part 3
takeoff

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION.

The takeoff and climbout performance charts are presented in a form which allows corrections to be made for the several factors which affect performance. Some of the charts may be used only when the engine power is known. In these cases the brake horsepower, or BMEP, may be determined from the Brake Horsepower Available For Takeoff charts in Part 2. Generally, only 95% of the predicted power is used to determine takeoff performance.

On those charts where wind corrections are provided, the user shall apply 50% of the reported headwind and 150% of the reported tailwind. This is the recommended procedure, which may be revised at the discretion of the pilot, dependent upon the source of measurement of the wind data.

All the takeoff charts are based on a wing flap setting of 20 degrees. Each type of chart is discussed in detail below. Sample problems with chase-around lines are also provided on the individual charts to aid in their use.

Indicated takeoff speeds based on the copilot's airspeed system, to be used for determining lift-off speed when on the ground, are shown on the Ground Run chart *(figure A3-3)*. Indicated takeoff speeds based on the pilot's airspeed system, to be used in flight when it is necessary to clear obstacles immediately after takeoff, are shown on the Liftoff, Landing, and Stall Speeds chart *(figure 2-5)*.

MAXIMUM TAKEOFF GROSS WEIGHT.

Safe operation of the aircraft requires that takeoffs not be attempted at gross weights for which acceleration, rate of climb, or obstacle clearance capability are marginal. There are four primary factors which must be considered when determining a safe limit for the takeoff gross weight.

1. The ability of the structure to withstand taxiing loads and inflight maneuvering loads is shown as design takeoff gross weights on the Gross Weight Limitation Chart in Section V.
2. The ability to take off or stop within the available runway is shown on the Critical Field Length charts *(figures A3-6 and A3-7)*.
3. The ability to have adequate rate of climb when airborne is shown on the Gross Weight Limited by Three-Engine Climb Performance chart *(figure A3-2)*.
4. The ability to clear obstacles within the takeoff corridor is determined by the Climbout Factor charts *(figures A3-12 through A3-14)* and the Gross Weight Limited By Climbout Over Obstacle chart *(figure A3-15)*.

For a given set of takeoff conditions, each of these four considerations will permit a different gross weight. Any one of the four weights may be the lowest, depending on the conditions. For this reason, all four factors must be considered for each takeoff, even though in many cases one or more of them may be eliminated after cursory examination. The lowest weight determined by these factors will be the maximum takeoff gross weight.

TAKEOFF WITHOUT ALLOWANCE FOR ENGINE FAILURE.

Charts are provided to show the takeoff performance of the aircraft without allowance for engine failure. They are intended as a guide to show the ultimate performance of the aircraft. Ordinarily, takeoff performance should be determined by allowing for the possibility of an engine failure.

The takeoff of the airplane is made with a wing flap deflection of 20 degrees and with four engines operating at maximum power. Performance for this configuration is illustrated by the Takeoff Factor chart *(figure A3-1)*, the Takeoff Performance — Ground Run chart *(figure A3-3)*, the Effect of Runway Slope on Ground Run chart *(figure A3-4)*, the Effect of Runway Surface Conditions On Ground Run chart *(figure A3-5)*, the Climbout Factor — Four-Engine — Ground Effect Not Included chart *(figure A3-12)* and the Gross Weight Limited By Climbout Over Obstacle chart *(figure A3-15)*. An acceleration check may be determined from the Takeoff Performance — Distance and Time Vs Speed chart *(figure A3-10)* or the Takeoff Performance — Acceleration Increment Time Check chart *(figure A3-11)*. These charts are based on lifting off at the takeoff speed shown on the Takeoff Performance — Ground Run chart *(figure A3-3)* and maintaining that speed until the immediate obstacles are cleared.

TAKEOFF WITH ALLOWANCE FOR ENGINE FAILURE.

Normal takeoff planning procedure allows for the possibility of an engine failure during the takeoff. There are two methods for which data are provided herein.

CRITICAL FIELD LENGTH METHOD.

The critical field length method utilizes data from the Takeoff Performance — Critical Field Length charts *(figures A3-6 and A3-7)*. When using this method, if an engine fails before the critical engine failure speed is reached, the aircraft is stopped. If an engine fails after the critical engine failure speed is reached, the takeoff is continued. Takeoff speeds are the same as those shown on the Takeoff Performance — Ground Run chart *(figure A3-3)*. Climbout flight path data are determined from the Climbout Factor — Three-Engine charts *(figures A3-13 and A3-14)*, and from the Gross Weight Limited By Climbout Over Obstacle chart *(figure A3-15)*.

REFUSAL SPEED METHOD.

The refusal speed method will be used when the available runway is longer than the critical field length. This method utilizes data from the Takeoff Performance — Ground Run chart *(figure A3-3)*, the Takeoff Performance — Refusal Speed charts *(figures A3-8 and A3-9)*, and the Takeoff Performance — Distance and Time Versus Speed chart *(figure A3-10)*. When using the method above, an acceleration check point (time and/or distance) and an acceleration speed will be determined to validate proper acceleration prior to reaching the refusal speed. The acceleration check may be accomplished by checking the time to accelerate between two predetermined speeds from the Takeoff Performance — Acceleration Increment Time Check chart *(figure A3-11)* rather than checking airspeed at a given check point. If an engine fails, or the acceleration speed is below designated acceleration check point, the aircraft is stopped. If an engine fails between the acceleration check point and refusal speed, the aircraft is also stopped. If an engine fails after reaching refusal speed, the takeoff should be continued.

However, it is possible for the aircraft performance to be better than predicted. This will generally be the case when 95% of the predicted BMEP is used to determine takeoff performance. The result can be acceleration to a higher speed than expected at the acceleration check point, from which the aircraft might not be stopped within the remaining length of runway. To avoid an attempt to stop from too high a speed, the takeoff should be continued if an engine fails after the aircraft has attained the acceleration check speed even though the acceleration check point has not been reached.

The following steps summarize what action should be taken when using the refusal speed method.

1. Stop (abort takeoff):
   a. If acceleration check speed is not attained by the time the acceleration check point, either time or distance, is reached.
   b. If engine failure occurs before acceleration check speed is attained.
   c. If an engine failure occurs between the acceleration check point and refusal speed.
2. Go (continue takeoff): If an engine failure occurs after reaching refusal speed.

If the acceleration check speed is less than the critical engine failure speed, it may not be possible to accelerate the aircraft to takeoff speed if an engine should fail shortly after attaining the acceleration check speed. In such cases the critical engine failure speed should be the abort criterion rather than the acceleration check point.

DISCUSSION OF CHARTS.

TAKEOFF PERFORMANCE — TAKEOFF FACTOR.

The Takeoff Performance — Takeoff Factor chart *(figure A3-1)* is used to provide a common factor for computing takeoff performance on the ground run, critical field length, and refusal speed charts, and for determining a climbout factor for the climbout flight path charts.

The chart uses BMEP corrected for OAT and pressure altitude to provide a common factor based on sea level standard day wet power with standard grade fuel as a zero factor. A sample problem to illustrate the method of using the chart is included on the chart.

GROSS WEIGHT LIMITED BY THREE-ENGINE CLIMB PERFORMANCE CHART.

The effect of pressure altitude and engine power on climb performance cannot be shown accurately as limit lines on the critical field length charts. For this reason, the Takeoff Gross Weight Limited By Three-Engine Climb Performance chart *(figure A3-2)* is provided to indicate the gross weight limit required to achieve the desired rate of climb. Curves are provided to indicate the gross weight for zero and 50 feet per minute rate of climb at lift-off with gear down and inoperative propeller windmilling, and for 50 and 100 feet per minute rate of climb with the gear up and the inoperative propeller feathered. The rate of climb in each case is based on climb at takeoff speed with the wing flaps set for takeoff and no ground effect.

The curves for lift-off with the gear down and inoperative propeller windmilling are for informational purposes only and are not to be used as a limiting factor in establishing the permissible takeoff gross weight. In no case should the gross weight for 50 feet per minute rate of climb with the gear up be exceeded.

The design takeoff gross weights of 107,000 pounds for normal operation and 112,000 pounds for war emergency are also indicated on the chart. These limits should not be exceeded even though the rate of climb may be adequate.

The use of this chart requires that the engine power and density altitude be known. The engine power may be determined from the Brake Horsepower Available For Takeoff Charts in Part 2. Generally, 95 percent of the predicted BMEP is used to enter this chart. The density altitude may be obtained from the density altitude curve of the Takeoff Performance — Takeoff Factor chart *(figure A3-1)*.

Sample Problem:

GIVEN: Density altitude = 2100 feet.
BMEP = 230 psi.

FIND: Gross weight for zero rate of climb at lift-off with gear down and inoperative propeller windmilling and for 50 feet per minute rate of climb with gear up and inoperative propeller feathered.

1. Enter the chart with density altitude of 2100 feet (A).
2. Read up to BMEP of 230 psi (B), and across to the zero rate of climb for lift-off (C).
3. Read down to find gross weight of 104,700 pounds (D). This gross weight is for information only.
4. Continue across the chart to the 50 feet per minute rate of climb line for gear up (E).
5. Read down to find the maximum gross weight at which 50 feet per minute rate of climb can be maintained of 125,500 pounds (F). See note on chart for structural limitations.

GROUND RUN CHART.

The ground run chart *(figure A3-3)* shows the distance required to accelerate from a standstill to takeoff speed on a dry, hard-surface, level runway with all four engines operating. Indicated takeoff speeds are shown based on the copilot's ground run airspeed calibration. The takeoff factor needed for the use of this chart may be obtained from the Takeoff Performance — Takeoff Factor chart *(figure A3-1)*.

Sample Problem:

GIVEN: Takeoff factor = 8.5.
Gross weight = 95,000 pounds.
Wind = 20 knots headwind 50 percent of reported headwind).

FIND: Takeoff ground run corrected for wind.

1. Enter the chart with takeoff factor of 8.5 (A) and read across to gross weight of 95,000 pounds (B).
2. Read down to find uncorrected ground run of 4375 feet (C).
3. Correct for wind by following headwind curve to 20 knots (D) and reading down to find corrected ground run of 3170 feet (E).

RUNWAY SLOPE CORRECTION CHART.

This chart *(figure A3-4)* is to be used to correct data obtained from the Ground Run chart *(figure A3-3)* when runways have slopes other than zero.

EFFECT OF RUNWAY SURFACE CONDITIONS ON GROUND RUN.

The Effect of Runway Surface Conditions on Ground Run chart *(figure A3-5)* is used to correct the takeoff ground run for various runway conditions affecting the coefficient of rolling friction. The coefficient of rolling friction values given on this chart are approximate since numerous factors, such as condition of the tires or the amount of water on a wet runway can result in a slight change from the values shown.

A sample problem to illustrate the use of the chart is included on the chart.

CRITICAL FIELD LENGTH CHART.

The critical field length as shown on *figure A3-6 and A3-7* is defined as the distance required to accelerate with four engines from a standstill to the critical engine failure speed, experience an engine failure, and then either come to a stop or continue accelerating with three engines to the takeoff speed in the same distance.

The stopping distance has been determined by the use of brakes only, and by the use of brakes plus two engines reverse thrust. Since, in most cases, reverse thrust may be used, it should not be difficult to duplicate this stopping distance even though runway conditions may not be so favorable. As an added safety margin, these data are based on a three second time delay after reaching the critical engine failure speed before the engines are cut and the brakes applied.

The three-engine acceleration part of the critical field length is based on the inoperative propeller windmilling. The indicated takeoff speeds may be obtained from the Ground Run chart *(figure A3-3)* for ground run calibration (copilot's system), or from the Liftoff, Landing, and Stall Speeds charts *(figure 2-5 in Section II)* for in-flight calibration (pilot's system).

A sample problem illustrating the use of the chart is included on the chart for brakes only *(figure A3-6)*.

REFUSAL SPEED CHART.

The usual situation during operation of the C-118A aircraft is to have an actual runway length greater than the critical field length for the given conditions. Since it is always desirable to safely stop an airplane within the limits of the runway in the event of an engine failure rather than risk a three-engine takeoff and go-around, the refusal speed charts *(figure A3-8 and A3-9)* are presented to allow the decision to stop to be made at the highest speed possible.

The refusal speed as shown on these charts is refined as the maximum speed which may be reached, accelerating from a standstill with four engines operating, and from which a stop may be made within a given runway length. If the critical field length and runway length are the same, then refusal speed and critical engine failure speed are identical. If, however, the runway length is greater than critical field length, then the refusal speed may be considerably higher than the critical engine failure speed. For this reason, the refusal speed is of primary importance during take off operation. It must be remembered that the validity of refusal speed is dependent upon a normal four-engine acceleration of the aircraft. If the acceleration is low, the aircraft will have used more runway than predicted in reaching the refusal speed, and insufficient runway will remain in which to stop the airplane. For this reason, use of acceleration check speeds or times is necessary to insure safe takeoff.

DISTANCE AND TIME VS SPEED CHART.

This chart *(figure A3-10)* shows the relationship between distance, time and speed during the takeoff acceleration. It is based on acceleration from a standstill on a dry, hard surface runway with four engines operating. It will also apply, approximately, to less favorable runway conditions if the ground run, which is used in entering the graph, has been corrected for such conditions. Wind corrections used with this chart are based on 50 percent of the reported headwinds. If actual winds during the takeoff run exceed 50 percent of the reported winds, the time to accelerate to a given check point, and the speed at the check point will be higher than computed.

The acceleration check speed and check point may be determined from this chart. To do this it is necessary first to obtain the ground run and indicated takeoff speed from the Ground Run chart *(figure A3-3)*. The ground run should be corrected for wind, runway slope and runway condition. A wind correction grid is provided on the chart to correct the takeoff speed. By entering the chart with takeoff speed and takeoff ground run corrected for wind, a contour line is established which is then used to determine the acceleration check speed and distance.

From the Refusal Speed chart for brakes only *(figure A3-8)*, determine the indicated refusal speed corrected for wind and slope for the available runway and correct for wind when entering the chart. Following the corrected refusal speed to the contour line previously established will determine the refusal distance. The acceleration check point is then determined, preferably at the next 1000 foot runway marker below refusal distance. Acceleration check speed (go-no-go speed) is then determined at the intersection of the contour line and the acceleration check point (go-no-go distance). This speed is then corrected for wind velocity. The following example illustrates the method of using the chart.

Sample Problem:

GIVEN: Wind = 15 knots headwind (50 percent of reported headwind).

Ground run (corrected for headwind and slope) = 3500 feet.

Takeoff speed = 111 knots IAS.

Refusal speed (corrected for headwind and slope = 104 knots IAS.

Density altitude = 2000 feet.

FIND: Acceleration check point and speed.

1. Enter the wind correction grid at the top of the chart with takeoff speed of 111 knots IAS (A) and follow the headwind guide lines to 15 knots (B) to obtain corrected takeoff speed of 96 knots IAS.
2. Read down to ground run (corrected for headwind) of 3500 feet (C) and establish a contour line by following the guide lines.
3. Enter the chart with a refusal speed of 104 knots IAS (D) and correct for headwind as in step 1, to find corrected refusal speed of 89 knots IAS (E).
4. Read down to the intersection of the contour line to find refusal distance of 2900 feet (F), continue following the contour line to the nearest 1000 foot marker below the refusal distance to determine the acceleration check distance (go-no-go distance) of 2000 feet (G).
5. The intersection of the contour line and the acceleration check distance of 2000 feet gives an acceleration check speed minus wind correction of 77 knots IAS, and a time to accelerate of 29 seconds. To correct for wind read up to wind velocity of 15 knots (H) and follow the headwind guide lines to find corrected acceleration check speed of 91 knots IAS (I).
6. Determine $1/\sqrt{\sigma}$ for 2000 feet density altitude from the ICAO Standard Atmosphere Table *(figure A1-12)* of 1.0299. Correct time to accelerate by dividing by this figure. Actual time at the marker will be $29 \div 1.0299 = 28$ seconds.

ACCELERATION INCREMENT TIME CHECK.

The Takeoff Performance — Acceleration Increment Time Check chart *(figure A3-11)* provides a means of checking the time to accelerate from 60 knots to 100 knots, or to refusal speed minus 10 knots, whichever is lower. The four-engine ground run, takeoff gross weight, and density altitude determine a total acceleration time line (the four-engine ground run used in entering this chart is actual ground run for the given conditions but without wind correction).

Following the speed-time line on the chart, the times are read at 100 knots, or refusal speed minus 10 knots, and at 60 knots. The difference between these times is the acceleration check time. Althrough wind has a large effect on the total time from brake release to takeoff speed, it does not appreciably affect the shape of the speed-time curve, therefore, no wind correction is necessary in determining the net time to accelerate from one indicated airspeed to another. However, runway slope will affect acceleration, for this reason the ground run is corrected for slope before entering the chart.

Sample Problem:

GIVEN: Four-Engine ground run (corrected for slope but without wind correction) = 4250 feet.
Gross weight = 90,000 pounds.
Density Altitude = 5000 feet.

FIND: Acceleration time from 60 knots to 100 knots.

1. Enter the chart with ground run corrected for slope but with no wind correction, of 4250 feet (A) and read across to gross weight of 90,000 pounds (B).
2. Correct for density altitude by reading down to the baseline in the altitude graph (C) and following the guide lines to density altitude of 5000 feet (D).
3. Read down to an airspeed of 100 knots (E) for a time of 36 seconds.
4. Follow guide lines to 60 knots (F) to find a time of 18.5 seconds.
5. Subtract the time at 60 knots (18.5 seconds) from time at 100 knots (36 seconds) to find acceleration time between these speeds. $36 - 18.5 = 17.5$ seconds.

CLIMBOUT FACTOR CHARTS.

The Climbout Factor charts *(figures A3-12 through A3-14)* are used to compute climbout data in conjunction with the Gross Weight Limited By Climbout Over Obstacle chart *(figure A3-15)*. Charts are provided for four-engine operation without ground effect and for three-engine operation with and without ground effect. The charts are plotted so that at zero height, the climbout factor given conditions will represent four-engine ground run (uncorrected for slope) on the four-engine charts, and critical field length on the three-engine charts, for the same given conditions.

The two methods of using the charts are illustrated on figure A3-13. Sheet 1 shows method of determining a climbout factor which is then used to determine the maximum gross weight allowable for clearance of an obstacle, on the Gross Weight Limited By Climbout Over Obstacle chart (figure A3-15). Sheet 2 illustrates the method of determining the height over a given point using a climbout factor determined from figure A3-15, based on a given gross weight and takeoff factor.

Climbout and Ground Effect.

Ground effect, in general, refers to a reduction in the overall drag of an aircraft when operated in close poximity to the ground. The degree of drag reduction will vary with distance of the wing from the ground, being greatest when the wing is at ground level. Ground effect will, for all practical purposes, disappear when the wing is greater than one half the wing span above the ground. Ground effect is greatest at low airspeeds and becomes a lesser drag reduction as airspeed increases.

Climbout data is provided for three-engine operation both with and without ground effect. Four-Engine operation is based on no ground effect since the normal climbout flight path is steep enough that the aircfrat will climb above the altitude where ground effect is noticable shortly after liftoff.

For three-engine operation, on a takeoff over level terrain or with only a slight downhill slope the flight path will be such that the aircraft performance will be influenced by ground effect for a longer period of time, which will result in a more rapid acceleration to climb speed than would be possible where takeoff is over terrain which slopes sharply downhill after the point of liftoff.

1. Ground Effect Included chart — Use this chart when the terrain does not slope downhill more than 5% from point of liftoff to the point where aircraft will have reached an altitude equal to one half the wing span.
2. Ground Effect Not Included chart — Use this chart when the applicable slope is greater than 15%.
3. Both Charts — If the applicable slope is between 5 and 15%, assume a climbout factor half way between the two charts.

GROSS WEIGHT LIMITED BY CLIMBOUT OVER OBSTACLE CHART.

The Gross Weight Limited By Climbout Over Obstacle chart *(figure A3-15)* is used to compute climbout data in conjunction with the Climbout Factor charts *(figure A3-12 through A3-14)*, and the Takeoff Factor chart *(figure A3-1)*. The chart may be used to determine the maximum allowable gross weight for clearance of an obstacle, using a takeoff factor and climbout factor obtained from the appropriate charts, or to determine a climbout factor for a given gross weight, which is then used to compute the altitude which may be expected over an obstacle. The following sample problems illustrate both methods of using the chart.

Sample Problem (1):

GIVEN: Climbout factor = 10.8.
Takeoff factor = 3.0.

FIND: Maximum gross weight for climbout over an obstacle.

1. Enter chart with climbout factor of 10.8 (A) and takeoff factor of 3.0 (B), obtained from figures A3-13 and A3-1.
2. At the intersection of climbout and takeoff factor lines read maximum allowable gross weight of 102,250 pounds (C).

Sample Problem (2):

GIVEN. Takeoff factor = −0.1.
Gross Weight = 100,000 pounds.

FIND: Climbout factor for use in determining altitude over an obstacle.

1. Enter chart with takeoff factor of −0.1 (D).
2. Read across to a gross weight of 100,000 pounds (E) and down to find a climbout factor of 10 (F).
3. Use this factor to determine height over a given obstacle on the appropriate climbout factor chart.

TAKEOFF DISTANCE TO 50-FT HEIGHT, THREE-ENGINE FERRY CONFIGURATION CHART.

The 3-engine ferry takeoff performance *(figure A3-16)* is based on starting the ground roll with maximum power on only the two symmetrical engines. The odd engine begins with idle power and increases to maximum power as rapidly as the rudder effectiveness permits control of the asymmetrical power. The takeoff speeds noted on the chart are 130% of the stalling speeds instead of the usual 115% for normal takeoffs. The inoperative propeller is considered either feathered or removed, and there is no allowance for engine failure during the takeoff. The ground run is approximately 87% of the takeoff distance to a 50 foot height.

DISTANCE TO STOP CHARTS.

The Distance To Stop charts *(figures A3-17 and A3-18)* are provided for stopping with brakes only and with brake plus two-engine reverse thrust. The charts show the distance required to stop from a given indicated airspeed for various runway surface conditions and density altitudes. Both charts are based on wing flaps in the takeoff configuration.

Sample Problem:

GIVEN: Airspeed at which brakes are applied = 83.5 knots.
Runway condition = Dry.
Density altitude = Sea level.

FIND: Required stopping distance with brakes only.

1. Enter the brakes only chart *(figure A3-17)* at an airspeed of 83.5 knots (A) and read up to the baseline (B).

2. From the legend on the chart determine the coefficient of friction for dry runway surface as 0.3. Read across from the baseline to this value (C).
3. Read up to density altitude of sea level (D) and across to find the required stopping distance of 2500 feet (E).

TAKEOFF AND LANDING CROSSWIND CHART.

The Takeoff and Landing Crosswind chart *(figure A3-19)* presents headwind (or tailwind) and crosswind components in knots for crosswind angles of zero to 90 degrees for headwinds and 90 to 180 degrees for tailwinds for wind speeds up to 50 knots. These components are used to obtain a correction factor to be applied to the minimum liftoff or nosewheel touchdown speeds which have been determined by reference to the liftoff or touchdown gross weight and selected wing flap settings.

To insure greater lateral stability, runway directional control, and to compensate for maneuver leads imposed upon the aircraft under varying or gusty wind conditions, a correction factor will be added to the liftoff or approach and touchdown speeds. The correction factor will be 50 percent of the crosswind component or one half of the reported differences between constant and peak wind velocities, whichever is greater. In no case will the correction factor exceed 10 knots.

To compute headwind, tailwind and crosswind components a wind angle relative to the takeoff or landing runway must first be determined from the existing surface wind conditions as follows:

1. Subtract the runway heading angle from the magnetic wind direction.
2. If the resultant angle is greater than 180 degrees (regardless of sign, + or −), it should be subtracted from 360 degrees. This result is the crosswind angle.
3. When the crosswind angle is less than 90 degrees the resultant component is a headwind. When the angle is greater than 90 degrees the resultant component is a tailwind.
4. The Takeoff and Landing Crosswind chart may then be entered to obtained the headwind and crosswind components.

Sample Problem:

GIVEN. Runway heading = 030.
Wind velocity and direction = 31 knots at 075.

FIND: Headwind and crosswind components.

1. Determine crosswind angle = 075 − 030 = 045.
2. Enter the chart at zero headwind and zero crosswind components and proceed along the crosswind angle of 45 degrees to the wind velocity arc of 31 knots (A).
3. Read down to find a crosswind component of 22 knots (B), and across to find headwind component of 22 knots (C).
4. Correction factor to be added to liftoff or touchdown speed of one half of the crosswind component (11 knots), exceeds the maximum allowable correction of 10 knots so in this case 10 knots would be used.

If the crosswind comonent falls within the CAUTION ZONE, a landing may dictate the utilization of thirty degrees flaps with a proportionate increase in approach and touchdown speeds. Whenever a correction factor is applied to a liftoff or touchdown speed, the pilot must be prepared to accept a correspondingly longer ground roll.

MINIMUM CONTROL SPEED VS BANK ANGLE.

The Minimum Control Speed Vs Bank Angle chart *(figure A3-20)* is provided to show the effect of bank angle on minimum control speed. The chart is based on one outboard engine inoperative with the propeller windmilling and the remaining engine operating at 2500 BHP. The minimum control speed will be lower with an inboard engine inoperative, with the propeller on the inoperative engine feathered, or with the engines operating at a lower BHP. The chart shows only the decrease in minimum control speed as the aircraft is banked away from the inoperative engine. If the bank angle is toward the inoperative engine, the minimum control speed will increase at approximately the same rate as it decreases when banking in the opposite direction. The relationship between minimum control speed and bank angle as shown on the chart illustrates the importance of initiating a bank into the inoperative engine as soon as possible after engine failure.

TAKEOFF PERFORMANCE — TAKEOFF FACTOR

2800 RPM

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

SAMPLE PROBLEM:

A. Outside air temperature = 10°C.
B. Pressure altitude = 6000 feet.
C. Density altitude = 6800 feet.
D. BMEP = 205.
E. Takeoff factor = 10.2.

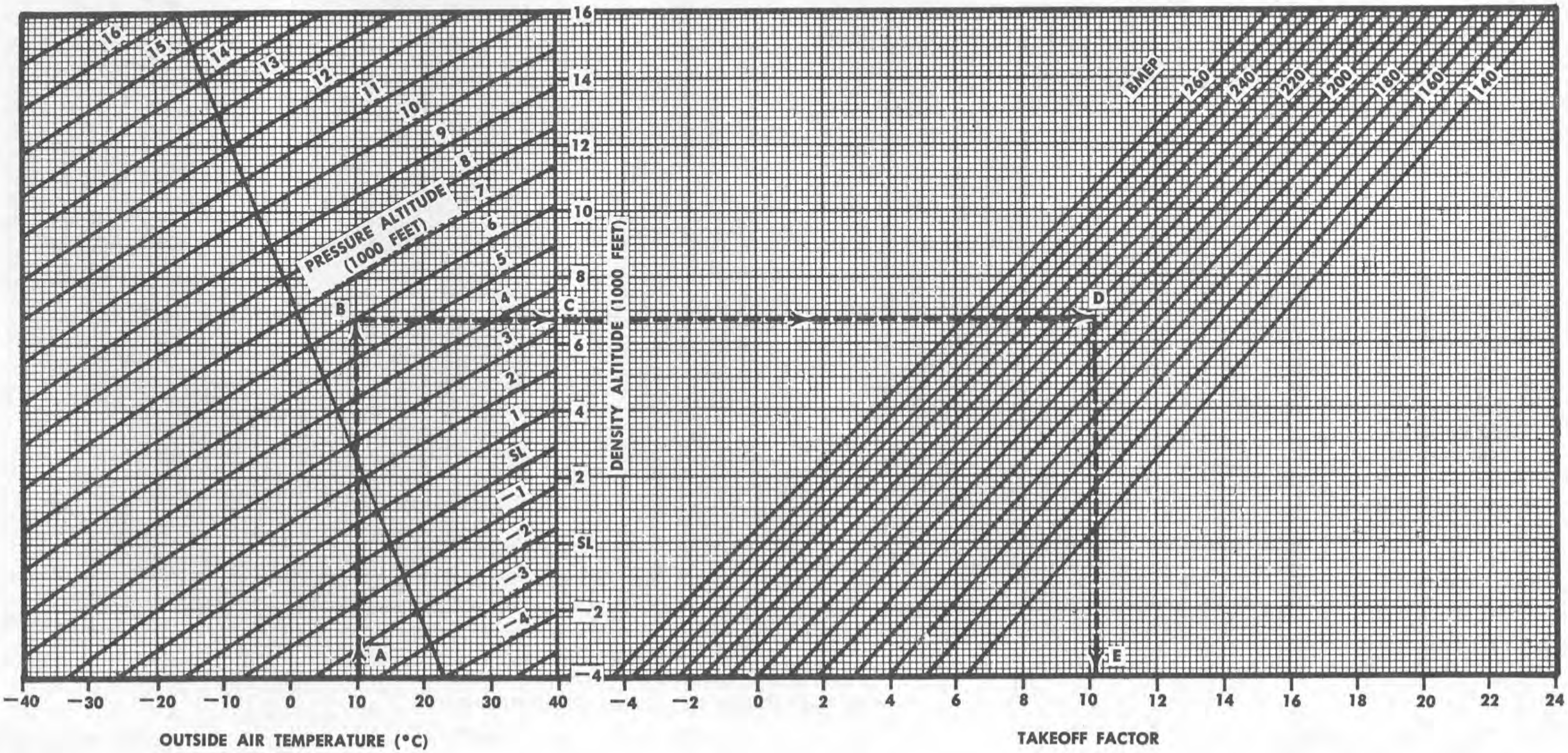

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Figure A3-1. Takeoff Performance — Takeoff Factor

TAKEOFF GROSS WEIGHT LIMITED BY THREE-ENGINE CLIMB PERFORMANCE

THREE ENGINES OPERATING 2800 RPM
WING FLAPS 20 DEGREES CLIMB AT TAKEOFF SPEED — NO GROUND EFFECT

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

NOTE:
The structural limit of 107,000 pounds must not be exceeded for normal operation nor 112,000 pounds for emergency.

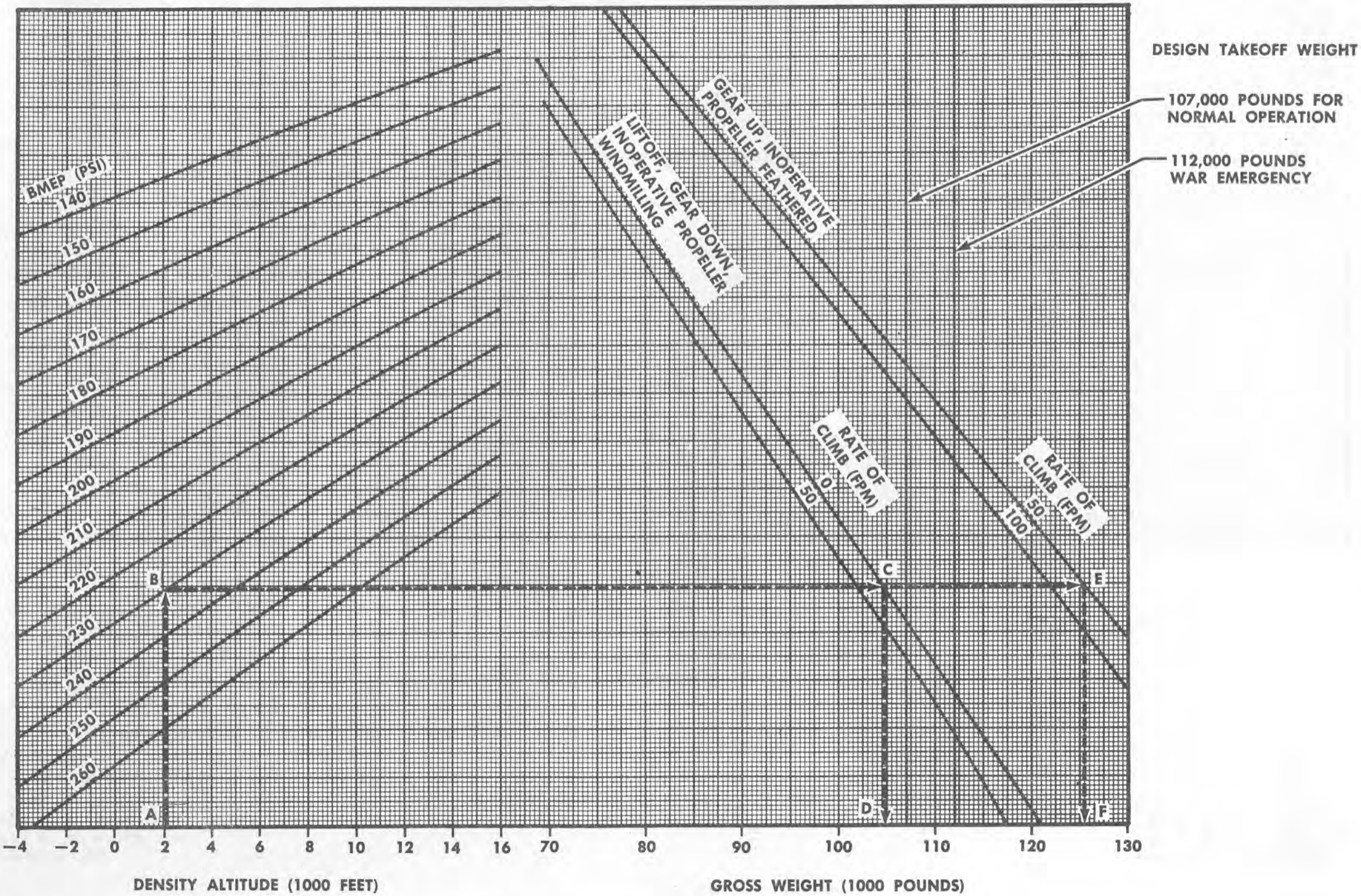

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Figure A3-2. Takeoff Gross Weight Limited By Three-Engine Climb Performance

TAKEOFF PERFORMANCE — GROUND RUN

ALL ENGINES OPERATING 2800 RPM
WING FLAPS 20 DEGREES

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

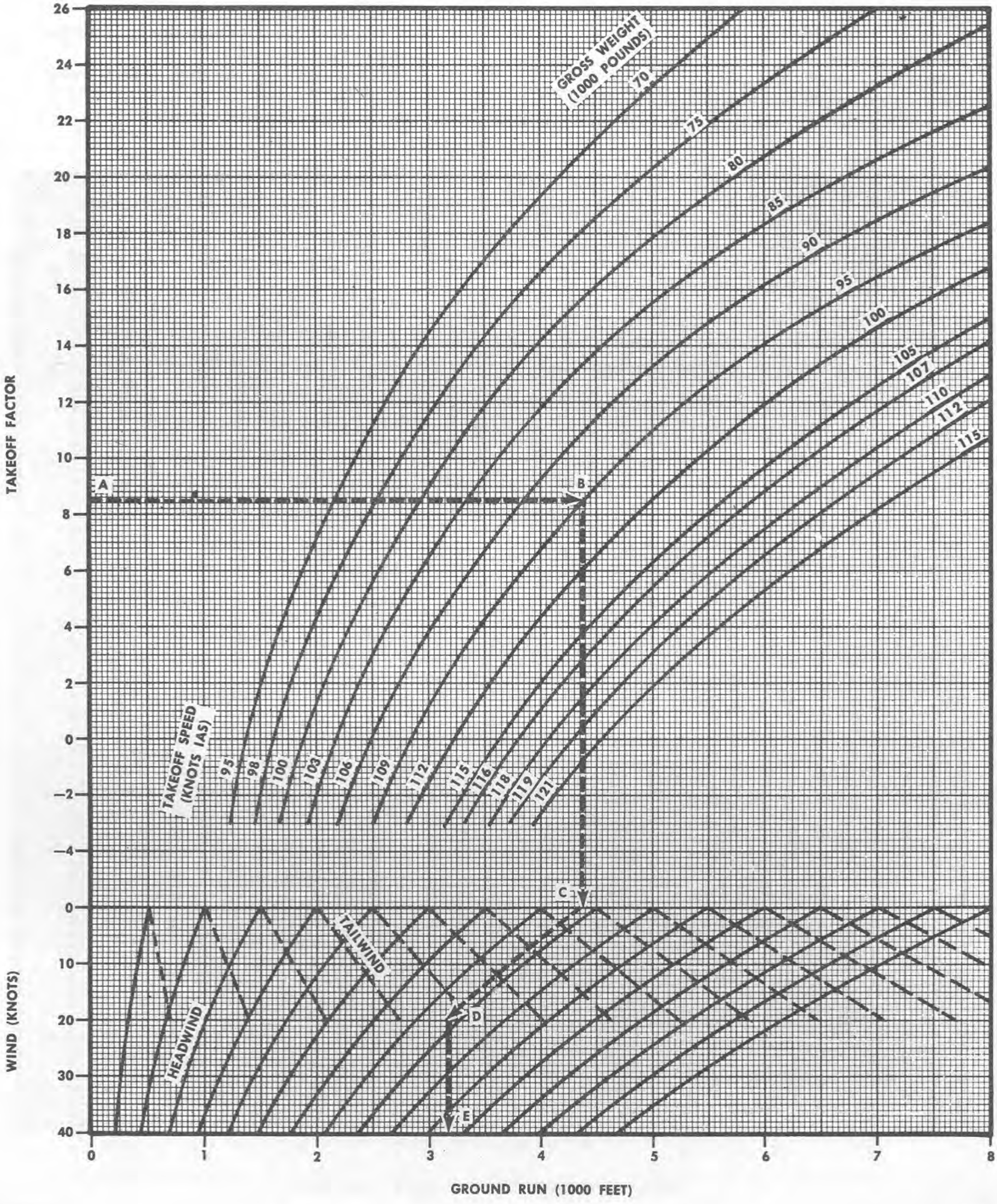


Figure A3-3. Takeoff Performance — Ground Run

TAKEOFF PERFORMANCE — RUNWAY SLOPE CORRECTION

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

NOTE:
This chart applicable to:
4 engine ground run,
Critical field length, brakes only.
Critical field length, and brakes plus two engine reverse.

SAMPLE PROBLEM:
A. Distance without runway slope = 4600 feet.
B. Runway slope = .035.
C. Distance with runway slope = 6200 feet.

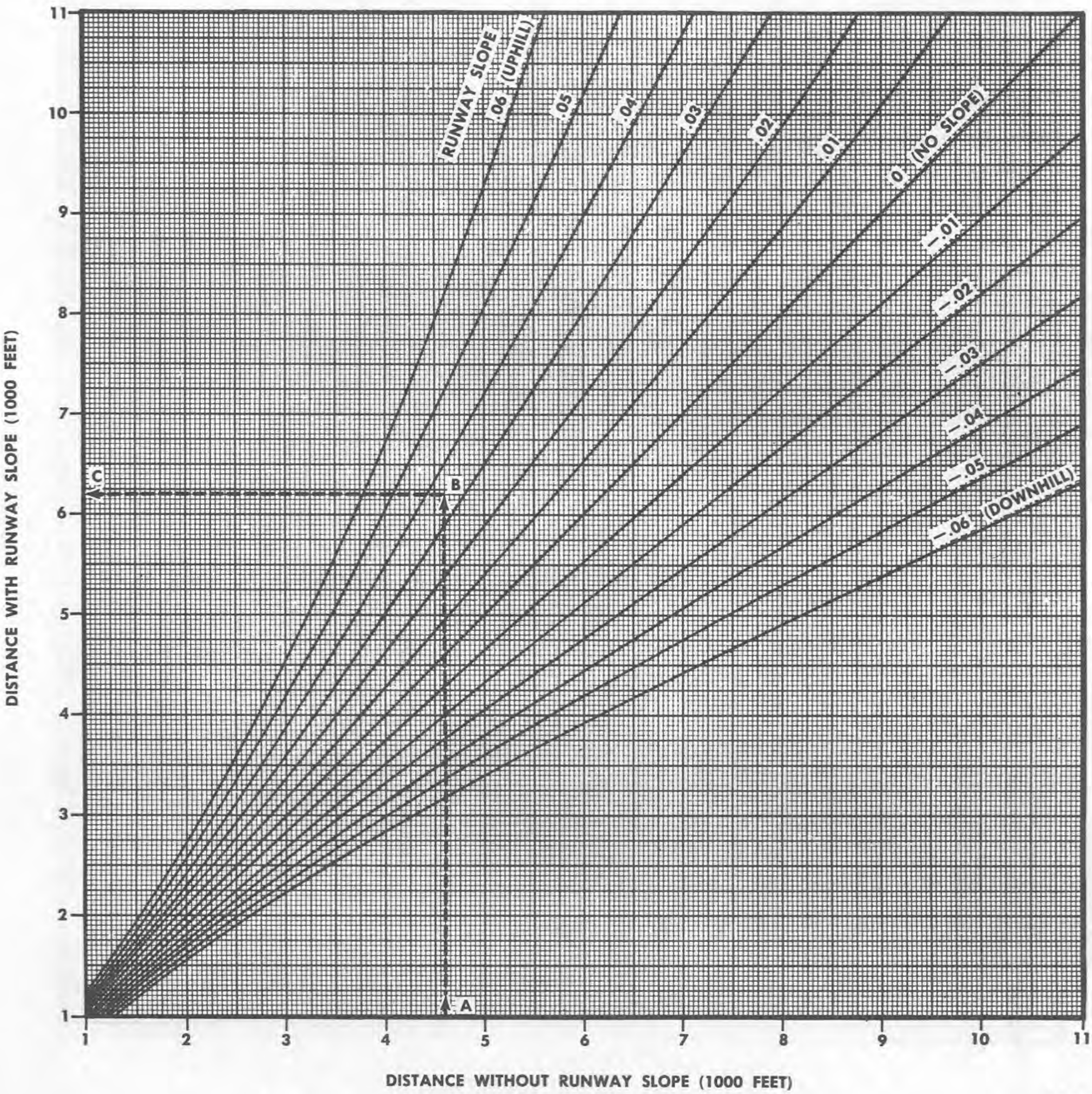


Figure A3-4. Takeoff Performance – Runway Slope Correction

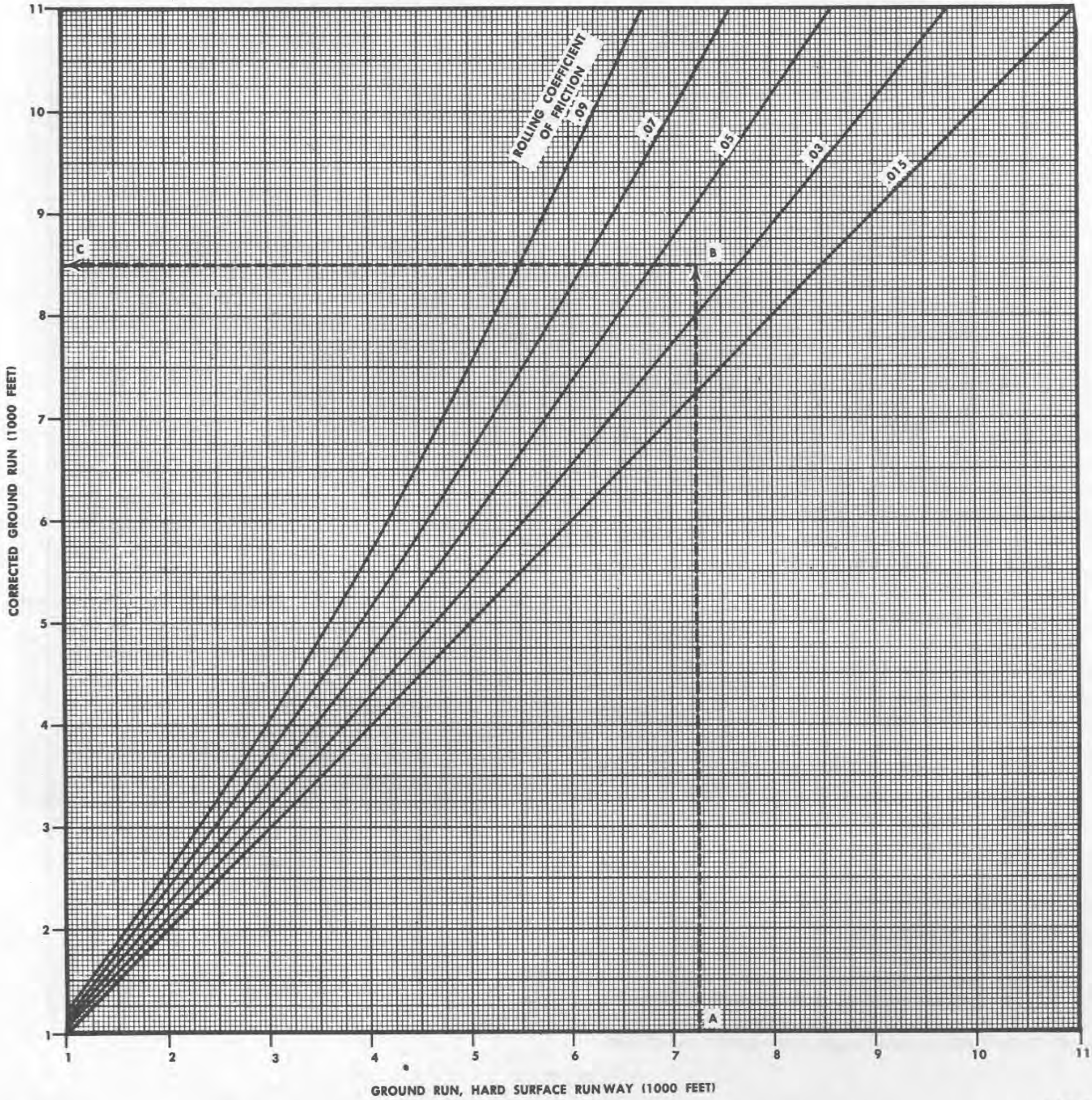
EFFECT OF RUNWAY SURFACE CONDITIONS ON GROUND RUN

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

RUNWAY SURFACE CONDITION	APPROXIMATE COEFFICIENT OF ROLLING FRICTION
HARD DRY	.015
DRY SOD TURF	.05
WET SOD TURF	.09

SAMPLE PROBLEM:
A. Ground run, hard surface runway = 7250 feet.
B. Rolling coefficient of friction = .04.
C. Corrected ground run = 8500 feet.



AA1-537

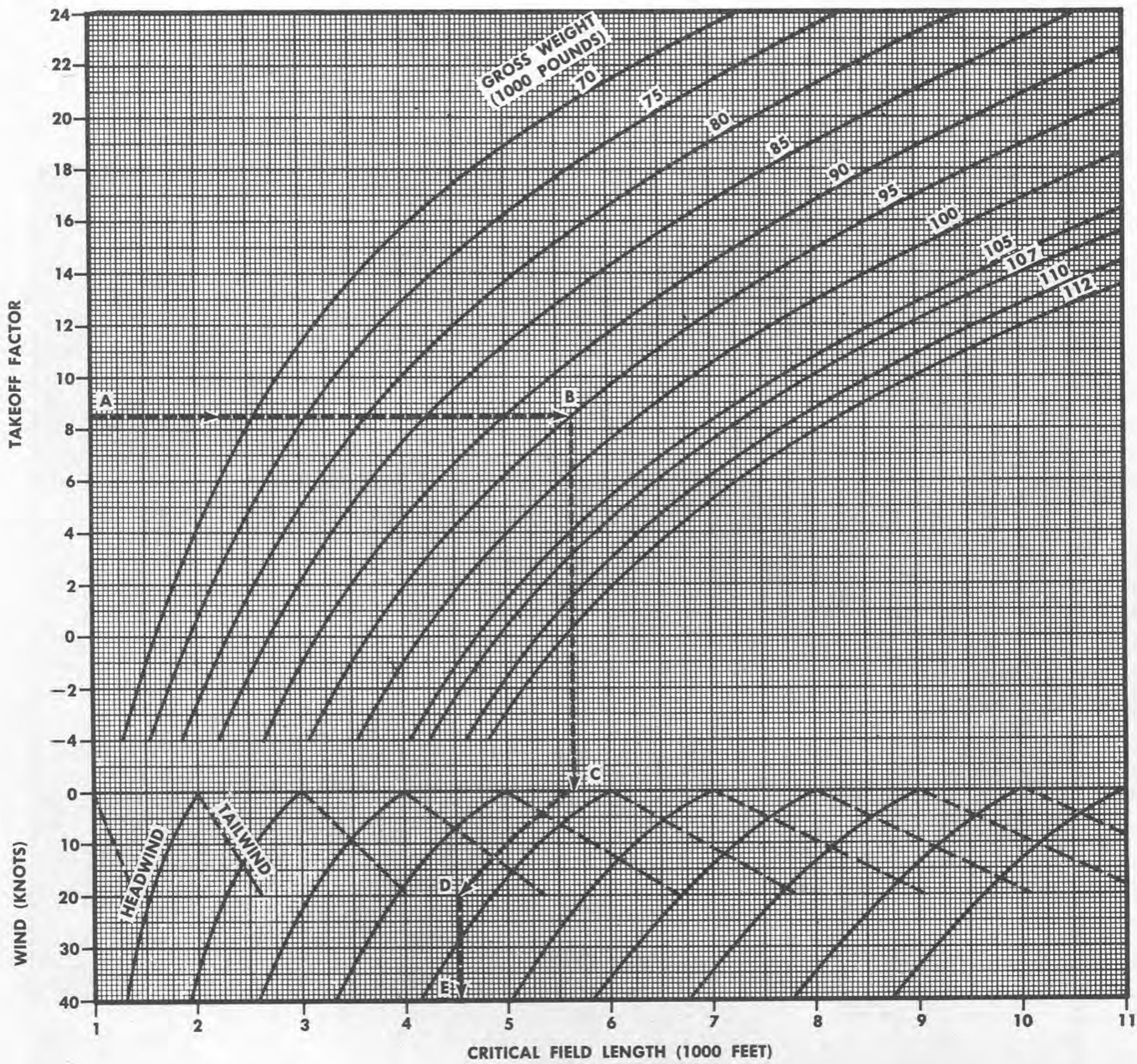
Figure A3-5. Effect of Runway Surface Conditions on Ground Run

TAKEOFF PERFORMANCE — CRITICAL FIELD LENGTH — BRAKES ONLY

2800 RPM
WING FLAPS 20°

MODEL: C-118A
DATA AS OF: 6-15-62
BASED ON: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130



SAMPLE PROBLEM:
A. Takeoff factor = 8.5.
B. Gross weight = 95,000 pounds.
C. Critical field length, no wind = 5650 feet.
D. Wind = 20 knots,headwind.
E. Critical field length with wind = 4525 feet.

AA1-509

Figure A3-6. Takeoff Performance — Critical Field Length — Brakes Only

TAKEOFF PERFORMANCE — CRITICAL FIELD LENGTH — BRAKES PLUS TWO-ENGINE REVERSE THRUST
2800 RPM
WING FLAPS 20°

MODEL: C-118A
DATA AS OF: 6-15-62
BASED ON: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

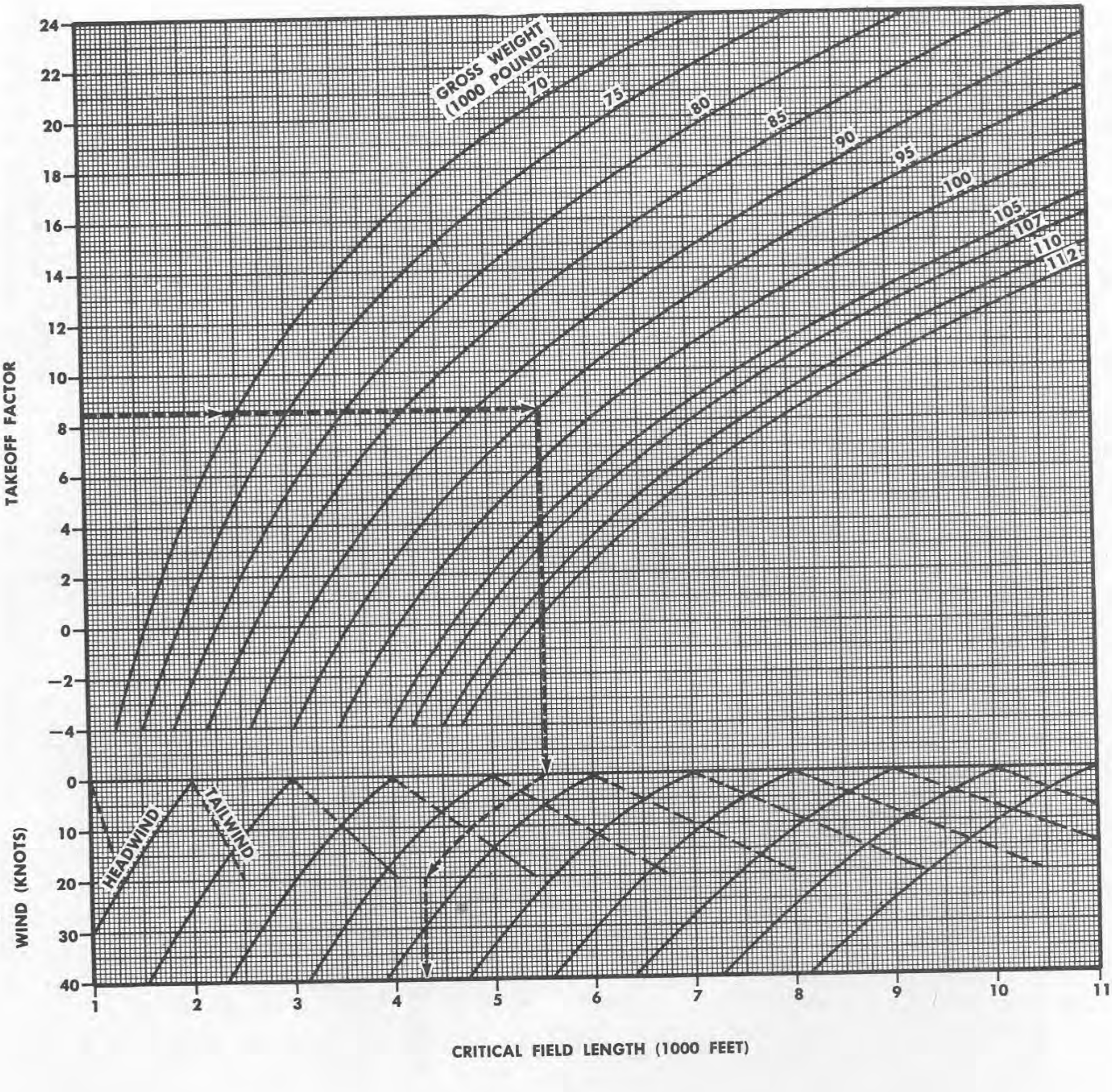


Figure A3-7. Takeoff Performance — Critical Field Length — Brakes Plus Two-Engine Reverse Thrust

TAKEOFF PERFORMANCE — REFUSAL SPEED — BRAKES ONLY

2800 RPM
WING FLAPS 20°

MODEL C-118A
DATA AS OF: 6-15-62
BASED ON: FLIGHT TEST

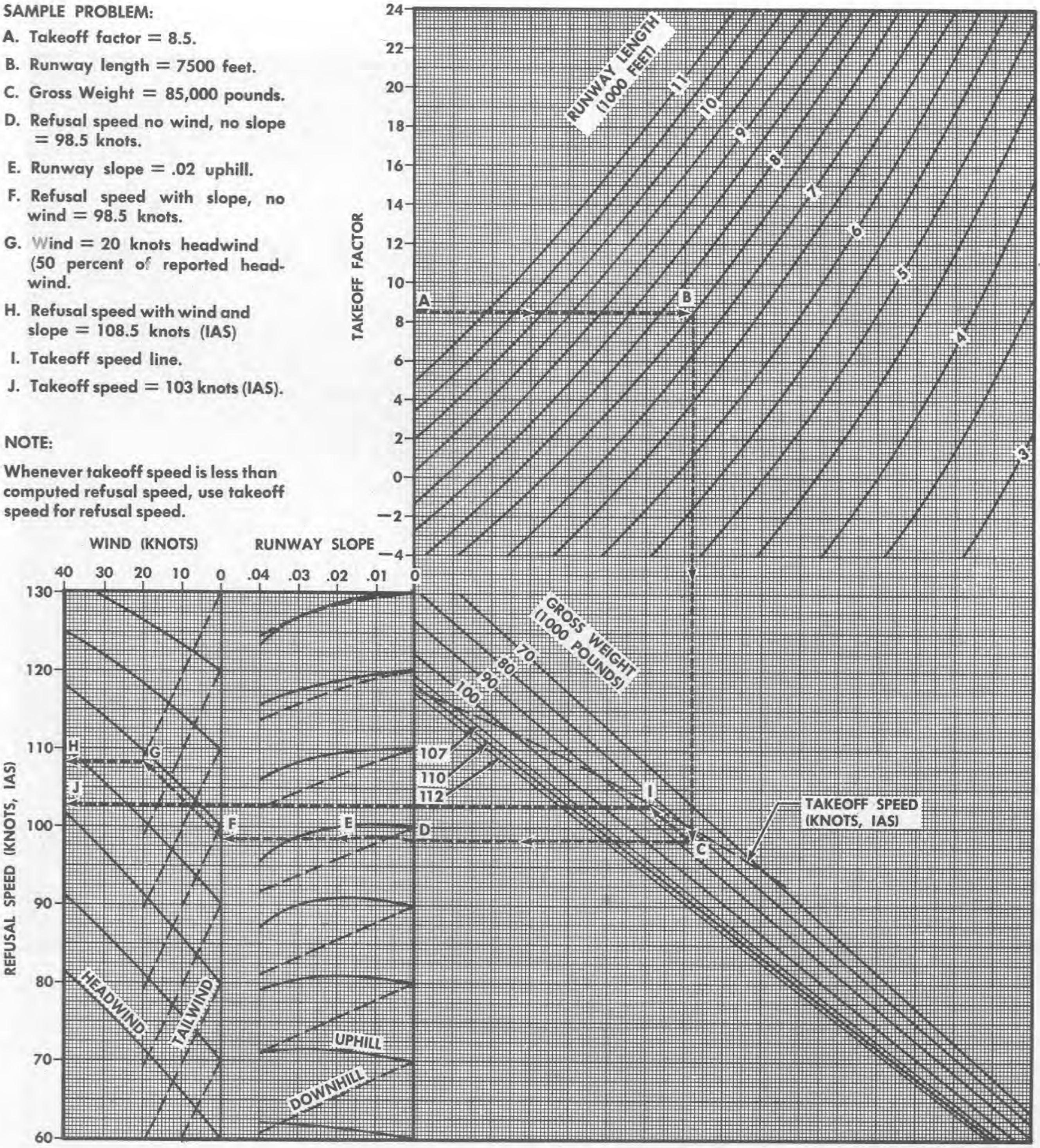
ENGINES: (4)R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

SAMPLE PROBLEM:

A. Takeoff factor = 8.5.
B. Runway length = 7500 feet.
C. Gross Weight = 85,000 pounds.
D. Refusal speed no wind, no slope = 98.5 knots.
E. Runway slope = .02 uphill.
F. Refusal speed with slope, no wind = 98.5 knots.
G. Wind = 20 knots headwind (50 percent of reported headwind.
H. Refusal speed with wind and slope = 108.5 knots (IAS)
I. Takeoff speed line.
J. Takeoff speed = 103 knots (IAS).

NOTE:

Whenever takeoff speed is less than computed refusal speed, use takeoff speed for refusal speed.



AA1-511

Figure A3-8. Takeoff Performance — Refusal Speed — Brakes Only

TAKEOFF PERFORMANCE — REFUSAL SPEED — BRAKES PLUS TWO-ENGINE REVERSE THRUST

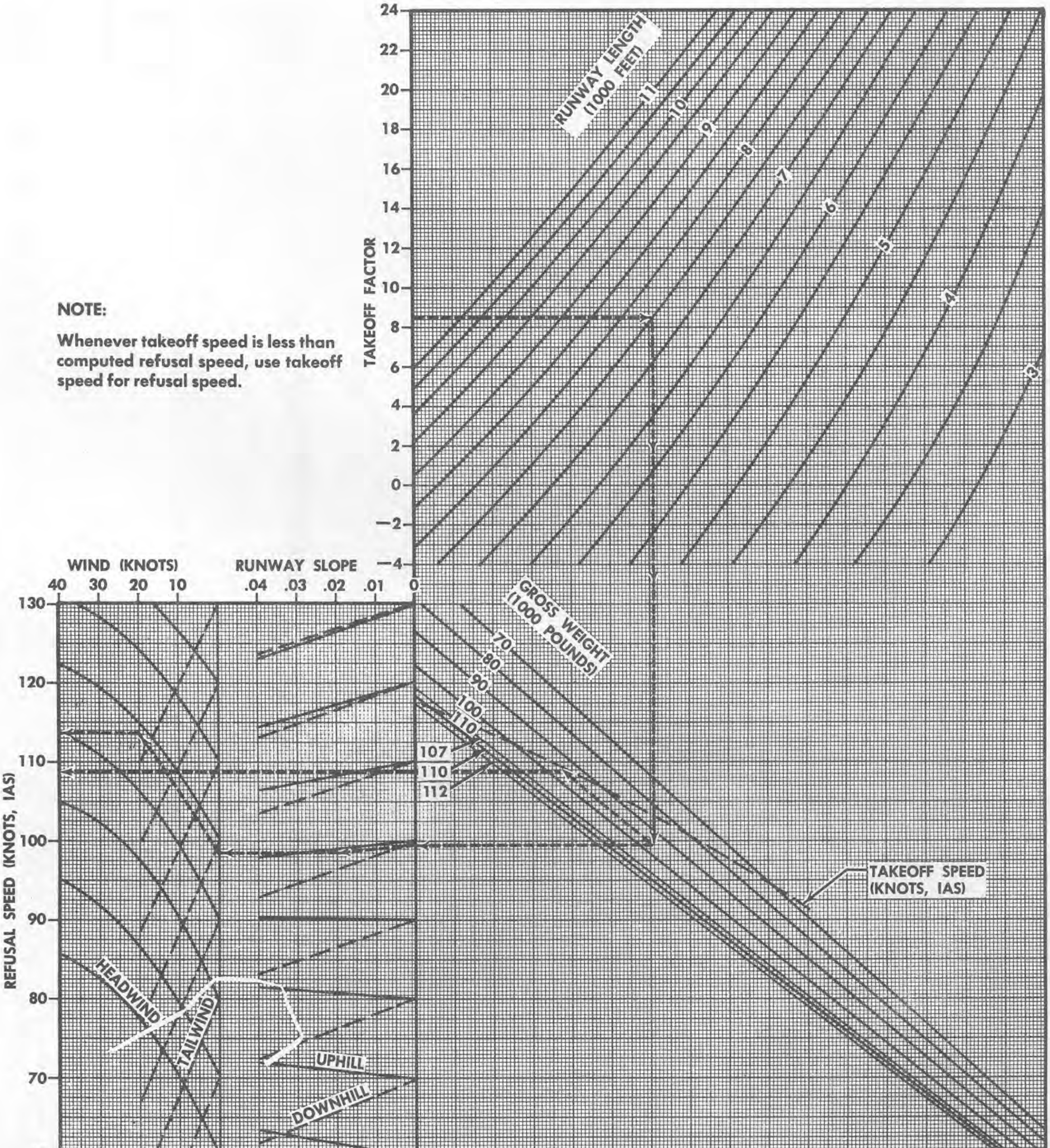
2800 RPM
WING FLAPS 20°

MODEL: C-118A
DATA AS OF: 6-15-62
BASED ON: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

NOTE:

Whenever takeoff speed is less than computed refusal speed, use takeoff speed for refusal speed.



AA1-512

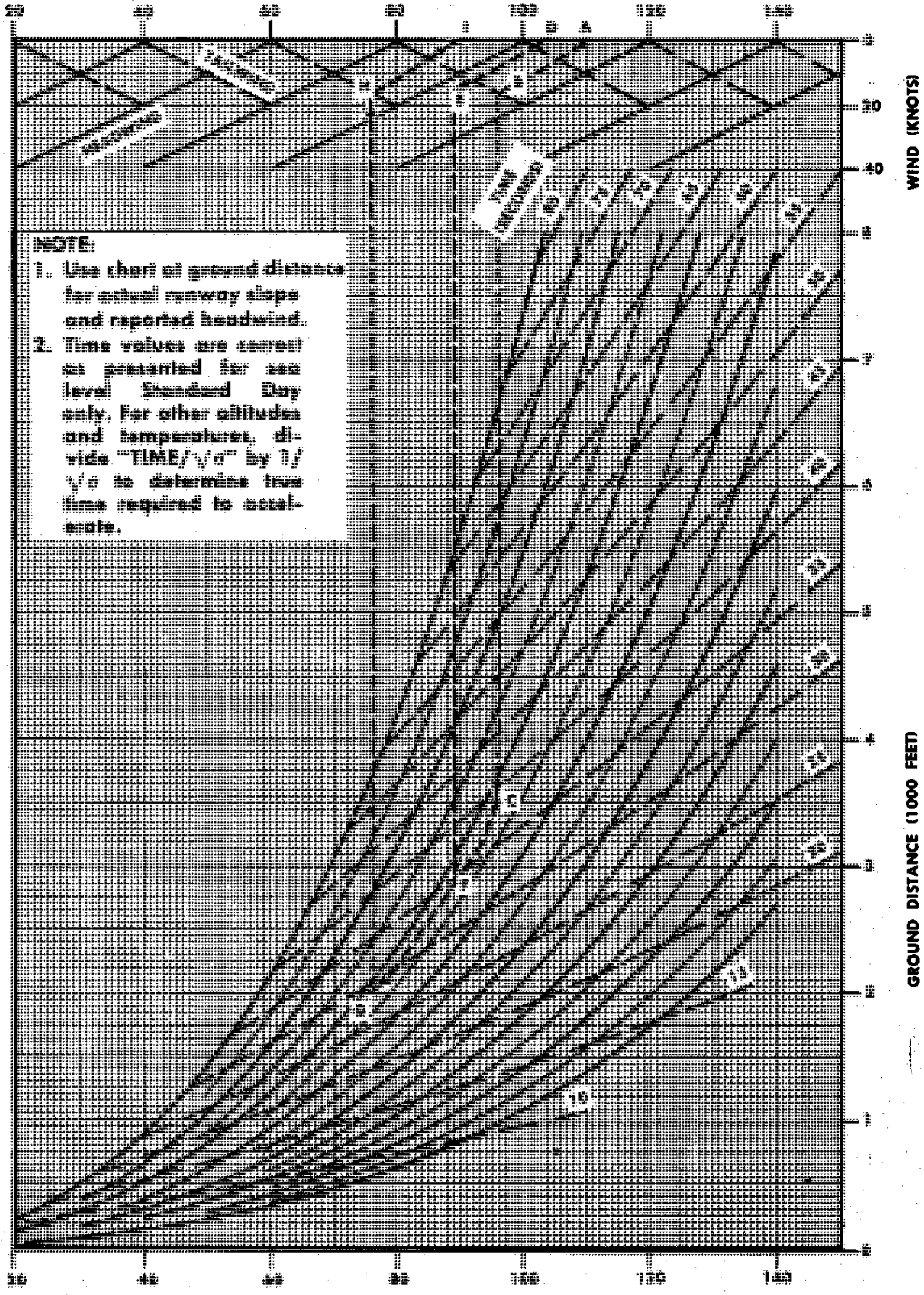
Figure A3-9. Takeoff Performance — Refusal Speed — Brakes Plus Two-Engine Reverse Thrust

TAKEOFF PERFORMANCE — DISTANCE AND TIME VERSUS SPEED

FOUR-ENGINE GROUND RUN

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130



NOTE:
1. Use chart at ground distance for actual runway slope and reported headwind.
2. Time values are correct as presented for sea level Standard Day only. For other altitudes and temperatures, divide "TIME/$\sqrt{\sigma}$" by 1/$\sqrt{\sigma}$ to determine true time required to accelerate.

AA1-538

Figure A3-10. Takeoff Performance — Distance and Time Versus Speed

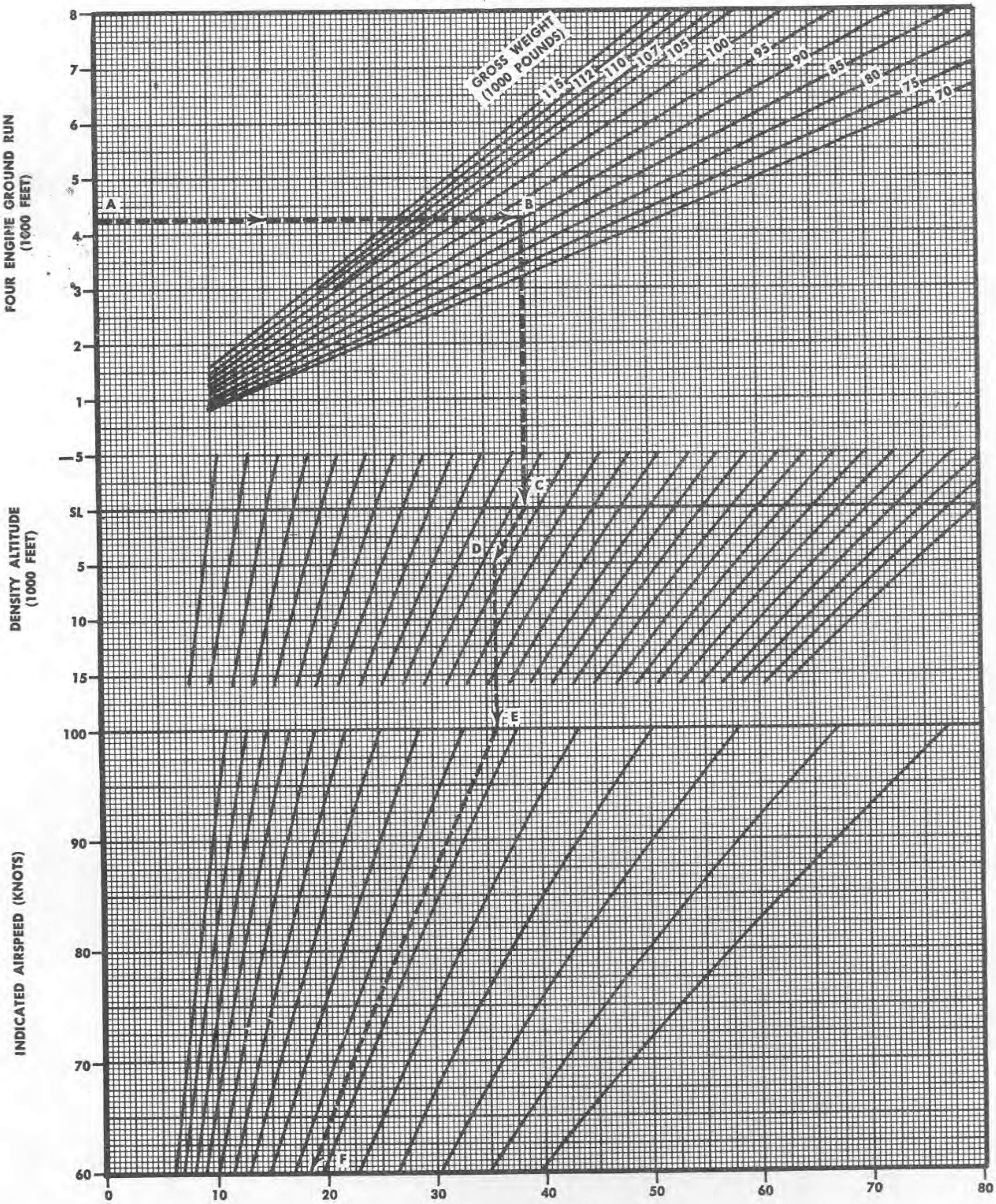
TAKEOFF PERFORMANCE— ACCELERATION INCREMENT TIME CHECK

FOUR-ENGINE GROUND RUN

MODEL: C-118A
DATA AS OF: 6-15-62
BASED ON: FLIGHT TEST DATA

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

NOTE:
Use this chart only for determining time increment between two indicated airspeeds.



AA1-514

Figure A3-11. Takeoff Performance — Acceleration Increment Time Check

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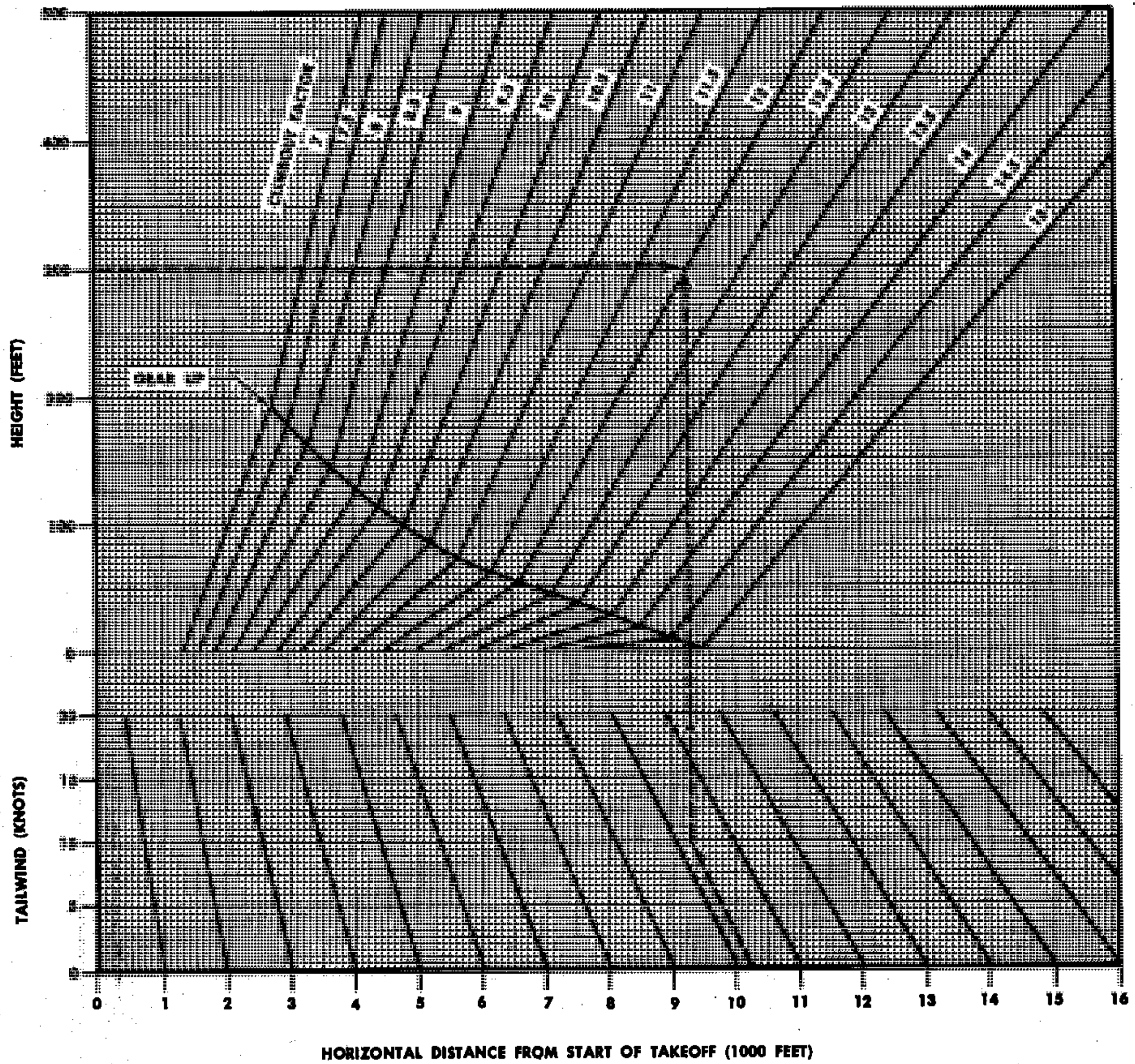
CLIMBOUT FACTOR — FOUR-ENGINE — GROUND EFFECT NOT INCLUDED

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130



AA1-536

Figure A3-12. Climbout Factor — Four-Engine — Ground Effect Not Included

CLIMBOUT FACTOR — THREE-ENGINE — GROUND EFFECT NOT INCLUDED

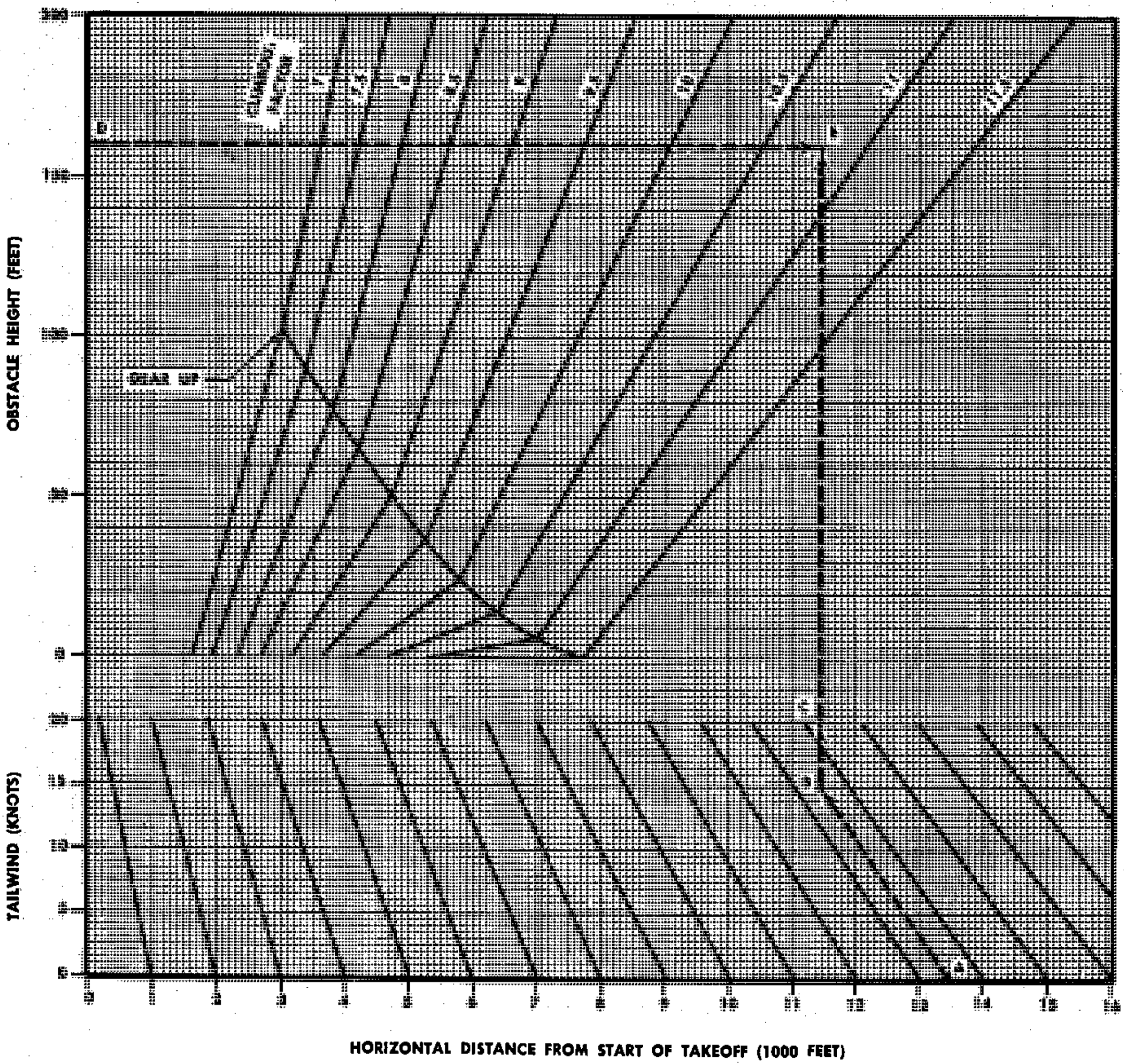
ZERO TO 200 FEET

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

SAMPLE PROBLEM:

A. Obstacle distance from start of takeoff = 13500 ft.
B. Tailwind = 15 knots
C. Obstacle distance corrected for wind = 11450 ft.
D. Obstacle height above runway = 160 ft.
E. Climbout factor to clear obstacle = 10.8



AA1-527

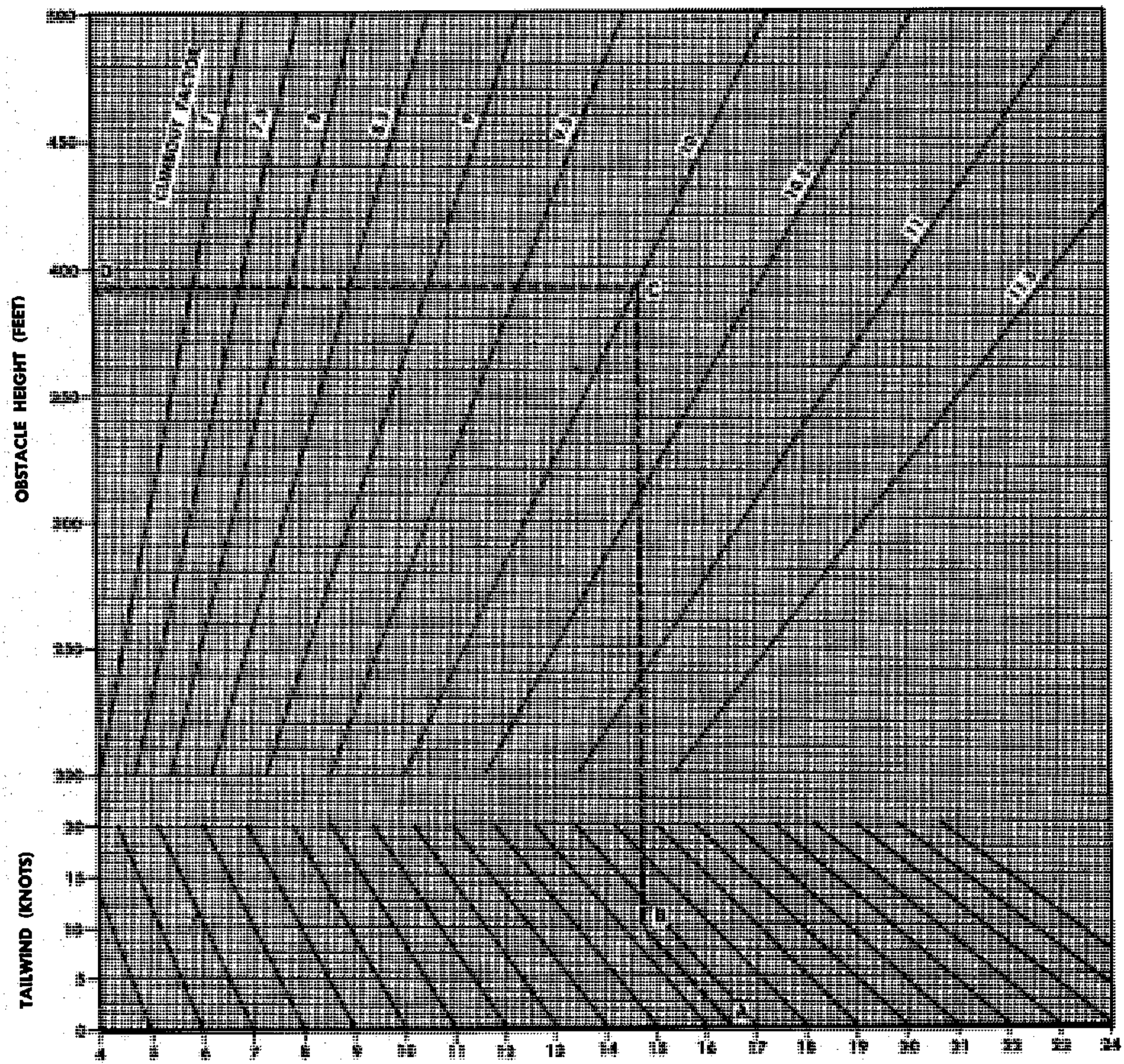
Figure A3-13. Climbout Factor — Three-Engine — Ground Effect Not Included (Sheet 1 of 2)

CLIMBOUT FACTOR — THREE-ENGINE — GROUND EFFECT NOT INCLUDED
200 TO 500 FEET

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

SAMPLE PROBLEM:
A. Obstacle distance = 16,500 feet
B. Wind = 10 knots (tailwind)
C. Climbout factor = 10
D. Altitude over obstacle = 393 feet



AA1-528

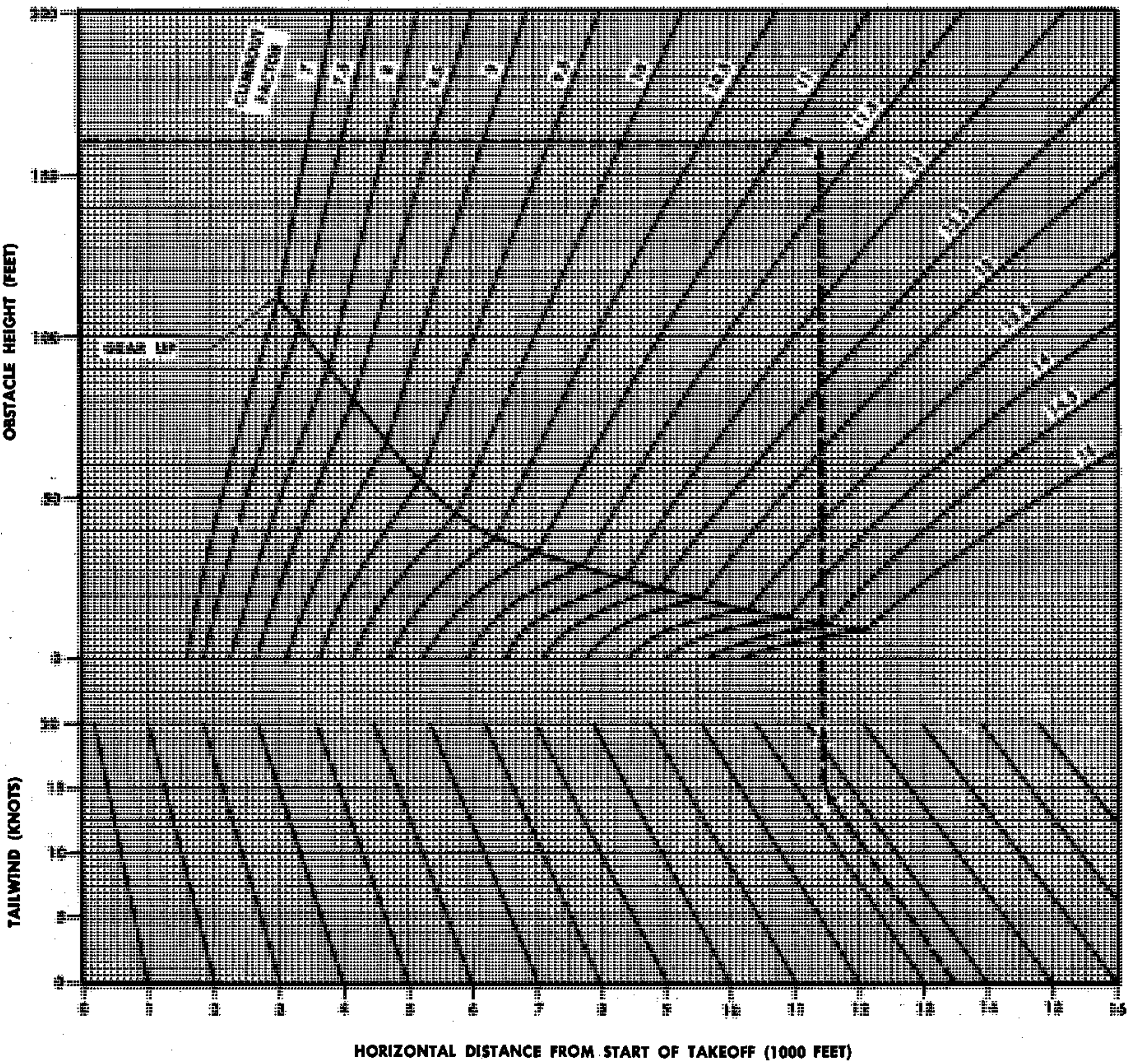
Figure A3-13. Climbout Factor — Three-Engine — Ground Effect Not Included (Sheet 2 of 2)

CLIMBOUT FACTOR — THREE-ENGINE — GROUND EFFECT INCLUDED

ZERO TO 200 FEET

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130



AA1-529

Figure A3-14. Climbout Factor — Three Engine — Ground Effect Included (Sheet 1 of 2)

CLIMBOUT FACTOR — THREE-ENGINE — GROUND EFFECT INCLUDED
200 TO 500 FEET

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

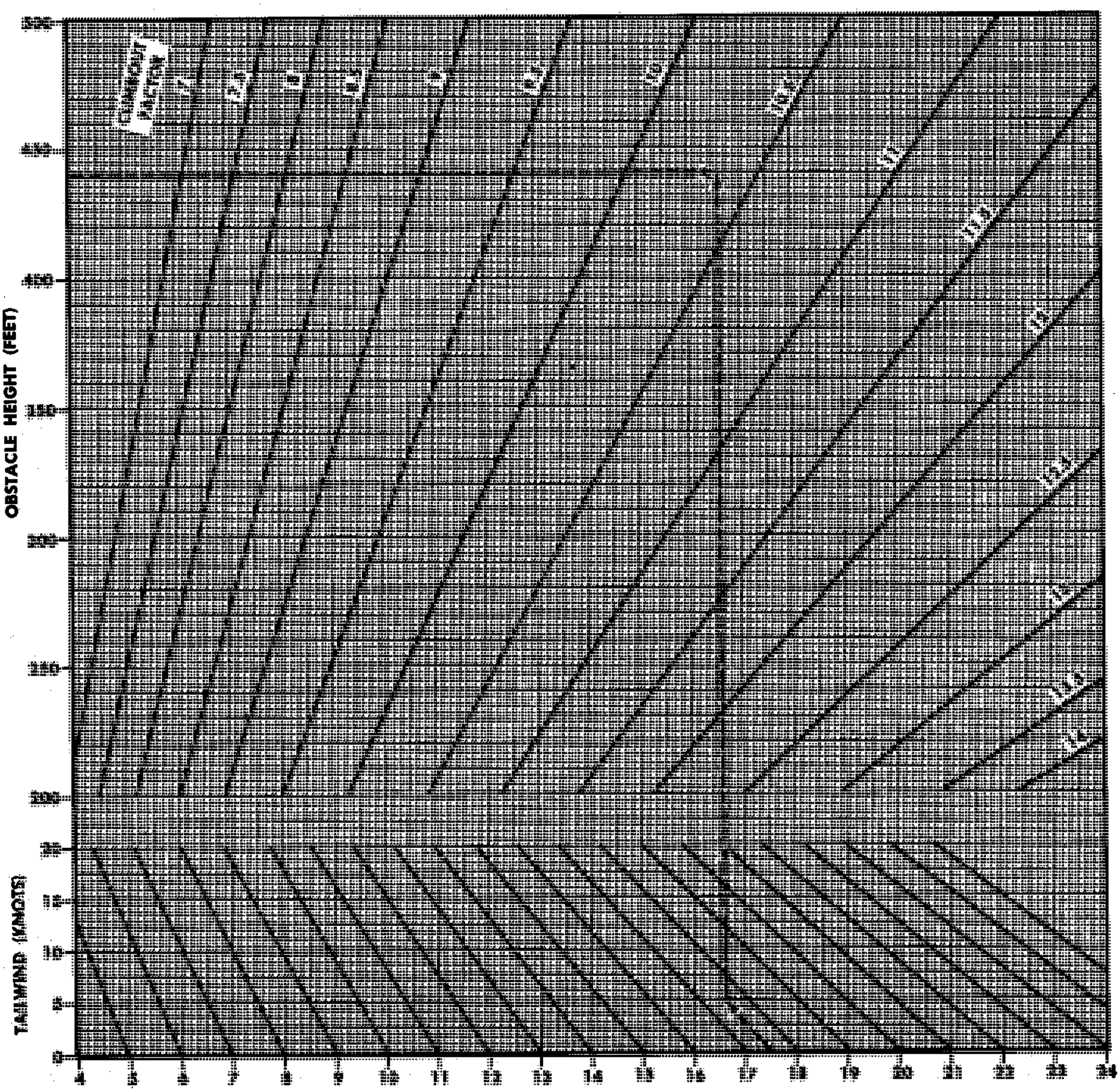
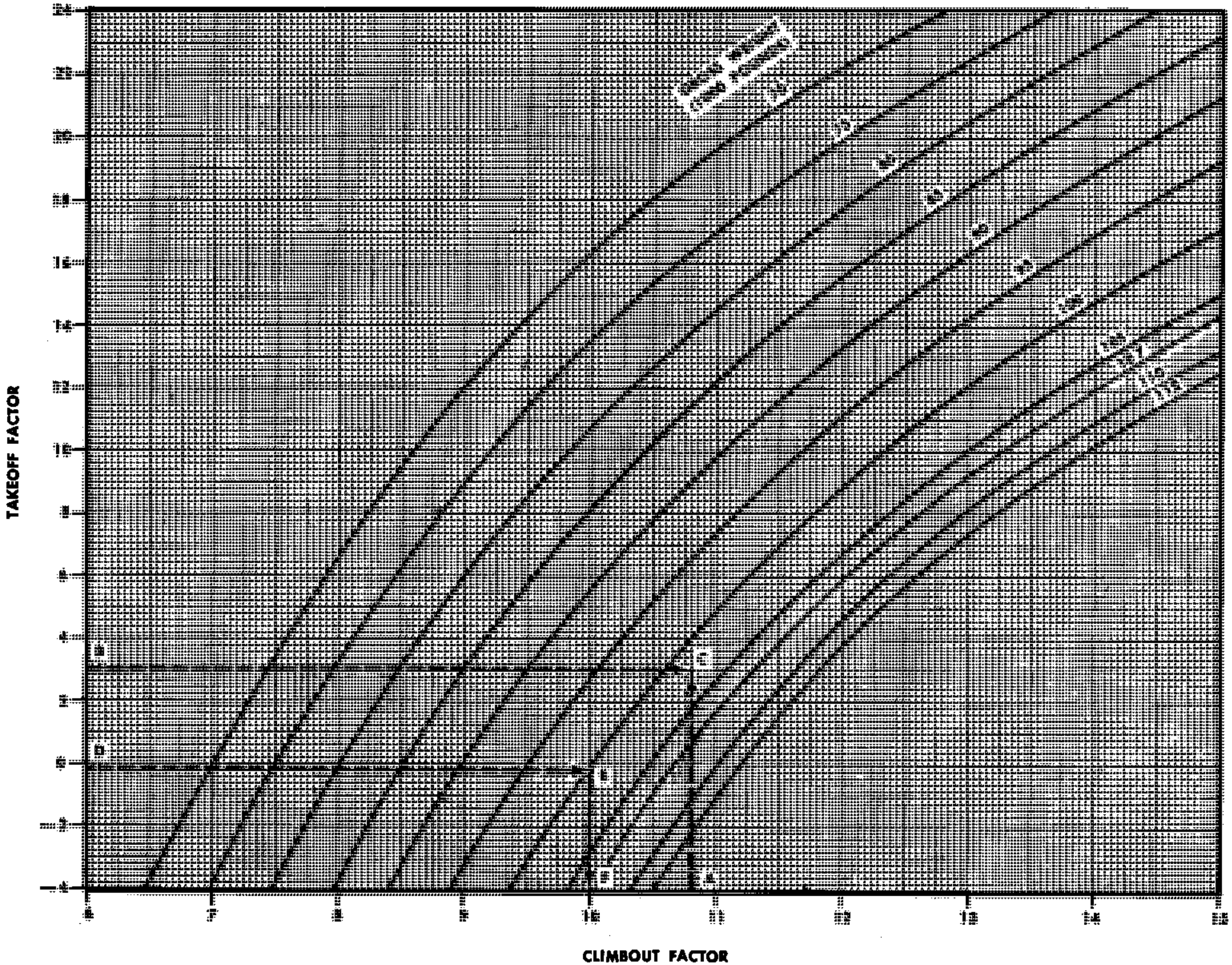


Figure A3-14. Climbout Factor — Three-Engine — Ground Effect Included (Sheet 2 of 2)

GROSS WEIGHT LIMITED BY CLIMBOUT OVER OBSTACLE

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130



AA1-531

Figure A3-15. Gross Weight Limited By Climbout Over Obstacle

TAKEOFF DISTANCE TO A 50-FOOT HEIGHT THREE-ENGINE FERRY CONFIGURATION

ONE ENGINE INOPERATIVE, PROPELLER FEATHERED OR REMOVED

HARD SURFACE RUNWAY
NO WIND
WING FLAPS 20 DEGREES
STANDARD ATMOSPHERIC CONDITIONS
NO OBSTACLE AT END OF RUNWAY

NO RUNWAY SLOPE
COWL FLAPS =
INOPERATIVE ENGINE, CLOSED (—4 DEGREES)
OPERATIVE ENGINE, OPEN (+3 DEGREES)

ENGINE(S): (4) R2800-52W

MODEL: C-118A
DATA AS OF: 6-15-62
BASED ON: CALCULATED DATA

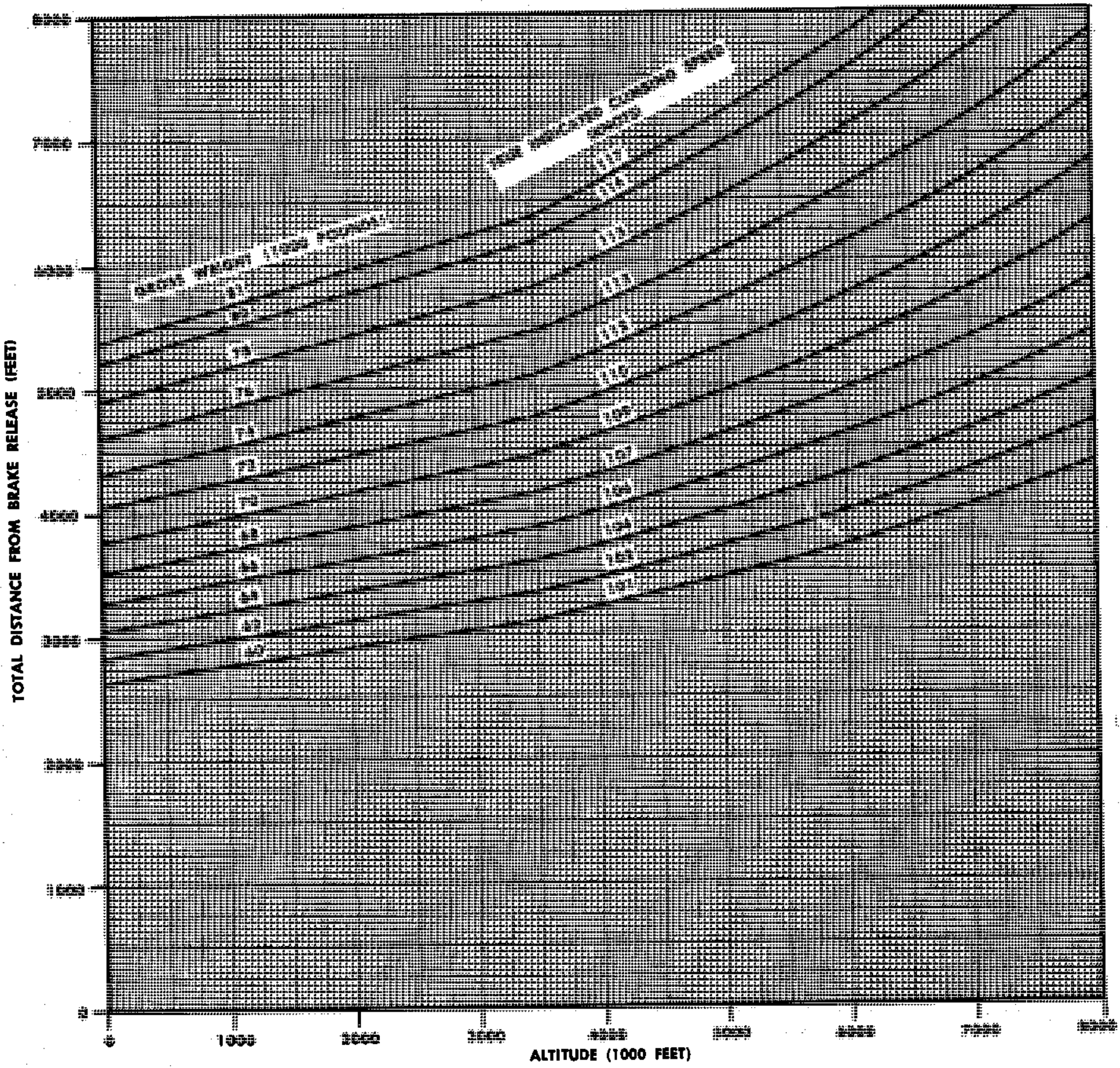


Figure A3-16. Takeoff Distance to a 50-Foot Height, Three-Engine Ferry Configuration

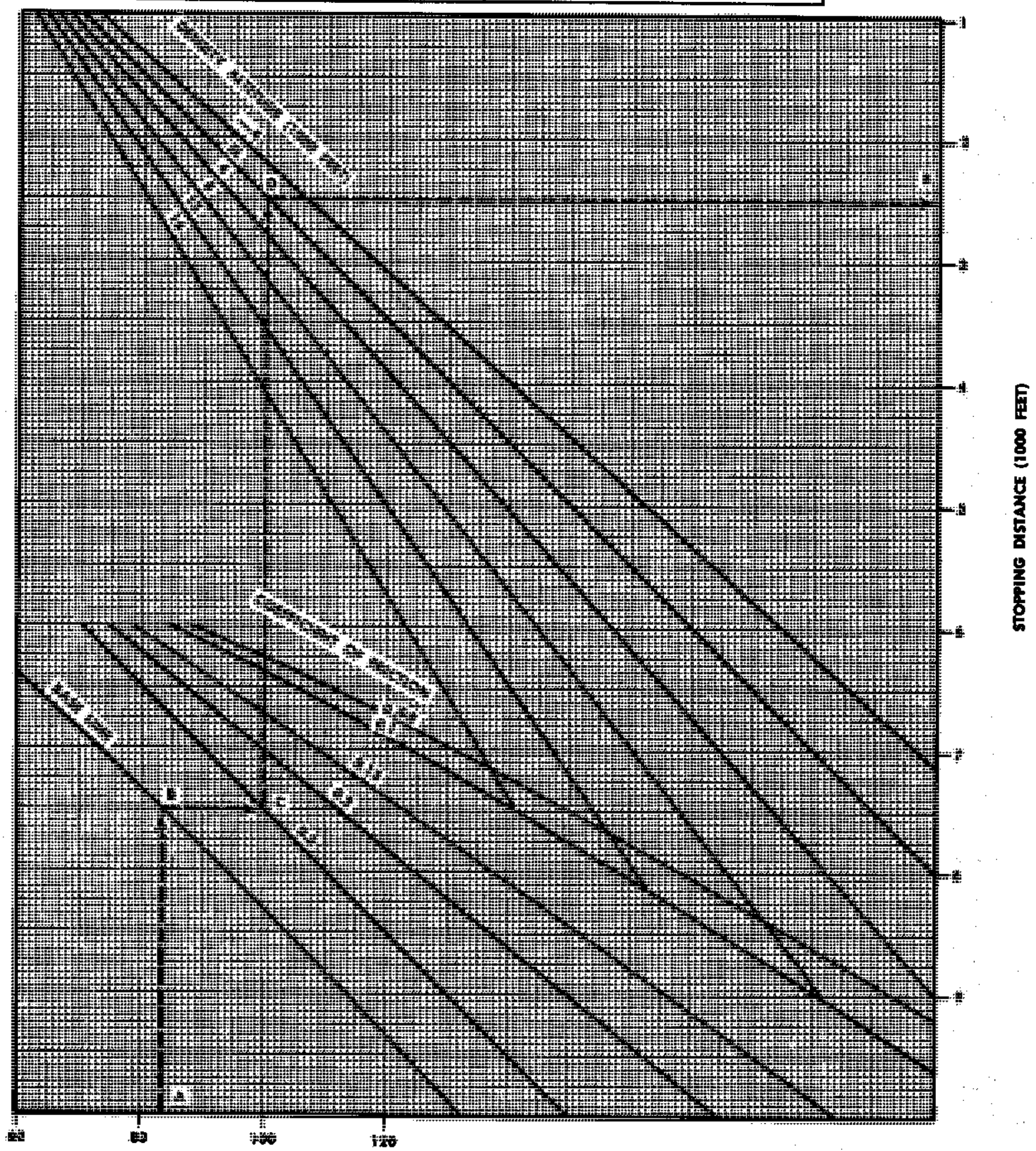
MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

DISTANCE TO STOP — BRAKES ONLY — PROPELLERS WINDMILLING

TAKEOFF FLAP ANGLE = 20 DEGREES

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

RUNWAY SURFACE CONDITION	AVERAGE COEFFICIENT OF FRICTION (μ)
DRY CONCRETE OR MACADAM	0.3
DRY TURF	0.2
WET CONCRETE OR MACADAM	0.15
SNOW OR WET GRASS	0.10
ICE	0.08



AA1-72

Figure A3-17. Distance to Stop — Brakes Only — Propellers Windmilling

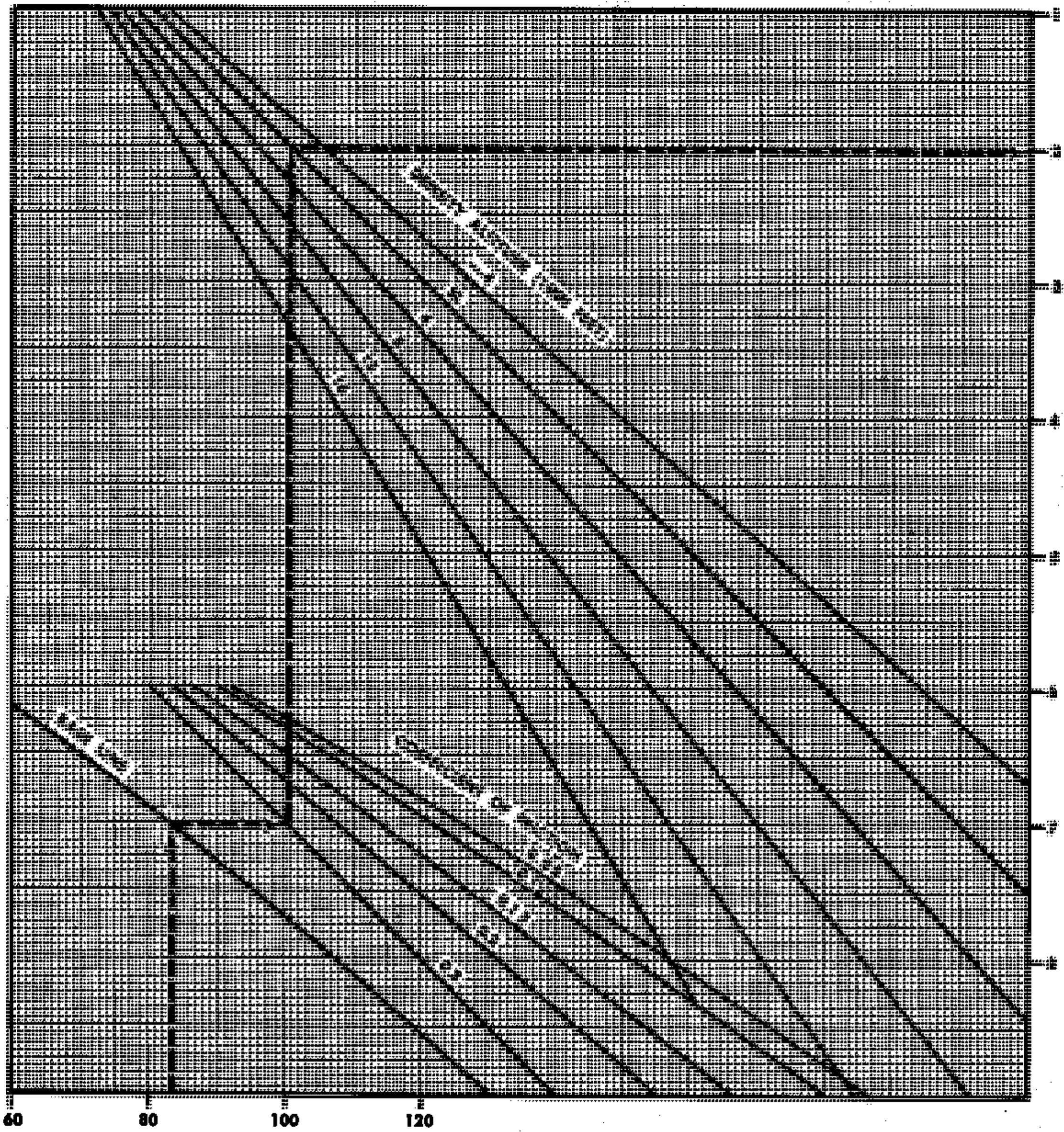
DISTANCE TO STOP — BRAKES PLUS TWO-ENGINE REVERSE THRUST

TAKEOFF FLAP ANGLE = 20 DEGREES

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

RUNWAY SURFACE CONDITION	AVERAGE COEFFICIENT OF FRICTION (μ)
DRY CONCRETE OR MACADAM	[illegible]
DRY TURF	[illegible]
WET CONCRETE OR MACADAM	[illegible]
SNOW OR WET GRASS	[illegible]
ICE	[illegible]



AA1-94

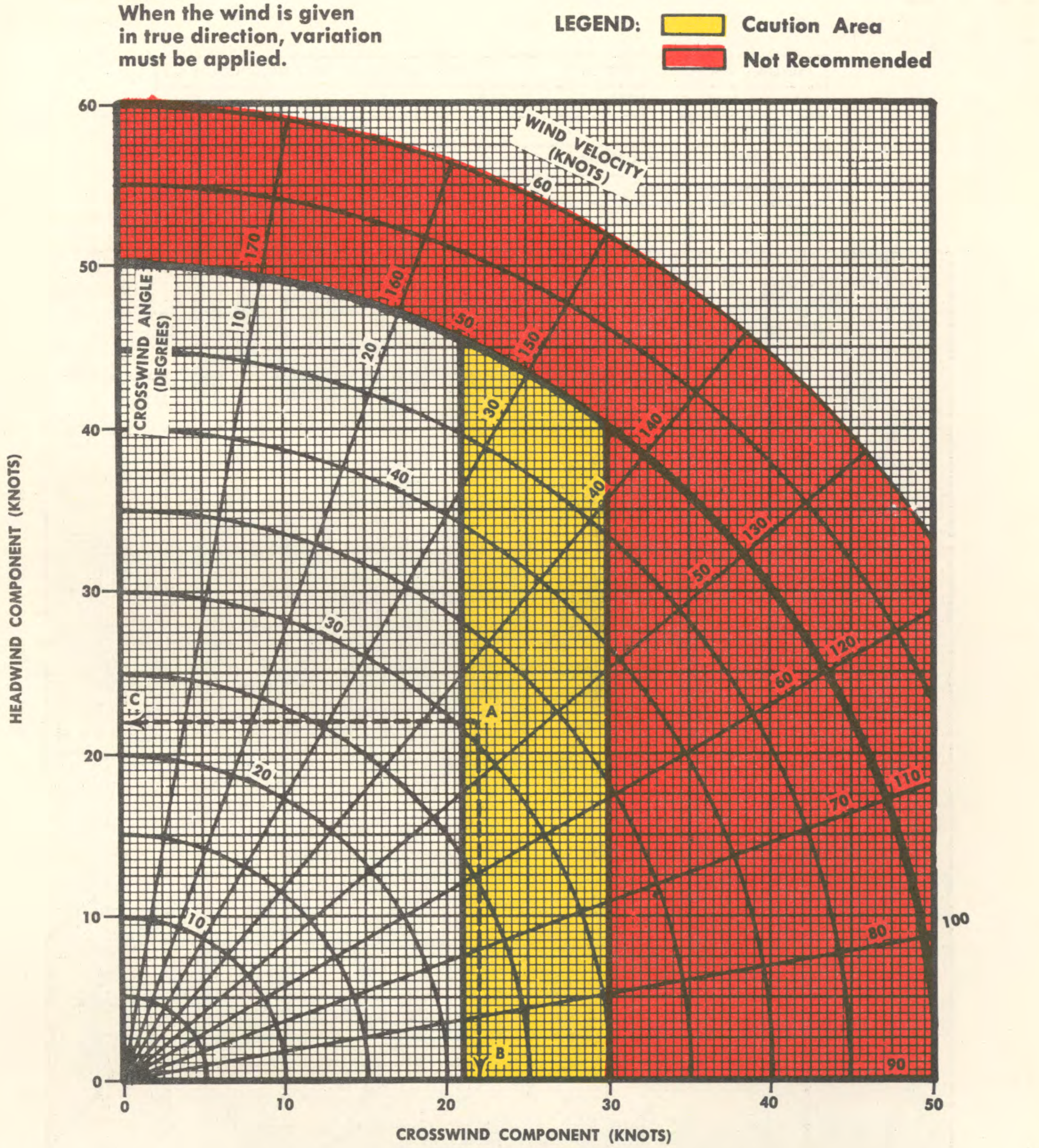
Figure A3-18. Distance to Stop — Brakes Plus Two-Engine Reverse Thrust

TAKEOFF AND LANDING CROSSWIND

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

NOTE:
When the wind is given in true direction, variation must be applied.



NOTE:
Maximum allowable nosewheel liftoff or touchdown speed is 139 knots due to tire structure limitations.

SAMPLE PROBLEM:
GIVEN:

Takeoff runway .030.
Wind: = 31 knots at .075.
Crosswind angle = .075 — .030 = .045.

A. Wind = 31 knots at 45 degrees crosswind angle.
B. Crosswind component = 22 knots.
C. Headwind component = 22 knots.

AA1-515

Figure A3-19. Takeoff and Landing Crosswind

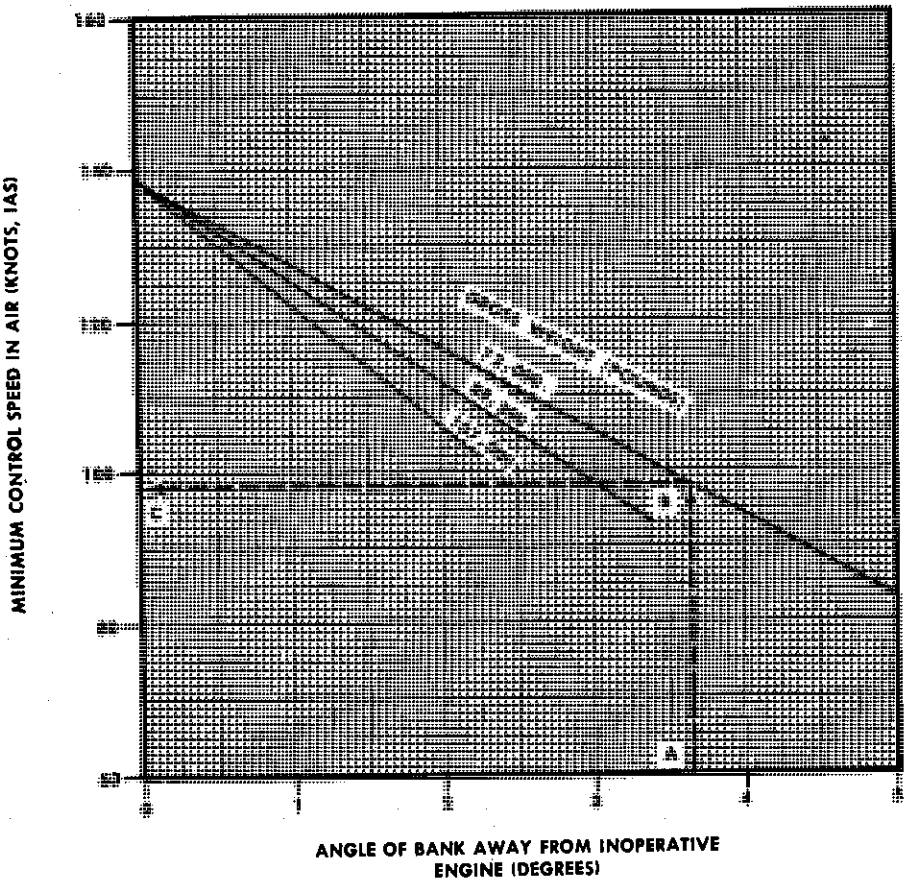
MINIMUM CONTROL SPEED VS BANK ANGLE

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

NOTE:
1. Based on one outboard engine inoperative, propeller windmilling.
2. Three engines operating at 2500 BHP/ENG.
3. Wing flaps 20 degrees.

SAMPLE PROBLEM:
A. Bank angle = 3.65 degrees.
B. Gross weight = 173,000 pounds.
C. Minimum control speed = 98 knots IAS.



AA1-540

Figure A3-20. Minimum Control Speed Vs Bank Angle