured floorings are cement, composition, and linoleum. Because most industrial buildings nowadays are of fireproof construction, the concrete floor as a base for surfacing is the most common. The concrete with a top surfacing becomes practically inert and is homogeneous, and can be made waterproof, but, on account of the nature of the material, concrete in itself is full of voids which have not the resistance to abrasion of a solid material. To make concrete "wearproof" it seems necessary to fill the voids. This may be accomplished by using as the final surface dressing a mixture of neat cement and fine sand. If such a mixture be well troweled or rolled with heavy rollers a surface will be produced which will resist wear under some conditions.

A surface as just described would be suitable for industrial buildings where the trucking is light. It must be borne in mind, however, that machinery produces vibrations which, while not noticeable to the casual observer, continually react on the floor construction and loosen particles of the cement and sand in the form of a fine, almost impalpable, powder. To make such a surface dustproof can be accomplished only by the use of some agency having the property of binding the particles more closely than the natural cohesion can bind them, or by causing a chemical reaction which will increase the abrasion resistance. There are liquids for surface treatment or integral mixing which are manufactured for this purpose. There are oils which, upon oxidation, fill the voids and bind the microscopic particles into a mass of great density. There are metallic substances which, when mixed with the top surfacing, present the wearing qualities of iron. All these have their adherents.

Experiments have been conducted in the use of terrazzo, so-called. This is a top surfacing of cement, sand and crushed stone or marble, trap rock or other hard wearing surface. The results of these experiments would seem to indicate that this kind of cement floor surface is satisfactory even under trucking conditions. This type of floor has been made up using ceramic chips instead of marble. Such a floor will stand hard abrasion as well as any of the terrazzo type.

In a previous issue of THE FORUM* the subject of granolithic floors was discussed. The general method of laying any cement type of top surfacing is the same as for granolithic. It may be well to call to mind a few of the essential steps:

1st. See that the floor to which the top surface is to be applied is thoroughly roughened and cleaned of all dust and loose particles.

2d. For the best results the floor should be washed with clean water and be in a damp condition before the leveling material is deposited.

3d. Level off to fixed screeds, and see that surface is even and true.

4th. Before this material has become too firmly set, deposit the final surfacing and roll or trowel with steel trowels.

When aggregates of any kind are mixed in the final surfacing they should be laid on the leveling course in an even layer and thoroughly rolled or

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*January, 1923.

troweled in. A floor made up of this type should prove to be a very satisfactory investment for the owners of an industrial building where the trucking and service are heavy.

Many of the composition floors have some cement as a base, but the proportion is so small that they cannot be classified as cement floors. Magnesium salts, calcium salts, wood and asbestos fiber, sodium silicates, sawdust and silex all are used in the preparation of composition flooring. In considering a floor of this class one must know that after the chemical action is completed the mass becomes inert, non-absorbent and not affected by climatic changes. It is, therefore, desirable to select a floor with the least vegetable content. Sawdust and wood floors may decay, hence too large a proportion of either of these is detrimental. They are also the cheapest components, and are serviceable principally as "fillers" to make more "body" to the composition. They do, however, act as buffers between the more solid particles, giving resilience to the floor and also imparting a tendency to prevent sound transmission.

Composition floors have a peculiar characteristic in that when struck with a solid substance they sound hard. When walked upon they feel anything but hard. Such flooring material will give good service under ordinary trucking conditions and will be found very comfortable for employes to stand upon. For heavy trucking or for situations where metals or cases are dropped, such a floor would not be ideal unless designed and laid with special care.

The majority of composition floors vary in thickness from ½ inch to 1⅛ inches, and can be laid over wood or concrete. This is a distinct advantage over cement type floors which cannot be used in thickness less than 1¾ to 2 inches. A floor of this type may, therefore, be laid over an old floor of wood or cement without disturbing the old surface. This necessitates at times changes in doors, etc., but in no case is the extent or expense of such a procedure comparable with what would be required if a cement type floor were to be used.

The "mastic" floors are composition floors, but of a different type from those previously described. Asphalt, asbestos, cork, wood flour, and other materials enter into the makeup of the floors. Marble chips, quartz, etc., are used where the floor must resist abrasion. These floors are laid in a variety of ways: some under heat, some in successive "building up" layers, and some in a plastic mass. The "mastic" type floors are never supposed to harden to the consistency of a hard cement. Part of their value lies in the resilience of the medium itself. Dents automatically iron themselves out and real damage, such as cracks or badly worn places, may easily be repaired. This type of floor is used in warehouses, on shipping platforms, in factories, etc., and is impervious to moisture.

One point in the construction of industrial buildings always gives trouble, and that is the proper and adequate arrangement of hangers and supports for pipes, shafting, etc. This is a real problem and reduces itself only with difficulty to a common rule for all buildings. The engineer must know all the requirements for the building and should have all contracts under his control in order to provide support for all future demands as the construction proceeds. It is simple enough to lay out hangers for steam, water, gas, electric, sprinkler pipes, and also for shafting, etc., if these are all decided upon sufficiently in advance. The real difficulty lies in anticipating future needs as developed by changes in machinery, etc., as well as by the increased business or manufacturing demands. There are various types of hangers which may be used in connection with concrete floors for pipe supports. Obviously, the best is the hanger which permits of adjustment of the point of support. Such a hanger will enable the builder to change locations of pipe lines without tearing up concrete. All these types are arranged to be set in on the forms, and some are equipped with integral reinforcing rods to allow for extra heavy loads and more even distribution. Some are arranged to be attached to the reinforcing rods. Use of any type which is easily set in place, which is securely held in the construction, and which allows adjustment of support spacing is a distinct asset to the building.

A discussion of floor construction is not complete without considering the stair and platform treatments. Here is great wear. In the average industrial building the employes use the stairs more than the elevators, unless the building is more than four stories. Hence twice, and generally four times, per day the stairs are called upon to withstand the wear incident to the passing of a number of people. On the treads, therefore, must be a wear-resisting, durable, non-absorptive, non-slip material. Terrazzo, ceramic, cement, composition as well as slate, marble and steel all are used for the tread surfaces.

There are, of course, the standard safety treads composed of a metal base grooved with non-slip material filled in the grooves, and also metal with steel filings or carborundum fused in the wearing surfaces, also other variations on the basic principles of these two types. Where marble, slate or metal is used as the tread, a safety edge should be provided and *set in place*. Where the plastic materials are used, these treads may be cast with carborundum or steel filings, mixed in the top surfacing or troweled in the surface as the "set" begins to take place.

Floors like facts are stubborn things. Once in place they are not easily moved. When we consider the floor, not as the walking surface alone, but as the support for machinery above and possibly below; when we realize the pipes, conduits, hangers, inserts, shafting and all the equipment units which the floor must contain or hold in place, we cannot but feel that however much care, study and thought we give to the selection and arrangement of materials, a satisfactory floor, standing up to its demands, is a well worth while reward.

Natural Lighting of Industrial Buildings

By WILLIAM R. FOGG

Secretary, The Ballinger Company, Architects and Engineers, Philadelphia and New York

THE natural lighting of industrial buildings will doubtless continue to be of considerable interest and importance to designers and owners in spite of the recent discovery that under many circumstances it costs as much to arrange for natural light as for artificial illumination. Sometimes it may cost more to provide for lost heat, for overhead charges and the like than for the current, maintenance and overhead of an adequate electric lighting system.[1]

The force of custom, the more pleasant working conditions of natural light (at least most people seem to prefer it), the opportunity for relieving eye strain by looking out of windows for long distances, and other such considerations will doubtless have greater influence on factory design than whatever slight economy may be possible by the exclusive use of artificial light. The discovery, nevertheless, is of immense value, particularly because of its effect on the design of buildings in congested areas where heretofore it has been considered necessary to provide large light wells in areas of high land value. This discovery will also be of value to industries manufacturing a product likely to be injured by sunlight or strong daylight.

The outstanding characteristic of natural light is its variable nature, not only in quantity from day to day and hour to hour, but also in its quality. In this respect artificial illuminants are far more easily controlled. It is known that on cloudy days the "sky light" is much brighter than is the blue sky of a clear day. For instance, Messrs. Perrot and Vogan,[2] in measuring the foot candle intensity of natural light in a 98-foot building with windows in the east and west walls, found these facts: At nearly noon (10:50 and 11 a.m.) on a cloudy day they measured a light intensity of 124 foot candles 4 feet in from the west wall, and on a bright, sunny day with clear sky only 20 foot candles in the same position. The dull gray clouds actually cast into the building over six times as much light as the blue sky reflected. At the east wall on the cloudy day they measured 120 foot candles intensity (6 feet from the glass), and on the sunny day 428 foot candles intensity. Thus on dull days both sides of a building (east and west) receive almost exactly the same amount of light, whereas on a sunny day the wall in shadow is deficient in light, while the wall in sunshine has an excessive intensity of illumination.

The curve showing the intensity of illumination at intervals across a building roughly corresponds in shape to a broad based U. The vertical sides of the U represent the intensity at the windows, and are about equal on cloudy days and very unequal on clear days. The broad base represents the much lower intensities found in the center of the building. The area of low intensity varies approximately with the width of the building. In the wide building just referred to the average intensity of illumination for the center third of the building was approximately $^{65}/_{100}$ foot candles on the cloudy day and 2 foot candles on the sunny day. Note that the bright sunlight in the east windows tripled the amount of light at the center as compared with a cloudy day. This data, if thoroughly analyzed, will be found to embrace the essential problem of the natural lighting of buildings. The high intensity at the windows must be carried to the center to the greatest possible degree, and yet the intense glare of the direct sunlight must be subdued.

Modern practice has attacked this problem in several ways,—by increasing the ratio of window area to floor area, by improvements in the character of the glass, by the use of interior wall and ceiling finishes of high reflecting power, and by the use of sawtooth construction where practicable.

Naturally, the design of a building is the greatest single factor determining the quantity of its natural light. Exterior objects, like other buildings in close proximity, may have a very serious and uncontrollable effect in special cases, but given a free-standing building, the amount of light depends very largely on the size and placing of the windows and upon the width of the building. When the shape of the land requires wide structures it is common practice to use light wells in the interior, or to divide the building into two or more sections separated by courts. So many factors govern the sizes, shapes and proportionate areas of these courts that space will not permit of an adequate treatment of them here. In general it is desirable to keep the width of a multistory building from 60 to 100 feet, so that no point will be more than from 30 to 50 feet from windows. It is obvious of course that the ratio of glass to floor area may be increased either by using narrow buildings or by increasing the story heights (and the window heights). These methods, while entirely practical under certain circumstances, generally involve considerable increases in first cost and maintenance that can be avoided by other methods. When the layout of machinery or other dominant factors require wider buildings, reliance must be placed entirely on window area, special glass and suitable reflecting surfaces for adequate center light.

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[1] See "The Cost of Daylight," by M. Luckiesh and L. L. Holladay of the Laboratory of Applied Science, Nela Research Laboratories, National Lamp Works of the General Electric Co., Cleveland. *Transactions of the Illuminating Engineering Society*, February, 1923.

[2] "Some Practical Daylight Measurements in Modern Factory Buildings," by Emile G. Perrot and Frank C. Vogan. *Transactions of the Illuminating Engineering Society*, August, 1919.

Within the last three decades the change in the fenestration of industrial buildings has been very marked. Around 1890-1900 the typical factory was lighted by double-hung wood sash windows often occupying less than 50 per cent of the available wall area. Since then the ratio of window area to wall surface has vastly increased, until it has become common practice to make 85 per cent of the available wall area of glass. By available wall area we mean the area between the top of the spandrel or curtain wall (at bench height above the floor) and the ceiling, for this is the only area in which windows can be placed effectively.

A recent improvement in concrete construction has made it possible to get practically 100 per cent of the available wall area in glass. By constructing the floor as a cantilever beyond the last row of columns and supporting the wall and windows on the edge of the projected floor slab, exterior piers may be entirely eliminated, so that continuous rows of sash may extend from end to end of the building, interrupted only by stair towers or corner pilasters applied for architectural effect. This type of building is illustrated on page 119. By means of this construction very wide buildings can be provided when needed with satisfactory interior light. It should be noted that the round columns obstruct less light than rectangular wall piers, and also that this construction is less costly than the types generally used.

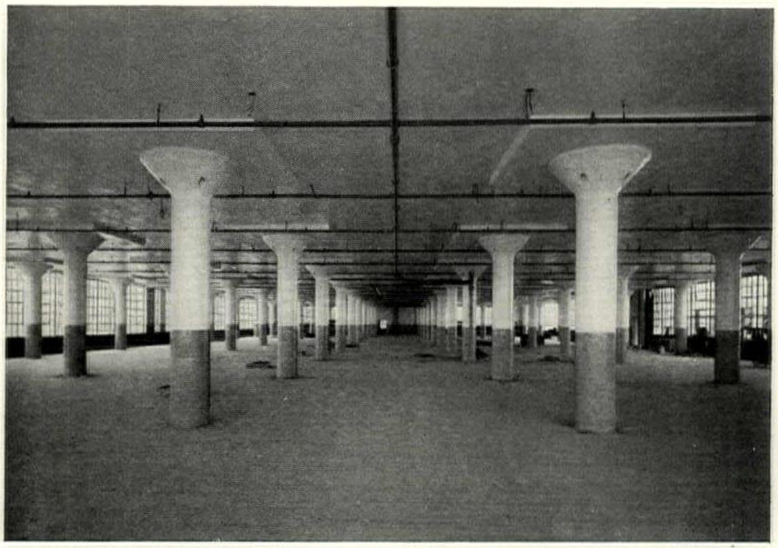
Overhead lighting of factory interiors is possible on the upper floors of multi-story buildings or in one-story structures by means of skylights, monitors, or sawtooth construction. In the article on Roof Types and Roof Surfaces in this issue (page 109) sufficient mention is made of the advantages and uses of each type to indicate their relative merits. The building providing the nearest ideal light is that with a sawtooth roof. The orientation and shape of the skylights prevent sun glare, for only north sky light is admitted. In ordinary practice the window area is about 33 per cent of the floor area exclusive of wall windows. It is important to note that for a given ratio of glass in the skylights to the floor area, greater interior illumination results from using a smaller number of large size sawtooth skylights than from using more sawtooth skylights of smaller sizes. This tends to save in the cost of construction. The usual maximum width of a sawtooth skylight is 25 feet with glass about 8 feet in height.

Since sawtooth skylights depend for their illuminating value upon sky light, as distinguished from sunlight, or in other words, upon reflected light instead of direct light, it is well to remember that a blue sky gives much less intensity of illumination than a cloudy or even a dull gray sky. If the upper surfaces of adjacent skylights were colored a dull black, so that they would absorb the direct sunlight, it would be found that the interior of a sawtooth building would be darker on a clear day than on a cloudy day. By using a bright surface, such as light colored gravel or some form of prepared asbestos which is nearly white on the roof surfaces, the direct rays of the sun on a clear day are reflected into the skylights with a consequent increase in the interior illumination.

Next in importance to the structural design of a building are the size and position of the windows and the kind of glass used. As regards the actual intensity of illumination of a building it matters little what type of window sash is employed to frame a given area of glass. The choice of sash is governed not so much by questions of lighting as by the factors of cost, ventilation, durability, appearance, and method of cleaning. When a given wall opening is required to admit the maximum of daylight, the thickness of the window frames, meeting rails, muntins, and other opaque parts may govern the choice of type. Windows should be placed as near the ceiling as is possible, not only for maximum light but for ventilation, when it is required. They need not extend below the general working plane of the room, for the light admitted below this point is of practically no value, and the wall space is generally needed for radiators or benches. Since much heat is lost through window glass, a saving is effected by stopping the glass at the working plane. To make best use of the window light the placing of machinery should be carefully considered, lest the process require that the operatives constantly work in their own shadows.

Of the many different types of windows on the market, a few are more commonly used than others. "Factory sash," or rolled steel sash, is used for large openings and offers little obstruction to the light. It comes in a variety of standard sizes, with sections pivoted or projected in various parts for ventilation. If thorough ventilation is desired, the upper openings should be at the extreme top, and the lower openings at or near the lower edge. Center openings only are of little value. When air conditioning is essential it is often better to rely entirely on the air conditioning apparatus for ventilation, using fixed sash without movable sections.

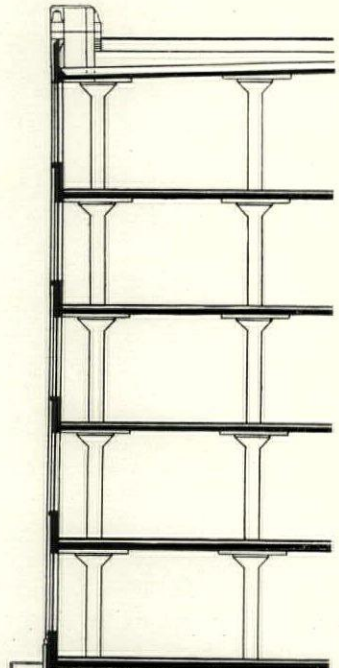
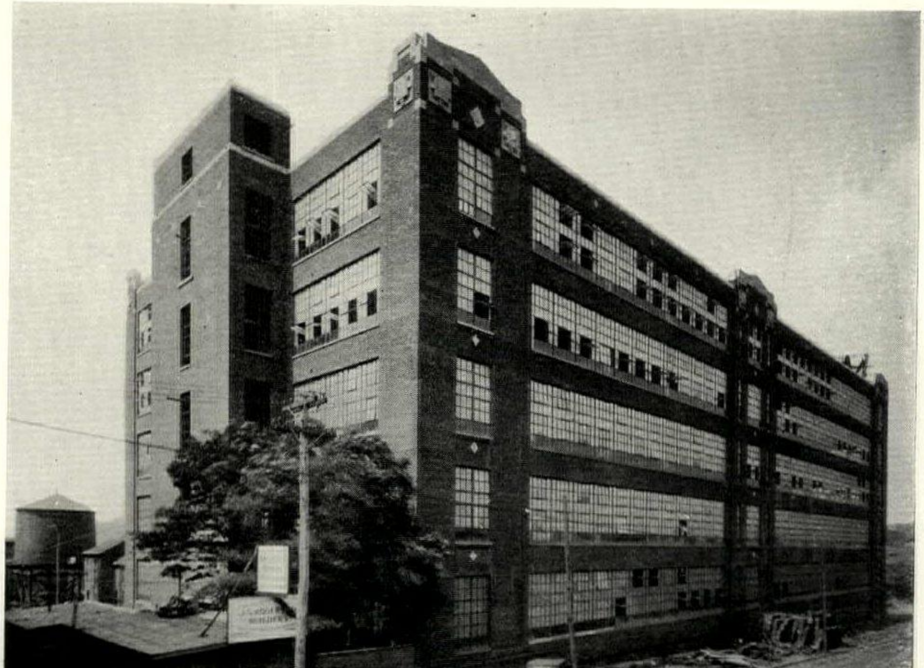
The use of sliding sash is generally limited to smaller wall openings, since the grouping of sliding sash frames requires mullions of appreciable thickness. Vertical sliding sash may have two sections, each independently counterbalanced with weights or springs, or they may be balanced one by the other, so that lifting the lower sash lowers the upper. Then there are several types combining a sliding and a projected or pivoted motion, operated by simple systems of levers, so that openings occur simultaneously at the top, bottom and center of the window, and the glass rests at an angle with the frame in a manner to prevent the rain from driving into the room. Rolled steel is used for low cost work and bent steel shapes or bronze for the higher grade windows required in office buildings and hotels.


Interior of James Lees & Sons Co. Factory, Bridgeport, Pa., showing excellent light obtained from continuous sash; building 121 feet wide

Continuous steel sash having ventilating sections often require mechanical devices to open and close them, particularly in monitors, sawtooth skylights, and other inaccessible places. For the shorter runs the torsion system is largely used; it employs a worm and sector, with arms fixed to the torsion shaft operating each ventilating unit in the series. For longer runs a combination of levers operated by rods that are pushed or pulled by the operator is employed. Sash opening devices may be manually or electrically operated. Reference to accompanying illustrations will show several of these installations.

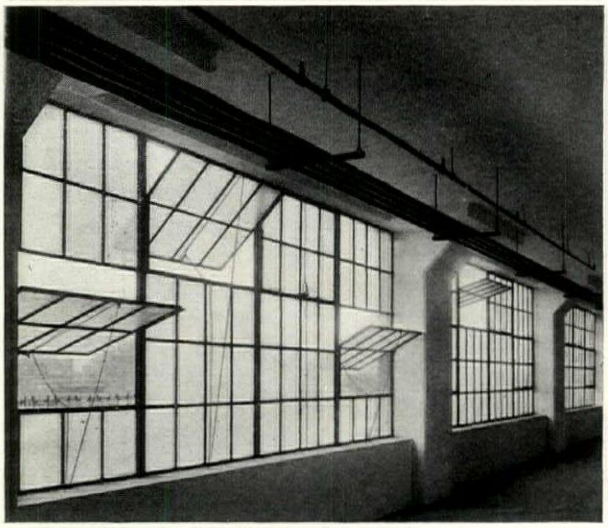
Window glass requires cleaning at regular intervals to maintain its efficiency. Three common methods are used, depending on the kind and size of the windows. Pivoted sash may often be cleaned entirely from within the building. Sliding sash, and other types having openings of sufficient size for a man to get through to the outside, are generally cleaned by workmen standing on the outer sill. Bolts for safety belts must be installed when this method is employed. Large areas of fixed sash are generally cleaned two or more times a year by means of painters' scaffolds suspended from the roof, or in low buildings by the use of a hose from the ground.

The kind of glass used in the windows has much to do with the amount of light which gets into the building. A clear or transparent glass transmits direct light most efficiently, but under many circumstances some forms of glass that are translucent but not transparent are preferred. Where transparency is desired, ordinary window glass of single or double thickness, or polished plate wire glass, constitutes the range of choice. Even if other forms of diffusing glass are used in the greater part of a window, it is well to have clear glass of some sort up to and perhaps a foot or so above eye level. Manufacturers have found in many cases that workers are more contented when they can see beyond the walls, and also that they seem to feel



Section through cantilever bay and exterior showing resultant continuous sash
James Lees & Sons Co. Factory, Bridgeport, Pa.
The Ballinger Company, Architects and Engineers

less eye strain from their work when a distant view may be obtained at will. It is imperative to use clear glass at the eye level when rippled or prism glass is used, for the glare of these types is most discomfiting when directly in the line of vision.

When wire glass is required, either for fire protection or to avoid the danger of shattered glass, it is generally necessary to accept a translucent glass, for the only transparent wire glass is polished plate wire glass, which costs much more than the ordinary "rough" wire glass. This is no hardship, however, for the rough glass tends to diffuse the light in a very important manner. Most of the light entering a window falls at an angle, penetrating to only a relatively short distance. Much of this light is absorbed by the floor, machinery and other dark objects at the working plane or below. To carry the light as far as possible toward the center of the building it is desirable to bend these oblique rays toward the horizontal, or else to have them strike a good reflecting surface such as a white ceiling from whence they will tend to spread toward the interior. Rough glass breaks up the direct light beams, diffusing them in all directions, so that some are thrown horizontally, some bend upward to the ceiling, and some of course are bent downward to the floor and are wasted. Enough light is diffused in the desired directions to make the use of a rough glass more efficient than that of a clear, plain glass for lighting the interiors of wide buildings. A more efficient method of bending the light rays is by the use of glass having prisms so cast upon its face as to correctly divert most of the rays to a horizontal plane. Prism glass is highly successful for this purpose, but its cost is generally prohibitive for large operations. Ribbed glass, having horizontal semi-circular ribs of small radius rolled into one face, is practically as efficient as prism glass and performs the same function at much less cost. Although theory requires that the ribs be placed horizontally, it is common practice to set them vertically as they then collect less dust. Other translucent glasses, such as "milky," "frosted," "ground," "flowered," and the like are low in efficiency and are used only for decorative or other special uses.



Rolled Steel Factory Sash with Ventilating Sections

Wire glass comes in large corrugated sheets which are very useful for skylights, marquises, and even for whole roofs or buildings. It may be employed with corrugated metal or asbestos sheets in a roof, forming a very simple and effective skylight. In the opinion of many engineers, corrugated glass is more efficient in sawtooth skylights than is flat glass because of its diffusive power.

Concrete Saw-tooth Construction with Fixed Sash
Tiffin Building, Long Island City, N. Y.
The Ballinger Company, Architects and Engineers

Glass is also pressed in forms to match roofing tile with which it may be used to form small skylights that are hardly visible from the ground. There are cement tiles having glass lights embedded in the centers and other special ways of using glass for the admission of light. An interesting special type of glass is one that is "non-actinic," which will not pass the ultra-violet and infrared rays which are harmful to some dyes, rubber and other materials. This glass has a slightly yellowish tint. Experiments have been carried on looking toward the discovery of glass that is a non-conductor of heat and heat rays, but no progress seems to have been made.

All glass is a good conductor of heat, hence much heat is lost in cold weather through the glass. When the air in a building contains a high percentage of moisture, the conductivity of glass causes condensation of this moisture whenever the outside temperature drops to the dew point of the enclosed air. The drops of water or steam collecting on the windows not only may drip on goods in process of manufacture and thus injure or spoil them, but also cut down the translucency of the glass to a certain extent. To avoid these conditions it is sometimes necessary to use double glazed windows in which two panes of glass are used in each section of the sash, the panes being separated by a dead air space which is a nonconductor of heat.

The last factor of primary importance in seeking good interior illumination is the manner of finishing the interior surfaces of the building, particularly the walls, ceilings and columns. As we have indicated, the strong intensity of illumination near the windows must be relied upon to give satisfactory lighting at the center. A very great difference in the center light may be observed by using various materials for the wall and ceiling finishes. White is the best color by far, and though there is a difference of opinion between the value of a matt surface or a gloss surface, the latter seems to be the more practical as it can be washed or wiped clean and the brightness renewed periodically.

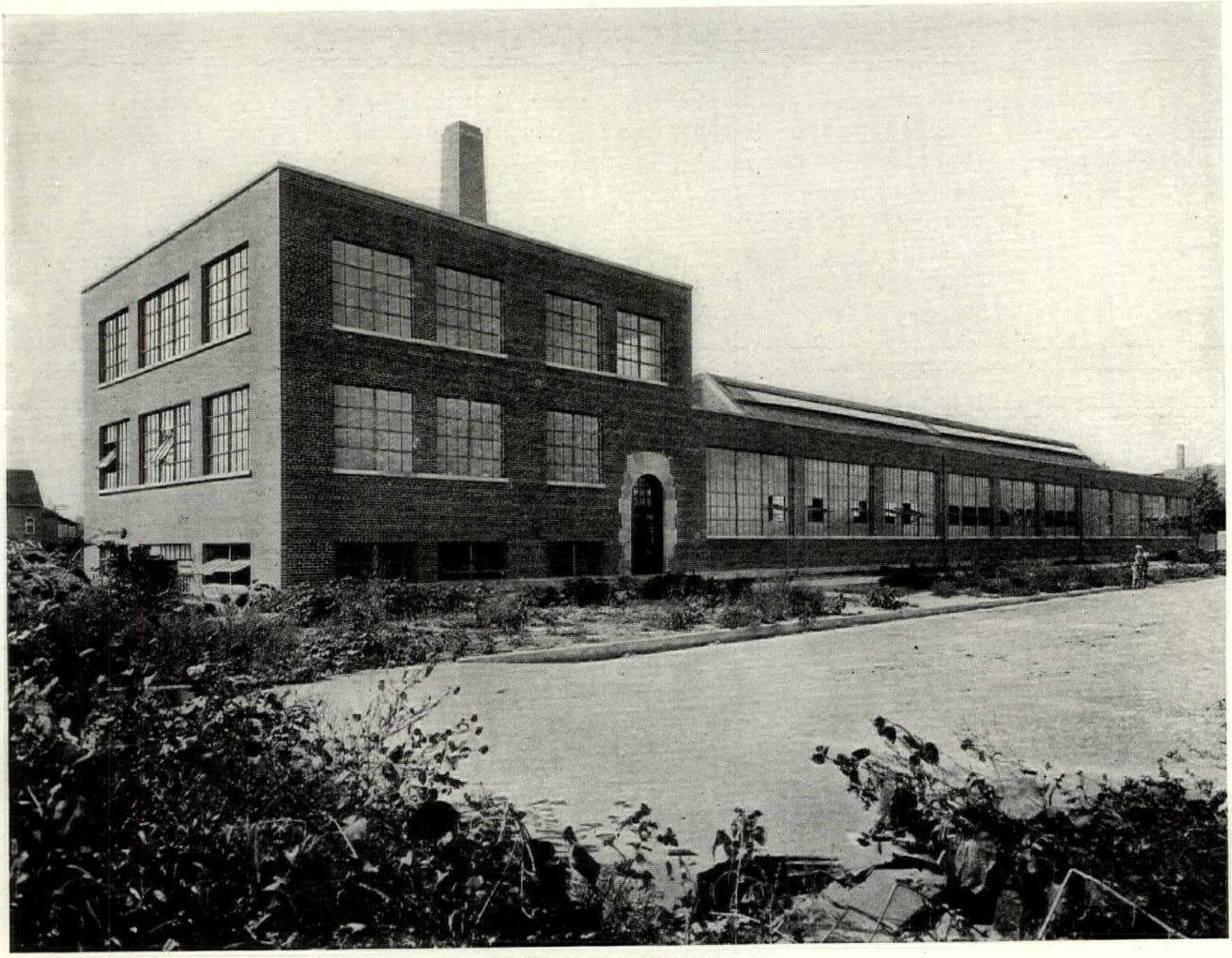
Direct sunlight is of such great intensity that it is often necessary to provide sun shades to reduce the glare. At best this is a bad matter, and when one seeks to find a wholly satisfactory type of window shade, the choice is exceedingly limited. Ordinary whitewash is sometimes used on the glass for a cheap makeshift, but it cannot be removed for cloudy weather or late afternoons. White cloth curtains of cotton duck or lighter material are employed, but they blow about in the wind and are not easily drawn back when the sun glare ceases. Various types of roll shades similar to those used in residences are made, and they may be applied directly to movable sections so that they will not obstruct open windows. Various modifications of the Venetian blind are also available, and these when correctly installed seem to be reasonably efficient. A good curtain installation should be easily controlled in sections, so that either the upper or lower part of the window may be shaded; it should not obstruct ventilation or prevent the opening of windows. Flapping curtains constitute a fire and accident hazard that should never be tolerated, and they are a source of annoyance to the workers. A fortune awaits the inventor of a means of eliminating sun glare and sun heat without restricting the intensity of illumination at the center of a building.

Good natural lighting in any building is largely a matter of maintenance once the structure has been erected. Glass accumulates dirt with surprising rapidity, and its translucency is much diminished thereby. Windows should be washed periodically, the interval depending partly upon the situation of the building, and partly upon the importance attached to maximum illumination.

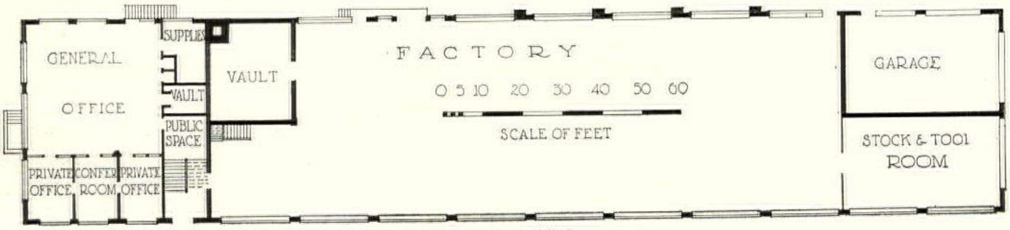
Baking Room, General Baking Co. Plant, Bronx, New York
Simple monitor roof supported by steel beams. Note appliance for opening sash
The Ballinger Company, Architects and Engineers

Chicago Solder Company Factory, Chicago

RICHARD E. SCHMIDT, GARDEN & MARTIN, ARCHITECTS



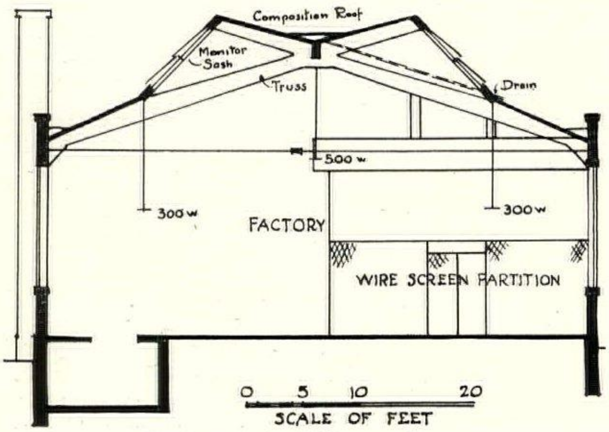
GENERAL EXTERIOR VIEW



First Floor Plan

Second Floor

THE interesting feature of this building is the single-story foundry with large monitor roof. It is supported by a modified scissors type of concrete truss, which in its essential features is patented by the architects. This type of truss has been used by them in spans up to 125 feet. The truss members and roof are monolithically poured concrete. The monitor with continuous steel sash on both sides is formed by cantilever beams extending from the roof. The roof of the monitor consists of a 3-inch slab extended from girders at the end of each cantilever beam and formed on the curve of a catenary to avoid dead load extending stresses. Tie rods are used as the bottom chord for trusses and between ends of cantilever beams at monitor.

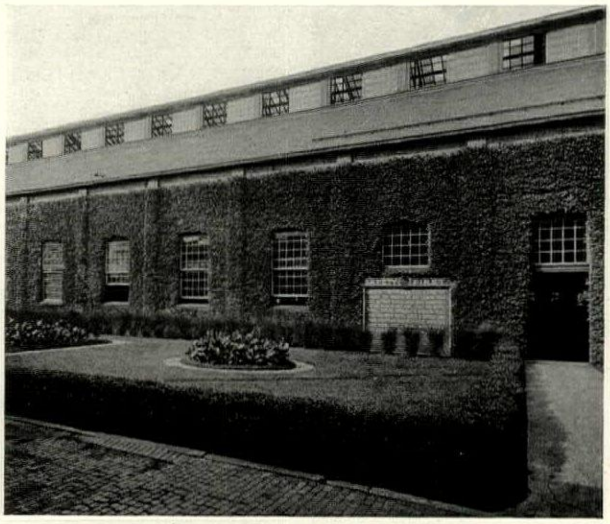


Section through Factory Room

Welfare Provisions for Industrial Plants

By CHARLES L. CLOSE

Manager, Bureau of Safety, Sanitation and Welfare, U. S. Steel Corporation



Flowers and Ivy at the Lorain Steel Company

WELFARE provisions in industrial plants can best be summed up by reviewing the activities which have proved practical by experience in a large industrial concern. Over $112,000,000 have been spent by the United States Steel Corporation since January 1, 1912 to improve the working and living conditions of its employes. This welfare work has been carefully organized and is conducted through the medium of a central department located at the corporation's offices in New York, and various standing committees, composed of representatives of the larger subsidiary companies. In addition to the corporation committees covering this field of activity, similar committees have been established in each of the subsidiary companies, at the plants and in the departments of the plants, reaching down to the rank and file of the workmen.

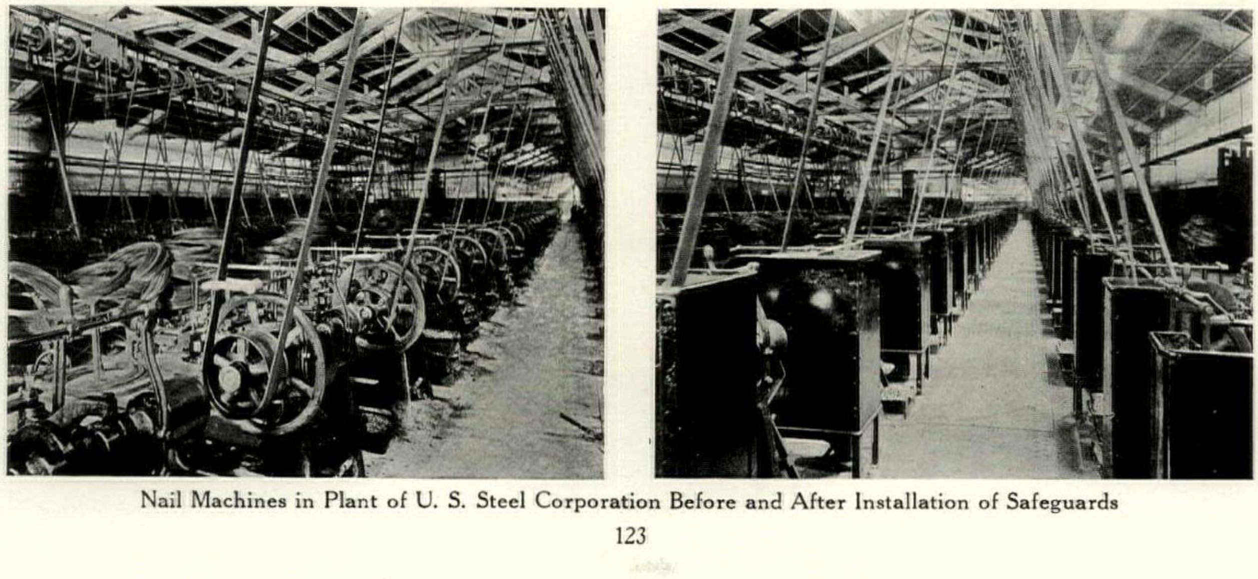
Employment.—Careful attention is given by the employment departments to the placement of new employes in the jobs for which they are best suited and physically fitted. Medical examination of employes has been established by the majority of the subsidiary companies. These examinations have proved very beneficial both to the employes and the companies. They serve as a guide to the plant officials in placing men in occupations which they are physically capable of performing and frequently bring to the timely attention of the men physical defects, often slight and easily corrected, which might, if neglected, develop into more serious ailments.

Accident Prevention.—The activities of the United States Steel Corporation in this respect have been governed by two prime factors,—engineering revision and education. About $12,000,000 have been expended in improving the general physical status of the plants and operations, and constructive effort has been made to educate the workmen in safety matters.

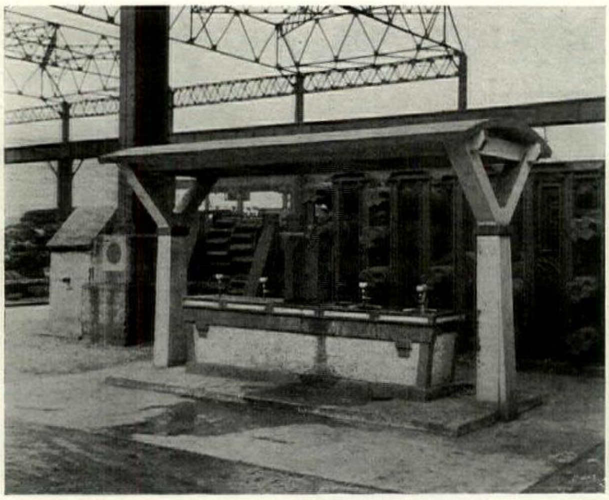
First Aid and Rescue.—Everything possible is done to safeguard employes from accident, but adequate provision is made for relief in case of injury. First aid and rescue crews have been organized in all of the mining companies and in many of the manufacturing companies. The primary object of first aid and rescue crews is to have available specially trained men who can take immediate charge of the situation whenever an emergency arises whereby life is imperiled and can give prompt and skillful attention to injured men.

Emergency and Base Hospitals.—As a necessary adjunct to first aid and rescue work 389 completely equipped emergency stations are maintained in the mines and mills, and 13 base hospitals have been constructed by the subsidiary companies at various locations where public hospitals are not available.

Sanitation.—The corporation has provided proper sanitary facilities at all the plants and mines for the



Nail Machines in Plant of U. S. Steel Corporation Before and After Installation of Safeguards



Drinking Fountain, Structural Steel Works

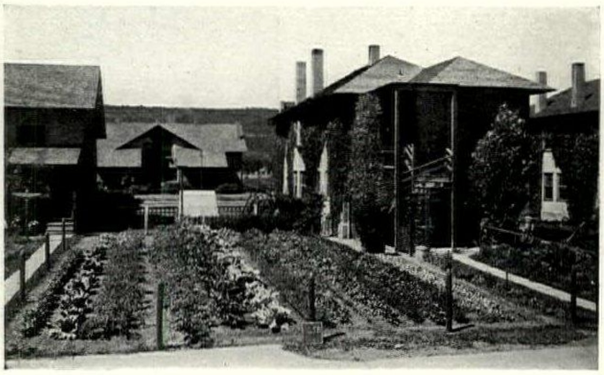
convenience and comfort of the employes, and much care and study have been given to the matter of safeguarding the health of the employes and their families. By the adoption of the most approved modern sanitary methods and practices physical conditions in the plants and dwelling communities have been raised to a very high standard, and the percentage of occupational diseases and ordinary illnesses among the workers and their families has been greatly reduced.

Careful attention is given to drinking water supply, and all sources are analyzed periodically to determine their purity and palatableness. The most modern sanitary methods are employed in the cooling and distribution of water, and the common drinking cup has been practically eliminated through the installation of sanitary drinking fountains.

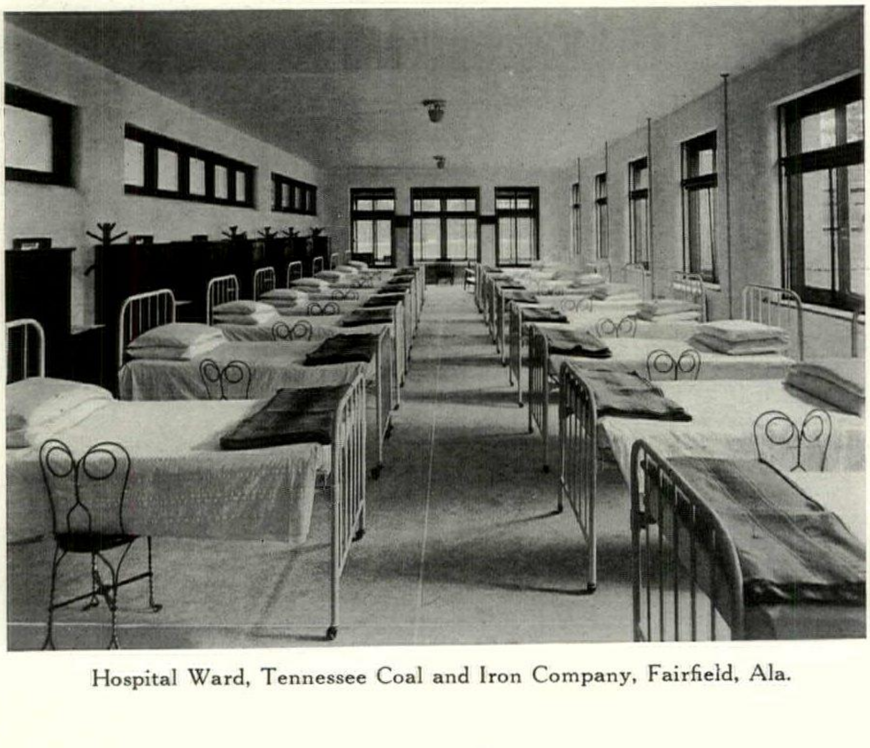
Plant Restaurants.—Restaurants have been installed in the plants of many of the subsidiary companies, where employes may obtain wholesome and attractive meals at moderate cost. These restaurants have proved very beneficial, especially to the single men living in lodging houses, and they have also lightened the labor of the housewife by relieving her of the burden of preparing the daily dinner bucket. The food served is of the best quality, and every endeavor is made to furnish properly balanced meals to meet the requirements of the men engaged in steel mill operations.

Clubs.—The club houses provided by many of the subsidiary companies for the use of their employes and members of their families and friends contribute much to the educational and social life of the community. These club houses are attractively planned and equipped and possess the characteristics of the most modern club buildings, including dormitories, libraries and reading rooms, gymnasiums and swimming pools, auditoriums and motion picture halls, dance halls, billiard and pool rooms, bowling alleys and many special features. The libraries and reading rooms are supplied with good fiction and works of educational value, current magazines, periodicals and daily papers, and the members are encouraged in the use of all the facilities of the libraries. The expenses of building maintenance, taxes, insurance and heat are usually paid by the companies, but the clubs are operated in the same manner as other similar organizations, the members, choosing their own officers and conducting all financial and social affairs. Initiation fees and dues are well within the means of all employes.

Good Fellowship Clubs have been organized by the employes in many of the plants. The management of these clubs is entirely in the hands of the members, who choose their officers and directors and



Rear Gardens in Housing Development
Morgan Park, Duluth, Minn.



Hospital Ward, Tennessee Coal and Iron Company, Fairfield, Ala.

conduct all affairs of the clubs. They render assistance in cases of sickness and other kinds of distress among their members, as well as financial assistance when necessary. They are not, however, benefit associations in the usual sense, from which members receive certain specified benefits. They also conduct other affairs incident to the social life of the community.

Gardens.—With a view to promoting thrift and improving living conditions, the employes of the corporation for many years have been encouraged to cultivate vegetable and flower gardens. In many places unoccupied land adjacent to the plant is utilized for community vegetable gardens, and the children of the workmen are taught practical gardening in plots provided for the purpose near the schools. The expense of plowing and plotting the ground is borne by the company, and assistance is given in the purchase of seeds, plants, garden tools and fertilizers. To stimulate a friendly rivalry, prizes are offered for the most attractive gardens. The value of these gardens in the development of higher standards of living is incalculable, and the yield from the vegetable gardens expressed in terms of money amounts to many hundreds of thousands of dollars annually.


Street View, Morgan Park, Duluth, Minn.

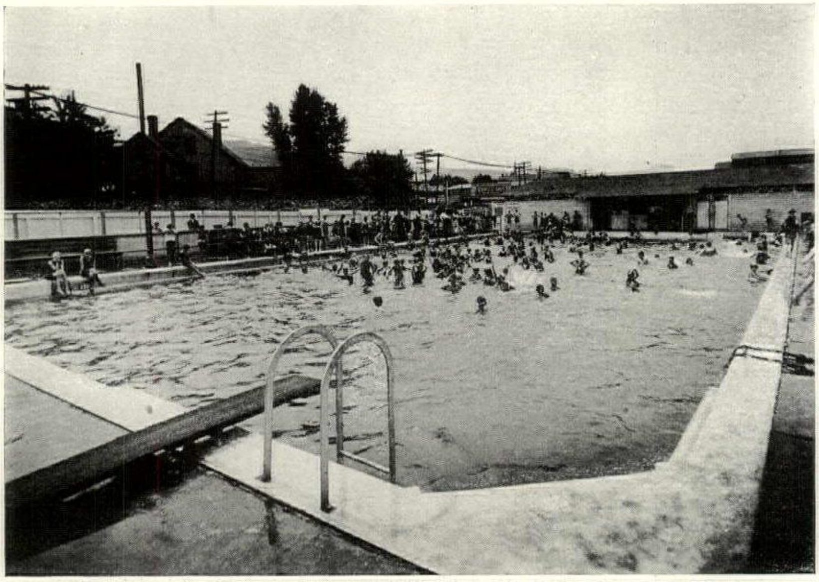
Cleanliness, order and pleasant surroundings while at work have a decided influence upon the workmen. To anyone familiar with steel mill operations, it would seem impossible to accomplish what has actually been done in this direction at most of the plants. The outsider probably cannot conceive that anything green, much less anything that blooms, could grow inside of a steel mill yard, yet many attractive flower gardens are maintained, even to those growing in the window boxes on some of the buildings. This not only makes the plant more attractive in appearance, but often it is the means of correcting some unsightly condition.


Employes' School, Gary Works, Gary, Ind.


Plant Cafeteria, National Tube Co., Riverside Works

Visiting Nurses.—Visiting nurses are employed by the subsidiary companies in a large number of districts. The assistance rendered by these nurses is both of professional and practical value. The object of this service is to improve the general health of the employes and their families. The principal duty of the nurses is to give instructions in those things which will enable the employes to better their conditions mentally, physically and materially. The services are free to those who desire to avail themselves of them, but they are not forced upon the employes, and nurses are not permitted to enter any home unless their services are requested.

Practical Housekeeping Centers.—Good housekeeping and well organized domestic activities are recognized as important factors in the creation of



Provision for Recreation and Athletics at Lorain Steel Co. Plant, Johnstown, Pa.

comfortable and pleasant home environment. For the benefit of the wives and children of the employes, particularly the foreign-born, practical housekeeping centers, fully furnished and equipped, have been established by the subsidiary companies at many of the plants and in the mining towns, where special instructors, usually visiting nurses, conduct classes in the preparation and cooking of food, the care and feeding of infants, dressmaking, and many other subjects of importance in the home. These centers have proved of great influence and value in the communities in which they have been placed.

Playgrounds.—The subsidiary companies have provided 175 playgrounds near the plants and mines to insure safe and attractive places of recreation for the children of the community. That the advantages afforded by these pleasure grounds are appreciated is shown by the fact that approximately 25,000 children use them daily during the summer months. Competent instructors are employed by the companies to supervise the grounds and the activities of the children.

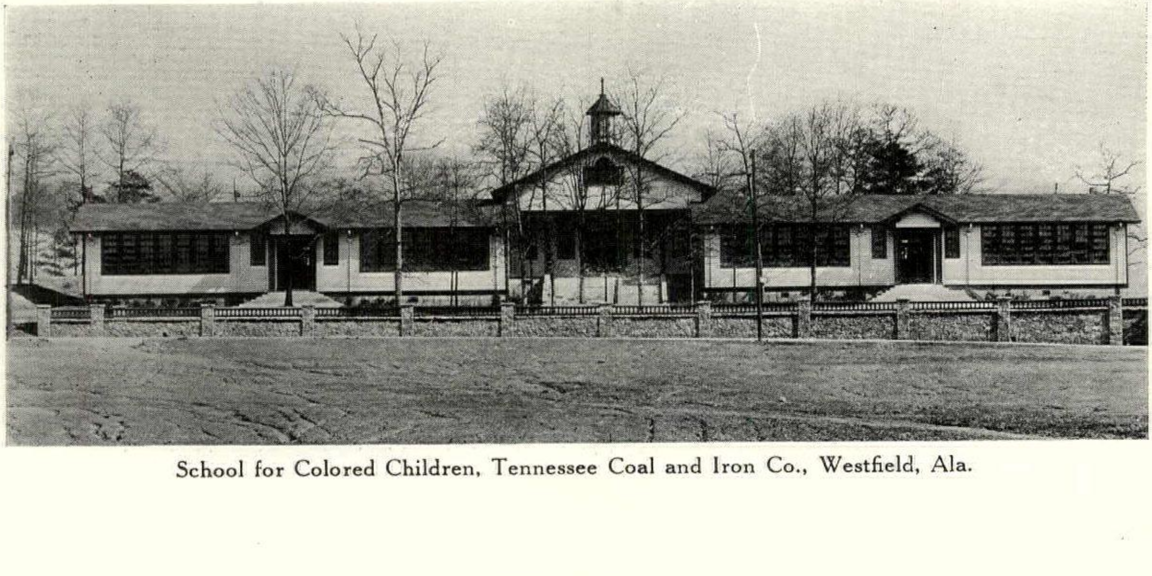
Recreation and Athletics.—109 tennis courts and 125 fully equipped athletic fields, with baseball diamonds, running tracks, etc., and amphitheaters for spectators, have been provided by the subsidiary companies in or near the plants or operations for those who enjoy healthful outdoor recreation, and all employes are encouraged to make the fullest possible use of these facilities.

Christmas Festivities.—The Christmas festivities held by the subsidiary companies at their various plants and operations are delightful and memorable occasions for the children. Usually these celebrations are held in the club houses or public halls, but where such facilities are not available, space in one of the mill buildings is provided.

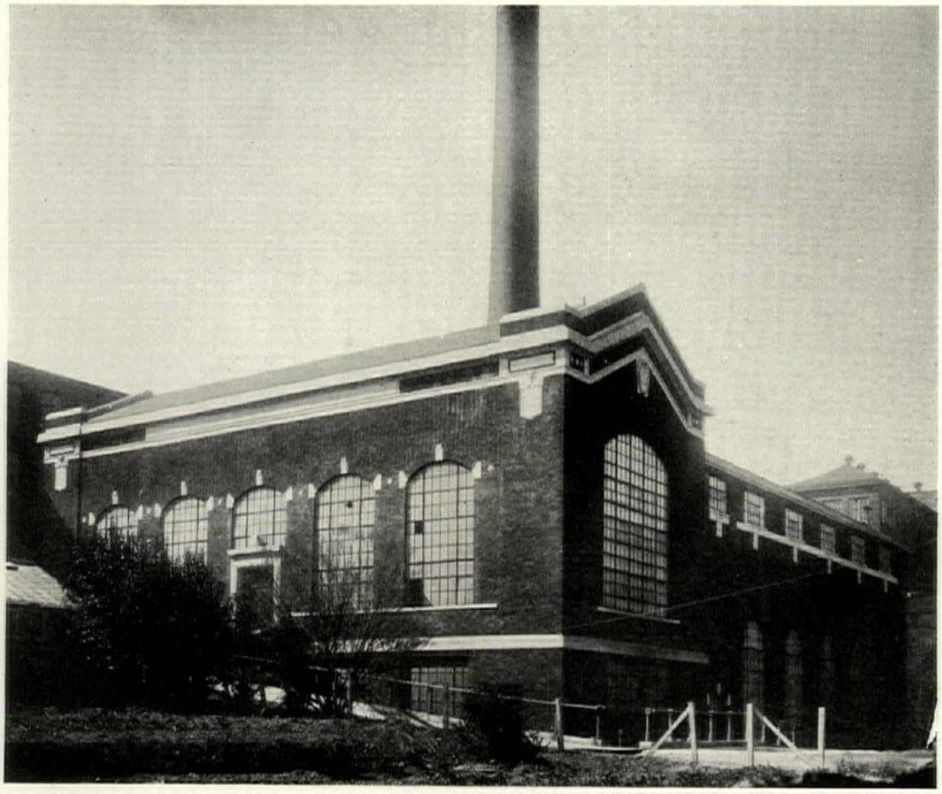
Education and Americanization.—The educational work undertaken by the corporation for the benefit of employes has been attended with much success. The courses are designed to meet the requirements of all grades of employees and cover a broad field of educational activity applicable to the steel industry, from the teaching of elementary subjects in the education and Americanization of the foreign-born worker to the more specialized and highly technical branches required in apprenticeship and vocational training. The instructors are men actively engaged in their respective lines in the mills or in the adjacent communities, and are chosen for their scholarship or their broad practical experience in the subjects which they teach.

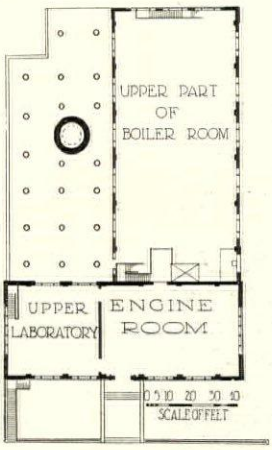
Housing.—The problem of providing good housing facilities for employes has long occupied the attention of the corporation and its companies.

Much thought and study have been given to the design and plans of the many houses constructed so that the employes will have homes with modern comforts. The houses are either sold to the employes at cost, or leased to them at low rental rates.



School for Colored Children, Tennessee Coal and Iron Co., Westfield, Ala.





First Floor Plan

THIS building combines boiler room, engine room and power laboratory. It is of steel construction, with brick walls and concrete floors. Coal and ashes are handled by elevator.

POWER BUILDING, GEORGIA SCHOOL OF TECHNOLOGY, ATLANTA
FRANCIS P. SMITH, ARCHITECT

THIS building is for the manufacture of display floats used in the annual parade of the Veiled Prophets in St. Louis. The second floor is for the use of members in dressing. The building has a steel frame with joist floors and steel roof trusses over rear portion. The exterior is of red brick with wood and steel sash, terra cotta trim, wood doors and composition roof. Heating is by direct radiation. The contract was placed in December, 1922, and the total cost was $76,000, or 16.7 cents per cubic foot. Lower floor walls red brick, plastered elsewhere. Ground floor, cement; others maple.

THE VEILED PROPHET "DEN," ST. LOUIS
KLIPSTEIN & RATHMANN, ARCHITECTS

Plumbing for Industrial Buildings

By JAMES A. COTTER

Plumbing Engineer, Boston

USE of plumbing in buildings has gone forward with great strides. All concerned in the design or plan of the building devote much thought to it, and no longer is the provision of plumbing facilities a hit-or-miss proposition. Being a matter which affects the health and well being of the community, the installation of plumbing is regulated by law, and law in most communities is now well defined as to minimum requirements. There is still, however, a great variance in these laws in different sections of the country, which emphasizes the fact that standardization is greatly needed. At the present time, there is being carried on by the Sub-committee on Plumbing of the Department of Commerce Building Code Committee, an exhaustive study in connection with practical experiments for the purpose of making a standard set of plumbing regulations.

The layout of the fixtures involves not only consideration of the initial cost but also the question of location. In the long, narrow type of buildings, the "toilet shaft," which could be placed on the exterior of the building at each end or at the center of long sides, affords an ideal location. By this method there is no valuable floor space sacrificed, and the element of loss of time in gaining access to toilets is reduced to a minimum. For the building whose area conforms more to a square, necessitating an interior light court or shaft, the toilets could be arranged around this shaft.

As for the interior of the toilets, fixtures should not be crowded. Narrow lavatories and urinals, especially when too closely placed, result only in loss of space, because when so installed they cannot be used properly on maximum demand. Like fixtures should be grouped. By so doing the arrangement or sequence of pipes and fittings will be best for economical roughing-in. For example, if men's and women's toilets are adjacent, it would be much better to place the water closets back to back than to have the water closets of one toilet room on one side and lavatories of the other toilet room on the opposite side of the dividing partition. Where a toilet room contains many fixtures it tends to better the arrangement by placing all of one type of fixtures in the center of the room, back to back, and having the other fixtures against the walls. Placing the fixtures adjacent along one wall or partition causes a long run of soil and waste pipes, and the question of pitch in the main becomes a very important factor. This is particularly true of lavatories. On floors of large areas the concentration of lavatories in the main toilet room should be avoided if at all possible, and instead there should be but few lavatories in the main toilet, and the remainder distributed.

The number of fixtures to be installed should be based on the number of people in the building and not, as is very often the case, by installing as many fixtures as a certain amount of floor space will accommodate. Where there are many employes, well distributed over several floors, an approximate rule which may be applied is one water closet for every 15 women, one water closet for every 20 men, and one urinal for every 25 men. When the total number of employes is relatively small, these ratios should be increased to one water closet for every 10 women, one water closet for every 15 men, and one urinal for every 20 men. Lavatories should equal in number the water closets supplied, except where the work done is of heavy nature, in which case facilities should be increased.

The arrangement of fixtures brings up the question of pipe space, of which there is not, generally speaking, enough allowed. It is very well to attempt the concealment of wastes and supplies, but the more this is done the greater should be the working space. The supplying pipes, which may of necessity require many valves and short nipples at the fixtures, are subject to much wear and tear, and these should be readily accessible for repair or removal. If concealed, the need of working pipe space is apparent. The fixtures should be so arranged that no dirt pockets are formed, and the lavatories so spaced that they may be thoroughly cleaned on all exposed sides. The urinals should be so set, if floor outlets are used, that space between, when the fixture is not of the interlocking type, is great enough to allow for proper cleaning. The better practice now is to fill in these urinal spaces and to face up this backing with material to match the walls of the room.

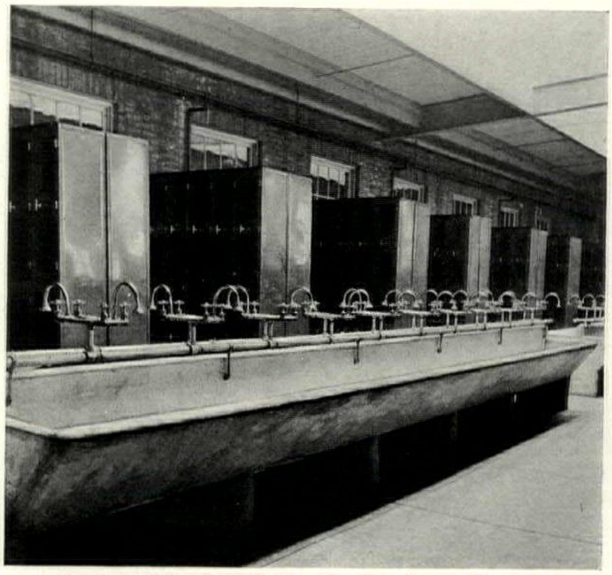
One of the dominant features of a toilet room should be cleanliness. To be maintained, of course, requires constant care on the part of an employe who should wash down at regular intervals the floors, walls and partitions. In order that these parts should not show the effect of careless use of fixtures or of washing, they should be made of hard, non-absorbing materials for about 6 feet above the floor. Above this height plaster with paint serves its purpose well. For floors, of the materials now used, polished cement with cove base appears to meet industrial conditions satisfactorily. White walls greatly emphasize this cleanliness feature, and the more this is developed in the design of the toilet room, the more the users of the facilities will help to maintain it. White glazed tile of large size works out very well. Partitions needed for enclosing water closets only, should rest on post supports, leaving a clearance to the floor permitting proper access to the floor, which aids in maintaining cleanliness.

The fixtures selected for industrial buildings should be substantially made and contain as few mechanical working parts as possible. The water closets should be of best quality porcelain ware of siphon action type, with non-absorbing seats. If it is possible, from a cost point of view, it is better to improve upon this last recommendation by installing a siphon jet closet. In a strictly factory building, the closet should be flushed automatically. Whether the building is of this type or not, the flushing of the closet should be accomplished by means of a flush valve of the oscillating handle type. The urinals should be of the floor outlet type of the larger widths. The flushing of this fixture should be similar to that of the water closets. The long enameled iron sink with supplies over the center, so that both sides may be used simultaneously, is preferred to the individual lavatory whenever the factory is considered. Faucets which permit of use of mixed water through one nozzle used in connection with sinks give good results. Where the building is more of the office type, individual lavatories with two faucets, of either compression or self-closing pattern, should be used. The shower should be supplied for those working in the boiler room, or where the work is of very heavy nature and attended with much dust.

When fixtures of one kind occur in battery, the greatest economy is attained by means of "loop venting." It is possible to have the run so long that intermediate vents will be required. For batteries of two dissimilar types, fixtures are installed to advantage by placing a common vent stack between the batteries and using the loop system on both groups of fixtures.

For soil and waste pipes, cast iron and wrought iron pipe each has its advantages. Although screw pipe is installed much faster than calked pipe, the fluctuating difference in cost of both does not warrant the suggestion as to which is preferable for ordinary toilet room use. For interior conductors which are to be exposed, appearance and space may be improved by the use of screwed pipe. Many kinds of pipe have been used for soil and waste lines where chemicals are encountered. The consensus of expert opinion is that with much acid in the waste the use of extra heavy soil pipe and fittings, thoroughly and heavily coated with asphaltum inside and out, serves the best interest of the building. Whenever installed it should be carried direct to sewer, and while inside the building it should be run exposed. There have been various kinds of especially prepared cast iron pipe for this use, but because of their special qualifications they are expensive, and the initial cost of installing makes their use very limited.

The material for supply pipes, as with soil pipe, should be determined after knowing the characteristics of the water which is to be used. For hot water, brass will outlive iron pipe, and its initial higher cost should not prevent its installation. The water supply in some localities has been found to act on brass in such a way that the zinc is taken out and deposited as an oxide, thereby destroying the pipe. This condition would call for the use of copper. If costs must be cut, galvanized wrought iron in the basement for cold water might be substituted for the brass. This should then be run exposed, to be readily accessible in case of repairs.



Wash and Locker Room for Employes Showing Continuous Basin with Combination Fixtures

Not too much attention can be given to the matter of accessibility of pipes after they are installed. If ample working pipe space in back of fixtures cannot be had, there should be plenty of floor boxes and wall openings provided. Soil and waste runs should end with cleanouts brought through the floor, if cleanouts are not accessible from below. Basement soil mains should have cleanouts behind every branch connection, and between branches if they are over 30 feet apart, and at every change in direction.

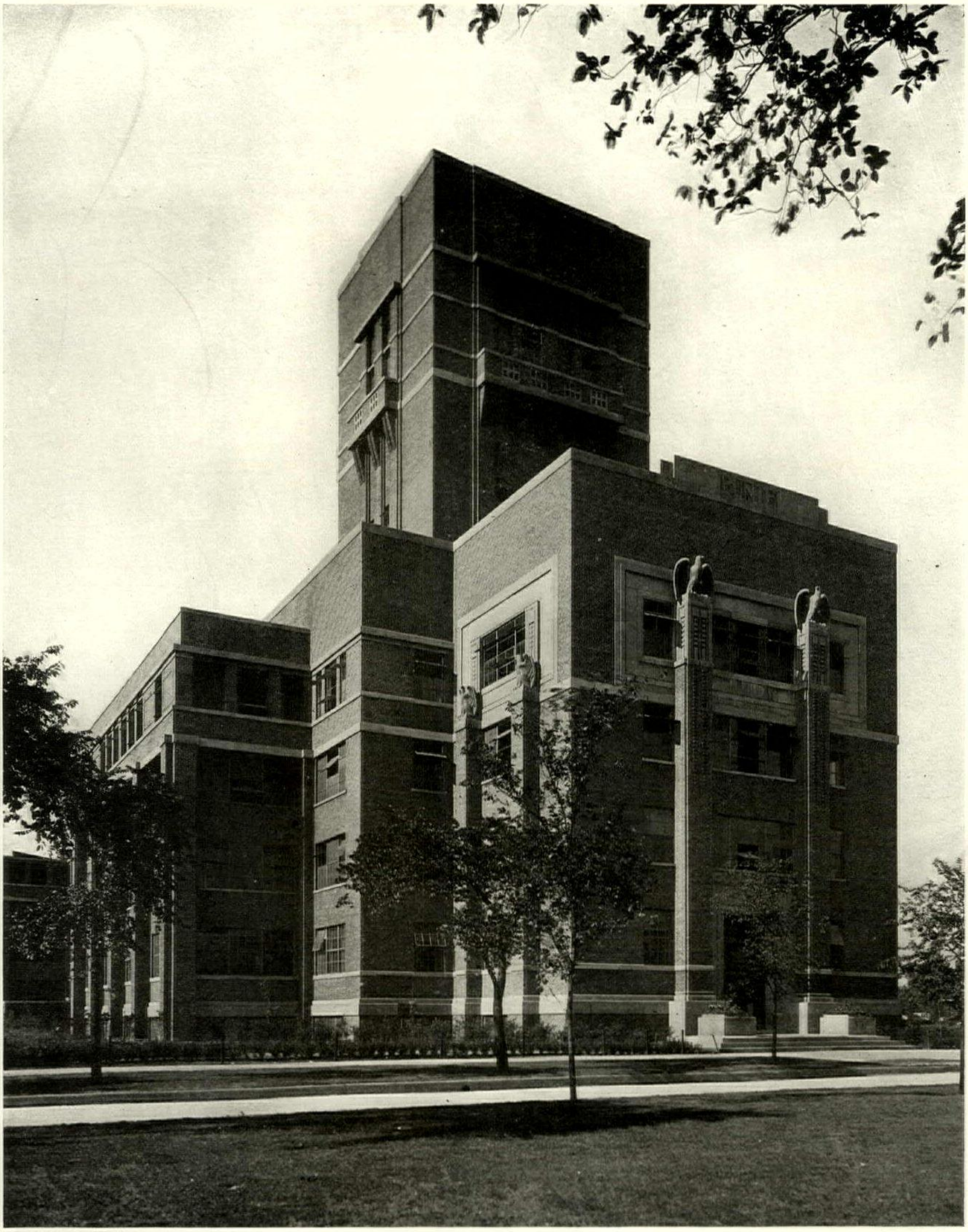
When considering use of hot water, the question arises of where it is to be used. Many industrial buildings require hot water for purposes other than supplying lavatories, sinks, slop sinks and showers. When this condition exists, the extra initial and the maintenance costs are not great, and may be negligible, in which case there should be no hesitancy on the part of the owner in installing a hot water system for fixtures. When this condition does not exist, the hot water should be supplied only to the plumbing fixtures just mentioned. One good argument that there should be hot water is that it is the exception rather than the rule to omit it. To supply hot water is proof positive to the employe that his personal comforts have been considered, and it is always well to create the proper impression on the employe.

Cold water is run to the fixtures, and it is rare when the additional expense for hot water adds greatly to the cost of installation. The building will have steam for heating, and often for power, and use could often be made of return steam to heat the water. If direct steam were used, the load thrown on the boilers for water heating would be small. When a hot water system is installed the best results are obtained by the use of a storage tank. By this method maximum and average demands are properly taken care of. The heating element in the tank, of whatever type, should be correctly determined for each building, so that the efficiency of the unit is at a maximum. The tank should have such accessories as a thermostat, relief valve, and vacuum valve. The material to use for the tank and coil should be determined by the same considerations as mentioned for piping. If iron pipe is to be used in the system poor results will follow if the sizes are not made liberal throughout. Many methods are employed for supplying the hot water to the proper fixtures, but whether it is a gravity or forced circulation, the overhead main supply with down feed risers returning to the tank may be given the preference. Too great an oversizing may work to the detriment of the system, if it is large, as this excess amount of water to be heated may overtax the capacity of the heating equipment.

Industrial buildings today often cover considerable ground, therefore their roof areas are large. This means that rain water disposal must be considered. Exterior leaders are probably the least practical, because they are exposed to the weather and therefore entail large maintenance cost, and since their life is not long, renewals are necessary in a few years. Interior leaders may be placed almost anywhere in the building. They can be readily run from the low points, which means that valleys may be run in any direction on the roof to best suit its needs. When the rain leader is run under a roof slab in a furred space, protection from possible freezing should be afforded. The roof connection to give satisfaction must be such that the roofer can work to it and make a finished and tight job. There are many good types on the market, and they may be had with large copper flanges over which the roofer may place his surfacing properly. The roof connection cannot be absolutely rigid; there must be some provision made for motion, and if not taken care of the roof connection will not hold. Stock connections which take care of this by having one member move on another and in which the joint is made tight by means of a gland or gasket, are readily procurable. These connections are made for either calked pipe or screwed pipe, or if they are not they may easily be altered and made serviceable for either kind of pipe. The piping to use, whether screw or calked, is always a debatable question, as in the case of soil stacks already mentioned. The rain leader as a rule should give the least amount of trouble of all the water pipes, and it may be the first pipe after the vent to be enclosed with furring.

The solution of the locker question is difficult. Lockers take up room, and it is space that is valuable, since very often, even though well planned, this area is allotted at a sacrifice. Naturally, the larger the establishment, the greater becomes this problem. A good layout will generally have a few outstanding characteristics. The locker room will be handy to the entrance and exit for employes. As working clothes are put on before starting work and removed on ending work, with this arrangement it becomes apparent that progressive motion by employes is attained. Many times this location is adjacent to working quarters, but care should be taken that the locker room does not afford the possibility of becoming a recreation room during the working hours. A crowded locker room does not work out satisfactorily. It causes congestion at quitting time, and in case of overlapping shifts much confusion arises. A well ordered establishment has the smallest possible amount of confusion. The lockers should be of a type which may be easily cleaned periodically, both inside and out. A locker with some sort of perforations not only helps in maintaining cleanliness through ventilation, but lends itself to a quick inspection without the necessity of opening the door if it be locked. Some type of a sanitary base will keep the room clean when washing down. A locker whose dimensions are too large will cause carelessness, and it will soon become a storehouse.

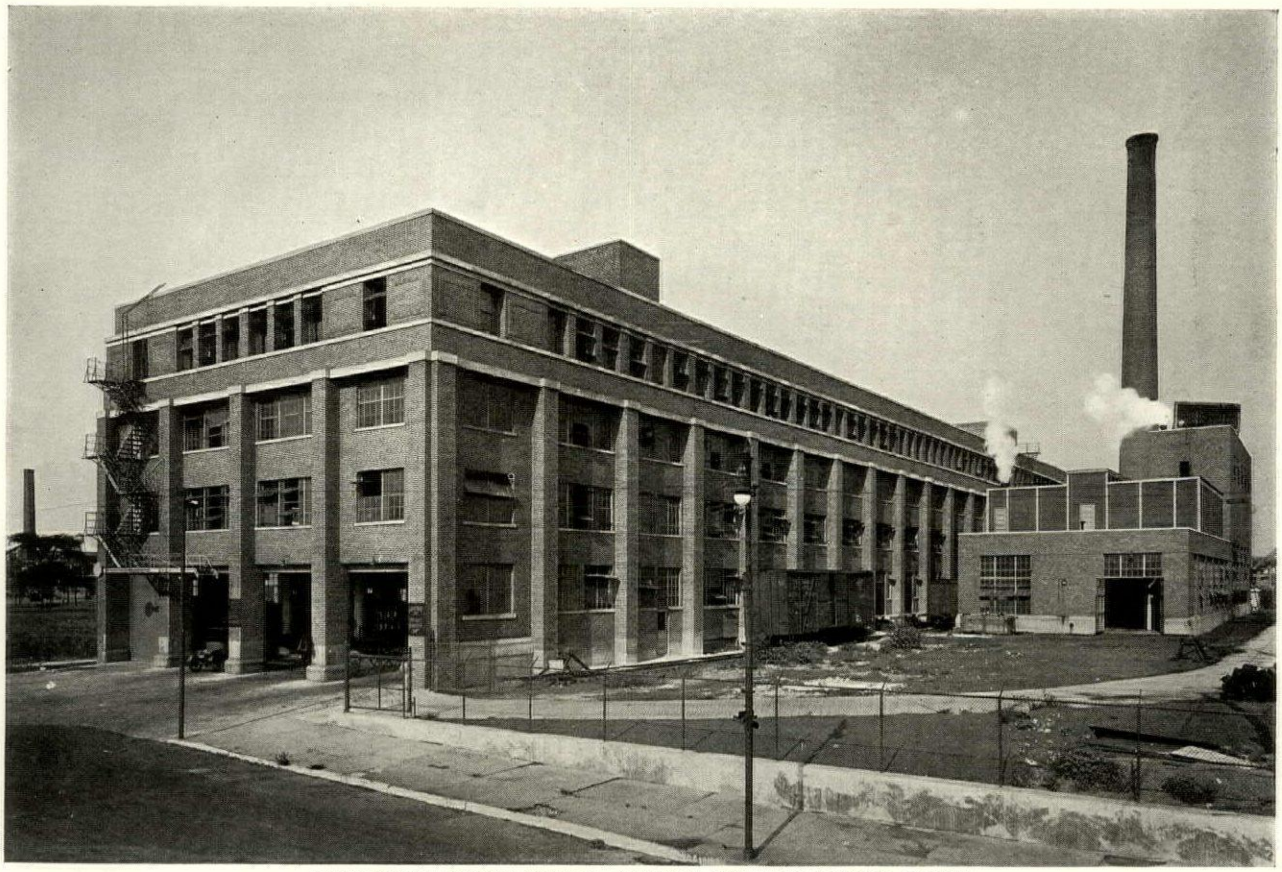
Drinking fountains should be installed in every industrial building. Those which afford the utmost in sanitary qualities and are the least complicated in the operation are the type to consider. The stream of water should be easy for one to receive, and its waste should fall free of the supply orifice. It is better to have the controlling valve separate rather than part of the bubbler. The drinking fountain as an individual fixture is to be preferred to a bubbler in conjunction with another fixture. The latter method allows but one to use the combination fixture, which often causes delay and therefore waste of time. It also has the appearance of a makeshift, and does not encourage care and cleanliness. Distribute the fountains well. The locations for the fountains are best determined after a study of floor areas and the distribution of employes, as the element of time becomes more important the greater the number of employes. Most of the industrial centers have water which has been filtered before it is used by the community, and therefore it is not necessary to have an elaborate purifying plant in the building where the people work. Cooling the water is an expensive proposition as a matter of maintenance and as to the installation of the necessary apparatus.



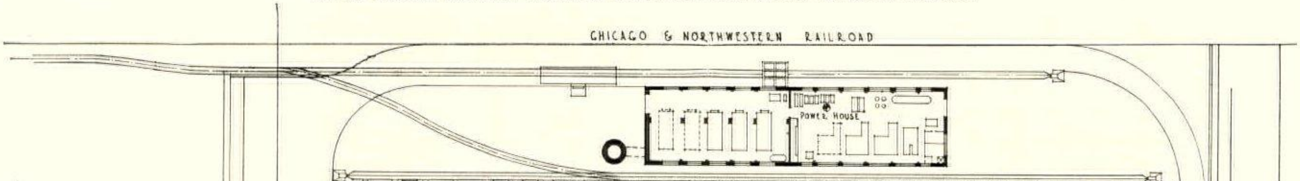
Since the long frontage of this structure occupies a prominent site on Chicago's system of boulevards, it has received careful architectural study. Use has been made of steel construction, the exterior materials being brick with trimming of stone and concrete. Steel sash are used for windows. It is said to be the largest candy factory in the world, but provisions have been made for future additions as indicated on the main floor plan. The plan was based on continuous study of plant operations for two months by an architect and engineer

CANDY FACTORY FOR BUNTE BROTHERS, FRANKLIN BOULEVARD, CHICAGO

RICHARD E. SCHMIDT, GARDEN & MARTIN, ARCHITECTS



VIEW FROM NORTH HOMAN AVENUE SHOWING POWER HOUSE

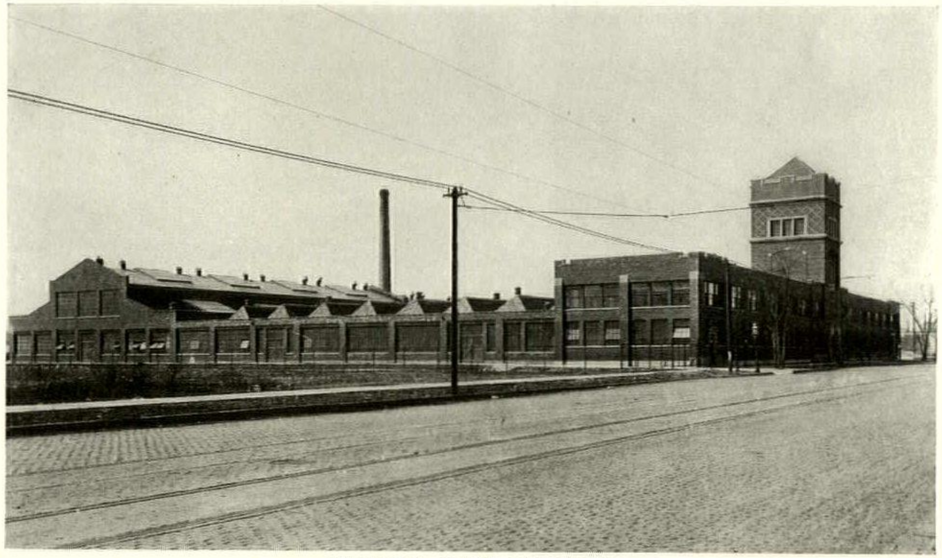


FIRST FLOOR PLAN WITH FUTURE ADDITIONS INDICATED

CANDY FACTORY FOR BUNTE BROTHERS, FRANKLIN BOULEVARD, CHICAGO

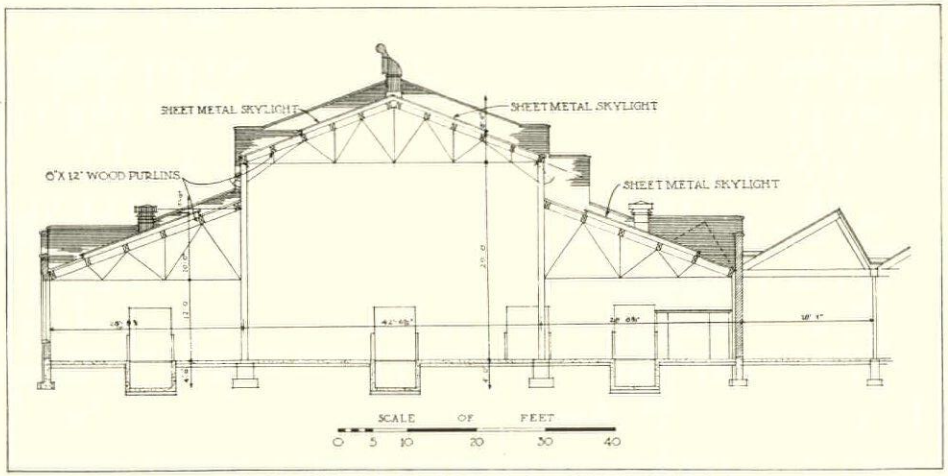
RICHARD E. SCHMIDT, GARDEN & MARTIN, ARCHITECTS

DETAIL OF ENTRANCE TOWER



GENERAL VIEW OF PLANT

Type of construction: Partly of 1-story sawtooth mill type, and partly of fireproof monitor type, giving daylight throughout. Exterior materials: Paving brick, laid in red mortar; stone trimmings. Heating: Direct low pressure system. General contract placed: 1921. Cubic foot cost, 30 cents. The building is used for the manufacture of small automotive parts.



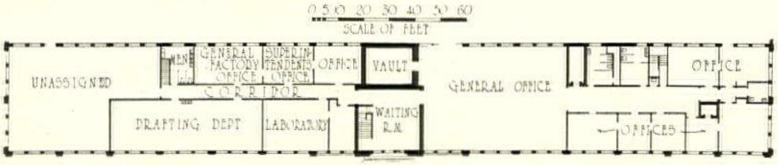
CROSS SECTION THROUGH DIE CASTING ROOM

SAMUEL N. CROWEN, ARCHITECT

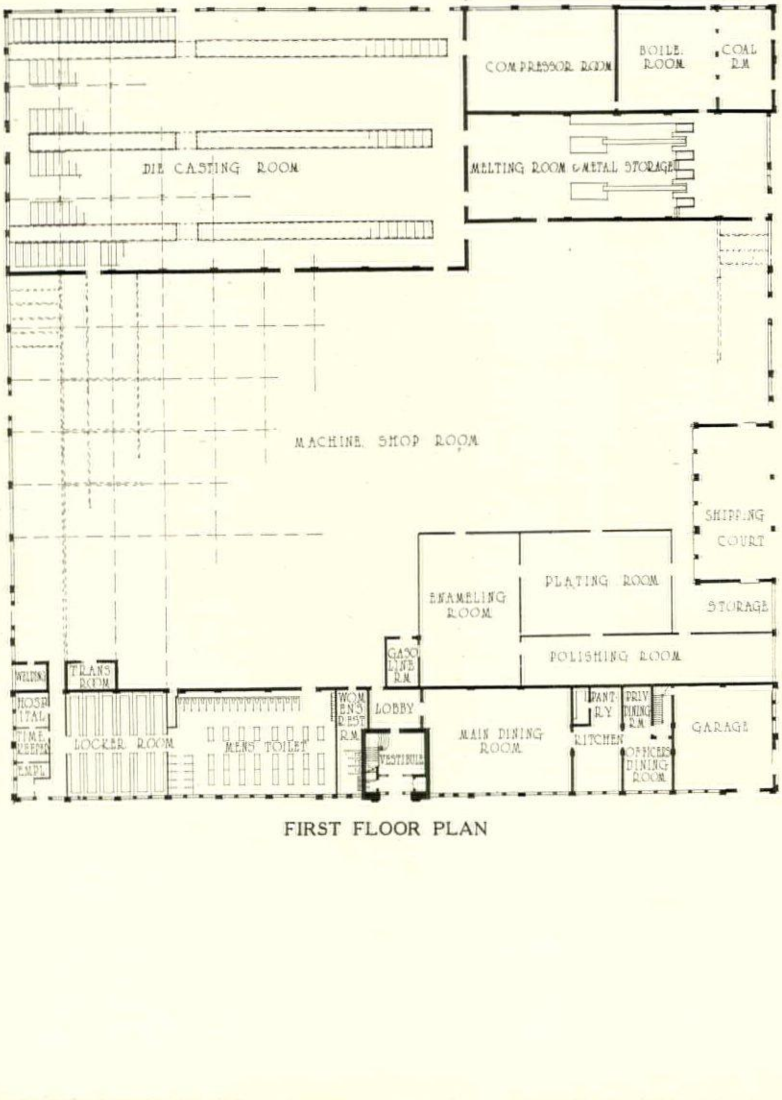
STEWART MANUFACTURING CO. PLANT, CHICAGO

STEWART MANUFACTURING CO. PLANT, CHICAGO

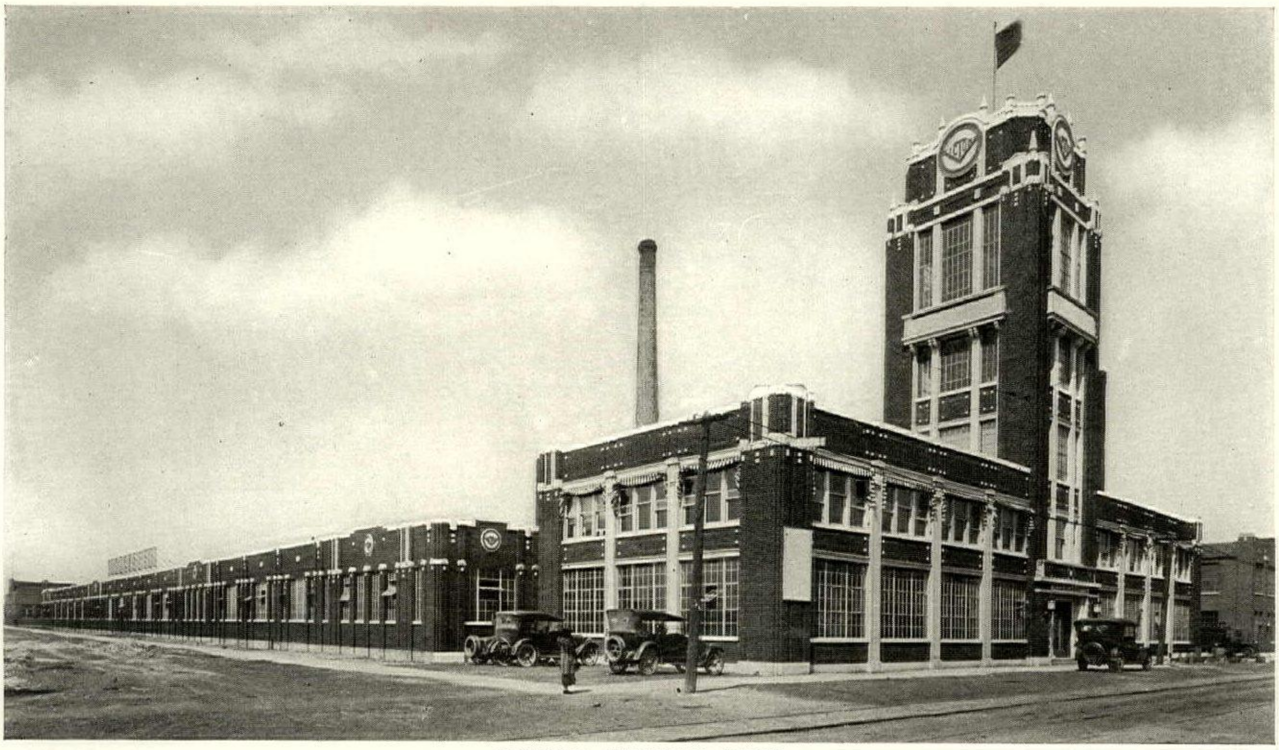
Illustrations on Plate 47



SECOND FLOOR PLAN



FIRST FLOOR PLAN



GENERAL EXTERIOR VIEW

DETAIL OF TOWER ENTRANCE

VICTOR MFG. & GASKET CO. PLANT, CHICAGO

ALFRED S. ALSCHULER, ARCHITECT

VICTOR MFG. & GASKET CO. PLANT, CHICAGO

Illustrations on Plate 48

Type of construction: Reinforced concrete.

Exterior materials: Reddish brown, rough textured brick laid with strip joints; terra cotta trimmings.

Interior materials: Plaster walls with wood trim.

Windows: Steel sash for lower floors; wooden sash above.

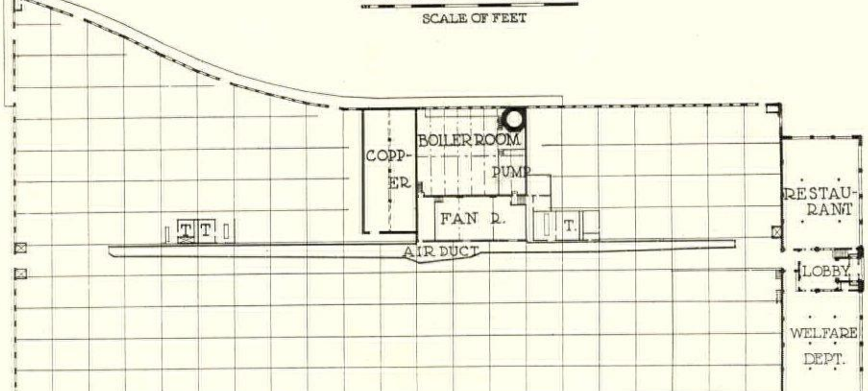
Heating and ventilating: Provided by three 150-h.p. horizontal return tubular boilers with Dutch oven extension furnaces operated at high pressure. The factory portion is heated by a hot blast system. The main supply fans are driven by an engine. The air is washed and the heating coils are supplied with high pressure steam direct from the boilers, and the remainder with low pressure steam or exhaust steam from the engine driving the blast system. The system is used for ventilation in summer.

General contract placed: 1919.

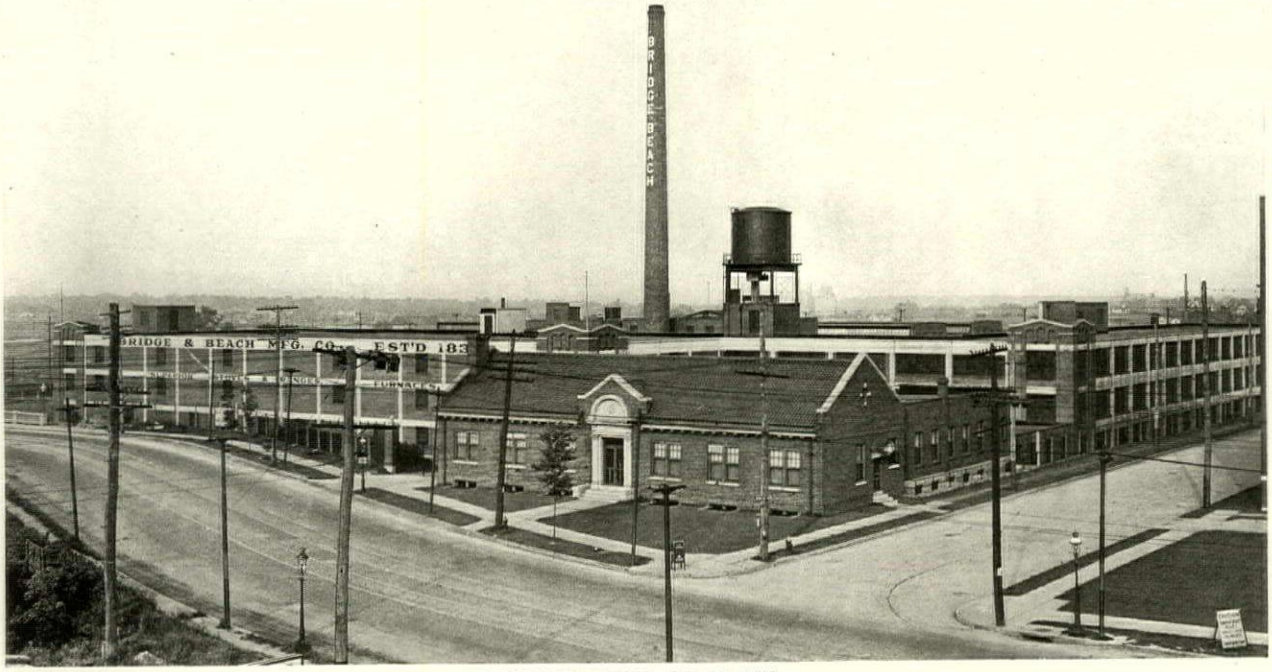
Total cost of building: $365,100.

Cubic foot cost: 20 cents.

Use of building: Manufacture of gaskets for automobile engines.

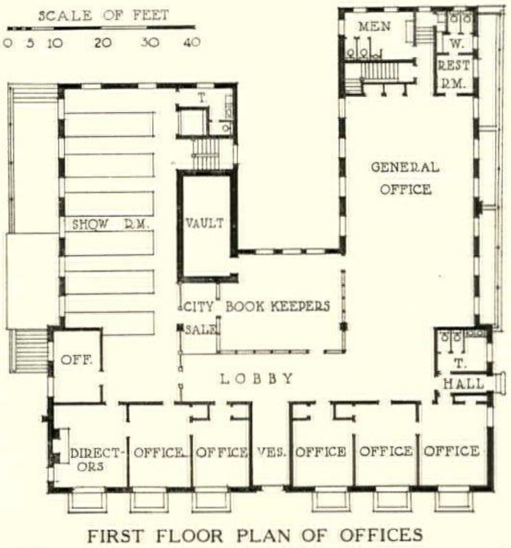


FIRST FLOOR PLAN



GENERAL VIEW OF PLANT

DETAIL OF OFFICE ENTRANCE



FIRST FLOOR PLAN OF OFFICES

Type of construction: Reinforced concrete, mill construction, and brick and steel. Live floor loads in warehouse and assembling building are 175 pounds per square foot. Plant is used for the manufacture of stoves and furnaces. Exterior materials: Hard, red machine pressed brick or washed concrete. Roofs: composition and tile.

Interior materials: Common hard brick walls with tooled joints; concrete ceilings and floors. Windows: Steel sash and factory ribbed glass. Sash in moulding shop continuous. Sash carried to within 2 inches of ceilings.

Heating: Direct radiation except in moulding shop where plenum chamber and duct system are used.

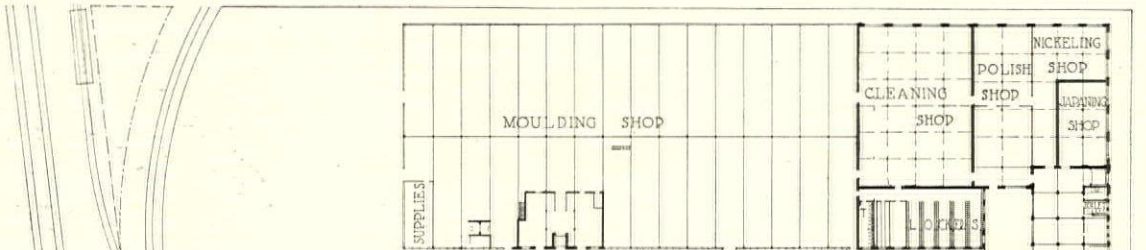
Date of general contract: October, 1919.
Cubic foot cost: 28 cents.

BRIDGE & BEACH MANUFACTURING CO. PLANT, ST. LOUIS

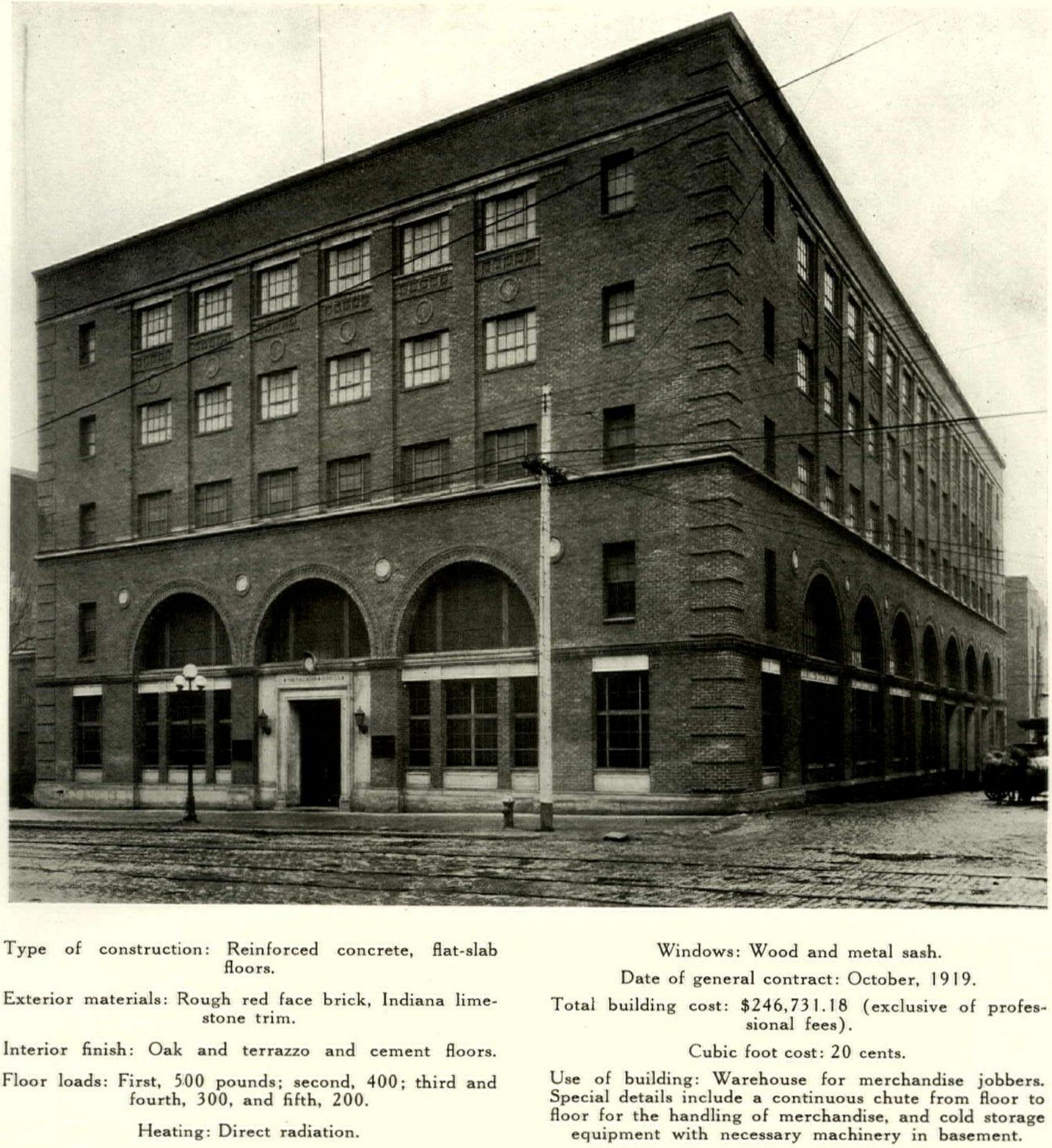
KLIPSTEIN & RATHMANN, ARCHITECTS

BRIDGE & BEACH MFG. CO. PLANT
ST. LOUIS

Illustrations on Plate 49



MAIN FLOOR PLAN



Type of construction: Reinforced concrete, flat-slab floors.

Exterior materials: Rough red face brick, Indiana limestone trim.

Interior finish: Oak and terrazzo and cement floors.

Floor loads: First, 500 pounds; second, 400; third and fourth, 300, and fifth, 200.

Heating: Direct radiation.

Windows: Wood and metal sash.

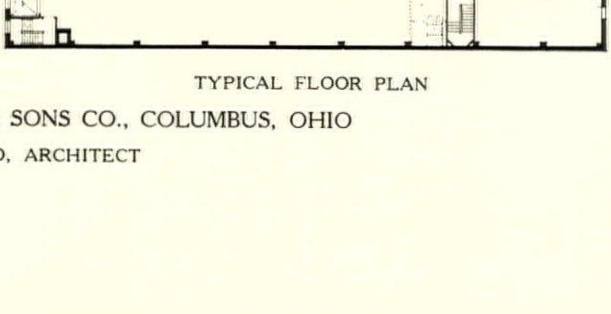
Date of general contract: October, 1919.

Total building cost: $246,731.18 (exclusive of professional fees).

Cubic foot cost: 20 cents.

Use of building: Warehouse for merchandise jobbers. Special details include a continuous chute from floor to floor for the handling of merchandise, and cold storage equipment with necessary machinery in basement.

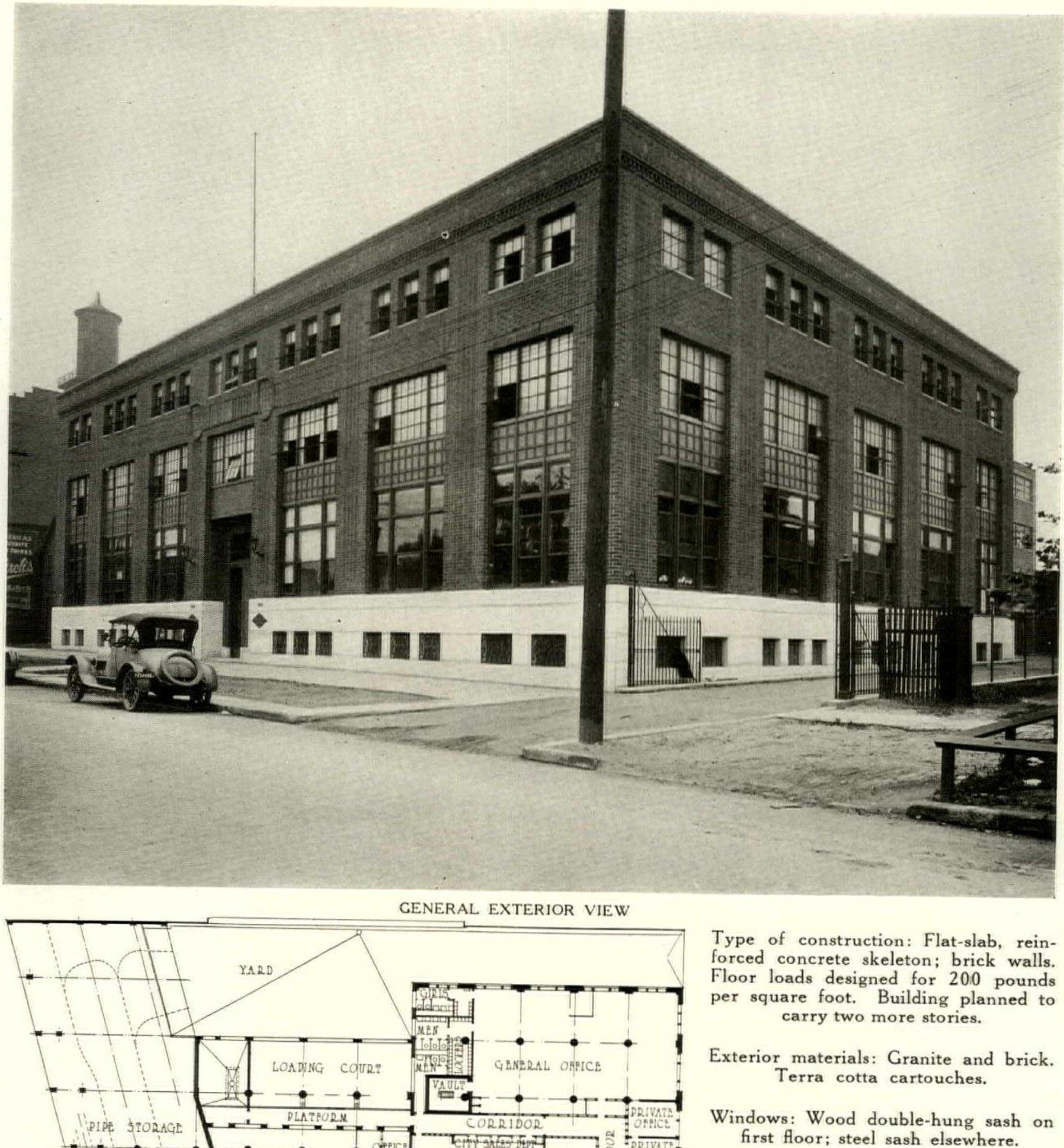
FIRST FLOOR PLAN



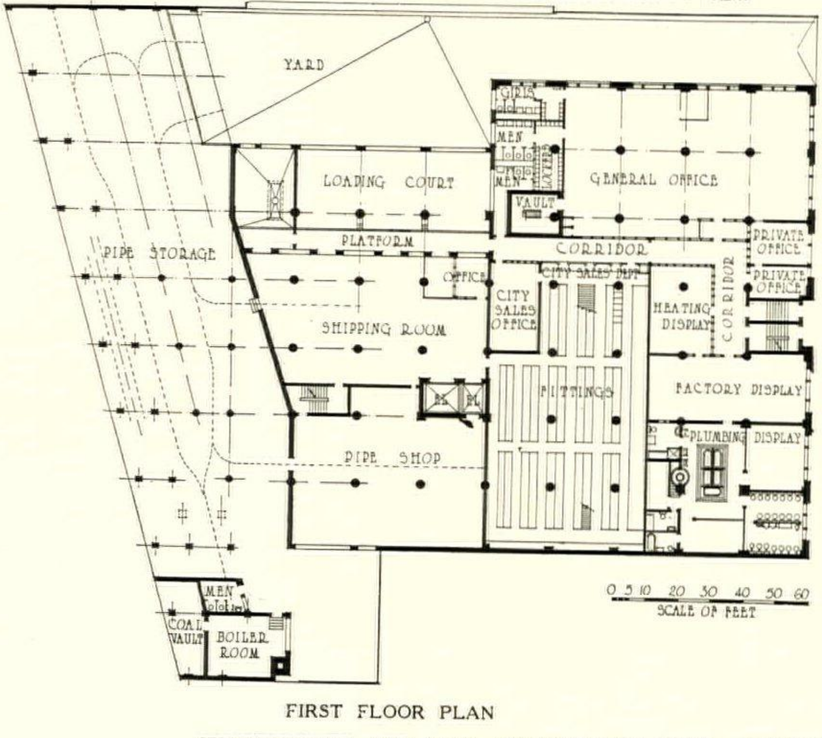
TYPICAL FLOOR PLAN

WAREHOUSE OF THE GEO. BOBB & SONS CO., COLUMBUS, OHIO

FRANK L. PACKARD, ARCHITECT



GENERAL EXTERIOR VIEW



FIRST FLOOR PLAN

Type of construction: Flat-slab, reinforced concrete skeleton; brick walls. Floor loads designed for 200 pounds per square foot. Building planned to carry two more stories.

Exterior materials: Granite and brick. Terra cotta cartouches.

Windows: Wood double-hung sash on first floor; steel sash elsewhere.

Heating: Vacuum system.

Date of general contract: May, 1919.

Total cost of building: $320,000.

Cubic foot cost: 23½ cents.

Use of building: Warehouse, plumbing and heating supplies. The display rooms for plumbing fixtures and the executive offices occupy the street frontage of the lower floor; shipping room and storage spaces are in the rear; open storage floors are above.

WAREHOUSE OF THE WALWORTH-OHIO COMPANY, CLEVELAND

THE CHRISTIAN, SCHWARZENBERG & GAEDE CO., ENGINEERS

Heating and Ventilation of Industrial Buildings

By CHARLES A. FULLER

Consulting Engineer, New York

THERE are three general types of systems to be considered in the solution of the heating problem for the average industrial plant, and they may be broadly classified as: (1) the "direct steam," (2) "forced hot water," and (3) "hot blast" systems. There are, of course, several sub-divisions under each of these main heads. Before any consideration can be given the sub-divisions, however, the first question to be answered is, Which of these particular systems is the most adaptable and the best suited for the particular plant in question?

Unfortunately, it is only in a very few isolated cases that the engineer has the advantage of being able to start with an entirely new proposition. In such a case, his one and only problem is that of economy, and by economy is meant not only operating cost, but also general health, comfort and personal efficiency of employes. Usually, however, the engineer is called in only after the plant has been in existence a number of years. Expansion has taken place along no definite, well organized lines, and the heating equipment has been installed by inexperienced contractors without consideration of economy or future growth. It is a proposition of this kind which involves the most difficult problems for solution, because the engineer is obliged to work, so far as possible, with existing equipment. Otherwise he will incur for his client heavy installation costs.

The writer has in mind a recent installation in a large industrial plant composed of several buildings of various types of construction. A forced hot water heating system would have met the requirements in an ideal manner, as to both economical use of exhaust steam and distribution of heat to the various buildings. Unfortunately, however, of all the radiation installed throughout the plant, practically none would have been applicable in connection with the use of hot water as a heating medium. The installation cost of an entirely new hot water system, with all of the existing radiation discarded, would have been so excessive as compared to that of a low pressure, steam distributing system, making use of all of the old radiation, that the interest on the additional investment would have more than counteracted the gain in economy.

Forced Hot Water System

One of the principal advantages of the forced hot water system in an industrial plant composed of several isolated buildings to be heated from a central plant is that the water can be circulated throughout the entire group from the central plant, irrespective of the relative elevations of the various buildings. The flow and return mains can be run underground or overhead as desired, and thus interference with roadways, traveling cranes, etc., can be avoided. Furthermore, the control of the amount of heat distributed to each building is entirely in the hands of the operating engineer. The flow and return temperatures can be controlled at the power plant in accordance with the outside wind and temperature conditions. A wide variation of water temperature is easily obtainable, so that the maximum and minimum can readily be taken care of. With steam distribution the temperature of the heating medium is practically constant, so that the control of the heat for varying weather conditions must be left entirely to the occupants of the building. The result is that an excessive amount of steam is used during mild weather.

Another advantage of forced hot water heating is the economy in the use of exhaust steam from generating units where the power load and heating load are nearly equal. Where condensing water is available, condensing engines or turbines can be installed and the hot water converters, used in connection with the heating system, can be substituted for the condensers during the heating season. The amount of vacuum carried on the generating units can then be varied to conform to the weather conditions and the required water temperatures on the heating system thus obtained.

Steam Heating Systems

Low pressure steam is undoubtedly most widely used in industrial heating, the distribution being obtained by means of some form of vacuum system. The term "vacuum system," as generally applied, is somewhat misleading, since it would imply that steam is circulated throughout the system below atmospheric pressure. This is not the case, however, as a vacuum is maintained only on the return system—that is, between the return trap on each heating unit and the vacuum pump in the power plant. The pressure carried on the supply main and the heating units usually varies from a few ounces to 1 or 2 pounds.

A vacuum system of steam distribution is well adapted for industrial plants, particularly where exhaust steam from generating units is to be used. The reason is that this exhaust steam can be circulated easily throughout the long horizontal runs which are usually encountered, with a maximum of 1 pound pressure on the supply main at the power plant. The back pressure on the generating units is therefore very low, and consequently their efficiency is considerably increased. The circulation throughout the plant in the mornings, before the

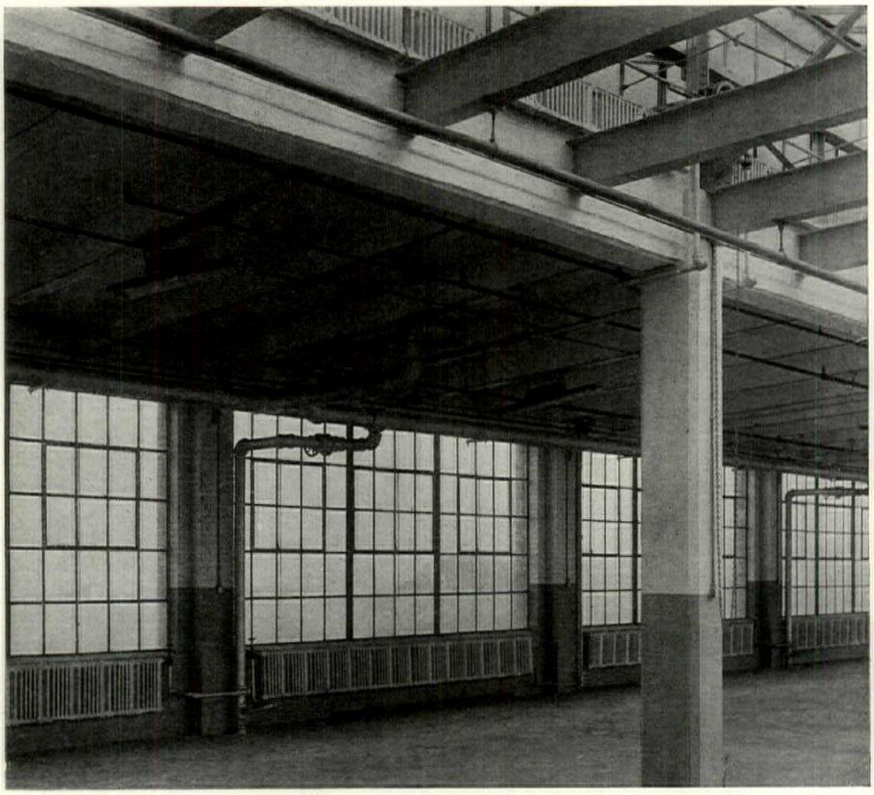


Fig. 1. Interior of Plant, Showing Wall Radiation with Downfeed System. Note Expansion Loops in the Supply Mains

generating units are started, is accomplished much more rapidly than with the gravity system, and the amount of live steam necessary during this period for actual heating is kept down to a minimum.

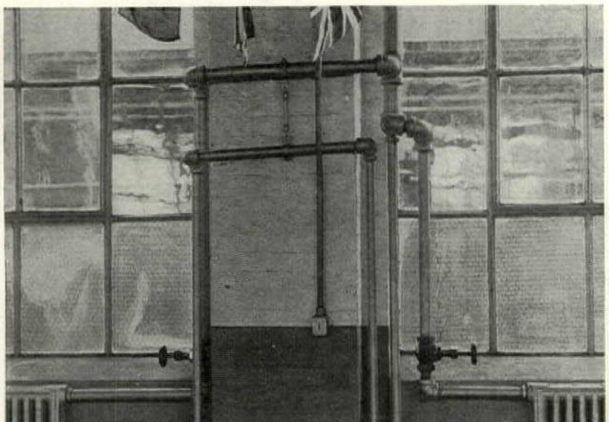


Fig. 2. Detail Showing Method of Dripping the Bases of Risers and Taking Off Radiator Connections on First Floor in Downfeed System

The downfeed system, with the distributing mains located on the ceiling of the top floor, usually provides the best type of piping arrangement for factory construction. The mains can be left exposed, and the additional radiation thus obtained will usually compensate for the heat loss through the roof. Otherwise, the sizes of the radiators on the top floor would have to be excessively large.

Fig. 1 shows the usual arrangement for the downfeed system. This also illustrates a good method of installing expansion loops in the supply mains. The method of making the riser connections, together with their cut-out valves, is also shown in this illustration.

Wall radiators are undoubtedly the best type of heating units to use in the average factory construction. In the case of such construction large window areas are usually encountered, and the wall radiators can be so proportioned as to fill the entire bay, thus providing even distribution of heat. This arrangement is clearly shown in Fig. 1, as well as the method of making the supply and return connections from the risers to the radiators. Fig. 2 illustrates a typical method of dripping the bases of these risers on the first floor, and of taking off the first floor radiator connections above the drip points. In the plant to which these illustrations refer there was no basement, and the return mains were run in trenches in the floor. The method of making the riser connections, together with their cut-out valves, is also shown.

Hot Blast Heating

There has been considerable discussion among engineers regarding the respective merits of hot blast heating and direct radiation, as applied to industrial heating. In the writer's opinion there are few cases in which the arguments do not strongly warrant the adoption of the hot blast method.

In order properly to analyze the comparison between the two systems, we must consider them from the standpoint of both installation costs and of operating costs. It seems to be the consensus of opinion that the hot blast system is more expensive to install than the direct radiating system, but the writer has found, in the cases of two different types of buildings, by direct comparison of actual estimates, that the direct system was considerably more expensive in terms of first cost. In one particular case the owners obtained, from various contractors, estimates on a direct system for a new machine shop. The lowest estimate received, for this system, was $33,000. The writer was called in at this point, and a hot blast system was immediately recommended. Plans and specifications were prepared, and the contract awarded for approximately $22,000. The type of building was the standard one-story machine shop with high ceilings and a large proportion of exposed glass area. In the case of the multiple-story building, with from 12- to 14-foot story heights, the cost of the two systems would be more nearly equal, for reasons which will be given later. Fig. 3 illustrates the exterior of a machine shop at Cleveland. The conditions in this type of buildings are ideal for the hot blast system as compared to the direct system. When these two systems are designed to meet the same conditions, the comparative costs will be found to be approximately in the ratio as shown by the figures already given.

Comparative Economies

When a building of the type just mentioned is heated by direct radiation, it will be found that the temperatures in the upper portion are considerably above the temperatures near the floor line. This condition must be taken into account when the necessary radiation is being estimated. A certain percentage must be added to the heat loss through the walls and glass to compensate for the higher temperatures in the upper section of the building. The percentage to be added will depend upon the maximum ceiling height, but it should be at least 1 per cent for each foot over 12. Not only does the additional radiation thus required represent additional installation cost, but it represents also an additional yearly operating cost. With a properly designed hot blast system, the temperatures throughout the entire building can be kept practically uniform, and the excess heat loss at the upper portion can be wholly eliminated. There is also an excessive heat loss through the walls directly behind the heating coils, owing to the high temperatures at these points. Practically all of the wall spaces below the windows will be covered with wall radiation, because this is not only the most desirable, but also the only available wall space for radiator location. The amount of wall area thus covered will represent a large percentage of the total exposed wall area.

The power cost for motor operation in connection with the hot blast system must naturally be taken into account. In the writer's opinion, however, the fuel saving represented by the two plants outlined here will be considerably in excess of the expense involved.

Another point in favor of the hot blast system is the element represented by the time required to warm the building in the morning. Properly arranged recirculating dampers, which should always be provided, and ample heating surface in the indirect heating stacks, will make it possible to raise the temperature of the building much more rapidly than would otherwise be the case. Moreover, because steam will have to be supplied to the building for a much briefer period of time, a considerable fuel saving will be effected.

Fig. 4 shows the plan of the hot blast system installed in the same plant at Cleveland, the exterior of which was shown in Fig. 3. The interior of the completed installation is presented in Fig. 5. This shows the method of installing the main supply ducts in the roof trusses, and also the branch supply ducts extending down the sides of the columns. In

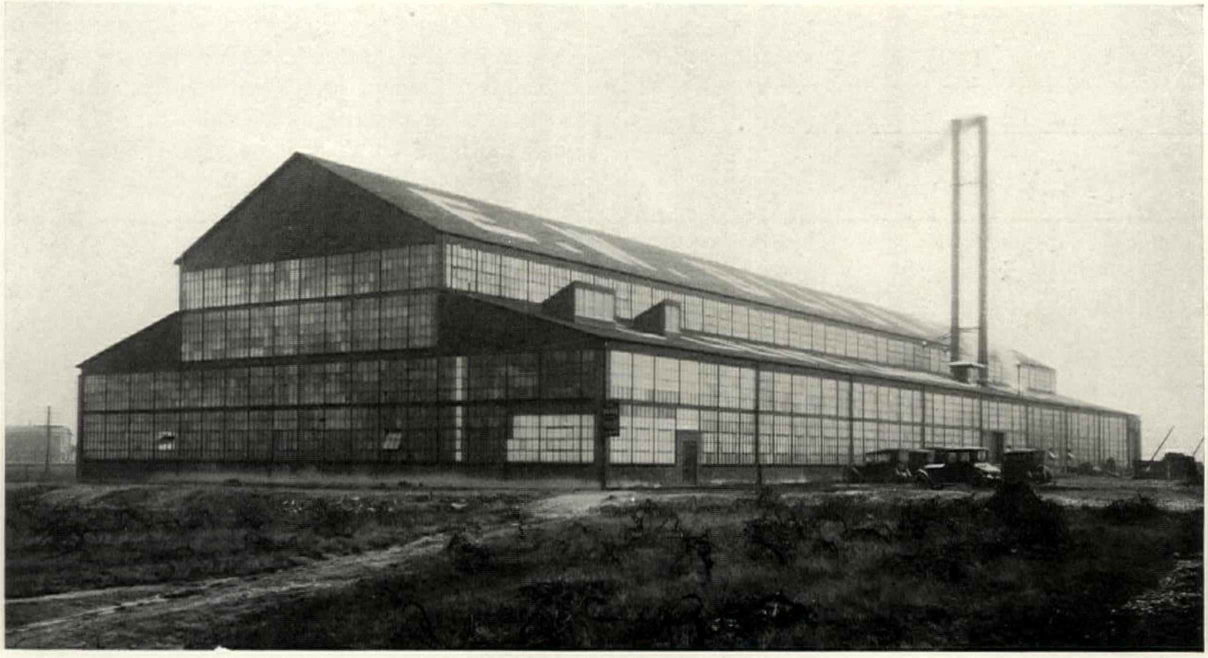


Fig. 3. Machine Shop, E. W. Bliss Co., Cleveland
A Type of Industrial Building Specially Adapted to Hot Blast System of Heating
Charles A. Fuller and Griggs & Myers, Consulting Engineers

this manner the entire duct system was so located that it neither occupied desirable working space nor interfered with the free passage of the traveling cranes. The air outlets were carried down to within about 10 feet from the floor, and each was provided with a damper. The angle of discharge is approximately shown in the illustration. On each side of the building there are two separate and distinct units, as shown on the plan. Such an arrangement is very desirable from the standpoint of breakdown service. Actual operation has proved, also, that it is necessary to operate only one equipment at a time during the greater portion of the heating season, if this arrangement is adopted. By alternating from one unit to the other at infrequent intervals during the day, a fairly even temperature can be maintained.

Details of Design

The building under discussion is devoted entirely to machine shop work. Consequently, the number of occupants is small in proportion to the volume of the room. The problem of design was therefore purely a problem of heating. The question of ventilation was not considered, since the ordinary leakage through the excessively large window areas was more than ample to supply fresh air for the occupants. The amount of air to be handled was therefore determined on the basis of the total heat loss from the building and an assumed maximum temperature of the entering air.

The building is 350 feet long and 125 feet wide at the floor line. There are approximately 25,000 square feet of glass, 1,500 square feet of 9-inch wall, 45,000 square feet of roof, and 43,500 square feet of floor. The heat loss was estimated on a basis of a 70° room temperature, with an outside temperature of 10° below zero. The transmission factors assumed were:

9-inch wall	.4	B.t.u.	per	hour
Glass	1.0	"	"	"
Roof	.3	"	"	"

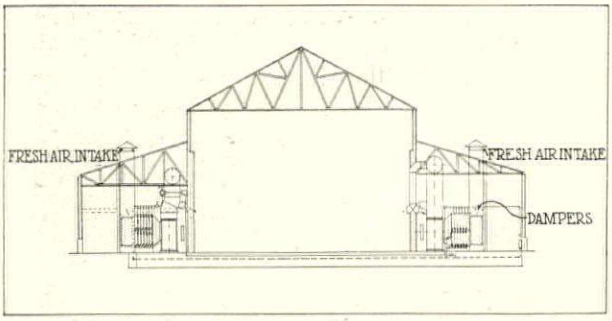
The transmission through the concrete floor was taken at .3 B. t. u. per degree of difference per hour, with 20 degrees maximum temperature difference. The total heat loss, with 10 per cent added for exposure, and 20 degrees for leakage, was 4,565,000 B. t. u. per hour. The temperature of air leaving the outlets was assumed at a maximum of 120°, an estimate which allowed for an available temperature drop of 50 degrees per cubic foot for heating. The amount of air to be handled was then obtained thus:

$$\frac{4.565{,}000 \times 55}{50} = 5{,}022{,}000 \text{ cubic feet per hour, or } 83{,}700 \text{ cubic feet per minute}$$

Each fan was designed to handle 45,000 c. f. m. against a static pressure of 1¼, the motor being 20-h.p. variable speed type.

The indirect heating stacks for each of the two units contained 3,400 square feet of heating surface, so arranged as to heat the total quantity of air from a temperature of 40° to a temperature of 130°. Having the air leave the heater at 130° allowed a temperature drop of 10 degrees in the duct system. The entering temperature was taken at 40° to allow for temperature in the morning.

The duct system of air distribution was designed on the basis of a friction drop of .1 inch water gauge per 100 feet of straight pipe. When the duct sizes are designed in this manner, the velocity of air in the different sections decreases toward the end as the duct sizes decrease. An equal flow of air is then obtained from each outlet without the use of deflecting dampers at the branch outlets. The velocity in the main trunk duct back of the first branch is approximately 1,500 feet per minute, and this



Cross Section of E. W. Bliss Machine Shop, Showing Hot Blast Heating Layout

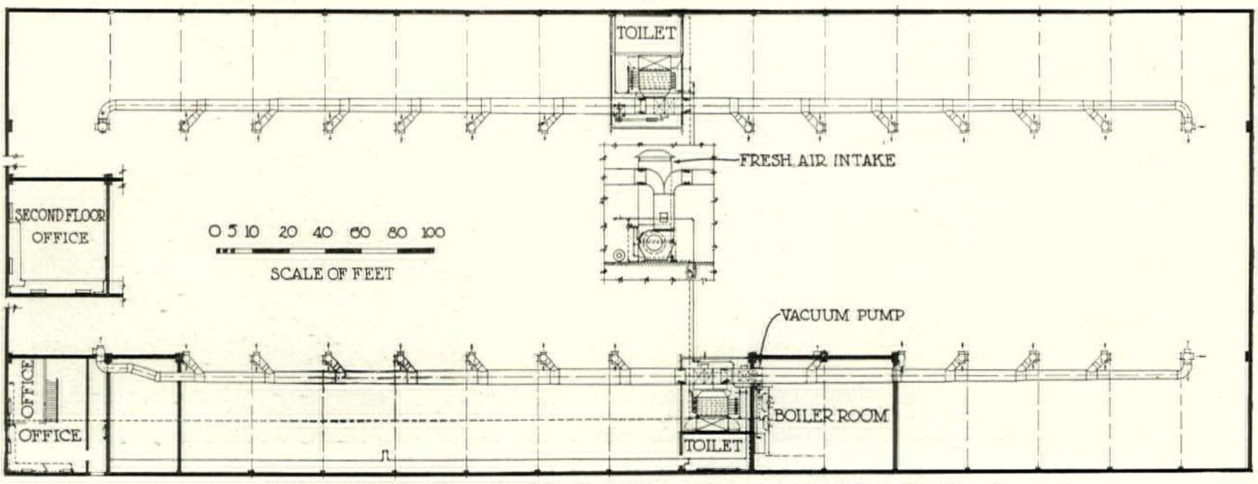


Fig. 4. Plan of E. W. Bliss Co. Machine Shop, Showing Hot Blast Heating Layout

velocity is decreased to about 900 feet at the end. The velocity in the vertical drops from the main trunk duct is decreased, immediately after the branch is taken from the main trunk duct, to 600 feet per minute and the outlet velocity to 500 feet per minute. A discharge velocity of 500 feet per minute will give a uniform temperature distribution throughout the entire room, and will not produce objectionable drafts, provided the outlets are placed at a height not less than 10 feet from the floor line.

The angle of discharge of the outlets leading to the center in the case under consideration was so arranged that the two currents of air would meet approximately at the floor line, and on the center line of the building. The outlets discharging toward the outside wall were arranged in such a way that the current would meet the floor directly at the outside wall line. All outlets were so constructed as to have the same area. The drops at each end of the duct system were provided with three outlets. One of these discharged toward the end wall, and was designed to carry 50 per cent more than the others in order to compensate for the heat loss at the ends of the building.

An examination of the sizes given on the plan will show that the dimensions of the branch connections directly at the main duct vary in size and are increased toward the end of each duct. The vertical drops beyond these connections, however, are all of uniform size, except the ends. An equal quantity of air is desired from each outlet, and the sizes of these branches are obtained on the basis of assuming that the velocity of flow from the branch duct is the same as that in the main duct at the point from which the branch is taken. Since the velocities are lower toward the end, these connections must naturally be increased in size in proportion to the decrease of the velocity.

Temperature Control

The important problem of automatic temperature regulation in connection with industrial heating is too frequently overlooked. It has an extremely important bearing upon the subject, from two distinct standpoints:

1. Economy of operation.
2. Personal comfort and the efficiency of the employe.

In regard to the first point, the average heating plant, particularly one in which steam is used, is operated in an extremely extravagant manner, when automatic regulation is not provided. Little or no attempt is made to regulate the room temperature by controlling the amount of steam distributed to the heating units in mild weather. The temperature control is usually accomplished merely by the opening of windows, a method which will frequently result in an even higher rate of steam consumption than in severe weather with the windows closed. Moreover, the windows are often left open after working hours, and sometimes even during the night, so that there is an increased demand for steam

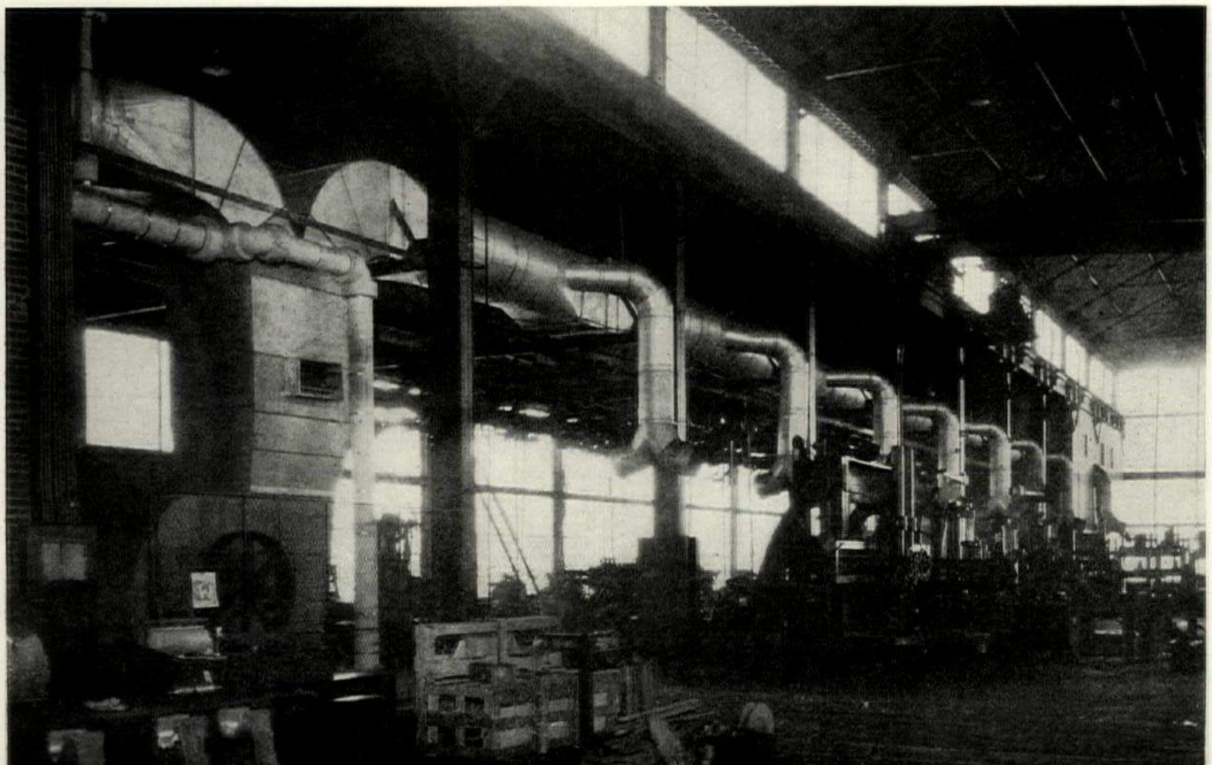


Fig. 5. Interior of E. W. Bliss Co. Machine Shop, Cleveland
Main Supply Ducts Installed in Roof Trusses with Branches at Columns

H. C. Goodman Shoe Factory, Columbus, O. Wall Radiation and Ventilation from Ducts in Monitor

in the morning. Automatic temperature regulation, properly installed and maintained, will eliminate a large part of this steam waste. Thermostats should be arranged in such a way that they cannot be tampered with by the occupants. As to the second point, it has been found that proper control of the room temperature has a greater bearing on the physical comfort and the efficiency of the occupants than adequate ventilation. In the writer's opinion, therefore, the increased output on the part of the employe as a result of properly regulated room temperature would alone prove a good financial return.

Air Conditions

In various kinds of manufacturing plants the question of air conditioning becomes one of great importance. In textile mills the air must be kept at a constant degree of humidity in order that the fabrics may be handled with the greatest possible efficiency. In plants where various kinds of confectionery are manufactured the air must be maintained at a constant temperature as well as at a uniform relative humidity both summer and winter. Thus, in such instances, one has to consider the problem of mechanical refrigeration and dehumidification in the summer and the reverse of these processes in the winter. All of these desired conditions can be readily obtained by means of the indirect system, as outlined here, combined with the proper apparatus inserted in the air intake to the fan.

If the problem involves only the question of humidity control, as in the case of textile mills and similar plants, it is then necessary only to install some form of air washer with automatic control of the temperature of water going to the sprays and of the various sections of heating stacks. If it is desired to maintain a certain specified relative humidity with a room temperature of 70°, it is a simple matter to determine, in grains per cubic foot, how much moisture should be contained in the air entering the room. If the sprays are properly designed, the air leaving the sprays, and before entering the reheating stacks, will be saturated, or in other words will contain 100 per cent relative humidity.

By means of psychrometric charts or tables it is possible to determine the temperature of air at saturation, or "dew point," when it contains the required amount of moisture. The air will contain the desired amount of moisture if the thermostats are inserted in front of the reheating coils, controlling the water to the sprays and steam to the tempering coils. The air is then held constantly at this predetermined temperature As the air leaves the air washer it passes through reheating coils, and in some cases may be raised above the desired final room temperature as, for example, when the heating of the room is accomplished by means of the indirect system. Such procedure, however, does not affect the final desired results, as the alternate heating and cooling of the air does not change the weight of moisture contained in the air, or in other words the "absolute humidity." When the air, after entering the room, cools down to the desired room temperature of 70°, thus giving up its sensible heat to counteract the loss through exposed walls and glass, its "relative humidity" will be at the desired point. Proper allowance must be made, however, for any factors within the room which might affect these conditions, and the "dew point" or temperature of saturation as just described, must be adjusted accordingly.

When it is desired to cool the air artificially in the summer, and to maintain a constant temperature with a fixed relative humidity, the problem becomes somewhat more complicated. Let us consider for illustration a warm day when the relative humidity is extremely high. It would require only a few degrees' lowering of the temperature before saturation, or the "dew point," would be reached. In order to lower the temperature below this point, a portion of the water vapor must be condensed, or its "latent heat" removed. The amount of heat which must be extracted in order to condense the water vapor represented by a given number of degrees' drop in the air temperature is several times as much as the specific heat of air through this same range of temperature. Furthermore, as already pointed out, in order to produce a specified relative humidity at some given temperature, it is necessary to lower the temperature below the given point and then to bring the air up to its required temperature. A study of the thermodynamics of this operation will readily show why so much more power is required to lower the air temperature through a given range than to raise its temperature an equivalent amount.

The cost of refrigerating mounts so rapidly with the quantity of air to be handled that from a practical standpoint it can be considered only under conditions that make refrigeration an absolute necessity. As to the question of physical comfort in extreme summer weather, it is vastly more important to lower the relative humidity than to lower the actual air temperature in the room.

Power Provision and Steam Plant Design

By ALLEN HUBBARD

Hollis French & Allen Hubbard, Engineers, Boston

IN treating a technical subject in a non-technical manner, there is grave danger of maltreatment. In these pages an attempt will be made to give a bird's-eye view of the essentials of a steam power plant. It is hoped that the picture may illustrate some points in such a manner that their importance will be emphasized.

Essentials of a Steam Plant

The first essential is a properly designed building or space to house the apparatus. Thousands of dollars have been and are being wasted because apparatus has been crowded into inadequate or improperly arranged spaces. This can be avoided by the intelligent co-operation of the architect and the engineer. The proper arrangement is that where there is reasonable room to get at all parts of the apparatus; where the fuel is most conveniently located, and ashes can be removed economically. Steam plants are located either in specially designed power houses or in spaces provided in larger buildings, often office buildings. The best results are obtained where the building is specially designed.

Much care and thought are spent on the question of economical operation. The ideal arrangement for using coal is to have it dumped into a hopper. It then passes down through the crusher to the conveyer, and is carried up and distributed automatically into the overhead coal storage hoppers. From the bottom, opposite each boiler, is a gate and chute which feeds the coal down to each boiler. The coal to each boiler is weighed and recorded on the journey down. The stoker hoppers receive the coal, and it is gradually fed into the furnace by the stokers. The rate of combustion is shown by the recording and indicating charts and gauges. The man in charge does not touch the coal. He simply watches the indicators, and moves a lever or valve as may be necessary.

The steam flow meter shows at all times whether a boiler is carrying its share of the load. The stoker receives the coal, and as it burns it is gradually worked along to the opposite side of the furnace where periodically the ashes are dumped into the ash hopper below the boiler. An ash car or some form of conveyer is used to remove these ashes to an overhead ash storage hopper. This is arranged to store ashes for perhaps a week's run. It is arranged with a gate in the bottom, properly protected from freezing in winter, so that by simply pulling a lever a truck is quickly loaded. While such an arrangement necessitates a considerable investment, there is a tremendous saving in labor as well as economy of fuel over the man-power system.

There is a twilight zone between the large and the small plant. Each plant problem requires its own solution. In solving it, all conditions must be taken into consideration. The cost of labor, fuel, disposal of ashes, size of load, load factors, space rental and other items must be considered.

Many steam plants installed in office and similar buildings are handicapped by lack of space. There was a saving in building cost, but the owner has probably paid out many times the amount saved in additional cost for labor and fuel, due to lack of economy of his boilers. This situation, however, is easily understood. The use of steam for industrial and heating purposes has been developed principally during the last 75 or 80 years.

In earlier days buildings were heated by stoves or fireplaces, and only brick flues were provided. As the advantages of steam heat became known, it came gradually into use. Architects and contractors worked out the requirements. Gradually the architect came to realize that space must be provided in the basement for the heating apparatus. He designed the building, set aside certain spaces, let the general contract, and told the heating contractor that was where his apparatus must go. To keep down the building cost this space was often too restricted, but the apparatus worked, and the heating contractor got his money.

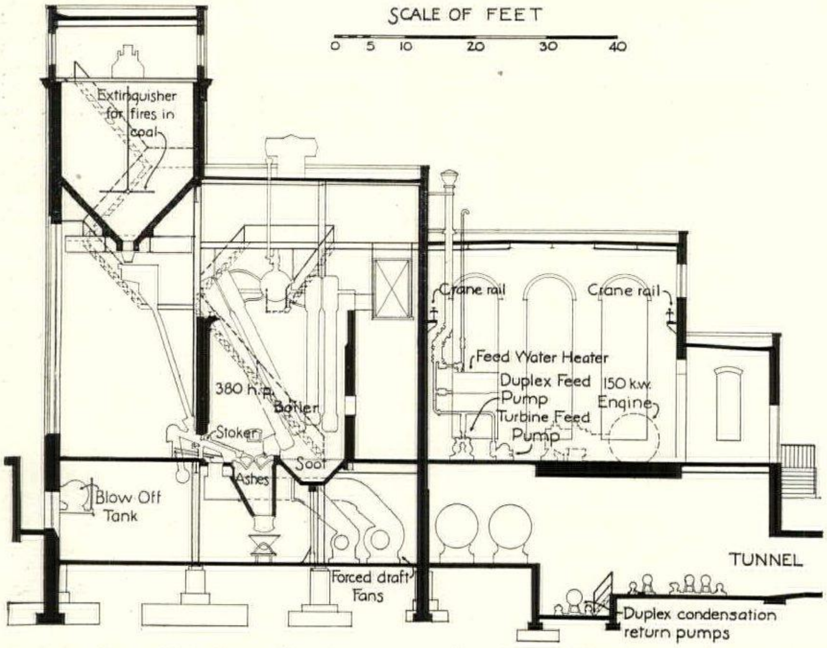
At the present time there is an abundance of data available and engineers know how to use it. Nearly all the leading architects today either have their own engineers, or an independent engineer makes the necessary calculation for space, and it is carefully provided in the building design. For smaller plants where there is neither space available nor coal enough burned to warrant the investment for mechanical stokers, coal conveyers, etc., as outlined here, there are less expensive hand stokers and other apparatus which tend to keep down the operating cost. Many of these smaller plants are fairly economical, but as a rule they are not as economical as the larger plants.

Perhaps the next most important thing is the chimney. Whether the draft is by gravity, forced or induced, or a combination of these, the chimney should always be ample. If there is possibility of future growth, the chimney should be calculated for the maximum load. It will cost comparatively little extra. We have often seen plants which have outgrown the chimney, and remedying it is usually a difficult and expensive operation.

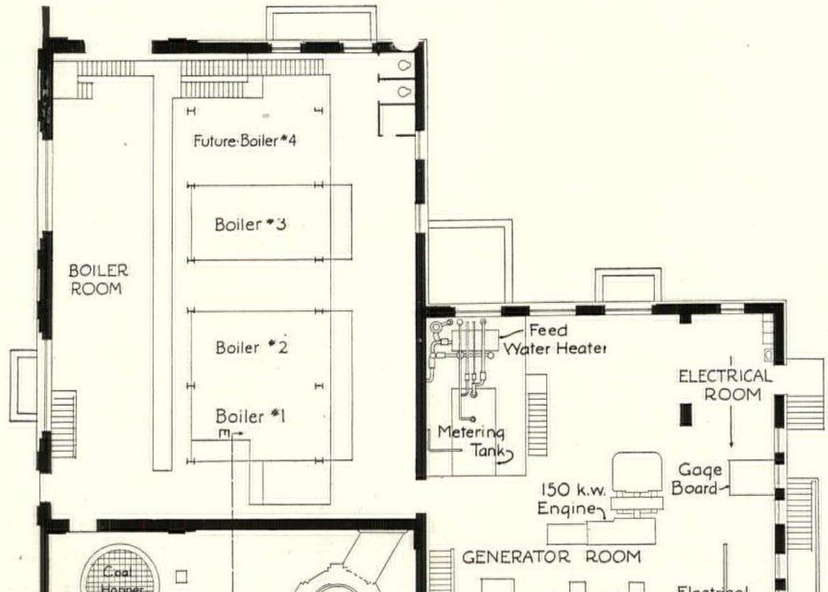
Boilers and Auxiliaries

The boiler equipment is the heart of a power plant, and the selection of the apparatus and its arrangement should be given very careful study. Fuel economy is almost entirely dependent on the success of this part of the design, and it is here that the largest share of the operating expense is involved.

There are so many considerations involved in deciding on the number and type of boilers for a given installation that it is impossible to lay down any rules which would be applicable in all cases. Each installation forms a separate problem. There is an endless variety of boilers and furnaces on the market, but in general they may be classified as being either of the fire-tube or the water-tube type. In the fire-tube type the products of combustion pass through the tubes, the water occupying the spaces around them. In the water-tube type the water passes through the tubes, and the gases surround them. As far as efficiency is concerned, tests have shown the two types to be approximately equal. Fire-tube boilers are built in commercial sizes of from 15- to 200-horse power and for pressures up to 150 pounds. It is not practical, for structural reasons, to exceed these sizes and pressure. The water circulation is not so rapid as in the water-tube type, and consequently boilers of this kind do not adapt themselves so readily to meeting the varying demands of a widely fluctuating load, where rapid forcing may be necessary at times. They do not require as much headroom as water-tube boilers for units of equal capacity, but they take up more floor space. Water-tube boilers can be made of larger sizes than are possible with the fire-tube type. They have greater overload capacity, respond more quickly to sudden demands, and are safer for higher pressures than the other type.



Section through boiler and engine rooms showing coal bunkers and operation of mechanical stokers



First Floor Plan, Power House, Sterling Hall of Medicine, Yale University
Hollis French & Allen Hubbard, Engineers

When deciding upon the type of boiler to use, it is necessary, therefore, to take into account the headroom and floor space available, the nature of the load to be carried, the size of units most desirable, and the pressure at which the plant is to be operated. If either type will meet these conditions equally well, first cost should be considered, and it will usually be decided in favor of the fire-tube boiler.

It is difficult to estimate correctly the load which a plant will have to carry, and allowance should be made for the fact that any calculations based on such an estimate can be only approximate. Provision should be made to handle the maximum estimated load, and there should be in addition sufficient reserve capacity to furnish a spare unit in case of breakdown and to permit of any units being cut out for cleaning or repairs.

The rating at which the boilers can be operated most economically depends primarily on the nature of the load. Loads may be classified into four broad groups, (1) continuous constant load, (2) continuous variable load, (3) 10- or 12-hour constant load, and (4) 10- or 12-hour variable load. The most economical rating at which the boilers will run will vary with these groups. Particular care should be taken to provide sufficient intensity of draft, especially where boilers are to be run above normal rating, so that the amount of friction in uptakes and main flue can be reduced to a minimum.

The setting provided for the boilers is an important part of the equipment. Ample combustion space should be furnished, full consideration being given to the kind of fuel to be used, method of firing, length of travel of flue gases, and ease of cleaning and repairs. The ash pit should be large enough to hold from 14 to 16 hours' accumulation of ashes, so that ash removal will not be necessary during night shifts. As boiler settings are subjected to greatly varying temperatures, the design should be such as to prevent, as far as possible, any strains which will cause cracks and consequent infiltration of air, resulting in seriously impaired efficiency. Prevention of the radiation of heat from boiler settings is well worth the extra expense involved in insulating the walls. When we realize that we have a temperature of between 2500 and 3000° Fahr. in the combustion chamber, it can be easily seen how much loss is possible. The comfort of the operating staff is also increased by insulating the boiler walls, which is especially desirable where the boiler room forms a part of the building which it serves.

Whenever high overloads are to be carried it is generally necessary to install mechanical stokers. These provide a continuous uniform feed to the boilers. They also permit the economical use of cheap fuels, and give practically smokeless combustion when properly installed. They are frequently installed for the latter reasons, regardless of any other considerations. In all types of mechanical stokers the coal is fed to the fire automatically from a hopper which is usually placed in front of the boilers. If the coal is fed automatically to these hoppers from storage overhead and the ashes are automatically removed, there is of course considerable saving in labor. The success of such installations depends on uniformity of feed, proper proportions of air and fuels, and use of self-cleaning grates.

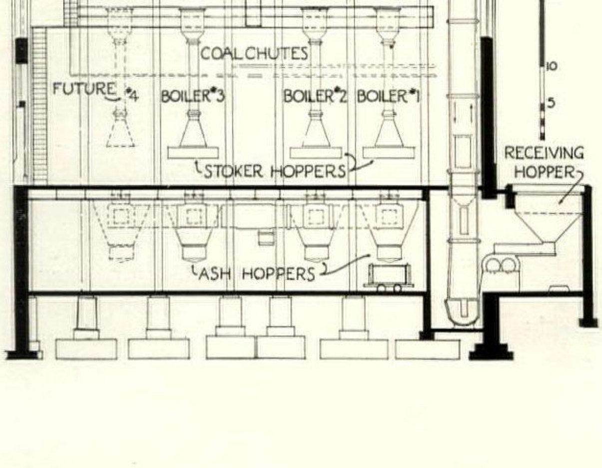
Economizers are often used to reclaim as much as possible of the heat from the flue gases. They usually consist of a series of vertical tubes surrounded by an iron casing. The feed water passes through the tubes, and the waste gases from the boilers pass over them. The resistance to the flow of gas through the economizer is taken care of by means of an induced draft fan. Often the fact that such a fan is installed is used as a reason for decreasing the height of the chimney, but this is not always advisable since the flue gases at times may have to be carried off by gravity, owing to the economizer or fans being out of commission. If the apparatus is installed in duplicate it is a question whether any economy is possible, owing to the cost. In considering the advisability of installing economizers, not only the cost of the apparatus should be taken into account, but also the extra cost of the building, due to the considerable extra space necessary for using this equipment.

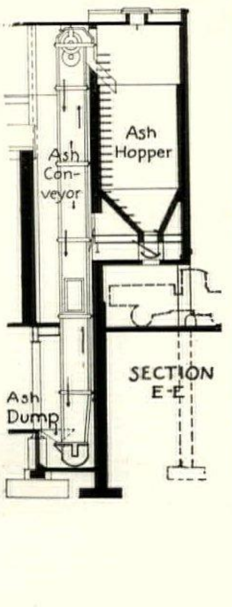
Practically all modern central stations and large isolated power plants are equipped for the use of

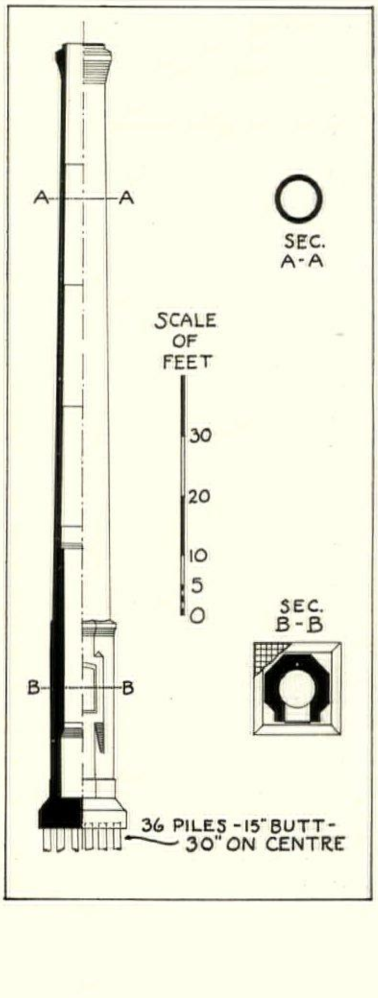
Section through coal bunkers and elevation of boilers (at left)

Section through ash hopper (in center) showing automatic handling of ashes.

Typical stack detail (at right)







superheated steam. In determining whether superheaters should be installed, such items as type and size of prime movers, character of service, first cost, piping, upkeep, etc., should be considered. With a properly designed superheater, integral with the boiler, the overall efficiency is usually somewhat higher than if saturated steam alone were generated. The increased economy of the prime mover may also make possible a reduction in the sizes of boilers, condensers and other auxiliaries.

Boiler feed pumps should be of ample capacity to carry the load at all times, with a spare unit for use in case of breakdown or repairs. Two types are in use,—reciprocating and centrifugal,—the former being the most popular, the latter, however, being gradually used to a greater extent in large plants. It should be remembered that the smaller sizes of centrifugal pumps have a comparatively low efficiency and should be avoided. When centrifugal pumps are used they may be driven by either steam or electricity. The choice will be determined by the conditions in respect to cost of current, etc. at the plant under consideration. In case electric drive is decided upon it would be wise to provide a steam-driven spare unit which could be started when the electric current is cut off for any reason. Reciprocating pumps should be large enough to carry the maximum load when running at a low speed, as this will tend towards prolonging the life of the apparatus and minimizing the cost of repairs.

It is not good practice to feed cold water to the boilers, and a feed water heater is usually provided to preheat the water. As there is generally a certain amount of exhaust steam available, for which there is no other use, considerable economy is realized by the use of this piece of apparatus. Even in those plants where the exhaust steam can be used for heating purposes, it is available for heating feed water during the non-heating season. Two types of heater are in general use,—the open and closed types. In the open type, the exhaust steam comes into contact with the water to be heated. In the closed type the steam and water are kept separate, the heat exchange taking place through the tubes of the heater.

It is important that return tanks for the reception of condensed steam, which is to be returned to the boilers, should be sufficiently large, since otherwise a considerable amount of hot water may run to waste owing to the fact that whenever the plant has been shut down and started up again, the amount of returns is for a time greatly in excess of that during normal operation.

An accurate record of the amount of steam generated should be kept, and for this purpose there are several makes of steam flow meters on the market, any of which are satisfactory. There should be a separate meter on each boiler. This device, together with an automatic coal scale for each boiler, will furnish a record of the overall efficiency of each boiler. In many cases it is good practice also to meter the returns. In plants where part of the steam is used in such a manner that the condensate is wasted, the combination of steam flow and condensate meters is especially valuable.

As all natural waters contain some impurities, it is usually advisable to provide some means of treating the feed water to prevent or reduce the formation of scale. The method to be used depends on the impurities present, and can only be decided after chemical analysis of the water.

Intelligent operation of the boiler plant is necessary to obtain the best results, no matter how well designed and equipped it may be. But however skillful the operating staff, it is at a great disadvantage if means are not provided for indicating just what is happening. Wherever practicable, instruments showing a continuous record should be installed. Among the most important items in this connection are those recording steam pressure, draft, flue gas temperature and composition, weight of coal fed to grates, weight of steam generated, temperature of feed water and temperature of returns. Sometimes an owner may decide to omit such recording devices on account of their cost. This is a mistake, for they well repay the outlay involved. Not only do they furnish him with information by which he can see for himself the manner in which the plant is working, but the psychological effect on the working force is a valuable asset.

Much of the apparatus which was formerly controlled by hand is now controlled automatically. At some point, however, the operator's attention should be focussed, and the extent to which use of automatic control is to be carried should be given very careful consideration in designing the details of the plant.

Piping

The mechanical equipment of the plant having been determined, consideration should be given to the piping system, and this should be done before the final dimensions of the space required for generation of power are fixed. Otherwise conditions may later arise requiring considerable modification of the original arrangement. With the increased cost of construction there is a tendency to eliminate the apparently unnecessary spaces for pipes. No greater mistake can be made than to cramp all sorts of piping into inadequate spaces where they cannot be reached for repairs.

It is, of course, understood that piping is necessary to make connections between the various pieces of plant apparatus and to the heating, domestic and process systems of the buildings served by the plant. These include high and low pressure steam, hot, cold and distilled water, compressed air, vacuum, vacuum cleaner, oil piping, refrigeration lines and possibly others if required for process of manufacture.

This being a condensed description, it is impossible to deal with elaborate specifications of pipe and fittings to be used in the various lines. In most of the lines there are well defined standards for pipe, fittings and valves. Special attention should be given to hot and cold water piping and to piping used for returning condensate to boilers, as the materials used are determined largely by the geographical location of the plant. For instance, water in certain localities requires the use of genuine wrought iron pipe for heating returns, whereas the steel pipe would be most economical. Another important item to be considered in the design of the piping systems is expansion and contraction in long runs. Failure to consider this may result in injury to the plant or continual expense to the owner on account of leaking joints and strained valves which cannot be shut tight. State and municipal boards and fire underwriters have numerous rules regarding oil, air and gas piping, and these should be consulted before installations are made, as they may even require some special construction in the building itself.

Valves and Valve Control

The demand for more elaborate systems of piping, largely for economic reasons, leads up to the question of valves and valve control. The number of valves required for a given system will vary with different designers. In general, valves are installed so as to shut off one piece of apparatus or section of piping so that all other parts of the plant can continue in operation. All branch lines on water, gas and air systems should have valves for the same reason. The desire to eliminate waste and prevent accidents has resulted in the design of many automatic valves, and the tendency to eliminate unnecessary manual labor has resulted in the extensive use of remote controlled motor-operated valves.

Piping System Codes

Marking of piping and valves has been the subject of considerable thought of late years, especially in industrial plants where a variety of lines are installed. Pipe lines are usually identified by giving easily distinguished colors to the different lines and by painting all of each line its given color, or else by painting piping a standard color with a narrow band of the distinctive color at say 5-foot intervals. Another scheme adopted is to have the piping, whether it is covered or not, a standard color, and the fittings and valves painted the key color. Most large industrial plants and power plants have worked out color schemes for their own use. The number of schemes is varied, and for new work can be rearranged to suit the wishes of architects, engineers or owners. This identification scheme has not been used to any great extent in office and public building work, because the number of lines is comparatively small, and they can usually be identified by connections to apparatus or by valve markings, a system which is comparatively simple.

The marking of valves is also an important factor in the completion of a plant. If complete and accurate, markings are a great help to employes; if inadequate, they are apt to cause trouble. The old scheme for marking valves was to attach to the wheel a brass or paper tag stating what piece of equipment or portion of building was controlled. Due to the more complex design of buildings and piping, the scheme of numbering all valves with brass tags and posting a valve diagram in a prominent place is more satisfactory. The diagram shows the location of each numbered valve, and a table with the diagram describes as accurately as possible the function of each valve.

Conduits and Tunnels

Where the power plant is installed as part of the main building, the question of piping connections is a comparatively simple matter. Where the power plant is a separate building, piping connections to the main buildings require careful study. Steam lines in particular cannot be buried in the ground without some sort of protection. This protection may take the form of wood stave covering, terra cotta tile, or concrete walking tunnels. When the last scheme is used, it is customary to install other equipment piping in the same tunnel. The wood conduit has been used extensively in certain localities, but should be considered very carefully where there is a possibility that ground water may be encountered. Terra cotta conduit is proving satisfactory in a great many installations. Care must be taken to provide proper under-drainage, otherwise ground water may work into the conduit and in time ruin the insulation and pipe. Neither conduit will give the protection and chance for inspection and changes that a concrete tunnel provides. To be of use tunnels should be at least 7 feet high inside; for lines on one side only not less than 4 feet wide, and for lines on both sides a tunnel 8 feet wide is none too large. Supports for tunnel and conduit piping, care for expansion and weights of materials are important, especially in long, straight runs.

Covering

It is common practice in most plants to cover all steam and water piping. This covering is primarily to eliminate heat loss (on cold water to prevent sweating) through radiation, although it is now quite common to cover exposed piping in office and public buildings so as to give a more complete control over room temperatures. Carbonate of magnesia and asbestos air cell coverings are most commonly used for steam piping and wool felt for hot and cold water lines. For general use, standard thick covering (7/8 inch thick for small sized pipes to 1 1/4 inches thick for large lines) is satisfactory. On boiler and engine room piping and tunnel piping double covering can be used to advantage in order to keep down the temperature of the surrounding air. At pre-war prices there was considerable saving if air cell covering was used instead of magnesia. At present prices, however, the costs of the two coverings applied are very nearly the same. Large cylindrical or large flat surfaces are usually covered, first with air cell or magnesia blocks wired on, and then with magnesia or asbestos plaster with smooth finish.

Fuels and Fuel Handling

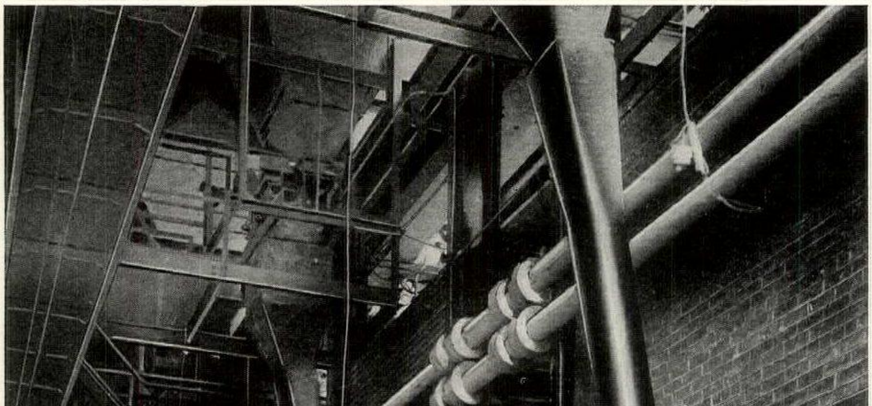
The coal saving made by the use of pipe covering is an important factor in these days of high fuel costs. Take as an example a steam pipe surrounded by 70° air and carrying steam at 5 pounds pressure. If this pipe is not covered there will be radiation loss of about 480 heat units per square foot per hour. If the same pipe is covered with standard thickness magnesia covering, 85 per cent of the heat will be retained in the pipe. By the use of special covering, it is possible to arrange for 90 to 95 per cent of this heat to be retained.

The great majority of steam power plants use either soft coal or oil for fuel. Most of the coal-burning plants receive their coal either directly from cars run to the plant siding or from coal trucks, while the comparatively few plants located on tide-water receive their coal from barges towed alongside.

The coal used is generally that obtained from the nearest reasonably good coal field, and the fuel handling and steam generating apparatus is that arranged to handle and consume most economically that particular grade of fuel. Adequate storage space, either in coal bunkers or in storage yards for the large plants, should be provided, unless a more or less continuous small lot delivery by truck can be depended upon at all times. The method of handling coal in hand-fired plants is so well known that only plants where economic operation demands automatic machinery will be considered here.

Soft coal as received from the mine contains lumps of varying sizes, some of which are too large to be readily handled or economically burned. To obtain the proper sizing of the fuel, all coal, before being placed in the overhead bunkers, is passed from the storage bunker or directly from the car or truck, through a "crusher," a machine consisting of revolving drums with teeth, between which the coal is automatically fed, thus reducing the large lumps to the proper sizes.

The elevating, or elevating and distributing conveyer, consists of an endless chain on which are mounted buckets which are filled as they pass under the chute from the crusher and arranged to elevate and dump automatically the coal on the distributing conveyer or in the overhead bunkers, as the case may be. The distributing conveyer is a similar device of bucket or belt type, except that it is arranged to receive the coal from the elevating conveyer and to carry it to and automatically dump it in the several overhead bunkers. The general arrangement of the plant determines whether or not it is necessary to use a distributing conveyer, and it is usually better to arrange the apparatus so that this device is not required. The overhead bunkers should be



Boiler-Room, Central Power Plant, Yale University, New Haven
Note mechanical stokers fed from coal bunkers above
Hollis French & Allen Hubbard, Engineers

placed high enough so that coal can be fed by gravity through a chute, either directly to the stoker hoppers or through an automatic coal weighing machine and thence to the stoker hoppers. To obtain the highest efficiency, the coal being fed to each boiler should be weighed, and the best of the larger plants are therefore equipped with automatic coal weighers installed for this purpose.

Steam plants located at tidewater or where coal deliveries are irregular should have large storage bunkers or storage yards. Where such storage is required, a traveling crane is often used so that the coal may be piled over a considerable area and still be readily conditioned, weighed and fed to the stokers. When required in the plant, the coal from the storage bunkers or yard is carried by the crane, or trucked, to a hopper which empties into the crusher, and the fuel then passes to the boilers as already outlined.

In order to reduce the fuel cost, many plants are designed to burn a mixture of high grade soft coal and coal of a lower quality, or screenings. Where storage must be provided for plants using mixtures, provision should be made for storing the different quality coals separately. The mixing is then done as the coal is used, and the proportions can be changed to meet variations in the calorific value or burning qualities of the coals.

Pulverized coal is one of the later developments for coal-burning plants, and with this system the coal is ground to a powder, then thoroughly mixed with the proper amount of air furnished by blast fans, and the mixture fed to the boilers in the form of a coal and air blast. The apparatus is designed to obtain as nearly perfect combustion as possible, and produces a very hot fire.

Mechanical stokers automatically dump the ashes either continuously or periodically into the ash pits. The ashes are removed from the ash pit mechanically or by hand. In either case the ash pits are in the form of hoppers with chutes from the bottom. These chutes discharge the ashes to either a car or a conveyer, either of which is arranged to carry the ashes to an elevating conveyer of the bucket type, arranged to automatically dump into an ash storage space. This ash storage is arranged at the proper elevation and position so that the ashes can be drawn therefrom through a chute and dumped into railway cars or trucks.

A properly designed coal-burning plant is very efficient. The coal consumed is controlled automatically to meet the varying load conditions, and fuel is handled with a minimum of labor.

Oil-Burning Plants

Oil-burning plants are of two general types,—steam atomizing and mechanical atomizing,—the difference being in the method of atomizing the oil and the introduction of air for its combustion. The selection of the type depends upon the design of the plant and the character of the load. Both types require oil storage tanks, pumping equipment, oil heaters, oil burners, and regulating devices for controlling the flow of oil and the air admitted for combustion and draft. Both can be used on natural, or induced draft, and the mechanical type can also be equipped with forced drafts.

Oil storage tanks should be of sufficient sizes to insure an adequate supply of oil at the plant, and are preferably located outside the plant and below the ground. In commercial buildings this is often impossible, and in this case the storage tank may be within the building, either below or above the boiler room floor, the former being far preferable.

Fuel oil when cool will not flow readily, and it is therefore necessary to provide steam heaters at the suction to heat the oil to about 90°. The warmed oil is then drawn by pumps from the storage tank and forced through a second heater, which is controlled by a thermostat, and delivered to the burners under comparatively low pressure for the steam atomizing, and under high pressure for the mechanical atomizing type. The atomized oil is forced into the combustion chamber where it mixes with the air, vaporizes, and is consumed. The various devices for burning fuel oil are very complete, can be controlled to maintain a uniform steam pressure under varying loads, and can be made entirely automatic. Oil-burning plants are clean, can be operated with a minimum of labor, and on account of the uniform flow of oil to the burners the air admitted can be regulated very closely, resulting in a high boiler efficiency.

Coal vs. Oil

Coal and oil are now competing fuels, and the question of fuel selection arises for each plant. This question involves two considerations,—first, the economic aspect over a period of years from the point of view of the country at large, and, second, the mechanical efficiency and money saving to the owner in operating costs. Our reliable information indicates that the natural coal resources of this country are, for all practical purposes, unlimited, but that the natural oil resources are very much smaller and that they may be exhausted in a comparatively few years under our present rate of consumption. If this be true, we would then be dependent upon oil shale and upon foreign fields for our oil supply. This situation would be serious and might prove disastrous in the event of this country's being at war. An adequate oil supply is now absolutely necessary to carry any such operation to a successful conclusion, and the amount of oil needed would be enormous. Government regulation of the use of crude oil for fuel in stationary steam plants is the most reasonable way of fairly conserving our natural oil supply, and this possibility is a factor to be considered in the selection of the fuel. The considerations determining fuel selection are cost, including maintenance, continuity of supply, labor and fixed charges.

Artificial Illumination of Industrial Plants

By A. L. POWELL, *Illuminating Engineer*

A COMPREHENSIVE discussion of this subject would require volumes rather than the few pages at our disposal. Years of study have been spent on this question, and much valuable data have appeared in the technical press. In spite of this handicap, it is our aim to outline a few of the fundamental principles which must be followed, and the relation of artificial lighting to overall efficiency.

Since all our industrial activity cannot be confined to daylight hours, it is obvious that some means of providing a substitute for natural light must be considered. All too frequently does a manufacturer provide the minimum amount, thinking of artificial lighting as an unavoidable expense when, as a matter of fact, proper lighting is one of his best aids in efficient plant operation.

A few years ago the practice in lighting a factory was to hang a lamp over each workplace, with possibly a few additional units in clusters for general illumination. This condition was necessary, due to the low efficiency and small sizes of the available light sources. Such a system has many disadvantages. Now, with efficient lamps, available in a wide range of sizes, the practice is to hang lamps well above the work, out of reach and above the ordinary angle of view. In this manner approximately uniform illumination is secured, often much better than the distribution of daylight.

Everyone realizes that a lamp in itself is not a complete or satisfactory lighting unit. It requires something, first, to shield the eye from the bright light source, and second, to direct the light where most needed. To accomplish these results we use suitable reflectors or diffusing devices. There are many excellent types of industrial reflectors on the market, some best suited for one set of conditions, and some for another. Industrial lighting involves the selection of the right kind of reflector and the use of the proper size and type of lamp correctly spaced and hung at such a height as to give the desired distribution of illumination. Obviously, different processes require varied amounts of light, depending on the character of work, finish, color, degree of accuracy necessary, etc. This is specified in foot candles, the unit of intensity.

We may well consider three main sections of the plant, (1) shipping platforms and courts, (2) manufacturing area, and (3) storage spaces, and on this basis analyze the treatment desirable.

On the shipping platform, suitable light will insure greater actual speed of trucking, make markings more easy to read, result in fewer mis-sent shipments, reduce spoilage and theft, and in the case of common carriers, will improve relations with the public. The demands for vision are not exacting, although tags, waybills, markings, etc., must be easily read. The quality of light, as regards diffusion in this part of the plant, is not as important as in the manufacturing areas. A unit giving reasonably good diffusion, emitting its light in an efficient manner, and distributing it over a wide angle, is desirable here. The standard dome reflector (Fig. 1), equipped with a bowl enameled lamp, meets the requirements to a remarkable degree. For a narrow platform, a single row of such units, spaced symmetrically, hung well above the center line of the platform, if not too wide, generally solves the problem. From 3- to 6-foot candles should be effective on the floor. This intensity will result with the type of unit recommended, if approximately ½-watt per square foot of area is

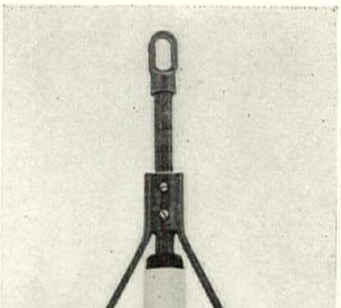


Fig. 2

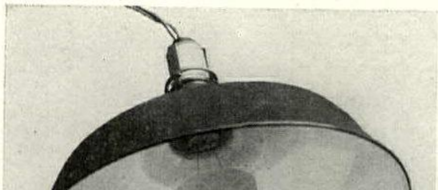


Fig. 1

Fig. 1. RLM standard dome reflector and bowl enameled lamp

Fig. 2. Typical prismatic glass direct lighting reflector of high efficiency

Fig. 3. Large white enameled steel reflector and an auxiliary of opalescent glass to diffuse the light

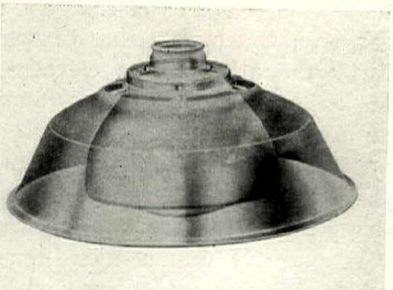


Fig. 3

provided. Knowing the spacing and width of the platform, it is a simple matter to calculate the size of lamp which should be installed. If the platform is unusually wide, two or more rows of units, symmetrically placed, may be necessary in order to secure a uniform distribution of light. If the shipping platform is directly visible from the street and it is desirable to introduce a certain amount of decoration for its advertising value, then diffusing, enclosing units of an ornamental type might well be used. As this equipment is less efficient than the type previously recommended, slightly higher wattage should be installed.

In manufacturing areas, the system known as general lighting is now almost universally employed in the modern plant. An approximately uniform distribution throughout the area is secured, overcoming many of the difficulties encountered with the old-fashioned local lighting, where small lamps are placed close to the working point. This uniform distribution is secured through the choice of the proper reflectors or globes, spacing these according to predetermined values, and hanging them at the correct heights. The size of wattage of lamp used governs the resultant foot candles or intensity of illumination. On a given spacing, larger lamps will produce more foot candles. Local or individual lamps have a certain field in industrial lighting, but this is not by any means as large as the uninformed imagine. There are some classes of work, such as the assembling of watch parts, which require such a high intensity, in order that the minute details be clearly visible, that it would be uneconomical to provide this with the overhead system. Such cases, however, are the exception rather than the rule. Again, where extremely large overhanging parts prevent the penetration of light, small auxiliary units are essential. Finally, certain classes of work in a vertical plane, such as horizontal boring and the moulding of deep forms, frequently require hand or drop lamps. The sum total of all of these instances, however, is remarkably low when we consider the plant as a whole.

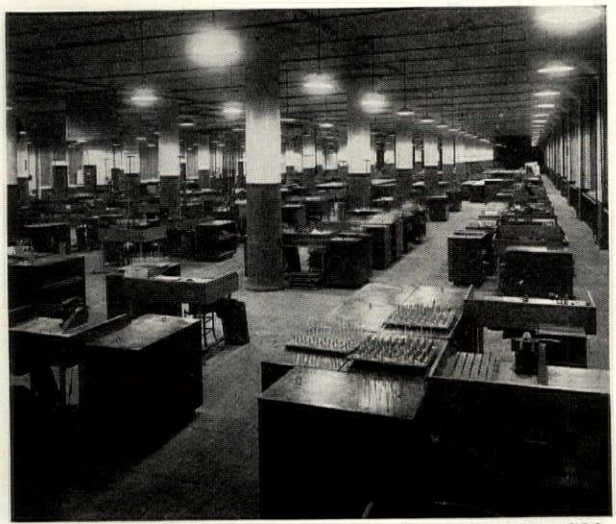


Fig. 4. Night view of general manufacturing area, 200-watt bowl enameled lamps in standard reflectors. Four outlets in 20-foot bay. Intensity of illumination over 12-foot candles

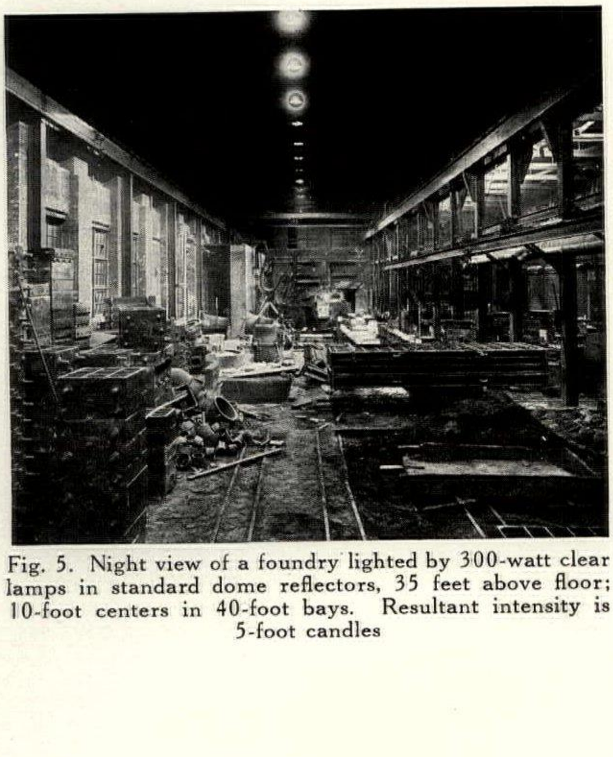


Fig. 5. Night view of a foundry lighted by 300-watt clear lamps in standard dome reflectors, 35 feet above floor; 10-foot centers in 40-foot bays. Resultant intensity is 5-foot candles

It is usually desirable to space outlets for general illumination symmetrically with regard to the bays or columns. As a general rule the maximum spacing should not exceed the ceiling height for work with exacting requirements. Thus, in a room with a 12-foot ceiling, we would have four outlets on 10-foot centers in each 20-foot bay. In a room with a 20-foot ceiling, outlets might be on 20-foot centers. The exact spacing of outlets will be a matter of plain common sense. If it is apparent that certain outlets will be above a piece of equipment which would cast a shadow, then one's judgment indicates they would not be useful there. A symmetrical arrangement may still be followed, for it does not require much ingenuity to shift rows of units a few feet to avoid obstacles and to insure correct direction of light on the work.

Various industries have lighting requirements peculiar to themselves in the manufacturing areas. There are, however, four general grades of work requiring intensities of these orders:

Processes where slight discrimination of detail is essential, such as rough machining, rough assembling, rough bench work, rough forging, grain milling, etc., 2- to 5-foot candles.

Work where discrimination of detail is essential, such as machining, assembly work, fine core making in foundries, cigarette rolling, etc., 4- to 7-foot candles.

Work where close discrimination of detail is essential, such as fine lathe work, pattern and tool making, weaving light colored textiles, etc., 6- to 10-foot candles.

Work where discrimination of minute detail is essential, such as watchmaking, engraving, sewing on dark goods, inspection, etc., 10- to 20-foot candles, and even more.

As already said, many types of equipment are

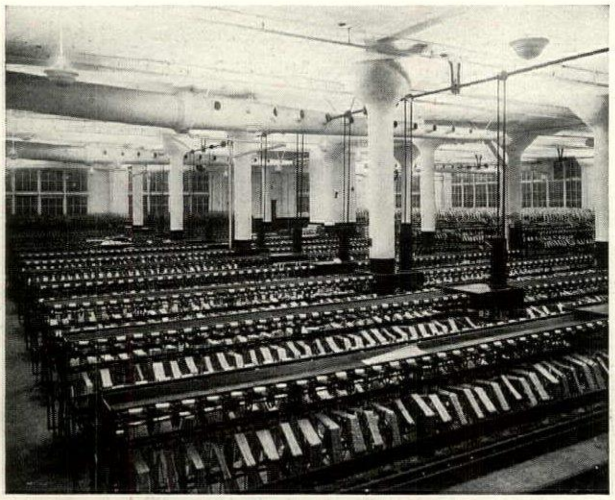


Fig. 6. Night view of winders in a silk mill lighted by 200-watt lamps in mirrored glass indirect fixtures, two in each bay

available for industrial lighting. The standard dome reflector and bowl enameled lamp, shown in Fig. 1, satisfactorily meet the requirements of nearly 80 per cent of the industrial processes. Another very efficient unit is the prismatic glass, deep bowl reflector, shown in Fig. 2. This is usually equipped with a clear lamp, and hence leaves something to be desired regarding diffusion. Where light must be produced from the sides of an area, or where maximum illumination of vertical surfaces is essential, the angle type, porcelain enamel steel reflectors are used.

For high-grade industrial lighting, a new unit, shown in Fig. 3, is appropriate. This consists of a large dome steel reflector and an auxiliary diffusing globe, fitted around the lamp. Small openings in the top of the reflector permit some of the light to go upward, rendering the ceiling luminous, making the room more cheerful and promoting safety while working around shafting and belting. At first thought it might seem that such a unit was not efficient, but tests indicate a high output, accompanied by excellent diffusion, which always results in soft illumination.

Whatever type of lighting unit is installed, the side walls and ceilings in the plant should be painted a light color, preferably white. A darker dado, approximately 4½ feet high, is desirable for a neat appearance. The ceiling and side walls are of considerable importance in reflecting and diffusing the light. The reflected light penetrates beneath overhanging parts, and materially softens or avoids shadows at operating points.

In storage areas, the light should be quite evenly distributed, since labels and markings must often be read, yet the demands in this respect are by no means as exacting as where close visual work must be carried on. The intensity should be highest nearest the doorways and down the main aisles, for here is found the densest traffic. An average intensity of at least 1-foot candle is desirable, this being obtained by using approximately ¼-watt per square foot of floor area where modern efficient lamps and standard dome reflectors are in service. These rules on maximum desirable spacing apply:

Ceiling 10 feet or less	16 feet
Ceiling 10 to 15 feet	20 feet
Ceiling above 15 feet	30 feet

With ceilings averaging 15 feet, one outlet in the center of each 20-foot standard bay is good practice.

Regardless of the type of lighting installed, if it is to remain satisfactory and adequate, a regular system of maintenance must be in force. A slight layer of dust on lamps and reflecting surfaces materially reduces the light output. Lamps which have become blackened in service should be replaced. The voltage of the lamps should correspond with that in the socket if satisfactory output and performance are desired. Too much stress cannot be laid on these factors.

Numerous tests have shown that a high proportion of the total light generated throughout the country is being wasted through lack of systematic maintenance. A typical case on record might be of interest. In this particular installation, the intensity as found was slightly over 2½-foot candles. Lamps and reflectors were washed, new lamps of the proper voltage were installed, and finally the walls and ceilings were refinished with paint of reflecting power. With no increase in wattage or power consumed, the resultant illumination was over 7-foot candles. It is apparent that this is a matter deserving serious consideration in caring for equipment.

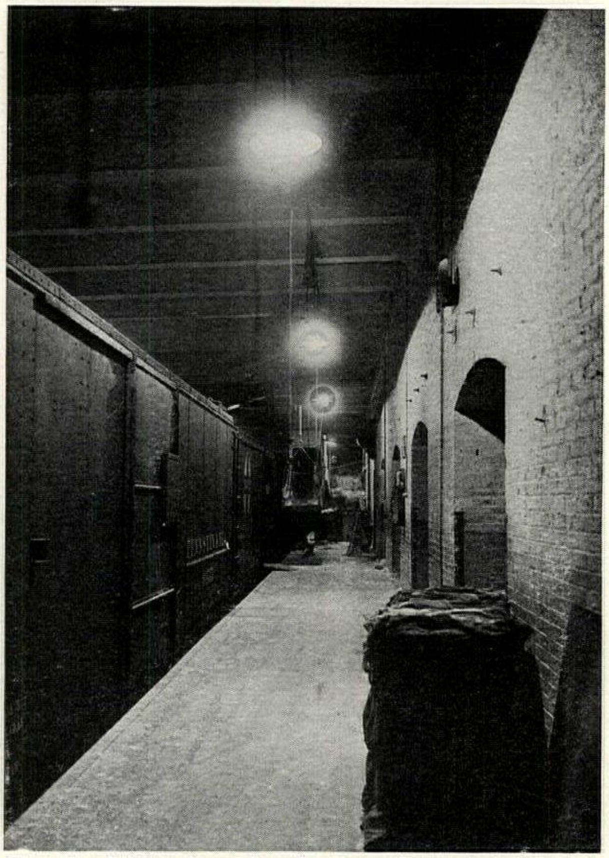
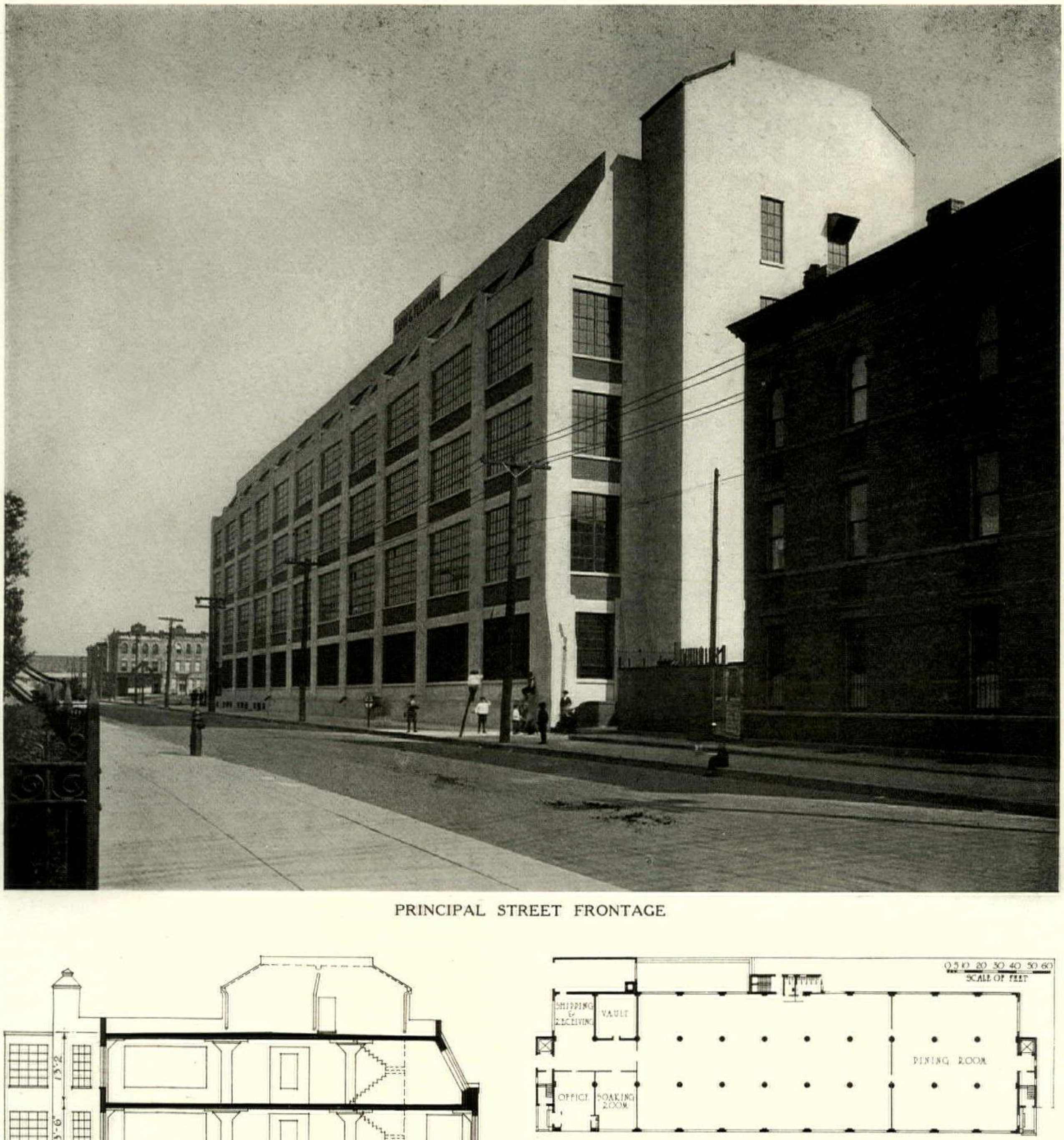
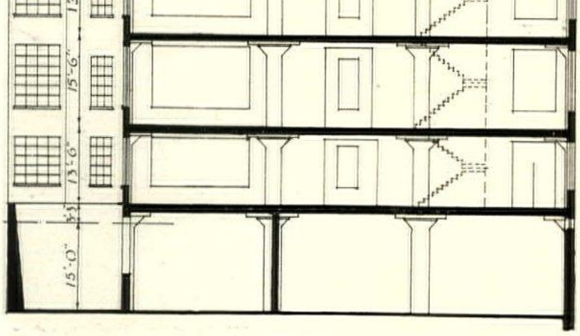


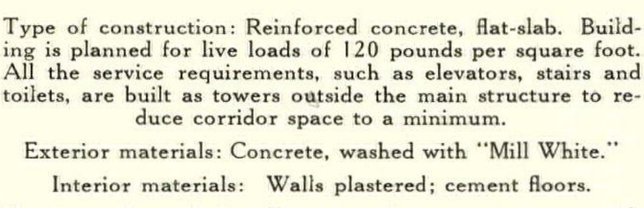
Fig. 7. Night view of a loading platform lighted by 100-watt enameled lamps in standard dome reflectors, 20 feet above floor



PRINCIPAL STREET FRONTAGE



CROSS SECTION



FIRST FLOOR PLAN

Type of construction: Reinforced concrete, flat-slab. Building is planned for live loads of 120 pounds per square foot. All the service requirements, such as elevators, stairs and toilets, are built as towers outside the main structure to reduce corridor space to a minimum.

Exterior materials: Concrete, washed with "Mill White."

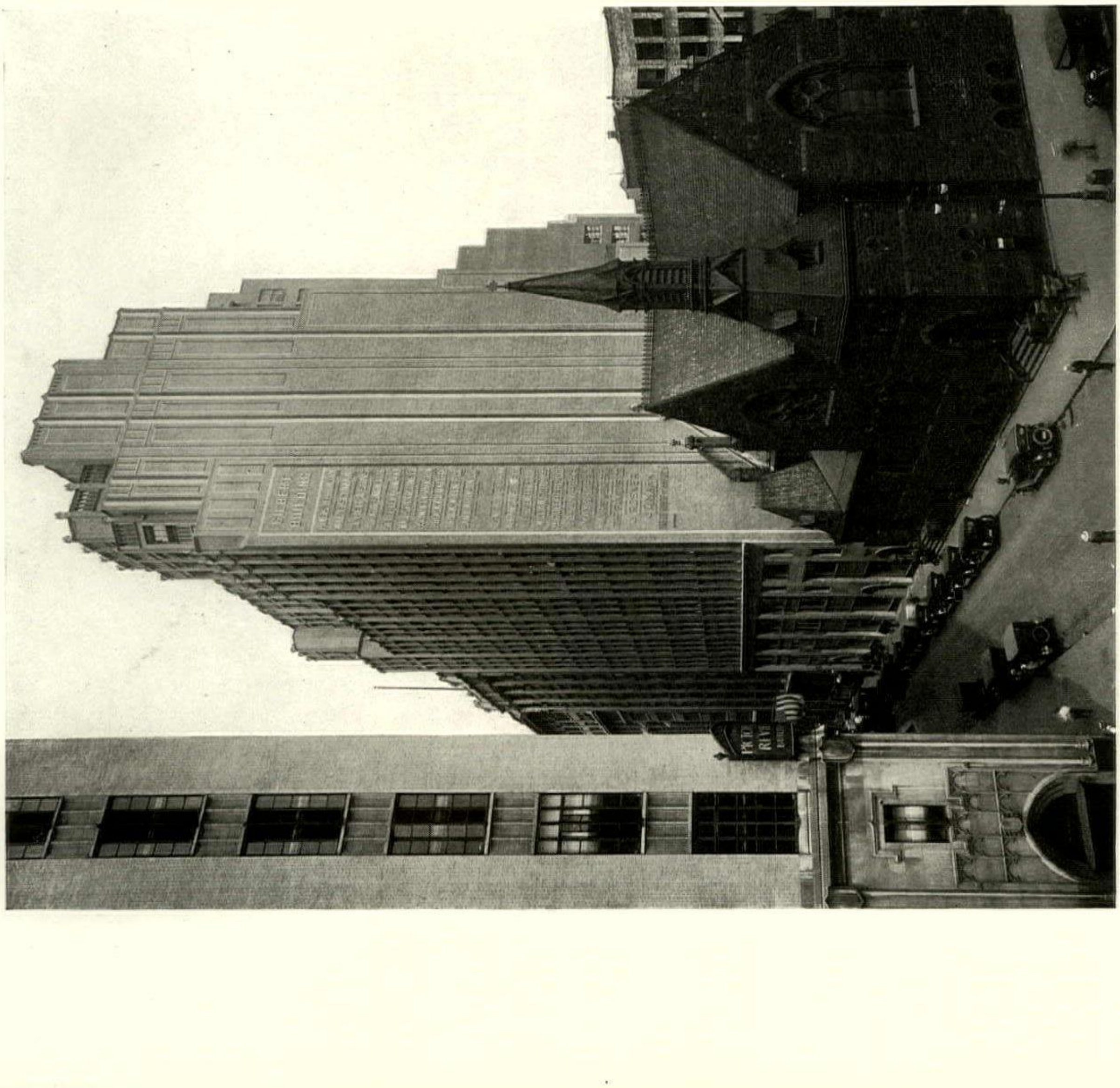
Interior materials: Walls plastered; cement floors.

Heating and ventilating: Two-pipe direct gravity steam with pump and receiver. Carrier air conditioning system to provide constant temperature and necessary humidity for a silk-throwing mill.

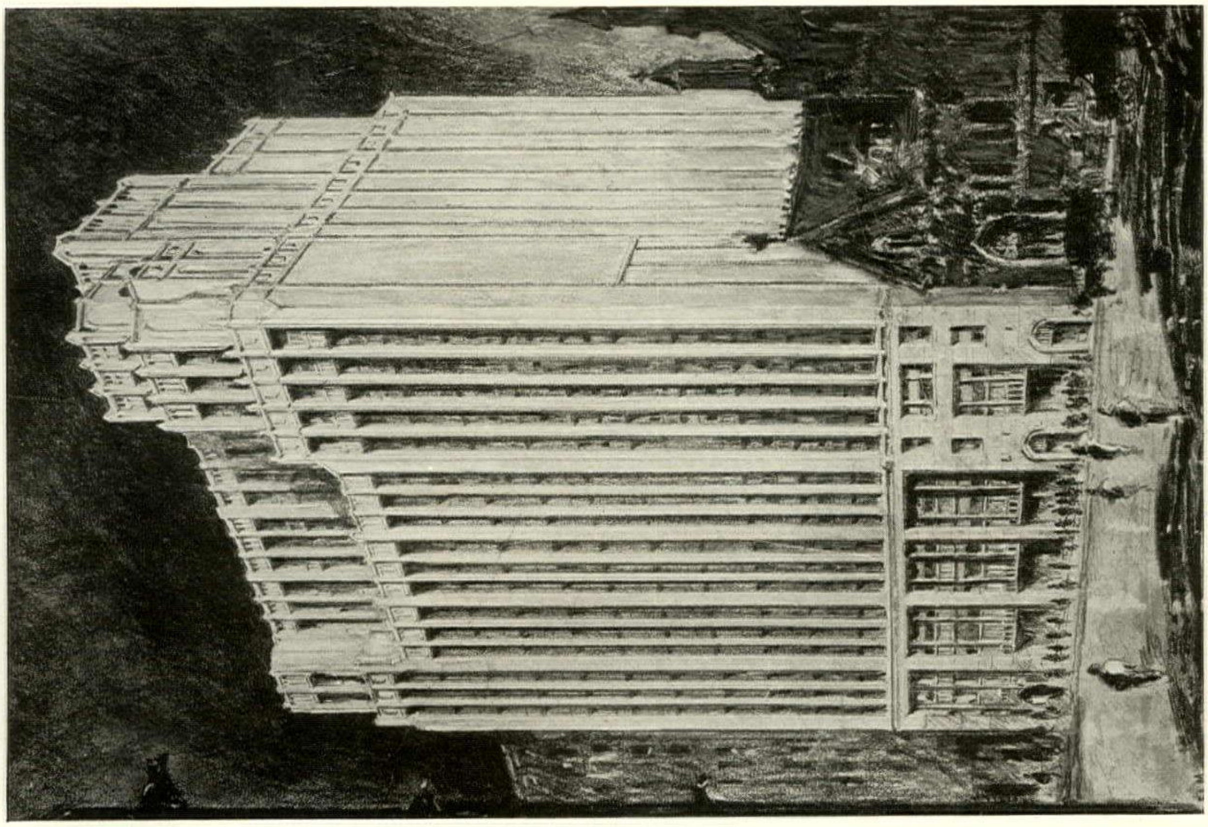
Windows: Steel sash, pivoted.

MILL BUILDING OF KAHN & FELDMAN, BROOKLYN

BUCHMAN & KAHN, ARCHITECTS



GENERAL EXTERIOR VIEW



PERSPECTIVE OF PRINCIPAL FACADE

GILBERT BUILDING, 205 WEST 39th STREET, NEW YORK

GEO. & EDW. BLUM, ARCHITECTS

GILBERT BUILDING, 205 WEST 39TH STREET, NEW YORK

Illustrations on Plate 53

Type of construction: Skeleton steel frame; curtain walls of brick lined with terra cotta blocks; reinforced concrete floor arches. Floor loads designed for 120 pounds per square foot.

Exterior materials: Lower stories of artificial stone; upper stories of face brick and terra cotta; side walls paneled with face brick in colors.

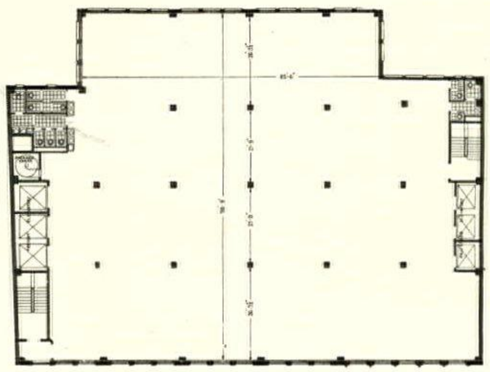
Interior materials: Cement floors; metal partitions in toilets; metal covered doors in steel frames.

Windows: Solid metal sash with wire glass.

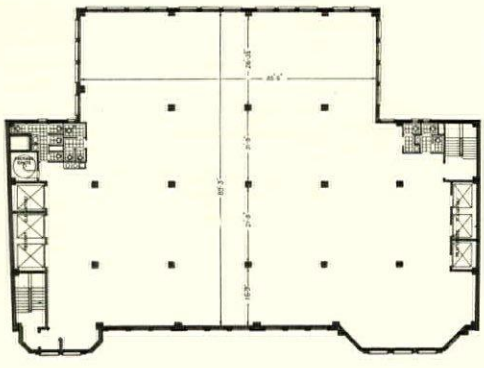
Heating: Steam vacuum system.

Cubic foot cost: 42 cents. Building completed, 1923.

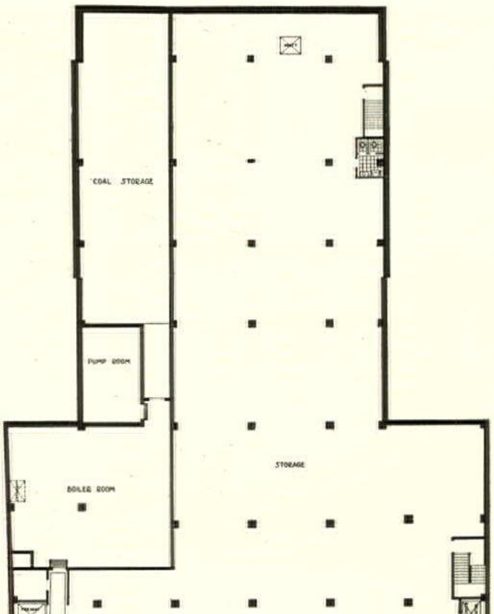
Use of building: Light manufacturing and loft purposes.



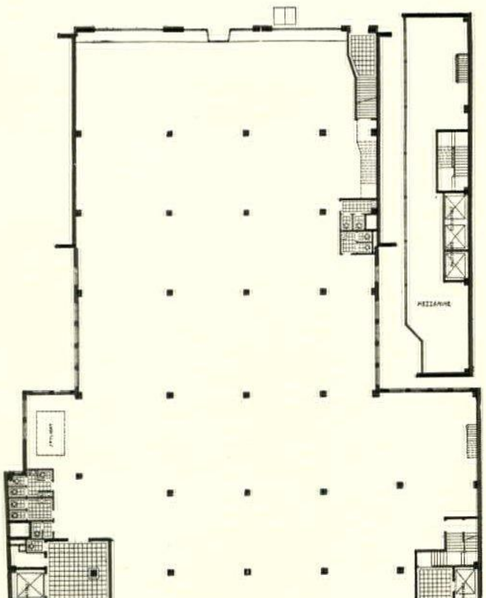
TENTH FLOOR PLAN



FOURTEENTH FLOOR PLAN



BASEMENT FLOOR PLAN



FIRST FLOOR PLAN

DETAIL OF ENTRANCE

GENERAL VIEW OF EXTERIOR

FLETCHER BUILDING, VARICK STREET, NEW YORK

HELMLE & CORBETT, ARCHITECTS

FLETCHER BUILDING, VARICK STREET, NEW YORK

Illustrations on Plate 54

Type of construction: Reinforced concrete; floor loads of 300 pounds per square foot.

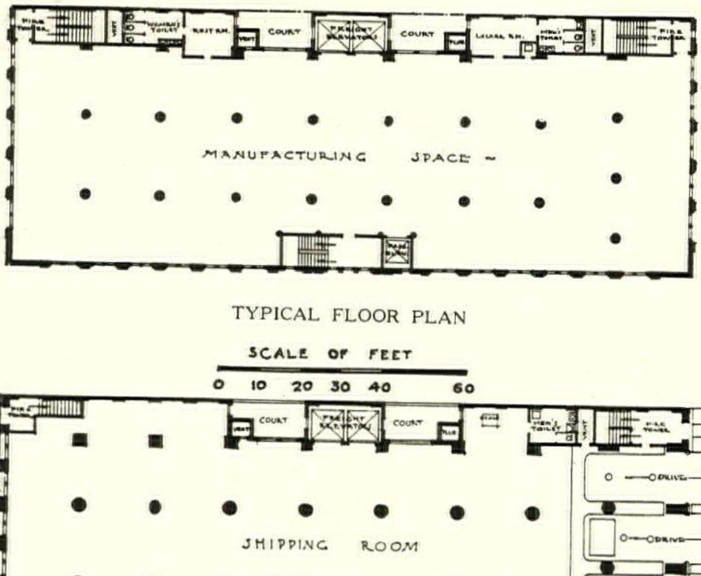
Exterior materials: Concrete, with trimmings also of concrete, cast in place.

Floors: Concrete.

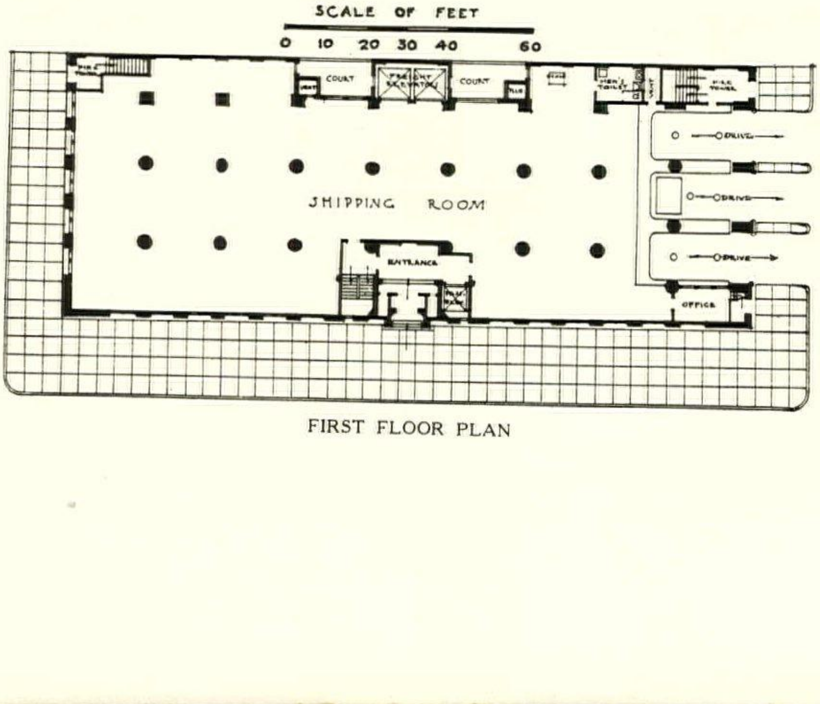
Windows: Hollow metal frames and sash.

Lighting: Semi-indirect.

Use of building: Warehouse and manufacturing.



TYPICAL FLOOR PLAN



FIRST FLOOR PLAN

Type of Construction: Reinforced concrete, flat-slab. Floor loads from 125 to 1,000 pounds per square foot. Building includes warehouse, factory, garage and offices.

Exterior materials: Veneer of brick and stone.

Interior materials: Unfinished except office portion. Cement floors, with marble or tile in corridors and toilets.

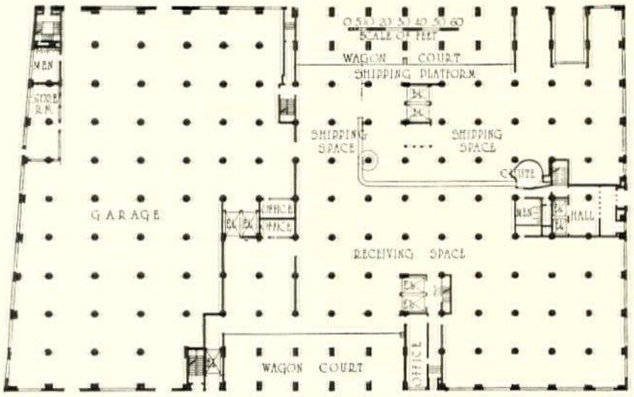
Windows: Steel, factory type sash; double hung sash for office portion.

Heating: Vacuum system.

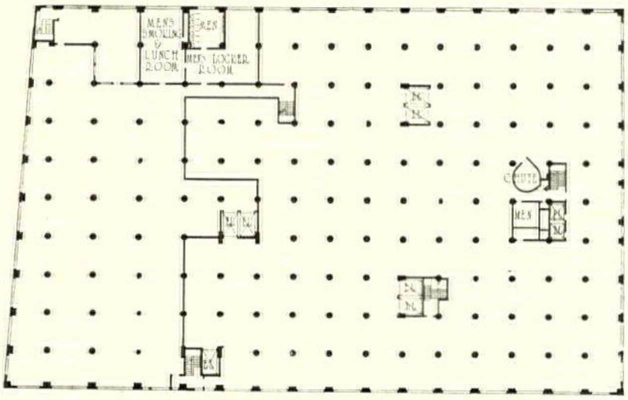
Date of general contract: May, 1920.

Cubic foot cost: 44 cents.

Use of Building: Warehouse and assembling purposes.



FIRST FLOOR PLAN

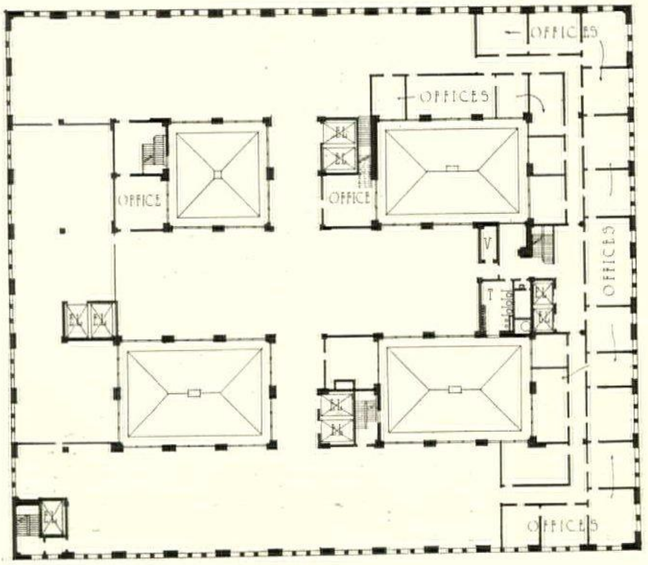


SECOND FLOOR PLAN

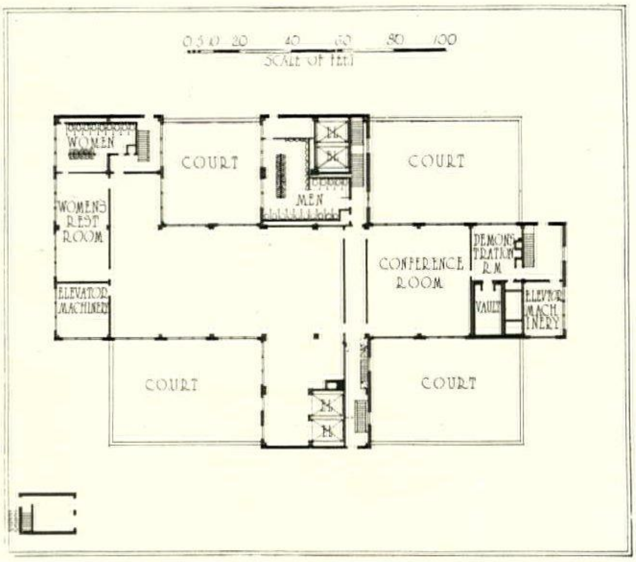
WAREHOUSE, WESTERN ELECTRIC CO., 395 HUDSON STREET, NEW YORK

McKENZIE, VOORHEES & GMELIN, ARCHITECTS

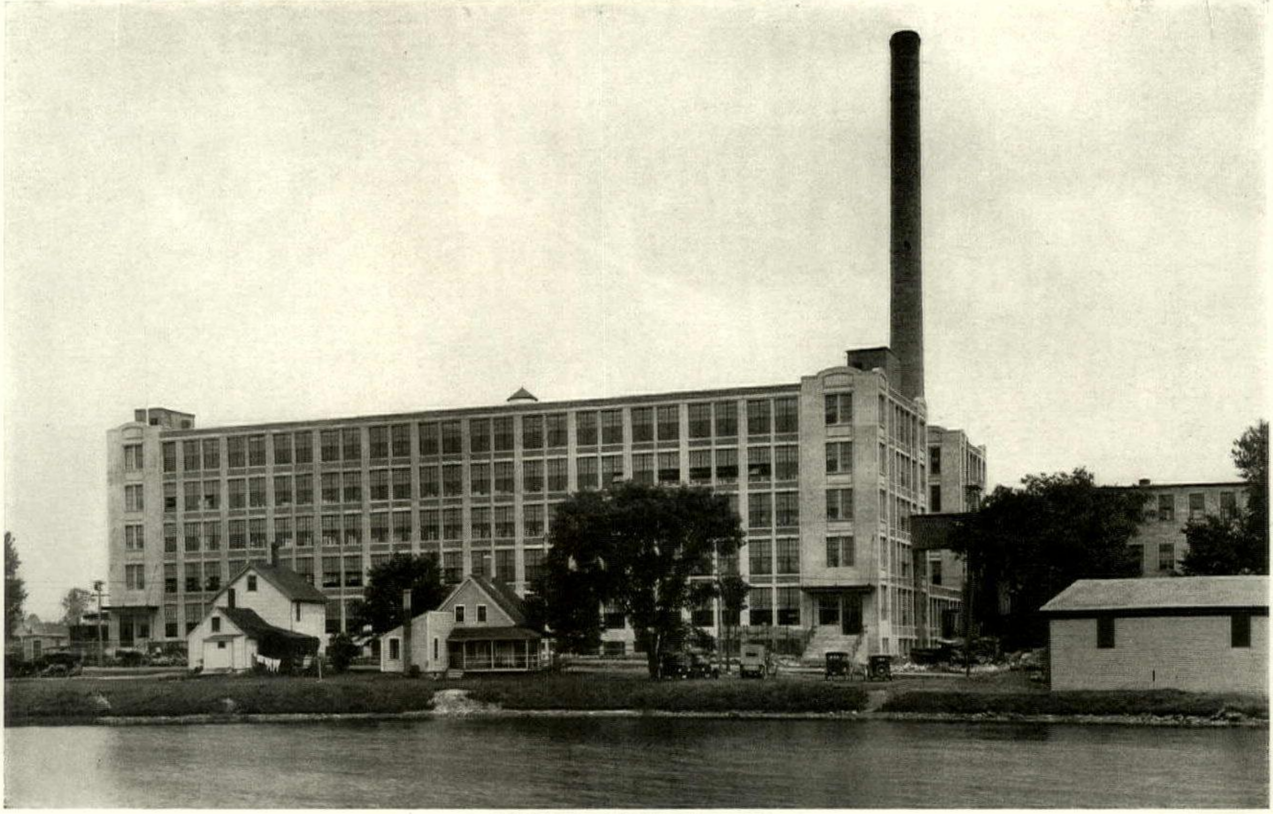
WAREHOUSE, WESTERN ELECTRIC CO.,
395 HUDSON STREET, NEW YORK
Illustrations on Plate 55



NINTH FLOOR PLAN



TENTH FLOOR AND ROOF PLANS



GENERAL EXTERIOR VIEW

DETAIL OF ENDS AT RAILROAD SIDING

Type of construction: Structural steel and concrete; metal sash; 1¼-inch laminated maple floors; partitions: brick or plaster and metal lath; roof: 3-inch plank covered with tar and gravel. Floor loads 125 pounds

Heating: Low pressure steam, with coils and radiators. Ventilating equipment used only over sorting benches. Use: Combined sorting, storage, combing and spinning mill for wool

SPINNING MILL, GOODALL WORSTED COMPANY, SANFORD, MAINE

LOCKWOOD, GREENE & CO., ENGINEERS

Electrical Power in Industrial Buildings

By JAMES A. McHOLLAN

Vice-president, The R. P. Bolton Company, Engineers

THE use of electricity for industrial power purposes is now so general that it is difficult to list the numerous services in which it is successfully used. Practically the only services in the modern building or factory for which electricity is not found to be economical are the heating of buildings, drying of materials and warming of water in large quantities. For all other services, such as the operation of elevators, pumps, compressors, shafting and factory machines of all kinds, electricity is the most economical power to use. It is a serious mistake to use steam engines to operate such machinery, and the use of steam power for such purposes always results in waste of fuel, requires more labor in maintenance, and is less cleanly, convenient and dependable in operation.

In selecting electric machinery it is customary to decide on a voltage and current suitable for operation on the system of the local electric company. This is advisable even if a private plant be installed, as the growth of electrical distribution from central stations is extending so rapidly that it is only a matter of a few years before not only will the private plants in this country be abandoned, but also many of our central stations, except those of the largest size and those in the most suitable locations, will be shut down and their function of power production concentrated in a lesser number of still larger stations, and finally these in turn will become the huge superpower stations which will, in the not distant future, serve the entire country with cheap electric power.

In view of such developments, the engineer who advises his client to engage in the production of electric power should be certain that when a private plant is installed the savings over the cost of purchased power should pay for the cost of the plant in a very few years, and before such a decision is finally reached the whole question should be threshed out between the property owner, his engineer and the local public utility's representative. In former years it was a waste of time to discuss such questions with representatives from the utilities, as it was a common practice for them to submit unreliable statements and estimates of costs which were prepared with the sole purpose of securing contracts for the sale of electricity. It is a pleasure, however, to record the fact that a much broader type of public utility executive is now to be dealt with. The aim is now to present facts and figures in an honest, impartial way, to foster good will and gain the confidence of the public rather than to mislead prospective customers with low estimates of power usage. In past years, the small private plant has served a useful purpose by forcing down the selling price charged by central stations for electric power, and this fact, plus an awakened conscience on the part of the electric companies in dealings with factory owners, makes it generally desirable to consider central station service in preference to a private plant.

These summarized notes of a general nature may be of aid to architects or engineers in selecting electric-driven machinery.

For all electric elevators of up to 400 feet per minute the single-wrap or V-groove drive is the most efficient. Such machines are now manufactured by leading elevator companies. This form of drive requires only one turn of the cables in grooves over the top of the hoisting sheaves. Wear and tear on the cables are reduced, less power is used, and more positive operation and control are secured.

Higher speeds of travel than necessary are often specified for elevator equipment. Where cars stop at every floor or at alternate floors, a speed of more than 250 feet per minute is of doubtful value, as the benefits of full speed of the elevator cannot be obtained in the short distance between stopping and starting points. Higher speeds require larger motors. To keep the speed of the elevator within reasonable limits means lower first cost and greater operating efficiency. Even for passenger elevators, it is a mistake to select cars of over 350 feet per minute unless express service is desired over at least half the traveling distance.

Electric power used by modern electric elevators is not large in terms of kilowatt hours per car mile, as may be seen from the test figures of elevators in a large New York building which are given below.

Where alternating current is used to operate motors of elevators traveling at high speed, that is,

Kilowatt Hours per Car Mile as Determined by Tests of Four Gearless Traction Elevators

	Elevator No. 1			Elevator No. 2			Elevator No. 3			Elevator No. 4		
Week	Car miles	Kw. hrs.	Kw. hrs. per car mile	Car miles	Kw. hrs.	Kw. hrs. per car mile	Car miles	Kw. hrs.	Kw. hrs. per car mile	Car miles	Kw. hrs.	Kw. hrs. per car mile
First	101.0	450	4.46	117.9	390	3.31	132.8	530	3.99	153.8	488	3.17
Second ...	85.4	370	4.33	86.7	300	3.46	110.5	448	4.06	135.0	445	3.29
Third	82.7	360	4.35	114.0	370	3.24	128.0	542	4.24	153.0	484	3.17
Fourth ..	93.5	410	4.39	97.0	400	4.12	128.1	519	4.05	158.4	502	3.17
Fifth	95.3	420	4.39	67.9	400	5.89	127.5	539	4.23	161.6	507	3.14
Sixth	90.0	410	4.55	81.2	390	4.80	131.7	522	3.96	158.7	494	3.11
Total	547.9	2420		564.7	2250		758.6	3100		920.5	2920	
Average			4.42			3.98			4.09			3.17

400 feet per minute and upwards, objection has frequently been raised to noises from vibration, hum and operation of magnets. This has retarded the use of a.c. motors for high-speed elevators, but recently several elevator companies have made improvements in this direction which permit the use of high-speed cars on a.c. systems without undue noise or other objectionable features.

The trend today in electrical systems is definitely toward alternating current. Therefore, select alternating current machinery for all new properties, unless these are to be located in large cities where direct current is in general use. The general advantages of alternating current systems are:

A.c. motors are cheaper than direct-current motors per horsepower.

Commutator troubles, which exist with direct-current motors, are eliminated with a.c. units.

Higher voltages may be used with a.c. system. 440 volts is becoming standard in the larger industrial plants, whereas with direct current 220 volts is the usual limit.

Less copper is used in a.c. feeders with the higher voltage. The cost of copper is therefore less; it also requires less labor for installation.

The chief disadvantage of a.c. systems is loss of power, due to low power factor. There is, however, equipment in the market which can be used to correct this condition.

With a.c. motors the flexibility of speed control is not so great as with direct-current motors. This need only be considered in a few special industrial processes, such as color printing, etc., where the speed control is required to be very delicate.

Centrifugal pumps are to be preferred to plunger pumps. Specify casings of centrifugal pumps to be horizontally split, as this type of casing enables the opening up for inspection and repair of the pump without disturbing the piping connections. Except for pumps which are in continuous service, the use of automatic controls for stopping and starting motors is always advisable. Where two or more pumps operate at one time, the automatic control board should be equipped with a transfer switch so that any one of the pumps can become the leading unit, and thus evenly distribute the wear and tear over all the units in service. Use noiseless check valves on all centrifugal pumps. Several satisfactory types are now on the market.

In operating factory machinery, the individual motor at each machine is to be preferred, although the cost to install is higher than with the group-drive system, which involves fewer motors of a larger size, less wiring and fewer switches. With the individual drive, however, the shut down of one motor means the shut down only of the machine it drives. A failure of a motor on group drive may shut down a number of machines or even an entire department. In overtime work, in many instances, the individual motor is the more efficient.

One disadvantage of the individual motor drive in a.c. systems is a low power factor, but this can be corrected by care in selecting the motors so that they operate at rated load or as near that point as practical. The elimination of overhead shafting, pulleys, belts, bearings, etc., which is effected with the individual drive system, greatly improves the working conditions in factories.

The enclosed type electric-driven compression machine is preferable to the absorption type of ice machine which is often used where a cheap and abundant supply of water is available. The compression plants, however, are more simple in operation, have fewer parts, take up less space, and are more generally used. The use of cooling towers, by means of which the condenser water can be cooled by contact with the air and re-used, reduces the cost of water, and wherever water has to be purchased the investment is always justifiable.

Compressors driven by electric motors by means of belt or chain drive are in general use. With small compressor units a gear drive is satisfactory. Automatic controls to stop and start the motors to maintain the desired air pressure should always be used. Where several units operate together to supply one service, a transfer switch on the controls should be provided.

Whether electricity is purchased or produced, the importance of measuring the electricity used by departments, groups of machines, or individual machines cannot be overestimated. Electric meters check accurately the amount of electric power used and its distribution throughout a plant. It is an aid to intelligent costkeeping and important, therefore, in every installation. The upkeep and maintenance of the meters are low; testing and calibrating are required about once per year.

When private power plants are installed to produce electric power, condensing turbines are the most efficient units to use. If any of the exhaust steam is to be used, the conditions as to back pressure, amount to be used, etc., should be carefully explained to the turbine manufacturers before machinery is selected and ordered.

In reciprocating engines there are types now manufactured which show a remarkably low steam consumption per horsepower. These engines also show a high efficiency under light or variable loads, a condition quite common in power-plant operation.

All auxiliary machinery in and around the engine room and boiler room of the power plant should be electrically operated. Reciprocating steam pumps or small steam turbine pumps, in the writer's opinion, should not be considered in a modern installation. The only exception should be a power plant where operation is intermittent.

The manufacture of electric machinery is becoming highly specialized, and manufacturers are concentrating more and more on producing fewer lines of equipment, and in gathering and distributing the most detailed information regarding their products.

Data on Fire and Accident Prevention Requirements

By C. STANLEY TAYLOR

THE purpose of this article is to provide complete reference data covering all important sources of dependable information regarding safeguarding against fire through the proper construction and equipment of industrial buildings, and those phases of accident prevention which should be had in mind in preparing the plans for such buildings. There will be found here a brief description of each source of such information, together with a reference to publications and data available. There is also presented a list of reference books which completely cover this subject.

When plans and specifications for an industrial building are being developed it is quite important that full information be obtained as to standards and requirements of insurance companies. If plans are developed in accordance with these requirements the result will mean not only a low rating and its accompanying low insurance costs, but will also introduce a high degree of safety, which protects the owner against the great indirect loss which he must suffer if an industrial building is burned and production crippled or stopped entirely.

Through the efforts of the fire insurance fraternity, a number of advisory organizations have been developed, each of which is briefly described in these paragraphs.

National Board of Fire Underwriters. This is an organization maintained by about 140 of the leading fire insurance companies for the purpose of research as to the causes of fire and for provision of standards and advisory service to aid in reducing fire losses by encouraging proper construction and equipment of buildings of every type. The headquarters of this association is 76 William street, New York, and architects may obtain any type of information on the subject of insurance engineering through this source. In co-operation with the National Fire Protection Association, the National Board of Fire Underwriters has developed in printed form a large number of standards and reference data covering practically all phases of fire prevention and protection. A number of these will be found listed under publications available through the National Fire Protection Association.

National Fire Protection Association. An organization maintained by a large number of insurance companies, by national institutes, societies and associations interested in the protection of life and property against loss by fire, and by individuals and corporations similarly interested. The purpose of the association is twofold: First, to formulate standards under which fire waste may be checked; the other, to educate the public in observing these standards and to point out the economic losses due to fire waste. This is a valuable source of information for the architect, and here will be found a partial list of reference publications which are available through this organization.

"Recommended Building Code" (National Board of Fire Underwriters).
This extensive publication presents practical requirements covering mill construction and other types of industrial buildings.

"Blower Systems."
For heating and ventilating, stock and refuse conveying.

"Dip Tanks."
Hardening and tempering tanks, flow coat work, spray booths, japanning and enameling, including ovens, foam extinguisher systems.

"Electric Wiring and Apparatus" (National Electrical Code).

"Electrical Fittings."
List of approved.

"Fire Pumps."
Steam.

"Fire Pumps."
Rotary and centrifugal, and electrical and gasolene engine driving of fire pumps.

"Oil-Burning Equipment."

"Hose Houses."
For mill yards, construction and equipment.

"Lightning."
Suggestions for protection against lightning.

"Protection of Openings."
In walls and partitions.

"Roof Openings."
Cornices and gutters.

"Sprinkler Equipment."
Automatic and open systems.

"Steam Pump Governors and Auxiliary Pumps."

"Tanks."
Gravity and pressure, concrete reservoirs and valve pits.

"Vaults."

"Standpipe and Hose Systems."

"Mill."
Slow-burning building construction, including scuppers.

"Valves."
Controlling water supplies for fire protection.

"First Aid Fire Appliances."
Installation, maintenance and use of.

Other publications issued by this organization and of interest in connection with the planning of factory buildings include:

"Field Practice—An Inspection Manual."
A practical handbook, representing the latest thought of the leading American fire prevention engineers.

"Safeguarding Factory Workers from Fire."
Rules for measuring exit capacities and determining permissible numbers of occupants.

"Fire Exits, Outside Stairs for."
Recommendations for their construction and installation.

"Exit Drills for Factories, Schools, Department Stores and Theaters."
Suggestions for their organization and execution.

"Roof Coverings and Their Fire-Resisting Properties."
"Water Distribution Systems and Protection."
By George W. Booth.
"Flow Capacity of Water Pipes."
By C. F. Wagner.
"Fire Pumps."
Notes and suggestions. Associated Factory Mutual Fire Insurance Companies. Booklet, 53 pages.
"Elevated Tanks."
By W. O. Teague. 23 pages.
Their improved design and construction.
"Factories and Their Fire Protection."
By Franklin H. Wentworth.
"Mill Construction Buildings."
By C. E. Paul
"Color, Paint and Varnish Factories."
By F. E. Roberts. 31 pages.
Processes and hazards.
"Shoe Factories."
Suggestions for their improvement as fire risks. Committee report.
"Cold Storage Warehouses."
Suggestions for their improvement as fire risks. Committee report.
"Refrigerating Machinery Explosions and Fires."

In addition to the publications indicated, a large volume of information has been developed by the association and is recorded in its *Proceedings.* Architects interested in any phase of fire prevention or protection are advised to write the National Fire Protection Association to obtain all available information on the particular subjects of interest.

Underwriters' Laboratories. An experimental station supported primarily by the National Board of Fire Underwriters for the purpose of reporting on the fire retardant and fire resistive qualities of all types of building materials, and the merits of appliances, devices and machines bearing on fire and accident dangers. A system of labeling has been developed by this organization by which materials and equipment which have been inspected by the underwriters may be immediately recognized and classified. Through this organization architects may obtain lists of inspected materials and devices which meet with the approval of insurance companies in accordance with the recommendations of the Underwriters' Laboratories. The purpose and accomplishments of this organization have been admirably set forth in a recent book entitled "A Symbol of Safety," by Harry Chase Brearley. This volume contains not only a complete description of the work of the laboratories but also some very valuable information on increasing the factor of safety in building construction.

Associated Factory Mutual Fire Insurance Companies. A large proportion of industrial fire insurance is covered directly through the Mutual Fire Insurance Company, which, through an extended study of the fire hazard in industrial buildings, has been able to reduce greatly the fire losses in this type of construction. An organization known as the Associated Factory Mutual Fire Insurance Companies is located in Boston, where an extensive laboratory has been maintained for a number of years for the purpose of studying fire protection devices and fire insurance engineering. A number of charts and publications have been issued by this organization, and the architect will find these of particular value in the designing of factory buildings. He will find here also a source of information covering any individual problem which may develop in his plans.

Another source of information of similar character is the Factory Insurance Association of Hartford, engineering service by insurance brokers. It is important for the architect to know that a number of the larger insurance brokers and companies maintain special engineering departments which have had particular experience in the checking of plans and recommended equipping of buildings to develop a high degree of safety against fire, and a resultant low insurance rate. This service is available to building owners usually without charge, provided the insurance policy is handled through the company or organization which provides this service. An architect may arrange with his client to submit plans to such an organization, and this advisory co-operation will be found invaluable before and after construction and in the process of establishing insurance rates. It will also be found that similar co-operation can be obtained through local insurance inspection bureaus and local agents of large fire insurance companies.

Important Reference Books

"Handbook of Fire Protection" (Crosby-Fiske-Forster).
This is a complete handbook of valuable reference data covering every phase of fire protection engineering, and providing all necessary technical information which the architect may need for incorporation in his plans.
"Fire Prevention and Fire Protection (Joseph Kendall Freitag).
A most complete handbook of theory and practice on fire prevention and protection as applied to building construction of every type. The handbook contains over 1,000 pages, and covers in detail all elements of insurance engineering, including planning, equipment and maintenance of buildings from the viewpoint of fire prevention.
"Automatic Sprinkler Protection" (Gorham Dana).
A complete treatise on the subject of automatic sprinkler equipment, giving full details as to all types of equipment together with proper methods of installation and maintenance. It is interesting to note in this connection that any information required in regard to the use of automatic sprinklers may be obtained through the service of the National Automatic Sprinkler Association, 80 Maiden lane, New York.

In another article in this issue of THE FORUM the importance of careful consideration by the architect of this question of fire prevention and protection is presented in greater detail, and through the sources outlined in preceding paragraphs the architect is offered full co-operation and provision of complete information on any phase of this subject.

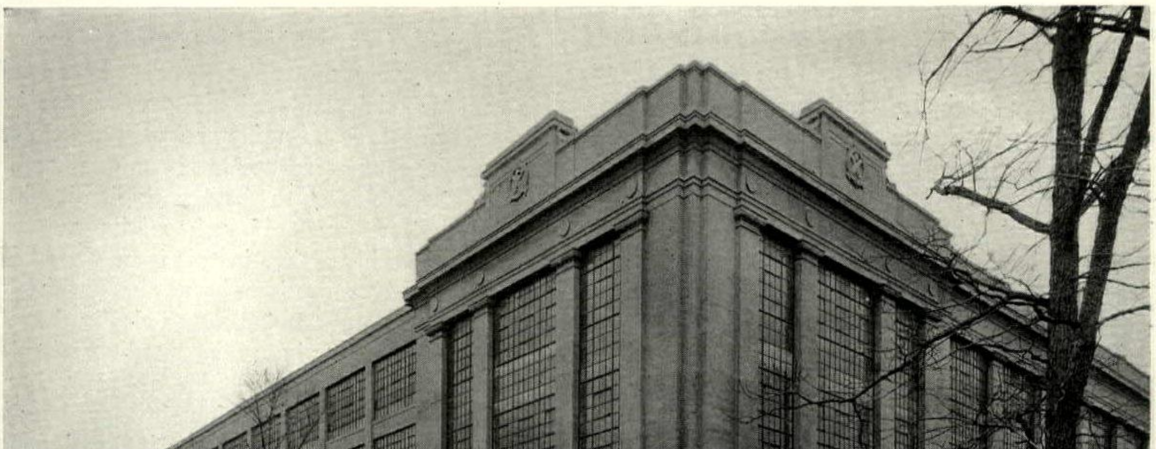
Checking Plans and Specifications for Safety

How to check plans and specifications for safety is told in a pamphlet just issued by the National Safety Council, 168 North Michigan avenue, Chicago, containing a check list of several hundred items which must be considered if serious hazards are to be avoided. The pamphlet, which has been prepared under the supervision of the council's Safe Practices Committee of 75 safety engineers, points out that if proper precautions are taken when drawing plans and specifications for new buildings or equipment, many accident hazards can be forestalled—an important matter to the plant engineer in these days of increasing pressure from government and insurance inspectors, compensation laws, and plant safety departments. Such engineering revision—or pre-vision—it is said, removes at little or no cost hazards which later could be corrected only at heavy expense if at all, and insures compliance with both government and insurance demands, the latter resulting in premium reduction. Under "General Plant Layout" are mentioned such items as the use of natural topography to eliminate dangerous grade crossings and unnecessary elevating of material with the attending hazards; proper drainage; proper location of drinking-water wells; smokestacks; buildings with serious fire or explosion hazards, etc. Attention is called to the necessity of considering the entire design in the light of future extension of the plant, increase in height of buildings, or changes in their industrial uses.

Other sections list the items requiring attention in connection with railroads, roadways for vehicles, and footways. Fences, intended for plant protection, may introduce accident and fire hazards if not properly designed, and these are next considered, followed by a section on pipe lines for water, steam, oil, gas, chemicals, etc. Some 30 items in connection with the general design of buildings are listed, and a number dealing with heating and ventilation, lighting, and toilets, washrooms, etc. The remaining sections are devoted to power supply, both steam and electric; elevators; cranes, derricks and hoists; conveyers; mechanical power transmissions; exhaust systems; abrasive wheels, and shop layout and machinery such as are found in a typical manufacturing shop. The list concludes with a section covering the special hazards of a chemical plant or department, this being presented as typical of the special check list which each engineer should develop for his own special industry.

For detailed information on each of the points covered, the engineer or architect is referred to various standards and handbooks, including the Engineering Standards Committee publications, the "Safe Practices" pamphlets, and other publications of the National Safety Council.

Prices and information concerning any of the publications mentioned here may be obtained through THE ARCHITECTURAL FORUM Book Department.



Detail of Corner Pylon, Siege Building, U. S. Arsenal, Rock Island, Ill. Reinforced concrete construction with architectural features of concrete cast in place. The main facade is 600 feet long

Bigelow & Wadsworth, Consulting Architects; Stone & Webster, Inc., Engineers

EDITORIAL COMMENT

ARCHITECTURE AND INDUSTRY

ART finds its inspiration everywhere. The record of artistic progress and development constitutes a graphic outline of the history of mankind. Christianity and idolatry, imperialism and patriotism, luxurious indulgence and frugal industry—every passion or prejudice of each generation since the dawn of history has contributed its impulse and left its imprint of artistic expression.

Industry has at all times been a prolific source of artistic inspiration. Like war and religion, it has found primary expression in a pictured history of all peoples and races. Artist-historians of the Nile valley, in ideal graphic presentation, recorded the industries of ancient Egypt. The publicists of the Chang period, through pictographic inspiration, encouraged and promulgated agriculture and kindred industries through a vast empire, and at the same time formulated the basis of the magnificent, patient art of China. So from the records of aboriginal peoples to the complex methods of artistic expression of the present day we find a close kindred relationship between art and industry. At times industry is the inspiration of art, and again art inspires industry.

As we consider the development of architecture in the United States, one interesting phase is the possibility of developing originality in design and expression. We are inclined to believe that there can be no really original architecture until we consider the somewhat paradoxical possibility of an important contribution to the development of American architecture through the medium of designing industrial buildings.

Should we examine those historical periods from which most of our precedent in architectural design is drawn today, we would find that perhaps factories are the only general class of buildings which were not in use during those centuries long passed. Until the development of our modern methods of transportation and communication, industry found its place in the homes of the people, and it has been only in comparatively recent years that the idea of industrial production at centralized points and in special types of buildings has been developed. The first actual factory building (probably developed in England) consisted merely of open sheds to afford covering against sunlight and rain, and in which the people of the village would gather to weave, spin, carve and perform the various offices of craftsmanship which flourished during that period. After the introduction of complicated machinery it became necessary to give more thought to the buildings in which this machinery and the necessary operatives were installed. Gradually the factory developed, usually in close proximity to congested residential districts, and ultimately it formed the nucleus of the manufacturing city or town.

During the early period of development of factory buildings very little attention was paid to any but the most practical consideration of providing a building within which the machinery and workers might be protected from the elements. After a brief period, however, the unhealthful conditions of factory workers caused an alarming and vital deterioration among the working classes due to long hours spent in poorly lighted and unsanitary buildings. It was realized also that the efficiency of production was greatly hampered, and as a result the design of factory buildings became of a more studied nature, in which, however, the æsthetic factor received no consideration. Within recent years a new element has been introduced in the design of industrial buildings, calling for a degree of artistic expression. Several conditions have contributed to this increasing demand for good architecture in the housing of industry. One of these has been institutional pride, which recognized the advertising value of a well designed manufacturing plant. Another has been the practical recognition of increased efficiency on the part of employes where sanitary and attractive working conditions prevail.

The spirit of community betterment is more and more aggressively protesting against the unsightliness of industrial plants. This growing consideration of atmosphere as a factor in the development of industrial projects presents an unusual opportunity for the architect to display originality in the planning and treatment of such buildings.

In an interesting article in this issue Cass Gilbert makes several constructive observations which bear out this contention. He believes logically that there is no reason why our industrial buildings should be ugly in order to be useful. He suggests that the materials commonly used for factory buildings, such as concrete and brick, offer interesting possibilities, many as yet untried, and that modern methods of factory construction present many opportunities of building carefully disposed masses of studied outline, striving for the benefits of simplicity, of surface colorings and textures at once satisfying and economical.

The great outstanding promise that industrial building holds for the profession is the opportunity of creating a style of architecture that will truly interpret modern conditions. Without precedent to fetter the hand of the designer, the simple requirements of industrial buildings should suggest appropriate forms that may eventually lead the way to the long sought American style.