November, 1944

Airports and Airport Buildings

Pencil Points

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YOU Are Making The Future!

The shape of things to come after the war is at this moment somewhat obscure. No one knows surely just how the world after Victory will work out—economically, politically, socially, or any other way. There are too many uncertain factors. Yet people persist in speculating about tomorrow (perhaps because of this very uncertainty) and they reach various conclusions, each according to the way he wishes his tomorrow to be.

In general, the dreams fall into two categories. Timid men, shaken by these troubled days, picture a future modeled after some part of the past which they remember as most friendly and peaceful, and to which they want to return. Younger and bolder spirits envision a new and exciting era in which men, grown weary not only of wars but of poverty and disease and hardship, will finally work together with wisdom and science toward the goal of universal human welfare, abundance, and peace. Architects who understand and value and strive to exercise creative imagination, might be expected to side with the second group. Perhaps most of them do.

At any rate, architects do have, more than most, a chance to influence the future by helping to form at least the physical environment in which people will work and rest and enjoy themselves. Already they are laying out the houses and schools and hospitals and stores and workshops of tomorrow. Already they are helping to plan and replan the communities in which their fellow men will live. Soon their drafting rooms will expand with increasing work and builders will commence to put together in solid materials the things first visualized on paper. We will then be in full swing on the way to making the new world we have talked about so long.

What sort of architecture will we produce? Will it reflect predominantly the views of those who want to turn back the clock? Will it be a hodgepodge of exhibitionistic mediocrity such as we see about us today, if we look at it honestly? Or will it be a brave new architecture created in the belief that this era must be true to itself and take advantage of all the possibilities our industrial civilization has laid before us to serve the needs of the people?

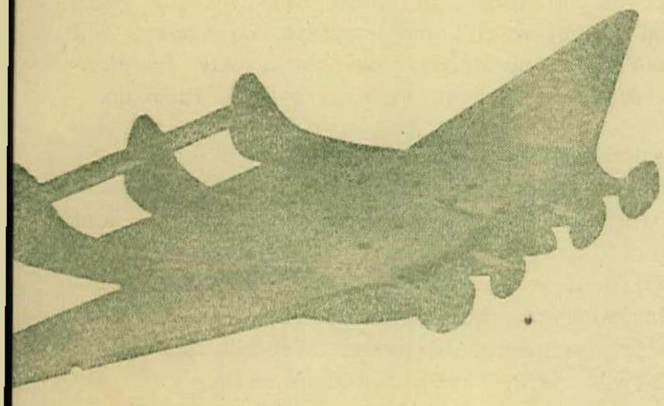
Our own sympathies, as stated again and again in this magazine since we took our positive stand for progressive architecture in May 1942, are with the forward-looking groups. We believe thoroughly in the vitality and honesty of their efforts to get rid of the superficial shell that had grown upon the practice of architecture during the age of eclecticism and to get back to the fundamental principles that have always guided good design. We have directed our editorial policy during the last two-and-a-half years to the encouragement of this return to basic thinking.

Apparently our change was in line with current trends, for our circulation has grown during this time until now we have more architects, more architectural draftsmen, and a larger total of professional men as paid subscribers than any magazine in the field. We welcome this endorsement as evidence that American architecture is moving toward a better, saner, and more honest type of design than we knew before.

This is, as Herbert Agar has said, "A Time for Greatness"—and will continue to be. And the greatness must be found in places of low as well as of high degree. Along with everyone else, the architect faces the challenge of the future. To meet it successfully, every architectural man must share the responsibility of building the better world. No job of his is so small that it cannot be directed to this end. Let us all resolve to write our part of the record of these next decades in such architecture as will take its place with the best in all history. It could be! Let's not have to say afterwards "It might have been!"

Kenneth Reid

AIR TERMINALS FOR MASS



Francis Meisch has probably had a better chance to study the design of airport structures "from the inside" than most American architects. In his capacity as Architect and Plant Engineer for Northwest Airlines, he has had many an occasion to develop schemes designed to indicate to municipalities along the airline's route what type and size of buildings his company needed; and he has spent much time on the problem of the air terminal building.

Photographs of the Burnelli Flying Wing, above, and the British "Miles X," appear through the courtesy of Skyways. Most of the drawings in and following this article were prepared by Mr. Meisch; the remainder were redrawn from his originals.

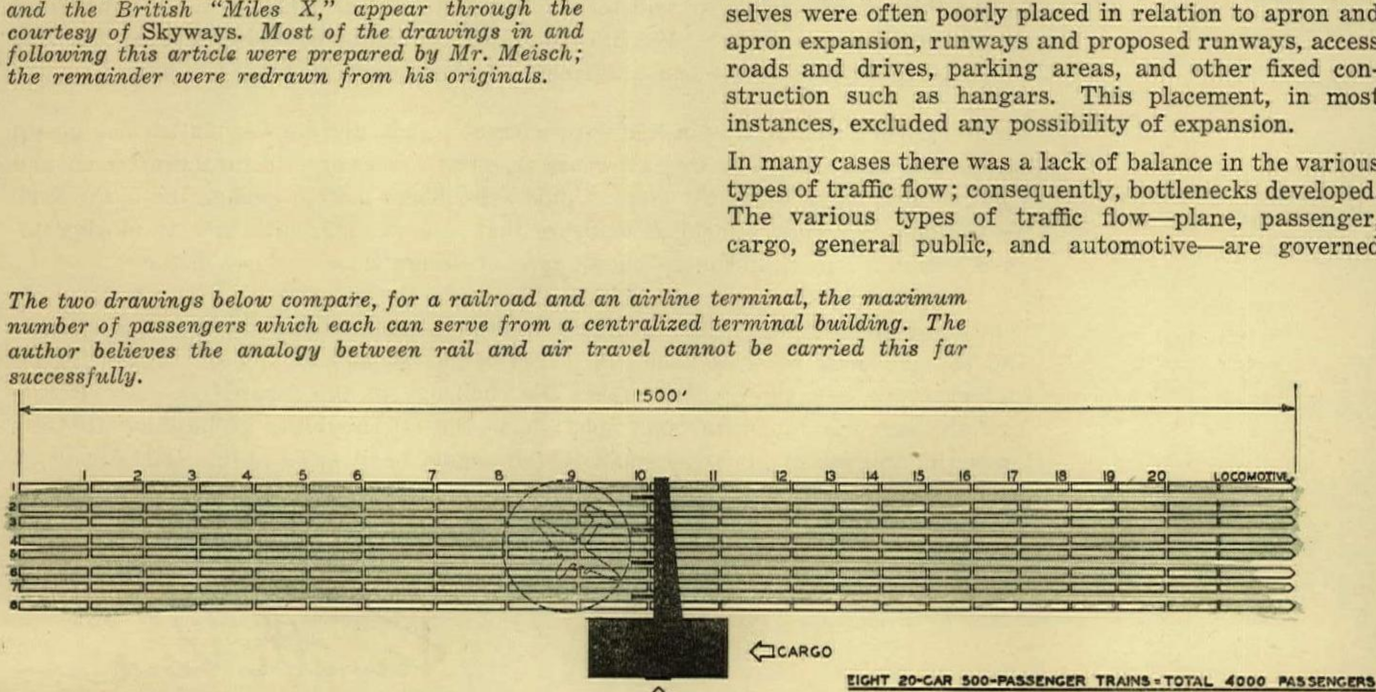
The Past

Up to now, airport administration buildings have been erected with little regard for function or changing conditions. The buildings were planned for smaller planes and plane loads than are now being handled or anticipated. Both administrative and terminal functions were combined within one structure, together with any number of related and unrelated minor activities. Too many of these functions, subject to expansion, were crowded into symmetrical structures built in too permanent a manner. The buildings were either low-cost structures which, through poor maintenance, soon deteriorated into veritable slums, or expensive municipal monuments, show places for the general public. The monumental stone or concrete edifices defied all attempts at economic remodeling or expansion to keep pace with the fast-growing air transport industry. Consequently, their useful life was terminated far ahead of their previously estimated economic life or amortization period.

The buildings had other faults. Often there were too little space and too few facilities for the airline passenger and the airline operational functions, in contrast to public areas. In addition, little thought was given to developing service and revenue-producing facilities of a high standard for the convenience of passengers, the public, and employees. The result was that the airlines were expected to pay the lion's share of the operating costs of these monuments. The buildings themselves were often poorly placed in relation to apron and apron expansion, runways and proposed runways, access roads and drives, parking areas, and other fixed construction such as hangars. This placement, in most instances, excluded any possibility of expansion.

In many cases there was a lack of balance in the various types of traffic flow; consequently, bottlenecks developed. The various types of traffic flow—plane, passenger, cargo, general public, and automotive—are governed

The two drawings below compare, for a railroad and an airline terminal, the maximum number of passengers which each can serve from a centralized terminal building. The author believes the analogy between rail and air travel cannot be carried this far successfully.



CENTRALIZED DESIGN RAILROAD TERMINAL.

AIR TRAVEL

by Francis R. Meisch

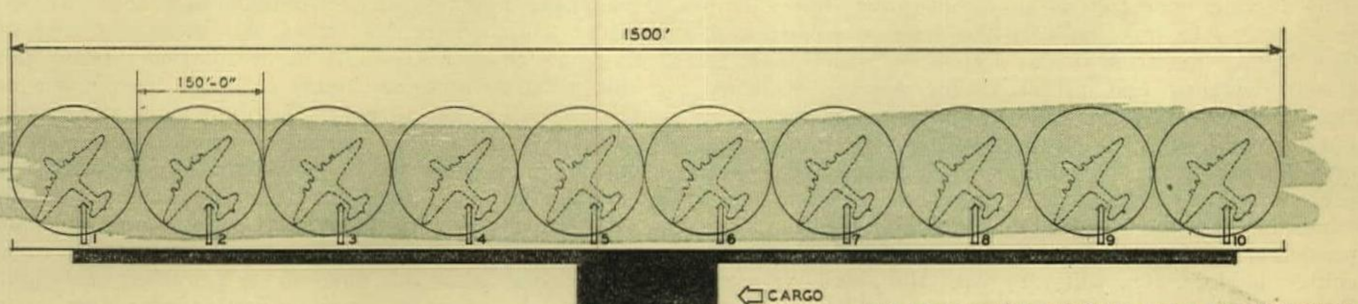
Architect and Plant Engineer, Northwest Airlines

by many factors. These factors, in the main, are air traffic circle capacity, runway configuration capacity, taxi-way pattern capacity, apron or gate capacity, terminal building capacity (for adequate handling of passengers, baggage, air cargo, the general public, and spectators), parking lot capacity, capacity of access drives and roads, and capacity of the highway between the airport and the city for volume or high-speed traffic. In terminal design, the building, the apron, the parking lot, and the access drives are of primary concern. The other considerations fall into the realm of airport planning or city planning. Balancing all the factors to provide uniform traffic flow is very essential.

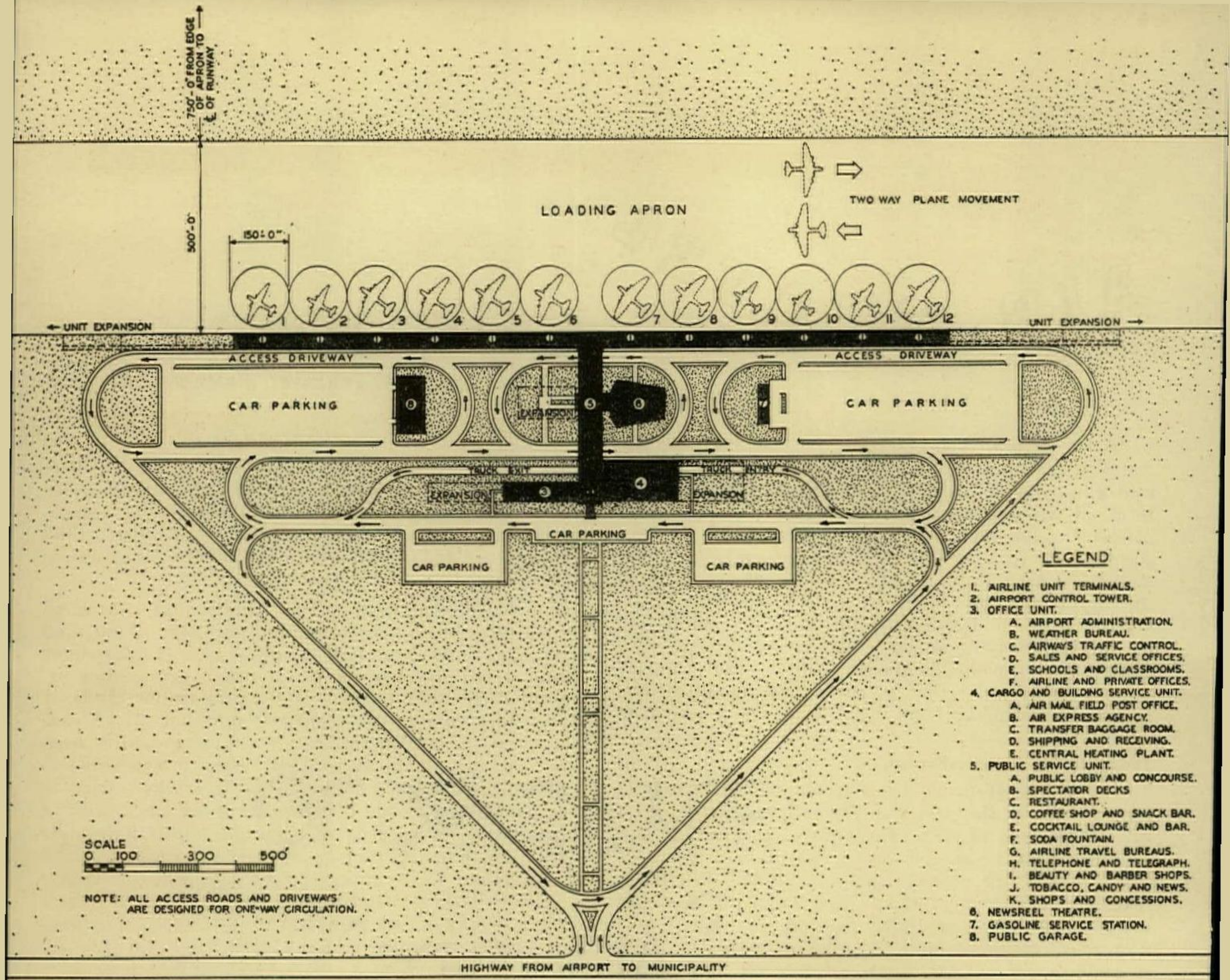
The Case for Decentralization

The prototype of many a poorly planned, monumental air terminal of the past was the railroad station with the central type of plan. The parallel between air and rail travel can be carried only so far before it breaks down. There are physical and operational differences resulting from many factors. The railroads have had the physical advantage of dealing with standard units—a standard gauge of track, a standard length of coach or pullman car with an approximately uniform height and a standard floor level at which all loading is accomplished. The airlines, on the other hand, have had and will continue to have equipment which, even within a single company, varies as to physical standards. Great variations exist in the length, height, and wingspread of aircraft, and the floor levels to which loads must be raised; in some instances the floor or deck to be loaded is in a sloping position when the aircraft is on the ground. This means that aircraft gate positions with fixed facilities for fueling, air conditioning, sewage disposal, water, power, turntables, etc., must be designed and spaced to accommodate the largest reasonably anticipated aircraft. When such positions are occupied by smaller aircraft, an operational waste of apron or gate area occurs, yet the cost of providing fixed facilities for fueling, air conditioning, sewage within a given apron area is at present too great to make it economically possible to eliminate this waste. Mobile services are possible but also expensive, and the number required constitutes an additional operational hazard.

An understanding of the physical-numerical differences in passenger and cargo handling problems of rail and air carriers is essential. Consider the 50-passenger plane which requires 150 lineal feet of gate space or, to put it in other terms, a 150-foot-diameter circle of apron area on which to maneuver into and out of loading position. In approximately the same apron area and clearances used up by this plane, it is possible to provide platform space and the eight tracks needed to accommodate sixteen standard railroad cars with a capacity of 900 passengers. In other words, the lineal feet of gate space used up by one 50-passenger plane is equivalent to the lineal feet of gate space providing access to four platforms and eight tracks on which trains of any length might load. A 20-car train handling 500 passengers will use 1500 to 1650 feet of track. While ten 50-passenger planes handling 500 passengers will require 1500 lineal feet of apron, actually, the apron area which they use could contain track and platform area for eight 20-car trains with a total capacity of 4000 persons. The amount of apron space required per person in air travel (based on 50-passenger aircraft) is roughly eight times the track and platform space required per person in rail travel. The amount of plane gate space per person is eighteen times the gate space required in rail travel. This physical difference is one of the great factors pointing toward the decentralization of air terminal facilities, as unusually great areas and distances are involved in the terminal mass handling of air passengers. It is these same physical factors which have made the solution to the



CENTRALIZED DESIGN AIRLINE TERMINAL



problem of loading air passengers and cargo under cover so difficult and so extremely expensive.

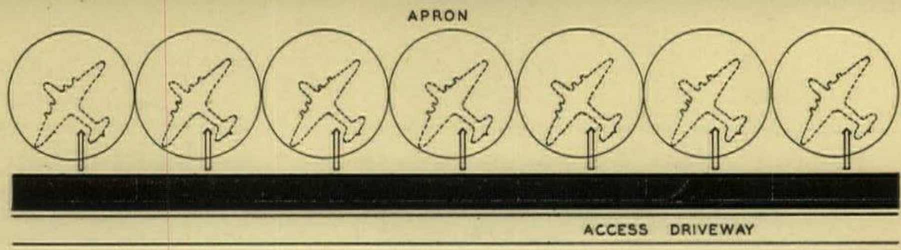
The time factor has a definite relation to the physical factors in both rail and air terminal design, but is more difficult to analyze. In air travel the passenger who is forced to enplane through a central building may have to walk several thousand feet to the plane, necessitating the "calling" of the flight a number of minutes ahead of scheduled departure. Railroad cars have several entrances; planes at the present time have only one, but the industry is looking forward to the installation of several doors in larger aircraft as a means of reducing terminal time. Aircraft must fuel at their gate position, except for some originating flights which may fuel at the hangar.

This fueling operation is time-consuming, but a ship must occupy its position until the process is completed. The fueling operation is also a function which must be closely watched and protected for safety. Railroad trains, on the other hand, usually need not wait to fuel but can change engines, while in the station, in a matter of a few minutes. The physical differences in aircraft present operational problems in passenger and cargo handling. Baggage carts may be standardized, but passenger loading steps and ramps, cargo loaders and chutes, ladders, etc., will vary with the plane. If more than one entrance is provided per plane, additional steps or ramps will be required. The railroads do not have this problem, nor the attendant one of storage for so much varied equipment. Due to the weight factor, it is very unlikely that planes will carry their access steps, etc., from place to place as an integral part of the plane.

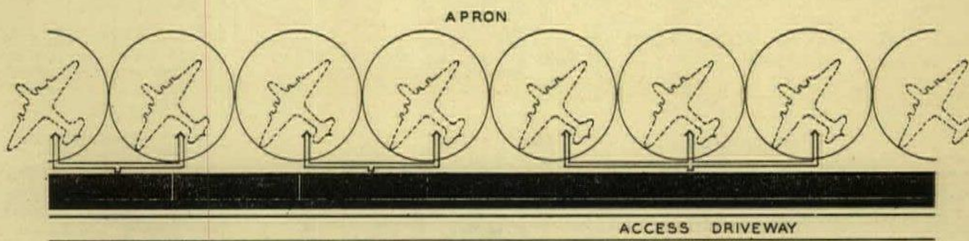
Rail travel is mass handling of people and baggage. Air travel is still personalized service, the individual handling of passengers. Air travel expects soon to be mass travel, and the airlines are looking for ways and means of expediting mass handling of passengers without eliminating the personalized service for which they are noted. Airports, in contrast to railroad stations, are usually situated some distance from the heart of the city. This location difference means that airline passengers arrive at the airport either in a private car, a taxi, an airline limousine, or a bus; and are often pre-ticketed. In the case of the airline limousine, the passenger may have already checked in at the downtown ticket office, where his ticket was picked up and his baggage checked through to destination. These pre-checked passengers are ready to board the plane when they arrive at the airport. Rail and plane ticket sales vary little in the time element, but making plane reservations and checking in plane passengers and their baggage involve a time factor which railroads do not have to consider. All plane seats are now reserved, and weight-control of passengers, baggage, and air cargo is essential. Railroads have no such problem of weight-control. In most instances railroad passengers carry their own baggage aboard, a procedure not likely to be utilized by airlines until two or more classes of air

AIR TERMINALS

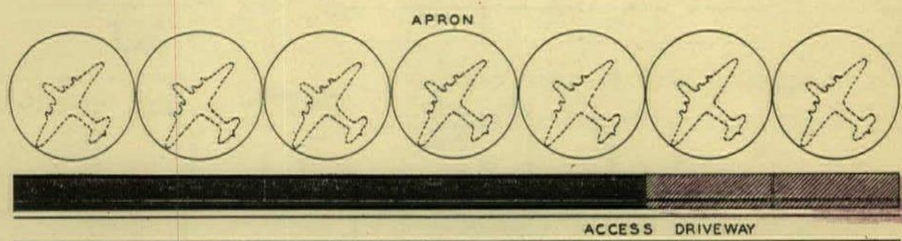
The larger air terminal might well have an "airport community center" containing necessary services and public facilities, with a small unit terminal at each gate position. Such a development permits building expansion or change in accordance with actual need.



TYPICAL UNIT PLAN.



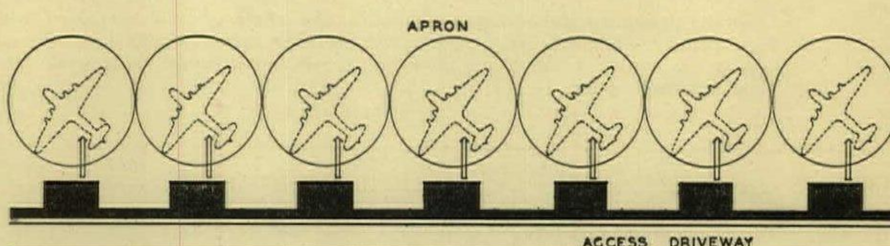
VARIATIONS IN UNIT PLAN.



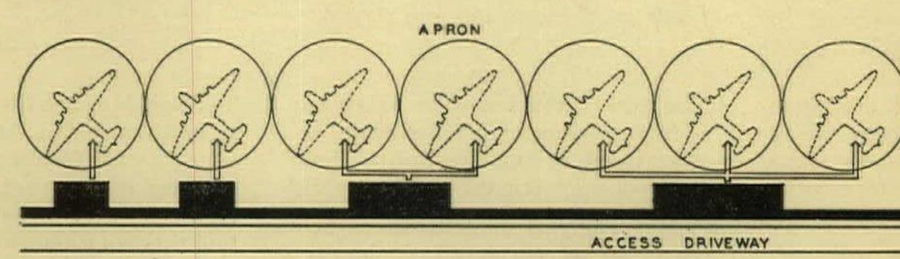
EXPANSION OF UNIT PLAN.

SCALE 0 50 100 200 300

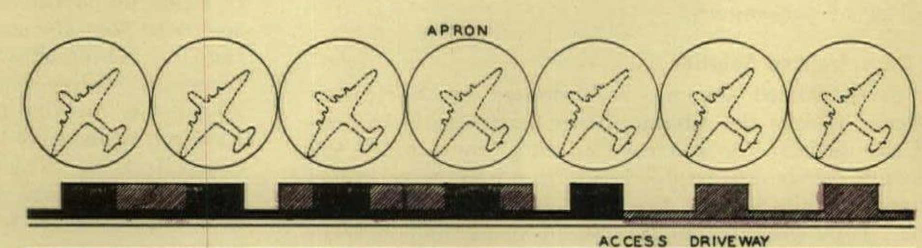
Northwest Airlines and United Airlines, at work simultaneously on the problem, arrived at very similar results. Above, United's unit scheme permits of extension only at the end of the row of continuous units. Below, Northwest's discontinuous dock scheme reduces initial building cubage and permits expansion between docks as well as at the end of the row.



TYPICAL DOCK PLAN.

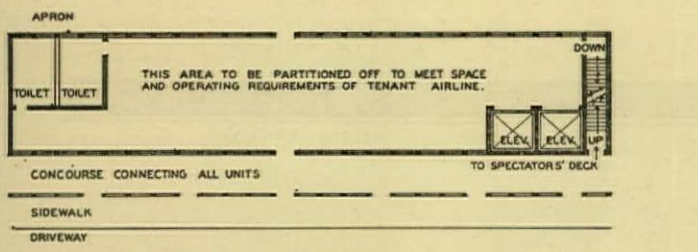


VARIATIONS IN DOCK PLAN.

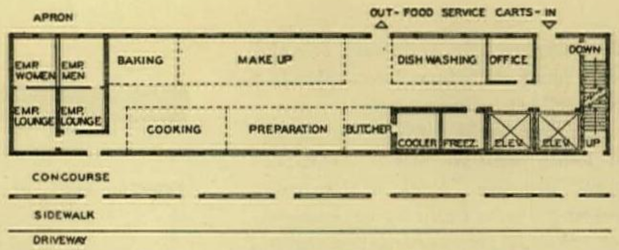


EXPANSION OF DOCK PLAN.

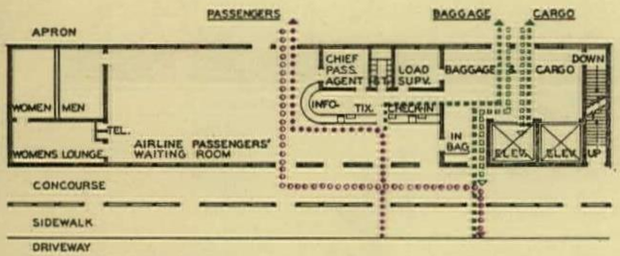
SCALE 0 50 100 200 300



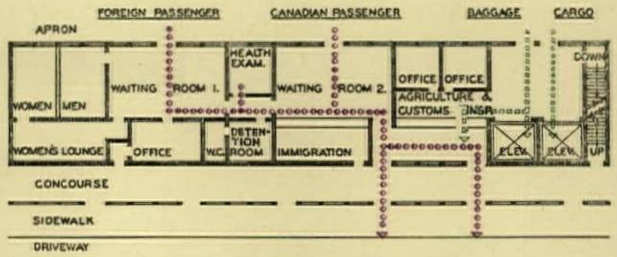
BASIC UNIT - GROUND FLOOR PLAN.
MINUS SUBDIVISION OF AIRLINE SPACE.
SCALE 0 10 20 30 40 50'



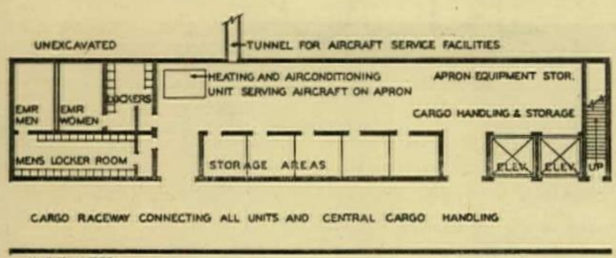
COMMISSARY UNIT - AIRCRAFT FOOD SERVICE PREPARATION.
BASEMENT PROVIDES BULK FOOD, FROZEN FOOD, AND ACCESSORIES STORAGE AS WELL AS LOCKER AND SHOWER ROOMS FOR COMMISSARY EMPLOYEES.



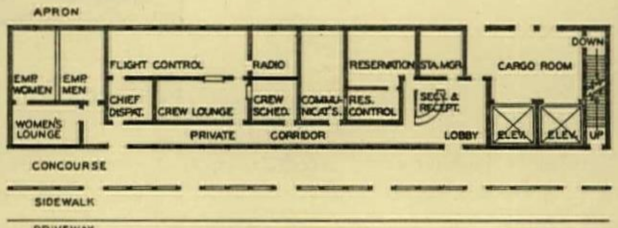
DOMESTIC TRAVEL UNIT - PASSENGERS AND CARGO.
SEE BASEMENT PLAN.
LEGEND: PASSENGERS TO PLANES ●●●. PASSENGERS FROM PLANES ○○○. BAGGAGE AND CARGO TO PLANES ■■■. BAGGAGE AND CARGO FROM PLANES □□□.



FOREIGN TRAVEL UNIT - CUSTOMS AND IMMIGRATION FACILITIES.
BASEMENT PROVIDES BOND ROOMS FOR CUSTOMS STORAGE AND ROOMS FOR AGRICULTURE QUARANTINE AS WELL AS EMPLOYEES' LOCKER ROOMS.

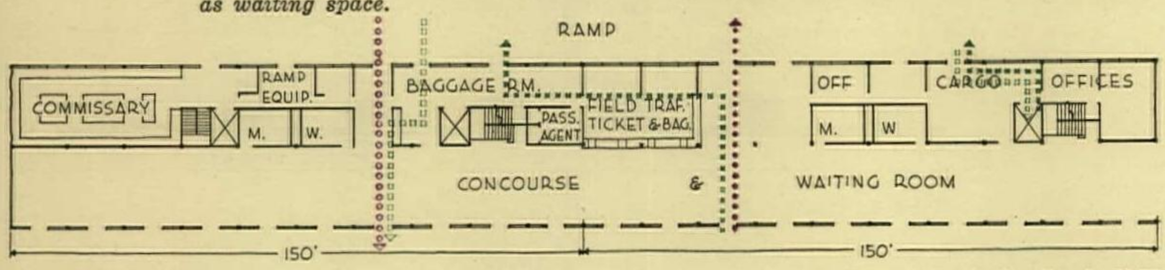


DOMESTIC TRAVEL UNIT - BASEMENT FLOOR PLAN.
GROUND FLOOR ALL-CARGO UNIT SIMILAR IN PLAN EXCEPT FOR RACEWAY.



AIRLINE OPERATIONS AND RESERVATIONS UNIT.
SPACE LAYOUT VARIES WITH EACH TENANT AIRLINE.

Above, varying developments within the shell of the standard unit. If the narrow concourse were adopted, additional waiting space would have to be provided. Below is a variation of the basic idea incorporating a wider concourse which can also serve as waiting space.



FLOOR PLAN

0 10 20 30 40 50 FT.

travel are set up. Plane reservations will probably be indispensable until a high frequency of schedule is available; and even then there is the possibility that some form of weight-control may remain.

This has been but a brief analysis of differences between rail and air travel as affects terminal design, but it illustrates the impossibility of planning air terminals on railroad standards for the centralized mass handling of passengers.

The Decentralized Solution

The decentralized scheme, as proposed by Northwest Airlines, utilizes the advantageous features of the centralized design. A central building containing the necessary services is established with a number of minor stations or units located like satellites along the loading apron. Total decentralization would mean the construction of entirely separate and wholly self-sufficient airline stations around the perimeter of the airport.

The trend toward decentralization has so far been limited to proposals of airlines which were searching for a solution to the terminal building problem. The nearest existing counterpart to the decentralized solution is the enclosed gate concourse at LaGuardia Field, New York; but this solution stops far short of the goals proposed by airlines. It was the major terminal, with its widely separated plane positions, that led Northwest Airlines to study decentralized designs. After close analysis it was seen that the decentralized solution had an advantage for the smallest station as well as for the largest terminal. While Northwest Airlines was arriving at its answer to the problem, United Air Lines in its research arrived at the same conclusion concerning decentralization. The basic scheme and underlying principles are identical in both airline solutions, although minor differences, with attendant advantages and disadvantages, occur.

Northwest Airlines proposed the discontinuous "unit" or "dock" solution, and United Air Lines proposed the continuous "unit" solution. The Northwest Airlines' scheme allows the individual docks to be expanded to the full length of the gate position, or additional docks and gate positions can be added at either end of the apron. This is done only when needs dictate, thus keeping the original investment small until economic justification for expansion exists. The dock scheme was proposed for large terminals where it was found that the airline functions for passenger traffic and cargo handling did not at the present time require terminal facilities the entire length of the gate position. If space were desired for airline field operations, communications, offices, commissary, etc., along the length of the gate position as well, then the continuous "dock" or "unit" was required.

United Air Lines' scheme was based upon housing some of these additional functions at the apron; hence, the continuous unit. This scheme presents internal expansion difficulties where several airlines are concerned. "Cushion" functions, which can be removed to provide for expansion, must be located in units between airlines. If this is not done, the airline or lines in the center push those airlines on the ends out into new units as more gate and terminal space is required. Using light demountable partitions, the physical changes are not difficult to make; but the resulting disruption in terminal activities for the airlines required to move is not at all desirable. Since their inception, various ideas from the two solutions have been interchanged and combined so as to provide a common solution to the industry's problem.

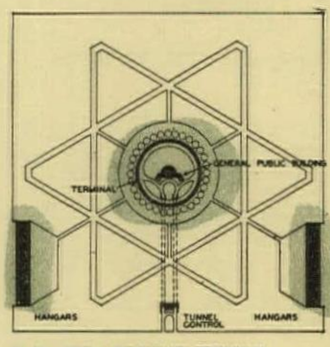
The basic premise of the decentralized scheme is the localization of the individual airline functions adjacent to the apron or gate positions, with a driveway on the off-field side so as to simplify and expedite the transition of passengers from automotive conveyances to aircraft. This permits a clear-cut separation of airline functions, from one another and from all other airport activities such as airport administration, concessions, government offices, fixed base operators, etc. Inter-connection is maintained between airlines, main public building, and administrative offices through the use of a covered concourse serving all docks or units. At terminals large enough to make the investment economical, a cargo raceway for handling transfer baggage, mail, and express should connect all airlines with one another, with the airmail field post office, and with the air express agency. This raceway can also provide space in which to run all building utilities from a central plant or control point.

The second premise is the concentration of the revenue-producing concessions, public service areas, airport administration, government, and private offices into a general public building or "airport community center." This structure is usually centrally located with respect to all gate positions. The list of facilities for such a building or buildings is long and varied. The number of facilities for an airport community center will vary with the size of the terminal and the municipality. In larger terminals it is possible to locate mail and express facilities in the general public building, or to provide smaller separate buildings (which are more easily expanded). The only airline function to be located in the general public building would be a common information center or separate airline travel bureau offices. The use of additional office space in the central public building would be a matter of individual airline policy.

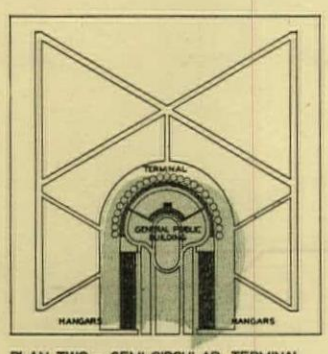
Advantages of Decentralization

Expandability has been discussed. Besides expansion in a horizontal plane, vertical expansion is possible, especially in the "units." The units should be structurally designed in the beginning to support an enclosed second story from which the large planes of the future may eventually be loaded by gangplanks. An elevated passenger drive might follow, with the old passenger drive at ground level becoming available for cargo truck operators.

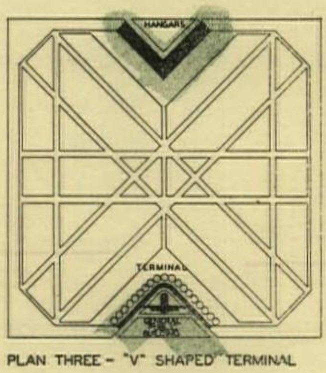
Flexibility is another advantage. The over-all scheme is adaptable to any shape of terminal area, providing sufficient room is available for expansion. The scheme may be symmetrical or unsymmetrical. The central public building may be either at the apron edge between the units, or set back, allowing the units to occupy the valuable apron frontage. Flexibility exists in the design



PLAN ONE - CIRCULAR TERMINAL.

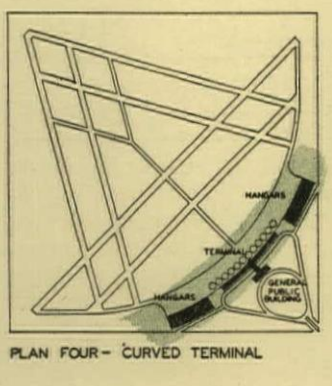


PLAN TWO - SEMI-CIRCULAR TERMINAL.

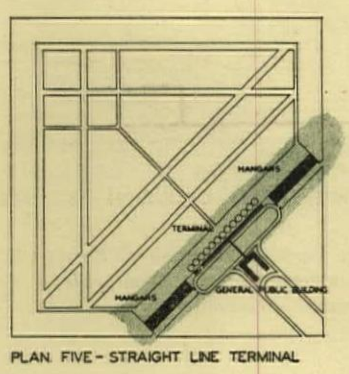


PLAN THREE - "V" SHAPED TERMINAL

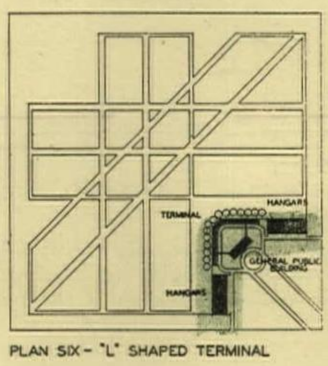
AIR TERMINALS



PLAN FOUR - CURVED TERMINAL



PLAN FIVE - STRAIGHT LINE TERMINAL



PLAN SIX - "L" SHAPED TERMINAL

The decentralized dock scheme is adaptable to any shape or location of terminal buildings on the field.

of the units. Once a basic unit is established (width, length, cross section, fixed facilities such as ramps, stairs, toilets, lifts, etc.), each airline can arrange its partitions, counters, exits, and entrances to suit its own particular operating methods. Flexibility exists in the use of the units. Units may be designed for domestic operations, for foreign operations complete with customs and immigration facilities, for cargo warehouses, for airline commissaries, or for airline offices; or they may be converted from one function to another. To this end a standard cross section, free of columns, with exterior walls constructed of uniform structural bays, is desirable, in order to allow an interchange of door and window panels to provide freedom in planning.

Segregation is another advantage. Each airline has control of its own operations and can render more personalized service to its patrons. The airline passenger is separated from the general public and from cargo operations, thus simplifying passenger handling by airline personnel. Fewer opportunities will exist for mishandling cargo and passenger baggage. The spectator is given an observation deck from which he can watch apron loading activities without interference with the operations. This all helps to avoid congestion and to facilitate the mass handling of passengers.

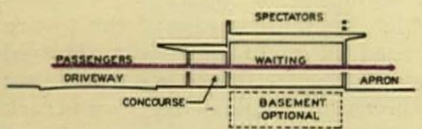
Economy is still another advantage. The decentralized terminal can be developed by stages to parallel the economic demand and justification for facilities. Thus there can be no over-expansion. The investment in decentralized terminals can be amortized over a long period without fear of obsolescence and inadequacy, which have made so many terminals economic liabilities in the past.

Passenger convenience is a great advantage. The decentralized terminal is planned primarily to expedite passenger handling and to bridge the gap between air and ground travel in the most convenient, effortless way. The passenger is no longer forced, together with the general public, through a central building where delays occur and congestion abounds. The concessions and services of the central building are still available, ready to serve the passenger who has time to spend at the terminal. The airline passenger purchases air travel because it means time and convenience to him. For this reason it is to the best interests of the industry to cut passenger time at the terminal to a minimum. Immediate passenger requirements such as toilet facilities, telephones, telegrams, vending machines for bottled drinks, candy, cigarettes, etc., can be provided in each unit terminal, thus eliminating the necessity for the hurried passenger to rush to the main building.

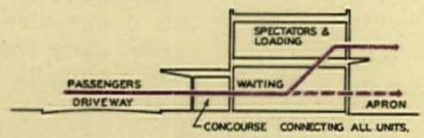
Safety and *efficiency* are still other advantages which result from segregation and localization of operations.

Unlimited Possibilities

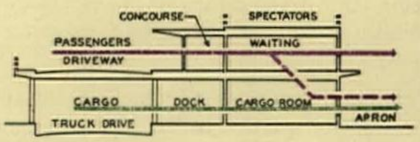
The patterns and schemes which result from a decentralized solution are unlimited. The fundamental governing item is the size of the aircraft, which determines the unit terminal length or gate position size. Major



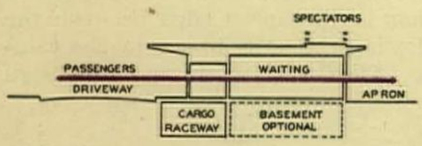
SINGLE LEVEL OPERATION—INITIAL STAGE.
CARGO HANDLING ON APRON PASSING IN FRONT OF EACH UNIT OR FROM PASSENGERS DRIVEWAY THROUGH UNIT TO APRON.



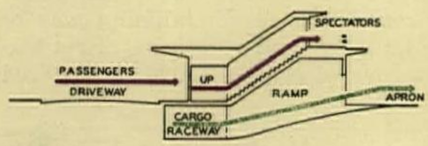
EXPANSION: PARTIAL TWO LEVEL OPERATION.
CARGO HANDLING STILL ALONG APRON OR THROUGH UNIT TO APRON.



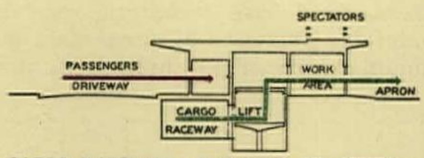
EXPANSION: FULL TWO LEVEL OPERATION.



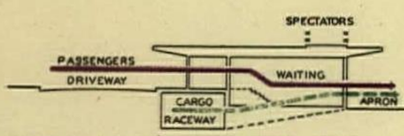
CARGO HANDLING - BASEMENT RACEWAY.



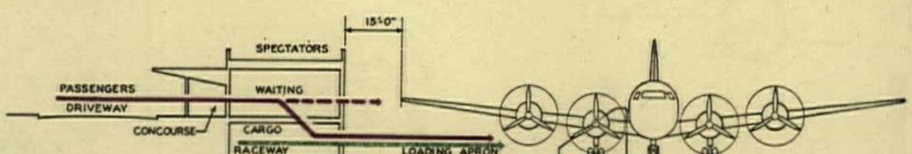
CARGO HANDLING - RAMP TO APRON.



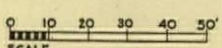
CARGO HANDLING - ELEVATOR TO APRON.

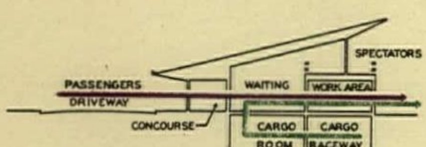


SPLIT LEVEL SCHEME - INITIAL STAGE.

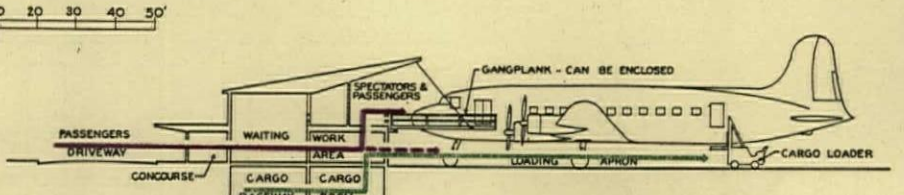


TWO LEVEL SCHEME - TWO LEVEL OPERATION - INITIAL AND ULTIMATE STAGE.





TWO LEVEL OPERATION - INITIAL STAGE.



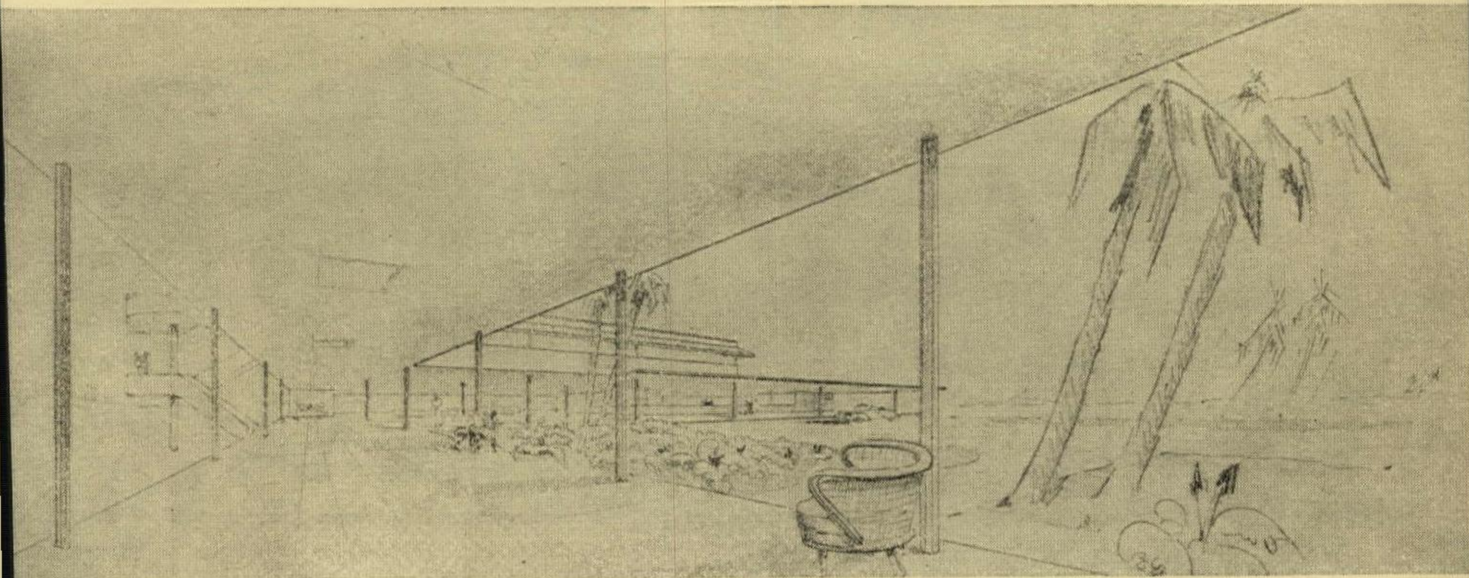
TWO LEVEL INTO THREE LEVEL OPERATION - ULTIMATE STAGE.

Northwest Airline's dock unit scheme is readily susceptible to vertical expansion. Units should be structurally designed in the beginning to support a second story from which future large planes may be loaded. Eventually the passenger driveway might also be elevated.

terminals are now being designed with gate positions 150 feet on centers, but 175 feet is considered ideal. Minor stations serving one or two airlines can get by with units (not gate positions) as short as 75 to 100 feet in length. Unit terminals can be designed to any width, but a 30-foot unit, plus a 10-foot combination vestibule and concourse, has been regarded as the minimum.

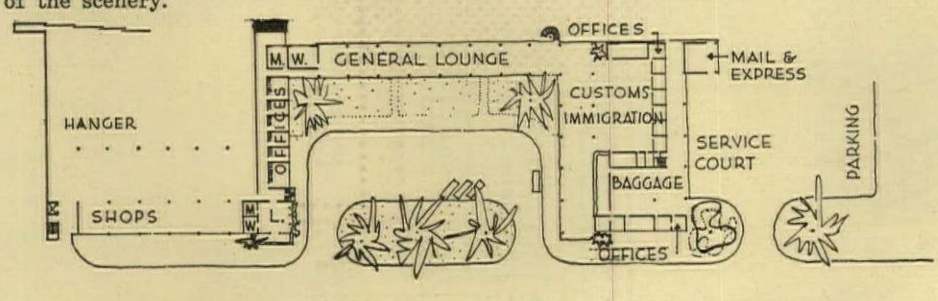
The use of mechanical and electronic aids will offset the strain on communications caused by decentralization. The major terminal will require, for passenger and employee use, an intra-airport system of ground transportation connecting all unit terminals with the general public building. Conveyor belts or cargo trains will connect the unit terminals with the central cargo functions. Impressive, though not monumental, architectural solutions can result through establishment of a basic "appearance" scheme for the over-all terminal development. Adequate airline publicity and directional assistance can be obtained through the use of controlled signs on each unit without marring the architectural effect. Above all, it is important to locate the decentralized scheme on the airport so as to provide space for the maximum anticipated expansion without interfering with runway clearances or fixed construction, as well as to provide for adequate vehicular circulation and parking. The decentralized scheme should not result in stereotyped solutions; fundamentally, it is a planning principle which serves as a guide, not a limit.

In the remainder of this article numerous applications of the unit idea, as well as several examples of possible specialized developments, are presented. All are schemes developed by the architectural department of Northwest Airlines under the supervision of Francis R. Meisch.



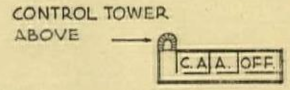
TERMINAL BUILDING FOR A SITE IN HAWAII

This design was prepared to indicate the type and extent of facilities which the airline would require if it should extend its service to Honolulu. Though not a "unit" development, the same principles of traffic flow govern its arrangement. The general lounge, glazed on both walls and having above it a promenade deck for sightseers, takes full advantage of the scenery.

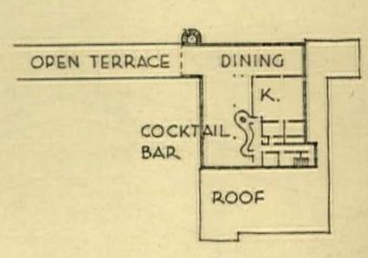


GROUND FLOOR

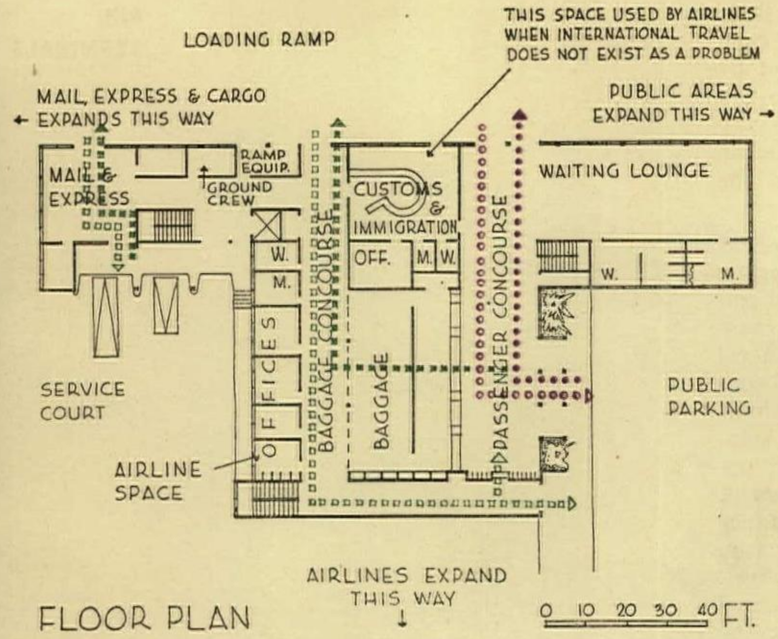
0 20 40 60 80 100 FT.



THIRD FLOOR



SECOND FLOOR 0 20 40 FT.

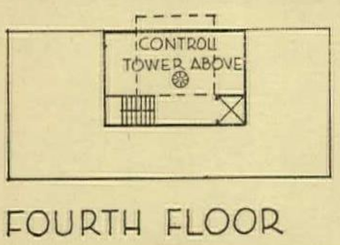


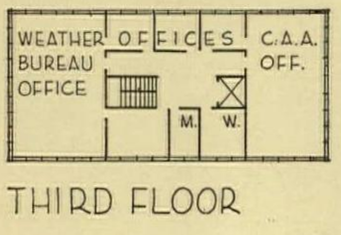
This small, combined administration building and airline terminal, adaptable to many a proposed postwar airfield, can be expanded both horizontally and vertically. Originally only one story high, it can have its wings extended, or stories added, or both—piecemeal or all at once. It might conceivably be so altered as to interior arrangements that unit docks could be added along the loading apron. In the ground floor plan of the final stage, the original extent is indicated by colored shading.

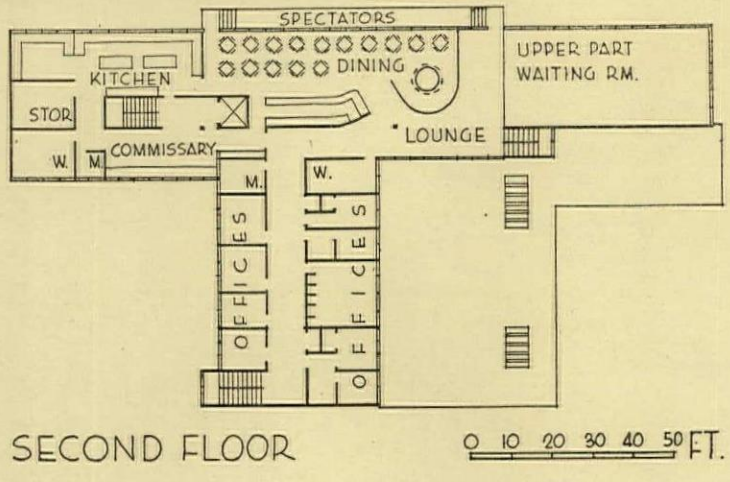
INITIAL STAGE

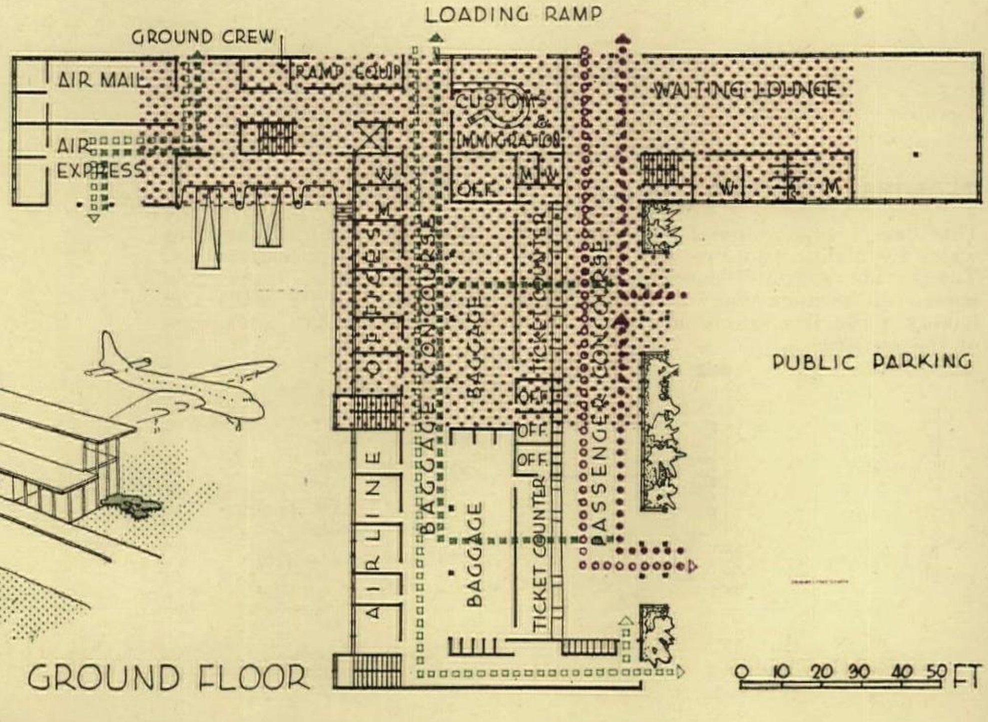
ADMINISTRATION BUILDING DESIGNED TO EXPAND AS NEED ARISES

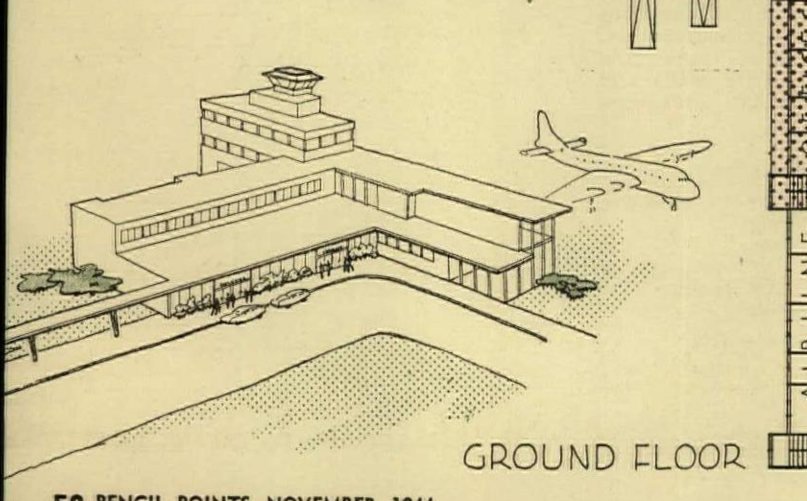
FINAL STAGE





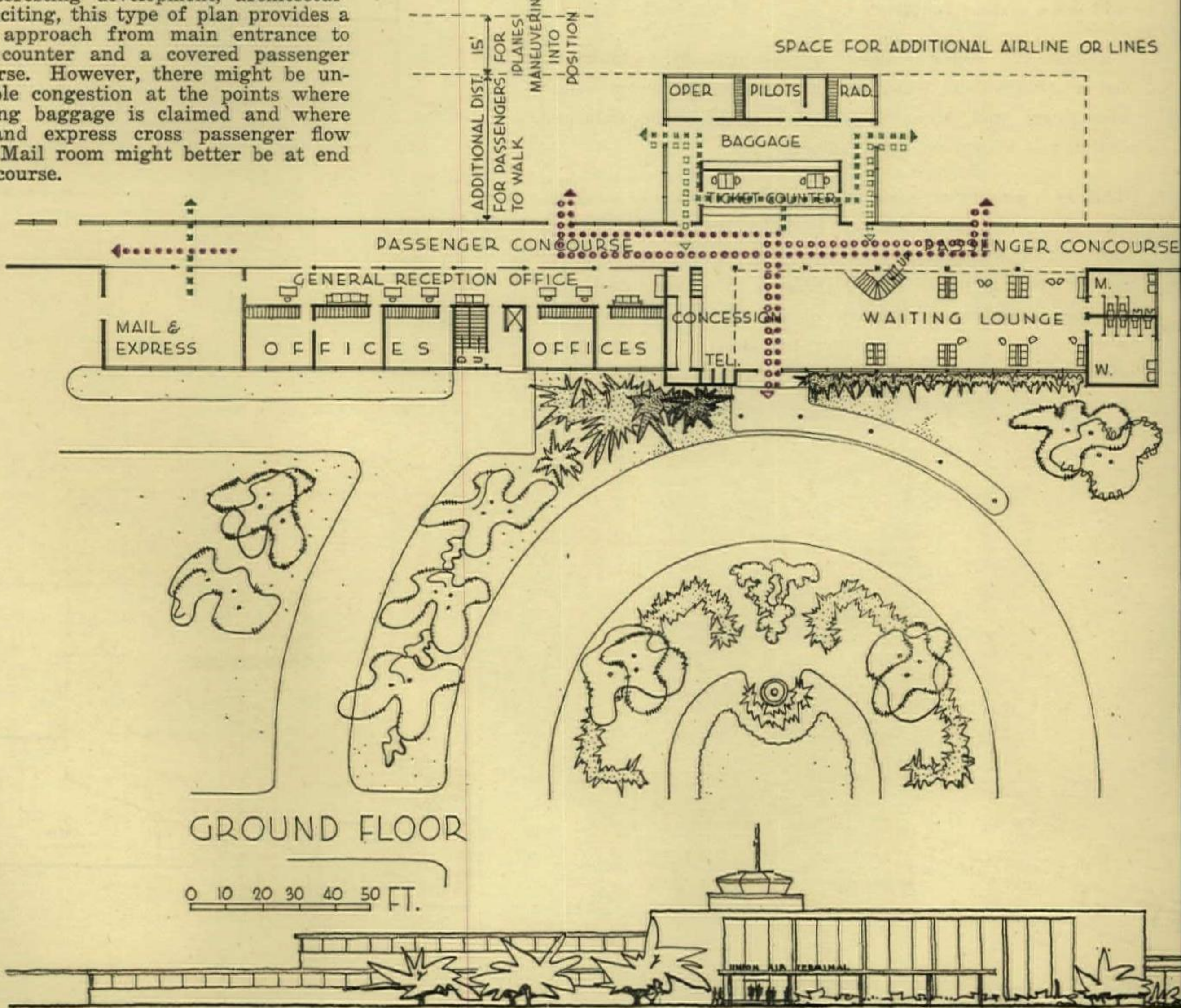


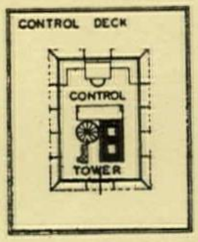




ADMINISTRATION BUILDING FOR A LARGER AIRPORT

An interesting development, architecturally exciting, this type of plan provides a direct approach from main entrance to ticket counter and a covered passenger concourse. However, there might be undesirable congestion at the points where incoming baggage is claimed and where mail and express cross passenger flow lines. Mail room might better be at end of concourse.





CONTROL TOWER FLOOR PLAN

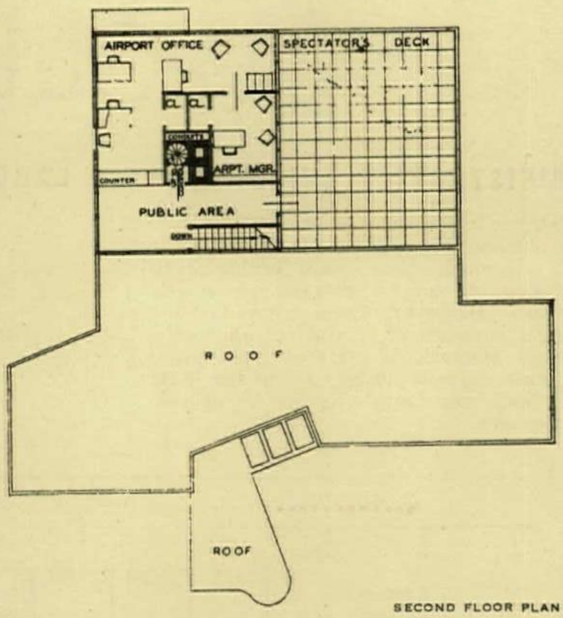
THE COUNTRY CLUB TYPE OF AIRPORT

REQUIRES AN EXPANDABLE BUILDING FOR POSSIBLE COMMERCIAL DEVELOPMENTS

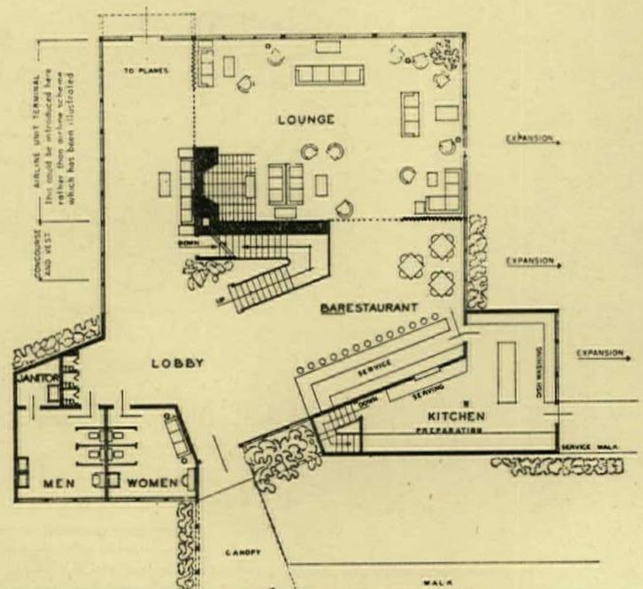
If private flying is to increase rapidly in volume after this war (and many people are doing more than guessing that it will) then private flying fields will become a necessity. But it would be folly to design the buildings which they will require without thought for potential commercial development. Even if the private field eventually becomes only a minor "way station," it will need facilities for passengers and some airline functions.

On these two pages is shown a conception of a clubhouse, for a private field, which can be enlarged to accommodate passengers and other commercial traffic. The enlarged building is shown on the following pages.

This is a preliminary study only, and like many preliminaries has its faults. When he submitted it Mr. Meisch called attention to some of these. For instance, location of the chimney is poor. Rising through the control tower as it does, it obstructs visibility; it should be relocated so it would not interfere with either the view or the operation of delicate weather-recording instruments. This would necessitate restudy of the first-floor fireplace location.

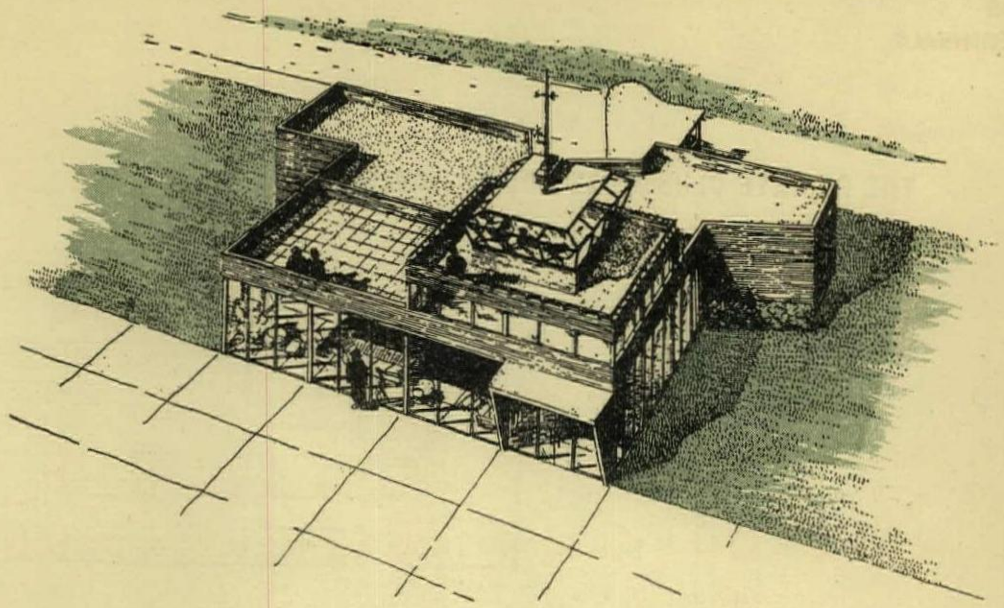


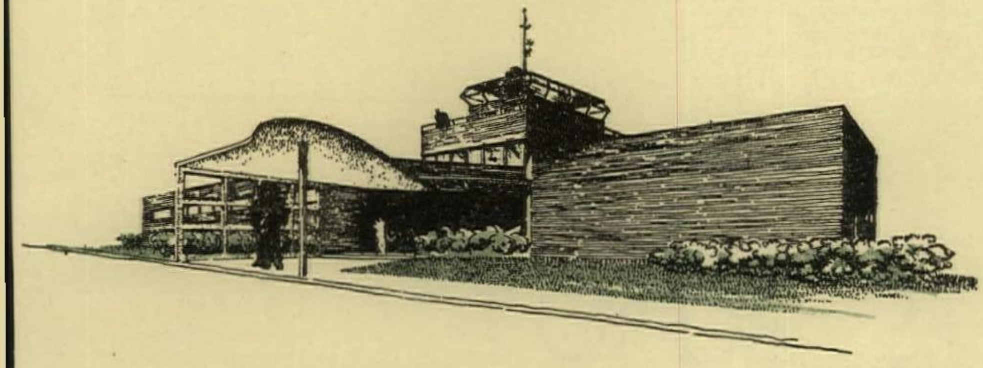
SECOND FLOOR PLAN



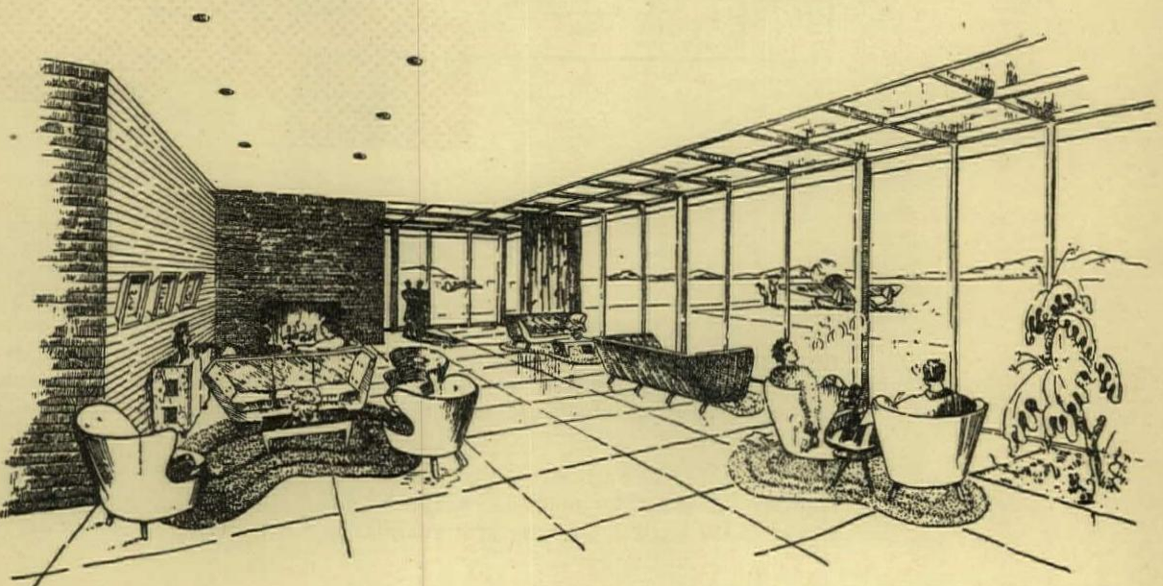
GROUND FLOOR PLAN

DRIVEWAY

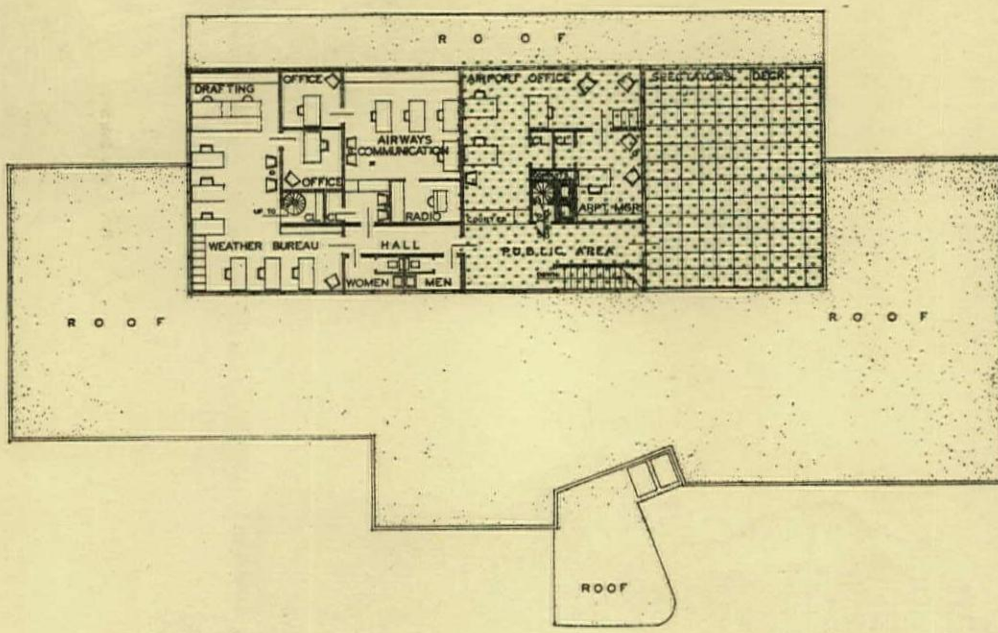


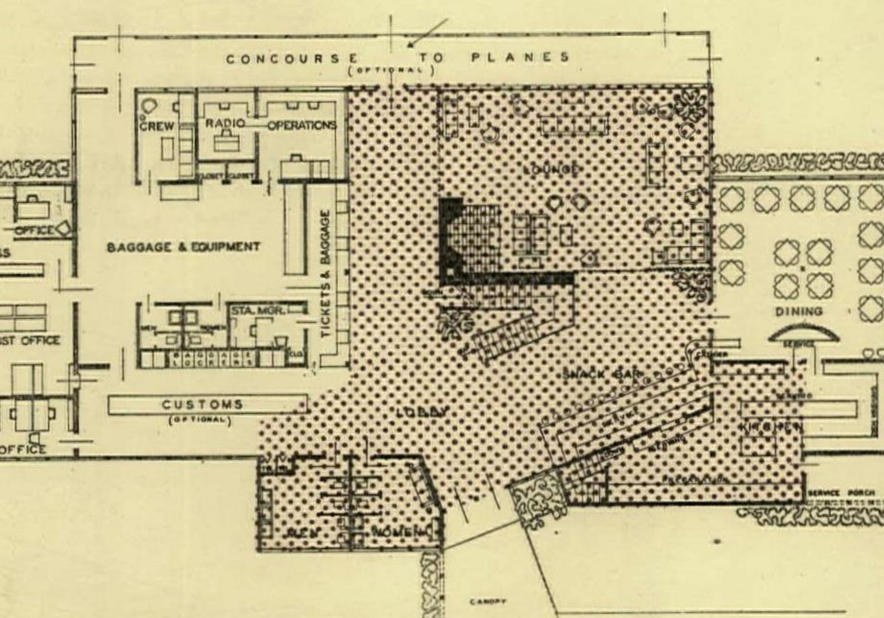


Exteriors and interior of the clubhouse for the private field. At top, aerial view from the field; center, view from the driveway; below, interior of the lounge looking toward the fireplace wall. The flying field is at the right, visible through a glass wall. To understand how the addition of commercial facilities affects the building, turn the page.



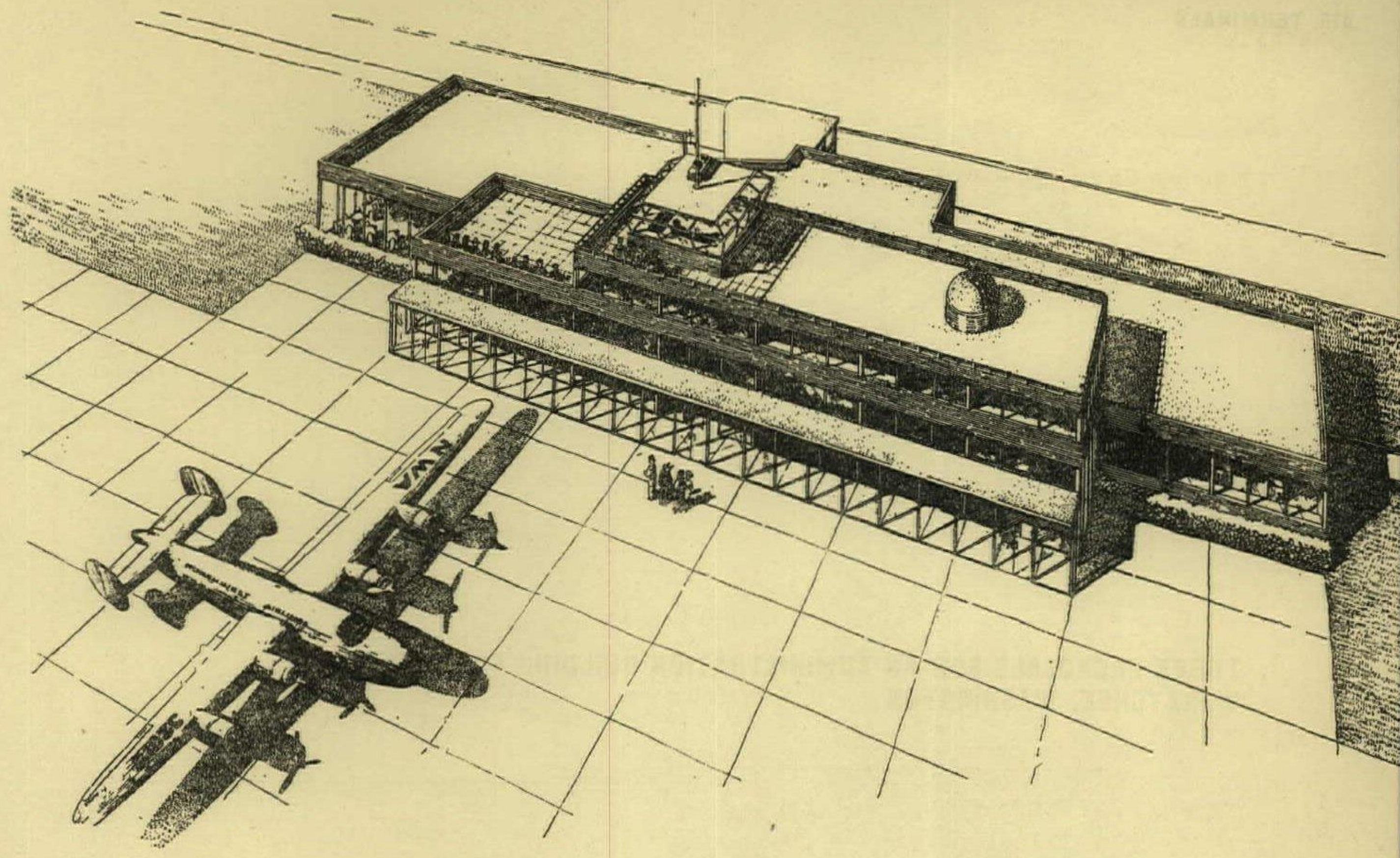
THE PRIVATE CLUBHOUSE ADDS COMMERCIAL FACILITIES



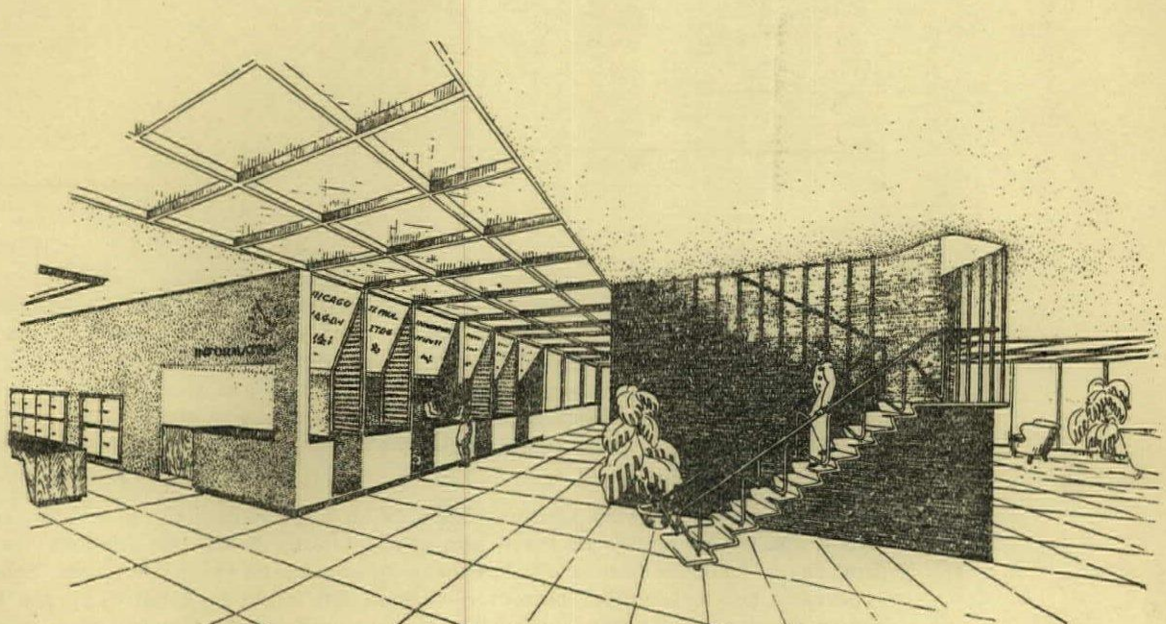


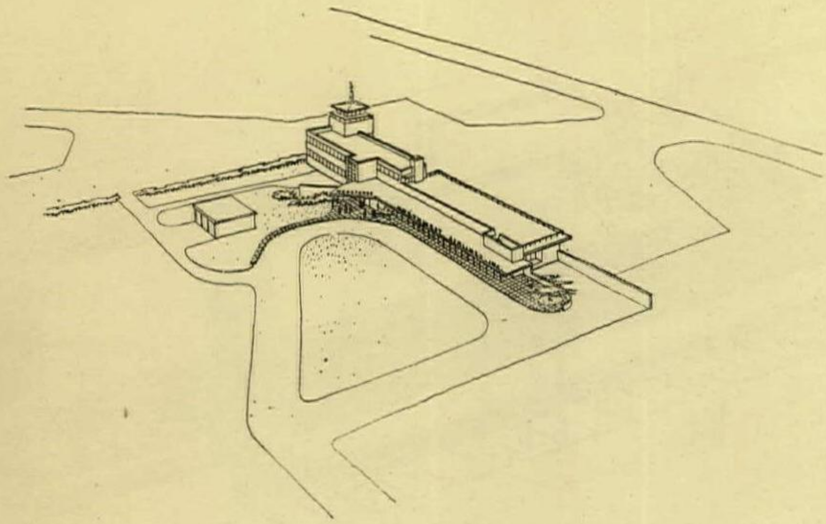
The area of the former clubhouse, detailed on the preceding page, is shown by colored shading. This project was an early development in Northwest Airlines' architectural department; currently they would advocate adding a standard unit terminal to the left-hand side of the clubhouse area, rather than the specialized—and possibly limiting—plan shown.

Mr. Meisch has also criticized the second floor layout in that a better relationship is required between CAA facilities, weather bureau, pilots' chart room, and airport office. Access to the control tower is preferably from CAA offices.

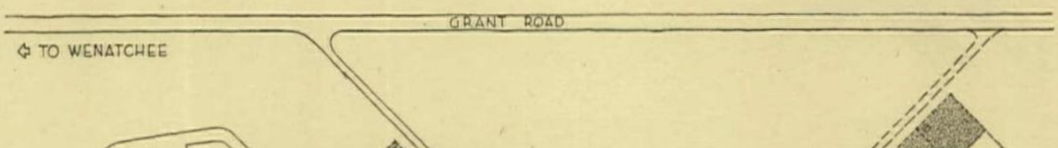


Two views of the small terminal which started out as a clubhouse; above, aerial perspective from the flying field; below, interior showing ticket counter which replaced the left-hand wall of the old building. Although some faults can be found with the building as a terminal, the whole conception has an important virtue: it can be altered economically to suit changing needs—something which can hardly be said of most existing air terminals.





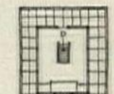
THREE PROPOSALS FOR AN ADMINISTRATION BUILDING FOR WENATCHEE, WASHINGTON



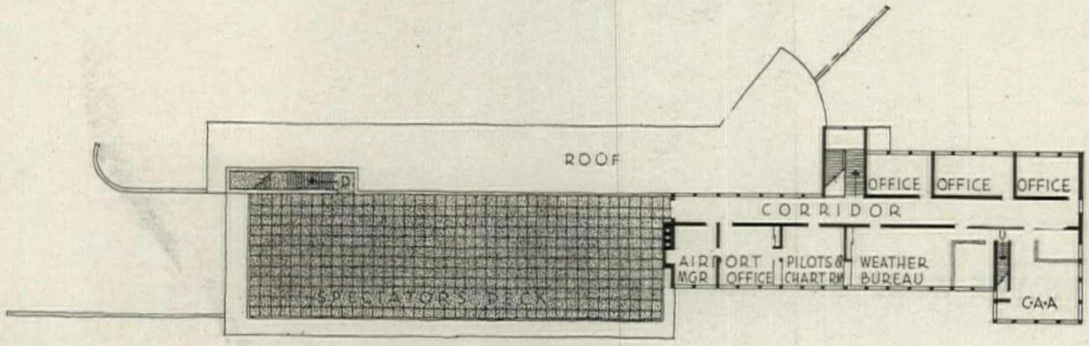
PLOT PLAN SCHEME A

Wenatchee, a small community in the State of Washington, required an administration and terminal building for its airport. The community receives scheduled air transport service, but the present extent of use is limited and traffic at the port is not expected to grow beyond a reasonably modest maximum. In this and the two following pages are shown Northwest Airlines' suggestions, which are now under consideration. They embody the company's latest thinking on unit terminal design in a rather interesting fashion.

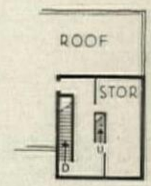
CAA had provided certain facilities, such as an existing transformer vault, runway layout, etc., which had to be taken into consideration. Northwest Airlines has made three suggestions, the first of which, Scheme A, appears on these two pages. Scheme A appears to be too large for present conditions, but might be required in the future. Notice, on airport plan above, provision for both unit terminal and hangar expansion.



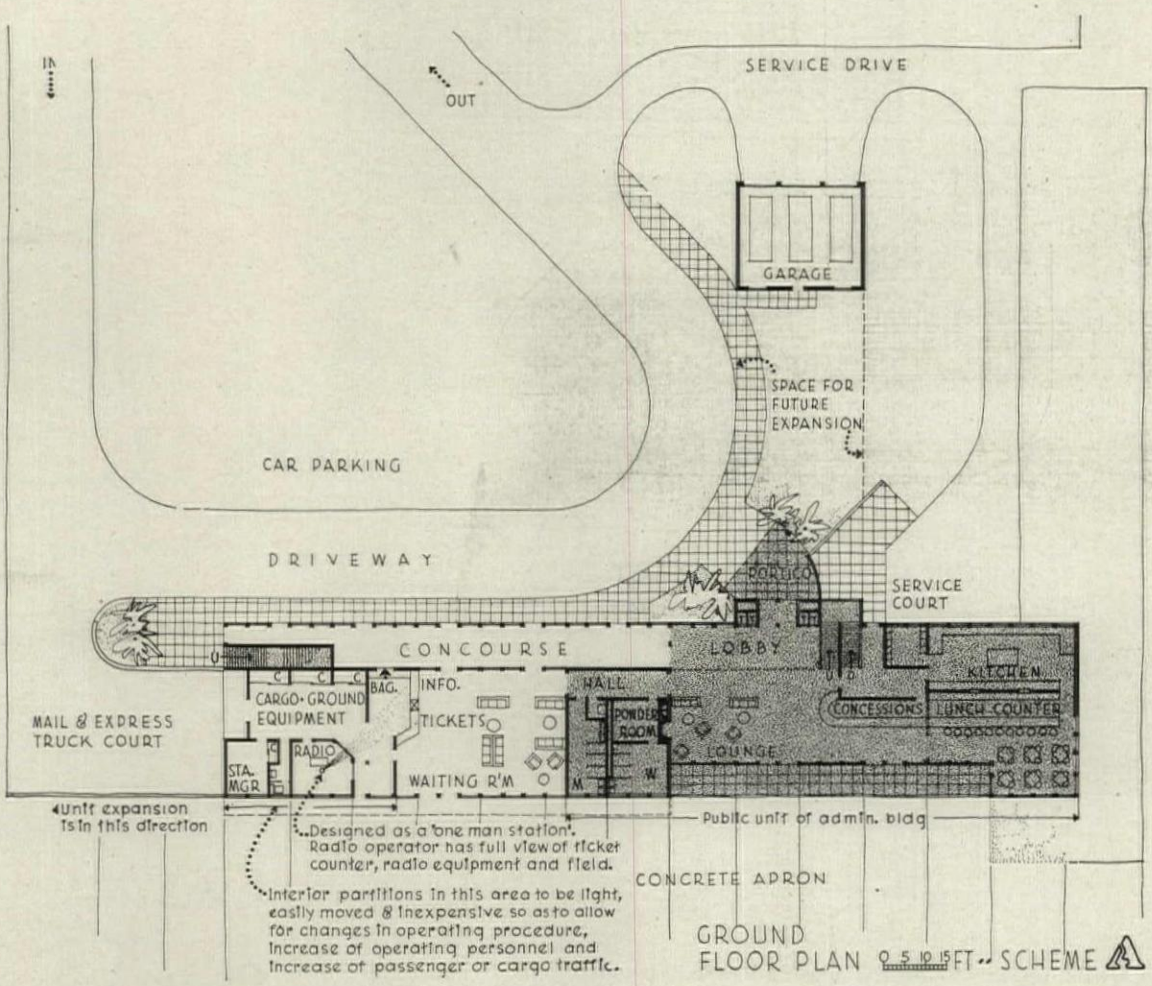
TOWER PLAN 0 5 10 15 20 25 FT



SECOND FLOOR PLAN 0 5 10 15 FT · · SCHEME A

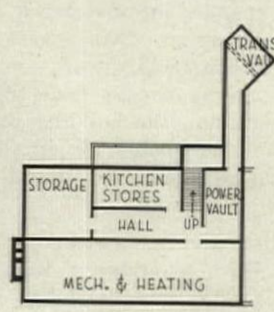


ROOF LEVEL PLAN 0 5 10 FT

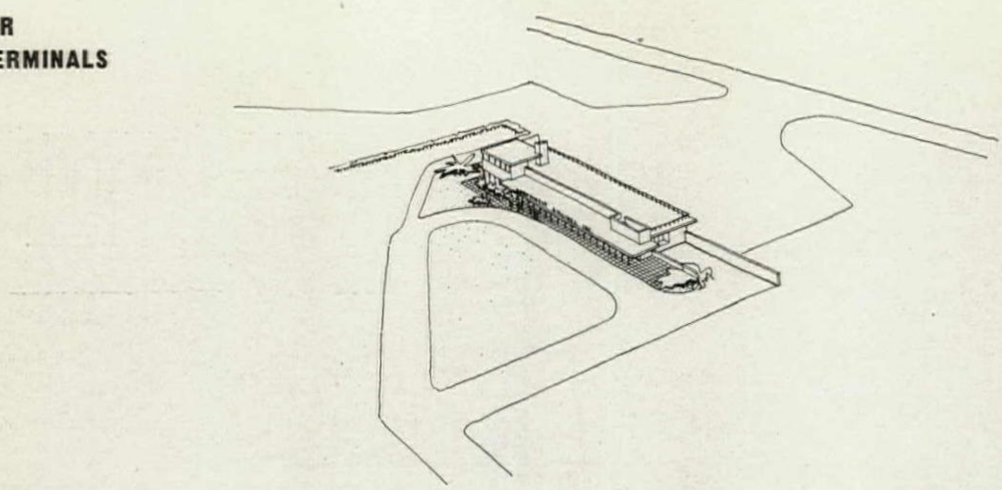


GROUND FLOOR PLAN 0 5 10 15 FT · · SCHEME A

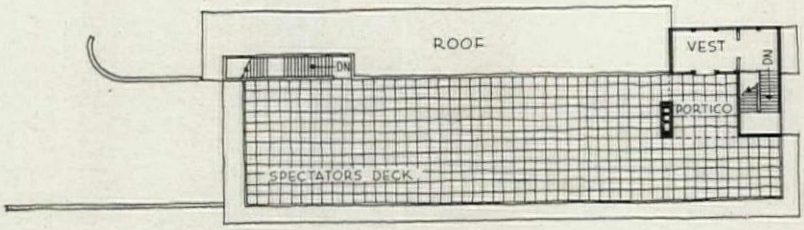
Gray areas in plans above show extent of public areas. In some cases, the concourse is considered to be entirely public space; but it might also be considered a passenger concourse, particularly if terminal units are added as indicated, and hence is here included in the area from which the general public might be excluded. Again, the toilets might be considered part of the unit terminal rather than public space; in so small a building one set of such facilities can serve both parts.



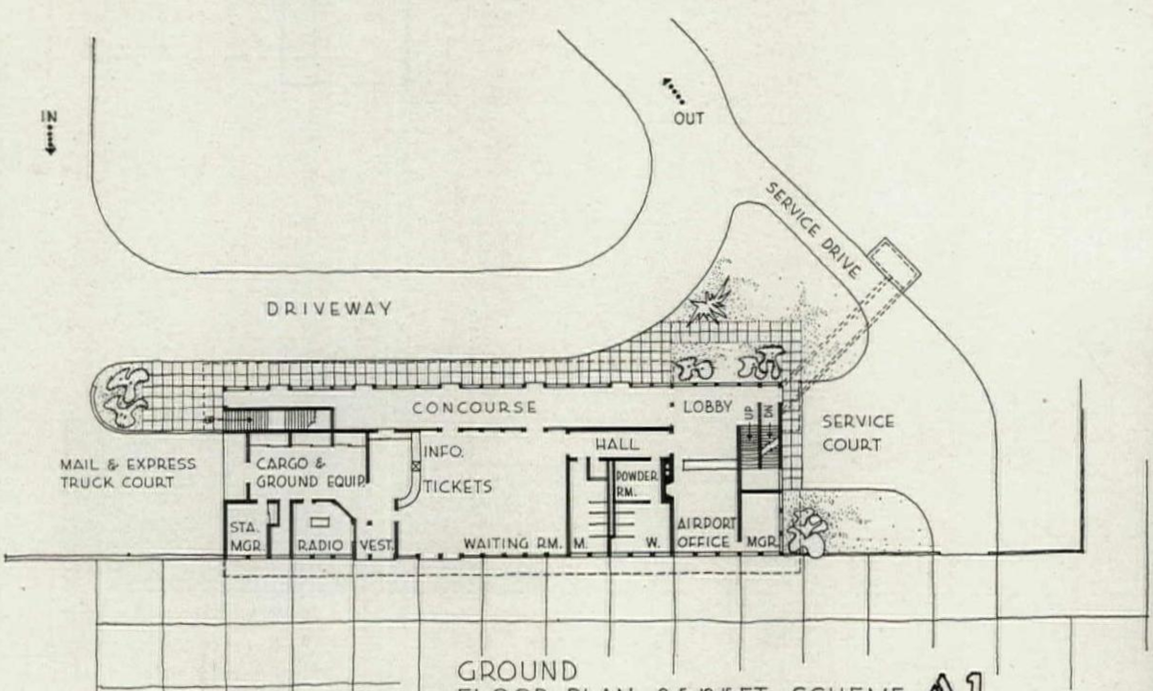
BASEMENT PLAN 0 5 10 FT



SECOND SCHEME FOR THE WENATCHEE ADMINISTRATION BUILDING



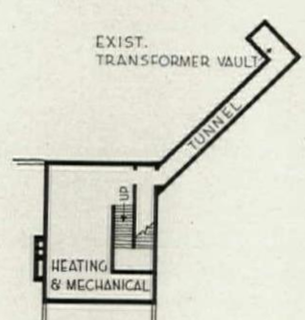
SECOND FLOOR PLAN



GROUND FLOOR PLAN 0 5 10 15 FT. SCHEME A1

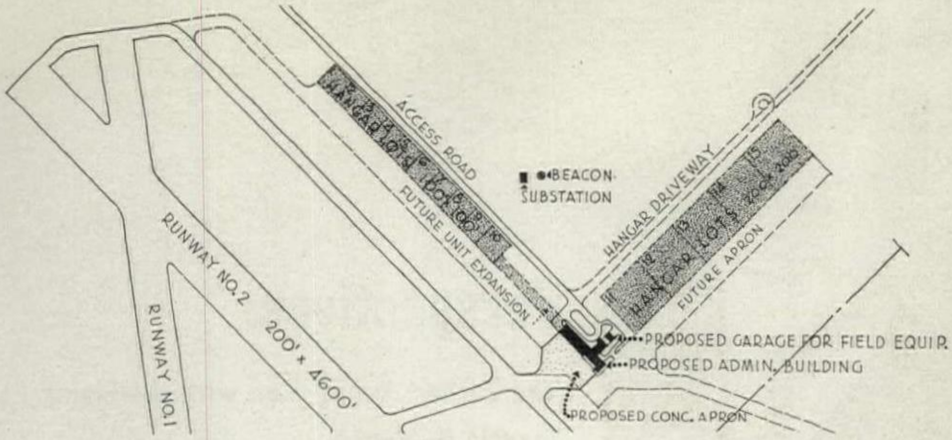
This second scheme would appear to be the most sensible type of solution for current needs, and can be expanded into Scheme A, shown on the preceding page, when conditions warrant. Like Scheme A, it is designed for "one-man" operation. Public facilities are limited to a deck for spectators, to which there is access directly from the walk and driveway. Aside from the unit terminal, the building contains only an office for the airport manager and his small staff. In all these schemes the amount of concrete paving necessary for initial traffic is held to a minimum.

According to the author, the V-shaped site, so common at CAA-planned ports, is one of the most difficult for which to design a terminal if proper automotive circulation, expandability, and flexibility in use are to receive due consideration.

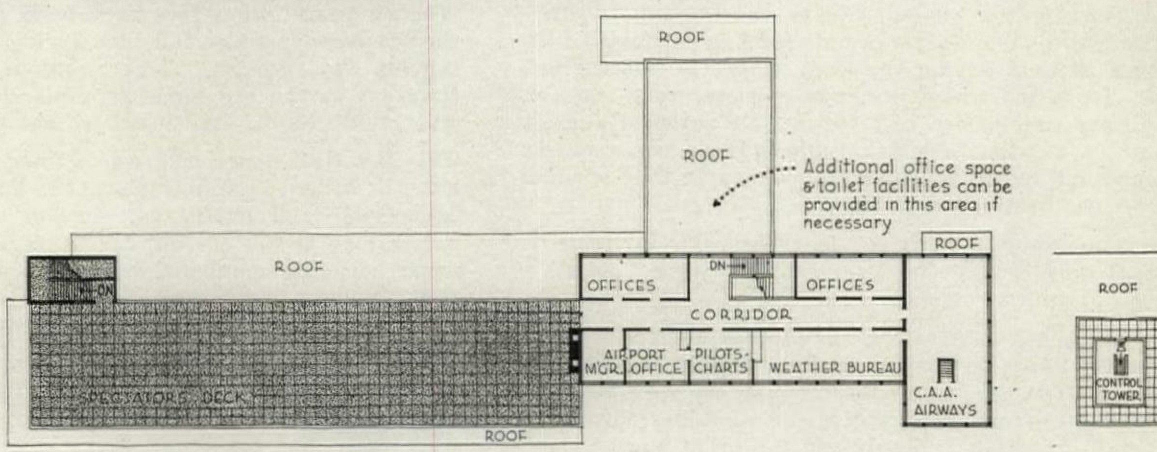


BASEMENT PLAN 0 5 10 15 FT.

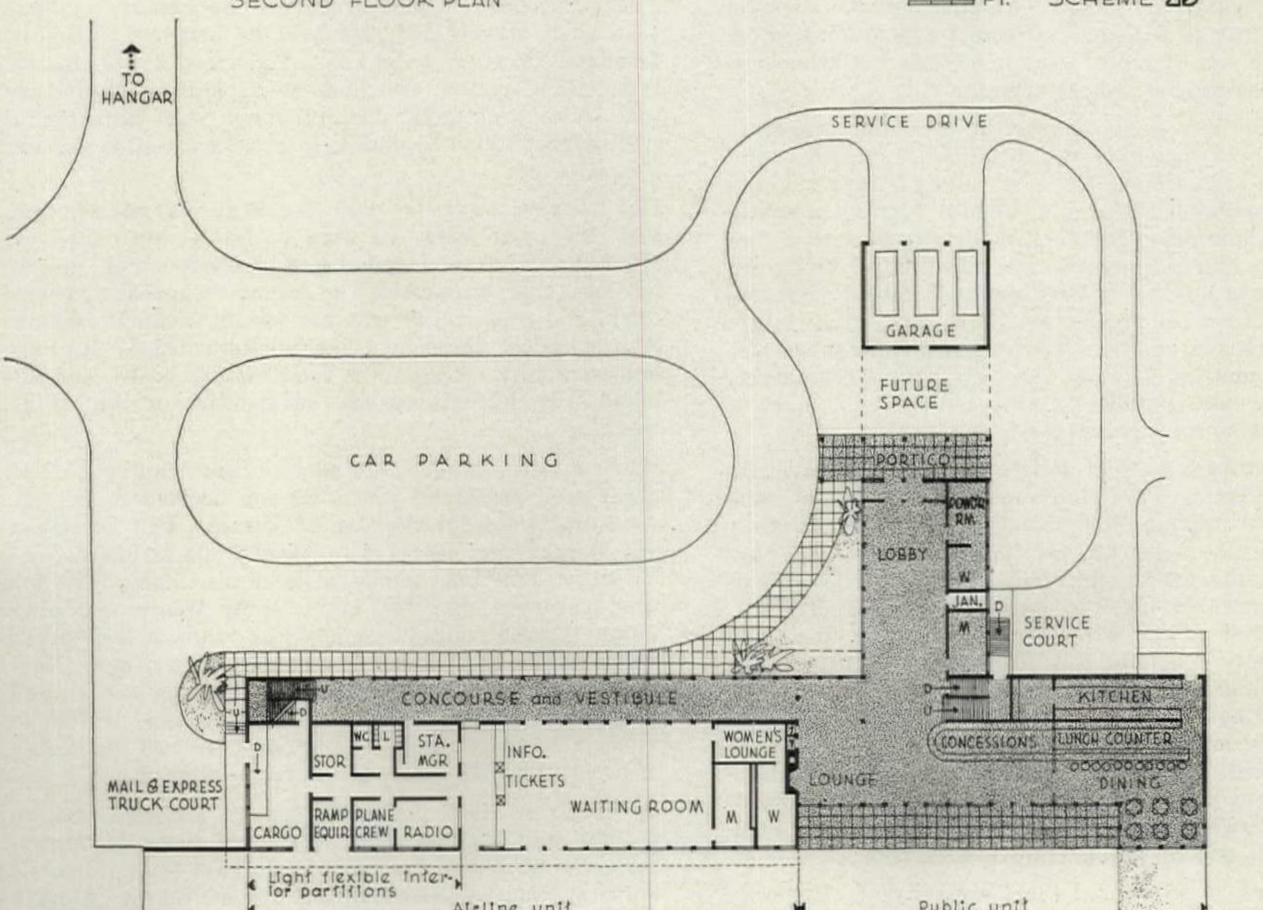
Plot plan for Scheme B, substantially similar to that for Scheme A, has provisions for two different kinds of hangars: small, for individual planes; large, to house several planes each. Only one access road is needed at present, although another can be added if needed. A building of this size seems unwarranted for present traffic volume and the forseeable future; it would require too large a staff for economical operation, particularly in airline offices. Basement plan is substantially the same as for previous schemes.



THIRD SCHEME FOR WENATCHEE SEEMS TOO AMBITIOUS



SECOND FLOOR PLAN 0 5 10 15 FT. SCHEME B TOWER



GROUND FLOOR PLAN 0 5 10 15 FT SCHEME B

Perspectives:

The Earnest Young Man with the Flying Parti: Francis R. Meisch

Although Francis Meisch has just celebrated his twenty-ninth birthday, he has a pretty good idea of the place to which he'd eventually like to retire. He was reasonably sure of the kind of higher education he wanted quite a while before it was time for him to start it. He looked around, during the early stages of the current war, for a job which would help prosecute it and, at the same time, had a rosy future. He satisfied himself that the aviation industry fulfilled these two requirements, and he got an architectural job with an airline. He's done pretty well at it.

He is not smug in being so sure of himself; far from it. He is only deadly serious about his work. Meisch's ideals are pretty strongly with him, at work or at play.

As long as he can remember, Francis R. Meisch has been interested—as he deprecatingly puts it—in drawing and painting. We aren't sure how far back his memory carries, so we can't tell you about his being born with a brush in his hand; but we can state that he was born, and where: in St. Paul, Minnesota, on October 9, 1915. That is a matter of record. Furthermore he lived in St. Paul until he finished his formal education, and St. Paul is the site of his present home office. Chronologically, the story goes something like this:

Meisch acquired some facility in sketching, together with an appreciation of nature, during summer vacations from high school. He spent most of these working on his grandmother's farm in the hilly country of southeastern Minnesota. The facility developed into a certain ability and led, before high school days were over, to an intense interest in architecture. By the time college days came along, he was sure that architecture was to be his profession, even though those were also the days immediately after the New York stock market hit bottom, when architects were selling their share of apples on city street corners.

When he entered college, Meisch had already read both Louis Sullivan's "Autobiography of an Idea" and Wright's "Autobiography." He expected to find the study of architecture a logical, exciting adventure. He says he was disappointed to find that the best "philosophy of design" available involved considerable cold cribbing. It was rather an unpleasant experience, that freshman year; faculty and students alike were confused over what architecture really was. Meisch began to wonder if his reading had misled him. He felt pretty bad over it at times, and after one year he quit to go to work for an architect—any architect—to find out for himself whether architecture *was* the glamorously idealistic profession he had envisioned, or just another business, albeit one in which facility with a pencil helped.

By the time he re-entered the University of Minnesota he had a feeling that he knew what he wanted out of a formal education. He worked his way through a five-year course in four and a quarter years and got his degree in March, 1939. His earlier practice at landscape sketching helped mightily, enabling him to do renderings and other free lance work part time during the academic year and full time during vacations. Working his way through college meant no janitorial jobs; it meant furthering himself in his chosen profession. Everything he did he turned to that same account.

This practical experience was gained in offices fairly close to home—in Minneapolis, St. Paul, and Eveleth, Minnesota; and in the St. Anthony Falls Hydraulic Laboratory at his University. It varied in kind from small homes to municipal buildings, from hospitals to power plants; and a good half of it was what even he calls engineering, rather than architectural, in nature.

In 1939, with a graduate scholarship to his credit, he entered Massachusetts Institute of Technology. After getting his Master's in 1940 at Cambridge he went back west again, but not home. For a year he instructed in the Department of Architecture at North Dakota Agricultural College, where he taught Sophomore Design, assisted in the other design courses, and had classes in freehand drawing, water color, history of furniture and interior decoration, and history of painting and sculpture. The architectural department was quite small. An instructor had to double in brass as well as possess lots of it.

Defense was the cry in 1940. Anybody who had his eyes and ears open knew we were in for a war ourselves. Besides, "defense" entailed lots of construction jobs if not lots of architecture. The combined appeal of patriotism and practicality was not lost on Francis Meisch. At the end of the school year he returned to St. Paul and went to work again at the drafting board, and debated with himself on the advisability of continuing teaching.

When a defense job in a part of the country he had never seen presented itself, Meisch decided to take it. As a draftsman for the firm of Shanley, Van Teylingen and Henningson, he went to Great Falls and West Yellowstone, Montana, and to Idaho Falls, Idaho. The job was concerned with the U. S. Army Winter Training Camp program, and, like many war projects, was terminated before it reached the construction stage. Next he went to work in Las Vegas, Nevada, for the McNeil Construction Company of Los Angeles, as a draftsman in their engineering unit. The job here was the design of contractor's facilities for a magnesium plant.

By this time 1942 had rolled along, Meisch began to feel the need of some permanent connection. He remembered the boost the first world war gave the automobile industry, and he looked around for a field which could expect the same stimulus from World War II, one whose ground-floor doors were still open. Aviation was, of course, the answer. But Meisch wasn't satisfied with "aviation" in general; he took a long, hard look at aviation manufacturing and decided it was by no means as attractive as the business of commercial airline operation. Air transport had scraped along for years, with most airlines running on financial shoestrings. The war boomed them. He didn't see how their business could decrease after the war; by all the signs it should expand as only a few had previously dreamed it could. Manufacture of aircraft, on the other hand, would probably be a rather tough business once military contracts ceased. So, on the score of prospects, air transport was his choice.

What about the need for architectural services? Could he justify being an architect for an airline? He rather thought he could. He got a job in the engineering department of Northwest Airlines, whose home offices are in St. Paul. That was in February, 1942, and he has been plugging away excitedly at buildings and facilities for airlines ever since.

Ton-mile costs now roll glibly off the end of his tongue, to be translated, by the time they become pencil scratches on a luncheon tablecloth, into more efficient buildings—offices, terminals, overhaul shops, etc.—or airports, or headquarters, or any phase of aviation construction to which design talent can be applied. In ordinary times, "ever since 1942" would not be a very long period, but during an air war and in the aviation industry it is the equivalent of a normal decade. Meisch did not come by his familiarity with ton-mile rates without an intense apprenticeship.

In the course of his work for the airline he had as his first project the completion of, and installation of machinery and equipment in, a shop addition to Northwest's main overhaul hangar. There followed one project after another related to war contract construction: more shops, offices, restaurant facilities, and other work. A major job was the design and setting up of a large outdoor bomber modification center, complete even to utilities and equipment. This was in a terrific rush, and was handled by the Army's Corps of Engineers after development of the basic scheme. There was another, more complex modification center, set up by the airline, and there were hangars for the Air Transport Command.

Meisch's guess about the future of air transport seems confirmed by one phase of his current activities. Soon after the tremendous importance of military aviation was recognized, and larger, faster, more powerful planes were designed and built, all kinds of municipalities, from the largest to the smallest, began thinking and asking questions about expanding airports, building new airports, providing new administration buildings and the like, and getting and sustaining airline service. The Engineering Division of Northwest Airlines was flooded with requests for advice, opinions, information.

The Engineering Division began to get uncomfortable about the situation. They did not customarily wear turbans, nor did they peer into crystal balls. Their company was far too occupied with the day-to-day problems of running the business to give such requests the serious attention everybody realized they deserved. It became apparent that somebody had to do some research, and consequently the Engineering Department, in addition to being concerned with design and construction, found itself studying, analyzing, collating, drawing conclusions on postwar airport and airport building design problems. It had to be 'way ahead of the rest of its company's departments. Not only did it have to solve existing problems, it had also to anticipate the problems of the next few years, and find solutions for them.

That is progressive architecture indeed! Is it any wonder that Meisch is excited over it? Only twenty-nine, and with a bear by the tail—if he weren't a phlegmatic Minnesotan, the mere prospect would be his ruination. At times it must exasperate him to have to deal in today's stodgy realities. As it is, he works with a Plant Engineering Section to which he gives much credit, under a Chief Engineer and Chief Plant Engineer who apparently have high regard for his abilities. The majority of his company's airport and airport building problems and design are routed to Meisch.

In 1942, the same year that he went to work for Northwest, Meisch married Elaine Hanson, interior decorator, whom he met working over a drafting table. His year-old son exhibits talents more destructive than constructive—a common enough failing at that age. As is common, too, in these days, his job cuts deeply into his personal life; in truth, he is more subject than most of us to absences from home. Expected and unexpected travel, much of it by air, often takes him away for days on end. If he finds spare time, he reads, paints, or sketches in water color, but he has to forego etching, an old love, because he has neither the time nor an etching press.

Francis Meisch's grandfather settled the family homestead, the four quarter-sections in southeast Minnesota where a younger Meisch spent his high school vacations. The original farmhouse and outbuildings stood in a river valley from which spread small wild canyons whose sides were steep, eroded bluffs. The stand of buildings has since been replaced by one farther back from the principal valley, closer to the more profitable farmland which the family accumulated as it prospered.

Some day Meisch hopes to build his own family a home on the fairly level top of one of the spurs between the finger-like ravines, above the site of the old homestead. The view up and down the valley is superb, he says; and the sunsets are gorgeous. He hopes he won't be so busy, so he can sit outdoors and paint, and smoke the pipe he prefers to the more convenient cigarette, while, perhaps, he discourses with a friend pleasantly, if rather earnestly, about the merits as students of young men from Middlewestern farms, young men to whom spring-houses and barns and silos are architecture, to whom a ten-story building is a novel sight, to whom eggs and darts are henfruit and arrows. He found them pretty good material when he was teaching, 'way back before he got into that air transport game.

Meisch, Vernon Lundquist, Northwest's Chief Plant Engineer, and Richard Frahm, architectural designer, discuss an airport planning problem.

Developed Under Supervision

An Integrated, Long-Range Plan for the

BY EDWIN A. KEEBLE*

THE WORK OF INTEGRATED AIRPORT PLANNING has dual characteristics: it is large-scale planning of the first order; yet, to serve its function properly and to keep pace with developments in planes and aviation in general, it must be absolutely as accurate in design, construction, and detail as a B-29. Obviously no one man could build a B-29. Numerous experts and functions are involved: engineers, aviators, production men, bankers, public agencies, and so on; all play their parts. Similarly, a successful solution to the highly complex problem of creating a great airport, used by various agencies and groups, demands the abilities of several individuals and specialists. The story told here shows how the architect's special abilities fit him for the job of master coordination in such multi-faceted planning.

The model for Nashville's airport development shows the relation of the parallel-runway field layout to the airways station (center foreground), an aircraft plant (left of station), a cargo terminal (horseshoe-shaped structure), and National Guard and commercial facilities (aprons in background). Note, also, the car-to-plane driveway scheme.

Separation of functions on different levels is apparent in this sketch of the motor approach to the airways station. At the lower level is the service truck dock, with work space above. Private cars, buses, or taxis drive up directly to the main concourse entrance or turn to enter parking space near the plane stations.

Few realize the position in which badly planned airport facilities placed us at the beginning of the war. This must never happen again. Unless we are extremely vigilant, we are now in the last war in which our continent will remain unmolested. In the future, concentrated attacks by air can be met only with similar tactics. It is therefore criminal negligence, if not sabotage, to permit airports to grow like carbuncles, as most of them have in the past. And this applies quite as much to the development of our commercial air life lines as it does to ports designed partly or entirely for military use.

In this vital work, the architectural profession has both the opportunity and the ability to serve. Indeed, the challenge is too broad not to include in the scope of its solution all of the effort and skill which every interested agency and planning profession has to offer. Nor is this merely a theoretical proposal; experience already exists to show that, with a studied planning approach to the problem, the various agencies and groups cooperate to the fullest.

Background

The planning of Nashville's airport has been an active process for a number of years. The degree of intensity and the range ahead have varied, but the process has continued. It has graduated—slowly at first, abruptly under the impetus of war—from the old depression state when municipal authorities were unable, usually for financial reasons, to utilize longe-range professional planning.

In retrospect, it must be remembered, however, that men like WPA Director Col. Harry Berry (for whom the Nashville field is named) were "selling" airports to a very skeptical public. At that time plans were often spot decisions by public-agency engineers who were already exhausted by a multiplicity of detail on problems incidental to the gigantic relief effort. These men gave their best, but what could we expect from tired men "going from place to place, some weeks designing an airport a day"?

In at least one important respect, Nashville's record is more fortunate than that of most cities: careful study of the initial problem and a smart decision by the original airport committee, based on a full engineering report, resulted some ten years ago in the selection of an excellent site $4\frac{1}{2}$ miles from the center of the city.

* Formerly of the Nashville firm of Warfield and Keeble, Architects. At present a Lieutenant with the U. S. Naval Reserve.

# of an "Airport Architect"

Nashville, Tennessee, Airport

The development of the port itself, however, while not exactly haphazard, progressed in a typically uncontrolled manner. Each of the several interested groups went ahead more or less intelligently, but independently, without benefit of coordination or agreement on common long-range objectives. When in 1939 a plan was suggested to provide future multiple runways for possible military needs, it should really have come as no surprise to receive the reply that we did: "This is no military airport. The Army can build its own airports." All Nashville was aroused when the Army concluded that further development of the airport for army use would be uneconomical. Everyone wanted to know why.

Action

From that day on, the story of the port's development has been logical, swift, and coordinated. The citizenry has firmly backed Nashville's aviation-conscious Mayor, Thomas L. Cummings, in his efforts to get to the bottom of the problem in an orderly and systematic way. The results have been unique and interesting.

The first move was the employment of an Airport Architect! Tennessee's progressive Bureau of Aeronautics agreed to provide funds for the initial work. Then followed an outstanding coordinated effort.

In the work, the following were involved: the City of Nashville, Davidson County and Tennessee State Highway Departments, the Army Air Corps, American and Eastern Airlines, the Tennessee National Guard, Consolidated Vultee Aircraft Corporation, the City and County Planning Commission, TVA power lines, many interested land owners, and hundreds of private flyers. With the facilities that existed before the coordinated program was set up, no one of these could undertake alone a detailed study of every problem involved, give the day-to-day attention required for a sensible solution, or persuade other groups or individuals to fall in line.

The first big job undertaken by the airport architect, with the aid of the City and County Planning Engineer, Charles Hawkins, and his staff, was to prepare data to prove to the Army that there was no better place in the area than Nashville for the development of a first-class airport.

From this, developmental plans were prepared showing a future field with a traffic capacity substantially in excess of existing fields in America's largest metropolitan areas. Drawings of outstanding airports were reproduced at the same scale as the Nashville drawings to demonstrate relative possibilities.

When the Army Colonel in charge said: "Let's get practical about this thing," he was perhaps surprised to be presented not only with detailed estimates based on a TVA, WPA, Vultee, joint-sponsored contour map, but unit costs from the latest experience of the District Engineer's office, plus a statement from the Mayor that the City was ready to buy the additional land as necessary.

Results to Date

The project went ahead. Many a diplomatic campaign was conducted to keep the parallel runways parallel and to prevent buildings from being built on space assigned to future runways. The Air Transport Command units stationed at the field, the U. S. Engineers supervising the work, the management of Consolidated Vultee, etc., joined forces to "hold the fort."

Meanwhile, the City authorized the architect to prepare preliminary developmental plans for the airways station as well as the field. By now everyone understood that these elements were as inseparable as is the wing from a plane. The Civil Aeronautics Authority rendered its usual indispensable cooperation and assistance relative to field standards and layout. The airlines, through their research departments, aided substantially in the solution of both field and station problems.

While preliminary plans are now fully developed, exact space uses and adjustments are still in the process of study. Changes will be made, of course; but the project will be kept alive and ready for the day when it can go forward smoothly, rather than as a last-minute conception based on high-point surveys, high-pressure decisions, and mediocre compromises. Nashville not only intends to achieve one of the world's most appropriate airports, but to eliminate the waste of public funds inevitably involved in haphazard, nonintegrated, or superficial planning.

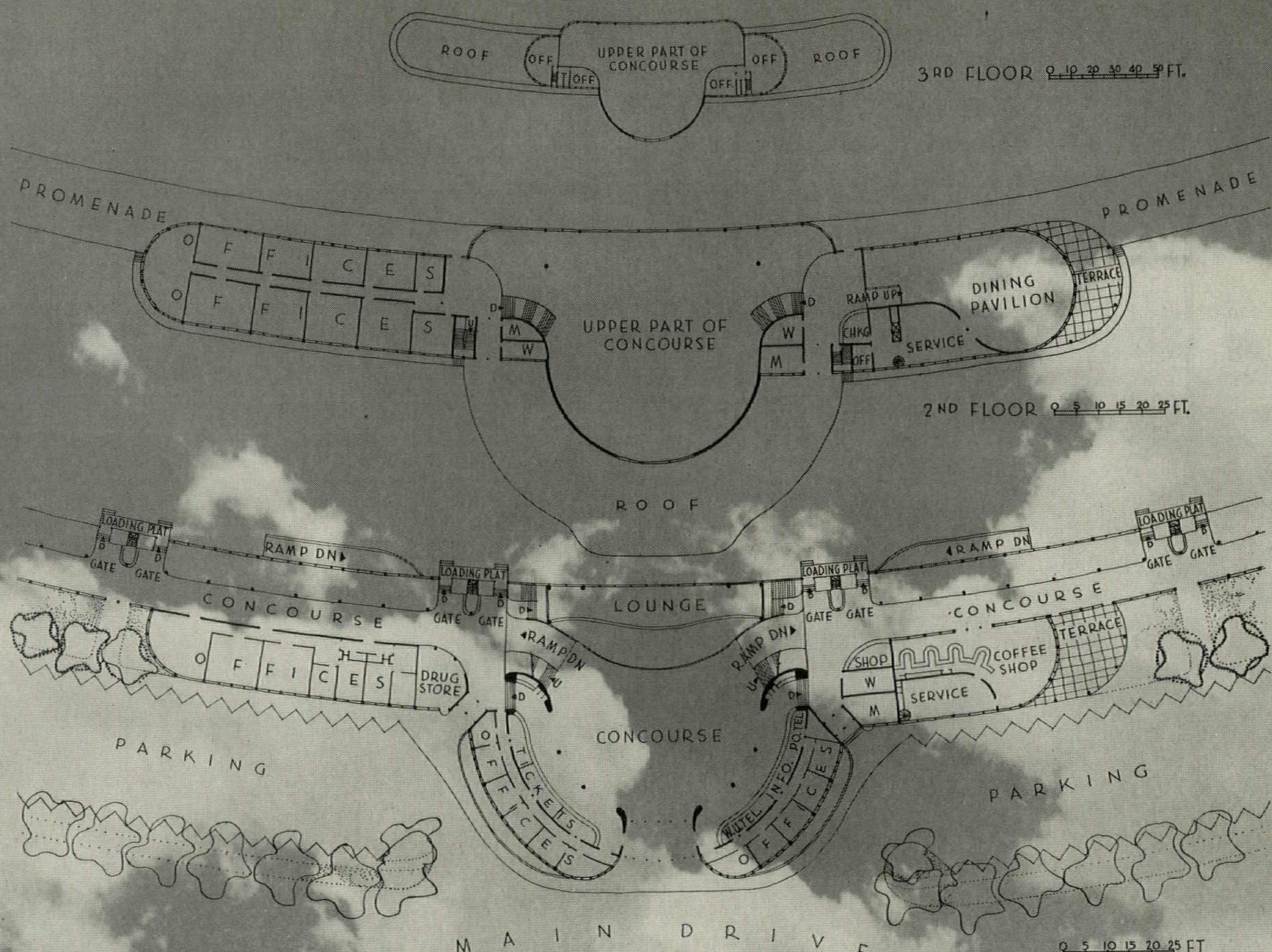
Planning Principles

If any one guiding principle may be said to underlie the total concept of Berry Field's development, it is the importance of holding transit time to a minimum. Regard for the comfort and convenience of air travelers, so often compromised in airport schemes, has resulted in a coordinated effort at every level.

As already mentioned, the site was fortunately selected at a convenient distance from downtown Nashville. To implement this advantage, a four-lane State highway, with center grass plots and grade separations at busy crossings, has been built from the city limits direct to the port; another highway installed by the County joins the port and the largest residential area, and blueprints are ready—and funds available—for a City boulevard to connect the State highway with the center of the city proper.

Every effort is being made to insure for all time that a trip to the airport will not exceed ten minutes. This in itself, however, is only part of the problem. Unless the airport station is also planned to minimize time, the advantage gained by swift travel from city to port can be seriously jeopardized. Thus, in the projected design for the terminal building, the comfort and convenience of the passengers—easy transfer from plane to car, bus, or cab, and vice versa—have been the reference points used throughout.

For private cars, there will be *adequate* parking space so arranged that persons meeting or seeing passengers off may park close to a particular plane station. To indicate the way to Stations 8, 12, 15, 19, or whatever, there will be road markers along the access driveways guiding the driver into the proper channel. A curbside information booth will further aid the incoming motorist. *(Continued on page 66)*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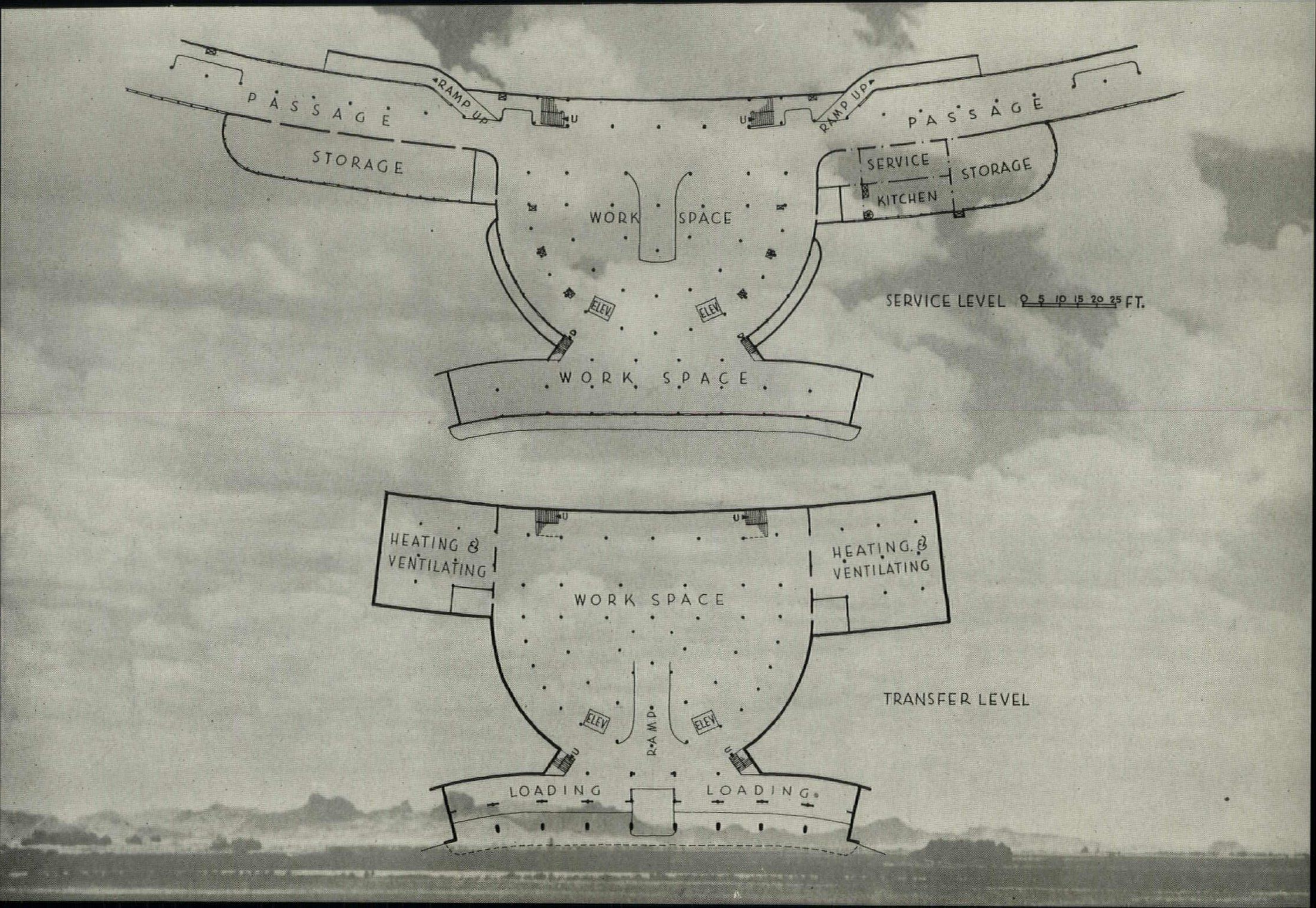

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LOADING
LOADING
TRANSFER LEVEL

Later studies of the individual plane-station entrances and exits make provision for unobstructed access for buses and taxis to all plane stations. Each pair of access gates is designed to serve not more than four planes. Through collaboration with the airlines, baggage will be handled only once and will be waiting at the curb when the arriving passenger reaches his cab, bus, or private car.

Snack bars, lounges, and rest rooms, distributed along the enclosed concourse ramp, will be extended as traffic demands. The main dining room, coffee shop, movie, drug store, novelty shop, barber shop, etc., are centrally located.

The station is to be built in stages. Each unit, such as the dining room, reservations offices, etc., may be added to individually or collectively as needed. Drives and parking spaces are of course integral parts of the scheme, designed to grow along with it.

Mail and express are wholly separated from passenger circulation. Located on a lower level, along with incidental offices, the space will be arranged to accommodate standard small motor vehicles, if desired, with ramps up to the field at the various plane stations. When occasion demands, an ambulance or diplomatic car can use the same system to reach a plane door.

Long-Range Considerations

From time to time the question is asked, "What need has Nashville for all of this?" A few of the more interesting statistics tell the story. Nashville's airport has never lost money. Prewar figures indicated about 600,000 passengers per year into, out of, or through such cities as New York, London, Paris, and Berlin at their peaks. Airline planes using the Nashville airport had a capacity of approximately 400,000 passengers per year. 500 complete plane movements per day was a 60-day average before the Army took over the airport.

Some 25,000 to 30,000 persons per day enter, leave, or pass through the city. Air transport is making a serious bid for a large part of this business. The city should continue to grow. Its airport could be expanded in an orderly fashion to handle the entire number if need be.

Meantime, full use will be made of the existing facilities by all types of commercial planes. "Air Parks" are being planned for private flying. One or more of these will be capable of expansion into a field similar to the principal one. This would also absorb cargo traffic when passenger requirements demand full use of Berry Field.

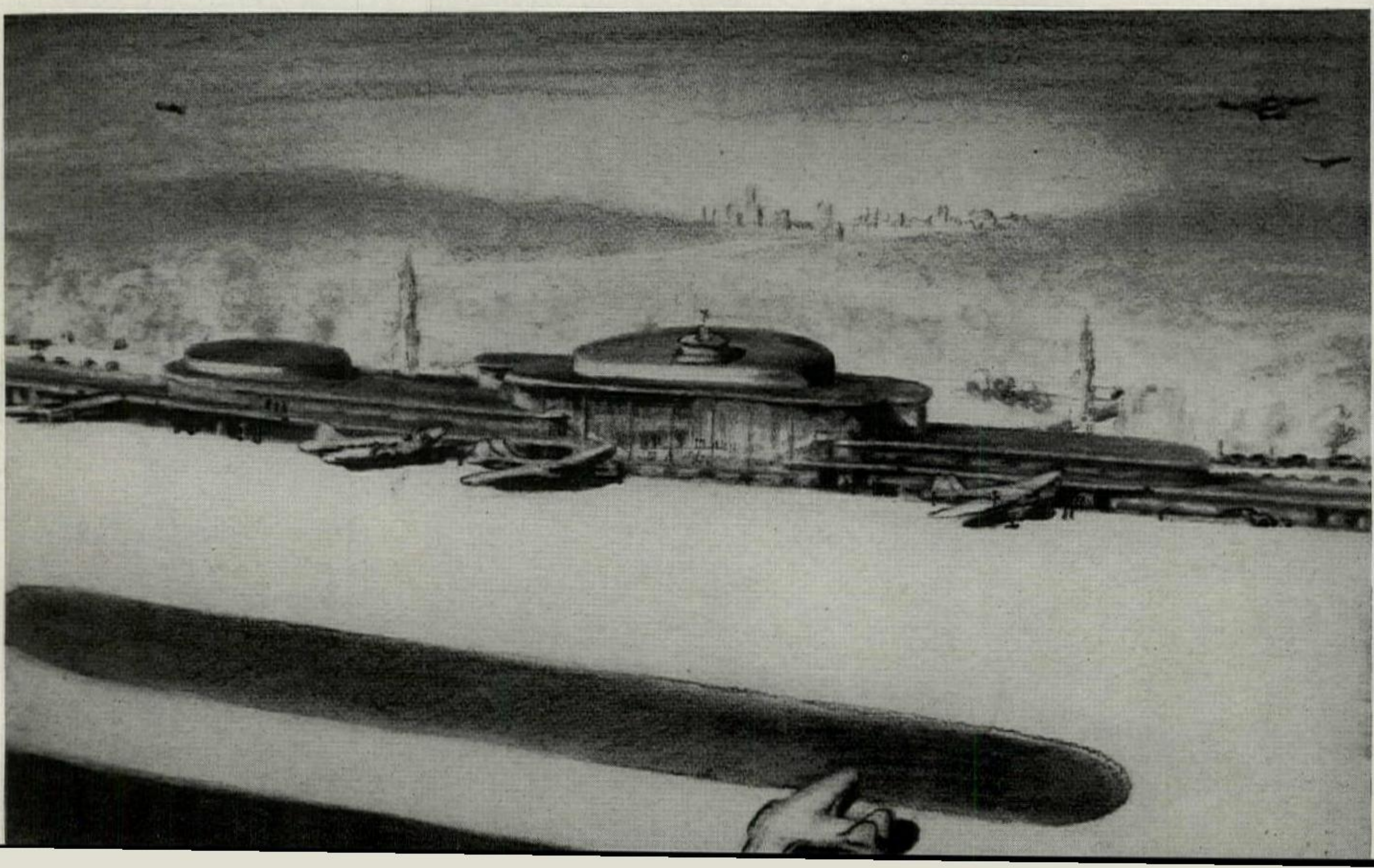
Nor has an accurate valuation of growing air center activities been overlooked. Every city is frantically drawing its cart wheel of airlines. Nashville had one in 1931. It projected lines in eleven directions, connecting the nation's most important commercial areas by straight lines crossing at a logical refueling point. Ten have been operated or are immediately contemplated.

The runways are now more than 5,000 feet in length. Space for their extension to 7,500 feet is available, if and when needed. Ultimate lengths of 10,000 feet will be retained as possibilities in the scheme.

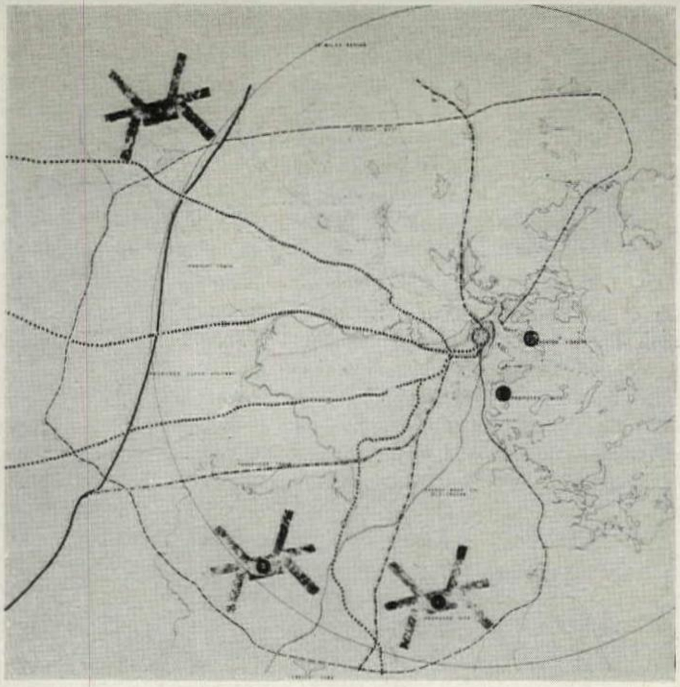
Along such lines the problem has been studied. Consequently this city was probably the first to have a definite plan for its airport which provided enough field traffic capacity for future needs combined with enough plane stations to absorb the field capacity.

In this entire development of the Nashville port, its buildings, and its relation to the city and the region, it is important for the architectural profession to realize the part that the architect played as master coordinator, and the new dimension that this function brings to the word "architecture." This could never have been done on the basis of the attitude that classifies architecture as mere frosting. Nor has the opinion that "there is no 'architecture' to it" produced any spectacularly successful airports. The profession must complete the process of correcting the "ivory tower" ideology in order to earn the right to serve in a capacity where it is so badly needed.

On the field side of the building are multiple plane-station entrances at either side of the main block



Boston was chosen by the designers as a good location for a terminal cargo airport because of its industrial importance, its future air cargo expectancy (estimated at a million tons annually), and its favorable geographic position, 200 miles nearer Europe than any other large American port. The site first selected was the Old Harbor district near rail yards, ship docks, and business center. For various reasons this was abandoned, however, and three outlying sites were selected as preferable alternates. These are about 15 miles from the center of town, suitable land is available, and they are near existing highways and railroads. A possible future railroad freight belt, proposed by Dr. Martin Wagner, would also pass near each.



PROJECT FOR AN AIR CARGO TERMINAL

Jorge Gonzalez-Reyna and Yusuf Meer, Designers

Two advanced students in the Graduate School of Design at Harvard University, Jorge Gonzalez-Reyna of Mexico, and Yusuf Meer of Iraq, while working early last spring on their problem of designing a Cargo Air Terminal for Boston, evolved a highly ingenious system for the efficient handling of air cargo from plane to warehouse to truck and vice versa. Since the rate at which commercial air cargo flying can develop in future depends greatly upon costs, any study of the problem of rapid, large-scale transshipment from plane to ground transportation at the airport is worth while as an attempt at reducing costs. The scheme presented here has already aroused some interest among officials and engineers of one of the leading air lines, and the two designers have applied for patents covering a number of original mechanical features incorporated in their design.

The future of air cargo flying is considered by many aviation authorities to be a highly promising one, with tremendous possibilities for expansion. From small beginnings a decade or more ago in this country, the air express business has grown rapidly and steadily until in 1942 almost 12 million ton-miles were flown. This much was accomplished using the facilities of the regular commercial airlines' systems, with airports designed primarily for handling passenger business. During this period, costs per ton-mile have been steadily reduced, indicating that as further progress is made after the war, more and more articles of commerce can be profitably shipped by air. Much study has already been given to the possibilities of long-distance shipment of fruits and produce. Savings resulting from the elimination, through high-speed transportation, of spoilage in such perishable goods as strawberries and lettuce, may soon be great enough to overcome the difference between rail or truck rates and those of air carriers. When that point is reached, there will be an increasing need for airports and terminals especially designed to handle this type of business.

This particular air terminal design (shown in plan on the following page) was laid out to provide ideal conditions for handling one million tons of cargo a year. Three warehouses, each able to handle 400,000 tons of this, stand on the large apron, reaching out their conveyor belt-loading mechanisms like huge arms to receive the incoming and outgoing planes. Four 10,000-foot runways extend in two compass directions, considered adequate for the wind conditions at the selected site. Behind the warehouse lie parking spaces, and beyond them are hangars for the large planes. Feeder planes are presumed to be taken care of by hangars on other fields.

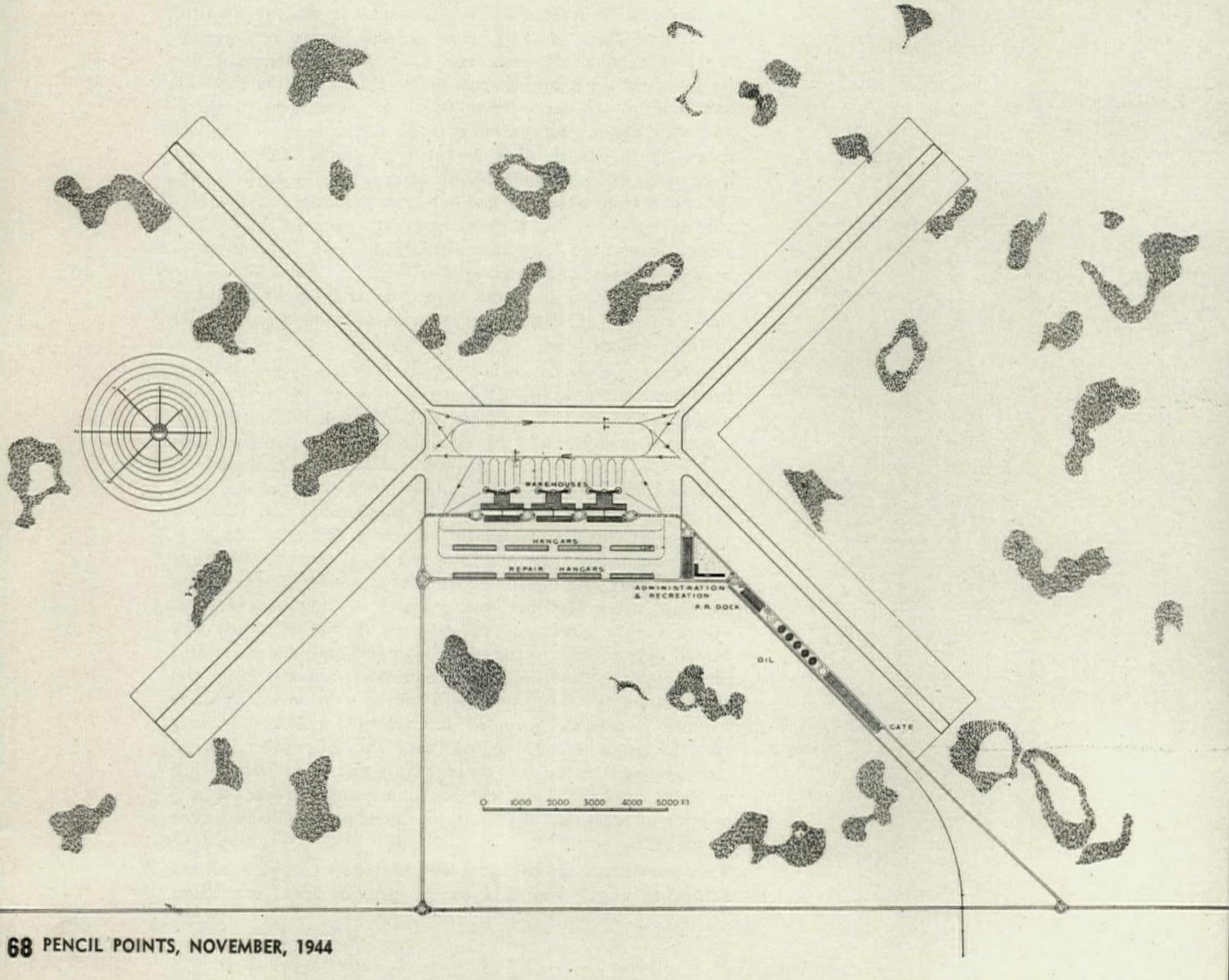
Ground circulation of planes is indicated on the drawings. Crossings have been eliminated. Most of the ground transportation for cargo will be furnished by trucks but a rail spur, equipped with docks, will bring in and take out a small part of the total volume. The principal use of the railroad, however, is to bring in fuel and supplies for the hangars. An administration building adjoins the end of the railroad line.

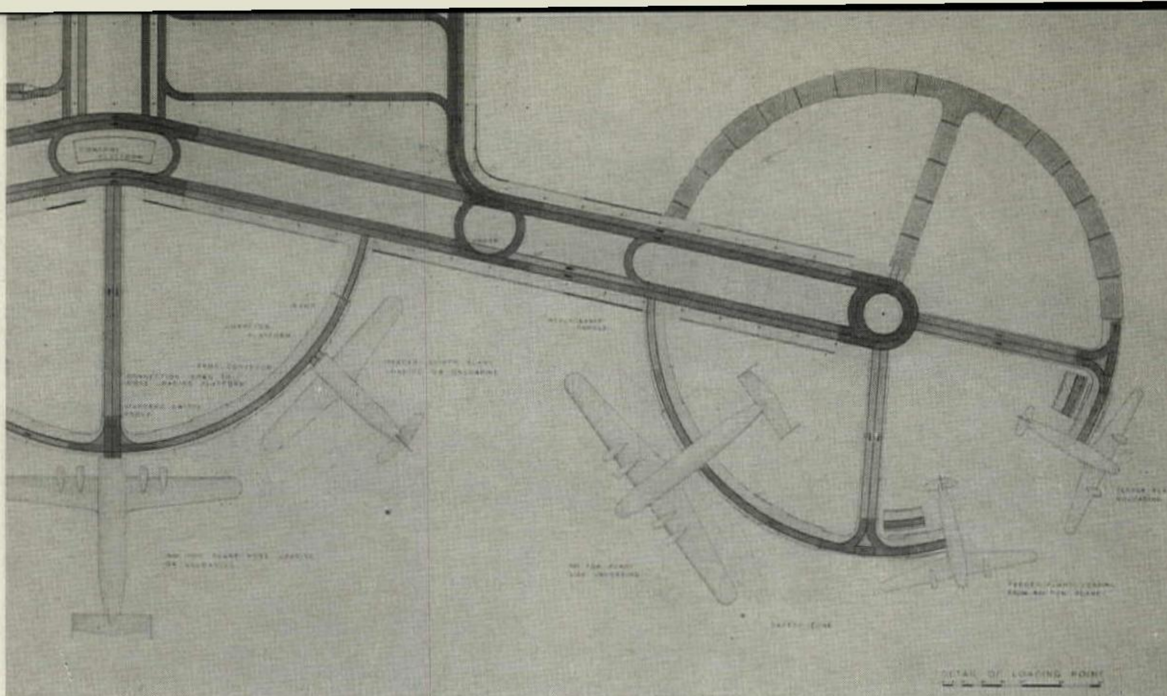
The most interesting feature is, of course, the warehouse design, with its special conveyor system. Two possible types of airport warehouses were studied. In the first, which is not illustrated but which is essentially similar in operation to the one shown, no cargo has to be crated. The packages, already in standard size crates, would be brought by truck to the warehouse a reasonably safe time ahead of their scheduled departure by plane. After being properly recorded and sorted, they would be stored for but a short time on the warehouse floor in preassembled rows according to destination, ready to be quickly put on the conveyor belt at the right time to synchronize with the arrival of the plane at its loading point. Cargo arriving by plane would likewise be stored for only a short time before being loaded on trucks for delivery. The storage area of this type of warehouse could therefore be somewhat smaller and the operations would be relatively simple. Both types would have an adequate cold storage room.

In the larger type, plans of which are shown on page 72, uncrated packages from a number of sources would be received at the warehouse from trucks, picked up along the covered trucking platform by a cargo train of tractor-drawn hand trucks, and transferred to the receiving belt. After recording, sorting, and crating, they would be taken to the proper storage space or to the loading point of the conveyor system and thence to the waiting planes.

CARGO AIRPORT

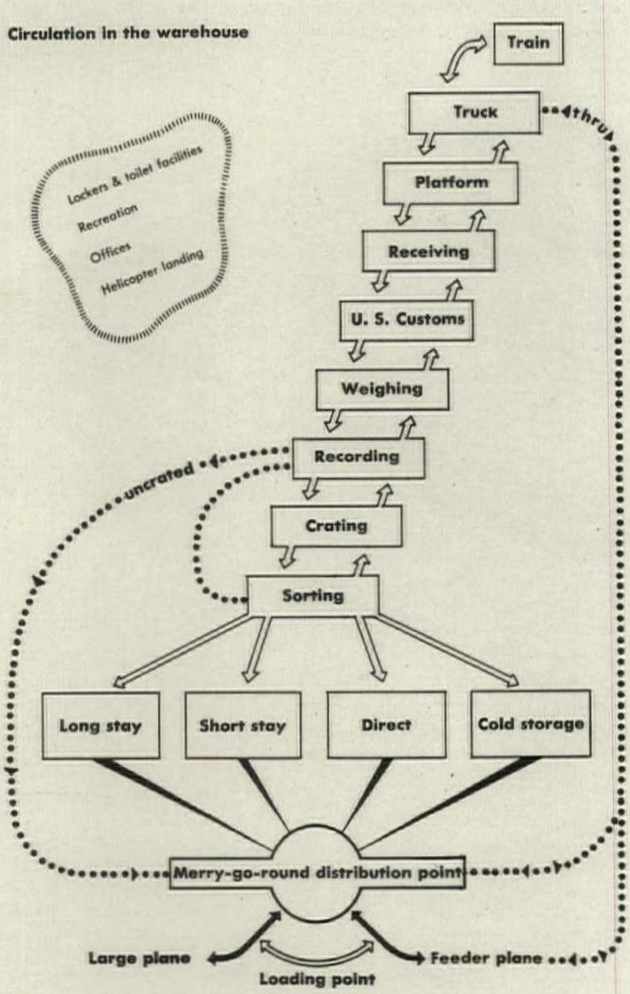
Plan of the proposed cargo air terminal designed to increase speed of transshipment between planes and surface carriers, thereby reducing ton-mile cost from origin to destination and tending to increase volume of traffic handled.

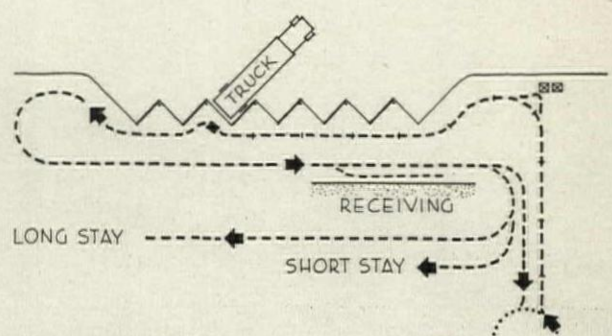


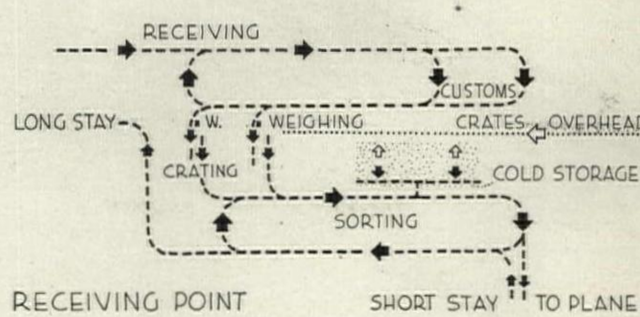


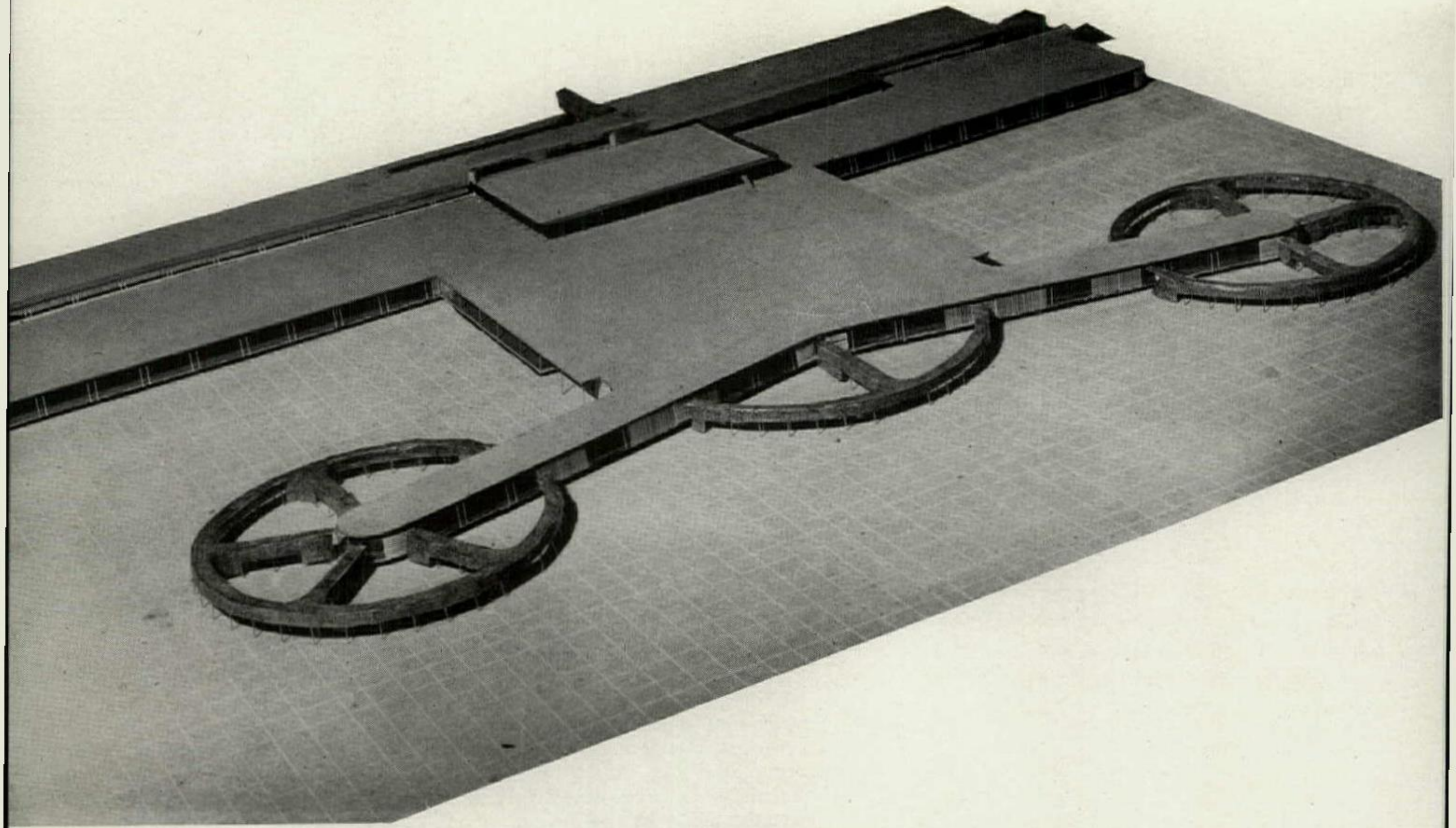
Plan of detail of conveyor system at loading point, with portable sections permitting simultaneous side-loading and nose-loading of large and small planes. Note that some portable conveyor units are arranged to telescope together to permit entry of planes, while others are moved out of the way. The entire belt system is designed to circulate the cargo selectively and rapidly in accord with the analysis charted below at the left. The small charts in the right hand column show diagramatically the movement of cargo through the warehouse, the lower one being a detail of operations taking place at or near the receiving point.

Circulation in the warehouse

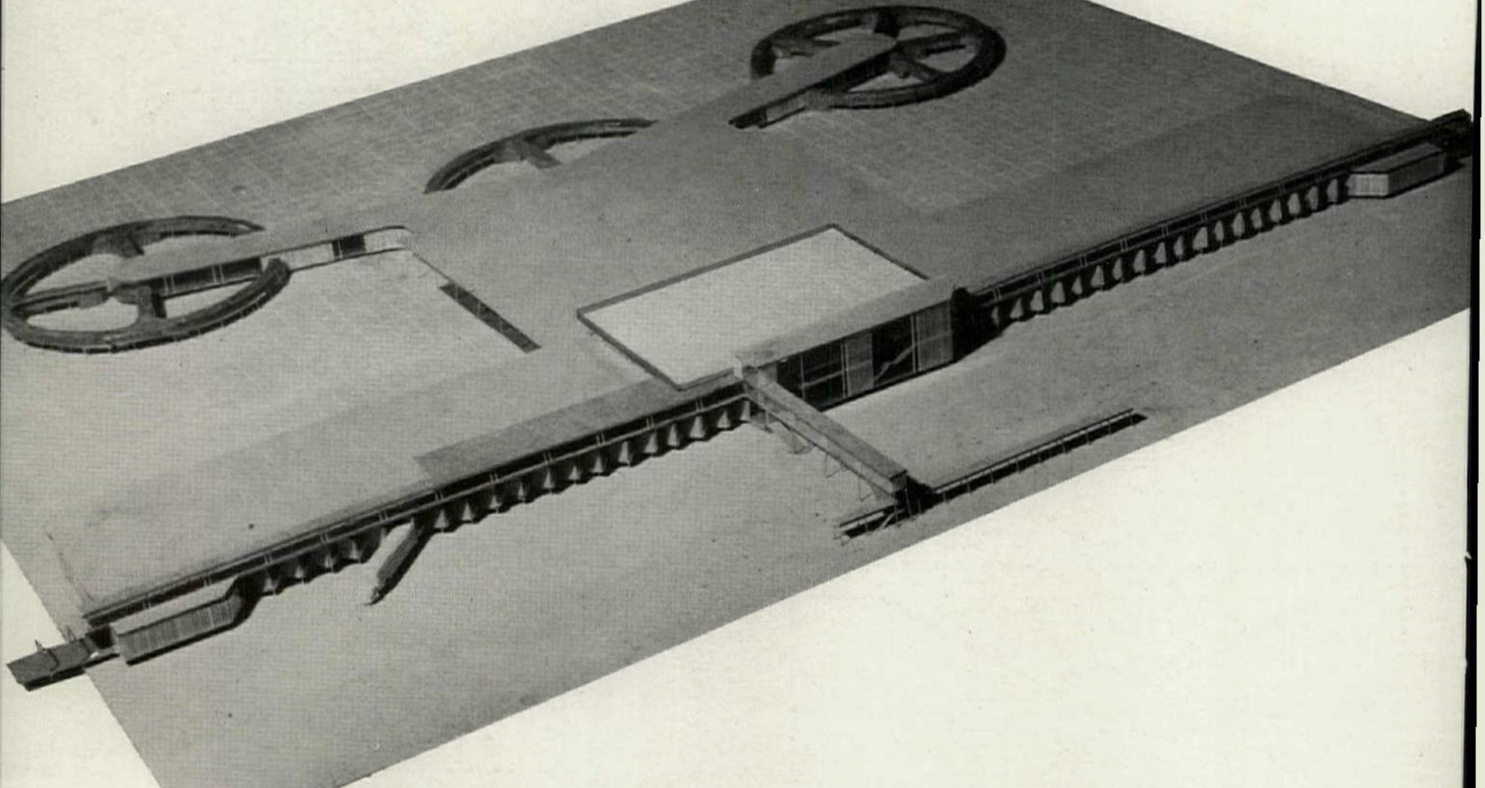




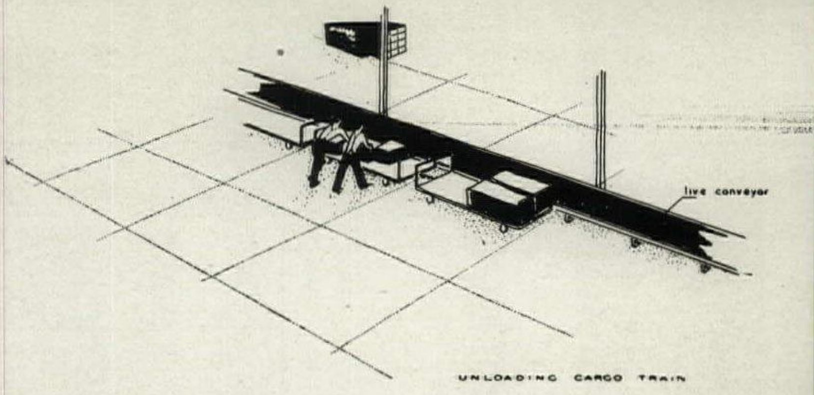




A scale model of the warehouse shows clearly the disposition of the several parts of the scheme. A flat roof was chosen as being simpler in construction, easy to maintain, and better for temperature control. Lighting inside is to be artificial, employing cold cathode tubes. Office space, together with lockers and other employee facilities for four shifts, are in the (comparatively) small superstructure which has a helicopter landing platform for its roof to take care of possible small shipments, mail, and whatever personnel may be flown in and out by this method. The side of the warehouse away from the field is arranged to accommodate standard motor trucks for loading and unloading. An overpass permits circulation between the office floor and the parking space without crossing the path of trucks.



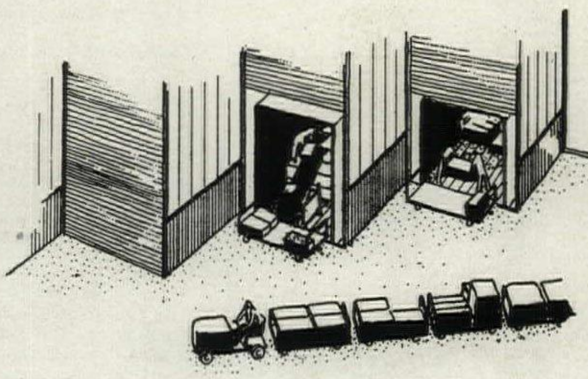
Shipments are to be handled from the belt conveyor to the motor truck loading stations or to the different parts of the warehouse for storage by means of conveniently sized hand trucks which can be assembled into trains drawn by electric tractors.



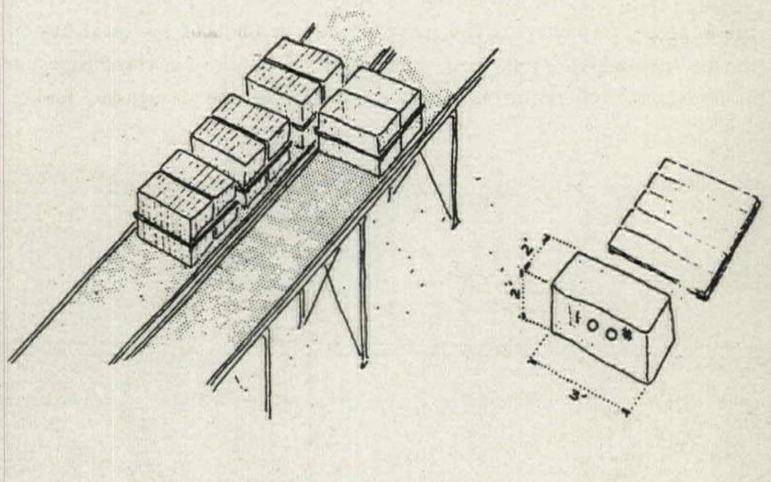
UNLOADING CARGO TRAIN

CARGO AIRPORT

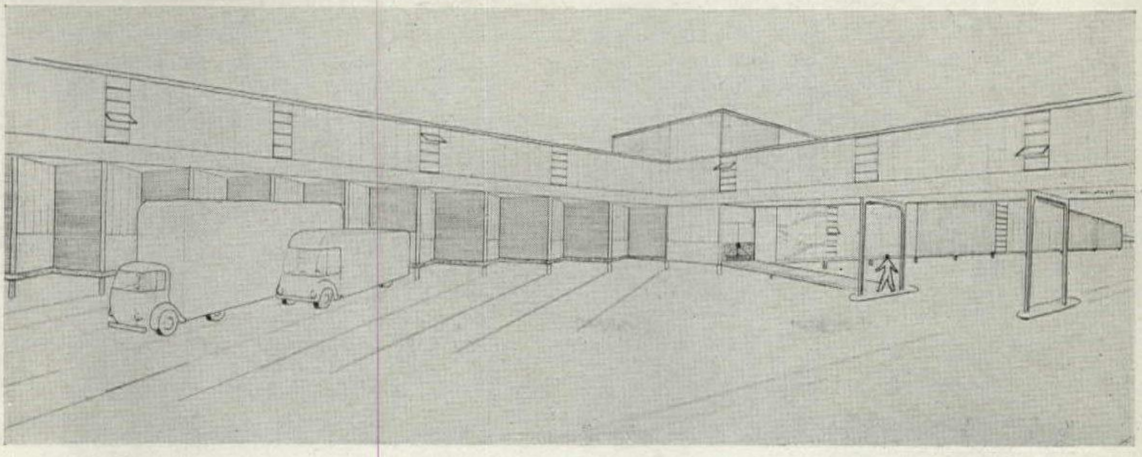
A cargo train, shown arriving at the truck loading platform where shipments may be properly distributed to the receiving vehicles or picked up to be handled into the warehouse, recorded, assembled into plane cargoes, and eventually put on a conveyor line which takes them to the proper planes.

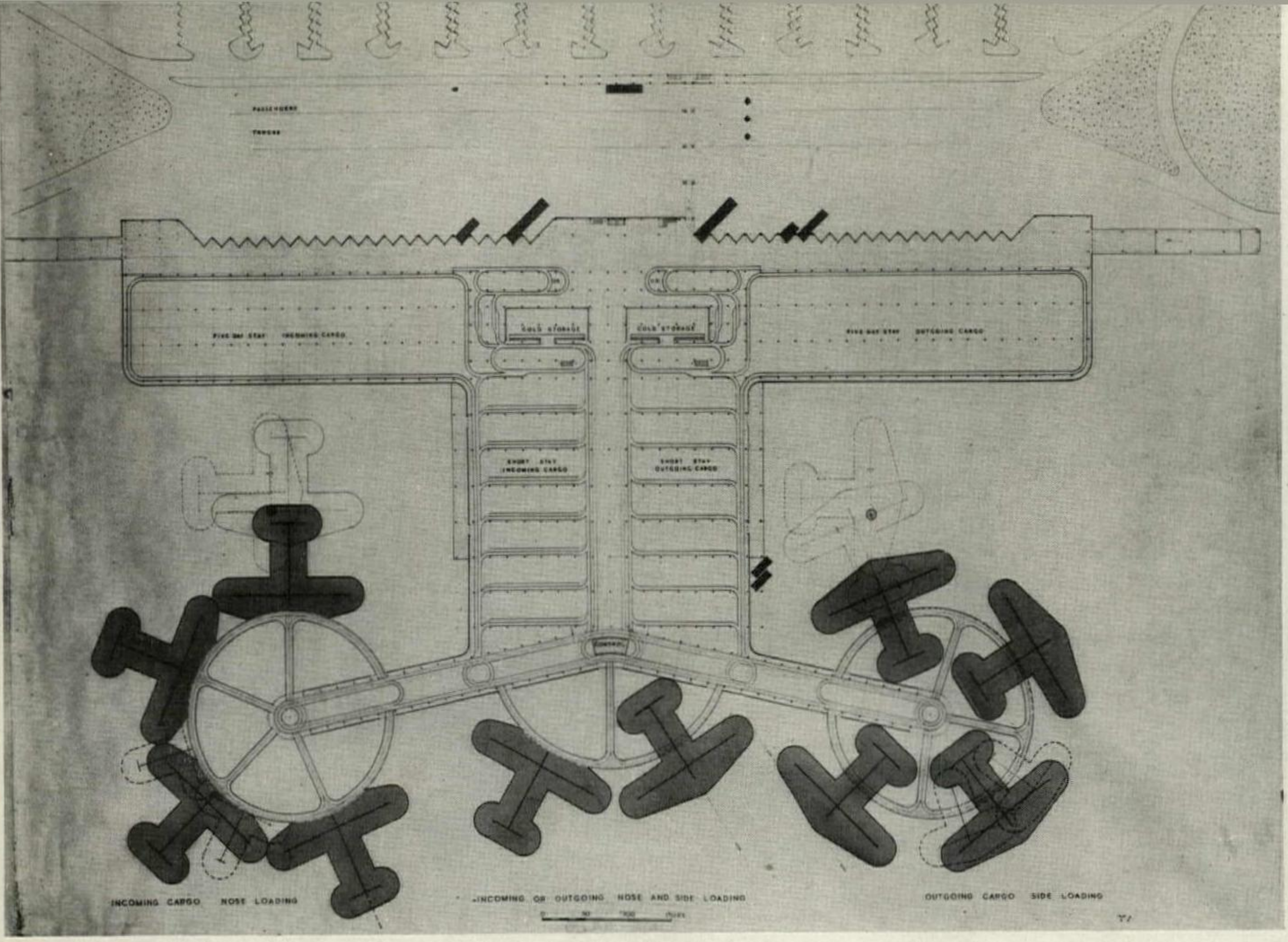

UNLOADING TRUCK

The system would work best, its designers feel, if some sort of standard crate were adopted for convenient handling all along the line. These should be about 3'x 2'x 2' and should contain, on the average, about 100 pounds. Wire mesh is recommended as the crate material because it is light and flexible.

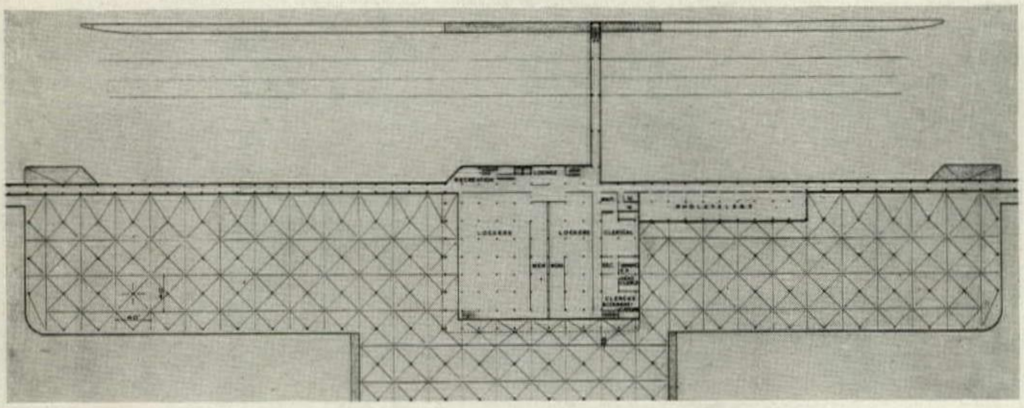


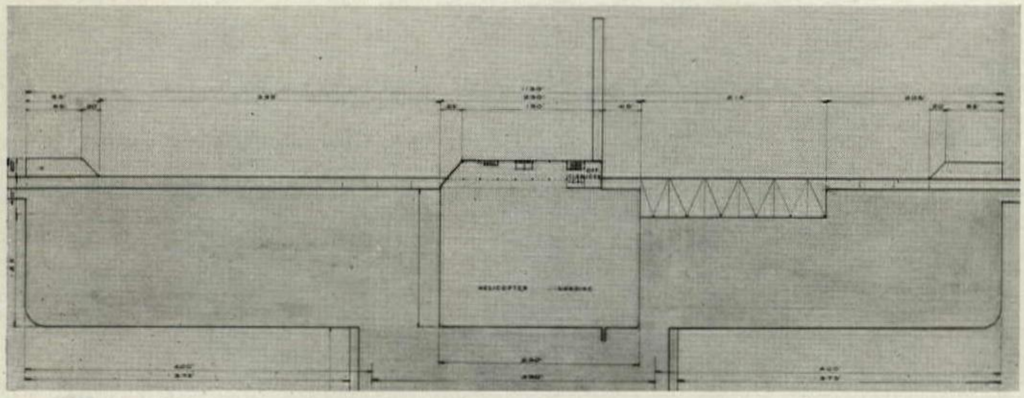
Outside the warehouse, trucks can back easily into position for loading or unloading at their designated stations along the zigzag face of the building. This arrangement increases maneuverability of trucks and avoids traffic difficulties.





Organization of the warehouse is shown on these plans. The conveyor belts were calculated to carry a 10- to 12-ton load, the expected capacity of the large plane (or 65% of its total 15-ton payload). When a plane arrives at the loading point, the pre-assembled cargo row is set moving on the conveyor at a speed of 150 feet a minute so that it will reach the plane in less than five minutes. This, according to the designers, makes it possible to load the plane within twenty minutes.





This article, designed to acquaint the airport architect with the fundamentals of airport operating and control systems, was prepared with the cooperation of Westinghouse Electric & Manufacturing Company engineers. The typical lighting plan shown on Page 74 was produced with the assistance of the New York Regional Office of CAA. All other drawings and photographs are from Westinghouse.

Airport Equipment

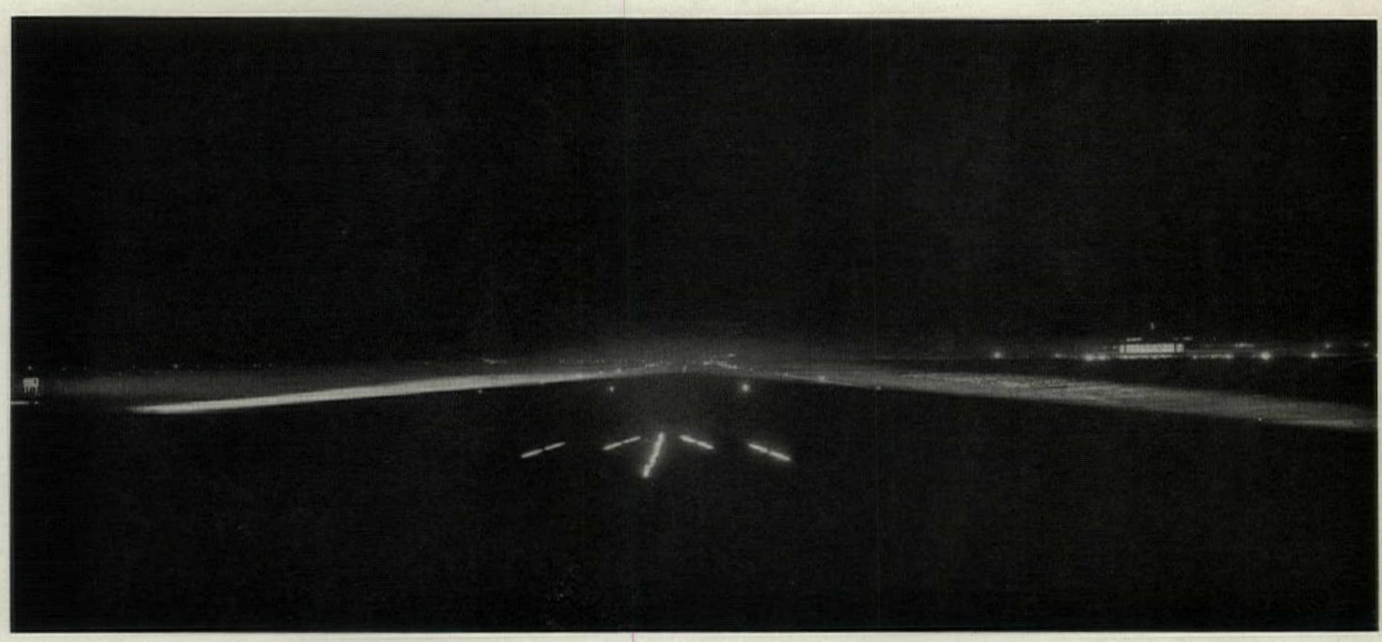
A PRIMER FOR THE ARCHITECT

In the postwar years, night flying is sure to increase as present flight schedules are enlarged and long-distance flights become more frequent. Obviously, proper lighting of airfields is a sine qua non for the successful handling of this new traffic.

In his capacity as the coordinator of the various elements that make up an airport design, the airport architect needs at least a bowing acquaintance with the subject. True, few architects will actually design a port's lighting installation or lay out the wiring system—jobs that require the specialized skill of engineer experts. But a knowledge of the various types of lighting for different classes of airports, plus some basic specific data, will not only give the airport architect a better appreciation of the work of one of his most important collaborators, but may also affect judgments as to location of airport structures, design of the buildings themselves, or arrangement of specific facilities within the buildings.

Determination of the amount, type, and complexity of an installation—general airfield lighting, boundary and runway lighting, other types of navigation aids and outside lighting connected with airport structures—is a problem to which a separate solution must be found in each instance.

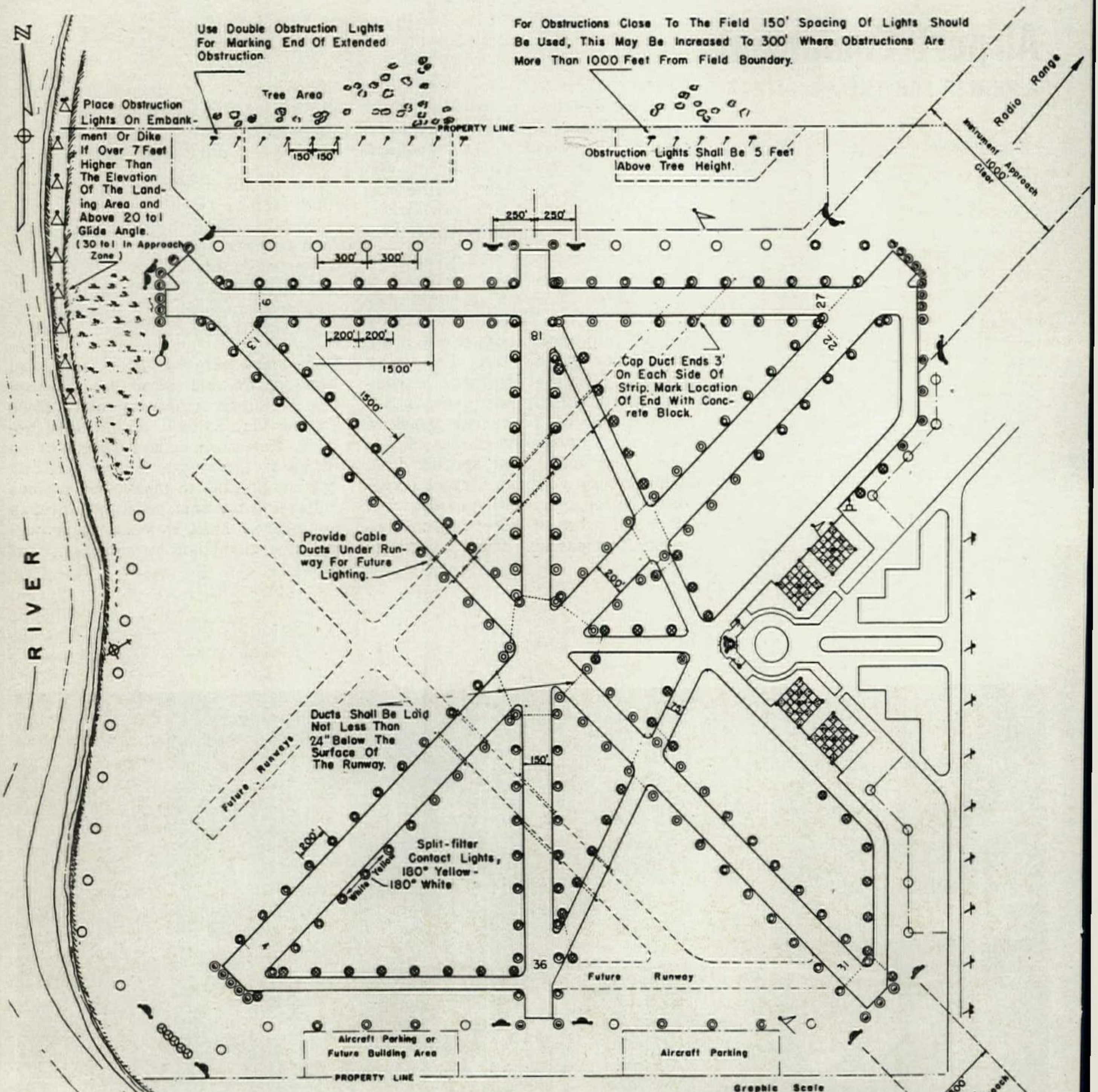
Size, class and use-type of port, local topography, and the nature of existing buildings or natural obstructions in the vicinity are all limiting factors. For example, an airport located in open country may not require any warning lights to mark obstructions adjoining the port, whereas a field in or near a built-up community will require an elaborate installation of



Airport Lighting Composite Plan

NOTE: This plan, designed to indicate a variety of typical airport lighting problems and solutions, is schematic rather than illustrative of a particular installation.

- Boundary Light (White)
- Flush Boundary or Contact Light (White)
- Flood Light With Obstr. Lights
- Flush, Two Color Split Filter (White – Yellow)
- Flush Contact Light (Yellow)
- Flush Taxi Guidance Light (Blue)
- Flush Range Light (Green)
- YELLOW AUXILIARY Range Lights
- Red Obstruction Light
- Red Obstruction Light – Cone Mounted
- Red Obstruction Light on Pole
- Double Obstruction Light (Red)
- Revolving Beacon (Green and White)
- Code Beacon
- Wind Tee Lighted
- Wind Cone
- Ceiling Projector (1000' From Observation Point)



obstruction lights. Even the weather will affect the type of installation.

For airports in northern areas subject to heavy snowfall, where the snow may obscure ground lighting, supplementary above-ground units such as runway floodlights are a wise precaution. Another reason why fixed standards or rules are impracticable is that technological advance in types of planes, aviation practices, or lighting equipment itself brings frequent revision of practice, and what is standard today may be obsolete tomorrow. Range of types of lighting installation extends from a simple system with lights outlining the boundaries of the entire usable area (or of the runways) to systems for major air terminals that normally will require an elaborate installation including beacon, range, contact, boundary and obstruction, flood, and apron lights, etc.

Luckily, engineers and architects have the invaluable resource of the Civil Aeronautics Administration to turn to for guidance, current standards, consultation, and advice. Furthermore, manufacturers of airport lighting equipment have integrated their products to meet CAA standards; and the airport architect finds himself in the rare situation of working on a problem wherein the needs are either well known or constantly being kept up to date, and the means of serving these needs are available in the most efficient form that modern technology allows. It is an excellent instance of the government agency, the private manufacturer, and the creative designer all assuming their joint responsibility in furthering architectural progress.

Categories of Airport Lighting

Airport lighting has three fundamental jobs to do:

1. Provide pilots with a clear identification of the airport.
2. Define field or runway areas to assist pilots in both landings and take-offs.
3. Warn against obstructions and control field traffic.

In describing the different standard lighting units for airport use, it must be kept in mind that under war limitations certain ones of these are not currently available. In fact, for wartime airport lighting, CAA in conjunction with the Army is limited to bare essentials, omitting several desirable, but not absolutely vital, refinements. Our discussion, however, is concerned with optimum facilities for the postwar port, and we list and describe the full range of units which will probably be in use when war restrictions end.

The typical airport lighting plan shown here is a composite drawing made up from pre-war CAA standards, plus a few improvements in practices which have since become standard. The plan is, of course, diagrammatic rather than typical of any specific condition in order to indicate use of a wide variety of facilities.

The "recommended minimum facilities" shown in tabular form on Page 84 are taken from CAA's "Airport Design," published in April of this year (available from the Superintendent of Documents, Washington 25, D. C., for 25 cents).

Lighting for the Identification of Airports

To give the nighttime pilot unmistakable indication of an airport's location, a high-mounted, rotating, searchlight-type beacon ⚲ is recommended for all classes of airports.

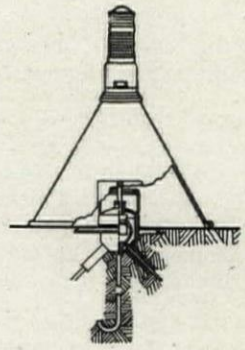
This type of beacon has a lens at each end of the drum unit—one clear, the

other green—providing an alternating color flash visible in the angle of approach from a considerable distance. At large airports, installation is usually at the top of the control tower. In other instances it may be mounted on a specially designed tower (not less than 50 feet in height) or on a prominent topographic feature.

In addition (subject to the type of port), it may be necessary to supplement the rotating beacon with an auxiliary beacon that flashes a two-letter identifying code signal in International Morse code. ©

Lighting that Assists Landings and Take-Offs

Boundary Lights. To define the limits of the usable field area, a system of boundary light units is recommended for all classes of ports other than purely strip-type fields.



Spaced approximately 300 feet on centers, they fall into one of two categories:

1. The more usual type is a unit mounted on a steel cone, ○ with clear prismatic globe at the top, bringing the light itself about 3 feet above grade.
2. A clear-lens unit that is flush-mounted, ⏀ *(Revised symbol)* employed where the lights adjoin a parking space or other place where cones would constitute dangerous obstructions.

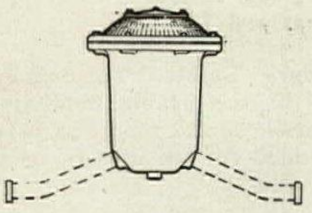
Range Lights. Designed for use on all-way fields, these units have green prismatic globes and are located at the ends of runways to inform the pilot of the best landing direction. Usual practice is to code each runway: that is, if 2 range lights occur at one end of a runway, 2 occur also at the opposite end of the same runway; for another runway, there will be 3 range lights at each end, etc. Runway coding is not essential, however, where a runway contact light system (see below) is used.

As a rule, the use of range lights is limited to fields having an all-night operator to control them; in some instances, however, range lights are installed in the boundary circuit and they all remain on all night.

Otherwise, a full boundary system or complete runway marker system is used.

The preferred type of range light is a flush-mounted unit ◉ (just below grade). These units are installed ex-

Symbols shown in the text are recommended by the Civil Aeronautics Administration. Drawings and photos indicate physical appearance.

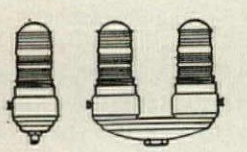


actly at the ends of runways, as shown in the typical layout.

A cone-mounted unit is used and may be necessary in cold climates where flush units would frequently be obscured by either falling or blowing snow. If used, these are installed beyond the end of the runway, in the field boundary light system.

For use where the field boundary is more than 300 feet from the end of the runway, an auxiliary yellow cone-type range light is used (see condition at Runway 4 on typical layout). These are installed at whatever usable distance exists between the end of the runway and the field boundary.

Obstruction Lights. Wherever obstructions occur in the vicinity of the field, warning lights are installed on a level with or slightly above the obstruction to be marked. A survey of the port site will determine the number required. The CAA general recommendation is that all local obstructions "higher than 1/20 the distance from the field boundary should be removed wherever possible. If these occur in the approach zone to the runway, the ratio of 1/30 applies; for the instrument runway, 1/40. When such obstructions cannot be removed, they must be marked by obstruction lights."

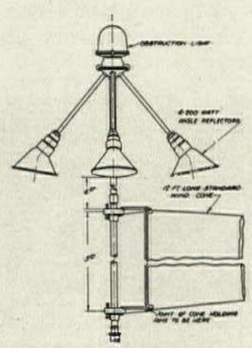


The light units are either single globes or paired units, with lamps covered by a red cover glass. Where there is an extended obstruction, such as a clump of trees, double units are used to mark the outside limits of the obstruction; between these markers, single-globe lights are installed on poles on from 150-foot centers (obstructions close to the field) up to 300-foot

centers (where obstructions are more than 1,000 feet from the field boundary).

Obstruction lights may be independent units for attachment to an existing structure, or erected on poles to define the obstruction area; or they can be mounted on cones to locate on elevated features such as embankments or dikes. In addition, obstruction lights (double) are mounted on any floodlight standards that may occur. As in every other phase of airport lighting, CAA is well equipped to advise on desirable installation of obstruction lights.

Illuminated Wind Cone. The lighted wind indicator is recommended by CAA for all classes of airports. This consists of a standard 12-foot

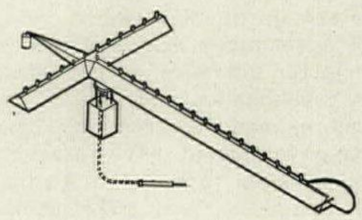


wind cone, lighted by reflectors mounted above on an arm. This unit may be installed on the beacon tower, on a hangar, or other airport building. White light is used.

Another standard type is an internally lighted cone. A single red obstruction light is used above the installation, unless it is mounted in assembly with some other unit (such as the beacon) which is higher, in which case the obstruction lights are at the top of the assembly.

Contact Lights. Contact lights are flush-mounted, installed along both edges of the runway on 200-foot centers to define the runway area. Except for the final 1,500 feet of a runway, white light is used; for the last 1,500 feet of runways, flush markers use a split filter —half clear, half yellow. The yellow shows toward the farthest end so that an incoming or outgoing pilot sees all clear lights except for the last 1,500 feet which show yellow. Lenses of contact lights throw two main beams—each in the angle of approach and slightly "toed in" toward the center line of the runway.

Illuminated Wind Tee or Tetrahedron. Recommended for Class 3, 4, and 5 airports to give helpful indications on wind conditions to incoming pilots, the wind tee consists of a metal T-bar lined with green lamps—18 on the leg of the T, 12 on the crossbar. The unit is set on low-friction bearings that allow it to swing with the wind.



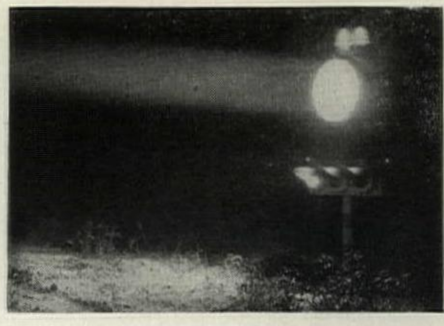
Usual location is on ground outside the landing area where gusts and eddies will not be produced by buildings.

The tetrahedron has the same application but is a larger unit; its position can be readily determined from ground level prior to take-off.

Landing Area Floodlighting. Where landing floodlighting is used, units are placed at the edges of the landable area at either end of the runway. They must not be in line with the edges of the runways; preferred installation is at 250 feet either side of the center line of the runway.

One of the earliest types of airport lighting, it is recommended as standard equipment for airports with runways in excess of 3,700-foot lengths. It is also advantageous in solving certain special problems.

In snow country, for instance, where blowing snow may obscure all surface lights, while the air at 15 or 20 feet is perfectly clear, floods turned on at both ends of the runway have



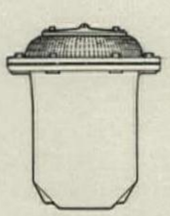
been found extremely useful in defining it for incoming pilots. The units are either single or double standard type, with paired obstruction lights topping the assembly. The lens is prismatic so that the beam has narrow vertical divergence and is spread horizontally as required for the particular runway.

Apron Floodlighting. Floodlights of various kinds are also used to illuminate aprons or other exterior areas adjacent to airport structures. Apron floods are usually attached to the buildings themselves, while general floodlights are customarily on standards located where the light is needed.

Ceiling Projector. The ceiling projector is actually a piece of

meteorological equipment, as it is a light used to determine ceiling heights by projecting a beam at a fixed angle (usually 90 degrees) up to cloud level. To compute the height, a sighting device known as a clinometer is operated at a known distance (generally 1,000 feet) from the ceiling projector. The distance between projector and observation point, plus the angle reading, plus trigonometry give the answer. Light from the ceiling projector is white.

Taxi Lights. Taxi guidance lights are of a flush type similar to contact lights but equipped with a blue lens. These are used along the left-hand edge of taxi strips, where they are most readily visible to the pilot. They are used to direct pilots to follow an assigned route from one point of the field to another.



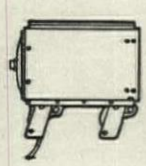
Approach Lights. For airports with runways in excess of 4,700 feet, approach lights are recommended

Incandescent — *Neon*

for every instrument runway. These look like inverted street lights and are located in the approach zone and provide a red, high candle power beam. Their purpose is to lead the incoming pilot into the runway under conditions of poor visibility.

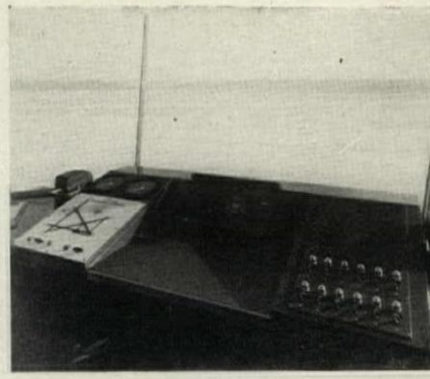
In addition to the units described above, red and green traffic lights may also be used for special instructions to pilots maneuvering planes on the field. Then there are some new and experimental types of airport lighting units. At the Washington National Airport, for example, a flush-mounted combination arrow and cross indicator is installed at each end of runways. When the green arrow is lighted, the pilot knows that the runway is clear and in which direction he should come in; when a flashing red cross shows, however, the pilot knows that the runway is blocked.

For use of the control tower operator to signal landing or take-off instructions, there is a portable, plug-in light device called a traffic pistol



light. Designed with some of the characteristics of a pistol—sighting element and a pair of hand-holds with triggers—the unit is manually operated and transmits code flashes.

Over-all control of a field's lighting system heads up at some central point—in the control tower, if there is one. For the more thoroughly integrated systems, all switches are organized into a single control panel or desk, with each switch accompanied by a pilot light to indicate operation. Frequently the panel or desk includes a facsimile map of the whole airfield that provides a quick



close-up check on what lighting is turned on and where.

As noted above, the types of lights and their application on airports are well defined by Federal regulations. However, many new types will be forthcoming for traffic-control use at airports. It is in this province that much research is now going forward. The use of lights for traffic control promise to simplify the control tower operator's job considerably by permitting him to signal incoming and outgoing planes rather than by giving verbal instructions by radio.

Basic to any lighting installation, naturally, is an efficient source of electrical power. If the port is built beyond the power lines, this problem may involve inclusion of a local power generating plant with switchboard panels, transformer, and distribution equipment, and space planned for storage of fuel to serve the engine room.

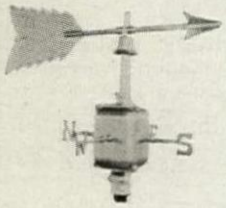
Communication and Radio Navigation Facilities

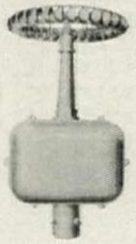
Very important to an airport's efficiency are the various elements of radio and telephonic communication —for the radio beacon, ground-to-plane, and port-to-port communication. Regular telephone service must also be provided, of course, and at the larger ports a public address system, used for paging, announcements, and issuing general orders, is usually standard equipment. To service any or all of these systems, space must be provided for installation of transmitting or receiving equipment, wiring panels, and control boards. Even for ports that are connected with existing telephone networks, an interior telephone system to connect the various buildings at the port will usually be needed.

Meterological Equipment

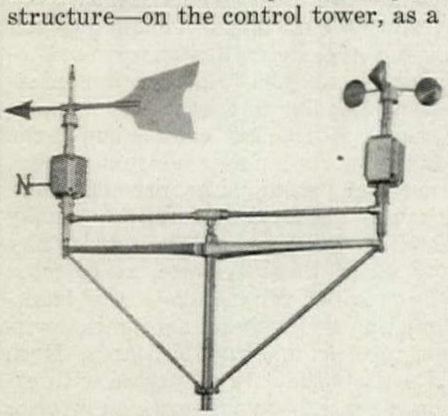
Of prime importance to the safe and efficient conduct of modern air traffic are those mechanisms and devices that provide reliable information about the winds and weather. Already mentioned (under the heading of Lighting Equipment) is the ceiling projector which, in combination with a clinometer, facilitates a calculation of ceiling levels. Wind cones and tees (also described under lighting) are other basic elements providing wind-direction information. Local weather bureaus supply weather information to airports, but even so, it is considered important for the individual airport to maintain its own on-the-spot indicators and calculators.

These include mechanisms that indicate the wind direction and record velocity. The direction transmitter, a latter-day version of the weather vane, consists of an arrow and fin, mounted to swing in the wind and accompanied by the letter "N" to indicate true north. The velocity trans-





mitter is made up of cup-like units mounted around a central axis. The wind-catching cups spin in the wind, and transmit the velocity to a dial for reading. These two units are usually mounted on a special framework, located near or at the top of an airport structure—on the control tower, as a



rule. If these units are higher than other equipment in the location, obstruction lights will be used to mark the support holding the weather-indicators.

Other weather-determining units are: balloons and theodolites for measuring cloud heights in the daytime; microbarographs for accurate measurement of prevailing air pressures; aneroid barometers for pressure measurements; pressure change indicators for use in forecasting; thermographs for temperature measurement and recording; special thermometers, rain and snow gauges; and radiosonde equipment for learning weather conditions at different altitudes.

Facilities for Portable Equipment

Additional facilities for which the airport architect may have to provide are storage places or garages for mobile and auxiliary electrical generating and lighting equipment, either truck mounted or assembled on portable carts; fire-fighting equipment may require most of the facilities of a community firehouse; engine starter units, snow plows, etc., may also need storage space.

Water and Sewage Disposal

As in all building operations, provisions will have to be made to provide water supply and sewage disposal. In remote locations it may be necessary to construct a complete water system —wells, purification elements, water-pumping equipment, and a circulating system.

Usually the sewage system will be linked to an efficient municipal or state disposal system; but beyond the service lines a complete self-contained system may be required to collect, digest, and eventually absorb the sanitary wastes from the various airport services. A carefully designed septic tank system will serve most small airport requirements, with either a drain field or (in some places where the soil will absorb liquids at a rate sufficient to lower the water level 1 inch in 5 minutes) sand filters. Where gravity flow cannot be counted on, specially engineered layouts involving sewage pumps may be necessary.

Some Fundamentals of Airport Design

This section contains two informative articles and a series of six charts which contain, in condensed form, much information necessary to the airport designer. William Varker, who contributes an article on basic design factors, has had a hand in the development of many airports built during the current war. Elwyn E. Seelye, consulting engineer, who has likewise had much experience in this field, presents a brief analysis of factors affecting soil stabilization and paving for airports. The charts are from a forthcoming manual by Mr. Seelye.

I Criteria for Site Selection and Airport Development

by William Varker, Architect and Airport Consultant

With air transport growing so rapidly, prospective traffic volumes will be many times anything experienced before the war. So much has been learned about airport design and management in the last five years that it is now recognized to be just as highly specialized a development as hospitals, hotels, or if you please, great railroad terminals. Each includes many operational functions which must be carefully coordinated if the overall design is to be efficient and is to permit maximum use for minimum cost of construction and maintenance.

No two communities and no two sets of local conditions are sufficiently alike to permit of identical solutions in any of the fundamentals. Soil, atmospheric, and air traffic conditions may be similar: highway connections; distribution of industrial, commercial, and residential areas; and topography will probably be substantially different. Therefore each airport deserves a careful pre-analysis as to its design criteria preliminary to selecting a site or even tentatively designing the airport. An artistic rendering of a dreamy design is highly dangerous; it may become the ideal of the authorities, impossible to achieve.

Essential Steps in Preliminary Design

First: Make an analysis of air traffic requirements. What will be the volume of commercial and private flying? How many passengers may eventually be handled and during what hours? How will they get to the air terminal build-

1. FACTORS IN PLANNING

1. SIZE OF COMMUNITY SERVED **Small—up to 25,000** **Medium—25,000 to 250,000** **Large—over 250,000**	**Large cities** will require one or more Class IV or V airports (see chart 5 for CAA classes, etc.) as terminals for regularly scheduled service and one or more Class I, II or III airports for non-scheduled services (see 2 below for service classification). **Medium size cities** will be adequately served by one Class III airport, capable of expansion to Class V and with additional Class I or II airports as may be required. **Small communities** will require one Class I or II airport. All airports should be planned for expansion. Separation of regularly scheduled from non-scheduled flying is desirable when volume of traffic will make this economical. Such separation should be foreseen and planned.
2. TYPE OF SERVICE COMMUNITY MAY REQUIRE	**Regularly scheduled:** Passenger, express and slow cargo, air-mail, aerial taxi service. **Non-scheduled:** Private flying, schools for air training, sales and service of airplanes and parts, aerial taxi, crop dusting, fire prevention and conservation, tourist and sport travel, aerial photography, industrial freight, helicopters, air patrols by CAA and others, glider trains, private gliding. All these services should be studied to estimate present and future volume of traffic.
3. REGIONAL PLANS AND EXISTING AIRWAYS	Consult State and CAA for conflict with other airports and airways. Several small communities may be best served by one airport; consolidation may allow a larger airport with increased services. Proximity to existing important airways may increase traffic at airport; may require airport be designed for emergency landings of large planes.
4. PLANE MOVEMENTS PER HOUR (P.M.H.)	**Peak number** of plane movements anticipated, present and future, should be estimated to determine the maximum number of runways required for use at one time. **Landings** require 2 or 3 times the time needed for takeoffs. **Contact operation:** One runway—30 landings + 30 takeoffs = 60 P.M.H. **Contact operation:** Two runways—50 landings + 50 takeoffs = 100 P.M.H. **Contact operation:** More than two runways—plane movements on ground and in air must be completely analyzed for interference. **Instrument operation:** One runway—12 landings + 18 takeoffs = 30 P.M.H. **Instrument operation:** Two runways—20 landings + 30 takeoffs = 50 P.M.H. It is anticipated that technical advances will increase instrument operation rates to approximate contact operation rates.
5. SUGGESTED DESIGN PROCEDURE	1. Prepare or select a preliminary master plan based on above factors. Show all future requirements. 2. Select site—see chart 2. 3. Prepare master plan—see chart 3.

Note: Number of plane movements per hour shown in this table is based upon expectations for the very near future. In the case of instrument operation, for instance, present max. pmh is 12 to 18, but development of common types of instruments will very shortly permit 30.

Fundamentals of Airport Design

2. FACTORS IN SITE SELECTION	
PROXIMITY TO OTHER AIRPORTS	6 miles between centers minimum.
GROUND TRANSPORTATION	Site should be served by adequate ground transportation facilities for passengers, freight, employees, and visitors. Generally an express highway will be required for Class III, IV, V airports. Speed, allowable traffic volume, cost of existing or proposed facilities, distance from city are factors.
FUTURE EXPANSION	Sufficient land available to buy or option to allow for economical development of master plan.
APPROACH ZONES	See Chart 4. Standards indicated must be complied with at any stage of master plan.
EXISTING OBSTRUCTIONS	Practicability of removal of high buildings, stacks, power lines, etc., should be determined.
TOPOGRAPHY	Balanced costs of grading and drainage should be attained. Flat land requires excessive drainage. Hilly land requires excessive grading. investigate floods at valley sites; destructive winds at elevated or exposed sites. Look for sites slightly above level of flat country or on long easy slopes in hilly country.
WIND	Sites with prevailing wind from 1 or 2 directions may require runways in only 1 or 2 directions, thus reducing cost, taxiing time.
VISIBILITY	Avoid known areas of frequent fogs; often found along large water bodies and near industrial areas.
SOIL*	A1, A2, or A3 soils desirable; A4 to A7 soils require surface and subsurface drainage and substantial base and sub-base courses. Construction over A8 soil extremely costly.
CONSTRUCTION MATERIALS	Short haul to deposits of A1, A2, A3 soils or to stone quarries important.
UTILITIES	Study cost of providing sewer, water, gas, electricity, gasolene, telephone, etc.
EXISTING AIRWAYS	Locate close to existing airways if other factors balance.
ZONING	Zoning regulations should be available or contemplated to limit future building outside airport in accordance with Approach Standards.

*See accompanying text.

ing? How much parking space will be necessary for passenger automobiles?

How much space is necessary for ticket offices, airline business offices, hangars, repair shops? To what degree will national and international flying affect the design? What percentages of commercial flights will be for passengers, what for mail, express, or freight? In short, what is expected of the airport immediately after it is put in operation, and what can be estimated as to its probable requirements 10 or 20 years later? There appears to be no record of any terminal facility now in operation which is large enough or which has proper arrangements for present operation, let alone for necessary expansion.

Second: Having in mind general requirements, and resultant knowledge of approximate overall sizes, a study should be made of connecting transportation for passengers, mail, and cargo; and a search should be begun for a location. Recent experience in airport design indicates that the first cheap, large, level piece of ground should not be accepted without thorough inquiry. It may prove the most expensive in the long run. High speed transportation must be made available. Soil and subsoil conditions must be studied so that earth moved for grading may be stabilized, the surface may be paved economically, and maintenance may be satisfactory. Also, the flattest ground available may prove more expensive to drain than slightly rolling ground, as earth is now moved so inexpensively that such movement is frequently more economical than costly drainage systems. At this point competent civil engineers with experience in earth movement, soil mechanics, paving, etc., must be consulted.

With regard to the runway pattern, too much depends on the volumes to be handled and the problem is too broad to be described here. There will be airports with only one landing strip and there will be others with as many as sixteen or more and with networks of connecting taxiways and aprons. If volumes of flights are such that two or more runways must be operated simultaneously, certain very definite safety standards must be observed particularly with regard to distances between the two simultaneously operated runways; and minimum horizontal and vertical separation must be maintained by planes in the air. Thus, especially in those areas where bad weather flying will be necessary for a substantial number of days in the year, a real problem presents itself. The runway systems of the future will develop on either the parallel pattern or the tangential. There seems no practical reason for the so-called overall paving of vast areas as the planes must, in any event, follow narrow, well defined paths to avoid collision.

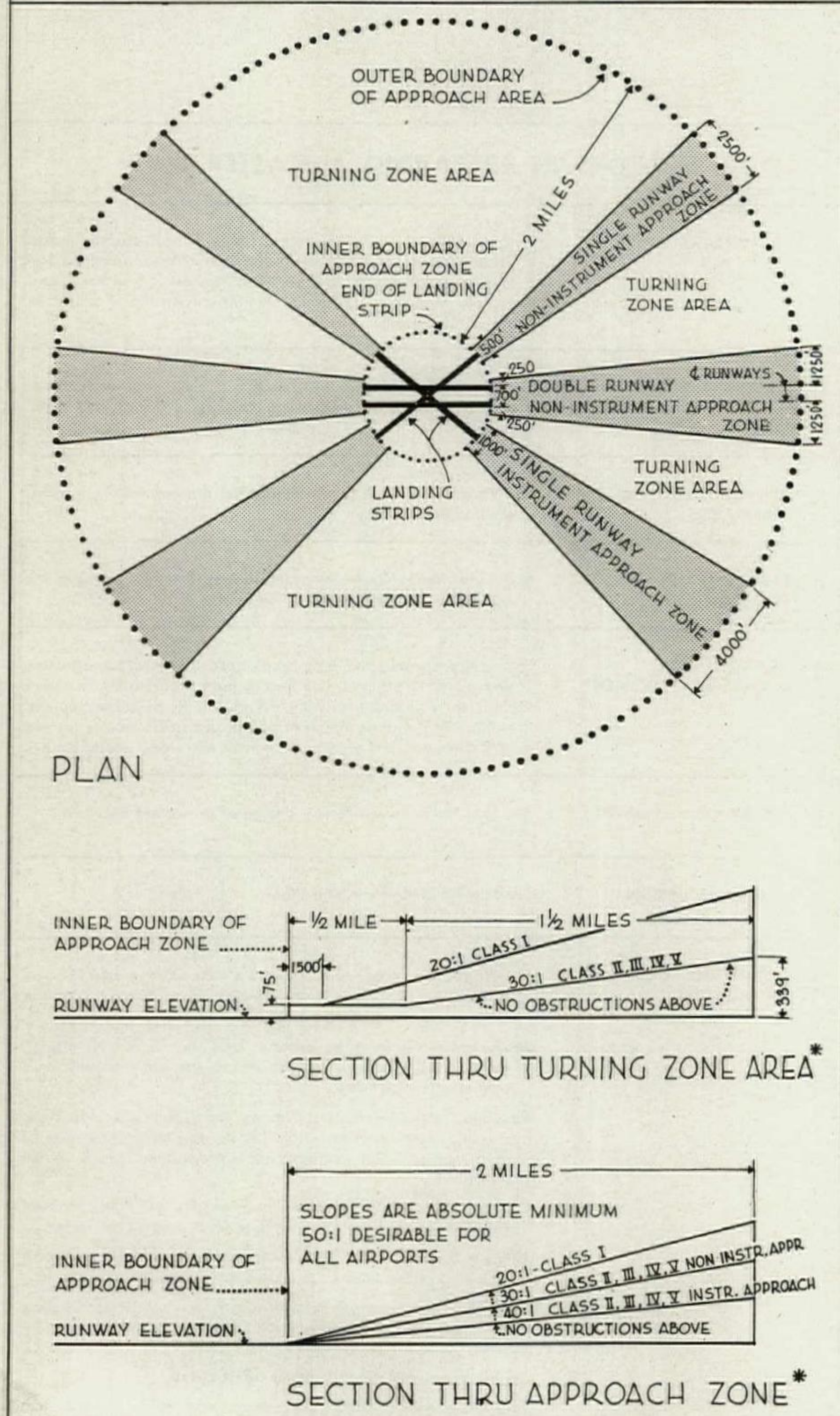
Third: The design of the airport itself may now be started. Consideration must be given to existing or future highways and to other forms of high speed transportation, and connections must be brought in to a focal point within the airport. On large terminals this must be as near the center of the runway pattern as possible in order that plane taxi distances may be reduced and time may be conserved. On smaller airports it may still prove desirable to establish the focal point on one side of the runway pattern. It will be seen immediately that this central point must handle not only passengers, visitors, and sightseers, but also baggage, mail, express, and freight; and the flow of these various types of traffic must be smooth, and eventually separated from one another, so as to avoid confusion. If the runway pattern is established first, the operational facilities will be squeezed into what space remains, not based on ideal operation. If the operational facilities are considered first, bearing in mind the movements of the planes, the runway pattern may more easily be designed in relation to the central station.

Handling employees is also important in an airport of any size. Workers must find it easy to get to work. This becomes no small problem when it is realized that in at least one airport now being designed in the United States 40,000 employees are eventually contemplated. This becomes effective when the airport handles 20,000,000 passengers per year and has a maximum peak

3. FACTORS IN PREPARING A MASTER PLAN

1. PRELIMINARY SURVEYS	Prepare property, location, topographic, and obstruction maps. Secure data for wind rose and aerial photographs. Soil survey data should include identification of surface and subsoil, soil profiles, ground water table, location of available material deposits.
2. DIRECTION AND NUMBER OF LANDING STRIPS	See Chart 5 for percentage of time that prevailing winds allow use of runways. Construct wind rose and compute coverage.
3. AIRPORT SIZE STANDARDS	See Chart 5 for CAA requirements for runway widths, lengths, grades, etc.
4. GROUND FACILITIES AND LIGHTING	See Chart 6 for CAA recommendations. Provide parking for employees, passengers and visitors.
5. LIMITATION ON BITUMINOUS PAVEMENT	For service aprons, parking aprons, hardstandings, turnarounds, and all other pavement subject to high shearing stress occurring when planes turn with locked wheels or subject to the action of oil and gasolene dripping and spilling, use concrete or surface-treated gravel; bituminous pavement not indicated.
6. DESIGN OF PAVEMENT	See text for factors affecting design of pavement thickness.
7. DRAINAGE DESIGN	See text for design considerations.
8. COMPLETED PLANS TO INCLUDE:	Grading: Plans, profiles, and sections with existing and finished grades for both present and ultimate development. Location of available construction material. Drainage: Plans, profiles, sections, and details for all piping, ditches, subdrainage, and structures for both present and ultimate development. Runways, Taxiways, Aprons, Parking Areas, Access Roads: Plans showing location, intersection details, expansion joint details; cross sections and profiles. All future paved areas to be indicated. Lighting: Size, type, location and details of lights, cables, transformer, underground ducts, control points and wiring. Utilities: Sewer, water, telephone, power complete for airport including connections to outside source or disposal. Buildings: Location of all present and future buildings, including off-site proposed development. Plans in detail for present work . Zoning Plans: Sufficient to enact as local law. Stage Construction: Show time when construction of each item or part of master plan should be started and completed in order to satisfy estimated future air traffic requirements. Construction should not interfere with operation of airport.

4. APPROACH STANDARDS



*ADAPTED FROM DWG. 152-C, CIVIL AERONAUTICS ADMINISTRATION

hour operation of between 200 and 300 plane movements.

Current Developments Indicate Future Needs

Fortunately it now appears evident that it will not be necessary to provide ever-increasing runway lengths for larger and faster planes. Improvements in motive power and knowledge of airfoil have apparently arrested this trend. Even if auxiliary acceleration power becomes necessary for take-offs, it is unlikely that runways will have to be increased substantially over maximum lengths now in use. However, commercial passenger planes have already been built with wing spreads and wheel loadings very much greater than is commonly known (for instance, wing spreads over 300 feet and wheel loadings over 100,000 pounds) so that widths of runways and the bearing surface of paving needs careful analysis. This of course applies only to those airports which will service large commercial planes.

Many smaller airports, however, may be required to handle equally large cargo planes. Also they may be required to handle tractor planes towing gliders requiring wider runways, and in many cases special taxi-way facilities. Whether these extreme sizes must be serviced in the early stages or not, it would seem wise to plan the airport for maximum eventual use and to construct initially for those services which are presently required.

Tremendous strides have been made in flying in what has hitherto been considered bad weather, and all airports wishing to be classified for commercial flying by the CAA must include provisions not only for instrument flying but for handling planes expeditiously on the ground, so that incoming planes will not be held unnecessarily long in the air.

Commercial Expansion

If the airport is to handle any commercial flying at all, tentative schedules and volumes of passengers should be established in order to determine the size of air terminal buildings, approach highways, parking areas, etc. It frequently occurs that municipalities are disagreeably surprised to find out what these amount to. Here again space must be allowed for expansion, as all these facilities should be designed to accommodate the maximum volume expected over a long period of time, whether the full facilities are ever built or not.

Site Selection

In selecting a site care must be taken that the designer be familiar with CAA

Fundamentals of Airport Design

requirements as to approach zones, to see that no hazardous obstruction exists. Also it is incumbent upon the planners to refrain, if possible, from selecting a location which will deteriorate existing residential units or limit the expansion of proper residential or other areas which might find the noise and confusion of an airport unbearable.

Surface transportation to and from the airport becomes quite a problem as the success of air travel will to some extent be determined by the length of time it takes the passenger to get to his destination from his point of origin, including transportation to and from the airport at both ends. Commercial airlines agree that it will probably be necessary to make available, under their own control, transportation for those passengers who wish to use it, and therefore one requirement is a centrally located terminal to which passengers may come to buy tickets and deposit baggage. While this may not prove a serious problem in some communities, it becomes decidedly difficult in others, and in fact the location of this central station may actually have a bearing on the selection of the site.

Wherever possible, locations should be sought adjacent to express highways, as it will frequently be found preferable to travel longer distances at higher speeds than to risk the serious delays, often unavoidable, of travel on city streets.

Experience has proved that when the over-all problem is separated into a number of smaller problems, each studied separately and in relation to the whole, the plan in its entirety will develop and will permit of a minimum expenditure. In this way none of the essentials should be omitted and unnecessary items will not be included. Therefore the over-all cost should be less than if a more elegant, arbitrary scheme, into which the essential functions are forced, is adopted. Such unnatural planning always costs more in the end.

I would like to point out that the design of an airport, like any other engineering problem, is no mystery. There is a world of information available for those who seek it, and the conscientious designer will merely take off his coat and go to work to find out what his problem is. When he has done so with thoroughness the solution for the whole is very likely to stand up on its own hind feet and look him in the face.

The article by Mr. Seelye, on "Drainage, Soil Mechanics, and Pavement Design," which is also part of this section, starts on the following page.

5. SIZE STANDARDS (Adapted from "Airport Design Information," Civil Aeronautics Administration, May 1944).

CLASS OF AIRPORT	CLASS I	CLASS II	CLASS III	CLASS IV	CLASS V
Type of community	Small communities not on present or proposed air carrier system. Includes communities up to approximately 5,000 population	Larger communities on present or proposed feeder line airways and having considerable aeronautical activity. General population range 5,000 to 25,000	Important cities on feeder airlines and many intermediate points on main lines. General population range 25,000 to several hundred thousand	Cities in this group represent the major industrial centers of the nation and important junction points or terminals on the airways system	Same as Class IV
Type of plane which airport may safely accommodate	Small private-owner planes up to 4,000 lb. gross weight, or those whose wing loading times power loading does not exceed 190	Large private planes, some small transport planes in gross weight range between 4,000 and 15,000 lb., or having wing loading times power loading of 190 to 230	Present-day transport planes between 10,000 and 50,000 lb. gross weight, or having wing loading times power loading of 230 and over	Largest planes in use and those planned for immediate future; gross weight 74,000 lb. and over; wing loading times power loading 230 and over	Same as Class IV
Length of landing strips[1]	1,800 to 2,700 ft.	2,700 to 3,700 ft.	3,700 to 4,700 ft.	4,700 to 5,700 ft.	Over 5,700 ft.
Width of usable landing strips	300 ft.	500 ft.	500 ft.	500 ft.	500 ft.
Length of runways	None	2,500 to 3,500 ft.	3,500 to 4,500 ft.	4,500 to 5,500 ft.	Over 5,500 ft.
Width of runways	None	150 ft., night operation; 100 ft., day operation only	200 ft., instrument landing; 150 ft., night operation	Same as Class III	Same as Class III
[2]Percentage of time that prevailing winds, including calms[3], permit use of landing strips and runways	70%	75%	80%	90%	90%
Minimum distance between center lines of parallel runways	—	700 ft.	700 ft.	700 ft.	700 ft.
Minimum distance between center line of runway and airport buildings: Instrument landing runway / All other runways	— / —	750 ft. / desirable 500 ft.; minimum 350 ft.	750 ft. / desirable 500 ft.; minimum 350 ft.	750 ft. / desirable 500 ft.; minimum 350 ft.	750 ft. / min. 350'; des. 500'
Minimum distance between center line of runway and aprons and loading platforms: Instrument landing runway / All other runways	— / —	500 ft. / 250 ft.	500 ft. / 250 ft.	500 ft. / 250 ft.	500 ft. / 250 ft.
Landing strip and runway grades—transverse	2% maximum	2% maximum	1½% maximum	1½% maximum	1½% maximum
Landing strip and runway grades — uniform longitudinal	2% maximum	1½% maximum	1½% maximum	1% maximum	1% maximum
Grade breaks — longitudinal[4] (maximum algebraic difference)	3%	2½%	2%	2%	2%
Gross plane weights for runway and apron paving based on present-day aircraft, to be considered distributed equally between two main wheels or sets of wheels	No paving recommended	30,000 lb	74,000 lb.	120,000 lb.	120,000 lb.
Probable future (10 years) maximum static gross plane weight to be considered in designing runway and apron paving, and drainage structures	20,000 lb.	60,000 lb.	150,000 lb.	300,000 lb.	300,000 lb.
Recommended gross weight to use for design	20,000 lb.	60,000 lb.	150,000 lb.	300,000 lb.	300,000 lb.
Probable range of static airplane tire pressures	10 to 25 psi.	15 to 50 psi.	30 to 75 psi.	50 to 85 psi.	50 to 85 psi.

NOTES:

[1] All the above landing strip and runway lengths are based on sea-level conditions; for altitudes above sea-level increase runway length 25 ft. per 100-ft. increase in elevation. One surfaced runway is recommended for each landing strip for Class II, III, IV, and V airports.

[2] Landing strips and runways should be sufficient in number to permit takeoffs and landings to be made within 22½ degrees of true wind direction for the percentage shown above of winds 4 mph. and over, based on at least a 10-year Weather Bureau wind record where possible.

[3] Winds 3 mph. and less.

[4] Longitudinal intersecting grades on a runway or landing strip should be joined by a vertical curve, if the algebraic difference in grades is 0.40% or more. The vertical curve should be at least 300 ft. in length for each 1% change in grade. It is also recommended that the tangent interval between the point of tangency of the curve and the point of curvature of the succeeding be not less than 100 ft. If economically practical, grade breaks should be so controlled that the sight line will be unobstructed from any point 10 ft. above the surface of the runway to any other point 10 ft. above the runway.

6. FACILITIES, LIGHTING, TAXIWAYS

A. MINIMUM FACILITIES RECOMMENDED BY CAA*

AIRPORT CLASS	I	II	III, IV, V
Drainage	Include	Include	Include
Fencing	"	"	"
Marking	"	"	"
Wind Direction Indicator	"*	"	"
Hangar	"	"	"
Shop	—	"	"
Fueling	—	"	"
Weather Information	—	"	"
Office Space	—	"	"
Parking	—	"	"
Weather Bureau	—	—	"
2-Way Radio	—	—	"
Visual Traffic Control	—	—	"
Administration Building	—	—	"
Taxiway and Aprons	—	—	"
Instrument Approach System (if needed)	—	—	"

B. MINIMUM LIGHTING RECOMMENDED BY CAA*

AIRPORT CLASS	I	II	III	IV, V
BASIC LIGHTING, including: Airport Beacon, Boundary Lights[2], Range Lights, Obstruction Lights, Illum. Wind Cone[1]	Optional	Include	Include	Include
Contact Lights (including Range Lights)	—	"	"	"
Illum. Tee or Tetrahedron	—	—	"	"
Landing Area Floodlights[3]	—	—	"	"
Apron Floodlights	—	—	"	"
Ceiling Projector	—	—	"	"
Taxi Lights	—	—	—	"
Approach Lights[4]	—	—	—	"
KWH Needed	10-15	15-20	20-40	40-80+

NOTES: 1, Installation of auxiliary beacons depends on airport location.

2, Use in lieu of contact lights at all-way type of field having no all-night operator to select landing direction.

3, Provide at all lighted fields where blowing snow occurs.

4, Install at each instrument-approach runway.

*See also their lighting standards.

C. TAXIWAY STANDARDS RECOMMENDED BY CAA*

AIRPORT CLASS	II	III	IV	V
Minimum Width of Taxiways	50 ft.	50 ft.	50 ft.	50 ft.
Minimum Distance, Runway Center Line to Taxiway Center Line	275 ft.	275 ft.	275 ft.	275 ft.
Minimum Distance, Boundary Fence, Obstructions, etc., to Taxiway Center Line	100 ft.	150 ft.	150 ft.	200 ft.
Maximum Longitudinal Grade	3%	2½%	2½%	2½%
Maximum Transverse Grade	1½%	1½%	1½%	1½%
Minimum Angle of Taxiway Intersection with Runway Ends	60°	60°	60°	60°

Runway grades should not be altered to meet taxiway intersections or connections. At large airports where traffic is heavy it may be advisable to construct a warming-up apron and bypass on taxiways connecting to the ends of runways. Taxiways should not connect to the ends of runways at an angle of less than 90° to incoming traffic.

II Drainage,

by

The war has stimulated design and construction of military airports and provided useful experience to serve as a basis for designing to meet future civilian needs. For these, both improved quality and reduced costs are essential.

Once location and width of runways have been determined, the primary engineering problems are: (a) drainage; (b) properly compacted foundation for the pavement; (c) determination of type and thickness of pavement in accordance with bearing capacity of foundation and anticipated wheel loads. This applies equally to taxiways, runways, and parking areas.

Drainage design requires careful study of topography, volume of rainfall, rate of runoff, and adequate facilities to take care of drainage even beyond the limits of the airport itself. A properly designed drainage system will result in a ground-water level substantially below subgrade of runways. (If this is not the case, ground water may cause settlement, loss of stability, frost heave, and disintegration.) Liberal allowances should always be made to remove adequately any unusually heavy rainfall.

Military and Civilian Drainage Systems

The type of drainage provided depends on the use and purpose of the field. Drainage for military fields of tactical and strategic importance should be so designed that ponds never form on runways. However, on training and satellite fields temporary "ponding," for short periods after storms, is usually permissible.

Drainage of civilian fields also depends on their use and classification. The drainage system for a scheduled air transport field should obviously be more elaborate than the system for a pleasure-flying field. For civilian fields the drainage system is frequently designed to remove within two hours the runoff from the maximum one-hour rainfall expected in two to five years. In any case, even in turf areas between runways, water should not be allowed to stand in ponds for a sufficient time to allow the water to saturate the base beneath any paved areas.

Careful attention must be paid to the problem of maintaining firm shoulders at pavement edges. This condition may

Fundamentals of Airport Design

Soil Mechanics, and Pavement Design

Elwyn E. Seelye, Consulting Engineer

be attained by giving turf shoulders more pitch than the adjacent pavement or by providing a gutter or swale just beyond the pavement, with inlets spaced at suitable intervals. The practice of constructing gutters and inlets within the paved area of the landing strip is at present discouraged.

In general, storm drainage pipes or French drains should never be placed under the pavement nor should the surface drainage system be combined with the sub-drainage system. Filter backfills for sub-drainage trenches must be carefully designed lest dangerous cavities occur in the soil beneath landing areas.

Soil Mechanics

Practical application of the theory of soil mechanics has contributed greatly to improvement of the subgrade, subbase, and base. Our experience has produced better runways and reduced cost of pavement because, in many cases, it permits a reduced thickness of paving for the same or higher load capacities. Briefly, the methods used have been as follows:

Borings were taken of the entire area affected by new construction, careful analyses were made of samples not only of the soils on the airport, but of soils, sand banks, and gravel pits in the general vicinity for use in obtaining a proper mixture of the various types of materials to produce a properly stabilized and compacted subgrade to receive paving.

Careful control was exercised in compacting the soil and base layers at the correct moisture content to insure maximum compaction. Continual check was also made to correct deficiencies in the graduation of soil mixtures combined for the purpose of stabilization. The plasticity of the soil in the embankments and base courses was also carefully controlled. Only a very narrow range is allowable, as excessive plasticity will result in subsequent softening and frost heaving, while a certain degree of plasticity is essential to secure the required compaction and bearing value.

The speed with which military airfields are constructed, involving use of hundreds of pieces of equipment and movement of thousands of cubic yards of earth a day, presents a real problem in securing the control described above. No time can be spent in carefully preparing soil samples for transport to some distant laboratory. As a solution, complete field laboratory trucks, equipped with soil testing apparatus, are used. These mobile units work right in the thick of earthmoving operations.

Charts are made for use with the testing equipment so that few calculations are necessary. As examples: moisture contents are determined by placing a small amount of soil in a graduated flask and reading the moisture content direct from a chart, or by pushing a spring needle into the soil by a device that translates the resistance into moisture content readings. The degree of compaction of runway embankments is determined by filling a small hole made in the soil layer with pre-calibrated sand of known density. The weight of soil removed compared with the weight of the sand will give the percent of compaction with a simple slide-rule operation. Plasticity is determined by rolling a small amount of soil into a thread beneath the palm of the hand.

Stability of the soil is determined by lightly tapping a grooved pat of the wet soil in a small dish until the separated soil flows together. The propensity of soil to settle is determined by measuring the shrinkage occurring when a moist soil sample is dried. Soils subject to shrinkage of more than 2 or 3 percent are not used under landing or parking areas. Soils subject to shrinkage of more than 1 percent are not used under any paved landing or warm-up areas.

No Precedents for Pavement Design

The gravest problem of the airfield and soils engineer is to design and construct with very low safety factors for conditions of loading and impact for which there are few established empirical practices or criteria. Highway and railroad loadings have not changed for years, and in their design there is for guidance a wealth of practical knowledge based on experience in practically every locality under every kind of weather and soil condition.

In contrast, engineers were called upon to design for the 37,000 lb. wheel load of the B-17, B-24, C-46, and C-54 planes when the heaviest transports in use before the war had about 30,000 lb. gross weight or 15,000 lb. wheel load. The next step was to design for the 60,000 lb. wheel loads of the B-29, B-32, and C-74. In both cases no precedents for adequate design had been established. Postwar commercial plane wheel loads are indicated by the 84,000 lb. Boeing 314, the 60,000 lb. B-24D2, the 52,000 DCA and the 80,000 lb. planes now on order by the large airlines. Planes with 150,000 lb. wheel loads are anticipated in the near future, and airfields now under construction are being designed to handle a gross weight of 300,000 lbs. In comparison the legal maximum truck wheel load is 9,000 to 12,000 lbs.

Methods in use to design for these unprecedented airplane wheel loads include:

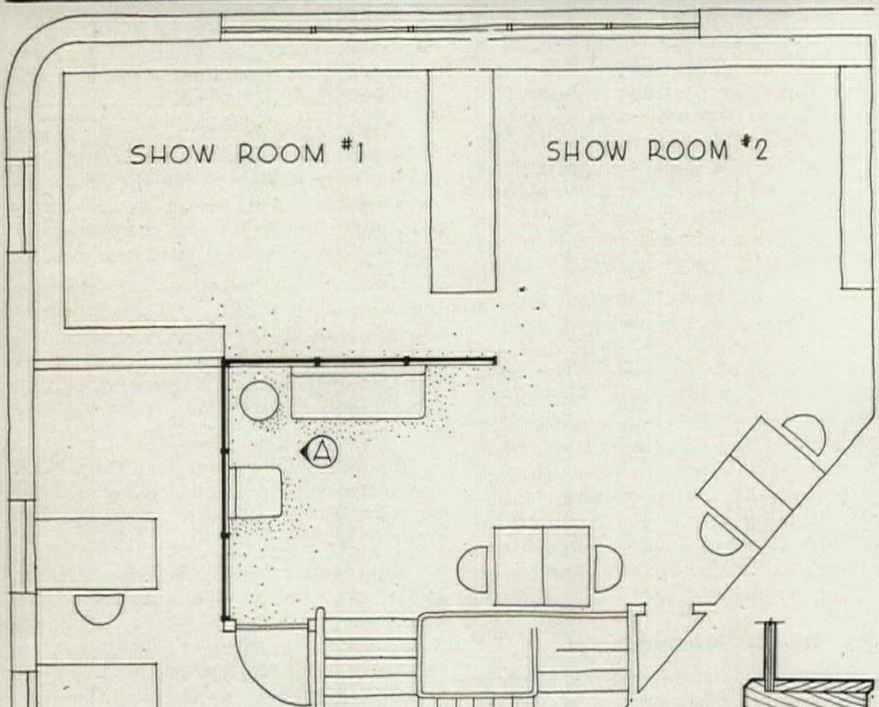
1. Plotting the pavement thickness and soil bearing value which experience has proven to be adequate for the loads encountered up to the present, and "extrapolating" (or projecting these curves) against the wheel loads of the future.

2. Loading an elliptical or circular plate equal to the anticipated future contact area of the plane tire with 1½ times the anticipated load and measuring the settlement and reaction of different soil types and trial runway sections.

3. Loading a plane undercarriage with the proposed load and testing a trial runway section to destruction by continuous traffic.

4. Mathematical analysis of the stresses to be expected in the sub-grade and pavement and design of a thickness according to a safety factor allowing the assumed number of landings or stress repetitions desired for the proposed runway life.

While all of these methods are subject to heated controversy and criticism at present, it is hoped that we will never repeat the experience of having runways and aprons constructed by prewar "good enough" methods fail completely with as few as 100 take-offs or landings. This occurred in the early days of the war.



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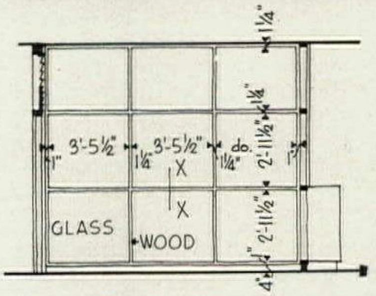

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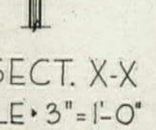

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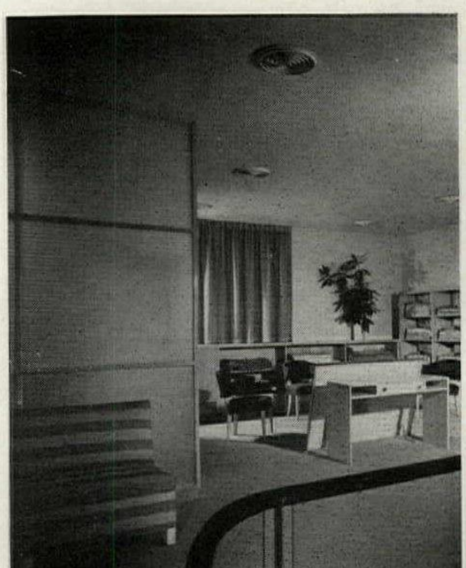
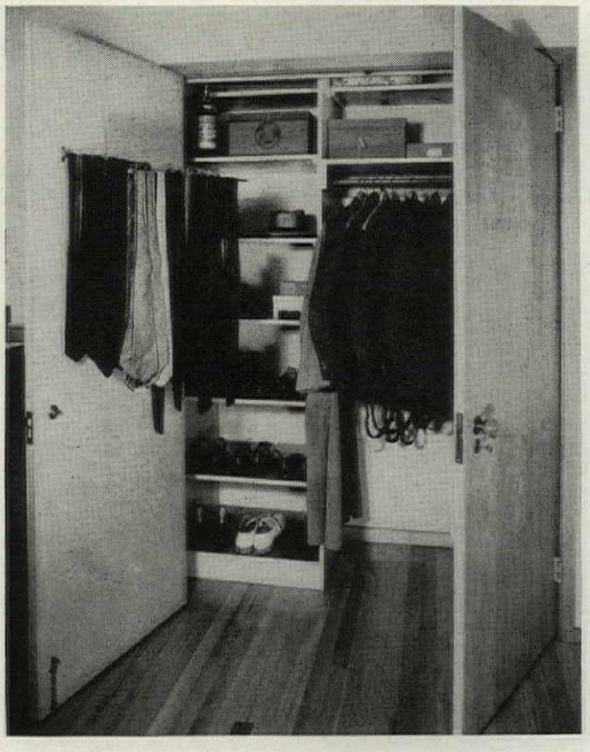
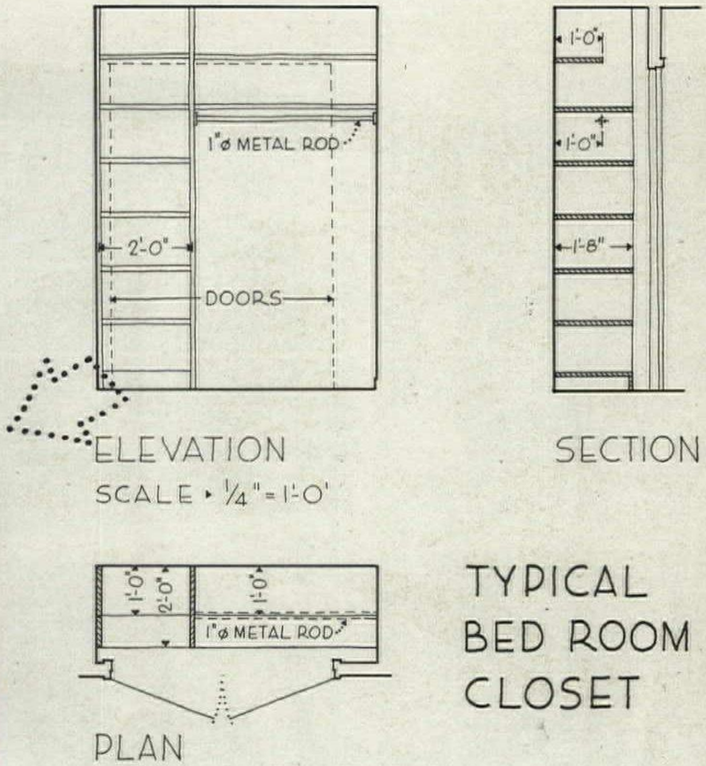
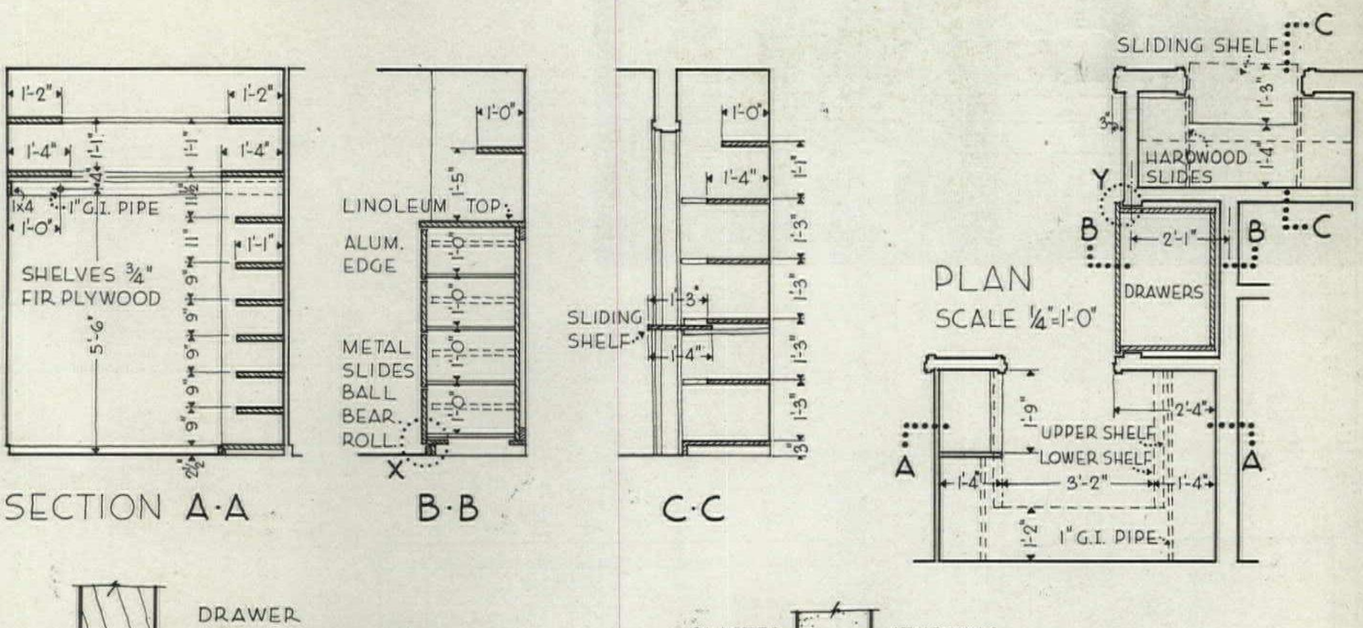
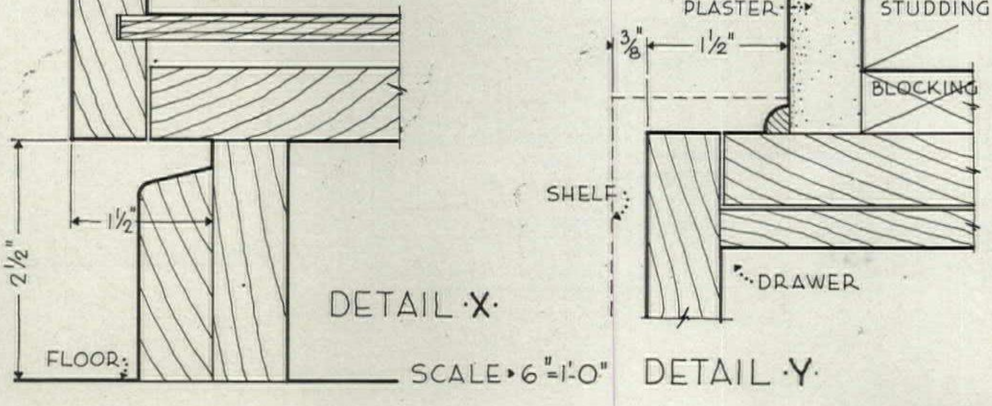




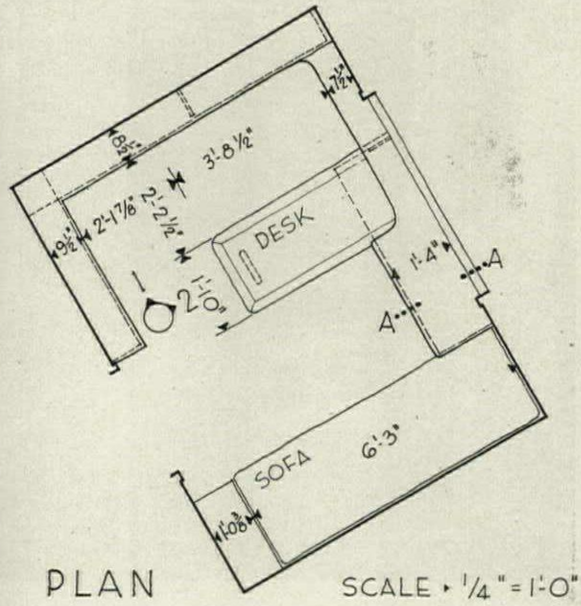


TYPICAL BED ROOM CLOSET





DRESSING RM. CLOSETS AND DRAWERS



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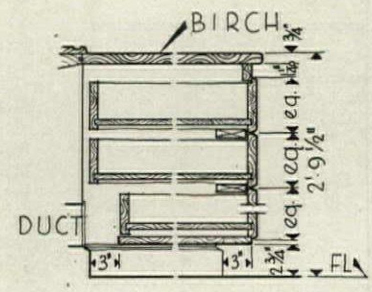

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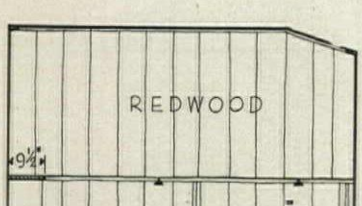

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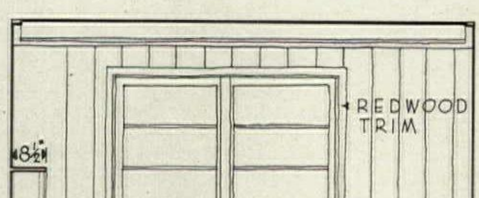

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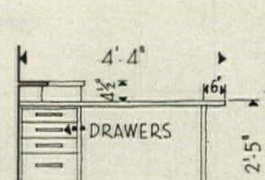

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