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Problems encountered in the development of an airport

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PROBLEMS ENCOUNTERED IN THE DEVELOPMENT
OF AN AIRPORT

By

A. H. Armstrong, B. S.

THESIS FOR THE DEGREE OF CIVIL ENGINEER
NEWARK COLLEGE OF ENGINEERING

June 1932

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PREFACE

The progress of a nation and its transportation facilities have always advanced hand in hand.

Just as it has always been the Civil Engineer's problem to develop facilities for other means of transportation, such as roads, harbors, and railroad terminals, so is it his problem today to build airports.

In presenting the problems encountered in the development of an airport, the writer has considered the airport's place in city and regional planning, as well as the part it plays in air transportation.

An expression of thanks is given to Mr. Wm. S. La Londe, Jr., professor in Civil Engineering at the Newark College of Engineering who has assisted greatly by reading the thesis, and giving valuable suggestions. Acknowledgment is also made to the following: Armco Manufacturers Association; Mr. Harry H. Blee, Chief, Division of Airports, Department of Commerce; Messrs. Henry V. Hubbard, Miller McClintock and Frank B. Williams, co-authors of Harvard City Planning Studies - Airport.

A. H. Armstrong.

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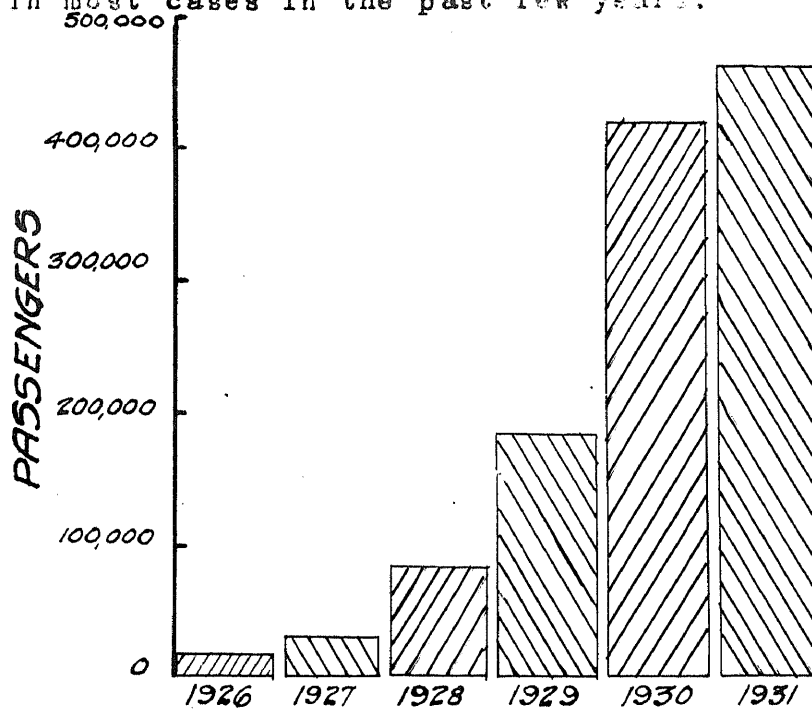
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INTRODUCTION

The degree to which the municipality is responsible for the establishment and maintenance of airports has been the subject of discussion pro and con ever since the beginning of the phenomenal expansion in all phases of aviation not so many years ago. The increase in extent of air transport lines, number of passengers carried, quantity of mail and express shipments, and the consequent increase in the demand for suitable terminals was induced by the confidence and interest which the public manifested in 1927, particularly after the epochal non-stop flight of Colonel Lindbergh to Paris.

The responsibility for airport establishment and operation devolved on the municipal governments by a process of elimination by a more or less natural gravitation to its logical sponsor. The policy of the Federal government was defined in the Air Commerce Act of 1926, by which "It shall be the duty of the Secretary of Commerce to - - - - provide for the examination and rating of air navigation facilities available for the use of aircraft of the United States as to their suitability for such use."

The Federal government will not undertake the establishment of airports except for military purposes. The effectiveness of the policy whereby the transport company becomes the tenant of the municipality has been shown by its general adoption in most cases in the past few years.



Yearly total of passengers carried on regular Air Transport schedule in U.S.

Passenger miles flown (one passenger carried one (1) mile).

1930--103,747,249

1931--112,000,000

Passenger fare average per mile \$0.083 for 1930.

PRELIMINARY STUDY OF EXISTING AND PROPOSED AIRWAYS

Early in the study of the airport site, it should be determined whether the city is on a regional or national airway route, existing or planned, or reasonably to be predicted. If the city is not and is not likely to be on such a route, then it should be considered whether or not the distance from the city to the nearest airport which is on such a route is so great that people can save enough time by flying, as compared with other means of transportation, to warrant a local airport for this purpose. It is evident that any time up to perhaps half an hour might be consumed by a person in town in getting from his residence or from his place of business to the airport. If now it takes him only fifteen minutes to fly from the local airport to an airport on the main airway, it might actually save him time to make the whole of this journey by automobile or possibly by railroad, in which case the local airport would serve only local needs and not be particularly valuable as a connection with the general national airway net.

Any decisions as to the airport will further be influenced by what kind of station on this route

the local airport is going to be. To borrow the language of the railroad, will the local airport be a terminal, a junction point, a regular stop, a flag stop, or, although it is along the route, will it be so located that no stop could profitably be made by long-distance traffic except under extraordinary circumstances? If it is a terminal station, then terminal storage facilities will be necessary, and a close coordination must be arranged between the long-distance traffic by air and local air traffic, or other forms of transportation, presumably radiating from the terminal airport and serving a local region. If it be a junction point, an intersection of two airways, then transfer facilities will need to be given special consideration. If it be a regular stop for practically all service, then the capacity of the airport must keep pace with the whole capacity of the airway as it grows. If, however, the airport is what might be called a flag stop, the field must still be large enough to accommodate any transportation units which are used on the route, but the intensity of use of the field will be much less than the intensity of use of the airway.

CHAPTER I

ECONOMIC SELECTION OF A SITE

An airport is primarily a part of a transportation system, but should also be considered as a functional area being a unit of all the functional areas which go to make up the total land occupied or controlled by the community. Therefore, its location is also a city and regional planning problem, and should be solved not only from the point of view of air transportation, but also from the point of view of the greatest efficiency and the least mutual harm for all the community.

The problems encountered in the economic selection of a site will be discussed from four angles:

1. Accessibility
2. Relationship to other functional areas
3. Size, shape
4. Acquisition of lands

Accessibility

The principal advantage of air transportation is that it saves time, and with the growing speed of planes (at a higher unit cost of operation) the time consumed in getting to and from an airport will be a very important factor. The better the transit facili-

ties, the farther in miles the airport can be located from the center of population. Other things being equal, the problem is to secure the greatest proximity to point of time to the center of population per dollar invested.

The bus and taxi, like the private automobile, use the public highway system, and the relation of this kind of transportation in relation to the site to be selected depends upon a satisfactory highway system. Operating companies at some airports transport their passengers to and from the center of population, thus assuring good connections at the Airport. Since an elevated line gives service that is much faster than ordinary surface transportation, proximity to such a line already existing would be a very desirable feature in the location of an airport. Proximity to a subway is by far more desirable if the land values are not prohibitive. Where this condition exists, the sites, located so that future subways running to the airport would connect with the main system, should have consideration. Surface car lines would not be a very important factor in most cases as they are usually restricted to crowded streets. Where they are operating over a private right-of-way, they may be an

aid, but should not be counted as one of the governing factors.

The relation of the airport to the main highway system in most cases will be the master consideration which will determine the effective nearness of the airport to the center of population. The following are the factors making for consistent rapidity for the connecting traffic:

1. Separation of grades at the principal highway intersections.
2. Elimination of railroad grade crossings.
3. Freedom from ferry crossings and drawbridges.
4. Adequate width of highway.
5. Proper control of traffic along the highway.

The site should be near enough to a main highway as to be very readily accessible from it; but should not abut directly upon it for any considerable length. A location set off from a heavily traveled lane eliminates the real or mental hazard, of both pilots and public, which is present when airplanes pass close to wires and traffic. Land abutting upon a highway has a high frontage value, which is not an asset to the airport as such. Sufficient access, however, is necessary.

Unless a site could be selected either adjacent to or over an important railroad terminal or station there is no particular advantage in being located on the main line of a system. The transfer of passengers and freight from plane to train would have to be done by some other means of transportation in most cases. Being near the one railroad might place the airport at a disadvantage for communication with other main line railroads in the community.

Transfers from airplane to ship, with the possibility of seaplanes being used, would make a location on a waterway desirable. There are disadvantages to this location such as fog and risk in taking off directly over water, unless the size of the field or surrounding area available for landing gives a margin of safety by permitting the airplane to gain a sufficient altitude to make a safe landing in event of engine failure.

A study of the atmospheric conditions should be made of the entire district under consideration to determine fog and smoke conditions. Records of the weather bureau show that in the New York metropolitan area dense fog (fog that obscures objects 1,000 feet away) decreases very rapidly from the southern to the

northern portion of the district, and slightly from the eastern to the western portion. Dense fog occurs at Sandy Hook seven per cent. of the days of the year; at the Battery, five per cent.; at Central Park, two per cent.; and at Mount Vernon, one per cent. The prevalence of radiation fog (ground mist) varies but slightly throughout the district, any one of the low flat areas being about as subject to these fogs as any other.

A survey will be necessary to determine the areas where smoke prevails. Most of the industrial smoke of the metropolitan district originates west of Manhattan, and is carried out over the district by the prevailing westerly winds. In general the density of this smoke decreases from the southern to the northern parts.

Relationship to Other Functional Areas.

The effect of the residential district upon the airport is not likely to be harmful except that tall apartment homes, school buildings, hospitals, churches with spires, or trees, if located too near to the field, may be obstructions. The site properly located, and the carrying out of a zoning plan for the surrounding property would eliminate this difficulty.

The effect of a commercial district is disadvantageous in the following ways: it creates hazards by its closely built character, its tall structures, and the air currents generated above it.

High factory chimneys located in an industrial district constitute a hazard, especially when they are isolated, even though they may be as much as a mile distant from the field. Smoke and the air currents found over such regions make flying more difficult and dangerous. The approaches and surroundings of an airport in an industrial area are likely to be less appealing to the tastes of the people patronizing air transport. Some of these disadvantages are possible of control. Chimneys can be replaced by means of the installation of forced draft, and the danger from smoke and air currents lessened by locating to the windward of the smoke area.

An airport is not a thing to be sought in a residential district, for the sake of the residential district. Nevertheless, the airport cannot be excluded completely from all residential districts because this would be likely to render impossible the efficient location and operation of a very important functional area. A small field, with planes consequently forced

to fly over houses at low altitudes, certainly would be both dangerous and noisy. Another objection that has brought complaints is parking in the vicinity of the airport. A field properly designed with runways of sufficient length and parking areas planned within its limits should eliminate most of these objections.

An airport located in a commercial district might create a barrier which would be a serious disadvantage to the ordinary expansion of business, and access to the business area.

There should be no injurious effect of an airport upon an industrial district.

In discussing the relation of an airport to the recreational areas it should be borne in mind that airplanes are primarily a means of transportation, and not a recreation. The small percentage of the population that make use of them for recreational purposes will become less as the novelty wears off, and we all become accustomed to, and confident in the service as rendered by transport companies. A park system is a functional area, and every unit of it is either serving an important need or is planned for the purpose of serving a need as the surrounding population of the city increases. A site selected as

a separate unit, but near a park system should be advantageous for the airport, and should not be injurious to the park. Freedom from tall structures, and the beauty of the surroundings, with the possibility of the connecting highways running through the park system, is desirable.

Size - shape

In the United States the size of airports depends upon by whom and for what the airports are to be used as the following list indicates:

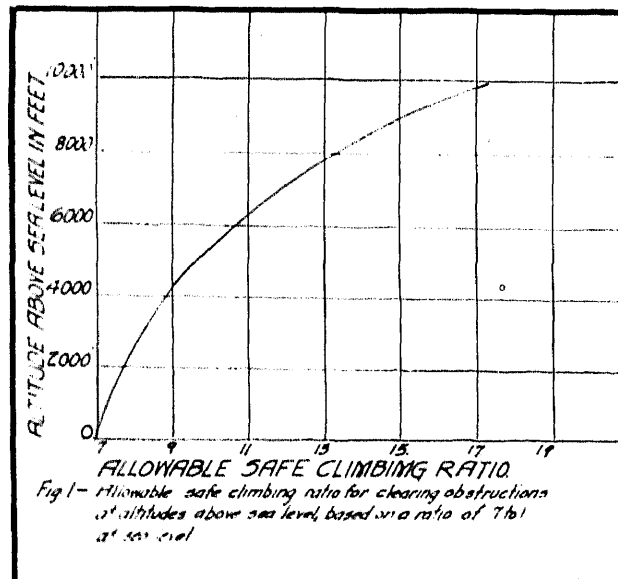
1. Air mail
2. Transport
3. Schools
4. Air taxi service
5. Sight-seeing
6. Use by private planes
7. Testing

At first all or most of these activities could be cared for at the one airport, but as the amount of mail and passenger traffic increased, the other uses could be segregated to separate fields. In selecting the site, the ultimate use with full allowance for future expansion should be borne in mind.

A comprehensive layout of all the areas that will satisfy the internal needs should be made and superimposed upon a map of the proposed site. A study of the effect of the surrounding territory on the size and shape of the total area required can then be made.

For airports located at sea level, surrounding obstructions diminish the effective landing lengths for planes landing over these obstructions by amounts equal to seven times the height of the obstruction above the landing area. For instance, obstacles 50 feet high along the border of the field diminish the effective landing length for planes by 350 feet. This also applies to planes when taking off.

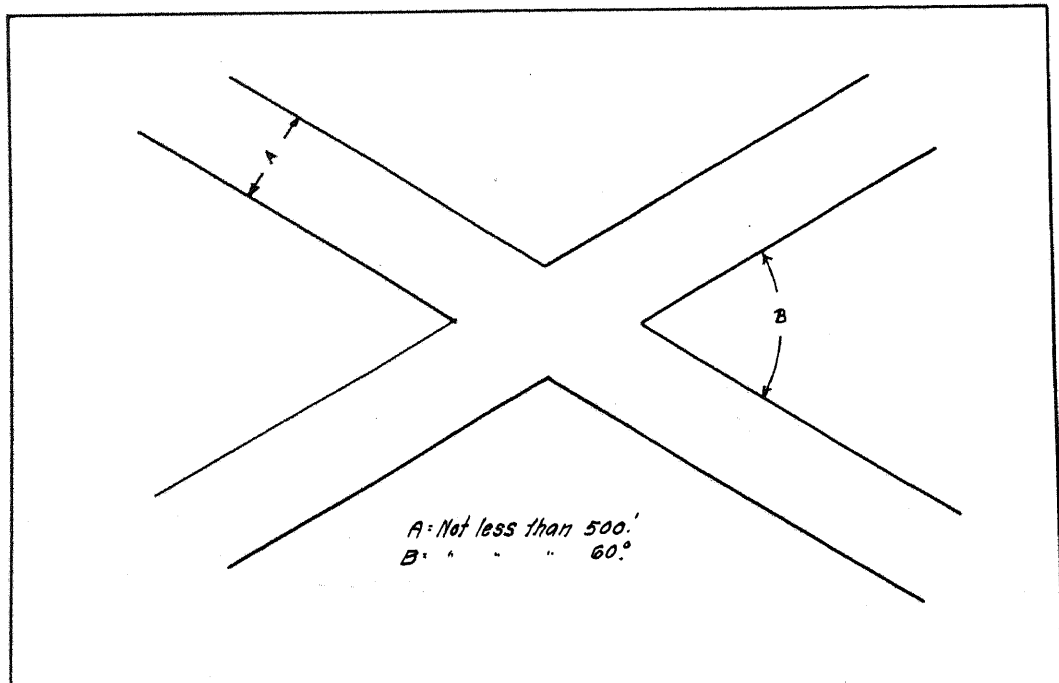
For airports located at altitudes in excess of 1000 feet above sea level, the allowable safe climbing ratios for clear obstruction shall be increased to the value shown in the accompanying figure furnished by the Department of Commerce.

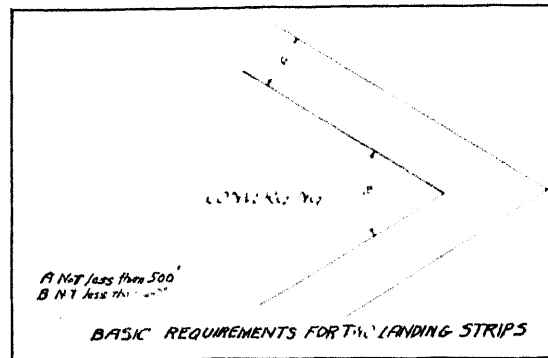


The ratio of 7 to 1 at sea level is a minimum requirement and every individual obstruction needs analysis. An obstacle at the end of a runway, even though the ratio should be as much as 10 to 1, might prove to be a dangerous hazard.

The internal requirements affecting the size of the site are as follows: effective landing area, building and parking space. The Department of Commerce demands certain basic principles to be adhered to in the layout of all airports.

In reference to the effective landing area, if sufficient space is not available for landing and taking off in all directions, there shall be at least two landing strips 500 feet or more in width crossing or converging at an angle of not less than 60°.

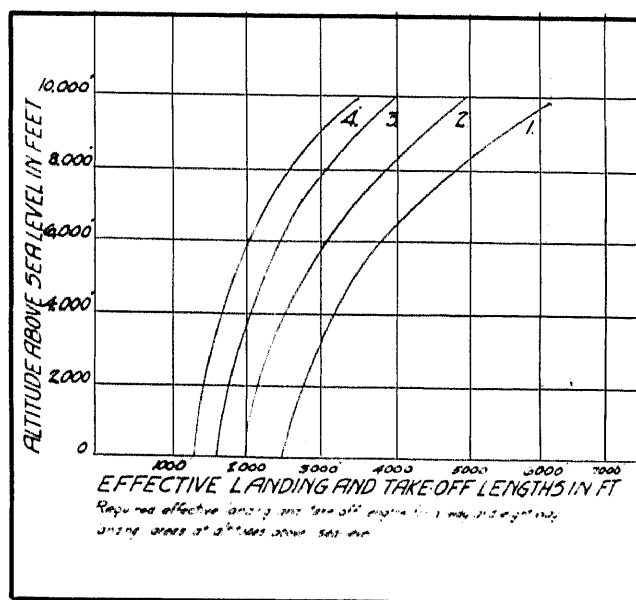




In addition to the basic requirements airports are rated. This is shown by a letter figure and a letter indicating facilities, size of effective landing area, and lighting equipment respectively. An A-1A is the highest rating attainable.

For a "1" rating, the size of the effective landing area shall be at least 2500 feet in all directions or it shall have landing strips not less than 500 feet wide, permitting landing in at least eight directions at all times, the landing strips not to cross or converge at angles of less than 40° nor any one of the landing strips to be less than 2500 feet in effective length.

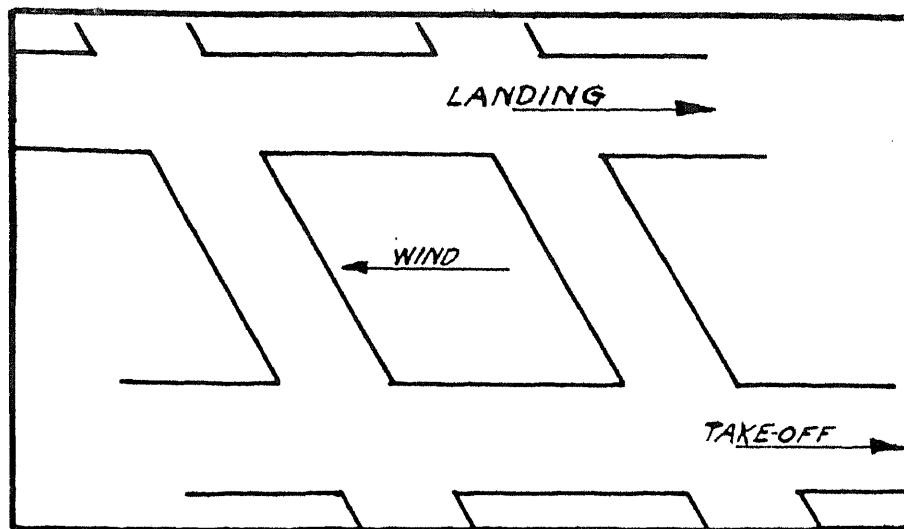
When the airport lies at an altitude in excess of 1000 feet above sea level, the dimension of the effective landing area or the lengths of the effective landing strips shall be increased to the corresponding values shown in the accompanying figures.



All the above rules should be carefully considered, but just meeting the requirements of the Department of Commerce would not be enough to take care of future needs. There is a considerable weight of opinion at present that, in view of the tendency toward larger and faster planes, the landing strips should properly be planned with an ultimate length of

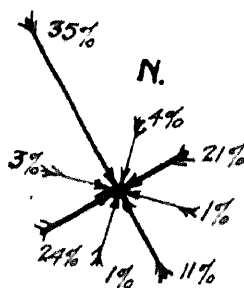
at least 3000 feet. Provision for future expansion is highly desirable, and it is unlikely that improvements in the ability of aircraft to alight and arise from the field will result in a reduction in size of the field, because any such improvement would almost automatically bring about a completely offsetting increase in the number of aircraft. As with parks, there is a size beyond which it is disadvantageous for the city to go in setting aside areas through which no streets may pass, and also there is a sufficient size for an airport, so that if the future use outgrows it, the answer would not be a larger airport, but a differentiation of function and another airport somewhere else.

Separate landing and take-off areas have been advanced as a means of increasing the capacity of airports, but one area can be arranged so that a landing and take-off could be made simultaneously. Figure following shows such an arrangement. Instead of an all way field, the use of landing strips properly marked affords a means of control.



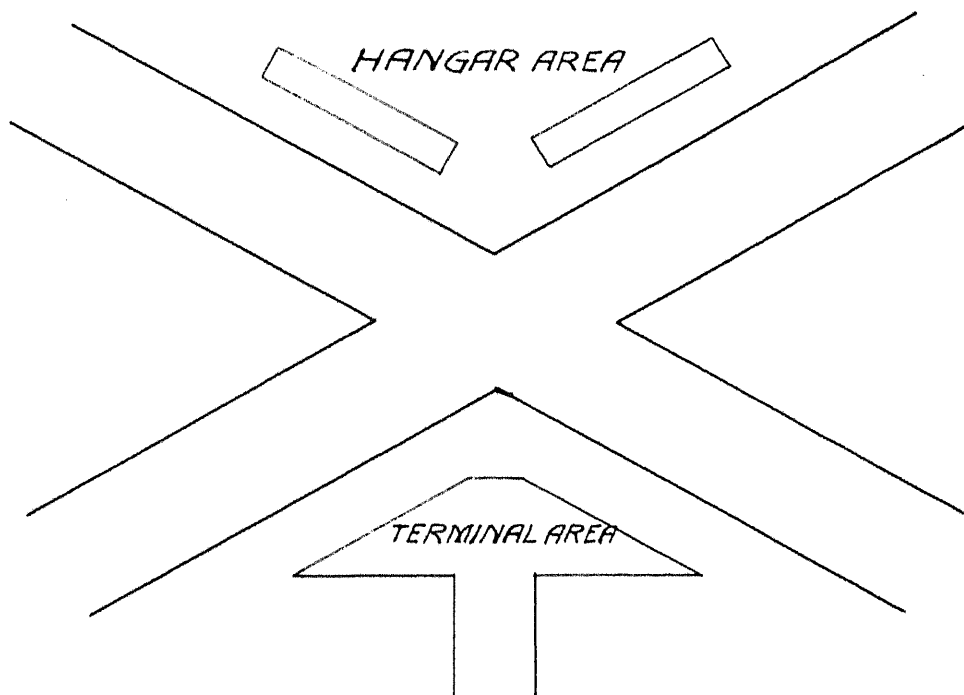
Number of runways depends upon the layout of the field.

Ideally, a landing field should be capable of containing, in the eight primary compass directions, the required length of effective landing strips, thus allowing landing and departure in practically any direction. If for unavoidable reasons, the field cannot be of ample dimensions in all directions, it should at least have ample dimensions in the direction of the prevailing winds.



Average yearly percentages showing direction of prevailing winds

Sufficient space for buildings should be allotted where the minimum interference with planes landing and taking off will result. A compact arrangement taking up the least area is the one in which the buildings are placed in one of the sections between the landing strips. This is objectionable as it may be advisable later to make the whole field available for landing, in which case the existence of these buildings on the field would seriously reduce the effective landing area.



The areas to be allotted for buildings will be discussed in the following order:

1. Hangar sites - storage of planes and appurtenances.
2. Accommodations - passengers and personnel.
3. Post Office and Weather Bureau, etc.
4. Shelter for maintenance equipment.

In planning the size of the several areas it will be necessary to make an assumption as to the capacity of the Airport. The landing area can be divided into two sections, one for landing, and one for planes taking off. This will probably increase the efficiency by about 50 per cent., but the number of landings that can be made per day will be limited by the extent to which a uniform traffic control system is perfected. The peak hours for transport planes usually occur from 7 to 10 A.M., and 4 to 7 P.M. Twenty landings per hour for these periods allows for a margin of safety. The remainder of the day's traffic might average 10 landings per hour, which would make a total for the day of 300 landings. Planes making short flights

will make several landings each day, but there will be other planes under repair or in dead storage so that it seems reasonable to assume hangar space for approximately 300 planes would meet this requirement.

Hangar sites 160' x 400' will allow for the erection of two hangars with spans of 120' to 160' and a set back of 20' from the property line. Planeways at least 150' in width should be placed between the sites to enable efficient manoeuvring of ships. Ten planes to the hangar would require 15 sites for the 300 of them. Each site including the adjacent planeway area contains 3 acres, therefore, approximately 45 acres will be required.

A terminal area should be allotted for either one large terminal building or several smaller buildings for the accommodation of passengers and personnel. Allowance for sufficient space surrounding the buildings should be made in this area for the control of vehicular traffic, and the handling of passengers boarding or debarking from planes. A prediction of the number of passengers that can be cared for by an airport is even more of an uncertain quantity than the area required for hangars. The capacity of a plane might be doubled, but the storage space required in a hangar might be in-

creased by only 30 per cent.

Six hundred landings and departures each day with an average of ten passengers to each plane would mean that 6000 people would pass through the terminal area every 24 hours. Even though this number should not be reached, the maximum of 400 an hour during the busiest time of the day might have to be accommodated. This area should be at least 600 feet square.

The post office and weather bureau should either be in the terminal area or adjacent to it.

Space to allow for the erection of buildings to shelter field maintenance equipment should be segregated to a distant part of the field.

Several parking areas will be better than one large area. Either provision for parking on the hangar sites or several separate parking areas should be planned for this section. A large parking space, accessible to the terminal area, should be provided.

AREA - Airport Proper

Landing Area	200	acres
Hangar Sites	45	"
Terminal and Administration	10	"
Parking	10	"
Connecting Streets	<u>10</u>	"
	275	

A total area of 300 to 400 acres at sea level might be necessary depending upon the requirements of the surrounding territory.

Acquisition of Lands

The investment in land area for an airport is usually a considerable item of immediate expense. The fact that a site requires a large investment for land induces the temptation to eliminate it from consideration on this account, although it may have many desirable features. This has proved to be poor economy in certain cases for the reason that the raw land cost is used as a basis of comparison rather than the total cost which includes necessary expenditures for clearing, grubbing, grading, draining and surfacing.

A site composed of many small parcels might involve legal entanglements that would be costly and also take up valuable time in settling.

A municipality has an advantage in having the powers of condemnation as an airport is considered a public need.

CHAPTER II

ENGINEERING SELECTION OF A SITE

An item which often received too little consideration in selecting a site is the matter of relative cost of preparation. The extent of grading, drainage and surfacing will depend upon natural conditions such as topography of the ground and character of the soil. In some instances an item of cost for flood control or an item for the use of pile foundations for buildings should be considered.

In order to make a study of the proposed site, a topographic map should be obtained. This will show the relative elevation of the tract, affording a means of calculating the yardage to be removed where grading is necessary. It will show the location of the natural drainage channels and the amount of their slopes.

Grading

The grading estimate should be considered from several standpoints.

1. The maximum gradient permitted by the Department of Commerce for slopes of landing area shall at no point exceed $2\frac{1}{2}\%$. The mean slope shall not be more than 2% in any direction.

2. The surface gradient of the area influences the rate and amount of surface run-off from rainfall. This influences the size and spacing of the lines of the drainage system.

3. Most airports will ultimately have paved landing areas or runways, and the gradient should be held to low limits.

From any of these standpoints grades of less than 2% are desirable.

Considering first earth and turf surfaces, uniform gradients up to 1.0% are preferable to level fields because the run-off induced by the gradient helps to remove the surface water before the soil becomes soggy. This is particularly true of dense, heavy soils such as clays. In soils that are apt to wash, gradients must be reduced. A moderate gradient makes possible the use of longer drain lines than may be used in level ground without going to too great a depth.

Where runways or paved areas are planned, a gradient of approximately 0.5% provides ample surface run-off.

Drainage

The relative costs of drainage for several sites might differ by as much as One Thousand Dollars an acre.

The factors that add to the cost of drainage are:

1. High water table
2. Poor upper stratum of soil (clay)
3. Lack of a natural slope (such as meadowlands)
4. Difficulties in providing a proper outlet beyond the airport limits.

The basis of design for airport drainage system will be discussed. Data pertaining to soil characteristics is shown under appendage one.

The sources of soil moisture are precipitation, flow over the surface from adjacent territory, and underground seepage from higher areas or tide water.

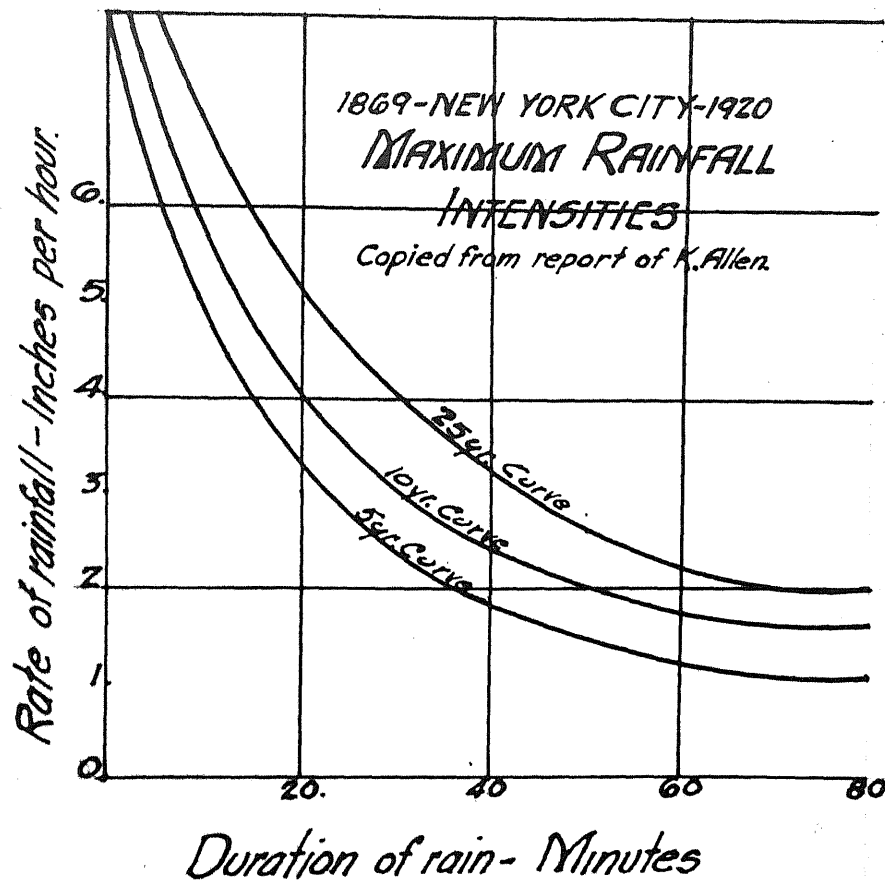
Of the water from the first two sources, part flows over the surface to depressions and ditches, part percolates into the earth, and part evaporates. The seepage from the second two sources usually causes the level of the ground water to rise. Tide water,

of course, can be a source only when the site is in the vicinity of tidal waters. The water that percolates through the ground during a heavy rain causes the water table or level of ground water to rise above the ground in the low areas. If the surface of the ground is of an impervious material, the precipitation will run on the surface and collect at the low areas. With a low water table, and a permeable soil, both surface and sub-soil, the precipitation percolates through and there is no need of drainage. The application of dust-laying material or the paving of landing strips, thus sealing the surface, makes surface drainage necessary in the latter case.

The amount of water to be carried off depends upon:

1. Rainfall
2. Character of soil
3. Slope of ground
4. Type of surfacing

The rational method, making use of precipitation curves compiled from records over a long period for local conditions, can be used for determining the run off.



The use of the five year curve should be ample for an airport:

The character of soil has been covered under that topic, but briefly, an impervious soil increases the amount of surface runoff.

The steeper the slope of the ground, the less chance there is of the water percolating through

the surface soil. This results in an increase in the amount of surface runoff as stated under "Grading".

The type of surfacing is a very important item, and an allowance of at least 20% for paving surface for the landing area of an airport should be made.

With the above as a basis, an assumption can be made for "C", the coefficient of runoff or percentage of surface water reaching the inlet.

"I" is the intensity or rate of rainfall in inches per hour at the time of concentration. The time of concentration includes the inlet time, the period consumed by water in flowing from the most distant point in the drainage area to the catch basin and "time of flow" in the pipe. The "inlet time" is very important as it materially influences the whole design. For an airport with a low gradient and grass areas, the inlet time can be taken as 25 minutes. Using the five year curve the value of "I" will be 2.6 inches per hour. The value of "C" for 20% pavement and 80% grass area or some other pervious material will be .80 for pavement and .15 for grass, general slope of field 0.5%.

Average value of "C"

$$.30 \times 20\% = .12$$

$$\underline{.15 \times 30\% = .18}$$

$$C = .30$$

Instead of increasing the value of "C" as the time of concentration increases with additional increments of time for flow of water between manholes, use an average value of .30.

Note: The amount of precipitation that falls on one acre at the rate of 1" per hour is equivalent to 1 cubic foot per second.

Therefore: $I \times C = 2.6 \times .30 = .78$ cubic feet per second runoff per acre.

$$\text{Therefore: } Q = A \times C \times I$$

in which

Q = runoff in cubic feet per hour

A = drainage area

C = Coefficient of runoff

I = intensity of rainfall inches per hour

The method of removing this runoff water is termed surface drainage. The removal of ground water is accomplished by a sub-drainage system.

A method for the removal of surface water that has been used extensively on airports consists

of drains placed along the edges of the planeways. In most cases the drain consists of either tile concrete or metal pipe surrounded by a porous material. This porous material was in many cases carried to the surface. The objections to this method are:

1. Inability of water to get through upper surface to drain.
2. Loose particles scattered by planes.
3. Difficulties during freezing weather.

There has been no satisfactory method of binding the surface over these drains without making it practically impervious to water.

This trench method or combination of the surface and sub-drain systems was resorted to because of the fear that the installation of catch basins would be hazardous.

Open grating flush type catch basins have been installed on airports with satisfactory results. If the ground is apt to get soggy around the basin, underdrains should be placed, and the surface paved for a radius of approximately five feet.

For sections of the field having runways, the catch basin can be placed about ten feet in from the edge on the paved runway. For an all-way field

catch basins can be placed at the low points of the field. With a loose material as a surface, the spacing of the basin should be arranged so that a minimum amount of surface washing will take place.

With the trench method of receiving the surface water, the mains in many cases have been designed to allow for a runoff period of two to three hours. With the installation of catch basins, a quick runoff is necessary, and the system is similar to the ordinary storm water sewer. As in a storm sewer system, the catch basin should be connected to manholes.

Submains and mains need be only deep enough to provide ample grade of flow for the area being drained. The flow line gradient should be at least 0.3%, and in no case less than .25% for laterals. While it is preferable to maintain a minimum of 0.3% gradient of flow line in submains and mains, they may have as low as .2% gradient and give satisfactory flow.

The purpose of the sub-drainage is to remove the ground water and lower the water table. It functions by releasing the pocketed air and causing a line of least resistance. The drain consists principally of a trench backfilled with cracked stone or some other pervious material. As a means of aiding the flow

of the water, pipes of the following materials may be used:

1. Tile
2. Concrete
3. Corrugated metal pipe with bottom $\frac{1}{3}$ perforated.

In general, the sub-drains are placed at the top of an underlying impervious stratum, at the bottom of an overlying water-bearing stratum, or at such depths as to keep the water table sufficiently low enough to prevent gravitational and capillary water from being harmful.

QUANTITY OF CAPILLARY WATER RAISED POUNDS PER SQUARE
FOOT OF SOIL PER DAY

	Height Above Source			
	1 Foot	2 Feet	3 Feet	4 Feet
Medium Fine Sand	2.27	2.07	1.23	0.91
Medium Clay Loam	2.05	1.62	1.00	0.90

This means that with the water table one foot below the surface of a medium clay loam, 2.05 pounds of water will rise to the surface (and evaporate). If the water table is lowered, less water will be raised by

capillary action. When the capillary water is present in large quantities, the upper soil is made impermeable.

RECOMMENDED DEPTH AND SPACING OF SUBDRAINS FOR VARIOUS
SOIL CLASSES

Soil Classes	Depth of Bottom of Drain in Feet	Distance Between Subdrains in Feet
Sand	3-4	150-300
	2-3	100-150
Sandy Loam	3-4	100-150
	2-3	85-100
Loam	3-4	85-100
	2-3	75-85
Silt Loam	3-4	75-85
	2-3	65-75
Sandy Clay Loam	3-4	65-75
	2-3	55-65
Clay Loam	3-4	55-65
	2-3	45-55
Silty Clay Loam	3-4	45-55
	2-3	40-45
Sandy Clay	3-4	40-45
	2-3	35-40
Silty Clay	3-4	35-40
	2-3	30-35
Clay	3-4	30-35
	2-3	25-30

The three principle systems under which subdrains may be arranged are:

1. Herring-bone system
2. Gridiron "
3. Parallel "

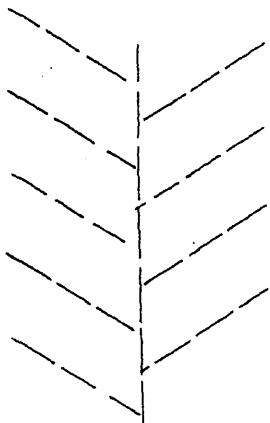
Ground

Clay
Loam
Sand

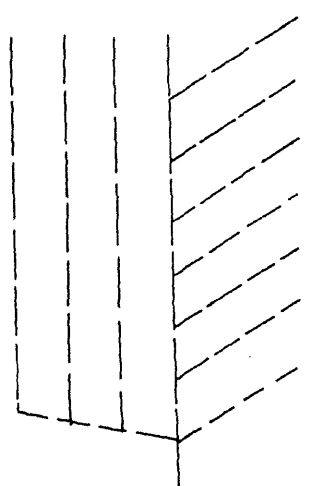
Clay
Loam
Sand



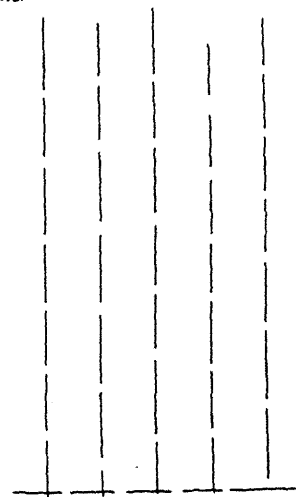
SUB-DRAINAGE SYSTEM



HERRING-BONE SYSTEM



GRIDION SYSTEM



PARALLEL SYSTEM

or a modification of any of three principle systems.

In computing the capacity of a sub-drainage system, lowering the water table 1/2" per day is the equivalent of 1/2" of rainfall per 24 hours.

One inch per hour is equivalent to a runoff of 1 cubic foot per second per acre.

Therefore: $\frac{1}{2} \times \frac{1}{24} = \frac{1}{48}$ of a cu.ft./sec/acre

The minimum size of 4" for tile and 6" for metal pipe is more than sufficient for the upper portion of the system.

The interceptors and mains should be figured on the basis of .02 cubic feet per second per acre. Where there is a possibility of other seepage, the capacity should be increased by about 50%.

When a sub-drainage system is designed in conjunction with a surface drainage system, the mains for the surface drainage will accommodate the sub-drainage runoff without the necessity of an increase in their sizes.

A field designed only for sub-drainage should have proper consideration for surface drainage before there is any change in the surface from a pervious to an impervious condition.

Surfacing

A landing area with a smooth surface capable of withstanding the loads subjected to it is a very important factor in promoting safety in aviation.

In the early days sod, with a good light subsoil, answered this purpose very well. With the increase in the number of landings, and the use of heavier and faster planes, it has become necessary to provide a more durable surface.

The essential conditions for airport surfacing are:

1. Sufficient bearing power to withstand plane loads plus the impact
2. Smoothness to allow an ordinary automobile to travel at the rate of forty miles an hour.

The conditions to be desired are:

1. Good traction
2. Freedom from dirt
3. Low cost
4. Low maintenance cost
5. Long life

Metal tail skids of planes are being replaced by small wheels with pneumatic tires. This eliminates the necessity of having soft surfaces, and also reduces the high maintenance cost due to ruts caused by the tail skids. With their continued use it is doubtful that any surface could ever have been perfected suitable for all purposes.

Surfaces for airports can be classified as follows:

1. Low type
2. Intermediate type
3. High type

The low type consists of selected earth mixed with the native soil, such as sand and clay, or covering the base with some porous material such as gravel, crushed stone, slag or cinders. The only advantage of this low type is that the initial cost is low. The disadvantages are: high maintenance cost, damage to planes from loose particles, poor traction and dust in dry seasons.

The intermediate type of surfacing consists of a bituminous material, either hot or cold, with an aggregate "usually a local one" or a native soil. The methods of construction for this type are surface

treatment, penetration, mixing in place or pre-mixing.

The penetration method has found favor in many airports throughout the country. It is similar to the old macadam pavement with the addition of the bituminous material as a binder. The advantages of the penetration method are: reasonable first cost, minimum amount of equipment necessary, moderate maintenance cost, good traction, lack of dust and loose particles. A very important feature is its salvage value as a base for a more permanent pavement. The

The high-type surfaces consist of reinforced Portland cement concrete, sheet asphalt or asphaltic concrete on a Portland cement concrete base. The advantages of the high type surfaces are low maintenance costs and long life. The initial cost is high, and it is inadvisable for most airports to consider such an undertaking until the needs are of a definite character.

Even though there exists a possibility of heavier planes being used in the future, surfaces should be designed on present day requirements. The larger planes may have additional wheels and larger tires, thereby distributing the loading. With the further

perfection of the shock absorbers, the unsprung part of the plane will be lighter, thus reducing the impact.

CHAPTER III

BUILDINGS AND APPURTENANCESBuildings

The character of an airport is judged to a great extent by the appearance of its buildings. Early in the development a decision should be made as to the type of architecture and color scheme to be used.

Colonial and Spanish types of building have found favor with some of the large transport companies of the country. The architecture should be plain and well proportioned.

The color scheme selected should allow for visibility from the air. For the sides of the buildings, a buff color proves satisfactory. Chrome yellow is recommended as the color for the roofs.

There are three general types of airport buildings, viz.: hangars, terminal buildings, and those built to house equipment.

Hangars are primarily used for the storage of airplanes, but may be used for one or more of the following additional purposes:

- Light repairs
- Major repairs (overhauling)
- Storage (airplane appurtenances)
- Field office

Flying school

Show room.

The uses of the terminal building or buildings should include accommodations for the passengers the same as those in a railroad terminal. Additional space should be allotted to provide for:

1. Operating companies
2. Field staff
3. Post Office
4. Weather Bureau

A temporary building should be erected, and later replaced with an appropriate structure, or a permanent building constructed in units comparable with the growth of the airport for terminal and administration purposes.

There is nothing of a special nature about the buildings for the housing of equipment. Space should be provided for the field maintenance equipment and the forces operating this equipment. It is also necessary to provide housing for certain of the fixed equipment.

Of the several types of buildings, the hangars are most characteristic of an airport. Regardless of the use to which a hangar is to be put there are certain general requirements to be con-

sidered, viz.:

1. Unobstructed floor space
2. Unobstructed entrance
3. Protection from fire
4. Heating
5. Lighting

Rectangular hangars are most adaptable to the majority of airport needs. The lay-out may be varied with wide limits of size and space needs, dependent upon cost and use. Due to the necessity for constant motor overhauls, much work is performed on planes within the same area that serves as storage. Repairs usually require equipment in the form of machines, which should be housed in a lean-to separate from storage or working areas, yet easily accessible therefrom.

Six or eight-sided hangars have been erected on several airports. The machine shop is in the center like the hub of a wheel and adds to the efficiency of the working area. These hangars are not so well adapted to addition or alteration as the rectangular hangar and cannot accommodate large planes so efficiently.

Three types of hangar structures have been used, namely: frame, reinforced concrete and structural

steel frame.

The frame hangar has a very apparent disadvantage in the high fire risk, and high maintenance cost.

The reinforced concrete hangar has a low fire risk, long life, low maintenance cost. Among its disadvantages are included difficulty in alteration with little or no salvage value.

Structural steel frame is especially suitable for hangar buildings because of its adaptability to various plans.

The controlling feature in the plan of a hangar is the size of the door opening. To insure against obsolescence the minimum size of the door opening should be 100 feet wide and 20 feet in height. For each 10 feet of increase in width an additional foot added to the height seems to be within the scope of good practice. A maximum width of 150 feet is considered ample for some years to come.

There is an economic limit to the depth of a hangar due to the efficient handling of the planes. For hangars of one door opening, a depth of 120 feet should not be exceeded. Hangars with doors at either end may have a depth of 200 feet.

Structural Features of Steel Frame Hangars.

The three types of trusses used are bow string, pitched and flat. The bow string truss is economical for spans up to 150 feet. A saving can be effected by the use of standard trusses as fabricated by several large companies. In addition to the usual roof loading, the truss should be designed to carry a load of two tons imposed at any panel point. In combination with channels or bar joist purlins an excellent roof structure is formed.

Two inch boards supported by purlins spaced on five foot centers with a covering of built-up roofing forms a typical roof. Steel decking is also used, but the slight reduction in the insurance rate does not warrant additional expense.

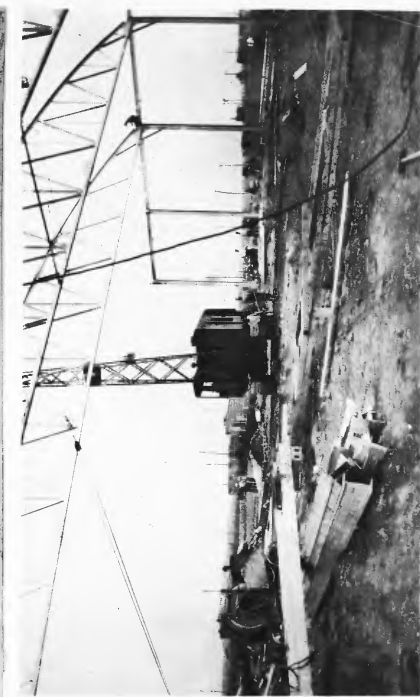
Steel columns supporting the trusses, with the wall space between composed of either brick or cement concrete block, and steel sash windows, allows for facility in alteration and the admission of light.

The floor should be of concrete pitched to trap-type interior basins. If the sub-base is apt to settle, piles should be driven to support a beam and slab-type concrete floor.

Doors have proven to be the greatest special

STEEL FRAME HANGARS.

NEWARK AIRPORT.



problem in the construction of hangars. Many needed improvements to the doors have been made in the past few years. The requirements of hangar doors may be set down as follows:

1. Speed of operation
2. Ease of operation
3. Protection against weather
4. Strength
5. Low maintenance.

In general there are two types of hangar doors, viz.: slide and overhead.

There are two methods of operating the slide type doors.

1. Slides across the end of the hangar beyond the sides. (straight sliding doors.)
2. Slides across the end of the hangar and along the side wall. ("Around the corner" door.)

The straight sliding doors require cumbersome frames at the sides for stacking when in an open position. The "around the corner" doors restrict the use of a portion of the side walls.

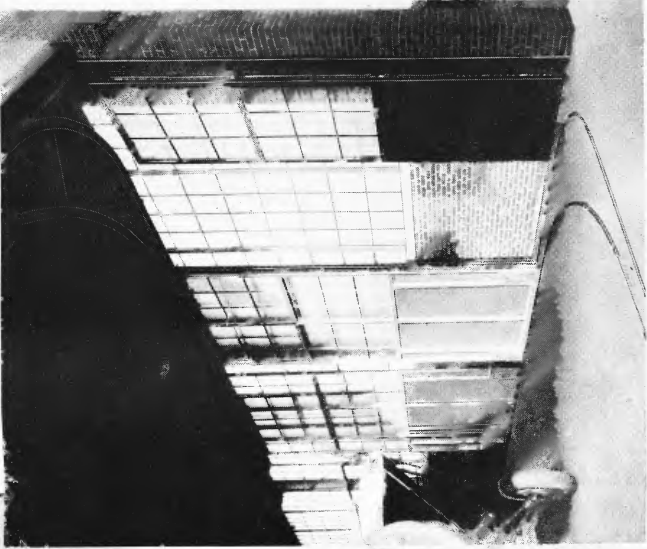
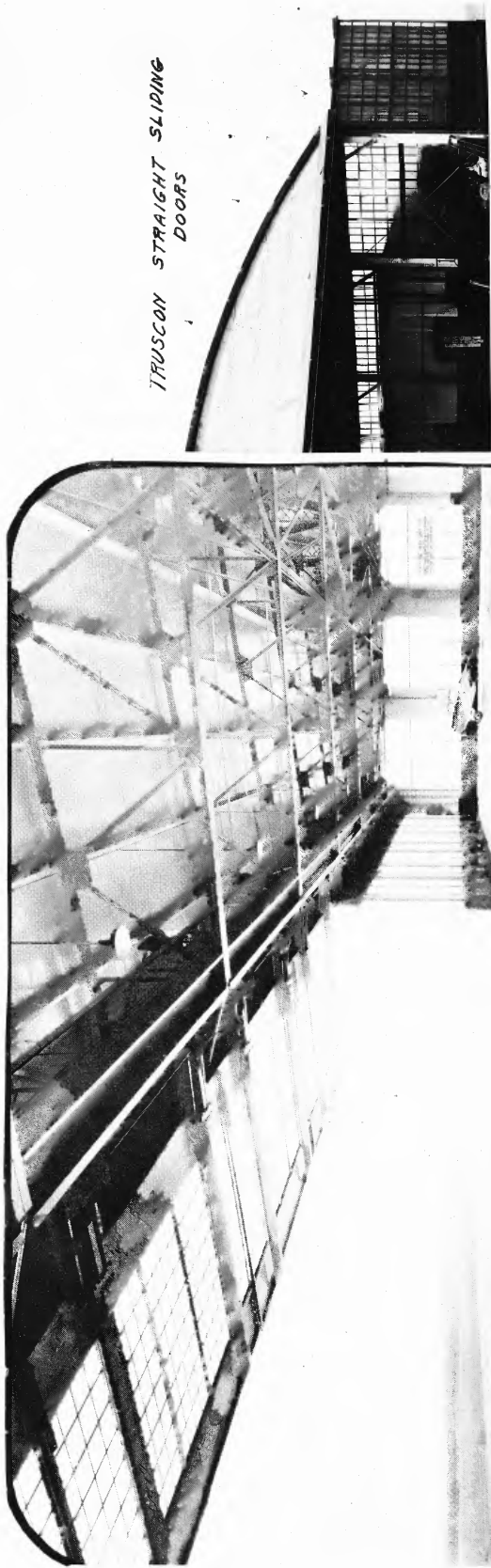
The doors are usually divided into sections or leaves ten feet in width. Two rollers are at the bottom of each leaf. The rollers are equipped with ball bearings.

With the introduction of the "around the corner" door the roller was designed to swivel freely. The doors are guided at the bottom by small rails imbedded in the floor or beam and at the top by means of rollers coming in contact with structural steel angles. The method of locking the doors by slipping a bolt into a hole in the floor has been improved by the introduction of a friction bolt. By depressing a handle, the weight of the door is transferred from the bottom roller to a pad, which comes in contact with the rail on which the door rests.

Rubberized canvas is used for weather-stripping between the leaves and at the jambs, and adjustable steel plates at the bottom. The framing of the doors consists of either seamless steel tubing or small channels and I-I-beams. Steel plates are fastened to the lower portion the upper portion being composed of sash panels to provide adequate natural lighting of the hangar interior.

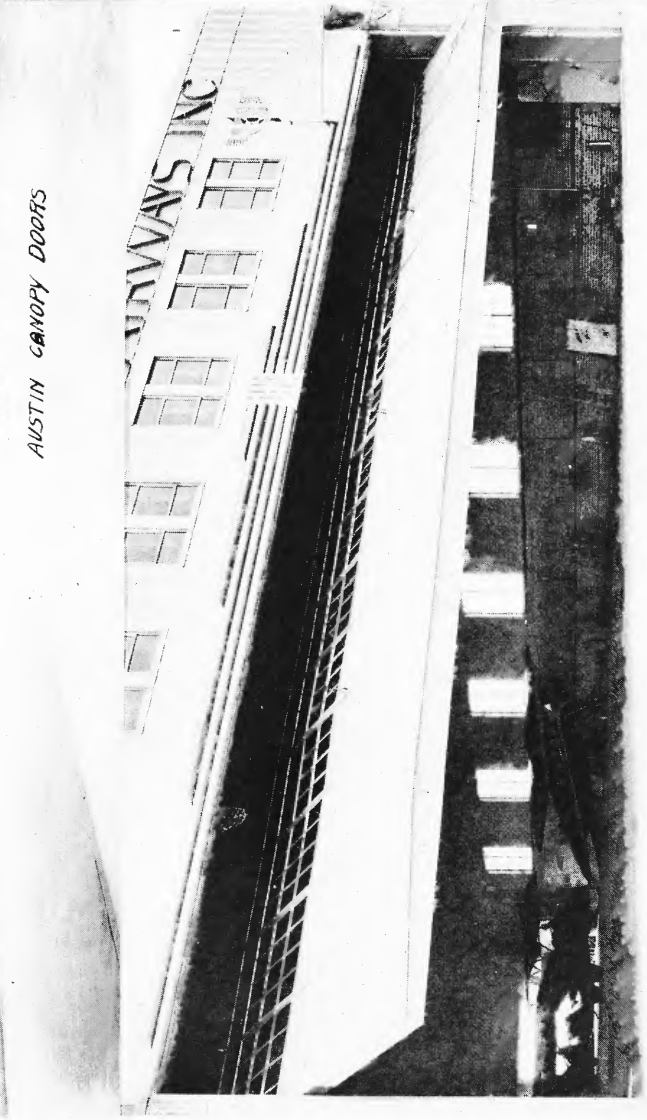
The overhead type of hangar door has passed the experimental stage and there is undoubtedly a definite trend toward its use. These doors offer the advantage of speedy and positive operation, and are usually controlled electrically but may be hand operated. Probably the two best known types of overhead doors are the Austin Canopy Door and the Byrne One-piece Door.

TRUSCON STRAIGHT SLIDING DOORS



"AROUND THE CORNER" DOOR
FENESTRA

AUSTIN CANOPY DOORS



Fenestra Byrne Door in the hangar of the Continental Airways Inc., Chicago, Ill.

The Austin Canopy door may be divided into any convenient number of individual doors and operated singly or in groups. The operating mechanism for each leaf consists of a heavy screw and traveling nut device actuated through a train of gearing by a high torque motor which is provided with an electrically operated quick acting automatic brake. Auxiliary hand chain apparatus is included for emergency use. The top of the door is hinged and the bottom swings outward and upward through a quarter circle.

The Byrne door is made in one piece up to spans of 150 feet. It operates by means of heavy, high tensile alloy steel cables, spaced about 20 feet on centers. The cables, attached near the center of gravity, extend up the outside of the door and are carried over roller bearing sheaves around a central power drum with traction grooves and thence to conveniently located counterweights. In opening, the Byrne door lifts vertically 8 inches, then tilts as it rises until, when fully opened, it is practically horizontal, half inside and half outside of the door opening. The Byrne door requires a considerably smaller motor for operation than that used for the Austin door.

In addition to opening within 19 to 30 seconds, the overhead type doors have the following advantages over the slide types of door:

1. Operated from one position either from within or without.
2. Does not occupy floor space.
3. No frame necessary at sides for staking.
4. No tracks required.
5. Weather-tight
6. Guides do not clog or freeze.

Heating Hangars

In certain sections of the country it becomes necessary to consider the heating of hangars. The economic consideration of the use of materials in construction because of their insulating qualities is one of the first requirements to be met. In addition to the usual surface heat losses, an allowance of 4 air changes per hour is necessary because of the frequent opening of the doors.

The heating requirements vary, depending upon the usage. The working area of the hangar should have a temperature of 45 degrees when the building is used for storage purposes, and 60 degrees when used for maintenance. The temperatures are to be maintained in the building when the outside atmosphere is 10 degrees above the lowest recorded temperature in the district. The lean-to section where personnel is housed, should be maintained at a temperature of 70 degrees.

The heating of a building consists in warming the air which it contains. When steam radiators are used, their heat is absorbed by the air around them, which rises immediately, displacing all cool air above it until it reaches the roof or ceiling. Radiators must supply additional heat until the air in the hangar is warmed in horizontal strata successively from the highest to the lowest. The result is that the hottest point of the building is under the roof where transmission into the outside air is at a maximum. With the use of unit

heaters a large amount of condensation takes place and the use of a return pump is recommended. Low pressure steam heating systems are mostly used for modern hangars. Depending upon the size of the boiler and the corresponding stack height, there may be used a forced draft system in order to keep the height of the smoke stack within allowable limits. The heating plant is usually located in the lean-to portion of the hangar, isolated from the rest of the building by fire-proof construction.

With the development of unit heaters the above conditions have been corrected. A fan blows the air across steam coils; thus the warmed air is directed where desired and causes a circulation of air. There are two types of unit heaters, the floor-mounted and the suspended.

The floor-mounted type is placed on the floor at the side of the hangar. The warmed air is directed horizontally across the hangar and the cool air is drawn in at the bottom. The outlet should be about 12 feet from the floor and tilted slightly downward.

The suspended type of unit heaters are located above the truss line of the hangar. The fan draws the already warm roof-air through the heating element, heating it still further and discharging it downward with sufficient velocity to accelerate its mixture with the air at the floor level. A greater number of units are used, and this gives a distribution system, the units being arranged to blow the heated air toward the exposed parts of the hangar about one-third above the floor. In addition to

the circulation of air with this system the units are directed to cause a movement of air around the hangar.

Hot air furnaces with blowers have been used and are found to be economical, but the necessary installation of cumbersome ducts is objectionable.

Fire Protection

In many cases the installation cost of a sprinkler is justified by the saving made through reduction in the insurance rates on the building. Although there is no reduction in the insurance on the planes, fire protection should be considered from the standpoint of loss of revenue and customer patronage. In addition to the sprinkler system the usual equipment such as hand equipment should be maintained.

With the rapid spreading of plane fires, it is essential that the sprinkler system operates quickly. The open-head sprinkler with heat-actuated water supply valves releasing mechanisms, has proven more satisfactory than the sealed-head type of sprinkler. For results of tests made with both systems refer to appendix "number two" of this paper.

The Lowe Actuator and the deluge water-release valve in conjunction with open head sprinklers form an excellent system. The Lowe Actuators are attached to the ceiling and work on the same principal as on aneroid barometer. A rise in temperature causes a variation in pressure which is transmitted to the deluge valve through a small copper tubing about 1/8 of an inch in diameter. A device at the deluge valve is so adjusted, that a rate of rise of temperature above fifteen degrees Fahrenheit per minute causes the valve to open. The sprinkler pipes are open to the atmosphere and there is little resistance to the water that rushes through and out of the sprinkler heads. Each head releases a minimum of 1.5 gallons of water per minute and covers an area of not more than 85 square feet.

Lighting.

For the purpose of marking the field and providing sufficient illumination for safety in landing airplanes at night, the following types of equipment are employed on the airport.

1. Marker Lights.
2. Landing Floodlights.
3. Beacon Light.
4. Illumination of wind indicator.
5. Ceiling Projector.
6. Illuminated Air Markings.

Marker Lights.

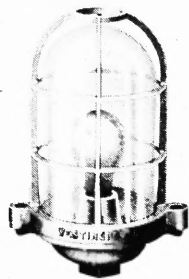
The boundary of the landing area should be outlined with lamps equipped with either clear or yellow vapor-proof globes, and spaced not more than 300 feet apart. These marker lights are termed "boundary lights".

At each end of the runways two or more of the boundary lights should be equipped with green glass globes "approach lights" and indicate positions of the favorable approach to the field or runways.

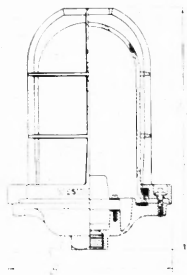
Buildings, radio towers, poles, trees, and high chimneys on, or in the vicinity of the airport must be clearly marked with red lights. These marker lights are termed "obstacle" or "obstruction lights".

Two types of marker lights are made; namely, the locking type and the screw type. Both units are furnished with cast aluminum bodies in which drain holes are provided to prevent water, caused by condensation from entering the conduit.

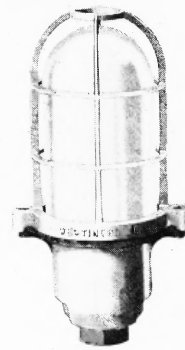
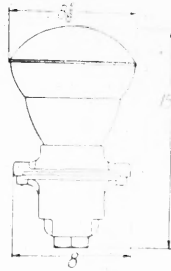
MARKER LIGHTS LOCKING TYPES



MARKER LIGHT, LOCKING TYPE FOR MULTIPLE SERVICE



MARKER LIGHT, LOCKING TYPE FOR SERIES SERVICE



MARKER LIGHT, LOCKING TYPE FOR SERIES SERVICE

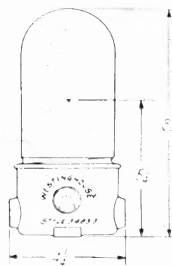
SCREW TYPES



MARKER LIGHT, SCREW TYPE FOR MULTIPLE SERVICE



BOTTOM OUTLET



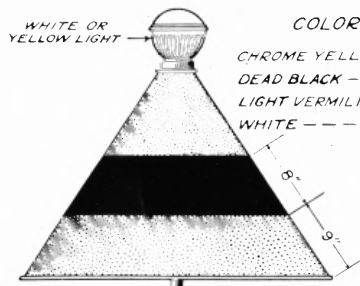
SIDE OUTLET



MARKER LIGHT, SCREW TYPE WITH HOLOPLANE GLOBE 2323

FLUSH TYPE

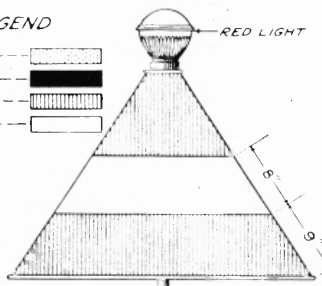
DEPARTMENT OF COMMERCE STANDARD CONE MARKINGS



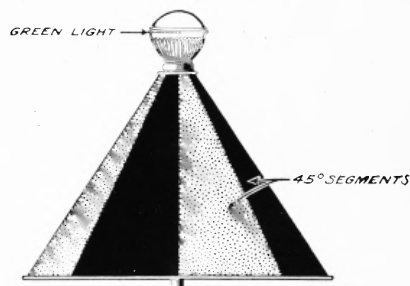
CONE PAINTING FOR WHITE OR YELLOW LIGHTS

COLOR LEGEND

- CHROME YELLOW
- DEAD BLACK
- LIGHT VERMILION
- WHITE

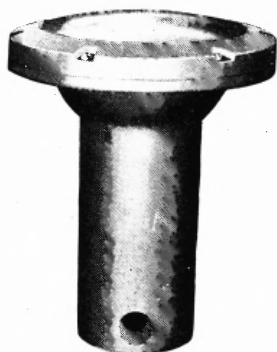


CONE PAINTING FOR RED LIGHTS



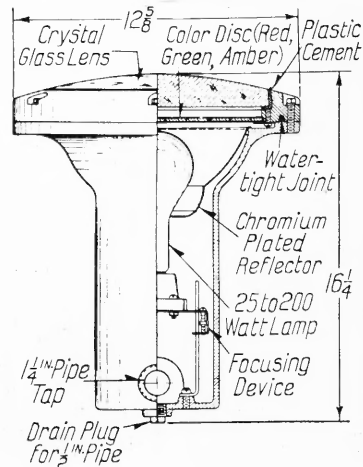
CONE PAINTING FOR GREEN LIGHTS

BOUNDARY LIGHTS WITH U. S. DEPT. OF COMMERCE STANDARD PAINTED CONES FOR DAY MARKING



FLUSH TYPE MARKER LIGHT

TAKEN FROM
WESTINGHOUSE CATALOG
#218-A



The globe of the locking type unit is held firmly between two felt gaskets, one on the body and the other on the globe-holding ring. The body of the screw type unit is threaded and equipped with a rubber gasket which provides a water-proof seat when the globe is in place.

Underground feeds of either the series circuit with high tension 2350 volts lines, or the multiple circuits with low tension lines, or a combination of the two may be used. If the series circuit is used, a film or disc cut-out should be installed to maintain the circuit in case of lamp failure. To safeguard life and property from coming in contact with the high voltage, in the event of a boundary lamp post being demolished by collision, the series lamp is connected through a safety coil located in the base of the post.

On multiple circuits, lamps of not less than 25 watts should be used for clear and yellow lights, and lamps of not less than 50 watts for red or green lights. In the case of series circuits, S - 24-1/2, 6.6 - ampere, 600 lumen lamps should be used for clear and yellow lights, and 1000 lumen lamps for red or green lights. Diffusing globes or frosted lamps should be used for all clear lights to prevent glare. Boundary lights should be mounted and day marked in the manner shown on the following page.

A marker light of the flush type has been developed and can be located in the runway and utilized for traffic control. Planes may taxi over them without damage to either plane or the marker.

The flush type marker light is of cast iron, hot galvanized and is fitted with a waterproof door and heavy crystal glass lens. Color plates can be provided between the lens and the lamp to indicate approach, obstruction or for signaling purposes.

Landing Floodlights.

The landing floodlights system should be so designed as to provide an even distribution of illumination (free from abrupt changes in intensity and from shadow areas) over the entire landing area. It should also offer a high degree of reliability and require a minimum of skilled attention. It should be immediately available for use, through the operation of control located at a convenient point, and should permit landing under all conditions of wind direction without the necessity of landing directly toward the light source. Glare is very confusing to the pilot as it results in the loss of perspective and detail and hence makes him uncertain of his altitude.

Ground surface conditions usually determine what method of floodlighting is most desirable for landing-field illumination. Two general systems are now in use for floodlighting airport landing areas:

1. The centralized system consisting of one or more light sources located at or near a single point.
2. The distributed system consisting of a number of light sources spaced at more or less equal intervals along one or more sides of the landing area.

The centralized system is more widely used as it makes a simpler and more compact installation. It gives a more uniform distribution of illumination and confines all the glare to a single source. However, in floodlighting areas of irregular or wavy contour, it is often necessary to use the distributed system in order to obtain proper light distribution and eliminate shadows. The presence of shadows on the landing area is especially objectionable for the reason that when viewed from the air they appear as depressions.

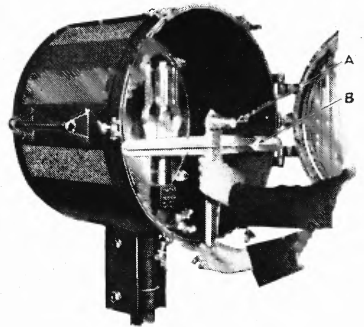
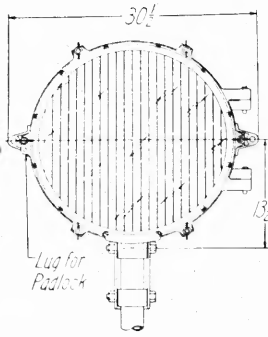
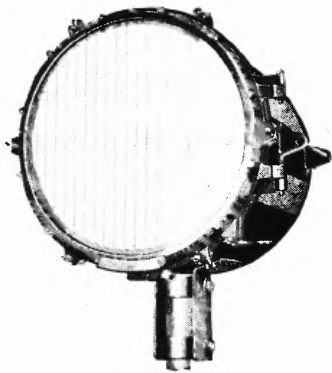
The lighting equipment should give a soft steady light, free from any tendency to flicker or change in intensity or color, and with a gradual fade out at the sides of the beam.

Surface colors will vary on fields in different localities ranging from dark to light and have reflective factors approximately from 10 to 40 per cent. As objects are visible largely in proportion to the amount of light they reflect to the eye, it follows that the ground color should influence to some extent the amount of light required. The vertical beam intensity of illumination (measured on a plane normal to the surface of the field) over the usable portion of the landing area should be of one quarter of a foot candle power.

Best results are obtained by using a light source mounted close to the ground (6 to 10 feet) and producing a fan of light with a very narrow vertical divergence and a sharp cut-off at the top and with the top of the beam as nearly parallel to the surface of the landing area as practical.

Units using more than one lamp should be so constructed

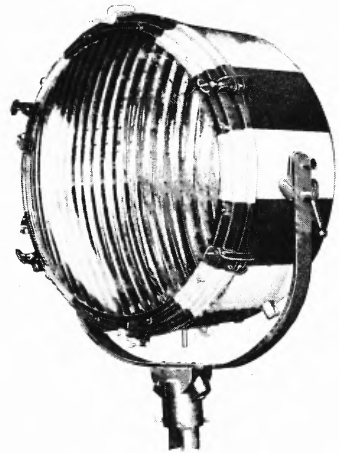
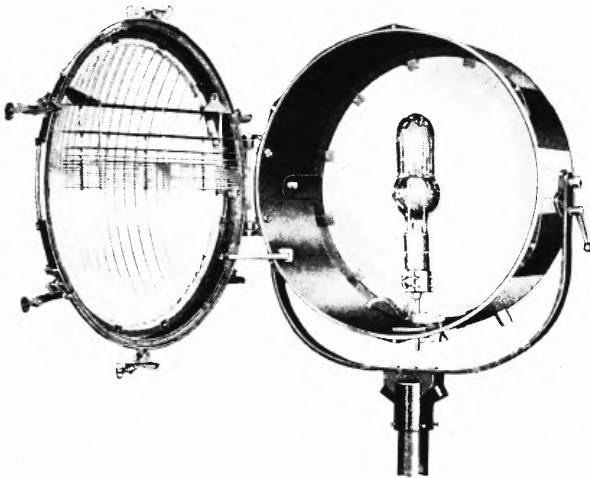
AIRPORT LANDING FIELD FLOODLIGHTS



LANDING FIELD FLOODLIGHT

FOCUSING LAMP WITH DAYLIGHT LAMPSETTER

TYPE CAG-25



TYPE CAG-25 AIRPORT LANDING FIELD FLOODLIGHT

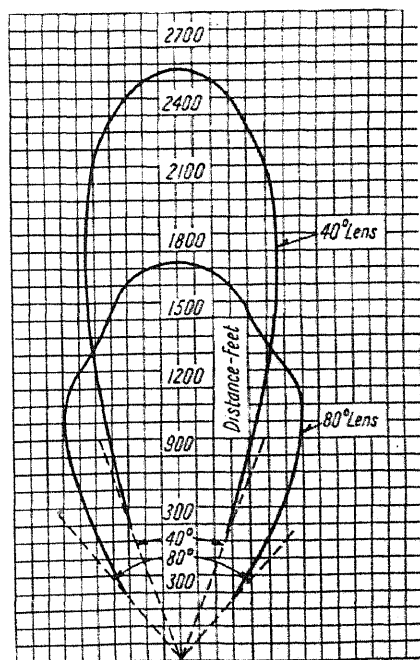


TAKEN FROM WESTINGHOUSE CATALOG #2184

that the failure of one or more lamps will not interrupt the service of remaining lamps. When more than one unit is used suitable provision should be made to prevent a short circuit in one unit from interrupting service of the other units.

Where the floodlighting is accomplished by a single light source an automatic lamp changer should be provided to bring a new lamp into action upon the failure of the first one. Even with the lamp changer, an auxiliary unit should be provided entirely independent of the main light source.

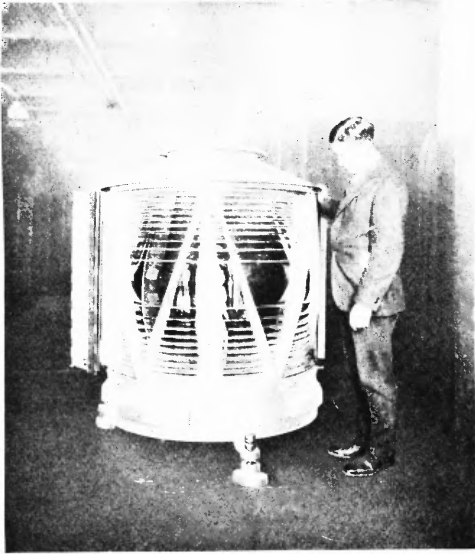
Lights when used in groups are usually of the convex spread lens type. The light is spread in a horizontal plane without changing the natural beam spread of the vertical. The lenses are furnished having either a twenty-five, forty, sixty or eighty degree spread, and the selection of the correct lens depends largely upon the shape of the field.



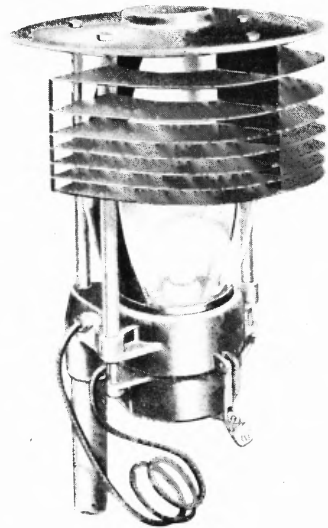
LANDING FIELD FLOODLIGHT TYPE CAG-25
LIGHT DISTRIBUTION CURVE WITH 3-KW., 32-
VOLT GT-38 BULB LAMP

AIRPORT FLOODLIGHT

SINGLE SOURCE

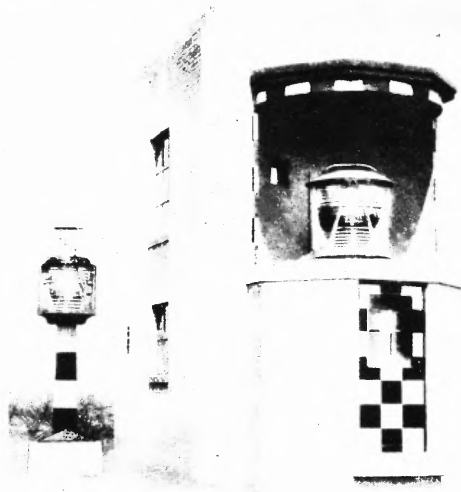


B.B.T. floodlight for airport illumination



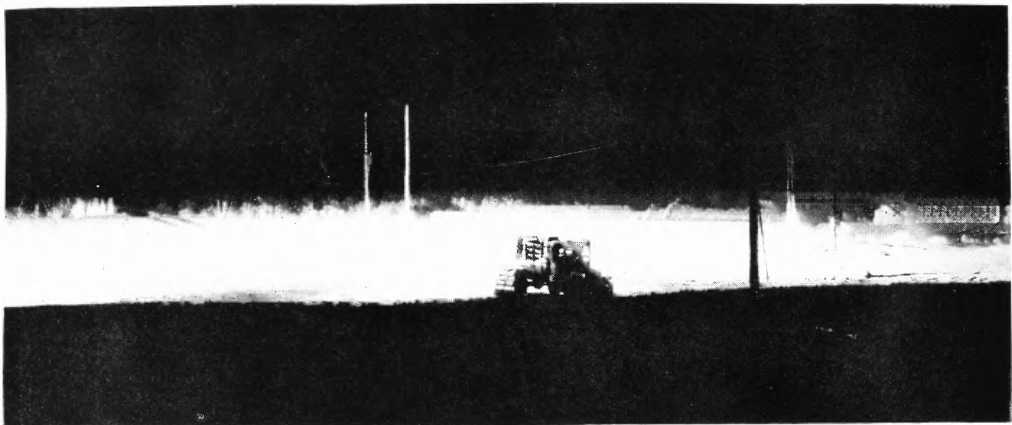
Type AKP

CROUSE - HINDS



Courtesy, Sylvania Electric Co.

Field floodlighting equipment of the arc type at Bettis Field, Pittsburgh, Pa. The light is protected when not in use by circular doors below the canopy. Notice the markings and the auxiliary incandescent light. Kenneth Franzheim, Architect



Illumination from B.B.T. floodlight equipped with 150-amp. arc

The projectors are provided with a set of vanes or louvers which cut off the stray light above a point one or two degrees above the horizontal. It is customary to turn the lights slightly downward so that all of the light is thrown on the landing field and none above the horizontal. A focusing mechanism should provide a three-way adjustment and permit positioning of the lamp filament. Lamps approximately 24 inches in diameter are recommended in group floodlighting.

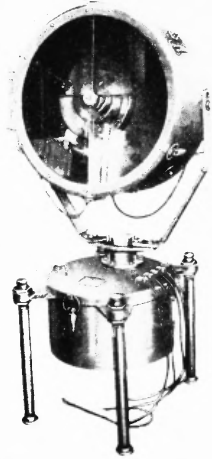
For a unit of a single lamp source a spread of 180 degrees is desirable. The B.B.T. floodlight with a Fresnel lens, composed of 21 hand-cut and hand-fitted dioptric elements or panels mounted in a bronze frame meets this requirement. The lens is three feet six inches in width.

The light source may be either a 150 amp semi-automatic arc mechanism or a 10 kw incandescent lamp. The arc lamp produces a more intense illumination and a more uniform divergence of the light beam. The vertical spread of the beam is about 2 degrees above and 2 degrees below the horizontal. Beyond these limits of the beam there is practically no stray light or glare.

Beacon Light

The effectiveness of an airport beacon light is not dependent upon candlepower alone; another important consideration is

AIRPORT BEACON LIGHTS



G.E. REVOLVING TYPE



Type DCB24 Revolving Beacon

GROUSE-HINDS



G.E. LAMP CHANGER

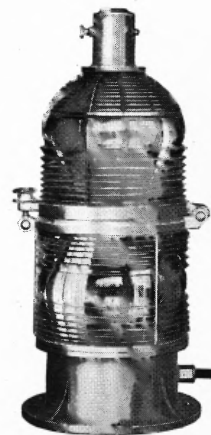


NIGHT VIEW OF AIRPORT OPERATIONS OFFICE WITH ROTATING BEACON ON TOP



TYPES DCC AND DCD AIRPORT AND AIRWAYS ROTATING BEACONS

WESTINGHOUSE CO.



AIRWAYS CODE BEACON

WESTINGHOUSE CO.

the duration of flash. It is necessary for the aviator to be able to fix the position of the light in his mind while traveling at great speed through three dimensional space.

The airport beacon may have fixed lenses, or a combination of lenses, with a flashing light source; flash panel lenses; Neon lights, with or without optical apparatus and should have not less than 100,000 candlepower for long range. They should have a definite Morse code characteristic. Rotating beacons may be used making six revolutions per minute, with at least one parabolic mirror or other equivalent optical apparatus, with a horizontal beam divergence of from 4 degrees with at least 6,750,000 beam candlepower to 6 degrees or more with at least 1,750,000 beam candlepower. The lamps ordinarily used in the rotating searchlight beacons are 1,000 watt, 115 volt or 30 volt; T-20 bulb, Mogul Airway Beacon lamps, with an average life of 500 hours. Beacons having a single light source should be provided with an automatic lamp changer for bringing a spare lamp into the focal position, or else there should be an auxiliary beacon of at least 10,000 candlepower which is so designed as to be turned on automatically in event of lamp failure. Beacons sending a beam of one color light toward the north and a beam of another color light toward the south are useful and can be used as an auxiliary beacon;

Illuminated Wind-Direction Indicator.

Take-offs and landings should be made upwind whenever practicable; hence it is important that provision be made to indicate

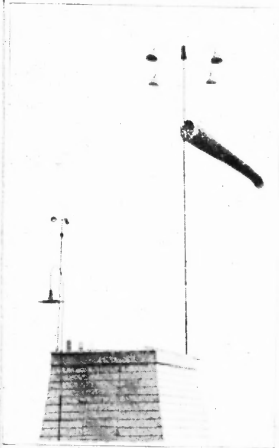
to the pilots the direction of the wind blowing over the landing area. The wind-direction indicator - either a wind cone or a wind tee, or other equivalent device - should be illuminated so as to make it visible at night from a distance of at least 1,000 feet in any direction and located so as to give a true indication of the direction of the wind on the landing area, and be readily visible to aircraft approaching from any direction. Wind cones may be externally lighted by using a system of industrial reflectors with at least four 100-watt lamps, or the equivalent, so mounted above the cone as to make it visible in every direction. It is recommended that wind tees be illuminated by outlining with either exposed incandescent lamps or neon tubes, preferably placed along the center lines of the strokes of the tee.

Ceiling Projector:

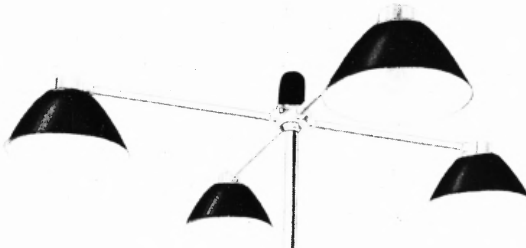
The ceiling projector is used in conjunction with an alidade to determine the height of the ceiling or the under surface of the lowest cloud or mist layer. The projector may be tilted to an angle of $63^{\circ} 26'$ and the height read in feet directly on the alidade by pointing the arrow to the spot on the cloud. Distance between the projector and alidade should be 500 feet when an angle of $63^{\circ} 26'$ is used.

An incandescent searchlight can be used with a parabolic reflector of not less than 10 inches in diameter and with at least a 250-watt lamp of the concentrated filament type used for spotlight or headlight service and a stray light shield given a beam spread of not more than 7 degrees.

Wind Sock and Wind Tee



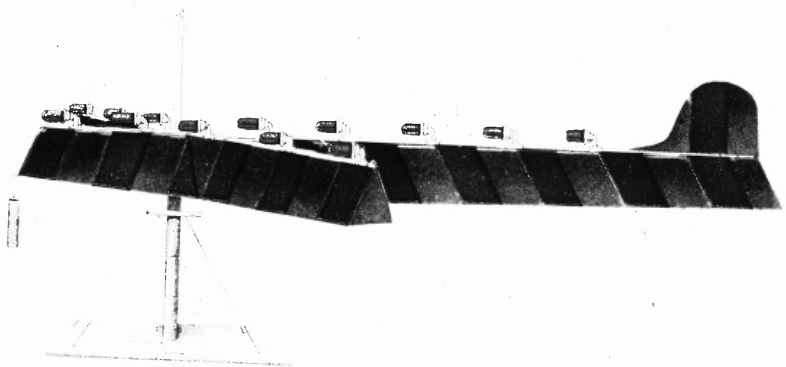
Wind Sock Installation



Wind Sock Fixture

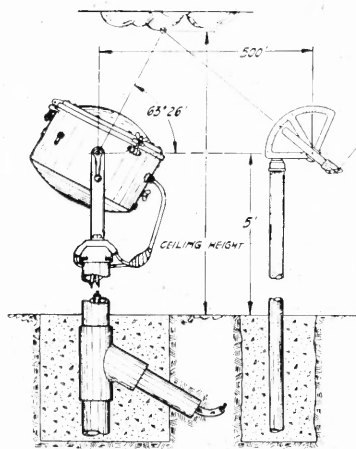


Wind Sock Obstacle Light

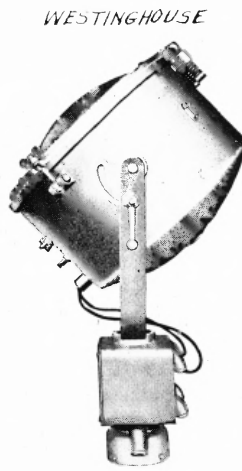


Wind Tee Installation

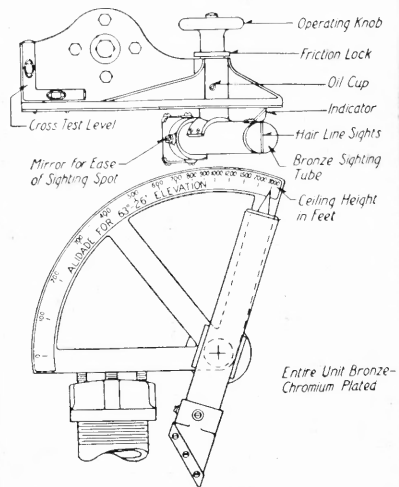
CHOOSE HANDS.



METHOD OF INSTALLING CEILING PROJECTOR AND ALIDADE



CEILING PROJECTOR



Entire Unit Bronze-Chromium Plated

Illuminated Air Markings.

There are three general systems of illumination that are applicable to air marking as follows:

1. By direct light, in which the markings are outlined by exposed incandescent lamps or by neon tubes
2. By reflected light, in which either floodlight projector with spread lenses or industrial reflectors are so arranged as to give a uniform distribution of light of proper intensity (10 foot-candles) over the entire surface of the markings.
3. By transmitted light, in which incandescent lamps are mounted under translucent glass strips of suitable color.

APPENDIX ONE

SOIL CHARACTERISTICS.

APPENDIX ONE

SOIL CHARACTERISTICS

In the development of an airport a knowledge of soil characteristics is essential to properly treat such subjects as drainage, surfacing and building foundations.

The results of borings should be tabulated to show to what depth the surface soil extends, and the nature of the underlying material. There may be found any of the following combinations:

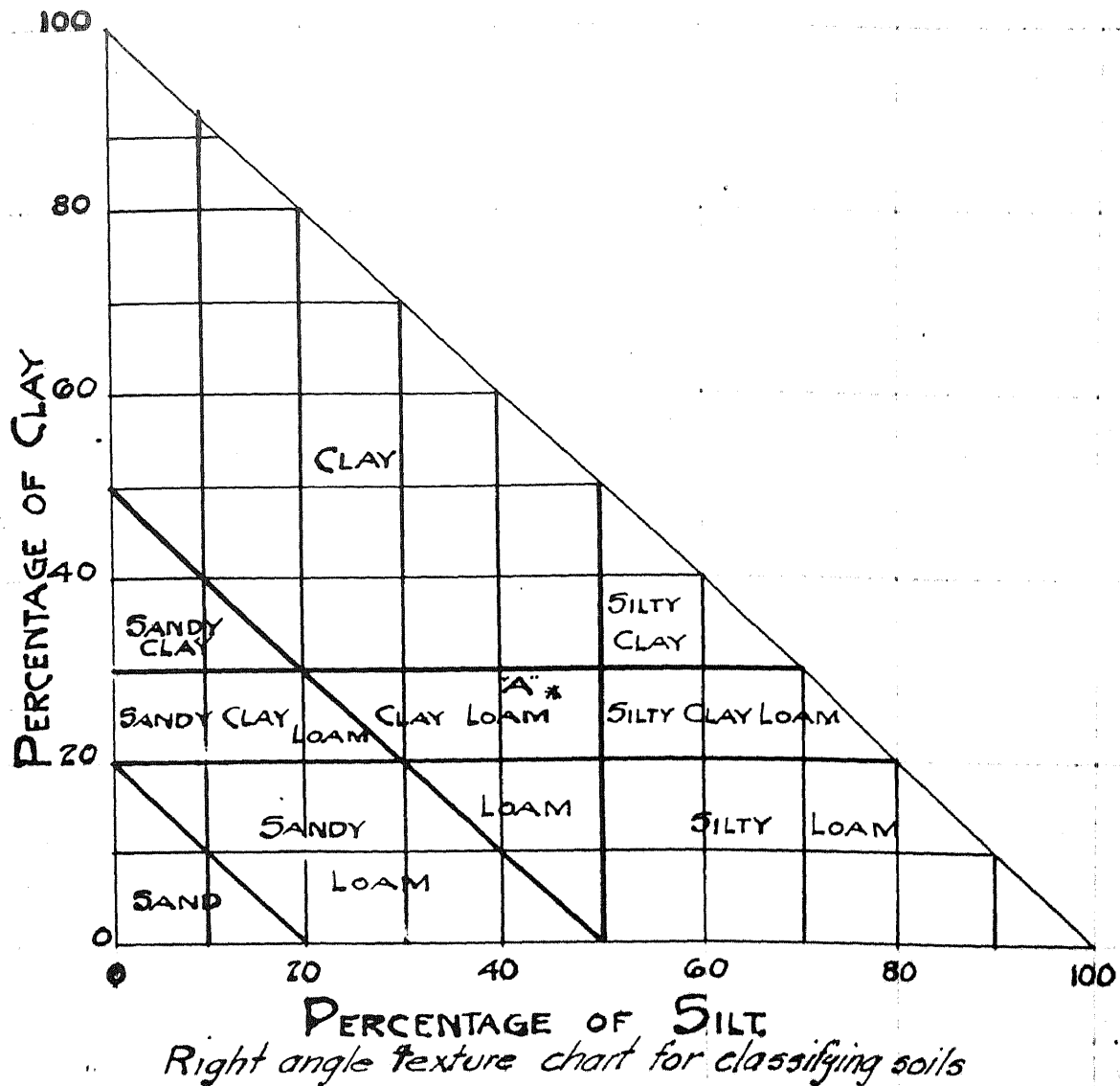
1. Porous surface - porous subsoil.
2. Porous surface - impervious subsoil.
3. Impervious surface - porous subsoil.
4. Impervious surface - impervious subsoil.

The analysis of the samples will show the physical structure, texture and chemical composition of the soils which has a direct bearing on the ability of the different soils to take up moisture and permit or retard the movement of water through them.

A soil generally contains particles of various sizes giving it a certain texture.

SIZES OF PARTICLES IN SOIL SEPARATES

<u>Separate</u>	<u>Diameter in Millimeters</u>
Fine Gravel	2. -1.
Coarse Sand	1. -0.5
Medium Sand	0.5 -0.25
Fine Sand	0.25 -0.1
Very Fine Sand	0.1 -0.05
Silt	0.05 -0.005
Clay	0.005-0.0



The porosity of a soil depends upon the texture, that is, the size and arrangement of the particles, or the voids in the soil. It is a volumetric measure of the water that a given volume of soil can hold.

The percentage of the various separates determines how the soil shall be classified.

CLASSIFICATION OF SOILS

<u>Class</u>	<u>Per Cent Sand</u>	<u>Per Cent Silt</u>	<u>Per Cent Clay</u>
Sand	80-100	0-20	0-20
Sandy Loam	50-80	0-50	0-20
Loam	30-50	30-50	0-20
Silt Loam	0-50	50-100	0-20
Sandy Clay Loam	50-80	0-30	20-30
Clay Loam	20-50	20-50	20-30
Silty Clay Loam	0-30	50-80	20-30
Sandy Clay	50-70	0-20	30-50
Clay	0-50	0-50	30-100
Silty Clay	0-20	50-70	30-50

Use of the right angle soil texture chart enables the sample to be classified readily.

(See chart on page following)

PROPERTIES OF COMMON SOILS

<u>Kind of Soil</u>	<u>Effective Size of Soil Grains, M. M.</u>	<u>Per Cent of Pore Space</u>
Coarse Sandy Soil	.1432	34.91
Sandy Soil	.07555	34.91
Sandy Loam	.03035	38.83
Loam	.02197	44.15
Clayey Loam	.01810	47.10
Loamy Clay	.02542	49.19
Heavy Red Clay Soil	.01111	44.15
Fine Clay Soil	.008612	48.00
Finest Clay Soil	.004956	52.94

This table shows that the smaller the grain size, the greater the per cent. of pore space.

The permeability or perviousness of a soil depends upon the readiness with which liquids or gases will pass through the soil. This depends upon the size of the pores, and how they are connected together. This is more dependent upon the soil structure than the texture. In the above table the soil (clay) with the greatest porosity is the least permeable.

The moisture equivalent of a soil is defined as the amount of moisture (expressed as a

percentage of the dry weight of the sample) retained by the soil when it is subjected to a centrifugal force equal to 1000 times the force of gravity.

From many studies of subgrade soils, A. C. Rose gives the following conclusions:

1. The adverse character of the subgrade soil depends primarily on the volume change caused by variations in moisture content or frost action. The main adverse action of the volume change occurs in one direction - the vertical.

2. The volume changes of the soil distort the subgrade, which displaces the pavement unevenly and subjects it to excessive localized stresses.

3. The adverse character of the subgrade soil is shown to increase with the clay content.

4. The clay content and adverse character of the subgrade soil is indicated by certain simple and practical field tests, called the field moisture equivalent and the linear shrinkage tests.

5. Detailed subgrade soil surveys may be readily made by using U. S. Bureau of Soils maps in connection with these field tests.

6. A simplified and rapid method for making a reconnaissance soil survey is by the use of

a U. S. Bureau of Soils map in connection with a trilinear soil classification chart, without the use of field or other tests. Generally speaking, sands, sandy loams, loams, and silty loams are considered good subgrade soils; sandy clay loams, clay loams, silty clay loams, sandy clays, and silty clays, doubtful subgrade soils; and clay, bad subgrade soils.

7. The drainage condition of a subgrade soil, as well as the bearing power, is indicated as poor when the critical point - a stability ratio is one - is exceeded. The stability ratio is defined as the moisture content divided by the field moisture equivalent.

Soils of different chemical characteristics have different effects on the material (deterioration of drainage pipes). With few exceptions, however, the direct chemical action of the soil on the culvert material has been found to be of minor importance as compared with the chemical action of the hydraulic traffic in or through the pipe. Therefore, by classifying the various soils chemically, it is possible at the same time to classify pipe service conditions.

The major chemical classifications of soils and waters are: alkaline, salt marsh, acid, mineral, normal and arid. An analysis for elements corrosive to concrete, cast iron, and corrugated metal pipes is being sought. An analysis typical of a sulphate water and mine water indicate that some protective measures should be taken to prolong the life of the drainage system.

Soil moisture is of three kinds: gravitational, capillary and hygroscopic.

1. Gravitational water is free to move under the influence of gravity. It is the only kind which can be removed by ditches, drain pipes or other means.

2. Capillary moisture clings to the soil particles by surface tension and reaches the particles either when the free water passes through the soil, or by capillary attraction from a wetter to a drier stratum. It is not affected by gravity, being able to move upward as well as in any other direction, and cannot be removed by drainage. It can, however, be controlled by lowering the water-table. Capillary water can only be removed by heating, evaporation, freezing, or subjecting it to great pressure.

3. Hygroscopic moisture (absorbed water) is that which condenses from the atmosphere upon the surface of the soil particles and combines with the soil. It cannot all be driven off, except by excessive heat and it fails to freeze at -78°C . It is of little or no importance to the engineer.

The tables and chart used in Appendix One were taken from Handbook of Culvert and Drainage Practice by Araco Culvert Manufacturers Association.

APPENDIX TWO.

TEST OF SPRINKLER EQUIPMENT.

COPY OF RESULTS OF TESTS
 CONDUCTED BY THE CITY OF NEWARK UNDER THE SUPERVISION OF
 M. W. PARSONS, JR., ENGINEER IN CHARGE - AIRPORT CON-
 STRUCTION. SPRINKLER EQUIPMENT INSTALLED BY AUTOMATIC
 SPRINKLER COMPANY OF AMERICA.

Conducted November 20, 1929,
 Newark Airport - Colonial Hangar - Newark, New Jersey.

The hangar is an exposed steel truss structure, measuring 120' x 120', one story 35' high, with cement block curtain walls, steel frame and glass end doors, plank roof supported by steel framing, gravel floor, open finish. The ceiling to the height of the roof trusses is divided into 6 bays by beaver board.

The hangar proper is equipped with 6 separate Rate-of-Rise Deluge Sprinkler Systems, one for each of the 6 bays.

TEST 1-A - DELUGE SYSTEM

To determine the sensitiveness of the Rate-of-Rise Deluge.

Sprinkler System to small fires and its speed of operation. For this test the Automatic Deluge Valves on all 6 systems were set in operative condition. To save time in preparing for succeeding tests, the open head type of sprinklers ordinarily used in the Deluge System had previously been replaced with regular 165 degree solder type heads with the exception of one head in each system which was left open.

The operation of the Deluge Valve and the functioning of the system was shown by the discharge of water from the open sprinkler.

Fire was lighted consisting of 10 lbs. of loosened excelsior placed in a pile about 20' from the north wall in Bay #2

and ignited by means of a torch.

Deluge Valve controlling Bay #2 operated in 21 seconds and water issued from the one open sprinkler head in this bay in 25 seconds. The Deluge Systems in Bays #1 and #3 also operated.

Test 1-B - WET PIPE System

To determine the sensitiveness of the Wet Pipe Sprinkler System to small fires and its speed of operation.

In this test all 6 systems were converted into Wet Pipe Systems (all piping being filled with water under pressure).

The first fire consisted of 20 lbs. of loosened excelsior placed in a pile about 20' from the north wall in Bay #2 and was ignited by means of a torch. The fire burned itself out in $2\frac{1}{2}$ minutes without fusing a sprinkler head.

A second fire consisting of 40 lbs. of loosened excelsior, placed at approximately the same location, was ignited by a torch. This fire burned itself out in between 4 and 5 minutes without fusing a sprinkler head.

A third fire was then built, consisting of 80 lbs. of loosened excelsior, placed at approximately the same location as in the previous fires, and ignited by a torch. 1 minute and 3 seconds after ignition, the first sprinkler head fused, and 2 minutes and 15 seconds after the start of the fire a second sprinkler head fused. The first head which opened was located at such a distance from the fire that the water discharged did not reach the fire. The second head was located near the fire and practically extinguished it.

Test 2-A - WET PIPE System

To determine the time required to actuate systems with a creeping fire of increasing magnitude.

The systems in this test were exactly the same as the systems in Test 1-B.

In this test pans containing gasoline were used, 1 quart of gasoline being placed in each pan.

Fire was ignited progressively, starting with about 10 sq. ft. of burning gasoline in two pans placed approximately 10' from the north wall in Bay #2. 20 seconds after the first pans of gasoline were ignited, gasoline in four pans having a combined area of 20 sq. ft. and placed 5' south of the first pair of pans was ignited. 20 seconds later gasoline in six pans having a total area of 30 sq. ft. and placed 5' south of the second group of pans was ignited. After another interval of 20 seconds 5 gallons of gasoline was discharged thru an $1\frac{1}{2}$ " pipe onto a revolving disk about 3' in diameter, the gasoline being thrown in a circle 35' in diameter and becoming ignited from the fire in the pans. The discharge of gasoline onto the revolving disk was to represent an explosion (without danger to those witnessing the test) which may follow any creeping fire in a hangar.

1 minute and 20 seconds after the first two pans had been ignited, a sprinkler head directly over the fire fused. A

second head fused at 1 minute and $47\frac{1}{2}$ seconds after the fire was started and a third head fused 1 minute and 53 seconds after the fire was started.

A total of 6 heads in Bay #2 were fused but no heads were fused in any of the other 5 systems.

Test 2-B - DELUGE System

To determine time required to actuate systems under a creeping fire of increasing magnitude.

The systems under this test were the Deluge Systems with all sprinkler heads open.

The fire in this test was identical with the one in Test 2-A as to total area, amount of fuel employed, spacing and progress of ignition.

23 seconds after the fire was first started, the Deluge System in Bay #2 operated.

50 seconds after the fire was started, the Deluge System in Bay #1 operated.

65 seconds after the start of the fire, the Deluge System in Bay #3 operated.

It will be noted that water was being discharged from the open heads in the Deluge System in Bay #2 before the lighting of the progressive fire had been completed.

Test 3-A - DELUGE System

To determine time required to operate the system and the effect of the fire on-plane material.

The systems were exactly the same as the systems under Test 2-B.

The fire consisted of the same number and size of pans and quantity of gasoline as in Tests 2-A and 2-B plus one amphibian biplane with 45' wing spread and a number of additional separate wings so placed in racks as to represent the crowded condition found in some hangars.

The fire pans, revolving disk, and plane materials were located in Bay #3, the pans being in relatively the same position as they were in Bay #2 on preceding tests.

The fire was lighted progressively, as in Tests 2-A and 2-B.

25 seconds after the first two pans were ignited, the Deluge Valve in Bay #3 operated and water was discharged onto the fire 4 or 5 seconds later. Water was discharged from the open sprinklers in Bay #4, 40 seconds after the start of the fire, and from the open heads in Bay #2, 55 seconds after the start of the fire.

No damage was done to the plane materials as the Deluge System in Bay #3 operated so quickly that the gasoline discharged onto the revolving disk did not become ignited.

Test 3-B - DELUGE System

To determine time required to operate the system and the effect of the fire on plane material.

The systems were the same as in Tests 3-A with the exception that floor sprinklers were added to the systems in

the two center bays. These floor sprinklers are connected to the same Deluge Valves which control the supply to the overhead systems in the same bays.

The fire consisted of the same area, materials and time of ignition as in Tests 3-A with the exception that two of the last group of six pans had been moved over under the airplane wings which were placed about 10' from the revolving disk and about 2 quarts of gasoline had been thrown onto the lower wing of the pair nearest the revolving disk in order to facilitate ignition of the wings.

38 seconds after ignition of the gasoline in the two pans, water was delivered from both the overhead sprinklers and the floor sprinklers of the Deluge System in Bay #3.

Water was discharged from overhead sprinklers and floor sprinklers in Bay #4, 1 minute and 11 seconds after the start of the fire.

The Deluge Systems in Bays #2, #5 and #6 also operated but no time of operation was recorded.

Water was being discharged from the Deluge System in Bay #3 before the progressive lighting of the fire was completed.

The lower wing immediately over two pans of gasoline became ignited on the under surface but was promptly extinguished, with the result that only about 4 sq. ft. of the lower surface of this wing was destroyed.

Test 3- SPECIAL - DELUGE System

At the request of certain representatives of the Underwriters and Aircraft Industry, a special test of the Deluge System was made to determine whether this system would control a fire originating in or communicated to the inside of the fuselage of a plane and prevent the spread of the fire along the wings of adjoining planes.

The plane material used in this test consisted of an amphibian biplane with 45' wing spread placed in the center of Bay #4. An old fuselage and wings were assembled in Bay #3 to represent an improvised biplane with the top wings extending over the cockpit. This second plane was so placed that the fuselage was parallel to and only a few inches away from the fuselage of the main plane. Another pair of wings was placed in such position that they made contact with the wings of both planes.

The doors at each end of the hangar were open.

Two fire pans with a total area of 10 square feet and each containing two quarts of gasoline were placed under the end of the lower wing on one side of the improvised biplane, close to the fuselage. The lower wing immediately above the fire pans was drenched with gasoline.

An open tub about 30" in diameter, containing 3 gallons of gasoline, was placed in the cockpit of the improvised plane.

The gasoline in the fire pans was ignited by means of a torch and the entire surface of the lower wing above the pans was in flames immediately. Fire was communicated at once to the surfaces of the wings connecting the two planes. The gasoline in the tub became ignited about 15 seconds after the gasoline in the pans was ignited.

The Deluge Valve controlling system in Bay #3 operated in 20 seconds from the time fire was started and water was discharged on the fire from both the overhead and floor sprinklers about 5 second later.

Water was discharged from both the overhead and floor sprinklers in Bay #4 about 30 seconds after the start of the fire.

The only plane material destroyed was about half of the surfaces of the pair of wings immediately over the fire pans and all the covering of the pair of wings connecting the two planes. The covering of the old fuselage was not burned and only a small portion of the lower surface of the wings directly over the gasoline tub was destroyed, all other wing surfaces being so cooled by the discharge of water from the Deluge Sprinkler System that no further damage resulted.

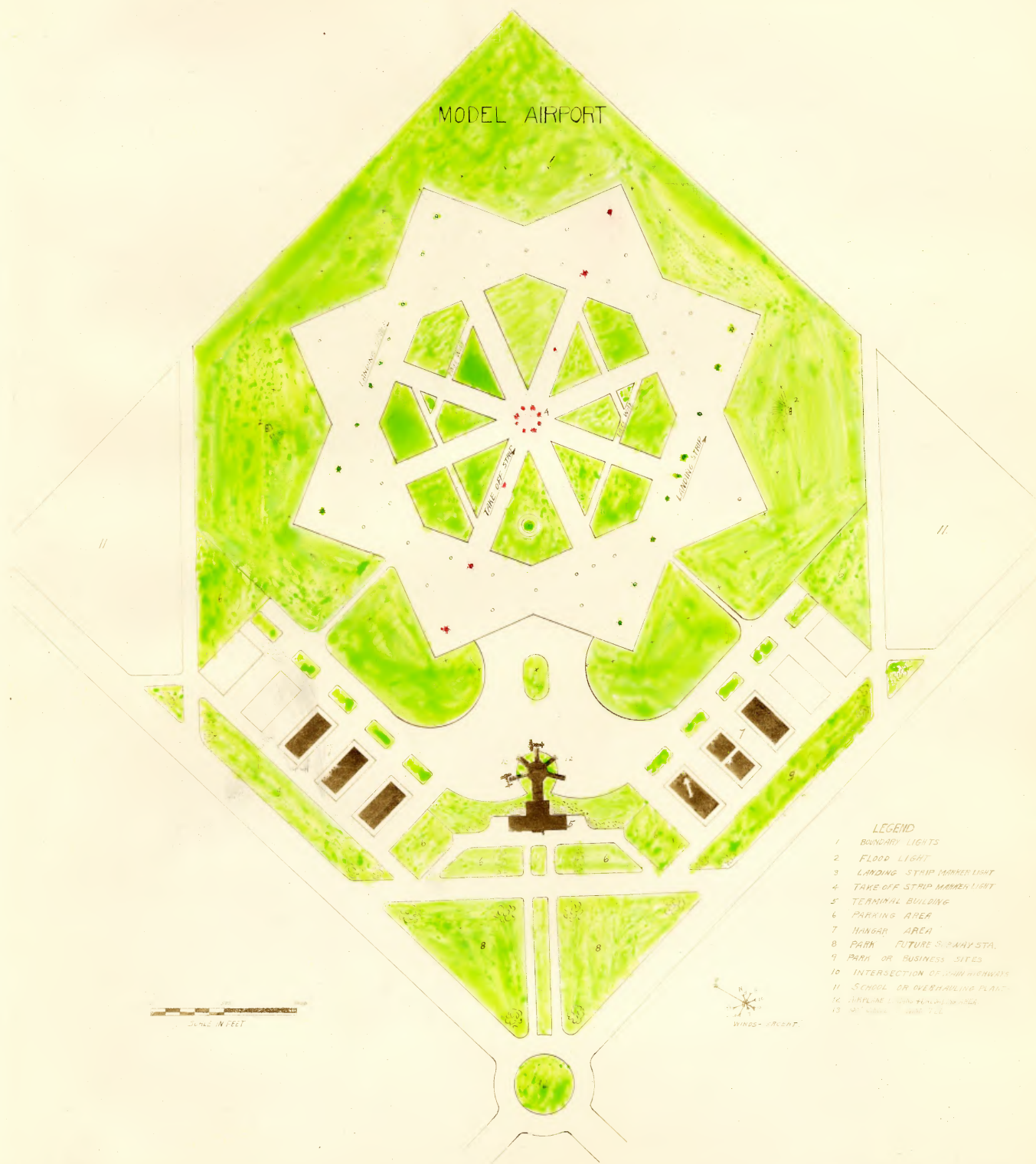
The original program contemplated two further tests, one with a wet pipe system and another of a dry pipe system but based on the knowledge gained from the preceding tests, these were deemed unnecessary and inadvisable.

CONCLUSIONS

As a result of the tests described herein, the following conclusions would appear to be justified:-

1. - In hangars, Wet and Dry Pipe Systems of automatic sprinklers are slow to operate, and in the presence of drafts may not open first over the fire.
- 2.- Because of delay in operation, sealed head automatic sprinklers will not prevent serious damage.
3. - Deluge Systems of open sprinklers controlled by Rate-of Rise-devices may be depended upon to operate quickly in airplane hangars, preventing spread of fire from plane to plane and damage to hangar.
4. - The Ceiling and Floor combination of deluge sprinklers provides the best protection for the prevention of large hangar fires and confines the loss of planes to a minimum.
5. - The Deluge System demonstrated successful combating of gasoline fires.

MODEL AIRPORT



- LEGEND**
- 1 BOUNDARY LIGHTS
 - 2 FLOOD LIGHT
 - 3 LANDING STRIP MARKER LIGHT
 - 4 TAKE OFF STRIP MARKER LIGHT
 - 5 TERMINAL BUILDING
 - 6 PARKING AREA
 - 7 HANGAR AREA
 - 8 PARK FUTURE SUBWAY STATION
 - 9 PARK OR BUSINESS SITES
 - 10 INTERSECTION OF HIGHWAYS
 - 11 SCHOOL OR OVERHAULING PLANT
 - 12 AIRLINE LIGHTS - FENCING OR AREA
 - 13 100' SQUARE LIGHT TOWER

Designed by:- A.H. Armstrong. - 1932.

MODEL AIRPORT LAYOUT

This layout features an eight-way field with two landing strips for each take-off strip, and interior taxi-ways.

The landing strips are 2500 feet long, and each pair 1300 feet apart with a parallel take-off strip 150 feet in width between the two. The landing strips are paved for a width of 300 feet, but if necessary the grass area can be used with safety.

The usual boundary lights form a circle enclosing the usable landing area of the airport. Instead of having green approach lights as part of the boundary system, green marker lights (flush type) are used along the middle of the landing strips. Red lights of a similar type denote the middle of the take-off strip.

With this layout, planes can take off at any time, regardless of the number in the air ready to make a landing.

There will be communication between the approaching ship and the airport, either by radio or a code system of flashing lights.

The following procedure might be given as an example of the use of the double landing strips:

Landing Strip "A" green lights on.

Landing Strip "B" green lights off.

#1 Ship to circle at an altitude of 500 to 1000 feet

#2 " " " " " " " " 1000 to 1500 feet

#3 " " " " " " " " 1500 to 2000 feet.

#1 is directed to land, and as soon as #1 touches the ground, green lights are turned off at "A", and on at "B".

#2 is directed to land, and as soon as #2 touches the ground, green lights are turned off at "B".

If #1 is clear of "A", the green lights are turned on at "A", and a signal is given to #3 to land.

The Terminal building is centralized with the hangars accessible to it, but not too close to interfere with the movement of planes about the terminal area.

Parking areas are provided near the terminal and hangar buildings.

The land along the main highways can be used for parks or business sites. This makes it possible to have the secondary street areas, preventing traffic congestion.

A large enclosed passageway connects the terminal building with a circular distributing room. Leading from this room to the field are five half-sunken, enclosed passageways entered through gates. The wings of the

planes are higher than these passageways, making it possible for them to be stationed very close to the ends of the passageways when loading and unloading passengers or cargo.

BIBLIOGRAPHY

- Report of Hoover Fact Finding Committee on "Choice of Airport Sites in New York Metropolitan Area 1927."
- Airports - Their Location, Administration and Legal Basis. Harvard City Planning Studies. Volume #1.
- Proceedings of the National Airport Conference of the Aeronautical Chamber of Commerce, 1930 and 1931 Editions.
- Airports (Monthly Magazine).
- The Aircraft Year Book 1929 - 1930 - 1931.
- Current Bulletins Issued by the Department of Commerce, Aeronautics Branch.
- Airport Rating Regulations.
- Air Traffic Rules.
- Airport Zoning and Eminent Domain Air Marking.
- Airport and Landing Fields.
- Suggested City or County Aeronautics Ordinance and Uniform Field Rules for Airports.
- The Federal Airways System.
- General Airways Information.
- Control of Airplane Hangar Fires.
- Engineering News-Record.
- Airport Drainage November 28th, 1929.
- Designing Concrete Pavements for Airport May 23rd, 1929.
- Drainage St. Louis Airport. November 7th, 1929.
- Drainage at Selfridge Flying Field. August 27th, 1931.

BIBLIOGRAPHY - (Concl'd.)

Proceedings American Society of Civil Engineers.

Soil Mechanics Research. Volume 57 Number 8.

Run-off Rational Formulas. Volume 57 Number 4.

Flow of Ground Water. Volume 57 Number 3.

Civil Engineering.

Earth as a Basic Material of Construction. August 1931.

The Civil Engineer's Part in the City Plan. March 1931.

Developing Aerial Transport. June 1931.

Asphaltic Emulsions for Economical Highways. November 1931.

American Society for Municipal Improvements.

Airports and Landing Fields. Volume 35.

Surfacing and Drainage. Volume 36.

Handbook of Culvert and Drainage Practice. Published by
Highway Products and Manufacturing Co., Inc.Airport Drainage and Surfacing. Fred E. Schnepfe -
Special Research Engineer American Road Builders
Association.The Design and Lighting of Airports. L. A. S. Wood,
Westinghouse Electric and Manufacturing Company.

Airport Lighting - General Electric Company.

Relation of Paving Materials and Surface Finishes to the
Lighting of Airport Runways. American City October 1929.