Planning of an Airport

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TEAM MEMBERS.

SYNOPSIS

Of all the transport system available, the air transportation systems possesses a few distinct advantages as compared to other transport systems especially in respect of rapidity, continuity and accessibility.

This report gives a comprehensive review on various infra-structure facilities provided in a modern airport for its effeicient and economic operations, that have been thoroughly investigated.

CONTENTS

CHAPTER - 1

INTRODUCTION

1.1 IMPORTANCE OF AIR TRANSPORT:

Travel is an integral part of human activities and to facilitate travel transport media are needed and as such the transport is an important factor for social and economic development of any country. Of all the transport systems namely, road, rail, water and air transportations systems possesses a few distinct advantages as compared to other transport systems especially in respect of rapidity, continuity and accessibility.

Airport Engineering deals with the planning, design, construction, operation and maintenance of facilities for providing the landing and take-off, loading and unloading , servicing, maintenance and storage of aircrafts All these require technical knowledge on diversified fields of Engineering. In this airport engineering, a civil engineer has not to do much about the design and manufacture of the aircraft nor about the navigation as such. However he is expected to do all about its landing and take-off which involves planning, construction, maintenance of runways, taxiways,aprons, terminal buildings water supply and drainage facilities which constitutes the main and major components of airport.

1.2 AIM OF THE PROJECT:

The present project is a complete and comprehensive report on various infra-structures facilities provided in a modern airport for its efficient and economic operations.

1.3 PRESENTATION OF THE PROJECT:

This report is present in the following sequence.

Chapter 2 discusses about the various classification of airports and aircraft characteristics.

Chapter 3 emphasises the importance of the aspects like the planning of an airport and the site selection of an airport.

Chapter 4 explains the geometric design of runways, taxiways and aprons.

Chapter 5 devoted to explain about the facilities in and around the terminal area.

Chapter 6 describes the various features of airport pavement and its design.

Chapter 7 illustrates the necessity and classifications of drainage of an airport.

Chapter 8 concerns with visual aids, day markings and night aids of an airport which are responsible for safe navigation.

Chapter 9 pertains to various methods commonly adopted in control of air traffic.

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C H A P T E R - 2

CLASSIFICATION OF AIRPORTS AND AIRCRAFT CHARACTERISTICS.

There are a very large number of airports all over the world. Some of these serve as International Airports and their design, construction and lay out confirms to the standards laid down by the ICAO. Other airports serve only domestic needs and can handle only a limited number of aircrafts per day. Depending upon the size, function or service which they can provide, airports have been classified into a number of groups so as to help identify them quickly. In a broader sense, airports are classified according to its function as civil use and military use.

2.1. GOVERNMENT OF INDIA, DEPARTMENT OF CIVIL AVIATION CLASSIFICATION :-

The aerodromes in India have been classified into the following categories :-

i) a. Central Government Aerodromes,
   b. Privately owned licensed aerodromes.

ii) a. State Government Aerodromes normally maintained in a serviceable condition.
    b. State Government Aerodromes not necessarily maintained in a serviceable condition.

iii) Air Force Aerodromes available for limited Civil use.

2.2. ICAO CLASSIFICATION :-

To identify quickly the size, function, which an airport provides, ICAO uses a letter code from A to G are used according to the length of the runway at Sea level for standard atmospheric conditions and numbers from 1 to 7 are used according to the strength of pavements.

2.3 FEDERAL AVIATION AGENCY :-

According to its function FAA gives a classification of Airports as,

i) Air carrier Airports which includes local, trunk, continental and Inter continental.

ii) General (or) secondary aviation airports which serves as executive, Commercial and Industrial airports.

2.4 AIRCRAFT CHARACTERISTICS :-

It is highly essential to know atleast the fundamental details of the aircraft characteristics briefly because it helps todetermine the thickness of the pavement, apron size, the length and height of the hanger, etc.

i) Type of propulsion :-

The propulsion of aircrafts are classified as piston engine, turbo engine, turbo jet engine and turbo fan engine. A little knowledge about the propulsion is essential for the design of pavements.

ii) Size :-

The wing span is one of the deciding factor for apron size, taxiway clearance, clearance at turnings, width of hanger etc. The fuselage length decides the wideth at the exit taxiways, apron size, length of hanger. The height decides the height of the hanger gate, ceiling and miscellaneous installations. The distance between main gears and turning radius decides the configuration of exit runways.

iii) Capacity :-

The capacity of an aircraft in terms of fuel, passangers and cargo is helpful in deciding the facilities to be provided in the terminal building, storage of fuel and the dispensing methods can be planned accordingly.

iv) Weight :-

Empty operating weight, pay load, zero-full weight, Maximum structural landing weight and maximum Gross take-off weight are the different terms in connection with the weight of an aircraft Maximum Gross take off weight plays an important role in the design of wheel load assemblies and tyre pressure and hence the structural design of pavements.

v) Range :-

Longer the range, longer the frequency of operation and hence more is the handling power of runway in respect of movements per hour.

vi) Speed :-

The speed of an aircraft is measured in nautical mile (1855m) and is equal to one minute of arc of earth's circumference. (112 not = 1917 kph) cruising speed is the speed of the aircraft relative to the ground and the other, namely, air-speed is the speed of the aircraft relative to the wind and is of importance to the pilot. Though speed is not an essential the planning, it emphasises an idea of the arrival the aircrafts.

vii) Turning radius :-

It helps to determine the radius of curves at the ends of the taxiway, position of the aircraft on the apron and other locations of the aerodrome.

viii) Arrangements and weight on the gear system :-

The main object of providing variety of gears is to distribute the load over wide area and also to maintain aircraft stability and its easy movements. For the design purpose the following information is essential.

a. Maximum take-off weight.
b. Maximum weight on main gear.
c. Maximum weight of nose gear.
d. Nose tyre pressure.
e. Main tyre pressure.
f. Main gear lateral spacing.
g. Main gear fore and aft axle spacing.

It is assumed that 10% of the weight is on the nose gear and 90% is on the main gears under the wings.

2.5 HEAT, BLAST AND NOISE INTERFERENCE :-

i) Heat and Blast :-

It affects the asphalt pavement adversely. Usually blast pads and blast fences are placed to reduce wake velocity which is coming at the back of the engine through the tail pipe. The specification used by ICAO in connection with the heat and blast control are,

a. Power and thrust of the engine usually nose in Positions are preferred.
b. Height of the tail pipe above pavement surface (1.6m for civil jets is more safety).
c. Angle of inclination of the tail pipe (2° for civil jets)
d. Whether the aircraft is in motion (or) not.

ii) Noise :-

The aircrafts make lot of noise during landing and take-off. Noise arises due to aerodynamic, comburtion, rotation of refers and propellers, compressor and Sonic booms.

It is necessary to have a buffer zone (or) non-residential area around the airport for good sound insulation. If a buffer zone cannot be provided, the erection of an accourtial barrier may be required.

C H A P T E R - 3

SITE SELECTION AND PLANNING OF AN AIRPORT.

Airport planning is a four domensional Problem, the fourth domension is the time while planning an airport the planner should bear in mind that it must be ideal in all aspects. The planner must know the latest techniques in the air transport industry and also the future development which might be developed in due course.

Airport planning is broadly classified as,

i) regional planning,

ii) city planning which relates the development of a new airport and improving an existing airport.

The planning of a system of airports for a country as a whole or a sizable part of a country, is called the regional planning.

3.1 FACTORS AFFECTING SITE SELECTION :-

The following factors are to be considered in selecting the site for an airport :

a) Population density.

b) Character and trend of the people and their economic standard.

c) Possible growth in economic of the country.

d) Geographic and topographic characteristic.

e) The land and water transport facilities and the municipal traffic authorities.

3.1.1. Survey :-

There are different types of surveys meant for different purposes as indicated below :

a) Traffic survey (Type and amount of traffic)

b) Materiological survey (direction, duration and intensity) of wind, rainfall, fog, temperature and barometric pressure).

c) Topographical survey which inclues contour map and obstruction map.

d) Soil survey (soil type,GWT, subsoil conditions etc.)

e) Drainage survey which inclues quantity of storm water, possible outlets locating in the viarity of the site possiblity of intercepting or diverting the natural streames.

f) Materials survey (availability of materials at the site).

g) Engineering surveys which includes preliminary survey for investigation and final survey for detailed estimates.

3.1.2. PLANS :-

After having carriedout the surveys, plans of different categories like district plan, Tourplan, detailed survey plan and obstruction map showing the topographical manmade features at the sites

3.1.3. ESTIMATE :-

The future development in the air land and water traffic requires to be estimated.

3.1.4. NETWORK :-

The required planning would decide the routes of travel, the location of different types of airports and thus form a network of air transport system.

3.1.5. AUTHORITY :-

Regional planning should be carriedout by airport aviation department under the central government the collobration with the state government.

3.2. CITY PLANNING :-

If a new city is built provisions of an airport should form a part of the city planning such that it forms an untegral part of its transportation system.

Before selecting a new site, we must think of whether the present airport can be improved (or) expanded by providing runway, taxiway extensions additional gate positions improving landing aids and re-arranging the existing terminal building (or) made use of specific purposes only (or) entirely abandowed depending upon its present facilities.

3.2.1. Factors in general :-

Following are the factors to be considered while planning a new airport.

I. Area to be served.
II. Population to be served.
III. Airport capacity.
IV. Type, size and shape of the airport.
v. Proposed use of an airport.
VI. Accessibility tousers.
VII. Whether the aircraft service is intermitent or regular.
VIII. The number of passengers and the amount of cargo the airport will ultimately handle.
IX. Type of activities to be served.
X. The training faculties to be provided at the airport.
XI. Air transport facilities like landingaids, terminal facilities.
XII. Facilities available from toun.
XIII. Private assistance from public or financial instructions.
XIV. Parking space for automobiles.
XV. Land values damage to property.
XVI. Present and expected aircraft traffic.

XVII. Tourist traffic.

XVIII. Future expansion.

XIX. Interference from adjourning airports should be minimum so that landing and take off operations can be carriedout safely. The minimum distance for,

a) Small general aviation craft = 1.6 Km.
b) Bigger planes. = 3.2. Km.
c) When provided with I.L.S. = 16 Km.
d) Jet planes. = 80 Km.

with this aircoiling path of two planes using adjacent airports respectively there will be no (or) minimum interference for carrying out air operations safely.

XX. Obstructions clearance and applicable zoninglaus.

XXI. Noise control.

XXII. Public opinion about constructing a new airport.

XXIII. Camouflage.

This applies only to military airfields in compact zones. It divides itself into the following,

a) Storage of planes (should be inconspicious)
b) Runways.
c) Other structures including fuel tanks.

The following fundamental should be considered while selecting a site for military airport.

a) provide plenty of trees.
b) attempt colour deeption by providing runways and structures of colour similar to its surroundings.
c) provide artificial colour.
d) utilize the topography to provide underground installations.
e) provide irregularity in design.
f) distribute structures and storage spaces for planes and fuel.

3.2.2. Economic Factors :-

Economic consideration in the selection of site is naturally of prime importance. The factors in the economic study are,

i) Cost of development which includes cost of land, cost of construction and cost of utilities.

ii) Cost of operation which covers cost of management maintenance cost replacement charges.

iii) Revenue from the airport.

3.2.2. Physical Factors :-

i) Effect of topography :-

	Description	Upland (or) a site at a higher elevation	Lowland or Vally
i)	Obstruction in the approach Zone	Few	More
ii)	Drainage system	Natural and relatively cheap	artificial and costiliest item.
iii)	Fog and haze hindrance.	Less and vissibi- is good.	more and visi- lity is poor.
iv)	Wind currents a deciding factor in the case of runway	more inform	Highly turbulent.
v)	Influence of watertable	much lower and thickness of pave- ment is less.	Much higher and hence thickness of the pavement is more.
vi)	Earth work required for grading.	more	Less
vii)	Accessibility for ground transportation.	More difficult	Easily accessibl ible.

ii) Visibility.:

poor visibility depends upon meterioligical conditions of the area, local natural features and man made conditions (smoke from individual plants). Hence we have to select a site which is having good visibility which is essential for the full time use of an airport in the approach zones.

iii) Direction of prevailing winds :-

It helps to provide,

a) Safety to the incoming and outgoing planes.

b) helps in providing reduced length of runways.

iv) Wind rose diagram :-

A wind rose diagram showing the surface wind velocity, their direction and percentage of prevalence should be determined. The three types are,

1) Showing direction and duration of wind.
2) Showing direction, duration and intensity of wind.
3) Showing direction, duration, intensity of wind and fog clearance.

v) Disturbance to residential areas. Noise pollution control should be sufficiently studies and effective measurements should be taken to prevent or minimise the noise created by the activities of the aircrft.

3.3 OBSTRUCTIONS :-

Both the natural and man made Obstructions constitute a hazard to the safe operation of aircrafts. Future growth of obstructions shall be prevented by enforcing zoning laws as benefly below.

3.3.1. Zoning :-

Prevention of obstructions to navigations of aircrafts is the main object of zoning.

Uses :- i) It protects flight paths.

ii) Control the development of property undisuable structures and tress.

iii) Protection against certain types of manufacture which produces smoke (or) corrosive chemicals or obnoxious odour.

Obstructions can be divided into two classes,

a) Objects above a certain imaginary surface.

b) Objects exceeding the limiting light above ground

3.3.2. Definitions :-

While dealing with the obstructions in the approach zones we have to know certain well defined definitions noted below :-

I) HORIZONTAL SURFACE :- It is an imaginary plane circuklar in shape its centre at reference point and radius 1500 to 3900mm with its height 45mm above the established airport devation.

II) APPROACH SURFACE :- It is an imaginary inclined plane directly above the approach area. Its shapre varies for instrument and non-instrument runways.

III) CONICAL SURFACE :- It is an imaginary surface which extends upwards and outwards from the periphery of the hotal surface with a slope of 1 at 20 measured in vertical plane passing through airport reference point.

IV) TRANSITIONAL SURFACES are imaginary surfaces extending upwards and outwards from the side edges of all approach surfacee, thus forming the sloping sides of an imaginary channel over which the plane may navigate. They are inclined with a slope of 7 in 1 at rightangles to the extended centre line of the runway. Fig. 3.1 illustrates the above mentioned concepts.

3.3.3. <u>Specifications</u> :-

The specifications given to the length width and runway slope are furnished below :

Runways	Length from a point 6m away from the end of runway.	Width	Slope
Instrumental runways	3000m	300m adjacent to runway. 1200m at the end of 3000m section 4800m additional 12000m section	50 in 1 for inner 3000m. 40 in 1 for outer 12000m section.
Non Instrumental runways.	15000m	60 to 150m adjacent to runway. 600 to 750m at the end of 300m section.	40 in 1 20 in 1 for small airports.

ii) Objects exceeding the limiting height above ground. They are caused by erections at the airport such as windcone beacons tower, buildings flood lights etc. or erection in neighbouring area such as tall buildings pole lines trees towers etc.

	Approach Zones	Other than approach Zones.
Within 4.8 km from the end of the runway	30m above ground (or) above the level of the approach end of the runway whichever is more.	52m above grainly or above the elevation of airport which ever is more.
Beyond 4.3 km	More are in height by greater than 7.5m for every 1.6 KM within next 11.2 Km from 4.8 km end 75m.	Increase inlit by more than 30m for each additional mile 150m.

Objects whose elevations would increase the final appraoch minimum flight altitude are considered as Obstructions.

Objects within a civil airway (or) airtraffic control area more than 52m above the gravity (or) more than an elevation that would require the increase in established min. flight **altitude whi**chever is more is considered as an obstruction.

Finally all obstructions exceeding the limiting height from the ground, should be indicated by red light signals as an indication at night for the might operation.

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C H A P T E R - 4

AIRPORT GEOMETRIC DESIGN

Geometric design depends upon aircraft performance, pilot technique, and whether conditions. This design standards are varying with the topography and meteorological condition of the area and the highest class of aircraft expected to use the airport.

The geometric designs are recommended and prepared by different agencies like :

i) International civil Aviation Organisation (ICAO).
ii) Federal Aviation Agency (FAA)
iii) Airforce and Navy.

The geometric design standards for elements of the airports are primarily the standards meant for :

i) Runways.
ii) Taxiways.
iii) Turning radius.
iv) Apron.
v) Separation clearance.

4.1 RUNWAY :-

Runway must be of adequate length, width, smoothness and strength to allow safe landing and take-off of many types of aircraft under varying conditions of weather and piloting skill. In addition to this the runway must be well drained.

The main parameters of the runway are briefly discribed below :-

4.1.1. Length of runway :-

Selecting the length of runway is perhaps the most important decision which must be made in the planning of the landing area. Basic runway lengths are given in table below. Where required corrections have to be applied for changes in elevation, temperature and gradient are given as below.

i) Elevation correction.
ii) Correction for temperature.
iii) Correction for gradient.

Air-port cla-ssi-fica tion	Basic length of main run-way in met-res.	Max. width of run way in meters	Max. width of ta xiway in meters	Approach surface slope		Maxi. mum long itud inal gra-dient %	Maxi. effe-ctive gradi ent %	Maxi. transve se grad ient %
				Instr ument run-way.	Non ins tru-run way			
A	2500 or above	45	23	1:50	1:40	1.25	1.0	1.5
B	2150 to 2500	45	23	1:50	1:40	1.25	1.0	1.5
C	1000 to 2150	45	23	1:50	1:40	1;5	1.0	1.5
D	1500 to 1800	45	18	1:50	1:40	1.5	1.0	1.5
E	1280 to 1500	45	15	1:50	1:30	1.5	1.0	1.5
F	1080 to 1280	30	12.5	1:50	1:30	1.5	1.0	.15
G	900 to 1080	30	12.5	1:50	1:25	1.5	1 0	1.5

4.1.2 Width of runway :-

The width of runway varies from 45m for A to 30m for G type airport. Another factor which governs the width of the runway is that the otermost part of machine of the largest aircraft using the airport should not extend beyond the pavement. Shoulders are provided an either side of the landing ship. For instrumental runway width is 300m. Instrumental runway cross section is shown in Fig. 4.1.

4.1.3. Sight Distance :-

Normally there is no sight distance restriction as the longtudinal gradients are quite gentle. When two runways or taxiways and a runway intersect there are chances of collision of aircrafts if adequate sight distance are not provided.

4.1.4. Transverse Gradient :-

The transverse gradient for the runway recommended by the Federal Aviation Agency (FAA) and International Civil Aviation Organisation (ICAO) is listed 1.5 percent and is labeled "maximum". A minimum gradient is not specified, but it is also quite important, since improper drainage of the pavement can adversely affect the performance of aircraft during the take-off and can be quite hazardous if large puddles form. Steeper gradients are normally permitted on the shoulders than on the pavement. The usual transverse gradient adopted for runway is as shown in FIG. 4.2.

4.1.5. Longitudinal Gradient and Changes in Gradient

The longitudinal runway gradient affects the runway length. Uphill take-off and down-hill landing both increase the required runway length. For safety during take-off and landing operations, abrupt grade changes in runways should be avoided. Frequent changes in the gradient can also much greater and maneuverability on the ground is less than that of an automobile, good visibility along the entire length of runway is required. Thus not only the amounts of change in the gradient but also the distances between the changes are important in planning the profile of a runway. These features are shown in FIG. 4.3

4.1.6 <u>Runway Intersection</u> :-

Another feature which deserves attention is the geometric design of runway intersection is shown in FIG.4.4. The principle criterial for the design of runway intersections are as follows :

i) Smooth profiles on each runway at the intersection so an abrupt "bump" is not felt by the high speed traffic.

ii) Provide adequate drainage so pending in the intersection is virtually eliminated.

To satisfy these criterial gradients and vertical curve data are recommended.

4.1.7 <u>Runway Clearances</u> :-

The runway clearances as recommended by International Civil Aviation Organisation are based on previous experience and judgements. These clearances are provided to ensure that movement along different runways and taxiways do not interfer with each other.

Airport Classification	Clearance between the edge of parallel runways	Distance between edge of one runway and any point on the edge of taxiway.		Distance between any point on one taxiway& the edge of another taxi way.	Distance between any point on one taxiway & a fixed distance
		Instrumental runway	Non-Instrumental runway.		
A	210	165	90	70	39
B	210	150	75	69	30
C	210	150	75	52	30
D	150	150	75	52	30
E	150	150	75	45	24
F	150	145	70	33	24
G	150	145	70	26	18

4.1.8. Pavement Loading :-

A runway of any particular strength or class should be capable of bearing the specified loading for a frequency of operationscorresponding to the expected traffic, but not less than ten operations of landing or take-off per day. The International Civil Aviation Organisation's recommendation is that the pavement loading should be based on Equivalent Single Isolated Wheek Load (ESIWL).

4.2. DESIGNING AND PLANNING OF RUNWAY :-

Design and planning of runway depends on the following parts :-

i) Direction and number of runway.
ii) Length of runway and other geometric features.
iii) Thickness of runway pavement.
iv) Pattern and capacity of runway.

Direction of runway mainly depends on the effect of wind direction on movements on aircrafts. Effect of wind direction and speed of the wind. The wind in the opposite direction of the take-off reduces the runway length. Hence in order to derive the direction of landing and take-off the wind rose diagram to the locality is effectively made use off. The total thickness of the pavement is made up of sub-base and the surface course laid and completed in layer placed are above the other after preparing and compacting the subgrade.

With a view to avoiding congestion of traffic, the pattern of runways and taxiways should be such that maximum capacity of traffic control facilities may be effective without the necessity of holding in-coming planes in the air while others are taking off. The system should permit each plane, as it lands, to taxi to the loading area without returning along the landing strip, so as to make the runway free for other planes. The various runway patterns are shown in FIG 4.5.

4.3 Taxiway :-

The main function of a taxiway is to provide access to the aircrafts from the runway to the loading apron or service hangers and back. Taxiway should be so arranged that the aircraft which have just landed and are taxing towards the apron, do not interfere with the aircrafts taxing for take-off. As far as possible the intersection of taxiway and runway should be avoided.

The speed of an aircraft on a taxiway is much lower than its speed on a runway during landing or take-off. Thus the design standards for the taxiway are not as rigid as they are for runway.

The length of the taxiway should be as short as practicable. This will save, the fuel consumption.

The width of the taxiway is much lower than the runway width. The speed of the aircraft on a taxiway is lower than the speed on a runway the pilot can confortably manoeuvre the aircraft over a smaller width of taxiway than runway.

The wideth of the safety area includes the taxiway pavement shoulders on either side plus the area that is graded and drained. This may extent upto a point where it intersects a parallel runway, taxiway or apron. The surface must be impervious, smooth and should not disintegrate due to the not blast of the jet engines. The longitudinal gradient should not be exceed 1.5% for A and B types and 3% for other types, of airports. The cross section of taxiway is shown in FIG 4.6.

Transverse gradient is essential for quick drainage of surface water. The rate of change of longitudinal gradient directly affects the available site distance on the pavements.

The intersection of taxiway and runway should provide a smooth junction. Since the speed of aircraft on taxiway is lower than on runway smaller value of sight distance will be sufficient on taxiways. An intersection of taxiway is shown in FIG 4.7.

4.4. TURNING RADIUS :-

Whenever there is a change in the direction of a taxiway a horizantal curve is provided. The curve is so designed that the aircraft can negotiate it without significantly reducing the speed. Circular curve of large radius is suitable for this case. The radius can be obtained from the formula.

$$R = \frac{V^2}{125.f}$$

Where, =

R = Radius in metre.

V = Speed in Km/hour.

f = Co-efficient of friction between the tyre and the pavement surface.

The value of f may be assumed as 0.3.

4.5. APRON :-

The details of the apron depend upon the characteristics of the highest type of aircraft expected to use it. Holding apron is also known as a Run up or a Warnup pads. These are located where the aircrafts wait for their turn to take-off and where they are finally checked before the take-off. In the case of holding aprons the area of the apron should be large enough so that it can by pass another aircraft standing ahead with adequate dearance. The holding apron are as shown in the FIG. 4.8.

4.6. SEPARATION CLEARANCE :-

From the view point of safety, the two paralled traffic ways should be separated by an adequate distance from each other. The separation distance depends upon the type of aircraft, the wing span of aircraft and the navigational aids available at the airport. The traffic ways should also be separated sufficiently from the adjacent obstructions, eg. buildings.

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CHAPTER 5

TERMINAL AREA AND ITS FACILITIES

The terminal area is the major interface between the airfield and the rest of the airport. It includes the facilities for passengers and baggage processing, cargo handling and airport maintenance, operations and administrative activities.

5.1 PASSENGER TERMINAL SYSTEM :-

The passenger terminal system is the major connection between ground access and the aircraft. It varies in size and arrangement depending upon the volume of traffic to be handled. The two approaches in the arrangement of the terminal building are,

i) Centralized terminals in which all passenger baggages are processed in one building. It avoids the problems of trasferring passengers and baggages from one building to another and

ii) Unit terminals, where the traffic volumes are very high each airline may have its own separate terminal building.

5.1.1. COMPONENTS OF THE SYSTEM :-

The passenger terminal system is composed of three major components.

i) The access inferface where the passenger transfers from the access mode of travel to the passenger-processing component. Circulation, parking and outside loading and unloading of passengers are the activities that take place with in this component.

ii) The processing component where the passenger is processed in preperation for starting or ending an air trip. The primary activities that take place here are ticketing, baggage check-in, baggage claim, seat assignment, federal inspection services and security.

iii) The flight interface where the passenger transfers from the processing component to the aircraft. The activities that occur here include assembly, conveyance to and from the aircraft, and aircraft loading and unloading

The components of the passengers terminal system together with the specific physical facilities corresponding to them are shown in FIG. 5.1.

5.1.2. <u>FUNCTIONS OF THE PASSENGER TERMINAL</u> :-

It must accomodate the following facilities,

i) airline operation, which requires space for a variety of activities like passenger and baggage handling counters, office space etc.,

ii) facilities for the convenience of passenger, like bank, Magazine stall, public telephone, toilet etc.,

iii) offices for airport management which requires space for office for airport Manager and his staff.

5.1.3. LEVELS OF OPERATION :-

For small volumes of traffic the one-level operation is economical, where the processing of passengers and baggages take place at the same level and is shown in FIG. 5.2.

At high traffic volume airport a two-level operation as shown in fig. 5.3. can be adopted where the departing passengers are usually processed on the upper level, and the arriving passengers on the level.

A three-level operation is adopted in the case of international Airport.

5.2 AUTOMOBILE PARKING FACILITIES :-

Automobile parking should be located adjacent to the terminal building so that walking distance are kept to a minimum. Car parking must be provides and therecommended basic parking area is 8'6" wide and 18' long.

The parking are often segregated into short-term and remote parking facilities and these facilities are more convenient to charging rent for their use.

5.2.1. VEHICULAR CIRCULATION :-

To avoid congestion and delays in traffic, it is essential to well plan the circulation of vehicular traffic. The circulation of traffic on an airport should generally be oneway and counter clockwise.

5.3. APRON :-

Apron provides the connection between the terminal buildings and the airfield. It includes aircraft-parking areas called ramps, and aircraft circulation and taxing areas for access to these ramps.

5.3.1 APRON-GATE SYSTEM :-

The size of the apron-gate area depends on three factors. namely

(i) Number of aircraft gates.

(ii)Size of the gates.

(iii) Aircraft parking layout at each gate.

5.3.2. NUMBER OF GATES:-

The number of gates required depends on the number of aircraft to be handled during the design-hour and on the amount of time, each aircraft occupies a gate.

5.3.3. GATE SIZE :-

The size of a gate depends on the size of aircraft which is to accommodate and on the type of parking used.

The type of parking used or

i) Nose-in : In this type, the aircraft is parked perpendicular to the building line.

ii) Angled Nose in : Thus type is similar to Nose in type except that the aircraft is not parked perpendicular to the building line.

iii) Angled Nose out : This type is similar to the Nose-out type except that the aircraft is not parked perpendicular to the building line.

iv) Nost out : In this type, the aircraft is parked with its nose pointing away from the terminal building.

5.4 AIRCRAFT PARKING SYSTEM :-

Aircrafts are, grouped adjacent to the terminal building in a variety of ways which are referred to as parking system. They are of four types,

6.4.1 FRONREL SYSTEM :-

In this system aircrafts are parked on the apron in a line as shown in FIG. 5.4.

5.4.2. OPEN APRON SYSTEM :-

When the number of aircraft is larger this type of parking system is adopted. FIG. 5.5 illustrates this concept.

5.4.3. FINGER SYSTEM :-

It is the extention of Frontal system. Fingers are proceeded from the terminal building which enters into the apron area. It can be straight, Y shaped or T shaped as shown in FIG. 5.6.

5.4.4. SATELLITE SYSTEM :-

As shown in FIG 5.7. Satellite can be defined as a small building located on the apron and connected to the main terminal building by means of a tunnel or pier. Aircrafts are parked around each Satellite building.

5.5. CARGO TERMINAL AND HANDING CONSIDERATION :-

The Cargo Terminal is the forwarding and reliving airport in the huts of all gound handling activities.

It has to make provision for inbound as well as outbounds domestic and international cargo. The size and use of Cargo flow and future storage requirements. It can be located on the same side of passenger terminal

A small building for handling, processing and storage of cargo may be required, separate from the main passenger terminal building, become it is not possible to processed entirely in the passenger terminal building when the volume of cargo is large.

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CHAPTER - 6

AIRPORT PAVEMENT

Airport pavements are designed to provide adequate support for the loads imposed by aircraft. The primary function of a pavement is to provide a firm, Stable, durable and smooth all year, all-weather surface free from dust or particles that may be blown or picked up by aircraft propellers and to distribute the concentrated loads so that the supporting capacity of the subgrade soil is not exceeded.

The two types of pavements namely flexible pavement and rigid pavement are briefly described below :

6.1 FLEXIBLE PAVEMENT :-

In flexible pavement, bituminous materials and aggregates are placed on high quality granular materials. It may consist of one or more layers of material like surface course, base course and subbase course. The Surface course is a mixture of bituminous material and aggregate where as base course consists of untreated or treated crushed stone mixed with various types of binders such as asphalt and portland cement and the subbase course is usually composed of unprocessed pitrun material or material selected from a suitable excavation on the site.

6.2 RIGID PAVEMENT :-

A pavement is referred as rigid pavement, when it consists of a slab of portland cement concrete, usually placed on a prepared foundation of imported material.

6.2.1. Factors in the selection of pavement :-

i) Safety of aircraft operation.
ii) Nature and density of anticipated air-traffic.

iii) Characteristics of the soil on which the landing facilities is to be built.

iv) The degree of permanency required and the size of the budget.

v) The climatic conditions of the area, such as humidity, rainfall and temperature.

vi) Magnitude of wheel loads.

vii) The availability of construction materials and construction equipment.

viii) Maintenance costs.

6.3. <u>PAVEMENT JOINTS</u> :-

There are two types of joints namely longitudinal joints and transverse joints.

The longitudinal joints are provided so as to divide the pavement in parallel strips when the width of the road is morethan 12'.

The transverse joints can be further sub-divided into 4 types as expansion joints, contraction joints warping joints and construction joints.

Joints in the transverse direction may be provided to accommodate the longitudinal expansion of the slab when the temperature increases or to take care of its contraction when the temperature falls. Two allow angular movement or twisting of the slab also due to temperature variations warping joints may be provided in the transverse direction. Construction joints are necessary at the end of the day's work.

6.4. <u>GENERAL DESIGN OF AIRPORT PAVEMENT</u> :-

In the determination of pavement thickness, the following points are considered.

i) <u>Design wheel load</u> :-

In general aircrafts are supported by a nose gear and two main landing gears located inwing area on each side. Modern aircrafts are fitted with tricycle assembly. Each landing gear consists of one, two or four wheels. Equivalent single wheel load is defined as, wheel producting the same deflection as the assembly of two or more wheels produced together.

ii) <u>Strength characteristics of materials</u> :-

The strength characteristics of different pavement layers are evaluated in different manner as per each design method. CBR or plate bearing test are carried out for flexible materials. For rigid materials like cement concrete mix, the flexture strength, elastic modulus and poisson ratio are obtained as strength pavement.

iii) <u>Subgrade supporting capacity</u> :-

The supporting capacity of the subgrade is considered significant in flexible pavement. In case of rigid pavement this value seems to influence thickness requirement negligibly.

6.5. <u>DESIGN METHOD FOR FLEXIBLE PAVEMENT</u> :-

i) CBR method.
ii) Mcleod method.
iii) Burmister method.
iv) FAA method.

One such method i.e. Mcleod method is briefly discussed below.

6.5.1. <u>Mcleod method</u> :-

Norman W. Mcleod through canadian department of transport conducted extensive plate bearing tests on air field and highway pavements and developed a design method.

The thickness of the pavement is calculated by using the formula.

$$T = K.\log \frac{p}{3}$$

Where,

T = thickness of gravel materials.

P = gross wheel load.

S = subgrade support, and

K = base course constant.

6.6. DESIGN OF RIGID PAVEMENT :-

The design criteria for the rigid pavements are based upon allowable tensile stress in concrete. Proper compaction and treatment of the sub-base course, sub-grade under rigid pavement are important. The commonly adopted method for this type of pavement design is illustrated below.

Westergard's method

When load transfer devices are not provided, the weakest part is the corner of the concrete slab and the thickness design is based upon westergand Analysis for stress at the corner of slab as modified by Teller and Sutherland, according to whom.

$$Sl = \frac{3W}{t^2} = \left| L - \left(\frac{a.\sqrt{2}}{e} \right)^{1.2} \right|$$

Where,

Sl = flexuralstress at the corner of the slab in lbs/in^2

W = the wheel load including impact allowance in lbs, placed on the corner of the slab.

a = radius in inches of circular area, equivalent area of contact between the tyre and the pavement

L i = Radius of relative stiffness as given by the equation.

$$= \frac{Et^3}{12(1-\mu^2)\ k}$$

Where,

E = Modulus of elasticity of concrete in lb/in^2 using value $4' \times 10^6$ to 5×10^6 lb/in^2

= Modulus of subgrade reaction in $lb3/in^2$

= (P/z)

Where P = Pressure on the subgrade

z = the deflection under this pressure.

The working stress S1 in the above formula has been based on the 28 day flexural strength of concrete. To allow for increase of strength with age, this is multiplied by a Co-efficient 1.35 to give strength at six months and divided by a factor of safety 1.25 to 1.5 for runways and 1.8 to 2.0 for aprons and taxiways.

When load transfer devices are provided, the concrete pavement may be assumed to be continuous over layer area and as aircraft wheels seldown go near the edge of the pavement, the weakest point is then considered to be the centre of the slab. The thickness design of the payment in theat case is based on the following expression (westergard) for the stress at the location.

$$S2 = 0.275\ (1 \pm \mu)\ \frac{W}{t^2}\ \log_{10} \left\| \frac{Et^3}{kb^4} \right\|$$

Where S2 = flexural stress at the centre of the slab in lbs/in^2

$b = (1.6a^2 + t^2)^{\frac{1}{2}} - 0.675t$ where $a < 1.724t$

$b = a$ where $a > 1.724t$.

In addition to the design loads, the pavement must be of adequate thickness and have sufficient stability so that it will not fail under the imposed traffic loads and shall withstand the abrasive action of traffic, adverse weather conditions and other deteriorasing ingluences.

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C H A P T E R - 7

AIRPORT DRAINAGE

An adequate drainage system is essential for the safety of aircraft and long life of pavement. Improper drainage results in heavy ponding on the pavement surface which can be hazardons to safe landing or take-off of aircrafts. The function of airport drainage are as follows :

i) Removal of surfacee run-off from the airfield,

ii) Interception and direction of surface and grandwater florr originating from lands adjacent to the airfield area and

iii) Lowering of sub-surface water level in the airfield area.

7.1. SPECIAL CHARACTERISTICS AND REQUIREMENTS :-

i) Extensive area under consideration.

ii) Varying soil conditions.

iii) Heavy concentrated wheel loads of air-crafts.

iv) Wide runways, taxiways and aprons.

v) Flat longitudinal and transverse grades.

vi) Shallow water courses.

vii) Absence of side ditches.

viii) Concentration of outfall flow.

DRAINAGE PIPE CHARACTERISTICS :-

The drainage pipe should have sufficient capacity for the rapid removal of groundwater and surface water. It should be sufficiently strong durable and safe to withstand the heavy concentrated wheel loads of the aircraft.

At the initial stage itself proper consideration should be given due to the possibility of future runway extension and addition of runways and taxiways.

7.2. GENERAL DESIGN DATA :-

In the design of drainage system the following Information are collected.

i) A contour map of the airport site and land adjacent to the site showing all natural water courses, the area contributing run-off at the site and possible outfalls and ditches are prepared.

ii) An additional is prepared showing the existing layout of the runways, aprons, building area and future development with tentative finished grade contours indicated therein.

iii) The rainfall data and duration of storms are taken from the Meteorological studies, data on the infiltration properties of the soils encountered and actual run-off records for drainage areas having similar characteristics of soil. Necessary hydraulic data, graphs and tables for the design including standard specification. Also structual characteristics for pipes, sutters, manholes, inlets, gratings, fittings etc. and temperature data, depth of frost penetration are collected.

iv) Centre line profiles of all runways, taxiways and apron area in the necessary cross sections. Boring plans of soil strata along with ground water profile etc. are prepared.

7.3. CLASSIFICATION OF DRAINAGE.:

7.3.1. SURFACE DRAINAGE.:

It deals with the removal of surface run-off resulting from the selected design storms without damage to the airfield facilities. The design capacity to the storm water systems should be adequate to accomplish the following objectives with the range of economic feasibility and with proper considerations being given to the importance of particular airfield.

i) The possibilities of the removal of surface run-off from storms greater than design storms with the minimum damage to the airfield facilities and with the shortest interruption of normal traffic are considered.

ii) Maximum reliability of the operations practicable under all climatic conditions is estimated.

iii) Maximum maintenance and operation of the difficulties and expenses etc. are observed.

iv) Adaptability to future expansion and interruption of normal traffic is also considered.

7.3.2. SUB-SURFACE DRAINAGE.:

The function of sub-surface drainage are

i) To remove water from a base course.

ii) To remove water from the subgrade beneath a pavement.

iii) To intercept, collect and remove water flowing from springs or porous strata.

7.3.3 BASE DRAINAGE.:

Base Drainage is normally required where

i) Frost action occurs in the subgrade beneath a pavement.

ii) The groundwater is expected to rise to the level of base course and

iii) The pavement is subject to frequent inundation and the subgrade is highly impervious.

7.3.4. SUBGRADE DRAINAGE.:

Subgrade drainage is desirable at locations where the water may rise beneath the pavement to less than 1ft. below the base course.

7.3.5. INTERCEPTING DRAINAGE.:

Intercepting drainage is highly desirable where it is known that sub-surface waters from adjacent areas are seeping toward the airport pavements.

7.4. METHODS FOR DRAINING SUBSURFACE WATER.:

Base courses are usually drained by installing subsurface drains adjacent to and parallel to the edges of pavement. The previous material in the trench should extend to the bottom of the base course. The center of the drain pipe should be placed a minimum of 1ft. below the bottom of the base course.

Subgrades are drained by pipes installed along the edges of pavement and in some instances where the ground water is extremely high underneath the pavements.

Intercepting drainage can be accomplished by means of open ditches well beyond the pavement areas. If this is not practical, then subdrains can be used.

7.5. TYPES OF PIPES.:

The types of pipes usually used for subdrains are described below.

i) Metal concrete or vitrified clay pipe. The perforated area is usually placed adjacent to the soil. The perforations normally extend over one third of the circumference of pipe.

ii) Bell and spigot pipes are laid with the joints open. They are made of vitrified clay, cast Iron or plain conc.

iii) Porous Concrete pipe collects water by seepage through the concrete wall of the pipe. This type of pipe is laid with the sealed joints.

iv) Skip pipes manufactured from both vitrified clay and iron is a special type of bell and spigot pipe with slots at the bells.

7.6. FILTER MATERIALS.:

The term filter materials applies to the granular material which is used as a backfill in the trenches where subdrains are placed. In order that the free water may reach the drain quickly, the filter material must many times more perions than the protected soil. But if it is too pervious the soil particles are likely to move into the filter material and clog it. So, the criteria of selecting the gradation of the filter material are as follows.

i) To prevent clogging of a perforated pipe with filter material, the following requirements must be fulfilled.

$$\frac{\text{85\% size of filter material}}{\text{Diameter of perforation}} \geq 1.5$$

ii) To prevent the movement of particles from the protected soil into the filter material, the following conditions must be satisfied.

$$\frac{\text{15\% size of filter material}}{\text{85\% size of protected soil}} \leq 5 \text{ and}$$

$$\frac{\text{50\% size of filter material}}{\text{50\% of size of protected soil}} \leq 25$$

iii) To permit free water to reach the pipe, the following condition must be satisified.

$$\frac{\text{15\% size of filter material}}{\text{15\% size of protected soil}} \geq 5$$

iv) To prevent segregation of filter material, the following condition must be satisfied.

$$\frac{\text{60\% size of filter material}}{\text{10\% size of filter material}} \leq 20$$

DRAINABILITY OF SOILS.:

Certain types of soils, such as gravelly sands, sand and sandy loams are usually self draining and require very little,if any subsurface drainage. Sub surface drainage can be effective for draining clay loams, sandy clay loams and certain silty loams. For soils containing a high percentage of silt and clay, sub-surface becomes very problematical.

CHAPTER - 8

VISUAL AIDS, DAY MARKINGS AND NIGHT AIDS

The main aim is to aid the pilot in landing and take off during the day as well as night and also there is a bad weather in which the visibility is very much restricted. In night time the Colour signal lights are used to convey the information to the pilot to make safe landing and take off.

8.1 RUNWAY MARKING :-

Which includes the following articles.

8.1.1. RUNWAY DESIGNATION MARKINGS :-

If there is a small obstructions near the runway, it is desirable to displace thresholding. In all runways, there is a two digit number marked, which is measured from the clock wise of magnetic north viewed from direction of approach.

8.1.2. RUNWAY CENTRE LINE MARKINGS :-

This consists of broken lines to indicate the pilot in making necessary judgement at the time of landing.

8.1.3. RUNWAY THRESHOLD MARKING :-

Which is located at 6m from the extremity of the runway. The amount of displacement will depends upon the object extending above the approach system. In case of threshold which is displaced position, the arrows at interval are provided between the threshold marking indicates the direction of landing.

8.1.4. RUNWAY TOUCH DOWN ZONE MARKINGS :-

This consists of a pair of markings symetrically disposed on each side runway centre line, 22.5m in the length at longitudinal interval at 150m from the begining of the threshold marking.

8.1.5. RUNWAY SIDE STRIP MARKINGS :-

These are provided on runways more than 45m wide They are placed on the edge of runways except the runway width is more than 45m and the spacing at 42m.

The above types of marking arrangements are shown in FIG. 8.1.

8.2. TAXIWAY MARKING :-

This type of markings should be contrast to the runwaymarking preferably white or yellow. The centre line is marked by continuous strip terminating towards the runway edge except in the case of exit taxiway, when the centre line is curved on the runway. Which is shown in FIG. 8.2.

8.3. WIND DIRECTION INDICATOR :-

The Wind direction indicator is truncated Cone, which is located at conspicuous place and lighted at night time. The dimension of wind cone is recommanded by I.C.A.O. is 8.6m in length and diameter is 0.9m. The wind direction indicator is built in such a way that to give a clear indication of wind speed.

8.4. AIRPORT LIGHTING.:

The coloured signal lights which convey the information to the pilot during night time is necessary to safe landing and take-off.

Airport lifhting is divided in to following classifications.

8.4.1. APPROACH LIGHTING.:

The aircraft landing at night, the pilot should suffer very difficult to judge his position with respect to alignment along the correct direction of approach the height above the landing area and the distance from the run-way edge. Which is assist by the standard systematic pattern of guiding lights in the approach area. The first approach lights should be visible to the pilot at a distance of 900m from the threshold of the runway. The intensity of outermost lights Guide the approach is about 2,00,000 Candle power and the thresholding lights have 50 to 100 Candle power. Approach lights are shown in FIG.8.3.

8.4.2. CIRCLING GUIDANCE LIGHTING.:

This serves the pilot to join the downwind leg and bringing his track parallel to the runway andto make distinction from the threshold passing. Also to keep the runway threshold will enable him to turn the base leg and to get the final approach.

8.4.3. RUNWAY ALIGNMENT BECONS.:

Which assist the pilot to judge the aircraft position and the height above the landing area whenever the other means of guide light is not available. The light is coloured white and green alternatively at every Five seconds.

8.4.4. RUNWAY LIGHTING.:

For runway lighting 'Narrow Gauge Pattern of lights' are used. Which has the high intensity of powers. These lights are located to 30 feet on both sides of centre line and 200 feet from the threshold, extending upto 3600 feet along the runway. The spacing of lights along the centre line is 200 feet. Runway lighting of narrow guage pattern are shown in FIG.8.4.

8.4.5. STOP WAY LIGHTING.:

Stop way lighting is used when taking off towards the Stopway and the extends of Stopways are available. The colour of stopway lighting colour is red.

8.4.6. APRON LIGHTING.:

The main purpose of apron lighting is to provide safe manoeuvering of aircraft by pilot and to facilitate the passengers to embark or disembark. The arrangement of light is such that it doesnot produce any glare reflections.

8.5. AIRPORT BECONS.:

An airport becon is a very strong beam of the search light type giving out white and green flashes. It rotates 6rpm and project beams of lights in two direction 180° apart. The flashes are visible to the pilot from any direction of approach to indicate the appropriate situations of an airport,and it is mounted on 6m above the top of the building.

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CHAPTER - 9

AIR TRAFFIC CONTROL

The air traffic control is to ensure the safeguard life, property and the expedite of traffic movement.

9.1. FUNCTIONS OF AIR TRAFFIC CONTROL.:

The main functions of a traffic control is given as follows.:

i) Airtraffic Control.:

Which facilitate to guide the aircraft desiring to land or take off and to control the taxing of arriving and departing of aircrafts on the airfield between aprons and the runway.

ii) Airway traffic control.:

This regulates the movement of aircraft along the air routes with adequate lateral and vertical separation to avoid collision.

iii) AIRWAY COMMUNICATION.:

Which deals with conveying the weather information to the pilot during the flight. It also relay traffic control messages between A.R.T.C. and to pilot.

iv) NON-AIRWAY TRAFFIC CONTROL.:

When personel flighting is done by a large number of people, the movement of the aircraft is not flying along the airway. It must be regulated to prevent interference to the main traffic.

9.2. LANDING AIDS CONTROL.:

This includes the following systems.

9.2.1. INSTRUMENTAL LANDING SYSTEMS I.L.S.:

Which divides into instrumental and Non-instrumental landing system. In the case of non-instrumental system the pilot completely depends upon his vision of the surroundings, there is no instrumental facilities available in the aircraft, in order to locate its path and landing. In case of instrumental landing system is the telecommunication to the pilot to approach the airfield. There are 3 components involved in the instrumental landing system i.e.

9.2.1.1. Localiser.:

It is a beam signal to line up the aircraft along the correct alignment for approaching the runway. Localiser is in the form of antenne is located on the prolongation of runway centreline at a distance of 300m from the end of runway edge.

9.2.1.2. Glidepath.:

Glidepath is the radio beam facilitates the pilot to the correct angle of descent the runway. The glide slope antenne is placed 250m to 400m down the runway from the threshold.

9.2.1.3. The Middle and outer marker.:

These are the low powered signals to indicate the pilot during his descent as to how far he has progressed while approaching the runway. The first signal that the pilot approaches is called outermarker. The second signal, the pilot gets before landing is called the middle marker.

9.2. RADAR SYSTEM.:

An instrument called radarscope is used to facilitate the safelanding of aircrafts. By means of radarscope the controller gets a picture of descending aircraft both in plan and elevation. From this, the controller gives instructions to pilot by Voice communication to the correct alignment and to correct glide path.

9.2.3. APPROACH LIGHT.:

After left the middle marker, the pilot might have to depend upon his vision. The pilot therefore in the last seconds of landing have to change from instrument to the visual conditions. Approach lights are provided to aid the pilot during transition.

9.2.4. AIRPORT SURFACE DETECTION EQUIPMENT.:

In poor visibility the controller at the tower is unable to see the aircrafts for this case the surface detection equipment is used to know the position of aircrafts.

9.3. AIRWAYS AIDS.:-

9.3.1. BEACON.:

A beam of lights are used to aid the mavigation. These are spaced at about 40KM apart.

9.3.2. CODED RADIO MESSAGES.:

Which is used to convey the message from the ground control to aircraft.

9.3.3. LOW FREQUENCY/MEDIUM FREQUENCY RADIO RANGES.:

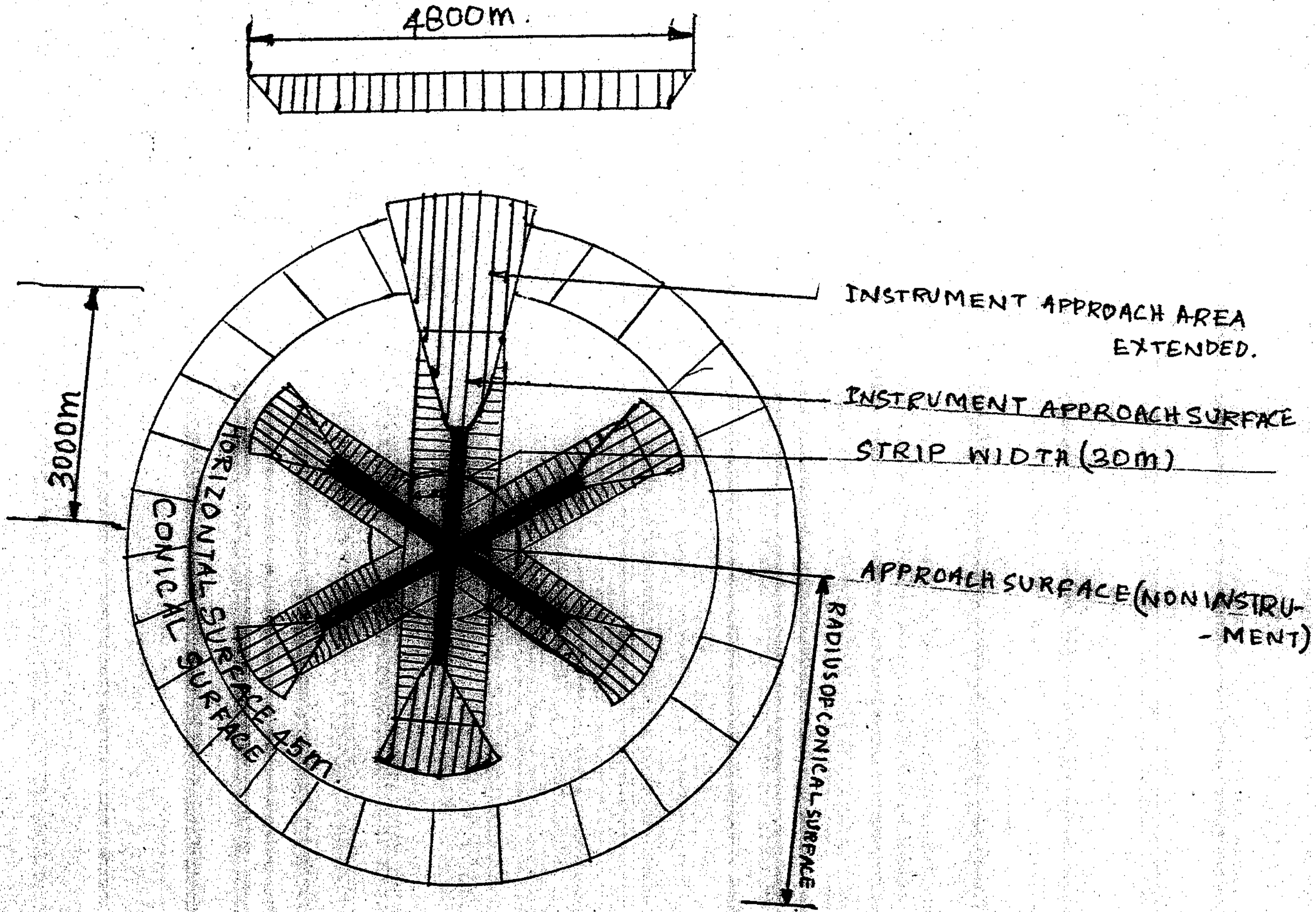
Which is the radio signals emitting in Four directions equal to 90° along the airway route.

The pilot get the correct tunne of the radio waves, which is the correct route.

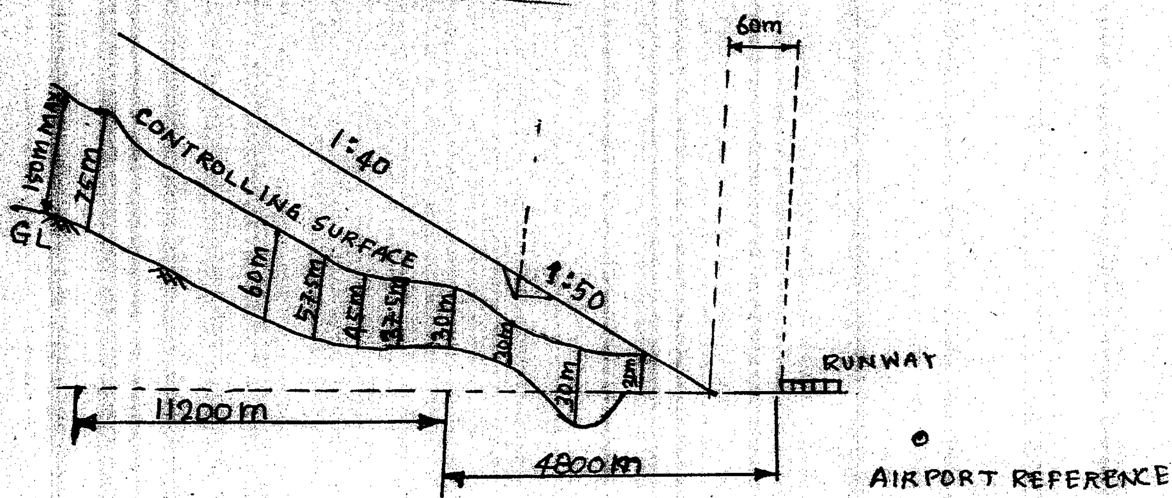
9.3.4. DIRECTION FINDER :-

From radio direction finder tunned the radio signals at 36°, one receives, two points of high volume. It is working on the same principles of Radio Direction Finder (RDF). The loop antenne is fixing at the transmitter the peak occurs, when it is 90° to it the null occurs. The Automatic Direction Finder (ADF) keeps the antenne pointed towards the point of transmission.

& & & & & & & & & & &



IMAGINARY SURFACES



APPROACH ZONE PROFILE

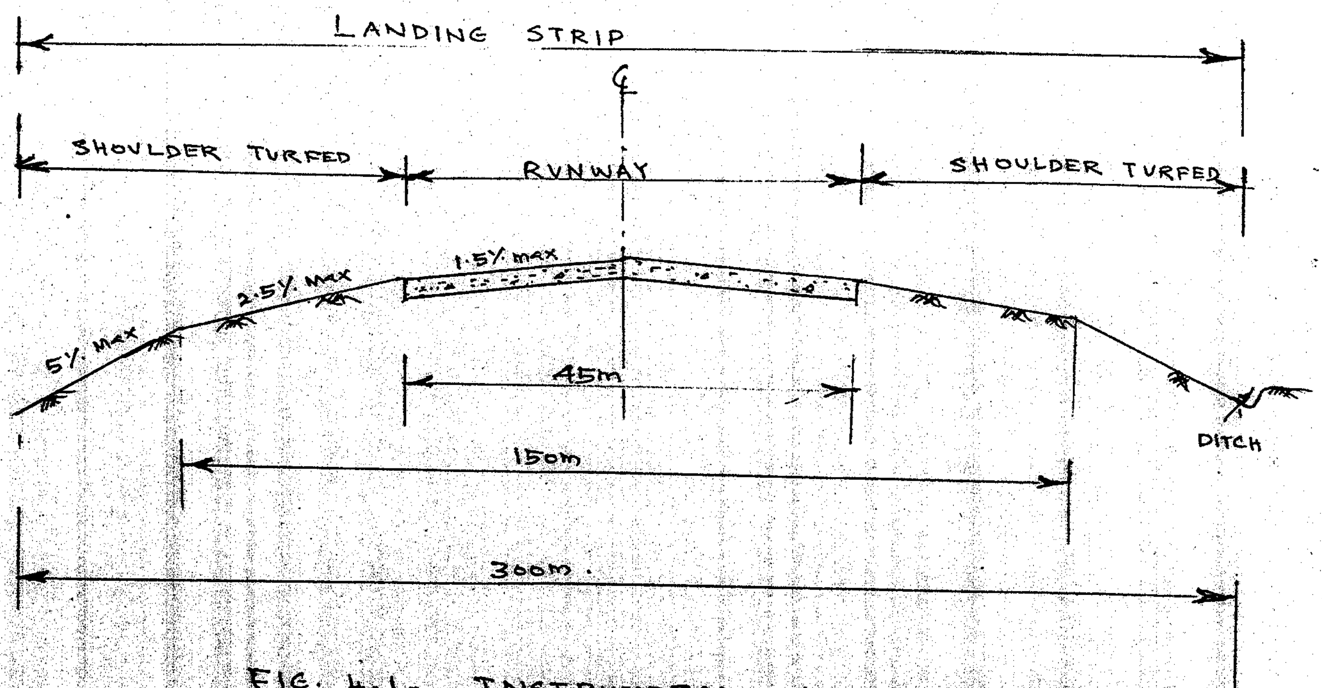


FIG. 4.1- INSTRUMETAL RUNWAY CROSS-SECTION

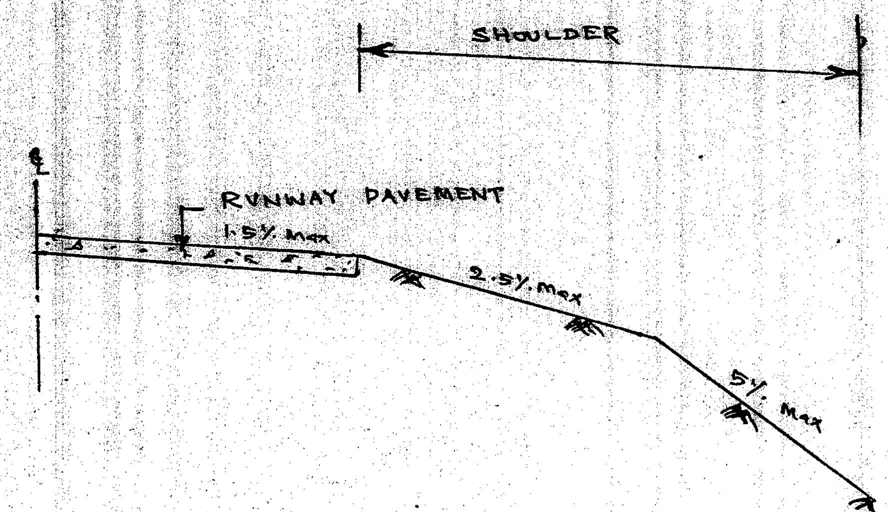


FIG. 4-2. TRANSVERSE GRADIENTS FOR RUNWAYS.

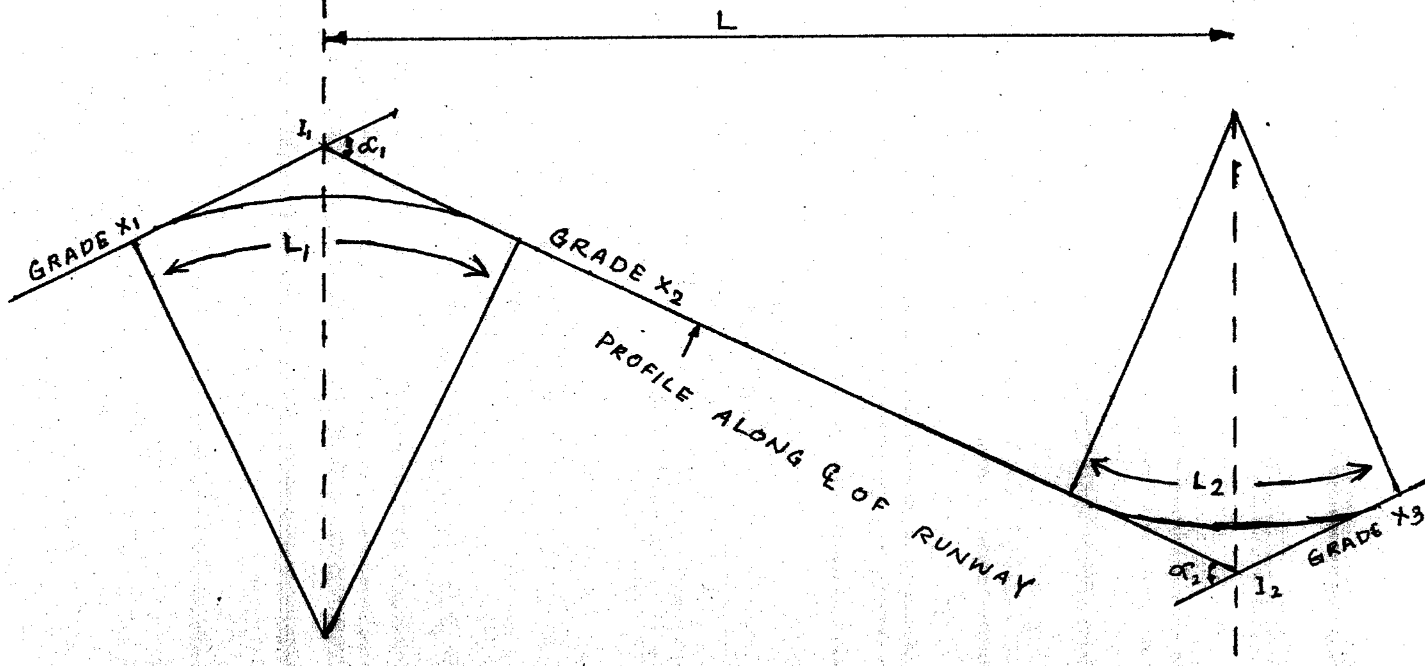


FIG 4·3 LONGITUDINAL GRADE AND GRADE CHANGE.

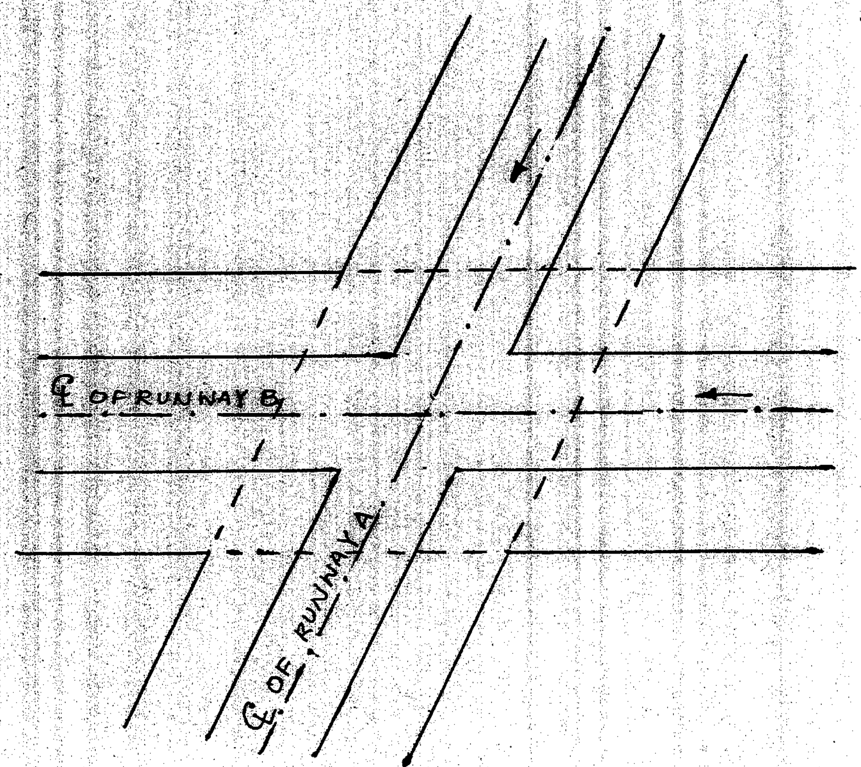
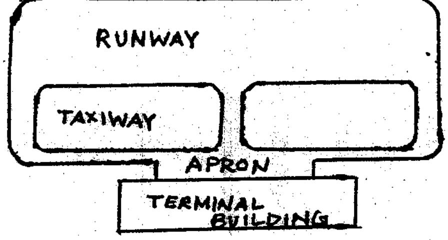
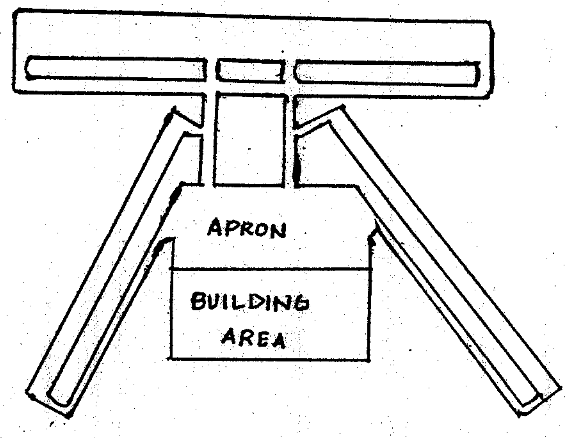


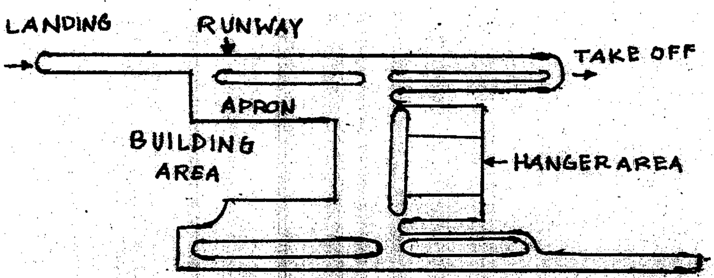
FIG 4·4 RUNWAY INTERSECTION.



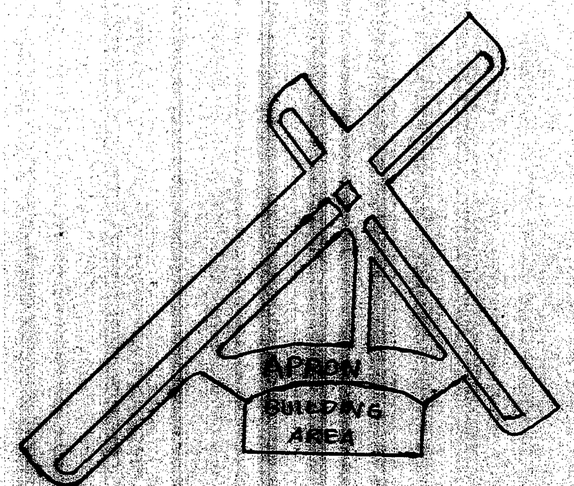
A SINGLE RUNWAY



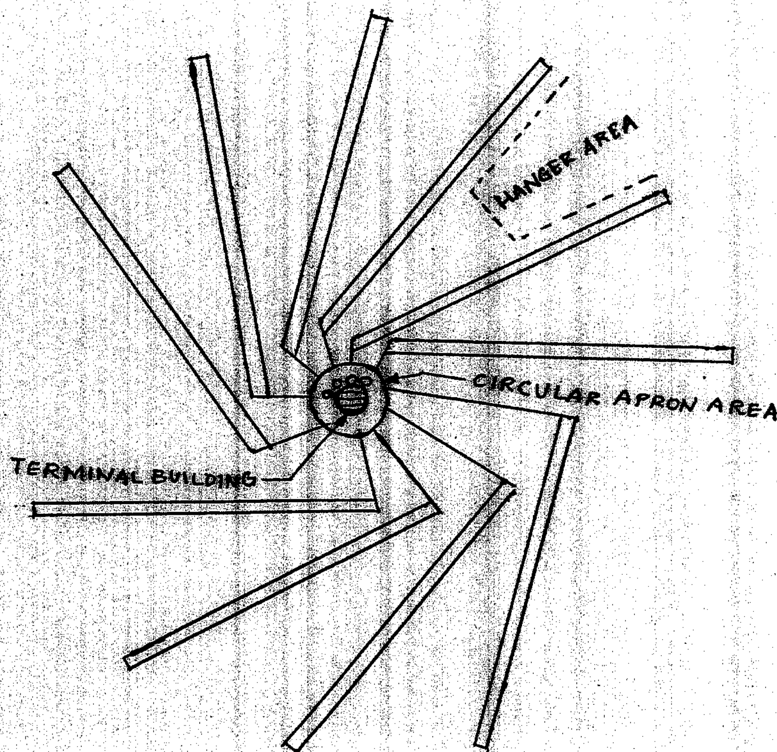
THREE RUNWAY AIRPORT LAYOUT



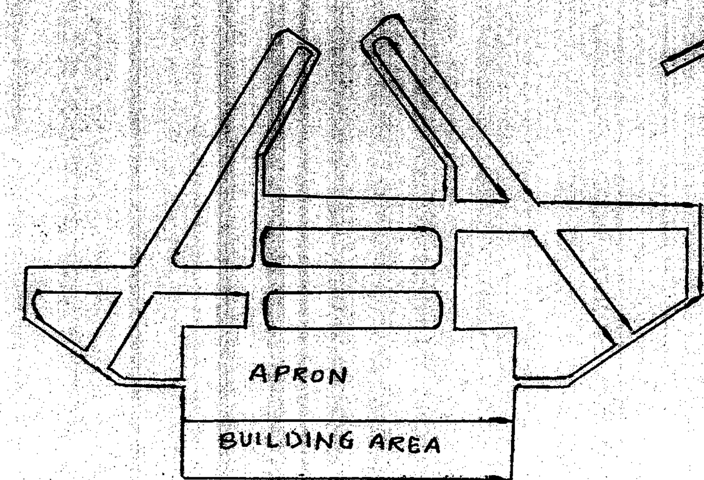
DUAL OFFSET RUNWAY



TWO RUNWAY AIRPORTS LAYOUT WITH INTERSECTING RUNWAYS



30° TANGENTIAL PATTERNS



AIRPORT LAYOUT WITH TWO SINGLE RUNWAYS

FIG. 4.5. RUNWAY PATTERNS

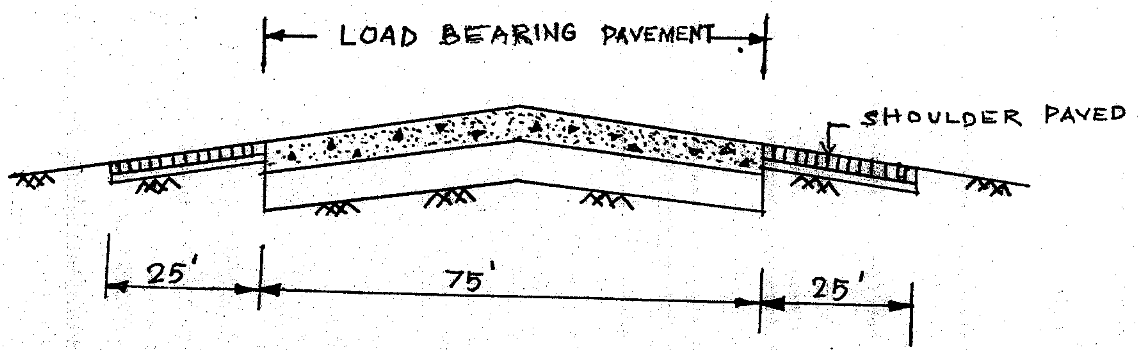


FIG 4·6 TAXIWAY CROSS SECTION

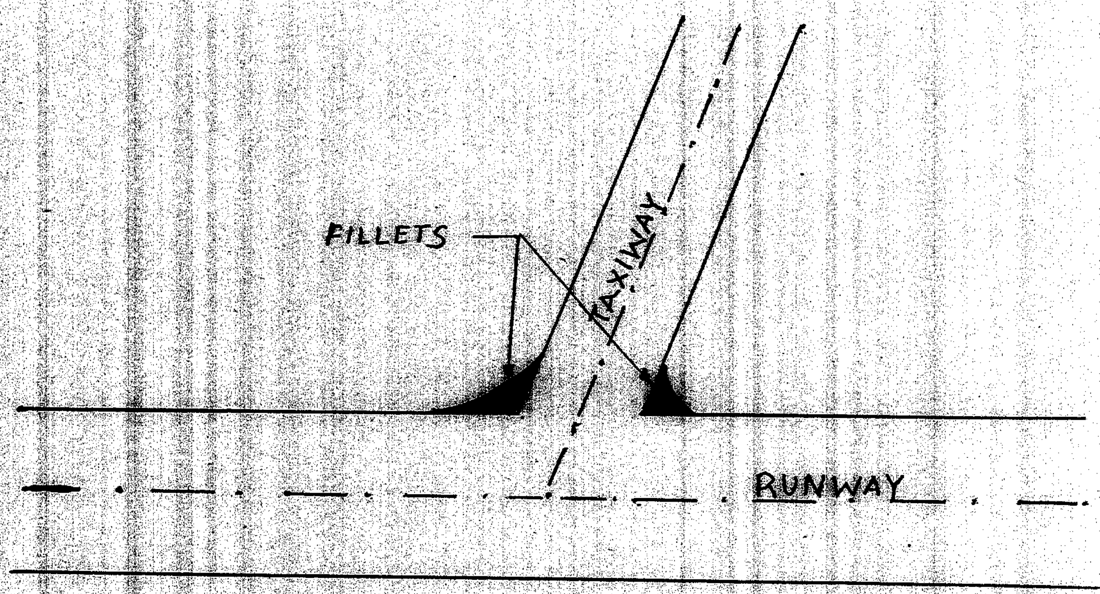
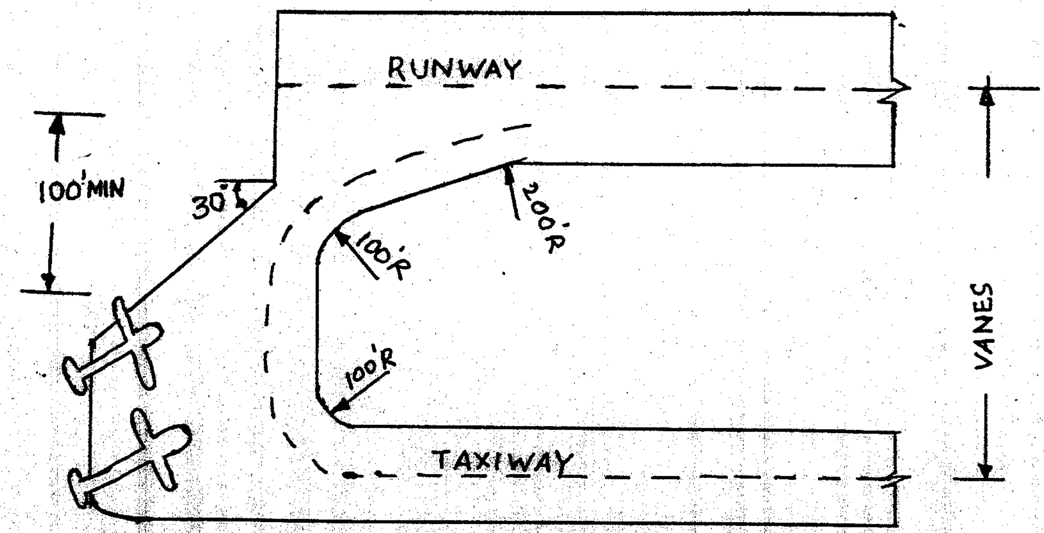
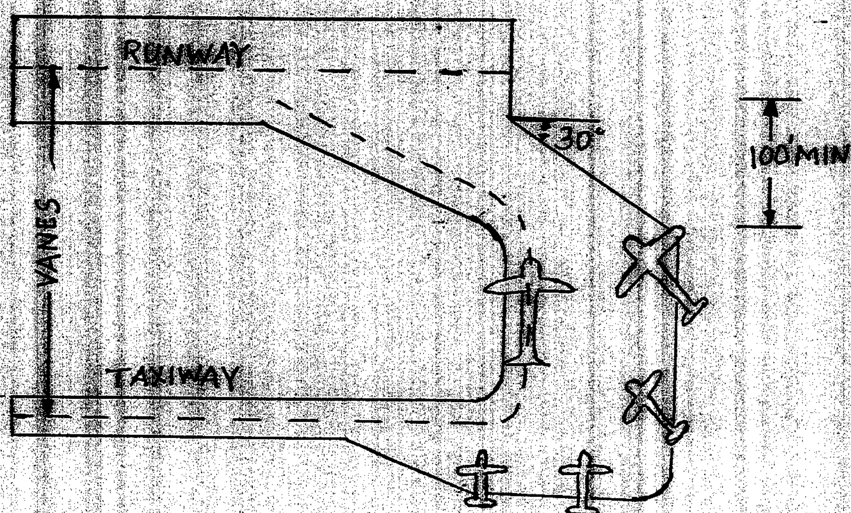


FIG 4·7 TAXIWAY INTERSECTION



HOLDING APRON FOR TWO LARGE AIRCRAFT



HOLDING APRON FOR FOUR LARGE AIRCRAFT

FIG. 4.8. HOLDING APRON

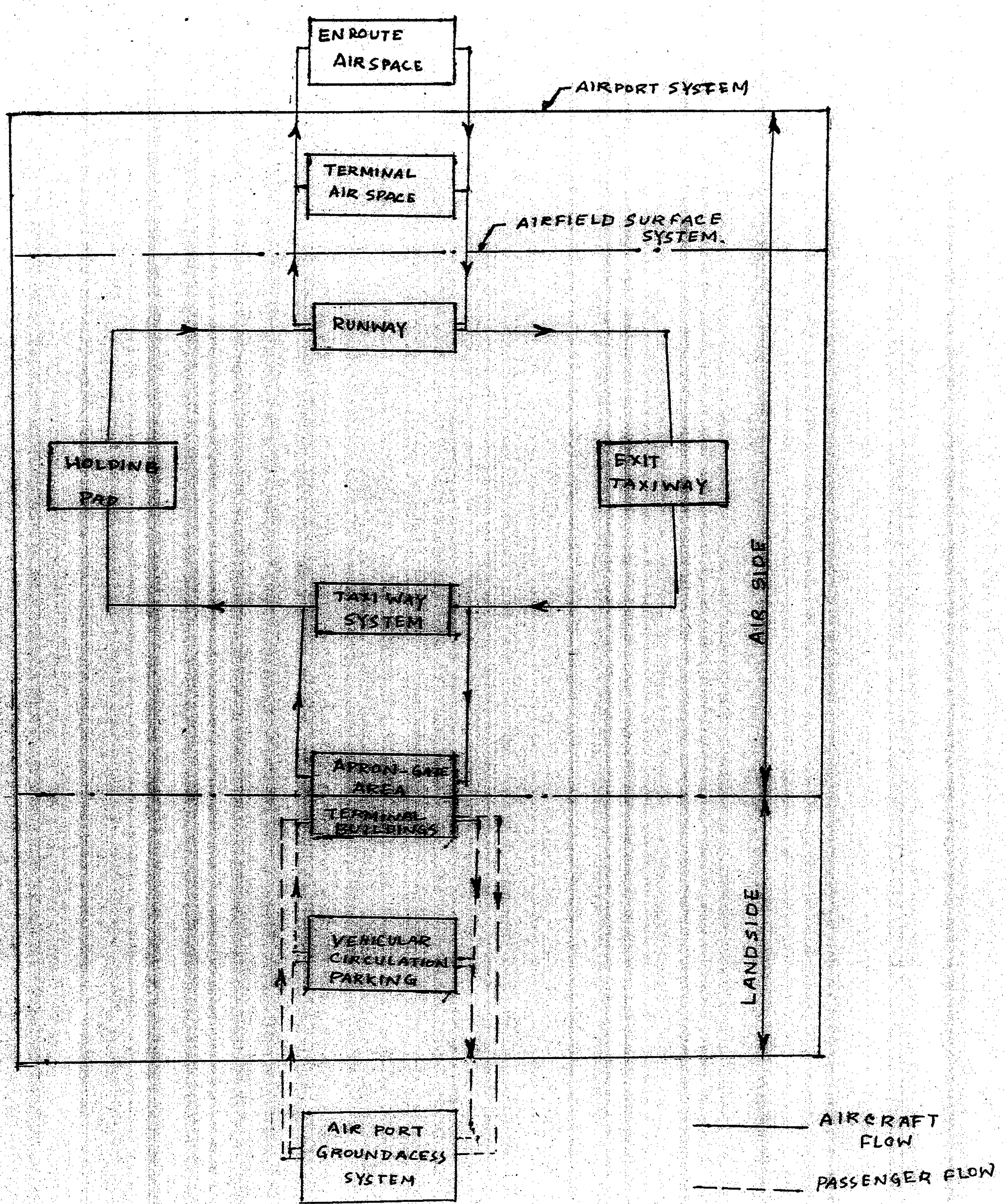


FIG 5.1 COMPONENTS OF AIRPORT SYSTEM.

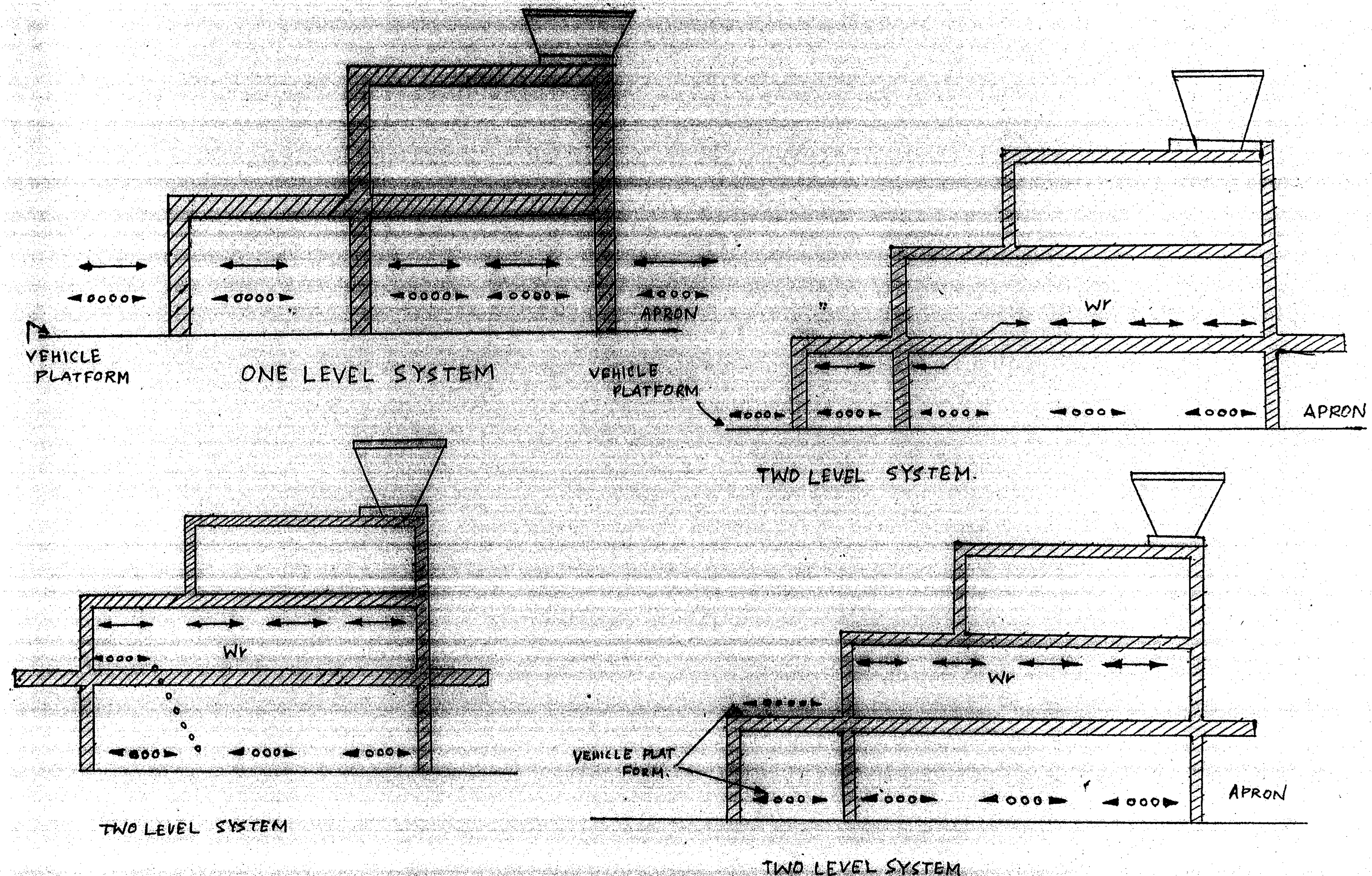


FIG. 5.2. LEVELS OF OPERATION.

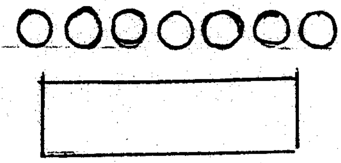


FIG. 5.4. FRONTAL SYSTEM

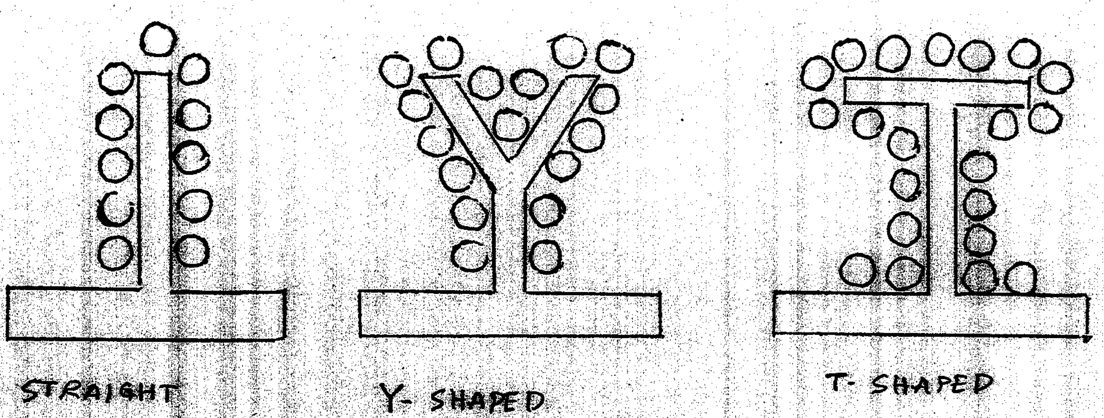


FIG. 5.6. FINGER SYSTEM

FIG. 5.5. OPEN APRON SYSTEM

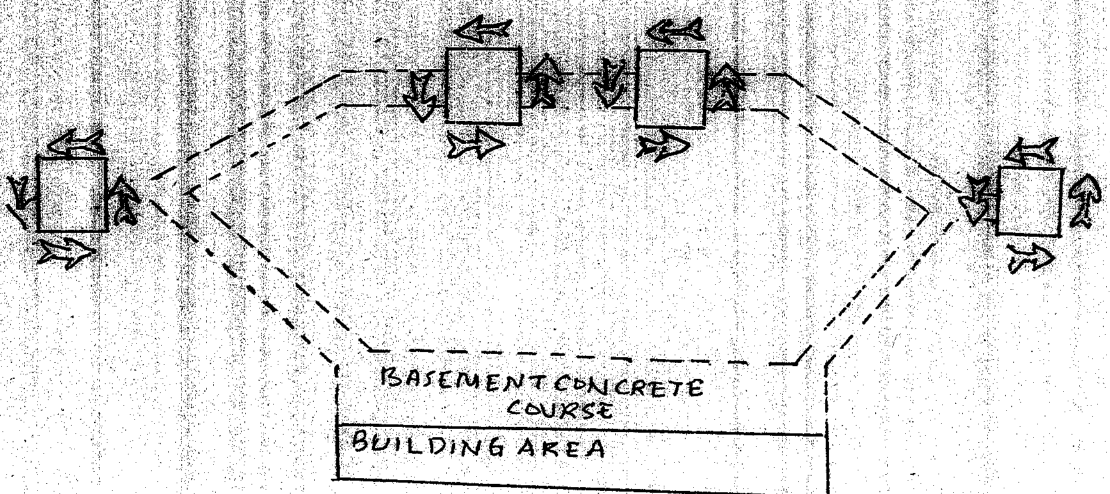


FIG. 5.7. SATELLITE SYSTEM

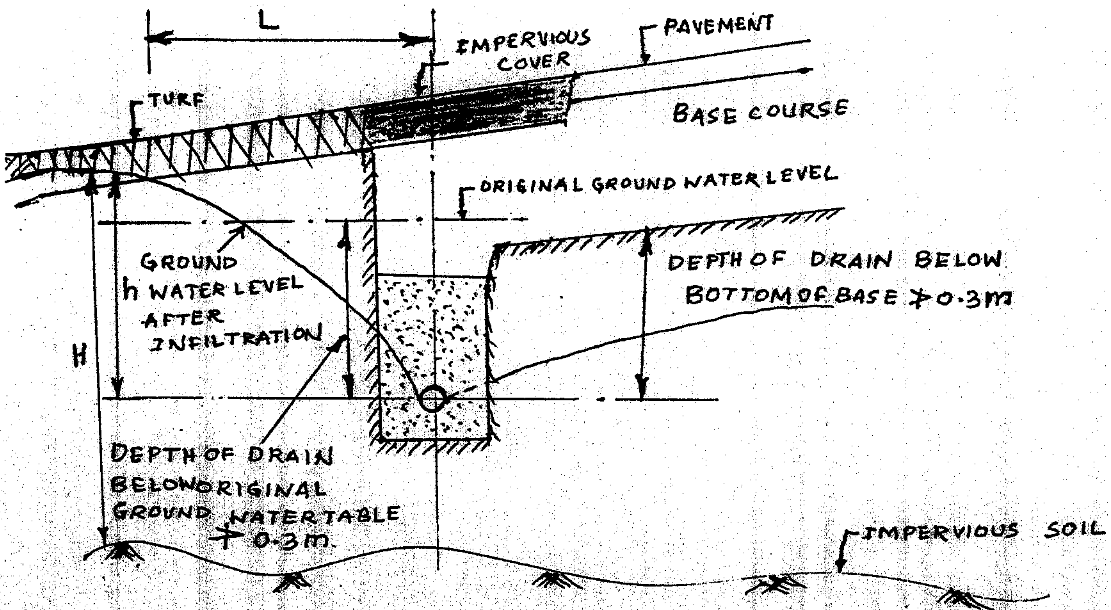
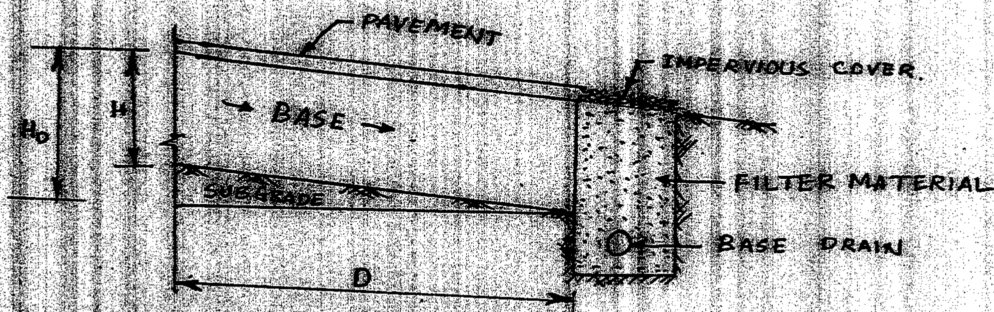


FIG. 7.1. SUBGRADE DRAINAGE



HALF SECTION OF PAVEMENT

FIG. 7.2 BASE COURSE DRAINAGE.

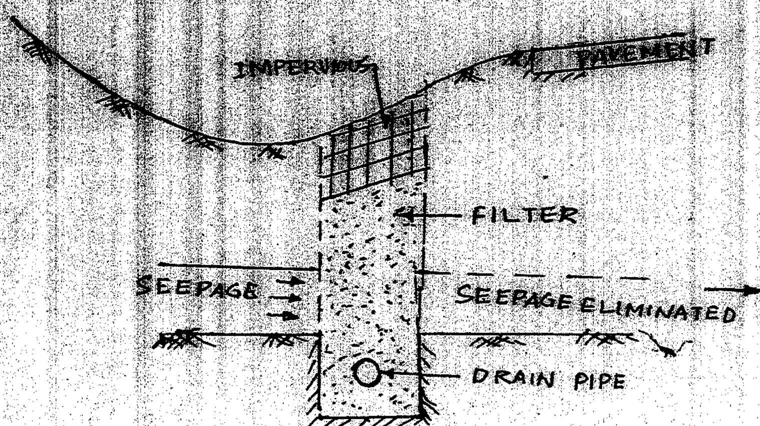


FIG. 7.3. INTERCEPTING DRAIN

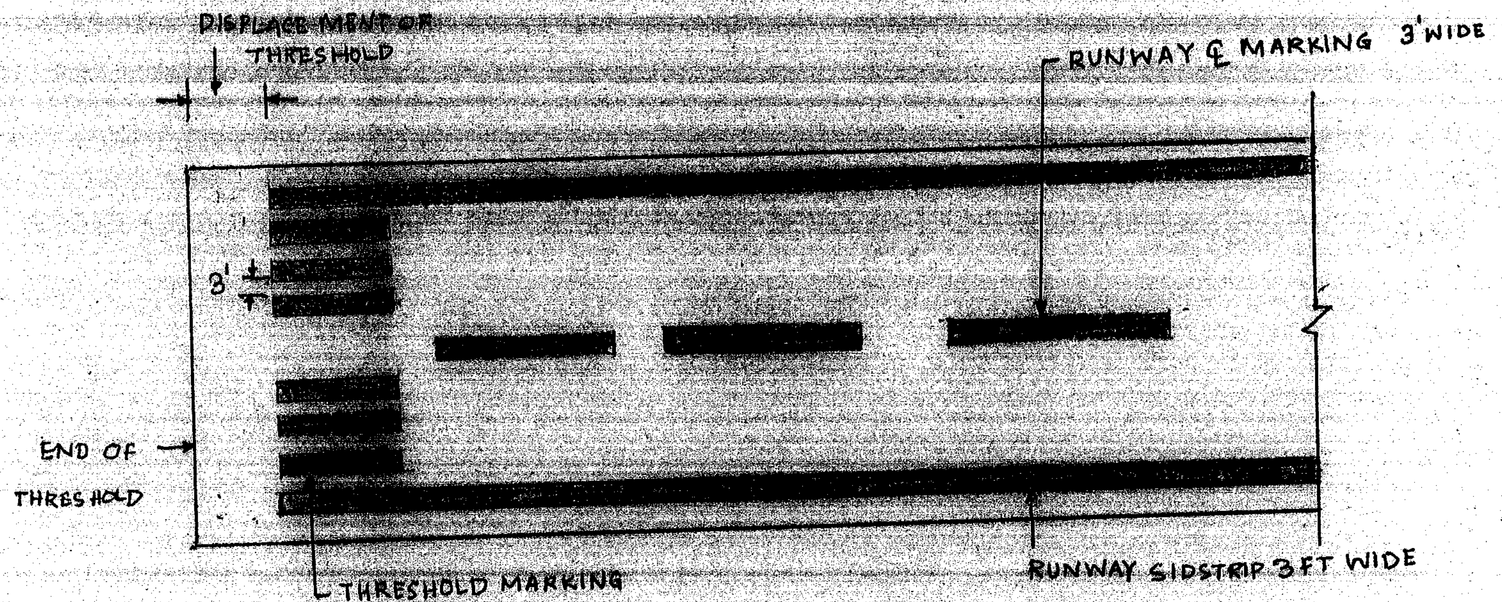


FIG 8.1. RUNWAY MARKING

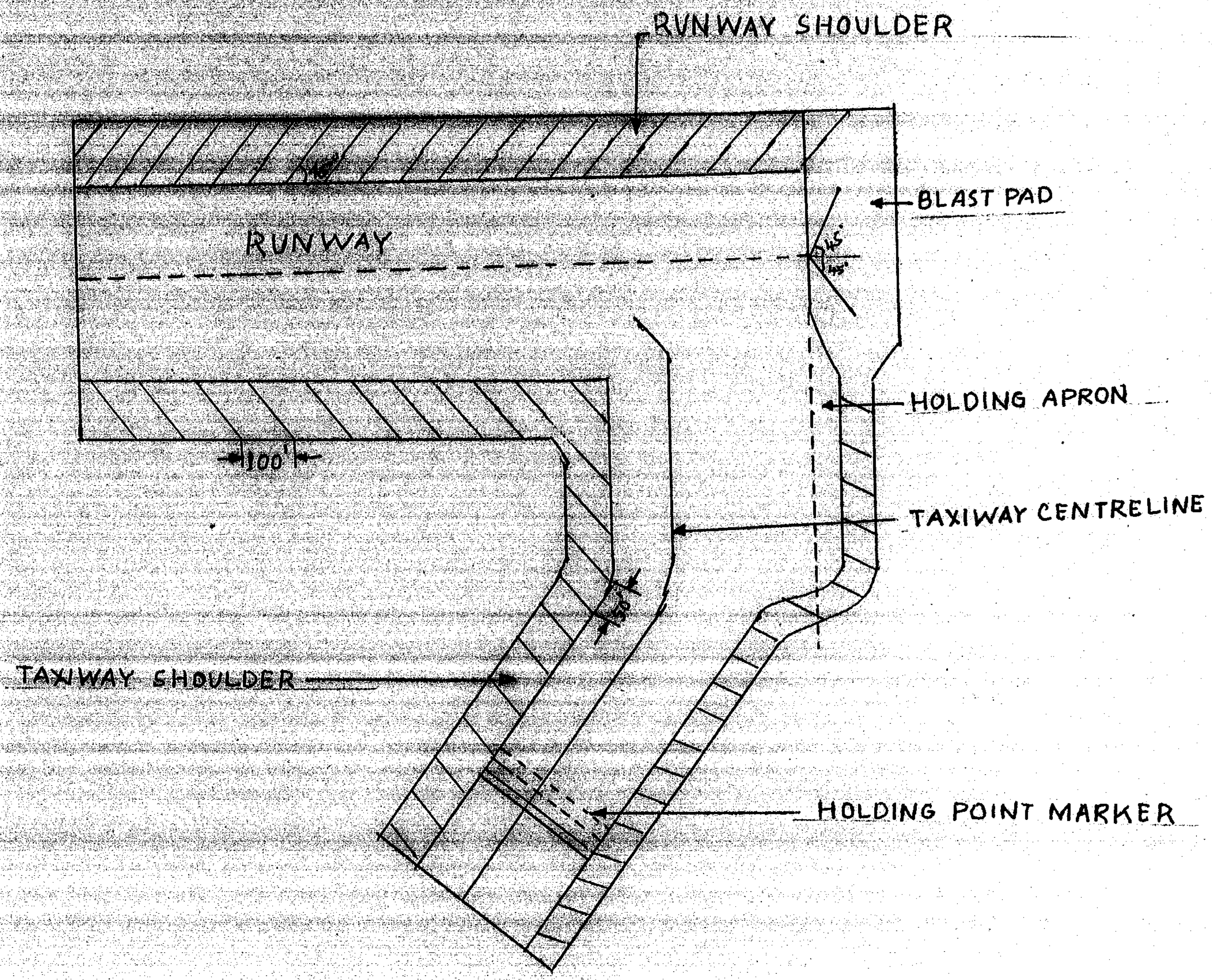


FIG. 8.2. _ TAXIWAY MARKING

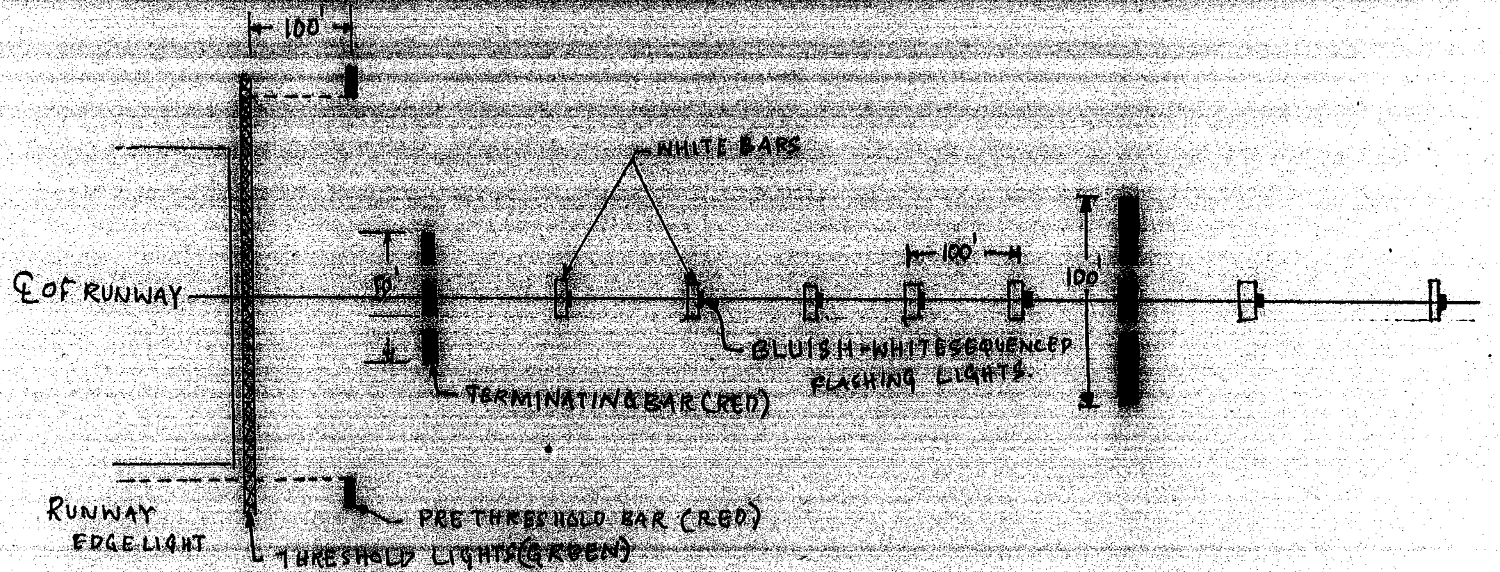


FIG. 8.3. SYSTEM OF APPROACH LIGHTING.

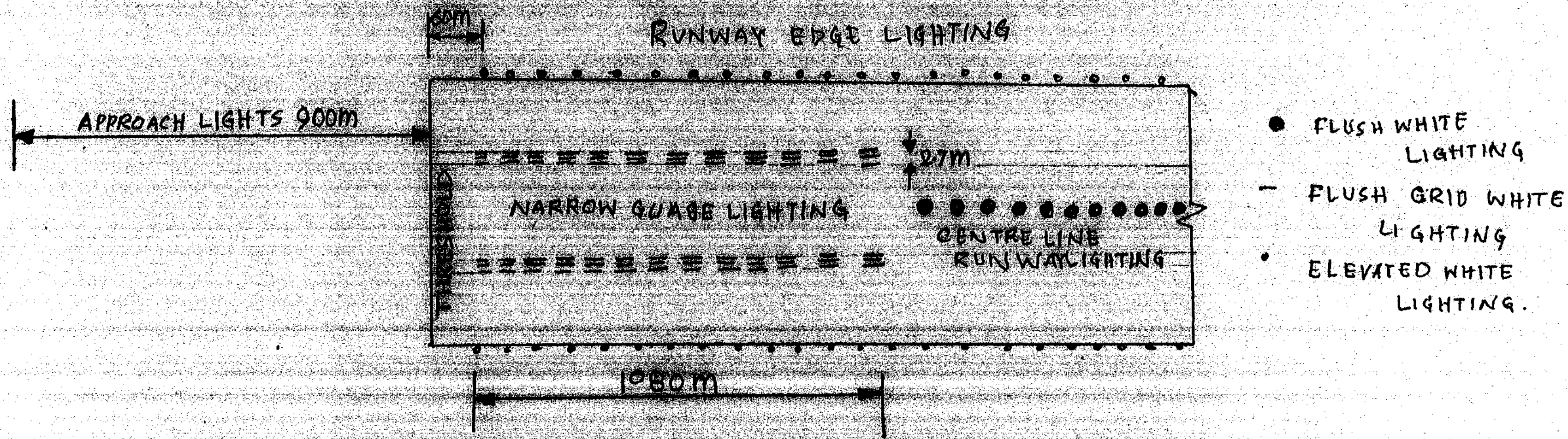
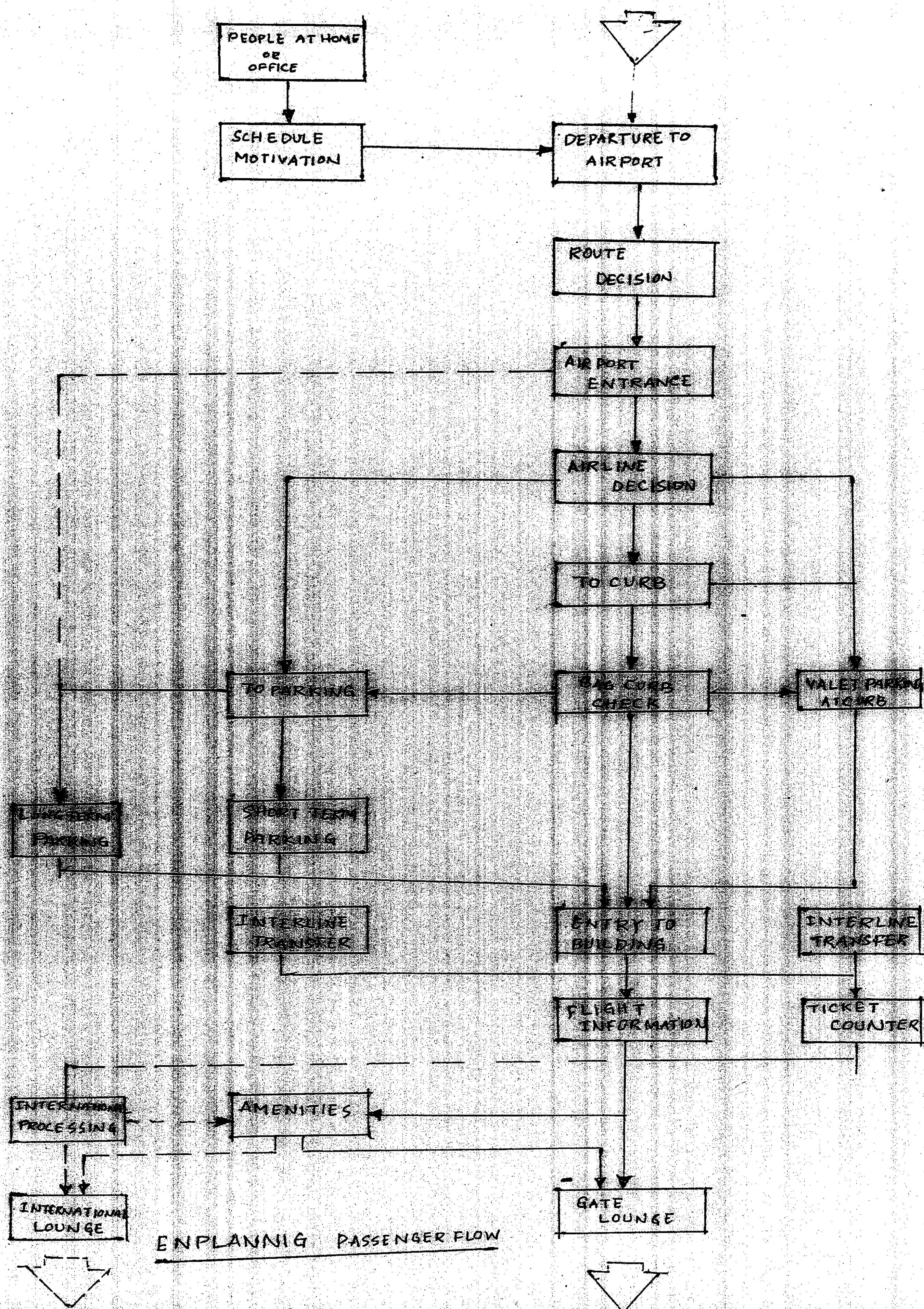
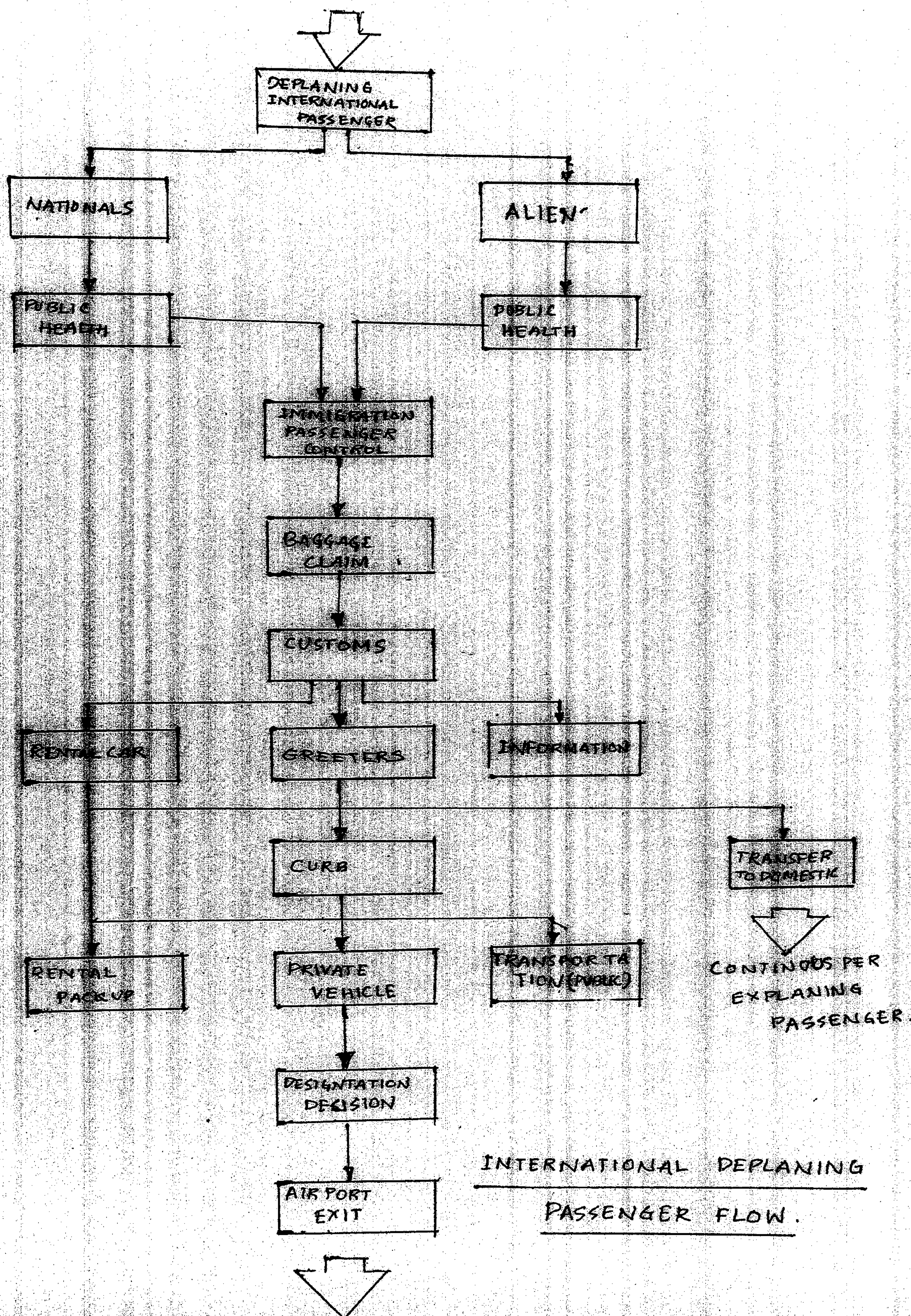


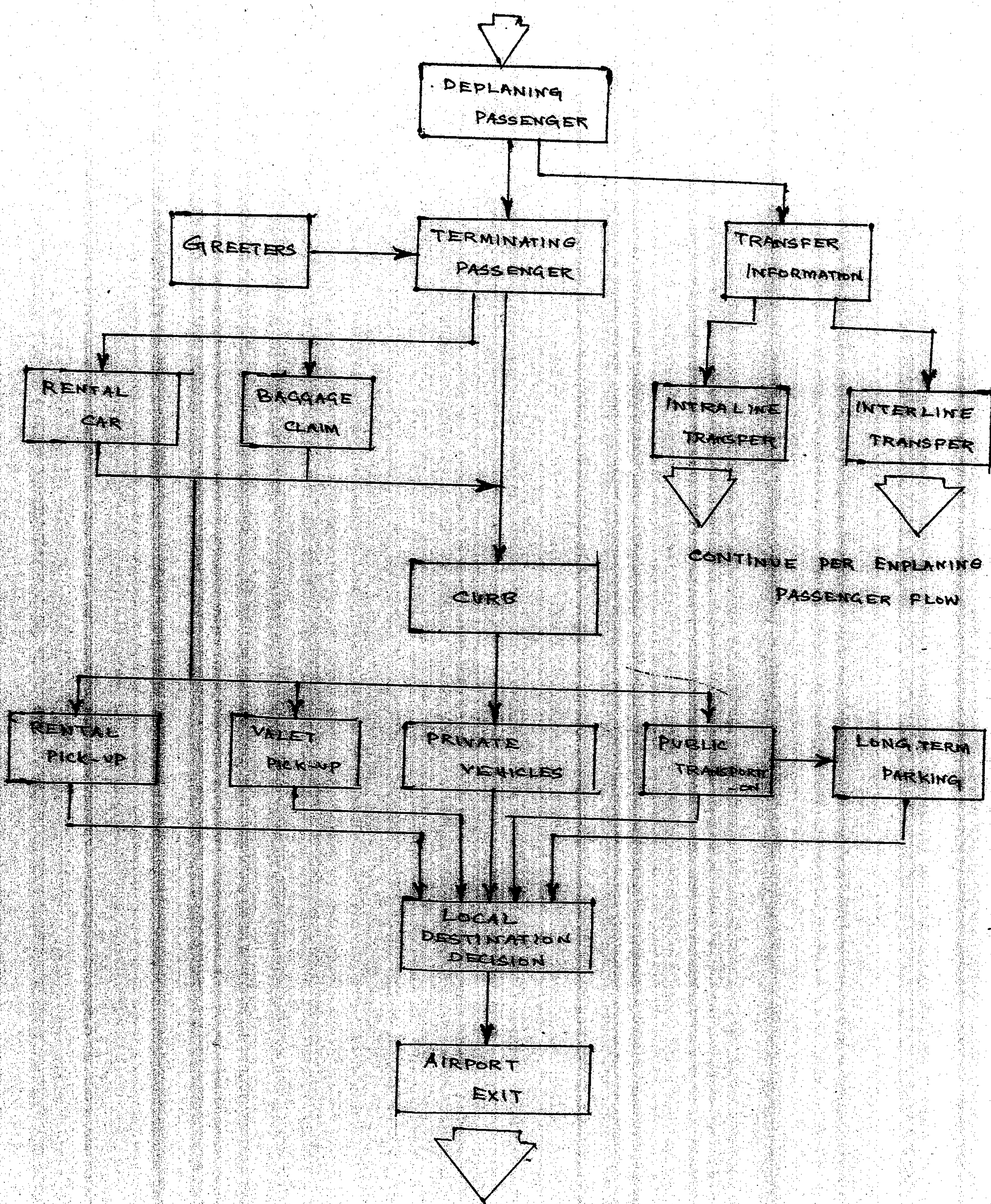
FIG. 8.4. NARROW GUAGE PATTERN RUNWAY LIGHTING.



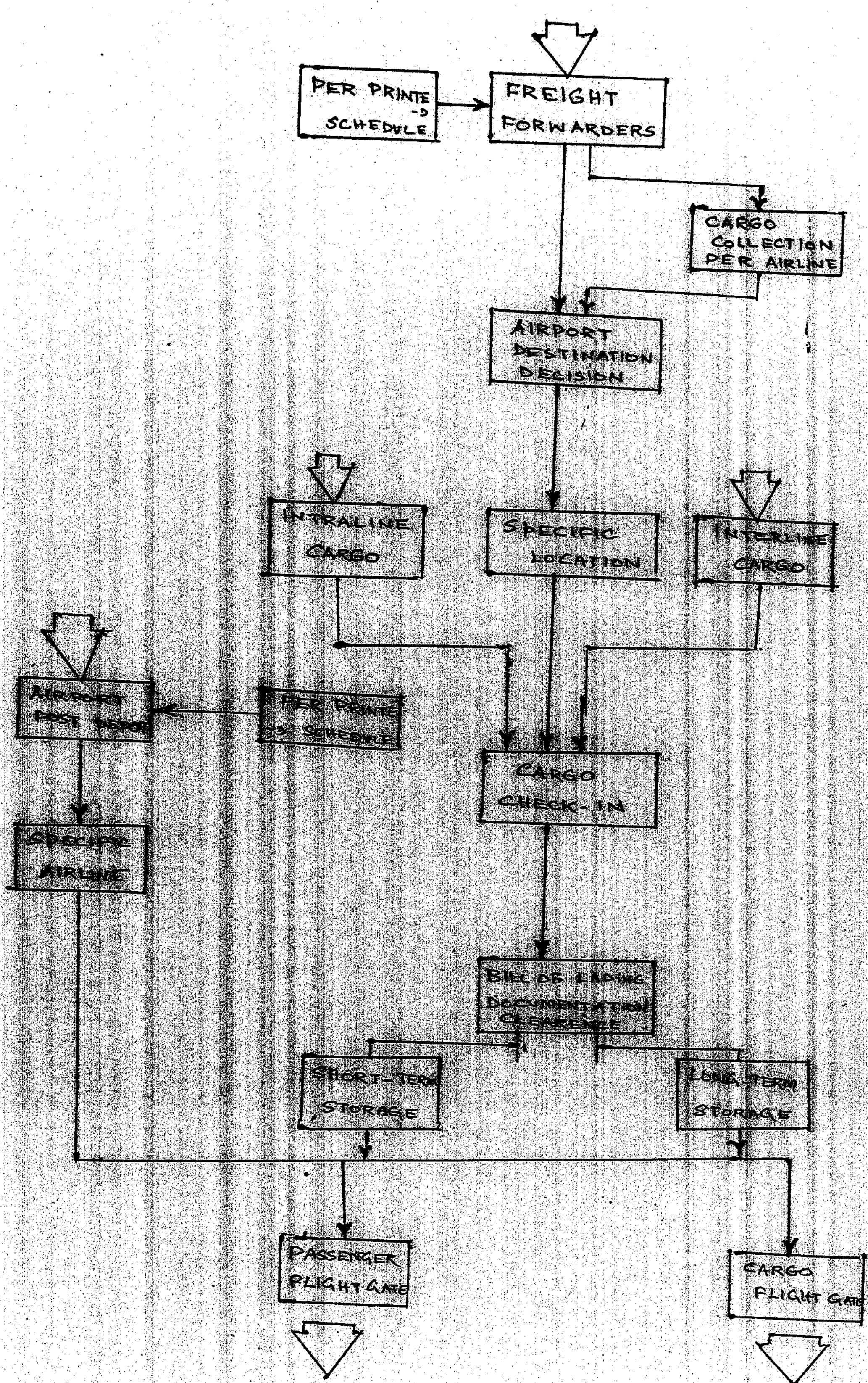
ENPLANNIG PASSENGER FLOW



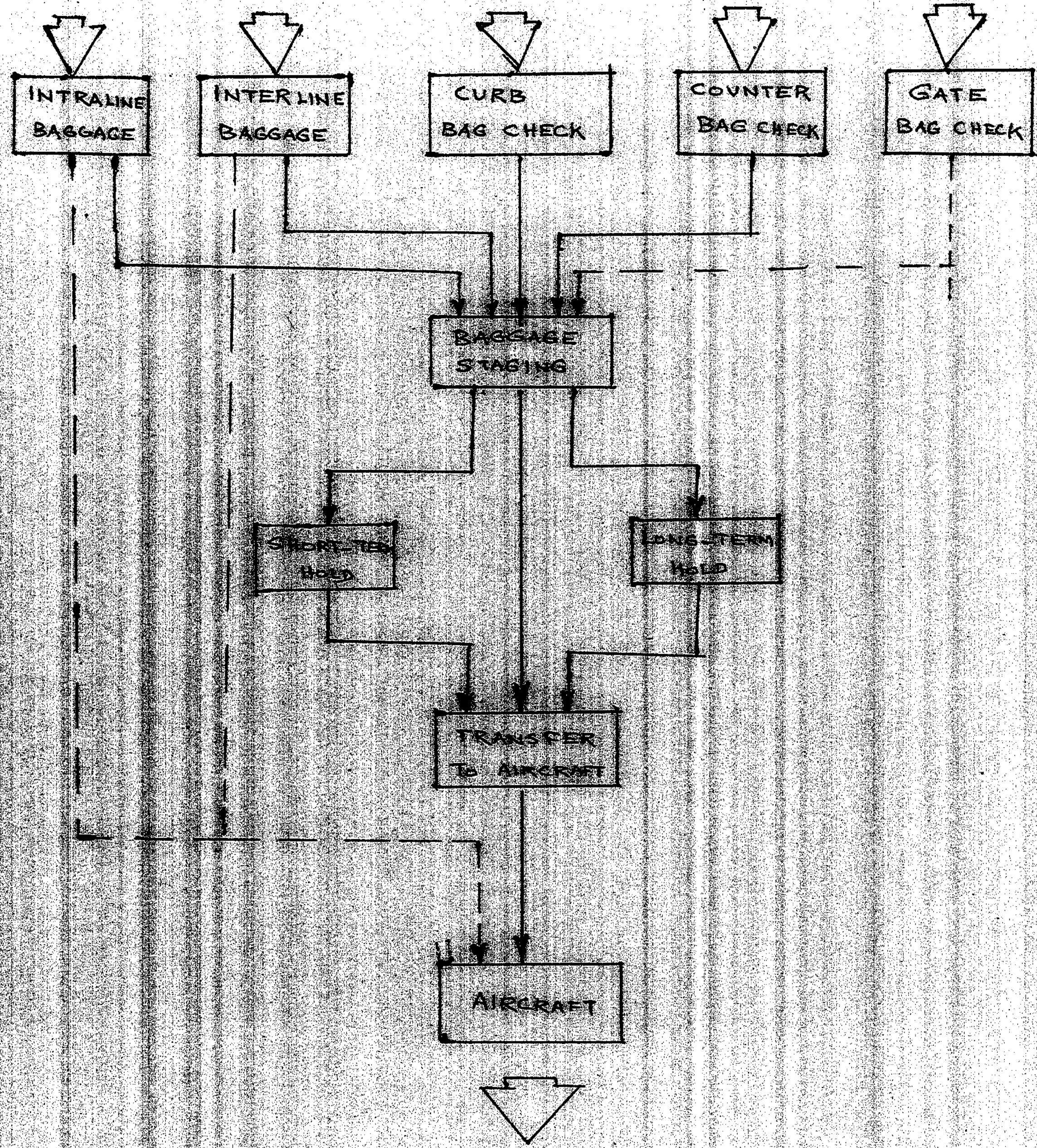
INTERNATIONAL DEPLANING PASSENGER FLOW.



DOMESTIC DEPLANING PASSENGER FLOW



ENPLANING CARGO



ENPLANING BAGGAGE