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SAFETY REGULATION

Flight Engineering Report No. 14

APPLICATION OF TRANSPORT CATEGORY OPERATING RULES

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U S DEPARTMENT OF COMMERCE
CIVIL AERONAUTICS ADMINISTRATION
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UNITED STATES DEPARTMENT OF COMMERCE

Jesse H Jones, Secretary

CIVIL AERONAUTICS ADMINISTRATION

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INFORMATION AND STATISTICS

PREFACE

The Civil Air Regulations establishing the Transport Category were adopted by the Civil Aeronautics Authority May 28, 1940 as Amendment Number 56 thereto, to become effective July 1, 1940. Although these regulations have been the subject of a considerable revision which became effective July 1, 1942, they have from the beginning contained a set of operating rules applicable to any transport category airplane when used in scheduled operation carrying passengers. Due primarily to the outbreak of the war, the application of these operating rules with a single exception involving the operation of a flying boat over water, has been postponed with the result that almost no experience with their application has been obtained. Because of this, and in anticipation of the general application of these rules in the foreseeable future, a study has been undertaken to determine the nature of the problems involved in that application. The results of the study are presented in this report. The report is addressed primarily to the Engineering Staff of Air Carrier Operators as an outline of methods which may be employed by them for the purpose of determining the status of their operation in respect of compliance with the operating rules.

Any questions relating to the contents of this report should be addressed to Flight Engineering and Factory Inspection Division, however, any question relating to the actual operating on a schedule route or interpretation of the operating rules should be referred to the appropriate representatives of Air Carrier Division.

The study has been aided by many helpful suggestions offered by the personnel of that Division. With assistance from Wallace M. Frei, Lyle C. Bjorn, and Carolyne S. Pyle, the report has been prepared by Omer Welling, Chief, Flight Analysis Section.

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INTRODUCTION

The transport category operating rules are defined by CAR 61.712 and succeeding sections of the Civil Air Regulations. The purpose of these rules is to provide an approximately uniform level of safety throughout the operations governed by them. The Regulations attempt to accomplish this by specifying certain minimum rates of climb which must exist at any altitude at which the operation is undertaken and a relation between the dimensions of the flight path, when these are determined under certain specified conditions, and the dimensions of the route. For the purposes of this report the two perhaps most important characteristics of these rules are the following:

1. The impact of all of the rules upon the actual operation is to impose a series of limitations upon the take-off weight. That is; with the sole exception that upon arrival at an intended destination and, due to the direction and velocity of the wind, it being found impossible to land, the airplane must proceed to an alternate, which has been designated in the flight plan; compliance with all of the operating rules must be considered before the airplane takes off. It is believed that a study of the text of CAR 61.712 will explain why this is true.

2. Insofar as analysis of a route to be flown is concerned, the unit of operation which must be considered, is a trip. This is actually a corollary of the characteristic identified immediately above and is due to just the necessity to consider all of the operating limitations prior to take-off. It will be seen in the succeeding portions of this report that there will be for any airport of take-off a maximum take-off weight which cannot be exceeded. For any actual trip, however, the maximum permissible take-off weight may be lower than this because the enroute limitations or the landing limitations may dictate a lower take-off weight for that particular trip.

The process of applying the operating rules to a given route and airplane requires assembling certain basic information concerning the route, its airports, the airplane, and the weather; conducting an analysis of this information for the purpose of determining the maximum take-off weight permitted by the rules for each airport of take-off and for each trip dispatched from that airport; and finally the establishing of certain dispatching rules which will set these maximum permissible take-off weights and the conditions determining them.

It is the purpose of this report, by means of discussion and an example of their application to an actual airplane which has been the subject of a great deal of operating experience, and to a route over which this airplane has been flown in scheduled operation, to illustrate so far as possible by this means the following concerning the transport category operating rules:

1. The nature of the rules themselves.

2. The type, extent, and possible source of the basic information which is required in order that they be applied.

3. The various problems involved in and the process by means of which this information is applied to an analysis of a route, its airports, and the airplane to be operated over it to determine the conditions under which the operation must take place.

4. Possible forms in which to present the analysis identified above for the purpose of showing the proposed operation to be in compliance with these operating rules.

5. The nature and extent of the information required for the process of dispatching under these rules.

6. The possible gain in the weight of the airplane which is permitted under these rules resulting from taking advantage of certain refinements which the rules themselves permit. The principal one of these so permitted is an allowance that 50% of any head wind component may be considered in determining the maximum take-off weight upon a runway of given length.

For the purposes of this report the route from Chicago, Illinois to Salt Lake City, Utah has been selected, primarily because it contains terrain and airports of altitudes such as very nearly to cover the extreme ranges of altitude to be encountered any-where within the continental limits of the United States. The route selected follows the civil airways between the points designated and is the most direct such route. It will be noted that this is a route over which scheduled operation has been maintained for a number of years and over which the airplane, which has also been selected for the purposes of this report (see below) has been regularly operated.

The Douglas DC-3 S1C3G airplane has been selected not only because it is the airplane actually operated over the route selected, but also because the necessary airplane information is available (see reference a). It is desired to point out that this airplane has not been designed to comply with the transport category requirements, is not at present operated under the transport category operating rules, and is not now authorized to operate at some of the weights dealt with in this report. It happens, however, that the application of the performance requirements of the category, which are the only such requirements involved in the problem dealt with in this report, permits the operation of the airplane at weights very closely approximating those at which its scheduled operation has been authorized. The fact, therefore, that it is not a transport category airplane in no way detracts from its usefulness for the purposes of the report.

As used in this report, the word "trip" refers to an individual flight from a station to the first intended destination or, if no landing is made there, to one of the alternates. It does not refer to a through flight involving intermediate stops. In other words a through flight involving intermediate stops is composed of a number of "trips" one greater than the number of intermediate stops.

BASIC INFORMATION REQUIRED

This section of the report identifies and discusses the necessary basic information concerning the route, its airports, the airplane, and the weather to which reference has been made above.

ROUTE

The basic information concerning the route which is required for this purpose is essentially the topography of the terrain included within the limits of the civil airway which the route follows. The airway is by definition ten miles wide and ordinarily consists of a series of straight courses joined at abrupt angles occurring at radio range stations or at the intersection of two legs of the radio range emanating from two different stations. The most convenient source which has been found for this information is the Sectional Aeronautical Charts published by the United States Coast and Geodetic Survey, Department of Commerce, which are for sale at a price of 25¢ per chart.

As has been stated under INTRODUCTION, the route selected for this study is that extending along green civil airway number 3 from Chicago, Illinois to the Fort Bridger, Wyoming radio range station about 70 miles west of Rock Springs, Wyoming, and thence along red airway number 1 to Salt Lake City, Utah. The terrain traversed by this route appears in the following Sectional Aeronautical Charts:

U-3. . . . . . . Salt Lake City

U-4. . . . . . . Cheyenne

U-5. . . . . . . Lincoln

U-6. . . . . . Des Moines

U-7. . . . . . . Chicago

The most convenient form in which to present the information for these purposes appears to be a composite profile along the center line of the airway showing, for any point along the center line, the altitude of the highest point of terrain at any point within the width of the airway. This may be done by measuring along the airway on the Aeronautical Charts the distance from some arbitrarily chosen station to the intersection of successive contours with the center line or boundary of the airway and plotting these points to a suitable scale of distance and elevation. This has been done for the route considered in this report and appears in Figure 1. During this process no situation was encountered at any point along the route which permits advantage to be taken of the provision contained in CAR 61.7125 that a comparatively isolated region of comparatively high terrain extending for not more than twenty miles along the airway may be omitted from consideration within the airway if it extend into the airway less than five miles. In view of the fact that the terrain covered by this route involves some of the most rugged to be found anywhere within the United States, it is suggested that this provision may be found usable in only a few isolated cases.

AIRPORT

The required basic information concerning an airport is perhaps best illustrated by means of Figure 2 which presents this information for the airport at Cheyenne, Wyoming. It may be noted that this Figure is actually a composite chart involving five separate but related diagrams. These will be discussed in order.

a. Plan

This diagram is merely a plan (to scale) of the runways. Its basic purpose is to indicate their length and their angular relation one to the other. It may also be used to indicate the outline of the landing approach areas, where these exist or are of significance, as well as to indicate the course of any take-off flight path which, in order to avoid obstacles, departs from the runway center line extended. The altitude of the airport, which is also necessary, is stated in this plan. The most convenient source for this information which we have found is the instrument approach charts also prepared and published by the United States Coast and Geodetic Survey.

b. Profiles along center line of runways.

The purpose of this diagram is basically, to indicate the effective landing length as defined by CAR 61.7124, as well as to provide a composite profile which may be compared with the take-off flight path for the airplane at various weights in order to determine the maximum weight permitted by the take-off requirements of CAR 61.7122. The principal source of this information has also been the instrument approach charts, mentioned above supplemented by the quadrangle sheets published by the Geological Survey, Department of Interior, covering the area in the neighborhood of the airport.

c. Wind velocity producing unit cross component on all runways.

This is a working diagram the purpose of which will appear hereafter. It is merely a diagram indicating for each of the runways the wind velocity which, when blowing from a given true compass direction, will produce a unit cross component on that runway. Mathematically it is a plot cosecant δ vs. δ where δ is the angle between the wind direction and the center line of the runway.

d. Axial component on all runways produced by unit wind velocity.

This is also a working diagram and is simply a plot of cosine δ vs. δ .

e. Axial component on each of other runways produced by a wind creating unit cross component on the main runway.

The basic purpose of this diagram is to indicate the axial component upon each of the other runways when the wind is in such direction and of such velocity as to make operation upon the otherwise most suitable (usually longest or instrument approach) runway impossible. The diagram

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has been prepared by multiplying, for each value of wind direction, the value read from diagram c. above by the value read from diagram d, for each of the other runways, at the same wind direction. It may be noted that this diagram as well as c. and d. above are all based upon a unit cross component of wind velocity.

They are also based upon the tacit assumption that flight operations will take place upon the most suitable runway of any airport used so long as wind conditions do not make this impossible. This predicates a critical cross wind component for any airplane to be operated in the airport. Since, however, this basic information is equally useful no matter what airplane may be considered, and the critical cross wind component may differ from airplane to airplane, in order to make it equally applicable to any airplane it is necessary that it be based upon unit values.

It is believed that this airport diagram contains all of the basic information concerning an airport which is required. It may be noted that any appreciable grade in the runway surface may be represented upon this diagram in the profiles. Information such as is contained in the diagram must be assembled for each airport, whether scheduled destination or possible alternate, which the operator desires authorization to use.

AIRPLANE

The required basic information concerning the airplane is the magnitude of certain items of performance which are identified and discussed hereunder. Normally, most or all of this performance information will be contained in the airplane operating manual required by CAR 04.755-T to be furnished with the airplane or may be derived therefrom. The source of the information contained in this report has been reference (a). The items of performance involved are:

1. The maximum take-off weight permitted by the regulations for the altitude of take-off. This information appears in Figure 3 herein as a plot of take-off weight versus altitude and has been taken directly from Figure 5 of reference (a). It should be noted that this maximum take-off weight is independent of the dimensions of the airport.

2. The accelerate-stop distance at various weight and altitudes. This appears in Figure 4 as a plot of the distance against weight at various altitudes and has been taken directly from Figure 14 of reference (a).

3. The take-off flight path at various weights and altitudes. This appears in Figure 5 as a group of flight paths one for each of a series of airplane weights at each of a series of altitudes from sea level to 7,000 feet. This figure has been prepared from the data of Table III of reference (a) and while it is convenient for the purpose of illustrating the general nature of the variation of the take-off flight path, it is not especially convenient for the purposes of the necessary interpolation between the arbitrarily selected increments of weight and altitude which have been used in its preparation. It is also not convenient if the effect of wind, which is permitted by the operating rules, is to be considered

because the nature of the effect of wind upon the distance traversed during each of the elements of flight path is not identical from element to element. For this reason, the same information is also presented in Figure 6 as a series of diagrams, one for each element in the take-off flight path, which shows the distance traversed during and, if any, the height attained by the airplane at the end of the element.

The effect of wind upon these dimensions is confined to the horizontal distance traversed and may be obtained by multiplying each of these distances by an appropriate factor involving the velocity of the axial component of the wind. In the case of the ground run shown in Figure 6a, this factor is $\left(1 - \frac{V_W}{2V}\right)^{1.85}$ where V_W is the actual axial wind velocity component, consideration of the effect of half of which is permitted by the regulations, and V is the airplane true airspeed. Since the airplane airspeed remains a constant indicated airspeed for airplane weights up to 27,000 pounds equal to 96.8 MPH $V = 96.8 \times \sqrt{\rho_o/\rho}$. For greater weights, $V = 96.8 \sqrt{\rho_o/\rho} \sqrt{\frac{W}{27{,}000}}$.

For each of the other elements of the take-off flight path the factor is simply $\left(1 - \frac{V_W}{2V}.\right)$

4. The maximum one engine inoperative operating altitude. This appears in Figure 7 and is a plot of the altitude at which the rate of climb with the enroute configuration of the airplane is $.02 \times V_{s_o}$. This information has been taken directly from Figure 4 of reference (a).

5. The maximum landing weight permitted at the altitude of landing. This appears in Figure 8 as a plot of maximum landing weight against altitude and has been taken from Figure 6 of reference (a). This is also independent of the dimensions of the airport of landing.

6. The landing distance at various weights and altitudes. This appears in Figure 9 as a nomograph of landing distance vs. weight at various altitudes and wind velocities. It has been derived from Figure 7 of reference (a). The wind velocities of the nomograph are the actual velocities of the axial component of the actual wind and the reductions in landing distance indicated are those due to 50% of this axial velocity in accordance with the terms of CAR 61.7123(b). Also, no wind velocity gradient with height has been considered. The nomograph may be entered with an airplane weight, altitude, etc., to obtain a corresponding landing distance or it may be entered with 60% or 70% of an effective landing length, an altitude of landing, and a wind velocity to obtain the maximum permissible landing weight on that runway, landing in that direction.

7. The cruising performance of the airplane. This is necessary in order to estimate the amount of fuel consumed and, therefore, the amount by which the weight of the airplane is reduced upon reaching any point along the route to be flown. The most convenient form for this information would appear to be a diagram showing pounds of fuel per air mile as a function of airplane speed. This appears in

Figure 10 for the airplane considered in this report and has been prepared from unpublished test data in our files.

8. The critical cross wind component beyond which take-off or landing operation become impossible or inadvisable. Reference has been made to this in the discussion of the airport information above. To the best of our knowledge such a critical cross wind component has never been established for the airplane considered in this report. It has been variously estimated from 10 to 20 MPH and is assumed in this report to be 15 MPH.

WEATHER

The minimum of the necessary information concerning the weather appears to be a forecast of weather conditions, including winds aloft, over the route to be flown valid for the period of time to be occupied by the flight under consideration. This is now normally a necessary part of the information which must be available before a trip is dispatched. The significance of the forecast in respect of the subject of this study is that it determines whether or not alternate destinations must be considered in dispatching the flight and if so, whether one or more. Since the landing weight requirements must be met at the intended destination and also at any alternate designated in the flight plan, this may affect the maximum weight which may be taken off for the trip. The forecast also indicates the probable ground speed for a given cruising airspeed and thus the time required to reach any point along the route and, therefore, the amount by which the take-off weight will have been reduced upon arrival at such point.

Although not absolutely necessary, certain climatological data, in particular the wind rose, may be desirable, particularly if it be desired to allow for the effect of wind upon the maximum weight which may be taken off from a particular runway due to its dimensions. Also, although not now permitted to be considered by the regulations, it appears possible that in the future there may be need for the establishment of mean temperatures at each of the airports for certain seasonal periods.

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METHOD OF ANALYSIS

The analysis, involving the above basic information, which is required in the process of applying the operating rules to a route has for its purpose the establishment of the maximum weight permitted by the rules at which the airplane may be dispatched from a given station on a given trip. Aside from the performance of the airplane which is, of course, common to all routes and all trips on which the airplane is flown, the elements which determine this maximum weight are essentially characteristics of the route to be flown. The remainder of this section of the report, therefore, discusses the analysis required by consideration of each of these route characteristics.

ALTITUDE OF TAKE-OFF

The maximum take-off weight which is permitted at the altitude of the take-off airport may be read directly from Figure 3 and, of course, remains the same for any trip dispatched from that airport.

DIMENSIONS OF TAKE-OFF RUNWAY

The regulations require a comparison between the dimensions of the take-off runway and those of two possible take-off flight paths, each based upon the assumption of engine failure during the take-off. These are separately considered hereunder.

a. Accelerate-stop distance.

This distance may be read from Figure 4 of this report, and the regulations require that the actual length of the take-off runway equal or exceed this distance. In the event that it be desired to consider the effect of wind upon the maximum weight permitted by the dimensions of the take-off runway, these distances may be corrected for the effect of an axial component of wind along the runway by multiplying the values read from Figure 4 by the factor $\left(1 - \frac{V_W}{2V}\right)^{1.85}$ where V_W is the actual velocity of the axial component and V is the velocity of the airplane, namely, $96.8 \times \sqrt{\rho_o/\rho}$ MPH for airplane weights up to 27,000 pounds and, above that weight, $96.8 \times \sqrt{\rho_o/\rho}\sqrt{\frac{W}{27,000}}$ MPH.

b. Take-off flight path.

The dimensions of the take-off flight path are contained in Figure 5 and those of the various elements in the flight path in Figure 6. The regulations require that the airplane, following this flight path, must have attained a height above the surface of the take-off runway of at least fifty feet before or at the moment of passing the far end of the runway. They also require that, still following this flight path, the airplane clear all obstacles to flight either by a vertical margin of fifty feet or a horizontal margin of three hundred feet without requiring an angle of bank in excess of 15° in order to provide this horizontal clearance. The effect of wind upon the dimensions of the flight path has been discussed under "BASIC INFORMATION REQUIRED" above. In order to determine the maximum

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weight permitted for take-off, it is necessary to compare the dimensions of the flight path at various weights with a profile of each of the runways such as, for example, those contained in Figure 2b, considering the take-off to be made first in one direction, then another. In comparatively simple cases such as are illustrated by Figure 2b, it is usually possible to pick by inspection a single critical point at which the airplane must have a certain height. For example, assuming a take-off made to the west in Figure 2b, it is necessary that the airplane have attained a height of 80 feet at 6,800 feet from the start of the take-off. Referring now to Figure 5, for an altitude of 6,000 feet and a height of 80 feet 6,800 feet from the start of the take-off, the maximum weight, by interpolation, is 24,000 pounds. At an altitude of 7,000 feet the same process indicates a maximum weight of 22,900 pounds. The altitude of this airport is 6,140 feet. Linear interpolation with altitude between the two weights established above gives a maximum take-off weight at the altitude of the airport for a take-off in that particular direction of 23,846 pounds.

This process must be repeated for each direction of take-off which is to be considered. In other cases, a take-off to the southeast for example, there may be some uncertainty whether the critical point be the fifty feet of height which the airplane must have attained 6,800 feet from the start of the take-off, or the ninety feet of height 8,300 feet from the start, and it may therefore, be necessary to try each of these in order to determine which is in fact critical. If it be desired to avoid interpolation over so great a range of weight or altitude as is required by the information contained in Figure 5, a group of flight paths covering more closely spaced increments of airplane weight and applying to the precise altitude of the airport under consideration may be constructed from the data of Figure 6 and the above process carried on with this diagram instead, or these flight paths may be constructed upon transparent paper to the same scale as the airport diagram and superimposed directly upon the appropriate runway profile. If it be desired further to consider the effect of wind upon the maximum take-off weight permitted by this limitation, a number of groups of take-off flight paths at the altitude of the airport, each group representing a separate value of wind velocity, may be constructed from the data of Figure 6 and the above process carried out for each value of the wind considered, thus establishing a relation of the maximum take-off weight permitted for a take-off in that particular direction and the velocity of the wind which it is desired to consider.

ALTITUDE OF ENROUTE TERRAIN

The regulations require that at any point of terrain along the route to be flown the one engine inoperative operating altitude at the weight which the airplane is estimated to have upon reaching that point shall exceed the altitude of the terrain by at least 1,000 feet. The maximum one engine inoperative operating altitude at any weight may be obtained directly from Figure 7. It will ordinarily be possible, by inspection of the profile of the route to be flown, to select one obviously critical point of terrain or several possibly critical points. For example, referring to Figure 1 and considering a trip from Cheyenne, Wyoming to Salt Lake City, Utah, the first possible critical point is that lying 34 miles west of Cheyenne having an altitude of 8,500 feet. It is, however, not certain that the two points, one lying 360 miles west of Cheyenne and having an altitude of 10,200 feet and the other 388 miles west of Cheyenne having an altitude of 10,000 feet, may not be critical. In such case it will probably be necessary to investigate all three of these points. The maximum weight which the airplane may have on reaching these points may be read directly from Figure 7 by entering the diagram at the altitude of the terrain involved plus 1,000 feet and reading the corresponding weight.

In order to determine the maximum take-off weight which this limitation imposes, it is necessary to estimate the weight of fuel which will be consumed from time of take-off to the time of arrival at any one of these points to be considered. The rate of fuel consumption is a function of airspeed, airplane weight, and altitude and, for a given set of values of these, may be read directly from Figure 10. In order to arrive at the weight of fuel consumed it is, therefore, necessary to know the altitude at which the flight is to take place, the true airspeed, and an estimate of the wind velocity component along the intended route from which ground speed may be estimated. The existence of a 10 MPH head wind along the route will increase the air distance which must be flown over the actual ground distance to be travelled by the ratio of the cruising airspeed to the difference between the cruising airspeed and the wind velocity. From an estimate such as this the weight of fuel consumed may be determined and when added to the maximum weight permitted at any point of terrain will give the maximum take-off weight which this limitation permits.

ALTITUDE OF LANDING

The maximum landing weight permitted by the regulations at the altitude of the landing airport may be read directly from Figure 8. The maximum take-off weight permitted by the landing limitation requires an estimate of the weight of fuel consumed in reaching the point of landing which may be made in the same manner as has been discussed immediately above and this latter added to the maximum permissible landing weight.

DIMENSIONS OF LANDING RUNWAY

The regulations require that, at the weight which shall exist upon arrival at the intended destination of a trip, the landing distance shall not exceed 60% of the effective landing length of the runway most suitable for landing in still air, and also that, if the wind direction and velocity at the time of arrival are such as to make the use of that particular runway impossible, the landing distance when corrected for 50% of any axial component of wind velocity upon the runway which it may, therefore, be necessary to use, shall not exceed 60% of the effective length of such runway.

The regulations further require that if the first of these two conditions can be met at the intended destination but not the second, there must be at least one alternate destination specified in the flight plan at which both may be met, except that the landing distance must not at the

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alternate destination exceed 70% of the effective length of any runway used for landing. The landing distance for a given altitude and weight may be read directly from Figure 9. The effective landing lengths are shown on the airport diagram, Figure 2, for example. The simplest analysis complying with the terms of this requirement would be to determine the maximum landing weight permitted by the runway having the shortest effective landing length at the scheduled destination and to limit the weight at which a trip is dispatched to a weight not in excess of this maximum landing weight on the shortest runway plus the weight of fuel estimated to be consumed in making the trip. This procedure may, however, unnecessarily limit the weight at which the trip may be dispatched and there is an alternative procedure which accounts for the minimum axial component of wind velocity which must exist along each of the runways other than that most suitable for landing in calm air when the wind velocity and direction are such as to render the use of this latter runway impossible.

Referring to Figure 2c, for example, and assuming 15 MPH as the critical cross wind component beyond which operation of the DC-3 airplane is assumed to be impossible, it may be seen that any combination of wind velocity (divided by 15) and direction which, when plotted upon this diagram, lies above the curve therein corresponding with the East-West runway, but below the curve corresponding with the Northwest-Southeast runway, permits operation on the Northwest-Southeast runway without the critical cross wind velocity for that runway being exceeded. Considering also, the possibility of operation on the North-South runway, the angular headings of such winds lie between 116° and 158° or between 296° and 338°. Referring now to Figure 2e it may be seen that any wind lying within this range of directions which produces a unit cross component upon the East-West runway will also produce an axial component along the Northwest-Southeast runway varying from 2.65 at 116° to 1.00 at 158°. That is, any combination of wind velocity and direction making it impossible to use the East-West runway for landing but desirable to use the Northwest-Southeast runway will produce an axial component on this latter runway equal to at least 100% of the critical cross wind component or 100% of 15 MPH equals 15.0 MPH and the regulations permit allowing for the effect of 50% of this wind velocity upon the landing distance.

Extending this type of reasoning to the conditions indicating the necessity to use the North-South runway, it will be found that these involve winds having direction lying between 338° and 47° or 158° and 227° and that the axial component along the runway under these conditions will be at least 90% of 15 MPH or 13½ MPH. When allowance is made for the effect of half of this wind velocity upon the landing distance, it will be found that the landing weight which the regulations permit upon the North-South runway has been increased over that established by the simpler analysis outlined above.

It may be noted that this method of analysis presumes an operating procedure at such airports such that the decision to use one or another runway rests solely upon the direction and velocity of the wind and upon a critical cross component of wind velocity for any airplane operated therein. It also presumes the possible existence of wind directions and corresponding velocities such as to render the use of the entire airport impossible. For example, any combination of wind velocity (divided by the critical crosswind velocity) and direction which when plotted upon Figure 2c lies above any of

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the three curves thereon is a combination producing cross components on all available runways in excess of the maximum permissible.

Either of the analyses described above may also be applied to any alternate destination which it has been necessary to consider either because of weather conditions or the inability of the airplane to comply fully with the landing distance limitations discussed herein at the intended destination; and the maximum take-off weight permitted by the regulations involving the dimensions of the landing runways is that resulting from the appropriate maximum landing weight, determined by these analyses, plus the weight of fuel estimated to be consumed in flying from the point of take-off to the destination.

ANALYSIS FORM

Figure 11 is a tabular form which has been designed to serve as a convenient summary of the results of a trip analysis. This table does not provide for consideration of the effect of wind upon the dimensions involved in the take-off, but does provide for the analysis of the effect of wind upon the landing distance which has been suggested immediately above. This is, in part, a reflection of the nature of the regulations themselves, in that they require consideration of wind in determining the landing distance limitations upon the take-off weight, but merely permit its consideration in determining the take-off flight path limitations.

APPLICATION TO ROUTE

As has been indicated in the introduction to this report, the basic operation involved in the application of the operating rules to a route, once the necessary information has been assembled, is to analyze separately each trip which is to become a part of the intended operation. This section of the report is devoted to the application of the method of analysis described in the immediately preceding section to several possible trips along the route considered and to certain discussion of the results obtained. Trip analyses involved have been made by means of the form illustrated by Figure No. 11.

The selection of the particular trips to become the subject of the analyses which follow have been made in order to furnish information concerning the following points:

(1) In order to indicate the effect of the operating rules upon the maximum weight which may be take-off at various stops along a through flight, the following trips have been analyzed.

Chicago to Omaha

Omaha to Cheyenne

Cheyenne to Salt Lake City

(2) In order to illustrate the fact that the maximum weight which may be carried on a single trip over a given route depends upon the direction along the route in which the trip is flown, the trip from Salt Lake City to Cheyenne has been analyzed for comparison with the results of the analysis of the trip from Cheyenne to Salt Lake City.

(3) In order to indicate the effect, if any, of the lengths of trip upon the maximum weight which may be carried, as well as to indicate the nature of the information which must be supplied to the dispatcher at a given station for any trip originating at the station, the following trips have been analyzed.

Cheyenne to Laramie

Cheyenne to Denver

Cheyenne to North Platte

Cheyenne to Rock Springs

(4) In order to investigate the effect of the altitude of the station upon the maximum weights which may be dispatched for various trip lengths the following additional trips have been analyzed:

Omaha to Des Moines

Omaha to North Platte

The trip analyses follow immediately in the order in which the trips have been listed above.

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TRIP ANALYSIS

A. Trip - From: CHICAGO, ILLINOIS , To: OMAHA, NEBRASKA

B. Cruising Conditions:

1. Altitude = 4,000 ft. 2. Indicated Airspeed =165 mph. 3. True Airspeed = 175mph. 4. Forecast (Head) (~~Tail~~) Wind = 15 mph.

C. Maximum Take-Off Weight Permitted by:

1. Altitude of Take-Off = 610 ft., Weight = 26,120lbs.,

2. Dimensions of Take-Off Runway Compared With:

a. Accelerate-Stop Distance:

(1) Runway	N - S	NE - SW	E - W	NW - SE
(2) Weight	29,650	30,000+	28,750	30,000+

b. Take-Off Flight Path:

(1) Take-Off Direction	N	S	NE	SW	E	W	NW	SE
(2) Weight	26,300	23,325	26,170	27,675	23,000	26,200	28,000	25,880

3. Altitude of Enroute Terrain:

a. Ground Miles from Take-Off	80	300	370		
b. Altitude	800	1,080	1,200		
c. Air Miles from Take-Off	88	328	405		
d. Airplane Weight There	29,310	29,270	29,240		
e. Weight of Fuel from Take-Off	286	1,067	1,317		
f. Take-Off Weight	29,600	30,340	30,560		

4. Altitude of Landing:

	Scheduled	Alternate	Alternate
a. Place	OMAHA	DES MOINES	
b. Altitude	977	950	
c. Ground Miles from Take-Off	432	551*	
~~d. Air Miles from Take-Off~~	~~472~~	~~603~~	
e. Airplane Weight There	25,200	25,200	
f. Weight of Fuel from Take-Off	1,533	1,958	
g. Take-Off Weight	26,733	27,158	

5. Dimensions of Landing Runways:

a. Scheduled Destination: Place OMAHA, NEBRASKA

(1) Landing Direction	NW	SE	E	W	NE	SW	N	S
(2) Effective Length	5,427	5,427	5,060	5,060	5,020	5,020	5,090	5,090
(3) Minimum Axial Wind	0	0	12.8	12.8	18.0	18.0	4.5	4.5
(4) Landing Weight	33,200	33,200	34,000	34,000	34,000+	34,000+	32,600	32,600
(5) Take-Off Weight	34,733	34,733	35,533	35,533	35,533+	35,533+	34,133	34,133

b. Alternate Destination: Place DES MOINES

(1) Landing Direction	NE	SW	E	W	NW	SE	N	S
(2) Effective Length	4,500	4,500	3,150	3,150	3,650	3,950	3,000	3,600
(3) Minimum Axial Wind	0	0	15	15	15.0	15.0	15.0	15.0
(4) Landing Weight	32,600	32,600	29,400	29,400	31,200	32,400	27,700	30,900
(5) Take-Off Weight	34,558	34,558	31,358	31,358	33,158	34,358	29,658	32,858

c. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

D. Maximum Take-Off Weight for Trip =23,000 lbs. For Take-Off Any Direction
26,120 lbs. No Take-Off E, S, or SE.

E. Remarks:

* VIA OMAHA

520764

TRIP ANALYSIS

A. Trip - From: OMAHA, NEBRASKA, To: CHEYENNE, WYOMING

B. Cruising Conditions:

1. Altitude = 8,000 ft. 2. Indicated Airspeed =165 mph. 3. True Airspeed =185 mph. 4. Forecast (Head) (~~Tail~~) Wind = 25 mph.

C. Maximum Take-Off Weight Permitted by:

1. Altitude of Take-Off = 977 ft., Weight = 26,080 lbs.,

2. Dimensions of Take-Off Runway Compared With:

a. Accelerate-Stop Distance:

(1) Runway	NW - SE	E - W	NE - SW	N - S
(2) Weight	30,300	29,550	29,350	29,750

b. Take-Off Flight Path:

(1) Take-Off Direction	NW	SE	E	W	NE	SW	N	S
(2) Weight	27,000	27,000	26,500	26,500	26,400	26,400	26,500	26,500

3. Altitude of Enroute Terrain:

a. Ground Miles from Take-Off,	472	507			
b. Altitude	6,200	8,543			
c. Air Miles from Take-Off	546	586			
d. Airplane Weight There	27,800	25,700			
e. Weight of Fuel from Take-Off	2,020	2,170			
f. Take-Off Weight	29,820	27,870			

4. Altitude of Landing:

	Scheduled	Alternate	Alternate
a. Place	CHEYENNE	LARAMIE	NORTH PLATTE
b. Altitude	6,140	7,270	2,800
c. Ground Miles from Take-Off	472	527	689*
d. Air Miles from Take-Off	546	609	807
e. Airplane Weight There	24,250	23,500	25,200
f. Weight of Fuel from Take-Off	2,020	2,280	2,980
g. Take-Off Weight	26,270	25,780	28,180

5. Dimensions of Landing Runways:

a. Scheduled Destination: Place CHEYENNE, WYOMING

(1) Landing Direction	E	W	NW	SE	N	S		
(2) Effective Length	6,300	6,800	6,800	6,350	4,700	4,700		
(3) Minimum Axial Wind	0	0	15.0	15.0	13.5	13.5		
(4) Landing Weight	32,750	32,750	33,000+	33,000+	30,250	30,250		
(5) Take-Off Weight	34,770	34,770	35,000+	35,000+	32,270	32,270		

b. Alternate Destination: Place LARAMIE, WYOMING

(1) Landing Direction	NW	SE	N	S	NE	SW	E	W
(2) Effective Length	6,300	6,300	5,200	5,200	6,300	6,300	5,200	5,200
(3) Minimum Axial Wind	0	0	14	14	15	15	15	15
(4) Landing Weight	33,000+	33,000+	33,000+	33,000+	33,000+	33,000+	33,000+	33,000+
(5) Take-Off Weight	Not Critical							

c. Alternate Destination: Place NORTH PLATTE, NEBRASKA

(1) Landing Direction	NW	SE	N	S	E	W		
(2) Effective Length	6,824	6,624	4,437	4,437	4,600	4,600		
(3) Minimum Axial Wind	0	0	10.5	10.5	11.25	11.25		
(4) Landing Weight	33,000+	33,000+	32,800	32,800	33,000+	33,000+		
(5) Take-Off Weight	Not Critical							

D. Maximum Take-Off Weight for Trip = 26,080 lbs.

E. Remarks:

* VIA CHEYENNE

5-4769

TRIP ANALYSIS

A. Trip - From: CHEYENNE, WYOMING, To: SALT LAKE CITY, UTAH

B. Cruising Conditions:

1. Altitude = 12,000 ft. 2. Indicated Airspeed = 165 mph. 3. True Airspeed = 198 mph. 4. Forecast (Head) (Tail) Wind = 30 mph.

C. Maximum Take-Off Weight Permitted by:

1. Altitude of Take-Off = 6,140 ft., Weight = 24,070 lbs.,

2. Dimensions of Take-Off Runway Compared With:

a. Accelerate-Stop Distance:

(1) Runway	E - W	NW - SE	N - S	
(2) Weight	29,800	29,800	24,000	

b. Take-Off Flight Path:

(1) Take-Off Direction	E	W	NW	SE	N	S		
(2) Weight	25,000	24,000	24,200	24,900	22,700	22,700		

3. Altitude of Enroute Terrain:

a. Ground Miles from Take-Off	34	360	388		
b. Altitude	8,540	10,200	10,050		
c. Air Miles from Take-Off	40	424	457		
d. Airplane Weight There	25,700	24,400	24,500		
e. Weight of Fuel from Take-Off	188	1,982	2,150		
f. Take-Off Weight	25,888	26,382	26,650		

4. Altitude of Landing:

	Scheduled	Alternate	Alternate
a. Place	SALT LAKE	ROCK SPRINGS	
b. Altitude	4,220	6,745	
c. Ground Miles from Take-Off	401	565*	
~~d. Air Miles from Take-Off~~	~~472~~	~~665~~	
e. Airplane Weight There	25,200	23,860	
f. Weight of Fuel from Take-Off	2,220	3,120	
g. Take-Off Weight	27,420	26,980	

5. Dimensions of Landing Runways:

a. Scheduled Destination: Place SALT LAKE CITY

(1) Landing Direction	N	S	NW	SE	E	W		
(2) Effective Length	5,550	5,550	5,550	5,550	4,575	4,575		
(3) Minimum Axial Wind	0	0	15	15	15	15		
(4) Landing Weight	32,000	32,000	33,000+	33,000+	30,850	30,850		
(5) Take-Off Weight	34,220	34,220	35,220+	35,220+	33,070	33,070		

b. Alternate Destination: Place ROCK SPRINGS

(1) Landing Direction	E	W	NW	SE	NE	SW		
(2) Effective Length	6,700	6,700	6,000	6,000	5,200	5,200		
(3) Minimum Axial Wind	0	0	10.5	10.5	10.5	10.5		
(4) Landing Weight	33,000+	33,000+	33,000+	33,000+	33,000+	33,000+		
(5) Take-Off Weight	----	----	----	----	----	----		

c. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

D. Maximum Take-Off Weight for Trip = 22,700 lbs.

24,070 lbs. If No Take-Off N, S, or W.

E. Remarks:

*VIA SALT LAKE CITY

5-20764

TRIP ANALYSIS

A. Trip - From: SALT LAKE CITY, To: CHEYENNE

B. Cruising Conditions:

1. Altitude = 13,000 ft. 2. Indicated Airspeed = 165 mph. 3. True Airspeed = 202 mph. 4. Forecast (Head) (Tail) Wind = 0 mph.

C. Maximum Take-Off Weight Permitted by:

1. Altitude of Take-Off = 4,220 ft., Weight = 25,400 lbs.,

2. Dimensions of Take-Off Runway Compared With:

a. Accelerate-Stop Distance:

(1) Runway	N - S	NW - SE	E - W	
(2) Weight	28,250	28,250	25,650	

b. Take-Off Flight Path:

(1) Take-Off Direction	N	S	NW	SE	E	W		
(2) Weight	25,740	25,020	25,740	25,020	24,260	24,260		

3. Altitude of Enroute Terrain:

a. Ground Miles from Take-Off	13	41	367		
b. Altitude	10,100	10,200	8,540		
c. Air Miles from Take-Off	13	41	367		
d. Airplane Weight There	24,500	24,400	25,700		
e. Weight of Fuel from Take-Off	65	200	1,800		
f. Take-Off Weight	24,565	24,600	27,500		

4. Altitude of Landing:

	Scheduled	Alternate	Alternate
a. Place	CHEYENNE	LARAMIE	DENVER
b. Altitude	6,140	7,270	5,308
c. Ground Miles from Take-Off	401	456*	498*
d. Air Miles from Take-Off	401	456*	498*
e. Airplane Weight There	24,270	23,500	24,900
f. Weight of Fuel from Take-Off	1,950	2,220	2,420
g. Take-Off Weight	26,220	25,720	27,320

5. Dimensions of Landing Runways:

a. Scheduled Destination: Place CHEYENNE

(1) Landing Direction	E	W	NW	SE	N	S		
(2) Effective Length	6,300	6,800	6,800	6,350	4,700	4,700		
(3) Minimum Axial Wind	0	0	15	15	13.5	13.5		
(4) Landing Weight	33,200+	33,200+	33,200+	33,200+	30,250	30,250		
(5) Take-Off Weight	Not Critical							

b. Alternate Destination: Place LARAMIE

(1) Landing Direction	NW	SE	N	S	NE	SW	E	W
(2) Effective Length	6,300	6,300	5,200	5,200	6,300	6,300	5,200	5,200
(3) Minimum Axial Wind	0	0	14	14	15	15	15	15
(4) Landing Weight	33,000+	33,000+	33,000+	33,000+	33,000+	33,000+	33,000+	33,000+
(5) Take-Off Weight	Not Critical							

c. Alternate Destination: Place DENVER

(1) Landing Direction	N	S	NW	SE	E	W	NE	SW
(2) Effective Length	7,000	7,000	7,016	7,016	6,475	6,475	6,423	6,423
(3) Minimum Axial Wind	0	0	15	15	15	15	15	15
(4) Landing Weight	Not Critical							
(5) Take-Off Weight	Not Critical							

D. Maximum Take-Off Weight for Trip = 24,260 lbs. For Take-Off In Any Direction
24,565 lbs. If No Take-Off E. or W.

E. Remarks:

*VIA CHEYENNE

S-20764

TRIP ANALYSIS

A. Trip - From: CHEYENNE, WYOMING, To: LARAMIE, WYOMING

B. Cruising Conditions:

1. Altitude = 10,000 ft. 2. Indicated Airspeed = 165 mph. 3. True Airspeed = 192 mph. 4. Forecast (Head) (Tail) Wind = 0 mph.

C. Maximum Take-Off Weight Permitted by:

1. Altitude of Take-Off = 6,140 ft., Weight = 24,070 lbs.,

2. Dimensions of Take-Off Runway Compared With:

a. Accelerate-Stop Distance:

(1) Runway	E - W	NW -- SE	N - S	
(2) Weight	29,800	29,800	24,000	

b. Take-Off Flight Path:

(1) Take-Off Direction	E	W	NW	SE	N	S		
(2) Weight	25,000	24,000	24,200	24,900	22,700	22,700		

3. Altitude of Enroute Terrain:

a. Ground Miles from Take-Off	34				
b. Altitude	8,540				
c. Air Miles from Take-Off	34				
d. Airplane Weight There	25,700				
e. Weight of Fuel from Take-Off	140				
f. Take-Off Weight	25,840				

4. Altitude of Landing:

	Scheduled	Alternate	Alternate
a. Place	LARAMIE		
b. Altitude	7,270		
c. Ground Miles from Take-Off	55		
d. Air Miles from Take-Off	55		
e. Airplane Weight There	23,500		
f. Weight of Fuel from Take-Off	227		
g. Take-Off Weight	23,727		

5. Dimensions of Landing Runways:

a. Scheduled Destination: Place LARAMIE

(1) Landing Direction	NW	SE	N	S	NE	SW	E	W
(2) Effective Length	6,300	6,300	5,200	5,200	6,300	6,300	5,200	5,200
(3) Minimum Axial Wind	0	0	14	14	15	15	15	15
(4) Landing Weight	32,700	32,700	31,400	31,400	33,000+	33,000+	31,500	31,500
(5) Take-Off Weight								

b. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

c. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

D. Maximum Take-Off Weight for Trip = 22,700 lbs.

23,727 lbs. If No Take-Off N or S.

E. Remarks:

TRIP ANALYSIS

A. Trip - From: CHEYENNE, WYOMING , **To:** DENVER, COLORADO

B. Cruising Conditions:

1. **Altitude** = 8,000 ft. 2. Indicated Airspeed =165 mph. 3. True Airspeed =185 mph. 4. Forecast (Head) (Tail) Wind = 0 mph.

C. Maximum Take-Off Weight Permitted by:

1. **Altitude of Take-Off** = 6,140 ft., Weight = 24,070 lbs.,
2. **Dimensions of Take-Off Runway Compared With:**

a. Accelerate-Stop Distance:

(1) Runway	E - W	NW - SE	N - S	
(2) Weight	29,800	29,800	24,000	

b. Take-Off Flight Path:

(1) Take-Off Direction	E	W	NW	SE	N	S		
(2) Weight	25,000	24,000	24,200	24,900	22,700	22,700		

3. Altitude of Enroute Terrain:

a. Ground Miles from Take-Off	8				
b. Altitude	6,300				
c. Air Miles from Take-Off	8				
d. Airplane Weight There	27,650				
e. Weight of Fuel from Take-Off	30				
f. Take-Off Weight	27,680				

4. Altitude of Landing:

	Scheduled	Alternate	Alternate
a. Place	DENVER		
b. Altitude	5,308		
c. Ground Miles from Take-Off	97		
d. Air Miles from Take-Off	97		
e. Airplane Weight There	24,900		
f. Weight of Fuel from Take-Off	356		
g. Take-Off Weight	25,256		

5. Dimensions of Landing Runways:

a. Scheduled Destination: Place DENVER

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight	Not Critical							

b. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

c. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

D. Maximum Take-Off Weight for Trip = 22,700 lbs.

E. Remarks: 24,000 lbs. If No Take-Off N or S.

S-20764

TRIP ANALYSIS

A. Trip - From: CHEYENNE, WYOMING **, To:** NORTH PLATTE

B. Cruising Conditions:

1. Altitude = 7,000 ft. 2. Indicated Airspeed = 165 mph. 3. True Airspeed = 183 mph. 4. Forecast (Head) (Tail) Wind = 0 mph.

C. Maximum Take-Off Weight Permitted by:

1. Altitude of Take-Off = 6,140 ft., Weight = 24,070 lbs.,
2. Dimensions of Take-Off Runway Compared With:

a. Accelerate-Stop Distance:

(1) Runway	E - W	NW - SE	N - S	
(2) Weight	29,800	29,800	24,000	

b. Take-Off Flight Path:

(1) Take-Off Direction	E	W	NW	SE	N	S		
(2) Weight	25,000	24,000	24,200	24,900	22,700	22,700		

3. Altitude of Enroute Terrain:

a. Ground Miles from Take-Off	0				
b. Altitude	6,200				
c. Air Miles from Take-Off	0				
d. Airplane Weight There	27,800				
e. Weight of Fuel from Take-Off	0				
f. Take-Off Weight	27,800				

4. Altitude of Landing:

	Scheduled	Alternate	Alternate
a. Place	NORTH PLATTE		
b. Altitude	2,800		
c. Ground Miles from Take-Off	217		
d. Air Miles from Take-Off	217		
e. Airplane Weight There	25,200		
f. Weight of Fuel from Take-Off	780		
g. Take-Off Weight	25,980		

5. Dimensions of Landing Runways:

a. Scheduled Destination: Place NORTH PLATTE

(1) Landing Direction	NW	SE	N	S	E	W		
(2) Effective Length	6,824	6,624	4,437	4,437	4,600	4,600		
(3) Minimum Axial Wind	0	0	10.5	10.5	11.3	11.3		
(4) Landing Weight	33,000+	33,000+	30,000	30,000	31,200	31,200		
(5) Take-Off Weight	Not Critical							

b. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

c. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

D. Maximum Take-Off Weight for Trip = 22,700 **lbs.**
24,000 lbs. If No Take-Off N or S.

E. Remarks:

5-20764

TRIP ANALYSIS

A. Trip - From: CHEYENNE, WYOMING, To: ROCK SPRINGS, WYOMING

B. Cruising Conditions:

1. Altitude = 10,000 ft. 2. Indicated Airspeed = 165 mph. 3. True Airspeed = 192 mph. 4. Forecast (Head) (Tail) Wind = 0 mph.

C. Maximum Take-Off Weight Permitted by:

1. Altitude of Take-Off = 6,140 ft., Weight = 24,070 lbs.,

2. Dimensions of Take-Off Runway Compared With:

a. Accelerate-Stop Distance:

(1)	Runway	E - W	NW - SE	N - S	
(2)	Weight	29,800	29,800	24,000	

b. Take-Off Flight Path:

(1)	Take-Off Direction	E	W	NW	SE	N	S		
(2)	Weight	25,000	24,000	24,200	24,900	22,700	22,700		

3. Altitude of Enroute Terrain:

a.	Ground Miles from Take-Off	34				
b.	Altitude	8,540				
c.	Air Miles from Take-Off	34				
d.	Airplane Weight There	25,700				
e.	Weight of Fuel from Take-Off	140				
f.	Take-Off Weight	25,840				

4. Altitude of Landing:

		Scheduled	Alternate	Alternate
a.	Place	ROCK SPRINGS		
b.	Altitude	6,745		
c.	Ground Miles from Take-Off	237		
d.	~~Air Miles from Take-Off~~	237		
e.	Airplane Weight There	23,860		
f.	Weight of Fuel from Take-Off	980		
g.	Take-Off Weight	24,840		

5. Dimensions of Landing Runways:

a. Scheduled Destination: Place ROCK SPRINGS

(1)	Landing Direction	E	W	NW	SE	NE	SW		
(2)	Effective Length	6,700	6,700	6,000	6,000	5,200	5,200		
(3)	Minimum Axial Wind	0	0	10.5	10.5	10.5	10.5		
(4)	Landing Weight	33,000+	33,000+	33,000+	33,000+	31,250	31,250		
(5)	Take-Off Weight	Not Critical							

b. Alternate Destination: Place

(1)	Landing Direction								
(2)	Effective Length								
(3)	Minimum Axial Wind								
(4)	Landing Weight								
(5)	Take-Off Weight								

c. Alternate Destination: Place

(1)	Landing Direction								
(2)	Effective Length								
(3)	Minimum Axial Wind								
(4)	Landing Weight								
(5)	Take-Off Weight								

D. Maximum Take-Off Weight for Trip = 22,700 lbs.
24,000 lbs. If No Take-Off N or S.

E. Remarks:

5-20764

TRIP ANALYSIS

A. Trip - From: OMAHA, NEBRASKA, To: DES MOINES, IOWA

B. Cruising Conditions:

1. Altitude = 3,000 ft. 2. Indicated Airspeed = 165 mph. 3. True Airspeed = 172 mph. 4. Forecast (Head) (Tail) Wind = 0 mph.

C. Maximum Take-Off Weight Permitted by:

1. Altitude of Take-Off = 977 ft., Weight = 26,080 lbs.,

2. Dimensions of Take-Off Runway Compared With:

a. Accelerate-Stop Distance:

(1) Runway	NW - SE	E - W	NE - SW	N - S
(2) Weight	30,300	29,550	29,350	29,750

b. Take-Off Flight Path:

(1) Take-Off Direction	NW	SE	E	W	NE	SW	N	S
(2) Weight	27,000	27,000	26,500	26,500	26,400	26,400	26,500	26,500

3. Altitude of Enroute Terrain:

a. Ground Miles from Take-Off	62				
b. Altitude	1,200				
c. Air Miles from Take-Off	62				
d. Airplane Weight There	29,240				
e. Weight of Fuel from Take-Off	195				
f. Take-Off Weight	29,435				

4. Altitude of Landing:

	Scheduled	Alternate	Alternate
a. Place	DES MOINES		
b. Altitude	950		
c. Ground Miles from Take-Off	119		
d. Air Miles from Take-Off	119		
e. Airplane Weight There	25,200		
f. Weight of Fuel from Take-Off	374		
g. Take-Off Weight	25,574		

5. Dimensions of Landing Runways:

a. Scheduled Destination: Place DES MOINES

(1) Landing Direction	NE	SW	E	W	NW	SE	N	S
(2) Effective Length	4,500	4,500	3,150	3,150	3,650	3,950	3,000	3,600
(3) Minimum Axial Wind	0	0	15	15	15	15	15	15
(4) Landing Weight	29,900	29,900	25,800	25,800	28,500	29,900	24,900	28,300
(5) Take-Off Weight	30,274	30,274	26,174	26,174	28,874	30,274	25,274	28,674

b. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

c. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

D. Maximum Take-Off Weight for Trip = 25,274 lbs.

E. Remarks:

S-30764

TRIP ANALYSIS

A. Trip – From: OMAHA, NEBRASKA, To: NORTH PLATTE, NEBRASKA

B. Cruising Conditions:

1. Altitude = 4,000 ft. 2. Indicated Airspeed = 165 mph. 3. True Airspeed = 175 mph. 4. Forecast (Head) (Tail) Wind = 0 mph.

C. Maximum Take-Off Weight Permitted by:

1. Altitude of Take-Off = 977 ft., Weight = 26,080 lbs.,

2. Dimensions of Take-Off Runway Compared With:

a. Accelerate-Stop Distance:

(1) Runway	NW – SE	E – W	NE – SW	N – S
(2) Weight	30,300	29,550	29,350	29,750

b. Take-Off Flight Path:

(1) Take-Off Direction	NW	SE	E	W	NE	SW	N	S
(2) Weight	27,000	27,000	26,500	26,500	26,400	26,400	26,500	26,500

3. Altitude of Enroute Terrain

a. Ground Miles from Take-Off	70	255			
b. Altitude	1,700	2,800			
c. Air Miles from Take-Off	70	255			
d. Airplane Weight There	29,130	28,920			
e. Weight of Fuel from Take-Off	223	813			
f. Take-Off Weight	29,353	29,733			

4. Altitude of Landing

	Scheduled	Alternate	Alternate
a. Place	NORTH PLATTE		
b. Altitude	2,800		
c. Ground Miles from Take-Off	255		
d. Air Miles from Take-Off	255		
e. Airplane Weight There	25,200		
f. Weight of Fuel from Take-Off	813		
g. Take-Off Weight	26,013		

5. Dimensions of Landing Runways

a. Scheduled Destination Place NORTH PLATTE

(1) Landing Direction	NW	SE	N	S	E	W		
(2) Effective Length	6,824	6,624	4,437	4,437	4,600	4,600		
(3) Minimum Axial Wind	0	0	10.5	10.5	11.3	11.3		
(4) Landing Weight	33,000+	33,000+	30,000	30,000	31,200	31,200		
(5) Take-Off Weight	Not Critical							

b. Alternate Destination Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

c. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

D. Maximum Take-Off Weight for Trip = 26,013 lbs.

E. Remarks:

5-20-64

location of the gradient along the runway it must be concluded that no generally applicable procedure for correction is possible.

REFERENCES

a. Flight Engineering Report No. 9.

b. Sectional Aeronautical Charts U-3, U-4, U-5, U-6 and U-7.

FIGURES

destination and proceed instead to one of the alternate destinations may be taken prior to reaching the scheduled destination and may, as a consequence, involve a more direct route from the point where the decision is reached to the alternate, than that via the scheduled destination. Such a procedure will involve the consumption of less fuel than will the procedure followed in this report and, in cases where the conditions surrounding the landing are critical, will introduce an error in the take-off weight for the trip so determined. This would appear to indicate the desirability of considering, in the trip analysis, possible alternative routes to an alternate destination where these may critically affect the allowable take-off weight for the trip.

4. CAR 61.7122(c) requires that correction be made to the results obtained from the comparison of the dimensions of the runway of take-off with those of the two alternative take-off flight paths for any appreciable gradient of the take-off surface. The trip analyses contained in this report have not considered this possibility. They have instead, assumed all take-off surfaces to be perfectly level. In order to provide some indication of the magnitude of the effect of surface gradient upon the runway dimensions required it is necessary to consider separately, the portions of the flight paths involving acceleration or deceleration along the take-off surface and those involving steady climbing flight. In the case of the former, a 1% grade produces an additional acceleration or deceleration, acting down grade, of 0.32 ft/sec/sec. Since the accelerations or decelerations involved on a level surface are of the order 5 to 10 ft/sec/sec., the distances involved may be increased or decreased by a 1% grade by 3 to 6%. In the case of the distances traversed during steady climbing flight, the effect of grade is analogous to requiring more or less rate of climb since, for example, if the far end of the runway of take-off is 50 feet above the point at which the airplane leaves the ground it must, in the intervening distance, climb 100 feet in order to have attained a height of 50 feet above the take-off surface instead of climbing only 50 feet on a level surface. Since the slope of the flight path is numerically:

$$\frac{C}{88V}$$

and for the airplane considered in the report, V = 96.8 MPH, therefore, the slope of the flight path is:

$$\mathcal{B} = \frac{C}{88 \times 96.8} = .0001175C$$

The slope of a 1% grade is .01. It follows that the increase in rate of climb required to compensate for this increase in required slope of the flight path is:

$$\Delta C = \frac{.01}{.0001175} = 85 \text{ ft/min.}$$

The most troublesome aspect of correction for surface gradient is that its distribution along the runway is unlikely to be uniform or identical from runway to runway. When, in addition to this, it is pointed out that the magnitude of its effect is also dependent upon both the extent and

The most convenient unit into which this information may be organized appears to be that pertaining to a station. That is, for each station on a route there should be prepared a list of all trips originating at the station containing, for each, the maximum weight authorized for the trip and any special instruction made necessary by operating restrictions such as have been discussed above. Although the trips analyzed in this report have failed to disclose such a case, it is very possible that the maximum weight for a given trip may depend upon the particular alternate or alternates specified in the flight plan. It is also possible that the cruising conditions of altitude, speed, and wind velocity and direction may influence the maximum trip weight. If so, this will require for each trip a listing of the trip weight for each significant combination of alternates and of cruising conditions. Once this has been done for each station on the route, the operating information is complete.

CONCLUDING REMARKS

1. While the contents of this report may be appropriate material from which to draw general conclusions concerning the nature of the transport category operating rules or of the process, illustrated therein by means of which compliance with these may be determined, it is suggested that no such conclusion may, with the same propriety, be drawn concerning the effect of these rules upon the maximum weight at which any airplane may be operated in scheduled operation or upon the airport dimensions required for the reason that, as has been pointed out in the introduction, the report has dealt with a single airplane and that airplane has been neither designed to comply with the requirements of, nor certificated in the transport category. In other words, the report is by no means a definitive treatment of the transport category operating rules, but rather, merely an illustrative example of their application to a particular airplane and route.

2. The preparation of the airport diagrams (figures No. 2 and 12 through 19) has involved selecting what CAR 61.7123(a) calls "---the landing area most suitable for landing in still air," which has been assumed to be a runway. In making this selection, consideration was given to the length of the runways and to that one equipped for instrument approaches. In most cases, these two considerations dictated the selection of the same runway. That is, the instrument approach runway was the longest available or one of two of equal length. The two exceptions encountered were Des Moines, where the range leg is some distance from the airport, and North Platte, where the range leg lines up with one of the shorter runways. Since the instrument approach procedures for these require weather minimums sufficiently great to permit the pilot to select any runway after breaking through the bottom of the overcast, the longest runway was selected in each case. In the general case, it is suggested that still other features may warrant consideration in making this selection such, for example, as width of paving, convenience of location with respect to loading facilities or direction of destination, or of other runways, frequency distribution of wind velocity, and direction, etc.

3. The trip analyses contained in this report are based upon the assumption that the trip proceeds to the scheduled destination and, if conditions there make landing impossible, continues flight to one of the alternates, etc. It is recognized that the decision to pass up the scheduled

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Since the purpose of calculating these distances is to compare them with the actual length of the runways, that purpose may be served by the reciprocal process of dividing the actual lengths by these factors and using these corrected lengths to enter Figure 4. The results, so obtained are as follows:

Runway	NW-SE	E-W	N-S	NE-SW
Actual Length	6,546	4,749	5,075	6,047
Apparent Length	6,546	5,410	5,790	7,000
Maximum Weight				30,000+

The next step is to calculate the effect of the minimum axial wind velocities upon the take-off flight paths, also at the altitude of Chicago, for various weights. The process has been described in item 3 of the discussion of the basic information required concerning the airplane and involves using Figure No. 6. The corrected flight paths appear in Figure No. 20. When these are compared with the profiles in Figure No. 19 for each direction of take-off, the following limitations on the take-off weight result:

Direction	NW	SE	E	W	N	S	NE	SW
Wind	0	0	13.5	13.5	13.5	13.5	15	15
Weight	28,000	25,880	24,000	26,900	26,900	24,200	27,250	28,100
Gained	0	0	1,000	700	600	875	1,080	425

These results indicate that, although consideration of the wind has resulted in gains in take-off weight ranging from 425 to 1,080 pounds, the gains are not great enough to eliminate the necessity for further restrictions upon the take-off E, S, and SE in order to permit these to be made at the maximum weight permitted by the altitude of the take-off. In other words, the application of the third alternative discussed above to the case of Chicago is not adequate to accomplish the desired effect. The results also indicate that, if the second alternative be adopted, the minimum axial wind velocity in any of these directions would necessarily exceed 15 MPH. The comparatively great difference between the weights permitted by the accelerate-stop distance and those permitted by the take-off paths is due primarily to the presence of obstacles of considerable height at the ends of several of the runways (see Figure 19).

INFORMATION FOR DISPATCHERS

The foregoing trip analyses and the ensuing discussion of the results of these have indicated generally the nature of the information required by the dispatcher in order to control the weight of an airplane operated under the transport category operating rules. Fundamentally, this information is obtained directly from the trip analyses but may be modified by the particular solution adopted in case the problem of restrictions in certain take-off directions arises.

the axial component of wind on any such runways at the time of the take-off which, although not impossible, would appear to involve a difficult operating problem since the weight at which the airplane is to be dispatched must be fixed sometime in advance of the take-off and winds are notoriously capricious. Finally, an operating procedure such as has been described earlier in this report in connection with the method of analysis to determine the maximum landing weight permitted by the dimensions of the landing runway, whereby the decision to use any particular runway for take-off rests solely upon the direction and velocity of the wind and upon a critical cross wind velocity for the airplane may be adopted and, based upon this procedure, a maximum take-off weight in any possible direction may be established. The adoption of this alternative requires an analysis, similar in nature to that made above for landings, to establish the maximum take-off weights. Since the process of this analysis differs in detail from that for landing, it will be illustrated hereunder for the case of Chicago.

EFFECT OF WIND UPON MAXIMUM TAKE-OFF WEIGHT AT CHICAGO

It is assumed for this purpose that the critical cross wind velocity for take-off is 15 MPH although it should be pointed out that the critical value for take-off may very well differ from that for landing. Referring now to Figure No. 19 and calling the NW-SE runway most suitable for take-off, the minimum axial component of wind velocity for each runway may be established and tabulated as follows:

RUNWAY	MINIMUM AXIAL WIND
NW-SE	0
E-W	13.5
NE-SW	15.0
N-S	13.5

The next step is to calculate the effect of these wind velocities upon the accelerate-stop distance of Figure 4 at the altitude of Chicago for various weights. As has been pointed out in Method of Analysis earlier in the report, these distances are reduced by an amount obtained by multiplying the no-wind values by the factor.

$$\left(1 - \frac{V_W}{2V} \right)^{1.85}$$

Substituting the appropriate values of V_W and V, the values of this factor for the wind velocities involved are:

WIND	FACTOR
0	1.00
13.5	.876
15.	.862

TRIP	MAXIMUM WEIGHT	CRITICAL ROUTE DIMENSION	RESTRICTED TAKE-OFF DIRECTIONS
Chicago to Omaha	26,120	Altitude of Take-Off	E., S., SE
Omaha to Cheyenne	26,080	Altitude of Take-Off	None
Cheyenne to Salt Lake	24,070	Altitude of Take-Off	N., S., W.
Salt Lake to Cheyenne	24,565	Altitude of Enroute Terrain	E., W.
Cheyenne to Laramie	23,727	Altitude of Landing	N., S.
Cheyenne to Denver	24,070	Altitude of Take-Off	N., S., W.
Cheyenne to North Platte	24,070	Altitude of Take-Off	N., S., W.
Cheyenne to Rock Springs	24,070	Altitude of Take-Off	N., S., W.
Omaha to Des Moines	25,274	Altitude of Landing	None
Omaha to North Platte	26,013	Altitude of Landing	None

The results, so arranged, illustrate what appear to be two characteristics of the operating rules. The first of these is that the shorter the trip the more likely are the limitations based upon the conditions involved in landing to govern the maximum trip weight. Compare for example, the various trips originating in Omaha or those originating in Cheyenne; although for this latter group, the effect is obscured by the fact that all destinations except that for the shortest trip (Laramie) are at lower altitudes than Cheyenne while this particular destination is at a greater altitude. The other characteristic is that a given height of enroute terrain is more likely to be critical in respect of trip weight if it lies relatively near the point of take-off than if it lies relatively near the destination. Compare the trip Cheyenne to Salt Lake City with the trip Salt Lake City to Cheyenne.

In the matter of restricting the take-off, upon which the table immediately above is based, there appear to be at least three possible alternatives. The most obvious and by far the simplest is to abandon take-off in the directions involved altogether. This may however, be entirely too restrictive. Alternatively, there can be established for each direction a minimum axial component of wind velocity which, when applied as a correction to the dimensions of the airplane flight path as outlined earlier in the report, will permit take-off in that direction at the maximum weight otherwise permitted, plus an operating rule prohibiting take-off in any of these directions unless the axial component of wind velocity for the particular direction equals or exceeds the critical value so established. This would require the dispatcher to have means of knowing the velocity of

DISCUSSION OF RESULTS

Perhaps the first point which should be made concerning the result of the foregoing analyses is that in no case has the landing distance limited the take-off weight at either a scheduled or an alternate destination. Not only is this true but also the maximum take-off weight permitted by this particular limitation exceeds the weight permitted by the critical limitation (and therefore, for the trip) by a wide margin in every case except at Des Moines, Iowa for the trip; Omaha to Des Moines. This result is regarded as characteristic of the particular airplane involved and not necessarily of the proportions of the regulations themselves. It appears much less likely of occurrence in the case of a four engine airplane designed to comply with the requirements of the transport category and most probably involving appreciably higher wing loading.

The remainder of the results may be conveniently summarized by means of the following table:

TRIP	MAXIMUM WEIGHT	CRITICAL ROUTE DIMENSION
Chicago to Omaha	23,000	Take-Off East
Omaha to Cheyenne	26,080	Altitude of Take-Off
Cheyenne to Salt Lake	22,700	Take-Off North or South
Salt Lake to Cheyenne	24,260	Take-Off East or West
Cheyenne to Laramie	22,700	Take-Off North or South
Cheyenne to Denver	22,700	Take-Off North or South
Cheyenne to North Platte	22,700	Take-Off North or South
Cheyenne to Rock Springs	22,700	Take-Off North or South
Omaha to Des Moines	25,274	Altitude of Landing
Omaha to North Platte	26,013	Altitude of Landing

It may be noted concerning the results tabulated above, that in a majority of cases the maximum weight permitted for the trip is determined by the dimensions of the runway involved in taking off in a particular direction. This suggests the possibility of increasing the maximum weight by imposing certain restrictions upon the direction of take-off or upon the wind conditions under which the take-off may be made in certain directions. The nature of the necessary restrictions is discussed hereunder but, if restrictions are tolerable, the foregoing table may be rewritten as follows:

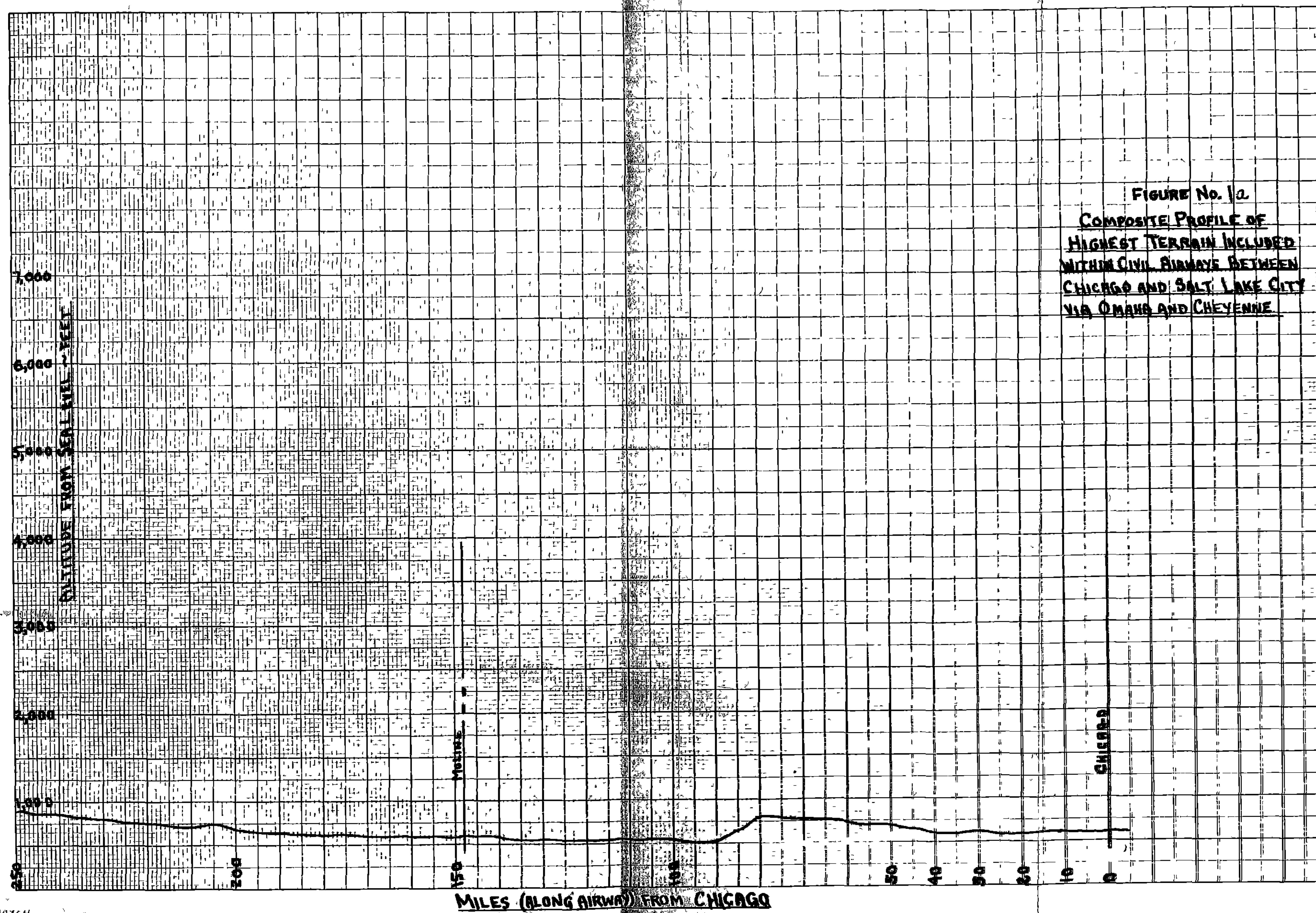
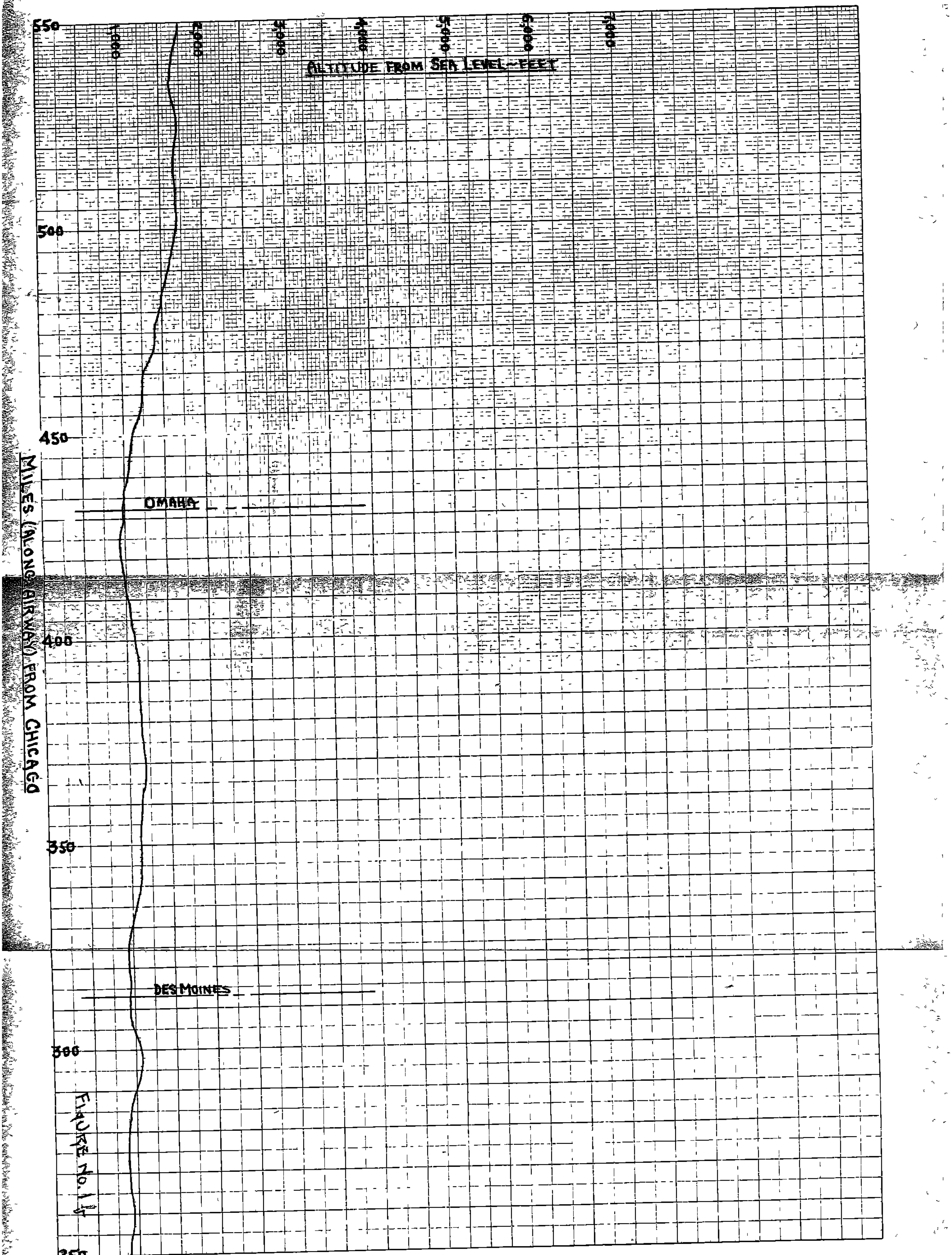
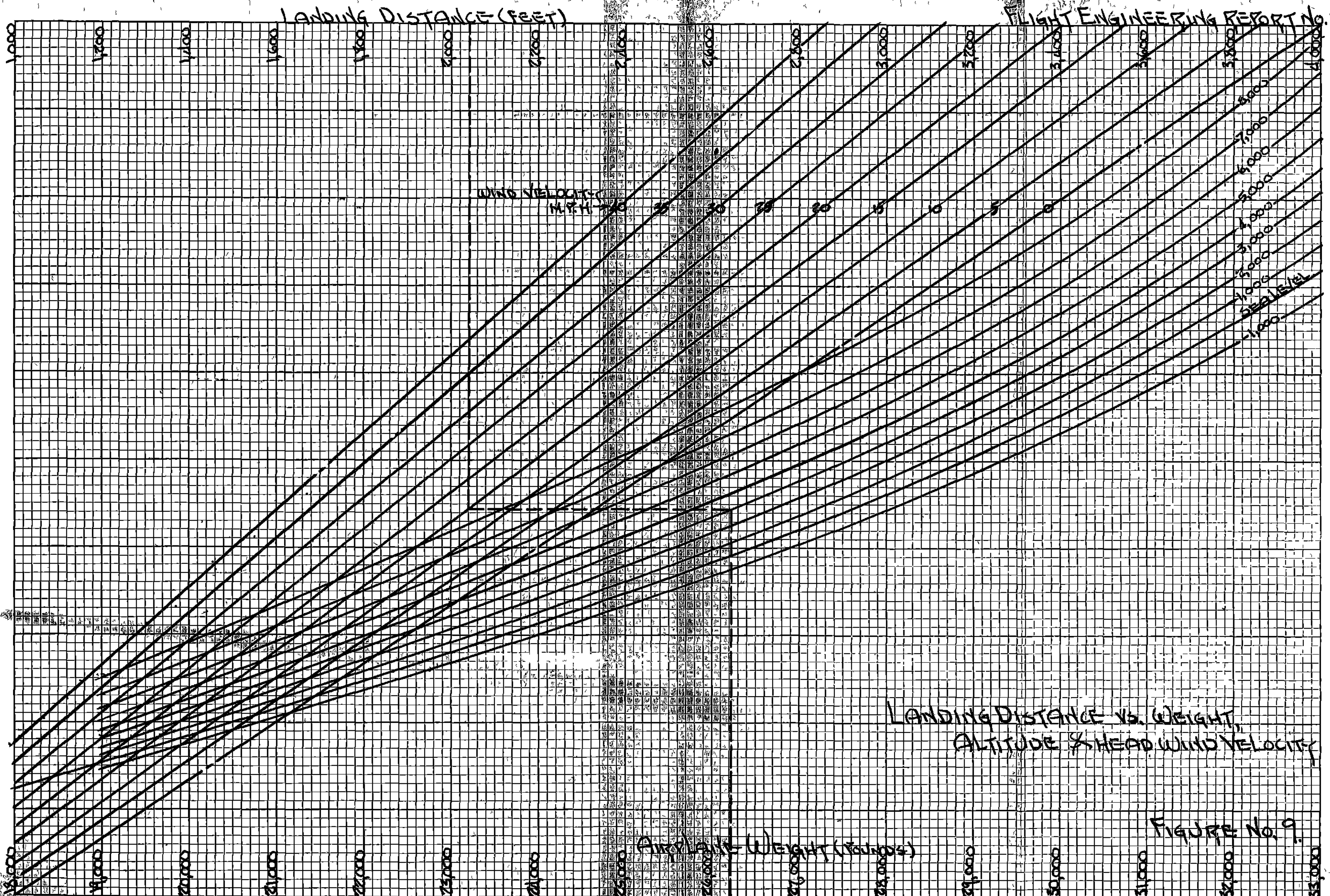


FIGURE No. 1a
COMPOSITE PROFILE OF
HIGHEST TERRAIN INCLUDED
WITHIN CIVIL AIRWAYS BETWEEN
CHICAGO AND SALT LAKE CITY
VIA OMAHA AND CHEYENNE
ALTITUDE FROM SEA LEVEL ~ FEET
7,000
6,000
5,000
4,000
3,000
2,000
1,000
MOLINE
CHICAGO
250
200
150
100
50
40
30
20
10
0
MILES (ALONG AIRWAY) FROM CHICAGO



ALTITUDE FROM SEA LEVEL-FEET
1,000
2,000
3,000
4,000
5,000
6,000
7,000
MILES (ALONG AIRWAY) FROM CHICAGO
550
500
450
400
350
300
OMAHA
DES MOINES

FIGURE No. 15



LANDING DISTANCE VS. WEIGHT, ALTITUDE & HEAD WIND VELOCITY

FIGURE No. 9.

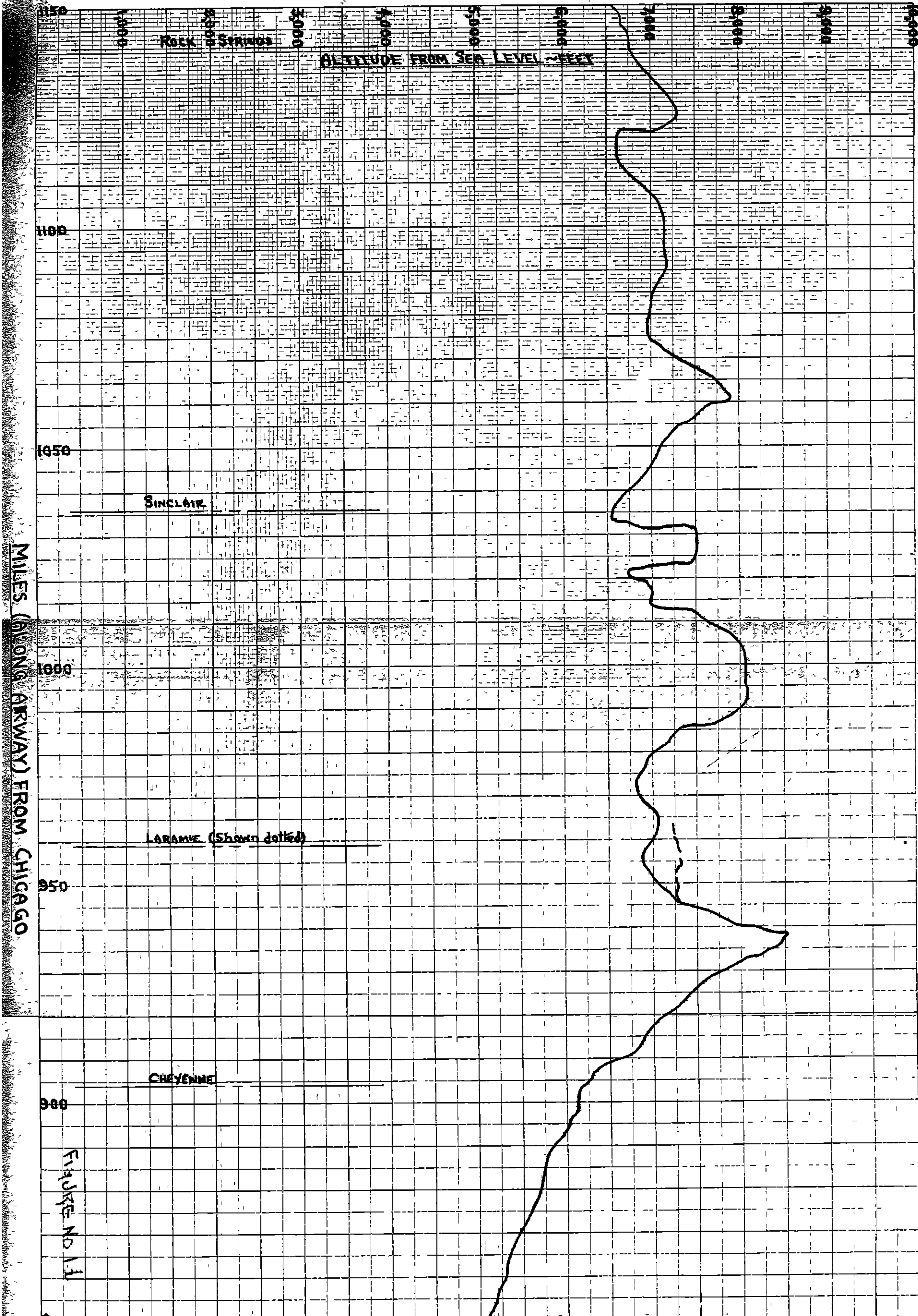

ALTITUDE FROM SEA LEVEL ~ FEET
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
MILES (ALONG AIRWAY) FROM CHICAGO
1150
1100
1050
1000
950
900
850
ROCK SPRINGS
SINCLAIR
LARAMIE (Shown dotted)
CHEYENNE

FIGURE NO 11

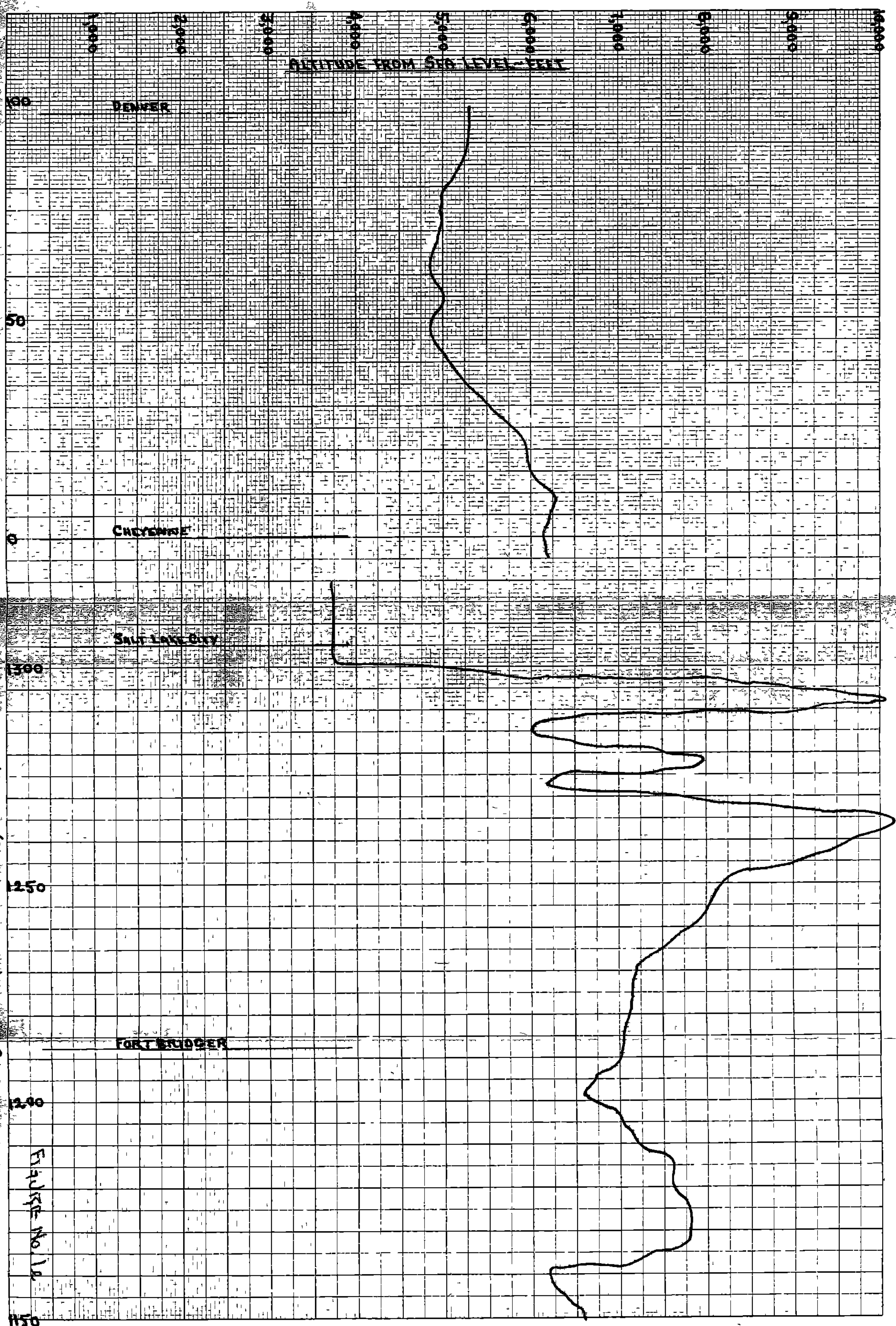
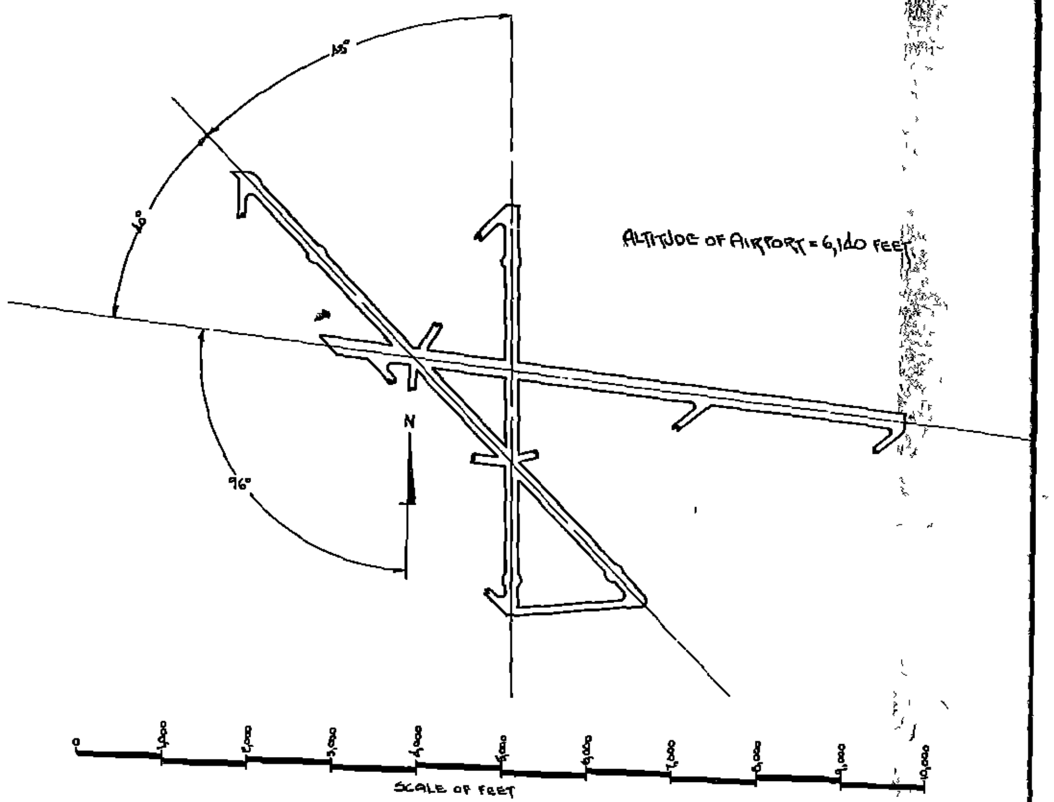
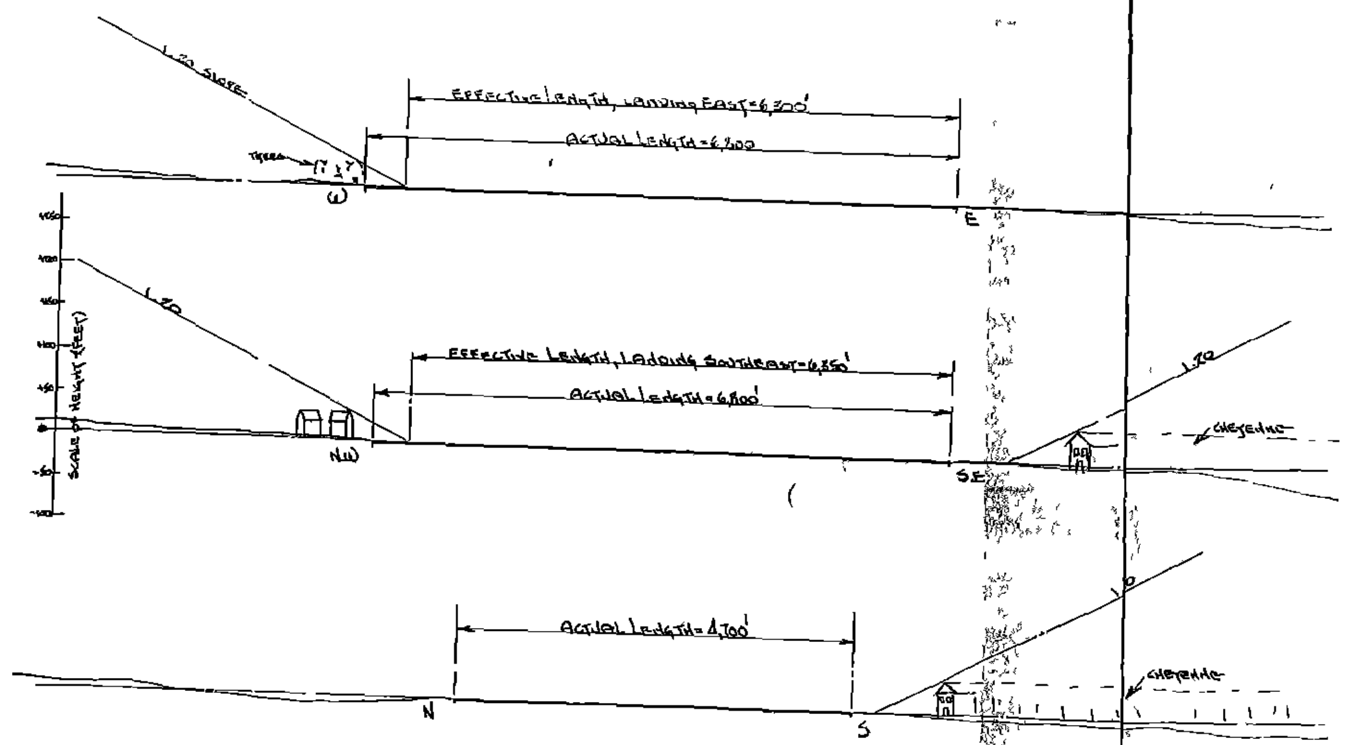

1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
ALTITUDE FROM SEA LEVEL-FEET
100
DENVER
50
CHEYENNE
0
MILES (ALONG AIRWAYS) FROM CHEYENNE
SALT LAKE CITY
1300
1250
FORT BRIDGER
1200
1150
MILES (ALONG AIRWAY) FROM CHICAGO

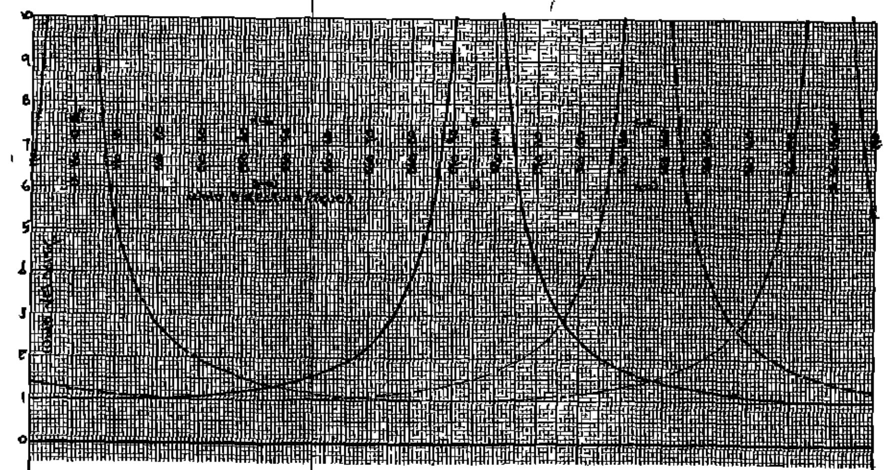
Figure No. 16



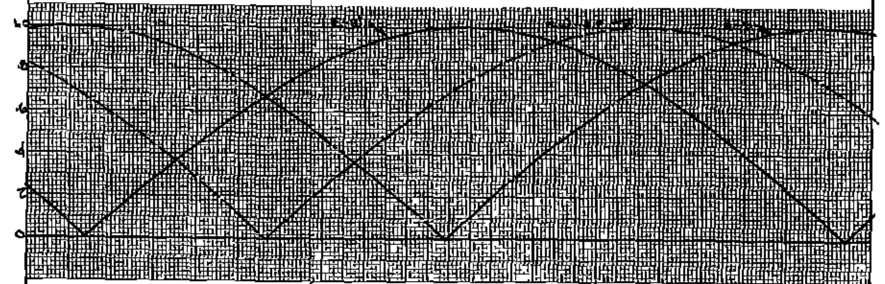
A.- PLAN OF AIRPORTS



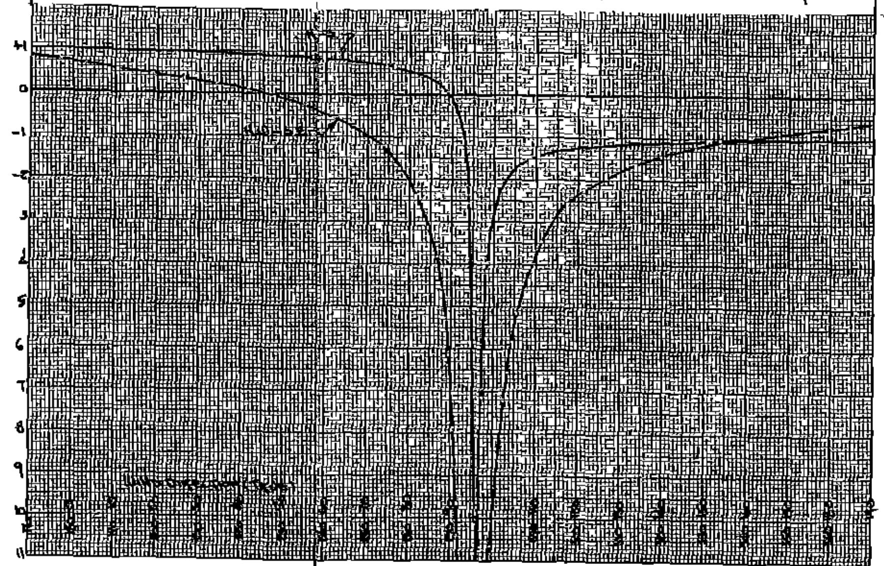
B.- PROFILES ALONG ℄ RUNWAYS.



C.- WIND VELOCITY PRODUCING UNIT CROSS COMPONENT ON ALL RUNWAYS.



D.- AXIAL COMPONENT ALL RUNWAYS PRODUCED BY UNIT WIND VELOCITY.

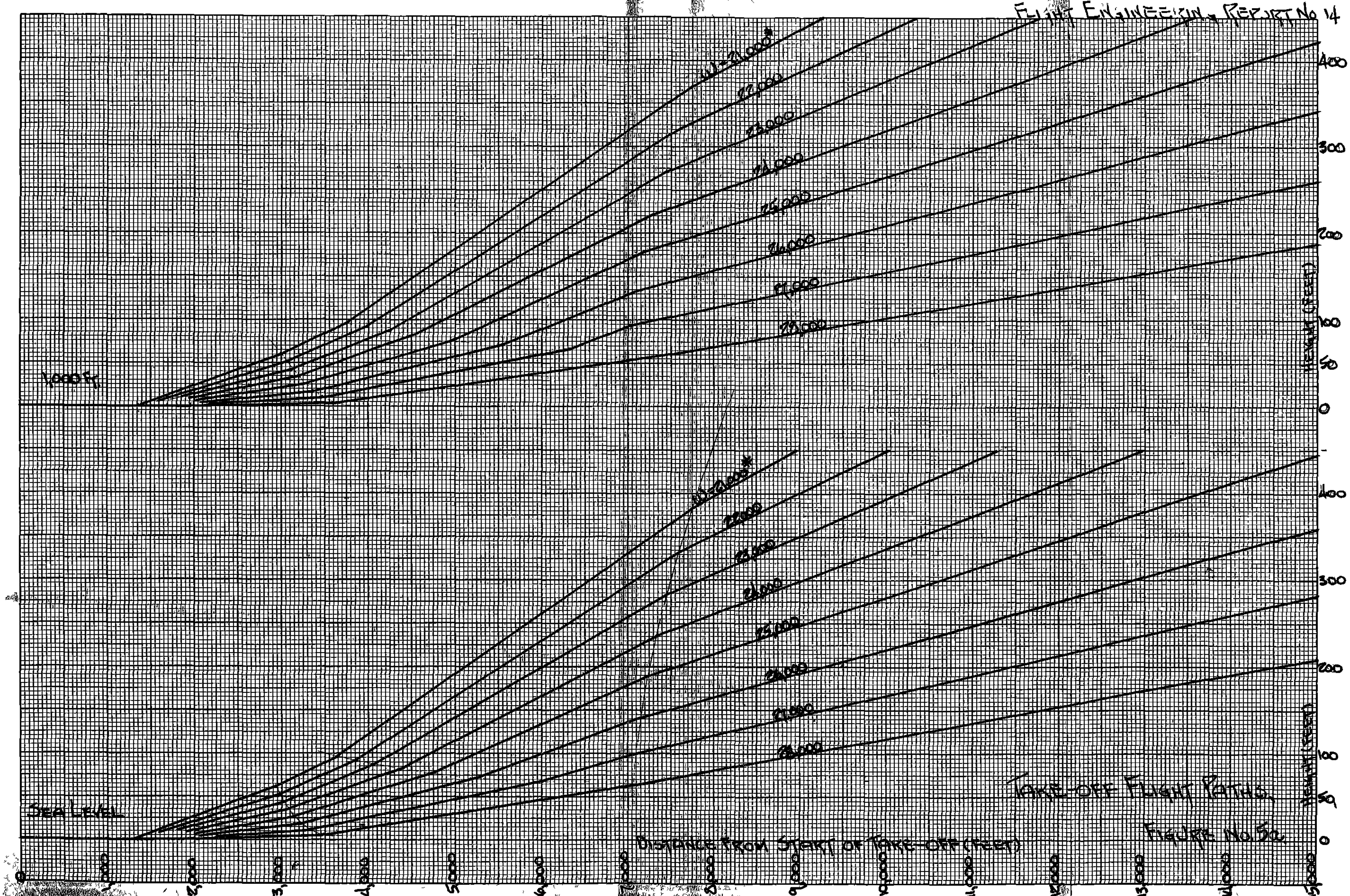


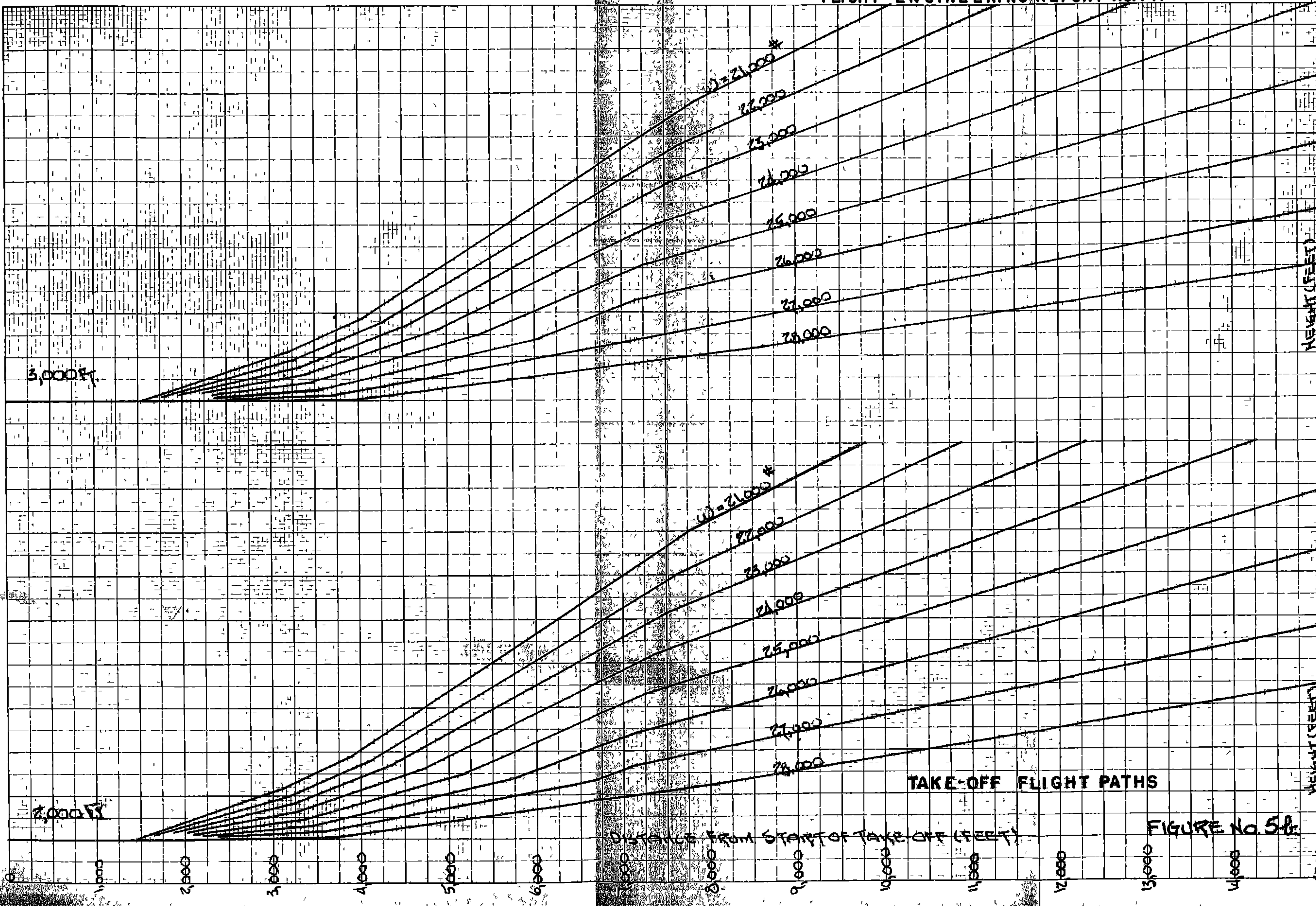
E.- AXIAL COMPONENT ON NW-SE & N-S RUNWAYS PRODUCED BY WIND CREATING UNIT CROSS COMPONENT ON E-W RUNWAY

AIRPORT DIAGRAM
CHEYENNE, WYOMING

FIGURE No. 2

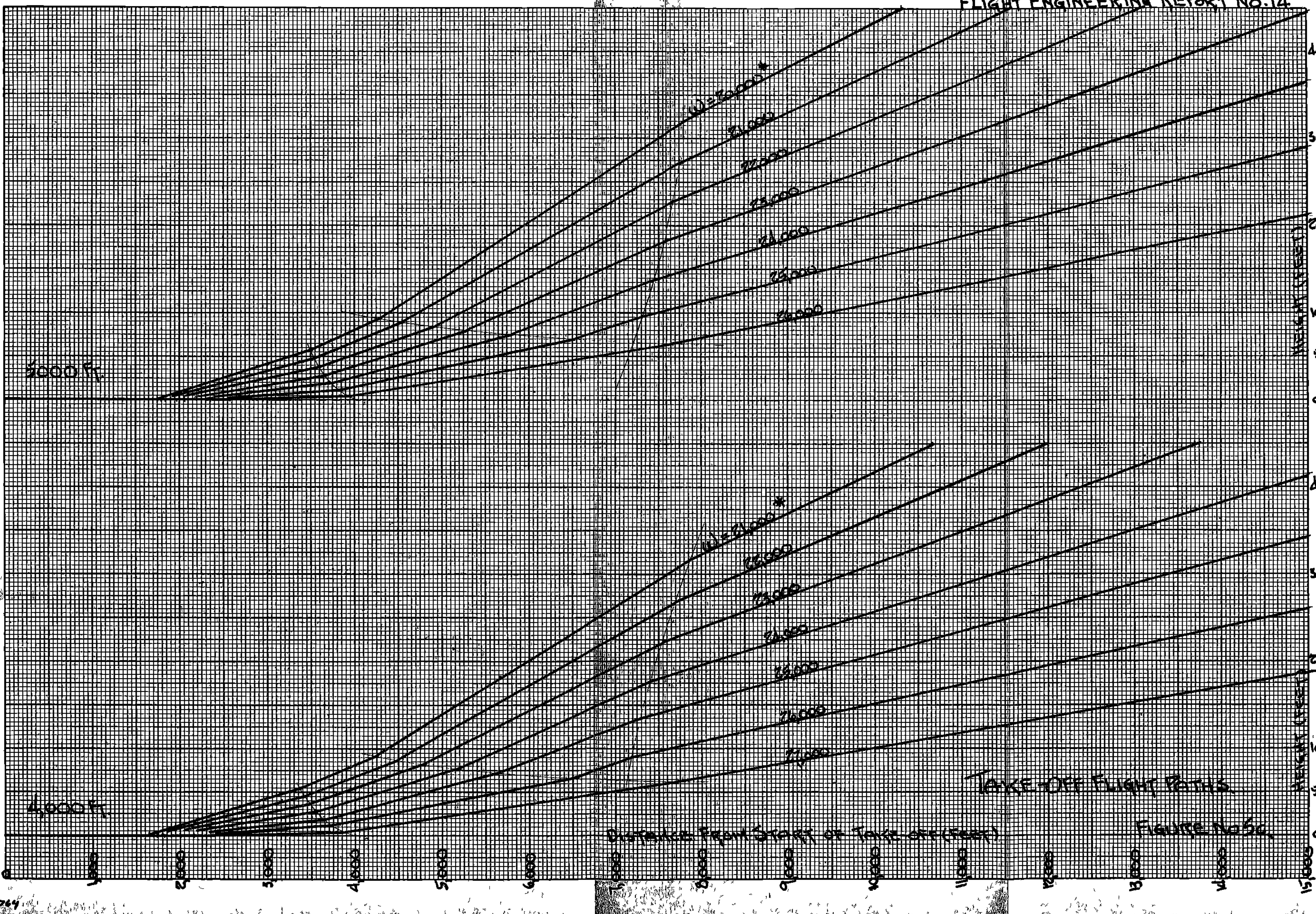
5-20/64


FLIGHT ENGINEERING REPORT No 14
1000 Ft.
SEA LEVEL
W = 21,000#
22,000
23,000
24,000
25,000
26,000
27,000
28,000
HEIGHT (FEET)
0
50
100
200
300
400
DISTANCE FROM START OF TAKE-OFF (FEET)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
TAKE-OFF FLIGHT PATHS.
FIGURE No. 52



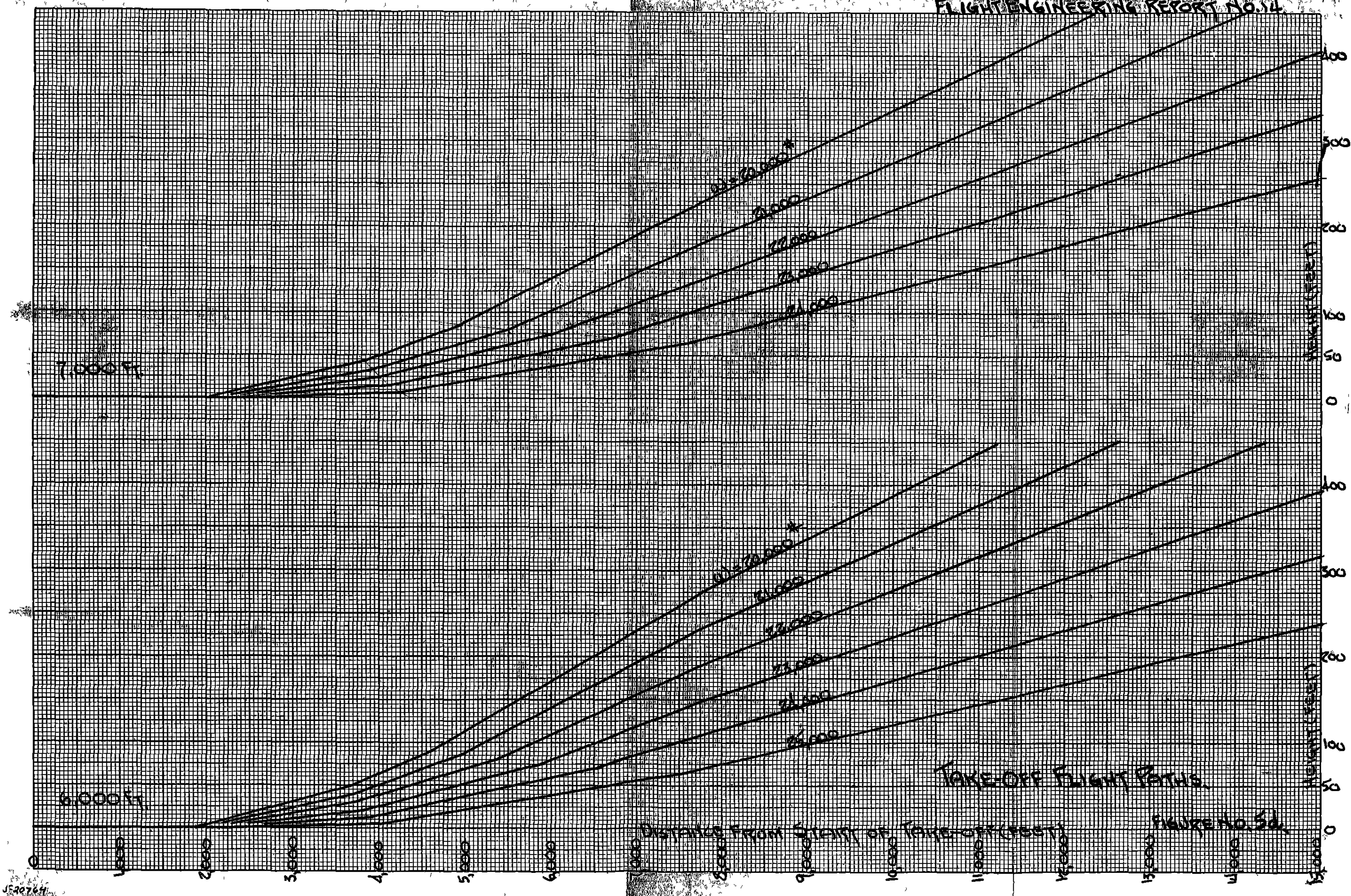
TAKE-OFF FLIGHT PATHS

FIGURE No. 5b



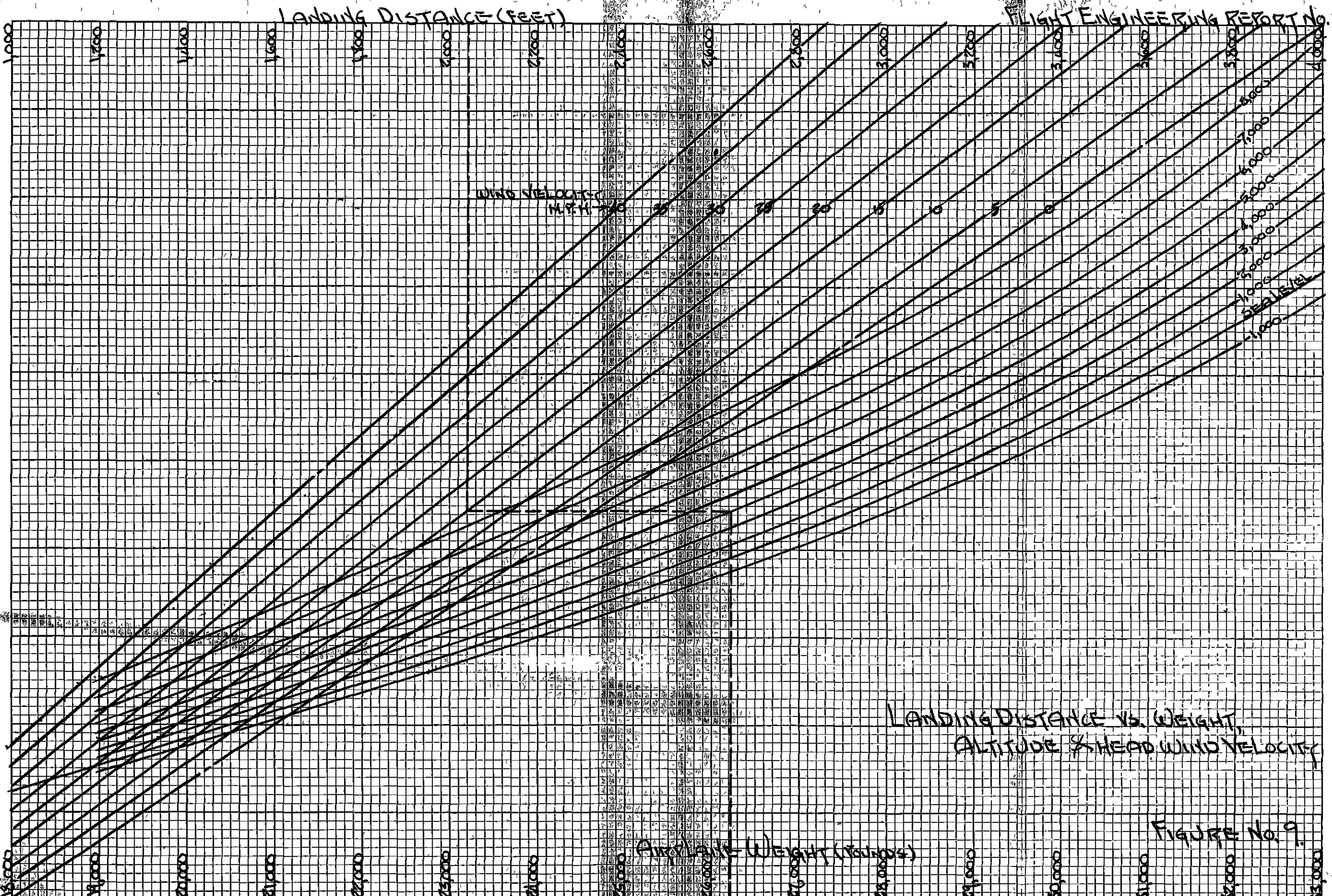
TAKE-OFF FLIGHT PATHS

FIGURE No 5c



TAKE-OFF FLIGHT PATHS.

FIGURE No. 5d.



LANDING DISTANCE VS. WEIGHT, ALTITUDE & HEAD WIND VELOCITY

FIGURE No. 9.

TRIP ANALYSIS

A. Trip - From: ____________________, To: ____________________

B. Cruising Conditions:

1. Altitude = ____ ft. 2. Indicated Airspeed = ___ mph. 3. True Airspeed = ___ mph. 4. Forecast (Head) (Tail) Wind = ___ mph.

C. Maximum Take-Off Weight Permitted by:

1. Altitude of Take-Off = ____ ft., Weight = ____ lbs.,

2. Dimensions of Take-Off Runway Compared With:

a. Accelerate-Stop Distance:

(1) Runway				
(2) Weight				

b. Take-Off Flight Path:

(1) Take-Off Direction								
(2) Weight								

3. Altitude of Enroute Terrain:

a. Ground Miles from Take-Off					
b. Altitude					
c. Air Miles from Take-Off					
d. Airplane Weight There					
e. Weight of Fuel from Take-Off					
f. Take-Off Weight					

4. Altitude of Landing:

	Scheduled	Alternate	Alternate
a. Place			
b. Altitude			
c. Ground Miles from Take-Off			
d. Air Miles from Take-Off			
e. Airplane Weight There			
f. Weight of Fuel from Take-Off			
g. Take-Off Weight			

5. Dimensions of Landing Runways:

a. Scheduled Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

b. Alternate Destination: Place

(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

c. Alternate Destination: Place

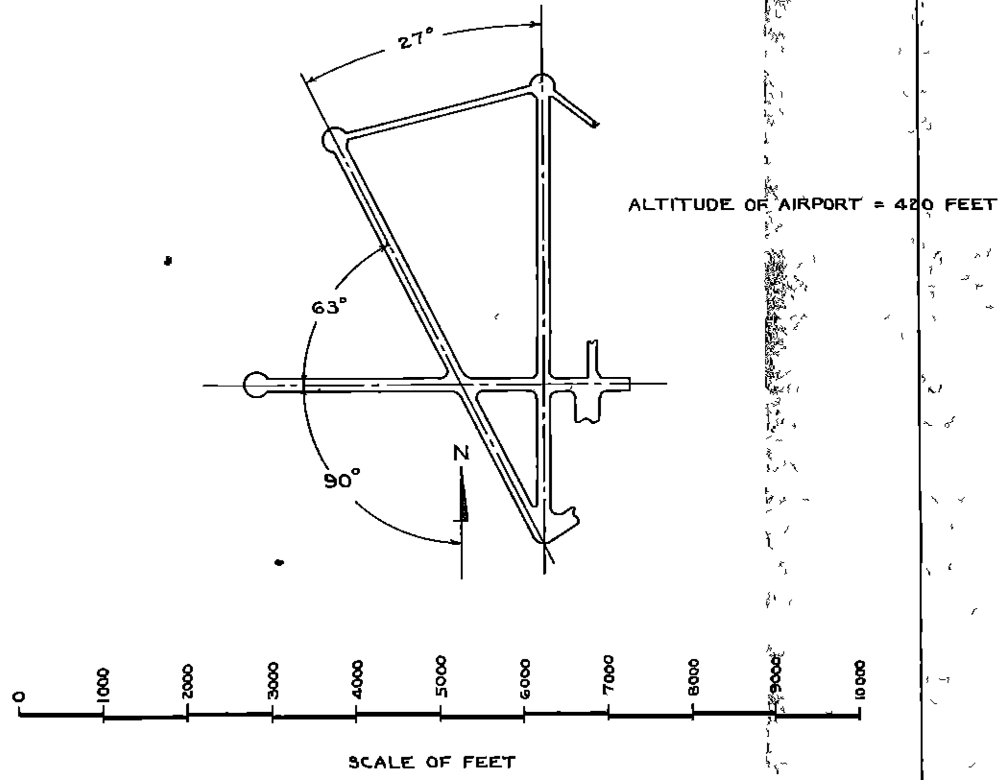
(1) Landing Direction								
(2) Effective Length								
(3) Minimum Axial Wind								
(4) Landing Weight								
(5) Take-Off Weight								

D. Maximum Take-Off Weight for Trip = ____ lbs.

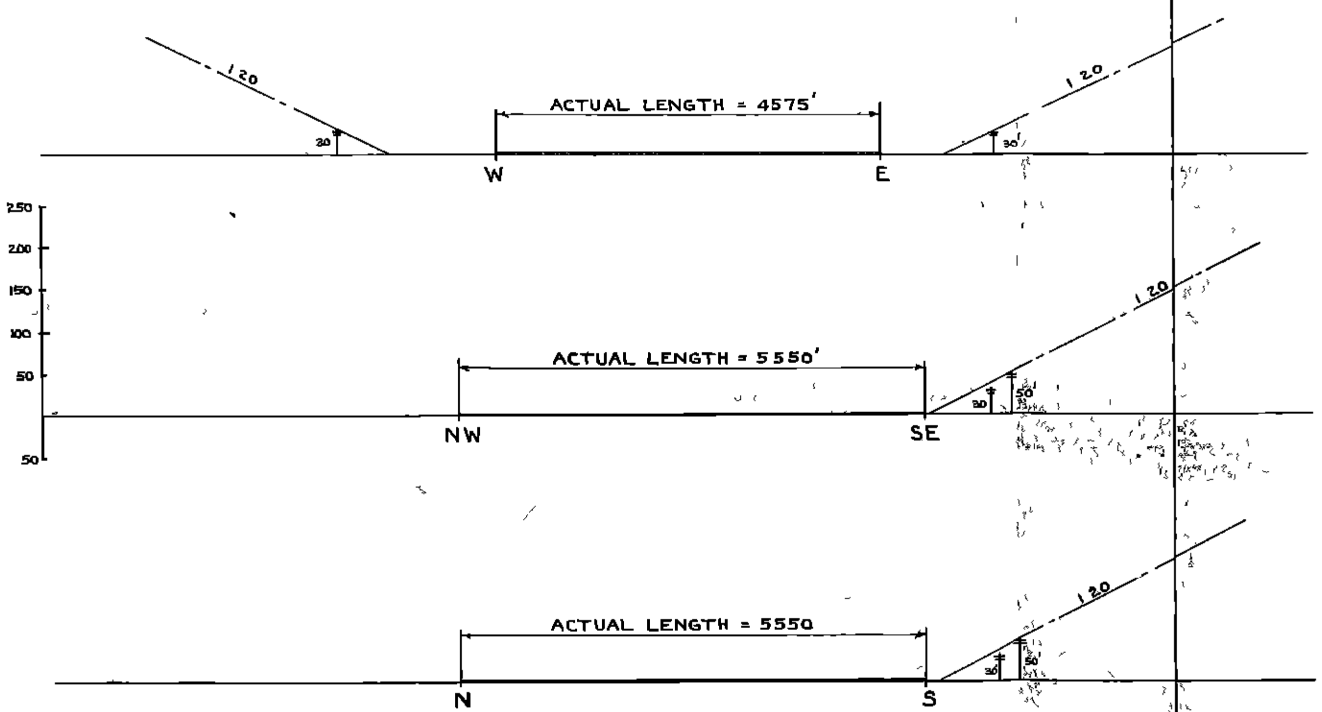
E. Remarks:

5-20764

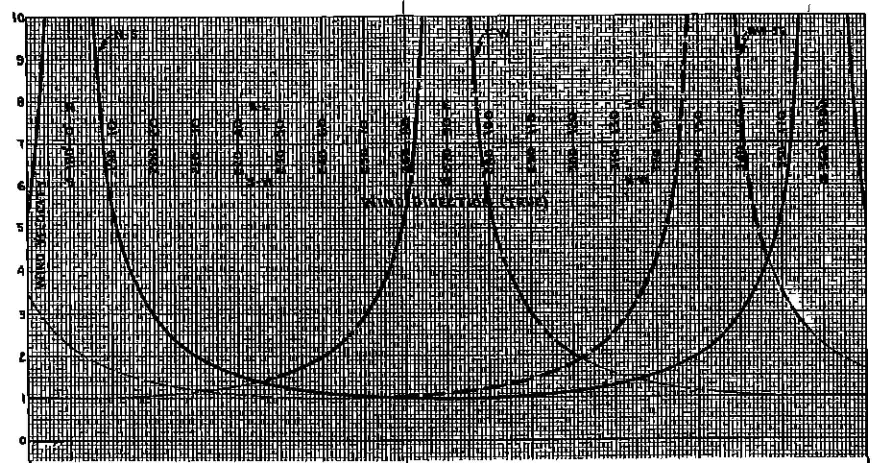
Figure No. 11



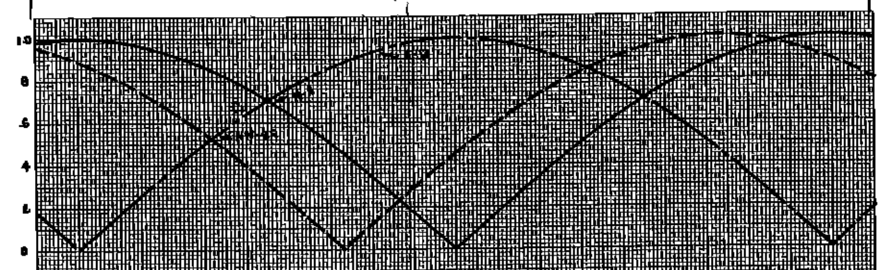
A.- PLAN OF AIRPORT



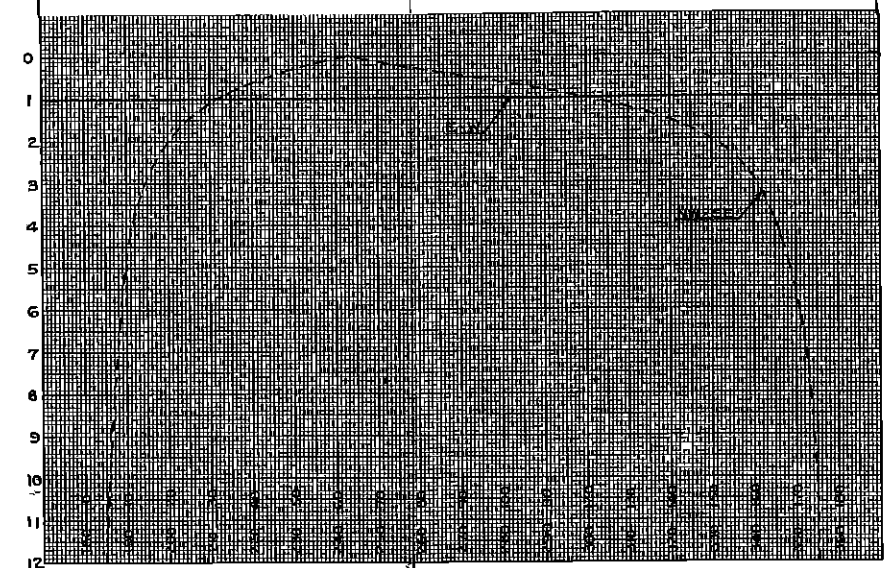
B.- PROFILES ALONG ℄ OF RUNWAYS



C - WIND VELOCITY PRODUCING UNIT CROSS COMPONENT ON ALL RUNWAYS



D, AXIAL COMPONENT ON ALL RUNWAYS PRODUCED BY UNIT WIND VELOCITY



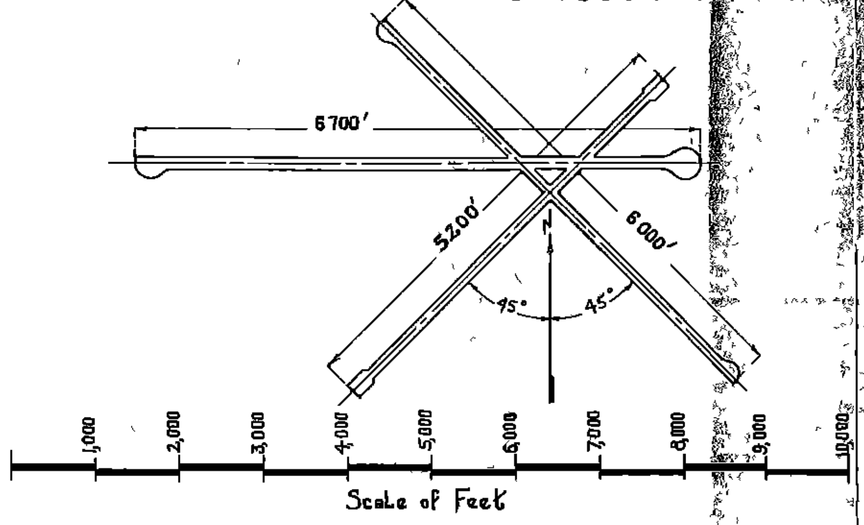
E - AXIAL COMPONENT ON NW-SE ℄ E-W RUNWAYS PRODUCED BY WIND CREATING UNIT CROSS COMPONENT ON N-S RUNWAY

AIRPORT DIAGRAM
SALT LAKE CITY, UTAH

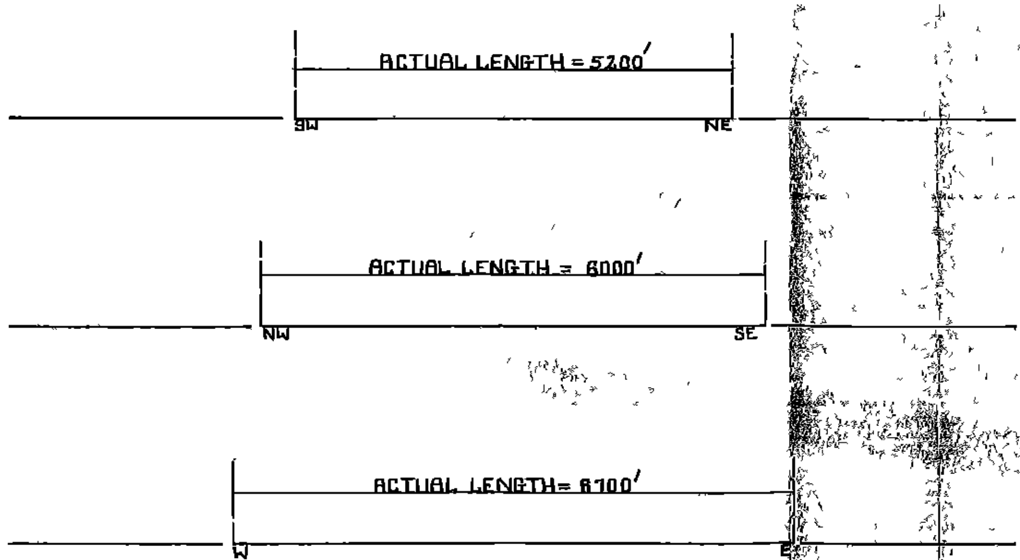
FIGURE NO 12

FLIGHT ENGINEERING REPORT NUMBER

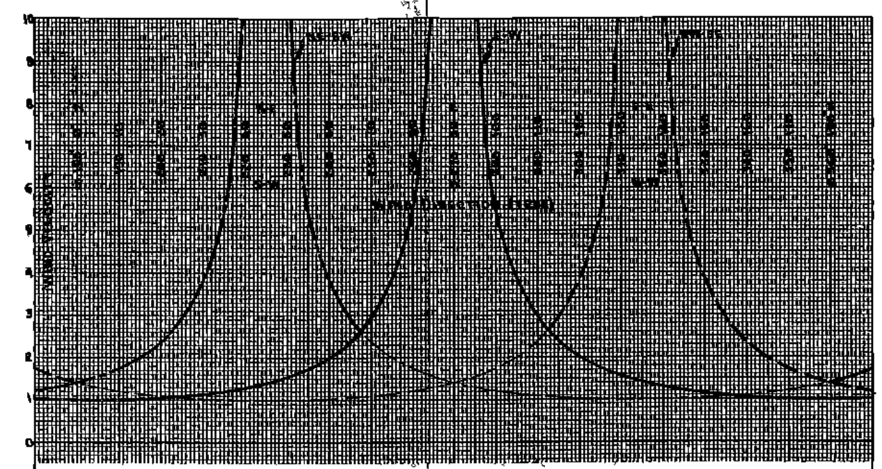
ALTITUDE OF AIRPORT 6745 FEET



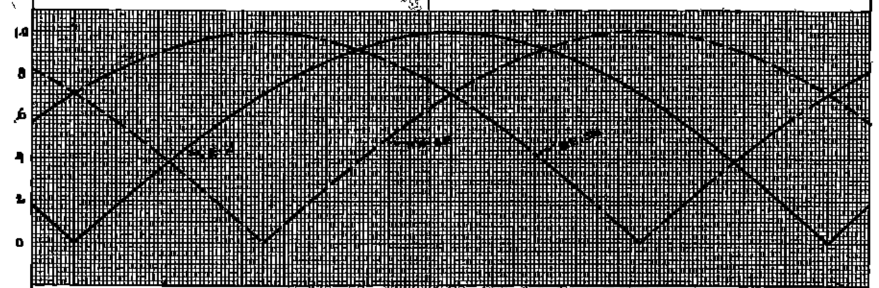
A- PLan of Airport



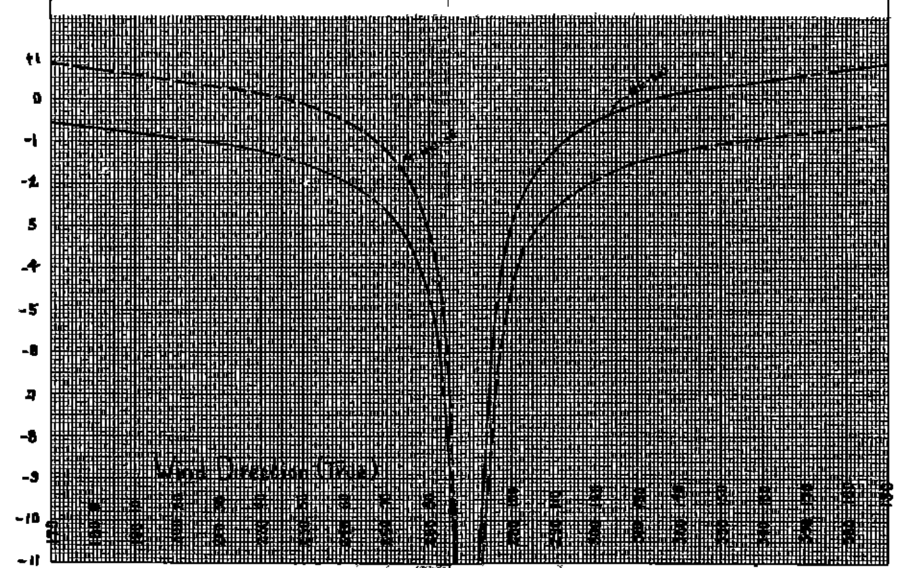
B- Profiles Along ℄ of Runways



C.- WIND VELOCITY PRODUCING UNIT CROSS COMPONENT ON ALL RUNWAYS



D.- AXIAL COMPONENT ON ALL RUNWAYS PRODUCED BY UNIT WIND VELOCITY

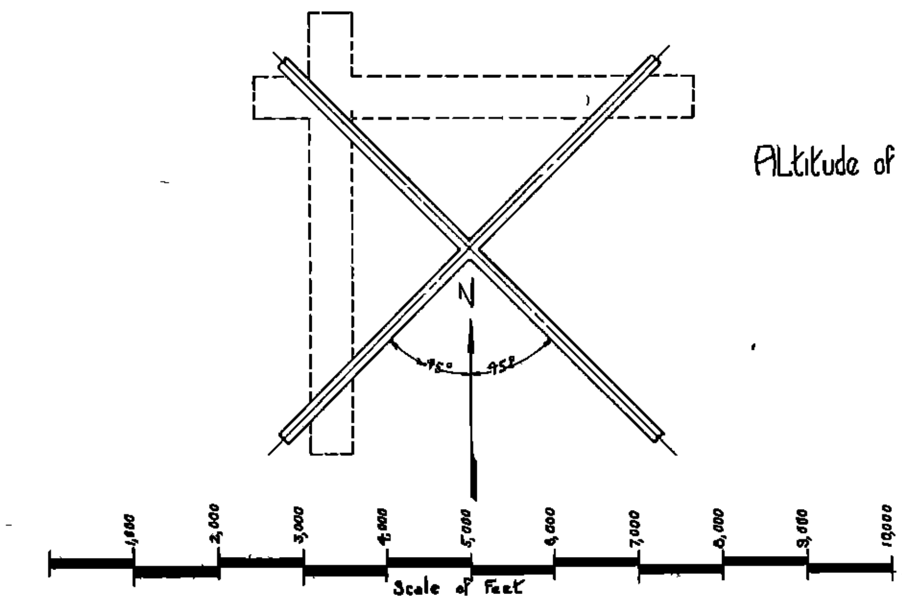


E.- AXIAL COMPONENT ON NW-SE NE-SW RUNWAYS PRODUCED BY WIND CREATING UNIT CROSS COMPONENT ON E-W RUNWAY

AIRPORT DIAGRAM
ROCK SPRINGS, WYOMING

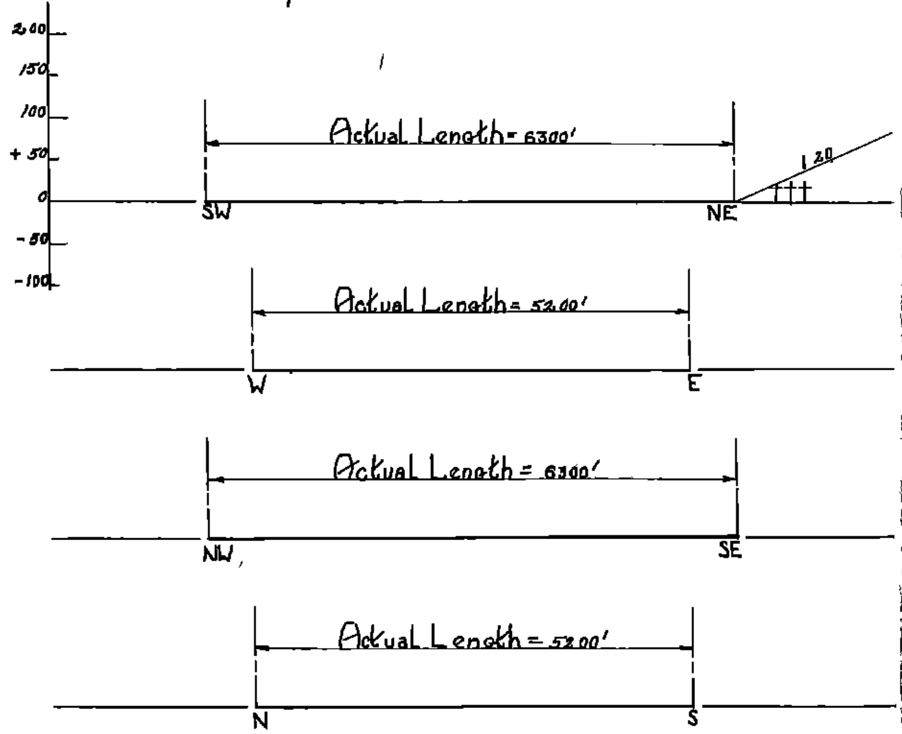
FIGURE NO 13

5-20764

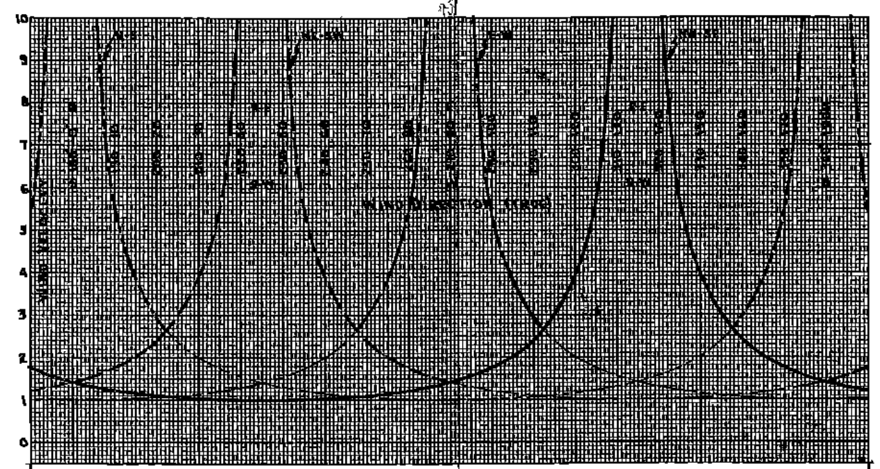


Altitude of Airport = 7270 Feet

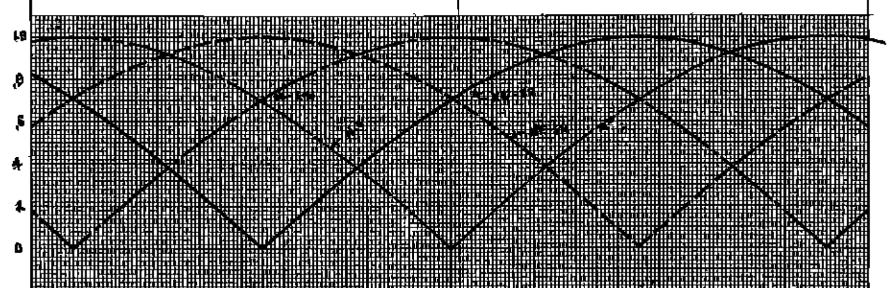
A- Plan of Airport



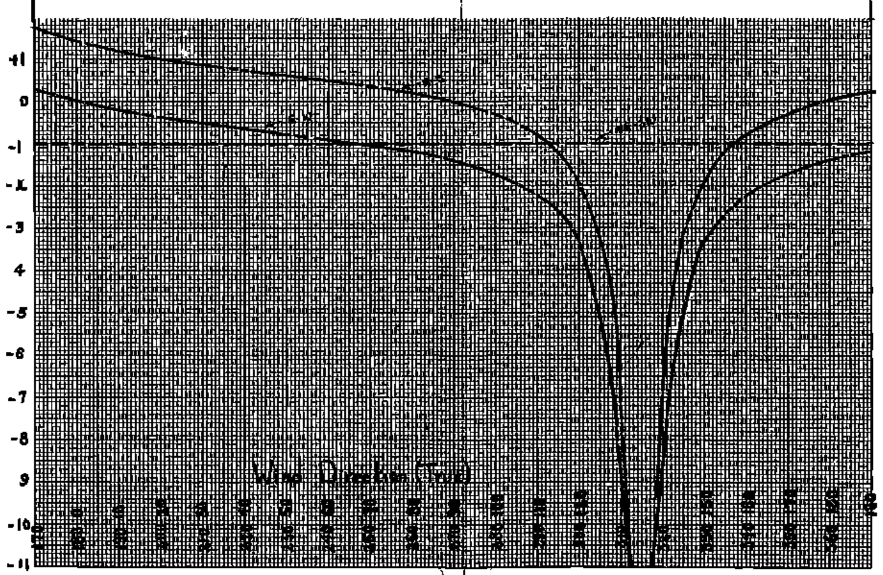
B- Profiles Along ℄ Runways



C,- WIND VELOCITY PRODUCING UNIT CROSS COMPONENT ON ALL RUNWAYS



D,- AXIAL COMPONENT ON ALL RUNWAYS PRODUCED BY UNIT WIND VELOCITY

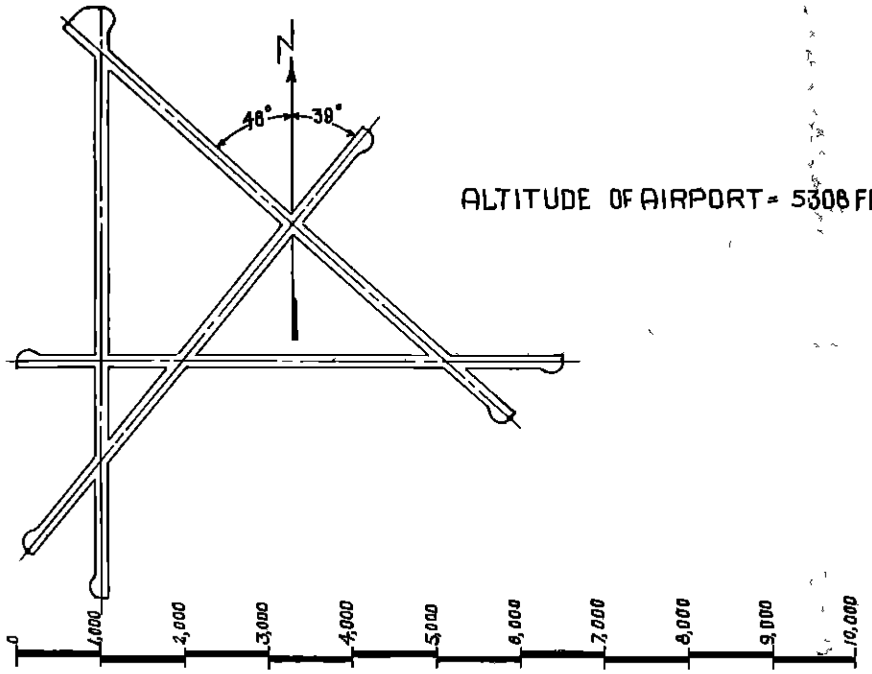


E,- AXIAL COMPONENT ON N-S NE-SW & EW RUNWAYS PRODUCED BY WIND CREATING UNIT CROSS COMPONENT ON NW-SE RUNWAY

AIRPORT DIAGRAM
LARAMIE, WYOMING

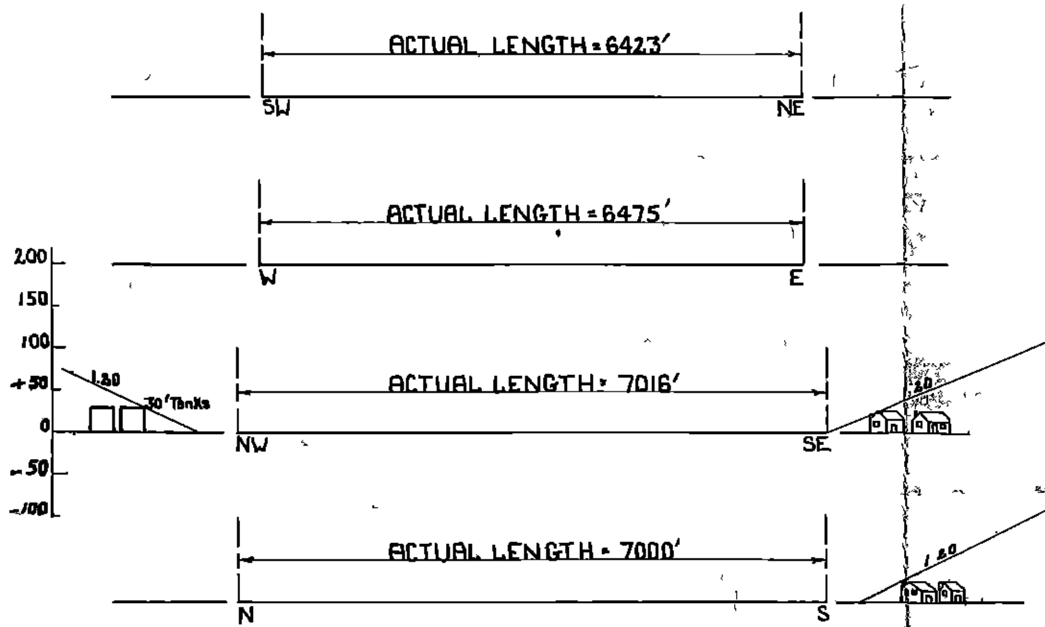
FIGURE NO 14

5-20764

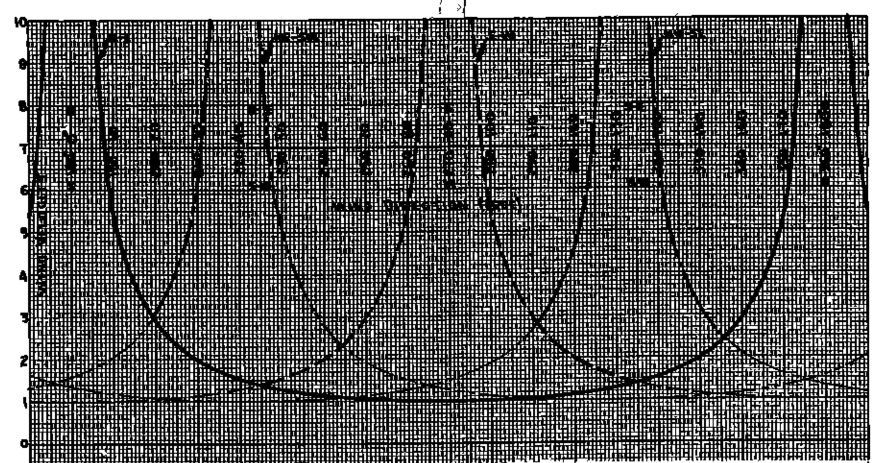


ALTITUDE OF AIRPORT = 5308 FEET

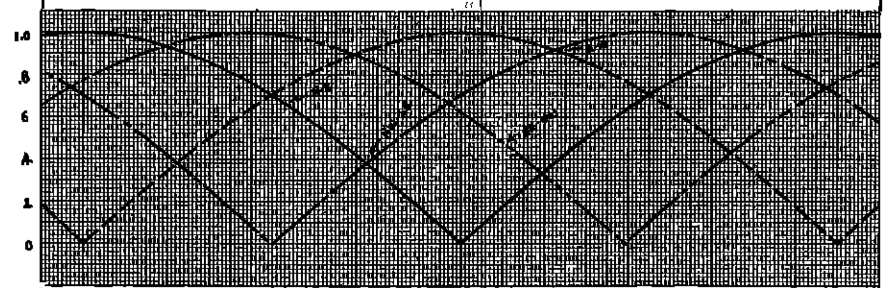
A - PLAN OF AIRPORT



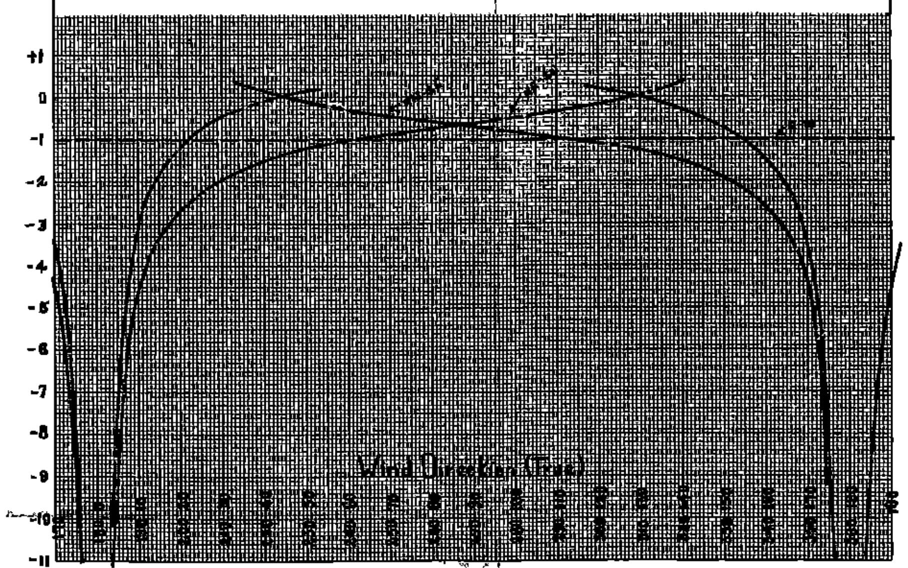
B - PROFILES ALONG ℄ OF RUNWAYS



C,- WIND VELOCITY PRODUCING UNIT CROSS COMPONENT ON ALL RUNWAYS



D,- AXIAL COMPONENT ON ALL RUNWAYS PRODUCED BY UNIT WIND VELOCITY



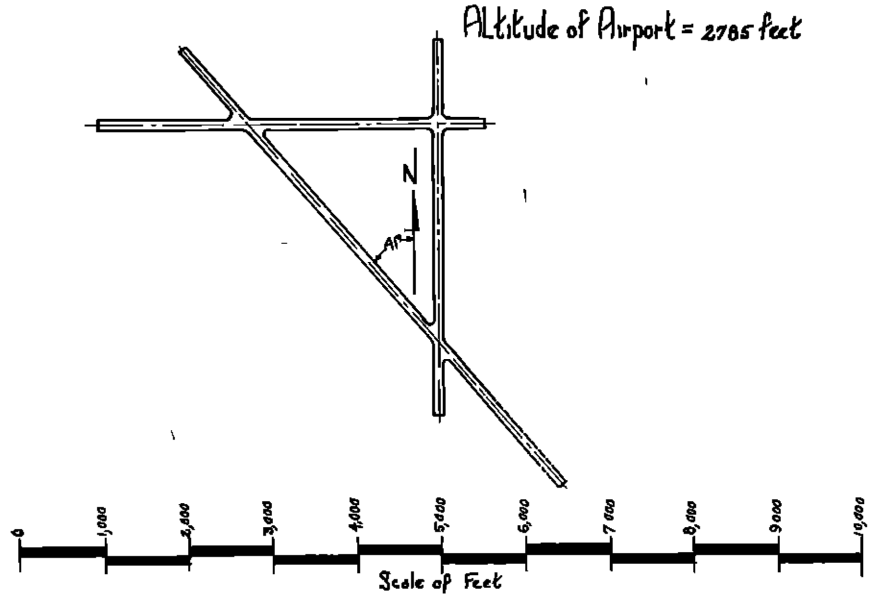
E,- AXIAL COMPONENT ON NE-SW & E-W RUNWAYS PRODUCED BY WIND CREATING UNIT CROSS COMPONENT ON N-S RUNWAY

AIRPORT DIAGRAM
DENVER, COLORADO

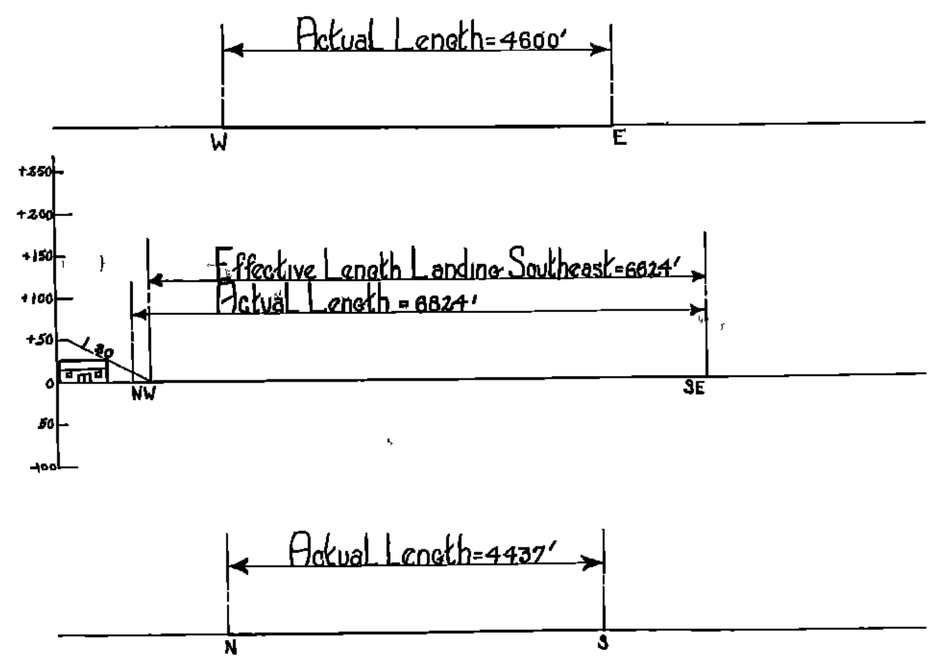
FIGURE NO.15

S 20764

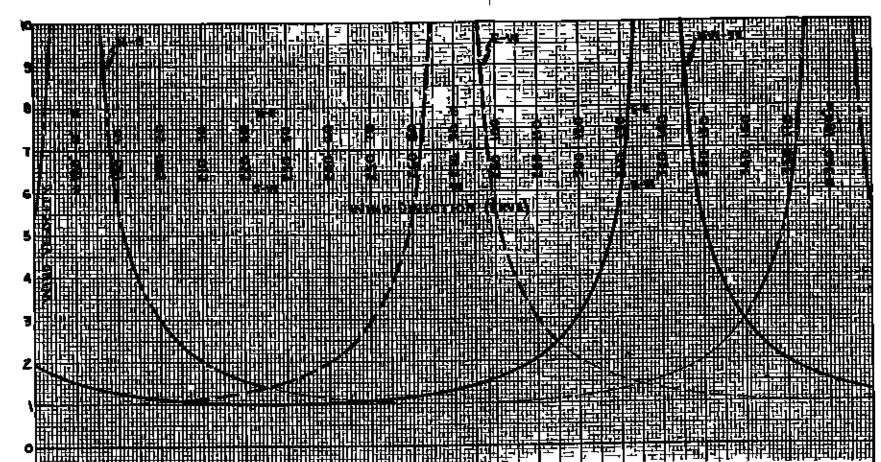
FLIGHT ENGINEERING REPORT NUMBER



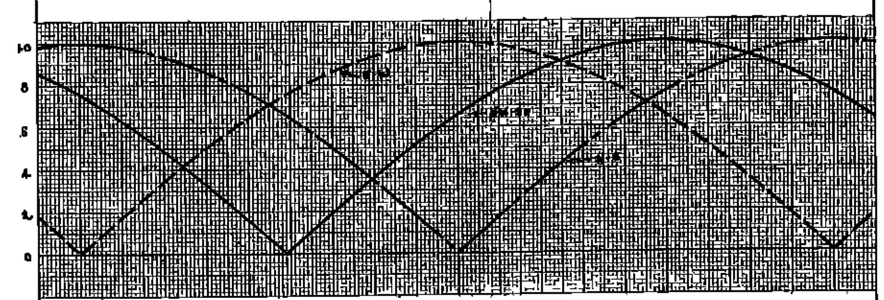
A-Plan of Airport



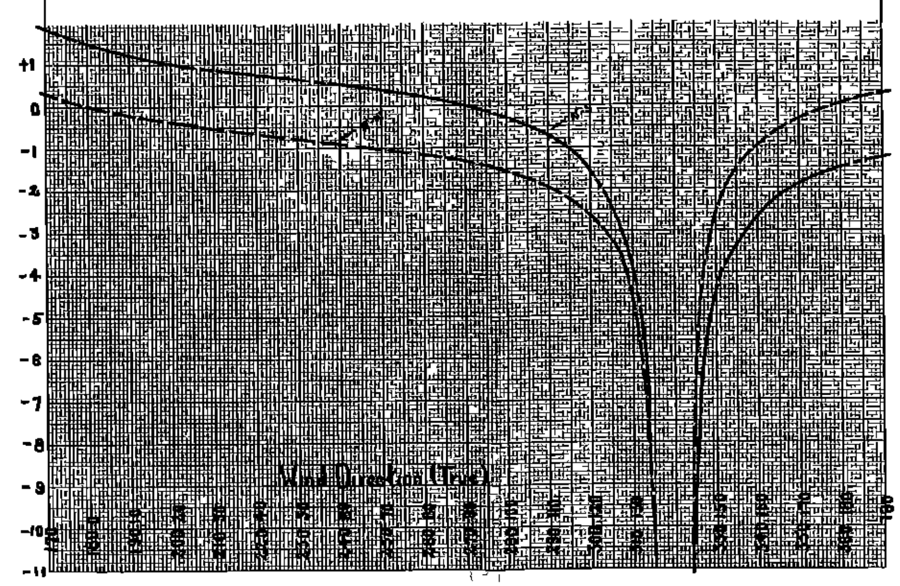
B-Profiles Along ℄ Runways



C, - WIND VELOCITY PRODUCING UNIT CROSS COMPONENT ON ALL RUNWAYS



D, - AXIAL COMPONENT ON ALL RUNWAYS PRODUCED BY UNIT WIND VELOCITY

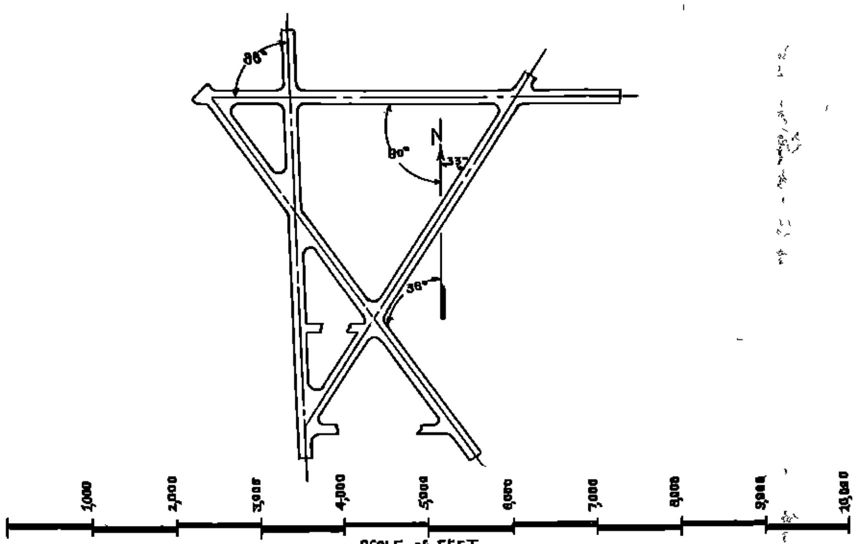


E, - AXIAL COMPONENT ON N-S AND E-W RUNWAYS PRODUCED BY WIND CREATING UNIT CROSS COMPONENT ON NW-SE RUNWAY

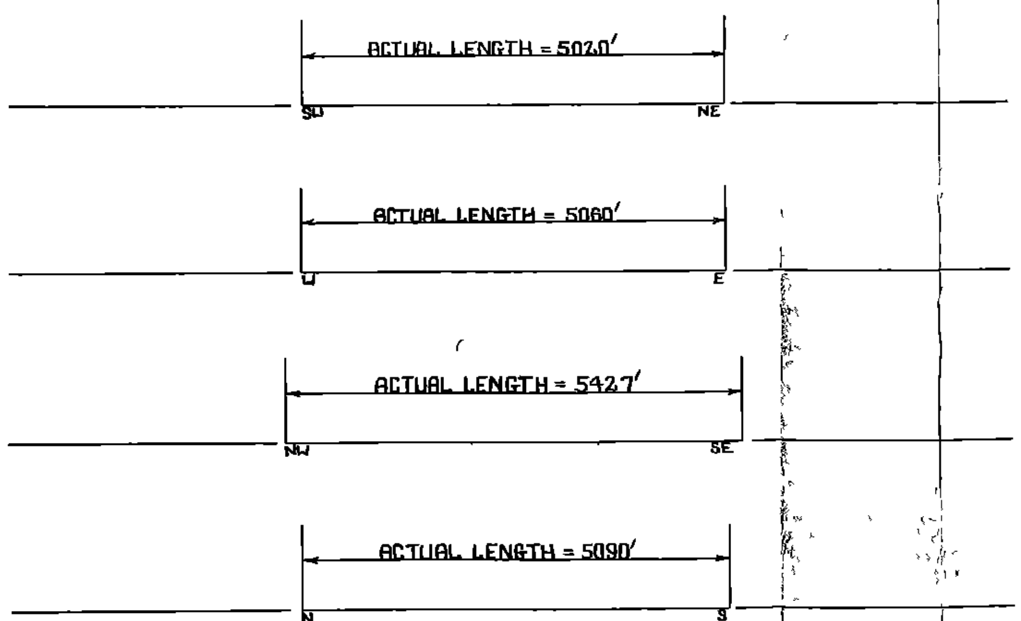
AIRPORT DIAGRAM
NORTH PLATTE, NEBRASKA

FIGURE NO 18

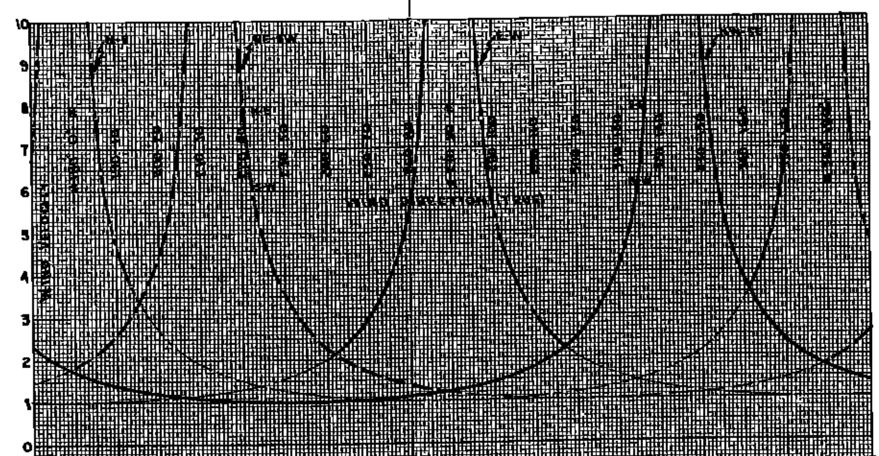
ALTITUDE OF AIRPORT = 977 FEET



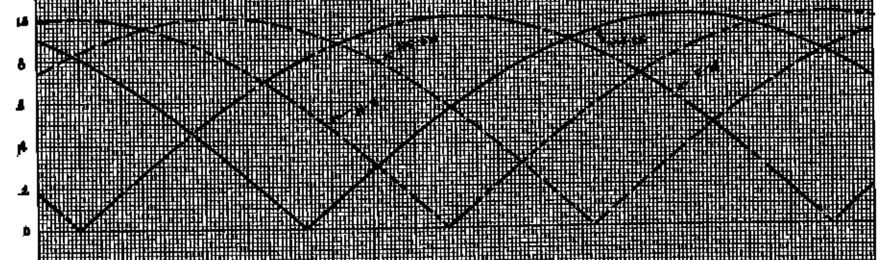
A-PLan of Airport



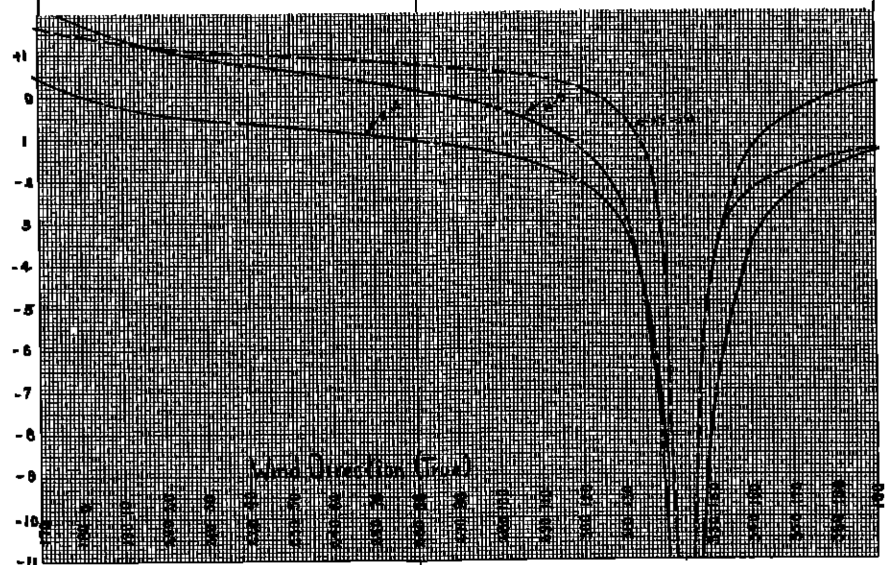
B- Profiles ALong ℄ Runways



C,- WIND VELOCITY PRODUCING UNIT CROSS COMPONENT ON ALL RUNWAYS



D,- AXIAL COMPONENT ON ALL RUNWAYS PRODUCED BY UNIT WIND VELOCITY

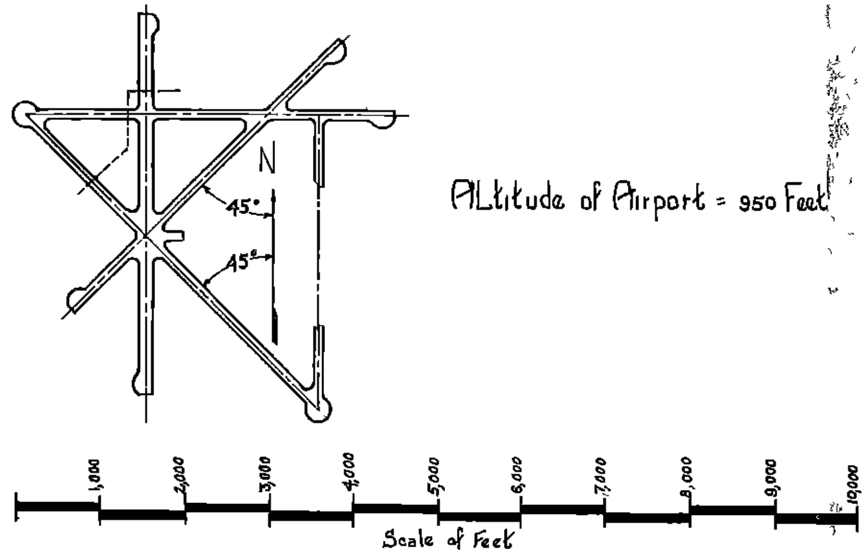


E- AXIAL COMPONENT ON NE-SW N-S & E-W RUNWAYS PRODUCED BY WIND CREATING UNIT CROSS COMPONENT ON NW-SE RUNWAY

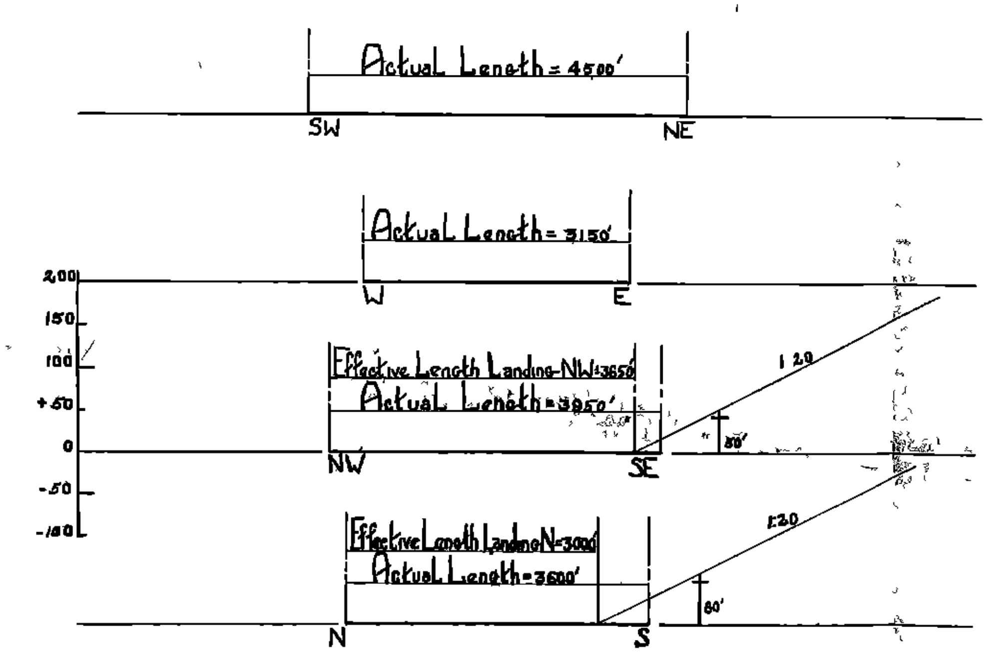
AIRPORT DIAGRAM
OMAHA, NEBRASKA

FIGURE NO 17

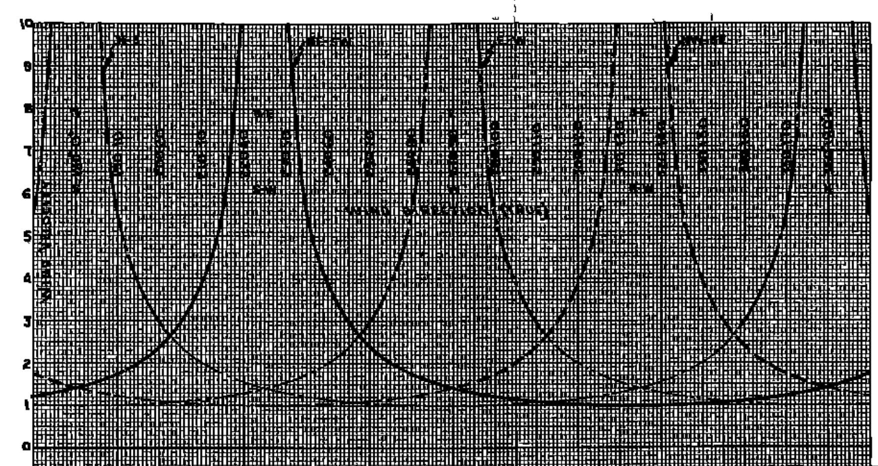
5-20764



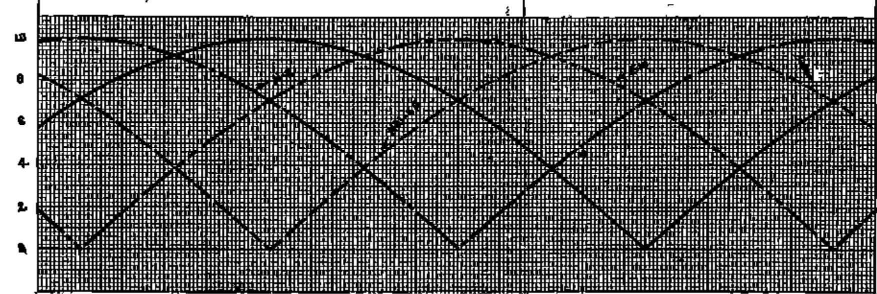
A- PLan of Airport



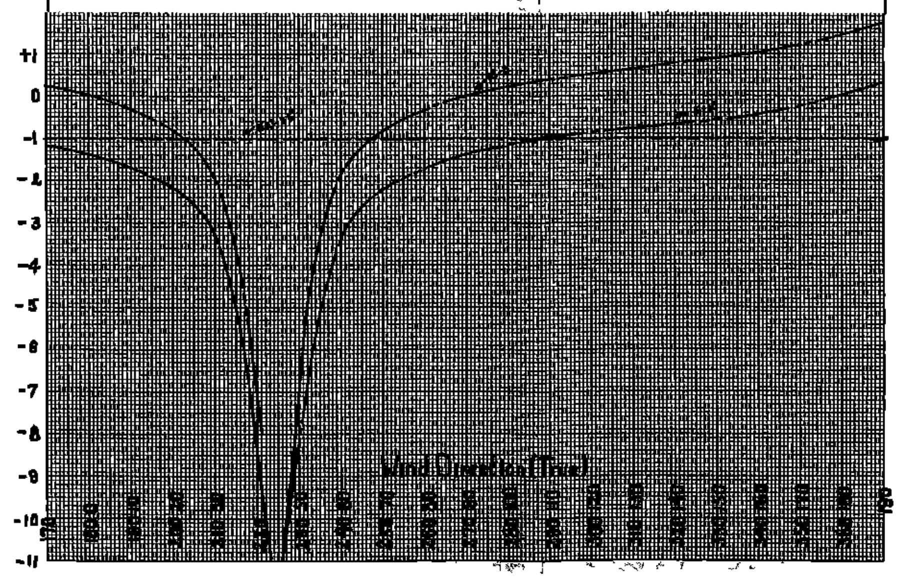
B- Profiles Along ℄ of Runways



C - WIND VELOCITY PRODUCING UNIT CROSS COMPONENT ON ALL RUNWAYS



D - AXIAL COMPONENT ON ALL RUNWAYS PRODUCED BY UNIT WIND VELOCITY

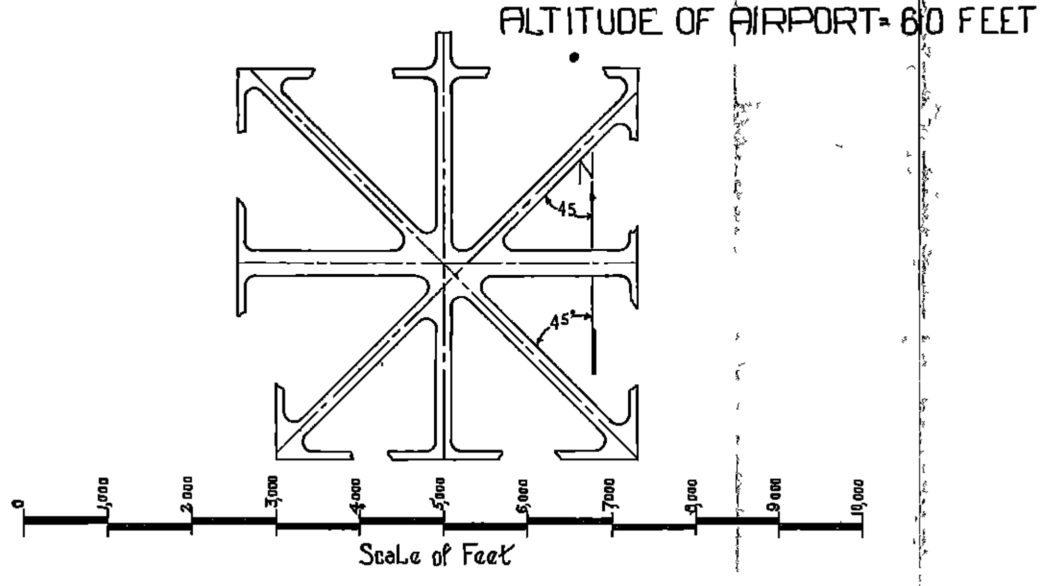


E - AXIAL COMPONENT ON NW-SE N-S & E-W RUNWAYS PRODUCED BY WIND CREATING UNIT CROSS COMPONENT ON NE-SW RUNWAY

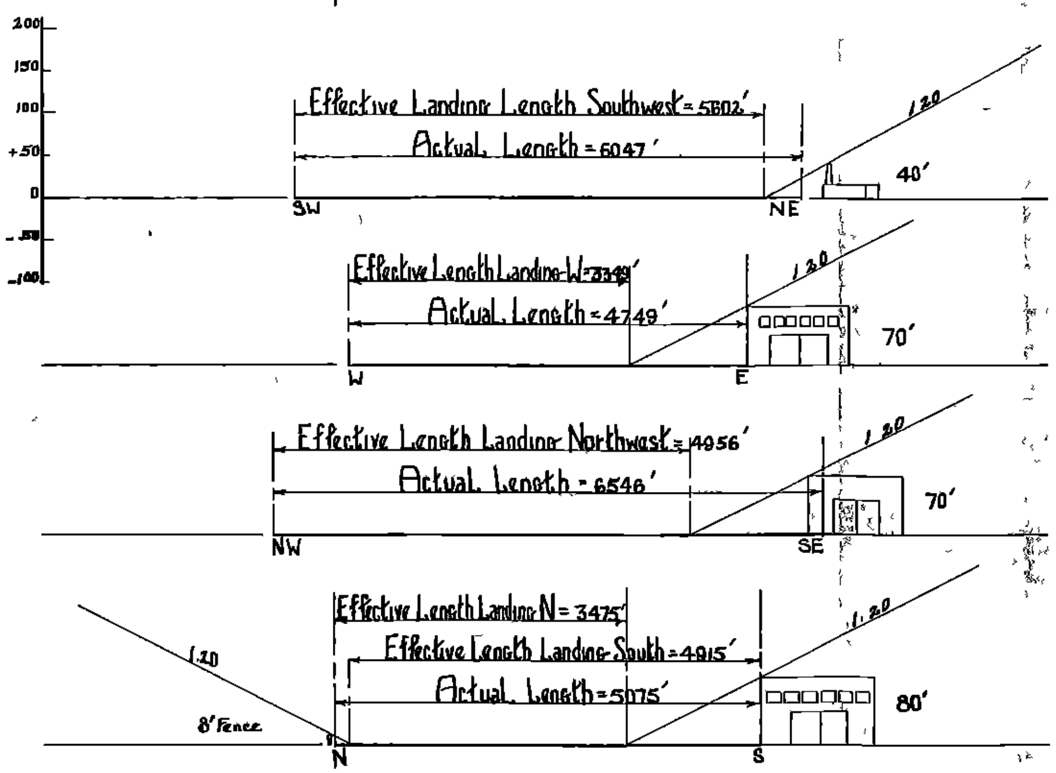
AIRPORT DIAGRAM
DES MOINES IOWA

FIGURE NO. 18

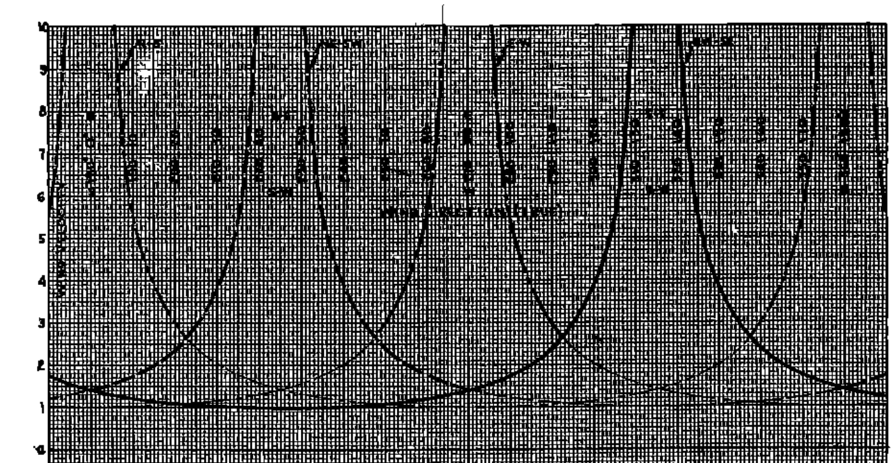
S-20764



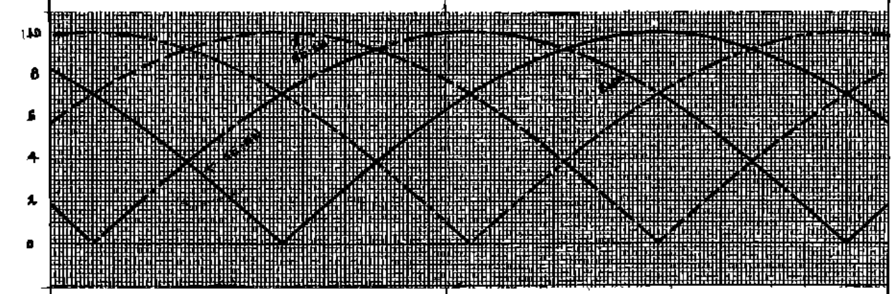
A- Plan of Airport



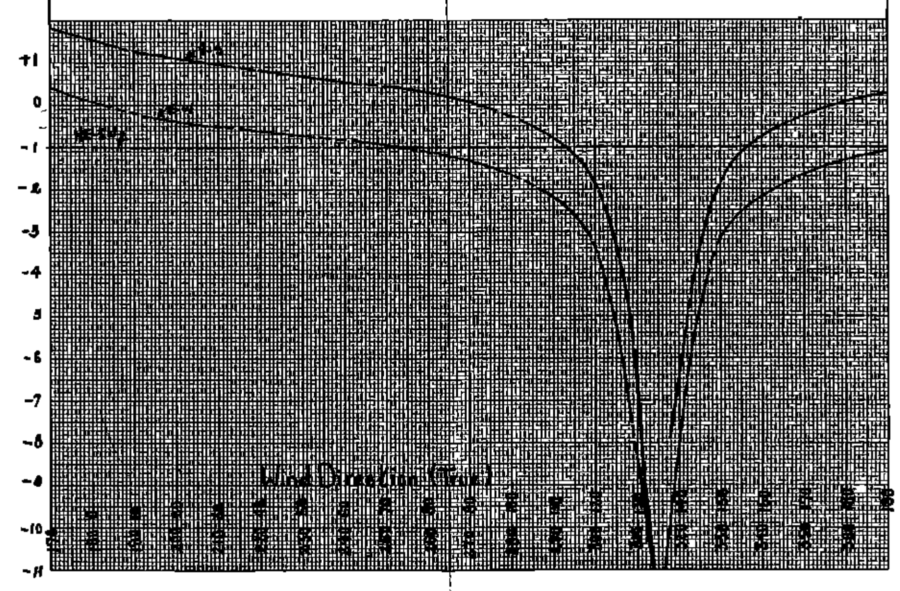
B- Profiles Along ℄ of Runways



C,- WIND VELOCITY PRODUCING UNIT CROSS COMPONENT ON ALL RUNWAYS



D,- AXIAL COMPONENT ON ALL RUNWAYS PRODUCED BY UNIT WIND VELOCITY

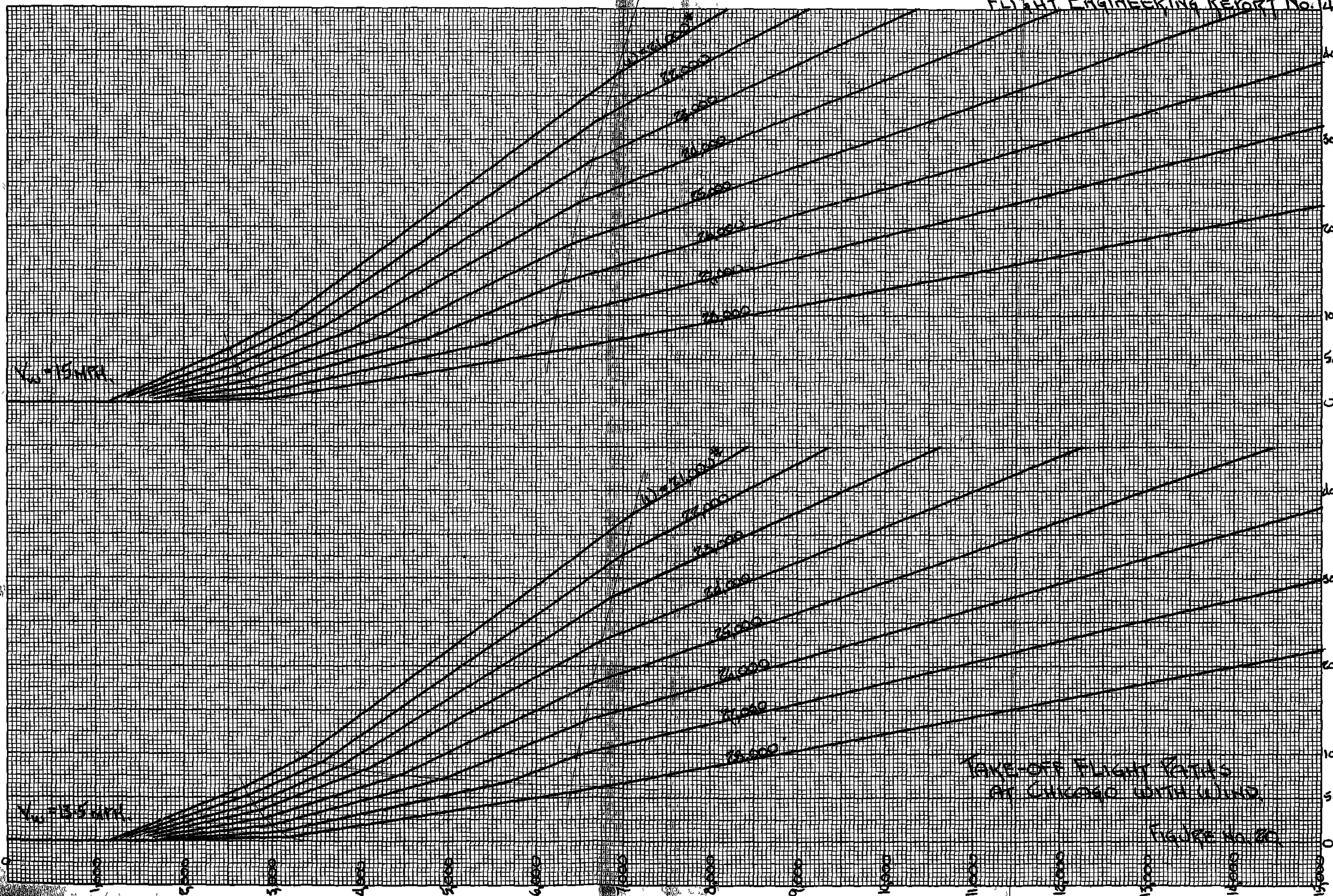


E,- AXIAL COMPONENT ON N-S, NE-SW & EW RUNWAYS PRODUCED BY WIND CREATING UNIT CROSS COMPONENT ON NW-SE RUNWAY

AIRPORT DIAGRAM
CHICAGO, ILLINOIS

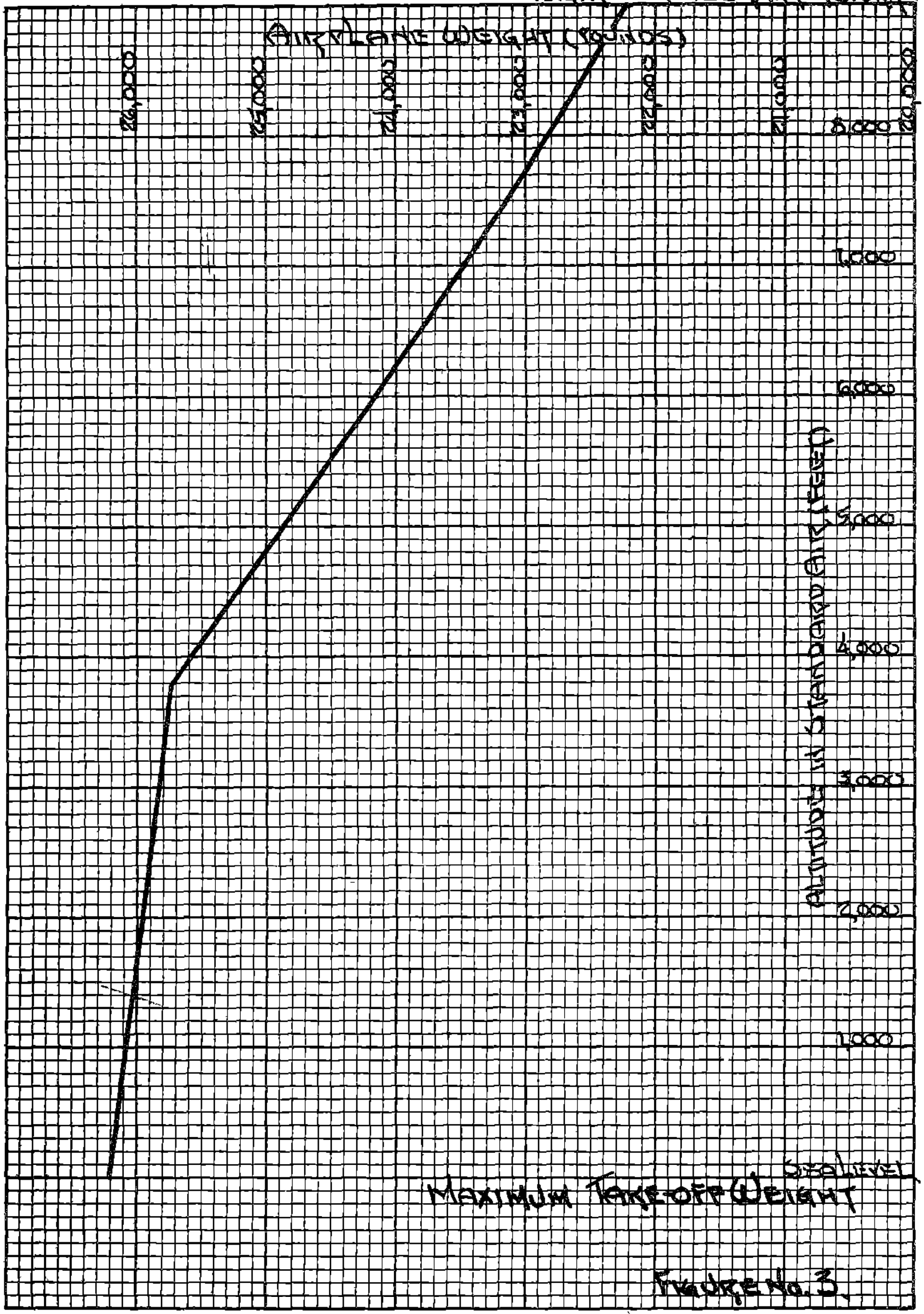
FIGURE NO 19

5-20764



TAKE-OFF FLIGHT PATHS
AT CHICAGO WITH WIND.

FIGURE No. 20



MAXIMUM TAKE-OFF WEIGHT

FIGURE NO. 3.

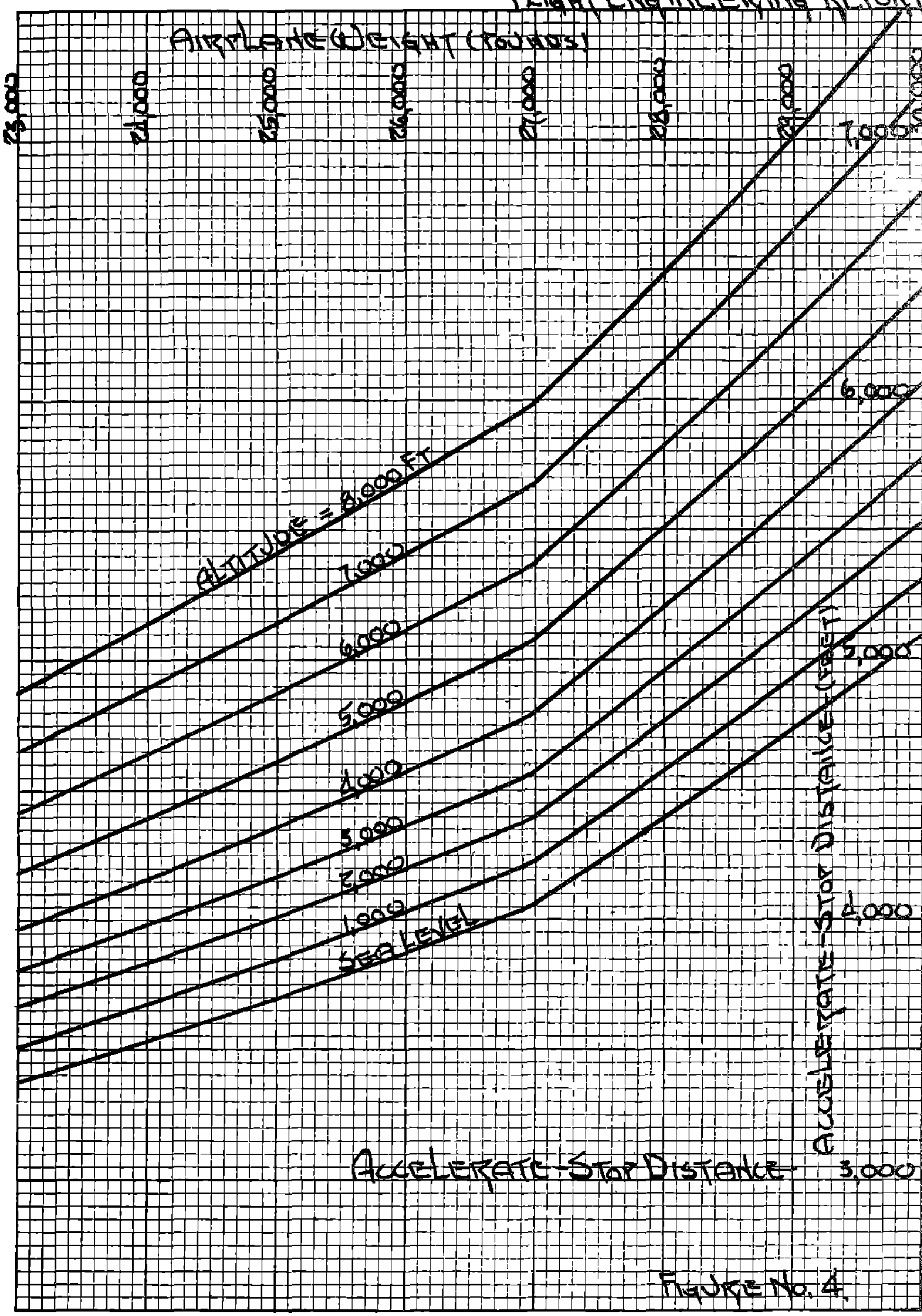
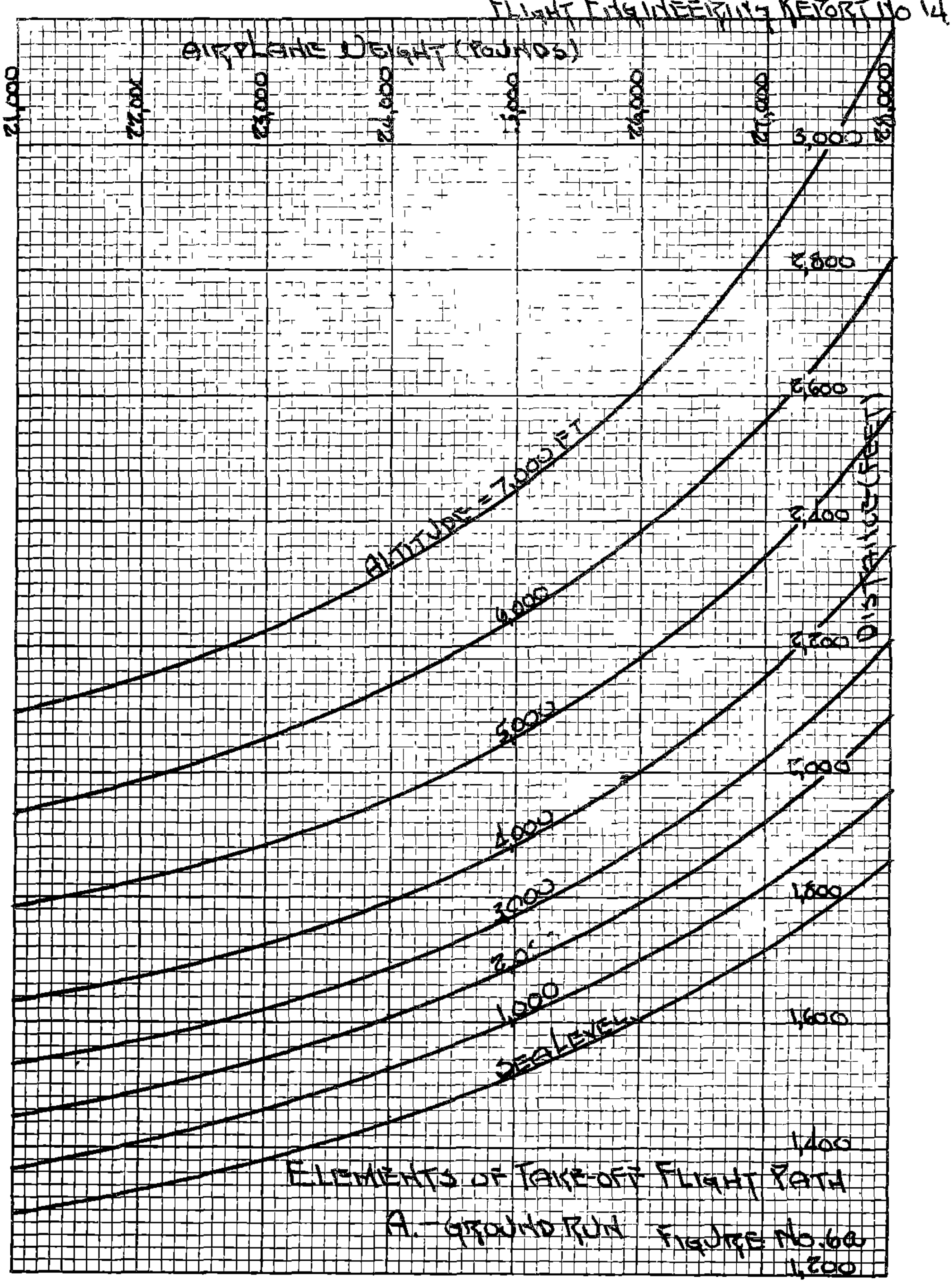
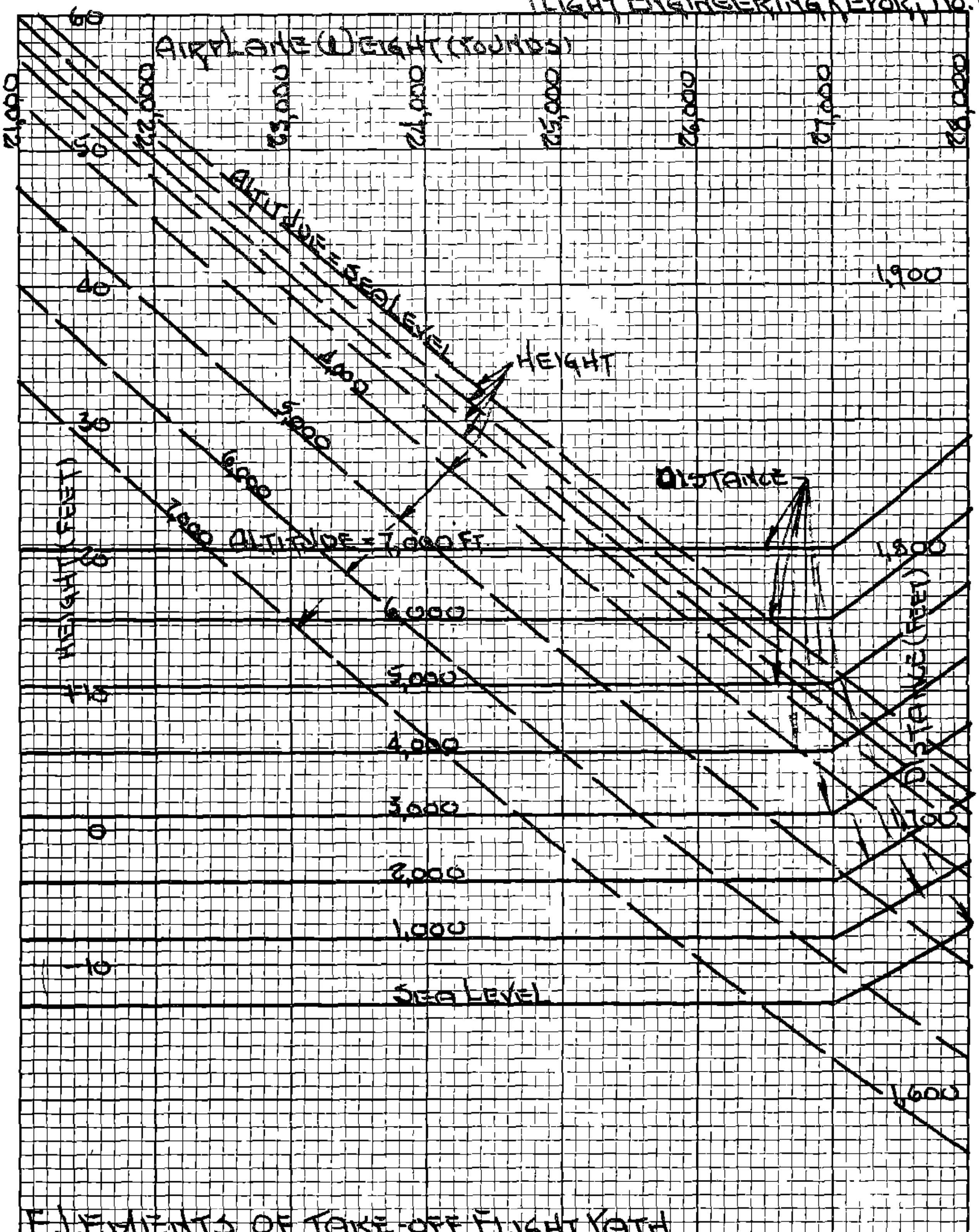


FIGURE No. 4

5-20764

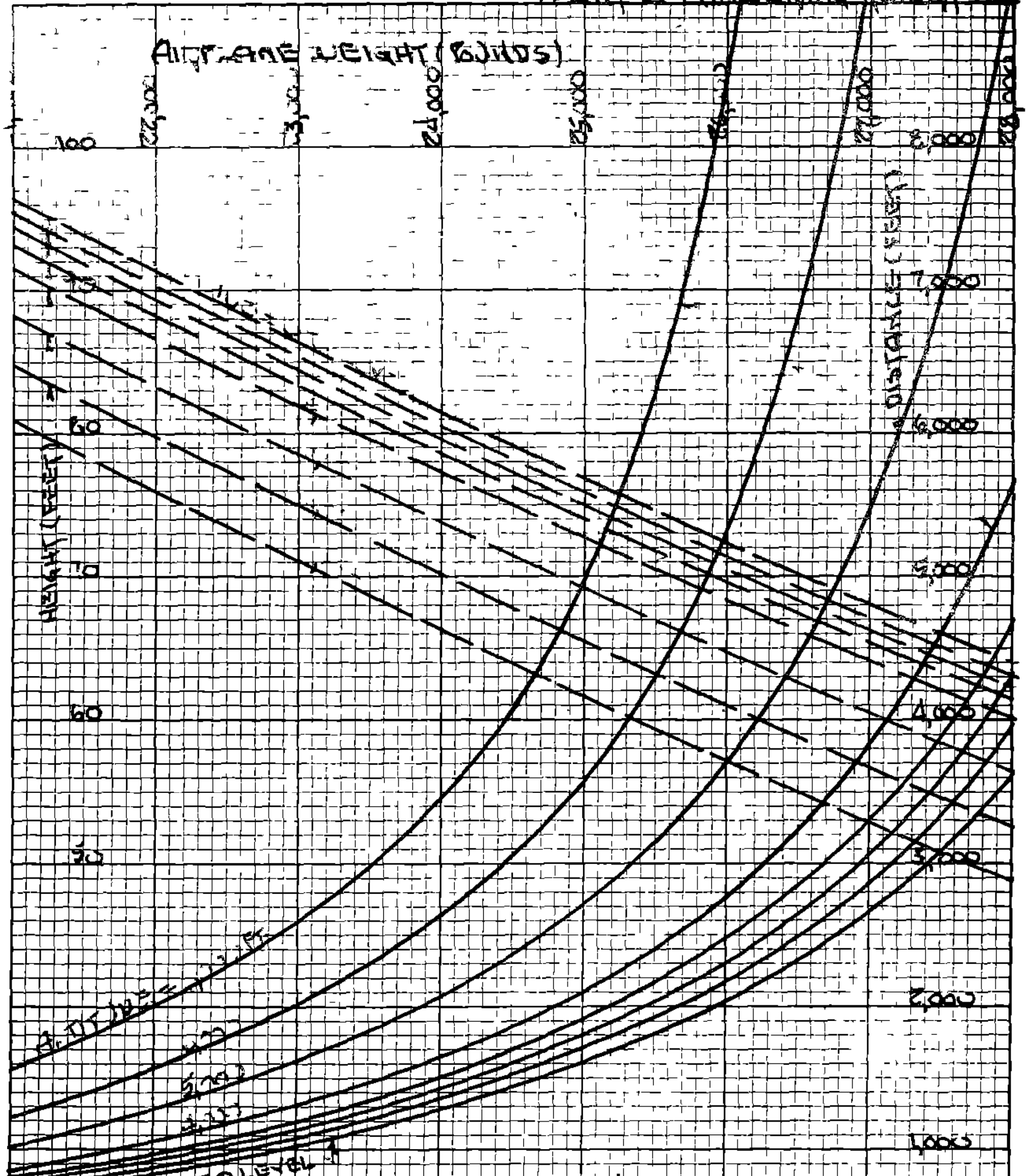

FLIGHT ENGINEERING REPORT NO 14
AIRPLANE WEIGHT (POUNDS)
21,000
22,000
23,000
24,000
25,000
26,000
27,000
28,000
DISTANCE (FEET)
3,000
2,800
2,600
2,400
2,200
2,000
1,800
1,600
1,400
1,200
ALTITUDE = 7,000 FT
6,000
5,000
4,000
3,000
2,000
1,000
SEA LEVEL
ELEMENTS OF TAKE-OFF FLIGHT PATH
A. - GROUND RUN
FIGURE NO. 68

1764



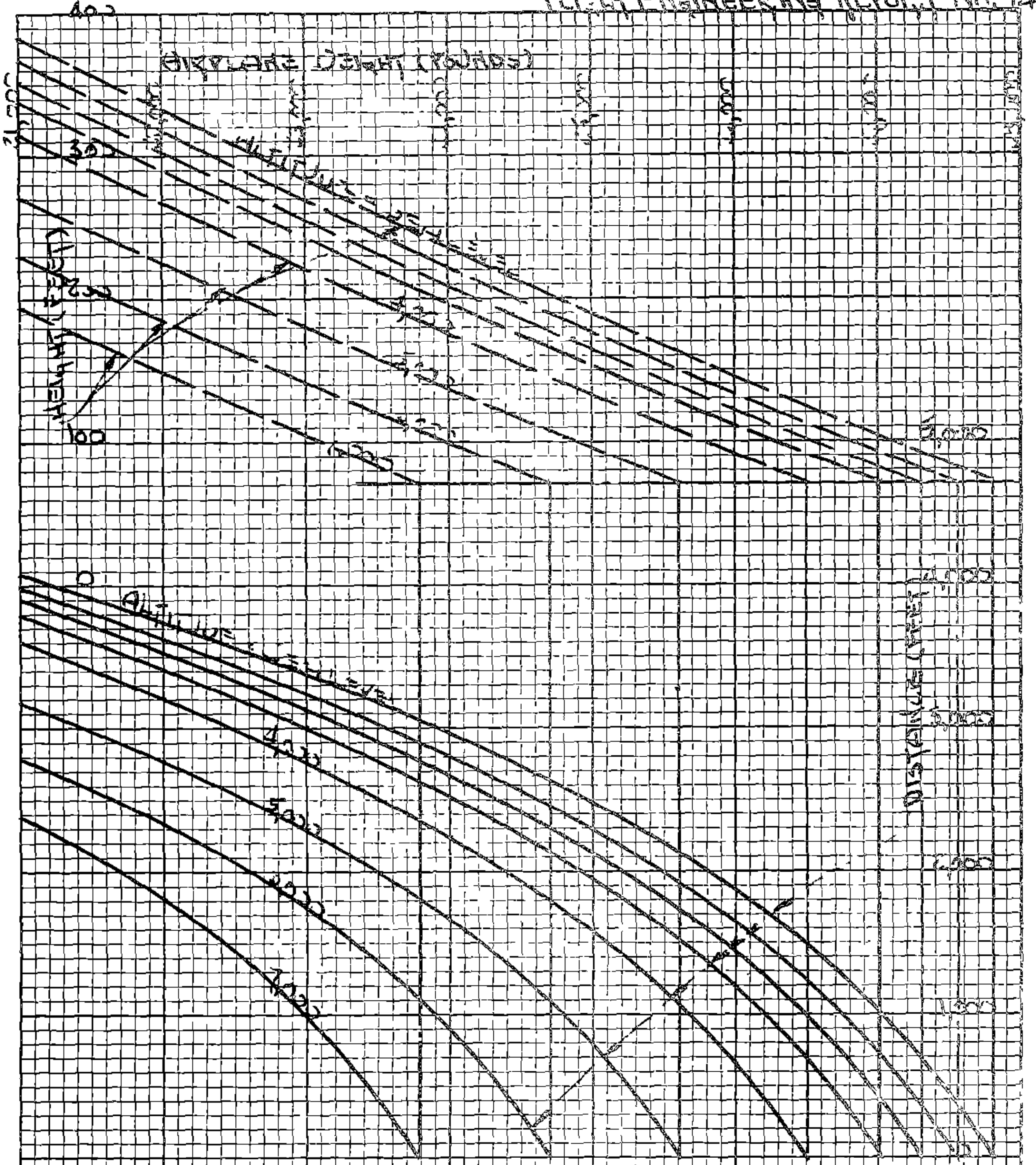
ELEMENTS OF TAKE-OFF FLIGHT PATH
B - DISTANCE & HEIGHT TRAVERSED RETRACTING GEAR.

FIGURE IV-6b



ELEMENTS OF TAKE-OFF FLIGHT PATH
— DISTANCE TRAVERSED, GEAR RETRACTED TO PROPELLER FEATHERED VS HEIGHT ATTAINED.

FIGURE NO. [illegible]

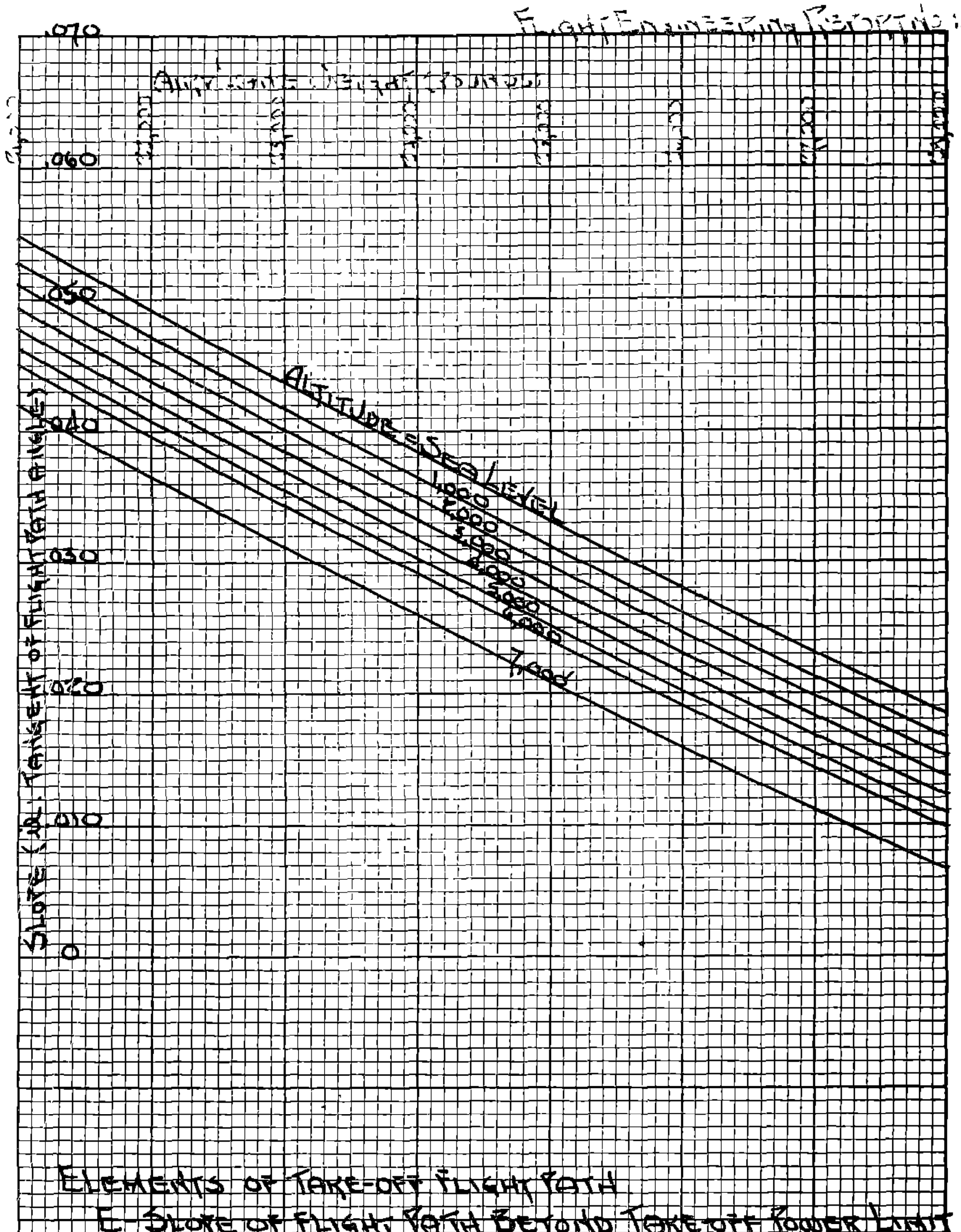


ELEMENTS OF TAKE-OFF FLIGHT PATH

D - DISTANCE TRAVERSED - PROPELLER FEATHERED TO ONE MINUTE FROM START OF TAKE-OFF & HEIGHT ATTAINED

FIGURE NO. 41

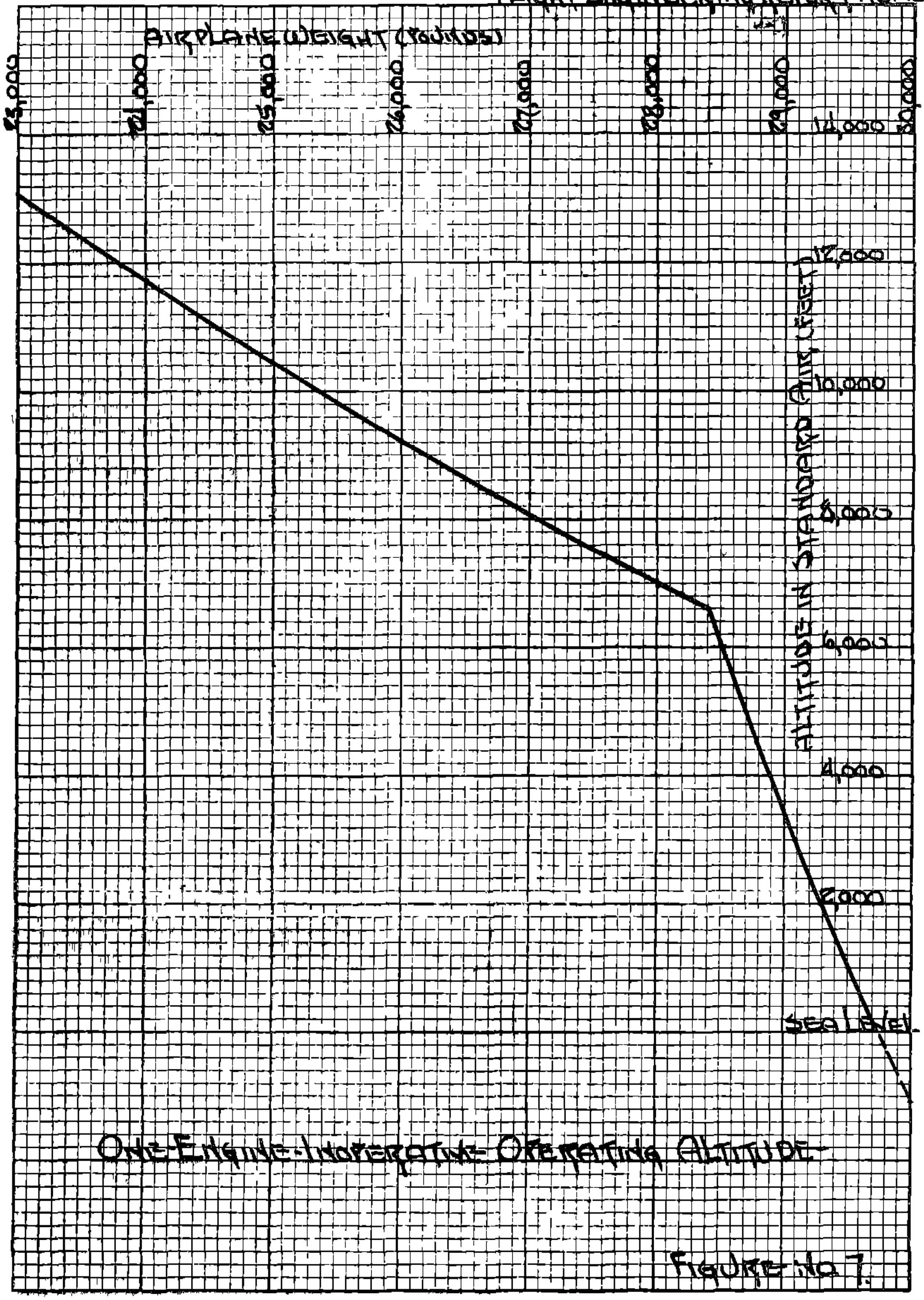
520764



Elements of Take-off Flight Path
E - Slope of Flight Path Beyond Take-off Power Limit

Figure No. 62

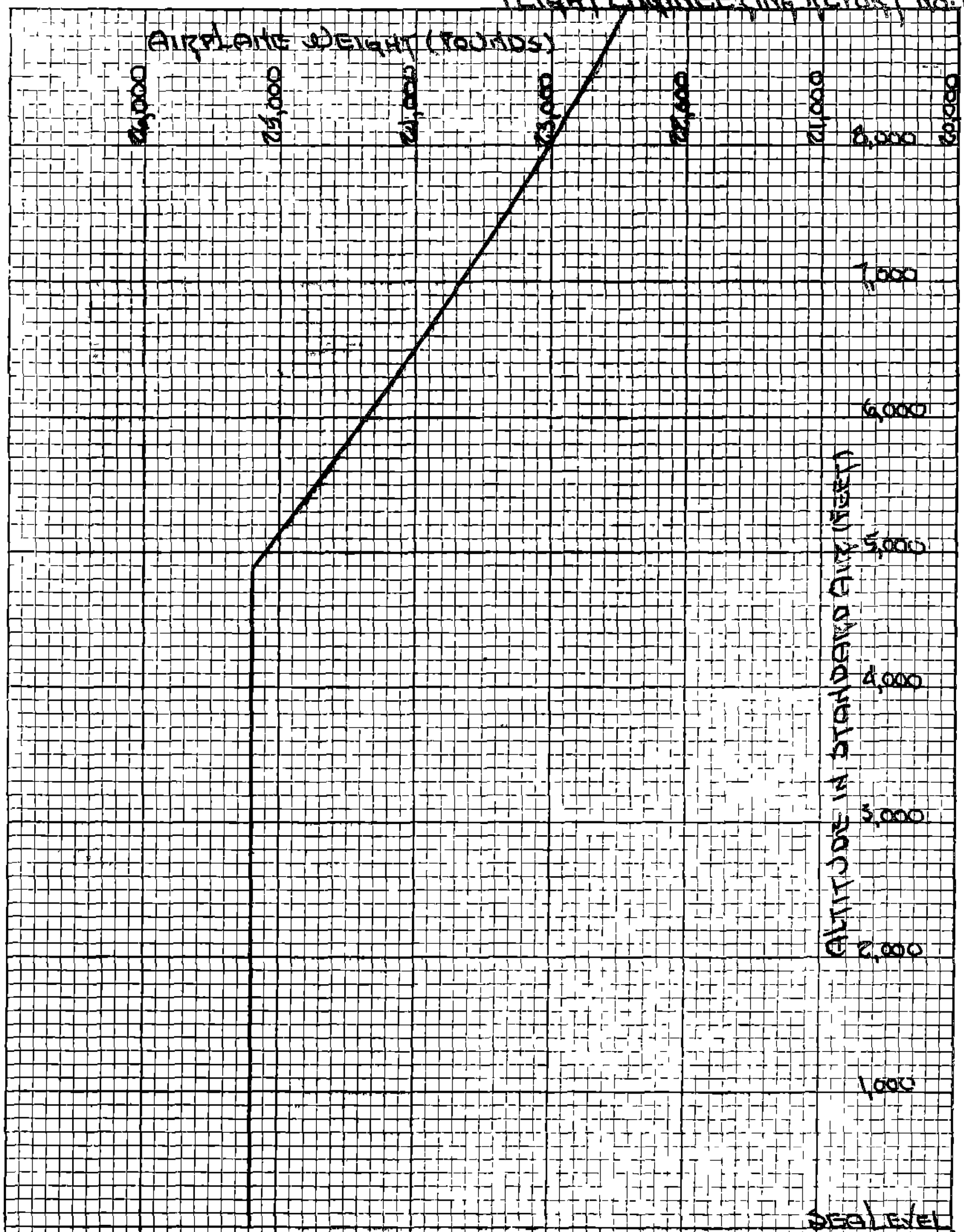
5 20764



ONE-ENGINE-INOPERATIVE OPERATING ALTITUDE

FIGURE NO. 7.

20764



MAXIMUM LANDING WEIGHT

FIGURE No. 6

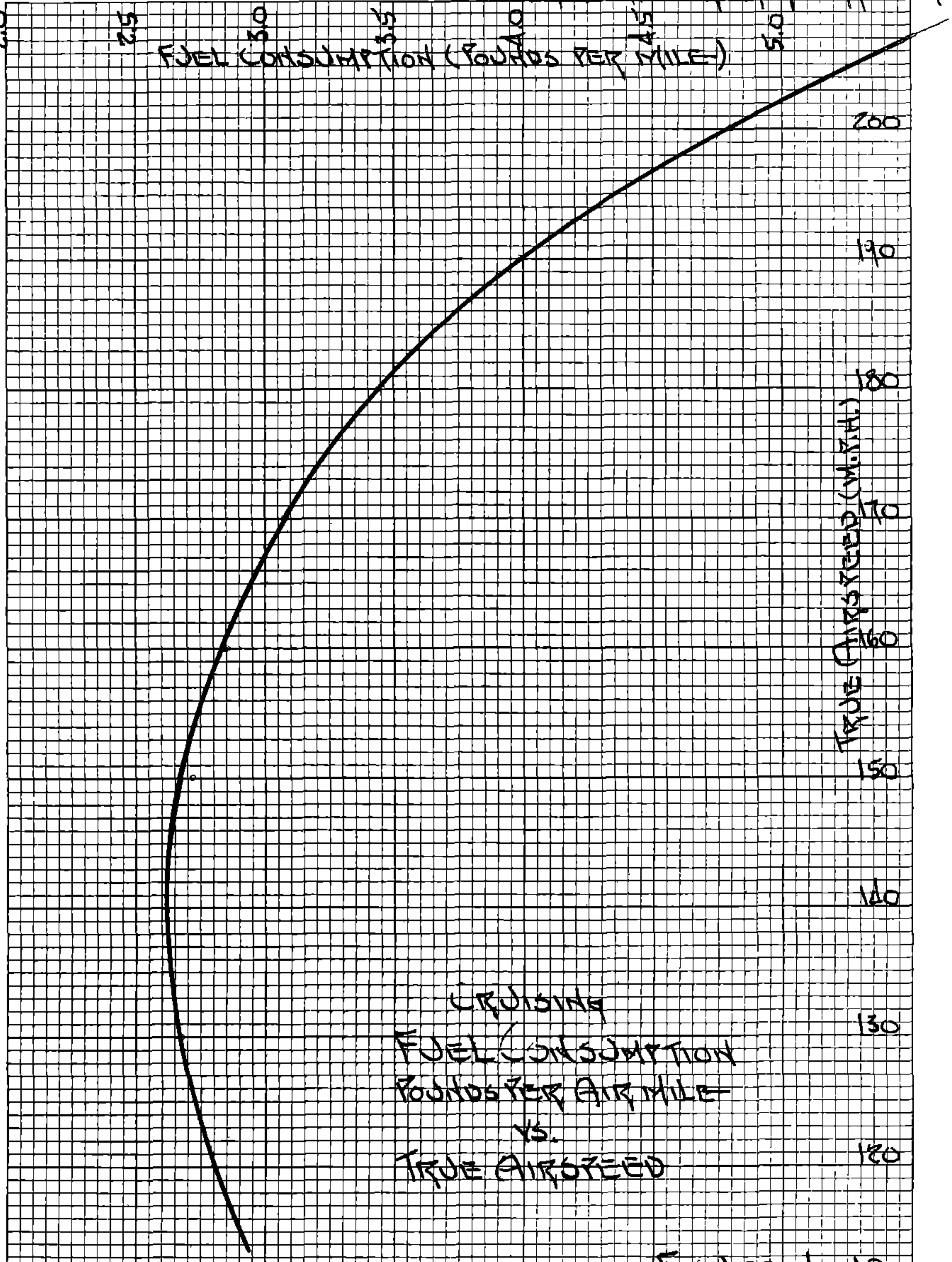

2.5
3.0
3.5
4.0
4.5
5.0
FUEL CONSUMPTION (POUNDS PER MILE)
200
190
180
170
160
150
140
130
120
TRUE AIRSPEED (M.P.H.)
CRUISING
FUEL CONSUMPTION
POUNDS PER AIR MILE
VS.
TRUE AIRSPEED

FIGURE NO. 10.