part 4
climb

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DISCUSSION OF CHARTS.

TIME, DISTANCE AND FUEL TO CLIMB CHARTS.

Two charts are provided *(figures A4-1 and A4-2)* from which may be determined the time elapsed, distance travelled and fuel consumed during an operational climb from sea level to cruise altitude. One chart is for 1400 brake horsepower per engine and the other is for 1500. In both cases the power is assumed to be constant from sea level up to the altitude at which that power may only be obtained with full throttle and 2600 RPM. Above that altitude power is assumed to decrease as the engine settings remain at full throttle and 2600 RPM.

The charts were prepared for standard atmospheric conditions. However, they may be used for conditions hotter than standard if the pressure altitude is increased by 0.7% for each degree Centigrade that the outside air temperature is above standard. This temperature difference should be the average temperature difference throughout the climb. For example, if, at the initial climb altitude, the outside air temperature is 15 degrees Centigrade above standard and it is determined that at the cruise altitude it will only be 5 degrees Centigrade above standard (for that altitude) then, in using these charts, it may be assumed that the average temperature difference is 10 degrees above standard. In this case the altitude correction for temperature will be 10 degrees times 0.7% per degree, or 7%. This means that if the cruise altitude were 20,000 feet the altitude correction would be 7% of 20,000 feet, or 1,400 feet. The charts would be read at 20,000 feet plus 1,400 feet, or 21,400 feet.

Although the charts are based on sea level as the initial climb altitude they may be used when the initial climb altitude is above sea level. For example, in the problem discussed above assume that the initial climb altitude is 6,000 feet, the initial climb gross weight is 98,000 pounds and 1400 BHP is to be used. Enter the chart on figure A4-1 at 98,000 pounds and proceed vertically upward to 6,000 feet altitude plus 7% of 6,000 feet. This would be 6,000 feet plus 420 feet, or 6,420 feet. Note that at this point the distance is 30 nautical miles and the time is 11 minutes. Now proceed upwards parallel to the guide lines to 21,400 feet altitude (determined above). At this point note that the distance is 156 nautical miles, the time is 49 minutes and the gross weight is 95,400 pounds. By subtracting these two sets of values we determine that in climbing from 6,000 to 20,000 feet the distance travelled will be 156 nautical miles minus 30 nautical miles, or 126 nautical miles. The time required will be 49 minutes minus 11 minutes, or 38 minutes and the fuel consumed will be 98,000 pounds minus 95,400 pounds, or 2,600 pounds.

No correction has been established for colder than standard conditions. In such cases read the charts at the actual pressure altitude.

EMERGENCY CEILING CHARTS.

Two charts are provided *(figures A4-3 and A4-4)* showing the altitude at which 100 feet per minute rate of climb may be maintained with METO power at any given gross weight. One chart is for standard fuel grade and the other is for alternate fuel grade. On both charts there are curves for four engines, three engines and two engines operating. Grids are included to allow corrections to be made for hotter than standard temperatures. The charts are based on a clean configuration and a climbing airspeed of 136 knots IAS.

EMERGENCY CLIMB CHARTS.

The Emergency Climb charts *(figures A4-5 through A4-13)* indicate the rate of climb at various combinations of power, indicated airspeed, gross weight and density altitudes. Charts are provided for both four- and three-engine operation in the takeoff configuration with the gear up and with the gear down, enroute configuration (flaps and gear up), and in the landing configuration (flaps full down and gear down). A chart is also provided for two-engine operation in the enroute configuration. No chart is provided for two-engine operation in the landing configuration since a negative rate of climb exists during two-engine operation with both flaps and gear down.

All charts are based on the cowl flaps at +3 degrees on the operative engines. Thre three- and two-engine charts are based on the cowl flaps at −4 degrees and the propellers feathered on the inoperative engines.

The speeds for best rate of climb and the power off stall speeds for various gross weights are indicated on each chart. A sample problem to illustrate the method of using the charts is included on figure A4-5.

PERFORMANCE CLIMBS CHART.

This chart *(figure A4-14)* shows the variation of rate of climb vs gross weight for several three-engine configurations. Four of these configurations may occur during the climbout after a takeoff with engine failure and the fifth is the three-engine enroute configuration. They are all based on sea level standard atmospheric conditions. A scale is included to show the takeoff speed vs gross weight.

POWER SETTINGS FOR CLIMB TABLES.

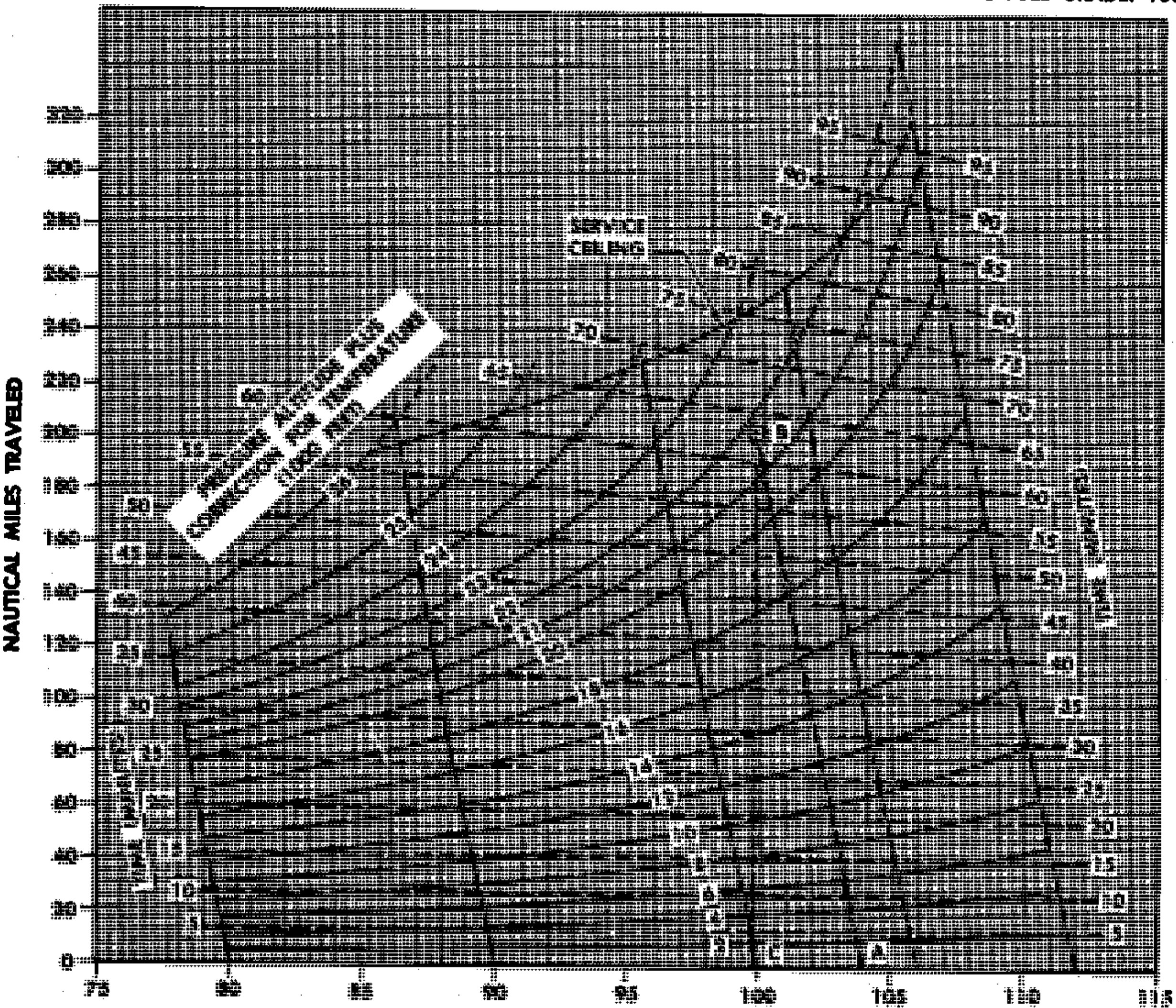
Four tables are provided, tabulating the power settings necessary to maintain climb power for various altitude and carburetor air temperature combinations. The tables are based on a constant RPM and BMEP for a given brake horsepower and show the manifold pressures necessary to maintain the required brake horsepower at a given altitude and carburetor air temperature. The range of fuel flow for these power settings is shown on each table. Tables are provided for four-engine climb at 1400 BHP/engine *(figure A4-15)* and 1500 BHP/engine *(figure A4-16)*, and for three- and two-engine climb at 1600 BHP/engine *(figure A4-17)* and 1700 BHP/engine *(figure A4-18)*.

TIME, DISTANCE AND FUEL TO CLIMB—1400 BHP

ALL ENGINES OPERATING—AUTO RICH MIXTURE
CLIMBING AIRSPEED=156 KNOTS CAS

MODEL: C-118A
DATA AS OF: 2-16-59
DATA BASED ON FLIGHT TEST

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



NOTES:

1. For standard atmospheric conditions and for colder than standard atmospheric conditions use no correction for temperature.
2. For hot day the correction for temperature is equal to 0.7% of the pressure altitude for each °C above standard (for example when climbing from sea level to 15,000 feet the correction is 0.7% of 15,000 feet, or 105 feet for each °C above standard. If the temperature were 6°C above standard the correction would be 105 x 6, or 630 feet. Add 630 feet to 15,000 feet and read time, distance and fuel to climb to 15,630 feet.
3. Based on 1400 BHP from sea level up to altitude at which full throttle is reached with 2600 RPM in high blower. Based on full throttle and 2600 RPM above that altitude.

SAMPLE PROBLEM

GIVEN:

1. Gross weight at start of climb = 104,000 pounds.
2. Climb from sea level to 20,000 feet pressure altitude.
3. Average temperature deviation = 12°C above standard.
   (Correction for temperature = 0.7% of 20,000 x 12, or 1680 feet).

A. Enter chart at 104,000 pounds gross weight.
B. Follow contour to 20,000 feet pressure altitude plus 1680 feet correction for temperature, or 21,680 feet. Read time to climb, 63 minutes, and distance travelled, 202 nautical miles.
C. Weight at end of climb = 99,800 pounds. Fuel consumed during climb = 104,000 − 99,800, or 4200 pounds.

Figure A4-1. Time, Distance and Fuel to Climb — 1400 BHP

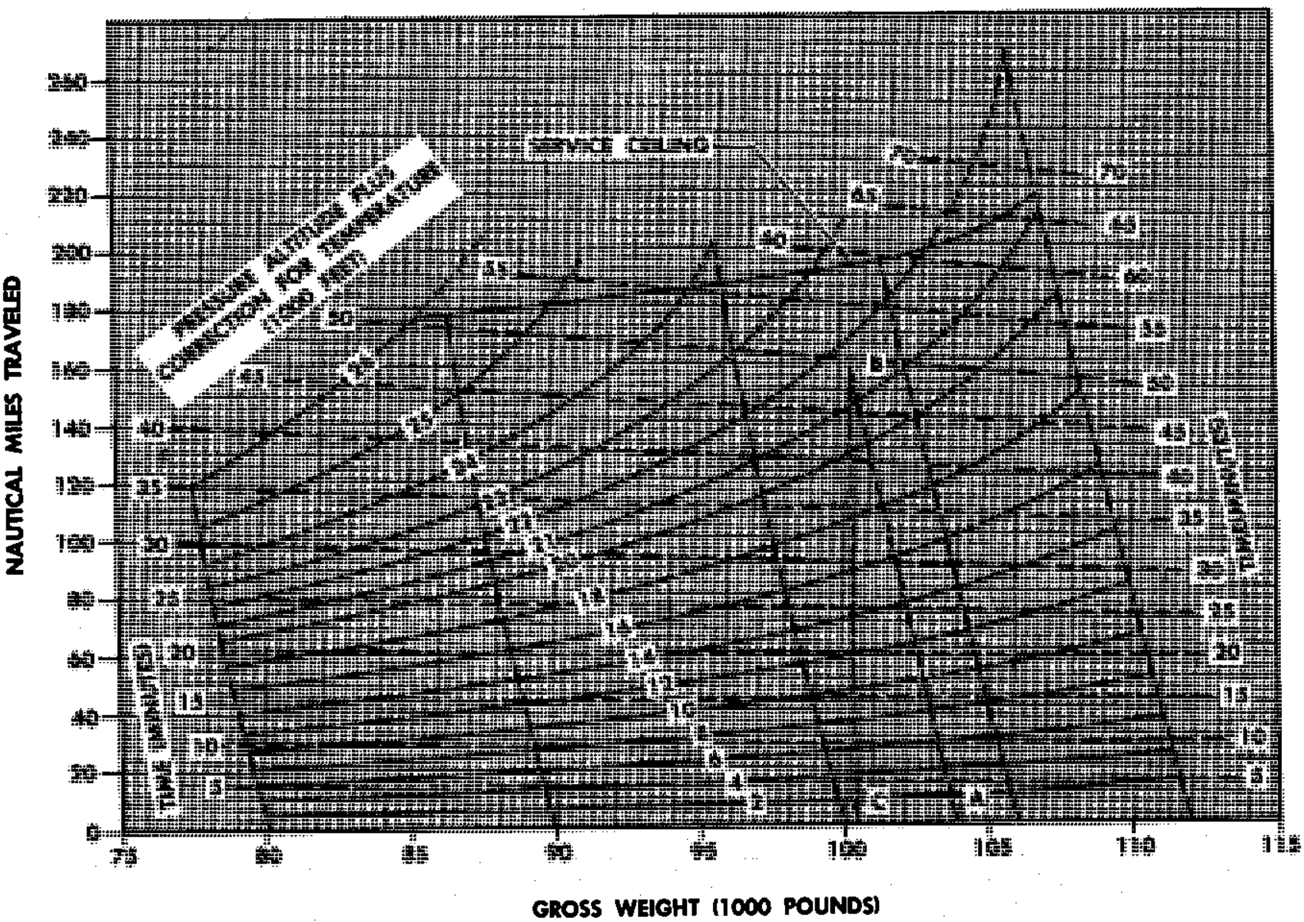
AA1-243

TIME DISTANCE AND FUEL TO CLIMB—1500 BHP

ALL ENGINES OPERATING—AUTO RICH MIXTURE
CLIMBING AIRSPEED=156 KNOTS CAS

MODEL: C-118A
DATA AS OF: 2-15-59
DATA BASED ON: FLIGHT TEST

ENGINES: (4) R 2800-52 W
FUEL GRADE 115/145
ALTERNATE FUEL GRADE: 100/130



NOTES:

1. For standard atmospheric conditions and colder than standard atmospheric conditions use no correction for temperature.
2. For hot days the correction for temperature is equal to 0.7% of the pressure altitude for each °C above standard (for example when climbing from sea level to 15,000 feet the correction is 0.7% of 15,000 feet, or 105 feet, for each °C above standard. If the temperature were 6 °C above standard the correction would be 105 x 6, or 630 feet. Add 630 feet to 15,000 feet and read time distance and fuel to climb to 15,630 feet.
3. Based on 1500 BHP from sea level up to altitude at which full throttle is reached with 2600 RPM in high blower. Based on full throttle and 2600 RPM above that altitude.

SAMPLE PROBLEM

GIVEN:

1. Gross weight at start of climb = 104,000 pounds.
2. Average temperature deviation = 12°C above standard.
   (Correction for temperature = 0.7% of 20,000 x 12, or 1680 feet.)

A. Enter chart at 104,000 pounds gross weight.
B. Follow contour to 20,000 feet pressure altitude plus 1680 feet correction for temperature or 21,680 feet. Read time to climb 49 minutes, and distance travelled, 158 nautical miles.
C. Weight at end of climb = 100,350 pounds. Fuel consumed during climb = 104,000 — 100,350 or 3650 pounds.

AA1-242

Figure A4-2. Time, Distance and Fuel to Climb — 1500 BHP

EMERGENCY CEILING

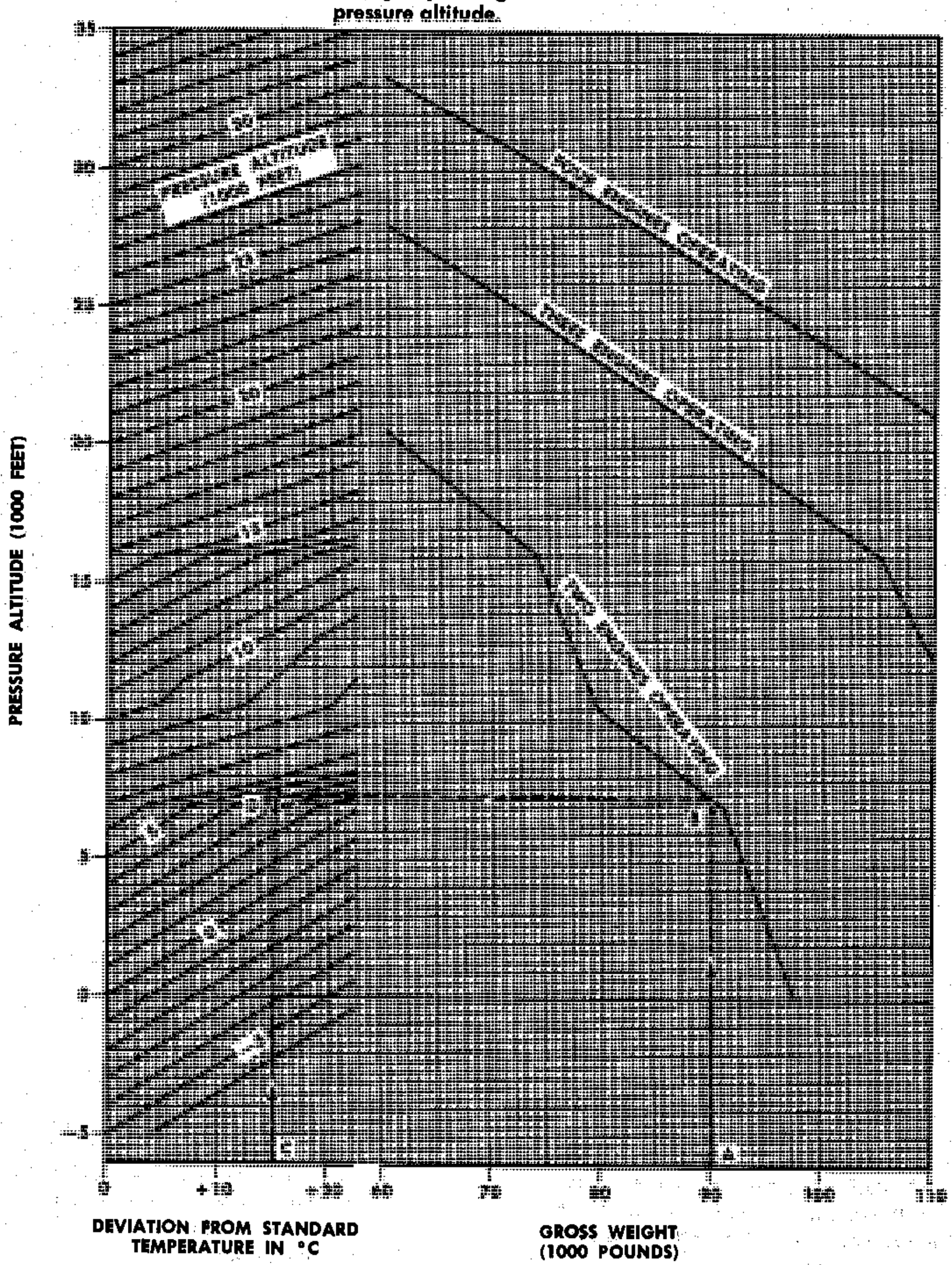
100 FEET PER MINUTE RATE OF CLIMB AT
METO POWER
CLIMBING SPEED — 136 KNOTS, PILOT'S IAS

MODEL: C-118A
DATA AS OF 2-15-59
BASED ON FLIGHT TEST

ENGINE(S): R2800-52W
FUEL GRADE: 115/145

SAMPLE PROBLEM:

A. Gross weight = 90,000 pounds.
B. Two engines operating.
C. Temperature = 15°C above standard.
D. Emergency ceiling = 4300 feet pressure altitude.



AA1-227

Figure A4-3. Emergency Ceiling — Standard Fuel Grade

EMERGENCY CEILING

100 FEET PER MINUTE RATE OF CLIMB AT METO POWER
CLIMBING SPEED — 136 KNOTS, PILOT'S IAS

MODEL: C-118A
DATA AS OF: 2-15-59
BASED ON: FLIGHT TEST

ENGINE(S): R2800-52W
FUEL GRADE: 100/130

SAMPLE PROBLEM:

A. Gross weight = 90,000 pounds.
B. Two engines operating.
C. Temperature = 15°C above standard.
D. Emergency ceiling = 400 feet pressure altitude.

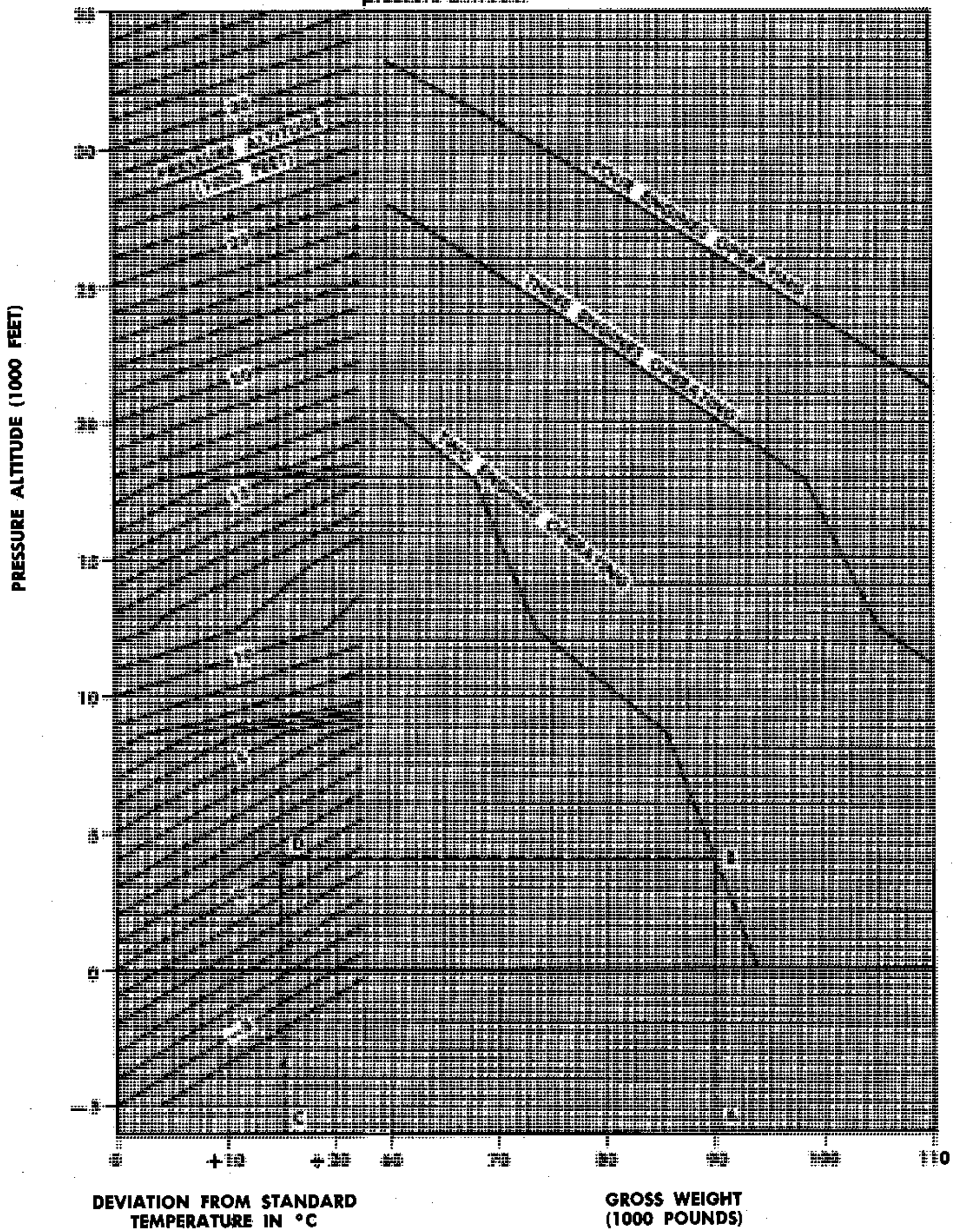


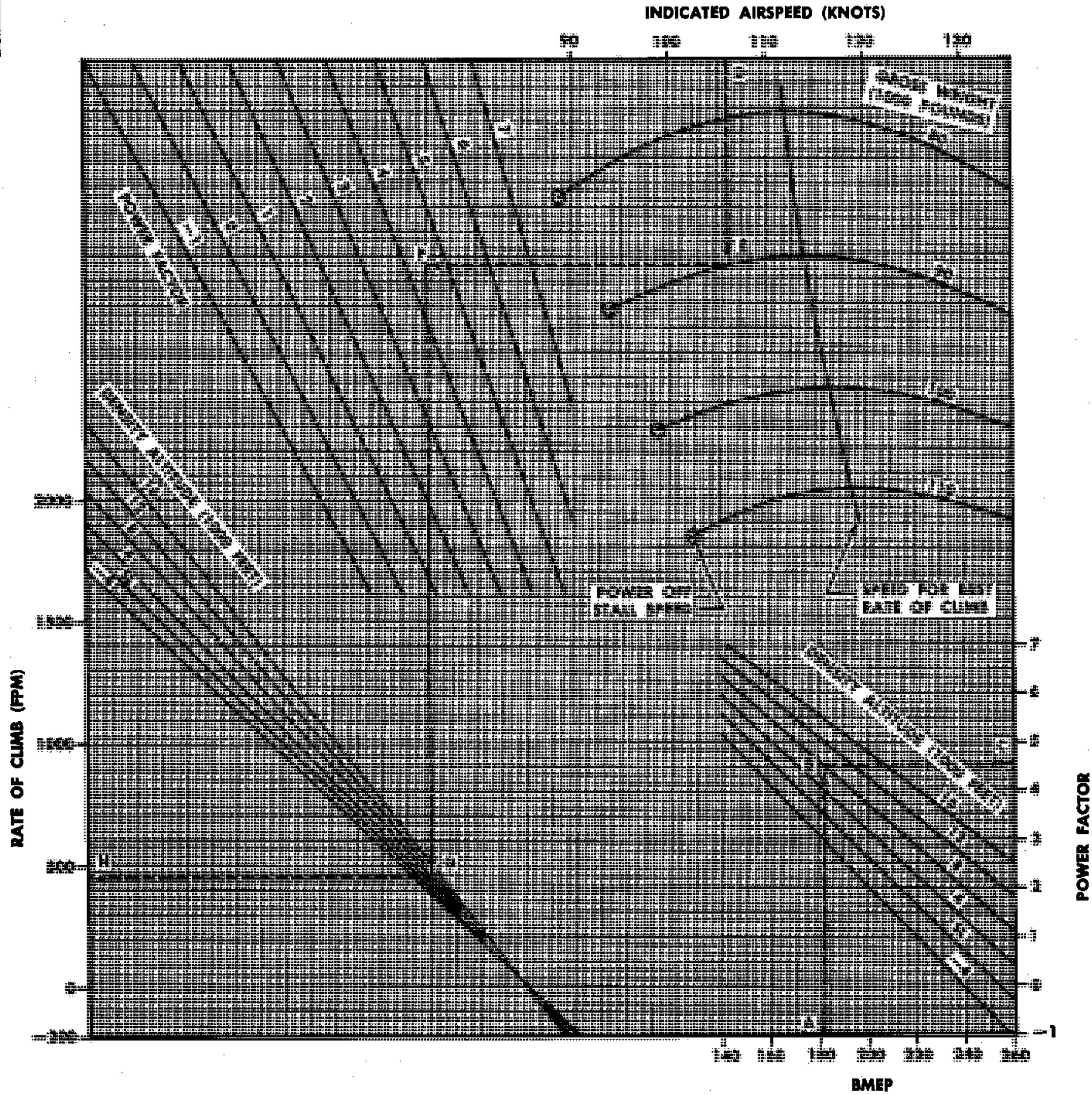
Figure A4-4. Emergency Ceiling — Alternate Fuel Grade

FOUR-ENGINE EMERGENCY CLIMB — TAKEOFF CONFIGURATION — FLAPS 20 DEGREES, GEAR DOWN

COWL FLAP SETTING: +3 DEGREES ON ALL ENGINES

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. BMEP = 182 PSI.
B. Density altitude = 8,000 feet.
C. Power factor = 4.5.
D. Indicated airspeed = 106 knots.
E. Gross weight = 90,000 pounds.
F. Power factor = 4.5.
G. Density altitude = 8,000 feet.
H. Rate of climb = 450 FPM.

AA1-42

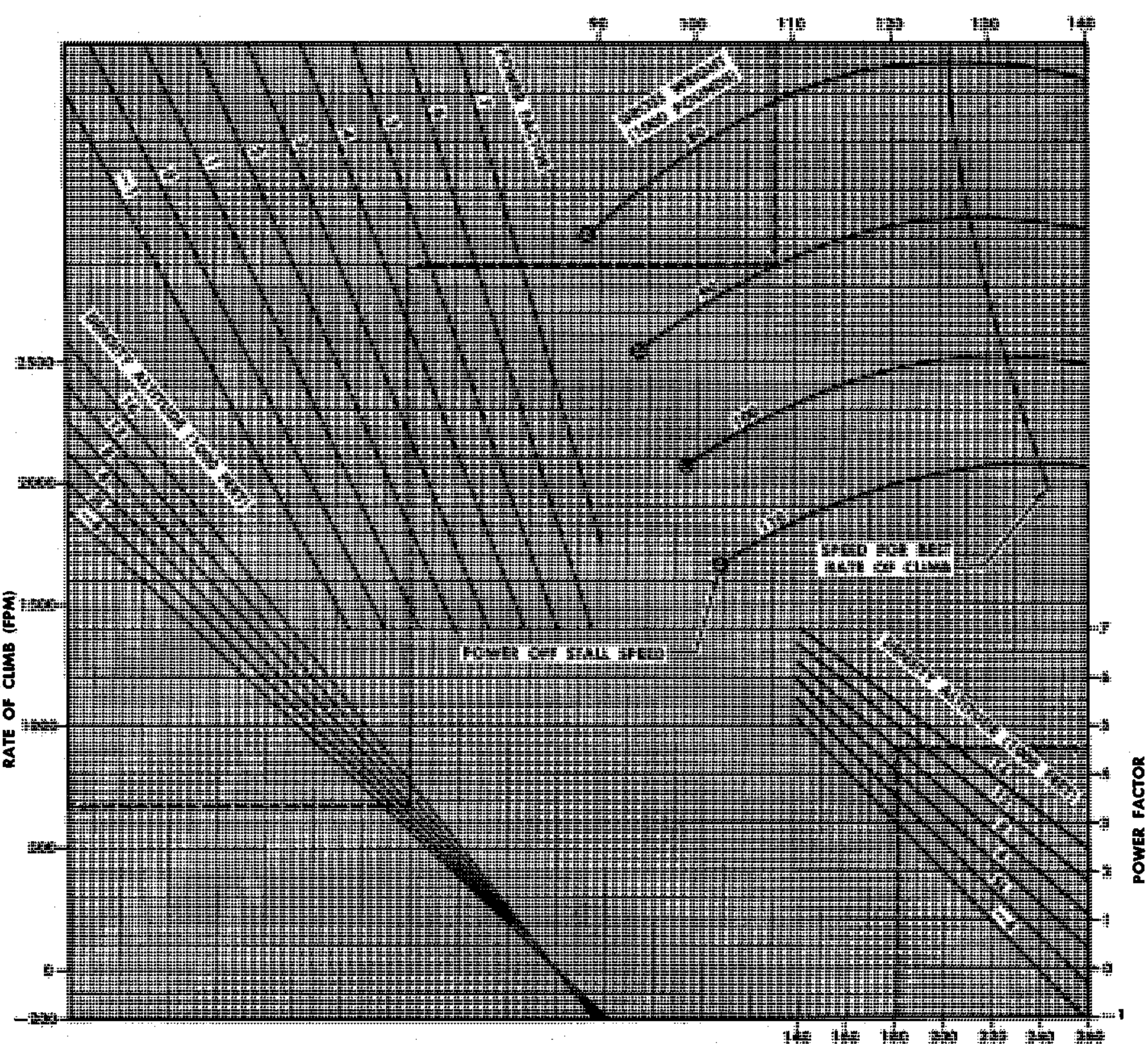
Figure A4-5. Four-Engine Emergency Climb—Takeoff Configuration—Flaps 20 Degrees, Gear Down

FOUR-ENGINE EMERGENCY CLIMB — TAKEOFF CONFIGURATION — FLAPS 20 DEGREES, GEAR UP

COWL FLAP SETTING: +3 DEGREES ON ALL ENGINES

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



AA1-516

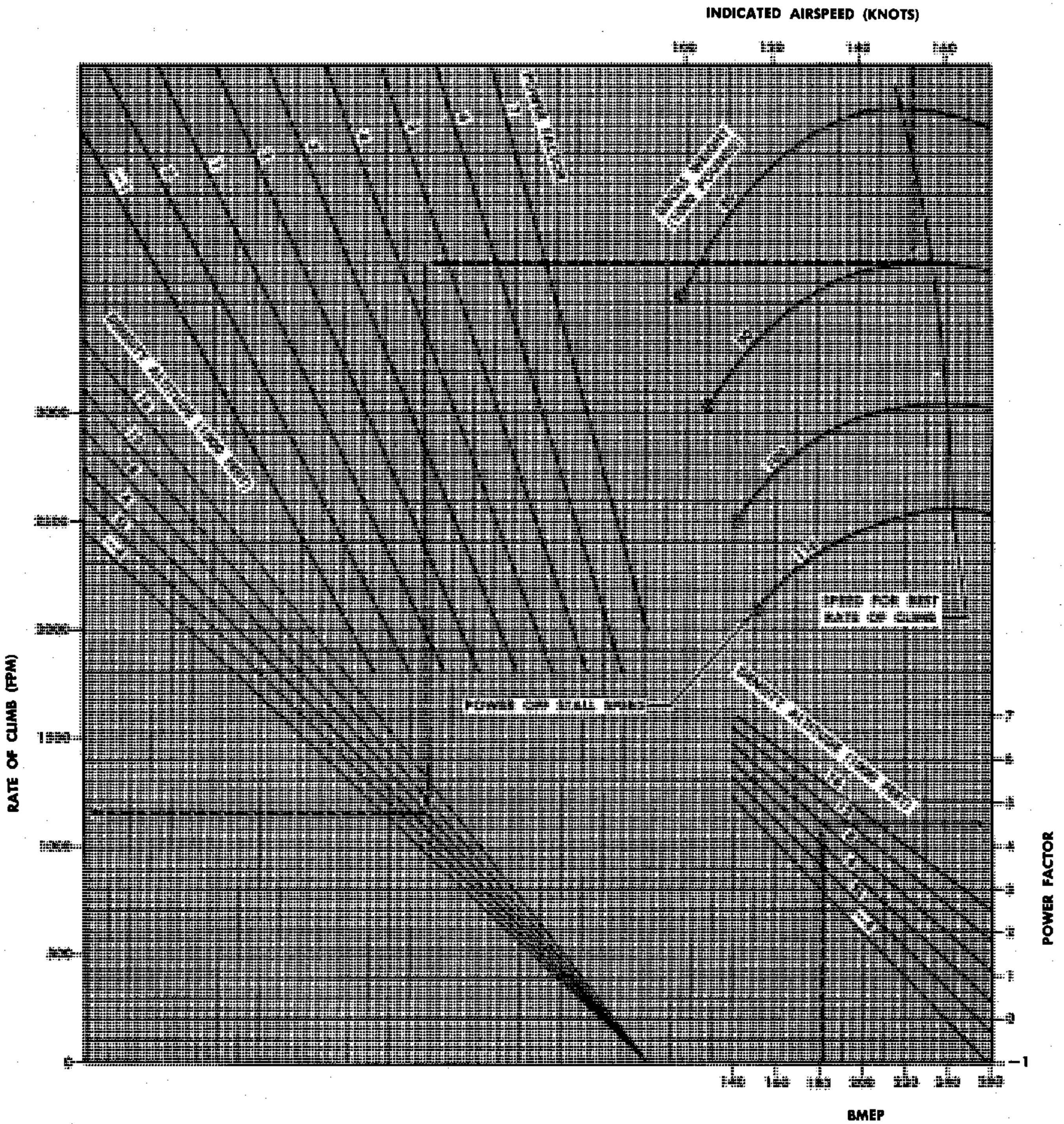
Figure A4-6. Four-Engine Emergency Climb — Takeoff Configuration — Flaps 20 Degrees, Gear Up

FOUR ENGINE EMERGENCY CLIMB — ENROUTE CONFIGURATION — FLAPS UP, GEAR UP

COWL FLAP SETTING: +3 DEGREES ON ALL ENGINES

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



AA1-517

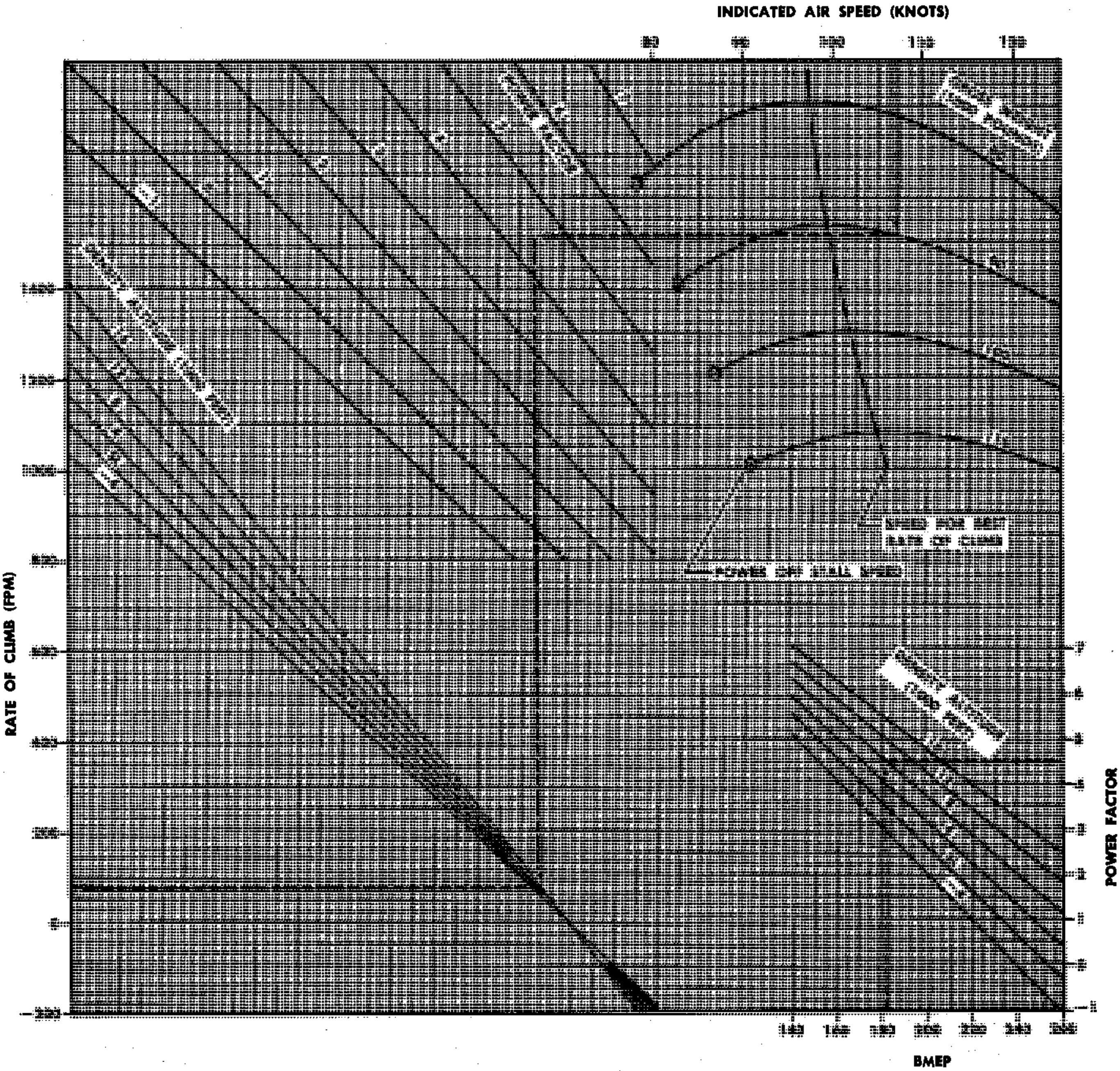
Figure A4-7. Four-Engine Emergency Climb — Enroute Configuration — Flaps Up, Gear Up

FOUR ENGINE EMERGENCY CLIMB — LANDING CONFIGURATION — FLAPS FULL DOWN, GEAR DOWN

COWL FLAP SETTING: +3 DEGREES ON ALL ENGINES

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



AA1-51B

Figure A4-8. Four-Engine Emergency Climb — Landing Configuration — Flaps Full Down, Gear Down

THREE-ENGINE EMERGENCY CLIMB — TAKEOFF CONFIGURATION — FLAPS 20 DEGREES, GEAR DOWN

COWL FLAP SETTING: +3 DEGREES ON OPERATING ENGINES
−4 DEGREES ON OPERATIVE ENGINE
PROPELLER FEATHERED ON INOPERATIVE ENGINE

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

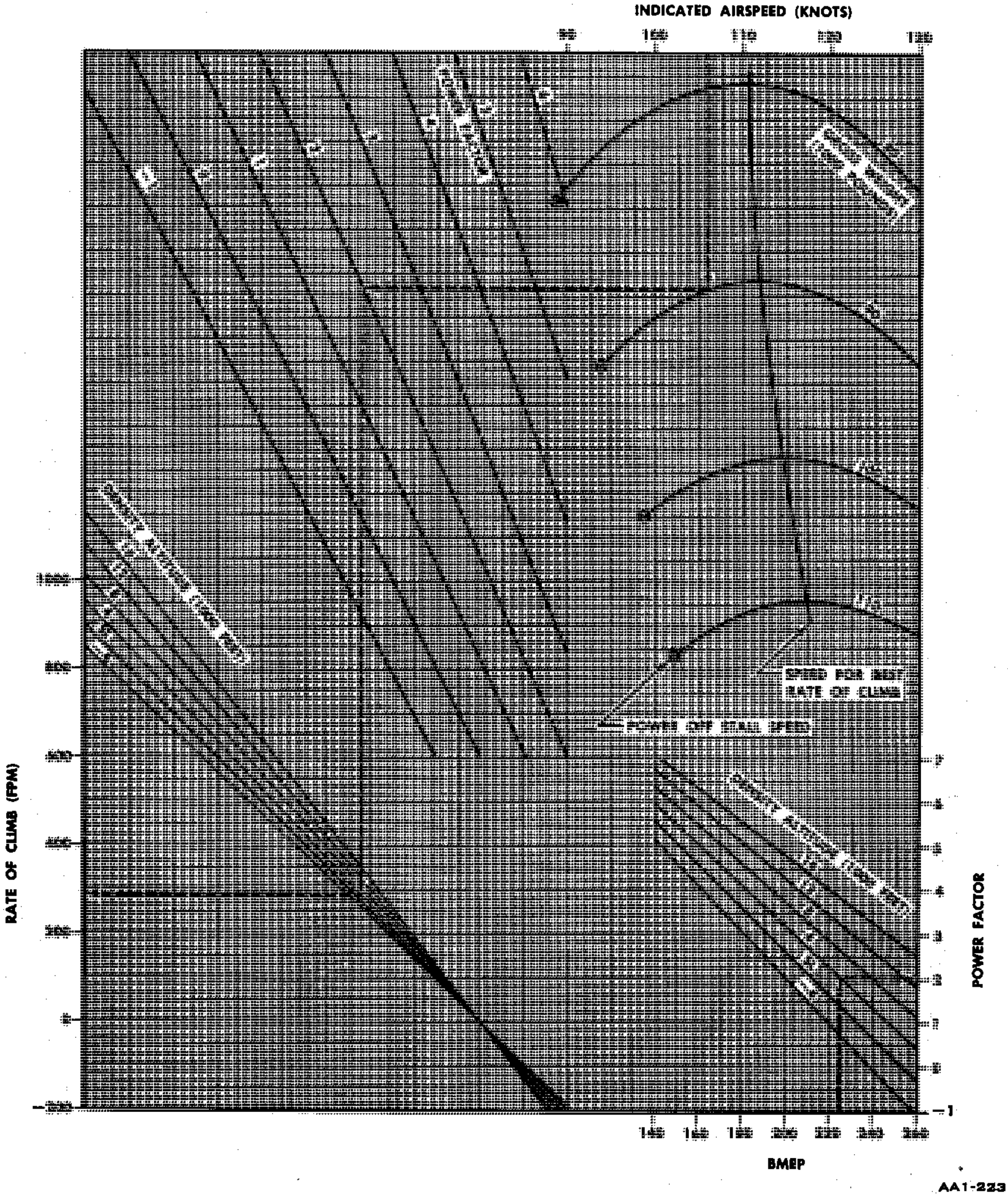


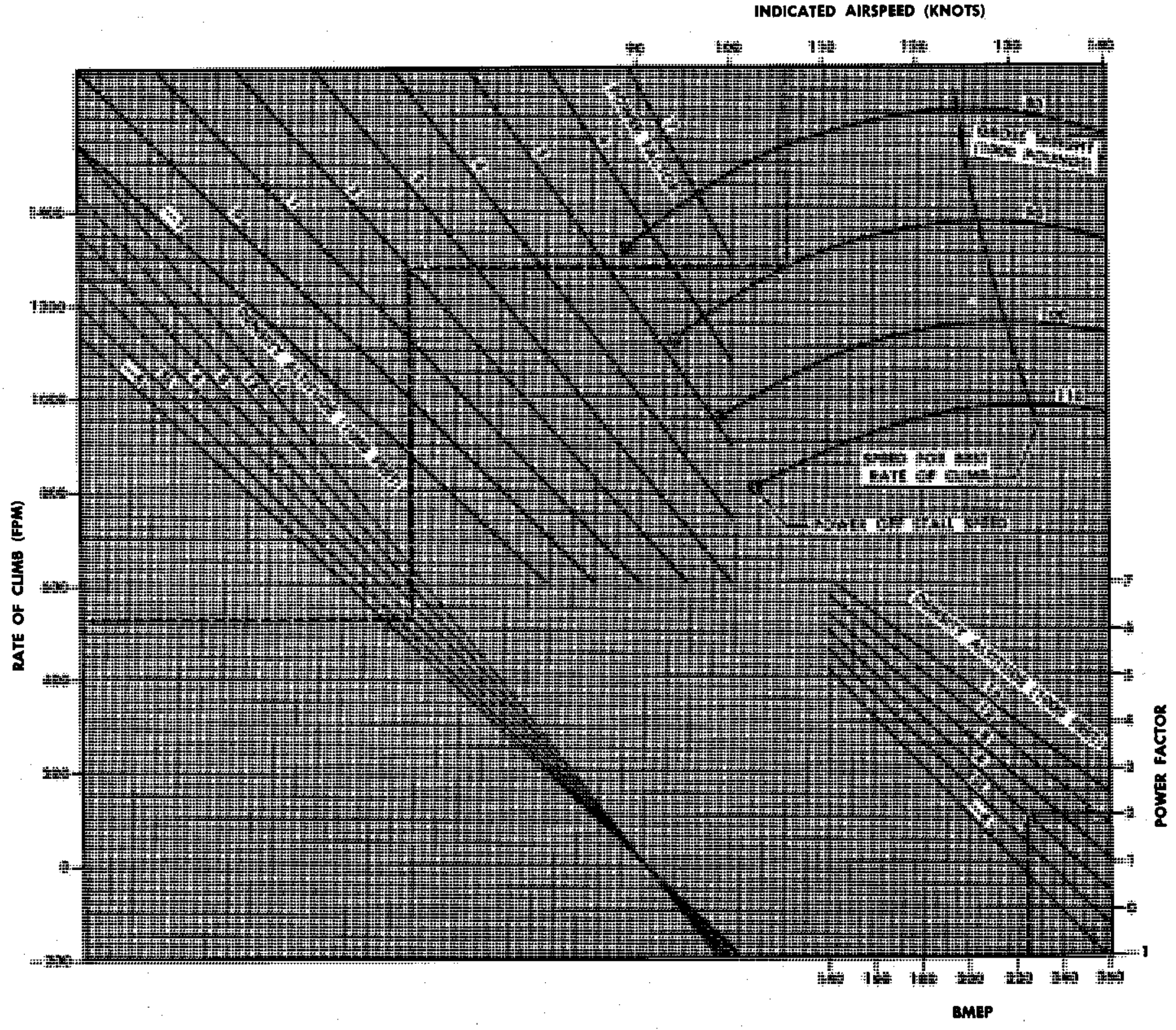
Figure A4-9. Three-Engine Emergency Climb — Takeoff Configuration — Flaps 20 Degrees, Gear Down

THREE-ENGINE EMERGENCY CLIMB — TAKEOFF CONFIGURATION — FLAPS 20 DEGREES, GEAR UP

COWL FLAP SETTING: +3 DEGREES ON OPERATING ENGINES
−4 DEGREES ON INOPERATIVE ENGINE
PROPELLER FEATHERED ON INOPERATIVE ENGINE

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



AA1-519

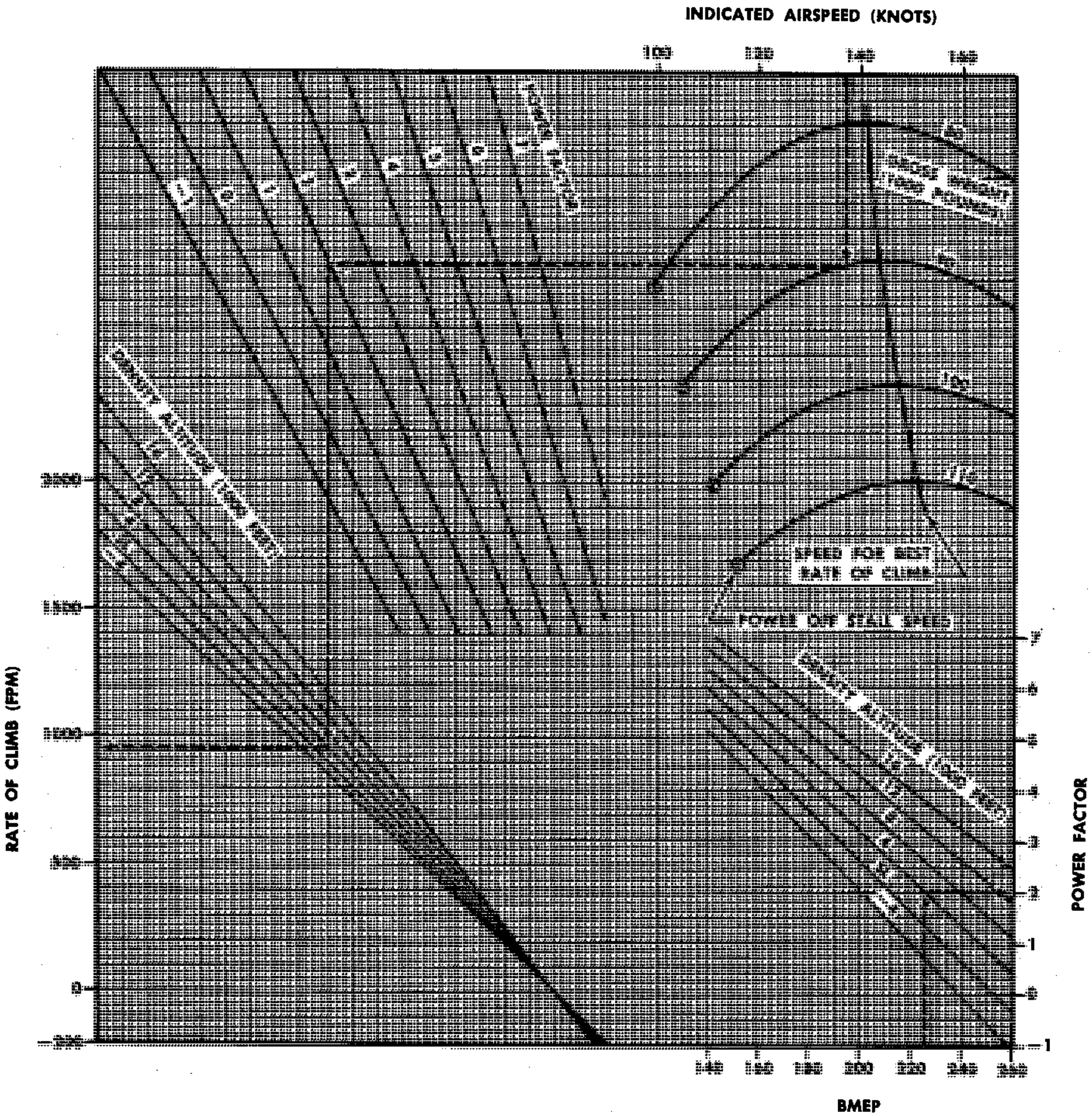
Figure A4-10. Three-Engine Emergency Climb — Takeoff Configuration — Flaps 20 Degrees, Gear Up

THREE-ENGINE EMERGENCY CLIMB — ENROUTE CONFIGURATION — FLAPS UP, GEAR UP

COWL FLAP SETTING: +3 DEGREES ON OPERATING ENGINES
−4 DEGREES ON INOPERATIVE ENGINE
PROPELLER FEATHERED ON INOPERATIVE ENGINE

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



AA1-520

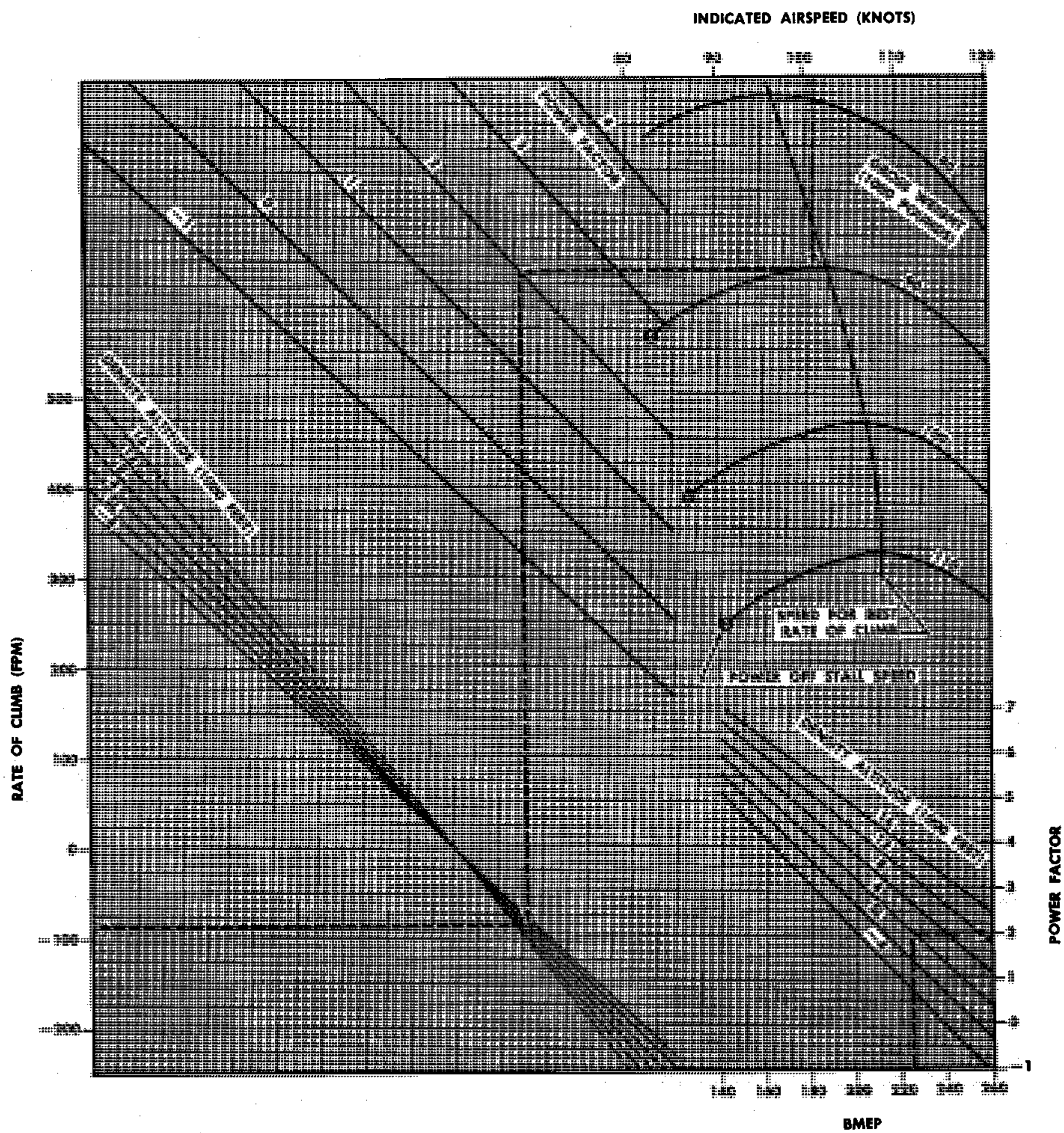
Figure A4-11. Three-Engine Emergency Climb — Enroute Configuration — Flaps Up, Gear Up

THREE-ENGINE EMERGENCY CLIMB — LANDING CONFIGURATION — FLAPS FULL DOWN, GEAR DOWN

COWL FLAP SETTING: +3 DEGREES ON OPERATING ENGINES
−4 DEGREES ON INOPERATIVE ENGINE
PROPELLER FEATHERED ON INOPERATIVE ENGINE

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



AA1-521

Figure A4-12. Three-Engine Emergency Climb — Landing Configuration — Flaps Full Down, Gear Down

TWO-ENGINE EMERGENCY CLIMB — ENROUTE CONFIGURATION — FLAPS UP, GEAR UP

COWL FLAP SETTING: +3 DEGREES ON OPERATING ENGINES
−4 DEGREES ON INOPERATIVE ENGINES
PROPELLERS FEATHERED ON INOPERATIVE ENGINES

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

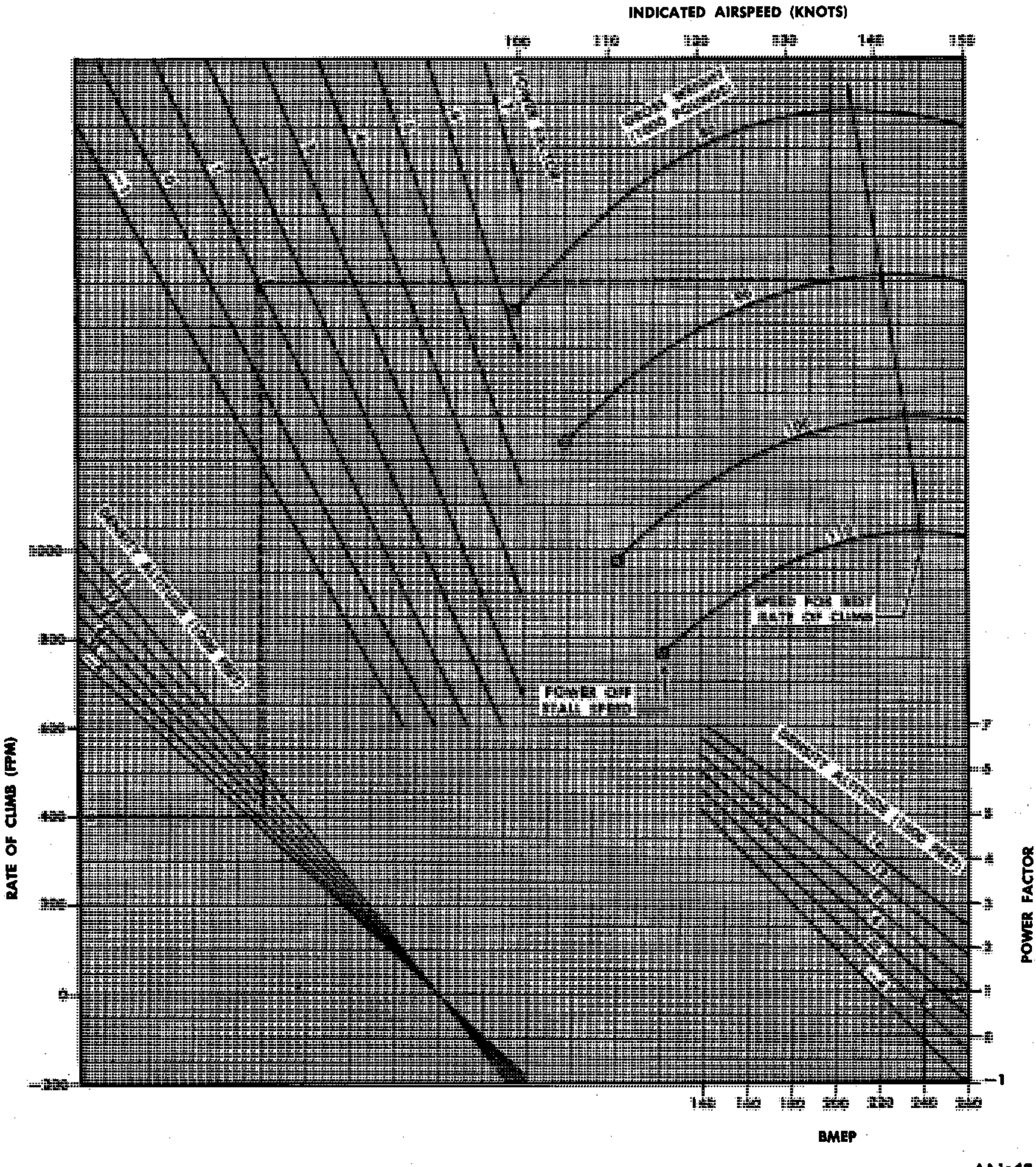


Figure A4-13. Two-Engine Emergency Climb—Enroute Configuration—Flaps Up, Gear Up

PERFORMANCE CLIMBS

SEA LEVEL

STANDARD ATMOSPHERIC CONDITIONS

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

ENGINE(S): (4) R2800-52W
WITH W/A INJECTION

TAKEOFF SPEED V_{TO} (KNOTS EAS)

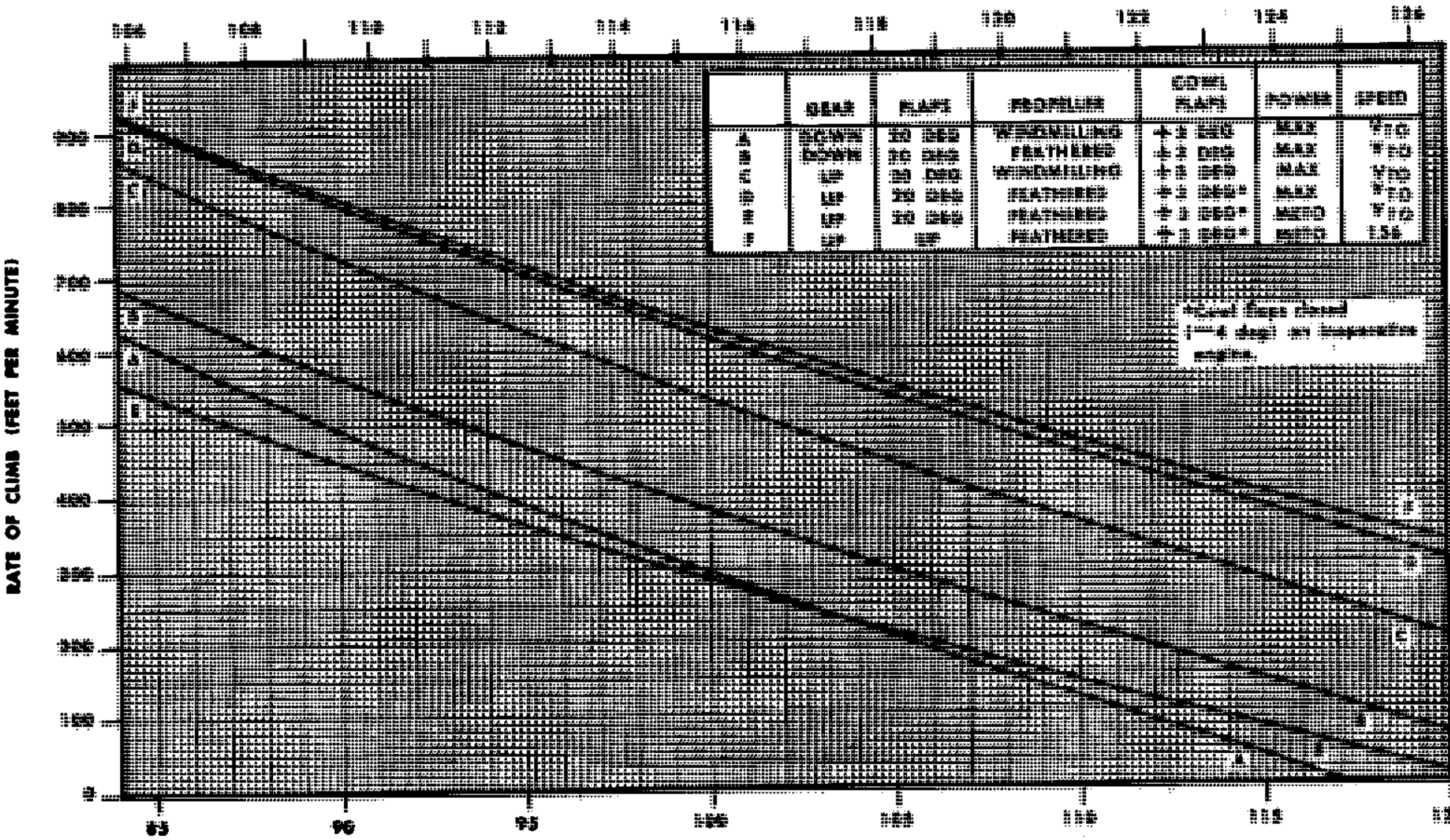


Figure A4-14. Performance Climbs

AA1-52

POWER SETTINGS FOR CLIMB AT 1400 BHP/ENGINE

2300 RPM*

172 BMEP* (NOMINAL)

150 TO 160 KNOTS IAS

200* CHT OR LESS DESIRED

Fuel Flow per Engine	*Low Blower*	*High Blower**
Normal Auto Rich	980 (lb/hr)	1000 (lb/hr)
Minimum	900 (lb/hr)	920 (lb/hr)

Pressure Altitude	*Manifold Pressure (In. Hg) at Carburetor Air Temp. °C*							
	−30°	−20°	−10°	0°	+10°	+20°	+30°	
18,000	38	*	*	*	*			HIGH BLOWER
16,000	37½	38	39	40	40¼			HIGH BLOWER
14,000	34½	38	39	39¾	40¼			HIGH BLOWER
12,000	34¾	35½	36	36½	37½			HIGH BLOWER
10,000	35	35¾	36¼	37	37¾	38½	39	LOW BLOWER
8000	35¼	36	36½	37¼	38	38½	39	LOW BLOWER
6000	35½	36¼	36¾	37½	38	39	39½	LOW BLOWER
4000	35¾	36½	37	37¾	38½	39	40	LOW BLOWER
2000	36	36¾	37½	38	39	39½	40	LOW BLOWER
S. L.	36¼	37	38	38½	39	40	40½	LOW BLOWER

*Above full throttle altitude, increase RPM to maintain highest M.P. shown under appropriate CAT. For each 100 RPM increase, fuel flow must increase 60 lb/hr and BMEP decrease 7. Do not exceed 2500 RPM except in emergency.

Figure A4-15. Power Settings for Climb at 1400 BHP/Engine

POWER SETTINGS FOR CLIMB AT 1500 BHP/ENGINE

2400 RPM*

177 BMEP* (NOMINAL)

150-160 KNOTS IAS

Fuel Flow per Engine	*Low Blower*	*High Blower**
Normal Auto Rich	1100 (lb/hr)	1150 (lb/hr)
Minimum	1020 (lb/hr)	1070 (lb/hr)

Pressure Altitude	*Manifold Pressure (In. Hg) at Carburetor Air Temp. °C*							
	−30°	−20°	−10°	0°	+10°	+20°	+30°	
18,000	40	*	*	*	*			HIGH BLOWER
16,000	40	40¾	41½	42¼	43	*	*	HIGH BLOWER
14,000	36¼	40¾	41½	42¼	43	43¾		HIGH BLOWER
12,000	36½	37¼	38	38¾	43	43¾		HIGH BLOWER
10,000	36¾	37½	38¼	39	39¾	40½	41	LOW BLOWER
8000	37	37¾	38½	39¼	40	40¾	41¼	LOW BLOWER
6000	37¼	38	38¾	39½	40¼	41	41½	LOW BLOWER
4000	37½	38½	39	39¾	40½	41¼	41¾	LOW BLOWER
2000	38	38¾	39¼	40	40¾	41½	42¼	LOW BLOWER
S. L.	38½	39¼	39¾	40½	41¼	42	42¾	LOW BLOWER

*Above full throttle altitude, increase RPM to maintain highest M.P. shown under appropriate CAT. For a 100 RPM increase, fuel flow must increase 60 lb/hr and BMEP must decrease 7. Do not exceed 2500 RPM except in emergency.

Figure A4-16. Power Settings for Climb at 1500 BHP/Engine

POWER SETTING FOR CLIMB AT 1600 BHP/ENGINE
2500 RPM — THREE AND TWO-ENGINE OPERATION
181 BMEP* (NOMINAL)
150-160 KNOTS IAS

Fuel Flow Per Engine	*Low Blower*	*High Blower*
Normal Auto Rich	1220	1320
Minimum	1140	1240

Pressure Altitude (Ft)	*Manifold Pressure (In. Hg.) at Carburetor Air Temp. (°C)*							
	−30°	*−20°*	*−10°*	*0°*	*+10°*	*+20°*	*+30°*	
18000	43							*HIGH BLOWER*
16000	43	43¾	44½	45¼	46			*HIGH BLOWER*
14000	38½	43¾	44½	45¼	46	46¾		*HIGH BLOWER*
12000	38¾	39½	40¼	41	46	46¾		*HIGH BLOWER*
10000	39	39¾	40½	41¼	42	42¾	43¼	*LOW BLOWER*
8000	39¼	40	40¾	41½	42¼	43	43½	*LOW BLOWER*
6000	39½	40¼	41	41¾	42½	43¼	43¾	*LOW BLOWER*
4000	39¾	40¾	41¼	42	42¾	43½	44¼	*LOW BLOWER*
2000	40¼	41	41¾	42½	43¼	44	44¾	*LOW BLOWER*
S.L.	40¾	41½	42¼	43	43¾	44½	45¼	*LOW BLOWER*

Figure A4-17. Power Settings for Climb at 1600 BHP/Engine

POWER SETTING FOR CLIMB AT 1700 BHP/ENGINE
2500 RPM — THREE- AND TWO-ENGINE OPERATION
192 BMEP (NOMINAL)
150-160 KNOTS IAS

Fuel Flow Per Engine	*Low Blower*
Normal Auto Rich	1320
Minimum	1240

Pressure Altitude (Ft.)	*Manifold Pressure (In. Hg.) at Carburetor Air Temp. (°C)*							
	−30°	*−20°*	*−10°*	*0°*	*+10°*	*+20°*	*+30°*	
18000								
16000								*HIGH BLOWER*
14000								
12000	41¼							
10000	41½	42½	43¼	44				
8000	41¾	42¾	43½	44¼	45	45¾	46¼	
6000	42	43¼	43¾	44½	45¼	46	46½	*LOW BLOWER*
4000	42½	43½	44	44¾	45½	46¼	47	
2000	43	43¾	44½	45¼	46	46¾	47½	
S.L.	43½	44¼	45	45¾	46½	47¼	48	

Figure A4-18. Power Settings for Climb at 1700 BHP/Engine