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By Lenore D. Fallmer
Signature and Grade
1/11/54

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HANDBOOK

FLIGHT OPERATING INSTRUCTIONS

Classification cancelled
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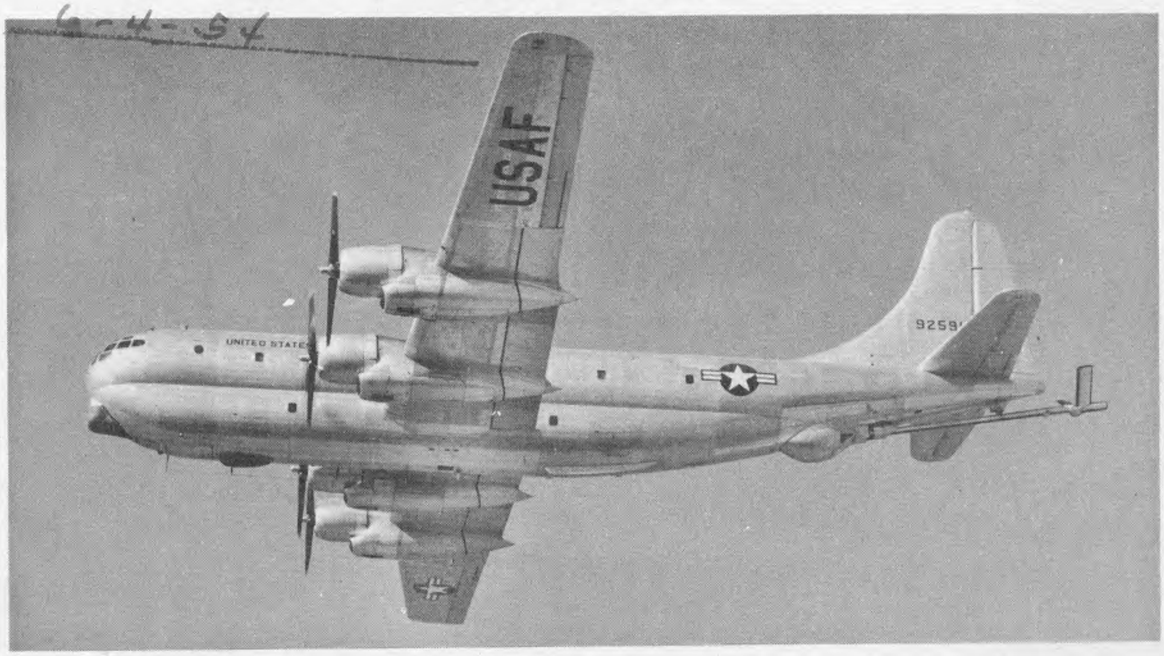
AUTH: MCMTO-1-7-E
By Norma Brown
Signature and Grade
Date 6-4-54

USAF SERIES

KC-97E

AIRCRAFT



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Gartner Printing & Litho Co. — 2335 — 12-21-51

10 AUGUST 1951

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F O R W A R D

IMPORTANT *In order that you will gain the maximum benefits from this handbook it is imperative that you read these pages carefully.*

This handbook contains all information necessary for safe and efficient operation of the airplane. These instructions are not intended to teach basic principles of flight, but are designed to provide you with a general knowledge of the airplane, its flight characteristics, and specific normal and emergency procedures to be used in operating the airplane and its related equipment. Your flying experience is recognized, and elementary instructions have been avoided.

The instructions are based on engineering reports and on flight observations by Air Force and manufacturer's test pilots. Every effort has been made to make the handbook easy to read and assimilate. Read the complete book for an over-all picture of the airplane; use it as a reference manual to answer specific questions. Remember that changes are made to the airplane from time to time and it is therefore necessary to revise the Flight Handbook frequently to reflect changes affecting operating procedures. In addition, changes affecting the airplane or flight procedures are issued immediately as short Technical Orders (01-20CA series) that supersede the Flight Handbook. These short Technical Orders are distributed as soon as the change is effective and should be used to supplement the handbook regarding late modifications of the airplane. Short Technical Orders are incorporated into the Flight Handbook at the earliest revision. Consult your base Technical Order index to be sure you have the latest issue of the Flight Handbook and for the effectivity of short Technical Orders.

The handbook is divided into seven sections, an appendix, and an index, as follows:

SECTION I, DESCRIPTION

The function of this section is to describe the airplane, its equipment, systems, and controls which are essential to flight and which will be needed for one complete non-combat mission in good weather at medium altitude. All emergency equipment which is not part of the auxiliary equipment and all miscellaneous equipment is also covered in this section.

SECTION II, NORMAL OPERATING INSTRUCTIONS

This section contains the steps of procedure to be accomplished from the time the aircraft is approached by the flight crew until it is left parked on the ramp after accomplishing one complete non-combat mission in good weather at medium altitude.

SECTION III, EMERGENCY OPERATING INSTRUCTIONS

This section clearly and concisely describes the procedure to be followed in meeting any emergency (except those in connection with the auxiliary equipment) that could reasonably be expected to be encountered.

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SECTION IV, DESCRIPTION AND OPERATION OF AUXILIARY EQUIPMENT

This section includes the description, normal operation, and emergency operation of all equipment not directly contributing to flight but which enables the airplane to perform certain specialized functions. Included in this category are such items of equipment as; cabin pressurizing, heating, and ventilating system, anti-icing systems, communication and associated electronic equipment, lighting equipment, oxygen system, navigation equipment, cargo, and in-flight refueling (IFR) equipment.

SECTION V, CREW DUTIES

This section covers the responsibilities of all crew members who have been assigned in addition to the minimum crew required. It is a compact collection of material wherein each crew member can readily determine his complete responsibilities when accomplishing a mission.

SECTION VI, ALL WEATHER OPERATION

The function of this section is to set forth the proper technique and procedure to be employed under conditions of cold weather, hot weather, and desert operation; instrument flight; and turbulent air flight.

SECTION VII, OPERATING LIMITATIONS

The function of this section is to cover general operating limitations and restrictions, which include minimum crew requirements, general flight restrictions, airplane component restrictions, weight limitations, and instrument markings.

APPENDIX I, OPERATIONAL DATA

Provides data on operational performance including takeoff, climb, detailed cruise control, and landing.

ALPHABETICAL INDEX

This index includes all paragraph headings and illustration titles listed alphabetically by each important word of the headings and titles and indexed to the page numbers where the information can be found.

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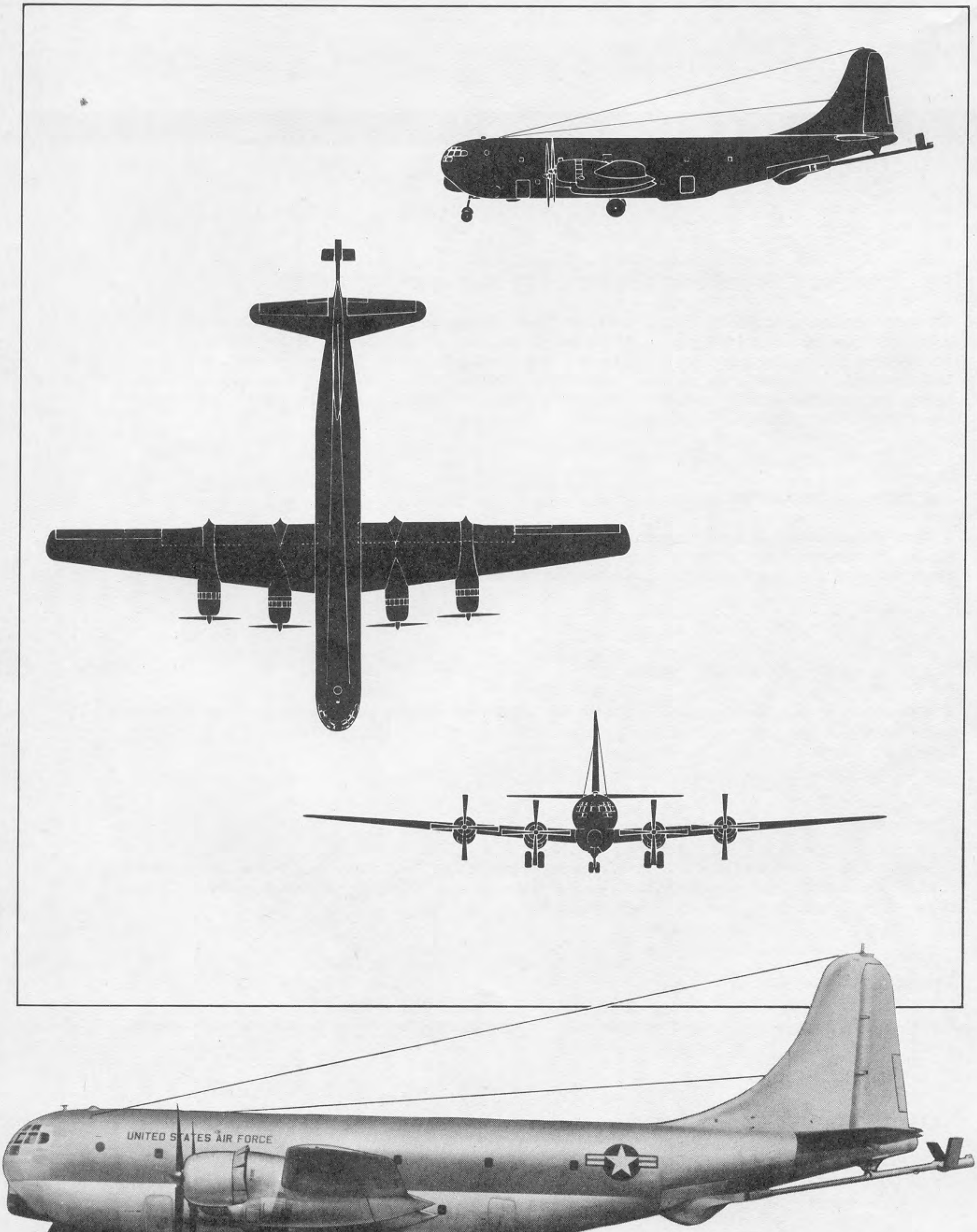

The Airplane

022004

Section I. Description

1-1. AIRPLANE.

1-2. GENERAL.

1-3. The Boeing KC-97E airplane is a four engine, long range, high altitude, high speed transport. It is equipped for use as a flying boom tanker for the in-flight refueling of other aircraft. Provisions have been incorporated into this airplane to convert it into a cargo carrier, a troop transport, or a stretcher casualty carrier. This IFR equipment is easily removed or installed to permit maximum utilization of the airplane as either a cargo carrier or tanker. The airplane is powered by four Pratt and Whitney R-4360-35A engines. Each engine drives a Hamilton Standard Hydromatic constant speed propeller with full feathering and reverse pitch features. The fuselage is furnished with complete heating, ventilating, and pressurizing equipment for use either in flight or on the ground. The following equipment is operated hydraulically; brakes, nose wheel steering, windshield wipers, and rudder boost, all other equipment, is operated electrically. The normal crew consists of pilot, copilot, engineer, navigator, and radio operator.

ITEM	C-97A	C-97C	KC-97E
Flying boom	None	Replaces aft cargo doors	Replaces aft cargo doors
Rendezvous radar antennae	None	Under wing tips, top of dorsal fin	Flush wing mounting, and vertical tail fin mast
Wing flood lights	None	On the fuselage below the wings	On the fuselage below the wings
IFR fuel tanks	None	Four tanks in the main cargo compartment	Four tanks in the main cargo compartment
IFR tanks servicing hatch	None	Right side of fuselage above wing	Right side of fuselage above wing
Alternators	Two	None AF49-2591 and AF49-2592 Two AF49-2596	Two
Generators	Four	Eight AF49-2591 and AF49-2592 Six AF49-2596	Six

Figure 1-1. Main Differences Table

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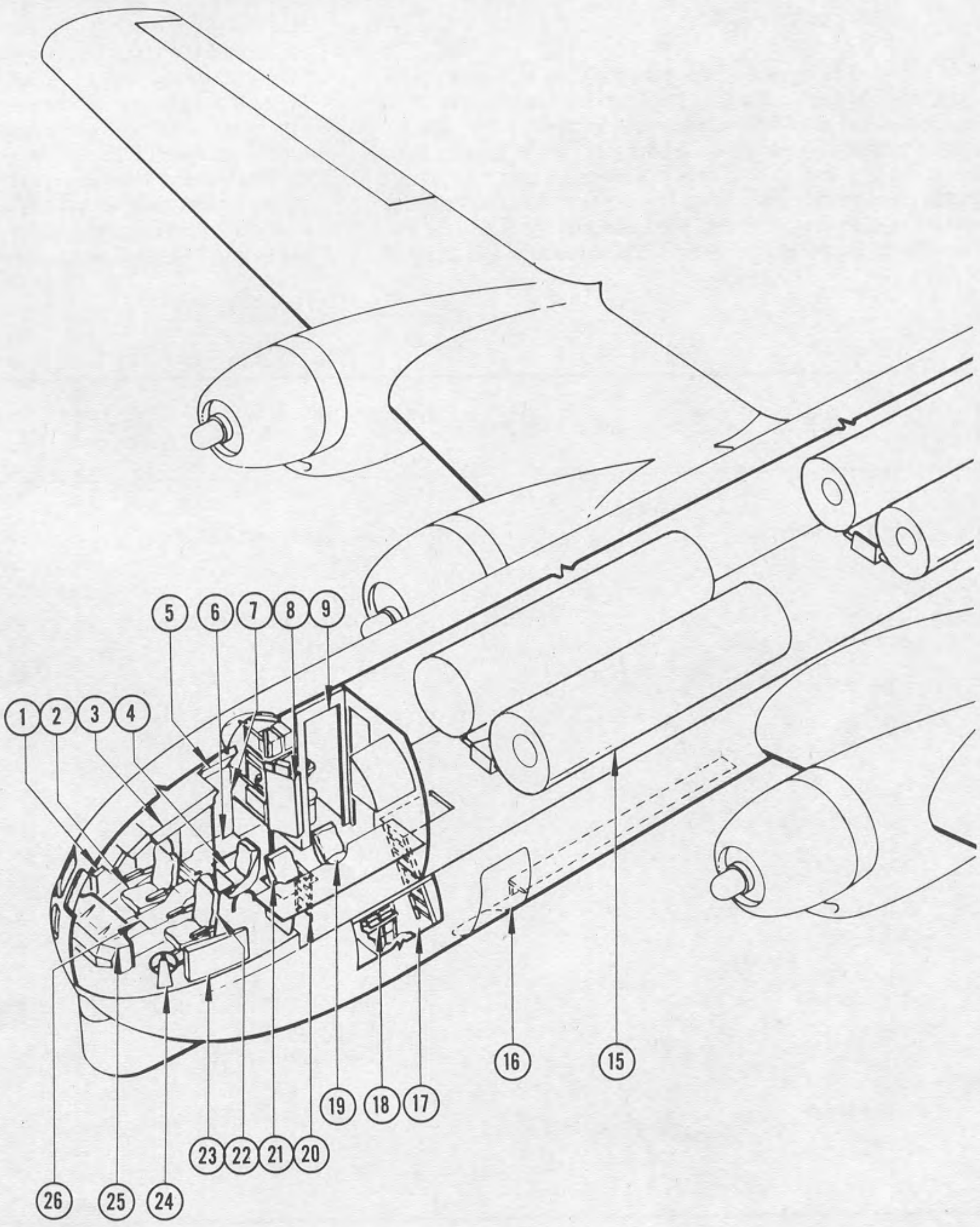

Figure 1-2. General Arrangement (Sheet 1 of 2)

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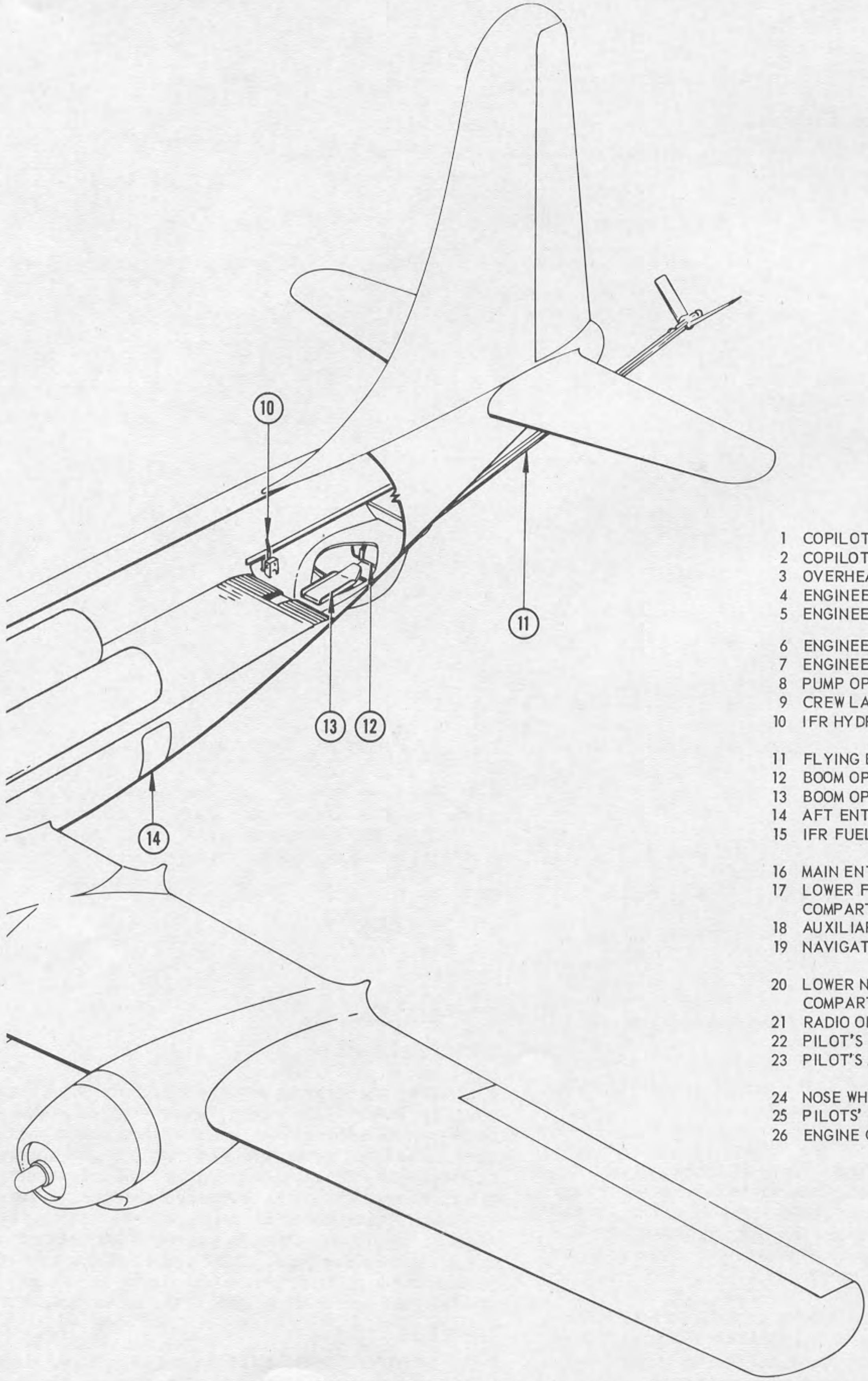

1 COPILOT'S AUXILIARY PANEL
2 COPILOT'S SEAT
3 OVERHEAD PANEL
4 ENGINEER'S SEAT
5 ENGINEER'S AUXILIARY PANEL

6 ENGINEER'S TABLE
7 ENGINEER'S INSTRUMENT PANEL
8 PUMP OPERATOR'S PANEL
9 CREW LAVATORY
10 IFR HYDRAULIC HAND PUMP

11 FLYING BOOM
12 BOOM OPERATOR'S PANEL
13 BOOM OPERATOR'S STATION
14 AFT ENTRANCE DOOR
15 IFR FUEL TANKS

16 MAIN ENTRANCE DOOR
17 LOWER FORWARD CARGO COMPARTMENT LADDER
18 AUXILIARY POWER PLANT (APP)
19 NAVIGATOR'S SEAT

20 LOWER NOSE COMPARTMENT LADDER
21 RADIO OPERATOR'S SEAT
22 PILOT'S SEAT
23 PILOT'S AUXILIARY PANEL

24 NOSE WHEEL STEERING PEDESTAL
25 PILOTS' INSTRUMENT PANEL
26 ENGINE CONTROL STAND

Figure 1-2. General Arrangement (Sheet 2 of 2)

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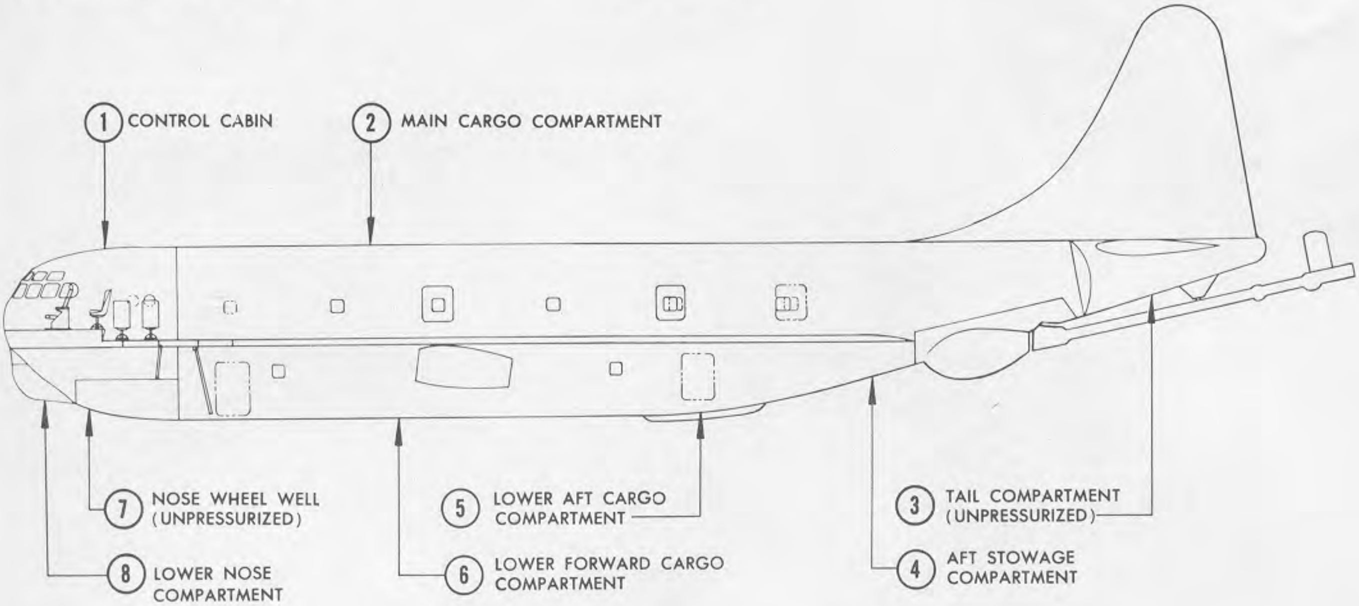

Figure 1-3. Compartments

1-4. OVERALL DIMENSIONS. Approximate overall dimensions of the airplane are as follows:

Wing Span	141 feet 3 inches
Fuselage Length	110 feet
Height (to top of fin)	38 feet 3 inches
Tread (of outboard tires)	28 feet 6 inches
Overall Length	
(boom retracted)	117 feet 6 inches
(boom extended)	136 feet 10 inches

1-5. GROSS WEIGHT. The design gross weight of this airplane is 150,000 pounds.

1-6. SPECIAL FEATURES. Special features of this model are the installation of flying boom in-flight refueling equipment; additional generator controls and electrical connections, fuel system connection, and the structural provisions for the IFR equipment. Structural provisions have also been made for the installation of an aerial delivery system.

1-7. INTERIOR ARRANGEMENT AND CREW MOVEMENT. The fuselage is divided into six pressurized and two unpressurized compartments (figure 1-3). Hatches and ladders are provided for extensive crew movement.

1-8. MAIN DIFFERENCES TABLE.

1-9. For ease of pilot's recognition and operation of the KC-97E airplane, the main visual differences between the KC-97E and the KC-97A and C-97A and C airplanes are shown in the main difference table (figure 1-1).

1-10. ENGINE.

1-11. GENERAL.

1-12. The airplane is powered by four Pratt and Whitney, R-4360-35A, 28-cylinder engines installed in four interchangeable, quick change power packages. Each engine is equipped with a single-stage, single-speed internal supercharger, and an exhaust-driven General Electric trubosupercharger. A torquemeter installation is in the nose section of the engine. Water injection is provided for operation at high power settings. Each engine is capable of developing a maximum take-off power at sea level of 3250 BHP dry or 3500 BHP using water injection.

1-13. CARBURETOR. Each engine is equipped with a Stromberg injection carburetor. The carburetor is supplied by either ram air or supercharged air.

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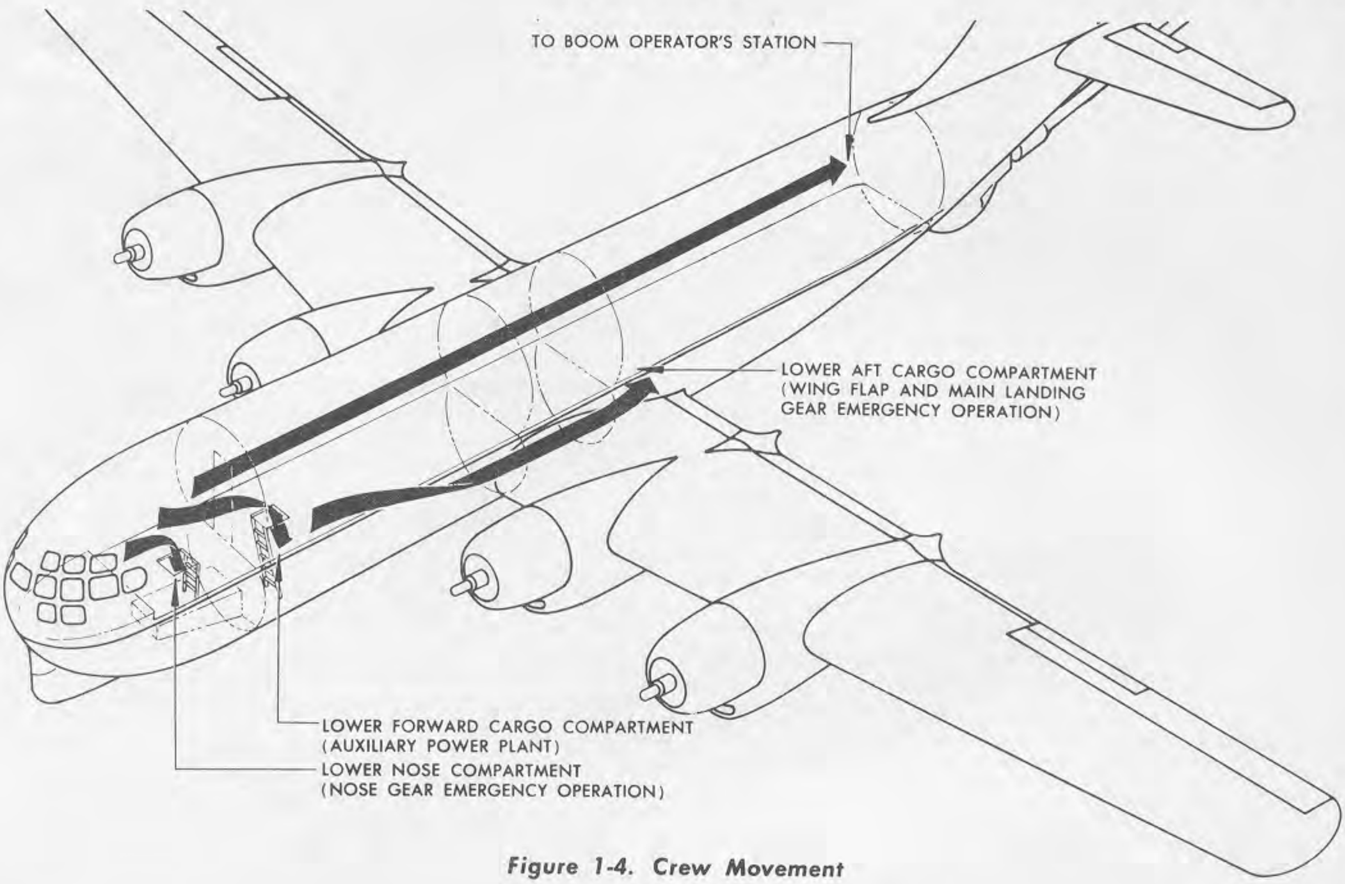

Figure 1-4. Crew Movement

A by-pass valve (figure 1-17) downstream from the intercooler is positioned by ram air and supercharged air differential pressures. A carburetor preheat valve is provided downstream from the turbo compressor (figure 1-17). Opening the valve allows recirculation of a portion of the pressurized air through the supercharger resulting in a higher turbo air output temperature.

1-14. SHELTERED AIR DOOR. A sheltered air door and a sheltered air inlet (figure 1-17) are located below and behind the air scoop entry of each power package. In the sheltered position, the sheltered air door closes the air intake scoop and opens the sheltered air inlet. Moisture is partially eliminated from the carburetor air by this method. A carburetor air filter is a part of each sheltered air door and sheltered air inlet assembly. When the sheltered air door is in the sheltered position, the filters will filter the air passing through the sheltered air inlet to the carburetor.

1-15. TURBOSUPERCHARGER. The turbosupercharger is an exhaust-driven contrifugal air compressor which is used to compress atmospheric air to boost carburetor intake pressure at higher altitudes. This results in greater power output, fuel economy, and better performance of the engine during high altitude cruising operation. A supercharger-driven oil pump provides lubrication to the turbo from a separate oil tank mounted inside the engine oil tank. A small percentage of the turbo output is used to pressurize the cabin.

1-16. WATER INJECTION. The water injection (Anti Detonation Injection) system has two 30-gallon tanks, one in each wheel well. Each tank contains an alcohol and water mixture and supplies the two engines on that side of the airplane. Duration of the supply at 3500 brake horsepower per engine is approximately 10 minutes.

1-17. ENGINE COOLING. The flow of cooling air for each engine is controlled by two ground-adjustable and seven electrically operated, flight adjustable, cowl flaps.

1-18. PRIMING. Each engine is primed through a solenoid valve on top of the carburetor. The engine primer is controlled by a primer switch and an engine selector switch on the overhead panel. Priming fuel is injected into the engine blower housing.

1-19. STARTER. Each engine is started by a direct-cranking electric starter mounted on the lower right side of each engine accessory drive case.

1-20. ENGINE CONTROLS.

1-21. THROTTLES. Two sets of throttles (28, 35, figure 1-13) are on the engine control stand. One set near the forward end of the stand is for the pilots'

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use and is interconnected to the other set near the aft end for the engineer's use. The pilots' set has "OPEN--CLOSED--REVERSE OPEN" positions with intermediate positions. Switches which are operated by pilots' throttle movement are the propeller reversing switches, wing flap throttle warning switches, landing gear throttle warning switches. The pilots' throttles can be moved into the "REVERSE OPEN" position by raising the handles and moving aft over the "CLOSED" stop. A friction can be felt as the propeller reverse-pitch switches are actuated. Holding the pilots' throttles forward against the "CLOSED" stop maintains the throttles in reverse idle. Further movement into the "REVERSE OPEN" range opens the throttles. A solenoid operated catch prevents movement of the throttles into the "REVERSE OPEN" range during flight. The engineer's throttles have "OPEN--CLOSED" and intermediate positions. When the pilots' throttles move into the "REVERSE OPEN" range, the engineer's throttles advance into the "OPEN" range. Once the pilot has moved the throttles into the "REVERSE OPEN" range, the engineer can control reverse pitch operation. The pilots' throttle levers must be raised and moved forward over the "CLOSED" stop to return the propellers to forward pitch. Holding the throttles aft against the "CLOSED" stop maintains the throttles in forward idle. The pilots' throttle operation is conventional in the "OPEN--CLOSED" range.

1-22. THROTTLE BRAKE LEVER. A lever (13, figure 1-13), to the right of the pilots' throttles, provides a friction braking force to hold the throttle levers in any desired position. Increasing friction is applied as the lever is moved from the "UNLOCKED" to the "LOCKED" position.

1-23. MIXTURE CONTROL LEVERS. Four levers (19, figure 1-13) are on the aft end of the engine control stand. The levers have "FUEL CUTOFF--AUTO LEAN--AUTO RICH" positions. Placing the levers in "FUEL CUTOFF" shuts off fuel flow at the carburetor. A graduated scale between "FUEL CUTOFF and AUTO LEAN" provides a manual mixture control and is used in conjunction with the torquemeters. A lean or rich mixture is maintained by placing the levers in "AUTO LEAN" or "AUTO RICH."

1-24. MIXTURE LOCK LEVER. A lever (18, figure 1-13) adjacent to the mixture control levers provides a friction braking force to hold the mixture control levers in any desired position. Increasing friction is applied as the lock lever is moved from the "UNLOCK" to the "LOCK" position.

1-25. IGNITION SWITCHES. Four rotary-type engine ignition switches (1, figure 1-12) are on the overhead panel. A main ignition lever selects "RIGHT," "LEFT," "BOTH," and "OFF" positions for all seven magnetos simultaneously and a push-pull bank and plug selector knob selects left or right bank of each magneto individually. This selection permits relatively close detection of individual spark plug failure.

1-26. EMERGENCY IGNITION CUTOFF HANDLE. A red pull handle (5, figure 1-12) below the ignition switches permits simultaneous cutting of all engine ignition. When the handle is pulled out, a sliding bar just above the handle moves to the right, actuating each main ignition switch lever to "OFF." When the handle is released, spring pressure returns the handle and sliding bar to their original position.

FLUID SPECIFICATIONS AND GRADES

FLUID	RECOMMENDED			ALTERNATE	
	SPECIFICATION		GRADE	SPECIFICATION	GRADE
FUEL	MIL-F-5572		115/145	MIL-F-5572	100/130
ENGINE OIL	MIL-O-6082		1100		
PROPELLER OIL MIXTURE	MIL-O-6081	AND	50% 1010		
	MIL-O-6082		50% 1100		
TURBO OIL	Above 15° F MIL-O-6082		1065	Below 15° F MIL-O-6081	1010
HYDRAULIC FLUID	MIL-O-5606				
WATER INJECTION (ADI)	Above - 40° F			Below - 40° F	
	50% ALCOHOL-AN-A-24 50% WATER-DISTILLED			60% ALCOHOL-AN-A-24 40% WATER-DISTILLED	

Figure 1-5. Servicing (Sheet 1 of 2)

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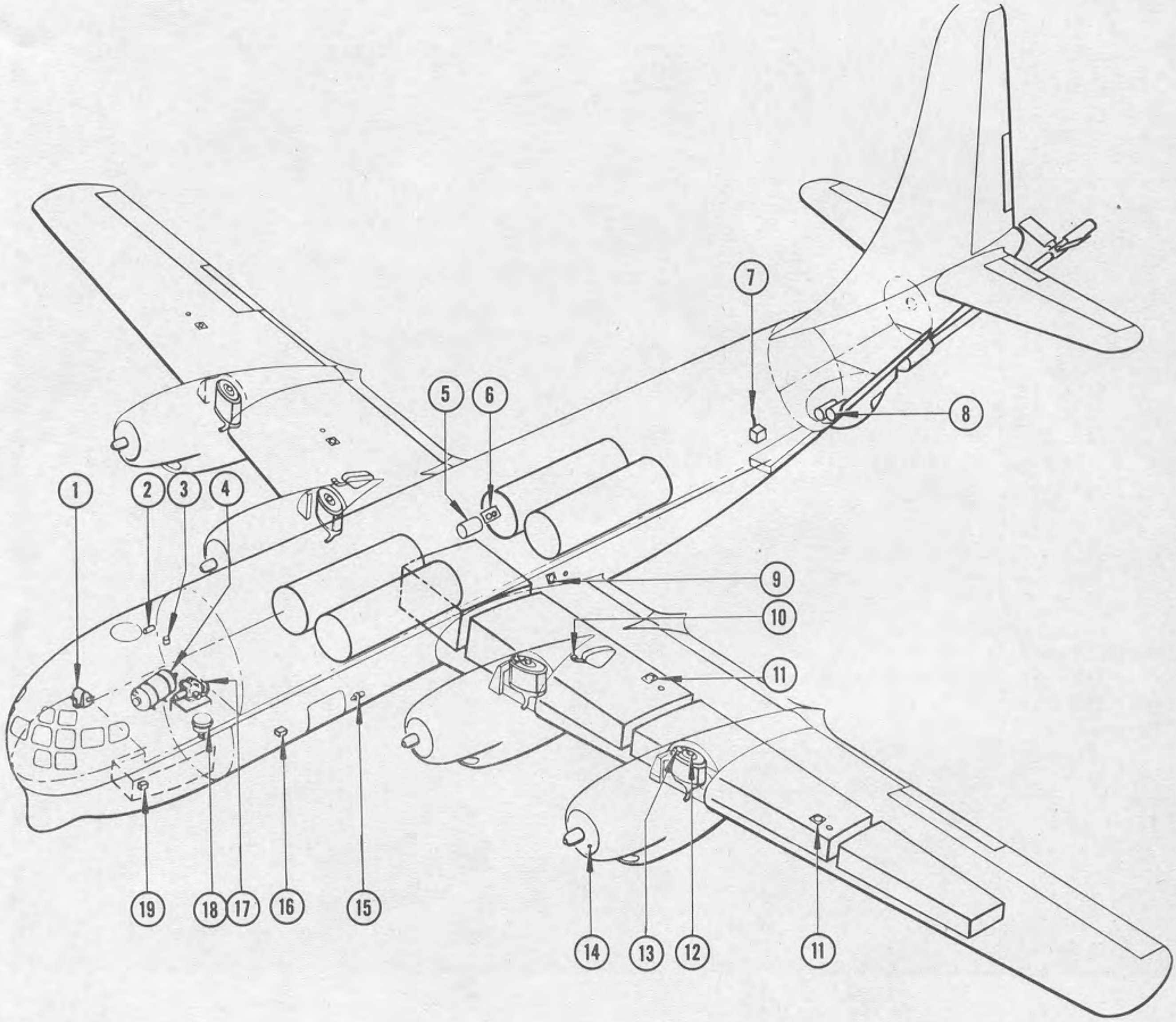


1 MAIN HYDRAULIC RESERVOIR
2 WATER TANK
3 FORWARD CARGO DOOR HYDRAULIC RESERVOIR
4 CENTRAL OIL TANK
5 IFR HYDRAULIC TANK

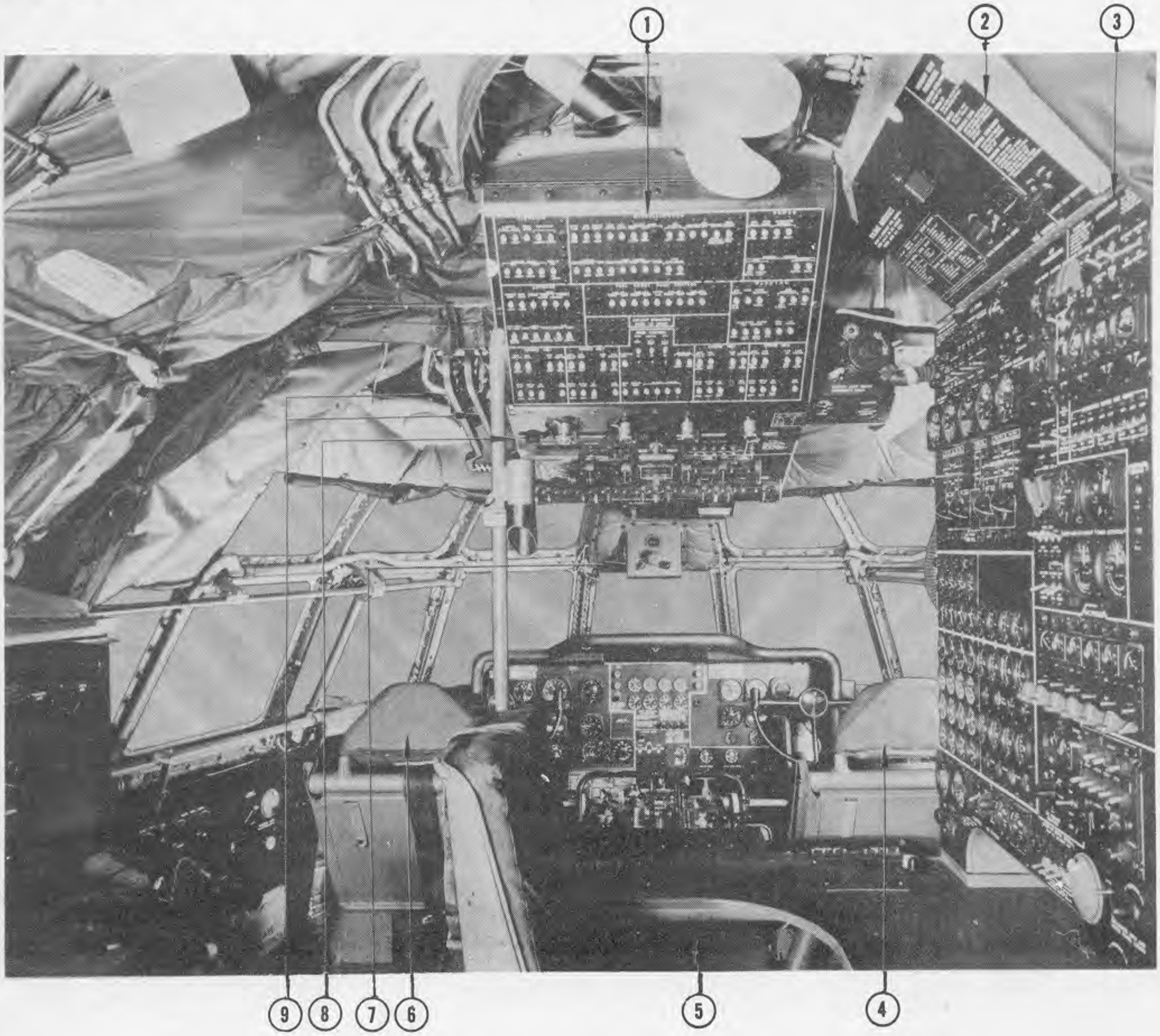
6 IFR FUEL TANK FILLER
7 IFR HAND PUMP HYDRAULIC RESERVOIR
8 IFR NITROGEN BOTTLES
9 CENTER WING FUEL TANK

10 ANTIDETONATION FLUID TANK
11 WING FUEL TANK
12 ENGINE OIL TANK
13 TURBOSUPERCHARGER OIL TANK
14 PROPELLER OIL TANK

15 OXYGEN SYSTEM FILLER VALVE
16 DC EXTERNAL POWER RECEPTACLE
17 AUXILIARY POWER PLANT
18 BATTERY
19 AC EXTERNAL POWER RECEPTACLE

Figure 1-5. Servicing (Sheet 2 of 2)

022006 b



1 OVERHEAD CIRCUIT BREAKER PANEL
2 ENGINEER'S AUXILIARY PANEL
3 ENGINEER'S INSTRUMENT PANEL
4 COPILOT'S STATION
5 ENGINEER'S STATION
6 PILOT'S STATION
7 PILOTS' COMPASS PANEL
8 OVERHEAD PANEL
9 EMERGENCY BRAKE LEVERS

Figure 1-6. Control Cabin

1-27. ENGINE STARTING SELECTOR SWITCH. A rotary-type "OFF--1--2--3--4--" switch (29, figure 1-12), on the overhead panel, is used to select the engine to be started. When the switch is in the "1," "2," "3," or "4" position, starter, primer, and ignition boost circuits are connected to the selected engine. When the switch is in the "OFF" position, the starter, primer, and ignition circuits are disconnected from all engines.

1-28. STARTER SWITCH. Direct cranking starters are controlled by a push-button switch (4, figure 1-12) on the overhead panel. The starter, prime and boost switches are grouped on a raised and guarded base. Each switch controls all four engines, through a rotary engine starting selector switch, adjacent to the raised base. The starter circuit breaker is on the overhead circuit breaker panel.

1-29. PRIMER SWITCH. Engine priming is electrically controlled by a push-button switch (3, figure 1-12) adjacent to the starter switch. The priming fuel is injected into the engine blower housing. The primer circuit breaker is on the overhead panel.

1-30. IGNITION BOOST SWITCH. An ignition boost is controlled by the third push-button switch (6, figure 1-12) on the starter control base. Depressing the switch causes a hotter spark for starting. A circuit breaker is on the overhead circuit breaker panel.

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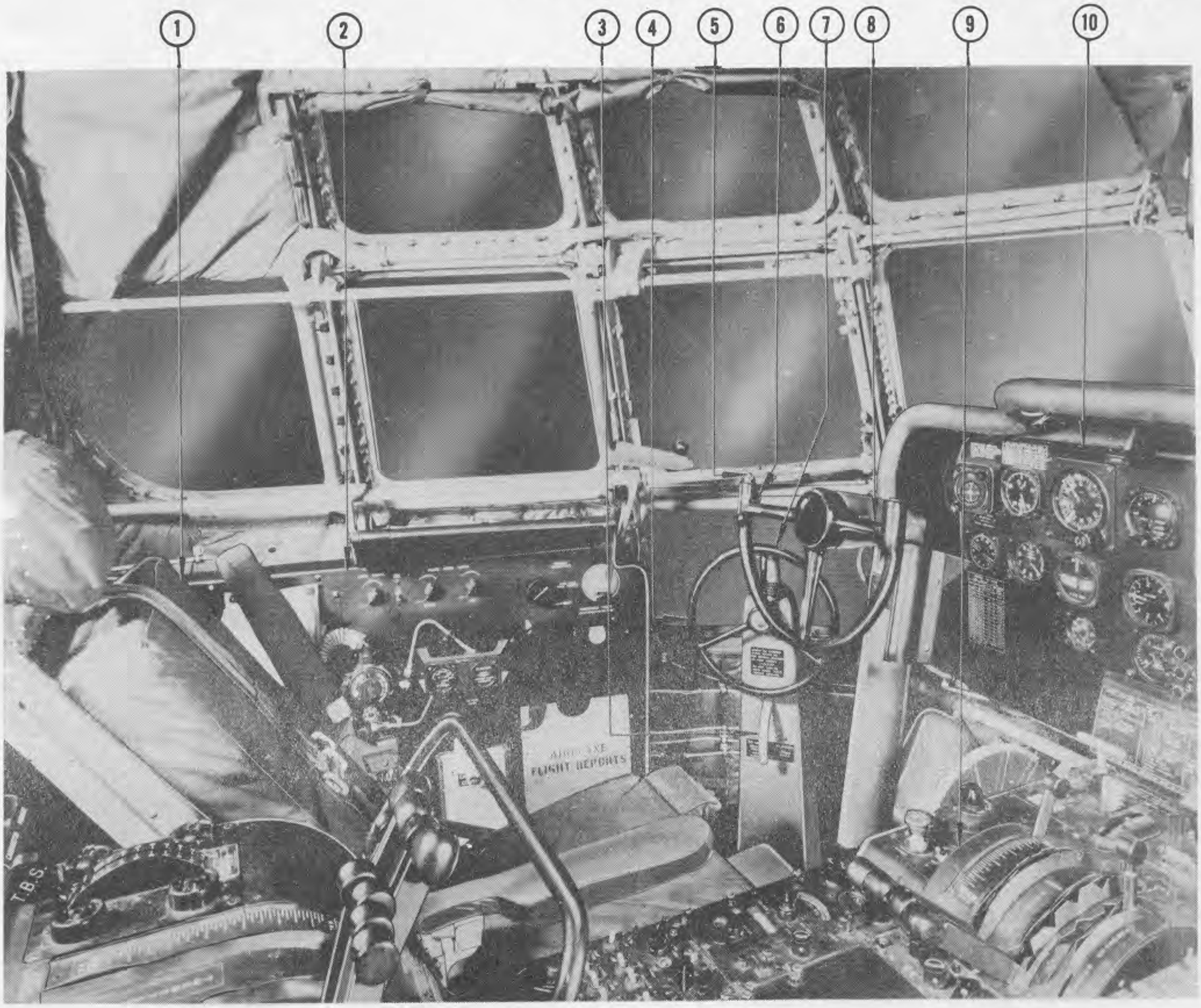

1 PILOT'S SEAT
2 PILOT'S AUXILIARY PANEL
3 PARKING BRAKE HANDLE
4 STEERING WHEEL
5 PILOT'S MICROPHONE SWITCH
6 AUTOPILOT RELEASE SWITCH
7 NOSE WHEEL STEERING EMERGENCY DISCONNECT BUTTON
8 PILOT'S CONTROL WHEEL
9 ENGINE CONTROL STAND
10 PILOTS' INSTRUMENT PANEL

Figure 1-7. Pilot's Station

1-31. COWL FLAP SWITCHES. Four cowl flap switches (20, figure 1-13), one for each engine, are on the aft end of the engine control stand. These switches electrically control the opening and closing of the cowl flaps. The switches have "OPEN--off--CLOSE" positions and are spring-loaded from the "OPEN" and "CLOSE" positions to the off position. A gang bar permits actuation of all four switches at the same time. The cowl flaps will remain stationary when the switch is released to off. Cowl flap control circuit breakers are on the overhead circuit breaker panel and the main circuit breaker panel (1, 9, figure 1-24).

1-32. TURBO-BOOST SELECTOR LEVER. The engine turbosuperchargers are controlled by a calibrated, "0 to 10" selector lever (29, figure 1-13) on the engine control stand. Pressure boost derived from the turbo depends on the operating speed of the turbine wheel. As the selector lever is advanced from "0 to 10" the exhaust waste gate is moved towards the closed position directing more exhaust gases against the turbine buckets causing the compressor to rotate at higher speeds, resulting in higher manifold pressure. Circuit breakers are on the AC power panel (5, figure 1-25).

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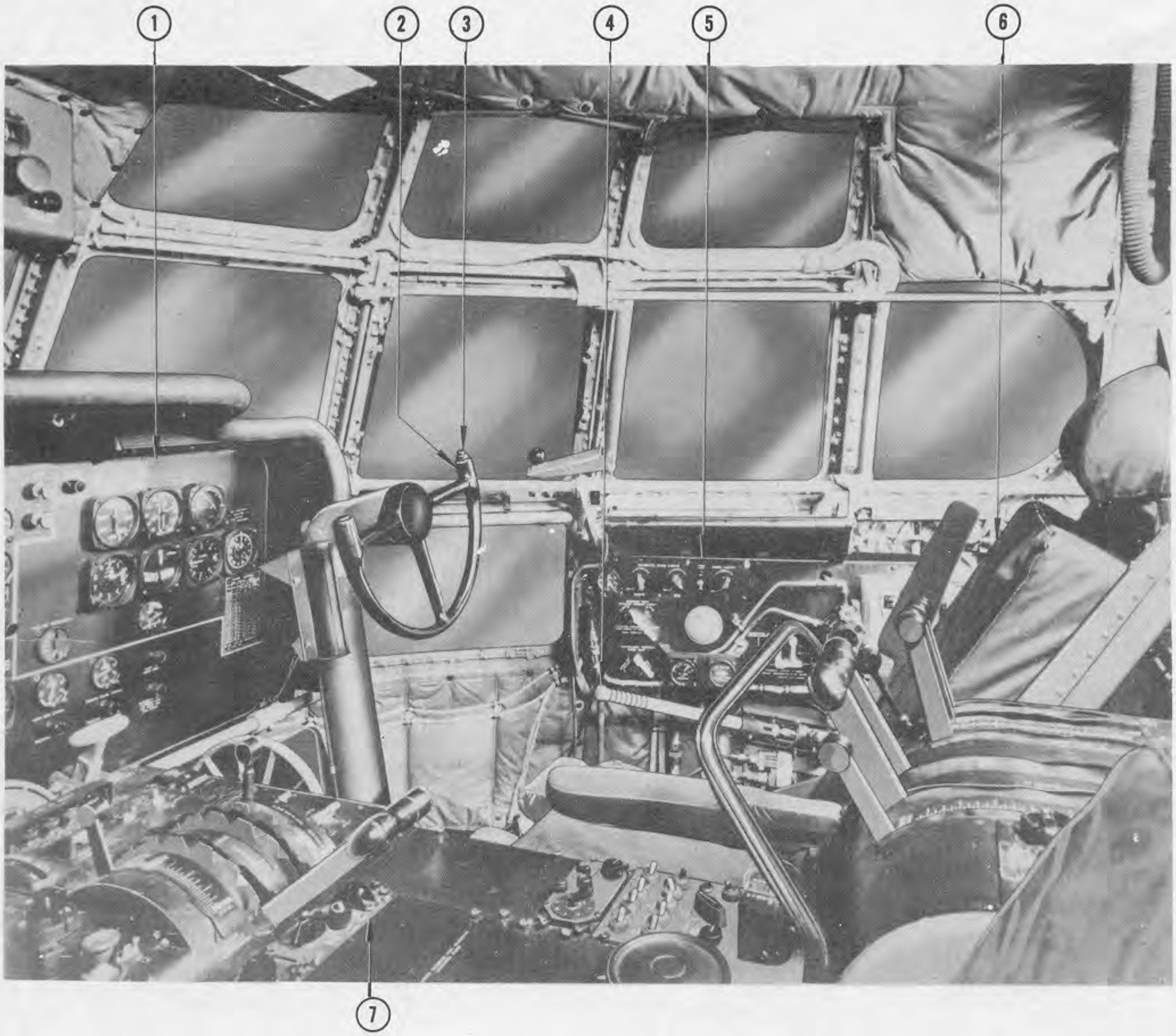

1 PILOTS' INSTRUMENT PANEL
2 AUTOPILOT RELEASE SWITCH
3 COPILOT'S MICROPHONE SWITCH
4 EMERGENCY HYDRAULIC HAND PUMP
5 COPILOT'S AUXILIARY PANEL
6 COPILOT'S SEAT
7 ENGINE CONTROL STAND

Figure 1-8. Copilot's Station

1-33. TURBO-CALIBRATING KNOBS. Four knobs (30, figure 1-13) grouped around the turbo selector lever are used to set a uniform manifold pressure for each engine. Each calibrating knob can be adjusted to regulate the carburetor air inlet pressure to the desired value. The calibrating knobs provide a means for compensating for small variations in engine characteristics. In this way, the manifold pressures of all engines can be equalized. The calibrating knobs are shielded by a barrier and locked to prevent accidental repositioning. There is a calibrating knob index mark on each barrier.

1-34. CARBURETOR AIR SWITCHES. Four switches (25, figure 1-13), on the aft end of the engine control stand, control the sheltered air door. The switches have "RAM-SHELTERED" positions. A gang bar permits actuation of all four switches at the same time. In the "RAM" position, air enters the air scoop and passes directly into the induction system. In the "SHELTERED" position, the shutoff door closes the air intake scoop and allows air to enter the induction system from the bottom of the air scoop. Moisture is partially eliminated from the carburetor air by this method. Circuit breakers for the system are on the overhead circuit breaker panel and the main circuit breaker panel (1, figure 1-24) and (9, figure 1-24).

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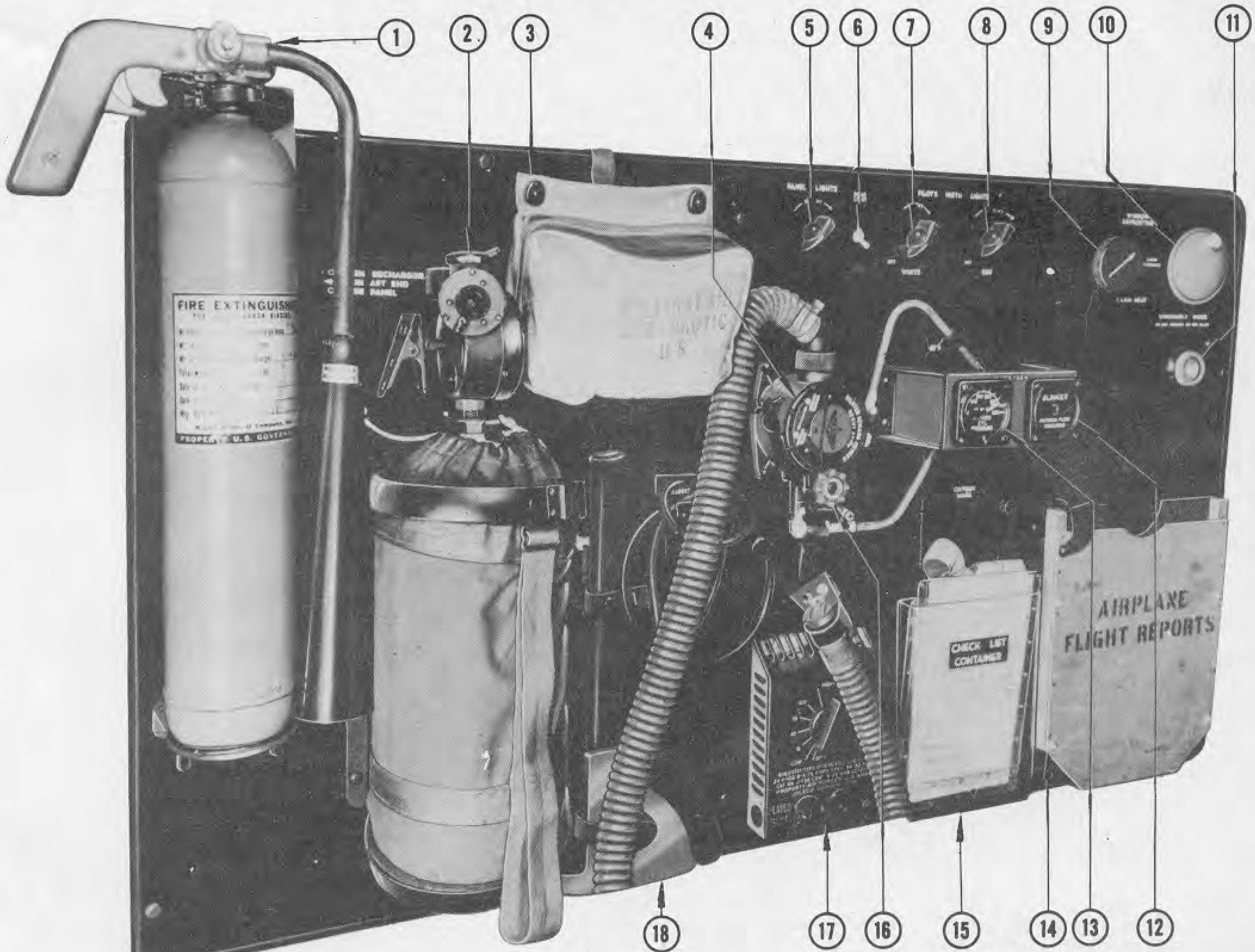

1 FIRE EXTINGUISHER
2 OXYGEN BOTTLE
3 FIRST AID KIT
4 OXYGEN FLOW REGULATOR
5 PILOT'S AUXILIARY PANEL LIGHT RHEOSTAT
6 DOME LIGHT
7 PILOT'S INSTRUMENT PANEL LIGHT RHEOSTAT (LEFT SIDE WHITE)
8 PILOT'S INSTRUMENT PANEL LIGHT RHEOSTAT (LEFT SIDE RED)
9 WINDOW DEFROSTING CONTROL
10 ASH TRAY
11 WINDSHIELD WIPER SPEED CONTROL KNOB
12 OXYGEN FLOW INDICATOR
13 OXYGEN PRESSURE INDICATOR
14 AIRPLANE FLIGHT REPART CONTAINER
15 PILOT'S CHECK LIST CONTAINER
16 OXYGEN REGULATOR EMERGENCY VALVE KNOB
17 PILOT'S HEATED SUIT CONTROL PANEL
18 FIRE AXE

Figure 1-9. Pilot's Auxiliary Panel

1-35. CARBURETOR PREHEAT SWITCHES. Four "OPEN--OFF--CLOSE" switches (27, figure 1-13) on the aft end of the engine control stand, control the carburetor preheat valves. The switches are spring-loaded to "OFF" from the "OPEN" position. In the "OPEN" position the valves allow recirculation of a portion of the pressurized air through the supercharger (figure 1-17) thus resulting in a higher turbo air output temperature. The supercharger must be operating before preheat is possible. Circuit breakers for the carburetor air preheat switches are on the overhead circuit breaker panel (1, figure 1-24).

1-36. INTERCOOLER FLAP SWITCHES. Four "OPEN--off--CLOSE" switches (21, figure 1-13) on the aft end of the engine control stand, control the intercooler flaps. The switches are spring-loaded to the "off" position. Holding the switch in the "OPEN" position increases the amount of flap opening allowing cooling air to pass through the intercooler. Holding the switch in the "CLOSE" position decreases the amount of flap opening. A gang bar permits actuation of all four switches at the same time. Circuit breakers for the intercooler flap circuits are on the overhead circuit breaker panel (1, figure 1-24).

1-37. WATER INJECTION (ADI) PUMP SWITCH. Anti-detonation fluid injection is controlled by the "ON--OFF" ADI pump switch (10, figure 1-13) on the forward end of the engine control stand. When

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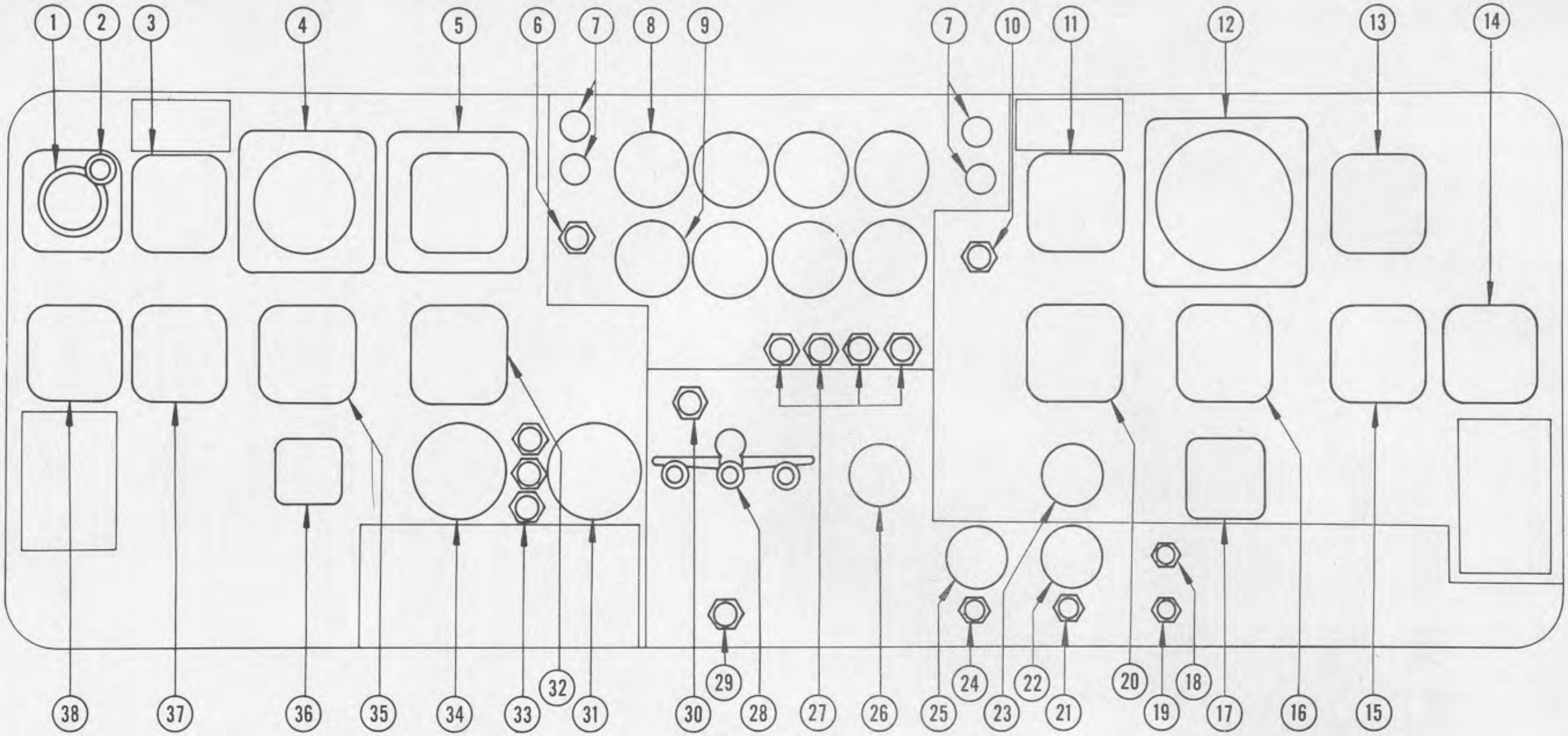

1 COURSE INDICATOR
2 MARKER BEACON LIGHT
3 MAXIMUM ALLOWABLE AIRSPEED INDICATOR
4 DIRECTIONAL GYRO INDICATOR

5 GYRO-HORIZON INDICATOR
6 MAIN INVERTER WARNING LIGHT
7 MANIFOLD PRESSURE PURGE VALVE BUTTONS
8 MANIFOLD PRESSURE GAGE

9 TACHOMETER
10 AUTOPILOT INVERTER WARNING LIGHT
11 AIRSPEED INDICATOR
12 MASTER DIRECTION INDICATOR
13 GYRO-HORIZON INDICATOR

14 RADIO COMPASS INDICATOR
15 RATE-OF-CLIMB INDICATOR
16 RATE-OF-TURN INDICATOR
17 CLOCK
18 DOOR WARNING LIGHT

19 EMERGENCY BRAKE PRESSURE LOW WARNING LIGHT
20 ALTIMETER
21 SERVICE BRAKE PRESSURE LOW WARNING LIGHT

22 HYDRAULIC PRESSURE GAGE SERVICE BRAKE SYSTEM
23 OUTSIDE AIR TEMPERATURE INDICATOR
24 MAIN HYDRAULIC PRESSURE LOW WARNING LIGHT

25 HYDRAULIC PRESSURE GAGE MAIN HYDRAULIC SYSTEM
26 WING FLAP POSITION INDICATOR
27 PROPELLER RPM LIMIT LIGHTS
28 LANDING GEAR POSITION INDICATOR

29 BOOM ENGAGED INDICATOR LIGHT
30 LANDING GEAR WARNING LIGHT
31 ALTITUDE LIMIT SWITCH
32 RATE-OF-CLIMB INDICATOR
33 ALTITUDE INDICATOR LIGHTS

34 LOW RANGE RADIO ALTIMETER
35 TURN-AND-BANK INDICATOR
36 CLOCK
37 ALTIMETER
38 RADIO COMPASS INDICATOR

Figure 1-10. Pilots' Instrument Panel

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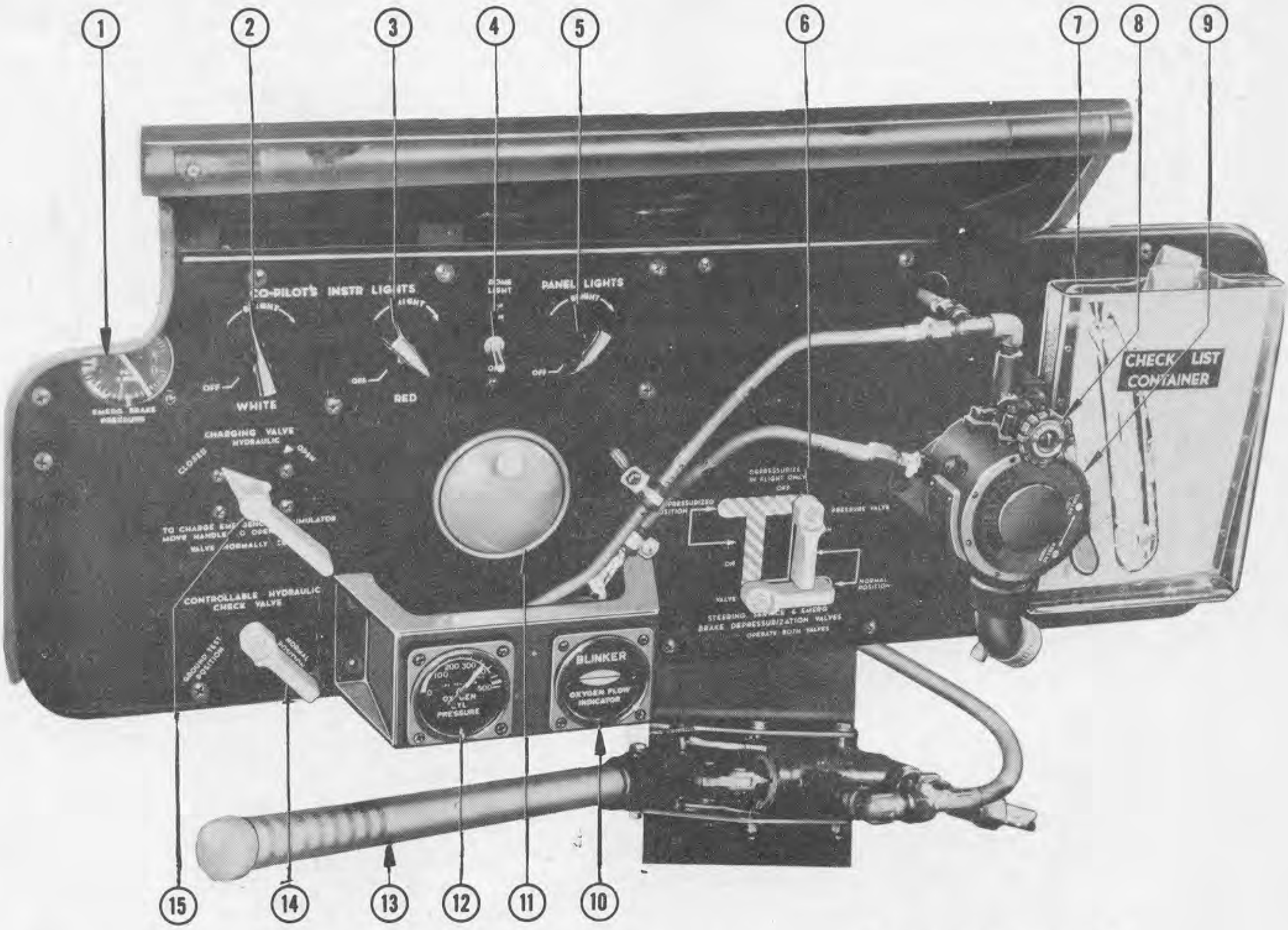

1 EMERGENCY BRAKE SYSTEM PRESSURE GAGE
2 PILOT'S INSTRUMENT PANEL LIGHT RHEOSTAT (RIGHT SIDE WHITE)
3 PILOT'S INSTRUMENT PANEL LIGHT RHEOSTAT (RIGHT SIDE RED)
4 DOME LIGHT SWITCH
5 COPILOT'S AUXILIARY PANEL LIGHT RHEOSTAT
6 HYDRAULIC SYSTEM DEPRESSURIZATION HANDLES
7 COPILOT'S CHECK LIST CONTAINER
8 OXYGEN REGULATOR EMERGENCY VALVE KNOB
9 OXYGEN FLOW REGULATOR
10 OXYGEN FLOW INDICATOR
11 ASH TRAY
12 OXYGEN PRESSURE INDICATOR
13 HYDRAULIC HAND PUMP
14 HYDRAULIC SYSTEM CONTROLLABLE CHECK VALVE HANDLE
15 EMERGENCY BRAKE SYSTEM CHARGING VALVE HANDLE

Figure 1-11. Copilot's Auxiliary Panel

the ADI pump switch is "ON" both pumps supply pressure to anti-detonation fluid regulators. A manifold pressure switch automatically opens the regulator shutoff valve when the manifold pressure reaches 45 inches of Hg, permitting anti-detonation fluid to enter the regulator which delivers the anti-detonation fluid to the engine's induction system. The shutoff valve closes when the manifold pressure drops to 41 inches. Anti-detonation fluid injection is automatically controlled by the regulator after the valves are opened. Circuit breakers for the ADI system are on the overhead circuit breaker panel (1, figure 1-24) and main circuit breaker panel (9, figure 1-24).

1-38. CYLINDER HEAD TEMPERATURE SELECTOR SWITCH. A selector switch (5, figure 1-14) on the engineer's table allows selection of the desired set of cylinders for cylinder head temperature indication. The selector switch has "OFF--A4--B2" positions. With the selector switch in "A4" position each cylinder head temperature gage indicates cylinder head temperature of the A4 cylinder for its respective engine; similarly for the "B2" position. When the selector switch is "OFF" the temperature indicating circuits are de-energized.

1-39. ENGINE INDICATORS.

1-40. TACHOMETERS. Four single-indicating engine tachometers are on both the pilots' and the engineer's instrument panels (9, figure 1-10) and (60, figure 1-15). The tachometers are generator motor units. Each tachometer transmitter is engine-driven and generates its own current which controls the indicator motor at a synchronized speed.

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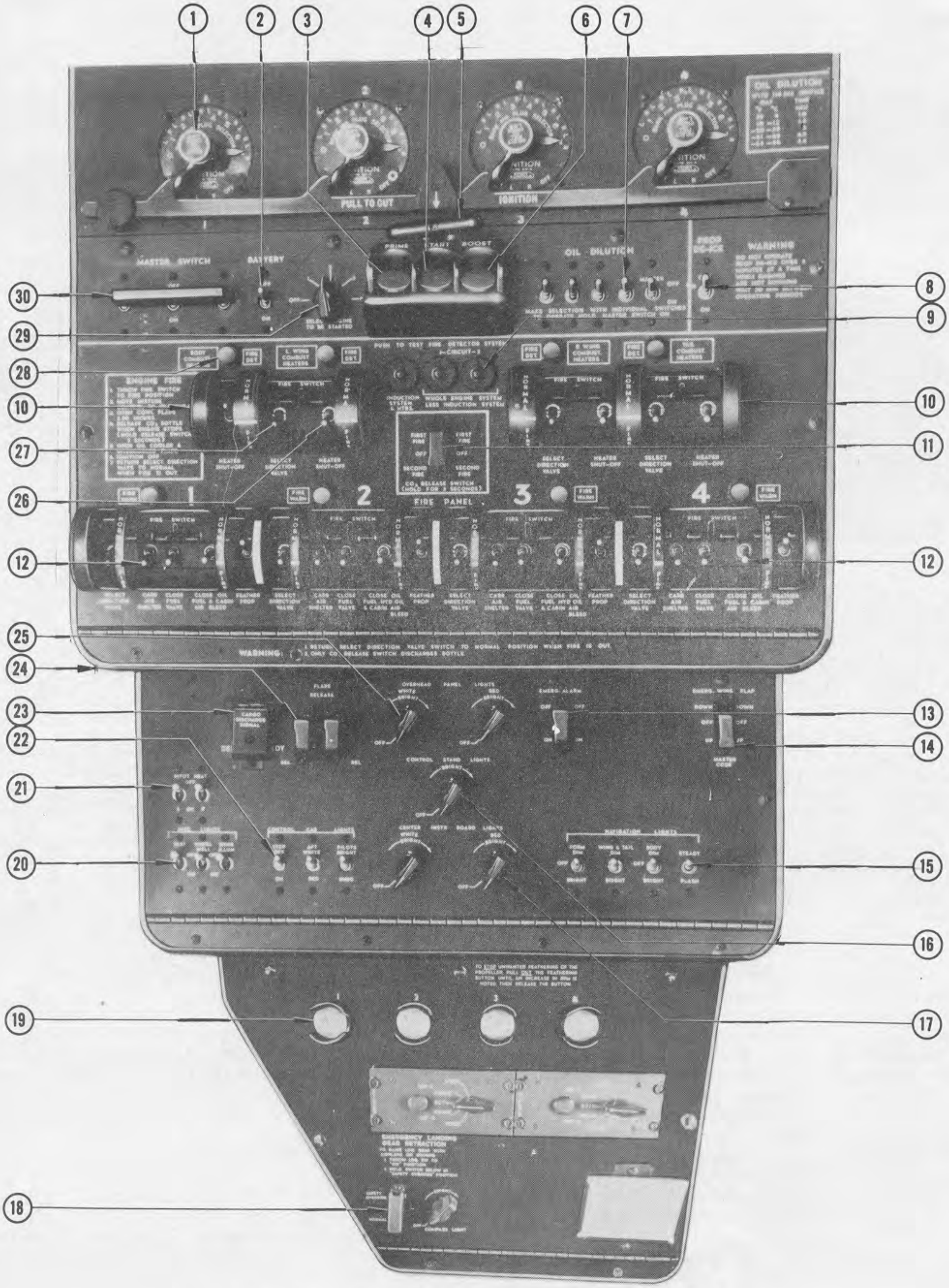


Figure 1-12. Overhead Panel (Sheet 1 of 2)

022046 a

1 IGNITION SWITCHES
2 BATTERY SWITCH
3 PRIMER SWITCH
4 STARTER SWITCH
5 IGNITION CUTOFF HANDLE

6 IGNITION BOOST SWITCH
7 OIL DILUTION SWITCHES
8 PROPELLER DEICE SWITCH
9 FIRE DETECTOR SYSTEM TEST SWITCHES
10 COMBUSTION HEATER FIRE SWITCHES

11 FIRE EXTINGUISHER SWITCH
12 POWER PACKAGE FIRE SWITCHES
13 EMERGENCY ALARM SWITCH
14 EMERGENCY WING FLAP SWITCH
15 NAVIGATION LIGHT SWITCHES

16 ENGINE CONTROL STAND LIGHTS RHEOSTAT
17 CENTER INSTRUMENT BOARD LIGHTS RHEOSTAT
18 LANDING GEAR EMERGENCY RETRACTION SWITCH
19 PROPELLER FEATHERING BUTTONS
20 MISCELLANEOUS LIGHTS

21 PITOT HEAT SWITCHES
22 CONTROL CABIN LIGHT SWITCHES
23 CARGO DISCHARGE SIGNAL SWITCH
24 FLARE RELEASE SWITCHES
25 OVERHEAD PANEL LIGHT RHEOSTATS

26 HEATER SHUTOFF SWITCH
27 SELECT DIRECTION VALVE SWITCH
28 COMBUSTION HEATER FIRE WARNING LIGHTS
29 ENGINE STARTING SELECTOR SWITCH
30 MASTER SWITCH

Figure 1-12. Overhead Panel (Sheet 2 of 2)

1-41. MANIFOLD PRESSURE GAGES AND PURGE VALVES. Four manifold pressure gages (8, figure 1-10) and (58, figure 1-15), are on both the pilots' and engineer's instrument panel. The manifold pressure gages give a direct reading of manifold pressure in inches of Hg. Four manifold purge valve buttons (7, figure 1-10) on the pilots' instrument panel provide a means of removing moisture from the manifold pressure gage lines. At idling speeds, a suction is developed and depressing the valve allows the moisture to be drawn into the engine.

1-42. TORQUEMETERS. Four individual torquemeters (56, figure 1-15) are on the engineer's instrument panel. The torquemeters indicate torque pressure in PSI and are used as an aid to determine equal power distribution. The torquemeters are of the alternating current type and have replaceable fuses on the AC power panel (5, figure 1-25).

1-43. CYLINDER HEAD TEMPERATURE GAGES. Four cylinder head temperature gages (59, figure 1-15) of the direct current type are on the engineer's instrument panel. The cylinder head temperature indicators are resistance bulb type units. There are two resistance bulbs on each engine, one in cylinder A4 and the other in cylinder B2. Circuit breakers for the cylinder head temperature gages are on the overhead circuit breaker panel (1, figure 1-24).

1-44. CARBURETOR AIR TEMPERATURE GAGES. Four carburetor air temperature gages (54, figure 1-24) are on the engineer's panel. The carburetor air temperature indicators are of the direct current type and have circuit breakers on the overhead circuit breaker panel (1, figure 1-24).

1-45. COWL FLAP POSITION INDICATORS. The position of the cowl flaps are indicated in inches of opening by four cowl flap position indicators (57, figure 1-15) on the engineer's instrument panel.

1-46. INTERCOOLER FLAP POSITION INDICATORS. Four intercooler flap position indicators (53, figure 1-15) on the engineer's instrument panel show intercooler flap positions in inches of opening.

1-47. WATER INJECTION (ADI) LIGHTS. Four amber ADI pressure lights (5, figure 1-13) are on the forward end of the engine control stand. Low ADI fluid pressure at the regulator is indicated if a light remains illuminated at power settings above 45 inches manifold pressure.

1-48. PROPELLER.

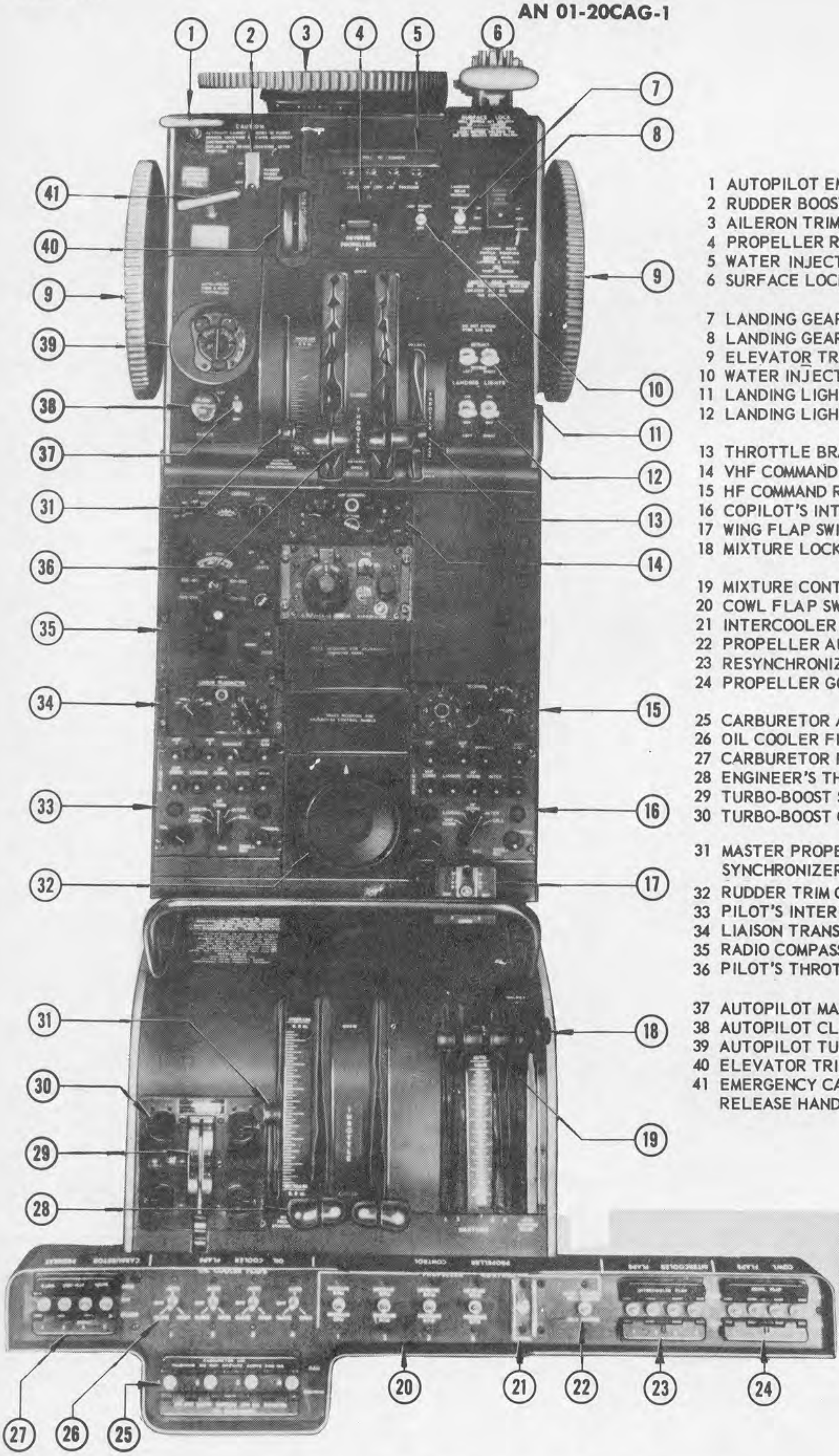
1-49. GENERAL.

1-50. The airplane is equipped with Hamilton Standard, four-blade, hydromatic propellers. This propeller differs from other Hamilton Standard models in that a nonrotating control unit, incorporating an independent oil system, is mounted between the engine nose section and the propeller. Controls are provided to automatically synchronize engine speeds, or reverse any or all propellers. Deicing is accomplished through electric heating elements in each blade and in each shank. An oil replenishing system is provided to replace oil lost from the propeller independent oil system with engine nose section oil.

1-51. PROPELLER CONTROLS.

1-52. PROPELLER GOVERNOR SELECTOR SWITCHES. Four propeller "DECREASE RPM--off--INCREASE RPM" governor selector switches (24, figure 1-13), on the aft end of the engine control stand are used to manually control and synchronize the propeller speeds for each of the four engines. Nor-

022046 b



1 AUTOPILOT EMERGENCY DISCONNECT HANDLE
2 RUDDER BOOST PRESSURE SWITCH
3 AILERON TRIM CONTROL WHEEL
4 PROPELLER REVERSE SIGNAL FLAG
5 WATER INJECTION (ADI) LIGHTS
6 SURFACE LOCK HANDLE

7 LANDING GEAR WARNING HORN SWITCH
8 LANDING GEAR SWITCH
9 ELEVATOR TRIM CONTROL WHEEL
10 WATER INJECTION (ADI) PUMP SWITCH
11 LANDING LIGHT RETRACTION SWITCHES
12 LANDING LIGHT SWITCHES

13 THROTTLE BRAKE LEVER
14 VHF COMMAND CONTROL PANEL
15 HF COMMAND RECEIVER
16 COPILOT'S INTERPHONE CONTROL PANEL
17 WING FLAP SWITCH
18 MIXTURE LOCK LEVER

19 MIXTURE CONTROL LEVERS
20 COWL FLAP SWITCHES
21 INTERCOOLER FLAP SWITCHES
22 PROPELLER AUTO CONTROL SWITCH
23 RESYNCHRONIZER SWITCH
24 PROPELLER GOVERNOR SELECTOR SWITCHES

25 CARBURETOR AIR SWITCHES
26 OIL COOLER FLAP SWITCHES
27 CARBURETOR PREHEAT SWITCHES
28 ENGINEER'S THROTTLE LEVERS
29 TURBO-BOOST SELECTOR LEVER
30 TURBO-BOOST CALIBRATION KNOB

31 MASTER PROPELLER SYNCHRONIZER LEVERS
32 RUDDER TRIM CONTROL WHEEL
33 PILOT'S INTERPHONE CONTROL PANEL
34 LIAISON TRANSMITTER CONTROL PANEL
35 RADIO COMPASS CONTROL PANEL
36 PILOT'S THROTTLE LEVERS

37 AUTOPILOT MASTER SWITCH
38 AUTOPILOT CLUTCH CONTROL BUTTON
39 AUTOPILOT TURN AND PITCH CONTROLLER
40 ELEVATOR TRIM TAB INDICATOR
41 EMERGENCY CABIN PRESSURE RELEASE HANDLE

Figure 1-13. Engine Control Stand

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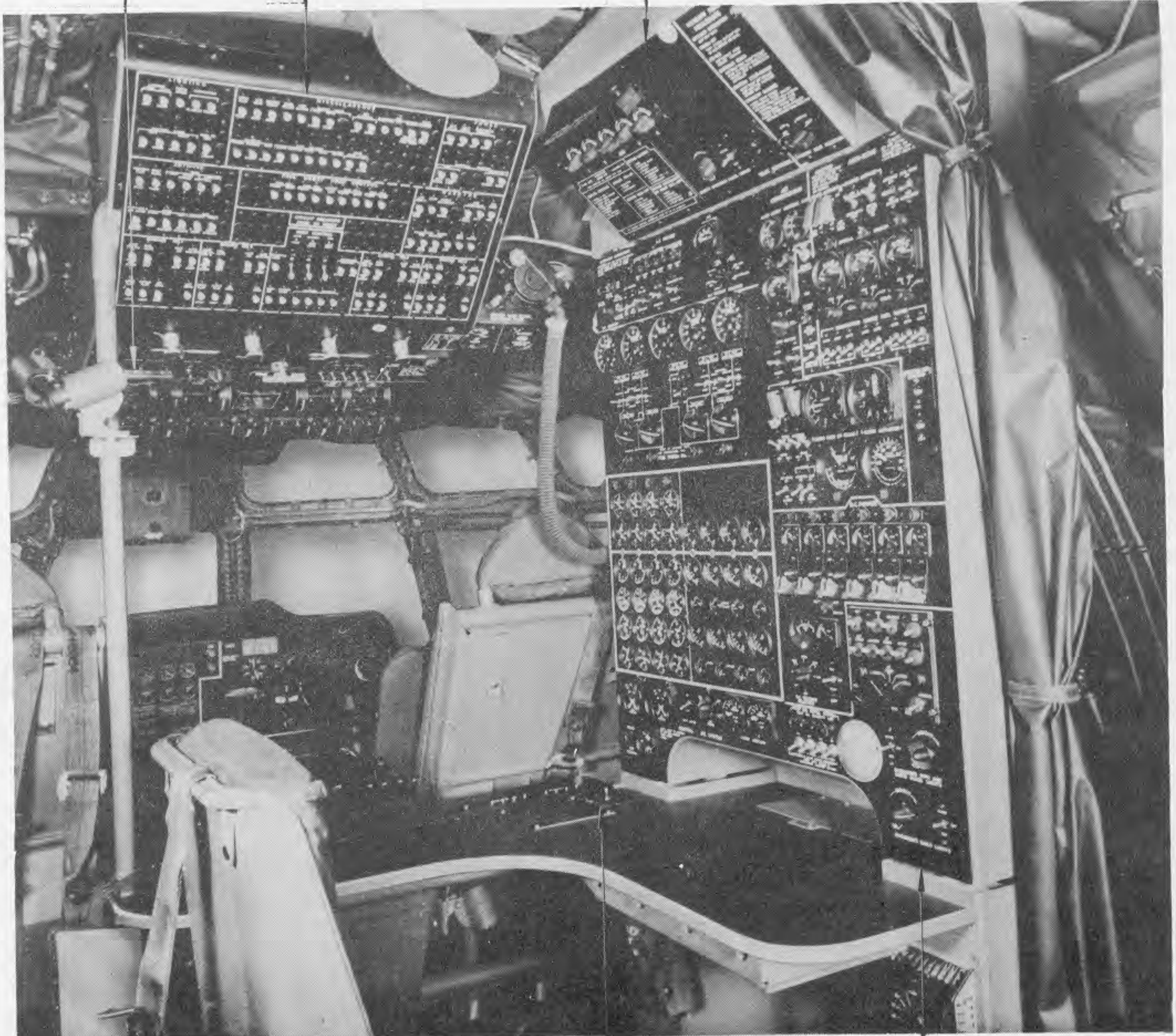

Figure 1-14. Engineer's Station

mally, the automatic synchronizing system of propeller control is used, but in case of malfunction, operation of the selector switches will override the master lever and synchronizer operation. The selector switches are spring-loaded to neutral in the "INCREASE RPM" and "DECREASE RPM" positions. An "ON--OFF", switch-type circuit breaker for the manual RPM control selector switches is on the overhead circuit breaker panel (1, figure 1-24),

1-53. PROPELLER AUTO CONTROL SWITCH. The automatic propeller synchronizing system is controlled by a "NO. 1 MASTER--off--NO. 2 MASTER" switch (22, figure 1-13) on the aft end of the engine control stand. This switch is used in the propeller synchronizing system to select either engine No. 1 or No. 2 as a master which the other engines follow. Once the master engine has been selected, the other engines act as slaves, synchronizing with the master engine. Alternate selection of a master engine is provided for in case of a master engine failure. A safety feature in the synchronizing system limits the range of control the master engine has over the slave engines (plus or minus approximately 175 RPM from the master engine speed). In case of master engine malfunction, this feature prevents the pro-

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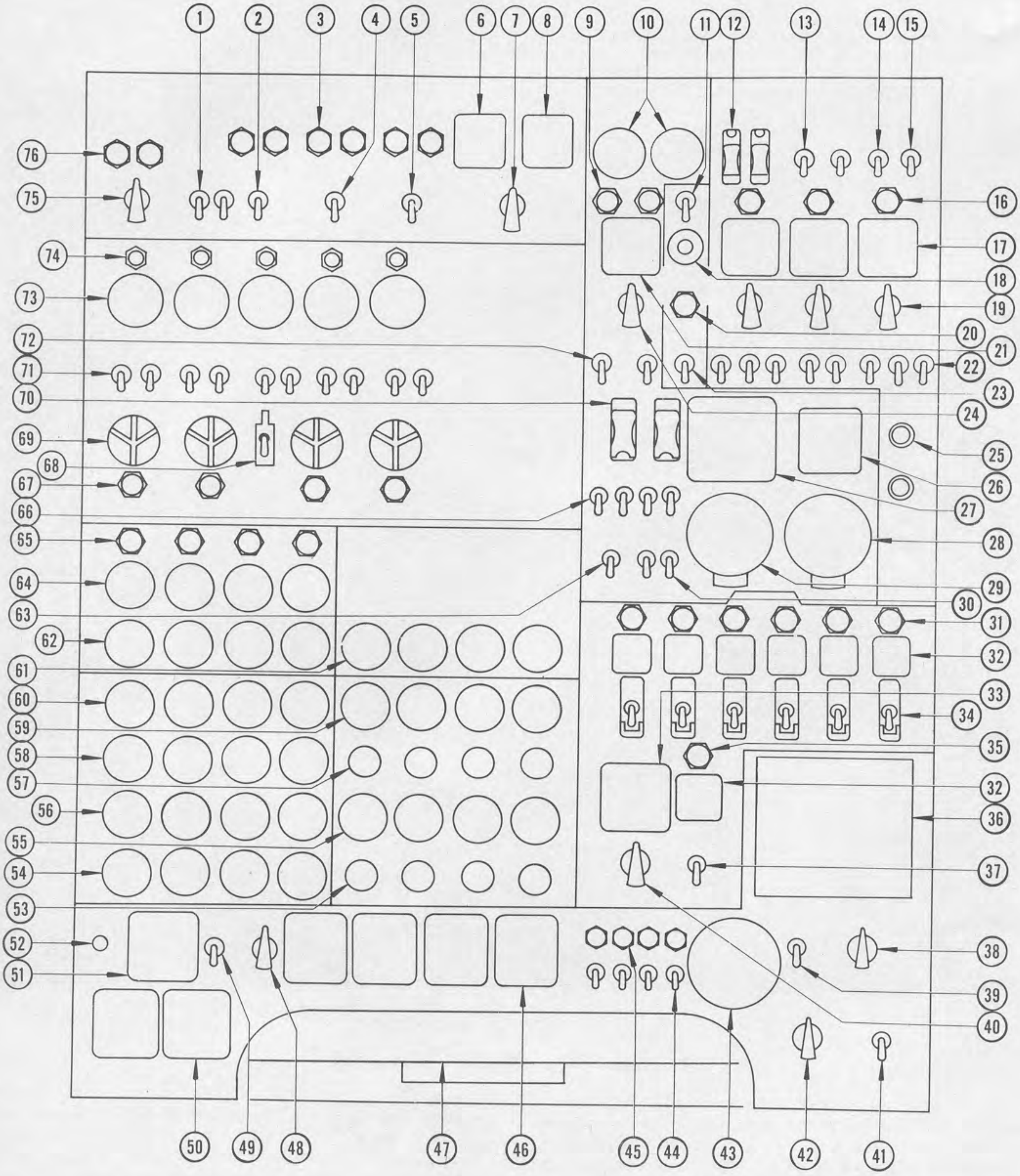

Figure 1-15. Engineer's Instrument Panel (Sheet 1 of 2)

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1 ALTERNATOR SWITCHES
2 ESSENTIAL INVERTER SWITCH
3 INVERTER WARNING LIGHTS
4 SECONDARY INVERTER SWITCH
5 AUTOPILOT INVERTER SWITCH

6 AC VOLTMETER
7 AC VOLTAGE SELECTOR SWITCH
8 FREQUENCY METER
9 BODY HEATER OVERHEAT WARNING LIGHTS
10 CABIN TEMPERATURE INDICATORS

11 HEATER OVERHEAT RESET SWITCH
12 EMERGENCY ANTI-ICE SWITCHES
13 LIMITED ANTI-ICE SWITCHES
14 MASTER ANTI-ICE SWITCH
15 WING HEATER GROUND OPERATION SWITCH

16 OVERHEAT WARNING LIGHTS
17 ANTI-ICING HEATER AND DUCT TEMPERATURE INDICATORS
18 HEATER OVERHEAT TEST SWITCH
19 TEMPERATURE INDICATOR SELECTOR SWITCHES

20 HEATER (AND APP) LOW FUEL PRESSURE WARNING LIGHTS
21 BODY HEATER TEMPERATURE INDICATOR
22 COMBUSTION HEATER FUEL VALVE SWITCHES

23 HEATER (AND APP) FUEL VALVE SWITCH
24 BODY HEATER TEMPERATURE SELECTOR SWITCH
25 PROPELLER DEICING INDICATORS
26 CABIN ALTITUDE AND DIFFERENTIAL PRESSURE INDICATOR

27 CABIN RATE-OF-CLIMB INDICATOR
28 CABIN ALTITUDE SELECTOR
29 CABIN PRESSURE RATE-OF-CHANGE SELECTOR
30 VENTILATING FAN SWITCHES

31 GENERATOR FIELD LIGHTS
32 DC LOADMETERS
33 DC VOLTMETER
34 GENERATOR SWITCHES
35 APP GENERATOR FIELD LIGHT

36 ENGINEER'S INTERPHONE CONTROL PANEL
37 APP GENERATOR SWITCH
38 ENGINEER'S INSTRUMENT PANEL LIGHTS RHEOSTAT
39 ENGINEER'S INSTRUMENT PANEL LIGHTS SWITCH

40 DC VOLTAGE SELECTOR SWITCH
41 ENGINEER'S TABLE LIGHTS SWITCH
42 ENGINEER'S TABLE LIGHTS RHEOSTAT
43 ASH TRAY
44 PROPELLER OIL REFILL SWITCHES

45 PROPELLER OIL QUANTITY WARNING LIGHTS
46 ENGINE OIL TANK QUANTITY INDICATORS
47 OXYGEN MASK STOWAGE
48 OIL TANK SELECTOR SWITCH

49 OIL TANK TRANSFER PUMP SWITCH
50 CABIN AIR FLOW INDICATORS
51 CENTRAL OIL TANK QUANTITY INDICATOR
52 MASTER FIRE WARNING LIGHT
53 INTERCOOLER FLAP POSITION INDICATORS

54 FUEL FLOW INDICATORS
55 CARBURETOR AIR TEMPERATURE GAGES
56 TORQUEMETERS
57 COWL FLAP POSITION INDICATORS
58 MANIFOLD PRESSURE GAGES

59 CYLINDER HEAD TEMPERATURE GAGES
60 TACHOMETERS
61 OIL TEMPERATURE GAGES
62 OIL PRESSURE GAGES
63 AIR CONDITIONING MASTER SWITCH

64 FUEL PRESSURE GAGES
65 FUEL PRESSURE WARNING LIGHTS
66 TURBO BLEEDER SWITCHES
67 FUEL VALVE POSITION WARNING LIGHTS
68 CENTER TANK LINE VALVE SWITCH

69 FUEL SELECTOR SWITCHES
70 CABIN AIR SELECTOR SWITCHES
71 BOOST PUMP SWITCHES
72 BODY HEATER SWITCHES
73 FUEL TANK QUANTITY INDICATORS

74 FUEL QUANTITY INDICATOR TEST SWITCHES
75 ALTERNATOR BUS SELECTOR SWITCH
76 ALTERNATOR WARNING LIGHTS

Figure 1-15 Engineer's Instrument Panel (Sheet 2 of 2)

peller RPM of the slave engines from going either above or below the controlled range. An "ON--OFF," switch-type circuit breaker for the auto control switch is on the overhead circuit breaker panel (1, figure 1-24).

1-54. MASTER PROPELLER SYNCHRONIZER LEVERS. Two levers (36, figure 1-13) on the engine control stand, one to the left of the pilots' throttles and the other to the left of the engineer's throttles, are used to operate all four propeller governors simultaneously when selecting desired engine RPM. The levers are interconnected so that movement of one lever throughout the range from "DECREASE RPM" position to "INCREASE RPM" position is duplicated by the other lever. Forward movement of the synchronizer levers causes an increase in RPM while aft movement causes a decrease in RPM. The levers are used in conjunction with the automatic propeller synchronizing and are operative only when the propeller auto control switch (22, figure 1-13) is in the "NO. 1 MASTER" or "NO. 2 MASTER" position. When placing the propeller synchronizer levers in the full "INCREASE RPM" position, the master synchronizer motor drives the four propeller governors to their maximum RPM limits. When these limits are reached by all four propellers, a holding relay cuts off all synchronizing action. Synchronizing action will remain off as long as the propeller synchronizer levers are in the full "INCREASE RPM"

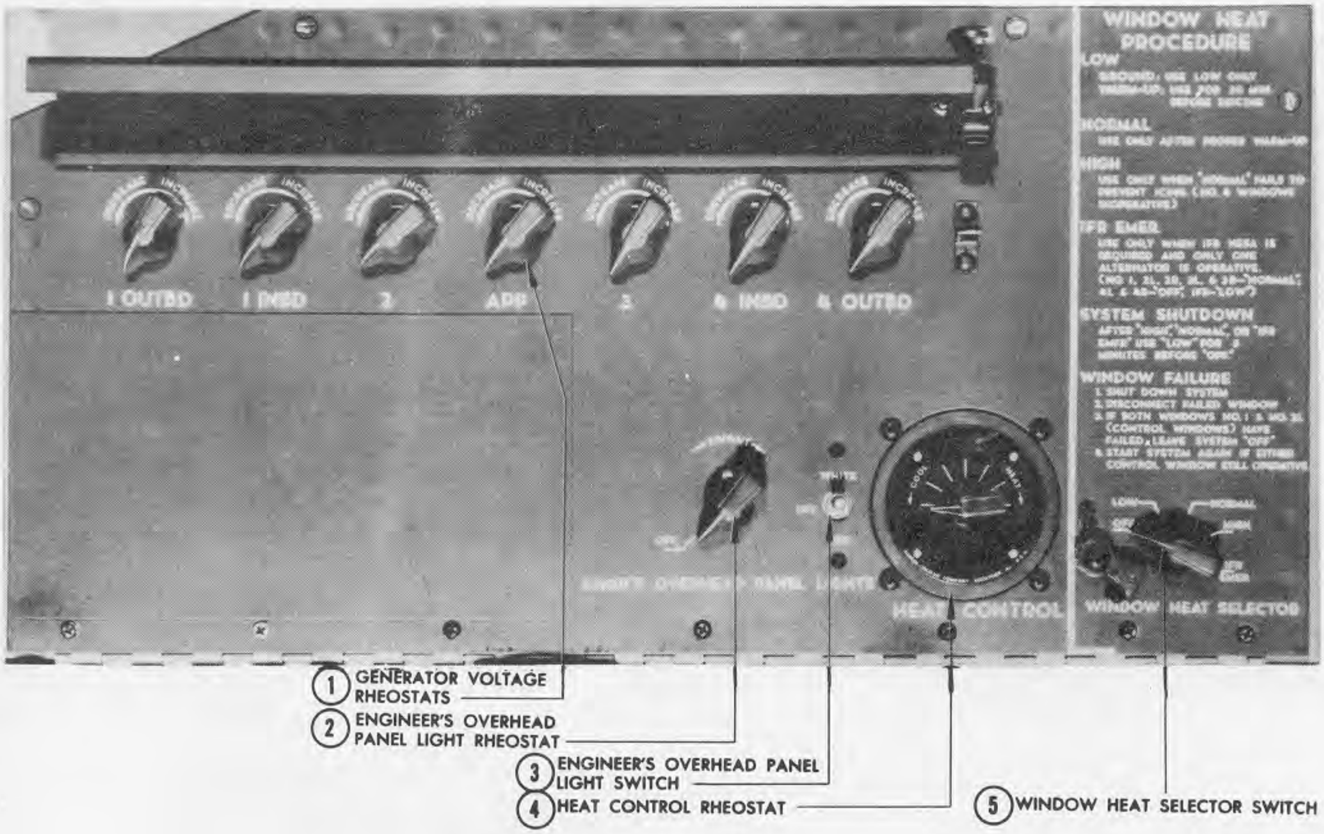

Figure 1-16. Engineer's Auxiliary Panel

position. Thus failure of the master engine on take-off will have no effect on the speed of the slave engines. Circuit breaker protection is provided by the circuit breaker switch provided for propeller auto control on the overhead circuit breaker panel (1, figure 1-24).

1-55. RESYNCHRONIZER SWITCH. A spring-loaded "RESYNC--off" switch (23, figure 1-13) on the aft end of the engine control stand, is used to synchronize the propellers after RPM selection has been made with the master propeller synchronizer levers. Because of normal tolerances in setting individual governor limits, the slave engines may not be in the synchronizing range (plus or minus 175 RPM from the master engine RPM). In this case the master propeller synchronizer levers will not set the speed of the propellers in proper synchronization, thus causing prop noise beat. When using the resynchronizer switch, by pushing to "RESYNC," holding, and then off a few times, complete engine synchronization can be obtained. This switch is used immediately after any movement of the master propeller synchronizer levers except when they are in full "INCREASE RPM" or full "DECREASE RPM" position. Circuit breaker control for the "RESYNC" switch is the same circuit breaker as used for the auto control switch on the overhead circuit breaker panel (1, figure 1-24).

1-56. PROPELLER FEATHERING BUTTONS. Four propeller feathering buttons (19, figure 1-12) are on the extreme forward end of the overhead panel. The buttons have "PUSH FEATHER," "PULL UNFEATHER," and neutral positions. The feathering operation is initiated when the feathering button is pushed. After a fixed time a spring action returns the button to the neutral position. Unfeathering is initiated when the feathering button is pulled out and held. The unfeathering action will terminate when a prescribed propeller blade angle has been reached. The button will return to neutral when released.

1-57. PROPELLER OIL REFILL SWITCHES. Four "ON--OFF" switches (44, figure 1-15) on the engineer's panel are used to energize the propeller oil refilling circuit. Placing the switches "ON" allows engine oil to flow into the propeller oil tank provided the float switch in the propeller oil tank is approximately at 2.5 quart level as indicated by a warning light. When the propeller oil quantity level reaches approximately 4 quarts, the supply of engine oil is automatically shut off.

1-58. PROPELLER INDICATORS.

1-59. PROPELLER RPM LIMIT LIGHTS. Four propeller RPM limit lights (27, figure 1-10) on the pilots' instrument panel illuminate to show when the maximum RPM limit settings are reached. An "ON--OFF," switch-type circuit breaker for the limit control lights is on the overhead circuit breaker panel (1, figure 1-24).

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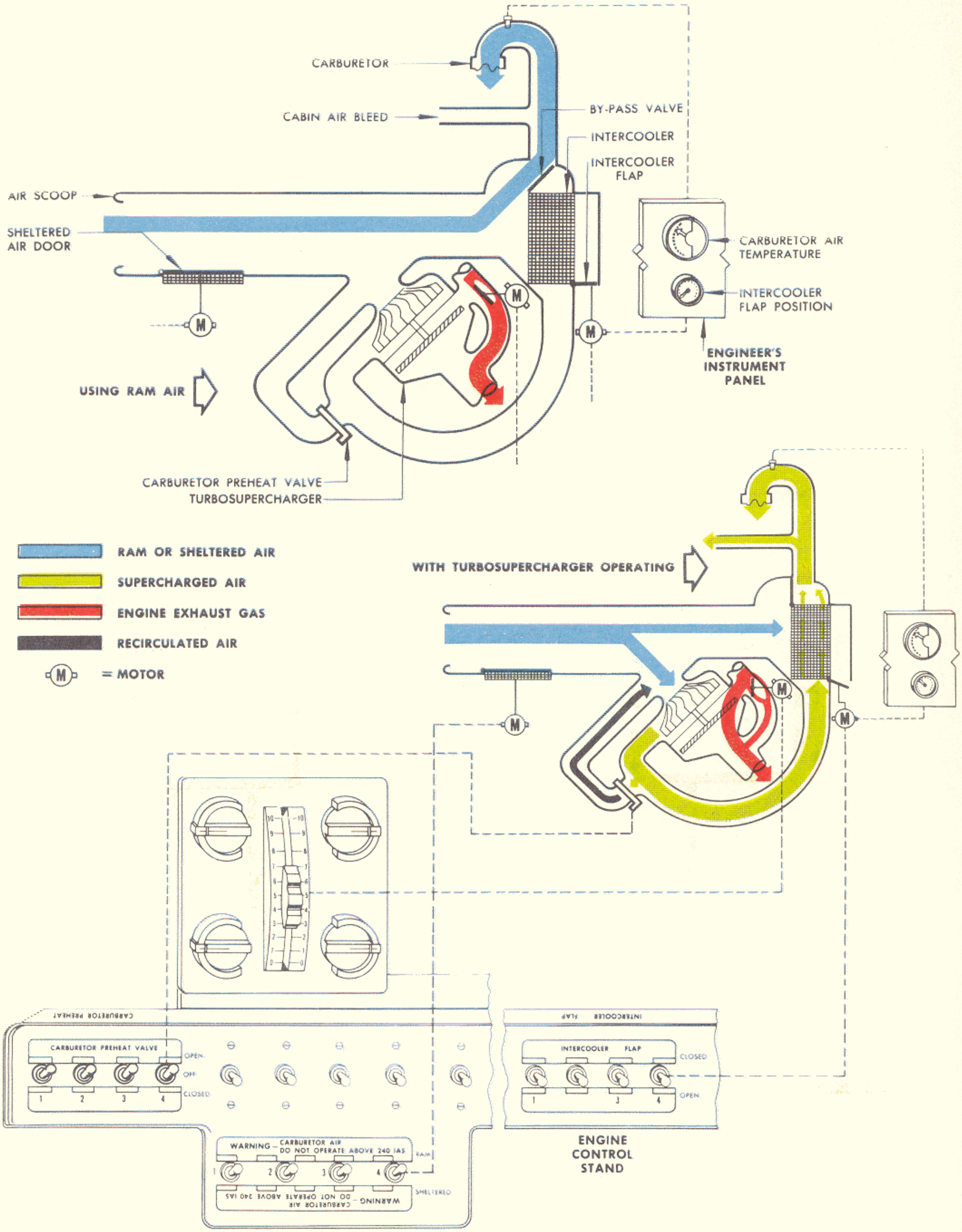

Figure 1-17. Induction System

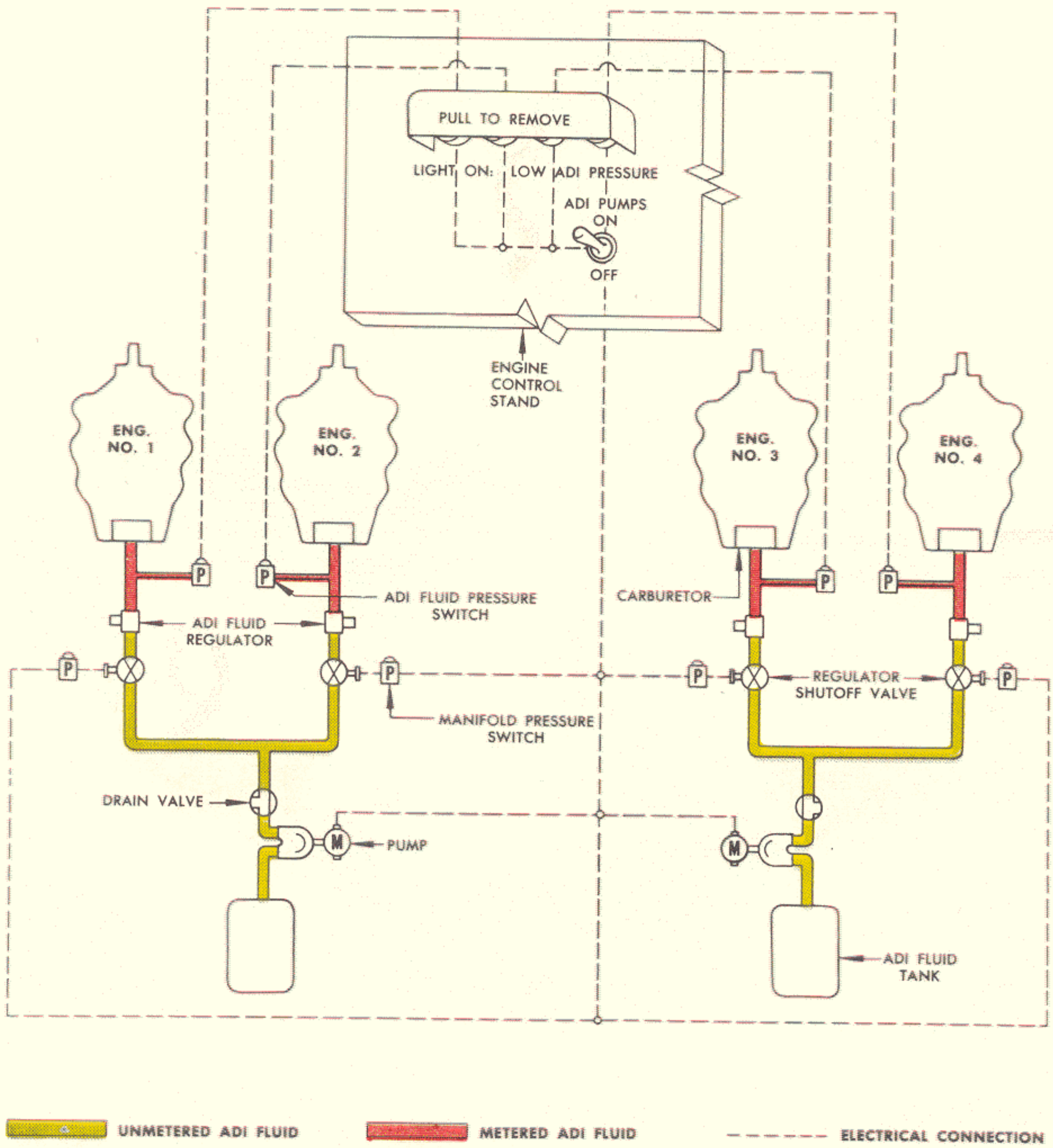

Figure 1-18. Water Injection (ADI) System

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1-60. PROPELLER OIL QUANTITY WARNING LIGHTS. Four red warning lights, (45, figure 1-15) above the refill switches, are on a separate circuit and illuminate whenever the float switch drops to approximately the 2.5 quart level regardless of refill switch position and go off when approximately 1.5 quarts have been added. A circuit breaker on the overhead circuit breaker panel (1, figure 1-24) protects both warning light and oil refill circuits.

1-61. PROPELLER REVERSE WARNING FLAG. A red "LOCKED" flag (4, figure 1-13) is provided in a housing on the engine control stand. When the airplane leaves the ground, and all three landing gear oleo switches are actuated, power will be supplied, after an 8 second time delay, to engage a reverse throttle lock on the pilots' throttles, preventing throttle movement into the "REVERSE OPEN" range. When the lock is engaged, the red flag will pop up and expose the "LOCKED" marking on the flag, indicating that the propellers can not be reversed. When any one of the landing gear oleo switches is actuated upon contact with the ground, power is supplied to release the reverse throttle lock and permit throttle movement into the "REVERSE OPEN" range. When the lock is released, the red flag drops down and an "UNLOCKED" marking on the housing is exposed, indicating that the propellers can be reversed.

NOTE

If the reverse throttle lock does not release automatically on the ground, it may be released manually by pushing down the red flag.

1-62. OIL SYSTEM.

1-63. GENERAL.

1-64. ENGINE OIL SYSTEM. Each engine has an individual oil system which includes an oil tank with a normal usable capacity of 35 U.S. gallons and an expansion space of 7 U.S. gallons.

1-65. CENTRAL OIL SYSTEM. This system (figure 1-19) has a central tank in the lower nose compartment with a capacity of 56 U.S. gallons and an expansion space of 2 U.S. gallons. This supply is used to replenish each engine oil tank as needed. The oil is transferred by an electric pump which has a normal pumping capacity of 6 gallons per minute, and is directed to the desired engine tank by a selector valve.

1-66. OIL SPECIFICATION AND GRADE. Refer to figure 1-5.

1-67. OIL SYSTEM CONTROLS.

1-68. OIL COOLER FLAP SWITCHES. The oil cooler flaps for each engine are operated by "OPEN--OFF--AUTO--CLOSE" switches (26, figure 1-13) on the aft end of the engine control stand. The switches are spring-loaded to "OFF" when held in the "OPEN" or "CLOSE" position. When a switch is in the "AUTO" position, the oil coolers automatically maintain oil temperature within the normal operating range. If extreme operation conditions exist or failure of the automatic circuit causes abnormal oil temperatures, the oil cooler flaps can be operated by the manual "OPEN" or "CLOSE" positions. The flaps are held in any desired position by positioning the switch in "OFF." Approximately 15 seconds are required to fully open or close the oil cooler flaps when the manual switch positions are used.

1-69. OIL DILUTION SWITCHES. One master "OFF--ON" and four individual "OFF--ON" switches (7, figure 1-12) on the overhead panel operate the oil dilution solenoids. The four individual switches provide a means of selecting the engines to be diluted and dilution is accomplished by use of the master dilution switch.

1-70. OIL TANK SELECTOR SWITCH. A rotary switch (48, figure 1-15) on the engineer's instrument panel controls a tank selector valve. The switch has "ENG. 1--ENG. 2--ENG. 3--ENG. 4--OFF" positions. When this switch is positioned in any one of the four engine positions oil from the central tank will be directed to the desired engine. When the switch is "OFF" the valve is closed. In case of an electrical power failure, the selector valve can be operated manually by removing four screws, pulling the electrical unit slightly forward and turning it to the desired tank as indicated by an index on the selector valves. The valve is on the forward wing spar, accessable from the forward lower cargo compartment.

1-71. OIL TANK TRANSFER PUMP MOTOR SWITCH. An "ON--OFF" switch (49, figure 1-15) spring-loaded to "OFF" and adjacent to the tank selector switch on the engineer's panel is used to turn on or off the central oil tank transfer pump.

1-72. OIL SYSTEM INDICATORS.

1-73. OIL QUANTITY INDICATORS. Oil quantity indicators (50 and 52, figure 1-15) for the engine oil tanks and central oil tank, on the engineer's instrument panel, indicate oil quantity in U.S. gallons.

1-74. OIL PRESSURE GAGES. Four oil pressure gages (62, figure 1-15) are on the engineer's instrument panel. The oil pressure gages indicate oil pressure in PSI and are of the alternating current type with replaceable fuses on the AC power panel (5, figure 1-25).

1-75. OIL TEMPERATURE GAGES. Four oil temperature gages (61, figure 1-15) of the direct current type are on the engineer's instrument panel. Circuit breakers for the oil temperature indicators are on the overhead circuit breaker panel (1, figure 1-24).

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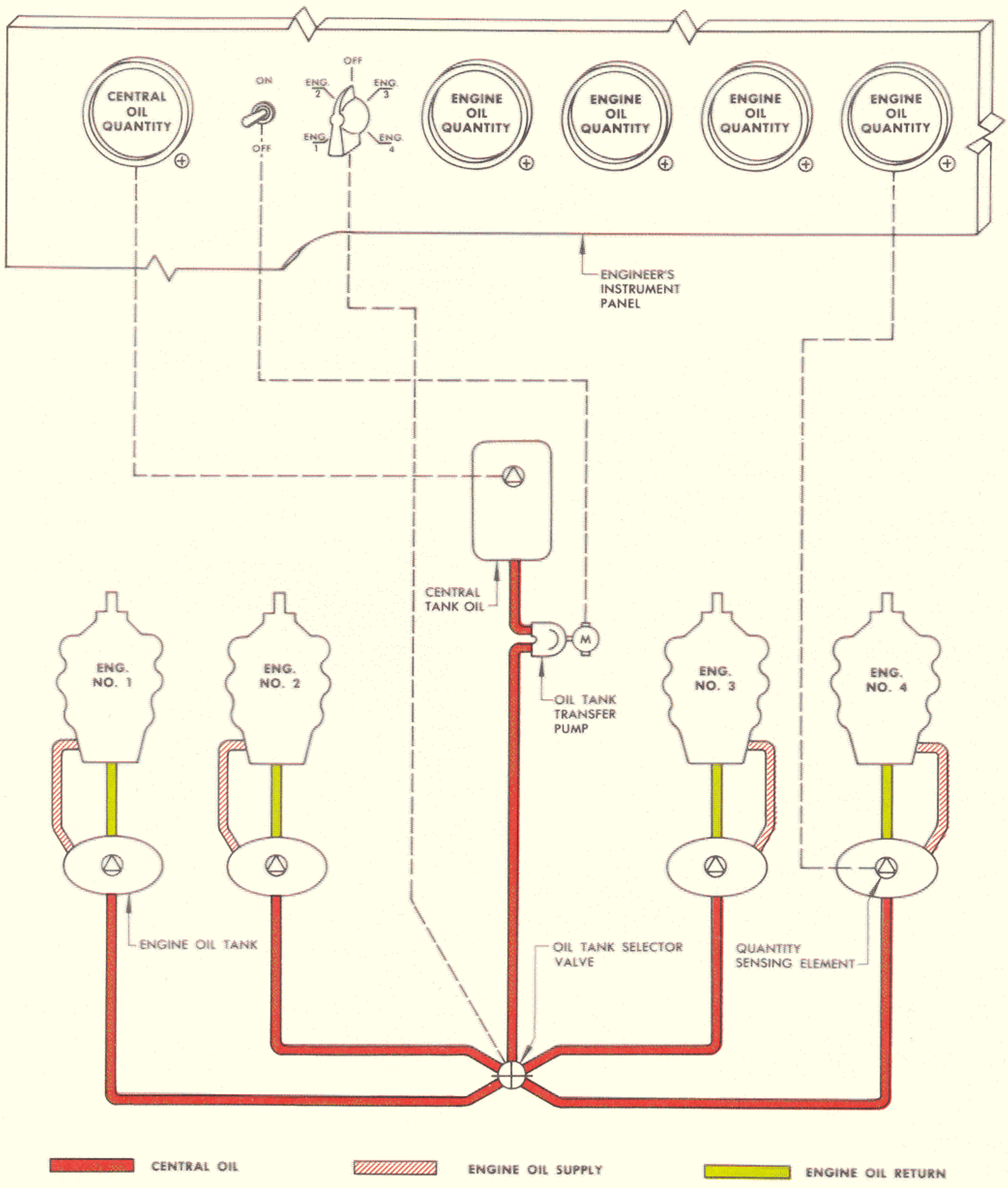

Figure 1-19. Central Oil System

1-76. FUEL SYSTEM.

1-77. GENERAL.

1-78. The main fuel system (figure 1-21) has a wing tank for each of the four engines and an auxiliary tank in the center wing section. The center wing section tank supplies fuel to a manifold system which is arranged to allow fuel to be supplied to any engine from any one or more tanks. Two submerged fuel boost pumps are provided for each wing tank. The boost pumps are installed in each wing tank in such a manner that the amount of unavailable fuel in extreme flight altitudes is minimized. The boost pumps are controlled by switches on the engineer's instrument panel. Check valves in the boost pump lines prevent transfer of fuel between tanks. The center wing section tank is provided with one boost pump controlled by a switch on the engineer's instrument panel. A manually operated manifold shut-off-valve located aft of the rear spar, is provided to isolate the center tank from the manifold system if jet fuel is being carried in the center tank for in-flight refueling operations. This valve is to be open at all times except when jet fuel is being carried in the center tank.

FUEL QUANTITY DATA (U.S. GALS.)

TANK	NO.	USABLE FUEL	UNUSABLE FUEL	EXPANSION SPACE	TOTAL VOLUME
NO. 1	1	1770	8.7	50.3	1829
NO. 2	1	1520	13.9	67.5	1601.4
NO. 3	1	1520	13.9	67.5	1601.4
NO. 4	1	1770	8.7	50.3	1829
CENTER	1	1210	8.1	33.3	1251.4

USABLE FUEL TOTALS

Tanks Nos. 1, 2, 3, and 4	6,570 gallons
Tanks Nos. 1, 2, 3, 4, and Center	7,790 gallons

NOTES

1. Unusable fuel quantities given are for level flight attitude.
2. Red figures indicate calculated data. Calibrated data will be furnished when available.

Figure 1-20. Fuel Quantity Data (US Gallons)

022054

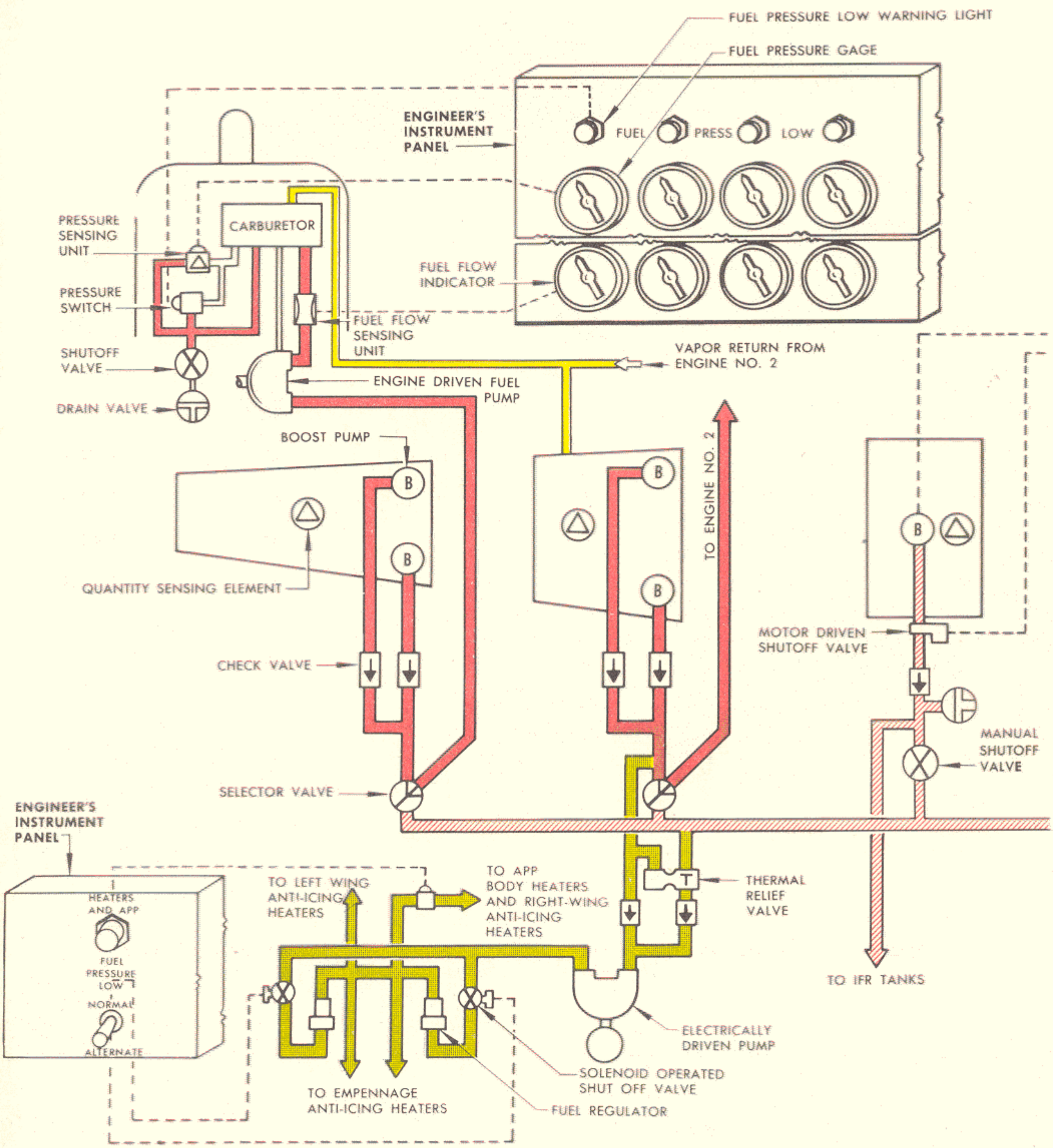

Figure 1-21. Fuel System (Sheet 1 of 2)

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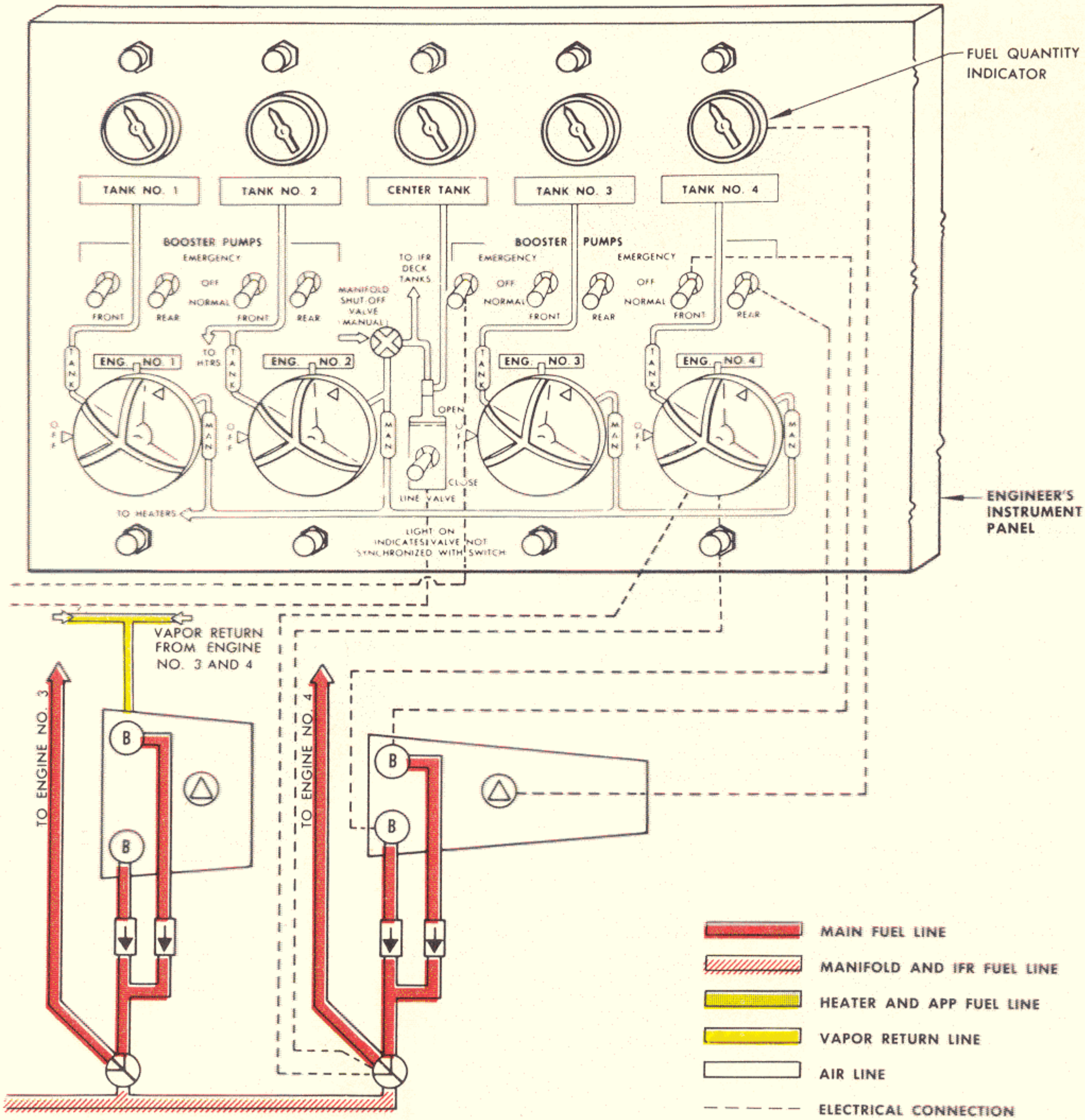

Figure 1-21. Fuel System (Sheet 2 of 2)

022009 b

1-79. FUEL SPECIFICATION AND GRADE. Refer to figure 1-5. Alternate fuel grade operating limits will be found in Section VII.

1-80. FUEL VAPOR RETURN LINES. The fuel vapors from engines No. 1 and No. 2 are vented back to wing tank No. 2 and the vapors from engines Nos. 3 and No. 4 are vented back to tank No. 3. The rate of return flow is approximately 5 pounds per hour, with a maximum of 200 pounds, (33.3 U.S. gallons) per hour.

1-81. FUEL SYSTEM CONTROLS.

1-82. FUEL SELECTOR SWITCHES. Four rotary-type fuel selector switches (69, figure 1-15) on the engineer's instrument panel control the fuel selector valves. The fuel selector switches for the four main wing tanks have five positions which permit the following combinations:

a. Fuel from "Tank-to-Engine."
b. Fuel from "Manifold-to-Engine."
c. Fuel from "Tank-to-Manifold and Engine."
d. Fuel from "Tank-to-Manifold."
e. "OFF"

Circuit breakers for the fuel valves are on the overhead circuit breaker panel (1, figure 1-24).

1-83. CENTER TANK LINE VALVE SWITCH. An "OPEN--CLOSE" switch (68, figure 1-15) controls the center tank valve. With the switch "OPEN" fuel will flow from the center tank into the manifold system. With the switch in the "CLOSE" position fuel cannot be drawn from the center tank.

1-84. BOOST PUMP SWITCHES. Each of the two submerged fuel boost pumps in each main wing tank is controlled by a "EMERGENCY--OFF--NORMAL" switch (71, figure 1-15) adjacent to the fuel selector switches. One "EMERGENCY--OFF--NORMAL" switch controls the boost pump in the center tank. The fuel pressure will be approximately 15 PSI when the boost pump switches are on "NORMAL" and 28 PSI when the switches are on "EMERGENCY." When the switches are "OFF" the boost pumps are stopped. Circuit breakers for the fuel boost pumps are on the overhead circuit breaker panel (1, figure 1-24).

1-85. FUEL SYSTEM INDICATORS.

1-86. FUEL TANK QUANTITY INDICATORS. Five indicators (73, figure 1-15) on the engineer's instrument panel show the quantity of fuel in pounds for each tank. Push-button test switches (74, figure 1-15) adjacent to the indicators are used to show circuit continuity of the fuel quantity indicating circuits. Fuses for the tank quantity indicators are on the AC power panel (5, figure 1-25).

1-87. FUEL PRESSURE GAGES. Four individual fuel pressure gages (64, figure 1-15) on the engineer's instrument panel indicates fuel pressure in PSI for each engine. Fuses for the fuel pressure gages are on the AC power panel (5, figure 1-25).

1-88. FUEL FLOW INDICATORS. Four individual fuel flow indicators (54, figure 1-15) show rate of fuel flow to each engine in gallons per hour and hundreds of pounds per hour. Fuses for the fuel flow indicators are on the AC power panel (5, figure 1-25).

1-89. FUEL PRESSURE WARNING LIGHTS. A fuel pressure low warning light (65, figure 1-15) adjacent to each fuel pressure indicator illuminates when fuel pressure is low. A circuit breaker for the fuel pressure warning system is on the overhead circuit breaker panel (1, figure 1-24).

1-90. FUEL VALVE POSITION WARNING LIGHTS. Four fuel valve position warning lights (67, figure 1-15) adjacent to the fuel selector switches illuminate if the valve is not synchronized with the switch, such as can occur with system lag, selector valve failure, or fire switch actuation.

1-91. ELECTRICAL SYSTEM.

1-92. GENERAL.

1-93. DIRECT CURRENT SYSTEM. Twenty-eight volt direct current power is supplied to the DC distribution system by six engine-driven generators (figure 1-21). Each generator has a normal rated capacity of 300 amperes. A battery in the lower nose section is provided for voltage stabilization. An external power supply can be connected to the direct current distribution system through an external power receptacle on the bottom of the fuselage. Circuit breakers and fuses (figure 1-24) provide circuit protection for all direct current operated equipment. See figure 1-27 for listing of major DC operated equipment.

1-94. REGULATED ALTERNATING CURRENT SYSTEM. Alternating current power of 115-volts, single-phase, regulated frequency (figure 1-22) is provided by three inverters: essential main inverter, secondary main inverter, and spare inverter. The essential inverter supplies power to an essential bus for operation of the fuel quantity indicators, driftmeter, radio equipment, turbosupercharger control, combustion heater ignition, and autopilot repeater. Inverter switches are on the engineer's instrument panel. The secondary main inverter supplies power to a secondary bus for operation of radar equipment and fluorescent lights. The spare inverter automatically supplies power to either essential or secondary bus in the event of essential or secondary inverter failure.

1-95. A transformer reduces essential bus voltage to 26-volts AC to supply an instrument bus from which the wing flap position indicator, engine instruments, and hydraulic pressure indicators receive power for their operation. A phase adapter is energized by the essential bus and produces 115-volt, 3-phase, AC for operation of the pilot's directional gyro, and gyro horizon.

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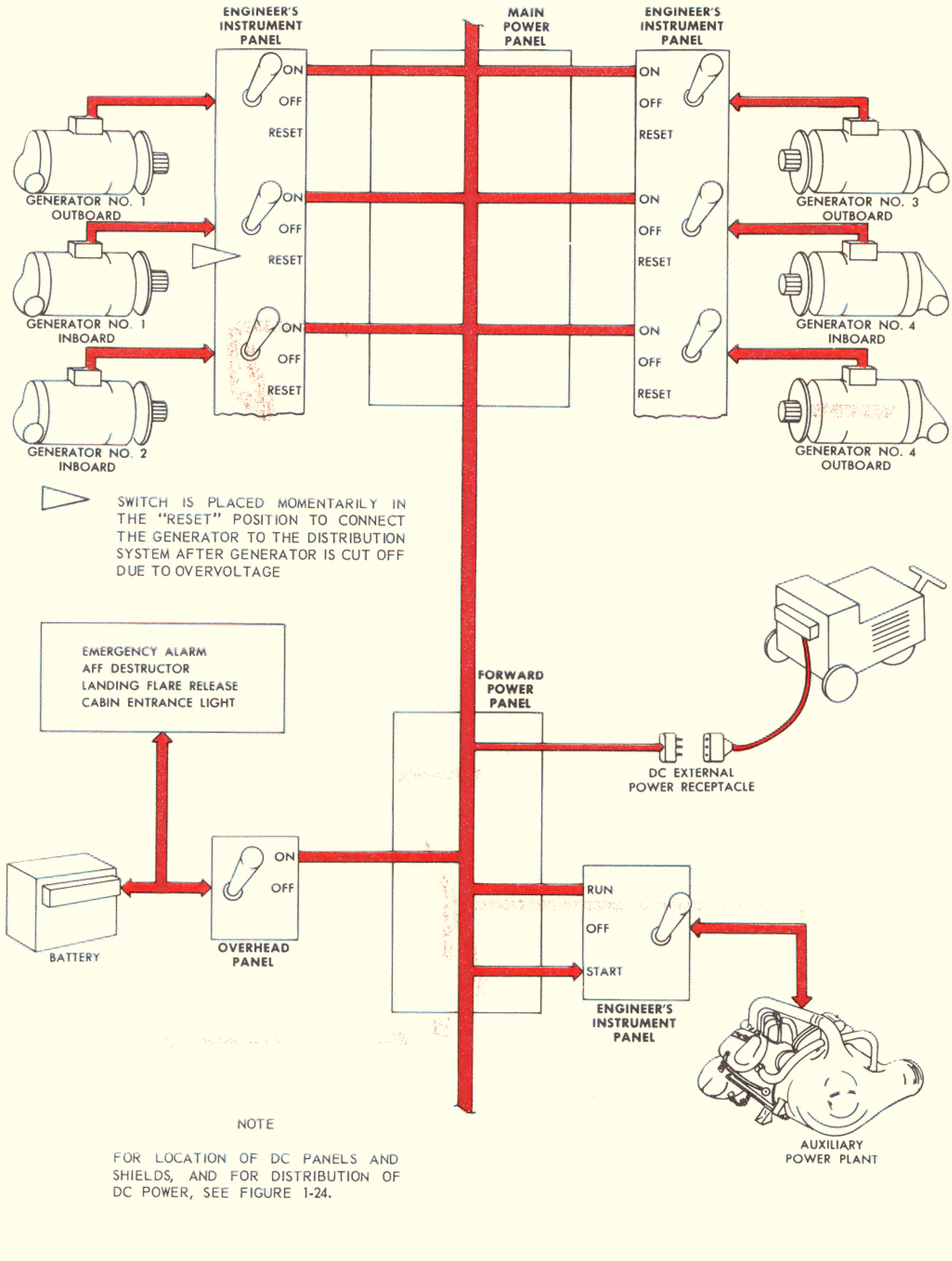


Figure 1-22. DC Generation System

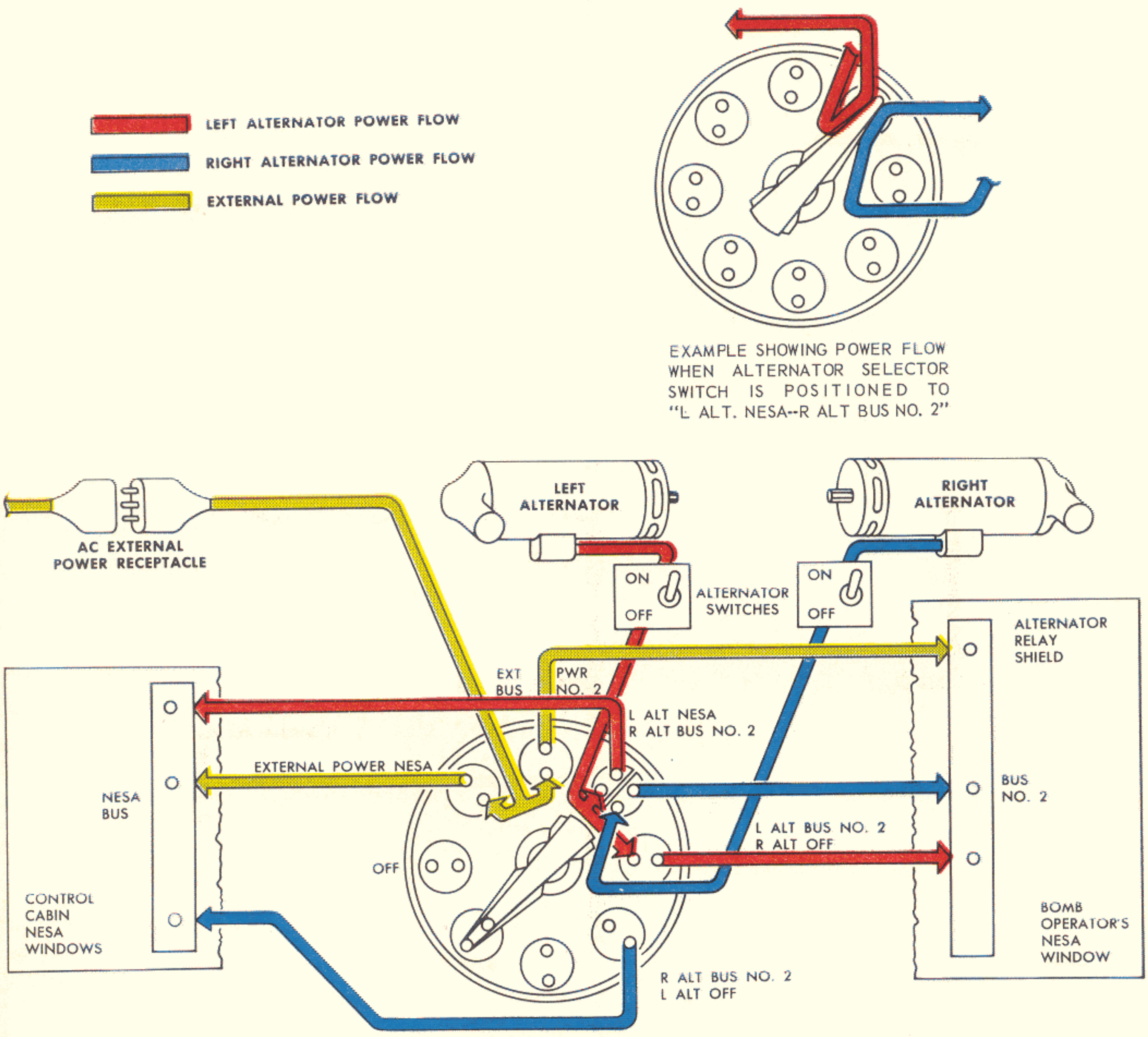
1-96. A normal autopilot inverter and a spare autopilot inverter supply 115-volt, 3-phase, AC to operate the autopilot and navigator's directional gyro. The autopilot inverters are controlled by a switch on the engineer's instrument panel.

1-97. UNREGULATED ALTERNATING CURRENT SYSTEM. Alternators on engines No. 2 and No. 3 supply alternating current of unregulated frequency for Nesa window operation. The alternators supply a Nesa bus for control cabin Nesa window operation, and a bus No. 2 for boom operator's Nesa window operation when the tanker equipment is installed. The alternators are controlled by switches on the engineer's instrument panel.

1-98. ELECTRICAL SYSTEM CONTROLS.

1-99. MASTER SWITCH. The "ON--OFF" master switch (30, figure 1-12) on the overhead panel completes the control circuit for battery and generators. The switch must be "ON" to get direct current to the DC bus.

1-100. BATTERY SWITCH. The "ON--OFF" battery switch (2, figure 1-12) is adjacent to the master switch on the overhead panel. Both the battery switch and master switch must be "ON" to supply battery power to the DC bus. Positioning the battery switch in "OFF" removes the battery from the DC bus.



UNREGULATED AC POWER

Figure 1-23. DC Generation System (Sheet 1 of 2)

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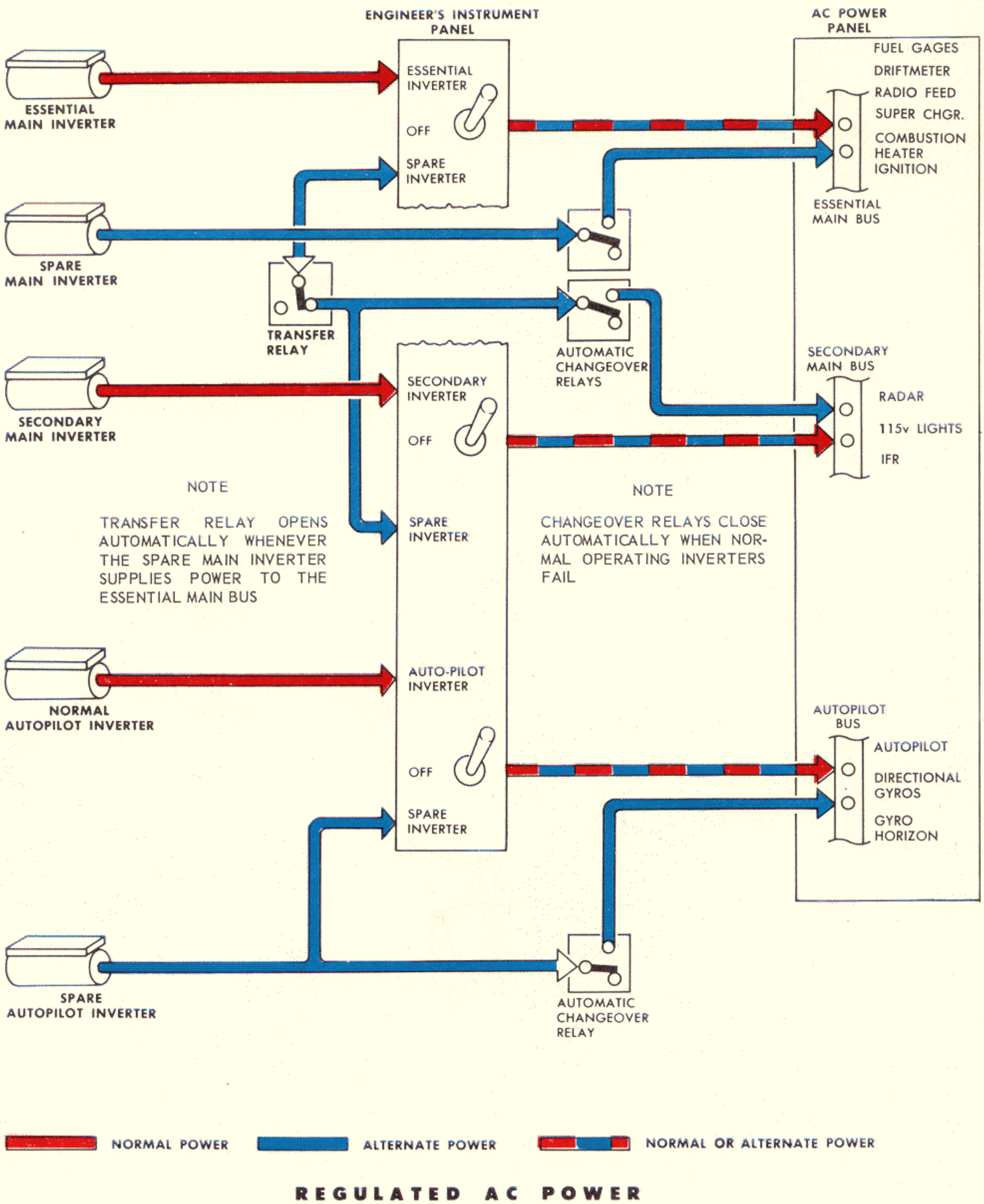

Figure 1-23. AC Generation System (Sheet 2 of 2)

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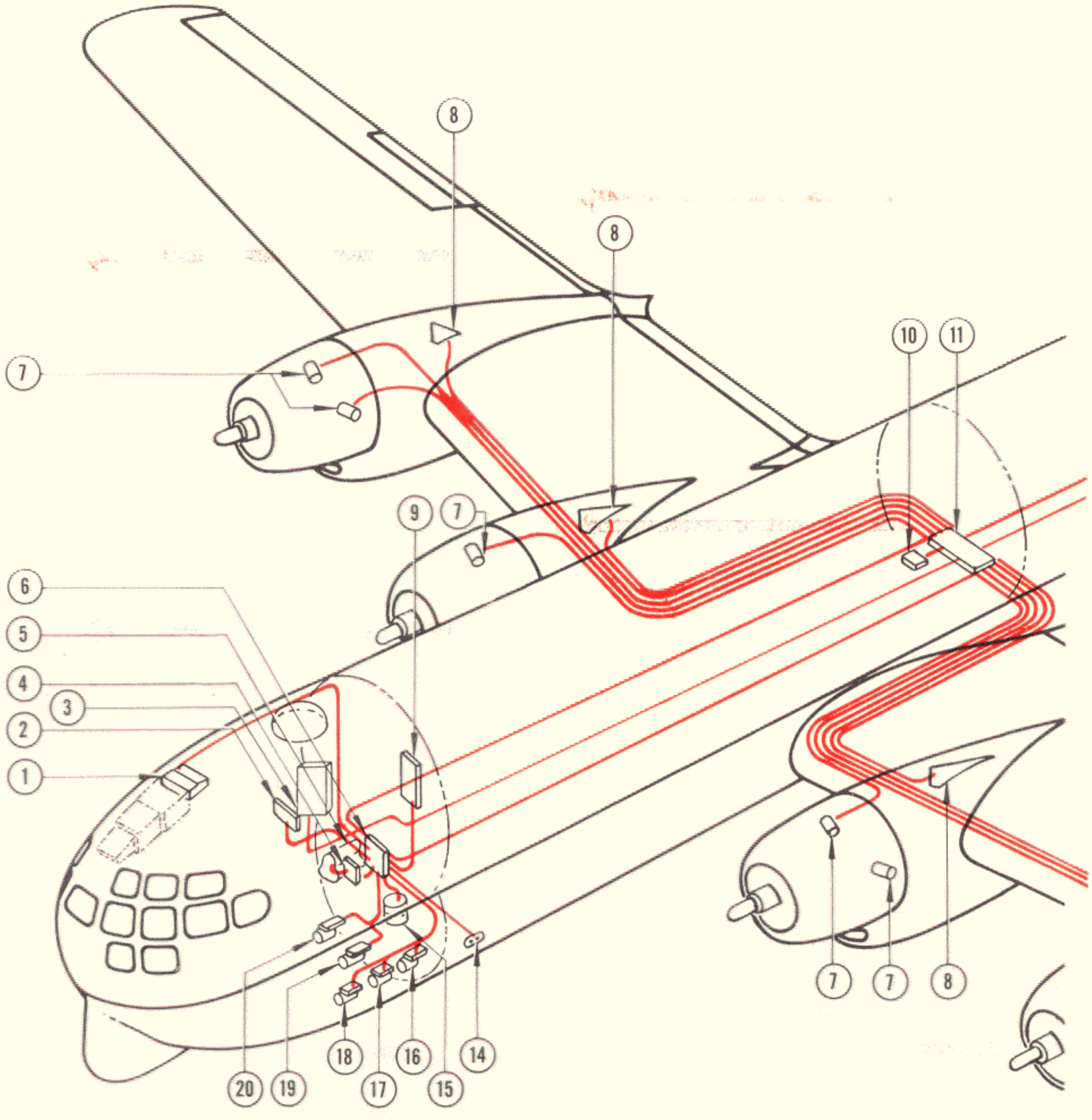

Figure 1-24. DC Distribution System (Sheet 1 of 2)

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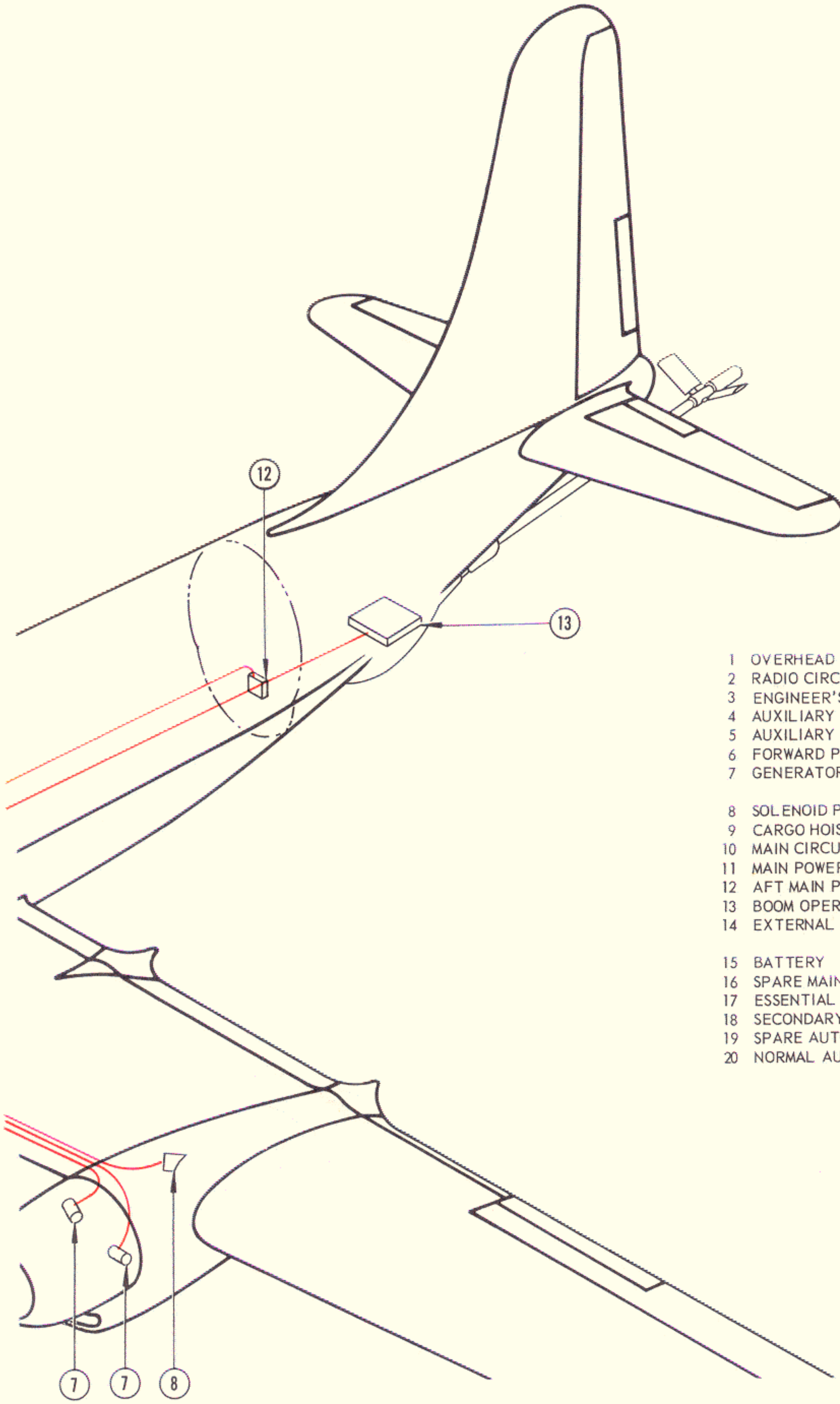

1 OVERHEAD CIRCUIT BREAKER PANEL
2 RADIO CIRCUIT BREAKER PANEL
3 ENGINEER'S IFR PANEL
4 AUXILIARY POWER PLANT SHIELD
5 AUXILIARY POWER PLANT
6 FORWARD POWER PANEL
7 GENERATOR

8 SOLENOID PANEL
9 CARGO HOIST SHIELD
10 MAIN CIRCUIT BREAKER PANEL
11 MAIN POWER PANEL
12 AFT MAIN POWER PANEL
13 BOOM OPERATOR'S PANEL
14 EXTERNAL POWER RECEPTACLE

15 BATTERY
16 SPARE MAIN INVERTER
17 ESSENTIAL MAIN INVERTER
18 SECONDARY MAIN INVERTER
19 SPARE AUTOPILOT INVERTER
20 NORMAL AUTOPILOT INVERTER

Figure 1-24. DC Distribution System (Sheet 2 of 2)

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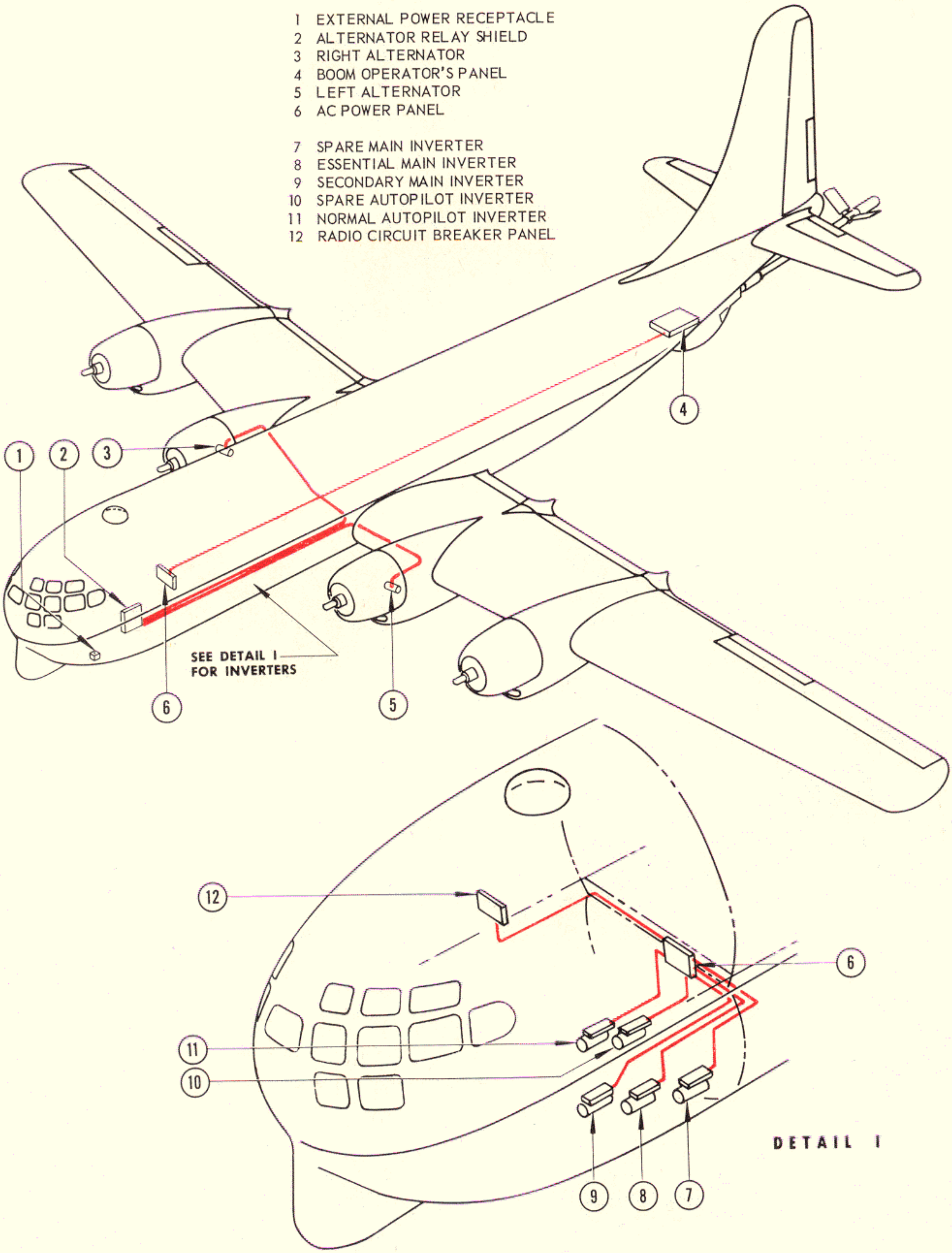

Figure 1-25. AC Distribution System

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CONTROL CIRCUIT AND OPERATING CIRCUIT PROTECTION CHART

NOTE

This chart is designed to locate circuit protection devices for both control power and operating power of electrical equipment. Where equipment is operated directly from its control and one protection device is employed, this is indicated by the word "SAME" in the OPERATING CIRCUIT column.

This chart may be used as a guide for emergency electrical isolation of electrical equipment by opening the desired circuits at their protective devices. Location code refers to figure 1-24 for DC power and to figure 1-25 for AC power.

CIRCUIT TITLE	CONTROL TYPE OF POWER	CIRCUIT LOCATION CODE	OPERATING TYPE OF POWER	CIRCUIT LOCATION CODE
ANTI-ICING				
Anti-ice and air conditioning fuel supply valves	DC	1	Same	
Combustion heaters	DC	1		
Combustion heater fuel valves	DC	1	Same	
Combustion heater ignition	AC	5	Same	
Emergency anti-icing	DC	6		
Empennage ground blower	DC	1	DC	12
Propeller deice	DC	1	DC	11
Ruddevator anti-ice	DC	3	DC	11
Window heat	AC	2	AC	2
Window heat (boom operator's)	AC	13 (Fig. 1-24)	AC	2
AUTOMATIC PILOT				
Autopilot inverters	DC	1	DC	6
Autopilot	DC	1	AC	5
CABIN HEATING, VENTILATING, AND PRESSURIZING SYSTEMS				
Body heaters	DC	6		
Body heater fuel valves	DC	6	Same	
Body heater ignition	AC	5	Same	
Cabin pressure regulation	DC	6	Same	
Control cabin fans	DC	1	Same	
Ground blowers	DC	6	DC	10
Turbo-bleed valves	DC	1	Same	
CARGO				
Aerial delivery motor	DC	12	DC	11
Cargo door	DC	12	DC	12
Cargo hoist	DC	9	DC	6
COMMUNICATIONS AND ASSOCIATED ELECTRONIC EQUIPMENT				
IFF radio destruction	DC	6		
Power distribution			AC	5
			DC	6
Radio and Radar equipment	AC	11	Same	
	DC	2	Same	
ELECTRICAL SYSTEM				
Alternators	DC	1	AC	3, 4
Auxiliary power plant	DC	4	DC	6
Generators	DC	10	DC	11
Generator field relays	DC	1	Same	
Inverters	DC	1	DC	
Power distribution			DC	6, 11
Voltmeters	AC	2, 5	Same	
	DC	10	Same	

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Figure 1-26. Control Circuit and Operating Circuit Protection (Sheet 1 of 3)

CIRCUIT TITLE	CONTROL TYPE OF POWER	CIRCUIT LOCATION CODE	OPERATING TYPE OF POWER	CIRCUIT LOCATION CODE
ENGINES				
Carburetor preheat valve	DC	1	Same	
Carburetor sheltered air door	DC	1	DC	10
Cowl flaps	DC	1	DC	10
Engine instruments			AC	5
			DC	1
Ignition booster	DC	1	Same	
Intercooler flaps	DC	1	Same	
Primer	DC	1	Same	
Starters	DC	1	DC	11
Turbosuperchargers	AC	5		
Water injection	DC	1	DC	10
FIRE EXTINGUISHING				
Combustion heater fire warning	DC	1	Same	
Fire detector			DC	1
Fire extinguishing	DC	1		
Fire warning test	DC	1	Same	
FLIGHT CONTROLS				
Emergency wing flaps	DC	10	DC	11
Rudder boost	DC	1		
Wing flaps	DC	1	DC	11
FUEL SYSTEM				
Boost pumps	DC	1	DC	10
Fuel gages			AC	5
Fuel leveling valve (IFR)	DC	3	Same	
Fuel pressure warning			DC	1
Fuel selector valves	DC	1	Same	
Fuel shutoff valve (Emergency IFR)			DC	3
IFR line valve	DC	1	Same	
Fuel transfer valves (IFR)	DC	3	Same	
HYDRAULIC SYSTEM				
Hydraulic pressure indicator			AC	5
Hydraulic shutoff valve	DC	1	Same	
IFR SYSTEM				
Auto fuel by-pass valve			DC	3
Hydraulic pressurizing pump	DC	3	Same	
Pump hydraulic by-pass valve			DC	3
Signal amplifier			DC	13
INSTRUMENTS				
Boom position indicator			DC	13
Directional gyro			AC	5
Engine instruments			AC	5
			DC	1
Fuel gages			AC	5
Gyro horizon			AC	5
Hydraulic pressure indicator			AC	5
Turn and bank indicator			DC	1
Wing flap position indicator			AC	5
Voltmeters	AC	2, 5	Same	
	DC	10	Same	

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Figure 1-26. Control Circuit and Operating Circuit Protection (Sheet 2 of 3)

CIRCUIT TITLE	CONTROL TYPE OF POWER	CIRCUIT LOCATION CODE	OPERATING TYPE OF POWER	CIRCUIT LOCATION CODE
LANDING GEAR				
Main landing gear	DC	1	DC	11
Nose landing gear	DC	1	DC	5
Oleo relays			DC	1
Portable auxiliary motor	DC	10	DC	11
Warning horn	DC	1	DC	1
LIGHTING				
Boom operator's lights	DC	13	Same	
Control cabin	DC	1	DC Same	
Control cabin entrance light	DC	6	Same	
Exterior lights (IFR)	DC	13	Same	
Fluorescent lights	AC	5	Same	
Formation lights	DC	1	Same	
Landing lights	DC	1	DC	10
Lower aft compartments	DC	10	Same	
Lower forward compartments	DC	6	Same	
Main cargo compartment	DC	10	Same	
Navigation lights	DC	1	Same	
Pump operator's panel lights	DC	3	Same	
MISCELLANEOUS				
Door warning			DC	1
Driftmeter	AC	5	Same	
Emergency alarm	DC	6	Same	
Landing flare release	DC	6	Same	
Suit heaters	DC	1	Same	
NOSE STEERING SYSTEM				
Nose steering emergency valve	DC	6	Same	
OIL SYSTEM				
Oil dilution	DC	1		
Oil quantity indicators			DC	1
Oil shutoff valves	DC	1	Same	
Oil transfer pump	DC	1	DC	6
PROPELLERS				
Auto RPM	DC	1	DC	
Emergency oil	DC	1	DC	11
Feathering	DC	1	DC	11
Manual RPM	DC	1		
Reversing	DC	1		
RPM limit	DC	1		
Throttle lock	DC	1	Same	
WARNING				
AC power			DC	1
Cargo discharge signal	DC	1	Same	
Combustion heater fire	DC	1	Same	
Door closed			DC	1
Fire detectors			DC	1
Fire detector test	DC	1	Same	
Fuel and hydraulic pressure (IFR)			DC	3
Fuel pressure			DC	1
Fuel quantity indicator test (IFR)	DC	3	Same	3
Landing gear and wing flaps			DC	1

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Figure 1-26. Control Circuit and Operating Circuit Protection (Sheet 3 of 3)

MAJOR DC ELECTRICAL LOADS TABLE

EQUIPMENT	NO. UNITS	AMPS PER UNIT	TAKE-OFF CLIMB	CRUISE	CRUISE COMBAT	LANDING
ANTI-ICING						
Empennage ground blower	1	15				1
Fuel valve	18	0.5	12.5	12.5	12.5	12.5
Propeller	4	260	260	260	260	260
Ruddevator	2	280		360	360	
ENGINES						
Actuator - carb. air	4	16.8		67.2	67.2	
Actuator - carb. heat	4	2.5		10	10	
Actuator - intercooloer flap	4	6.0		24	24	
Actuator - oil cooler	4	5.7	22.8	0:7	0.7	0.7
Motor - cowl flap	4	16.8	67.2	67.2	67.2	67.2
Motor - starting	4	244.5				
Prop - (reversing and feathering pump)	4	100				
Prop throttle lock	1	24				24
FLIGHT CONTROLS						
Wing flap	1	170 Retract 160 Extend	174.5			164.5
FUEL AND OIL						
Pump - ADI	2	11.8	23.6			
Pump - fuel boost	9	10.0 Normal 25.0 Emergency	41.2	41.2	82.4	41.2
Pump - oil transfer	1	140.6		140.6	140.6	
Valve - fuel tank select	4	5.0	10	10	10	10
HEATING AND VENTILATING						
Cabin fans	2	6.0	12	12	12	12
Casualty blankets	8	10.0				
Ground blowers	2	40				
Suit heaters	5	15.6				
IFR EQUIPMENT						
Hydraulic pressurizing pump	1	15.0	15.0		15.0	
LANDING GEAR						
Main gear motor	2	206 Retract 235 Extend	212			470
Nose gear motor	1	92 Retract 129 Extend	92			129
LIGHTING						
Interior lights			15	15	15	25
Landing lights	2	21.4	42.8			42.8
Navigation	8	1.2	10	10	10	10
Navigation- flasher	1	.42	9.7	9.7	9.7	9.7
Taxi lamp	2	5.0				
Pilot director lights	5.0	5.0		10	10	

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Figure 1-27. Major DC Loads (Sheet 1 of 2)

EQUIPMENT	NO. UNITS	AMPS PER UNIT	TAKE-OFF CLIMB	CRUISE	CRUISE COMBAT	LANDING
MISCELLANEOUS						
Actuator - cargo door	1	70.0			70.7	
Actuator - cargo hoist	1	3.0				
Motor - ADC	2	200.0			400.0	
Motor - cargo hoist	1	154.5				
POWER-ELECTRICAL						
Battery charging	1		81.5	61.2	40.8	20.1
Field - DC generator	6	7.0	42	42	42	42
Inverter - autopilot		52	52	52	52	52
Inverter - main		165	165	300	300	165
RADIO AND RADAR						
Command radio	1	41	41	20	20	41
Liaison radio	1	44		20	20	41
Radar	1			10	10	
VHF Command	1	20	20	20	20	20

Figure 1-27. Major DC Loads (Sheet 2 of 2)

1-101. GENERATOR SWITCHES. Six individual generator switches (34, figure 1-15) are on the engineer's instrument panel. The switches are marked "ON--OFF--RESET" and are guarded to the "ON" position. When a switch is "ON," the generator delivers power to the direct current distribution system, if generator voltage is sufficiently high. In the "OFF" position the switch prevents a reverse current relay from connecting the generator to the DC distribution system. The "RESET" position is used to reset the generator field relay to restore generator operation after the field relay has been tripped by generator overvoltage as indicated by an overvoltage light. When in the "RESET" position the generator switch is spring-loaded to "OFF."

1-102. GENERATOR VOLTAGE RHEOSTATS. Generator voltage rheostats, one for each generator, are behind a hinged cover guard (1, figure 1-16) on the engineer's auxiliary panel. The rheostats are to be used only for adjusting generator voltage to equalize generator load distribution.

1-103. DC VOLTAGE SELECTOR SWITCH. A rotary-type switch (40, figure 1-15) on the engineer's instrument panel provides a means of obtaining generator and direct current bus voltage readings on a single voltmeter adjacent to the switch. The switch is marked "OFF--GEN 1 OUTBD--GEN 1 INBD--GEN 2--BUS--GEN 3--GEN 4 INBD--GEN 4 OUTBD--APP." In the "OFF" position the switch disconnects the voltmeter from any power source. The voltage output of any one of the generators is read by placing the switch in the appropriate generator positions. An indication of auxiliary power plant generator voltage is obtained from the "APP" position. When the switch is in the "BUS" position the voltmeter is connected to the main DC power distribution bus.

1-104. BUS SELECTOR SWITCH. A rotary-type switch (75, figure 1-15) on the engineer's instrument panel is marked "OFF--EXT PWR NES A BUS--EXT PWR BUS NO. 2--R ALT BUS NO. 2 L ALT NESA--L ALT BUS NO. 2 ALT OFF--L ALT OFF R ALT NESA." This switch directs unregulated alternating-current power from the external AC power receptacle or right or left alternator to the unregulated AC busses as indicated by the switch position. When the switch is "OFF" all three unregulated AC busses are de-energized.

1-105. ALTERNATOR SWITCHES. The two alternators are turned on or off by two "ON--OFF" switches (1, figure 1-15) on the engineer's instrument panel. When the alternator switches are "ON," and engines No. 2 and No. 3 are running, unregulated AC current is delivered to the bus selector switch. Circuit breakers for the alternator control are on the overhead circuit breaker panel (1, figure 1-24).

1-106. MAIN INVERTER SWITCHES. Two switches control three inverters in the main inverter system A switch marked "ESS INV--OFF--SPARE INV" (2, figure 1-15) energizes and connects the main inverter to the essential bus when in the "ESS INV" position. A switch marked "SEC INV--OFF--SPARE

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INV" (4, figure 1-15) when in the "SEC INV" position energizes and connects the secondary inverter to the secondary bus. If the main inverter becomes inoperative a spare inverter is automatically energized and connected to the main bus. The "SPARE INV" position for these switches provides a manual means of disconnecting either inverter and energizing and connecting the spare inverter to the bus as selected. When the switches are "OFF" no power is supplied to the busses.

1-107. If the spare inverter is supplying power to the secondary bus and the main inverter switch is moved from "ESS INV" or "OFF" to the "SPARE INV" position, the spare inverter output will be transferred to the essential bus; also, if the main inverter becomes inoperative, the spare inverter will automatically be transferred from the secondary to the essential bus.

1-108. AUTOPILOT INVERTER SWITCH. A switch marked "AUTO-PILOT INV--OFF--SPARE INV" (5, figure 1-15) controls the normal autopilot inverter and the spare autopilot inverter. When the switch is in the "AUTO-PILOT INV" position power is supplied to the automatic pilot and the navigator's directional gyro by the normal autopilot inverter. If the normal autopilot inverter becomes inoperative the spare autopilot inverter is automatically energized. When the switch is in the "SPARE INV" position the spare autopilot inverter supplies power to the automatic pilot and the navigator's directional gyro, but should the spare autopilot inverter fail, when the switch is in the "SPARE INV" position, automatic changeover to the normal autopilot inverter will not take place. When the switch is "OFF" no power is supplied to the automatic pilot or the navigator's directional gyro. Circuit breakers for the autopilot inverter control are on the overhead circuit breaker panel (1, figure 1-24).

1-109. AC VOLTAGE AND FREQUENCY SELECTOR SWITCH. A rotary type switch (7, figure 1-15) on the engineer's instrument panel provides a means of obtaining regulated and unregulated AC bus voltage readings on a single voltmeter and AC frequencies on a single frequency indicator. This switch is marked "OFF--AUTOPILOT INV--SEC MAIN BUS--NESA BUS--BUS NO. 2--ESS MAIN BUS--ENG INST BUS." The voltmeter and frequency indicator are connected to these AC busses by positioning the voltage selector switch in the appropriate position. When the switch is "OFF" the voltmeter and frequency indicator are de-energized.

1-110. EXTERNAL POWER RECEPTACLES. An external power receptacle for DC power (14, figure 1-5) is on the bottom of the fuselage near the forward entry door. An unregulated AC power receptacle (17, figure 1-5) is in the forward end of the nose wheel well.

1-111. ELECTRICAL SYSTEM INDICATORS.

1-112. GENERATOR FIELD LIGHTS. Six red generator field lights (31, figure 1-15) are on the engineer's instrument panel. Illumination of a light indicates that a generator field relay has been tripped by high generator voltage. Tripping a field relay removes a generator from the DC power distribution system.

1-113. DC VOLTMETER. A single direct current voltmeter indicates individual generator or bus voltage. The voltmeter (33, figure 1-15) is on the engineer's instrument panel and is connected to each generator or bus through a rotary-type DC voltage selector switch.

1-114. DC LOADMETERS. Six direct current loadmeters (32, figure 1-15) on the engineer's instrument panel indicate individual generator load. The loadmeters are calibrated in percent of normal generator capacity.

1-115. INVERTER WARNING LIGHTS. Six inverter lights (3, figure 1-15) are on the engineer's instrument panel. There are two lights for each bus; essential, secondary, and autopilot. Each bus has an amber spare on and a red power failure light. These lights are illuminated if the spare inverter is supplying power to a bus or if there is no power on the bus at all.

1-116. ALTERNATOR WARNING LIGHTS. Two red warning lights (76, figure 1-15) on the engineer's instrument panel are illuminated whenever the alternators fail to energize the Nesa or No. 2 bus.

1-117. AC VOLTMETER. A single alternating current voltmeter (6, figure 1-15) on the engineer's instrument panel is provided for indications of alternator and inverter voltages. The voltmeter is used in conjunction with the AC voltage selector switch.

1-118. FREQUENCY INDICATOR. A frequency meter (8, figure 1-15) is located on the engineer's instrument panel. This meter indicates the frequency in cycles per second of the AC busses to which it is connected by the AC Voltage and Frequency Selector Switch.

1-119. AUXILIARY POWER PLANT.

1-120. GENERAL.

1-121. An auxiliary power plant, consisting of a two-cylinder gasoline engine, is located in the cargo compartment. The engine drives a 28-volt, 175-ampere, direct current generator. The generator functions as a motor when starting the auxiliary power plant. Fuel is supplied from tank No. 2 or from the fuel manifold. The fuel supply is automatically shut off whenever the auxiliary power plant is not operating. The auxiliary power plant has a self-contained oil supply. Combustion products and cooling air are vented overboard through an exhaust duct. Ignition voltage is supplied by a magneto. The generator and fuel control circuits are protected by a circuit breaker on the auxiliary power plant shield (3, figure 1-24).

1-122. AUXILIARY POWER PLANT CONTROLS.

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Figure 1-28. Auxiliary Power Plant

1-123. STARTER SWITCH. Electric starting is actuated by an "ON--OFF" starter switch (1, figure 1-28) on the auxiliary power plant shield. In the "ON" position, the generator functions as a motor to turn over the engine, provided the auxiliary power plant generator switch on the engineer's instrument panel is in the "START" position and the airplane master switch (30, figure 1-12) on the overhead panel is "ON." In the "OFF" position, the starting circuit is de-energized. The starter switch is spring-loaded from "ON" to "OFF."

1-124. IGNITION SWITCH. Ignition control is provided by an "ON--OFF" ignition switch (7, figure 1-28) on the auxiliary power plant. When the switch is in the "ON" position, the magneto is not grounded, provided the exhaust duct valve control lever is in the "OPEN" position and the master switch (30, figure 1-12) on the overhead panel is "ON." When the switch is in the "OFF" position, the magneto is grounded and the auxiliary power plant cannot be operated. The ignition switch is guarded in the "OFF" position.

1-125. AUXILIARY POWER PLANT GENERATOR SWITCH. The auxiliary power plant generator is controlled by a "RUN--OFF--START" switch (36, figure 1-15) on the engineer's instrument panel. When the switch is in the "START" position the generator functions as a motor for starting the auxiliary power plant. When the switch is in the "RUN" position the generator functions as a generator and supplies power to the forward power panel (5, figure 1-24). When the switch is "OFF" the auxiliary power plant generator can not be energized.

1-126. SPEED AND CHOKE CONTROL LEVER. Engine control is provided by a "CHOKE--IDLE--RUN" lever (2, figure 1-28) on the auxiliary power plant. When the lever is in the "CHOKE" position, the engine receives a rich fuel mixture. When the lever is in the "IDLE" position, the engine operates at a reduced speed. When the lever is in the "RUN" position, the engine operates at full speed, controlled by a speed governor.

1-127. EXHAUST DUCT VALVE CONTROL LEVER. An "OPEN--CLOSED" exhaust duct valve control lever (5, figure 1-28) is located on the exhaust duct. When the lever is in the "OPEN" position, an exhaust duct valve is open and the auxiliary power plant exhaust and cooling air is ducted overboard. When the lever is in the "CLOSED" position, the exhaust duct valve is closed and a micro-switch is actuated to ground the magneto, preventing operation of the auxiliary power plant.

1-128. ALTITUDE VALVE CONTROL. Altitude adjustments are made by turning the altitude valve control (4, figure 1-28) on the auxiliary power plant carburetor. The control is an irregularly shaped disk with two projecting tabs to aid in turning it. The valve has positions "0--5--10," representing altitude in thousands of feet. The altitude valve control must be set so that one of the three numbers is exactly opposite the pointer. No intermediate positions may be used.

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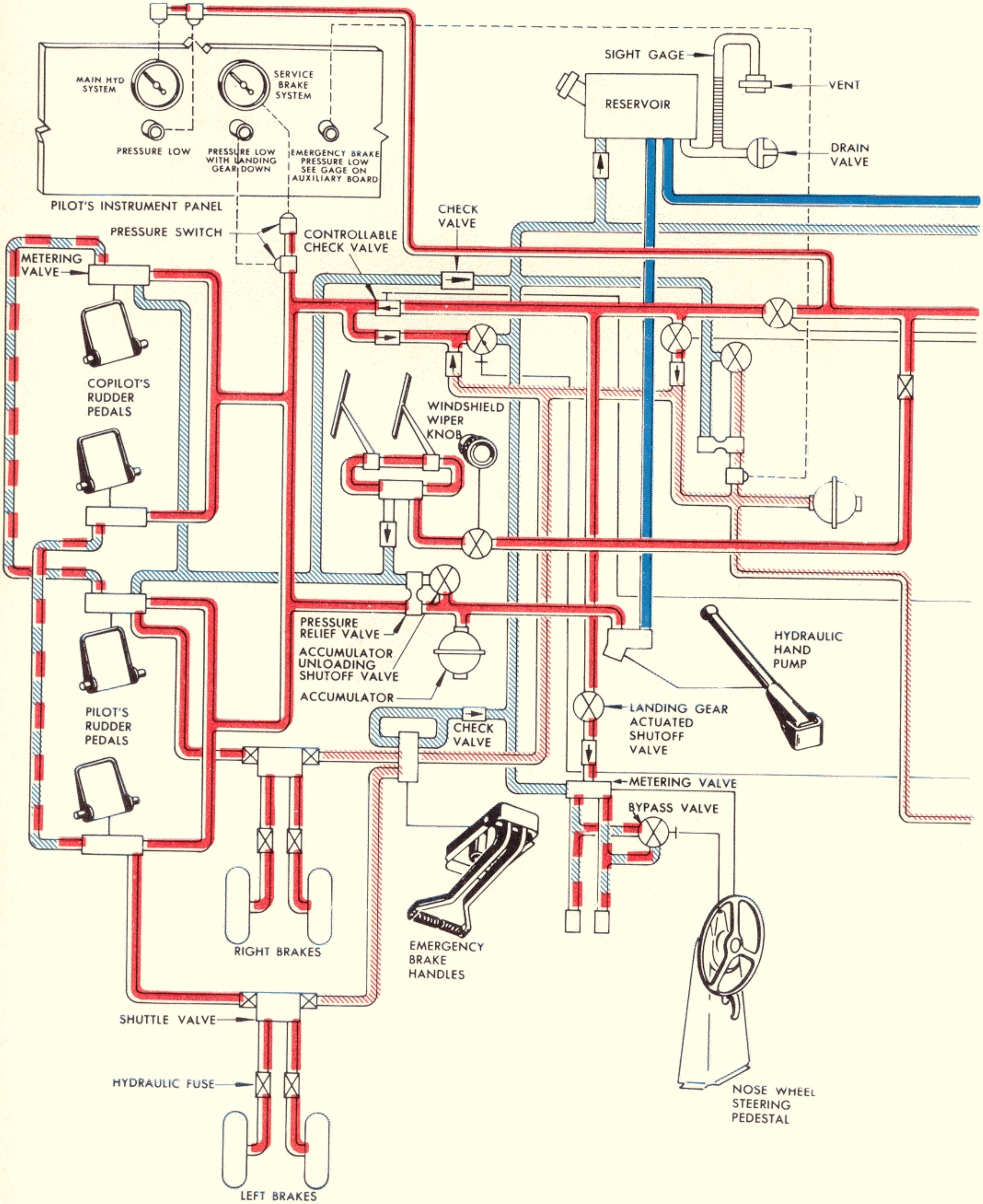

Figure 1-29. Hydraulic System (Sheet 1 of 2)

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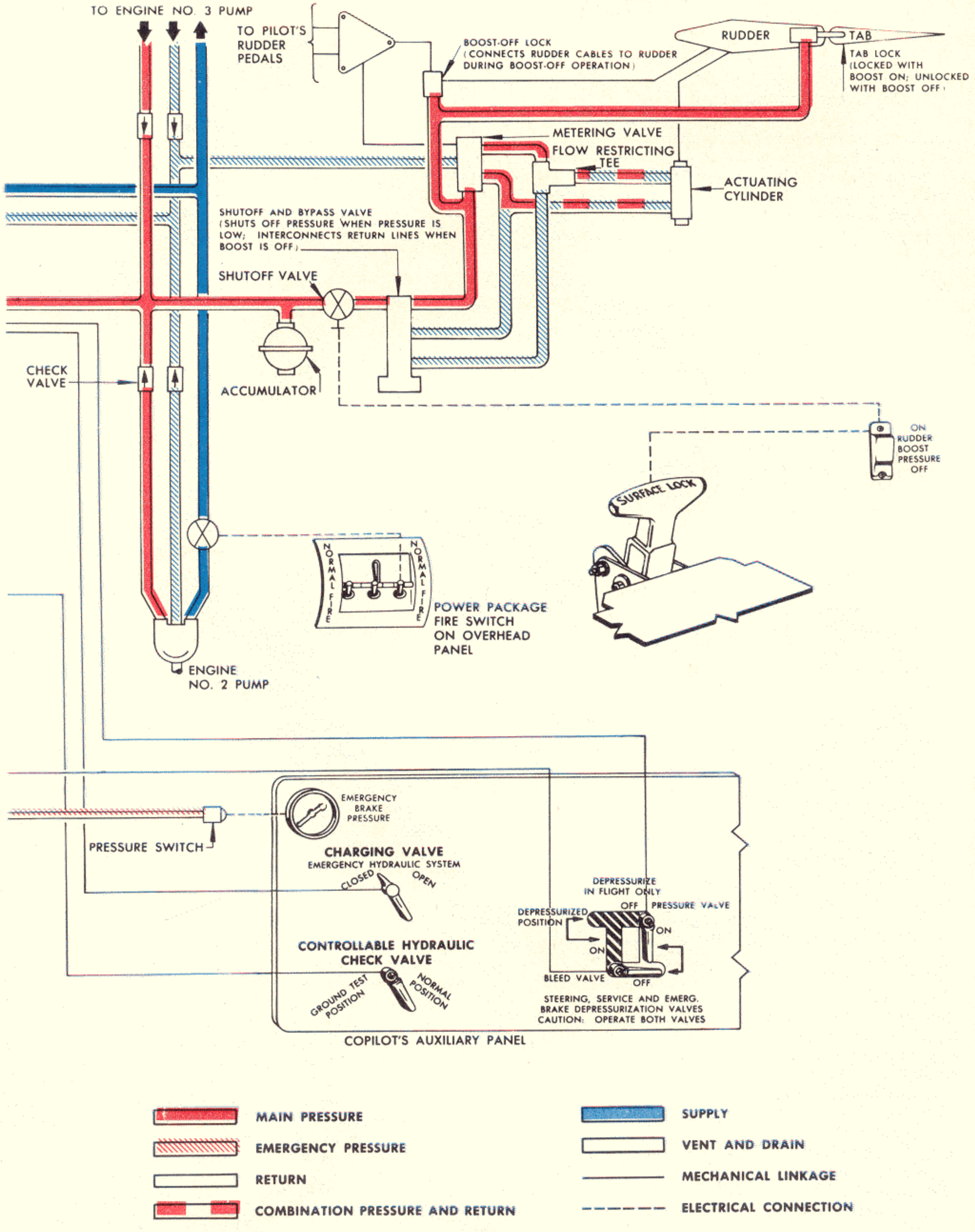

Figure 1-29. Hydraulic System (Sheet 2 of 2)

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1-129. HYDRAULIC SYSTEM.

1-130. GENERAL.

1-131. The main hydraulic system (figure 1-29) supplies pressure to operate the rudder boost, windshield wipers, nose wheel steering, and the service brake systems; main system pressure is also used to charge the emergency brake system. Pressure is supplied by engine-driven pumps on engines number 2 and number 3; the pumps are set to maintain 1500 PSI, and a check valve in each pump pressure line prevents loss of system pressure in the event one pump becomes inoperative. A hand pump and a controllable check valve are provided to ground test the entire hydraulic system. The hand pump can be used for limited operation of the hydraulic system in the event both engine pumps fail. A fluid reservoir in the control cabin has a normal operating supply of 3.5 U.S. gallons including a 0.5 U.S. gallon reserve for the hand pump. Provisions have been made for in-flight depressurization of the nose wheel steering, service brakes, and emergency brake systems. Pressure from the engine-driven pumps is always available for windshield wiper and rudder boost operation. Separate hydraulic systems for the operation of the cargo doors are described in Section IV.

1-132. HYDRAULIC SYSTEM CONTROLS.

1-133. CONTROLLABLE CHECK VALVE HANDLE. This handle (14, figure 1-11) on the copilot's auxiliary panel controls a check valve in the main system pressure lines. When the handle is in the "GROUND TEST POSITION" the check valve is opened and pressure from the hand pump can be applied to the nose wheel steering, windshield wipers, rudder boost, and brake systems. When the handle is in the "NORMAL POSITION" the check valve allows pressure to flow in one direction, the engine-driven pumps provide pressure to the entire system, while the hand pump can pressurize only the brake systems.

1-134. HAND PUMP. A hand pump (13, figure 1-11) below the copilot's auxiliary panel is provided for ground testing or limited operation of the hydraulic system.

1-135. DEPRESSURIZATION HANDLES. Two handles (6, figure 1-11) on the copilot's auxiliary panel control shutoff valves; one valve is in the main pressure line and the other between the pressure lines and reservoir. When the handles are positioned in "NORMAL" the hydraulic system is pressurized and operated conventionally. When the handles are positioned in "DEPRESSURIZED" the shutoff valve in the main pressure line is closed to isolate and maintain pressure in the windshield wiper and rudder boost systems, the shutoff valve leading to the reservoir is opened and the nose wheel steering and both brake systems are depressurized. The handles are interlocked in such a manner as to require that they be operated in sequence.

1-136. CHARGING VALVE HANDLE. A handle used to charge the emergency brake system is described under Brake System paragraph 1-191.

1-137. HYDRAULIC SYSTEM INDICATORS.

1-138. PRESSURE GAGES. Three gages are provided. Two are on the pilot's instrument panel: one indicates main system pressure (25, figure 1-10) and the other indicates service brake system pressure (22, figure 1-10). A gage (1, figure 1-11) on the copilot's auxiliary panel indicates emergency brake system pressure. All hydraulic pressure gages read in PSI.

1-139. WARNING LIGHTS. An amber warning light (24, figure 1-10) adjacent to the main system pressure gage on the pilots' instrument panel illuminates whenever the main system pressure is low. Two other lights are described under Brake System paragraph 1-200.

1-140. FLIGHT CONTROL SYSTEM.

1-141. GENERAL.

1-142. The airplane is controlled in flight from either the pilot's or copilot's station by conventionally operated aileron, wing flap, elevator and rudder surfaces. The surfaces are cable-operated except the wing flaps which are operated electrically and the rudder which has a hydraulic boost system in addition to the cables. The rudder cables move the rudder trim tab which aerodynamically positions the rudder surface. Wing flap and rudder boost circuit breakers are on the overhead circuit breaker panel (1, figure 1-24).

1-143. RUDDER BOOST SYSTEM. The primary purpose of the rudder boost system is to provide effective rudder control at low airspeeds with unsymmetrical power as would occur if an engine failed during take-off or landing. The main hydraulic system (figure 1-29) provides pressure to operate the rudder boost system. With rudder boost turned on, movement of the rudder pedals controls a metering valve connected to the cables. Hydraulic pressure from the metering valve operates an actuating cylinder which moves the rudder surface. The trim tab is automatically disconnected and locked in a centered position; operation of the rudder trim control wheel adjusts the metering valve for rudder trim during boost on. Since hydraulic pressure supplies the total force required to operate the rudder surface, artificial feel is induced in the rudder boost system by means of coil springs. For a given amount of pedal deflection the rudder surface will assume different positions for the conditions of boost on and boost off; therefore, the rudder boost system should not be turned on or off during any maneuver requiring rudder operation.

1-144. WING FLAPS. The electrically operated wing flaps are of the conventional Fowler type. The flaps also operate the left elevator trim tab to automatically trim the airplane when the flaps are raised or lowered. An auxiliary motor (8, figure 1-31) connected to the normal wing flap motor (7, figure 1-31) is used to raise or lower the flaps if the normal motor fails.

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This motor is portable and is also used for emergency operation of the main landing gear.

1-145. FLIGHT CONTROL SYSTEM CONTROLS.

1-146. SURFACE LOCK HANDLE. A red handle marked surface lock (6, figure 1-13) on the forward end of the engine control stand is provided to (1) lock the control surfaces, (2) partially lock the throttles, (3) turn off rudder boost pressure when the surfaces are locked. The handle has "UP-LOCKED" and "DOWN-UNLOCKED" positions. Before the handle can be raised to the "UP-LOCKED" position the ailerons and rudder must be in neutral, the elevators down, and at least two throttles closed for engines on opposite sides of the fuselage (engines 1 and 4 or 2 and 3 etc.). When the surface lock handle is moved to the "UP-LOCKED" position the surfaces are locked and movement of the throttles is restricted to prevent a take-off with surfaces locked; all four throttles can be advanced to 1600 RPM but only two throttles, one on either side of the fuselage, can be advanced beyond 1600 RPM. When the surface lock handle is in the "DOWN-UNLOCKED" position the surfaces are unlocked, throttle movement is unrestricted, and rudder boost can be turned on.

1-147. CONTROL COLUMN AND WHEEL. The dual control columns and wheels for elevator and aileron control are conventional. Each control column wheel contains an autopilot release switch and microphone switch (5, 6 figure 1-7 and 2, 3 figure 1-8) on the outboard side of the control column wheel.

1-148. RUDDER PEDALS. The rudder pedals are conventional in appearance and operation and are hinged for toe operation of the hydraulic brakes. A latch on the outside edge of each rudder pedal permits fore-and-aft adjustment of the pedal.

1-149. RUDDER BOOST PRESSURE SWITCH. The rudder boost pressure switch (2, figure 1-13) on the forward end of the engine control stand has "ON-OFF" positions and is guarded to "ON." This switch opens or closes a shutoff valve in the main hydraulic system pressure line leading to rudder boost actuating units. The rudder boost switch is wired in series with a switch operated by the surface lock handle. The rudder boost system is turned on by positioning the rudder boost switch to "ON" and the surface lock handle to "DOWN-UNLOCKED" position. Placing the switch in "OFF" closes the shutoff valve and automatically depressurizes the rudder boost system; the rudder is then cable-operated.

1-150. TRIM CONTROL WHEELS AND INDICATORS. Conventional trim control wheels and indicators (3, 9, figure 1-13) are on the engine control stand.

1-151. WING FLAP SWITCH. The wing flaps are normally controlled by a switch (17, figure 1-13) on the engine control stand. The switch has "DOWN--OFF--UP" positions. When the switch is in the "UP" position the wing flaps retract in approximately 25 seconds; when in "DOWN" the flaps extend in approximately 25 seconds. The flaps are held in any intermediate position by placing the switch in "OFF."

1-152. EMERGENCY WING FLAP SWITCH. A guarded "DOWN--OFF--UP" switch (14, figure 1-12) on the overhead panel controls the wing flap auxiliary motor. The switch is spring-loaded and guarded to "OFF." Holding the switch in "UP" or "DOWN" raises or lowers the flaps in approximately 25 seconds. Care must be used when the emergency wing flap switch is operated as there are no limit switches on the auxiliary motor. The flaps are held in any intermediate position by placing the switch in "OFF."

1-153. FLIGHT CONTROL SYSTEM INDICATORS.

1-154. WING FLAP POSITION INDICATOR. A wing flap position indicator (26, figure 1-10) on the pilot's instrument panel, registers flap position in degrees.

1-155. AUTOMATIC PILOT.

1-156. GENERAL.

1-157. The airplane is equipped with a type F-1 electrically operated automatic pilot. The automatic pilot, when engaged, provides a system of automatic control which holds the airplane on any selected magnetic heading without overswing when momentary displacements occur, and simultaneously keeps the plane stabilized in pitch and bank. While under automatic pilot control, the airplane can be made to climb, dive, and execute perfectly banked turns. A circuit breaker is provided on the overhead circuit breaker panel (1, figure 1-24) and fuses are provided on the AC power panel (5, figure 1-25).

1-158. A master direction indicator (12, figure 1-10), located on the right side of the pilots' instrument panel, moves in response to impulses set up by a gyro flux gate compass transmitter, and automatically transmits signals to the rudder servo to keep the plane on the desired heading. When the automatic pilot is energized, but not engaged, the master direction indicator serves as a conventional directional gyro indicator.

1-159. A rate gyro control unit (16, figure 1-10), located on the right side of the pilots' instrument panel, automatically transmits a rate of turn signal to the rudder servo to maintain directional control. When the automatic pilot is energized, but not engaged, the rate gyro control unit serves as a conventional turn and bank indicator.

1-160. A vertical gyro control unit (13, figure 1-10), located on the right side of the pilots' instrument panel, automatically transmits signals to the aileron and rudder servos, returning the plane to the proper attitude in pitch or roll whenever displacement occurs with reference to the vertical seeking gyro. A caging knob located on the lower right corner of the unit is used to erect the gyros in the vertical gyro control unit and the remote gyro flux gate compass to their vertical axes. When the automatic pilot is energized,

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but not engaged, the vertical gyro control unit serves as a conventional gyro horizon indicator.

1-161. AUTOMATIC PILOT CONTROLS.

1-162. AUTOPILOT MASTER SWITCH. An "ON--OFF" switch (37, figure 1-13) is located on the engine control stand. When the switch is in the "ON" position, power is supplied to the automatic pilot. When the switch is in the "OFF" position, the automatic pilot is de-energized.

1-163. AUTOPILOT CLUTCH SWITCH. A push-button switch (38, figure 1-13), located on the engine control stand, is used to engage the automatic pilot. When the switch is pushed in, four electrically operated clutches, one to each of the servos and one to the master direction indicator, are engaged. This connects the automatic pilot to the airplane control surfaces.

1-164. AUTOPILOT RELEASE SWITCH. A push-button type switch (6, figure 1-7 and 2, figure 1-8), located on each pilot's control wheel, is used to disengage the automatic pilot. When this switch is depressed, the autopilot clutch switch pops out, releasing the clutches and fully disengaging all automatic control.

1-165. AUTOPILOT EMERGENCY DISCONNECT HANDLE. An autopilot emergency disconnect handle (1, figure 1-13), located on the engine control stand, is used to manually disengage the servos from the control system of the airplane in event of electrical failure or other emergencies. When the handle is pulled, the servo pulleys are released and will turn freely when control surfaces are operated manually.

1-166. AUTOPILOT TURN AND PITCH CONTROLLER. An autopilot turn and pitch controller (39, figure 1-13) is provided on the engine control stand for maneuvering the airplane when the automatic pilot is engaged.

1-167. A knurled pitch control wheel is located on the right side of the controller and "UP--DOWN" markings are provided above the wheel. When this wheel is rotated towards "UP," the airplane will climb. When the wheel is rotated towards "DOWN" the airplane will dive. A climb or dive of up to 40 degrees can be made.

1-168. A knurled bank trim control wheel, marked "LEFT--RIGHT" is located on the left forward quarter of the controller. When this wheel is rotated in the "RIGHT" direction, the airplane will bank to the right. When the wheel is rotated in the "LEFT" direction, the airplane will bank to the left. The bank trim control wheel is used for making minor corrections in headings. Banks up to 10 degrees can be made.

1-169. A turn control knob, located on the top of the controller, is provided with a central detent position. When the knob is rotated to the right from this central detent position, the airplane will make a right turn. When the knob is rotated to the left from the detent position, the airplane will make a left turn. As long as the knob is out of the detent position, the airplane will continue to make a coordinated turn. When the knob is returned to the detent position, the airplane will resume level flight.

1-170. AUTOMATIC PILOT INDICATORS.

1-171. REPEATER DIRECTION INDICATORS. A repeater direction indicator (10, figure 4-14) is located on the navigator's instrument panel and a similar indicator (4, figure 1-10) is located on the left side of the pilots' instrument panel. These indicators are slaved to the master direction indicator.

1-172. LANDING GEAR SYSTEM.

1-173. GENERAL.

1-174. The fully retractable tricycle landing gear is electrically operated and consists of two main dual-wheel landing gears and a steerable dual-wheel nose gear. The landing gear is exceptionally friction free in operation and extends in approximately 4 seconds and retracts in approximately 10 seconds. The main and nose landing gears are mechanically locked in the up and down positions. Only motor or manual operation will unlock and retract or extend the gear. Three external safety locks, one for each landing gear (figure 1-30) are provided to prevent accidental collapse of the landing gear while on the ground. Red warning streamers are attached to the locks for easy recognition.

1-175. Manual operation is provided for each main and nose gear and portable auxiliary motor operation is provided for the main landing gear. In an emergency these controls can be quickly and easily reached.

1-176. Oleo actuated safety switches are provided on both main gear oleos and the nose gear oleo to prevent accidental retraction of the landing gear when the airplane is on the ground.

1-177. LANDING GEAR SYSTEM CONTROLS.

1-178. LANDING GEAR SWITCH. A "DOWN--OFF--UP" switch (8, figure 1-13) on the engine control stand controls normal landing gear extension or retraction. When the switch is in the "UP" position, the landing gear will retract provided all wheels are off the ground; when in the "DOWN" position, the landing gear will extend; and when in the "OFF" position, the landing gear actuation circuits are de-energized. The circuit breaker for normal landing gear control is on the overhead circuit breaker panel (1, figure 1-24). Each main landing gear motor receives power through a current limiter in the main power panel (6, figure 1-24). The nose gear motor receives power through a circuit breaker on the forward power panel (5, figure 1-24).

1-179. LANDING GEAR EMERGENCY RETRACTION SWITCH. The landing gear emergency retraction

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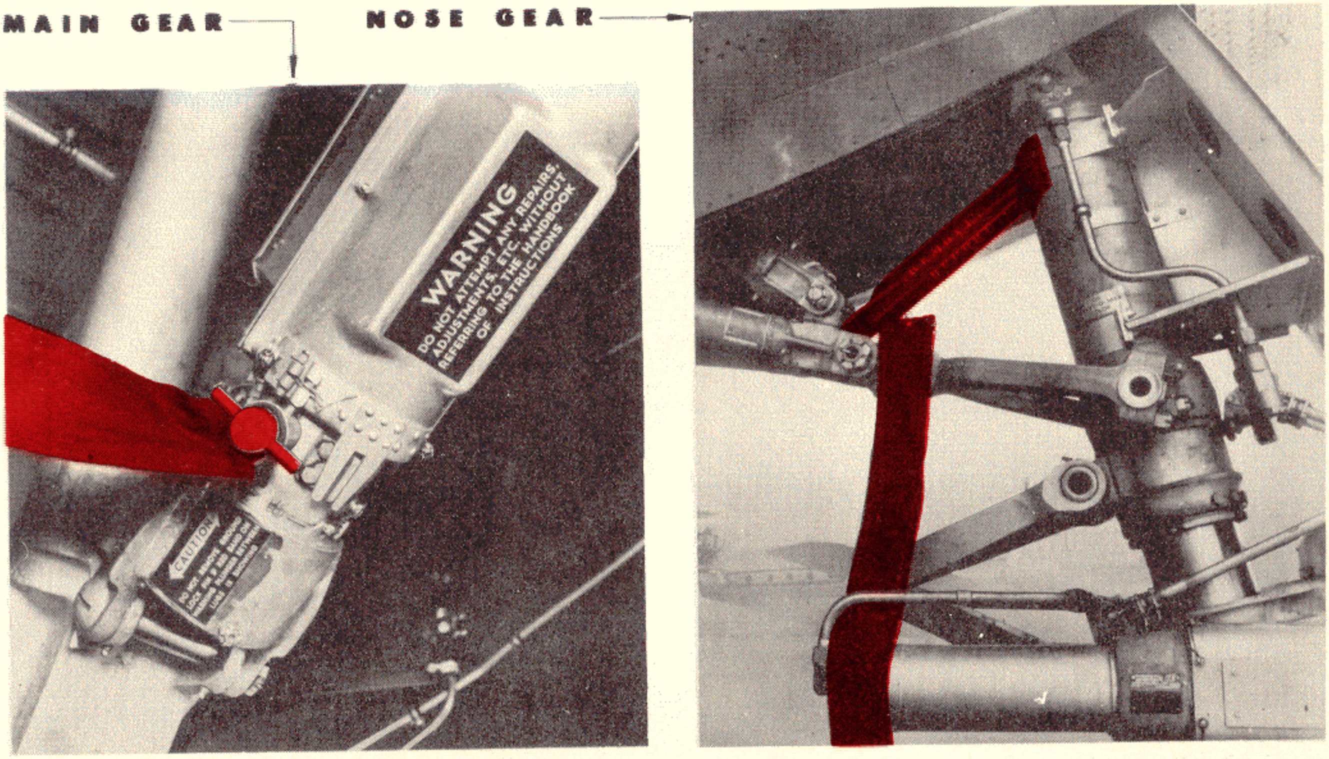

Figure 1-30. Landing Gear Ground Locks

switch (18, figure 1-12) on the overhead panel allows the landing gear to be retracted when the airplane is on the ground. The switch is spring loaded and guarded to the "NORMAL" position. Holding the switch in the "SAFETY OVERRIDE" position will override the oleo safety switch circuit. The normal landing gear switch must be in the "UP" position before the landing gear emergency retraction switch will energize the system. The landing gear emergency retraction is provided only for emergency retraction of the landing gear during takeoff or landing.

1-180. LANDING GEAR HAND CRANKS. In an emergency, the landing gear can be operated manually by hand cranks. The nose gear crank is on the underside of the lower nose compartment hatch. When the access door is raised (3, figure 1-31), the clutch lever is visible on the left and the crank receptacle on the right. The main gear cranks are adjacent to the emergency operation adapters on each side of the airplane, aft of the rear spar. There are pull handles (5, figure 1-31) near the emergency operation adapters which release the normal motor clutches, and engage the manual system.

1-181. AUXILIARY FLAP MOTOR. The auxiliary flap motor (8, figure 1-31), mounted above the normal wing flap motor, can be removed and used for emergency operation of the main gear; however the hand crank is simpler and quicker for emergency extension of the gear. To use the motor for landing gear operation, it must be removed from the mounting bracket by the wing nuts and mounted on the landing gear adapter. The motor is controlled by a switch at the top of the motor. The switch has three positions, and is moved in the indicated direction for the required operation. The circuit breaker for the auxiliary flap motor is on the main circuit breaker panel (9, figure 1-24).

1-182. LANDING GEAR SYSTEM INDICATORS.

1-183. LANDING GEAR POSITION INDICATORS. Three tab-window type indicators (28, figure 1-10) on the pilot's instrument panel show, by interchangeable tabs, the positions of the main and nose gears. When any gear is up and locked, an "UP" tab will appear in the window; a landing gear in an intermediate position will be indicated by a tab with slanting alternate red and white stripes; and a down and locked gear will be indicated by a tab showing a symbol of a wheel.

1-184. LANDING GEAR WARNING LIGHT. A red warning light (30, figure 1-10) on the pilot's instrument panel is on unless all three landing gears are extended and locked or unless all three gears are retracted and locked with all throttles more than 1/5 open.

1-185. LANDING GEAR WARNING HORN. The warning horn, on the ceiling above the copilot, will sound if any landing gear is not extended and locked, and any throttle is retarded to less than 1/5 open. A "NORMAL--HORN RELEASE" switch (7, figure 1-13),

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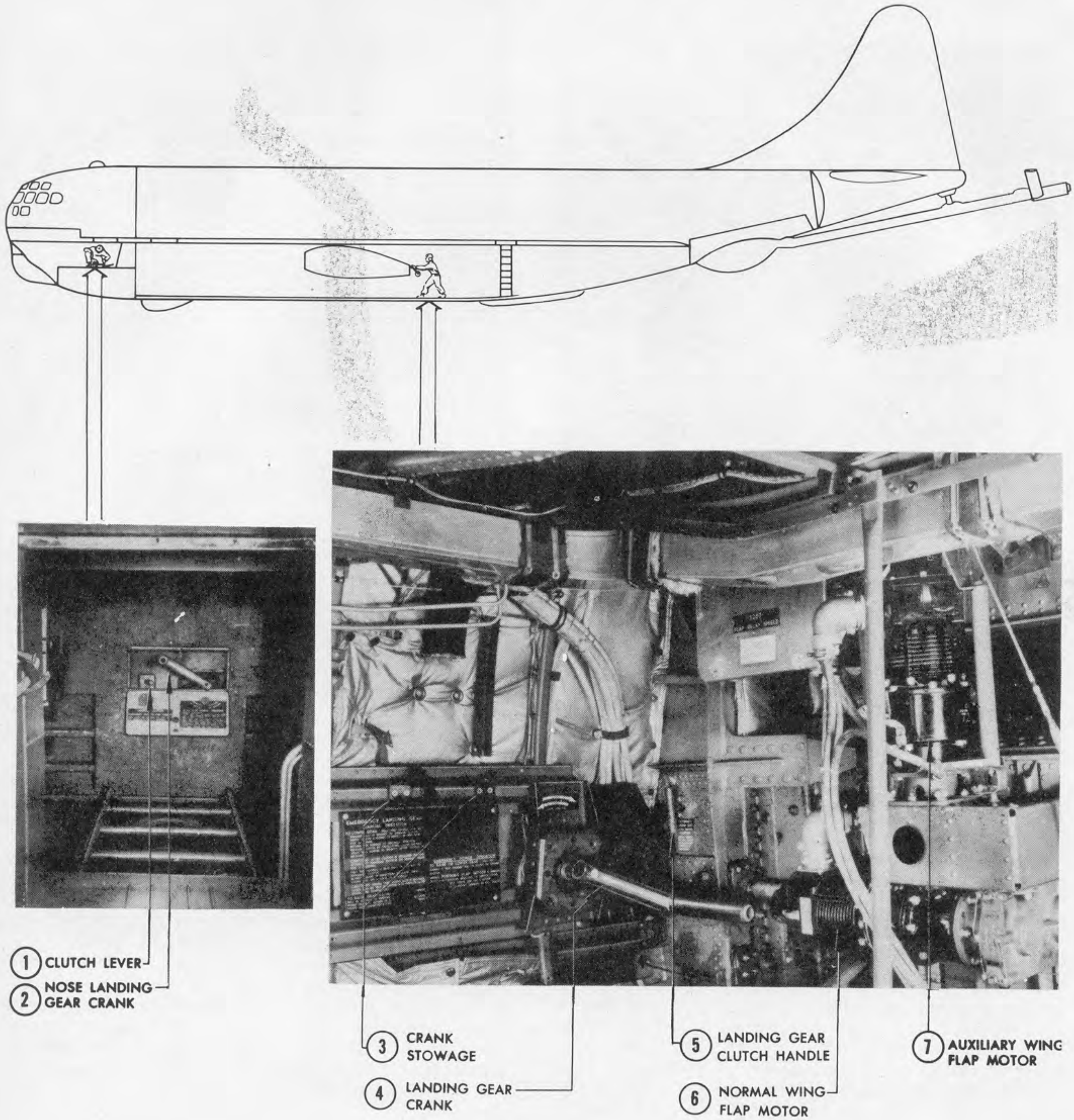

Figure 1-31. Landing Gear Emergency Controls

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spring-loaded to the "NORMAL" position, is provided on the engine control stand. When the switch is actuated to the "HORN RELEASE" position, the warning horn is silenced until again energized by retarding a throttle below 1/5 open.

1-186. NOSE WHEEL STEERING SYSTEM.

1-187. GENERAL.

1-188. The nose wheels are steerable to 68 degrees each side of center through hydraulically operated cylinders while the airplane is on the ground. When the nose wheel leaves the ground, hydraulic pressure is shut off by an oleo-actuated valve, and the nose wheel centers itself. In the event of hydraulic pressure failure, the nose gear has a conventional castor action allowing directional control of the airplane by engine and brake operation.

1-189. NOSE WHEEL STEERING SYSTEM CONTROLS.

1-190. STEERING WHEEL. Nose gear steering is controlled by a steering wheel (4, figure 1-7) mounted on a pedestal forward and to the left of the pilot's control column. An arrow on the wheel and a mark on the pedestal indicate when the nose wheel is centered. The nose wheel turns in the direction selected by the steering wheel and remains in that position until the steering wheel is returned to center. A cable follow-up system will return the nose wheel to its original course should the wheel be deflected momentarily by some obstacle.

1-191. NOSE WHEEL STEERING EMERGENCY DISCONNECT BUTTON. The push-pull button, on the steering pedestal (7, figure 1-7), when depressed, by-passes the steering cylinders, allowing the nose wheel to castor. This button is used to release the nose wheel in event of steering system malfunction. An indicator light, within the push-pull button, illuminates when the button is depressed. The button must be raised manually to re-engage the steering mechanism.

1-192. BRAKE SYSTEM.

1-193. GENERAL.

1-194. SERVICE BRAKE SYSTEM. Main hydraulic system pressure is used to operate the service brakes. Toe pressure on the pilot's or copilot's rudder pedals will actuate the brakes in the conventional manner.

1-195. EMERGENCY BRAKE SYSTEM. The emergency brake system is charged from the main hydraulic system through operation of a charging valve. Fluid pressure is stored in an accumulator and metered to the brakes by hand operated emergency brake levers.

1-196. BRAKE SYSTEM CONTROLS.

1-197. PARKING BRAKE HANDLE. A parking brake handle (3, figure 1-7) is on the nose wheel steering pedestal. Parking brakes are set by depressing the pilot's rudder pedals and pulling the spring-loaded parking brake handle upward. The parking brakes are automatically released when the pilot's rudder pedals are again depressed.

1-198. CHARGING VALVE HANDLE. A charging valve handle (15, figure 1-11) on the copilot's auxiliary panel provides a means of charging the emergency brake system. The handle has "OPEN--CLOSED" positions. When the handle is placed in "OPEN" a shutoff valve between the main and emergency systems is opened, and the emergency system is charged by main system pressure. Positioning the handle to "CLOSED" isolates the emergency brake system from the main hydraulic system.

1-199. EMERGENCY BRAKE LEVERS. Two hand-operated emergency brake levers (9, figure 1-6) meter emergency system pressure to the brakes. The levers are on the ceiling above the pilot's station.

1-200. BRAKE SYSTEM INDICATORS.

1-201. BRAKE SYSTEM PRESSURE GAGES. A pressure gage for the service brake system (22, figure 1-10) is on the pilot's instrument panel, and a gage for emergency brake system pressure (1, figure 1-11) is on the copilot's auxiliary panel. The gages are marked in PSI.

1-202. WARNING LIGHTS. Two amber warning lights (21 and 19, figure 1-10) on the pilot's instrument panel are provided for the service brake and emergency brake systems. A light will illuminate when the respective brake system pressure is low. Both lights are wired in series with a landing gear switch and will operate only when the gear is down.

1-203. FIRE EXTINGUISHING SYSTEM.

1-204. GENERAL.

1-205. FIRE DETECTION AND WARNING. Thermally actuated fire detector units are located throughout each power package and in each heater area. Illumination of warning lights in the control cabin informs the pilots and engineer of any fire condition detected. Circuit breakers for these circuits are on the overhead circuit breaker panel (1, figure 1-24).

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1-206. SYSTEM FIRE SHUTOFF. Provisions are made for emergency propeller feathering and emergency shutoff of engine and combustion heater systems when a fire condition is encountered. Power for these circuits is supplied through the circuit breakers in the affected systems.

1-207. CO_2 FIRE EXTINGUISHING. A CO_2 fire extinguishing system (figure 1-33) is provided to supply CO_2 to the nose, power, accessory, and induction sections of each power package, and to the left wing, right wing, and empennage heater areas. The CO_2 is stored in two sets of four steel bottles, one set located in each main landing gear wheel well. Two bottles in each set are fitted with solenoid-actuated release valves and CO_2 pressure through valve interconnecting tubing actuates the release valves of the remaining two bottles. The solenoid-actuated release valves are also interconnected so that if one solenoid fails to operate, CO_2 pressure from the other solenoid-actuated bottle will actuate the release valve. Each power package and combustion heater section is separated from the rest of the CO_2 system by an electrically controlled direction valve. A circuit breaker for the system is provided on the overhead circuit breaker panel (1, figure 1-24).

1-208. FIRE EXTINGUISHING SYSTEM CONTROLS.

1-209. FIRE DETECTOR SYSTEM TEST SWITCHES. Three push-button type test switches, (9, figure 1-12), are provided on the overhead panel. They are an induction system and heaters switch, a circuit 1 switch, and a circuit 2 switch. When the induction system and heaters switch is depressed, illumination of all eight individual warning lights and the two master warning lights within fifteen seconds indicates proper circuit continuity. When the circuit 1 or circuit 2 switch is depressed, illumination of the four nacelle warning lights and the two master warning lights within fifteen seconds indicates proper circuit continuity. Circuits 1 and 2 each represent a complete separate engine detection circuit, less the induction section. When the three switches are released, the test circuits are de-energized.

1-210. POWER PACKAGE FIRE SWITCHES. A set of five "NORMAL--FIRE" switches (12, figure 1-12) for each power package is provided on the overhead panel. These switches control CO_2 direction valve actuation and emergency shutoff of critical systems in the event of a fire in the power package area. A hinged plate permits simultaneous actuation of all five switches to the "FIRE" position.

1-211. A select direction valve switch is included in each set of power package fire switches. When the switch is in the "FIRE" position, the CO_2 direction valve for the selected power package is opened and power is supplied to the fire extinguisher switch. When the select direction switch is in the "NORMAL" position, power is supplied to close the CO_2 direction valve.

1-212. A carburetor air shelter switch is included in each set of power package fire switches. When the switch is in the "FIRE" position, the carburetor air switch for the selected power package is by-passed and power is supplied directly to open the sheltered air door, thus closing off the ram air supply to the induction system. When the switch is in the "NORMAL" position, power is supplied to the carburetor air switch for normal control of the sheltered air door.

1-213. A close fuel valve switch is included in each set of power package fire switches. When the switch is in the "FIRE" position, the fuel selector switch for the selected power package fuel tank is by-passed and the fuel selector valve is actuated to the shutoff position, cutting off all fuel flow from the tank. When the switch is in the "NORMAL" position, the fuel selector valve is controlled by the fuel selector switch in the normal manner.

1-214. A close oil, fuel, hydraulic oil, and cabin air bleeder switch, included in each set of power package fire switches, controls the fuel selector valve in the same manner as does the close fuel valve switch. In addition, when the switch is in the "FIRE" position, power is supplied to close an oil shutoff valve between the engine oil tank and the engine and close the turbo bleeder switch. For engines Nos. 1 and 4, when the switch is in the "FIRE" position, power is also supplied to close a hydraulic shutoff valve in the IFR hydraulic pump supply line when the IFR equipment is installed. For engines Nos. 2 and 3 power is supplied to close a hydraulic shutoff valve in the airplane's hydraulic pump supply line. When the switch is in the "NORMAL" position, power is supplied to open the oil shutoff valve, the hydraulic shutoff valve, to operate the fuel selector valve in the normal manner and to the turbo bleeder switch for normal control of the turbo bleeder shutoff valve.

1-215. A feather propeller switch spring-loaded to the "NORMAL" position, is included in each set of power package fire switches. When the switch is in the "FIRE" position, power is supplied to feather the propeller for the selected power package. When the switch is in the "NORMAL" position, the feathering circuit is de-energized.

1-216. COMBUSTION HEATER FIRE SWITCHES. Four sets of combustion heater fire switches (10, figure 1-12) are located on the overhead panel. These switches are for fire condition shutoff of the body combustion heaters, the right wing combustion heaters, the left wing combustion heaters, and the empennage combustion heaters. When in the "FIRE" position the single body combustion heater fire switch de-energizes the automatic cabin heating control system, shuts off the body heater ignition, closes the cabin air fire valves, and de-energizes and closes the combustion heater and auxiliary power plant fuel valves. When this switch is in the "NORMAL" position, normal control of the cabin heating system is allowed and the fuel valves supplying fuel from the engine fuel system to the combustion heaters and the auxiliary power plant, are again in operation.

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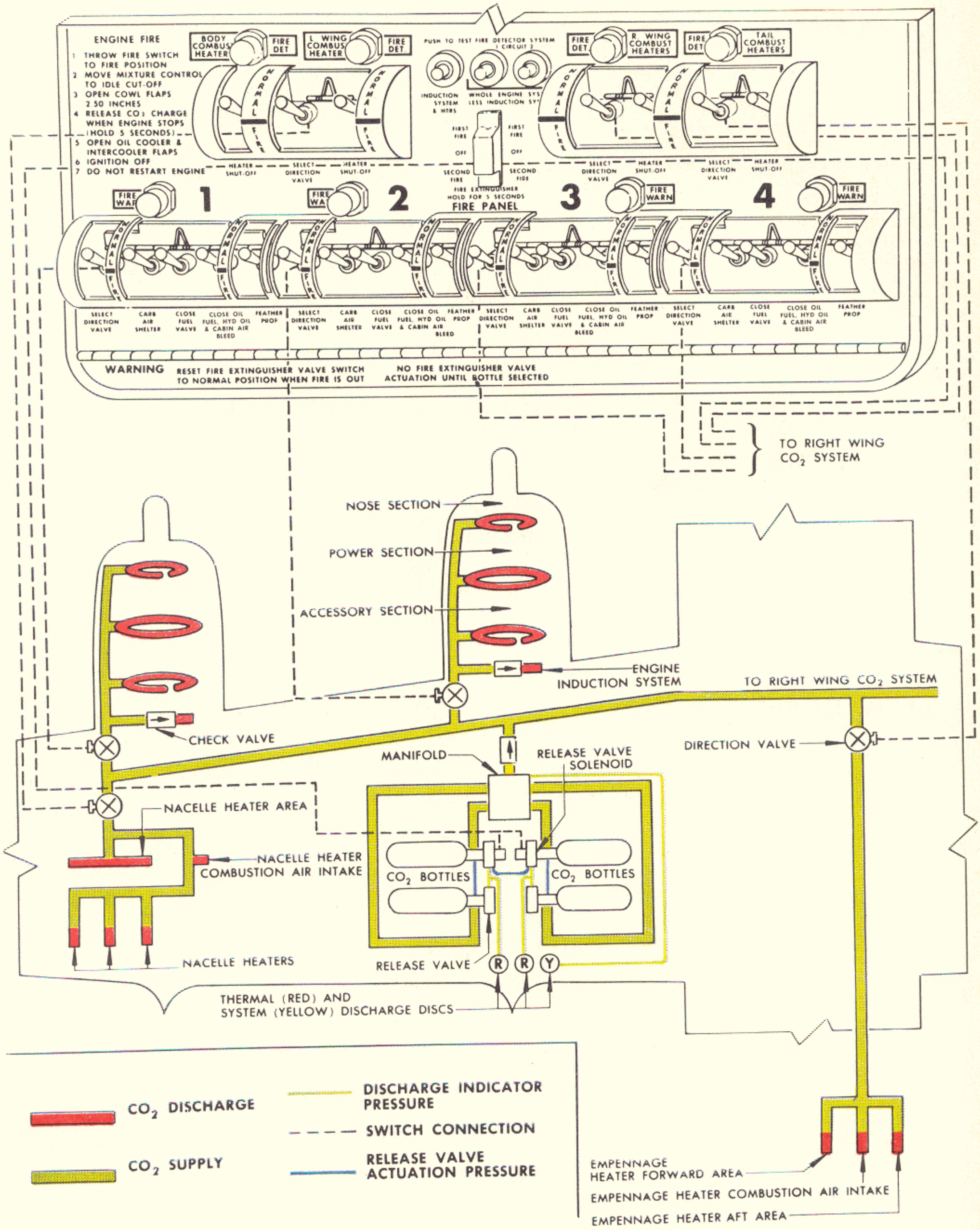

Figure 1-32. CO_2 Fire Extinguishing System

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1-217. The left wing, right wing, and empennage combustion heater groups are each provided with a set of two "NORMAL - FIRE" switches. One of these switches provides fire condition shutoff of the combustion heaters in the system and the other switch controls CO_2 direction valve actuation.

1-218. A select direction valve switch (27, figure 1-12) is included in each pair of wing and empennage combustion heater fire switches and controls CO_2 valve actuation. When this switch is in the "FIRE" position, the CO_2 direction valve for that group of heaters is opened and power is supplied to the fire extinguisher switch. When the switch is in the "NORMAL" position, power is supplied to close the CO_2 direction valve.

1-219. A heater shutoff switch (26, figure 1-12) is included in each pair of wing and empennage combustion heater fire switches. When this switch is in the "FIRE" position, ignition and fuel for the combustion heaters in that system are shut off and the limited anti-icing and fire valves of that anti-icing system are closed. When the switch is in the "NORMAL" position, normal control of these combustion heaters and their emergency air valves are allowed.

1-220. FIRE EXTINGUISHER SWITCH. A "FIRST FIRE - OFF - SECOND FIRE" switch (11, figure 1-12), spring loaded to the "OFF" position, is provided to select and discharge the CO_2 fire extinguisher bottles. When the select direction valve for the fire area has been opened by actuation of the appropriate select direction valve switch, holding the fire extinguisher switch in the "FIRST FIRE" position for 5 seconds will supply power to discharge CO_2 from the four bottles in the left wheel well. When the switch is held in the "SECOND FIRE" position for five seconds, the four CO_2 bottles in the right wheel well will be discharged into the system. When the switch is in the "OFF" position, the CO_2 discharge circuit is de-energized.

1-221. FIRE EXTINGUISHING SYSTEM INDICATORS.

1-222. FIRE WARNING LIGHTS. Eight red fire warning lights adjacent to the power package fire switches (12, figure 1-12) and the combustion heater fire switches, (10, figure 1-12) illuminate whenever fire conditions are detected in the power packages, the body combustion heater area, the left and right wing combustion heater areas, and the empennage combustion heater area.

1-223. MASTER FIRE WARNING LIGHTS. A red master fire warning light (51, figure 1-15) is located on the engineer's instrument panel, and a similar light is located on the pilot's compass panel (7, figure 1-6) above the pilot's windshield. When a fire condition is detected anywhere in the power package or combustion heater areas these lights will illuminate.

1-224. CO_2 DISCHARGE INDICATORS. A yellow indicator disk, mounted on the lower inboard side of each inboard nacelle, will blow out when the CO_2 bottles in that wheel well are discharged into the system. One of two red indicator discs, grouped with each yellow disc, will blow out when any one of the CO_2 bottles is discharged by thermal expansion.

1-225. INSTRUMENTS.

1-226. The control cabin instruments are grouped in alternating-current, direct-current, pitot-static and direct pressure, and miscellaneous instrument classes.

1-227. ALTERNATING-CURRENT INSTRUMENTS. The alternating-current instruments include the gyrosyn compasses; gyro horizon; dual radio altimeters; dual automatic radio compasses; torquemeters; wing flap, cowl flap, and intercooler flap position indicators; fuel flow, pressure, and quantity indicators; oil pressure gages and cabin air flow indicator.

1-228. DIRECT-CURRENT INSTRUMENTS. The direct-current instruments include the oil, carburetor air, cabin air, outside air temperature, and cylinder head temperature indicators; turn and bank indicators and hydraulic gages.

1-229. PITOT-STATIC AND DIRECT-PRESSURE INSTRUMENTS. The airspeed indicators, altimeters, and rate-of-climb indicators are connected to pitot-static sources. Cabin altitude and differential pressure indicator, rate-of-climb indicators, and the manifold pressure gages are direct-pressure indicators.

1-230. MISCELLANEOUS INSTRUMENTS. The tachometers are alternator-motor type units. These units operate independently of the airplane electrical system.

1-231. MISCELLANEOUS EQUIPMENT.

1-232. CREW SEATS, SAFETY BELTS, AND SHOULDER HARNESS. The pilot and copilot are provided with seats fully adjustable for height and for fore-and-aft movement. The engineer's, navigator's and radio operator's seats are swivel-type, secured to the floor, and adjustable for height and back angle only. All seats are provided with safety belts, with the pilot's, copilot's, and engineer's seats having, in additon, shoulder harness. The navigator is pro-

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vided with a vertically-adjustable astrodome stool which, when not in use, is stowed in the crew lavatory.

NOTE

Navigator's and radio operator's seats are not designed for crash loads.

1-233. SHOULDER HARNESS INERTIA REEL LOCK HANDLE. A handle with "LOCKED" and "UNLOCKED" positions is located on the left side of the pilots' and engineer's seats. A latch is provided for positively retaining the handle at either position. By pressing down on the top of the handle, the latch is released and the handle may be moved freely from one position to the other. When the handle is in the "RELEASED" position, the reel harness cable will extend to allow the crew member to lean forward. However, the reel harness cable will automatically lock when an impact force of 2 to 3 "g's" is encountered. When the reel is locked in this manner, it will remain locked until the handle is moved to the "LOCKED" position and then returned to the "RELEASED" position. When the handle is in the "LOCKED" position, the reel harness cable is manually locked so that the crew member is prevented from bending forward. The "LOCKED" position is used only when a crash landing is anticipated. This position provides an added safety precaution over and above that of the automatic safety lock.

1-234. BLACK-OUT AND SUN CURTAINS. To permit blacking-out of the airplane and for protection from sunlight, snap-fastened, roll-down curtains are fitted to all cargo compartment windows and to the upper row of control cabin windows. Sliding curtains are fitted to the navigator's window and to the astrodome. The pilot, copilot, and engineer can be isolated from the lighted radio and navigation stations during night flight by drawing sliding curtains across the control cabin. Instrument flying shields are stowed in a rack in the crew lavatory, or in the lower nose compartment, when not in use.

1-235. DATA CASES AND CHECK LIST CONTAINERS. The pilot's auxiliary panel is fitted with a plywood flight report case, and both pilot's and copilot's auxiliary panels are fitted with plastic check list containers. An airplane data case is mounted on the forward wall of the crew lavatory; all other items of equipment, such as load adjusters, are carried in the navigator's cabinet.

1-236. RELIEF EQUIPMENT. A crew lavatory compartment is located immediately forward of the control cabin bulkhead on the right side of the airplane. This compartment contains a urinal, toilet, wash basin, and water tank. Provision is made for the installation of an additional curtained chemical toilet and urinal on the left side of the main cargo compartment just forward of the rear cargo doors. When not in use, this equipment is stowed in the aft stowage compartment.

1-237. FOOD AND WATER FACILITIES. Ordinarily, hot food is provided only for crew members. It is prepared before flight and put in portable type B-2 food containers, which can be plugged into any suit heater receptacle. Two 4 1/2-gallon water tanks are mounted on the forward wall of the crew lavatory. Each tank is equipped with a spigot, one of which is connected to a rubber hose leading to the wash basin, while the other is used to fill paper drinking cups which are in a dispenser mounted on the wall to the left of the tanks.

1-238. LADDERS. A ladder is permanently installed at the forward end of the forward cargo hatch for the use of personnel passing between the lower forward cargo and the main cargo compartments. A removable ladder is installed between the floor of the lower aft cargo compartment and the main cargo compartment at the right side of the aft cargo hatch. A permanent ladder is installed in the lower nose compartment to provide access to that compartment through the hatch in the control cabin floor. All hatches can be opened and closed with the ladders in place.

1-239. ASH TRAYS. Ash trays for the crew members are conveniently located.

1-240. SIGNAL LAMP. An interaircraft signal lamp is mounted on the forward end of the navigator's stowage cabinet. It may be plugged into any one of the crew's electrical suit outlet boxes (24-volt outlet only).

1-241. DOOR WARNING LIGHT. A red light (18, figure 1-10) on the pilots' instrument panel warns when all the entry and cargo doors are not closed and latched.

1-242. WINDSHIELD WIPERS. The window panels directly in front of the pilot and copilot are each provided with a hydraulically actuated windshield wiper. A windshield wiper control knob, (11, figure 1-9), on the pilot's auxiliary panel is used to direct main hydraulic system pressure to both wipers.

1-243. EMERGENCY EQUIPMENT.

1-244. Fire extinguishers, first-aid kits, axes, and flashlights are located throughout the airplane (figure 3-1).

1-245. LIFE RAFTS AND DINGHY RADIO. The life raft container and dinghy radio are accessible only from inside the airplane and must be removed from the airplane through an emergency hatch above the wing.

1-246. EMERGENCY ALARM BELLS. Four alarm bells are located in the airplane as follows: one on the forward side of the nose wheel steering pedestal, one in the main cargo compartment, and one in each

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of the lower cargo compartments. An "ON--OFF" toggle switch (13, figure 1-12) on the overhead panel controls the bells. Power is supplied to the circuit directly from the battery.

1-247. PYROTECHNIC PISTOL. A single-shot, breech-loading, double-action pyrotechnic pistol and various colored flares are stowed in containers at the forward end of the radio operator's table. The pistol is fired from a mount that is protected against cabin pressure loss by a manually-operated external door. The pistol can be reloaded and fired repeatedly without removing it from the mount.

1-248. LANDING FLARES. Two flare tubes (9, figure 3-1), each containing one three-minute night landing parachute flare, are provided in the tail compartment. The flares are released electrically by actuating two flare release switches (24, figure 1-12) on the overhead panel. A circuit breaker is provided on the forward power panel (5, figure 1-24).

1-249. EMERGENCY HATCHES. Two emergency escape hatches (10, 14, figure 4-4) are provided on each side of the fuselage. The escape hatches are opened inboard by pulling a lever marked "PULL," located on the upper section of each hatch. The pilot and copilot are each provided with an emergency exit window. Each window can be opened by pulling a handle inboard and aft. This results in pulling the window inboard and sliding it aft along a pair of tracks. The astrodome (3, figure 4-4) is removed for emergency exit by first pulling an emergency release "T" handle connected to a rubber moulding around the base of the astrodome. This frees the moulding and permits it to be pulled out of the mounting sash. Then, by screwing another "T" handle mounted below the rubber moulding, into a hole provided at the center of the astrodome, the astrodome can be pulled down. The aft entry door is provided with an emergency release handle for jettisoning the door during flight. The release mechanism overrides the latch and disconnects the winch cable and support arm. The door hinge design is such that as the door falls past the full open position, the hinge will disengage, allowing the door to fall free.

1-250. AUXILIARY EQUIPMENT.

1-251. The following equipment and its operation is described in Section IV, Description and Operation of Auxiliary Equipment:

a. Cabin Heating Pressurizing and Ventilating Systems
b. Anti-icing Systems
c. Communications and Associated Electronic Equipment
d. Lighting Equipment
e. Oxygen System
f. Navigation Equipment
g. Cargo Carrying Equipment
h. In-Flight Refueling System

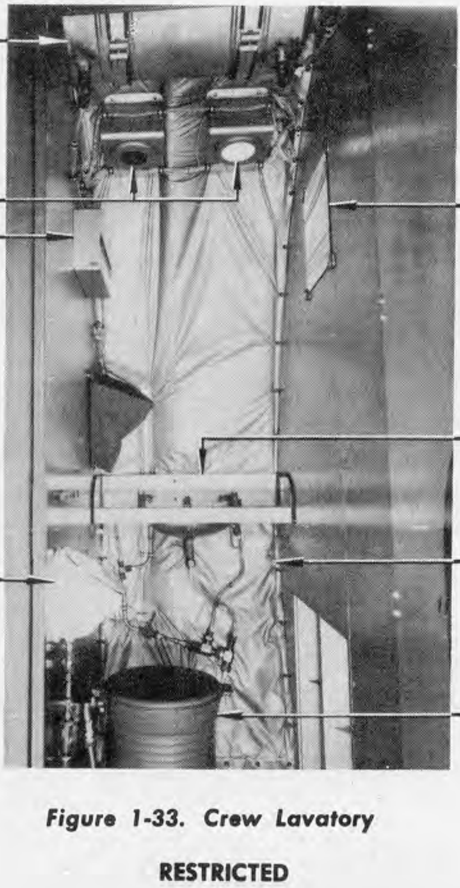

Figure 1-33. Crew Lavatory

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Section II Normal Operating Instructions

2-1. BEFORE ENTERING THE AIRPLANE.

2-2. FLIGHT RESTRICTIONS. See Section VII, for flight restrictions and operating limitations.

2-3. WEIGHT AND BALANCE. Obtain and check the take-off and anticipated landing gross weight and balance before flight. Check that the required fuel and payload has been loaded. See paragraph 7-7, Section VII for weight limitations. Do not attempt take-off or landing with a center of gravity outside of the specified limits. See AN 01-1B-40, Handbook of Weight and Balance, for weight and loading information. A load adjuster is included in each airplane to supplement and aid in weight and balance computing.

CAUTION

When flying without payload, airplane balance must be checked to be certain that the CG is within limits specified in the Weight and Balance Handbook AN 01-1B-40. If necessary, ballast should be added as required. Particular attention must be given if loading ramps are removed from the airplane.

2-4. EXTERIOR INSPECTION. Check the airplane in accordance with figure 2-1.

2-5. ON ENTERING THE AIRPLANE.

2-6. Entrance into the airplane is gained through a door on the left side of the lower forward cargo compartment or through a door on the left side of the lower aft cargo compartment. Ladders adjacent to each entry door provide access to the main cargo compartment through hatches in the floor. The control cabin is entered through the forward bulkhead door in the main cargo compartment. Another means of entrance to the airplane is through the main cargo doors when the ramps are lowered.

2-7. INTERIOR INSPECTION. (ALL FLIGHTS) After entering the airplane, check the following items:

a. Cargo ramps secured.
b. Cargo stowed and properly secured.
c. Troops or passengers seated and secured.
d. First aid kits and emergency rescue gear aboard and properly stowed.
e. Doors closed and locked.
f. Cabin-pressure relief valve closed.
g. Emergency cabin pressure release valve closed.

2-8. INTERIOR CHECK.(ALL FLIGHTS)

PILOTS	ENGINEER
1. Set parking brakes	1. All ignition switches "OFF"
2. Nose wheel centered; nose steering emergency disconnect button up	2. Check Forms 1 and F completed
3. Adjust seat, rudder pedals, safety belt and shoulder harness	3. Oxygen equipment - check operation and 400 PSI pressure
4. Check personal equipment	4. Check personal equipment
5. Check oxygen pressure and mask	5. Check hydraulic fluid quantity
6. Check hydraulic pressures, controllable check valve handle "NORMAL," charging valve handle "CLOSED," and depressurization handles "NORMAL"	6. Engine starting selector switch "OFF"
7. Wing flap switch "OFF"	7. Propeller deicer switch "OFF"
8. Check radio switches off	8. Anti-icing switches "OFF"

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2-8. INTERIOR CHECK (ALL FLIGHTS) (CONTINUED).

PILOTS

9. Landing gear switch "DOWN"; check warning lights
10. Pitot heat switches "OFF"
11. Have engineer turn propeller through

ENGINEER

9. Turn master switch "ON"; if external DC power source is connected leave battery switch "OFF"
10. If external power source is not available, turn battery switch "ON," start auxiliary power plant. (This is considered an emergency procedure)
11. Turn propellers through 8 blades with starters; do not "inch"

CAUTION

Energize starters intermittently in increments not to exceed 90 degrees of blade travel during any energizing period. Maintain contact with ground observer for reports of propeller movement. This procedure must be followed in order to minimize the possibility of damage in event of hydraulic lock. If hydraulic lock is noted, discontinue cranking. Remove drain plugs in lower three intake pipes and low spark plug from cylinder banks 3, 4, and 5. Pull propeller through a minimum of eight blades. When fluid ceases to drain, install drain plugs and spark plugs.

PILOTS

12. Landing light switches "RETRACT" and "OFF"
13. ADI pump switch "OFF"
14. Check emergency cabin pressure release valve handle in place
15. Check surface lock handle "UP-LOCKED"
16. Check rudder boost switch "OFF"
17. Autopilot emergency disconnect handle in place
18. Autopilot master switch "OFF"
19. Autopilot clutch disengaged
20. Check trim tab controls for free movement and zeroed
21. Recognition and navigation light switches "OFF"
22. Check operation of interphone
23. Check emergency alarm

ENGINEER

12. Check spare inverters
13. Check inverter switch "ESS. INV"
14. Alternator switches "OFF"
15. Cabin air selector switches "FLIGHT GROUND AUTO"
16. Turbo bleeder switches "OPEN"
17. Air conditioning master switch as required
18. Set cabin altitude selector and cabin rate-of-change selector as desired
19. Check generator switches "ON," check generator field lights
20. Boost pump switches "OFF"
21. Center tank line valve switch "CLOSED"
22. Check fuel and oil quantity
23. Check propeller oil refill switches "OFF" for normal operation, check warning lights
24. Check fire switches "NORMAL"
25. Check fire detector circuits
26. Check circuit breakers in

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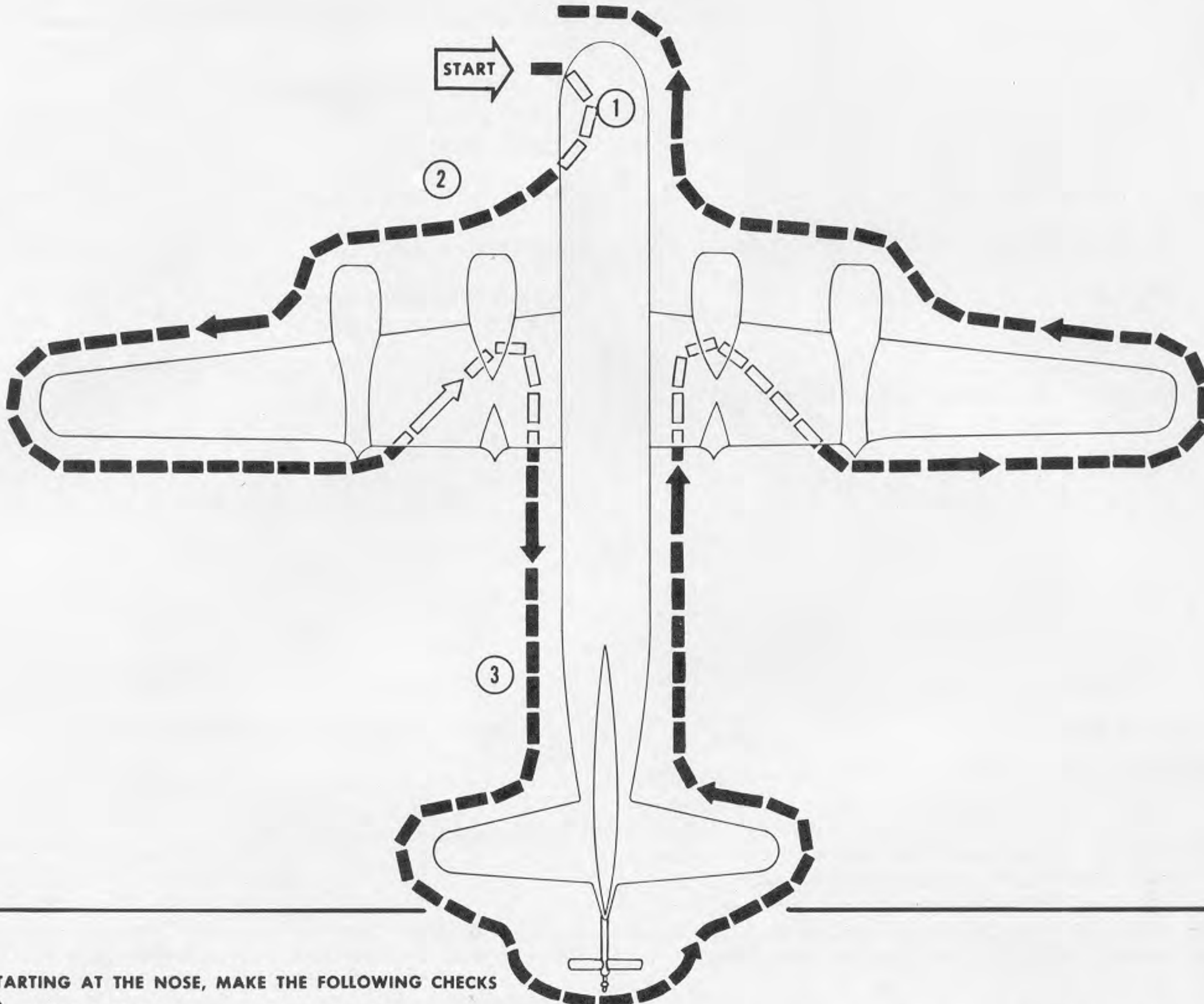

STARTING AT THE NOSE, MAKE THE FOLLOWING CHECKS

(1) NOSE SECTION

a. Radar dome for cracks, dents and general condition
b. Nose wheel well area for hydraulic leaks
c. Nose gear oleo strut for cleanliness and proper inflation (9.2 inches between centers of torsion link pins).
d. Nose wheel tires for cuts, blisters, proper inflation and tire-rim slippage (check red tire-rim lines for alignment).
e. Nose gear ground safety lock in place
f. Pitot covers removed
g. Forward entry door for damage and general condition
h. Driftmeter port for obstructions
i. Antenna

(2) LEFT WING SECTION

a. Condition of propeller blades for dents, nicks, and bent blades
b. Prop domes for oil leaks
c. Cowling and power package for oil leaks
d. Carburetor air ducts for obstructions
e. Walking outboard in front of the wing check the leading edge for general condition, air inlets for obstructions, and the underside of the wing for loose rivets, fuel leaks, and open inspection doors.
f. Walking inboard behind the trailing edge of the wing, check the ailerons for damage and the presence of aileron ground locks, the aileron trim tab for general condition, and the wing flap for any damage and general condition.
g. In the left main gear wheel well check for hydraulic leaks, proper oleo strut inflation (13.25 inches between centers of torsion link pins).
h. Check tires for cuts, blisters, proper inflation, and tire-rim slippage(red lines on tire and rim should align).
i. Left main gear ground safety lock and proper warning
j. Check chocks in place.

(3) EMPENNAGE SECTION

a. Walking aft along the left side of the fuselage check the fuselage skin for general condition.
b. Rear entry door for damage
c. Walking outboard forward of the left hand stabilizer check the leading edge for general condition
d. At the tip of the stabilizer check the thermal anti-icing louvres for obstructions and the tip of the stabilizer for damage
e. Walking inboard aft of the stabilizer, check for the condition of the elevators and elevator trim tabs, rudder alignment, and the presence of rudder and elevator ground locks and their proper warnings.
f. Check boom and nozzle for damage and general condition, leaks and chafing.

NOTE

Proceed along the right side of the airplane and repeat the applicable checks listed for the left side.

Figure 2-1. Exterior Inspection

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2-9. INTERIOR CHECK.(NIGHT FLIGHTS)

PILOTS

1. Check pyrotechnic equipment installed
2. Check spotlights
3. Check instrument fluorescent lights
4. Check landing lights
5. Check taxi lights
6. Check formation, navigation, and recognition lights
7. Check flashlight

ENGINEER

1. Check spotlights
2. Check fluorescent lights
3. Check flashlight
4. Check with boom operator for operation of all IFR lights

2-10. AUXILIARY POWER PLANT OPERATION.

2-11. GENERAL.

2-12. The auxiliary power plant can be operated only at altitudes up to 10,000 feet with the cabin depressurized. The auxiliary power plant may be started electrically or, when electrical power is not available, by a cord wound on the flywheel pulley. For manual starting, the auxiliary power plant must start on the fuel that is in the carburetor bowl. As soon as the engine starts, power from the generator will open the fuel valve.

2-13. PRE-START CHECK.

a. Examine the exterior of the auxiliary power plant for loose parts, oil leaks, fuel leaks, and loose electrical connections.

b. Check the oil level with the bayonet gage under the oil filler cap. The oil level should be up to the "F" mark on the gage.

2-14. ELECTRICAL STARTING PROCEDURE.

a. Turn the airplane master switch, on the overhead panel, "ON."

b. Place the auxiliary power plant generator switch on the engineer's instrument panel to "START."

c. Turn the battery switch "ON" or connect DC external power.

d. Move the exhaust duct valve control lever to "OPEN."

e. Turn the auxiliary power plant ignition switch "ON."

f. Hold the starter switch in the "ON" position and choke as necessary with the speed and choke control lever.

g. Release the starter switch to "OFF" when engine starts.

h. Allow the auxiliary power plant to idle for approximately 5 minutes.

i. Move the speed and choke control lever to "RUN."

j. After 2 or 3 minutes, move the auxiliary power plant generator switch to "RUN."

NOTE

Operation of the speed and choke control lever can best be determined by experience. As a result of the relatively high cranking speed, little or no choking is necessary at temperatures above 50° F (10° C). At lower temperatures it may be necessary to choke fully until the engine starts; then run the engine with the choke partly closed until the engine warms up. Do not place the lever in the "RUN" position until the engine is warm.

2-15. MANUAL STARTING PROCEDURE.

a. Turn the airplane master switch "ON."

b. Turn the auxiliary power plant generator switch on the engineer's instrument panel to "START."

c. Move the exhaust duct valve control lever to "OPEN."

d. Turn the auxiliary power plant ignition switch "ON."

NOTE

Leave the starter switch "OFF" when cranking manually.

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e. Wind starter cord around the pulley and pull from any convenient angle.
f. Choke as necessary with the speed and choke control lever. More choking will be required than when cranking electrically.
g. Allow the auxiliary power plant to idle for approximately 5 minutes.
h. Move the speed and choke control lever to "RUN."
i. After 2 or 3 minutes, move the auxiliary power plant generator switch to "RUN."

2-16. ADJUSTMENT FOR ALTITUDE. At various altitudes it will be necessary to change the carburetor mixture by adjusting the altitude valve control. Set the pointer opposite the figure nearest to the altitude at which the engine is operating.

2-17. STOPPING AUXILIARY POWER PLANT.
a. Turn the auxiliary power plant generator switch "OFF."
b. Move the speed and choke control lever to "IDLE" for approximately 5 minutes to allow cylinder head temperatures to decrease.
c. Turn the auxiliary power plant ignition switch "OFF."
d. After the engine has stopped, move the exhaust duct valve control lever to "CLOSED."

NOTE

The exhaust duct valve must be closed to allow pressurization of the airplane.

2-18. PROPELLER OPERATIONAL CHECK.

2-19. PROPELLER FEATHERING CHECK (ENGINES STOPPED).
a. Before starting engines, with power on airplane, check operation of propeller feathering pump motors.
b. Push feathering buttons, watch for change in static position of blades. Change in position indicates feathering pump operating.
c. At first indication of propeller feathering, pull feathering buttons out to neutral position.

2-20. PROPELLER REVERSAL CHECK.

CAUTION

Avoid continuous ground operation between 1600 to 2000 RPM because of propeller vibration.

a. Idle the engines at 1000 RPM.

CAUTION

Propeller reversal should be held to an absolute minimum of operating time to avoid overheating the engines.

b. Check that the areas of the front and rear of the airplane are clear.
c. Place propeller auto control switch in "NO. 1 MASTER" position.
d. Lift all of the throttles and pull back into reversing range, hesitating a few seconds at the reverse idling position.
e. Open the throttles to about 1400 RPM. Check that propellers have reversed and remain reversed.
f. Idle the engines, lift the pilot's throttles and return to normal range.

2-21. PROPELLER MANUAL CONTROL CHECK.
a. With engines operating at 1500 RPM and the propeller auto control switch in the "OFF" position, operate the propeller governor selector switch for each engine to the "DECREASE RPM" position until all tachometers are stabilized at the minimum RPM settings and the propeller RPM limit lights are again illuminated.
b. Operate the propeller governor selector switches to "INCREASE RPM" position until all engines are back to 1500 RPM and the propeller RPM limit lights are again illuminated. Either operation should take from 10 to 12 seconds.

2-22. PROPELLER FEATHERING CHECK (ENGINES RUNNING).
a. Idle engines at 1500 RPM.
b. Push feathering button in.
c. When RPM has decreased about 300 RPM pull button out to neutral position; engines should return to 1500 RPM.

2-23. PROPELLER AUTOMATIC CONTROL CHECK.
a. With all engines idling at 1500 RPM and the propeller auto control switch on "NO. 1 MASTER," move master propeller synchronizer lever to full "DECREASE RPM" position. Advance the throtties to obtain 25 inches of manifold pressure. Operate the resynchronizer switch.
b. Move the master propeller synchronizer lever towards "INCREASE RPM" to obtain 1500 RPM. Operate the resynchronizer switch.
c. Retard No. 1 throttle quickly. The slave engines should not drop below approximately 1325 R 'M.
d. Return No. 1 throttle to previous setting.
e. Leave the master propeller synchronizer lever in position and move the propeller auto control switch from "NO. 1 MASTER" to "NO. 2 MASTER" position.
f. Repeat steps "b" through "e."
g. Set master propeller synchronizer lever to full "INCREASE RPM," throttling as required to avoid restricted RPM range.

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COWL FLAP OPERATION	
CONDITION	COWL FLAP SETTING
GROUND	Full open. Do not exceed 220° C cylinder head temperature
TAKE-OFF	1.5 inch gap for OAT up to 20° 2.0 inch gap for OAT 20° C to 32° C 2.0 inch gap for OAT above 32° C (outboard engines) 2.5 inch gap for OAT above 32° C (inboard engines) Do not exceed 3.0 inch gap at take-off
FLIGHT	.75 inch minimum gap, gear and wing flaps up 1.0 inch minimum gap, gear and wing flaps down
AUTO RICH	Above 2250 BHP do not exceed 249° C cylinder head temperature Below 2250 BHP do not exceed 232° C cylinder head temperature
AUTO LEAN	Cruise. Do not exceed 232° C cylinder head temperature
To avoid exceeding 249° C cylinder head temperature during take-off reduce cylinder head temperature to a minimum prior to take-off. The initial temperature may be from 170° C to 185° C varying with the outside air temperature and gross weight, the lower limit being desired for hot days and/or heavy weights.	

Figure 2-2. Cowl Flap Operation

2-24. BEFORE STARTING ENGINES.

PILOTS

1. Note manifold pressure for power check
2. Check ignition switches "OFF"
3. Determine if propellers have been pulled through 8 blades

ENGINEER

1. Note manifold pressure for power check
2. Mixture controls "FUEL CUTOFF"
3. Crack throttles 1/2 inch (approximately 1000 RPM position)
4. Turbo-boost lever "O"
5. Hold propeller governor selector switches in "DECREASE RPM," check limit lights, then release to neutral
6. Propeller auto control switch "NO. 1 MASTER"
7. Move master propeller synchronizer lever to full "INCREASE RPM"

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2-24. BEFORE STARTING ENGINES (CONTINUED).

PILOTS

8. Check propeller feathering pump motors; push feathering buttons; at first indication of a change in blade angle, pull feathering buttons out to neutral

14. Receive engineer's report

ENGINEER

8. Cowl flap switches "OPEN"
9. Oil cooler flap switches "AUTO"
10. Carburetor air switches "RAM"
11. Carburetor preheat switches "CLOSE" then "OFF"
12. Intercooler flap switches "CLOSE"
13. Set fuel selector switches to Tank-to-Engine position
14. Report check complete, ready to start engines

2-25. STARTING ENGINES.

PILOTS

1. Engine starting sequence 3, 4, 2, 1
2. Check fireguard for all clear on engine No. 3

ENGINEER

1. Engine starting sequence 3, 4, 2, 1
2. Turn one boost pump switch for the tank of the engine being started to "NORMAL"
3. Set engine starting selector switch to "3"
4. Press start switch; after 8 blades, turn ignition switch to "BOTH"; then press ignition boost and prime switches

NOTE

While turning propeller through if any indication of nydraulic lock is noted discontinue starting procedure.

NOTE

All starts are to be made on prime only. Prime in shots of 2 seconds on and 1 second off until engine fires, and then prime continuously until engine reaches 800 RPM.

CAUTION

Do not prime engine before engaging starter. Avoid every possibility of liquid fuel collecting in the intake pipes or cylinders to prevent hydraulicking.

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2-25. STARTING ENGINES (CONTINUED).

PILOTS	ENGINEER
	5. Adjust RPM with throttle, check oil pressure; if oil pressure does not rise to 50 PSI almost immediately, stop engine and investigate
	6. As soon as the engine reaches 800 RPM, slowly move mixture control to "AUTO RICH"; be ready to return mixture control to "FUEL CUTOFF" at first sign of failure to continue running; continue cranking; if engine does not start within 1 minute from time of engaging, stop cranking and allow starter to cool for at least 2 minutes before repeating starting procedure; (do not attempt to assist start with throttle or mixture control)
7. Check fire guard for all clear for each engine to be started	7. After oil pressure rises, adjust throttle to 1000 RPM for engine warm-up
8. After starting, check hydraulic pressure	8. Repeat starting procedure for the remaining engines
9. Check removal of power cart	9. When all engines are running have external power source disconnected if used and turn battery switch "ON"

NOTE

For engine fire during starting, see Section III.

2-26. WARM-UP.

2-27. The engine idle speed is 650 RPM. Warm up the engines at 1000 RPM to prevent spark plug fouling.

2-28. The ground operation of each engine must be held at an absolute minimum. Engines shall be run only when it is necessary to perform the required checks. An engine should be shut down when possible, if running unnecessarily during a prolonged check of another engine. Ground running at low speeds causes fouling of the spark plugs.

2-29. When it is necessary to run an engine on the ground for an extended time, it shall be run up to a MAP equal to field barometric pressure, with propeller control lever in full "INCREASE RPM," for a period of one minute, every 10 minutes. This procedure will act to clear away the fouling deposits in the incipient stages.

2-30. If an engine has an abnormal magneto drop and backfiring, advance the throttle to a manifold pressure equal to the field barometric pressure. Depress the engine primer switch for at least 30 seconds, then release. Accomplish ignition system check and if the magneto drop is not yet eliminated, repeat this procedure. 022104

2-31. GROUND TESTS.

PILOTS	ENGINEER
1. Flight instruments uncaged and set	1. Check generator switches "ON"; alternator switches "ON"
2. Check radios	2. Check inverter switches "ON"
3. Surface lock handle "DOWN UNLOCKED" and check flight controls for free and correct movement	3. Check the manifold-fuel valves for correct operation by turning the center tank boost pump switch to "NORMAL," center tank line valve switch "OPEN"; then turn fuel selector switches, one at a time, to the "Tank-to-Manifold-and-Engine" position, and as each manifold valve is opened, the respective engine it supplies should indicate an increase in fuel pressure; reset each selector switch to "Tank-to-Engine" position, note small drop in fuel pressure, turn center tank boost pump switch "OFF," center tank line valve switch "CLOSE"
4. Autopilot master switch "ON"	4. Check fire detector system
5. Push autopilot clutch switch in and check control movement from one extreme range to the other, then pull autopilot clutch switch out	
6. Autopilot master switch "OFF"	6. Advance throttles to 1000 RPM
7. Rudder boost switch "ON."	
8. If gusty winds exist relock flight controls	
9. Emergency hydraulic system charging valve handle "OPEN," check emergency brake pressure then charging valve handle "CLOSED"	
10. Receive engineer's report	10. Report test complete, ready to taxi

2-32. TAXIING INSTRUCTIONS.

2-33. Set and uncage flight instruments after receiving taxi clearance, signal wheel chock removal, then release the parking brakes. Advance the throttles to approximately 1400 RPM to start initial roll. If the brakes still seem to be locked, depress the copilot's pedals. After the airplane starts rolling, retard throttles to keep engines at a low power adequate for taxiing. Maintain a minimum of 1000 RPM on two engines for DC power. Use the steering wheel to control airplane direction. Test brakes prior to reaching normal taxi speed. Use the brakes to control the speed but do not "ride" the brakes. Taxi slowly. When making sharp turns, allow the airplane to roll while turning to prevent tire damage resulting from pivoting on a locked wheel.

2-34. DURING TAXIING. Check for correct operation of the following:

a. Turn and bank indicators.
b. Directional gyros.
c. ADF indicator - Tracking
d. Hydraulic pressure within normal range.
e. Emergency brakes - test and recharge. Charging valve handle "CLOSED."
f. Propeller reverse warning flag down.

2-35. BEFORE TAKE-OFF.

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2-36. PRE-FLIGHT ENGINE CHECK.

PILOTS	ENGINEER
1. Set parking brakes	1. When oil temperature is above the minimum, notify pilot that the engines are ready for check
2. Manifold pressure purge valve buttons - Depress for 30 seconds	2. Autopilot inverter switch "AUTO-PILOT INV"
3. ADI pumps switch "ON"; check ADI pressure lights on	3. Check generator, alternator and inverter voltages
4. Perform propeller operational check	4. Perform propeller operational check (Check body heater off during reversing)
	5. Set each throttle to 700 RPM for ignition switch check. Momentarily turn each ignition switch from "BOTH" to "LEFT" to "BOTH" to "OFF" and back to "BOTH." A slight drop in RPM when on each magneto bank and a complete cutting out at "OFF" indicates a safe ignition system and the engine can be operated for a power check
6. Advance the throttle for one engine at a time to a manifold pressure equal to field barometric pressure (noted on manifold pressure indicators before starting engines)	6. Accomplish ignition system check when pilot sets power; switch ignition from "BOTH" to "RIGHT" and back to "BOTH," note RPM drop; switch ignition to "LEFT" and back to "BOTH," again note RPM drop, normal drop on either "LEFT" or "RIGHT" is 60 to 80 RPM; maximum drop should not exceed 100 RPM; maximum difference in drop between "LEFT" and "RIGHT" should not exceed 40 RPM
7. Check instruments for desired range	7. If abnormal magneto drop or engine roughness is observed, spark plug fouling may be cleared up by holding engine primer switch on for 30 seconds; if trouble still exists check the banks of each magneto as follows: leave main ignition lever on "BOTH," turn bank-and-plug selector knob from "0" to "1"; then pull knob and turn to "RIGHT" and then to "LEFT"; then push knob in and turn to next magneto; after checking all seven magnetos and determining faulty magneto, return the selector knob to "0" **CAUTION** Hold cylinder head temperature below a maximum of 220° C during ground operation
8. Advance the throttle beyond 45 inches MAP until ADI pressure lights go out, do not exceed 60 inches MAP; after ADI check, idle engine, check ADI pressure lights on	8. Check turbo-boost operation

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2-36. PRE-FLIGHT ENGINE CHECK (CONTINUED).

PILOTS / ENGINEER

ENGINEER

9. Check oil pressure and fuel pressure within limits; when ADI valve is opened note drop in fuel flow and increase in torquemeter pressure

10. Advance the throttle to 1700 RPM

11. Check cruising fuel-air mixture as soon as engine power stabilizes by moving mixture control to "AUTO LEAN"

NOTE

If engine RPM increases over 25 RPM, mixture is too rich; if a decrease over 75 RPM is noted, mixture is too lean. If the allowable RPM is exceeded try several low cruise ranges to determine accurate data.

12. Leave mixture control in "AUTO LEAN"

13. Advance throttle to field barometric pressure

NOTE

Acceleration of engine in auto lean should follow smoothly with no backfiring or roughness

14. Retard throttle to 1000 RPM

NOTE

Deceleration of engine in auto lean should follow smoothly with no backfiring or roughness

15. Move mixture control to "AUTO RICH"

PILOTS

16. Repeat above checks for remaining engines

ENGINEER

16. Repeat above checks for remaining engines

17. Retard throttles to "CLOSE" to check idle speed at 650 RPM

18. Move mixture control of each engine to "FUEL CUT-OFF" and return to "AUTO RICH" before engine dies

NOTE

A momentary rise of 20 RPM before normal drop-off indicates correct idle mixture; a greater RPM rise indicates mixture too rich and no rise indicates mixture too lean.

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2-37. PRE-FLIGHT AIRPLANE CHECK.

PILOTS

1. Check flight controls unlocked
2. Trim tabs set as desired
3. Wing flap switch "DOWN" to 25° then "OFF"
4. Check rudder boost switch "ON"
5. Check ADI pumps switch "ON"
6. Check master propeller synchronizer lever "INCREASE RPM"
7. Check autopilot master switch "OFF"
8. Set altimeters
9. Check gyros uncaged
10. Communications equipment checked
11. Windows, hatches and doors closed and latched
12. Instruments checked for desired range
13. Throttle lock adjusted

ENGINEER

1. Turbo-boost selector lever "O"
2. Master propeller synchronizer lever full "INCREASE RPM"
3. Propeller auto control switch "NO. 1 MASTER"
4. Mixture controls "AUTO RICH"
5. Carburetor preheat switches "CLOSE"
6. Carburetor air switches "RAM"
7. Oil cooler switches "AUTO"
8. Intercooler flap switches "CLOSE"
9. Check generator switches "ON"
10. Auxiliary power plant operating
11. Essential inverter switch "ESS. INV."
12. Autopilot inverter switch "AUTO-PILOT INV"
13. Check body and thermal anti-icing combustion heaters "OFF"

CAUTION

If combustion heaters have been operating, leave ground blowers on for 1 minute after turning heater switches "OFF" to purge combustion chambers of unburned gasoline.

14. Fuel selector switches "Tank-to-Engine"
15. Both boost pump switches for each wing tank "NORMAL"

NOTE

It is possible to take off with one boost pump in a wing tank inoperative, provided a normal amount of fuel is carried.

16. Center tank boost pump switch "OFF"; center tank line valve switch "CLOSE"

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2-37. PRE-FLIGHT AIRPLANE CHECK (CONTINUED).

PILOTS	ENGINEER
	17. Cowl flaps set to 2.5 inches maximum - Check cowl flaps visually
	18. Check instruments for desired range
19. Receive engineer's report	19. Report to pilot checks complete - Ready for take-off

2-38. TAKE-OFF.

PILOTS	ENGINEER
1. Refer to Section VII, "Operating Limitations," and "Take-off, Climb and Landing Chart" in the Appendix for take-off weight, speed and power settings	
2. For engine failure on take-off, see paragraph 3-5 Section III.	
3. Release brakes and taxi into take-off position, allow airplane to roll ahead a few feet and straighten nose wheel	
4. Advance throttles evenly and smoothly to approximately 50 inches MAP; call to engineer for take-off power NOTE For minimum take-off distance allow airplane to continue roll, when taxiing on to runway, and apply power immediately; any additional speed that can be gained while taxiing on to runway will improve initial acceleration and shorten take-off run.	4. On instructions from pilot set take-off power at 60 inches MAP CAUTION Do not exceed 60 inches MAP or 2700 RPM.
5. Steer airplane with nose wheel during take-off run until rudder becomes effective (50 to 60 MPH)	5. Make power check - Call results to pilot
6. Keep nose wheel in light contact with runway. Approximately 10 MPH prior to take-off speed apply light back pressure to control column and allow the airplane to fly itself off NOTE Copilot should call out as airspeed goes through critical engine failure speed on take-off (see Appendix 1)	6. Check RPM and check engine instruments for proper range during take-off

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2-39. AFTER TAKE-OFF.

PILOTS

1. When certain airplane will remain airborne, signal copilot to raise landing gear (retraction time 8 to 12 seconds)

NOTE

Do not apply the brakes unless excessive vibration occurs.

2. Climb for 200 feet at minimum safe 3 engine climb-out speed (figure 3-2) then assume an attitude which results in a gain of altitude and airspeed simultaneously

3. Signal copilot to raise wing flaps when at a safe altitude and minimum flap retraction speed has been reached

Minimum Flap Retraction

Weight	Airspeed (IAS)
170,000	163 MPH (141 kts)
160,000	158 MPH (137 kts)
140,000	148 MPH (128 kts)
120,000	138 MPH (120 kts)
100,000	128 MPH (111 kts)

4. Call to engineer for maximum continuous power

5. After reaching climb speed (see Appendix 1) call to engineer for climb power

ENGINEER

4. Set power at maximum continuous

5. Reduce power to climb power

NOTE

To avoid excessive engine vibration use reduced power climb settings unless the gross weight demands use of maximum continuous power

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2-40. CLIMB.

PILOTS	ENGINEER
1. Climb at a constant airspeed to aid engineer in setting cowl flaps for stabilized cylinder head temperature	1. Adjust cowl flaps
2. For best rate-of-climb, see "Take-off, Climb, and Landing Chart" in Appendix 1	2. Turn auxiliary power plant off and close exhaust duct valve lever
3. Turn ADI pump switch "OFF"	3. Check turbo-bleeder switches "OPEN,"
4. Wing flap switch "OFF"	4. Check cabin altitude selector and cabin rate-of-change selector as desired
5. Landing gear switch "OFF"	5. One boost pump switch "NORMAL" for each engine
6. Check instruments for desired range	6. Body heaters as required

2-41. ENGINE OPERATION DURING FLIGHT.

PILOTS	ENGINEER
1. At completion of climb, level off, maintain climb power until normal cruise speed is obtained. Order engineer to set cruise power	1. When requested by pilot, reduce power and set up desired cruising power (see cruise control data in Appendix 1)
2. Trim airplane for hands off flight	2. Cowl flap switches as necessary
	3. Intercooler flap switches as necessary
	4. Carburetor preheat switches as desired
	5. Boost pump switches as needed
	6. Fuel system switches as required
	7. Mixture controls set at cruise control position
	8. Use torquemeters to set up equal power settings on all engines
	9. See Appendix 1 for proper operating temperatures and power settings

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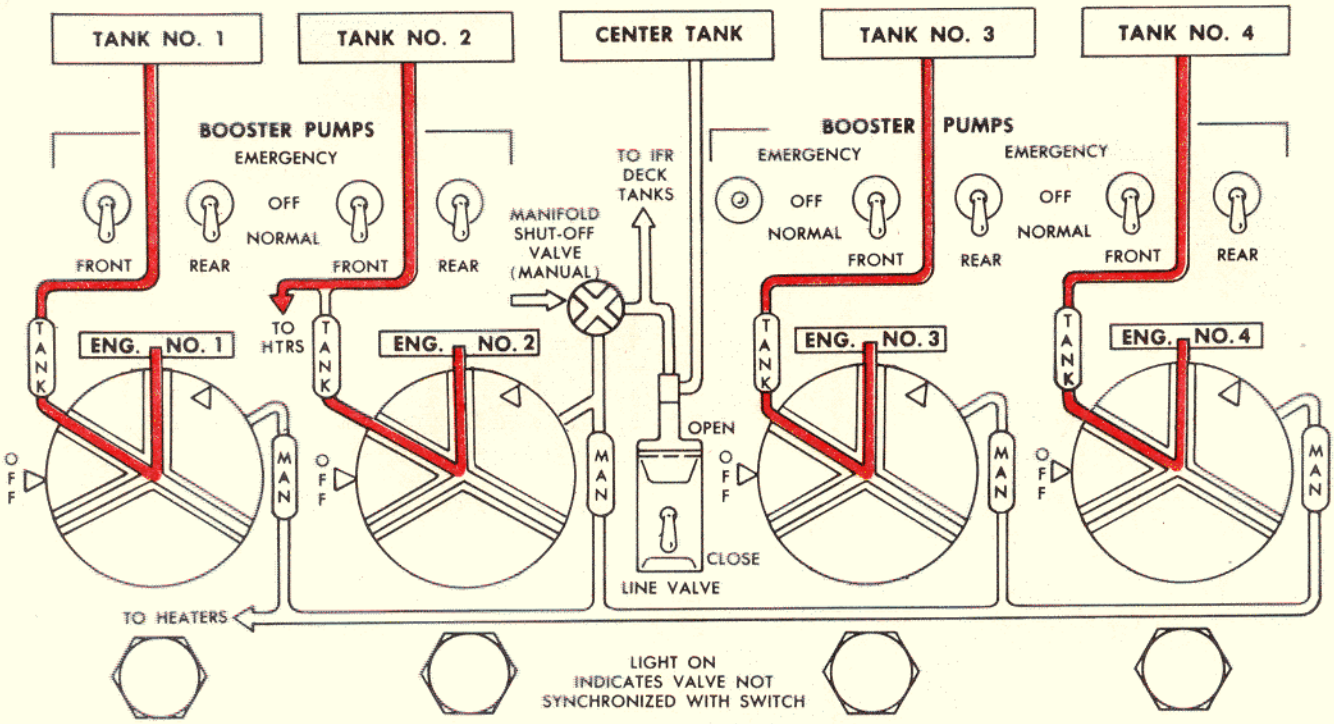
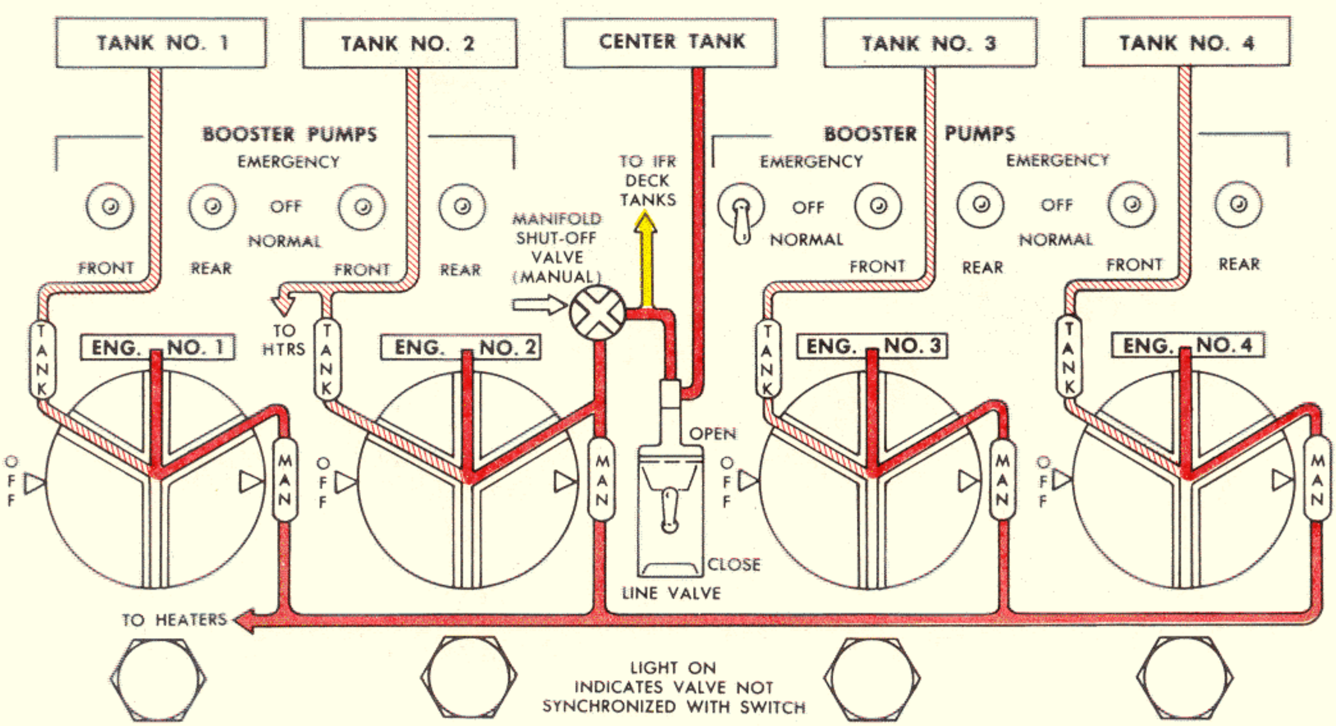


STARTING, TAKE-OFF, LANDING



CENTER TANK OPERATION

PRIMARY FLOW
SECONDARY FLOW
STATIC FLUID PRESSURE

Figure 2-3. (Sheet 1 of 2 Sheets) Fuel System Management

022062a

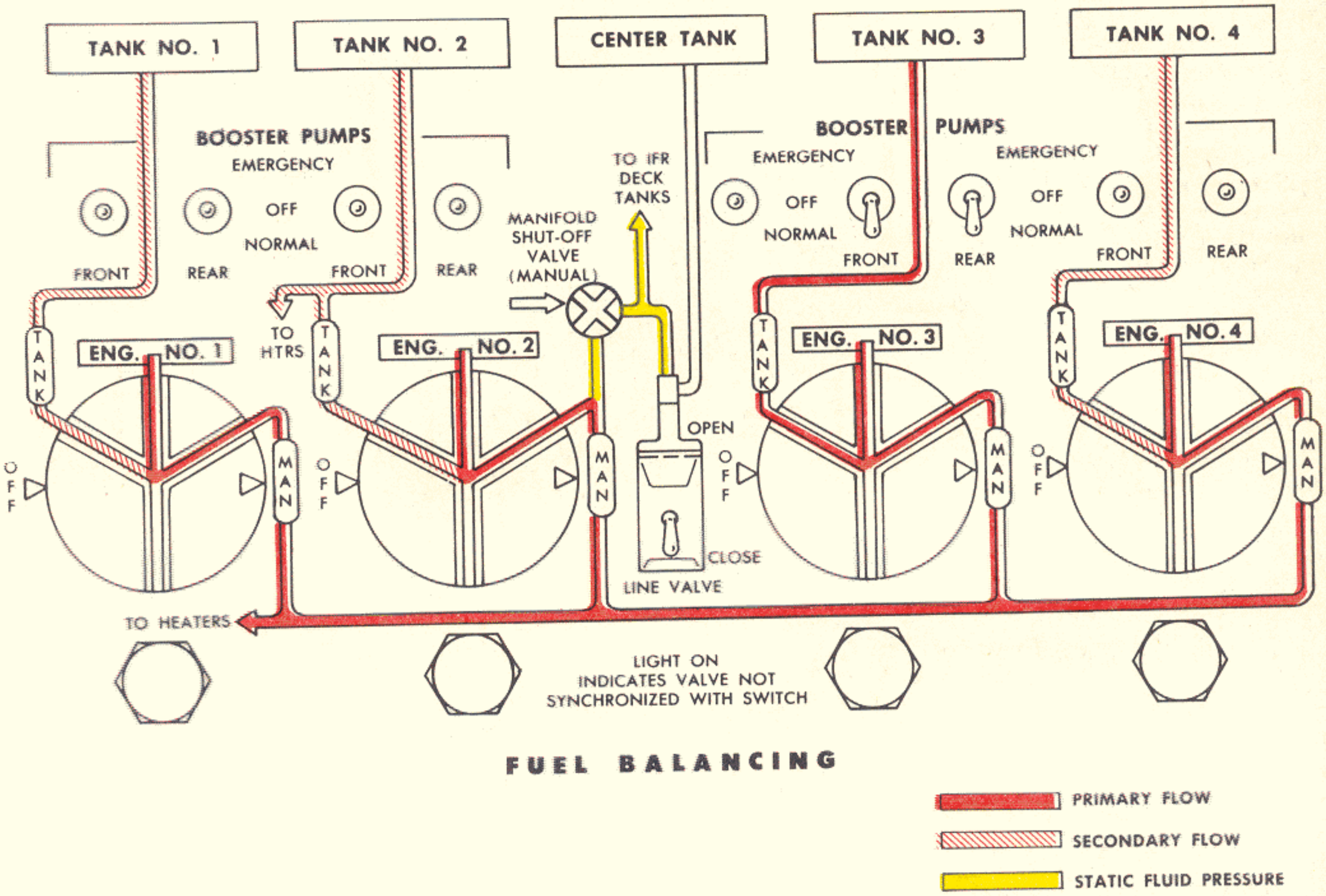


Figure 2-3. (Sheet 2 of 2 Sheets). Fuel System Management

2-42. FUEL SYSTEM OPERATION DURING FLIGHT.

2-43. After reaching a safe altitude, use the fuel in the center tank first (figure 2-3). Set the fuel selector switches to the "Tank-to-Manifold-and-Engine" position. Turn center tank boost pump switch to "NORMAL" and turn center tank line valve switch to OPEN. Turn wing tank boost pumps "OFF." Check fuel pressures for normal limits. If pressure is below normal turn on sufficient wing tank boost pumps to maintain normal pressure. After the center tank is empty, turn center tank boost pump "OFF" and turn line valve switch to "CLOSE."

CAUTION

When changing the fuel selector switches or boost pump switches, watch the fuel pressure. A restoration of fuel pressure, after a drop, may result in engine overspeeding due to power variation. The overspeeding occurs so rapidly that it is necessary to have a hand on the throttles ready for immediate power reduction whenever making a boost pump or selector switch change. At altitude, set boost pump speeds before accomplishing selector switch change. Always have at least one boost pump on when using the manifold system.

2-44. Balance uneven fuel quantities in the wing tanks to provide an optimum weight distribution (figure 2-3). Select the tank with the greatest amount of fuel and turn the boost pump switches to "NORMAL" after setting the fuel selector switches on the "Tank-to-Manifold-and-Engine" position. If the boost pump switches for the other tanks are on "NORMAL," turn the boost pump switches for the selected tank to "EMERGENCY" to create a differential pressure which will allow the selected tank to supply fuel in preference to the other tanks. When the fuel quantities are equal, return the selector switches to the "Tank-to-Engine" position and turn boost pump switches for that tank "OFF" or, if flying above 10,000 feet, turn at least one boost pump switch for each tank to "NORMAL." See figure 7-2 Section VII for fuel loading and usage restrictions.

CAUTION

When a fuel selector switch is changed, watch for proper synchronization of the selector switch and selector valve. This is indicated by the warning light illuminating during the change and going out as synchronization is accomplished.

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2-45. OIL SYSTEM OPERATION DURING FLIGHT.

2-46. TRANSFER OPERATION. To replenish the engine oil tanks while in flight, the oil tank selector switch is set to the desired tank to be refilled and the oil tank transfer pump switch is held "ON" until the desired quantity is reached. Turn the tank selector switch to the next tank to be filled and repeat the procedure. Return the tank selector switch to "OFF" when the oil transfer operation is completed.

NOTE

The central oil system pump transfers oil at the rate of 6 gallons per minute. Do not operate the pump longer than 8 minutes without a cooling period.

2-47. When oil dilution is to be performed for a period of 3.5 minutes or longer, make certain that the engine oil tanks are not filled to more than 30 U.S. gallons before landing.

CAUTION

Above altitudes of 15,000 feet do not fill the engine oil tanks above 27 gallons. This will prevent the tanks from overfilling during descent as a result of increased scavenging at low altitudes.

2-48. TURBOSUPERCHARGER OPERATION DURING FLIGHT.

2-49. CLIMB. When setting up power following first power reduction, apply turbo and part throttle as required to hold desired manifold pressure and to set cabin differential flow indicators within the green (normal) operating range. During climb, slight increases in the turbo-boost control and throttles will be required to maintain these values. For 2800 horsepower climbs use full throttle, turbos as required, and resultant cabin pressure.

2-50. CRUISE. Set up cruise power using "AUTO-RICH" mixture for powers above 1750 BHP with part throttle and turbo, using no more part throttle than required to maintain cabin differential within the green (normal) range. At altitudes above 15,000 feet and at certain powers, an indication of cabin differential air flow above the green (normal) range may be expected.

CAUTION

Use of "AUTO-LEAN" mixture above 1750 BHP will result in excessive temperatures which may cause turbo damage.

2-51. DESCENT. Throttle engines as required for descent and advance turbo-boost control to keep within green range. If full turbo-boost is inadequate for cabin requirements with symmetrical power, advance power on inboard engines and reduce outboard engine power to obtain desired air flow.

2-52. APPROACH. Turbo-boost selector lever "O" just before setting up 2300 RPM on final, or at 200 feet altitude.

2-53. CARBURETOR ANTI-ICING OPERATION DURING FLIGHT.

2-54. Under the majority of operating conditions, the air temperature rise in the turbosuperchargers will prevent carburetor icing. For added safety a sheltered air inlet and a carburetor preheat valve have been provided. Proper use of these controls should insure ice free operation for any icing condition. When entering regions where icing conditions exist or are anticipated a carburetor air temperature of 15 degrees centigrade is considered to be adequate to prevent carburetor icing when on ram air, and a temperature of 7 degrees centigrade is considered to be adequate when on sheltered air. Carburetor icing is not considered to be a serious problem during take-off because of the full throttle condition and the short time interval involved. However, below a carburetor air temperature of 7 degrees centigrade, sheltered air should be used to reduce moisture intake. The correct procedure to prevent carburetor icing when flying with turbo-boost on or turbo-boost off is given in the following paragraphs.

2-55. TURBO-BOOST ON. When operating where impact icing conditions exist, adequate carburetor air temperature of 15° C can be maintained by using the following procedure, apply each step as necessary:

a. Close intercooler flap; add turbo-boost if desired. (Do not exceed 3 inches differential pressure on cabin air flow gages.)

b. Turn carburetor air switches to "SHELTERED" and re-establish power.

CAUTION

Before going on sheltered air, open intercooler flaps 2 inches. This will provide an alternate air intake should the carburetor air filter in the sheltered air inlet become iced over.

NOTE

The use of sheltered air will reduce moisture intake and may cause a slight rise in carburetor air temperature at low altitude where only

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small amount of turbo is normally applied for pressurization. As power is reestablished (to make up for loss of ram) when operating at 15000 feet and above a considerable rise in carburetor air temperature will occur due to the increase in turbo-boost required and loss of cooling air flow through the intercooler. If the carburetor air temperature is above 20° C before accomplishing this step, the final carburetor air temperature will probably be above desired limits.

c. Carburetor preheat switches "OPEN"; add turbo-boost if desired.

NOTE

Carburetor air temperature rise resulting from use of steps a, b, and c or any combination of these steps will be proportional to the amount of turbo-boost applied.

2-56. TURBO-BOOST OFF. Before entering known impact icing or an area of visible moisture with the outside air temperature at zero to 7° C open intercooler flap and go on sheltered air as given in step "b" of the turbo-boost on procedure.

2-57. AUTOPILOT OPERATION DURING FLIGHT.

2-58. ENGAGING THE AUTOPILOT.

a. Uncage the gyro horizon.
b. Check clutch switch out. Check autopilot inverter switch "AUTOPILOT INV." Allow 1 minute for amplifier warm-up.
c. Turn rudder boost switch "OFF."
d. Turn autopilot master switch "ON."
e. Center the turn control and pitch controller.
f. Trim ship to fly "hands off."
g. Engage autopilot by pushing clutch switch in.

CAUTION

Pilot must keep safety belt fastened when engaging autopilot. Maintain straight and level flight when engaging the autopilot and turn the autopilot off in the event of any uncontrolled action of the airplane.

POWER OFF STALLING SPEEDS

INSTRUMENT READING CORRECTED FOR INSTRUMENT ERROR

GROSS WEIGHT LBS.	SPEED INDICATION	WING FLAPS UP GEAR UP			WING FLAPS 25° GEAR UP			WING FLAPS 45° GEAR DOWN		
ANGLE OF BANK		0°	30°	45°	0°	30°	45°	0°	30°	45°
160,000	MPH	145	156	173	124	134	148	114	122	135
	KNOTS	126	136	150	108	116	128	99	106	117
140,000	MPH	136	146	162	116	125	138	107	114	126
	KNOTS	118	127	141	101	108	120	93	99	110
120,000	MPH	126	135	150	107	116	128	99	106	117
	KNOTS	109	118	130	93	100	111	86	92	102
100,000	MPH	115	124	137	98	106	117	90	97	107
	KNOTS	100	107	119	85	92	101	78	84	93
80,000	MPH	103	111	122	88	94	105	80	86	96
	KNOTS	90	96	106	76	82	91	70	75	83

BUFFETING WILL COMMENCE AS FOLLOWS:

WING FLAPS UP - 20 MPH ABOVE STALL SPEED
WING FLAPS 25° - 10 MPH ABOVE STALL SPEED
WING FLAPS 45° - 5 MPH ABOVE STALL SPEED

Figure 2-4. Power-off Stalling Speeds

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2-59. TURNS AND BANKS. Turn the turn control knob until the desired angle of bank is reached. The bank attitude of the airplane may be changed by rotating the bank-trim control wheel.

2-60. CLIMBS OR DIVES. Rotate pitch control wheel for desired rate-of-climb or dive.

2-61. DISENGAGING THE AUTOPILOT. Pull out clutch switch or press disengaging button on control wheel.

NOTE

If the autopilot emergency release handle has been pulled the autopilot cannot be re-engaged while in flight.

2-6 . FLIGHT CHARACTERISTICS.

2-63. The flight characteristics are excellent for a heavy type airplane. Maneuvering and control of the airplane does not require undue force by the pilot. The airplane is very stable and trims out very easily. Very little changes in trim are required to maintain the desired altitude. Rudder control is excellent with rudder boost switch "ON."

2-64. STALLS.

2-65. STALL LIMITATIONS AND WARNINGS. Complete stalls are prohibited at extreme aft C.G. conditions and zero wing flap, because of the possibility of encountering severe elevator force reversal. For training purposes, it is permissible to enter 3 or 4 MPH IAS into the buffeting range to observe stall warning characteristics. Stall warning characteristics are normal. Warning of the impending stall comes in the form of buffeting of the horizontal stabilizer and elevator and occasional light buffeting of the ailerons. Severity of the buffeting increases as the stall is approached. The initial buffeting warning comes from 15 to 20 MPH IAS above the stalling speed with flaps up and 10 MPH IAS above the stalling speed with flaps 25°; and 5 MPH IAS above the stalling speed with flaps full down.

2-66. AILERON EFFECTIVENESS. The ailerons are effective in controlling roll through the buffeting range and may be used without fear of producing wing tip stall. Aileron effectiveness will decrease somewhat as speed is reduced in the buffeting range. No violent rolling action either precedes or accompanies the power-off stall under any flap setting conditions.

2-67. RUDDER EFFECTIVENESS. With boost on rudder control is fully effective through the stall range as the minimum rudder control speed is below the stall speed except as weights below approximately 90,000 lbs. With boost off rudder control is similar to that of any normal aircraft with conventional or unboosted controls.

2-68. RECOVERY FROM STALL ATTITUDES. Standard recovery techniques should be used in all cases.

2-69. NIGHT FLIGHT.

2-70. TAKE-OFF.

a. Line up with runway for take-off. Reset directional gyro to nearest 5° increment. Allow airplane to roll ahead a few feet with nose wheel straight.

b. Apply take-off power in a normal manner using the nose wheel for steering up to about 60 MPH. Then steer with rudder.

c. Maintain direction with the directional gyro.

d. At minimum 3 engine take-off and climb speed (see Appendix 1) lift the nose wheel and fly the airplane off the runway with a smooth but definite attitude change as indicated by the attitude gyro.

e. Climb out at 10 MPH faster than minimum climb speed for 25° flaps and 3 engine climb.

f. Retract landing gear when sure airplane will remain airborne.

g. When a safe altitude over all obstructions is reached, accelerate to the minimum flap retraction speed and retract flaps. While retracting flaps lift the nose sufficiently to maintain a positive rate of climb at all times. Maintain an attitude which results in a gain of airspeed and altitude both at the same time. Continue to increase altitude and airspeed until normal climb speed is reached and a positive rate of climb is established.

h. At maximum gross weight take-off hold take-off and normal rated power as long as necessary to establish desired airspeeds and rate of climb.

2-71. LANDING. When making a night landing, set up sufficient power for go-around procedure. Have copilot call out airspeeds and altitudes during final approach. Leave about 15 inches MAP on for flare-out and touchdown.

2-72. SPINS.

2-73. Intentional spins are prohibited. In case a spin is entered accidentally, use normal recovery procedure to regain level flight.

2-74. ACROBATICS.

2-75. All acrobatics are strictly prohibited.

2-76. DIVING.

2-77. Diving speed is limited to 348 MPH (302 knots) IAS or to a Mach number of 0.62, whichever is slower. Avoid abrupt pull-outs at any time.

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2-78. DESCENT.

PILOTS

1. For normal descent set manifold pressure 20 to 25 inches and maintain normal cruising speed

NOTE

For emergency descent see Section III.

ENGINEER

1. Adjust turbo lever as necessary to maintain desired cabin pressurization
2. Adjust cowl flaps as required
3. Adjust intercooler flaps as required
4. Set cabin altitude and cabin rate-of-change selector as required (see paragraph 4-34, Section IV) so that cabin altitude and aircraft altitude meet on approach at 500 feet above the landing destination

2-79. APPROACH.

PILOTS

1. Notify crew to prepare for landing
2. Receive engineer's weight and balance report
3. Check hydraulic supply
4. Hydraulic controllable check valve handle "NORMAL"
5. Hydraulic charging valve handle "CLOSED"
6. Hydraulic depressurization handles "NORMAL"
7. Apply brakes and check hydraulic pressure
8. Nose wheel steering emergency disconnect button up
9. Autopilot master switch "OFF," and release switch depressed
10. Rudder boost switch "ON"

CAUTION

To avoid a possible violent aircraft maneuver never turn rudder boost on during any maneuver which is requiring rudder action. Rudder deflection, with the same rudder forces differs with boost off

ENGINEER

2. Check weight and CG limits and report to pilot
3. Move mixture controls one at a time to "AUTO RICH"
4. Carburetor preheat switches "OFF"
5. Carburetor air switches as needed
6. Intercooler flap switches as needed
7. Check generator switches "ON"
8. Fuel selector switches "Tank-to-Engine"
9. Both boost pump switches for each main tank "NORMAL"
10. Start auxiliary power plant
11. Check center tank boost pump switch "OFF" and center tank line valve switch "CLOSE"

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2-79. APPROACH (CONTINUED).

PILOTS

12. Signal copilot to lower wing flaps to 25° then flap switch "OFF"

CAUTION

When releasing wing flap switch from "DOWN," check that the spring loaded action does not accidentally snap the switch through "OFF" to "UP."

13. Landing lights switch "EXTENDED" if required (180 IAS or less)

14. Altimeters set

15. Check instruments for desired range

16. Signal copilot landing gear switch "DOWN," check indicators

CAUTION

Do not extend landing gear above 230 MPH (200 knots) IAS.

NOTE

Landing gear extends in approximately 4 seconds.

17. Brakes off (pressure up)

18. ADI pumps switch "ON"

19. Signal copilot wing flaps full down when sure of landing

20. After extending full flaps, make approach at 30 MPH above power-off stalling speed

NOTE

Wing flaps at 25 degrees may be used in strong gusty wind. Observe stalling speed for 25 degree flaps.

ENGINEER

12. Master propeller synchronizer lever set to 2300 RPM

18. All body and anti-icing heaters switches "OFF"

19. Turbo-boost selector lever "O"

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2-80. LANDING.

2-81. NORMAL LANDING.

PILOTS

1. Make a gradual flare-out and ease the throttles off. Contact the ground with main gear first, in a slightly nose up attitude

CAUTION

When landing with a full forward CG, the airplane has a tendency to land in a three-point attitude or with nose wheel first. This tendency is partially offset by the use of a 35° wing flap setting. This flap setting is the optimum for best landing speed and elevator control.

3. Reverse inboard propellers as soon as nose wheel makes ground contact. Co-pilot moves control wheel forward and holds controls steady to prevent thrashing when reversing

NOTE

Two engines in the reverse idle position are very effective and are sufficient under most conditions.

4. In an emergency move all four throttles to reverse idle position. Apply power gradually in the reverse range after ascertaining that all propellers are reversed. On icy runways observe utmost caution when reversing outboard engines to prevent aircraft from weather cocking due to unbalanced thrust.

NOTE

Reverse thrust is most effective during initial part of landing roll. Reverse early and leave reversed down to 60 to 70 MPH (50 to 60 knots).

CAUTION

Care must be exercised when reversing propellers on runways where light dry snow or heavy dust exists, as pilot visibility may be impaired by blowing snow and dust forward at low aircraft speeds.

ENGINEER

1. Cowl flap switches "OPEN" when ground contact is made

2. Move master propeller synchronizer lever to full "INCREASE RPM"

3. Hold throttles in reverse idle and check that all propellers reverse by observing the synchronous movement of all tachometers; notify pilot if any propeller fails to reverse

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2-81. NORMAL LANDING (CONTINUED).

PILOTS	ENGINEER
5. Begin normal braking at 50 to 60 MPH. Keep toes off brake pedals. Apply light brake pedal pressures initially, increasing the pressures as required in order to obtain a steady rate of deceleration up to the end of the landing roll; do not allow plane to roll free and then have to brake heavily at end of runway in order to stop **CAUTION** Because of the airplane's momentum and the fact that the airplane is light on the gear for some distance after touchdown, it is possible to unintentionally lock a wheel even with very light brake pedal pressures. Apply brakes carefully, if needed.	
6. Return the throttles to the forward idle position noting by a slight RPM surge that all reversed propellers have returned to forward pitch	6. Check that all propellers return to forward pitch by observing synchronous movement of all tachometers
7. Steer with nose wheel and brakes as required	
8. When power is applied to engines for taxiing off runway, move wing flaps switch "UP"	8. Boost pump switches "OFF"

2-82. CROSS-WIND LANDING. If landing is made in a cross-wind, crab into the wind sufficiently to check drift. Use a 25° flap setting for best results. Before ground contact use rudder to correct direction of airplane and line up axis of airplane with direction of travel.

2-83. MINIMUM RUN LANDING. To make a minimum run landing because of short runways or similar reasons, make a normal approach. After contacting the runway with the main gear, ease the nose wheel down as rapidly as possible to the runway. Reverse all propellers by lifting the throttles up over the forward idle stop; hold against the reverse idle stop 2 to 3 seconds, until reverse pitch is assured, then continue to apply power in "REVERSE OPEN." When airplane comes almost to a stop, move throttles forward into forward idle position, again pausing while propellers change pitch. Use normal brakes as speed falls below 60 MPH IAS.

NOTE

Propeller reverse action has the most effective braking action during the first part of the landing roll. Normal brakes are more effective at slower speeds.

2-84. EMERGENCY LANDING. For emergency landings which include ditching, crash landings, landing with engine failures, landing gear failures, and brake failures see Section III.

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2-85. GO-AROUND.

PILOTS

1. Pilot will start forward throttle movement calling to engineer for go-around power
2. Signal copilot, landing gear switch "UP" when certain that wheels are off the ground and that the aircraft will remain airborne
3. Signal copilot to raise wing flaps to 25°. Wing flap switch "UP" then "OFF" at 25°
4. Make initial climb at minimum 3 engine climb speed for gross weight (figure 3-2)
5. When reaching minimum flap retraction speed for gross weight and safe altitude signal copilot for flaps "UP" and call for maximum continuous power
6. When reaching normal climb speed for gross weight call for climb power

ENGINEER

1. Advance propeller synchronizer lever to "2550 RPM" and advance throttles to go-around power when called for by pilot
2. Check pressures and temperatures within limits
3. Adjust cowl flaps as required
5. Set up maximum continuous power when called for by pilot
6. Set up climb power when called for by pilot

2-86. POST FLIGHT ENGINE CHECK.

PILOTS

1. Parking brake on
2. Advance throttles one at a time to field barometric pressure

NOTE

The following checks are to be made following the last flight of the day

3. ADI switch "ON"
4. Advance throttles one at a time to take-off power

NOTE

Check smooth acceleration during power advance

ENGINEER

1. Check cylinder head temperature within limits

CAUTION

Do not exceed 220° C cylinder head temperature during ground operation.

2. Check ignition system for normal drop of 60 to 80 RPM
4. Check manifold, fuel, oil, and torque pressures; fuel flow, and RPM within limits

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2-86. POST FLIGHT ENGINE CHECK (CONTINUED).

PILOTS

5. Retard throttles to 1700 RPM

NOTE

Check smooth deaccelera-tion during power reduction

6. Turn ADI switch "OFF"

ENGINEER

5. Move mixture levers to "AUTO LEAN"; check that the engine does not exceed maximum rise of 25 RPM or drop of 75 RPM

6. Retard throttles to 1000 RPM

7. Leave mixture levers in "AUTO LEAN" and advance throttles one at a time to field barometric pressure

8. Retard throttles to 1000 RPM

NOTE

Check smoothness of accelera-tion and de-acceleration in "AUTO LEAN"

9. Move mixture to "AUTO RICH"

10. Retard throttles to 700 RPM

11. Make ignition switch check by turning each ignition switch to "LEFT" to "BOTH" to "OFF" to "BOTH"

NOTE

A slight drop in RPM when on "LEFT" and complete cutting out on "OFF" indicates a safe ignition system

12. Close throttles. Check idle speed at 650 RPM

13. Move mixture levers toward "FUEL CUTOFF" and return to "AUTO RICH" before engine dies

NOTE

A momentary rise of 20 RPM before a normal drop-off indicates correct idle mixture strength; a greater RPM rise indicates too rich a mixture and no rise of RPM indicates mixture too lean

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2-87. STOPPING ENGINES.

PILOTS

1. Check wheels chocked and set parking brakes
2. Idle engines at 1000 RPM for oil dilution if necessary

ENGINEER

2. If oil dilution is desired, follow oil dilution instructions in section VI
3. When cylinder head temperatures are below 190° C move mixture control to "FUEL CUTOFF"

CAUTION

Do not open throttles when stopping engines

4. Turn ignition switches "OFF" when engines are stopped
5. Oil cooler switches "OFF"
6. Leave cowl flaps open for at least 15 minutes after engines are stopped

2-88. BEFORE LEAVING THE AIRPLANE.

PILOTS

1. Surface lock handle "UP-LOCKED"
2. All switches "OFF"
3. Parking brakes off if wheels are chocked

CAUTION

Surface lock handle must be locked before power is turned off

ENGINEER

1. Carburetor air switches "SHELTERED"
2. Intercooler flaps switches "CLOSE"
3. Turbo-boost selector lever "0"
4. All switches except generator switches "OFF"
5. Form 1 complete
6. Check that landing gear ground safety locks, pitot covers, and air-intake duct plugs are installed
7. Notify ground crew if propeller oil quantity low warning lights illuminated during flight and also whether any transfer of engine oil was made to the propeller control unit

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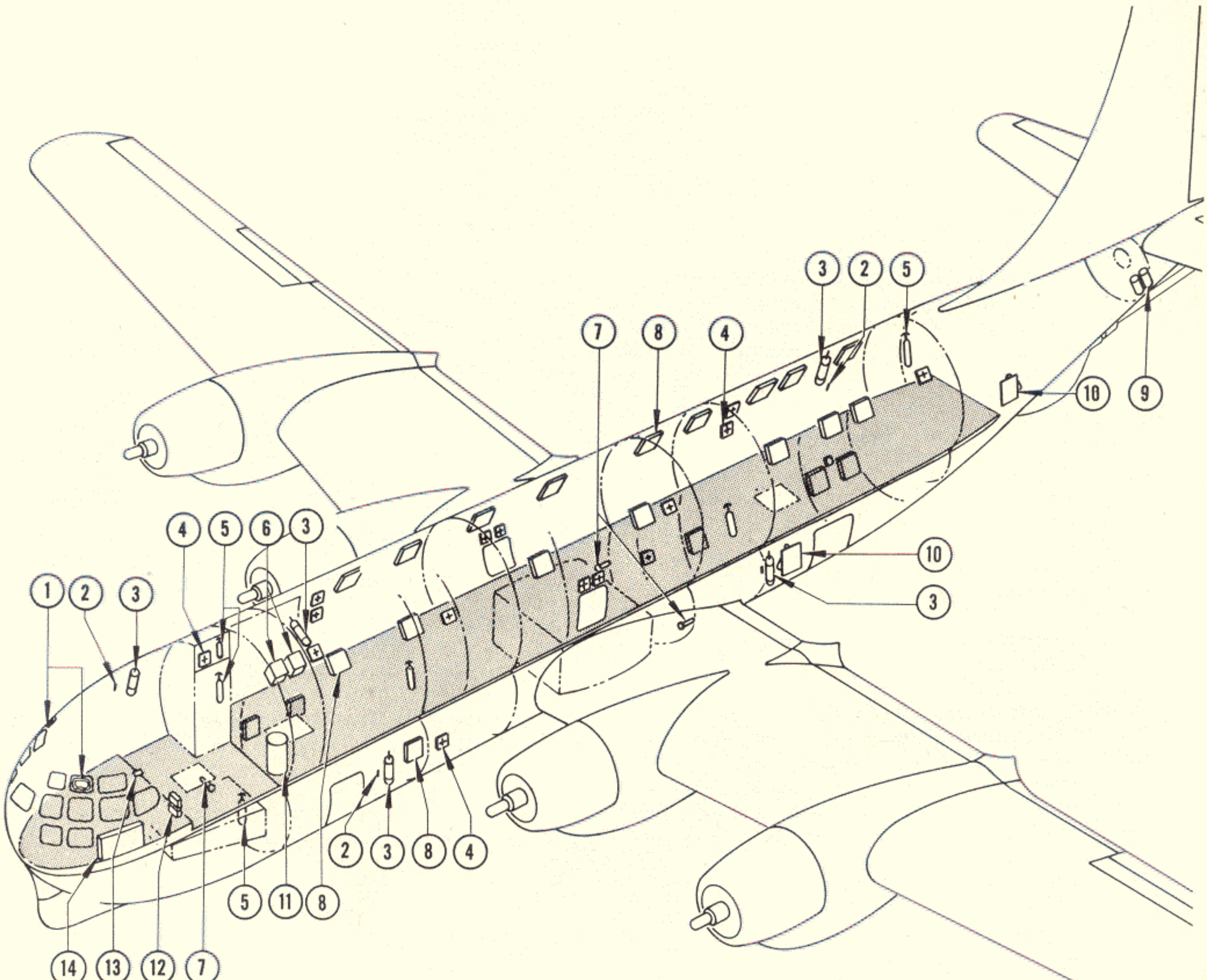
SECTION III

Emergency Operating Instructions



1 ESCAPE ROPES
2 PORTABLE OXYGEN CYLINDER RECHARGER
3 PORTABLE OXYGEN CYLINDER
4 FIRST AID KIT
5 FIRE EXTINGUISHER
6 DINGHY RADIO
7 FLASHLIGHT
8 OXYGEN MASK STOWAGE
9 LANDING FLARES
10 EMERGENCY PANEL FIRE EXTINGUISHER, FIRST AID KIT
11 LIFE RAFT
12 PYROTECHNIC PISTOL
13 PYROTECHNIC PISTOL MOUNT
14 PILOT'S AUXILIARY PANEL AXE, FIRST AID KIT, FIRE EXTINGUISHER AND PORTABLE OXYGEN CYLINDER

Figure 3-1. Emergency Equipment

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3-1. ENGINE FAILURE.

3-2. FLIGHT CHARACTERISTICS.

3-3. The airplane is easily handled under all flight conditions when engine failure occurs. The rudder boost system enables the pilot to correct for yaw by using only light to moderate rudder pedal forces at all times during take-off. Aileron control is fully effective at all times during take-off and cruise conditions. The aircraft is fully controllable with rudder boost off at all take-off speeds from the unstick point onward but requires somewhat higher rudder pedal forces. Trim tabs are fully effective at all times.

3-4. Symptoms indicating engine failure include low torque pressure, low fuel flow, decreasing cylinder-head temperature, dropping off of manifold pressure and RPM. Aircraft yaw or loss of performance is the primary index of power loss however. See Appendix 1 for recommended cruise procedure for two and three engine operation.

3-5. ENGINE FAILURE DURING TAKE-OFF.

PILOTS	ENGINEER
NOTE Before beginning every take-off the pilot should decide whether or not he will continue if an engine fails at or after the critical engine failure speed is reached.	
1. If engine fails before critical three engine failure speed is reached (see Appendix 1) close all throttles and apply brakes	
2. Use reverse thrust on symmetrical engines, if necessary	
3. In extreme cases, retract the landing gear	
4. If engine fails after critical three engine failure speed is reached and take-off is to be continued, retard the throttle on the failed engine. If the correct engine has been selected push the proper feathering button	4. Close the cowl flaps to 2.5 inches on the dead engine and operate the power package fire switches to "FIRE." Do not discharge CO_2 unless fire appears. Complete the engine feathering procedure
5. Do not attempt to become airborne at less than the minimum safe three engine take-off and climb speed for the existing gross weight (see figure 3-2)	
6. Pull airplane off with a definite change in attitude and signal copilot to move landing gear switch "UP" when definitely airborne	
7. Climb for 200 feet or until clear of obstructions at minimum safe 3 engine climb speed (figure 3-2) for existing gross weight, then assume an attitude which results in gaining airspeed and altitude simultaneously	7. Move mixture control to "FUEL CUTOFF," on failed engine, if ordered by pilot; fuel selector switch "OFF"; boost pump switches "OFF"

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3-5. ENGINE FAILURE DURING TAKE-OFF (CONTINUED).

PILOTS

8. Signal copilot wing flap switch "UP" when reaching minimum flap retraction speed

9. Leave take-off power on, if necessary, until best 3 engine rate-of-climb speed is reached (see Appendix 1)

10. Climb at best 3 engine rate-of-climb with rated power until safe go-around altitude is reached

11. Call for power as desired after 1000 feet altitude

ENGINEER

10. Set up rated power when requested by pilot

11. Set up power called for by pilot

12. Turn ignition switch "OFF"; generator and alternator switches "OFF"

NOTE

After all danger of fire is passed the cowl flaps may be closed to 1 inch to obtain minimum drag.

13. Do not restart engine until cause of failure has been determined and corrected

MINIMUM SAFE AIRSPEED FOR TAKE-OFF AND CLIMB-OUT

WEIGHT	TAKE-OFF	CLIMB-OUT ABOVE 50 FEET
170,000	135 MPH (117 kts)	150 MPH (130 kts)
160,000	130 MPH (113 kts)	145 MPH (126 kts)
140,000	120 MPH (104 kts)	135 MPH (117 kts)
120,000	110 MPH (96 kts)	125 MPH (108 kts)
110,000	105 MPH (91 kts)	115 MPH (100 kts)
100,000	100 MPH (87 kts)	110 MPH (95 kts)

(1) Minimum safe airspeed for becoming airborne with 3 engines

(2) Minimum safe 3 engine climb-out speed is increase in IAS over take-off speed due to ground effect. (See Appendix 1)

NOTE: Airspeed conditions: Flaps 25 degrees and landing gear down.

Figure 3-2. Minimum Safe 3-engine Take-off and Climb Speeds

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3-6. ENGINE FAILURE DURING FLIGHT.

PILOTS

1. Advance throttles to power as required to gain desired airspeed. Close throttle for failed engine

3. Push in the respective propeller feathering button

NOTE

The propeller can also be feathered by actuation of the fire gang switch; however, since this switch also actuates the oil shutoff valve its general use is not recommended.

4. Adjust throttles on remaining engines to power as required to maintain airspeed

9. For best operation, refer to the two and three-engine long range charts in the Appendix

ENGINEER

1. Check mixture controls in "AUTO RICH"

2. Move mixture control for failed engine to "FUEL CUTOFF"

3. If master engine propeller is feathered, as indicated by a slight RPM drop on the remaining engines, move the propeller auto control switch to the other master position and momentarily actuate the resynchronizer switch

4. Actuate power package fire switches to "FIRE."

5. Set failed engine fuel selector switch "OFF" and turn the respective boost pump switches "OFF." See figure 3-6 for fuel system emergency operation for failed engine

6. Hold the propeller governor switch for the feathered propeller in "DECREASE RPM" until the limit light indicates the low RPM limit

7. Position cowl flaps to 2.5 inches and close intercooler flaps

8. Ignition switch for failed engine "OFF"

9. Turn generator switches and alternator switch for failed engine "OFF"

CAUTION

Do not restart engine until cause of failure is determined and corrected

NOTE

After the engine has cooled sufficiently and all danger of fire is past, the cowl flaps should be closed to 1 inch to obtain minimum drag

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3-7. UNFEATHERING A PROPELLER DURING FLIGHT.

PILOTS

NOTE

Before practice feathering cool engine gradually by reducing power or opening cowl flaps until cylinder head temperature is below 190° C

1. Before unfeathering it is recommended that airspeed be decreased to approximately 185 MPH

6. Pull the propeller feathering button out; release at 800 to 1000 RPM

14. Trim airplane as required

ENGINEER

1. Set all power package fire switches to "NORMAL"
2. Set fuel selector switch to "Tank-to-Engine" and turn at least one boost pump switch to "NORMAL"
3. Open the throttle for the feathered engine to approximately 800 to 1000 RPM position
4. Hold the propeller governor selector switch for the feathered propeller in "DECREASE RPM" until the limit light indicates the low RPM limit
5. Rotate the turbo-calibrating knob full counter-clockwise
6. Turn engine ignition switch to "BOTH"

CAUTION

Watch for oil pressure rise

7. When engine reaches 800 RPM slowly move mixture control to "AUTO RICH"
8. Warm up engine at 1000 RPM; when operating temperatures are reached, hold the propeller governor selector switch in the "INCREASE RPM" position until the desired RPM is obtained
9. Adjust cowl flaps and intercooler flaps as desired
10. As the RPM is increased advance the throttle slowly to the position of the other throttles
11. Momentarily actuate the resynchronizer switch
12. Turbo-bleed switch "OPEN"
13. Slowly rotate the turbo-calibrating knob clockwise to the barrier index and/or until the manifold pressure aligns with that of the other engines
14. Turn generator and alternator switches for that engine "ON"

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3-8. LANDING WITH ONE OR MORE ENGINES INOPERATIVE.

PILOTS	ENGINEER
1. If an inboard engine is inoperative, no trim will be necessary; if an outboard engine is inoperative some trim will be necessary	
2. If both inboard engines are inoperative and feathered, the hydraulic pumps will be inoperative NOTE Brake pressure will be available if brake pedals are not depressed after engine failure. Several applications will remain for use on landing. Use the hand pump to maintain pressure	
3. If one engine is inoperative, make a normal approach or if at high gross weight or if two engines are inoperative make an approach slightly higher than normal	3. Start auxiliary power plant
4. Make a long approach, if possible, to aid in preparation and control of the airplane	4. Turbo boost selector lever "O"
5. Propeller synchronizer lever set at 2550 RPM	
6. Rudder boost switch "ON"	6. Boost pump switches on operating engines "NORMAL"
7. Signal copilot to extend wing flaps as required	
8. On final approach, when certain that field can be reached, signal copilot to lower landing gear	
9. Signal copilot to extend wing flaps full down. Use wing flaps as an aid for controlling altitude on final. As power is reduced remove most of the rudder trim to avoid unbalance during final flare out	
10. Make a normal power off landing flare out	
11. Use reverse propeller action on symmetrical engines to aid in stopping	11. Cowl flaps open

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3-9. GO-AROUND WITH ONE ENGINE INOPERATIVE.

PILOTS	ENGINEER
1. Start forward throttle movement calling for take-off power on the operating engines	1. Set up take-off power when called for by pilot
2. Signal copilot for landing gear switch "UP"; wing flap switch "UP" to 25° then "OFF." NOTE In an emergency the landing gear and wing flaps can be raised simultaneously if three or more generators are operative	2. Turbo boost selector lever "O"; check pressures and temperatures within limits
3. Signal copilot flaps switch "UP" when reaching minimum flap retraction speed	
4. Call for rated power when best 3 engine rate-of-climb speed is reached	4. Set up rated power when called for by pilot; set cowl flaps as required
5. When reaching go-around altitude call for power as required	5. Set up power called for by pilot

3-10. PRACTICE MANEUVERS WITH ONE OR MORE ENGINES INOPERATIVE.

3-11. Engine failures can be simulated for practice. To simulate a feathered propeller condition, retard the throttle or throttles of the desired engines to 15 inches MAP. The engine failure procedure can be called out without actually doing the steps.

3-12. If a throttle is retarded during take-off before a safe airspeed is reached, it is better to close the remaining throttles and remain on the runway using propeller reverse action and brakes to stop the airplane.

3-13. If engine failure is simulated just after leaving the runway, use rudder and ailerons to maintain directional control. Use trim tabs to reduce control forces during climb-out. Climb out at 3 engine climb speed for 25° flap. Raise the landing gear as soon as possible after leaving runway. Raise the wing flaps when a safe airspeed and altitude are reached. Do not hurry wing flap retraction as the aircraft will climb gaining altitude smoothly and rapidly.

3-14. To simulate a landing with failed engines, retard the throttle or throttles desired to 15 inches MAP and trim airplane for directional control. Unbalanced power can also be used to maintain directional control. Increase RPM to 2550 RPM. Hold a constant approach airspeed as an increase or decrease is airspeed will change trim. When power is reduced trim will also change as well as when power is increased. Make a slightly higher than normal approach and lower wing flaps as required. When it is certain that the field can be reached, lower the landing gear; and when landing is certain, lower full wing flaps. As power is reduced slowly entering flare out, remove most of the rudder trim.

3-15. When making a simulated instrument pull out, advance throttles and propeller synchronizer lever to rated power. Start landing gear up and retract wing flaps to 25 degrees. When a safe airspeed and altitude are reached, raise wing flaps completely and set climb power.

3-16. PROPELLER FAILURE.

3-17. If a propeller overspeeds during take-off, not to be confused with momentary surge, move the overspeeding propeller governor selector switch to "DECREASE RPM" and hold until RPM is reduced to 2700 RPM. Then release the governor selector switch to neutral. Continue to use the propeller governor

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selector switch as necessary to maintain 2700 RPM. If RPM cannot be reduced by the "DECREASE RPM" position and the manual control circuit breaker is "ON," reduce power until RPM is reduced as desired.

3-18. In flight, if the governing action of the propeller fails and causes the engine to overspeed, move the propeller governor selector switch to "DECREASE RPM" and hold until RPM is decreased to the speed of the other engines. If the propeller governor selector switch has no control over the propeller RPM, feather the propeller by pushing the feathering button. In the event of uncontrollable overspeeding and the propeller cannot be feathered, retard the throttle until RPM is reduced. While this is being done, reduce power on other engines and slow the airplane up as this will aid in reducing the RPM on the overspeeding engine. The wing flaps can be lowered to 25 degrees to reduce the airspeed further if necessary. If flying at high altitude reduce altitude as low as practical as greater air density will aid greatly in reducing overspeeding.

3-19. If the automatic propeller synchronizing system fails to control the RPM with the propeller auto control switch in either the "NO. 1 MASTER" or "NO. 2 MASTER" position, place the auto control switch to neutral. Control and synchronize the propellers manually with the four propeller governor selector switches.

3-20. FIRE.

3-21. ENGINE FIRE DURING STARTING.

PILOTS	ENGINEER
	1. Notify pilot of engine or nacelle fire and location
2. Warn crew of fire emergency and location by interphone and three short rings on alarm bell	2. Discontinue priming but continue cranking
	3. If fire continues to spread stop cranking
	4. Fuel valve switch for engine on fire "FIRE"
	5. Boost pump switches for engine on fire "OFF"
	6. Select direction valve switch for engine on fire to "FIRE"
	7. CO_2 fire extinguisher switch to "FIRST FIRE"
8. If fire is out of control call for assistance	8. If fire still continues, inform pilot fire is out of control and move mixture controls on operating engines to "FUEL CUTOFF," fuel selector switches "OFF" and boost pump switches "OFF"
9. Inform crew by interphone and one long ring on alarm to abandon airplane	9. Turn all electrical power switches "OFF" before leaving airplane

CAUTION

If it was necessary to use CO_2 to control fire, do not attempt restarting engine before determining cause of fire.

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3-22. ENGINE FIRE IN FLIGHT.

Any crew member seeing a fire will use the interphone "CALL" position to announce "FIRE ON - ENGINE." Engineer will advise pilot of nacelle and zone of fire.

PILOTS	ENGINEER
1. Double check location of fire and order engineer to follow fire procedure for engine on fire	1. On notification from pilot move respective power package fire switches to "FIRE"
2. Warn crew of fire emergency and location by spoken warning on interphone and three short rings on the alarm bell	2. Move mixture control to "FUEL CUT-OFF" and close throttle for engine on fire
3. If airplane drag is not critical, lower landing gear when fire is on inboard engine	3. Hold fire extinguisher switch in the "FIRST FIRE" position for 5 seconds, after the engine has stopped; if fire is not extinguished, move switch to "SECOND FIRE" position and hold for 5 seconds
	4. Open cowl flaps 2.5 inches
	5. Turn generator and ignition switches "OFF"
	6. Open oil cooler and intercooler flaps
	7. Turn boost pump switches "OFF"
8. If fire cannot be extinguished, open cabin emergency pressure release valve; notify crew to abandon airplane by giving bailout order on interphone and one long ring on alarm bell; or if fire is extinguished, land as soon as possible	8. After fire is extinguished and engine has cooled sufficiently, close cowl and intercooler flaps to obtain minimum drag

CAUTION

Move select direction valve switch to "NORMAL" to prevent CO_2 discharging into the same engine in the event of a second fire. Do not restart engine.

3-23. FUSELAGE FIRE. If a fire occurs in the fuselage section, keep the windows, compartment doors, and floor hatches closed to isolate and minimize the fire. Use the hand fire extinguishers (figure 3-1). If fire is caused by leaking fuel link, turn off applicable fuel valve and boost pump switches. If fire is caused by faulty electrical circuits, turn off applicable switches and land as soon as possible. If a fire is caused by the body heaters or empennage heaters, move the respective fire switches to "FIRE." If an empennage fire exists release the CO_2 charge. Extinguish body heater fires with hand fire extinguishers.

3-24. At first indication of smoke or fumes in the cabin, all crew members should don oxygen masks with regulators set at "100% OXYGEN." Close all hatches, doors, and ventilating ducts and attack the fire immediately with all available fire extinguishers. The airplane should be depressurized as rapidly as possible.

WARNING

The products of decomposition of carbon tetrachloride and the products of combustion of various combustible materials are toxic. Prolonged exposure to these fumes is dangerous. Carbon dioxide in concentrations available in the hand extinguishers in forward and rear pressurized compartments is non-toxic.

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3-25. WING FIRE. If a fire occurs in the right or left wing combustion heater group, move the respective fire switches to "FIRE" position and release CO_2. Fires in other wing areas cannot be reached with the fire extinguishing system. Turn off all switches controlling electrical installations in the wing and land as soon as possible.

3-26. ELECTRICAL FIRE. In the event of a short circuit that may be indicated by detection of fire, smoke or overheating of any electrical wiring or equipment, the following procedure is recommended for the engineer:

a. Inform the pilot that this emergency exists and that electrical power will be turned off.

CAUTION

When all electrical power is turned off, the propellers will be in fixed pitch, the turbo wastegates and fuel valves will remain positioned as they were prior to power off. Therefore in regard to the turbos and propellers, the altitude and airspeed must be held constant if power settings are to remain constant. However, if conditions warrant, the propeller RPM can be increased prior to turning electrical power off or a generator can be turned on while the propeller synchronizer is operated to increase the RPM.

b. Turn battery switch "OFF."
c. Turn all generator switches and the alternator selector switch to "OFF."
d. Put out the fire with hand fire extinguishers or if there is no fire, check throughout the airplane for sources of smoke or other indication. If source is found turn off applicable switch or pull the applicable unit circuit breaker.

CAUTION

Do not use the carbon tetrachloride fire extinguishers on electrical fires.

e. If source can not be found, turn off all electrical equipment switches and pull out all circuit breakers.
f. When smoke or odor has cleared, turn on generator switches one at a time, carefully observing equipment, instruments and wiring to determine trouble.
g. Turn battery switch "ON."
h. Turn essential inverter to "ESS. INV."
i. Turn on alternator selector switch if required.
j. Begin to turn on switches or push in circuit breakers, one unit of equipment at a time, for only the essential flight equipment such as propellers, landing gear, wing flaps, etc.
k. Continue to turn on equipment as needed, carefully observing the equipment, instruments or wiring and as soon as the fault is detected, isolate this circuit or equipment by turning it off or leaving it inoperable.

3-27. DISSIPATION OF SMOKE OR FUMES DURING FLIGHT. At the first indication of smoke or fumes utilize one of the following procedures and continue to ventilate until the airplane is completely clear of smoke or fumes. Check turbo bleed switches "CLOSED" if smoke is from an engine fire.

3-28. MINOR QUANTITIES OF SMOKE OR FUMES WITH CABIN PRESSURIZED.

a. Set cabin altitude above airplane altitude.
b. Set cabin rate-of-change selector to "MAX."
c. Increase turbo boost to increase ventilation airflow to 5 inches cabin differential pressure.
d. Turn on defroster air to assist cockpit ventilation.
e. Use oxygen.

3-29. MINOR QUANTITIES OF SMOKE OR FUMES WITH CABIN UNPRESSURIZED.

a. Air conditioning master switch "ON."
b. Cabin air selector valve switches in RAM TURBO" position.
c. Cabin emergency pressure release valve open.

3-30. HEAVY SMOKE OR FUMES WITH CABIN PRESSURIZED OR UNPRESSURIZED.

a. Retard throttles and reduce airspeed to approximately 150 MPH.

NOTE

Reduction in airspeed is required as overwing hatches can not be opened at higher airspeeds. Overwing hatches may require two men to open them. Rear hatches can be opened easily by one man.

b. Pull emergency cabin pressure release valve handle and use oxygen if necessary.
c. Airplane master switch "OFF" if gasoline fumes are evident.

NOTE

If flying under instrument conditions, close the cabin emergency pressure release valve after the overwing hatches have been opened. As soon as the lower nose compartment is free of fumes, turn the airplane master switch "ON" to restore power to the flight instruments.

d. Open both overwing hatches.
e. Open right or left rear hatch.
f. Open control cabin door. Control cabin ventilation may be assisted if desired by cracking open control cabin windows.
g. Open floor hatches if fumes are discovered in the lower compartments.
h. Increase airspeed as desired to assist ventilation.

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3-31. EMERGENCY DESCENT.

PILOTS

1. Close throttles

2. Signal copilot for landing gear switch "DOWN"; wing flap switch "DOWN"

NOTE

Landing gear and wing flaps can be started down immediately after closing throttles from normal cruising speed, speed will be down to wing flap extension speed by the time flaps are fully extended

3. Descend at 180 MPH (156 knots)

4. If required, oxygen masks on and connected

ENGINEER

1. Cowl flap switches "CLOSE"

4. If required, oxygen mask on and connected (Check with crew members)

3-32. EMERGENCY LANDINGS.

3-33. CRASH LANDINGS. (GROUND)

PILOTS

1. Warn crew with spoken warning on interphone and six short rings on alarm bell. Order crew to jettison all cargo and loose gear if time permits

2. Check that navigator, boom operator and radio operator have moved to positions behind control cabin bulkhead

CAUTION

Navigator and radio operator seats are not designed for crash loads.

3. Open pilot's and copilot's windows; have crew open and release emergency exits (figure 3-3)

ENGINEER

2. Turn auxiliary power plant off if running

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3-33. CRASH LANDINGS (GROUND) (CONTINUED).

PILOTS

4. Fasten safety belt and shoulder harness; lock inertia reel lock handle

ENGINEER

4. Fasten safety belt and shoulder harness; lock inertia reel lock handle

CAUTION

The crew member is prevented from bending forward when the inertia reel lock handle is in the "LOCKED" position; therefore all switches not readily accessible should be "cut' before moving the handle.

PILOTS

5. Signal copilot to lower wing flaps full down
6. Land with as slow a forward speed as possible with a normal nose-high attitude
7. Notify crew by interphone to brace for crash landing. Then give one long sustained ring on alarm bell.
8. Close throttles on impact

ENGINEER

5. Turn boost pump switches "OFF"
6. Move all four sets of power package fire switches to "FIRE"
7. Turn battery switch "OFF"
8. Move mixture controls to "FUEL CUTOFF" and pull emergency ignition cutoff handle on impact

3-34. LANDING WITH LANDING GEAR FAILURE.

PILOTS

1. Warn crew by interphone and six short rings of alarm bell.
2. Reduce landing weight as low as possible.
3. Check that all personnel in lower compartments have been removed to main compartment or main cabin and braced for crash landing
4. Order crew by interphone and by one long sustained ring on the alarm bell to open emergency exits, take crash landing positions, and brace themselves
5. Open window; fasten safety belt and shoulder harness; lock inertia reel lock handle

ENGINEER

1. Turn auxiliary power plant off if running.

5. Fasten safety belt and shoulder harness; lock inertia reel lock handle

CAUTION

The crew member is prevented from bending forward when the inertia reel lock handle is in the "LOCKED" position; therefore all switches not readily accessible should be "cut" before moving the handle.

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3-34. LANDING WITH LANDING GEAR FAILURE (CONTINUED).

PILOTS	ENGINEER
6. Signal copilot to lower wing flaps full down	
7. Land in a normal nose-high attitude when all three gears are retracted NOTE Land with as much of the landing gear down as possible in preference to a gear-up belly landing; land on a concrete or hard-surface runway rather than on a dirt or soft surface	7. Turn boost pump switches "OFF"
8. Land with as slow a forward speed as possible	8. Turn battery switch "OFF"
9. With nose gear only retracted, hold the nose of the airplane up as long as possible then ease it down to the runway	
10. With one main gear retracted, make contact on the nose gear and extended main gear simultaneously; hold control column forward and use aileron to hold the wing tip off the ground as long as possible - be prepared for a ground loop	
11. With one main gear and nose gear retracted make contact with the one gear; hold up nose and use aileron to keep the wing up as long as possible	
	12. Move all four sets of power package fire switches to "FIRE"
13. Close throttles after ground contact is made	13. Move mixture controls to "FUEL CUTOFF," pull emergency ignition cutoff handle when pilot closes throttles

3-35. LANDING WITHOUT BRAKES.

PILOTS	ENGINEER
1. Land with as slow a forward speed as possible	1. Turn off all body and thermal anti-icing combustion heaters
2. Wing flaps full down	
3. Land as short on runway as possible	

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3-35. LANDING WITHOUT BRAKES (CONTINUED).

PILOTS

4. Make contact with main landing gear first; then ease nose down

5. As soon as nose gear makes contact, move all four throttles to "REVERSE OPEN"

CAUTION

Observe reverse pitch operation limitations.

6. In extreme cases, retract the landing gear

7. After airplane slows down, reduce reverse thrust and follow emergency taxiing instructions if necessary

ENGINEER

4. Open cowl flaps on contact with ground

CAUTION

Overwing hatches must be opened before opening rear hatches and after reducing airspeed to 150 MPH or below. If rear hatches are opened first or airspeed is greater than 150 MPH, differential pressure may prevent opening of the overwing hatches. Overwing hatches may require two men to open them. Rear hatches can be opened easily by one man but caution must be exercised as the hatches will release with considerable inward force. Airspeed may be increased after the hatches are opened.

WARNING

Stow boom before leaving the airplane in flight.

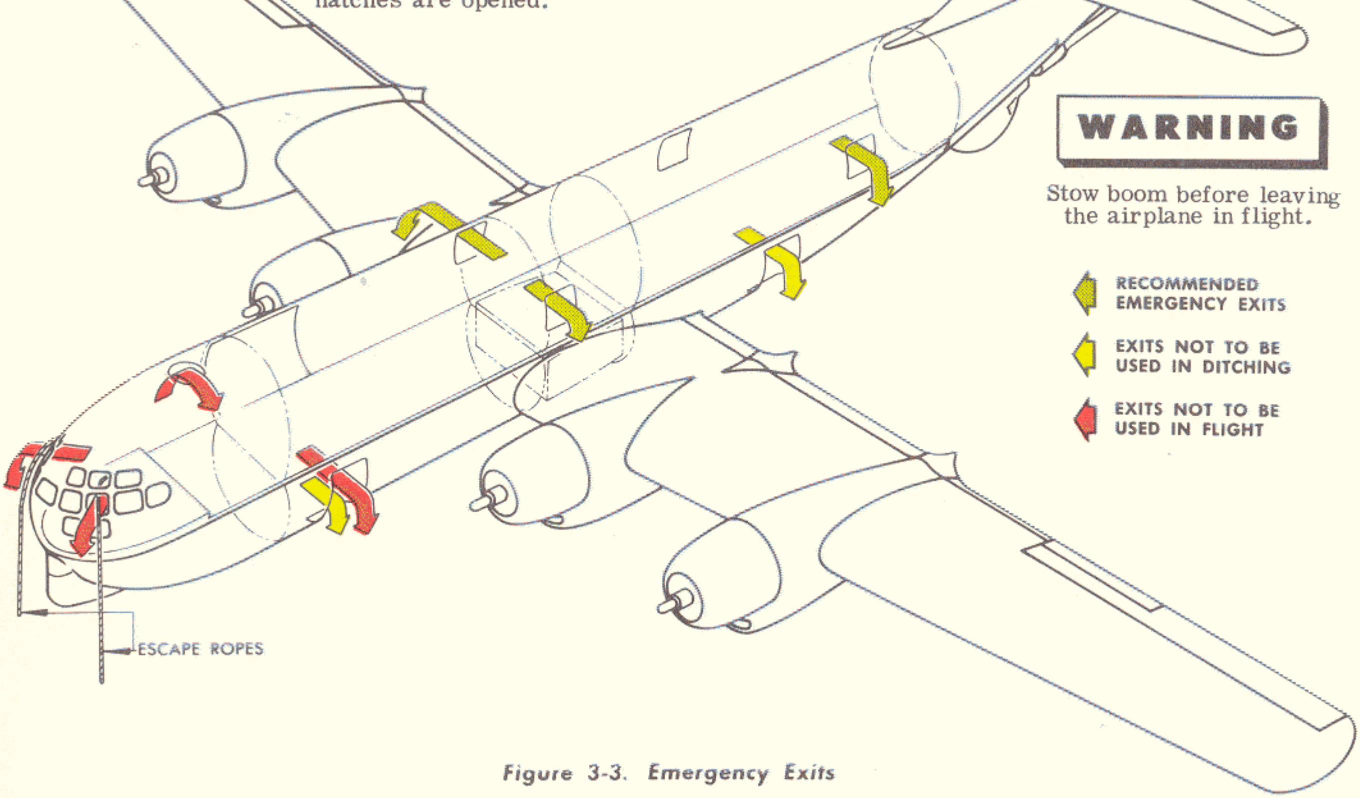

Figure 3-3. Emergency Exits

3-36. EMERGENCY TAXIING INSTRUCTIONS.

3-37. If, while taxiing, the hydraulic system and emergency brake fail, and the hydraulic pressure cannot be raised with the hand pump, use propeller reverse-thrust action for braking the airplane.

3-38. Since the steering system will usually be inoperative when the brakes fail, it will be necessary to use the engines for steering the airplane, as the nose wheel will caster freely.

3-39. To maintain maximum control during emergency taxiing, first move the inboard engine throttles to "REVERSE OPEN" and then close the outboard engine throttles to a low idling speed until the airplane slows to a safe speed for taxiing. Next reduce power on the inboard engines and idle the outboard engines at 1000 RPM. While taxiing leave the inboard engines in reverse thrust until the airplane is clear of obstructions. To provide governed forward speed of the airplane, increase the speed of the outboard engines to overcome the action of the reverse thrust engines.

3-40. When the airplane is clear of all obstructions, again operate the inboard engines to stop the airplane. Have the engineer place the mixture control levers for the outboard engines in the "FUEL CUT-OFF" position. While this is being done, move the inboard engine throttles to the forward idle position to return the propellers to normal pitch.

3-41. EMERGENCY EXITS AND ENTRANCES.

3-42. After a crash landing on the ground any normal exit or entrance may be used. After a ditching, the control cabin sliding windows and the escape hatches above the cabin floor should be used as emergency exits. In flight use exits aft of the engines only, (figure 3-3).

3-43. Emergency entrance to the airplane can be made by cutting or chopping through the structure at the locations indicated by orange-yellow markings on the inside and outside of the fuselage (figure 3-4).

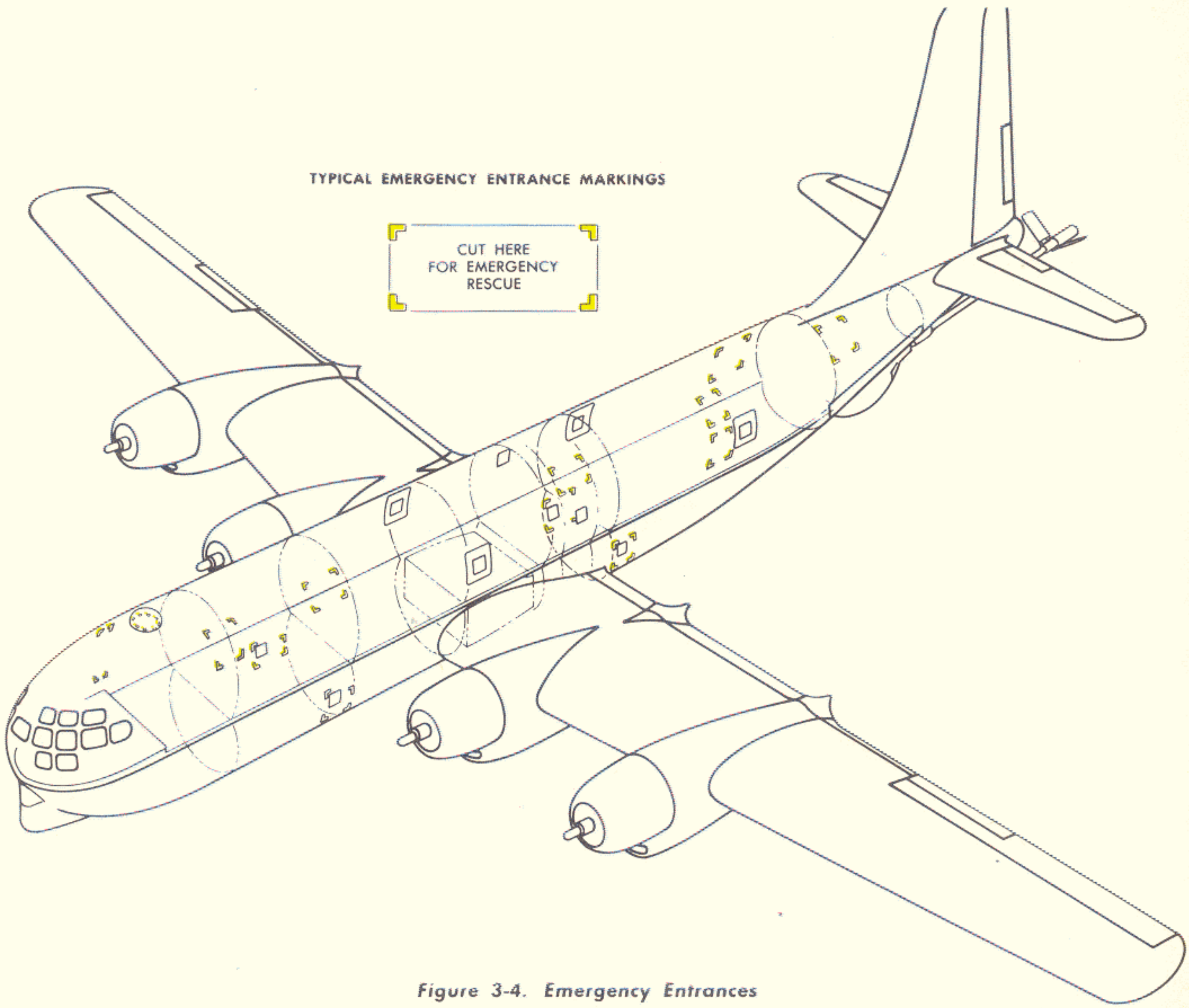

Figure 3-4. Emergency Entrances

3-44. DITCHING.

3-45. The airplane is well suited for ditching because the body configuration, with a high-rounded nose, upswept empennage, and boat-like lower fuselage, provides even greater safety than the B-29 airplanes which have been ditched safely on many occasions. In ditching, it may not be necessary to abandon the airplane. Under most conditions it will be better to remain on the airplane which provides an excellent platform for survival and rescue.

3-46. DITCHING EQUIPMENT. The pilot will ascertain before each over-water flight that the following equipment is on board and stowed in the proper places:

a. Life rafts. The number and type of rafts on board will be governed by the number of persons on board the aircraft.

b. Life vests. At least one life vest will be available for each person on board. Each crew member will test inflate his life vest by mouth, check seals on the CO_2 cartridges, and check that container caps are screwed down tightly before each flight. Crew members will wear life vests during all over water take-offs and landings and at anytime the pilot deems it necessary.

c. Emergency radio.

d. First aid kits.

e. Flares.

f. Drift signals.

g. Hand axes.

h. Flashlights.

i. Emergency water.

3-47. DITCHING PREPARATION. When it becomes apparent that ditching is necessary, the pilot signals the crew to prepare for ditching. A crew member notifies other personnel to prepare for ditching and assists in positioning and securing the personnel. If cargo is being carried, crew members open the rear cargo doors and jettison as much of the cargo as time permits, closing the doors before water contact is made. The lower compartment doors should not be opened. Open the hatches in the main cargo compartment and stow them in a secure position inside the airplane. Jettison all loose, unnecessary equipment. Place emergency equipment and life rafts

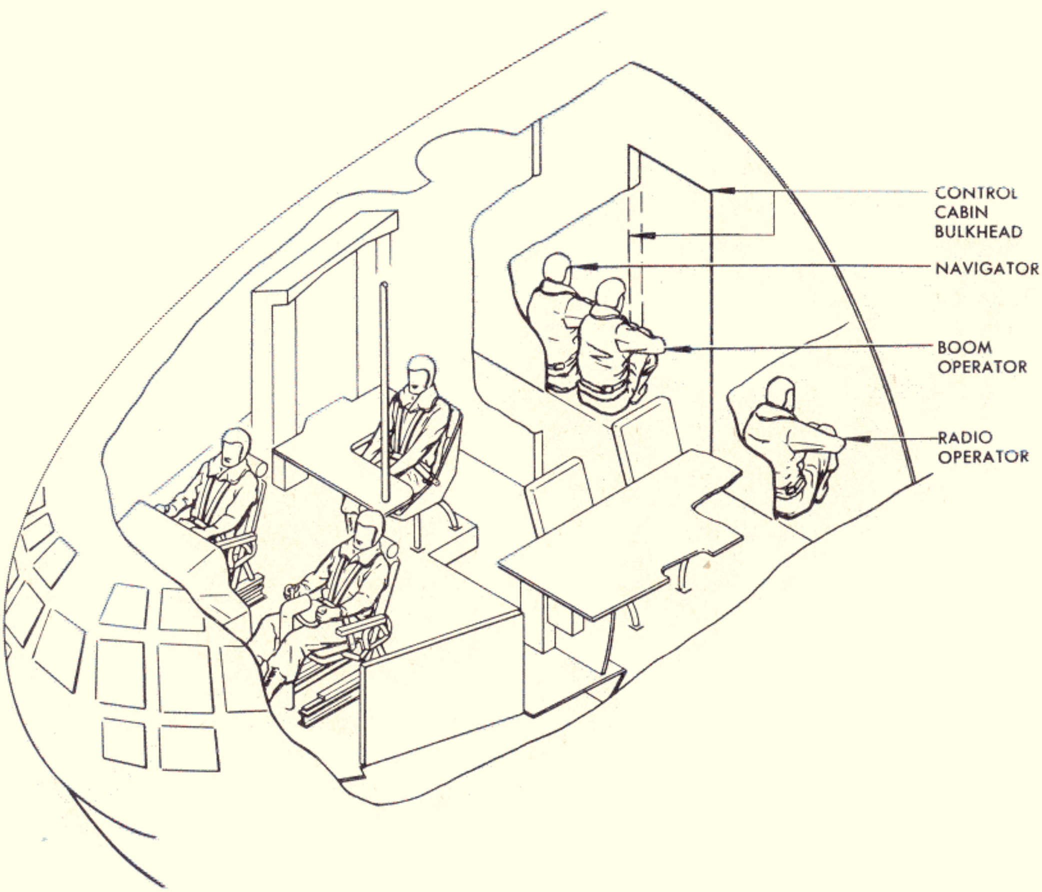

Figure 3-5. Ditching and Crash Landing Stations

near the emergency exits that open over the wing. Turn off the cabin heaters and check that the floor hatches are closed. If the auxiliary power plant is running, turn it off and close the exhaust valve. Turn on navigation and formation lights to assist in rescue. Pinch or bend all accessible tubing that vents outside the airplane to prevent water from entering.

3-48. DITCHING POSITIONS. When preparing for ditching, the crew and other personnel take the following positions:

a. Pilot and copilot remain in their seats with safety belts and shoulder harness fastened and inertia reel lock handle locked.

b. The engineer remains in his seat with safety belt and shoulder harness fastened and inertia reel lock handle locked.

c. The radio operator and navigator move to the aft side of the control cabin bulkhead, and sit on the floor facing aft.

CAUTION

Navigator's and radio operator's seats are not designed for crash loads.

d. The boom operator moves to the aft side of the control cabin bulkhead and sits on the floor against the bulkhead facing aft.

e. When contact is made and it becomes necessary to abandon the airplane immediately, use all exits in the upper fuselage as shown in figure 3-3. Inflate the life rafts outside of the airplane.

3-49. NORMAL DITCHING PROCEDURE. Experience has shown that the best results are obtained by use of the following procedure:

a. Ditch while power is available. Power will allow the pilot to choose the most favorable spot and condition for ditching.

b. Ditch at the lowest possible forward speed. At the time of surface contact, attempt to have the lowest possible forward speed consistent with safe control of the airplane. This will reduce the landing impact.

WARNING

Under no circumstances should the airplane be stalled in. The resulting leaks and structural damage would greatly reduce the safety of the ditching operation.

c. Ditch at the lowest possible rate of descent. One hundred feet per minute is recommended.

d. Feather the two inboard engines, if possible, to provide greater safety.

e. Ditch the airplane 5 degrees nose high. This is the normal landing attitude and gives the best distribution of landing shock over the fuselage.

f. Use a flap setting of 25 degrees. This flap setting is recommended in most cases; however, the primary object is a low rate of descent with as low a forward speed as possible. The use of more than 25 degree flaps is not desirable because it becomes increasingly difficult to get the desired 5 degree nose up attitude with greater flap angles. Flap setting should be varied according to the weight of the airplane and the power available.

g. Avoid contact in a nose-down position. Flare out just above the water and maintain an approximate normal landing attitude at impact.

h. Choose the direction of the ditching run carefully, The best procedure is to ditch into the wind unless high swells are running and there is little wind. In this event, best results will be achieved by ditching parallel to the waves or crests. Try to touch down along the crest, or just after it passes. Be careful to keep the wings level and do not allow a wing to dig in prior to body contact.

3-50. POWER OFF AND PARTIAL POWER DITCHING. In ditching with one or more engines inoperative, use the following procedure:

a. With two engines operative on the same side of the airplane, use power on the inboard engine only.

b. If No. 2 and No. 4 engines are operative considerable power may be used for control.

c. With symmetrical power conditions, use power as required to give the flattest approach and the lowest possible forward speed.

d. On let-down with any engine inoperative, it is advisable to hold the speed 30 MPH above stalling speed until flare-out, at which time the speed will be reduced to just above the stalling speed as the 5-degree nose-high landing attitude is assumed.

3-51. CROSS-WIND DITCHING. Crab the airplane with the rudder to kill the drift. Hold the wings level. Use a landing attitude of 5 degrees nose high with 25 degrees wing flaps.

3-52. NIGHT DITCHING. Night ditching must be conducted with the aid of instruments to establish the proper attitude of the airplane.

a. Hold the wings level to avoid digging a wing into the sea and cartwheeling the airplane.

b. If power is available, drop flares and use landing lights to examine the sea surface. If conditions are favorable, choose a ditching heading as previously recommended. If impossible to judge the surface conditions, head into the wind and use knowledge of the prevailing winds or wind fix.

c. Make an instrument let-down, holding the air speed 30 MPH above stalling speed, at the lowest possible rate of descent.

d. The landing attitude, with power available, should be 5 degrees nose-high with 25 degrees wing flap. If no power is available or unsymmetrical power is used, no wing flaps will be employed.

e. After choosing a ditching heading, if power is available, drop remaining flares in a line; make a procedure turn; and land alongside the flares.

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3-53. PILOT'S PROCEDURE. When it is determined that the aircraft must be ditched, the pilot:
a. Warns crew to prepare for ditching, giving approximate time left, and instructs copilot to give alarm bell warning.
b. Orders radio operator to start emergency procedures.
c. Takes emergency action on VHF. (Transmits "Mayday" three times, identification three times, and requests a fix or bearing.)
d. Turns over controls to co-pilot.
e. Checks and dons life vest, fastens shoulder harness and safety belt; loosens collar and tie; locks inertia reel lock handle.

CAUTION

The crew member is prevented from bending forward when the inertia reel lock handle is in the "LOCKED" position; therefore all switches not readily accessible should be "cut" before moving the handle.

f. Takes over from co-pilot and prepares to ditch aircraft.
g. Orders navigator to cabin to remove and stow cabin escape hatches.

NOTE

When passengers are carried, pilot orders navigator to supervise the passengers' ditching preparation.

3-54. When ditching is imminent (10 minutes left) the pilot:
a. Orders radio operator to send final distress signal.
b. Orders the co-pilot to assist him as required.
c. Orders all on board to secure themselves in their ditching positions.
d. If at night turns on formation lights.
e. Immediately prior to ditching, gives signal to brace for impact on interphone and orders copilot to ring alarm bell.

3-55. After ditching the pilot:
a. Destroys the IFF.
b. Proceeds to left forward emergency exit window and assists with life rafts. Takes command. Supervises loading of raft and enters last raft on left side.

NOTE

Launch rafts from leading edge of wing in order to prevent damage of the rafts by jagged edges of wing flaps which are usually torn off by the ditching impact.

3-56. COPILOT'S PROCEDURE. When it is determined that the airplane must be ditched, the copilot:
a. Rings alarm bell on pilot's order (6 short rings)
b. Takes over control while pilot adjusts and fits equipment.
c. On order from pilot, releases controls.
d. Checks and dons life vests; loosens collar and tie.
e. Fastens shoulder harness and safety belt and locks inertia reel lock handle.

CAUTION

The crew member is prevented from bending forward when the inertia reel lock handle is in the "LOCKED" position; therefore all switches not readily accessible should be "cut" before moving the handle.

3-57. When ditching is imminent, the copilot:
a. Rings alarm bell on pilot's order (one long sustained ring)
b. Assists pilot.

3-58. After ditching, the copilot:
a. Proceeds to cabin and exits through left forward emergency exit window, assists in inflating and loading life rafts from wing of aircraft.

3-59. ENGINEER'S PROCEDURE. When it is determined that the airplane must be ditched, the engineer:
a. Checks control cabin windows, emergency cabin pressure release valve, and APP exhaust port to make certain that they are closed and locked. Pinches all accessible tubing which vents outside the airplane.
b. Secures all loose equipment in control cabin.
c. Checks and dons life vest. Loosens collar and tie.
d. Stands by to assist pilot or navigator if required.

3-60. When ditching is imminent, the engineer:
a. Returns to seat, fastens safety belt and shoulder harness; locks inertia reel lock handle.

CAUTION

The crew member is prevented from bending forward when the inertia reel lock handle is in the "LOCKED" position; therefore all switches not readily accessible should be "cut" before moving the handle.

3-61. After ditching, the engineer:
a. Exits through left forward emergency exit window with life raft.

3-62. NAVIGATOR'S PROCEDURE. When it is determined that the aircraft must be ditched, the navigator:
a. Passes speed, course, altitude and estimated

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ditching position to radio operator for inclusion in distress signal.
b. Removes astro-dome.
c. Checks and dons life vest, loosens collar and tie.
d. Stows essential navigation equipment, including very pistol and flares, in bag and takes it with him to cabin.
e. Closes doors, removes and secures emergency exit hatches. If passengers are carried, supervises and instructs passengers in ditching procedures.

3-63. When ditching is imminent, the navigator:
a. Takes charge of main cabin.
b. Assumes ditching position sitting against the aft side of the control cabin bulkhead facing aft.

3-64. After ditching, the navigator:
a. Exits through forward emergency exit on left side, then enters first raft on left side and assists in tying rafts together as they are inflated.

3-65. RADIO OPERATOR'S PROCEDURE. When it is determined that the aircraft must be ditched, the radio operator:
a. On pilot's orders, sends emergency signal SOS followed as soon as possible by emergency message containing position, flight time, nature of emergency, and any other pertinent information available.
b. Turns IFF to emergency, obtains D/F service, bearing fixes, etc., in normal air ground frequency if possible.
c. Checks and dons life vest, loosens collar and tie.
d. Continues outlined emergency procedure every ten minutes.

3-66. When ditching is imminent, the radio operator:
a. Sends final distress (SOS) signal, position altitude, course speed, and intention of aircraft commander as to ditching.
b. Screws radio key down.
c. Proceeds to ditching position, seated on aft side of control cabin bulkhead facing aft.

3-67. After ditching, the radio operator:
a. Collects emergency radio and kit.
b. Exits through left forward emergency exit window.

NOTE

When passengers are carried, the radio operator takes charge of second raft on left side and ties onto other rafts.

3-68. BOOM OPERATOR'S PROCEDURE. When it is determined that the aircraft must be ditched, the boom operator:
a. Stows and latches the boom.
b. Turns off all IFR equipment.
c. Proceeds to ditching position.

3-69. ADDITIONAL FLIGHT PERSONNEL.

3-70. Additional flight personnel may be carried on passenger or casualty-carrying missions. Ditching positions and emergency exits for additional personnel will be determined by the type of mission and number of persons carried. The following procedures are presented to serve as a guide for determining the duties of the additional personnel.

3-71. SECOND ENGINEER'S PROCEDURE. When it is determined that the aircraft must be ditched the second engineer:
a. Proceeds to cabin and assists navigator in preparing emergency equipment for ditching.
b. Assists in jettisoning cargo.
c. Checks and dons life vest, loosens collar and tie.
d. Proceeds to ditching station.

3-72. When ditching is imminent, the second engineer:
a. Assumes ditching position.

3-73. After ditching, the second engineer:
a. Exits through left forward emergency exit window, helping with life rafts. Enters first raft and assists in tying onto other rafts as they are inflated.
b. Assists passengers or patients into rafts.
c. Takes charge of a life raft and when all rafts are inflated and copilot enters last raft, assists copilot in command.

3-74. BAIL-OUT.

3-75. OVER-WATER BAIL-OUT. Bail-out is not recommended unless visual contact is made with adequate surface help. If no rescue vessels are in the vicinity, bail-out should be used only as a last resort because of the extreme difficulty of getting the crew together in the water. The large life rafts offer more elaborate survival and signaling equipment than do one-man rafts. In any but the warmest seas, a man will survive only a few hours if kept afloat by means of a life vest alone. Wearing an exposure suit will increase this time but still cannot compare with the time of survival possible in a life raft.

3-76. If bail-out is required or decided upon, the following procedure is recommended:
a. If surface help is available head the airplane in a direction to allow the crew to drift onto the course and just ahead of the rescue vessel.
b. As in ditching, try to plan bail-out before the last minute. The pilot must warn the crew as soon as bail-out is decided upon. Give three short rings on the alarm bell and, if time permits, the copilot will warn the crew on interphone and receive acknowledgments.

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c. Exposure suits available in the airplane should be put on if time permits. It will take about a minute to put on a suit. Exposure suits should be worn over flying clothing. Then put on life vest and parachute harness. Mittens will be found in the leg pockets of the exposure suit.

d. When the prepare to bail-out signal is given, each man should make sure his individual life-raft pack is snapped onto the parachute harness; the raft line should run under the parachute harness and be tied to the ring on the waist strap of the life vest. Crew members should check each other to see that all straps and packs are properly adjusted.

e. The radio operator and navigator open the rear hatches. All available life rafts will be released just prior to bailing out.

be released just prior to bailing out.

f. If time permits, make two runs, dropping half the crew each time. The best altitude for bail-out is about 2000 feet. Fly at as low an air speed as possible. The pilot is the last man to bail out. Engage the autopilot just before leaving.

3-77. OVER-LAND BAILOUT. If bail-out is required or decided upon, the following procedure is recommended:

a. Try to plan bail-out before the last minute. The pilot must warn the crew as soon as bail-out is decided upon. Give three short rings on the alarm and, if time permits, the copilot will warn the crew on interphone and receive acknowledgments.

b. When the prepare to bail-out signal is given, each man should put on parachute harness and parachute.

c. Check parachute harness for proper fit crew members should check each other to see that all straps and packs are properly adjusted.

d. The radio operator and navigator open the rear hatches. If loading ramps are not installed the aft cargo door is opened.

e. The airplane should be slowed to as low an air-speed as possible and still be under positive control.

f. The pilot gives bail-out order over interphone and one long ring on alarm bell. On command the crew members begin bail-out, using exits shown in figure 3-3. The pilot is the last man to bail out. Engage the autopilot just before leaving.

3-78. <u>NOSE WHEEL STEERING EMERGENCY OPERATION.</u>

3-79. If the nose wheel steering mechanism is malfunctioning and the direction of the airplane is uncontrollable, actuation of the nose wheel steering emergency disconnect switch will by-pass the hydraulic pressure used for steering and allow the nose wheel to caster freely. When the switch is actuated a light within the switch is illuminated. The nose wheel will also caster freely if the pressure in the main hydraulic system is lost.

3-80. <u>EMERGENCY BRAKE OPERATION.</u>

3-81. Two hand-operated levers for emergency brake operation are above the pilot on the overhead structure. When using the emergency brakes, apply steadily. Do not pump the hand levers as this action will rapidly lower the hydraulic pressure in the emergency system. Only five or six applications of the emergency brakes are available.

3-82. <u>ENGINE OVERSPEED AND OVERBOOST.</u>

3-83. ENGINE OVERSPEED. Whenever engine overspeeding occurs the following information should be noted in the appropriate section of Form 1 and reported to the ground crew: the maximum RPM and manifold pressure which was obtained during flight, duration in minutes of the overspeed condition and overpower condition, and the reason for overspeed if known. This information is needed by the ground crew to determine whether an inspection or an engine change is necessary before further flight. If engine RPM was between 3100 RPM and 3300 RPM an inspection of the engine is necessary before further flight. If the engine exceeded 3300 RPM an engine change is necessary.

3-84. ENGINE OVERSPEED DURING TAKE-OFF. If the engine overspeeds during take-off (not to be confused with momentary overspeed caused by power surge), the following action is recommended:

a. Operate the propeller governor selector switch in the "DECREASE RPM" position until the engine speed is controlled.

b. Throttle the overspeeding engine until the RPM is reduced below 2700.

c. If this procedure fails and power is necessary, push in the feathering button and when the RPM is within limits, pull the button out. This action can be repeated until a safe air speed is established. Reduce power and feather the propeller as soon as practical.

3-85. ENGINE OVERSPEED IN FLIGHT. If the engine overspeeds in flight, the following procedure will be used:

a. Retard throttle.

b. If overspeed cannot be reduced by throttling, attempt feathering, decrease air speed, lower flaps and gear, and establish minimum safe air speed.

c. If overspeed cannot be controlled, descend to a minimum safe altitude.

3-86. ENGINE OVERBOOST. If a turbo control system malfunction, wiring failure, or fuse failure oc-

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curs during take-off or flight a rapid rise in manifold pressure, often accompanied by engine overspeeding, may occur provided the turbo waste gate is forced towards the closed position by exhaust gas loads. If this occurs reduce power by throttling effected engine immediately. Occurrences of this nature may be minimized in frequency and seriousness by monitoring manifold pressure during high power operation, taking quick action to retard the throttle if a manifold pressure increase occurs.

3-87. TURBOSUPERCHARGER EMERGENCY OPERATION.

3-88. If a turbo control system failure occurs, reduce engine power to 30 inches manifold pressure, 2100 RPM, turn the turbo calibrating knob completely counterclockwise and check the turbo amplifier fuse. If blown replace it; if not blown, replace the amplifier. Allow time for the amplifier to warm up, then reapply power and turbo slowly and check the control system operation. If normal control cannot be regained, it may be possible to obtain substantial turbo output by allowing exhaust gas loads to position the waste gate. The waste gate will tend to assume a balanced position, approximately 20° from closed, when exhaust gas forces are allowed to close it slowly. This position will give effective turbo output for climb and cruise powers. In order to take advantage of this characteristic, reduce power on the engine, remove the amplifier fuse, and then slowly open the throttle until optimum results are achieved. With electrical power thus removed from the turbo control system the waste gate will be free to respond to exhaust forces, the only restraining factors being waste gate and motor friction.

CAUTION

Never take-off with a fuse or amplifier removed, or an amplifier or waste gate motor disconnected. This could permit the waste gate to close and result in overboost. If it is necessary to take-off with a faulty control system on one engine, it is recommended that the waste gate be wired in the open position with several strands of heavy safety wire; do not disconnect the waste gate motor mechanically when doing this. In flight, if a control system develops faults always reduce power before changing fuses, amplifiers, or in any way removing electrical power from the turbo control system.

3-89. FUEL SYSTEM EMERGENCY OPERATION.

3-90. FUEL TANK FAILURE. If a fuel tank ruptures, empty the tank in the following manner: Set all fuel selector switches to "Tank-and-Manifold-to-Engine," turn the boost pump switches of the ruptured tank to "EMERGENCY," and turn all other boost pump switches "OFF." When the ruptured tank is nearly empty, turn one of the boost pump switches in each main tank to "NORMAL." When the ruptured tank is empty turn the fuel selector switch to the "Manifold-to-Engine" position and turn the boost pump switches, for the ruptured tank, "OFF."

3-91. FUEL LINE FAILURE. If a fuel line between the engine and fuel selector valve is ruptured, turn the fuel selector switch to "Tank-to-Manifold" and use the fuel as needed. Feather the propeller and shut down the engine.

CAUTION

If an abrupt rise in the rate of fuel flow occurs, while operating at constant power, a fuel leak in the nacelle is indicated. Feather the propeller and move the respective fuel selector switch to "OFF."

3-92. ENGINE-DRIVEN FUEL PUMP FAILURE. In the event an engine-driven fuel pump fails, turn both boost pump switches to "NORMAL," or use boost pumps as necessary to maintain fuel pressure within operating limits for the tank that is supplying the engine.

3-93. FUEL TANK BOOST PUMP FAILURE. If both boost pumps fail in a main wing tank check that the respective selector switch is on "Tank-to-Engine." The engine-driven fuel pump will draw the fuel from the tank under most conditions.

3-94. ELECTRICAL SYSTEM EMERGENCY OPERATION.

3-95. MAIN INVERTER FAILURE. If the essential main inverter fails, an automatic change-over relay connects the spare main inverter to the essential bus, regardless of whether or not the secondary bus is energized. The essential bus amber warning light goes on. If the secondary main inverter fails, an automatic change-over relay starts the spare main inverter and connects it to the secondary bus. The secondary bus amber warning light goes on. If either automatic change-over relays fails, place the corres ponding inverter switch in the "SPARE INV" po tion. If two main inverters fail, at least one b

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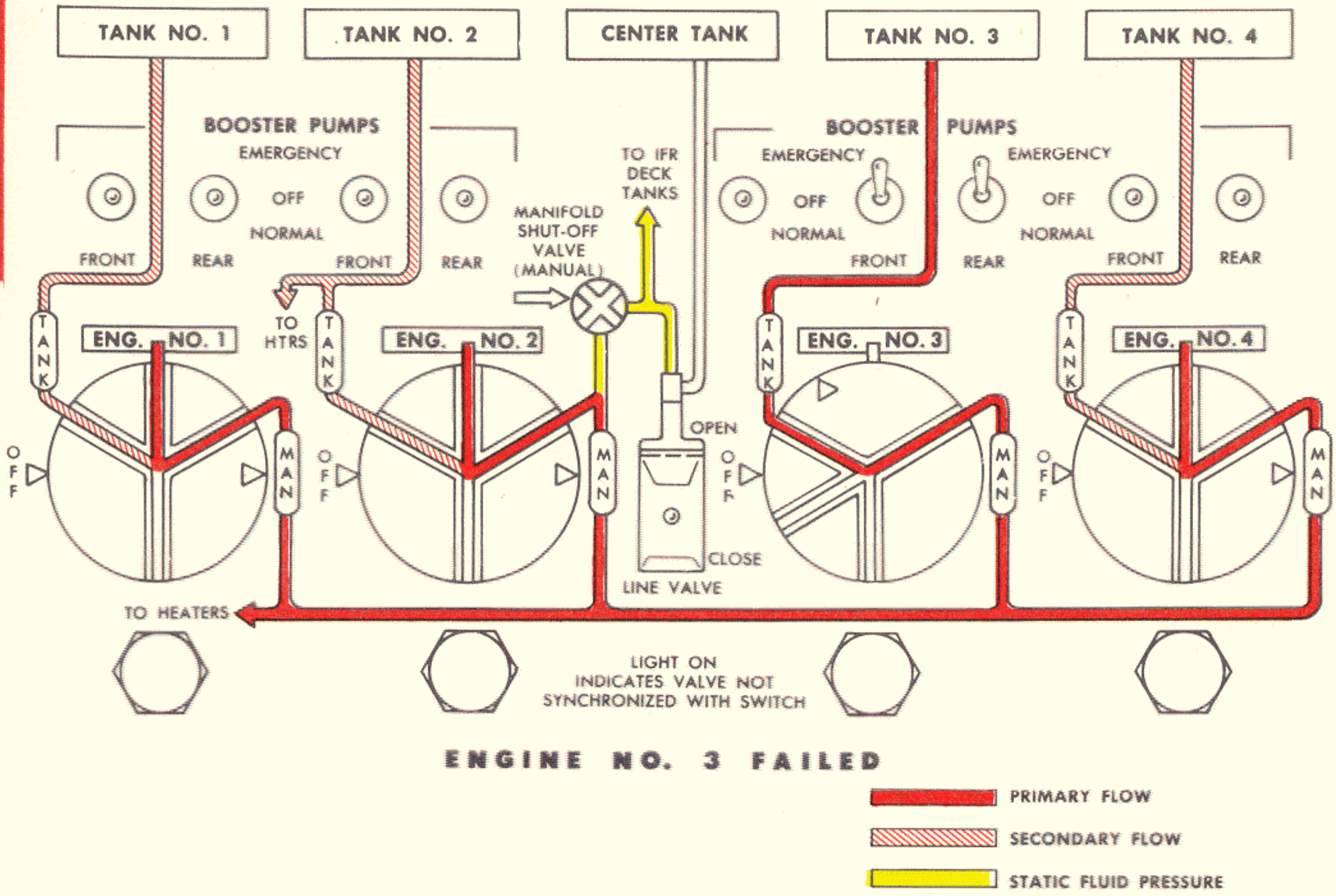

Figure 3-6. Fuel System Emergency Operation

de-energized. The corresponding power failure red warning lights go on. The secondary bus supplies power to radar equipment and fluorescent lights. The essential bus supplies all other AC equipment except the Nesa windows. This includes the following equipment: fuel quantity indicators, driftmeter, Loran receiver, IFF transmitter, high-range radio altimeter, turbosupercharger control, combustion heater ignition, autopilot repeater direction indicator, wing flap position indicator, hydraulic pressure gages, oil pressure gages, fuel pressure gages, cowl flap position indicators, fuel flow indicators, cabin air flowmeters, intercooler flap position indicators, torquemeters, pilot's directional gyro, and gyro horizon. The turn-and-bank indicator is still operative as its power is supplied by the DC system.

3-96. AUTOPILOT INVERTER FAILURE. If the normal autopilot inverter fails, an automatic change-over relay starts the spare autopilot inverter. The autopilot inverter amber warning light goes on. If the automatic change-over relay fails, place the autopilot inverter switch in the "SPARE INV" position. If both autopilot inverters fail, the autopilot and the navigator's direction repeater cease to function. The autopilot inverter power failure red warning light goes on. If necessary, pull the autopilot emergency disconnect handle.

3-97. INSTRUMENT TRANSFORMER FAILURE. If the instrument transformer fails, the following instruments will cease to function: wing flap position, fuel flow, cabin air flow, intercooler flap position, and torquemeters. Should this occur control engine power by manifold pressure and RPM instruments. Use auto lean or auto rich mixture setting to control fuel flow. Set cowl and wing flaps by visual observation. Hydraulic, oil and fuel pressure warning lights will still function in the event of a system malfunction.

3-98. PHASE ADAPTER FAILURE. If the phase adapter fails, the pilot's directional gyro and gyro horizon will cease to function.

3-99. ALTERNATOR FAILURE. If an alternator fails, turn on the good alternator and set the alternator selector switch to the desired position. If both alternators fail there will be no power available for Nesa window operation.

3-100. GENERATOR FAILURE. If generator overvoltage lights indicate that a generator has tripped off the line, the generator may be reset by positioning the respective generator switch to "RESET." When the operation of the affected generator is not

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necessary, it is recommended that the affected generator be left inoperative until the cause of the overvoltage has been determined.

3-101. The AC instruments listed below receive operating power from the airplane inverters; accordingly, a DC power failure results in these AC powered instruments becoming inoperative. The pointers on the indicators of the inverter powered instruments which operate on the autosyn principle will hold the position registered by the pointer at the time of power failure. These instruments are marked by an asterisk in the following list. The other instruments will return to zero or off-scale readings with the exception of the tachometers, and manifold pressure indicators which will continue to give normal indications since these instruments do not depend upon the airplane electrical system for power.

ENGINE INSTRUMENTS

AC	DC
*Fuel Flow	Carburetor Air Temperature
*Fuel Pressure	Oil Temperature
*Fuel Quantity	Oil Quantity
*Oil Pressure	Cylinder Head Temperature
*Torquemeter	
*Cowl Flap Position	
*Intercooler Flap Position	

FLIGHT INSTRUMENTS

AC	DC
Pilot's Gyro-Horizon	Copilot's Gyro-Horizon
*Cabin Airflow	Turn and Bank Indicator
*Hydraulic Pressure	Outside Air Temperature
*Magnesyn Compass Repeaters	
*Wing Flap Position	

3-102. THREE GENERATOR OPERATION. Three generators will supply enough power to operate all the DC equipment under normal conditions. As a precautionary measure the loadmeters should be checked frequently, especially when propeller deicers are operating.

3-103. TWO GENERATOR OPERATION. Operation with two generators will require more care, but under most conditions sufficient DC power is available. With propeller deicers operating, the auxiliary power plant must be started; all non essential DC equipment and the secondary inverter should be turned off. During landing, prior to extending the wing flaps or landing gear, the propeller deicers should be turned off. Do not extend or retract gear and wing flaps at the same time. Complete the operation of one system prior to operating the next system. Monitor DC loadmeters continually.

3-104. FAILURE OF ALL GENERATORS. If all generators fail it will be the result of a DC system fault or short circuit causing progressive overloading. This will result in burning out current limiters for each generator and possibly tripping of the overvoltage relays. Proceed as follows:

a. Turn off all inverters and all DC equipment. Do not move engine controls except throttles and mixture controls which should be set to "AUTO RICH." If turbo waste gates shift position control manifold pressure with throttles.

b. Maintain a safe heading and altitude using the pilot's turn-and-bank, airspeed, altitude, rate-of-climb indicators, and magnetic compass. This will allow time to trouble-shoot and remedy the fault.

c. The following equipment must be turned off.

1. Inverters
2. Alternators
3. All radios
4. Boost pumps
5. Heater switches
6. Autopilot
7. All aircraft lights except pilots' white instrument panel lights.
8. Do not operate any switches or controls except to set to the "OFF" position.
9. Turn generator switches "OFF."

d. Move all generator switches to "RESET" but do not move switches to "ON." Check all generators with voltmeter. Some generators will show normal voltage. Proceed to main power panel and check current limiters. Remove current limiters from no-voltage generators and install new current limiters on generators indicating correct voltage. Examine all current limiters carefully for burned out condition and voltage relays for scorched or hot condition for a clue to basic fault. Do not replace any system current limiters that are burned out.

e. Return to cockpit and turn on one generator showing normal voltage. Carefully monitor the loadmeter and turn on a second generator. Continue until operative generators are all on the DC bus system. Then turn on the essential inverter. Retard turbo boost selector lever to "O" and set fuel selector switches to "Tank-to-Engine." Be alert for sudden changes in engine operation as the control circuits are re-energized.

f. Turn on the ADF for use as a range and navigation receiver. In orderly sequence and required equipment, one unit at a time, constantly monitoring loadmeters to detect unusual fluctuations. Turn on only essential equipment. Continue to nearest landing field. Consider advisability of manually extending landing gear if two or less DC generators are operative. Do not use propeller deicers or reverse thrust on landing. If a landing emergency occurs, reverse inboard propellers only to prevent sudden bus failure again with possibility of unsymmetrical reverse power and consequent loss of directional control on runway.

3-105. <u>HYDRAULIC SYSTEM EMERGENCY OPERATION.</u>

3-106. In the event of engine-driven hydraulic pump failure or loss of pressure due to line failure, the

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hand pump can be used to charge the system. Rudder boost, windshield wipers, and nose wheel steering are not necessary to normal flight and landing, therefore turn them off. Check the controllable check valve handle for "NORMAL" position; service and emergency brakes are isolated from the remainder of the hydraulic system when the controllable check valve handle is in "NORMAL." Charge the brake systems with the hand pump as necessary to maintain brake pressure.

3-107. WING FLAP EMERGENCY OPERATION.

3-108. In case the wing flap motor used for normal operation fails, move the normal wing flap switch to "OFF" and hold the emergency wing flap switch, on the overhead panel, in the desired position. The emergency wing flap switch controls the auxiliary wing flap motor and by-passes all limit switches. Extend or raise the flaps until the desired degree is indicated on the wing flap position indicator. When raising the flaps stop them at 5 degrees; when lowering flaps stop them at 40 degrees and then very carefully inch the flaps to the extreme position.

3-109. AUTOMATIC PILOT EMERGENCY OPERATION.

3-110. Pull the autopilot emergency disconnect handle if the autopilot release buttons on the control wheels fail to disconnect the autopilot.

NOTE

The autopilot cannot be re-engaged in flight after using the emergency release handle.

3-111. LANDING GEAR EMERGENCY OPERATION.

3-112. MAIN LANDING GEAR EMERGENCY POWER OPERATION. If the main landing gear motor should fail, raise or lower the gear as follows:

a. Pull the red handle, near each emergency landing gear hand crank receptacle, to engage the clutch.

b. Install the portable auxiliary flap motor and operate the switch in the direction indicated on the switch cover.

c. Run the motor until the landing gear stops are hit and the motor clutch starts slipping (approximately 60 seconds required).

3-113. MAIN LANDING GEAR EMERGENCY MANUAL OPERATION. Extend the gear in the following manner:

a. Pull the red handle to engage the clutch.

b. Insert the crank and rotate 10 turns in the direction indicated.

c. Return the red handle to the original position.

d. Release the clutch by rapidly oscillating the crank. The gear will lower by gravity after the clutch is released.

CAUTION

After clutch is released do not attempt to re-engage the clutch or operate the gear for five seconds. This will allow time for the gear to free fall and prevent damage to the clutch mechanism or injury to the operator which would result if the clutch were re-engaged while the gear was free falling.

e. Pull the red handle to re-engage the clutch.

f. Rotate the crank in the direction indicated until the stops are hit and the lock is engaged.

CAUTION

Make certain that the down lock is engaged. The lock can be felt snapping into position after the stops are contacted.

3-114. Raise the gear in the following manner:

a. Pull the red handle to engage the clutch.

b. Insert the crank and rotate it in the direction indicated until the stops are contacted and the lock is engaged. (490 turns are required.)

CAUTION

Always reset the red pull handle after emergency operation is completed to allow electrical operation of the landing gear.

3-115. NOSE GEAR EMERGENCY OPERATION. Extend the nose gear in the following manner:

a. Disengage the motor clutch.

b. Remove the rubber plug from the socket and engage the crank through the two keyed sections by pressing down on the crank hub for the first full turn.

c. Rotate the crank through five turns. Remove the crank to permit free gear travel, pause 5 seconds; then re-engage the crank and drive the gear against stops. If not already engaged, this will set the lock with a preceptible snap. The full travel, including

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free travel, is 220 revolutions.

WARNING

Do not crank with the motor engaged. This will prevent the possibility of the motor starting suddenly with resultant injury to the operator.

3-116. Retract the gear as follows:

a. Disengage the clutch and assemble the crank as described in the preceding paragraph.

b. Crank the gear up. Approximately 220 turns of the crank are required to return the nose gear to the fully retracted position.

c. Replace the rubber plug.

CAUTION

Always return the motor clutch to the engaged position. To prevent damage to the motor by over-speeding, do not operate the motor with the clutch disengaged.

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Section IV Description and Operation of Auxiliary Equipment

4-1. CABIN PRESSURIZING, HEATING, AND VENTILATING SYSTEM.

4-2. GENERAL.

4-3. CABIN PRESSURIZING. Cabin pressurizing is provided to allow the crew to perform their duties at altitude with maximum efficiency. Pressurizing air (figure 4-1) is bled from the turbosupercharger of each engine and is supplied to the cabin through cabin air venturi tubes which limit the flow thereby preventing an excessive cabin air flow with resultant starving of the engines. Control of the cabin pressure altitude and pressure rate-of-change is accomplished by metering the discharge of air from cabin to atmosphere through three cabin pressure regulators. These regulators are designed to automatically maintain the selected cabin pressure altitude and pressure rate-of-change when the selections are within the capabilities of the pressurizing system. The recommended cabin altitude to maintain is 8000 feet for daytime operation and 5000 feet for nighttime operation.

4-4. Three methods of preventing structural damage as a result of excessive positive or negative pressure are incorporated into the system. The cabin pressure regulators automatically limit the differential pressure between cabin and atmosphere to 13.4 inches Hg (approximately 15,000 feet altitude differential) regardless of the cabin altitude setting. A cabin pressure relief valve in the forward end of the lower nose compartment will automatically dump cabin air into the nose wheel well whenever a cabin pressure regulator malfunction increases the differential pressure above 14 inches Hg. This valve can be adjusted by use of a crank (1, figure 4-2) under the engineer's seat when it is desired to manually control the cabin pressure. A fully automatic vacuum relief valve is located in the tail compartment bulkhead.

4-5. An emergency cabin pressure release valve in the aft end of the lower nose compartment, when actuated, will rapidly dump cabin pressure into the nose wheel well. This valve is opened by a cable system terminating in a pull handle on the engine control stand. It can be reset only by relatching a hinged plate on the valve itself.

4-6. CABIN HEATING AND VENTILATING. During pressurized flight, air for cabin heating, including control cabin window defrosting, is obtained from the cabin pressurizing system. This air is passed through two combustion-type body heaters located on the ceiling of the lower forward cargo compartment. A cabin air distribution manifold (figure 4-1), between the body heaters, directs the heated air into ducts which distribute it throughout the airplane. Fuel for the body heaters is supplied by the No. 2 tank or the manifold. This fuel is controlled through an auxiliary fuel panel in the left wing. The panel contains a normal and an alternate set of fuel shutoff valves and fuel regulators for the heaters and APP. Further control of the fuel to the body heaters is provided by fuel cycling valves which are electrically actuated through a heat control rheostat or through temperature sensing elements in the heaters and ducts.

4-7. Two electrically operated ventilating fans have been installed to circulate the air in the control cabin. The bulkhead mounted fan, located above and aft of the navigator's station draws air from the main cargo compartment through the fan housing to vanes which can be adjusted to deflect the oncoming air. A door at the end of the housing can be closed against spring pressure to completely close off the vent opening. The second fan is mounted above and aft of the engineer's station and directs air flow forward between the pilots' seats at head level. Control switches (29, figure 1-15) for both fans are on the engineer's instrument panel. Circuit breakers are on the overhead circuit breaker panel (1, figure 1-24).

4-8. During ground operations, air for heating and ventilating is supplied by two ground blowers. Fresh air is drawn through an inlet in the leading edge of each inboard wing by the blowers and passes through cabin air selector valves into the normal pressurizing lines. This air is also ducted to the combustion chambers of the body heaters. Fusible fire valves in the combustion air lines will close if reverse combustion air flow creates an overheat condition. Oleo actuated microswitches prevent use of the ground blowers when the airplane is airborne.

4-9. During unpressurized flight, air for heating and ventilating is obtained by picking up ram air in the ground blower inlets. This air passes through the ground blower ducts and the cabin air selector valves into the normal pressurizing lines.

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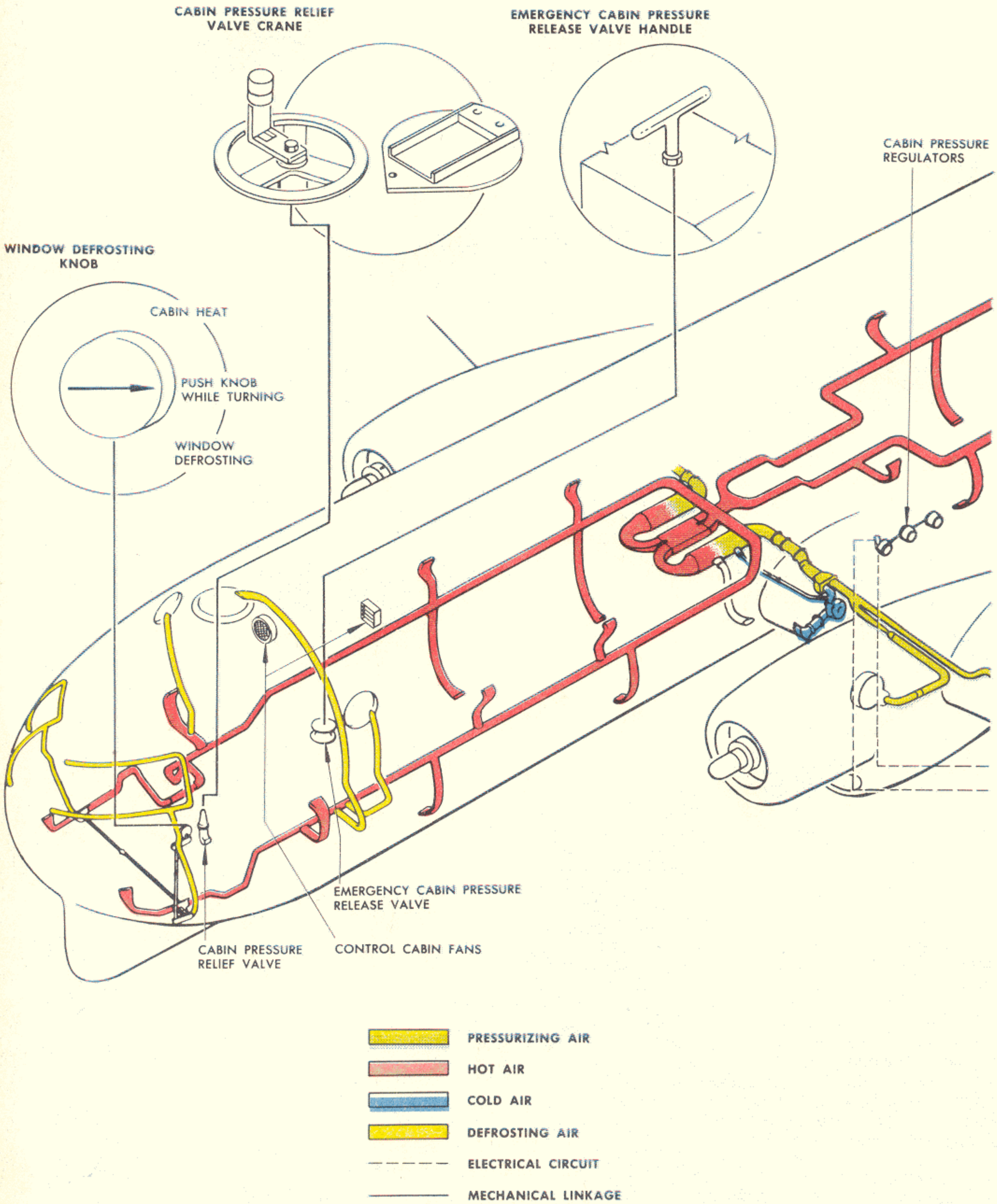

Figure 4-1. Cabin Pressurizing, Heating, and Ventilating System (Sheet 1 of 2 Sheets)

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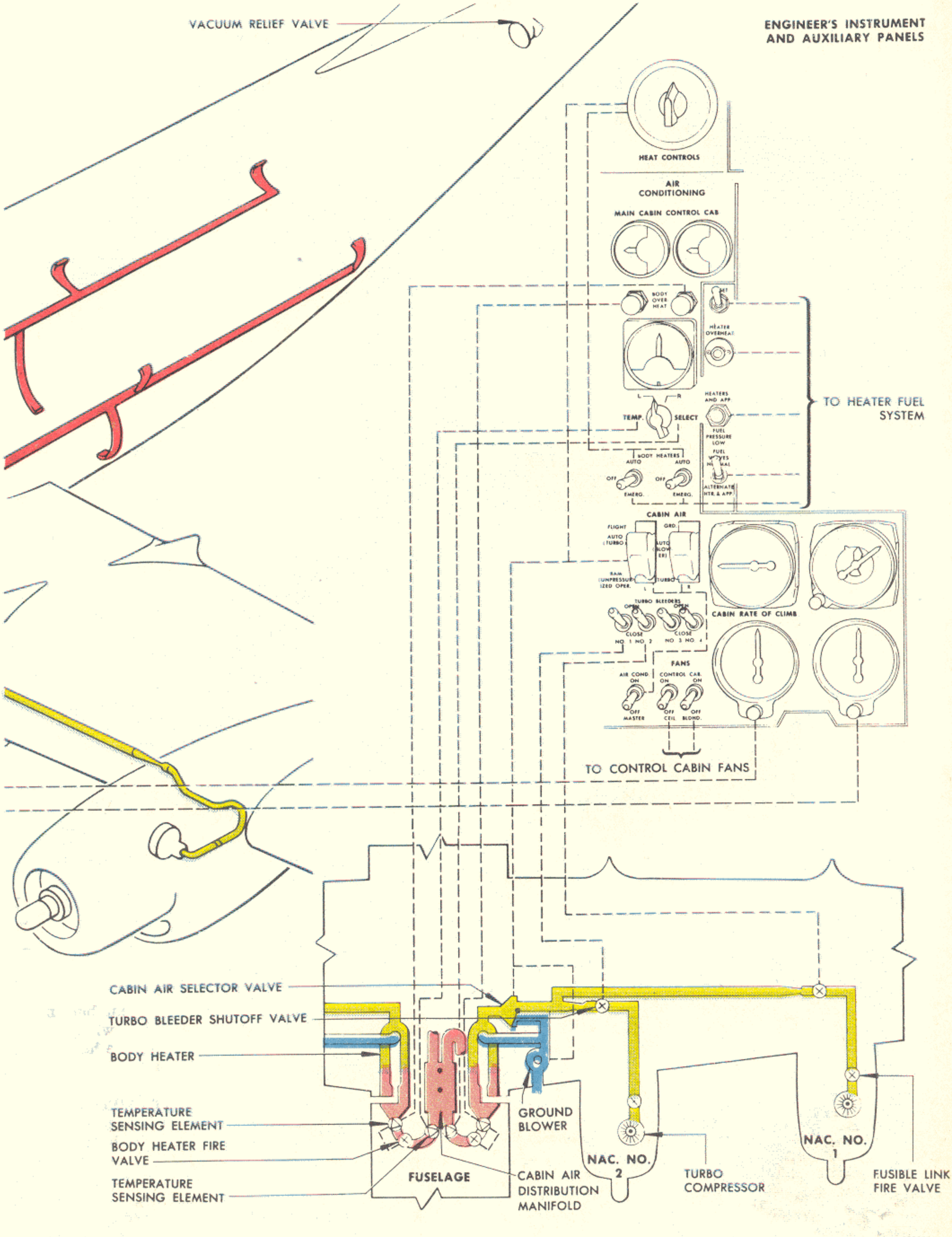

Figure 4-1. Cabin Pressurizing, Heating, and Ventilating System (Sheet 2 of 2)

4-10. CABIN PRESSURIZING, HEATING, AND VENTILATING SYSTEM CONTROLS.

4-11. AIR CONDITIONING MASTER SWITCH. An "ON--OFF" air conditioning master switch (63, figure 1-15) is on the engineer's instrument panel. Power to the heat control rheostat and the cabin air selector switches is provided when the air conditioning master switch is in the "ON" position. When the switch is in the "OFF" position these circuits are de-energized.

4-12. CABIN ALTITUDE SELECTOR. A cabin altitude selector (28, figure 1-15) is on the engineer's instrument panel. This selector has a dial and needle showing the cabin pressure altitude selection in either inches Hg or 1000 feet of altitude. A knurled knob at the bottom of the dial is used to adjust the needle to the desired cabin pressure altitude. This setting is electrically transmitted to the cabin pressure regulators which automatically maintain the selected setting. Power for the cabin altitude selector control circuit is obtained through a circuit breaker on the forward power panel (5, figure 1-24).

4-13. CABIN PRESSURE RATE-OF-CHANGE SELECTOR. A cabin pressure rate-of-change selector (29, figure 1-15) is on the engineer's instrument panel. This selector is similar in appearance to the cabin altitude selector except that it shows the cabin pressure rate-of-change in either inches Hg per minute or 100 feet of altitude per minute. The knurled knob is used to set the cabin pressure rate-of-change which the cabin pressure regulators are to maintain during any change in cabin altitude. Power for the selector circuit is obtained through a circuit breaker on the forward power panel (5, figure 1-24).

4-14. TURBO BLEEDER SWITCHES. Four "OPEN--CLOSE" turbo bleeder switches (66, figure 1-15), one for each turbo bleeder shutoff valve, are on the engineer's instrument panel. These switches, when positioned to "OPEN" or "CLOSE," will actuate the valves to the corresponding position. Power to the switches is obtained through a circuit breaker on the overhead circuit breaker panel (1, figure 1-24) and an oil, fuel, hydraulic oil, and cabin air bleeder fire shutoff switch (12, figure 1-12) on the overhead panel.

4-15. CABIN AIR SELECTOR SWITCHES. Two guarded switches (70, figure 1-15), marked "FLIGHT GROUND AUTO--RAM TURBO," on the engineer's instrument panel are used to control the left and right cabin air selector valves and the ground blowers. When the switches are in the "FLIGHT GROUND AUTO" position and the airplane is on the ground the cabin air is supplied by the ground blowers. During flight, with the switches in the "FLIGHT GROUND AUTO" position, the cabin air is supplied by the turbosuperchargers. When the switches are in the "RAM TURBO" position cabin air is supplied during flight by ram air passing through the ground air blower duct. When the airplane is on the ground, with the switches in the "RAM TURBO" position, cabin air is supplied by the turbosuperchargers. The ground blower power circuits are protected by circuit breakers on the main circuit breaker panel (9, figure 1-24).

4-16. BODY HEATER SWITCHES. Two "AUTO--OFF--EMERG." body heater switches (72, figure 1-15) are on the engineer's instrument panel. These switches control the fuel and ignition circuits to the body heaters. When the switches are in the "AUTO" position, the fuel and ignition circuits are energized through the heat control rheostat, the air conditioning master switch, a body heater fire switch (12, figure 1-12) and a circuit breaker on the forward power panel (5, figure 1-24). When the switches are in the "EMERG" position, the heat control rheostat and the air conditioning master switch are by-passed and power is supplied through only the circuit breaker and body heater fire switch.

4-17. HEAT CONTROL RHEOSTAT. A heat control rheostat (4, figure 1-16), marked with "COOL" and "HEAT" ranges, is on the engineer's auxiliary panel. This rheostat is used to set the operating cycle of the body heaters, thereby controlling the over-all heat output. Power to the heat control rheostat is supplied through the air conditioning master switch, body heater fire switch, and a circuit breaker on the forward power panel (5, figure 1-24). To prevent excessive heater temperatures, the circuits from the rheostat to the fuel control valves and ignition system are interrupted by cycling switches which open when the heater duct temperature reaches 193° C. These cycling switches automatically close and put the heaters back in operation as soon as they cool. If a dangerous overheat condition arises, overheat switches both upstream and downstream of the heaters will close and energize overheat relays. When these relays are energized they will close the cabin air fire valves downstream of the heaters, close off the heater fuel and ignition systems, and will illuminate the heater overheat warning lights. The relays will lock out the heaters until the overheat condition is eliminated and a reset switch is actuated.

4-18. HEATER OVERHEAT TEST BUTTON. This switch (18, figure 1-15), located on the engineer's instrument panel, is used to check the operation of the body and anti-icing overheat warning systems. When this button is pressed, the overheat relay is tripped lighting the overheat warning light and closing the heater fuel valves. The circuit breaker for this circuit is on the forward power panel (5, figure 1-24).

NOTE

Actuation of the heater overheat test button will close off all pressurizing air flow. This flow can be restored by positioning the heater overheat reset switch to "RESET."

4-19. HEATER OVERHEAT RESET SWITCH. This switch (11, figure 1-15) located on the engineer's instrument panel, releases heaters which have been locked out by the closing of the overheat relays. When moved to "RESET," locked overheat relays are tripped back allowing the automatic heater regulator system to operate. Circuit breakers are located on the overhead circuit breaker panel (1, figure 1-24).

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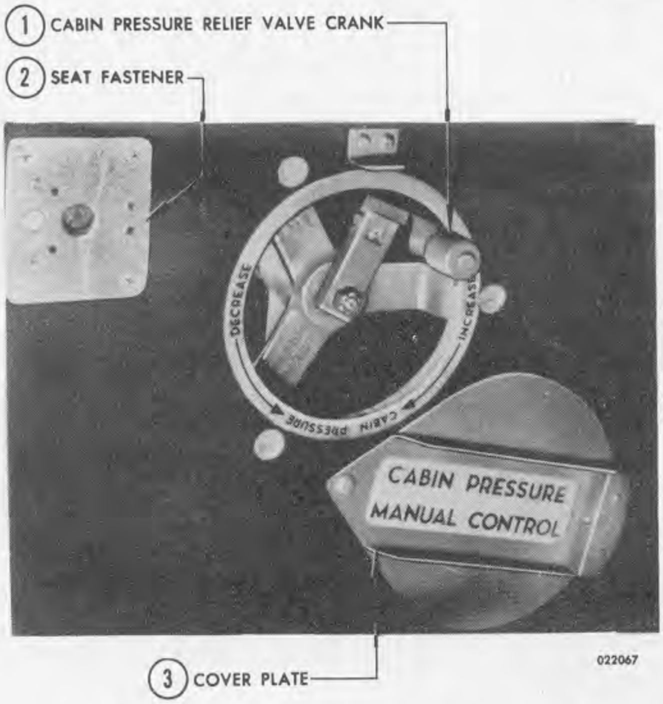

Figure 4-2. Cabin Pressure Manual Control Crank

4-20. HEATER AND AUXILIARY POWER PLANT FUEL VALVE SWITCH. This switch (23, figure 1-15) located on the engineer's instrument panel, selects one of two fuel valves through which fuel is taken for the operation of the anti-icing and cabin heaters and the auxiliary power plant. With this switch in the "NORMAL" position, fuel for the heaters and APP is taken directly from the No. 2 engine tank. In the "ALTERNATE" position, heater and APP fuel is drawn through an alternate fuel shutoff valve from the fuel tank manifold. The circuit breaker for this switch is located on the overhead circuit breaker panel (1, figure 1-24).

4-21. CABIN PRESSURE RELIEF VALVE CRANK. A crank (1, figure 4-2) recessed into the floor under the engineer's seat is mechanically linked to the cabin pressure relief valve. This crank is used to manually control the escape of air from the cabin in case the automatic cabin pressure regulators malfunction. The recess is marked with "INCREASE" and "DECREASE" arrows to indicate the cabin pressure change that will result when the crank is rotated. The cabin pressure relief valve must be manually adjusted by the ground crew following any use of the crank during flight.

4-22. EMERGENCY CABIN PRESSURE RELEASE VALVE HANDLE. A handle (41, figure 1-13) on the engine control stand is cable connected to the emergency cabin pressure release valve. Pulling this handle will open the valve and rapidly dump the cabin pressure into the nose wheel well. The valve and handle are reset by relatching the hinged plate on the release valve.

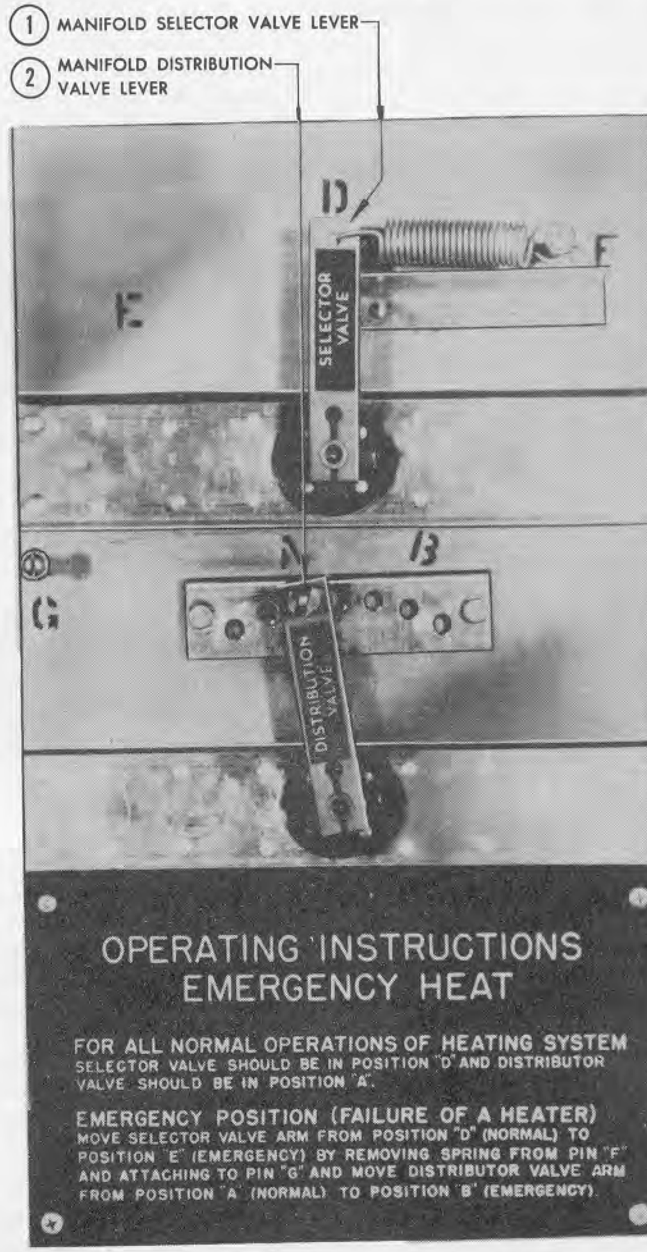

Figure 4-3. Cabin Air Distribution Manifold

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4-23. CABIN AIR DISTRIBUTION MANIFOLD. A manifold with a selector valve lever (1, figure 4-3) and a distribution valve lever (2, figure 4-3) is between the body heaters in the lower forward cargo compartment. The selector valve lever positions are marked "D" and "E" and the lever is held in place by a spring which is attached to pins marked "F" and "G." In case of a heater failure, the selector valve is used to mix the flow of heated air with unheated air. The normal position is with the selector valve lever on "D" and the spring on pin "F"; the mixing (emergency) position is with the selector valve lever on "E" and the spring on pin "G." The distribution valve lever controls the ratio of flow of mixed air between the control cabin and cargo compartment. The distribution valve lever positions are marked "A" (normal) and "B" (emergency) with additional positions between and beyond these two. The airflow to the control cabin is increased in relation to the airflow to the cargo compartment as the distribution valve lever is rotated counterclockwise. When the lever is in position "A" the entire output of the left body heater and a part of the output of the right body heater is supplied to the control cabin and forward areas. However, if either heater has failed and it is desired to have heat in the cargo compartment, the distribution valve lever should be moved to position "B."

4-24. CONTROL CABIN FAN SWITCHES. Two switches (30, figure 1-15) on the engineer's auxiliary panel are used to control the ceiling fan and the bulkhead fan in the control cabin. These switches are off in the down position and on in the up position. Power is supplied to the switches through two circuit breakers on the overhead circuit breaker panel (1, figure 1-24).

4-25. CABIN PRESSURIZING, HEATING, AND VENTILATING SYSTEM INDICATORS.

4-26. CABIN ALTITUDE AND DIFFERENTIAL PRESSURE INDICATOR. A cabin altimeter (26, figure 1-15) on the engineer's instrument panel indicates the cabin pressure altitude in thousands of feet.

4-27. CABIN RATE-OF-CLIMB INDICATOR. A cabin rate-of-climb indicator (27, figure 1-15) on the engineer's instrument panel indicates the rate of pressure change in the cabin in thousands of feet per minute.

4-28. CABIN AIR FLOW INDICATORS. The approximate pressure differential between the upstream and downstream sides of the cabin air venturi tubes is indicated in inches Hg on two dual reading cabin air flow indicators (46, figure 1-15) on the engineer's instrument panel. The differential pressure which will result in the desired cabin air flow is shown on these indicators by a green range.

4-29. CABIN TEMPERATURE INDICATOR. The control cabin and main cabin temperatures in degrees centigrade are indicated by a dual reading cabin temperature indicator (10, figure 1-15) on the engineer's instrument panel. The indicating circuits are protected by a circuit breaker on the overhead circuit breaker panel (1, figure 1-24).

4-30. BODY HEATERS TEMPERATURE INDICATOR. The outlet duct temperature of each of the body heaters is indicated in degrees centigrade by an indicator (21, figure 1-15) on the engineer's instrument panel. A "L--R" selector switch (24, figure 1-15) under the indicator is used to select the heater on which the indication is to be taken. The indicating circuits are protected by a circuit breaker on the overhead circuit breaker panel (1, figure 1-24).

4-31. BODY HEATER OVERHEAT WARNING LIGHTS. Two red warning lights (9, figure 1-15) on the engineer's instrument panel show when the left or right body heater overheat relays have been energized. The lights will remain illuminated, even when the overheat condition has been eliminated, until the heater overheat reset switch has been actuated.

4-32. HEATER AND AUXILIARY POWER PLANT FUEL PRESSURE WARNING LIGHT. A red warning light (20, figure 1-15) on the engineer's instrument panel will illuminate when the body heater, anti-icing heater, and APP fuel pressure is less than 12 PSI. Protection for the warning circuit is provided by a circuit breaker on overhead circuit breaker panel (1, figure 1-24).

4-33. CABIN PRESSURIZING, HEATING, AND VENTILATING SYSTEM NORMAL OPERATION.

4-34. GROUND OPERATION. The following steps are necessary to obtain ground ventilation:

a. Check cabin air distribution manifold valve levers in their normal positions.
b. Have power on airplane.
c. Airplane master switch "ON."
d. Air conditioning master switch "ON."
e. Cabin air selector switches "FLIGHT GROUND AUTO."
f. Control cabin fan switches on (if desired).

4-35. With ground ventilation obtained, the following steps are necessary to obtain heating:

a. Have fuel pressure from No. 2 tank or manifold available.
b. Move heat control rheostat into the "HEAT" range.
c. Check that the body heater overheat warning lights are not illuminated.
d. Heater fuel valve switch "NORMAL"; check that heater fuel pressure warning light is not illuminated.
e. Body heater switches "AUTO"; the body heaters should now be operating.

CAUTION

Energize the main inverter before placing the heaters in operation, to prevent unignited fuel from accumulating in heater combustion chambers.

f. Moniter the body heater temperature indicator; the heaters should cycle at approximately 176° C.
g. When the desired cabin temperature is being approached, rotate the heat control rheostat toward the "COOL" range.

CAUTION

During take-off and for at least two minutes prior to landing the heaters should be turned off. This will prevent overheat conditions from arising because of low ventilating air-flow through the heaters on take-off or reversed combustion air-flow during reversed propeller operation on landing.

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1 PILOT AND COPILOT SLIDING WINDOWS
2 CABIN PRESSURE RELIEF VALVE
3 PRESSURE TEST INLETS
4 ASTRODOME
5 PYROTECHNIC PISTOL MOUNT
6 EMERGENCY CABIN PRESSURE RELEASE VALVE
7 AUXILIARY POWER PLANT EXHAUST
8 BATTERY SHIELD
9 FORWARD CARGO DOOR
10 BULKHEAD DOOR
11 BOOM POD
12 VACUUM RELIEF VALVE
13 DRAIN PLUGS
14 ESCAPE HATCHES
15 AFT ENTRY DOOR
16 CABIN PRESSURE REGULATORS
17 FORWARD ENTRY DOOR
18 DRIFTMETER DOME
19 DRIFT SIGNAL CHUTE

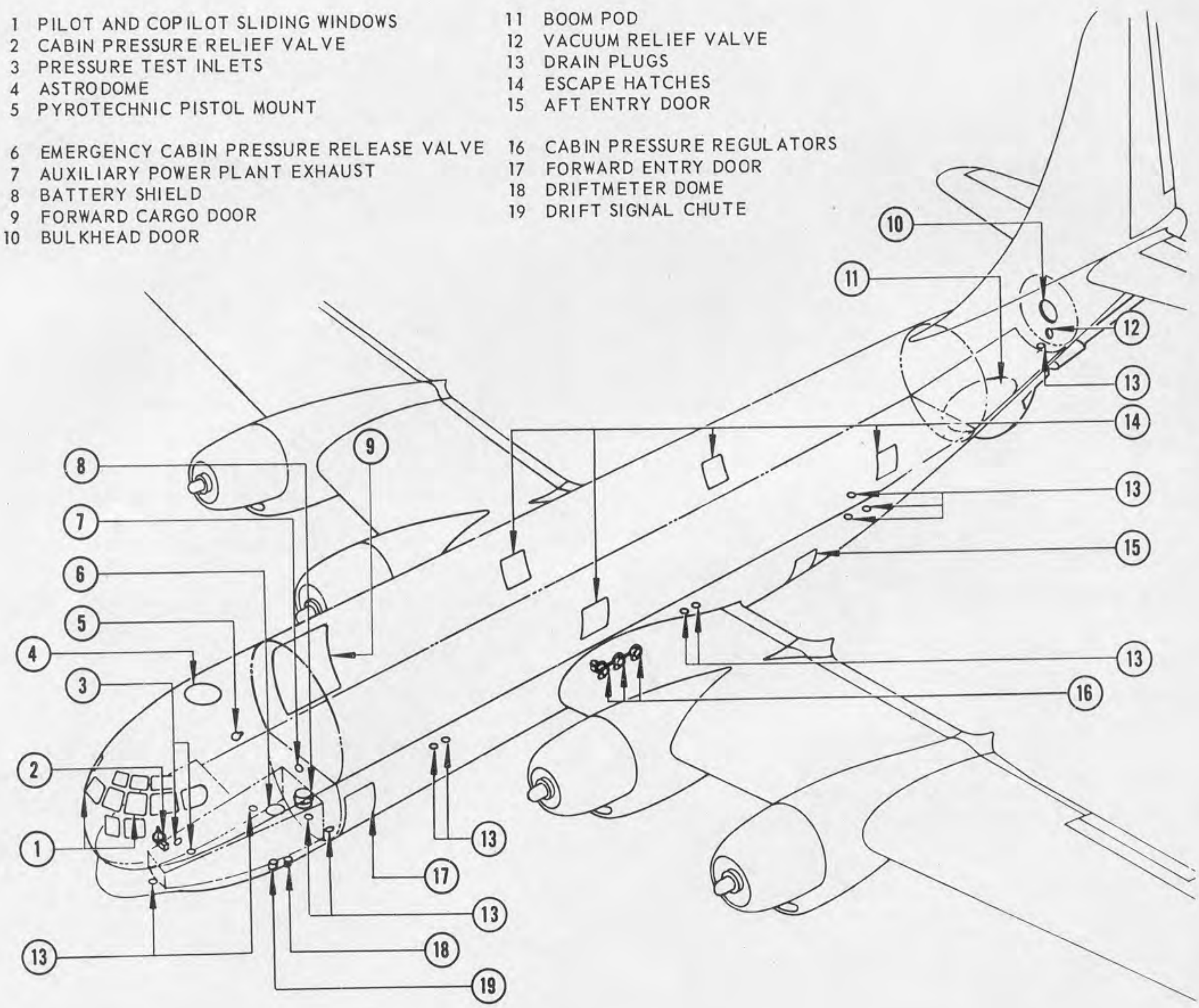

Figure 4-4. Cabin Pressure Check Points

4-36. FLIGHT OPERATION. There are several combinations of pressurizing, heating, and ventilating available during flight. These are: Ram air ventilating with or without heating, and pressurizing with or without heating. The steps necessary to obtain ram air ventilation and the steps necessary to set up heating during either ram air ventilating or pressurizing are the same as those used during ground operation. To set up pressurizing during flight, or on the ground before the start of a flight, the following steps should be used:

a. If possible, determine the cruise altitude and destination altitude before flight; decide on a cabin altitude for the flight.

b. Check that all cabin openings are closed including the cabin pressure relief valve, emergency cabin pressure release valve and the cabin pressure check points (figure 4-4).

NOTE

Some cabin pressure check points can be checked on the ground only.

c. Check that the shutoff cocks on the cabin pressure regulators are open.

d. Set the cabin altitude selector to departure station elevation plus 1000 feet; this will preclude the possi-

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bility of a crash landing on take-off with a partially pressurized cabin.

e. Check that the heater overheat warning lights are not illuminated.

f. During warm-up set the cabin rate-of-change selector to the "MAX" position for at least 3 minutes, then return it to "O"; this will allow time for the cabin pressure regulators to adjust themselves to the cabin altitude selection.

g. During climb reset the cabin altitude selector to the cruising cabin altitude and reset the rate-of-change selector to the desired value.

h. Turbobleeder switches "OPEN"; check that cabin air flow comes to within the green range.

i. During flight monitor the cabin altimeter, cabin rate-of-climb indicator and cabin air flow indicators; when changing the cabin altitude selector, first return the cabin rate-of-change selector, to "O" reset the cabin altitude selector, then reset the cabin rate-of-change selector.

j. During let-down select a cabin altitude slightly above destination station elevation so that the cabin will be unpressurized during landing.

k. Pull the emergency cabin pressure release valve handle before opening the doors.

4-37. SHUTDOWN. Position the air conditioning master switch, the turbo bleeder switches, and the body heater switches to "OFF."

CAUTION

Heaters must be purged with air after being shut down. During flight, heaters are automatically purged by ram air to the combustion chambers and by the normal flow of cabin ventilating air over the heaters. However, on the ground special care must be taken to purge the heaters with ground blowers. Ground blowers should be allowed to run for several minutes after heaters are shut down.

4-38. CABIN PRESSURIZING, HEATING, AND VENTILATING SYSTEM EMERGENCY OPERATION.

4-39. EXCESSIVE PRESSURE. A cabin pressure regulator malfunction resulting in an excessive pressure will cause the cabin pressure relief valve to open. When this occurs a loud hissing noise can be heard. If the malfunction cannot be corrected, the cabin pressure can be manually controlled by turning the cabin pressure relief valve crank in the desired direction.

4-40. INSUFFICIENT PRESSURE. In the event that cabin pressure falls below 19 inches Hg (12,000 feet indicated on the cabin altimeter), the following steps should be taken:

a. All crew members use oxygen.

b. Check air conditioning circuit breakers on overhead circuit breaker panel and forward power panel.

c. Check cabin openings for closure as shown on figure 4-4.

d. Check that heater overheat warning lights are not illuminated.

e. Check that the cabin air flow is within the green range; if flow is low, readjust power settings (if possible) to bring it into the green range.

f. If malfunction can be corrected, repressurize in the normal manner.

4-41. INSUFFICIENT HEATING. The possible malfunctions that could result in insufficient heating are covered in the following paragraphs.

4-42. If the heater fuel pressure warning light illuminates, proceed as follows:

a. Check circuit breakers.

b. Heater fuel valve switch "ALTERNATE."

c. If fuel pressure is still low, turn the fuel booster pump switch to "EMERGENCY" for the No. 2 tank or for any tank supplying the fuel system manifold.

4-43. If a low heater duct discharge temperature occurs, proceed as follows:

a. Move the heat control rheostat to the maximum "HEAT" position.

b. Check circuit breakers.

c. Actuate heater overheat reset switch to "RESET."

d. If heater does not come up to temperature, position the body heater switch for the malfunctioning heater to "EMERGENCY."

4-44. If a low cabin temperature occurs with normal heater duct discharge temperatures, proceed as follows:

a. If in pressurized flight, check cabin air flow.

b. If in unpressurized flight, position the cabin air selector switches to "RAM AIR OPEN."

4-45. If either body heater overheat warning light illuminates, proceed as follows:

a. Position the respective body heater switch "OFF"; this will prevent damage which could result if the heater lock-out circuit failed.

b. Allow heater to cool.

c. Check circuit breakers.

d. Reposition body heater switch to "AUTO"; actuate heater overheat reset switch to "RESET."

e. If heater still overheats, repeat procedure but reposition the body heater switch to "EMERG." after the cooling period.

f. If heater still overheats, reposition body heater switch to "OFF."

4-46. If one of the body heaters cannot be retained in operation, proceed as follows:

a. Move the distribution manifold selector valve lever from position "D" to position "E" by moving the spring from pin "F" to pin "G."

b. Move the distribution valve lever from position "A" to position "B."

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4-47. ANTI-ICING SYSTEMS.

4-48. GENERAL.

4-49. The anti-icing systems consist of the surface anti-icing system, the window anti-icing system, the propeller anti-icing system, and the pitot-head anti-icing system.

4-50. SURFACE ANTI-ICING SYSTEM. The surface anti-icing system acts as a deicer as well as an anti-icer since it can be used to remove snow and ice when the airplane is on the ground as well as preventing (and removing) ice in flight. The surface anti-icing system on this airplane is divided into three individual systems with one system in the empennage and one system in each wing. These are thermal systems using heated air. Air is taken into the system through ram air scoops in the leading edges of the wings and the dorsal fin. This air is heated by gasoline combustion heaters which use fuel from the main fuel system. The heated air is then directed to corrugated inner surfaces of the wing and empennage leading edges where heat transfer to the leading edges accomplishes the deicing. The heaters are turned on manually, but once started, the system operates automatically with automatic cycling of the heaters, individually and in groups, to maintain proper outlet air temperature; automatic warning lights indicating overheat and low fuel pressure conditions; differential pressure switches which turn off the wing heaters in the event of insufficient air flow across the heaters; and, in the empennage system, automatic blowers for ground operation. Manual controls are also provided for both emergency and normal operation.

4-51. PROPELLER ANTI-ICING SYSTEM. The propellers on this airplane are electrically deiced by means of integral prop blade heating elements. Controlled by a single switch, this system deices the propellers one at a time by means of a timer, all blades of one propeller being deiced simultaneously. During operation of the system the propeller being deiced is indicated by two tab-window type indicators on the engineer's instrument panel. An alternate timer for the system is in the lower forward cargo compartment, located next to the normal timer for accessibility when needed.

4-52. WINDOW ANTI-ICING SYSTEM. Seven of the front and side windows in the center row of windows in the control cabin are deiced by means of electrical (Nesa) window heat. Power for this heating is supplied by two engine-driven alternators. The use of this alternator power, which is also used by radar equipment on the airplane, is determined by a bus selector switch and the voltage delivered to the windows is determined by a window heat selector switch. In addition to the Nesa window heating the windows in the control cabin can be defrosted by heated air from the cabin heating system.

4-53. PITOT-HEAD ANTI-ICING SYSTEM. Ice formation on the pitot-heads is prevented or removed electrically by electric heating elements in each of the two pitot-heads.

4-54. ANTI-ICING SYSTEMS CONTROLS.

4-55. MASTER ANTI-ICE SWITCH. This switch (14, figure 1-15) controls the normal automatic regulating system. In the "ON" position, the cycling switches, pressure differential switches, empennage ground blowers and the overheat control and warning systems all operate. When this switch is in the "OFF" position, there is no automatic regulation of the surface anti-icer system. The master anti-ice switch is located on the engineer's instrument panel with its circuit breaker located on the overhead circuit breaker panel (1, figure 1-24).

4-56. COMBUSTION HEATER FUEL VALVE SWITCHES. These eight switches (22, figure 1-15) control the individual heater fuel valves, the action of the valves being determined by the automatic regulating system when the switches are in the "AUTO" position and the valves closed when the switches are in the "OFF" position. These switches are located on the engineer's instrument panel; their circuit breakers on the overhead circuit breaker panel (1, figure 1-24).

4-57. LIMITED ANTI-ICE SWITCHES. These two switches, (13, figure 1-15), located on the engineer's instrument panel, control selective deicing. The switch for the wing systems, when in the "OUTBD WING ONLY" position shuts off the heated air to the inboard wing sections. When this switch is at the "INBD & OUTBD WING" position, both inboard and outboard wing sections are deiced. The empennage switch, when set at "DORSAL & STAB ONLY" shuts off the flow of heated air to the vertical stabilizer. When at the "FIN DORSAL STAB" position, all the empennage leading edges are deiced. Circuit breakers for the limited anti-icing circuits are on the overhead circuit breaker panel (1, figure 1-24).

4-58. HEATER OVERHEAT RESET SWITCH. This switch (11, figure 1-15) located on the engineer's instrument panel, releases heaters which have been locked out by the closing of the overheat relays. When moved to "RESET," locked overheat relays are tripped back allowing the automatic heater regulator system to operate. Circuit breakers are located on the overhead circuit breaker panel (1, figure 1-24).

4-59. WING HEATER GROUND OPERATION SWITCH. This switch (15, figure 1-15) located on the engineer's instrument panel allows ground operation of the wing anti-icing systems with a lower air flow across the heaters than the minimum otherwise allowed by the differential pressure switches of the wing systems, by overriding the action of the differential pressure switch. This switch, which shuts off the heaters at a

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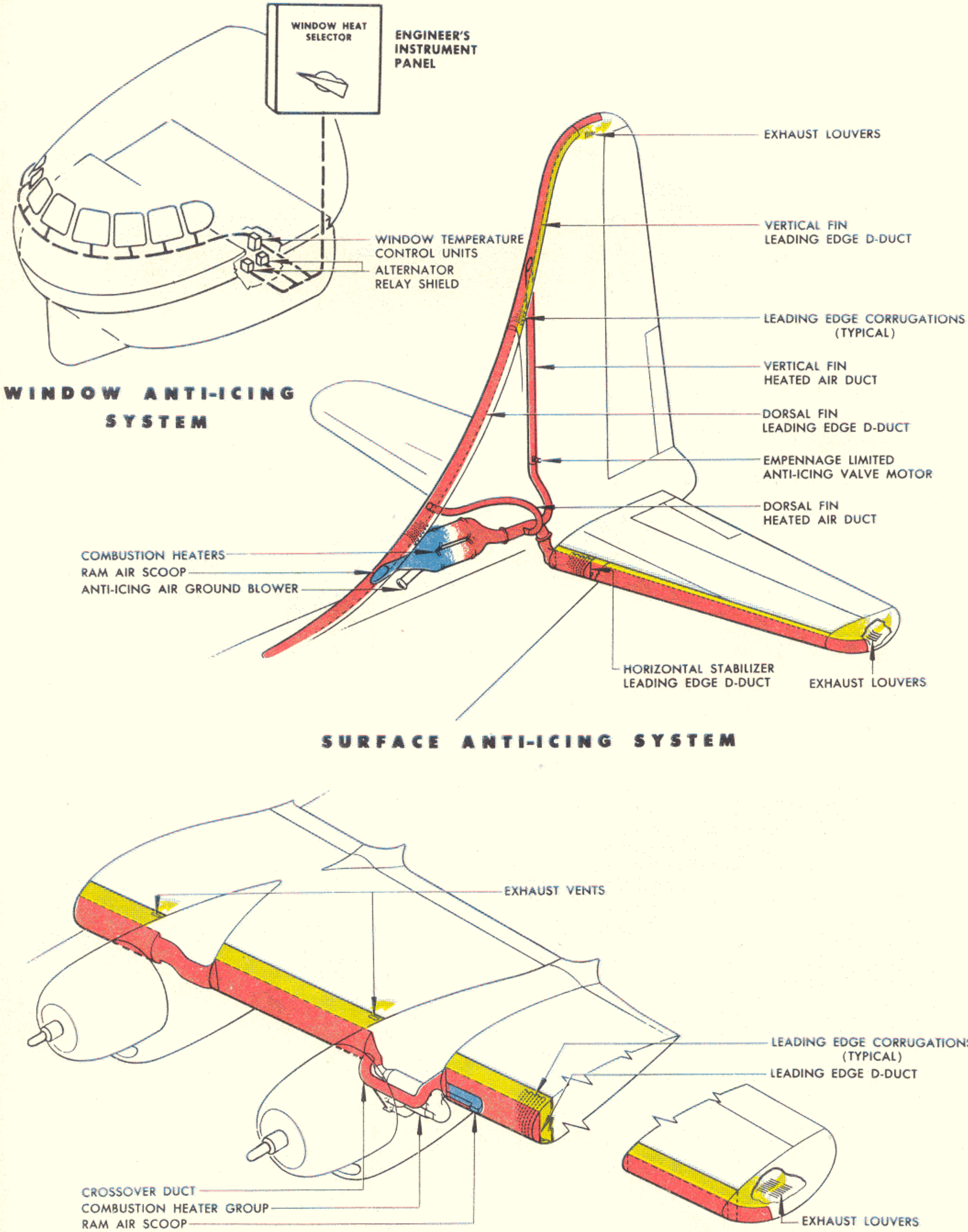

Figure 4-5 (Sheet 1 of 2 Sheets). Anti-icing System

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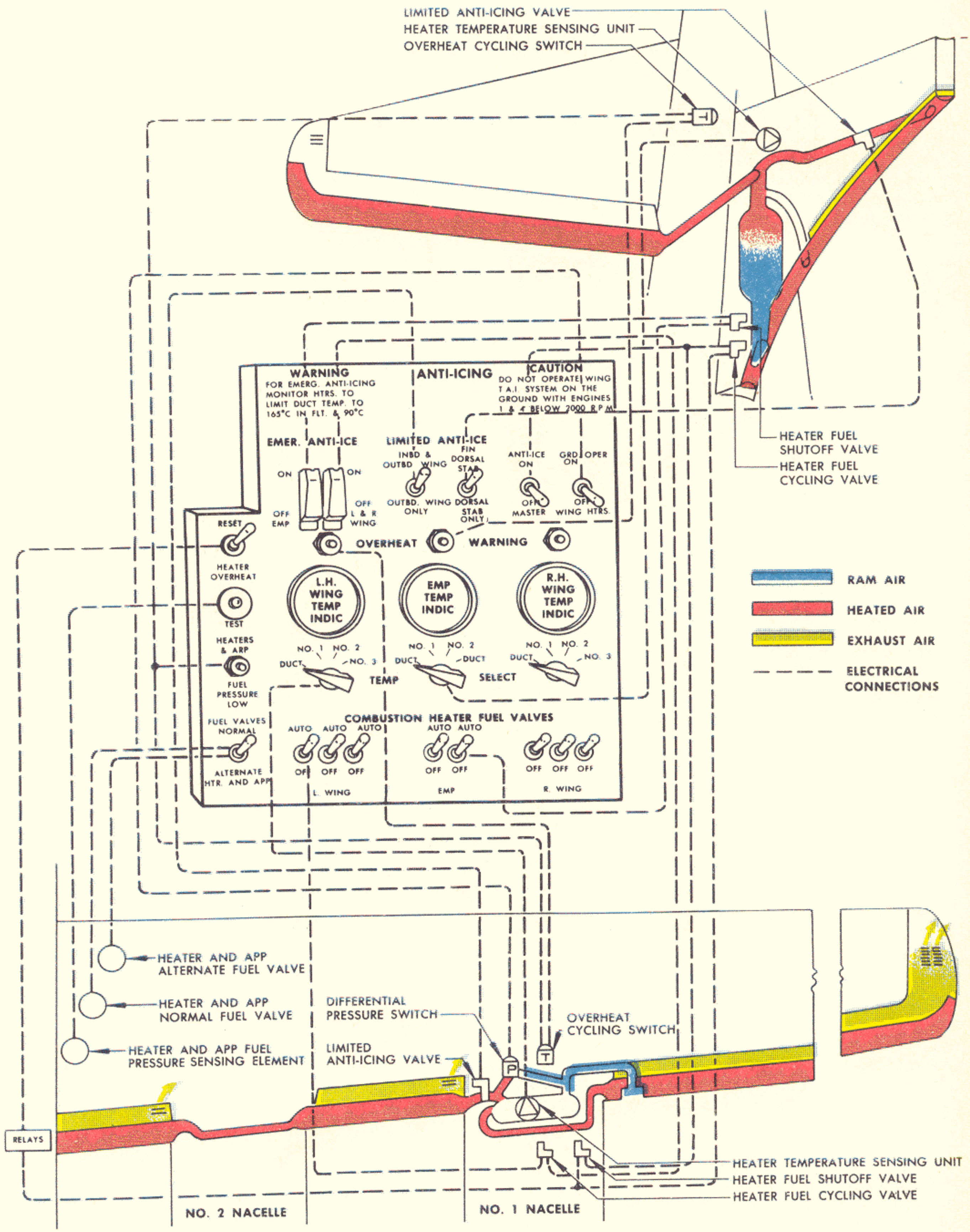

Figure 4-5 (Sheet 2 of 2 Sheets). Anti-icing System

preset differential pressure between ram air pressure and heater outlet air pressure, is in effect when the wing heater ground operation switch is "OFF." The circuit breaker for wing heater ground operation is in the overhead circuit breaker panel (1, figure 1-24).

4-60. EMERGENCY ANTI-ICE SWITCHES. These two switches (11, figure 1-15) located on the engineer's instrument panel, control emergency operation of the anti-icing system. In the "ON" position these switches directly operate the anti-icing systems of the wings and empennage by-passing the lockout controls of the overheat relays and the differential pressure switches. In the "OFF" position the emergency anti-icing circuits are inoperative. Circuit breakers are on the forward power panel (5, figure 1-24).

4-61. TEMPERATURE INDICATOR SELECTOR SWITCHES. Three rotary-type switches (19, figure 1-15) located on the engineer's instrument panel connect duct and heater temperature sensing circuits with their temperature indicators. The switches have "DUCT-1-2-3" positions. In the "DUCT" position, the heater outlet air duct sensing circuits are connected to their corresponding indicators. In the numbered positions the temperature sensing circuits of the corresponding numbered heaters in the wings and empennage are connected to their respective indicators. A circuit breaker is on the overhead circuit breaker panel (1, figure 1-24).

4-62. PROPELLER DEICER SWITCH. This switch (8, figure 1-12) on the overhead panel operates the propeller deicer system. In "ON" position current from the timer energizes relays which furnish power to the blade heating elements. In "OFF" position, the propeller anti-icing system is inoperative. The circuit breaker is on the overhead circuit breaker panel (1, figure 1-24).

4-63. WINDOW HEAT SELECTOR SWITCH. This switch (5, figure 1-16) on the engineer's auxiliary panel, selects one of three voltages to be applied to the window heating elements. In the "LOW--NORMAL--HIGH" positions increasing voltages are sent to the window heating elements. In the "OFF" position the Nesa window heating system is inoperative. The circuit breaker for this system is in the overhead circuit breaker panel (1, figure 1-24).

4-64. PITOT HEAT SWITCHES. Two switch-type circuit breakers (21, figure 1-12) on the overhead panel operate the pitot heaters. In the "ON" position the circuit is closed to the pitot-head heater element. In "OFF" the circuit is open.

4-65. ANTI-ICING SYSTEMS INDICATORS.

4-66. OVERHEAT WARNING LIGHTS. Three red lights (16, figure 1-15) on the engineer's instrument panel indicate excessive temperatures in wing and empennage anti-icing systems and the operation of the overheat controls.

4-67. ANTI-ICING HEATER AND DUCT TEMPERATURE INDICATORS. Three temperature indicators (17, figure 1-15) located on the engineer's instrument panel indicate centigrade temperature readings of heated air in the heaters and in the ducts delivering air to the wings and empennage.

4-68. HEATER AND AUXILIARY POWER PLANT FUEL PRESSURE WARNING LIGHT. A red warning light (20, figure 1-15) on the engineer's instrument panel will illuminate when the body heater anti-icing heater, and APP fuel pressure is less than 12 PSI. Protection for the warning circuit is provided by a circuit breaker on overhead circuit breaker panel (1, figure 1-24).

4-69. PROPELLER DEICER INDICATORS. Two dual tab-window indicators (25, figure 1-15) indicate the propeller being deiced. Each indicator has an "OFF" tab as well as two numbered tabs. One indicator has tabs for propellers No. 1 and No. 2, the other indicator has tabs for No. 3 and No. 4 propellers. Because of the propeller deicer timer these two indicators alternate in operation.

4-70. ANTI-ICING SYSTEMS NORMAL OPERATION.

4-71. NORMAL FLIGHT OPERATION SURFACE ANTI-ICING SYSTEM.

NOTE

The system should be turned on as soon as possible when icing is encountered. If icing is anticipated, the system should be turned on in advance so that no delay will result in bringing the surface leading edges up to proper temperature. The system should be kept on during the entire duration of the icing condition.

a. Turn fuel valve selector switch to "NORMAL."
b. Turn all heater fuel valve switches to "AUTO."
c. Set wing limited anti-ice switch to "INBD & OUTBD WING" and empennage limited anti-ice switch to "FIN DORSAL STAB."
d. Turn master anti-ice switch "ON."
e. Check operation of overheat warning and control circuits by turning the three temperature selector switches to the "DUCT" position and checking for a drop in the duct temperatures and the illumination of the warning lights upon pressing the heater overheat test button.

NOTE

Check each heater and duct temperature frequently during operation for maximum temperatures of 227° C for the heaters and 190° C for the ducts, turning off the fuel valve of any heater approaching this limit or any heater indicating an unusually low temperature.

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f. When heater overheat warning light comes on during operation, check all heater temperatures turning off any heater near the temperature limit. Then use heater reset switch to start the other heaters of that system operating again.

g. When heater and APP fuel pressure warning light illuminates, turn on No. 2 boost pump or the boost pump of any other fuel tank set to manifold. Then change the heater and APP fuel valve switch to "ALTERNATE."

4-72. NORMAL GROUND OPERATION SURFACE ANTI-ICING SYSTEM. To operate the surface anti-icing systems with outboard engines running at or above 2000 RPM, hold the wing heater ground operation switch "ON" and then proceed as in normal flight operation.

4-73. If operating the surface anti-icing systems without running the airplane outboard engines, use external auxiliary power and external ground blowers for the wings. Then with the main inverter switch in "NORMAL ON" proceed as in normal flight operation.

4-74. NORMAL FLIGHT OPERATION PROPELLER ANTI-ICING SYSTEM. Place prop deice switch in "ON" position and check prop deicing indicators occasionally for proper cycling. (The normal cycle is two minutes long, each propeller being heated for thirty seconds.)

4-75. NORMAL GROUND OPERATION PROPELLER ANTI-ICING SYSTEM. For ground operation with engines running operate the system as in normal flight. If necessary to operate the propeller anti-icing system while the airplane engines are not running, use external auxiliary power and proceed as in normal flight operation.

CAUTION

When the airplane engines are not running, do not operate the propeller anti-icing system for more than three cycles in succession on each propeller. Be sure to wait at least 30 minutes between periods of operation, for applying heat continuously for one and a half minutes without engines operating, will seriously damage the propeller blades.

4-76. NORMAL OPERATION WINDOW ANTI-ICING SYSTEM. For normal operation in flight turn window heat selector switch to "NORMAL" only after a 20 minute warm-up of the windows with the window heat selector switch in the "LOW" position. For ground operation use "LOW" heat only.

NOTE

Window heat selector switch must be turned on "LOW" for a 20 minute warm-up before deicing in "NORMAL" and for 5 minutes after deicing before turning the switch "OFF," to avoid damage to the window glass.

4-77. NORMAL OPERATION OF PITOT HEATERS. In flight turn the pitot heaters on by turning both pitot-heat switches to "ON." Ground operation of the pitot heaters should be limited to brief maintenance checks, extreme cold weather ground operation and take-offs during rain, snow and instrument conditions.

4-78. ANTI-ICING SYSTEMS EMERGENCY OPERATION.

4-79. EMERGENCY FLIGHT OPERATION SURFACE ANTI-ICING SYSTEM.

a. Place emergency anti-ice switches to "ON."
b. Turn all heater fuel valve switches "OFF."
c. Turn master anti-ice switch "OFF."
d. Check heater temperatures frequently, since there are no overheat lockout controls in the emergency circuits.
e. Turn off any heater approaching the maximum temperature limit of 254° C.

4-80. EMERGENCY GROUND OPERATION SURFACE ANTI-ICING SYSTEM. For emergency ground operation with outboard engines running at or above 2000 RPM, operate as in emergency flight condition. For emergency ground operation without running the airplane outboard engines, use external auxiliary power and external ground blowers for the wings. Then, with main inverter switch to "ESS. INV," proceed as in emergency flight operation.

4-81. EMERGENCY OPERATION PROPELLER ANTI-ICING SYSTEM. If the propellers are not deicing properly proceed as follows:

a. Check the circuit breaker.
b. Turn propeller deicer switch "OFF."
c. Change electrical connector in the lower forward cargo compartment from the normal deicer timer to the alternate timer.
d. Turn propeller deicer switch "ON" and check for proper operation.

4-82. EMERGENCY OPERATION WINDOW ANTI-ICING SYSTEM. When the windows are not being deiced sufficiently with the window heat selector switch in the "NORMAL" position, turn the selector switch to "HIGH."

NOTE

Windows No. 4L and 4R do not receive current for deicing when the window heat selector switch is in the "HIGH" position.

4-83. To operate the system with a window failure, shut the system off and disconnect inoperative windows at the upper and lower power leads of each window. Then, if either control window, No. 1 or No. 2L, are still operating, start the system again. However, if both control windows are inoperative, leave the system off.

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COMMUNICATION AND ASSOCIATED ELECTRONIC EQUIPMENT TABLE

TYPE	DESIGNATION	USE	PRIMARY OPERATOR	LOCATION
Interphone	AN/AIC-8	Intercrew Communication use with other radio equipment	Crew Members	All Crew Stations
VHF Command	AN/ARC-3	Short range, two-way voice and code communication	Pilot	Engine Control Stand
Liaison	AN/ARC-8	Long range, two-way voice and code communication	Radio Operator	Radio Operator's Station
HF Command mitter Receiver	AN/ART-13	Long range, two-way voice and code communication	Pilot	Engine Control Stand
IFF	AN/APX-6	Aircraft Recognition	Radio Operator	Radio Operator's Station
Radio Compass No. 1	AN/ARN-6	Signals for direction bearing, homing and radio range flying	Pilot and Navigator	Pilot's Instrument Panel Navigator's Panel
Marker Beacon	AN/ARN-12	Receive location marker signals on navigation beam	Automatic	Pilot's Instrument Panel
Radio Altimeters				
High Range	SCR-718C	Indicate Distance from airplane to ground	Navigator	Navigator's Panel
Low Range	AN/APN-1		Pilot	Pilot's Instrument Panel
Glide Path Receiver	AN/ARN-5B	Indicates glide angle for instrument landing	Pilot	Pilot's Instrument Panel
Omnidirectional Range Radio	AN/ARN-14	Provides VHF radio navigation aids	Pilot	Pilot's Instrument Panel
Loran	AN/APN-9	Indicates mapping fixes	Navigator	Navigator's Panel
Search Radar	AN/APS-42	Search and Navigation	Navigator	Navigator's Station
Dinghy Transmitter	AN/CRT-3	Send Distress Signals when forced down	Radio Operator	Radio Operator's Station
Radar Set	AN/APN-2B	Rendezvous	Navigator	Navigator's Station
Radar Set	AN/APN-68	Rendezvous	Navigator	Navigator's Station

Figure 4-6. Communication Equipment

4-84. COMMUNICATIONS AND ASSOCIATED ELECTRONIC EQUIPMENT.

WARNING

DO NOT OPERATE the following systems during in-flight refueling because of the possibility of fuel fumes in the airplane:

1. Inter-aircraft signal lamp
2. Radio compass
3. Marker beacon
4. Radio altimeter
5. Search radar
6. Suit heater rheostat
7. Trailing antenna reel
8. IFR radio
9. Loron radio
10. Localizer and ODR receiver
11. Glide path receiver
12. Control cab cooling fan
13. Air conditioning system
14, Auxiliary power plant
15. Anti-icing switches

4-85. All electronic equipment used for communications, navigation, and identification is listed in the chart shown in figure 4-6. The communication radios are connected through a radio junction box to the interphone system so that individual selection of the seven receivers can be made at each crew member's interphone control box. A radio power circuit breaker is provided on the forward power panel (5, figure 1-24). Fuses for the radar equipment and radio feed are provided on the AC power panel (5, figure 1-25).

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4-86. INTERPHONE SYSTEM. The interphone system is in operation whenever the main power system is energized. Controls are provided at all crew stations. Circuit breakers are provided on the radio circuit breaker panel (2, figure 1-24).

4-87. VHF COMMAND RADIO. The set is turned on and off by an "ON--OFF" switch on the VHF command control panel (14, figure 1-13) on the engine control stand. A circuit breaker for the set is provided on the radio circuit breaker panel (2, figure 1-24).

4-88. LIAISON RADIO. The transmitter is turned on and off by an "OFF--VOICE--CW--MCW" switch on the liaison transmitter control panel (33, figure 1-13) on the engine control stand. The receiver is turned on and off by an "AVC--OFF--MVC" switch on the liaison receiver (10, figure 4-12). Circuit breakers for the set are provided on the radio circuit breaker panel (2, figure 1-24).

4-89. HF COMMAND RADIO. The transmitter is turned on and off by an "OFF--VOICE--CW--MCW" switch on the transmitter control panel (9, figure 4-12) at the radio operator's station. The receiver is turned on and off by a "CW--OFF--MCW" switch on the receiver control panel (15, figure 1-13) on the engine control stand. A circuit breaker for the set is provided on the radio circuit breaker panel (2, figure 1-24).

4-90. IFF RADIO. The set is turned on and off by an "ON--OFF" switch on the radio control panel (9, figure 4-12) at the radio operator's station. A circuit breaker and a fuse are provided on the radio circuit breaker panel (2, figure 1-24).

4-91. AUTOMATIC RADIO COMPASS (ADF). The set is turned on and off by "OFF--COMP--ANT--LOOP--CONT" switches on the two automatic compass control panels, one on the engine control stand (34, figure 1-13), and a similar panel at the radio operator's station (6, figure 4-12). A radio magnetic indicator is located on the pilot's instrument panel (14, figure 1-10) and a dual radio compass indicator on the navigator's instrument panel (4, figure 4-12). A circuit breaker and a fuse are provided on the radio circuit breaker panel (2, figure 1-24).

4-92. MARKER BEACON RECEIVER. The receiver is in continuous operation whenever the DC bus is energized. Reception is indicated by an audio signal in the interphone system and a signal light (2, figure 1-10) on the pilots' instrument panel. A circuit breaker for the set is provided on the radio circuit breaker panel (2, figure 1-24).

4-93. RADIO ALTIMETERS. The high-range altimeter is turned on and off by an "ON--OFF" receiver gain knob on the set (2, figure 4-12) at the navigator's station. An indicator is located on the set. The low range radio altimeter is turned on and off by an "ON--OFF" knob located on the pilot's instrument panel (34, figure 1-10) along with red, green, and amber indicator lights. Circuit breakers and fuses are provided on the radio circuit breaker panel (2, figure 1-24).

4-94. GLIDE PATH RECEIVER. The set is turned on and off by an "OFF--U--V--W--X--Y--Z" switch on the instrument approach control panel on the engine control stand. The set feeds into the course indicator (1, figure 1-10) located on the pilot's instrument panel. A circuit breaker is provided on the radio circuit breaker panel (2, figure 1-24).

4-95. OMNIDIRECTIONAL RANGE RADIO. The set is turned on and off by an "OFF--TONE--PHASE" switch on the omnidirectional range control panel on the engine control stand. The set feeds into the course indicator (1, figure 1-10) located on the pilot's instrument panel. A circuit breaker is provided on the radio circuit breaker panel (2, figure 1-24).

4-96. LORAN RECEIVER - INDICATOR. The Loran equipment is turned on and off by a "POWER OFF" receiver gain control switch on the set (12, figure 4-12). A circuit breaker and a fuse are provided on the radio circuit breaker panel (2, figure 1-24).

4-97. SEARCH RADAR. The set is turned on and off by an "OFF--STANDBY--SEARCH--BEACON--WEATHER" switch on the radar control panel (5, figure 4-12) at the navigator's station. Two radar scope indicators are provided; one at the navigator's station and one overhead at the pilot's station. A circuit breaker and a fuse are provided on the radio circuit breaker panel.

4-98. RENDEZVOUS RADAR. This airplane is equipped with radar set AN/APN-2B and radar set AN/APG-68. One radar set (AN/APG-68 serves as a transponder (beacon) set enabling receiver aircraft carrying corresponding radar equipment to home on this airplane. The other set (AN/APN-2B) allows this airplane to home on receiver airplanes equipped with corresponding transponder sets. Since receiver airplanes of the same model often carry rendezvous radar sets which operate on different frequencies, it is important that the type of rendezvous equipment installed on the receiver airplane is determined, and the receiver radio operator be notified of the type of tanker rendezvous equipment, in planning a refueling mission.

4-99. DINGHY TRANSMITTER. Power is generated by turning the hand crank at the top of the unit.

4-100. LIGHTING EQUIPMENT.

4-101. GENERAL.

4-103. EXTERIOR LIGHTS. See figure 4-7 for a listing of the lights, their locations, and their switch and circuit breaker locations.

4-103. INTERIOR LIGHTS. See figure 4-8 for a listing of interior lights, their locations, and their switch and circuit breaker locations. A box of spare lamps is mounted on the aft left side of the control cabin bulkhead.

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EXTERIOR LIGHTING TABLE				
LIGHTS	QUANTITY	LOCATION	SWITCH LOCATION	CIRCUIT BREAKER
Taxi	2	On fuselage nose and nose landing gear	Overhead panel	Overhead panel
Landing	2	Under each outboard wing aft of rear spar	Engine control stand	Overhead panel
Navigation	6	Wing tips, tail cone, body	Overhead panel	Overhead panel
Formation	9	Three on the upper surface of each wing, three on top of fuselage	Overhead panel	Overhead panel
Wing illumination	2	One on each side of fuselage	Overhead panel	Overhead panel
Boom marking	2	In boom nozzle hood	Boom operator's panel	Boom operator's panel
Boom nozzle	2	In boom nozzle hood	Boom operator's panel	Boom operator's panel
Boom chock	1	Beside boom stowing chock	Boom operator's panel	Boom operator's panel
Pilot director	5	Fuselage underside	Boom operator's panel	Boom operator's panel
Inboard underwing	2	Fuselage underside	Boom operator's panel	Boom operator's panel
Outboard underwing	2	Fuselage underside	Boom operator's panel	Boom operator's panel
Underbody	2	Fuselage underside	Boom operator's panel	Boom operator's panel
Wheel well	2	In wheel wells	Overhead panel	Overhead panel

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Figure 4-7. Exterior Lights

INTERIOR LIGHTING TABLE				
LIGHTS	QUANTITY	LOCATION	SWITCH LOCATION	CIRCUIT BREAKER
Pilots' instrument panel	3	Top of panel under crash pad hood	Switch on overhead panel; rheostat on copilot's auxiliary panel	Overhead panel
Pilots' instrument panel (right side red)	4	Top of panel under crash pad hood	Switch type rheostat on copilot's auxiliary panel	Overhead panel
Pilots' instrument panel (left side white)	3	Top of panel under crash pad hood	Switch on overhead panel; rheostat on pilot's auxiliary panel	Overhead panel
Pilots' instrument panel (left side red)	4	Top of panel under crash pad hood	Switch type rheostat on pilot's auxiliary panel	Overhead panel

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Figure 4-8. Interior Lights (Sheet 1 of 4 Sheets)

LIGHTS	QUANTITY	LOCATION	SWITCH LOCATION	CIRCUIT BREAKER
Pilots' instrument panel (center white)	4	Top of panel under crash pad hood	Switch and rheostat on overhead panel	Overhead panel
Pilots' instrument panel (center red)	5	Top of panel under crash pad hood	Switch type rheostat on overhead panel	Overhead panel
Pilot's control column	2	Top forward side of control column	Same rheostat used for pilots' auxiliary panel lights (left side red)	Overhead panel
Copilot's control column	2	Top forward side of control column	Same rheostat used for copilots' auxiliary panel lights (right side red)	Overhead panel
Copilot's auxiliary panel	3	In tube at top of auxiliary panel	Switch type rheostat on copilot's auxiliary panel	Overhead panel
Pilot's auxiliary panel	3	In tube at top of auxiliary panel	Switch type rheostat on pilot's auxiliary panel	Overhead panel
Pilot's map	1	Left side of overhead panel	Switch type rheostat on overhead panel	Overhead panel
Copilot's map	1	Right side of overhead panel	Switch type rheostat on overhead panel	Overhead panel
Pilot's compass panel	1	On propeller feathering section of overhead panel	Switch and rheostat on pilot's compass panel	Overhead panel
Overhead panel (white)	5	Vertical step portion of the panel sections	Switch and rheostat on overhead panel	Overhead panel
Overhead panel (red)	7	Vertical step portion of the panel sections	Switch type rheostat on overhead panel	Overhead panel
Dias Step	2	One under radio operator's table and one near bottom of copilot's auxiliary panel	Switch on overhead panel	Overhead panel
Engineer's table (white)	2	Over the engineer's table	Switch and rheostat on engineer's instrument panel	Overhead panel
Engineer's table (red)	3	Over the engineer's table	Switch and rheostat on engineer's instrument panel	Overhead panel
Engineer's instrument spot	2	Top of engineer's instrument panel	Switch and rheostat on engineer's auxiliary panel	Overhead panel
Engineer's dome (white)	1	Overhead at engineer's station	Switch and rheostat on engineer's auxiliary panel	Overhead panel
Engineer's dome (red)	1	Overhead at engineer's station	Switch and rheostat on engineer's auxiliary panel	Overhead panel
Overhead panel spot	2	On right and left side of engine control stand	Switch and rheostat on engineer's instrument panel	Overhead panel

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Figure 4-8. Interior Lights (Sheet 2 of 4 Sheets)

LIGHTS	QUANTITY	LOCATION	SWITCH LOCATION	CIRCUIT BREAKER
Navigator's instrument panel (white)	3	In shield above and below instrument panel	Switch and rheostat on navigator's instrument panel; color selector switch on overhead panel	Overhead panel
Navigator's instrument panel (red)	4	In shield above and below instrument panel	Switch and rheostat on navigator's auxiliary panel; color selector switch on overhead panel	Overhead panel
Navigator's table	1	Over the navigator's table	Switch type rheostat on navigator's auxiliary panel; color selector switch on overhead panel	Overhead panel
Aft cabin dome (white)	1	Overhead in control cabin	Switch on navigator's auxiliary panel; color selector switch on overhead panel	Overhead panel
Aft cabin dome (red)	2	Overhead in control cabin	Switch on navigator's auxiliary panel; color selector switch on overhead panel	Overhead panel
Radio operator's panel (white)	2	In light shield below panel	Switch and rheostat on radio operator's panel; color selector switch on overhead panel	Overhead panel
Radio operator's panel (red)	3	In light shield below panel	Switch and rheostat on radio operator's panel; color selector switch on overhead panel	Overhead panel
Radar Control panel	1	In light shield below panel	Switch type rheostat on light shield below panel	Overhead panel
Spot extension	2	One at auxiliary power plant and one in lower nose compartment	Switch on light	Forward power panel
Entrance	1	Overhead in control cabin	One overhead in lower cargo compartment and one in control cabin	Forward power panel
Crew lavatory dome (white)	1	Overhead in crew lavatory	Switch in lavatory; color selector switch on overhead panel	Overhead panel
Crew lavatory dome (red)	1	Overhead in crew lavatory	Switch in lavatory; color selector switch on overhead panel	Overhead panel
Fluorescent (stowage compartment)	4	Overhead	Two overhead in stowage compartment	AC power panel
Fluorescent (lower forward cargo compartment	2	Overhead	Overhead in forward cargo compartment	AC power panel

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Figure 4-8. Interior Lights (Sheet 3 of 4 Sheets)

LIGHTS	QUANTITY	LOCATION	SWITCH LOCATION	CIRCUIT BREAKER
Dome (lower forward)	4	Overhead	Two overhead in lower forward compartment	Forward power panel
Dome (lower aft)	3	Overhead	Two overhead in lower aft stowage compartment	Main panel
Pilot's and copilot's interphone filter	2	On filters	Same rheostat as red overhead panel lights	Overhead panel
Engineer's interphone control box	4	On control box	Same switch and rheostat as engineer's instrument spotlights	Overhead panel
Radio operator's and navigator's electronic	22	On control panels for interphone, radio compass, trailing antenna, and IFF	Rheostat on navigator's instrument panel	Radio junction box
Pilot's and copilot's electronic control	19	On control panels for interphone, radio compass, VHF command, HF command, and omnidirectional range	Rheostat on overhead panel	Radio junction box
Dome lights	1	Boom operator's compartment	Boom operator's panel	Boom operator's panel
Boom operator's spotlights	2	Right and left of boom operator's station	Boom operator's panel	Boom operator's panel
Boom operator's panel lights	11	Forward and aft edges of boom operator's panel	Boom operator's panel	Boom operator's panel
Engineer's IFR panel lights	2	Engineer's auxiliary panel	Engineer's IFR panel	Engineer's IFR panel

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Figure 4-8. Interior Lights (Sheet 4 of 4 Sheets)

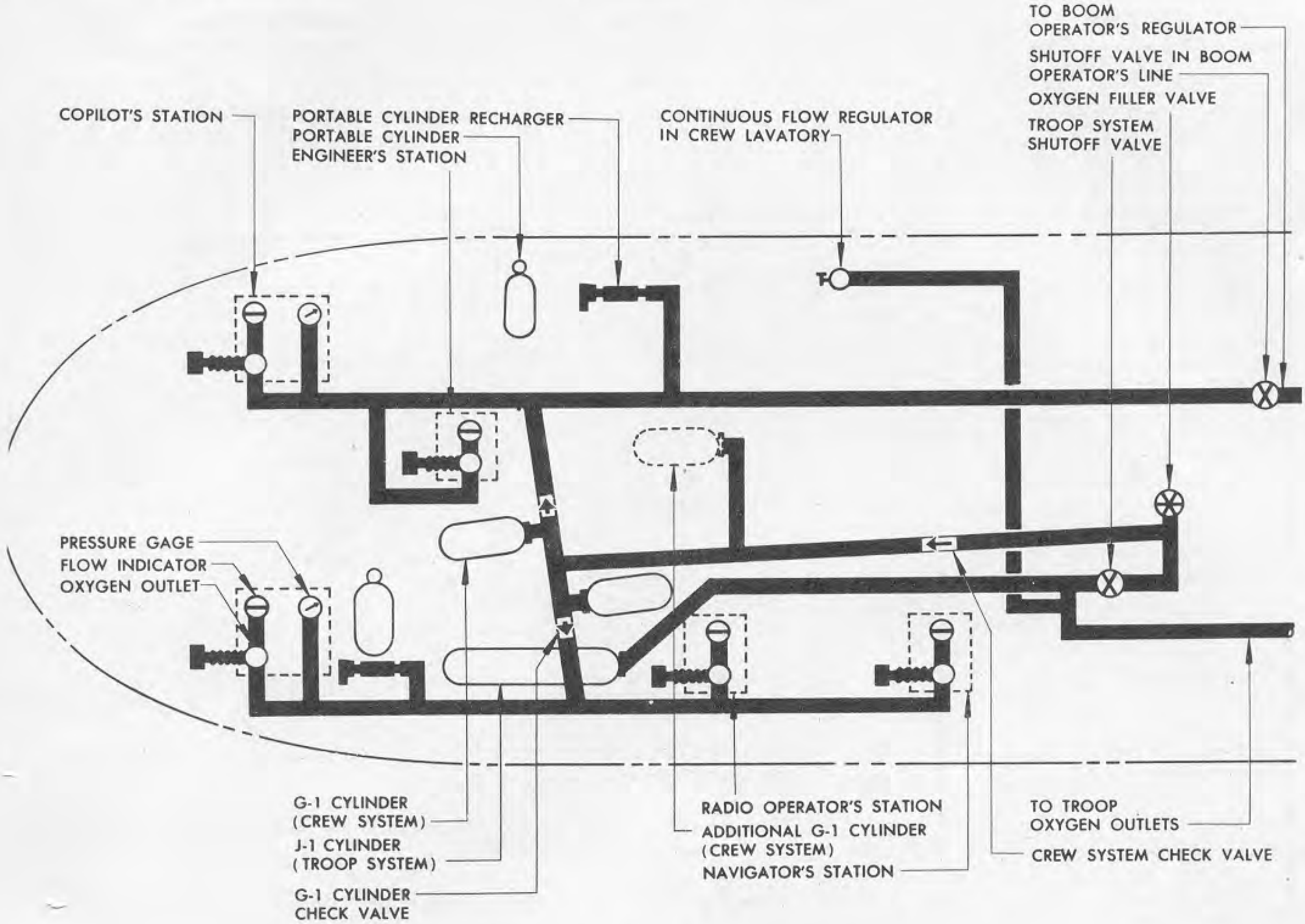

Figure 4-9. Oxygen System

4-104. OXYGEN SYSTEM.

4-105. GENERAL.

4-106. A low pressure oxygen system (figure 4-10) is installed for crew and passenger use in case of failure of the cabin pressurizing system. The oxygen system consists of two complete systems, a crew oxygen system and a passenger oxygen system, separated by a line shutoff valve. A common filler valve, located inside the lower forward cargo compartment just aft of the forward entry door, is used to service both systems.

4-107. The crew oxygen system is divided into two separate systems by the use of two check valves, one mounted on each of the two G-1 cylinders which normally supply crew oxygen. By the use of these valves the oxygen of one cylinder is limited to the use of the pilot, navigator and radio operator and the oxygen of the other cylinder is available only to the copilot, engineer, and, (when the shutoff valve in the boom operator's line is open) to the boom operator. These two G-1 cylinders of the crew systems are located in the lower nose compartment. Provision is also made for the installation of an additional G-1 cylinder near the top of the rear of the control cabin if additional oxygen is needed for the crew systems. A check valve is not used with this cylinder. However another check valve is mounted in the oxygen filler line between this cylinder and the oxygen filler valve, which allows this cylinder to be filled and permits its oxygen to be used in both of the crew systems. This check valve in the crew filler line also allows the crew systems to utilize the oxygen of the troop system (when the troop system shufoff valve is open), but automatically prevents the oxygen of the crew systems from going back into the troop system at any time. A pressure gage, a blinker type flow indicator, and a diluter-demand regulator are located at crew stations as shown in figure 4-9. Only demand oxygen masks will be used.

4-108. Six portable oxygen bottles (3, figure 3-1) are provided. In the control cabin one portable bottle

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and recharger assembly are on the pilot's auxiliary panel and one portable bottle and recharger assembly are forward of the engineer's instrument panel. In the main cargo compartment one bottle is on the ceiling near the forward bulkhead and one on the right side near the tail. Two more portable bottles are located in the lower cargo compartments; one on the left hand side of the lower forward cargo compartment, another on the left hand side of the lower aft cargo compartment.

4-109. Passengers, troops, or litter patients are supplied by one Type J-1 and two Type G-1 oxygen cylinders. Space provision have been allowed for an additional Type J-1 and two additional Type G-1 oxygen cylinders as required for any special mission. A pressure indicator for the passenger system is located on the right aft wall of the main cargo compartment. A continuous flow portable oxygen unit and recharger facilities are provided at the forward and aft ends of the main compartment, in the lower forward compartment and in the lower aft compartment. Continuous flow regulators provide outlets for each troop and litter station as well as the crew lavoratory, and continuous flow oxygen mask containers are installed throughout the cargo compartments. The passenger regulators are automatic and supply the proper amount of oxygen required with altitude. Only continuous flow oxygen masks will be used.

4-110. The approximate oxygen duration of the pilot, radio operator, and navigator's section; the copilot, engineer, and boom operator's section; and the troop section of the oxygen system is shown in figure 4-11.

4-111. OXYGEN SYSTEM CONTROLS.

4-112. REGULATOR DILUTER LEVER. A "NORMAL OXYGEN--100% OXYGEN" lever is located on each oxygen regulator. With the lever in the "NORMAL OXYGEN" position, the regulator automatically supplies the proper mixture of oxygen and air to the mask at all times. With the lever in "100% OXYGEN" the air intake port is closed and pure oxygen is supplied to the mask for emergency use.

4-113. REGULATOR EMERGENCY VALVE KNOB. An emergency valve knob (16, figure 1-9) and (8, figure 1-11) is provided on the regulator and is always safety-wired closed. This valve, when open, supplies a continuous flow of 100% oxygen to the mask for emergency use.

4-114. TROOP SYSTEM SHUTOFF VALVE HANDLE. Rotating this shutoff valve handle (2, figure 4-10) in the counterclockwise direction opens the valve and allows simultaneous recharging of the complete oxygen system, and also permits the crew to draw oxygen from the troop system. This valve is normally closed to prevent oxygen flow between the crew and the troop sections of the oxygen system. The troop system shutoff valve handle is located next to the oxygen system filler valve inside the lower forward cargo compartment just aft of the forward entry door.

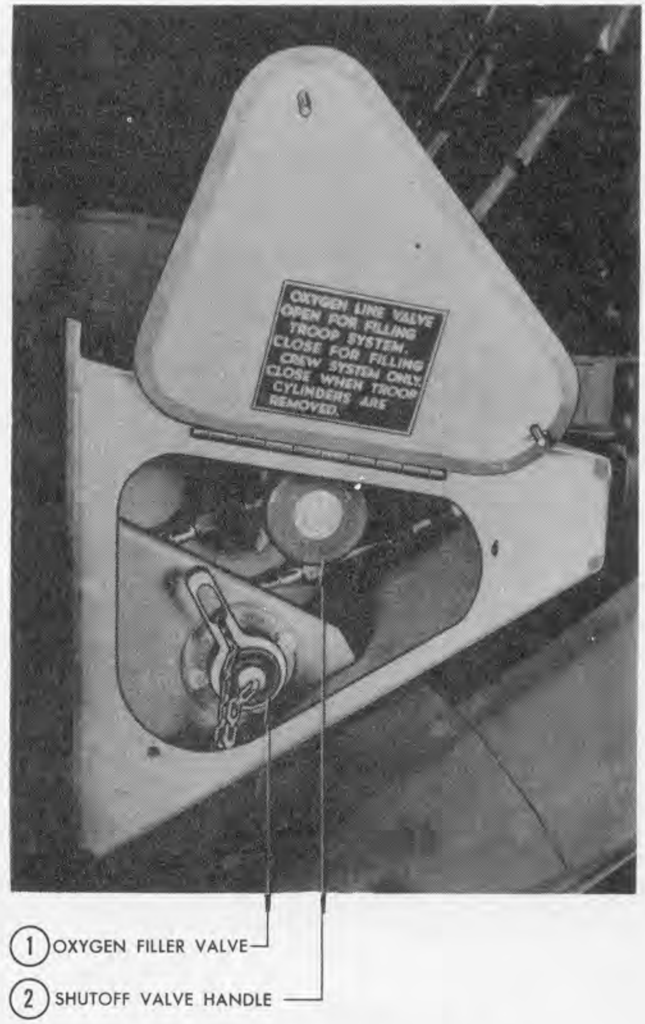

Figure 4-10. Oxygen Filler Valve

4-115. BOOM OPERATOR'S LINE SHUTOFF VALVE HANDLE. This valve handle is located in the oxygen line of the crew system which supplies the copilot's and engineer's stations and then runs aft to provide oxygen at the boom operator's station. When open, this valve allows the boom operator to use oxygen from the copilot-engineer oxygen system. When the valve is closed, the boom operator's station is without an oxygen source.

4-116. OXYGEN SYSTEM INDICATORS.

4-117. OXYGEN PRESSURE GAGES. Oxygen pressure gages (13, figure 1-9 and 12, figure 1-11) provided on the pilot's and copilot's auxiliary panels indicate oxygen pressure of the crew system in PSI. A pressure gage for the passenger section is located on the aft right wall of the main cargo compartment.

4-118. OXYGEN FLOW INDICATORS. A blinker-type oxygen flow indicator (12, figure 1-9) is provided near

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PILOT, RADIO OPERATOR AND NAVIGATOR

OXYGEN DURATION—HOURS

CABIN ALTITUDE (FEET)	GAGE PRESSURE—PSI							
	400	350	300	250	200	150	100	BELOW 100
30,000 (red)	1.4	1.2	1.0	0.8	0.6	0.4	0.2	EMERGENCY Descend to Altitude Not Requiring Oxygen
30,000	1.5	1.3	1.1	0.9	0.6	0.4	0.2	
25,000 (red)	1.1	1.0	0.8	0.6	0.5	0.3	0.2	
25,000	1.4	1.2	1.0	0.8	0.6	0.4	0.2	
20,000 (red)	0.8	0.7	0.6	0.5	0.4	0.2	0.1	
20,000	1.6	1.3	1.1	0.9	0.7	0.4	0.2	
15,000 (red)	0.7	0.6	0.5	0.4	0.3	0.2	0.1	
15,000	1.9	1.6	1.4	1.1	0.8	0.5	0.3	
10,000 (red)	0.5	0.5	0.4	0.3	0.2	0.1	0.1	
10,000	2.5	2.2	1.8	1.4	1.1	0.7	0.4	

Black Figures Indicate Diluter Lever "NORMAL"
Red Figures Indicate Diluter Lever "100%"

Cylinders: 1 Type G-1 Crew: 3

COPILOT, ENGINEER AND BOOM OPERATOR

OXYGEN DURATION—HOURS

CABIN ALTITUDE (FEET)	GAGE PRESSURE—PSI							
	400	350	300	250	200	150	100	BELOW 100
30,000 (red)	1.4	1.2	1.0	0.8	0.6	0.4	0.2	EMERGENCY Descend to Altitude Not Requiring Oxygen
30,000	1.5	1.3	1.1	0.9	0.6	0.4	0.2	
25,000 (red)	1.1	1.0	0.8	0.6	0.5	0.3	0.2	
25,000	1.4	1.2	1.0	0.8	0.6	0.4	0.2	
20,000 (red)	0.8	0.7	0.6	0.5	0.4	0.2	0.1	
20,000	1.6	1.3	1.1	0.9	0.7	0.4	0.2	
15,000 (red)	0.7	0.6	0.5	0.4	0.3	0.2	0.1	
15,000	1.9	1.6	1.4	1.1	0.8	0.5	0.3	
10,000 (red)	0.5	0.5	0.4	0.3	0.2	0.1	0.1	
10,000	2.5	2.2	1.8	1.4	1.1	0.7	0.4	

Black Figures Indicate Diluter Lever "NORMAL"
Red Figures Indicate Diluter Lever "100%"

Cylinders: 1 Type G-1 Crew: 3

PASSENGER

OXYGEN DURATION—MAN HOURS

CABIN ALTITUDE (FEET)	GAGE PRESSURE—PSI							
	400	350	300	250	200	150	100	BELOW 100
30,000	60	52	43	34	26	17	9	EMERGENCY Descend to Altitude Not Requiring Oxygen
25,000	66	56	47	38	28	19	9	
20,000	72	62	52	41	31	21	10	
15,000	80	69	57	46	34	23	11	
10,000	90	77	64	51	39	26	13	

Cylinders: 1 Type J-1
2 Type G-1

Figure 4-11. Oxygen Duration

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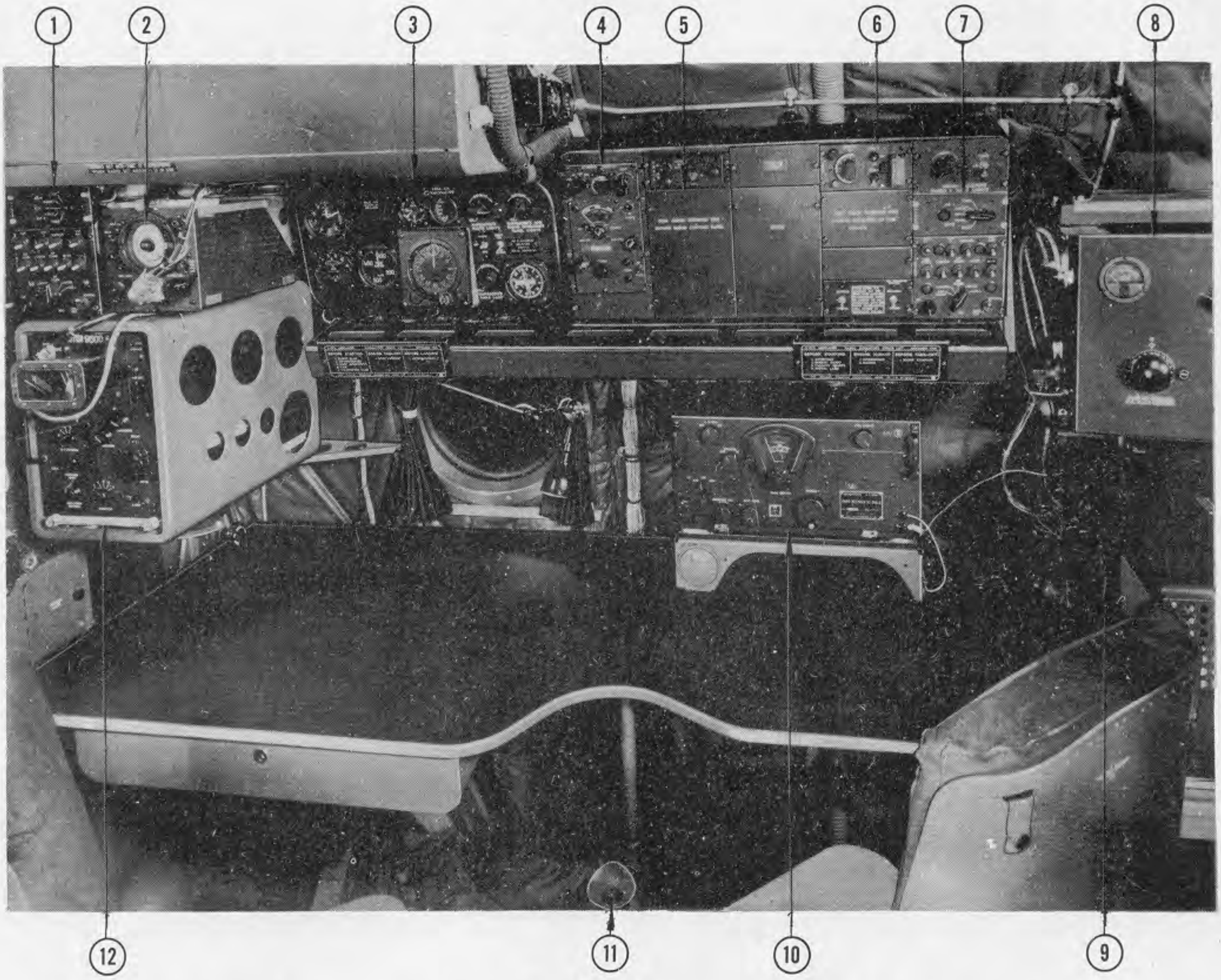

1 NAVIGATOR'S INTERPHONE PANEL
2 HIGH RANGE RADIO ALTIMETER
3 NAVIGATOR'S INSTRUMENT PANEL
4 AUTOMATIC RADIO COMPASS
5 SEARCH RADAR
6 IFF RADIO
7 RADIO OPERATOR'S INTERPHONE PANEL
8 HF COMMAND RADIO RECEIVER
9 HF COMMAND RADIO TRANSMITTER
10 LIAISON RECEIVER
11 DRIFTMETER
12 LORAN RECEIVER

Figure 4-12. Radio Operator's and Navigator's Stations

each crew member's oxygen regulator unit. Luminescent segments opening and closing as the crew member breathes indicate normal flow of oxygen.

4-119. OXYGEN SYSTEM NORMAL OPERATION.

4-120. BEFORE TAKE-OFF. Perform the following steps.

a. Check oxygen pressure gages. Pressure must be at least 400 PSI.

b. Check regulator diluter lever in "NORMAL OXYGEN" position.

c. Put on mask and connect mask hose to regulator.

d. Adjust mask as necessary.

4-121. IN-FLIGHT. The regulator diluter lever on each crew member's pressure regulator should be in the "NORMAL OXYGEN" position except when operating under emergency conditions. When the passengers use oxygen, a proper flow is automatically provided to the mask when the mask bayonet is attached to the oxygen outlet coupling. The coupling will automatically close when the mask bayonet is removed.

4-122. OXYGEN SYSTEM EMERGENCY OPERATION.

4-123. CREW. With symptoms of anoxia, or if smoke or fumes should enter the cabin, set the regulator diluter lever to "100% OXYGEN." If the regulator becomes inoperative, open the emergency valve by

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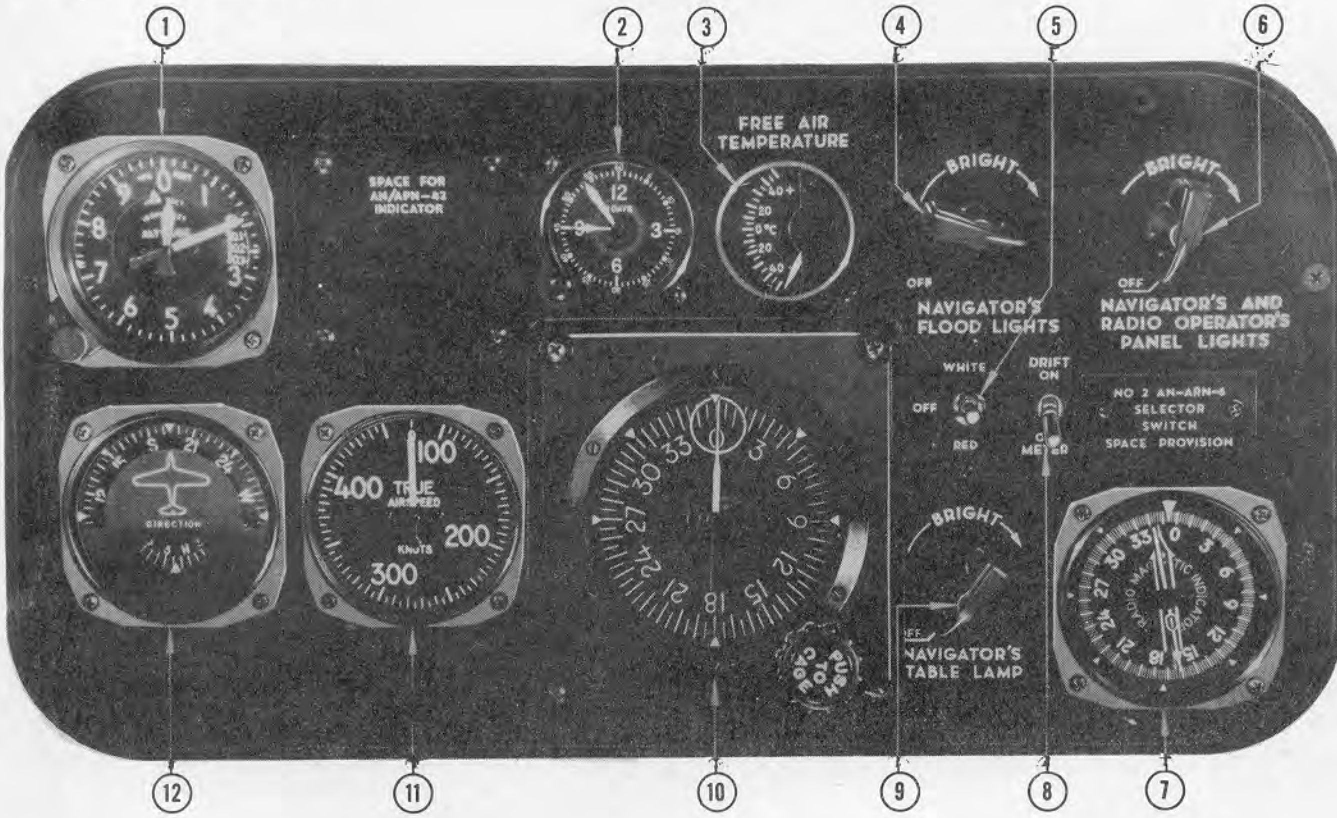

1 ALTIMETER
2 CLOCK
3 OUTSIDE AIR TEMPERATURE GAGE
4 NAVIGATOR'S FLOODLIGHT RHEOSTAT
5 NAVIGATOR'S FLOODLIGHT SWITCH
6 NAVIGATOR'S AND RADIO OPERATOR'S PANEL LIGHTS RHEOSTAT
7 DUAL RADIO COMPASS INDICATOR
8 DRIFTMETER SWITCH
9 NAVIGATOR'S TABLE LAMP RHEOSTAT
10 DIRECTIONAL GYRO
11 TRUE AIRSPEED INDICATOR
12 MASTER DIRECTION INDICATOR

Figure 4-13. Navigator's Instrument Panel

turning the red emergency knob counterclockwise.

CAUTION

When the regulator dilutor lever is placed in the "100% OXYGEN" position or the emergency valve control knob is turned on, inform the pilot immediately as these actions will substantially reduce the oxygen duration of the system.

4-124. If the oxygen regulator becomes completely inoperative, disconnect mask from oxygen system and connect to a portable bottle.

WARNING

When the regulator becomes completely inoperative, the pilot should be informed immediately, so that he can descend to an altitude not requiring oxygen.

4-125. PASSENGERS. If the passengers' continuous flow oxygen regulators become inoperative, the pilot should be informed so that he can descend to an altitude not requiring oxygen.

4-126. NAVIGATION EQUIPMENT.

4-127. NAVIGATOR'S INSTRUMENTS. The navigator's instrument panel (figure 4-13) contains the master direction indicator, a dual radio compass indicator, a directional gyro, an airspeed indicator, an altimeter, an outside air temperature indicator, and a clock.

4-128. ASTROCOMPASS. The navigator's astrocompass is stowed in the cabinet (19, figure 1-2) above the chart table. An astrodome and astrostool are provided.

4-129. DRIFTMETER. Provisions are made for the installation of a driftmeter at the navigator's station.

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Figure 4-14. IFR Fuel Tank Installation

4-130. IN-FLIGHT REFUELING (IFR) SYSTEM.

4-131. GENERAL.

4-132. The IFR boom consists of 2 concentric tubular sections which will extend from a minimum length of 27.7 feet to a maximum length of 47.4 feet. To permit movement in azimuth and elevation a yoke and trunnion attachment is used to attach the boom to the underside of the fuselage near the tail. A flexible hose couples the high capacity fuel system with the boom. A boom operator controls the boom with an airplane type control stick which is connected by cables to the ruddevator surfaces. The slipstream acting on these control surfaces provides the necessary force to position the boom while in flight. Telescoping of the boom is accomplished through a reversible hydraulic motor. During the contact made condition the boom actuates limit switches which initiate automatic disconnect when the boom reaches the boundary of the operating envelope (figure 4-16). Voluntary disconnects may be initiated by either the receiver pilot or the boom operator. Pilot director lights on the under side of the fuselage forward of the boom pod are also boom actuated. These lights direct the receiver pilot toward a smaller operating envelope known as the nominal contact position. Raising and lowering the boom on the ground and raising the boom through the last 8^{o} of upward travel while in flight is accomplished with a hydraulically operated hoist. A hydraulic cable tension motor maintains tension on the hoist cable while the boom is being controlled aerodynamically.

4-133. IFR FUEL SYSTEM. Once contact is made the engineer controls the IFR fuel system (figure 4-19). The main supply of IFR fuel is contained in four large cylindrical fuselage tanks. The two forward tanks are interconnected in such a way that they act as a single tank. The aft tanks are similarly connected so that the tank system acts as a single forward and a single aft tank. Hydraulically-driven IFR pumps and check valves are located in the forward end of each right-hand IFR tank. These pumps are capable of delivering up to 600 gallons of fuel per minute to a

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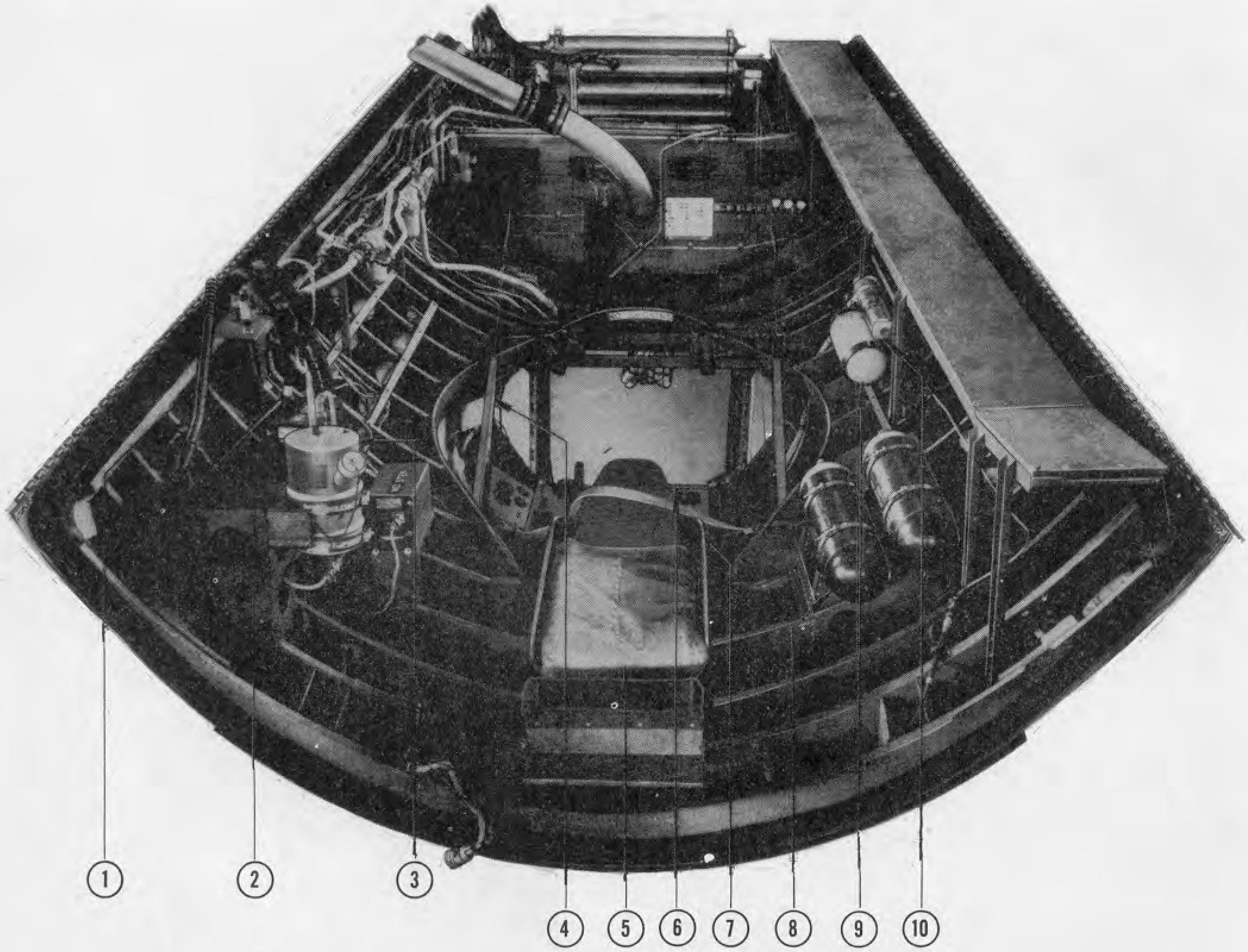

1 EMERGENCY HYDRAULIC HAND PUMP
2 EMERGENCY HYDRAULIC RESERVOIR
3 EMERGENCY HYDRAULIC HAND PUMP SELECTOR VALVE KNOB
4 DEPRESSURIZATION VALVE HANDLE
5 BOOM OPERATOR'S PLATFORM
6 BOOM OPERATOR'S PANEL
7 RUDDEVATOR CONTROL STICK
8 NITROGEN PURGE SUPPLY
9 BOOM OPERATOR'S OXYGEN SUPPLY
10 FIRE EXTINGUISHER

Figure 4-15. IFR Pod (Typical)

receiver airplane. The normal flow of IFR fuel is from the pumps through check valves, a line valve, a flow measuring venturi, and out through a self-sealing poppet valve in the boom nozzle. An automatic by-pass valve protects the IFR fuel system at disconnect by allowing the fuel to flow back to the aft fuselage tanks as soon as a disconnect is initiated. A fuel transfer line which connects the IFR tanks to the tanker engine fuel manifold permits transfer of wing tanks and center section tank fuel to the IFR tanks. Two IFR tank transfer valves isolate the IFR tanks from the engine manifold when fuel is not being transferred.

WARNING

To prevent contamination of the tanker engine manifold system, the IFR tank transfer valves must be kept closed and their electrical connectors disconnected when specification MIL-F-5624 or MIL-F-5616, jet fuel, is carried in the IFR fuselage tanks. When changing to specification MIL-F-5572 fuel after a refueling mission with either of the above grades of jet fuel, all trapped fuel must be drained from the IFR fuel system.

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4-134. IFR ELECTRICAL SYSTEM. The IFR electrical system operates on power received from the tanker's main 28-volt DC system and the 115-volt AC system. Power requirements during in-flight refueling place a heavy loading on the airplane's electrical system, and all electrically powered equipment that is non-essential to flight or the in-flight refueling operation should be turned off.

4-135. Electrically powered units in the IFR system include fuel shutoff valves, a hydraulic pressurizing pump, hydraulic valves, lighting and a signal amplifier.

4-136. The tanker signal system is an electrical system which works in conjunction with a signal system in the receiver airplane to set up the automatic features of the boom hydraulic and fuel systems for contact made and disconnect. In the ready for contact condition the tanker signal system deenergizes the line pump and the line valve circuits. Upon contact made the signal amplifier completes the line pump and line valve circuits and also locks the telescope control out of the hydraulic system to allow the boom to extend or retract as necessary. During contact made, coils in the boom nozzle and in the receiver receptacle inductively couple the two signal systems so that signals originating in either system may be transmitted to the other. The coupling of the signal systems allows either the receiver pilot or the boom operator to initiate a disconnect. If one of the boom position limit switches or the fuel pressure limit switch is actuated an automatic disconnect is initiated. At disconnect the signal system automatically controls the fuel cutoff and returns telescoping control to the boom operator; if the telescope at disconnect switch is in "AUTO" the boom will automatically retract.

4-137. A signal system override has been installed to serve as a secondary system in event of failure of the signal system. An override switch on the boom operator's panel when placed at "OVERRIDE" will allow part of the signal system to operate normally in conjunction with manual control by the boom operator, thus replacing the signal amplifier's duties. With the signal system override in affect, refueling operations may continue without use of the signal amplifier, the restrictions of the boom limit switches, or the signal coil in the nozzle. The boom operator must watch the boom position instruments and give corrective information to the receiver pilot to keep the boom within its flight envelope while in contact. Contact is established in the tanker signal system by depressing the trigger switch on the telescoping control handle as soon as it is ascertained that the nozzle is properly contacted in the receptacle. Disconnect is accomplished in the conventional manner by depressing the trigger switch on the ruddevator control stick; however, only the tanker signal system will go into a disconnect and the release of the nozzle from the receptacle is accomplished by initiating a disconnect in the receiver airplane. After a disconnect the signal system override does not affect boom movement as it would if the telescope at disconnect switch was at "AUTO." The signal system override does not affect the normal operation of the hydraulic and fuel systems and they will react normally whether the signal system override switch is in either "OVERRIDE" or "NORMAL."

4-138. Lights are installed on the fuselage, boom operator's compartment, and boom to illuminate the exterior of the airplane and boom for night operations. Four lights, flush mounted in the fuselage skin, illuminates the underside of the wing to the inboard nacelles. Three lights mounted on the boom pod underbody illuminate the fuselage and trailing edges of the wings. A flush mounted boom stowing chock light illuminates the stowing chock. The boom nozzle hood contains lights to illuminate the nozzle and boom color bands. All lights are controlled by "ON--OFF" switches, rheostats, and rheostat type switches at the boom operator's station. The boom operator also has an "ON--OFF" switch to operate a compartment dome light and a service light in the tail cone compartment.

4-139. The ruddevator anti-icing system consists of electrical heating elements installed along the leading edge of each ruddevator.

4-140. The Nesa window in the boom operator's compartment operates from the airplane's AC power system and is controlled by a "NORMAL--OFF--LOW" window anti-ice switch by the boom operator.

4-141. Circuit breakers for the IFR equipment are located on the boom operator's panel (13, figure 1-24), engineer's IFR panel (3, figure 1-24), the AC power panel (6, figure 1-25).

4-142. IFR HYDRAULIC SYSTEM. The IFR hydraulic system (figure 4-20) consists of a boom system and an IFR pump system. Both systems receive their pressure from two engine-driven hydraulic pumps mounted on the outboard engines. Hydraulic fluid supply comes from an 8 U.S. gallon reservoir to supply the engine-driven pumps. A pressurizing pump, mounted in the fluid supply line, assures an ample supply of fluid to the pumps. Oil coolers, mounted in the outboard nacelles, are placed in the supply lines to cool the fluid. Shutoff valves upstream from the oil coolers shut off fluid supply in the event of an engine fire.

4-143. The IFR hydraulic system is protected by a pressure relief valve which limits system pressure to a maximum of 3500 PSI. A hand pump, a 1.5 gallon reserve tank of hydraulic fluid, and a selector valve are provided for emergency telescoping and hoisting of the boom. Sight gages are provided on each tank.

4-144. Hydraulic pressure to operate the IFR pumps enters two vent type relief valves. These valves are controlled by a solenoid shutoff valve which is operated by a pressure switch in the boom hydraulic system. When the boom system pressure drops below 2700 PSI,

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the pressure switch electrically opens the solenoid valve which in turn closes the vent type relief valve. When the vent type relief valve closes, the boom system receives fluid at 4 GPM until 3000 PSI is reached. At 3000 PSI, the pressure switch allows the solenoid valve to open and the vent type relief valves will open to permit free flow of pressure to the No. 6 solenoid valves and the IFR pump's metering valve. The No. 6 solenoid valves are normally open and pressure will return to the reservoir. They are controlled the signal system and close only when the signal system is in a contact made condition; at which time they are closed by direct current from the battery. At the time of closing, pressure to operate the IFR pumps passes through the metering valve. When the IFR pumps metering valve is closed during a contact made condition, pressure will pass through the metering valve into the system return line; however, as the metering valve is opened by the engineer, pressure is sent to the IFR pumps and the return port in the metering valve is gradually shut off as IFR pump speed is increased.

4-145. NITROGEN SYSTEM. The nitrogen system (figure 4-21) consists of two nitrogen filled cylinders, two manually controlled shutoff valves, a pressure warning light, and a purge switch. The two shutoff valves control the flow of nitrogen for purging the IFR fuel lines. With the tanker signal system in ready and the boom in the stowed position, moving the purge switch to "PURGE" will allow nitrogen pressure to return residual fuel in the IFR fuel lines to the aft IFR tanks. Fully charged, the nitrogen cylinder pressure should be 1800 PSI.

CAUTION

Replace cylinders when the pressure is below 700 PSI.

4-146. IN-FLIGHT REFUELING SYSTEM CONTROLS.

4-147. BOOM OPERATOR'S IFR MASTER SWITCH. An "ON--OFF" master switch-type circuit breaker (35, figure 4-17) on the boom operator's panel supplies electrical power to the signal system and electrically operated controls, instruments, and indicators at the boom operator's station.

4-148. BOOM LOCK LEVER. The lock lever (24, figure 4-17) with "BOOM LATCHED--BOOM UNLATCHED" positions controls a cable-actuated latch which secures the boom. With the boom hoisted against the stowage support, placing the lever in the "BOOM LATCHED" position secures the boom. To release the boom it is necessary to apply a hoisting force on the boom to release pressure on the latch before moving the lever to the "BOOM UNLATCHED" position. The lock lever is located on the right side of the boom operator's panel.

4-149. HOIST LEVER. The hoist lever (4, figure 4-17) located to the left of the boom operator's panel has "DOWN--OFF--UP" positions. The hoist lever controls the direction and rate of flow of fluid to or from the hoist motor. With the hoist lever in the "UP" position the motor raises the boom. "Off" hydraulically locks the hoist motor, and vertical motion of the boom is prevented. In the "DOWN" position the lever allows the motor to rotate in the reverse direction as gravity lowers the boom. In flight a boom-actuated snub switch automatically transfers control from the hoist lever to the ruddevators when the boom is lowered approximately 8° below the stowed position. On the ground full elevation travel is controlled by the hoist lever. In this condition the snub switch is de-energized by the landing gear safety switch, and the boom operator's master switch; both of which must be closed to complete the circuit.

4-150. TELESCOPING LEVER. The telescoping lever (6, figure 4-17) with "FAST RETRACT--RETRACT--NEUTRAL--EXTEND--FAST EXTEND" positions is located on the left side of the boom operator's control panel. This lever controls the fluid rate and direction of flow to a reversible hydraulic motor which telescopes the sliding member of the boom. As the displacement of the lever in the "EXTEND" direction is increased, the rate of extension of the boom is increased, reaching a maximum extension rate at "FAST EXTEND." Similarly increased displacement of the lever in the "RETRACT" direction increases the rate of retraction of the boom, reaching a maximum retraction rate at "FAST RETRACT."

CAUTION

Do not continue to hold the telescope control lever in an "EXTEND" position with the boom stalled, or repeat high rate extension and retraction. This depletes the accumulators and results in uncontrolled extensions of the boom. Returning the lever to "NEUTRAL" for a few moments will restore control of the boom.

4-151. In the "NEUTRAL" position telescoping of the boom is prevented unless the tanker and receiver airplanes are in contact made; in this condition the telescoping control is inoperative, and the boom is allowed to extend and retract according to the relative displacements of the two airplanes.

4-152. TELESCOPING LEVER TRIGGER SWITCH. The trigger switch (36, figure 4-17) on the telescope control handle is used to manually put the signal system into a contact made condition when the signal system override switch is placed in the "OVERRIDE" position. The signal system override switch permits the signal system to operate without the use of the signal amplifier, boom limit switches, and signal coil in the boom nozzle.

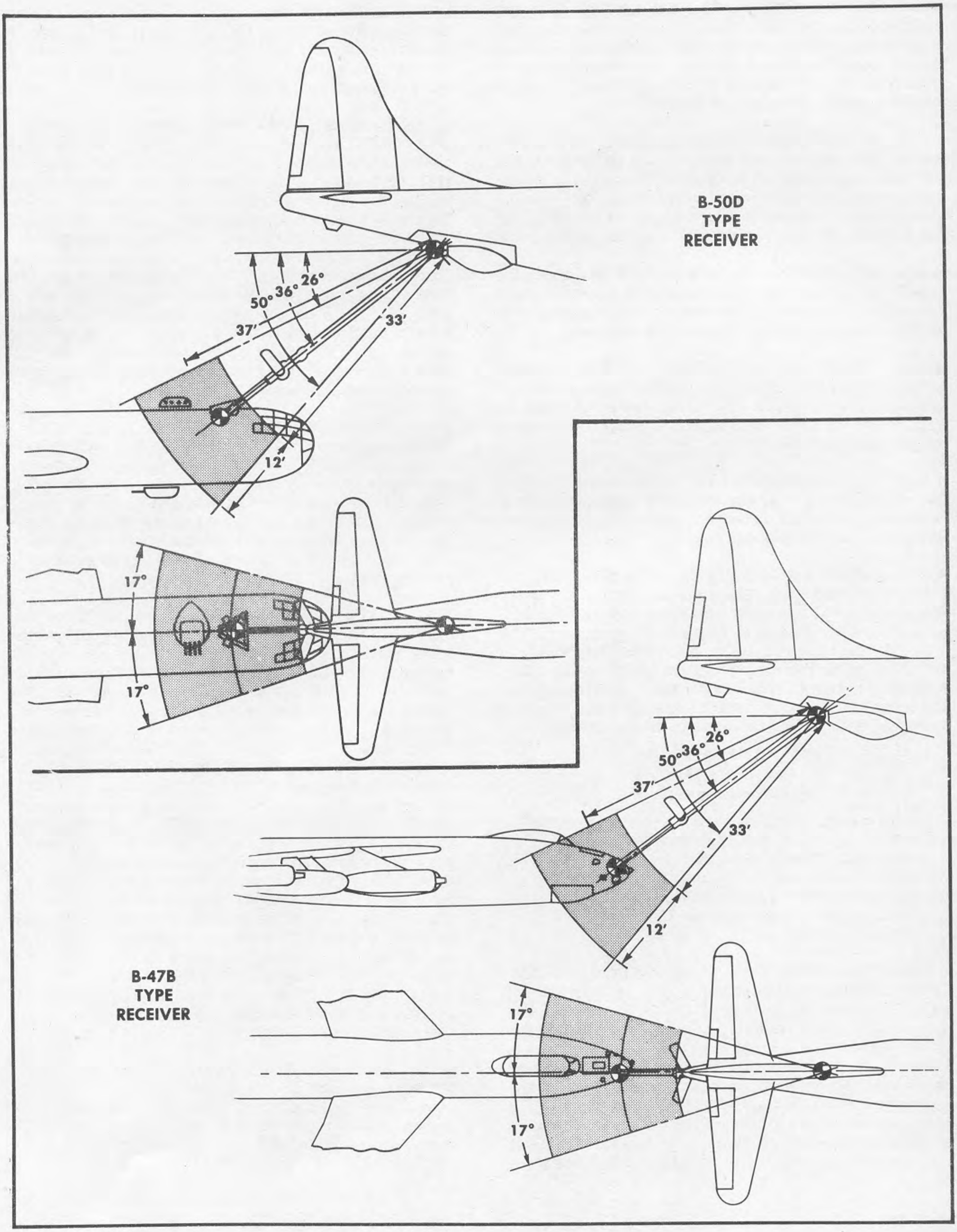

Figure 4-16. Boom Envelope Limits

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4-153. RUDDEVATOR CONTROL STICK. In flight, the ruddevator control stick, located to the right and slightly below the boom operator's platform, provides aerodynamic control of vertical and horizontal boom position. A control lock is provided and should be engaged when the boom is stowed.

4-154. RUDDEVATOR CONTROL STICK LOCK. The ruddevator control stick lock located on the bulkhead aft of the ruddevator control stick, locks the ruddevator control stick in a neutral position. To lock the control stick, the control lock is pulled forward, and the control stick is moved into a recess in the lock.

4-155. DISCONNECT TRIGGER SWITCH. Pressing this trigger switch on the hand grip of the ruddevator control stick initiates a disconnect in the signal system whether in ready for contact or contact made.

4-156. SIGNAL AMPLIFIER TEST BUTTON. A push-to-test button (34, figure 4-17) on the boom operator's panel, when depressed, advances the signal system to a contact made condition for an operational check of the signal system.

4-157. IFR SYSTEM RESET BUTTON. A push-to-reset button (33, figure 4-17) on the boom operator's panel, when depressed after disconnect, will advance the signal system to the ready condition.

4-158. TELESCOPE AT DISCONNECT SWITCH. The "AUTO--MANUAL" telescope at disconnect switch (31, figure 4-17) located on the boom operator's panel, selects control of boom telescoping at disconnect. The "AUTO" position results in automatic telescoping of the boom when the signal system advances to a disconnect condition. The "MANUAL" position leaves the boom static at disconnect and requires the use of the telescoping lever for further movement.

CAUTION

With the boom empty, do not select automatic retracting with less than 6 feet of the boom extended. This insures that the peak retracting rate has dropped off before the boom strikes the stop. With manual control of the boom, do not allow the boom to strike the stops at high retraction rates.

4-159. EMERGENCY HAND PUMP SELECTOR VALVE KNOB. A manual selector valve knob (3, figure 4-15) with "TELESCOPE--OFF--HOIST" positions and a hydraulic hand pump (1, figure 4-15) provide for emergency stowage in event of normal hydraulic failure. The pump is located on the right side of the forward end of the boom operator's compartment, and the selector valve knob is adjacent to the hand pump. The boom must be raised to within the 8^{0} range from stowed position before emergency hoisting is possible. With the selector valve knob on "TELESCOPE," pressure built up by the hand pump will retract the boom. During normal operation the "OFF" position is used to isolate the emergency system. The "HOIST" position of the selector knob allows pressure from the hand pump to hoist the boom to the stowed position.

4-160. HYDRAULIC PRESSURE SWITCH. An "AUTO--OFF--MANUAL" switch (32, figure 4-17) on the boom operator's panel provides control to pressurize the IFR hydraulic system. Power for this switch comes through the boom operator's master switch, so that the master switch must be "ON" and the hydraulic pressure switch in either "AUTO" or "MANUAL" for the IFR hydraulic system to become pressurized With the switch in "AUTO" the pressure in the IFR hydraulic system will be maintained at 2700 PSI to 3000 PSI. With the switch in "MANUAL" the pressure in the IFR hydraulic system will build up to the pressure setting of the relief valve (3080 $\pm$ 25 PSI). With the switch "OFF" the hydraulic system will gradually depressurize.

4-161. DEPRESSURIZATION VALVE HANDLE. A depressurization valve with an "OPEN--CLOSED" control handle (4, figure 4-15) provides for depressurization of the hydraulic system. When the boom hydraulic system is not in use, the handle is placed in the "OPEN" position to depressurize the system. Normal operating position of the handle is the valve "CLOSED" position which allows the system to be pressurized.

4-162. NITROGEN SUPPLY VALVE KNOBS. Two manual shutoff valve knobs (2, figure 4-17) on the boom operator's switch panel supply nitrogen to purge the main refueling line. When either of the nitrogen valve "OPEN--CLOSE" knobs are in the "OPEN" position, nitrogen pressure is supplied for purging. Nitrogen pressure will be vented to the atmosphere if the valve knobs are not in the "CLOSE" position. Therefore, the knobs must be in the "CLOSE" position except when purging.

4-163. NITROGEN PURGE SWITCH. A guarded purge switch (37, figure 4-17) with "PURGE--NORMAL" position is located on the boom operator's control panel. To purge fuel from the boom, the signal system must be in the ready condition; either No. 1 or No. 2 nitrogen valve must be opened; and the switch must be in the "PURGE" position. Positioning the switch to "PURGE" allows trapped fuel in the refueling lines to be returned to the aft IFR tank. During refueling operations, the purge switch is in the "NORMAL" position to prevent fuel from flowing through the purge line into the aft IFR tank.

4-164. FUEL CUTOFF BUTTON. A thumb operated button on the hand grip of the ruddevator control stick provides the boom operator with a fuel shutoff control during contact made. A momentary depression of this button shuts off the IFR pumps, closes the line valve and opens the automatic by-pass valve.

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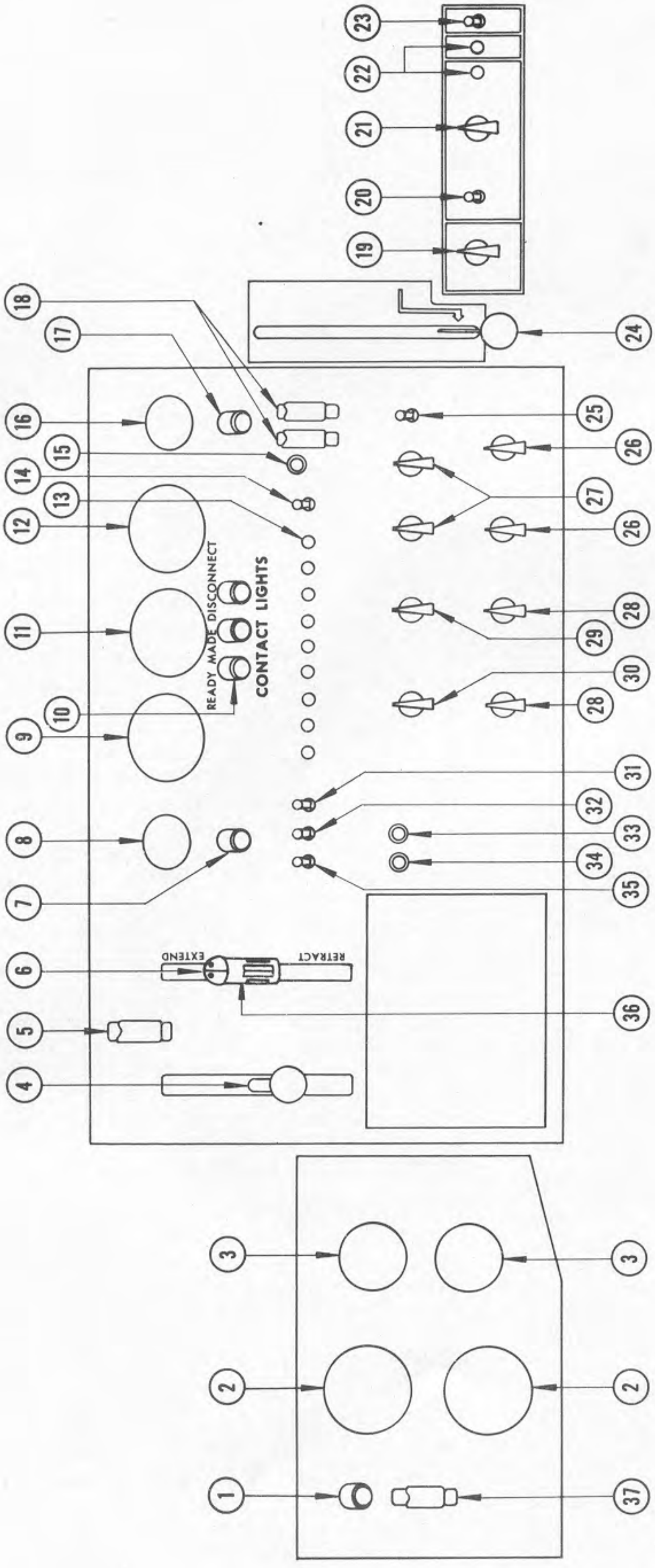

1 PURGE COMPLETED LIGHT
2 NITROGEN SUPPLY VALVE KNOB
3 NITROGEN CYLINDER PRESSURE GAGE
4 HOIST LEVER
5 SIGNAL SYSTEM EMERGENCY OVERRIDE SWITCH
6 TELESCOPING LEVER

7 HYDRAULIC PRESSURE WARNING LIGHT
8 HYDRAULIC PRESSURE GAGE
9 BOOM AZIMUTH INDICATOR
10 CONTACT LIGHTS
11 BOOM TELESCOPING INDICATOR
12 BOOM ELEVATION INDICATOR

13 CIRCUIT BREAKERS
14 WINDOW ANTI-ICE SWITCH
15 RESET EMERGENCY FUEL SHUTOFF BUTTON
16 FUEL PRESSURE GAGE
17 FUEL EMERGENCY SHUTOFF WARNING LIGHT
18 LIMIT CUTOUT SWITCH

19 INTERPHONE LIGHT SWITCH
20 PANEL LIGHT SWITCH
21 PANEL LIGHT RHEOSTAT
22 CIRCUIT BREAKER
23 DOME LIGHT SWITCH
24 BOOM LOCK LEVER

25 CHOCK LIGHT SWITCH
26 BOOM MARKING LIGHT SWITCH
27 UNDERWING LIGHT SWITCH
28 BOOM NOZZLE LIGHT SWITCH
29 UNDERBODY LIGHT SWITCH
30 PILOT DIRECTOR LIGHT SWITCH

31 TELESCOPE AT DISCONNECT SWITCH
32 HYDRAULIC PRESSURE SWITCH
33 IFR SYSTEM RESET BUTTON
34 SIGNAL AMPLIFIER TEST BUTTON
35 IFR MASTER SWITCH
36 TELESCOPING LEVER TRIGGER SWITCH
37 NITROGEN PURGE SWITCH

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Figure 4-17. Boom Operator's Panel

1 IFR MASTER SWITCH
2 RUDDEVATOR ANTI-ICE SWITCH
3 HYDRAULIC PRESSURIZING PUMP
4 PUSH-TO-TEST BUTTON
5 FUEL PRESSURE LOW WARNING LIGHTS
6 CIRCUIT BREAKERS
7 HYDRAULIC PRESSURE WARNING LIGHT
8 HYDRAULIC OIL SUPPLY VALVE SWITCH
9 HYDRAULIC PRESSURE GAGES
10 FUEL QUANTITY INDICATOR
11 IFR LINE VALVE WARNING LIGHT
12 IFR LINE VALVE SWITCH
13 CONTACT LIGHTS
14 PANEL LIGHT SWITCH
15 PANEL LIGHT RHEOSTAT
16 FUEL QUANTITY WARNING LIGHTS
17 IFR TRANSFER VALVE SWITCH
18 FUEL LEVELING VALVE SWITCH
19 FUEL EMERGENCY SHUTOFF WARNING LIGHT
20 FUEL PRESSURE GAGE
21 FUEL TOTALIZER RESET SWITCH
22 FUEL FLOW AND TOTALIZER INDICATOR

Figure 4-18. Engineer's IFR Panel (Sheet 1 of 2)

4-165. RESET EMERGENCY FUEL SHUTOFF BUTTON. This button (15, figure 4-17) on the boom operator's panel is used to restart fuel flow which has been shut off by the fuel cutoff button.

4-166. SIGNAL SYSTEM EMERGENCY OVERRIDE SWITCH. This "NORMAL--OVERRIDE" switch (5, figure 4-17) is on the boom operator's panel. When the switch is in the "OVERRIDE" position manual control by the boom operator replaces the signal amplifier's duties and refueling operations may continue without use of the boom limit switches and the signal coil in the boom nozzle. When the switch is in the "NORMAL" position, the function of the signal amplifier is restored.

4-167. LIMIT CUTOUT SWITCHES. Two guarded "INACTIVE--ACTIVE" limit cutout switches (18, figure 4-17) on the boom operator's panel, when in the "INACTIVE" position will cut out the elevation and extension limits on the boom for ground test purposes. The "ACTIVE" position is used during all flight operations to restore the two limits and prevent structural damage.

4-168. WINDOW ANTI-ICE SWITCH. A "LOW--OFF--NORMAL" window anti-ice switch (14, figure 4-17) on the boom operator's panel is provided to control the Nesa window heat for the boom operator's Nesa window. The "LOW" position is used to warm the glass slowly and the "NORMAL" position is used for all other operations requiring Nesa heat.

4-169. ENGINEER'S IFR MASTER SWITCH. When in the "ON" position, this "ON--OFF" switch (1, figure 4-18) on the engineer's IFR panel supplies power to all the switches and indicator lights on the panel. This switch also controls power to the automatic by-pass valve. When the switch is "OFF," all the controls and indicators on the engineer's IFR panel are de-energized and the automatic by-pass valve is prevented from closing.

NOTE

The engineer's IFR panel must be thoroughly checked for proper switch positioning before placing the IFR master switch in the "ON" position.

4-170. IFR LINE VALVE SWITCH. A "OPEN--CLOSED" switch (12, figure 4-18) on the engineer's IFR panel controls the IFR line valve during contact made. If the switch is positioned to "OPEN," the valve will open at contact made. At disconnect the valve will automatically close. The switch should then be positioned to "CLOSED" to prevent opening of the IFR line valve during boom operator's boom checks.

4-171. MANUAL OVERRIDE HANDLES. The IFR line valve and leveling valve, are motor-driven sliding-gate type valves equipped with "CLOSED--OPEN" manual override handles. By means of these override handles, which also serve as valve position indicators, the valve can be placed in any position between full "OPEN" and full "CLOSED" regardless of the control switch position. To re-establish electrical control once the valve has been operated manually, the manual override handle must be moved to "OPEN" or "CLOSED" and the motor must be run through one complete cycle so the valve and motor drive can become meshed.

4-172. IFR TANK TRANSFER VALVE SWITCHES. Two "OPEN--CLOSED" switches (17, figure 4-18) on the engineer's IFR panel control the IFR tank transfer valves. When both the switches are in the "OPEN" position, the valves are opened and fuel can be transferred from the wing tanks to the IFR tanks. Positioning the valve switches at "CLOSED" closes the valves and prevents fuel flow between the manifold system and the IFR tanks.

4-173. FUEL LEVELING VALVE SWITCH. This "OPEN--CLOSED" switch (18, figure 4-18) on the engineer's IFR panel is used to open and close the leveling valve between the forward and aft IFR tanks. The switch is guarded in the "CLOSED" position. In the "OPEN" position the fuel in the forward and aft IFR tanks will seek its own level.

The fuel leveling valve should be kept closed except during operations requiring leveling. This will prevent CG shifts due to fuel flowing between tanks during climbs or let-downs.

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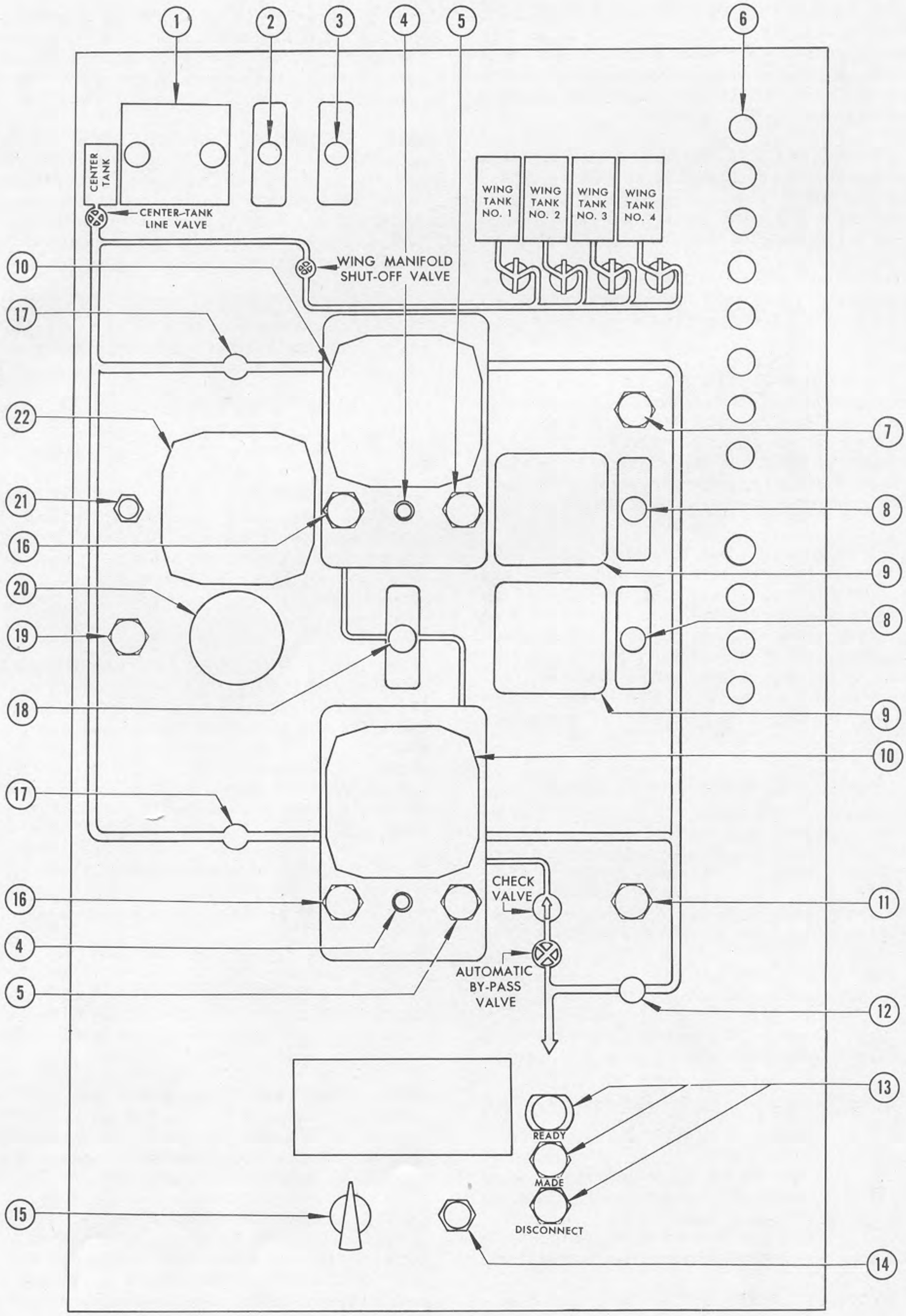

Figure 4-18. Engineer's IFR Panel (Sheet 2 of 2)

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4-174. HYDRAULIC OIL SUPPLY VALVE SWITCHES. Two "OPEN--CLOSED" hydraulic oil supply valve switches (8, figure 4-18) on the engineer's IFR panel are used to shut off the supply of hydraulic fluid to the two engine-driven IFR hydraulic pumps. The switches are guarded in the "OPEN" position.

4-175. PILOT DIRECTOR LIGHT SWITCH. The pilot director lights are controlled by an "OFF--DIM--LOW--MED--HIGH" rheostat type switch (30, figure 4-17) located on the boom operator's panel. Light brightness is controlled by selection of switch position.

4-176. RUDDEVATOR ANTI-ICE SWITCH. An "OFF--ON" switch (2, figure 4-18) on the engineer's IFR panel supplies electrical power to the ruddevator anti-icing boots.

4-177. MANIFOLD SHUTOFF VALVE. A manually operated wing manifold shutoff valve is located under the wing center section stub. The valve is normally wired in the open position. When jet fuel is carried in the center section tank this valve is to be wired in the closed position to prevent any possible contamination of the manifold system with jet fuel.

4-178. IFR PUMP CONTROL HANDLE. This handle located between the engineer's instrument panel and the engineer's IFR panel, controls the output of the IFR pumps. The handle quadrant is marked in 10 equally spaced increments reading from "0" to "10." With the handle at "0" the IFR pumps are inoperative. Advancing the control handle towards "10" increases the IFR pump speed. The handle can be locked in any position from "0" to "10" to maintain the desired fuel pressure in the IFR line.

4-179. HYDRAULIC PRESSURIZING PUMP SWITCH. This "NORMAL--TEST" switch (3, figure 4-18) on the engineer's IFR panel, is used to energize the hydraulic pressurizing pump during ground test only. The hydraulic pressurizing pump circuit is wired through the outboard engine ignition switches so that the outboard ignition switches must be on "BOTH" for the hydraulic pressurizing switch to operate with the pump switch "NORMAL." With the pump switch in the "TEST" position the outboard ignition switches are by-passed and the pressurizing pump can be operated for ground test when using a hydraulic test cart for hydraulic supply. The hydraulic pressurizing pump switch is guarded in the "NORMAL" position.

4-180. IN-FLIGHT REFUELING SYSTEM INDICATORS.

4-181. BOOM INDICATORS. Three instruments (9, 11, 12, figure 4-17) on the boom operator's panel indicate azimuth, elevation and telescoping positions of the boom. A circuit breaker on the boom operator's panel protects the electrical circuit connecting the indicators and their respective transmitters.

4-182. HYDRAULIC PRESSURE GAGES. A pressure gage (8, figure 4-17) on the boom operator's panel indicates the IFR hydraulic system pressure in PSI. Two gages (10, 12, figure 4-18) on the engineer's IFR panel indicate the hydraulic pressure in PSI from each engine-driven IFR hydraulic pump.

4-183. HYDRAULIC PRESSURE WARNING LIGHTS. An amber warning light (7, figure 4-17) on the boom operator's panel indicates that hydraulic pressure in the IFR system is low when the light is illuminated. A red warning light (7, figure 4-18) on the engineer's IFR panel will illuminate when the engine-driven hydraulic pump supply pressure is low.

4-184. NITROGEN CYLINDER PRESSURE GAGES. Two direct pressure gages (3, figure 4-17) on the boom operator's panel indicate pressure in PSI in each of two nitrogen supply cylinders.

4-185. PURGE COMPLETED LIGHT. A green purge completed light (1, figure 4-17) on the boom operator's panel is illuminated when purging is complete.

4-186. FUEL EMERGENCY SHUTOFF WARNING LIGHTS. Two amber lights will illuminate when the fuel flow in the IFR system has been shut off by depression of the boom operator's fuel cutoff button. One light (17, figure 4-17) is on the boom operator's panel and the other (19, figure 4-18) is on the engineer's IFR panel.

4-187. FUEL PRESSURE LOW WARNING LIGHTS. Two amber lights (5, figure 4-18) on the engineer's IFR panel will illuminate when the fuel pressure is low at the forward and aft IFR fuel pumps.

4-188. FUEL QUANTITY WARNING LIGHTS. Two amber lights (26, figure 4-18) on the engineer's IFR panel will illuminate when the forward and aft IFR tanks are full.

4-189. IFR LINE VALVE WARNING LIGHT. An amber light (11, figure 4-18) on the engineer's IFR panel, will illuminate when the IFR line valve is open.

4-190. FUEL QUANTITY INDICATORS. Two fuel quantity indicators (10, figure 4-18) on the engineer's IFR panel indicate the quantity of fuel in pounds in the two IFR tanks. A push-to-test-indicator button (4, figure 4-18) is located adjacent to each quantity indicator.

4-191. FUEL PRESSURE GAGES. Two fuel pressure gages, (20, figure 4-18) and (16, figure 4-17) on the engineer's IFR panel and the boom operator's panel respectively, indicate the fuel pressure in pounds per square inch in the IFR fuel line.

4-192. FUEL FLOW AND TOTALIZER INDICATOR. A combination fuel flow and totalizer indicator (22, figure 4-18) is mounted on the engineer's IFR panel. Fuel flow is indicated in pounds per minute and the fuel totalizer indicates the quantity of fuel transferred in pounds. A totalizer "NORMAL--RESET" switch (21, figure 4-18) is adjacent to the fuel flow and totalizer indicator. The switch must be in the "NORMAL" position for the totalizer to indicate the quantity of fuel transferred. Placing the switch in the "RESET" position resets the totalizer to zero.

4-193. CONTACT LIGHTS. Three contact lights, (13, figure 4-18) on the engineer's IFR panel, and three similar lights (10, figure 4-17) on the boom operator's panel indicate the condition of the IFR refueling system. When the blue ready light is illuminated the tanker IFR system is ready for contact with a receiver airplane. When the green made light is illuminated contact has been made and fuel can be transferred to a receiver airplane. When the amber disconnect light is illuminated the tanker and receiver airplanes have broken contact and the fuel flow in the tanker IFR system is stopped.

4-194. IN-FLIGHT REFUELING SYSTEM NORMAL OPERATION.

WARNING

It is mandatory that there be no smoking anywhere in the airplane during in-flight refueling operations.

4-195. PILOT'S PROCEDURE. Monitor use of all electrical equipment in accordance with the following warning.

WARNING

During in-flight refueling operations, do not operate suit heater rheostats, inter-aircraft signal lamp, radio compasses, localizer and glide path receivers, marker beacon, or any other electrical equipment not essential to flight or the refueling operation. Possible arcing can cause fire or explosion of fuel fumes.

4-196. For tanker pilot technique see paragraph 4-240.

4-197. BOOM OPERATOR'S PROCEDURE. The following checks and procedures are presented as an aid to successful operation of the IFR system before and during refueling flights.

WARNING

During in-flight refueling operations, do not operate the suit heater rheostat, inter-aircraft signal lamp, light rheostats, interphone selector, or any other electrical equipment not necessary to the refueling operation. Possible arcing can cause fire or explosion of fuel fumes.

4-198. PREFLIGHT CHECKS. The following external and internal checks should be accomplished by the boom operator before each refueling mission.

4-199. EXTERNAL CHECK.

a. Check that boom stowing lock is securely engaged and remove ground safety lock.
b. Check that all dust covers are removed.
c. Make visual check that ruddevators, nozzle, boom fairings, and boom are in good operating condition.
d. Make visual check that the boom and other associated equipment is properly installed and in good operating condition at attachment point.
e. Check external surfaces of the boom and boom operator's compartment for evidence of fuel or hydraulic leaks.
f. Check boom operator's compartment windows and pilot director lights for cleanliness and freedom from damage.
g. Check all exterior lights for freedom from damage, cleanliness, and security of mounting.
h. With wing flaps down, check outboard along rear spar and bottom of nacelle skates to firewall for evidence of hydraulic leaks. Check security of mounting of hydraulic tubing.
i. Check IFR tank drain ports for freedom from obstructions.
j. Check IFR tank filler caps visually for proper installation and access door properly closed.
k. Check with ground crew that boom grease fittings have been properly lubricated.

4-200. INTERNAL CHECK.

a. Enter airplane through aft entry door and check for leakage, condition, and security of all IFR equipment and tubing at rear spar location. Check manifold valve closed safetied if jet fuel is carried in center wing tank.
b. Upon entry into the main cargo compartment, check all hydraulic and IFR tank tubing for security, condition, and evidence of leaks.
c. Check that IFR tank interconnects and IFR pump sumps have been drained of moisture content in five places.
d. Check all hose connections for tightness.
e. Check that transfer valves are disconnected if jet fuel is carried in IFR tank and not in center wing tank.
f. Check hydraulic tank for proper fluid level.
g. Check that handles on solenoid valves No. 6, located on the hydraulic panel, are safetied with handle pointing toward electrical connector.
h. Check IFR tank filler lines for security and condition.
i. Check electrical connectors for security and general condition on fuel quantity transmitters, pressure switches, all fuel valves, and fuel flow electrical equipment.
j. Check that line valve is closed.
k. Check that fuel by-pass valve is open.
l. Check entire length of refueling line for security, general condition and evidence of leaks.
m. Check hand pump hydraulic supply tank for proper fluid level.
n. Check all electrical connectors on signal ampli-

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fier, fuel pressure transmitter, solenoid valves, boom operator's relay shield,boom operator's panel, ruddevator anti-ice, and other connectors for security and general condition.

o. Check entire boom operator's compartment for evidence of hydraulic leaks.

p. Check solenoid valves No. 1, 2, 4, and 5 for normal override handles safetied and pointing toward their electrical connectors.

q. In tail cone section, check No. 3 solenoid valve for manual override handle safetied and pointing toward its electrical connector.

r. Check all IFR equipment in tail cone for hydraulic leaks, security and general condition.

s. Check nitrogen bottles for security of mounting and condition. Check connections at bottles for tightness.

t. Check nitrogen pressure gages for pressure reading between 700 and 1800 PSI.

u. Check boom operator's panel for general condition. Check that all switches and controls are in nominal positions with power off and nitrogen valves closed.

v. Check hydraulic depressurization valve "CLOSED."

w. Push in all circuit breakers on boom operator's panel,

x. Check oxygen supply pressure, including portable bottle. Check for presence of personal oxygen equipment.

y. Check fire extinguisher for general condition and security of mounting.

z. Place IFR master switch to "ON." The following indicator lights will illuminate: hydraulic pressure warning light; ready for contact light.

aa. Push to test all indicator lights not illuminated.

ab. Check all control panel and compartment lights for operation, security, and general condition.

ac. Check all exterior lights for operation, security, and general condition.

NOTE

When checking the exterior lights, a second man will be required to make a visual check of all lights from the outside of the airplane. Boom lights may be checked when boom is down on operational ground check.

ad. Unstow ruddevator control stick and check for freedom of movement and proper operation.

ae. Check boom position instruments for proper reading; elevation 11^{O} up, azimuth 0^{O}, telescope 0 feet.

af. Check interphone and emergency alarm bell for proper operation.

ag. Turn IFR master switch "OFF" and prepare for operational ground check.

4-201. OPERATIONAL GROUND CHECK. This check requires the use of an external electrical power supply and the use of a hydraulic test cart which is capable of pumping a sufficient flow of at least 4 GPM at 3000 PSI for boom operation. If this equipment is not available, both outboard engines running at 2000 RPM will be adequate for this check. However, an inboard engine will then have to be operating to furnish hydraulic pressure for the parking brakes.

a. Connect external electrical power supply and attach hydraulic test cart to boom system hydraulic test connections in outboard engine nacelles, or start engines.

b. Place IFR master switch to "ON."

c. Place hydraulic pressure switch to "AUTO."

d. Place hydraulic pressurizing pump switch to "TEST."

e. Unlatch boom and lower onto a suitable support.

f. Place telescope at disconnect selector switch "MANUAL."

g. Advance signal system to ready for contact with reset button.

h. Extend boom; vary rate of extension to check for normal operation of telescoping system; check operation of extension indicator; full extension of the boom should read 20 feet.

i. Check the extension limit switch by the following procedure: extend boom to approximately the setting of the switch being tested (see range travel markings on boom position instruments); advance signal system to contact made with test switch; if signal system remains in contact made, reset signal system to ready for contact with reset switch and repeat test after moving boom closer to limit; limit switch must always be approached from within the flight envelope.

j. Extend boom fully.

k. Have the nozzle checked as follows: check self centering; check poppet valve; check primary seal; check static disconnect spring and retainer; check general condition of nozzle; check signal coil wire lead.

l. Check surge boot inflation for 50 PSI.

m. Place extension limit cutout switch in "INACTIVE" position.

n. Advance signal system to contact made with test switch; if extension limit cutout switch is working properly, signal system will stay in contact made.

o. Place extension limit cutout switch in "ACTIVE"; signal system should advance to disconnect.

p. Retract boom to approximately 15 feet extended; advance signal system to contact made with test switch.

q. Press trigger switch on ruddevator control stick; signal system should advance to disconnect.

r. Advance signal system to ready for contact with test switch.

s. Press trigger switch on ruddevator control stick; signal system should advance to disconnect.

t. Place telescope at disconnect selector switch in "AUTOMATIC."

u. Advance signal system to contact made with test switch.

v. Press trigger switch on ruddevator control stick; signal system should advance to disconnect and boom should retract completely.

w. Check that the fuel by-pass valve is open.

x. Check retraction limit switch by a similar procedure to that used to check extension limit switch in step "i."

y. Check operation of lights in boom nozzle hood.

z. Place hydraulic pressure switch to "AUTO ON." Hydraulic pressure should indicate 2700 - 3000 PSI.

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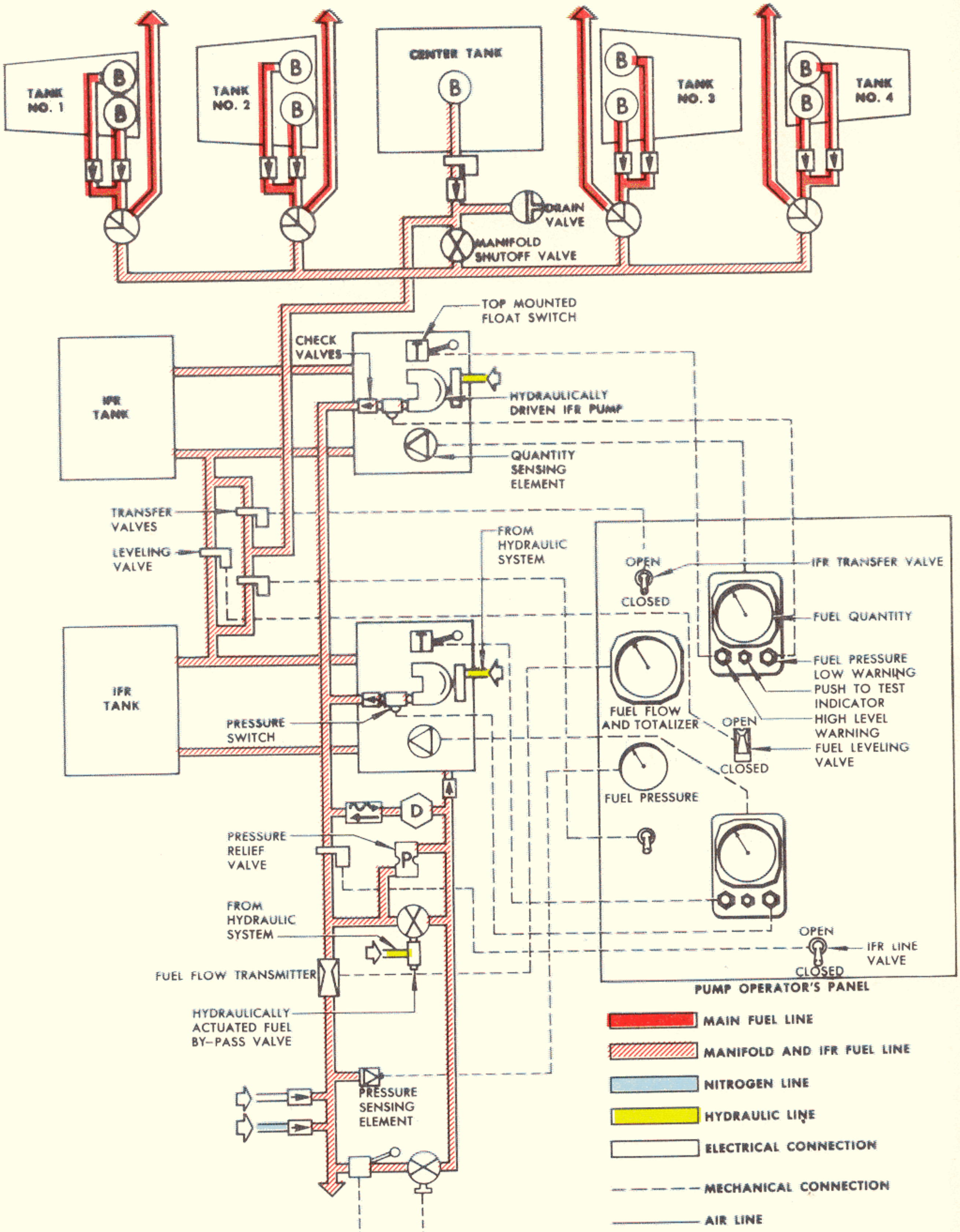

Figure 4-19. IFR Fuel System

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4-202. BOOM PRESSURE CHECK.

a. If a hydraulic test cart capable of delivering 20 GPM is not available to furnish adequate flow to IFR pumps for building up 35 PSI fuel pressure, start both outboard engines.

b. Place hydraulic pressure switch to "AUTO."

c. Extend boom approximately 15 feet.

d. Check with engineer that line valve switch is "OPEN."

e. Advance signal system to contact made with test switch.

f. Have engineer increase outboard engines RPM to 2000 if high capacity hydraulic test cart is not available.

g. Notify engineer to advance IFR pump control toward high until 35 PSI fuel pressure can be maintained. When 35 PSI fuel pressure is reached, press reset switch to return signal system to ready for contact. Have engineer retard IFR pump control to "O."

WARNING

IFR pumps should not be operated over one minute duration with zero flow in refueling line. Energy used to drive the IFR pumps is converted to heat and dissipated into the fuel which cools the pumps.

h. Slowly retract boom until refuel line pressure reads 100 PSI and hold this pressure for a maximum of 5 minutes.

i. Check refueling line and boom for leaks.

j. Extend boom to relieve pressure after above check is made.

k. Press trigger switch on ruddevator control stick and retract boom.

l. Stow boom by hoisting into chock and engaging boom latch.

m. Purge the boom by advancing signal system to ready for contact, opening both nitrogen valves, and placing purge switch to "PURGE." When purge complete light illuminates, return purge switch to "NORMAL" and close both nitrogen valves.

n. Place IFR master switch and hydraulic pressure switch to "OFF."

4-203. TAKE-OFF. Move to one of auxiliary crew seats provided just forward of the boom pod.

WARNING

The boom operator's station must not be occupied during take-off or landing.

4-204. AFTER TAKE-OFF CHECK. As soon as the airplane has cleared the traffic pattern and clearance has been obtained from the pilot, it is recommended that the following functional air check be made by the boom operator:

a. Place IFR master switch "ON." Allow 5 to 10 minutes for signal amplifier to warm up.

b. Unstow ruddevator control stick.

c. Push to test all indicator lights.

d. Place hydraulic pressure switch to "AUTO." Hydraulic pressure should build up to 3000 PSI and hydraulic pressure low warning light should go out.

e. Hoist boom with hoisting handle until boom can be unlatched from stowed position and lower until boom falls free. Boom should fall at about the horizontal position if the snub switch is operating properly.

f. Fly boom up and down to check that slack takeup is working properly.

g. Extend boom 10 feet and notify engineer that limit switches are to be checked.

NOTE

Before performing steps "h" through "k," advance signal system to ready for contact with reset switch and then to contact made with the test switch prior to each step. Swing the boom through limits being checked and observe instrument reading when limit switch actuates.

h. Check upper elevation limit switch (approximately 25°).

i. Check left azimuth limit switch (approximately 17°).

j. Check right azimuth limit switch (approximately 17°).

k. Check lower elevation limit switch (approximately 50°).

NOTE

Before performing steps "l" and "m" advance signal system to ready for contact with the reset switch before each step and move boom with telescope control lever to the approximate setting of limit being tested. Advance signal system to contact made with test switch. If signal system remains in contact made, reset signal system to ready for contact and repeat test after moving boom closer to limit. Limit must always be approached from within the flight envelope.

l. Check retraction limit switch (switch actuates at approximately 6 feet).

m. Check extension limit switch (switch actuates at approximately 18 feet).

n. Place extension limit cutout switch to "INACTIVE"; extend boom fully and press test switch; signal system should advance to contact made.

o. Place extension limit cutout switch to "ACTIVE"; signal system should advance to disconnect.

p. Retract boom to 15 feet extended with telescope handle.

q. Reset signal system to ready for contact with reset button.

r. Press trigger switch on ruddevator control stick; signal system should advance to disconnect; boom should not retract.

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s. Reset signal system to ready for contact with reset button.
t. Advance signal system to contact made with test switch.
u. Press trigger switch on ruddevator control stick; signal system should advance to disconnect; boom should not retract.
v. Place telescope at disconnect selector switch to "AUTO"; signal system should advance to disconnect and boom should retract completely.
w. Check with engineer to confirm proper operation of his indicator lights.
x. Check operation of fuel by-pass valve in each signal system condition; by-pass valve should be closed at all conditions except disconnect.
y. Place purging switch to "PURGE"; purge complete light should illuminate; signal system must be in ready for contact.
z. Return purging switch to "NORMAL."
aa. Place IFR master and hydraulic pressure switch to "OFF."
ab. Stow boom if contact is not anticipated a short time later.

4-205. BEFORE CONTACT.
a. Place IFR master switch to "ON"; allow 5 to 10 minutes for signal amplifier to warm up.
b. Place hydraulic pressure switch to "AUTO"; hydraulic pressure should build up to 3000 PSI.
c. Turn pilot director lights rheostat to dim intensity; intensity subject to change at request of receiver pilot.
d. Notify engineer that a contact is anticipated; confirmation should be made by engineer of what fuel system configuration and management is to prevail during contact.
e. Place telescope at disconnect selector switch to "AUTOMATIC."
f. Unstow and lower boom to 32° down elevation, 0° azimuth, and extended 10 feet.
g. Confirm that both tanker and receiver airplane's signal systems are in ready for contact.
h. Talk receiver into nominal contact position which is 34° down elevation, 0° azimuth, and approximately 2 feet from nozzle.

4-206. CONTACTING.
a. With receiver in nominal contact position, fly boom to align with receiver receptacle, then extend boom almost to the receptacle; contact should be established using a positive movement of the extension control, following through until a contact made light is obtained before neutralizing the extension control.

NOTE

Extremely slow insertions may cause an unsuccessful contact and extremely fast insertions are unnecessary and should be avoided. If a disconnect occurs before completion of fuel transfer, contact may be reestablished with the boom full of fuel.

4-207. DURING CONTACT. The following information should be closely adhered to and kept well in mind during contact with a receiver airplane:
a. Follow receiver's movements as transmitted through the ruddevator control stick; keep a slight pressure in the direction the receiver moves; the greater the displacement from normal, the more pressure maintained except in up elevation where only slight back pressure is required.
b. Inform receiver pilot of position in flight envelope and what corrective action should be undertaken to stay within envelope.

NOTE

It is considered particularly important to preface the commands to the receiver pilot by first giving the direction for the receiver pilot to move, then the estimated distance to be moved to reach the nominal contact position. This practice will prevent misunderstanding to a large extent and in addition minimize the amount of communication traffic. It is necessary for the boom operator to have a clear understanding of the actual limit switch envelope and to remember that the receiver airplane is capable of moving forward and aft, up and down, and from side to side. It is obvious that the instructions must be qualified. For example, if the receiver is too high in the envelope and the boom is nearly fully extended, directing the receiver pilot to move down (before moving forward) would result in actuating the extension limit switch because the receiver would move tangent to the boom envelope for that particular extension position.

c. Be alert so as to clear boom from receiver in event of an inadvertent disconnect.
d. Observe that IFR equipment is working properly and heed indicator lights and instruments.

4-208. TOWING. When refueling fighter type airplanes, it may be desirable to tow the receiver airplane. If this should be the case, upon approval of both the tanker and receiver pilots place the extension limit cutout switch in "INACTIVE." This will prevent an automatic disconnect from occurring when the extension limit stop is reached. Azimuth and elevation limit switches are not de-energized by this switch and an automatic disconnect will occur if the receiver leaves the refueling envelope. Manual disconnect can be accomplished by the boom operator and the receiver pilot depressing their disconnect buttons simultaneously.

WARNING

Before moving the elevation limit cutout switch to "INACTIVE" be sure that the pilots of both the tanker and the receiver have approved the action and are ready to enter the tow condition.

4-209. DISCONNECT. It is recommended that the

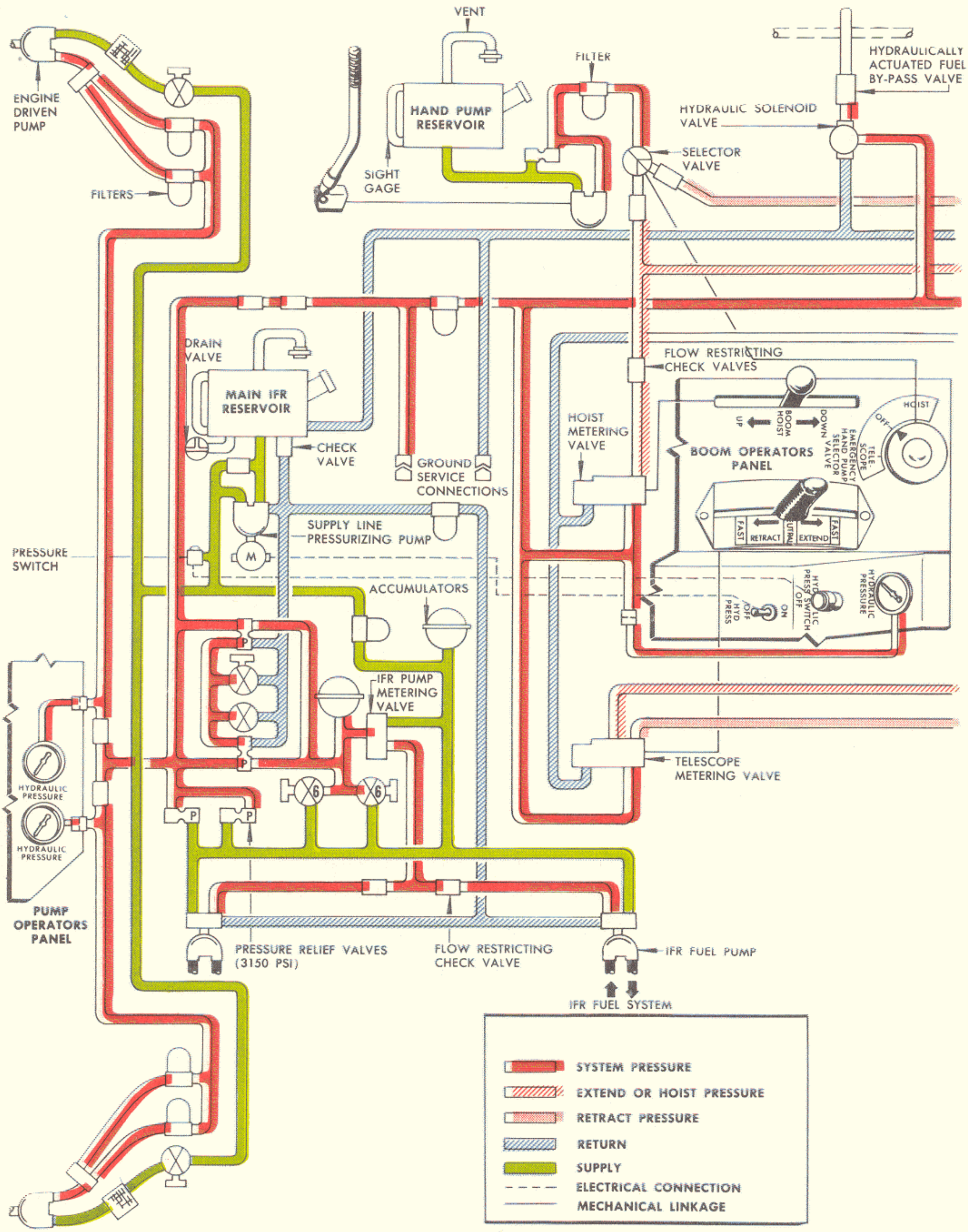
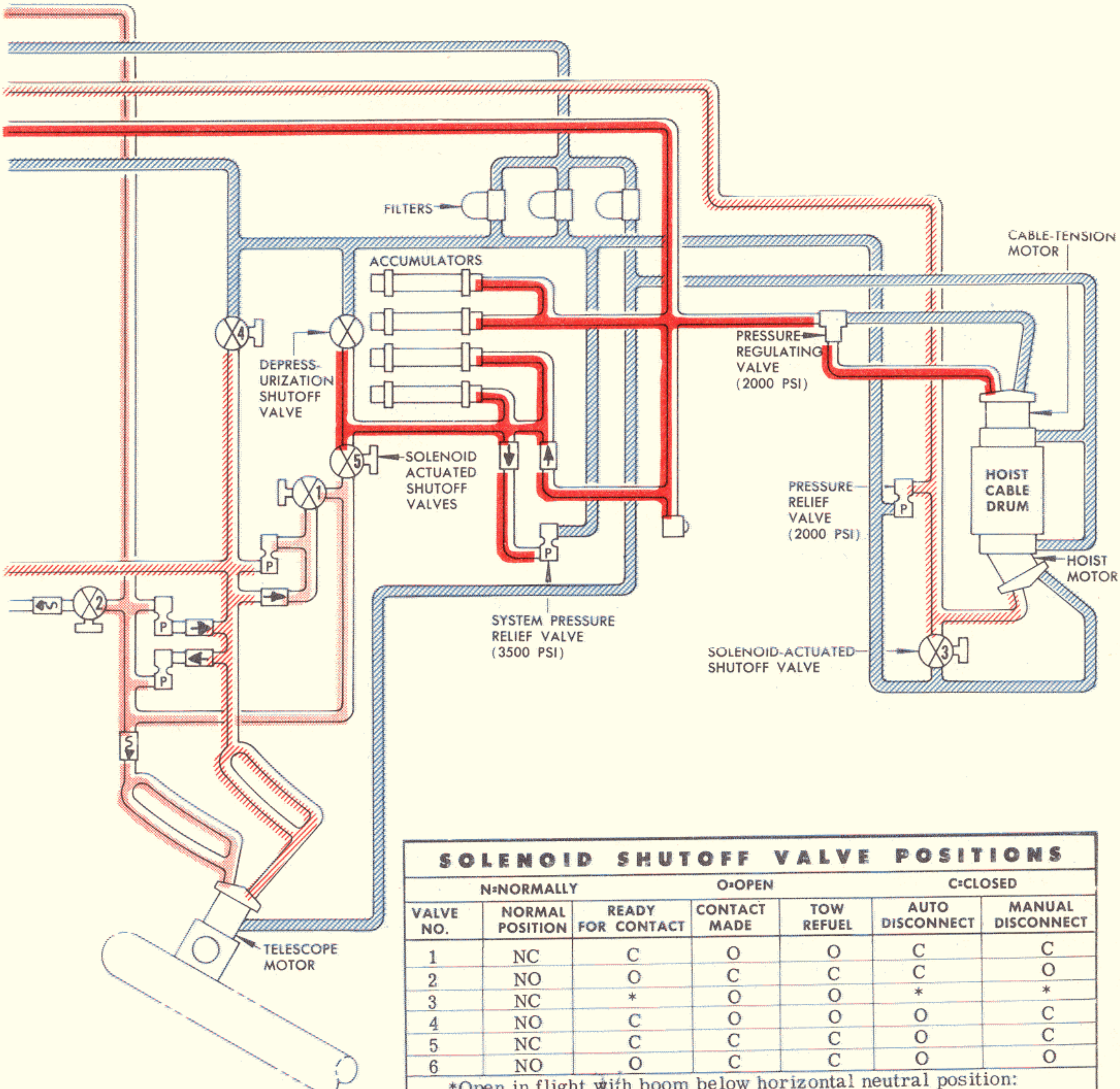


Figure 4-20. IFR Hydraulic System (Sheet 1 of 2)



SOLENOID SHUTOFF VALVE POSITIONS

N=NORMALLY O=OPEN C=CLOSED

VALVE NO.	NORMAL POSITION	READY FOR CONTACT	CONTACT MADE	TOW REFUEL	AUTO DISCONNECT	MANUAL DISCONNECT
1	NC	C	O	O	C	C
2	NO	O	C	C	C	O
3	NC	*	O	O	*	*
4	NO	C	O	O	O	C
5	NC	C	C	C	O	C
6	NO	O	C	C	O	O

*Open in flight with boom below horizontal neutral position: Closed at all other times.

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Figure 4-20. IFR Hydraulic System (Sheet 2 of 2) following procedure be used to disconnect from a receiver airplane:

a. Notify receiver pilot and engineer of coming disconnect.

b. Confirm from receiver pilot that the receiver signal system is not in an emergency condition.

NOTE

If receiver signal system is in an emergency condition, place telescope at disconnect switch to "MANUAL" and have receiver initiate the disconnect. After the receiver pilot has confirmed a disconnect, the boom operator will press the trigger switch on ruddevator control stick and clear the boom from the receiver.

c. Raise the boom with ruddevators as soon as it is clear of receiver structure and hoist against the chock; latch it and lock the ruddevator control stick.

d. Turn the hydraulic pressure switch to the "OFF" position.

e. Reset the signal amplifier to ready for contact by depressing the reset button.

CAUTION

The signal system must be reset to ready for contact to close the fuel by-pass valve and assure complete purging.

f. Purge the boom by placing the purge switch in the "PURGE" position and opening either No. 1 or No. 2 nitrogen valve knob; the purge completed light should be illuminated after 5 or 6 minutes, indicating that all the solid fuel has been removed from the boom.

g. When purge complete light illuminates, place purging switch in "NORMAL."

4-210. DISCONNECT - PURGE BEFORE DISCONNECT. If desired, the boom may be purged of fuel with the boom in contact before disconnect as follows:

a. Depress fuel cutoff button.

b. Ascertain that the receiver refueling operator is ready for in-contact purging.

c. Nitrogen purge switch in the "NORMAL" position.

d. No. 1 or No. 2 nitrogen valve knob "OPEN."

e. Nitrogen valve knob "CLOSE" when purge completed light illuminates.

f. Trigger the disconnect switch to initiate a manual disconnect.

g. Raise the boom with ruddevators as soon as it has retracted from the receiver slipway.

h. Retract and hoist the boom against the chock, latch it, and lock the ruddevator control stick.

4-211. AFTER DISCONNECT.

a. All nitrogen valve knobs "CLOSE."

b. Turn the IFR master and pilot director light switches "OFF."

c. Turn all other switches off.

d. Inform the pilot that all equipment at the boom operator's station is stowed and shut off.

e. Report to pilot on return to control cabin.

4-212. ENGINEER'S IFR PROCEDURE. The following IFR pump operating duties are handled by the engineer and are in addition to his normal flight duties. The checks and procedures are presented as an aid to successful operation of the IFR pump operating system before and during refueling flights.

WARNING

During in-flight refueling operations, do not operate the suit heater rheostat, inter-aircraft signal lamp, or any other equipment not essential to flight or the refueling operation. Possible arcing can cause fire or explosion of fuel fumes.

4-213. PREFLIGHT CHECKS. The following checks should be accomplished in addition to the engineer's normal preflight checks.

NOTE

All of the engineer's IFR controls are on the engineer's IFR panel with the exception of the IFR pump control lever which is mounted at the aft edge of the engineer's instrument panel.

a. Check engineer's IFR panel for security of mounting and general condition.

b. Check IFR master switch "OFF."

c. Check ruddevator de-ice switch "OFF."

d. Check all IFR fuel valve switches "CLOSED."

e. Check hydraulic oil supply shutoff valve switches "OPEN."

f. Check IFR pump control lever "0."

CAUTION

Hydraulic oil supply shutoff valves must be open at all times during normal operation and will be closed only in case of fire in either outboard engine or a hydraulic leak on the pressure side of either pump.

g. Push in all circuit breakers.

h. Turn IFR master switch "ON." Check that all valves are in the positions indicated by the valve switches on the IFR panel. IFR tank lights (if tanks are full), IFR fuel pressure low warning light, one contact light (if signal system is on), should illuminate.

NOTE

Line valve and IFR tanks shutoff valves should be run through several cycles before flight to insure that the electrical drive is operating.

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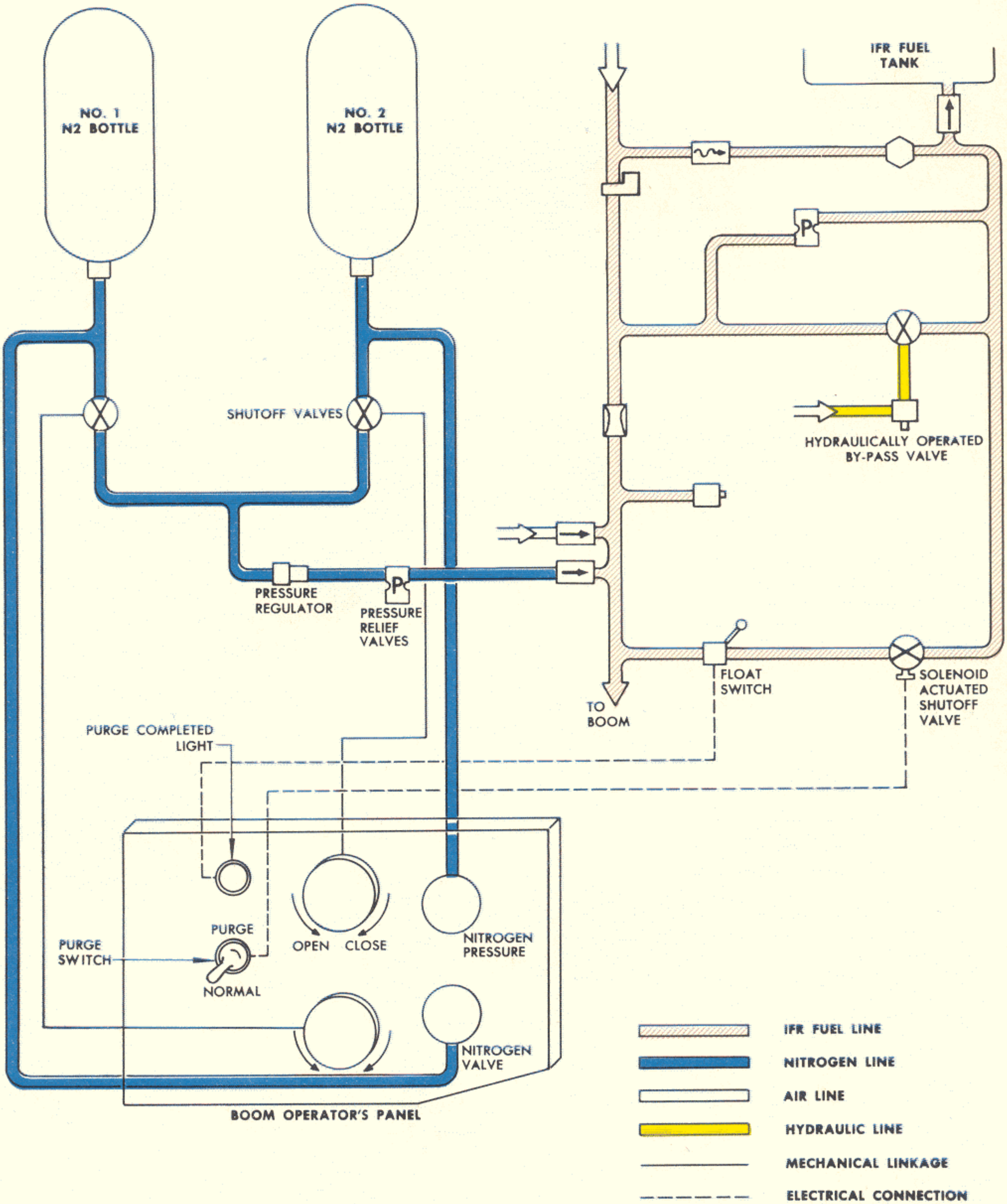

Figure 4-21. IFR Nitrogen Purge System

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i. Push to test all indicator lights not illuminated.
j. Check IFR fuel quantity indicators for proper reading with respect to amount of fuel in tank.

4-214. Zero the refuel line flow indicator by making the following adjustments on the fuel flow amplifier located on the radio rack:
a. Check that the IFR master switch has been "ON," for 10 minutes to insure that the amplifier is warmed up.
b. Rotate vernier zero knob clockwise; the indicator needle should move clockwise.
c. Set vernier zero knob for zero indicator reading.
d. Set density calibration control to value for fuel to be transferred.
e. Turn IFR master switch "OFF."

4-215. OPERATIONAL GROUND CHECK. The engines will have to be started to furnish hydraulic pressure and electrical power for the operational ground check if the proper ground equipment specified in the boom operator's procedure is not available. When the boom operator is ready for the operational ground check, the engineer should stand by and be ready to make the following check at his station.
a. Start engines at boom operator's request.
b. Hydraulic pressure should indicate 2700-3000 PSI when boom operator places hydraulic pressure switch to "AUTO."
c. Place IFR master switch to "ON."
d. Place hydraulic pressurizing pump switch to "TEST" if hydraulic test chart is used.
e. Place line valve switch to "OPEN."
f. Reset the fuel flow totalizer to zero.
g. Upon request from boom operator increase RPM on both outboard engines to 2000.
h. Upon request from boom operator, advance IFR pump control toward high until 35 PSI fuel pressure is reached in refueling line and retard to "O" after boom operator resets signal system to ready for contact.

WARNING

IFR pumps should not be operated over one minute duration with zero flow in refueling line. Energy used to drive the IFR pumps is converted into heat and dissipated into the fuel which cools the pumps.

i. Compare fuel pressure readings with boom operator.
j. Place IFR master switch to "OFF" when operational ground check is completed.
k. Place hydraulic pressurizing pump switch to "NORMAL" if hydraulic test cart was used.
l. Stop engines if required.

4-216. BEFORE CONTACT. As rendezvous is being effected the engineer will make the following preparations:
a. Unlatch the engineer's IFR panel and position it for operation.
b. Check all panel switches "OFF" or "CLOSED."
c. Turn the IFR master switch to the "ON" position and push all circuit breakers on the engineer's IFR panel.
d. Push in all indicator lights to test for operation.
e. Check fuel quantity indicators.
f. Notify the boom operator that all IFR line pump switches or levers are off and IFR valve switches "CLOSED"; the boom operator cycles the signal system to check boom limits; note the operation of the control lights but do not turn on IFR pumping equipment until the boom operator signifies that the signal system checks are complete and the signal system reset to ready for contact.
g. Turn the line valve switch to the "OPEN" position.
h. Check position of all fuel valve switches to agree with fuel transfer intentions.
i. Reset totalizer to zero reading.
j. Notify the crew that IFR pumping equipment is ready for contact.

4-217. CONTACTING.
a. At the request of the boom operator and when contact made light illuminates, advance IFR pump control toward high until desired fuel pressure and/or flow is obtained.

NOTE

If automatic disconnect occurs, reset the pump control lever to minimum setting before contact is re-established.

NOTE

A refuel line pressure in excess of 58 PSI in the tanker and 68 PSI in the receiver will initiate an automatic disconnect. Do not exceed 50 PSI.

4-218. DURING CONTACT. The following lists the duties of the flight engineer while refueling:
a. Maintain fuel pressure and/or flow at desired value.
b. Check the rate of flow for a value consistent with refuel line pressure.
c. Note quantity pumped and individual tank quantities as pumping proceeds, and call out quantities at regular intervals. If pumping stops, and the contact lights do not indicate a disconnect condition, the boom operator's emergency fuel shutoff switch may have been depressed. Check with boom operator, and if necessary check pump and valve circuit breakers to make certain that the fuel shutoff is not caused by engineer's IFR panel controls.
d. Maintain an equal fuel level in all IFR tanks.
e. Periodically observe hydraulic pressure. 3000 PSI desired, 2700 minimum.
f. Watch all indicator lights for proper indication.
g. Be ready to retard fuel flow control in event of fuel shutoff.
h. Be ready to stop IFR pumps if warning light illuminates, indicating pump failure or tank empty.
i. Be ready to turn on ruddevator deicing if needed.

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4-219. DISCONNECT. When the disconnect light is illuminated and it is certain that contact is not to be re-established, it is recommended that the following procedure be used:
a. Place IFR pump control lever to "0."
b. Fill fuel valve switches "CLOSED."

4-220. DISCONNECT - PURGE BEFORE DISCONNECT. If desired to purge during contact and before disconnect proceed as follows:
a. Check line valve indicator light to determine that line valve is closed.
b. Notify the boom operator that the IFR fuel system is positioned for purging.

4-221. AFTER DISCONNECT.
a. Turn IFR master switch "OFF."
b. Unlatch the IFR panel, swing it aft, and latch it in the stowed position.
c. Notify the pilot that all IFR equipment is turned "OFF" and the panel stowed.

4-222. RADIO OPERATOR'S AND NAVIGATOR'S PROCEDURE. The radio operator and the navigator should monitor use of their equipment in accordance with the following warning.

WARNING

During in-flight refueling operations, do not use suit heater rheostats, inter-aircraft signal lamp, radio compasses, rendezvous radar, loran radio, radio altimeter, trailing antenna, IFF radio, or any other electrical equipment not essential to refueling operations. Possible arcing can cause fire or explosion of fuel fumes.

4-223. IN-FLIGHT REFUELING SYSTEM EMERGENCY OPERATION.

4-224. SIGNAL SYSTEM FAILURE. It is possible to continue with IFR operations if the signal system is not working in either the tanker or receiver airplanes. Contact may be established as follows:

CAUTION

Boom position instruments and communications between aircraft must be working properly before emergency operations are attempted.

a. Place signal system override switch to "OVERRIDE."

WARNING

This switch de-activates the signal amplifier, thus discontinuing limit switch operation. While in an emergency condition, the boom operator must be constantly observing that receiver stays within the flight envelope.

b. Make normal contact approach and hold nozzle in receptacle until it is confirmed from receiver that the receptacle toggles have been actuated to hold nozzle.
c. Press contact switch on extension handle and observe contact made light.
d. Notify engineer to start fuel flow after contact has been established.
e. Proceed with normal refueling methods, constantly advising receiver pilot of corrective action to be used to stay within the flight envelope for the boom.

NOTE

The boom position instruments are the only indicators which reflect the position of the receiver.

f. When refueling is complete, initiate a disconnect by pressing the trigger switch on the ruddevator control stick.

NOTE

Step "f" will only initiate a disconnect in tanker signal system. The nozzle will remain in the receiver receptacle secured by the toggles until the receiver initiates a disconnect, either manually or automatically.

g. When the nozzle is free from the receptacle, manually retract the boom and clear receiver in a normal manner.

WARNING

Under no circumstances should an effort be made to retract the boom manually until it is verified by the receiver that a disconnect has been accomplished and the nozzle is free in the receptacle.

h. Hoist and stow boom.
i. Purge the boom at final contact.
j. Place IFR master switch and hydraulic pressure switch to "OFF."

4-225. ENGINE FAILURE. An engine failure on the tanker is more serious than a receiver engine failure. A tanker engine failure will probably cause the receiver to overrun the tanker, whereas a receiver engine failure will merely result in extension of the boom and possible separation. The tanker pilot should at all times when flying in formation be ready to advance throttles immediately on the good engines in case of an engine failure.

4-226. GAS FUMES VENTILATION PROCEDURE. To provide ventilation in the event of detection of gas fumes in the airplane, the following steps should be taken as listed:
a. Turn off IFR equipment.
b. Retard throttles and reduce IAS to 150 MPH.
c. Airplane master switch "OFF."
d. Open cabin emergency pressure release valve; use oxygen if necessary.

oxygen if necessary

e. Open cockpit door.

f. Open both over-wing hatches.

g. Open LH rear hatch.

CAUTION

Overwing hatches must be opened before opening rear hatch and after reducing airspeed to 150 MPH or below. If rear hatch is opened first or airspeed is greater than 150 MPH, differential pressure may prevent opening of the overwing hatches. Overwing hatches may require two men to open them. Rear hatch can be opened easily by one man but caution must be exercised since hatch will release with considerable inward force.

h. Open floor hatch to improve lower nose compartment ventilation, if required.

i. Increase IAS as desired to assist ventilation.

NOTE

If flying under instrument conditions, close the cabin emergency pressure release valve after the overwing hatches have been opened. As soon as the lower nose compartment is free of fumes, turn the airplane master switch "ON" to restore power to the flight instruments.

j. After fumes have been dissipated, the airplane master switch may be turned on and normal flight resumed.

4-227. EMERGENCY DISCONNECT. The word "BREAKAWAY" has been established and reserved for use as a code word to indicate an emergency condition. At any time during the contact-made condition, any crew member of the tanker or receiver can call "BREAKAWAY" when he feels that the circumstances are hazardous to the safety of the aircraft or malfunction of equipment warrants disconnect. On the word "BREAKAWAY," every crew member who has a manual disconnect switch should immediately operate that switch without delay or question. The tanker pilot, in such a situation, will pull up abruptly and apply power.

4-228. BOOM RETRACTION MECHANISM FAILURE. If the boom retraction mechanism malfunctions, necessitating a landing with a partially or fully extended boom, the landing should be made with extreme caution and the following steps should be taken:

a. Retract the boom as far as possible; any retraction from the fully extended position will greatly relieve the stresses on the boom, latch, and latch support.

b. Land with a dry boom.

c. Make as smooth a landing as possible to prevent excessive whipping action on the boom.

d. After any landing with boom extended, have the boom, stowing mechanism, and chock attachments to the fuselage carefully checked for structural damage.

4-229. SEQUENCE OF OPERATIONS FOR IN-FLIGHT REFUELING

4-230. BEFORE CONTACT

ENGINEER	PUMP OPERATOR
1. Interphone properly selected	1. Interphone properly selected
2. All electrically operated equipment not required for IFR operation OFF.	2. Hydraulic depressurization valve CLOSED
3. Have trailing antenna stowed	3. Master switch ON; ready light should illuminate
4. Proper tanker engine fuel control configuration selected	4. Check oxygen supply and have mask attached and available
5. Unstow IFR control panel and latch in operating position	5. Check No. 1 and No. 2 nitrogen cylinder pressure gages 700 to 1800 PSI
6. IFR pump control ZERO	6. Check No. 1 and No. 2 nitrogen supply valve knobs CLOSED and purge switch NORMAL
7. IFR master switch ON	7. Test all indicator lights
8. Push circuit breakers	8. Pilot director light switch DIM
9. Test indicator lights	9. Hydraulic pressure switch AUTO
10. Line valve switch OPEN	10. Check hydraulic pressure 3000 PSI

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4-230. BEFORE CONTACT (CONTINUED).

ENGINEER	PUMP OPERATOR
11. Ready for contact light ON	11. Telescope at disconnect switch, optional selection
12. Refer to appropriate receiver airplane pumping schedule charts	12. Unlock ruddevator control stick
13. Check all fuel valve switches to agree with fuel transfer intentions.	13. With pilot's permission, hoist, unlatch and lower the boom
14. Reset fuel totalizer to ZERO	14. Depress test button to set signal system to contact made condition; then check boom envelope limits
15. Emergency fuel shut-off light out (coordinate with boom operator)	15. Emergency fuel shut-off valve properly sequenced
16. Check fuel quantity indicators	
17. Check IFR fuel line pressure to be ZERO	
18. Minimum of 2000 RPM maintained on the outboard engines	
19. Report ready for contact to pilot	19. Depress reset button to return signal system to ready condition and report ready for contact

4-231. CONTACT

ENGINEER	PUMP OPERATOR
	1. Extend boom slightly less than half way and lower to 35°; direct the receiver pilot into the nominal contact position
	2. Make contact
3. At the request of the boom operator and/or when contact made light illuminates, advance IFR pump control toward high until desired fuel pressure and fuel flow is obtained	3. If contact appears normal, notify crew contact made and direct pump operator to start pumping fuel
4. Fuel leveling valve switch properly positioned	4. Advise receiver pilot of position in contact envelope from time to time giving receiver pilot specific directions to return to nominal contact position if any envelope limits are being approached
5. Maintain fuel pressure or fuel flow at desired value following appropriate schedule chart	5. Periodically check all IFR indicators

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4-231. CONTACT (CONTINUED).

ENGINEER	PUMP OPERATOR
6. Report progress of fuel transfer at intervals	6. Keep right hand on ruddevator stick to affect emergency disconnect or emergency fuel shut-off if required
7. Periodically check all IFR indicators and indicator lights	
8. Retard pump control in event emergency fuel shut-off light illuminates	
9. Be ready to stop IFR pumps if tank empty light illuminates	

4-232. MANUAL DISCONNECT - PURGE BEFORE DISCONNECT (OPTIONAL PROCEDURE)

ENGINEER	BOOM OPERATOR
1. IFR pump control at "0" setting	1. Ascertain that the receiver refueling operator is ready for in-contact purging
2. Line valve switch "CLOSED"	
3. Notify boom operator that the tanker fuel is ready for purging	3. No. 1 or No. 2 nitrogen valve "OPEN"
	4. Close nitrogen valve when receiver refueling operator reports purging complete
	5. Trigger switch to affect manual disconnect
	6. Raise the boom with ruddevators as soon as it is clear of the receiver

CAUTION

Due to air flow around the tail of the airplane the ruddevator control forces become much lighter as the boom approaches the horizontal. This leads to a tendency to overcontrol. Care must be exercised when raising the boom to the stowed position to prevent damage to the boom and the tail section of the airplane.

7. Hoist boom against the chock; stow boom and lock ruddevator control stick
8. Hydraulic pressure switch "OFF"

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4-233. WET BOOM DISCONNECT - REFUELING COMPLETED

ENGINEER

1. IFR pump control at "0" setting

2. IFR line valve switch "CLOSED"

5. IFR master switch "ON"

BOOM OPERATOR

1. Raise the boom with ruddevators as soon as it is clear of receiver

CAUTION

Due to air flow around the tail of the airplane the ruddevator control forces become much lighter as the boom approaches the horizontal. This leads to a tendency to overcontrol. Care must be exercised when raising the boom to the stowed position to prevent damage to the boom and the tail section of the airplane.

2. Hoist boom against the chock; stow boom and lock ruddevator control stick

3. Hydraulic pressure switch "OFF"

4. Depress the reset button

5. Both boom and engineer's IFR master switches "ON" (coordinate with engineer)

6. No. 1 or No. 2 nitrogen valve knob "OPEN"

7. Allow fuel line pressure to build up to 20 - 25 PSI; then move purge switch to "PURGE"

8. Check refuel line pressure indicator and purge light for purge completed

9. Move purge switch to "OFF" when purge is complete

10. Nitrogen supply valve "CLOSED"

4-234. AFTER REFUELING

ENGINEER

1. IFR pump control at "0" setting

2. IFR transfer valve switches properly positioned

3. Fuel leveling valve switch "CLOSED"

BOOM OPERATOR

1. Check receiver slipway for fire and static line clearance

2. Master switch "OFF"

3. Pilot director light switch "OFF"

4. All switches on boom operator's panel "OFF"

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4-234. AFTER REFUELING (CONTINUED).

PUMP OPERATOR

5. IFR master switch "OFF" after completed purge reported
6. Stow IFR panel
7. Notify pilot that IFR equipment is off and panel stowed

ENGINEER

5. Notify pilot that boom equipment is off, boom stowed, ready for landing, and boom operator leaving compartment

4-235. IFR FUEL SYSTEM MANAGEMENT - ENGINEER (Refer to figure 4-22).

4-236. READY FOR CONTACT.

Set Up Fuel Panel

1. Engineer's IFR master switch "ON."
2. Signal system in ready for contact.
3. Line valve switch "OPEN."
4. Hydraulic supply valve switches "OPEN," switch guards down.
5. IFR pump control lever "O."
6. All other engineer's IFR panel switches off or closed.

4-237. CONTACT MADE.

IFR Tanks To Boom

1. IFR master switch "ON."
2. Signal system in contact made.
3. Line valve switch "OPEN."
4. Hydraulic supply valve switches "OPEN."
5. IFR pump control lever advanced as required.
6. Fuel leveling valve switch "OPEN."
7. All other engineer's IFR panel switches off or closed.

4-238. TRANSFER FROM AIRPLANE FUEL SYSTEM.

Center Wing Tank to IFR Tanks (Additional to the "IFR TANKS TO BOOM" above)

1. Center wing tank boost pump switch "EMERGENCY."
2. Center tank line valve switch "OPEN."
3. IFR tank transfer valve switches "OPEN."

CAUTION

When carrying Specification MIL-F-5616, Grade JP-1 or MIL-F-5624, Grade JP-3 fuels in the center wing tank close the manifold shutoff valve to prevent contamination of the airplane fuel system. Drain all trapped JP-1 or JP-3 fuel before refilling center wing tank with MIL-F-5572 fuel. When carrying JP-1 or JP-3 fuels in the IFR tanks only, disconnect the electrical connectors from both IFR tank transfer valves to prevent contamination of the airplane fuel system. Drain all trapped JP-1 or JP-3 fuels from the IFR system before refilling with MIL-F-5572 fuel.

Main Wing Tanks To IFR Tanks

1. Desired main wing tank fuel selector switches "Tank-to-Manifold and Engine."
2. Main wing tank boost pump switches "EMERGENCY."
3. IFR tank transfer valve switches "OPEN."

WARNING

When transferring fuel from the airplane's main wing tanks to the IFR system care must be taken to maintain sufficient fuel in the airplane's wing tanks for safe landing.

4-239. TRANSFER TO AIRPLANE FUEL SYSTEM FROM IFR SYSTEM (Not shown in figure 4-22).

IFR Tanks To Airplane Manifold System

1. All main wing tank fuel selector switches "Manifold to Engine."
2. IFR tank transfer valve switches "OPEN"; fuel will flow from the IFR tanks to the airplane's manifold system by gravity feed.

NOTE

This method of transfer should only be used to maintain a cruise condition. A maximum flow rate of approximately 27 GPM for four engines is available at the engine selector valves at standard sea level pressure. This is approximately three times the flow requirement for 70% power cruise. The limitations of using this method of supplying fuel to the engines from the IFR tanks is similar to normal procedure of supplying the engines from wing tanks through the manifold without boost pumps in operation.

CAUTION

Nose up or nose down attitudes should be used with caution when supplying engines from IFR tanks whose fuel level is very low.

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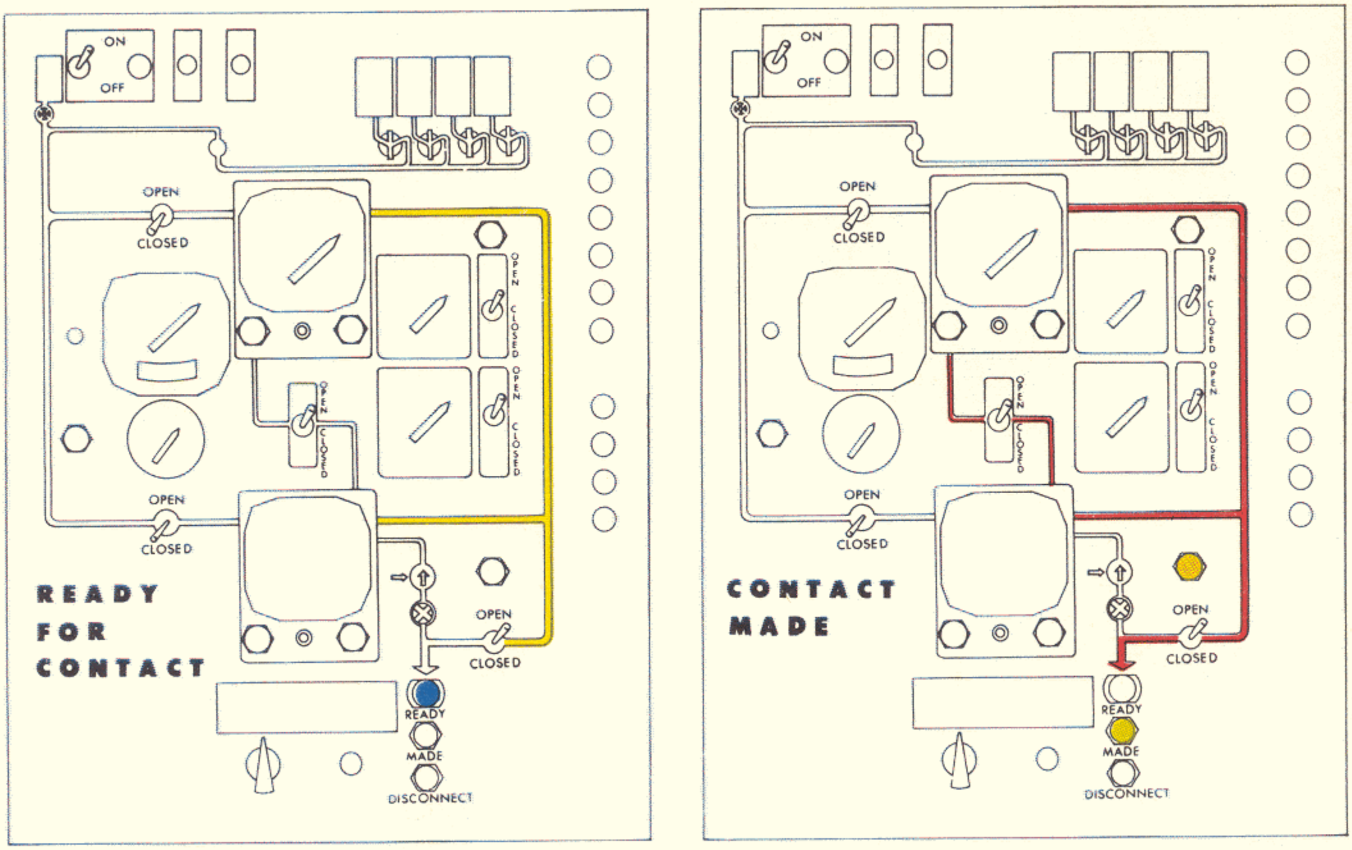

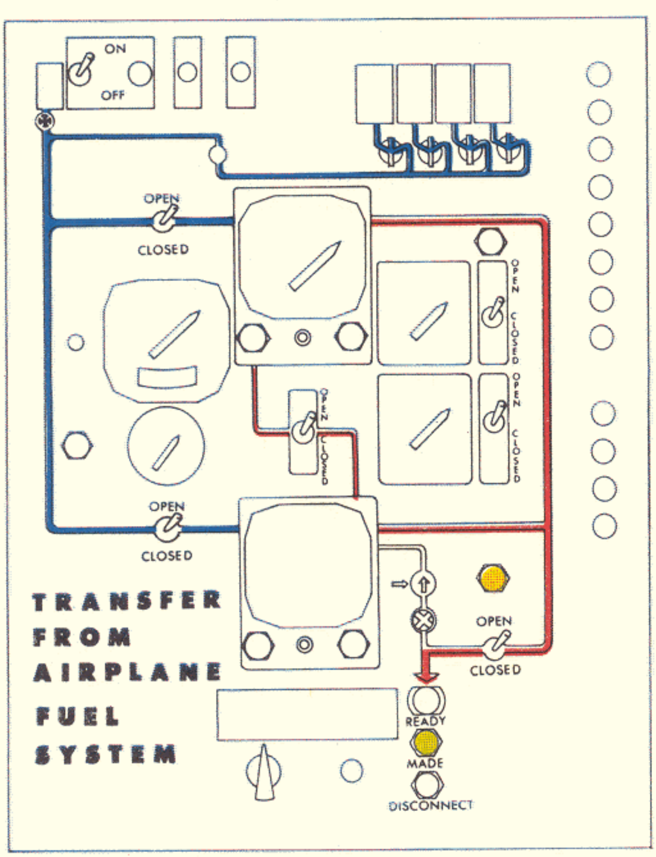

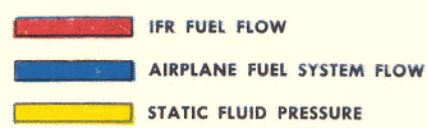

Figure 4-22. IFR Fuel Management

4-240. TANKER PILOT TECHNIQUE.

4-241. The following techniques represent pilot experience to date and are presented as an aid, but not as mandatory techniques and procedures.

WARNING

Do not use autopilot during an in-flight refueling operation. Inadequate or erratic autopilot functioning while in contact with the receiver airplane can result in structural damage to one or both of the airplanes.

NOTE

For in-flight refueling performance data see Appendix I.

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4-242. FLYING AT CONSTANT ATTITUDE. The tanker is essentially a platform for the flying boom. The tanker pilot should therefore fly the airplane in such a manner as to provide the most stable platform possible. During the time that contact is being established, flight at constant attitude is important for two reasons: to provide a stable platform for accurate operation of boom and to make it easier for the receiver pilot to get into the contact position. After contact is established, the first item is no longer applicable.

4-243. Establishing and maintaining contact in smooth air is relatively easy and tanker technique is of little importance. However, smooth air rarely occurs and in the mild to moderate turbulence which will generally prevail, it is important that care be exercised in flying the tanker. The tanker should arrive at refuel altitude and fly level in the cruise condition until rendezvous has been affected. As the boom is lowered in preparation for contact, the tanker pilot will observe that the airplane will slow down about 5 MPH and become slightly nose heavy. The airplane should then be retrimmed and power set up for the desired refueling airspeed for the particular receiver. Additional trim may be required as the receiver gets within 15 feet of the contact position since the bow wave of large receivers make the tanker slightly nose heavy. It is a most important requirement that the tanker pilot make no power changes after the receiver starts to move in for contact.

4-244. ALTITUDE. When the receiver airplane is of comparable performance (for example, the B-50D), it will generally be desirable to maintain approximately constant altitude from the beginning to the end of the refueling contact. The refueling altitude may be limited either by tanker or receiver. However, when higher performance receiver airplanes (for example, the B-47B) are refueled or, if for any other reason it is difficult to obtain the desired airspeed (for example, if the tanker has had to feather a propeller), a constant descent will provide higher airspeeds without impeding the contact. If this condition exists, shortly after fuel transfer has commenced the tanker pilot will gradually nose the tanker down as required to obtain the desired gradual increase in speed. It should not be necessary to exceed 150 to 300 feet per minute rate of descent which will not result in more than a 5000 foot loss in altitude during the refueling. The flight crew, prior to contact, will have established the desired initial and final airspeeds and approximate duration of the contact. With this information, the tanker pilot can vary the airspeed with ample accuracy by varying the rate of descent. Caution must be exercised not to exceed 250 MPH IAS since ruddevator control of the boom becomes critical above this speed.

4-245. Holding contact during descent is practicable although slightly more difficult than the level-flight conditions. Rates of descent of 500 to 700 feet per minute have been demonstrated in smooth air with high performance receivers. However, for a fuel transfer period of twenty-five to thirty minutes, this rate will be excessive in view of the altitude loss sustained.

4-246. AIRSPEED. As fuel is unloaded from the tanker, the airspeed will slowly increase. This is advantageous for the following reasons:

a. Refueling may be initiated at lower airspeeds. This is important when the tanker is beginning a high-altitude transfer at high gross weight. Also it is less tiring for the boom operator to make contact at lower airspeed.

b. Tanker engine cooling is improved as the refueling progresses when, because of an extended transfer, it might become critical at high altitude and high gross weight.

c. The receiver is assisted in maintaining a comfortable margin above stalling speed as its gross weight increases. This, of course, is particularly important when receivers having higher stalling speeds, than the tanker, are used.

4-247. TURN IN CONTACT. The receiver pilot can tolerate substantial changes in airspeed and altitude and banks up to 30° (depending upon atmospheric turbulence) if these maneuvers are entered into slowly and smoothly. Thus, moderate turns for navigational purposes can be made easily while in contact. There will usually be continuous slight tanker pitching because of nudging by the receiver airplane, even in smooth air. Therefore, it is most important that the tanker pilot remember to hold as steady an attitude as possible without large or sudden control movements. During the actual fuel transfer period, however, as the tanker gross weight decreases, the average, or mean, attitude will slowly become more nose down when the constant altitude procedure recommended for comparable performance receivers is followed.

4-248. ROUGH AIR. In rough weather strong gusts may require immediate corrective action but airplane pitching, yawing, or rolling due to moderate gusts should be ignored unless return to original attitude does not occur. The reason is that for two similar airplanes flying in such close formation, the gust effect on each is approximately the same. If the tanker pilot were to fight the controls, overcontrolling would usually occur resulting in inadvertent disconnect due to tanker and receiver airplane movements getting out of phase with each other. Momentary changes of airspeed due to turbulence or other causes should be disregarded. If, during a constant altitude refueling, the altitude goes beyond a tolerance of ± 200 feet, the pilot should edge back toward the nominal desired altitude by a gradual change in airspeed.

4-249. To sum up rough air pilot technique; in the first of two extremes the pilot makes little or no effort to offset, with elevator movement, the pushing and pulling of the receiver. In such a case the tanker and receiver continue to pitch until they get out of phase and go to automatic disconnect. In the second extreme the tanker pilot fights the controls to hold absolutely constant altitude, thereby forcing the receiver pilot to work much harder to hold the "green light" position. Good tanker flying requires that the pilot operate somewhere between these two extremes.

4-250. USE OF THROTTLE. Comparable performance receivers may not have sufficient power to maintain

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speed for contact during the latter part of a large fuel transfer at high gross weight. In this case it may be desirable for the copilot to reduce manifold pressure not more than 1/2 inch across the board on one engine at a time, repeating the power reduction every few seconds. If more abrupt power changes are made, the receiver airplane is likely to inadvertently disconnect by over running the tanker.

4-25¹. Information to date indicates that the maximum practical altitude for refueling certain jet type receivers may be below 20,000 feet and the optimum altitude for such transfers below 15,000 feet. At the higher altitudes, level-flight refueling airspeeds that tankers have been capable of have forced the jet receivers to operate on the back side of their power-required curves. In some cases the power requirements for the receivers were as high as 95% to 100% RPM. In this power range the jet receivers do not have sufficient power adjustment available to hold contact during the latter stages of the transfer. It has also been found that with rated power on the tanker (resulting in approximately 210 MPH in level flight) certain jet fighter receivers, with gear extended for stability reasons, can not close in on the tanker at 25,000 feet, even with 100% RPM. In such cases the descent procedure is recommended to enable the receiver to be flown at higher airspeed in a more normal attitude, easing the difficulty of holding contact.

4-252. CARGO-CARRYING

4-253. CARGO - CARRYING PROVISIONS. While the principal function of the airplanes in this series is to act as a tanker ship for refueling other aircraft in flight, this model was originally designed as a cargo ship, and accordingly, the following provisions are made in this tanker series for carrying cargo.

4-254. CARGO DOORS. This airplane has a single forward cargo door at the right side of the forward end of the main cargo compartment. This cargo door is hydraulically operated.

4-255. FORWARD CARGO DOOR OPERATION. Hydraulic pressure to open and close the forward cargo door is supplied by a hand pump (1, figure 4-23). The system is controlled by an "OPEN--NEUTRAL--CLOSED" selector valve handle (2, figure 4-23) located on a panel adjacent to the door. The door is opened by placing the selector valve in the "OPEN" position and operating the hand pump. Keeping the selector valve in the "OPEN" position holds the door fully open. When the selector valve is positioned to "NEUTRAL" or "CLOSED," the door will fall slowly to a nearly closed position. Placing the selector valve to "CLOSE" and operating the hand pump will fully close the door where it can be locked with the mechanical hand operated locks at the bottom of the door.

NOTE

Forward cargo door operation is not possible when the IFR tanks are in place.

Figure 4-23. Forward Cargo Door

2-256. DOOR WARNING SYSTEM. A door warning system indicates when the foreard entry door, forward cargo door and aft entry door, are not closed and latched. The forward and aft entry doors each have one "door closed" warning switch and one "door latched" warning switch. The foreard cargo door has two "door locked," two "door latched," and two "handle closed" warning switches. All switches are wired in parallel and are in the open position when all doors are closed. If any switch is left closed, a red warning light on the pilot's panel will illuminate. The door warning circuit is protected by a circuit breaker on the overhead panel. Prior to take-off, check that all doors are closed and locked. If a warning light illuminates before take-off, all doors should be unlocked, opened, closed, and locked. If the warning light remains on and all warning switches are found to be in the locked position, the circuit should be checked for a malfunction before take-off. If the door warning light illuminates during flight, decrease the cabin differential pressure by selecting a higher cabin altitude. If visual inspection of the door latching mechanisms indicates that the doors are locked, pressurized flight may be continued at reduced pressure.

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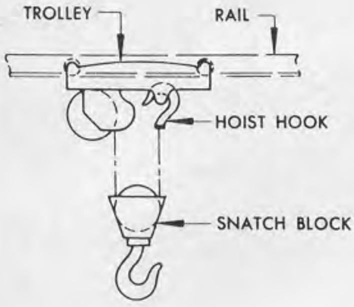
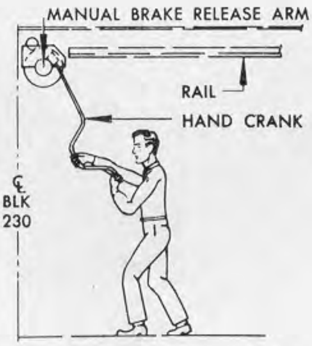
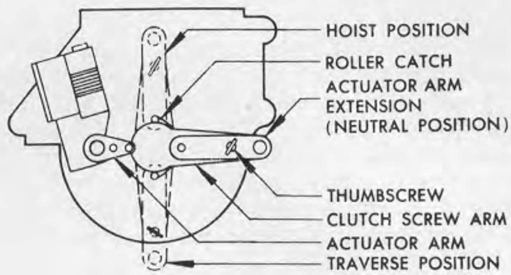
CARGO HOIST



L.H. SIDE VIEW
DETAIL I



L.H. SIDE VIEW
DETAIL II



R.H. SIDE VIEW
DETAIL III

LOAD LIMITATIONS

a. The hoist is capable of lifting and traversing 2500 pounds with a single part hoisting cable. By installing the snatch block in the hoist cable and connecting the hoist hook to the trolley, a load of 5000 pounds may be hoisted and traversed (Detail I). The snatch block is stowed in a container on the forward bulkhead of the main cargo compartment.
b. The hoist is designed for use in pulling loads forward in the airplane, but is limited in its ability to pull loads aft in the airplane. When overloaded in this condition, the drum clutch plates will slip.

CAUTION

Hoist motor has sufficient power to break the hoist cable with resultant danger to personnel. Avoid loading in excess of 2500 pounds with single cable or 5000 pounds with double cable or jamming into stops.

NORMAL OPERATION

a. Obtain power for the cargo hoist from either the accessory power unit or an outside source.
b. Connect the portable hoist control unit which is stowed on the forward bulkhead of the main cargo compartment to any one of the portable control cord receptacles located on the right side in the forward, center, and aft areas of the main cargo compartment.
c. At the cargo hoist electrical shield, located on the forward bulkhead of the main cargo compartment, move the control circuit breaker to "ON" and momentarily push the power reset button. The indicator light should remain on while power is on.
d. Operate the hoist by pushing the buttons on the portable control unit.
e. Pushing the emergency stop button automatically cuts off power to the hoist motor. To resume operation, momentarily push the power reset button at the electrical shield.
f. The hooks that are attached to the rail to support the cable may be pushed up and out of the way if maximum headroom is desired.
g. Limit switches are provided at both ends of the rail to limit the fore and aft travel of the trolley, and at both edges of the drum to limit the amount of cable unwound.

EMERGENCY OPERATION

a. In the event of power failure while hoisting a load, the load may be lowered by pulling the manual brake release lever located on the left end of the hoist motor unit (Detail II).
b. To lower a load from the traversing position under emergency conditions, first manually shift the hoist unit from the traverse position to the hoist position. Then use the manual brake release lever as explained in paragraph "a" and shown in Detail II.
c. The hand crank, stowed on the forward bulkhead of the main cargo compartment, may be inserted in a fitting on the hoist motor for hand operation of the hoisting unit (Detail II).
d. To manually shift the hoist clutches, first disengage the actuator arm extension from the actuator arm by removing thumbscrew. Reverse actuator arm extension and attach to clutch screw arm with thumbscrew (Detail III).

For hoisting rotate actuator arm extension up and engage roller in catch. Tighten thumbscrew.

For traversing, rotate actuator arm extension down and engage roller in catch. Tighten thumbscrew.

Replace actuator arm in normal position before attempting to operate hoist electrically.

Do not attempt manual operation of the hoist with actuator arm extension in neutral position.

Figure 4-24. Cargo Hoist Instructions

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4-257. CARGO LOADING SUPPORT STRUT. The cargo-loading support strut is provided for support of the fuselage at the tail skid jacking pad when loading the airplane. The jack-strut base is stowed in the rear stowage compartment and the support strut is stowed on the ceiling of the rear end of the lower aft cargo compartment. The support strut should be used as a support only and, when used with other jacks, it should always be raised last and lowered first.

4-258. CARGO FLOOR-LOADING LIMITS. The floor in the main cargo compartment can be loaded up to 200 pounds per square foot. The floor and the seats in the lower forward and the lower aft cargo compartments can be loaded up to 100 pounds per square foot. Tie-down fittings are provided in the cargo compartments for tying down cargo, securing stretcher supports, and attaching safety belts. All cargo tie-down fittings, excepting the engine-cradle tie-down fittings in the floor of the main cargo compartment, are permanently installed.

4-259. CARGO-HOISTING EQUIPMENT. An electric hoist, at the forward end of the main cargo compartment operates a hoisting hook, which is suspended from a trolley that travels fore and aft on an overhead monorail. The cargo-hoisting equipment is used to hoist cargo and IFR equipment from the ground through the rear cargo door opening, to move this hoisted equipment forward and aft in the main cargo compartment, and to lower it into position. The cargo hoist has a capacity of 2500 pounds when a single line is suspended from the cargo hoist trolley, and a 5000 pound capacity when a double line and snatch block is used. The snatch blocks are stowed on the forward bulkhead of the main cargo compartment bulkhead just to the right of the door. Reference is made to figure 4-17 for detailed cargo hoist operating instructions. A portable control unit to operate the electric hoist, is held in the operator's hand. There are five push buttons on the portable control unit: "UP," "DOWN," "FORWARD," "AFT," and "EMERGENCY STOP." Three plug-in receptacles for the control unit, along the right side of the main cargo compartment, enable the operator to control loading and unloading from the most advantageous position.

4-260. AERIAL DELIVERY SYSTEM. Provisions are made on this airplane for the kit installation of an aerial delivery system.

Section V — Crew Duties

This information will be added when available.

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Section VI All Weather Operation

6-1. GENERAL.

6-2. This section contains only those procedures which differ or are in addition to the normal operating instructions in Section II in regards to cold weather, hot weather, or desert operation, plus turbulent air flight, instrument flight, instrument approach, and instrument landing. The cold weather operation applies only to those airplanes which have been winterized.

6-3. COLD WEATHER OPERATION.

6-4. BEFORE ENTERING THE AIRPLANE. The following procedures will always be adhered to during cold weather operations:

a. At temperatures of 0° F (-18° C) or below, the engines and cabin must be preheated if the airplane is not in a heated hanger.

b. Check that the ring cowl heating assembly, the lower scoop air intake shield, and accessory section heating adapters are installed.

c. Check that the engines have been preheated until a cylinder head temperature of at least 0° C is obtained and the propellers can be pulled through easily.

d. Check "Y" drains and oil tank sump drains for oil flow. Have heat applied if necessary.

e. Check that sheltered air inlet filters have been removed.

f. Check the landing gear struts and limit switch boxes. Moisture entering the boxes will result in ice forming on the micro-switches which may prevent the retraction of the gear. Clean the strut oleos of snow, ice, and dirt with a cloth soaked in hydraulic oil. Check struts for proper inflation. See that no grit, or ice is clogged between oleo piston and oleo scraper ring; remove foreign matter with kerosene and lubricate piston with hydraulic fluid.

g. Check windows and astrodome for cracks. Open windows and hatches when removing airplane from heated hanger. This will prevent a rapid temperature drop from causing the glass to crack.

h. Have ice, snow, and excessive frost on wings, control surfaces, and control surface hinges removed.

i. Check engine stiffness periodically to determine when sufficient preheating has been applied.

j. Have all ground heating equipment removed. Have oil immersion heaters removed if used.

NOTE

The time interval between the removal of ground heating equipment and engine start must be held to a minimum.

k. Have propellers pulled through 12 blades.

l. Use external power.

6-5. ON ENTERING THE AIRPLANE. Have the auxiliary power plant and battery warmed sufficiently to enable the auxiliary power plant to be started and to maintain smooth operation. Start cabin heating system to defrost windows and to warm flight instruments, radios, and other equipment within the airplane. If the cabin heating system does not supply adequate heat at extremely low temperatures, heat from external heaters can be introduced into the forward and aft compartment through entrance doors.

NOTE

Do not utilize Nesa heat to defrost windshield unless normal defrosting system is inadequate.

6-6. BEFORE STARTING ENGINES. The following procedures must always be adhered to before starting in cold weather:

a. Check removal of all ground heating equipment, engine covers, and oil immersion heaters if used.

b. Check propellers pulled through 12 blades.

c. Check external power connected.

6-7. STARTING ENGINES. Open cowl flaps and start engines in the normal manner as described in section II. In addition to the normal starting procedure, the following procedure will be used when starting engines in cold weather:

a. At extremely low temperatures (below - 20° F), it may be necessary to use the mixture control to introduce additional fuel into the engine after starter is turning. While cranking, the mixture control should not be moved from "FUEL CUTOFF" for more than 3 seconds.

CAUTION

DO NOT prime engines or move the mixture control from "FUEL CUTOFF" until the starter is turning the engine.

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b. If there is no oil pressure after 30 seconds running, or if the oil pressure drops after a few minutes of ground operation, shut down the engine and have the ground crew check for blown lines or coolers and recheck for congealed oil or ice in the "Y" drain or oil tank sump drain. If oil pressure is registered but is consistently low, or if fluctuating oil pressure is experienced, have instrument pressure transmitter lines checked for congealed oil or air lock.

c. If oil pressure becomes too high for a prolonged period (200 PSI or above for more than 30 seconds), the oil may be diluted slightly by actuating the dilution switch intermittently to bring down the oil pressure. If 30 seconds of this intermittent dilution fails to reduce the excessive pressure, discontinue the use of the dilution switch; the oil pressure will drop as the oil warms.

d. After engine is started, use carburetor heat as needed to aid fuel vaporization and combustion and to promote smooth engine operation on the ground. If engine operates smoothly after initial rough operation, normally experienced the first few minutes after starting, carburetor heat will be unnecessary.

6-8. WARM-UP AND GROUND TEST. At extremely low temperatures, it may become necessary to partly close the cowl flaps in order to raise the cylinder head temperature enough to obtain smooth engine operation for engine check and full power run-up. Accomplish as much of the ground check as is possible with the wheels blocked to prevent slipping on a slick surface. For the final check before take-off, if engine run-up cannot be performed without the airplane slipping or skidding forward, reverse pitch power may be used on other engines to counteract the thrust of the engine being run-up. However, caution should be exercised in attempting this operation as reverse pitch causes insufficient engine cooling.

6-9. TAXIING INSTRUCTIONS. Cold weather taxiing presents two problems. Soft snow and congealed wheel bearing lubricants will retard the taxi roll causing a higher power requirement than for normal taxiing operation. Once the wheel bearing lubricant has warmed, the problem is reversed; rolling action is no longer retarded and it becomes a problem of braking the roll on a slippery surface. Also, in order that cylinder head temperatures remain as high as possible, thereby reducing spark plug fouling to a minimum, taxiing below 1200 RPM should be avoided as much as possible. The taxiing roll may best be slowed by intermittent use of the brakes. Never "ride" the brakes on a slick surface. When the brakes are ineffective, the reverse pitch propellers may be used to slow or stop the airplane.

CAUTION

Use of reverse pitch power causes uneven and inefficient cooling of the engine, even in cold weather, and continuous use for ground operations will result in serious overheating of parts of the engine. This overheating is not readily detectable on the engine instruments.

CAUTION

Avoid contacting snow with inboard propellers as extensive damage to propellers, engines, and engine mounts may result.

6-10. BEFORE TAKE-OFF. The following procedure should be accomplished in addition to the normal instructions in section II:

a. If an instrument take-off is anticipated, check all instruments (especially the flight indicator) for proper operation.

b. Check movement of control surfaces and trim tabs.

c. Operate wing flaps through at least one complete cycle and exercise the brakes.

6-11. TAKE-OFF. The following procedure will always be adhered to during cold weather take-offs:

a. Carburetor preheat switches "OPEN," then "OFF" if carburetor air temperature is low. Apply power, start to close cowl flaps as take-off run is begun, closing them completely as take-off speed is reached.

b. Maintain carburetor air temperature at +15° C, if possible, to aid fuel vaporization.

c. Turn pitot heat switches "ON" during take-off run if precipitation is encountered or if icing conditions are anticipated immediately after take-off.

d. Unless required for a short field take-off or for an unusually heavy load, it will not be necessary to use full manifold pressure to obtain take-off power. At sub-zero temperatures, full power output will be obtained at a reduced manifold pressure due to the increase in air density. The torquemeters may be utilized to determine when maximum take-off power is being delivered.

e. Operate the cabin heating system to assure proper functioning of the instruments.

f. The pilots should be cognizant of the fact that flight indicators are unreliable at cabin temperatures below - 45° F (-43° C) and that all flight instruments must be cross-checked.

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6-12. AFTER TAKE-OFF. The following procedures are in addition to the normal instructions in Section II:

a. Operate the landing gear through at least 3 complete cycles to prevent snow or ice from freezing the gear in the up position.

b. After first power reduction is made after take-off adjust the carburetor preheat as necessary to maintain the proper carburetor air temperature.

c. Check surface anti-icing systems in operation if precipitation is encountered.

6-13. CLIMB. Climb with cowl flaps closed, or as needed to keep cylinder head temperature below maximum limit for "AUTO RICH" operation.

6-14. Whenever visible moisture conditions exist, the following procedures will eliminate the possibilities of carburetor icing:

a. Keep intercooler flaps closed at all times below a carburetor air temperature of + 5° C.

b. Use the carburetor preheat system to avoid operation with a carburetor air temperature between - 10° C and + 7° C.

6-15. ENGINE OPERATION IN FLIGHT. Whenever visible moisture conditions exist, move throttles every 15 minutes to increase manifold pressure 5 inches and then back to the original setting. Clear out the induction system by increasing power sufficiently to obtain a carburetor air temperature of approximately 25° C for two minutes every hour.

6-16. Erratic engine operation and inefficient performance at extremely low temperatures may sometimes be encountered due to poor fuel vaporization at low carburetor air temperature and/or low cylinder head temperature encountered at low power settings. If this develops, check to be certain that the carburetor air temperature is within the proper operating limits. If the carburetor air temperature is at the low limit, raise it to the high limit. If difficulty persists, increase mixture strength by use of the mixture control to obtain smooth engine operation or change power setting to increase cylinder head temperature.

6-17. Under certain atmospheric conditions, carburetor icing can occur with carburetor air temperatures between - 10° C and + 7° C. The manifold pressure gages or torquemeters cannot be depended upon for warning of carburetor icing since this airplane incorporates automatic boost control. Consequently, if the possibility of carburetor icing is suspected, keep carburetor air temperature above + 7° C if possible. If at least + 7° C carburetor air temperature cannot be maintained with intercooler flaps closed, turn carburetor preheat switch "CLOSE" then "OFF." Do not open intercooler flaps below + 7° C carburetor air temperature. Performance is improved by operating near the maximum carburetor air temperature as minimum intercooler exit opening will be required. When external icing conditions are encountered, operate the surface anti-icing system continuously, and apply the minimum current to the Nesa glass required to remove ice from the windshield.

6-18. DESCENT. During descent to traffic altitude have engineer start the auxiliary power plant. Close cowl flaps during descent.

6-19. APPROACH. In addition to the normal approach procedure the following should be observed during cold weather operations:

a. Use carburetor preheat as necessary in preparation for a possible go-around.

b. Close the cowl flaps. At extremely low temperatures, it would be wise to effect a long, low approach for landing using engine power. This will aid in keeping cylinder head temperatures above critically low values.

c. If go-around is necessary, add power slowly but steadily and maintain carburetor air temperature at + 15° C if possible.

6-20. LANDING. In addition to the landing instructions in section II, the following procedures should be followed during cold weather operation:

CAUTION

Avoid contacting snow with inboard propellers as extensive damage to propellers, engines, and engine mounts may result.

a. On runways covered with loose snow of undetermined depth, accomplish landings using only 1/2 to 3/4 flaps to prevent possible damage to the flap trailing edges.

b. Manually open oil cooler doors immediately after landing to permit oil to cool while taxiing. This will permit oil dilution on arrival at the ramp.

c. Use reverse pitch power to decelerate on snow or ice and use brakes only if necessary after landing roll speed has been reduced.

6-21. STOPPING ENGINES. The following oil dilution procedure will be adhered to for stopping engines in cold weather in addition to the normal instructions in section II. Oil dilution is required if

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the expected minimum temperature is at or below 4° C (40° F). Oil dilution is performed immediately prior to stopping the engines, using the following procedure:

a. Service the engine oil tanks from the central oil system. When a dilution time of more than 3 1/2 minutes is required, make certain that the engine oil tanks do not contain more than 30 U.S. gallons.

b. Idle engines at 1000 RPM with cowl flaps and oil cooler flaps open until cylinder head temperature has been reduced below 150° C and oil temperature has decreased to a minimum, preferably to 50° C. If temperatures are appreciably higher the effectiveness of oil dilution is reduced, due to evaporation.

c. Dilute oil at 1000 RPM. Turn oil dilution switches "ON" and hold master dilution switch "ON" for a period corresponding to the lowest outside air temperature expected.

Outside Air Temperature °F	Outside Air Temperature °C	Time Minutes
40	4	1
25	-4	1
10	-12	2
-5	-21	3
-20	-29	4
-35	-37	5
-50	-46	6
-65	-54	7

NOTE

If oil temperature rises above 60° C or oil pressure drops below 15 PSI during dilution, shut the engine down and allow it to cool before continuing.

d. At the end of the dilution period, move the mixture controls to "FUEL CUTOFF." Hold the master dilution switch "ON" until the propellers stop rotating.

6-22. BEFORE LEAVING THE AIRPLANE. The following items are in addition to the normal instructions in section II:

a. After diluting oil, have a small amount of oil drained from the "Y" drains and oil tank sump drains. This will eliminate stagnant, undiluted oil from these low points and reduce the possibility of clogged drains.

b. Have a small amount of fuel drained from fuel drains and strainers.

c. In temperatures below - 20° F, have the battery removed after flight if airplane is to remain outside 24 hours or longer.

6-23. HOT WEATHER OPERATION.

6-24. BEFORE ENTERING THE AIRPLANE. In addition to the normal instructions in section II check the following for hot weather operation:

a. Check that all filters are installed and are clean of dust, corrosion, and mold.

b. Check inflation of oleos and tires frequently. Changes in air pressure caused by wide changes in temperature result in improper inflation. Overinflation is most often encountered.

c. Check for leaks in hydraulic system since heat and moisture cause valves and packings to swell.

6-25. ON ENTERING THE AIRPLANE. After entering the airplane, complete the following:

a. When external power is connected or when the auxiliary power plant is operating, turn the air conditioning master switch "ON" and the cabin air selector switches to "FLIGHT GROUND AUTO" to operate the ground blowers for air circulation.

b. Open windows, hatches, bulkhead doors, and entrance door to ventilate the airplane.

c. Check equipment for evidence of corrosion.

6-26. BEFORE STARTING ENGINES. If the auxiliary power plant is used for starting engines, turn the air conditioning master switch "OFF" to prevent electrical power drain until at least one engine has been started.

6-27. STARTING ENGINES. Do not overprime engines since fuel vaporization will be rapid in high temperatures.

6-28. WARM-UP AND GROUND TESTS. In hot weather operations it is necessary to keep engine operation at a minimum to prevent high cylinder head temperatures that will exceed the maximum temperature allowable for start of take-off run. Keep ground tests at a minimum.

6-29. TAXIING INSTRUCTIONS. Use the brakes as little as possible since it will be difficult to cool them in hot weather operation.

6-30. TAKE-OFF. Hot weather operations require the pilot to be more cautious of stalling speeds and temperature limitations. Emphasis is placed on the following:

a. Take-offs during hot periods of the day require longer runs. Efficiency up to 10 per cent is lost to heat at this time.

b. Close observance of stalling speeds is necessary.

6-31. AFTER TAKE-OFF. Retract wing flaps with caution.

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6-32. CLIMB. Climb at not less than specified climbing speed. Lower climb speeds cause high cylinder head temperature.

6-33. LANDING. Landing ground rolls are longer than those in normal temperatures. Ground speed increases with the same indicated airspeed due to thinner air.

6-34. BEFORE LEAVING THE AIRPLANE. Leave hatches and doors open as necessary for adequate ventilation.

6-35. DESERT OPERATION.

6-36. BEFORE ENTERING THE AIRPLANE. Check the following:

a. Check all filters installed and clean.

b. Check oleos and surface control hinge points free of dust and sand.

c. Check airplane position in relation to other airplanes. Sand blown by operating engines of one airplane can add hours to the maintenance problems of other airplanes.

6-37. ON ENTERING THE AIRPLANE. After entering the airplane complete the following:

a. When external power is connected or when the auxiliary power plant is operating, turn the air conditioning master switch "ON" and the cabin air selector switches to "AUTO" to operate the ground blowers for air circulation.

b. Open windows, hatches, bulkhead doors, and entrance door to ventilate the airplane.

6-38. BEFORE STARTING ENGINES. If the auxiliary power plant is used for starting engines, turn the air conditioning master switch "OFF" to prevent electrical power drain until at least one engine has been started.

6-39. STARTING ENGINES. Do not overprime engines since fuel vaporization will be rapid in high temperatures.

6-40. WARM-UP AND GROUND TESTS. In all hot weather and desert operations it is imperative that engine operation and ground tests be conducted in a minimum length of time. Be certain airplane is clear of other airplanes during ground operations.

6-41. TAXIING INSTRUCTIONS. When taxiing, keep adequate distance between airplanes to prevent propeller blown sand from causing damage to following airplanes.

6-42. TAKE-OFF. High temperatures require the pilot to be more cautious of stalling speeds. The following points are stressed:

a. Take-offs during hot periods of the day require longer runs.

b. Close observance of stalling speeds is necessary.

c. Close observance of cylinder head temperatures is necessary.

6-43. AFTER TAKE-OFF. Retract wing flaps with caution.

6-44. CLIMB. Climb at not less than specified climbing speed. Lower climb speeds cause high cylinder head temperature.

6-45. LANDING. Landing ground rolls are longer than those in normal temperatures. Ground speed increases with the same indicated airspeed due to thinner air.

6-46. BEFORE LEAVING THE AIRPLANE. Cover all ducts and air intakes as soon as possible to prevent the entrance of blowing sand. Leave some hatches or doors open for ventilation.

6-47. TURBULENT AIR FLIGHT.

NOTE

Flight through a thunderstorm should be avoided if it is at all possible. However, since circumstances may force you at some time to enter a zone of severe turbulence, you should be familiar with the techniques recommended for flying the airplane under such conditions. Power setting and pitch attitude are the keys to proper flight technique in turbulent air. The power setting and pitch attitude required for the desired penetration airspeed (figure 6-1), and established before entering the storm must - if maintained throughout the storm - result in a constant airspeed, regardless of any false readings of the airspeed indicator. Specific instructions for preparing to enter a storm and flying in it are given in the following paragraphs.

6-48. APPROACHING THE STORM. It is imperative that you prepare the airplane prior to entering a zone

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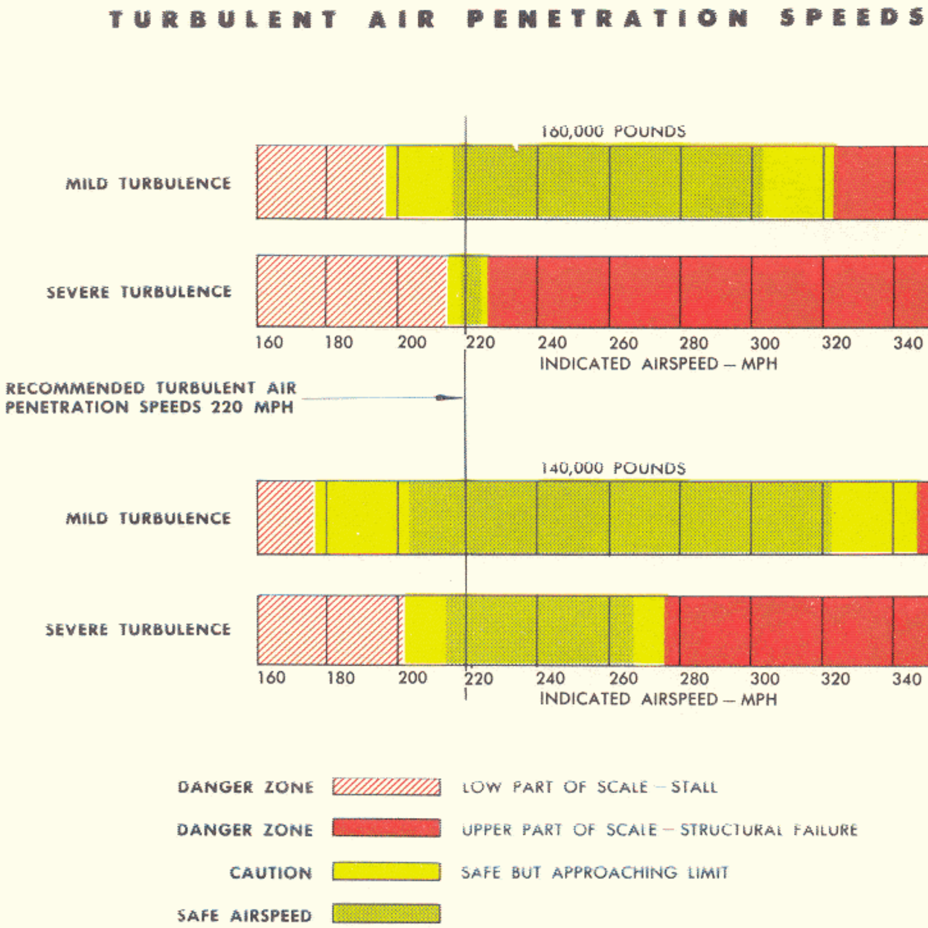

Figure 6-1. Turbulent Air Penetration Speeds

of turbulent air. If the storm cannot be seen, its proximity can be detected by radio crash static. Prepare the airplane as follows:

a. Disengage autopilot.

b. Master propeller synchronizer lever 2400 RPM for gyroscopic stability.

c. Mixture controls "AUTO RICH."

d. Pitot heater switches - "ON."

e. Carburetor heat - as required.

f. Throttles adjusted as necessary to obtain penetration speed. (See figure 6-1.)

g. Check gyro instruments for proper settings.

h. Safety belt tightened. (Check with crew members.)

i. Turn off any radio equipment rendered useless by static.

j. Reel in trailing antenna.

k. At night, turn cockpit lights full bright or use dark glasses to minimize effect of lightning.

CAUTION

Do not lower gear and wing flaps as they merely decrease the aerodynamic efficiency of the airplane.

6-49. IN THE STORM. Emphasis is placed on the following:

a. Maintain power setting and pitch attitude (established before entering the storm) throughout the storm. Hold these constant and your airspeed will be constant - regardless of the airspeed indicator.

b. Devote all attention to flying the airplane.

c. Expect turbulence, precipitation, and lightning, and do not allow them to cause undue concern.

d. Maintain attitude. Concentrate principally on holding a level attitude by reference to the artificial horizon.

e. Do not chase the airspeed indicator, since doing so will result in extreme airplane attitudes. If a sudden gust should be encountered while airplane is in a nose high attitude, a stall might easily result. A heavy rain, by partial blocking of the pitot tube pressure head, may decrease the indicated airspeed reading by as much as 70 MPH.

f. Use as little elevator control as possible to maintain your attitude in order to minimize the stresses imposed on the airplane.

g. The altimeter is unreliable in thunderstorm flying because of differential barometric pressures within the turbulent area. A gain or loss of several thou-

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sand feet may be expected. Make allowance for this error in determining minimum safe altitude.

NOTE

Normally, the least turbulent area in a thunderstorm will be at an altitude of 0-6000 feet above the terrain. Altitudes between 10,000 feet and 20,000 feet are usually the most turbulent.

6-50. OPERATION UNDER INSTRUMENT FLIGHT CONDITIONS.

6-51. GENERAL. The airplane has excellent qualities in regards to instrument flight. The airplane is very stable and remains in trim, thereby relieving the pilot from an additional flying strain.

6-52. Before attempting any instrument flight, check that all radios and flight instruments are operating properly. Also check that instrument lights are on and other cockpit lighting is dimmed or off.

6-53. INSTRUMENT TAKE-OFF. Check the following when making an instrument take-off:

a. Line up with runway for take-off. Reset directional gyro to nearest 5° increment. Allow airplane to roll ahead a few feet with nose wheel straight.

b. Apply take-off power in a normal manner using the nose wheel for steering up to about 60 MPH. Then steer with rudder.

c. Maintain direction with the directional gyro.

d. At minimum 3 engine take-off and climb speed (see Appendix 1) lift the nose wheel and fly the airplane off the runway with a smooth but definite attitude change as indicated by the attitude gyro.

e. Climb out at 10 MPH faster than minimum climb speed for 25° flaps and 3 engine climb.

f. Retract landing gear when sure airplane will remain airborne.

g. When a safe altitude over all obstructions is reached, accelerate to the minimum flap retraction speed and retract flaps. While retracting flaps lift the nose sufficiently to maintain a positive rate of climb at all times. Maintain an attitude which results in a gain of airspeed and altitude both at the same time. Continue to increase altitude and airspeed until normal climb speed is reached and a positive rate of climb is established.

h. At maximum gross weight take-off hold take-off and normal rated power as long as necessary to establish desired airspeeds and rate of climb.

6-54. INSTRUMENT FLIGHT. When instrument conditions prevail enroute and it is necessary for instrument flight, the following should be accomplished:

a. Check directional gyros and attitude gyros.

b. Set altimeters.

c. Check cruise power settings.

d. Check airspeed.

e. Check pitot heaters and surface deicing equipment.

6-55. INSTRUMENT LANDING. While making a procedure turn around on the range, extend the landing gear, extend the wing flaps 25 degrees, and advance propeller synchronizer lever to 2550 RPM. Maintain altitude with throttles and hold an airspeed of 180 MPH. After passing the final cone of the range, slow airspeed to 30 MPH above stall speed and reduce altitude to minimum required for the field of intended landing.

6-56. If the field is equipped with low approach radio facilities, make adjustments with throttle to ride the glide path. Hold the airspeed at 30 MPH above the stalling speed for 25 degree flap extension. Use discretion as to when the wing flaps should be fully extended.

6-57. GROUND CONTROL LANDING. When making a G.C.A. landing, set propeller synchronizer at 2550 RPM and extend the landing gear and the wing flaps (25 degrees). Trim the airplane. Use an approach speed 30 MPH above stalling speed for 25 degrees flaps. Extend full wing flaps on final approach. It is imperative that airspeed be held constant for ground control operators to make proper corrections.

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Section VII Operating Limitations

7-1. MINIMUM CREW REQUIREMENTS.

7-2. The minimum crew requirements for this airplane are a pilot, copilot, and engineer. Additional crew members as required will be added at the direction of the Commanding Officer.

7-3. ENGINE LIMITATIONS.
a. Do not exceed power plant limitations shown in figure 7-4.

7-4. PROPELLER LIMITATIONS.
a. Avoid continuous ground operation between 1600 and 2000 RPM because of propeller vibration.
b. Do not use propeller reverse thrust for ground maneuvering.
c. Do not let down between 1300 and 1600 RPM above 312 MPH (270 knots) IAS because of propeller stress.

7-5. AIRSPEED LIMITATIONS.

NOTE

The following limitations supplement those shown in figure 7-4.

a. Do not exceed 230 MPH (200 knots) IAS when extending the landing gear.
b. Do not exceed 220 MPH (190 knots) IAS when extending the wing flaps 25 degrees.
c. Do not exceed 230 MPH (200 knots) IAS when extending the landing lights.
d. Do not exceed 180 MPH (155 knots) IAS when opening the cargo doors.
e. Do not exceed 240 MPH (208 knots) IAS when opening or closing sheltered air doors.

7-6. FLIGHT RESTRICTIONS.
a. All acrobatics are strictly prohibited.
b. Operate the cowl flaps as shown in figure 2-1.

7-7. WEIGHT LIMITATIONS CHART.

7-8. The purpose of the Operating Weight Limitation Chart (figure 7-3) is to illustrate the weight carrying capabilities of the airplane in relation to various criteria that limit safe operation.

7-9. OPERATING WEIGHT. The operating weight upon which this chart is based is shown at the top of the chart. This value (80,400 pounds) is an average weight which includes the airplane basic weight shown on Chart "C" of AN 01-1B-40, Handbook of Weight and Balance, plus standard crew and full oil capacity. Since individual airplane basic weights vary, it will be necessary to adjust the charts for a specific airplane.

7-10. FUEL-PAYLOAD CAPACITY. The various combinations of fuel and payload capacity are shown in the envelope ABC. Payload is regarded as all fuel in the IFR tanks and center section tank. The horizontal axis of the hart indicates fuel loading and the vertical axis indicates the payload loading, including the center section fuel. The intersection of these two axis at "0" represents the airplane operating weight of 86,400 pounds.

7-11. MAXIMUM FUEL LOAD.

Wing fuel	6,656 gallons	39,480 pounds

7-12. MAXIMUM PAYLOAD.

Maximum payload (including center section fuel)	39,700 pounds

7-13. GROSS WEIGHT. The gross weights of the loaded airplane are indicated by diagonal lines.

7-14. WING FLIGHT LOAD FACTOR. Lines showing wing strength in terms of airplane load factors for combinations of fuel and payload are shown for 2.5 and 2.0 load factors. 2.5 is the load factor which the airplane structure makes good at the design gross weight of 153,000 pounds with the maximum payload of 39,700 pounds. Combinations of payload and fuel for which the airplane structure is good for less than 2.5 G's should be flown with caution, especially when

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making turns and pullouts. The airplane should never be loaded with any combination of payload and fuel which extends beyond the 2.0 G line.

7-15. LANDING GEAR LOAD FACTOR. The structure is designed for normal landings with payloads up to 39,700 pounds. Payload should not exceed this value except for aerial delivery. The gross weight at which the landing gear load factor will be 2.0 is shown by the gross weight line representing 175,000 pounds.

7-16. PERFORMANCE LIMITATION. Two performance limitation lines are shown. One line indicates the maximum weight at which a rate of climb of 500 feet per minute can be maintained with all four engines at normal rated power at sea level under standard atmospheric conditions. The other line indicates the maximum weight at which the service ceiling (rate of climb 100 feet per minute) is at least sea level under standard atmospheric conditions when using maximum power with one engine inoperative.

7-17. USE OF THE CHARTS. A sample problem is presented to illustrate the application of the charts.

7-18. Assume that a flight of the airplane calls for a 34,000 pound payload and 30,000 pounds of fuel. Starting with the operating weight of 86,400 pounds at "0" proceed along the vertical axis to 34,000 pounds; this increases the gross weight to 120,400 pounds. Next proceed along the horizontal axis to 30,000 pounds and project a line vertically to intersect the horizontal projection of the 34,000 pound line. By interpolation the intersection will indicate a gross weight of 150,400 pounds. It will be noted that this weight is below the flight load factor 2.5 line and also below the landing gear load factor 2.0 line.

7-19. Another example to demonstrate a problem where the operating weight of the airplane is greater than that shown on the chart, assume an operating weight of 91,000 pounds instead of 86,400 pounds or a difference of 4,600 pounds. Using the same requirements as in the previous example and proceeding as before, the gross weight will be found at 150,400 pounds by interpolation; but to this value 4,600 pounds must be added to correct the chart for the heavier airplane. This increases the total gross weight to 155,000 pounds. This value is below the landing gear load limit factor of 2.0, but above the 2.5 line by 1,500 pounds. To reduce the gross weight necessary to keep within the envelope below the 2.5 line, the payload must be reduced by 1,500 pounds.

ALTERNATE FUEL GRADE OPERATION LIMITS (100/130)

CONDITION	RPM	BHP	TPSI	INCHES Hg at S.L.	MAX C.H.T.	DESIRED C.H.T.	MAX. C.A.T.	DESIRED C.A.T.	MIXTURE POSITION
TAKE-OFF (WET)	2700	3250	280	56.5	250°C*	210-220°C	40° C		AR
TAKE-OFF (DRY)	2700	3000	280	56.0	250°C*	210-220°C	40° C		AR
NORMAL RATED	2550	2500	228	48.0	250°C*	210-220°C	40° C	15-40° C	AR
MAX. AUTO LEAN	1965	1625	192	38.0	232°C*	210-220°C	40° C	15-40° C	AL

* For airplanes with engines not incorporating modifications of the exhaust valve tappet guides and rocker oil manifold screws, limit AUTO RICH cylinder head temperature to 232°C and AUTO LEAN cylinder head temperature to 210°C.

Figure 7-1. Alternate Fuel Grade Operating Limits

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FUEL LOADING AND USAGE RESTRICTIONS TABLE

PAYLOAD	GROSS WEIGHT	FUEL LOADING RESTRICTIONS	FUEL USAGE RESTRICTIONS
Up to 29,000 pounds	Up to 150,000 pounds	Fuel in tanks 1 and 4 must be equal to or greater than fuel in tanks 2 and 3.	Fuel in tanks 1 and 4 must always be equal to or greater than fuel in tanks 2 and 3.
From 29,000 pounds to 39,700 pounds	Up to 128,000 pounds		
	128,000 pounds to 150,000 pounds	Not over 2835 pounds each (473 gal.) in tanks 2 or 3 unless 1 and 4 are full.	
Over 39,700 pounds	Over 128,000 pounds	Tanks 1 and 4 must be full with remaining fuel in tanks 2 and 3.	Fuel in tanks 2 and 3 must be used before starting to use fuel in tanks 1 and 4.

NOTES

1. Use fuel in the center tank as soon as practical.
2. Fuel in center tank must be included in payload weight.
3. See "Handbook of Weight and Balance" AN 01-1B-40 for additional weights, restrictions and limitations.

Figure 7-2. Fuel Loading and Usage Restrictions

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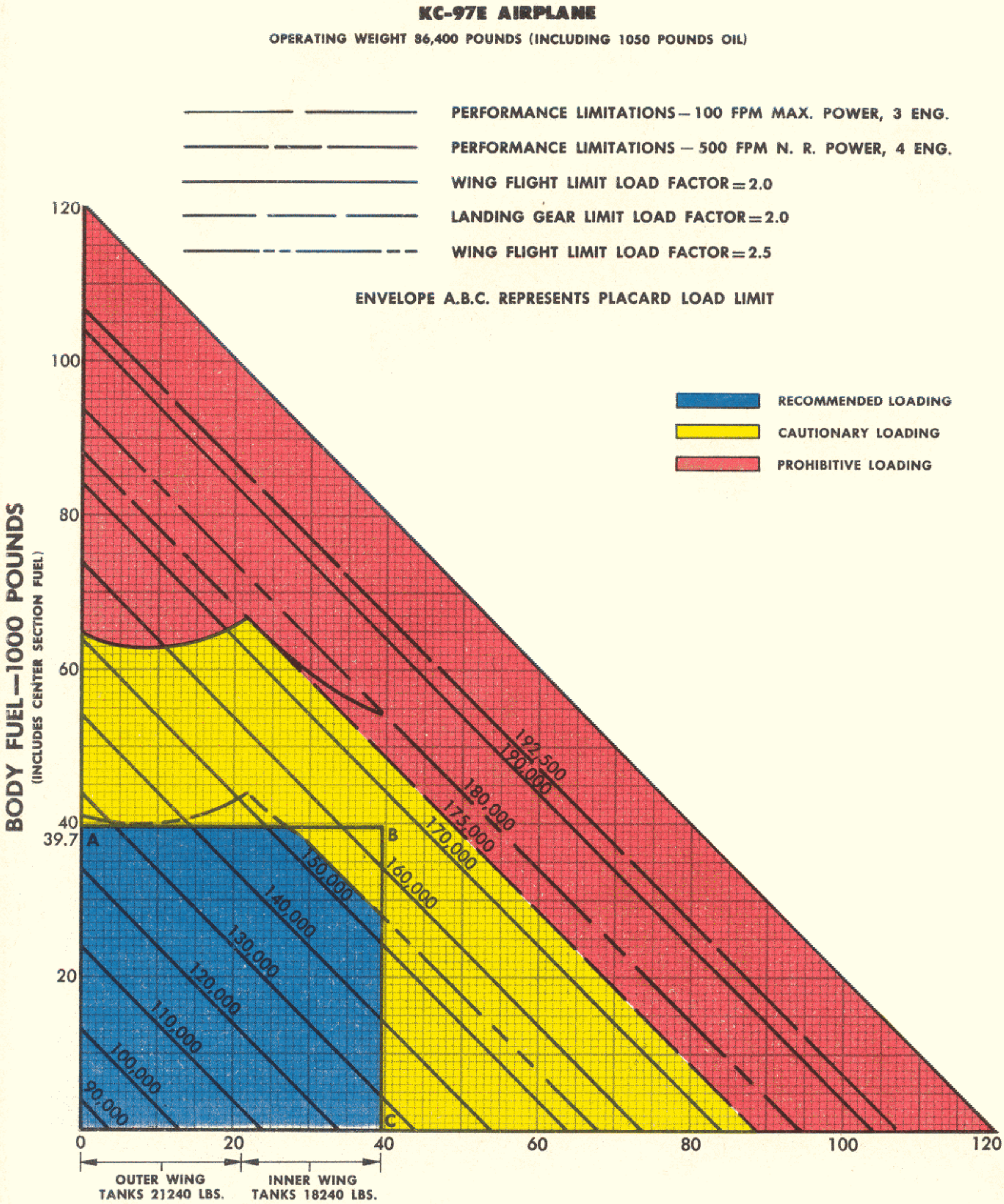
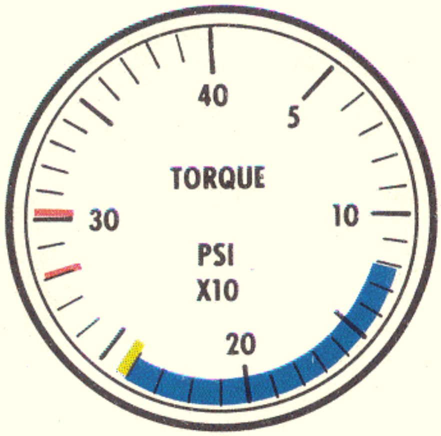


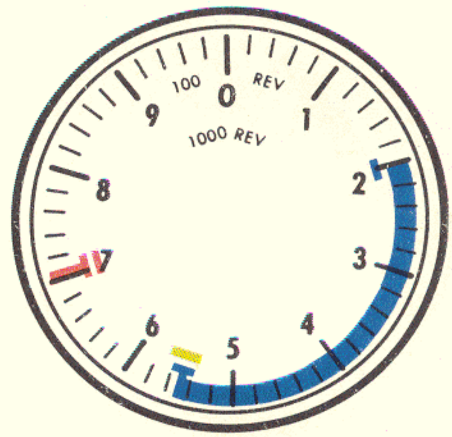
Figure 7-3. Operating Weight Limitations

TORQUEMETER



120 PSI	MINIMUM FOR FLIGHT
120 PSI TO 242 PSI	AUTO-LEAN PERMITTED
242 PSI	MAXIMUM CONTINUOUS AUTO-LEAN OR AUTO-RICH (operation above this pressure limited to 5 minutes in Auto-rich)
280 PSI	MAXIMUM — DRY
301 PSI	MAXIMUM — WET

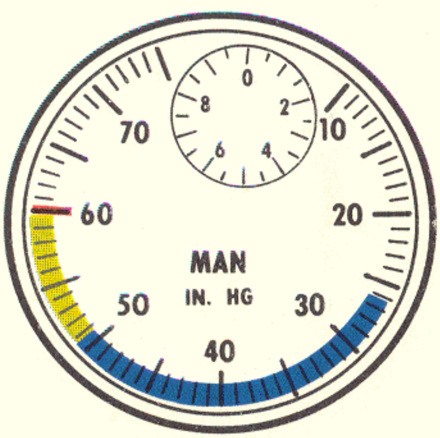
TACHOMETER



1200 RPM TO 2550 RPM	AUTO-LEAN PERMITTED
2550 RPM	MAXIMUM CONTINUOUS AUTO-LEAN OR AUTO-RICH (operation above this RPM limited to 5 min in Auto-rich)
2700 RPM	MAXIMUM

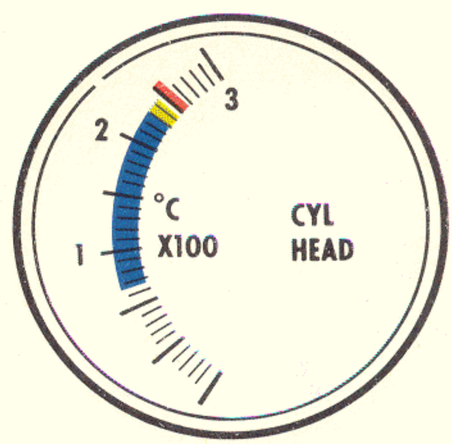
FUEL GRADE
115/145

MANIFOLD PRESSURE



26 IN. HG.	MINIMUM IN FLIGHT
26 IN. HG. TO 50.5 IN. HG.	AUTO-LEAN PERMITTED
50.5 IN. HG. TO 60 IN. HG.	AUTO-RICH REQUIRED
60 IN. HG.	TAKE-OFF (WET OR DRY)

CYLINDER HEAD TEMPERATURE



65°C TO 232°C	AUTO-LEAN PERMITTED
232°C TO 250°C	AUTO-RICH REQUIRED
250°C	MAXIMUM (FOR 5 MINUTE PERIOD)

Figure 7-4 (Sheet 1 of 5 Sheets). Instrument Markings

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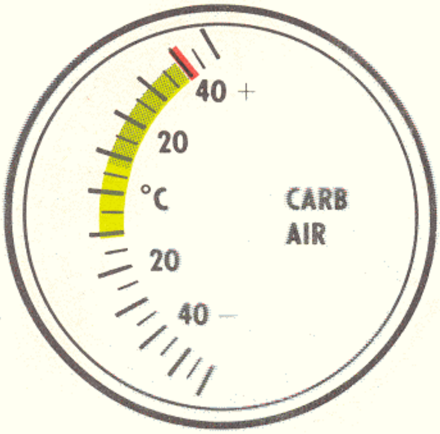
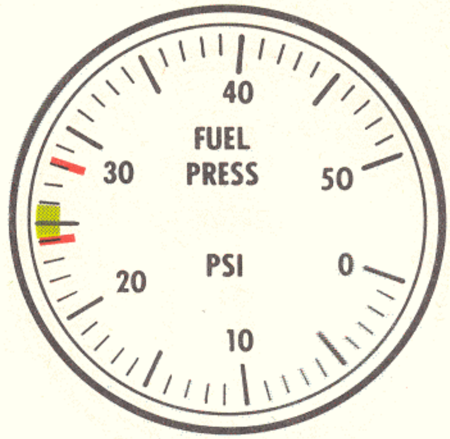
CARBURETOR AIR TEMPERATURE



(yellow)	− 10°C TO 7°C	DANGER OF ICING
(green)	7°C TO 40°C	CONTINUOUS OPERATION
(red)	40°C	MAXIMUM — DANGER OF DETONATION

FUEL PRESSURE



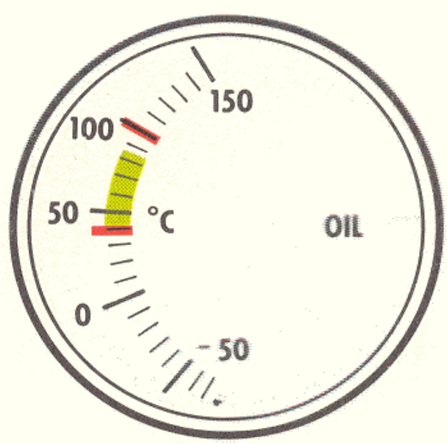
(red)	24 PSI	MINIMUM FOR FLIGHT
(green)	24 PSI TO 26 PSI	CONTINUOUS OPERATION
(red)	28 PSI	MAXIMUM

FUEL GRADE
115/145

OIL PRESSURE

(red)	50 PSI	MINIMUM FOR FLIGHT
(green)	80 PSI TO 95 PSI	CONTINUOUS OPERATION
(red)	100 PSI	MAXIMUM

OIL TEMPERATURE



(red)	40°C	MINIMUM FOR FLIGHT
(green)	40°C TO 85°C	CONTINUOUS OPERATION
(red)	100°C	MAXIMUM

Figure 7-4 (Sheet 2 of 5 Sheets). Instrument Markings

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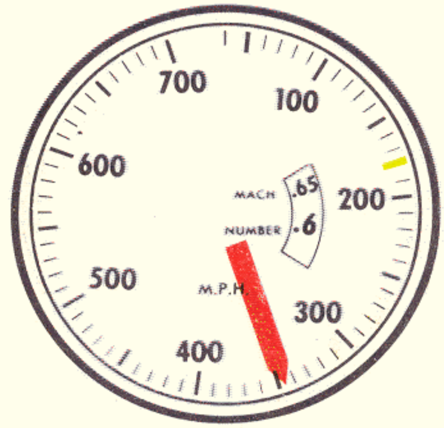
AIRSPEED

180 MPH FULL FLAPS (LANDING GEAR 230 MPH)
348 MPH MAXIMUM AIRSPEED

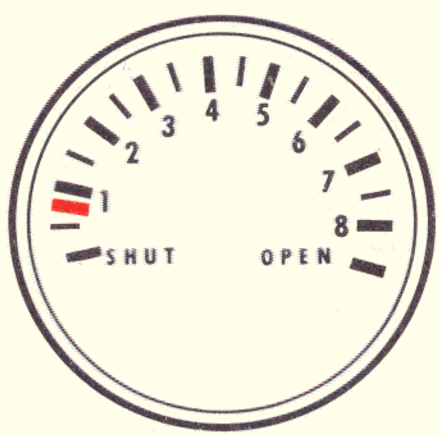
MAXIMUM ALLOWABLE AIR SPEED



180 MPH FULL FLAPS (LANDING GEAR 230 MPH)

This instrument setting is such that the red pointer will move to indicate a limiting structural airspeed of 348 MPH or the airspeed representing the limiting Mach Number of 0.62, whichever is less.

COWL FLAP INDICATOR



.75 INCHES MINIMUM OPENING

Figure 7-4 (Sheet 3 of 5 Sheets). Instrument Markings

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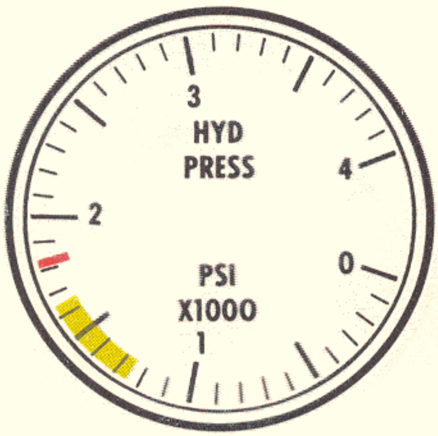
MAIN HYDRAULIC PRESSURE



(yellow)	1250 PSI TO 1650 PSI	NORMAL
(red)	1825 PSI	MAXIMUM

SERVICE BRAKE HYDRAULIC PRESSURE

(yellow)	520 PSI	ONE BRAKE APPLICATION REMAINING
(yellow)	1250 PSI TO 1650 PSI	NORMAL
(red)	1825 PSI	MAXIMUM

EMERGENCY BRAKE HYDRAULIC PRESSURE

(yellow)	520 PSI	ONE BRAKE APPLICATION REMAINING
(red)	1825 PSI	MAXIMUM

Figure 7-4 (Sheet 4 of 5 Sheets). Instrument Markings

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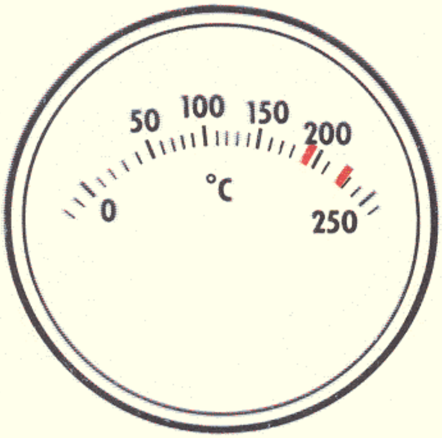
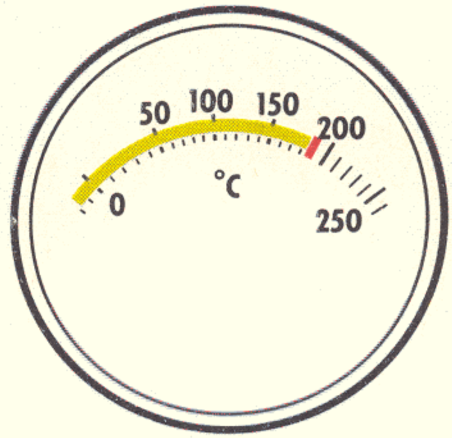
ANTI-ICING HEATER TEMPERATURE



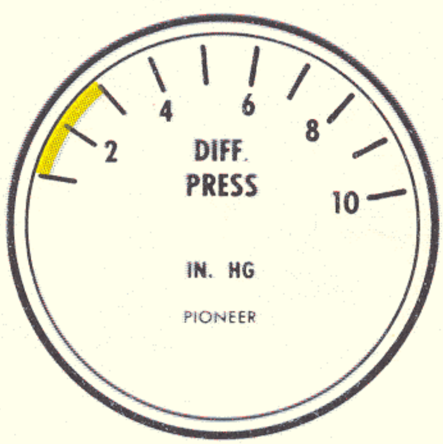
190°C MAXIMUM DUCT TEMPERATURE
227°C MAXIMUM HEATER TEMPERATURE

BODY HEATER TEMPERATURE



−20°C TO 182°C NORMAL
182°C MAXIMUM

CABIN AIR FLOW



1 IN. HG. TO 3 IN. HG. NORMAL

Figure 7-4 (Sheet 5 of 5 Sheets). Instrument Markings

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Appendix I — Operational Data

INTRODUCTION

The performance and cruise control charts contained herein are based on actual flight tests of a C-97A airplane. However, all of the charts may be applied directly to the KC-97E tanker airplane with the boom in the stowed position.

Limited performance flight tests on a KC-97A tanker airplane indicate that the additional drag of the KC-97A airplane over the C-97A airplane is negligible and that the variation of performance is of the magnitude which could be expected between any two aircraft of the same model designation. The KC-97A and KC-97E tanker airplanes are very nearly identical to the C-97A airplane with the exception of the installation of the In-Flight Refueling system. The boom operator's blister and the refueling boom are installed in place of the rear cargo doors and signal lights are mounted on the bottom of the fuselage. Four 1800 gallon refueling tanks are installed on the main cargo deck of the airplane.

Flight tests on a KC-97A tanker airplane were accomplished with the boom in the stowed position and with the boom in the nominal contact position. Results of these tests indicate that when the boom is in the contact position during formating and fuel transfer the additional drag of the boom decreases the high speed available by ten miles per hour equivalent airspeed from those presented in the charts.

Data is presented for standard atmospheric conditions with the exception of takeoff which is presented for all conditions of temperature and pressure altitude likely to be encountered. Charts for emergency operation on three and two engines are included.

The more commonly used curves have been assigned type numbers to help prevent misunderstandings when referring to them. As shown below, -2, -3, or -4 following the type number refers to the number of engines operating.

Curve	Type
A1	Nautical Miles Per Pound
A1-4	4 Engines
A1-3	3 Engines
A1-2	2 Engines
A2	Long Range Summary
A3T	Long Range Time Prediction
A3D	Long Range Distance Prediction
A6	Climb Prediction
A7	Airspeed and Altimeter Position Corrections
A8	Landing Distances
A9	Emergency Climb
A10	Stopping Distances
A11	Recommended Takeoff and Climbout Speeds
A13	Equivalent Takeoff Performance Weights
A14	Takeoff Flight Paths
M1	Power Schedule Table
M4	Power Schedule and Fuel Flow

These charts will enable the flight planner to determine takeoff, climb, level flight and landing performance for a complete mission. Examples are shown wherever such clarification is necessary.

The following two charts are contained in this section as an added convenience: Standard Altitude Table (figure A-1) and Density Altitude Chart, (figure A-2).

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TEXT INDEX

FIGURE INDEX

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FIGURE INDEX (CONTINUED)

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This table is based on NACA Technical Report No. 218

ALTI-TUDE FEET	DENSITY RATIO ρ/ρ_o	$\frac{1}{\sqrt{\sigma}}$	TEMPERATURE DEG. C	TEMPERATURE DEG. F	SPEED OF SOUND RATIO a/a_o	PRESSURE IN. OF Hg.	PRESSURE RATIO P/Po
0	1.0000	1.0000	15.000	59.000	1.000	29.92	1.0000
1000	.9710	1.0148	13.019	55.434	.997	28.86	.9644
2000	.9428	1.0299	11.038	51.868	.993	27.82	.9298
3000	.9151	1.0454	9.056	48.301	.990	26.81	.8962
4000	.8881	1.0611	7.075	44.735	.986	25.84	.8636
5000	.8616	1.0773	5.094	41.169	.983	24.89	.8320
6000	.8358	1.0938	3.113	37.603	.979	23.98	.8013
7000	.8106	1.1107	1.132	34.037	.976	23.09	.7716
8000	.7859	1.1280	-0.850	30.471	.972	22.22	.7427
9000	.7619	1.1456	-2.831	26.904	.968	21.38	.7147
10000	.7384	1.1637	-4.812	23.338	.965	20.58	.6876
11000	.7154	1.1822	-6.793	19.772	.962	19.79	.6614
12000	.6931	1.2012	-8.774	16.206	.958	19.03	.6359
13000	.6712	1.2206	-10.756	12.640	.954	18.29	.6112
14000	.6499	1.2404	-12.737	9.074	.950	17.57	.5873
15000	.6291	1.2608	-14.718	5.507	.947	16.88	.5642
16000	.6088	1.2816	-16.699	1.941	.943	16.21	.5418
17000	.5891	1.3029	-18.680	-1.625	.940	15.56	.5202
18000	.5698	1.3247	-20.662	-5.191	.936	14.94	.4992
19000	.5509	1.3473	-22.643	-8.757	.932	14.33	.4790
20000	.5327	1.3701	-24.624	-12.323	.929	13.75	.4594
21000	.5148	1.3937	-26.605	-15.890	.925	13.18	.4405
22000	.4974	1.4179	-28.586	-19.456	.922	12.63	.4222
23000	.4805	1.4426	-30.568	-23.022	.917	12.10	.4045
24000	.4640	1.4681	-32.549	-26.588	.914	11.59	.3874
25000	.4480	1.4940	-34.530	-30.154	.910	11.10	.3709
26000	.4323	1.5209	-36.511	-33.720	.906	10.62	.3550
27000	.4171	1.5484	-38.493	-37.287	.903	10.16	.3397
28000	.4023	1.5768	-40.474	-40.853	.899	9.720	.3248
29000	.3879	1.6056	-42.455	-44.419	.895	9.293	.3106
30000	.3740	1.6352	-44.436	-47.985	.891	8.880	.2968
31000	.3603	1.6659	-46.417	-51.551	.887	8.483	.2834
32000	.3472	1.6971	-48.399	-55.117	.883	8.101	.2707
33000	.3343	1.7295	-50.379	-58.684	.879	7.732	.2583
34000	.3218	1.7628	-52.361	-62.250	.875	7.377	.2465
35000	.3098	1.7966	-54.342	-65.816	.871	7.036	.2352
36000	.2962	1.8374	-55.000	-67.000	.870	6.708	.2242
37000	.2824	1.8818	-55.000	-67.000	.870	6.395	.2137
38000	.2692	1.9273	-55.000	-67.000	.870	6.096	.2037
39000	.2566	1.9738	-55.000	-67.000	.870	5.812	.1943
40000	.2447	2.0215	-55.000	-67.000	.870	5.541	.1852
41000	.2332	2.0707	-55.000	-67.000	.870	5.283	.1765
42000	.2224	2.1207	-55.000	-67.000	.870	5.036	.1683
43000	.2120	2.1719	-55.000	-67.000	.870	4.802	.1605
44000	.2021	2.2244	-55.000	-67.000	.870	4.578	.1530
45000	.1926	2.2785	-55.000	-67.000	.870	4.364	.1458
46000	.1837	2.3332	-55.000	-67.000	.870	4.160	.1391
47000	.1751	2.3893	-55.000	-67.000	.870	3.966	.1325
48000	.1669	2.4478	-55.000	-67.000	.870	3.781	.1264
49000	.1591	2.5071	-55.000	-67.000	.870	3.604	.1205
50000	.1517	2.5675	-55.000	-67.000	.870	3.436	.1149

Standard Sea Level Air:

T = 15° C.
P = 29.921 in. of Hg.
W = .07651 lb/cu. ft.

ρ_o = .002378 slugs/cu. ft.
a_o = 1116 ft./sec.
1" of Hg. = 70.732 lb/sq. ft. = 0.4912 lb/sq. in.

Figure A-1. Standard Altitude Table

022183

DENSITY ALTITUDE CHART

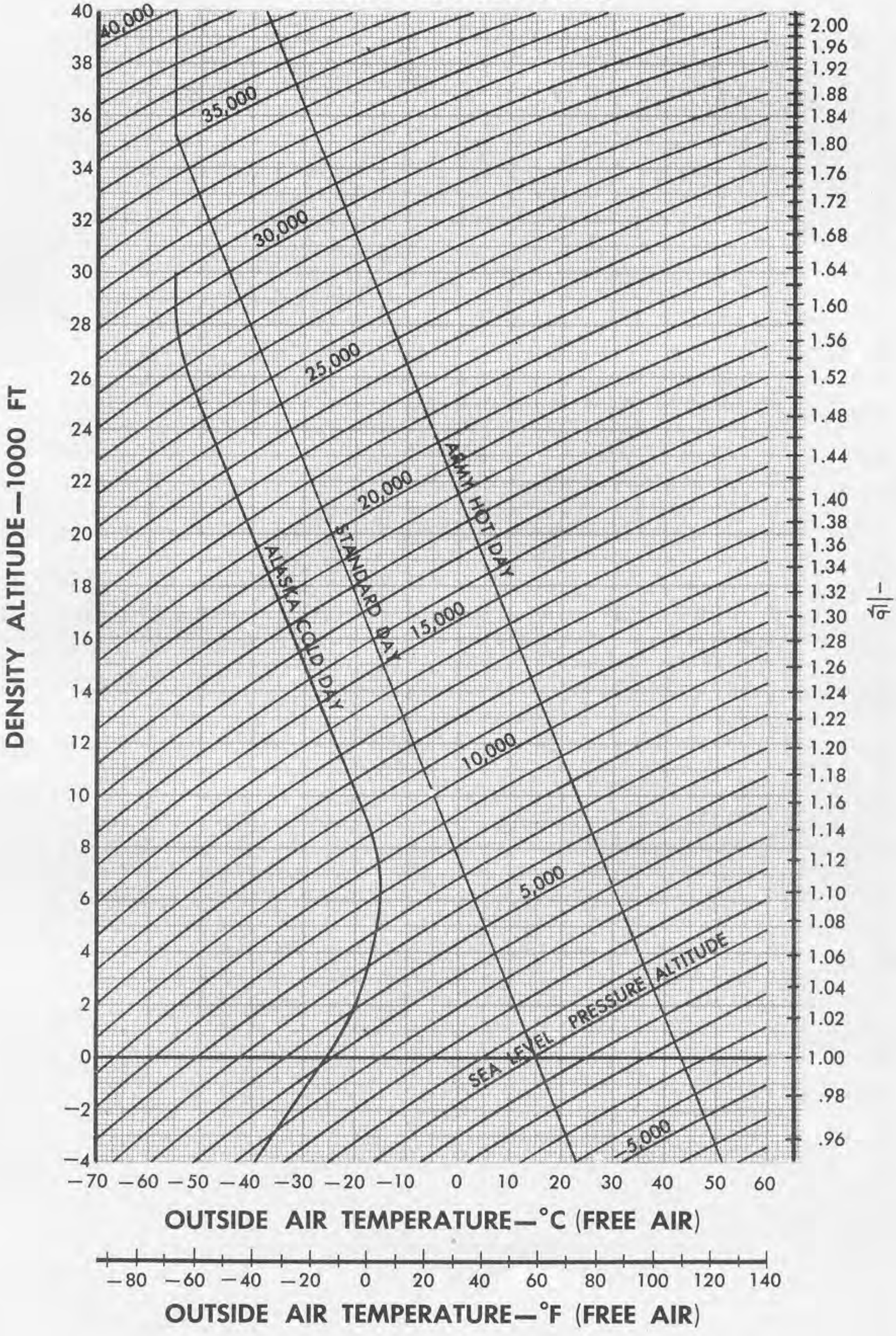


Figure A-2. Density Altitude Chart

022184

FLIGHT CONTROL CHARTS AND DATA

A-1. AIRSPEED, ALTIMETER AND OUTSIDE TEMPERATURE INDICATOR CORRECTIONS.

A-2. The following airspeed symbols are defined here to clarify the terms used throughout this appendix.

Term	Abbreviation	Definition
Indicated Airspeed	(IAS)	Instrument reading uncorrected
Calibrated Airspeed	(CAS)	Indicated airspeed corrected for instrument and position errors
Equivalent Airspeed	(EAS)	Calibrated airspeed corrected for compressibility
True Airspeed	(TAS)	True Airspeed = EAS x $1/\sqrt{\sigma}$

Where indicated airspeed (IAS) is noted on performance charts it is used as though there were no mechanical errors in the instrument. However, it is possible for an airspeed meter installed in the airplane to have a mechanical error of several miles per hour, which cannot be neglected when accurate flight control is desired. The instrument correction card values must be applied to the chart IAS values to obtain the actual instrument reading in such cases.

A-3. All airspeed systems have some degree of error built into them because of the impossibility of picking static and total sources which provide completely accurate pressures for all flight conditions. The errors in the system are caused mainly by difference between atmospheric pressure and that at the static pressure orifices. Total pressure picked up by a properly installed pitot is generally quite accurate. However, in most attitudes the static outlet is not in a region of true static pressure. This error for a given airplane attitude will vary as the square of the velocity. Moreover as the airplane angle of attack changes the flow pattern over the entire airplane is altered resulting in further changes in pressure at the static source. Both these errors depend on the geometry of the airplane and can therefore be calibrated for all airplanes of a series. Such a calibration will not change over a period of time unless the region of the static source is damaged or revised.

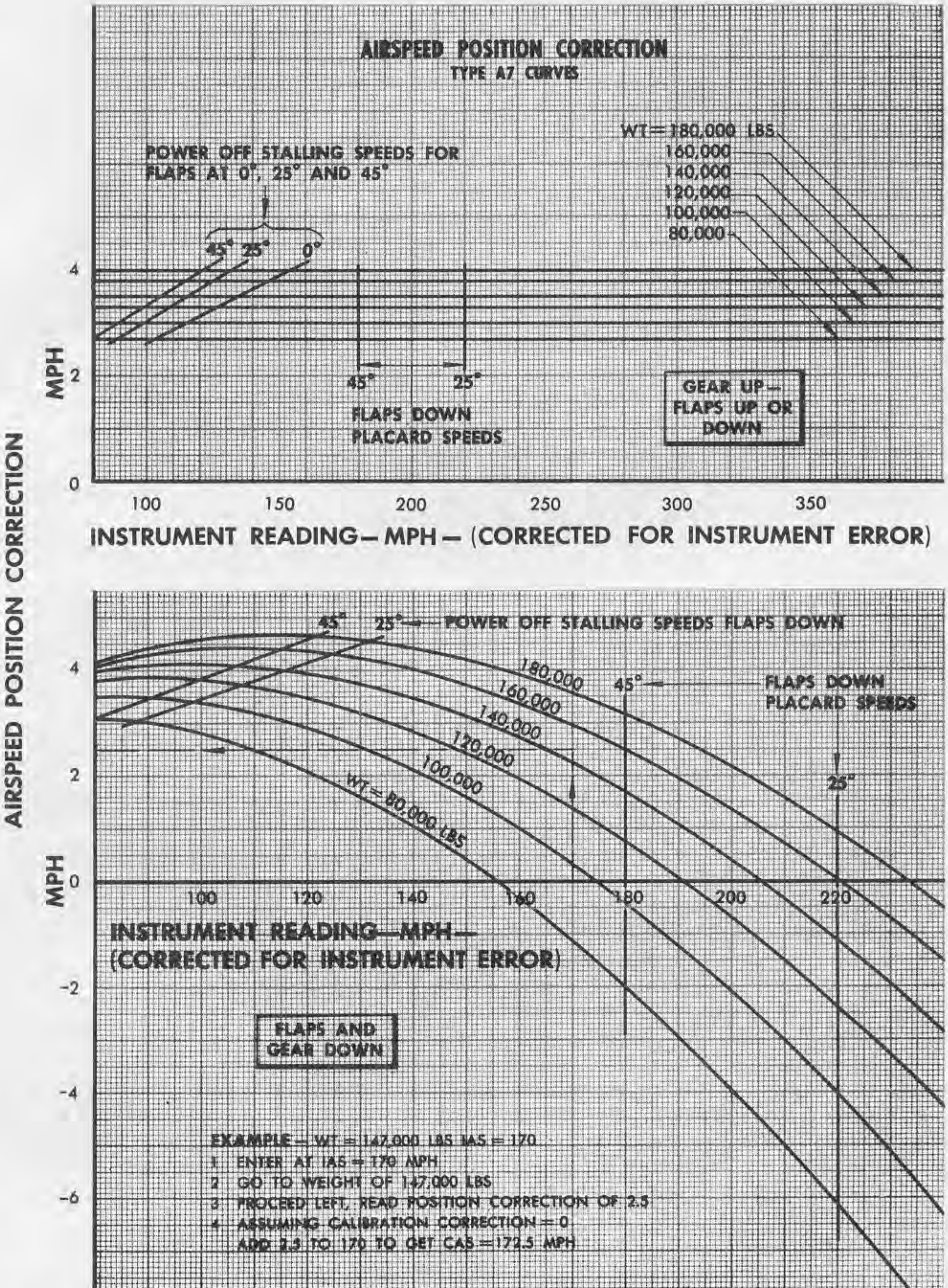
A-4. Figure A-3 presents the airspeed position corrections for the pilot's and copilot's airspeed indicator or other airspeed indicators which may be connected to the static sources located at stations 319 or 322, stringer 6. Notice that with landing gear up the correction is constant at all wing flap positions for any particular weight. With gear and flaps down the correction is variable, the instruments usually read low except at high speed and low weight.

A-5. Altimeter position corrections are shown on figures A-4 through A-6 for the following configurations: flaps up gear up, flaps down gear up, and flaps and gear down. In general, the altimeter reads low.

A-6. As speed increases, compressibility effects on airspeed and outside temperature indications become more and more significant. Airspeed corrections for compressibility are shown on figure A-7 and temperature correction for compressibility is shown on figure A-8. Note that compressibility effect causes both airspeed and outside temperature indicators to read high.

A-7. The temperature correction chart is based on temperatures with the temperature bulb installed in the nose wheel well. Tests indicate that this location appears to give a very accurate and reliable calibration.

022185



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-3. Airspeed Position Correction

022186

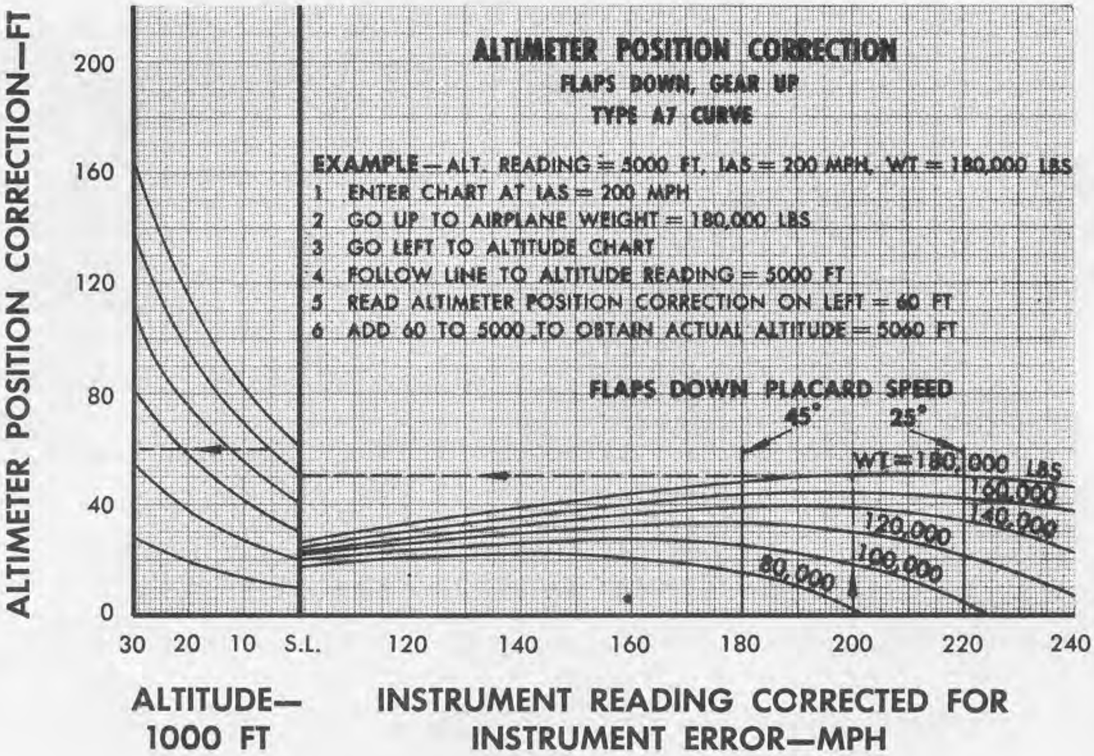
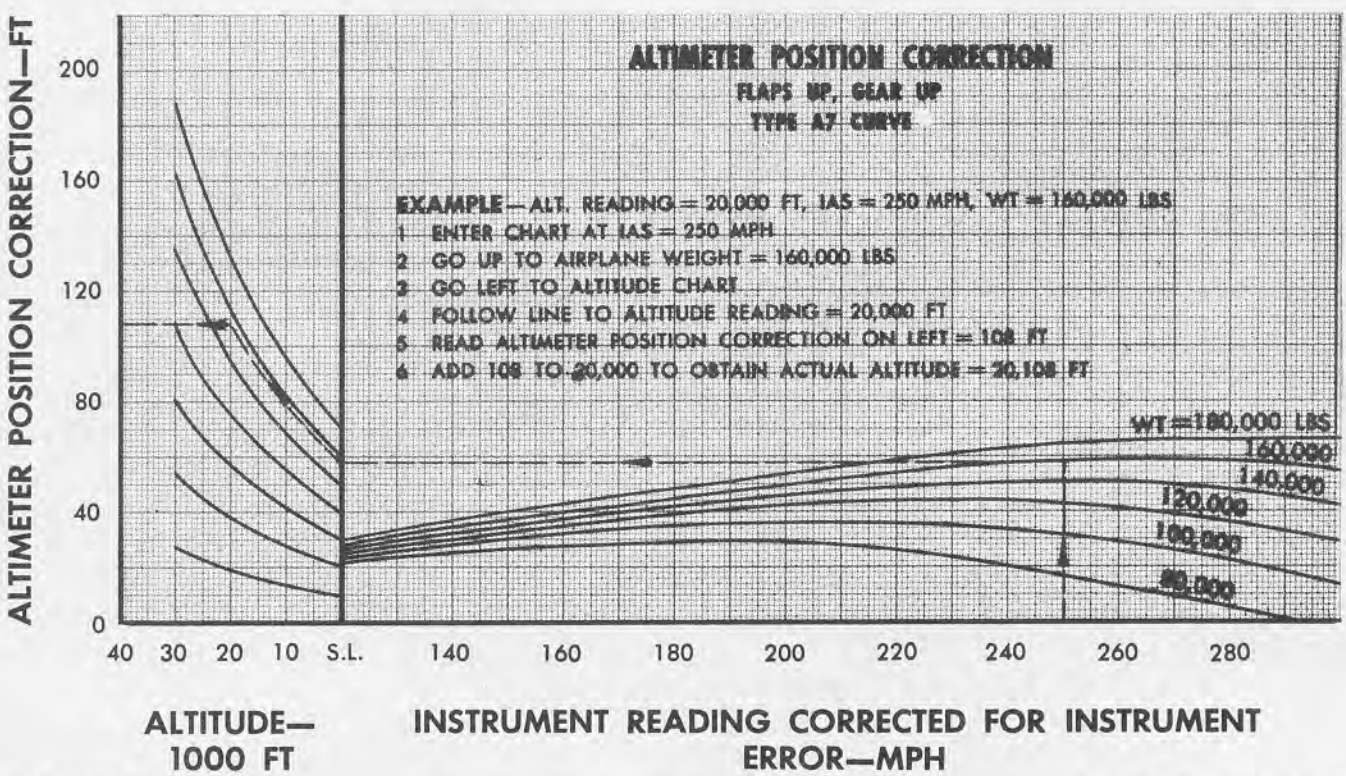


Figure A-4. Altimeter Position Correction, Flaps Down, Gear Up

81148



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-5. Altimeter Position Correction, Flaps Up, Gear Up

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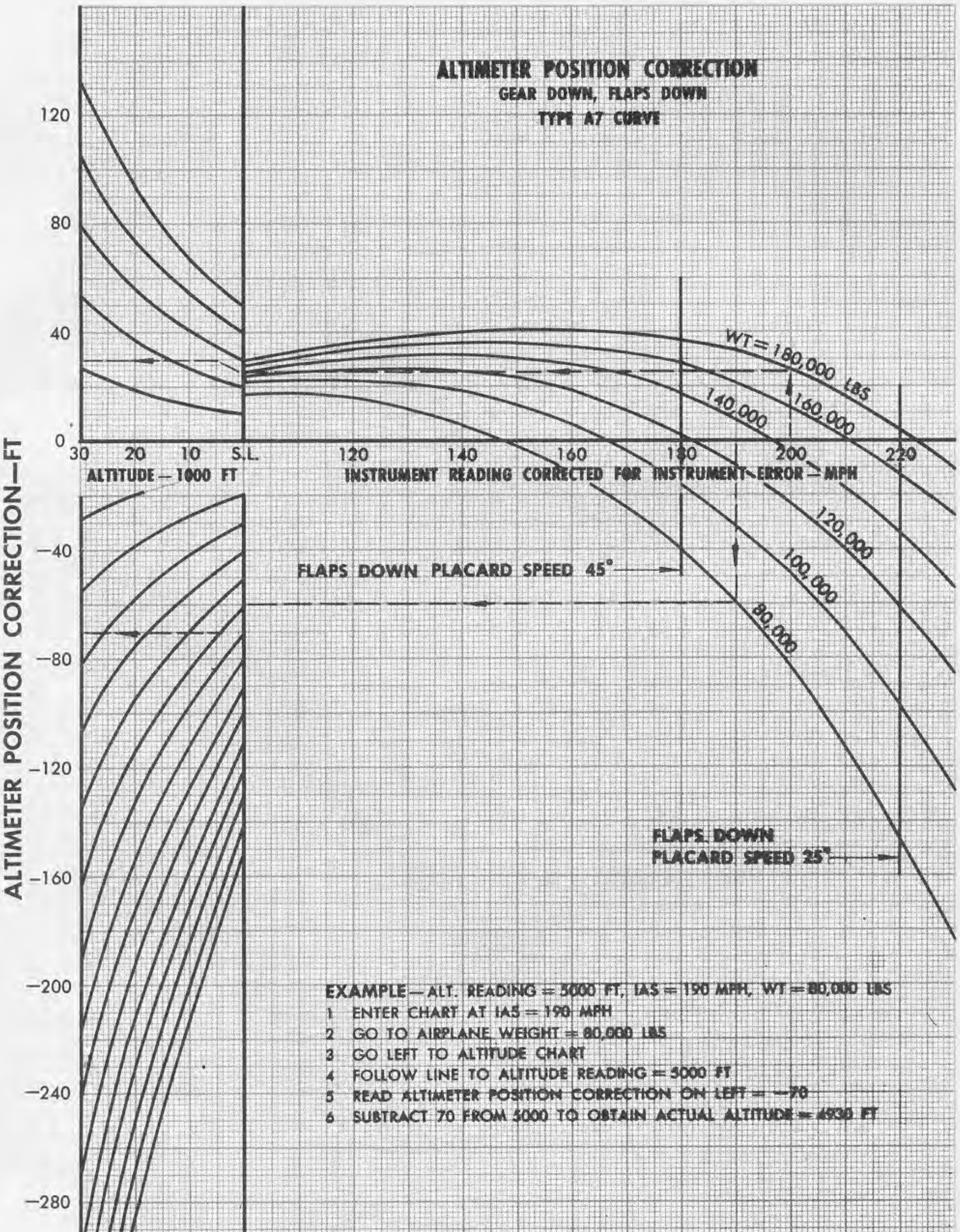
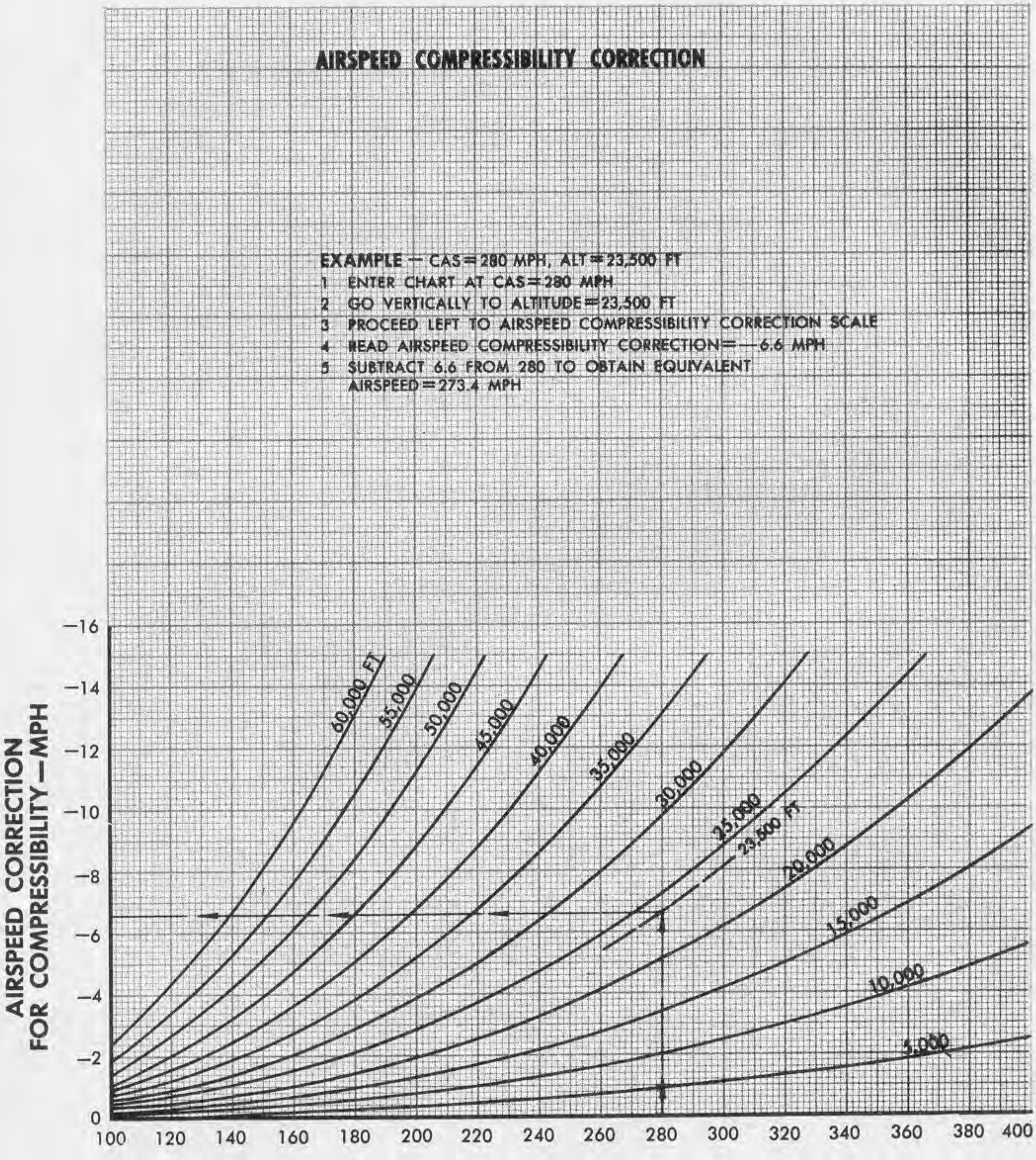


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-6. Altimeter Position Correction, Flaps Down, Gear Down

022188



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-7. Airspeed Correction for Compressibility

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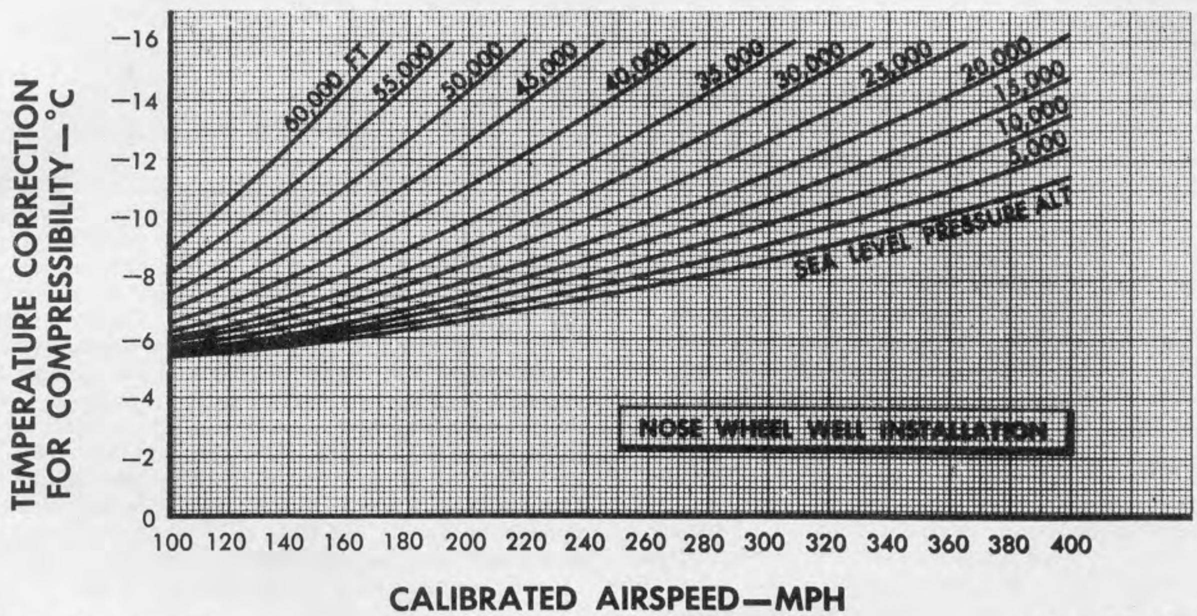


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-8. Temperature Correction for Compressibility

022190

A-8. TAKEOFF PERFORMANCE.

A-9. Takeoff performance is of considerable importance in the operation of tanker airplanes, since the amount of fuel available for transfer may be determined by the maximum weight limitations imposed by the available field length and takeoff conditions. The prediction of takeoff performance is complicated by the fact that variations in pilot technique cause large differences in the resulting airplane performance. Aside from pilot technique the major variables affecting takeoff performance are gross weight, power available, altitude and ambient air temperature. In addition, rather large effects are sometimes due to humidity, wind velocity and runway slope. Variations in pilot technique may only be eliminated by outlining a recommended takeoff procedure and calculating the performance charts based on adherence to this procedure. The effects on takeoff performance of altitude, outside air temperature, and takeoff power variation are very conveniently reduced to a single variable by introducing the concept of "equivalent performance weight." This term is a measure of performance capabilities and is explained in paragraph A-21. Using equivalent performance weight the charts for takeoff distance and flight path during climbout become relatively simple.

A-10. Sufficient information is provided to determine accurately the maximum gross weight for takeoff at any desired safety level under a wide range of atmospheric conditions. For routine takeoffs a simplified method is also presented which requires the use of a minimum number of charts but assures the maximum safety level. Charts and information are included under the following subheadings:

Power Available for Takeoff
Speeds for Takeoff and Initial Climbout
Takeoff Weight Limitations
Takeoff Distance and Flight Path (two sections)
Wind and Slope Corrections
Examples for use of Takeoff Charts

A-11. In the takeoff performance charts pressure altitude has been used as the ambient barometric reading. Since some weather stations give barometric readings in other units the following table may be used to convert them to pressure altitudes:

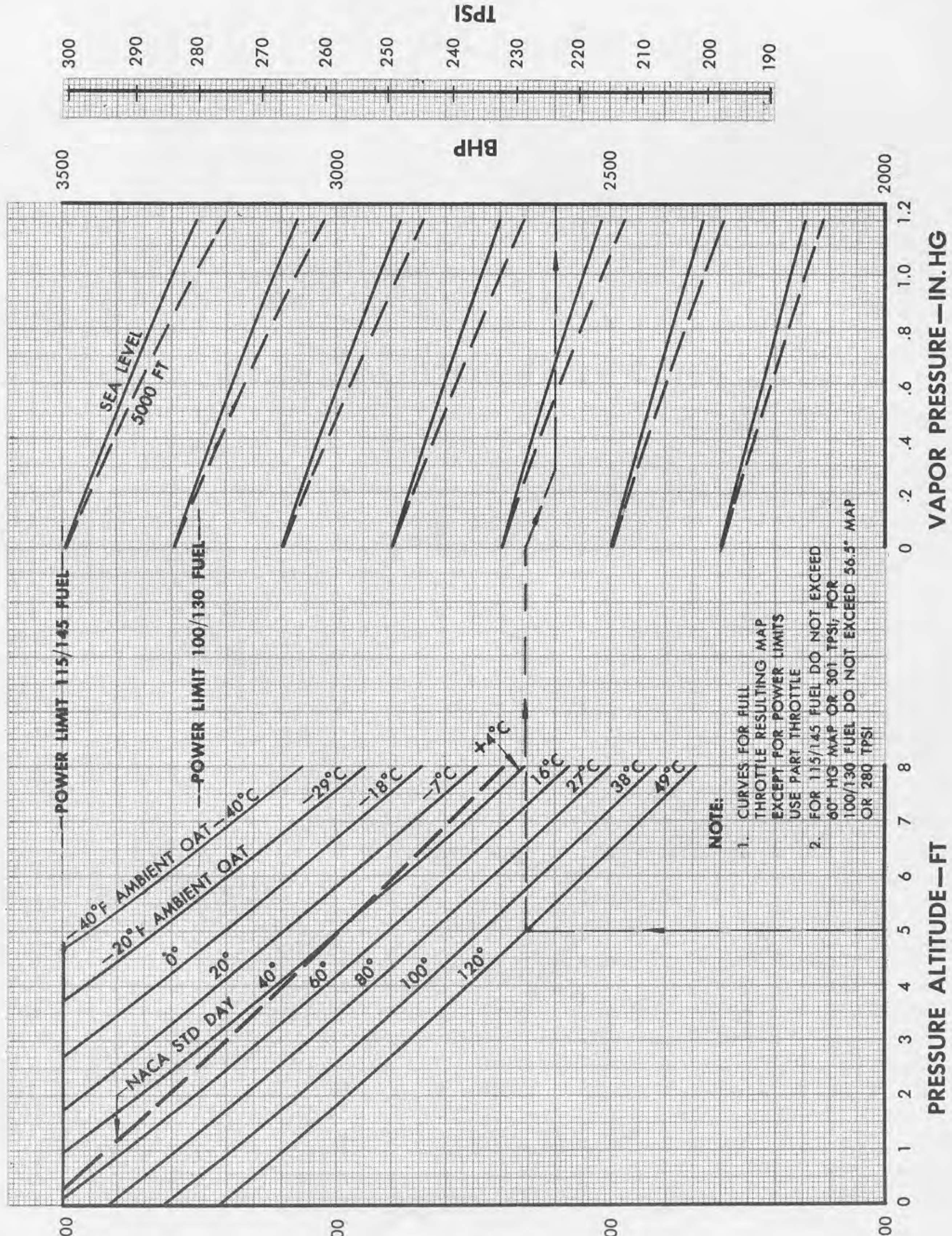
Pressure Altitude feet	Barometric Reading In. Hg.	Mm. Hg.	Millibars
-1000	31.02	788	1050
Sea Level	29.92	760	1013
1000	28.86	733	977
2000	27.82	707	942
3000	26.81	681	908
4000	25.84	656	875
5000	24.89	632	843
6000	23.98	609	812
7000	23.09	586	782

A-12. POWER AVAILABLE FOR TAKEOFF. Wet takeoff power available is shown on figure A-9. This chart indicates the power developed by an average engine in good mechanical condition. Data are included for altitudes from sea level to 8000 feet and for ambient outside air temperatures of -40 to 120°F. The NACA standard day power curve from which the chart was derived is shown by dashed lines as is the power limit using 100/130 grade fuel. The powers shown are for dry air and should be corrected by the humidity nomogram included on the chart. A psychrometric chart for obtaining vapor pressures from wet and dry bulb temperatures or from relative humidity readings appears on figure A-10. In case no humidity readings are available, an 80% relative humidity correction is recommended as a good average value.

A-13. In order to obtain best takeoff performance and not exceed engine cooling limits the cowl flaps should be set for takeoff according to the following schedule:

1.5 inches gap for OAT up to 20° C
2.0 inches gap for OAT 20° to 32° C
2.0 inches gap for OAT above 32° C (outboard engines)
2.5 inches gap for OAT above 32° C (inboard engines)
Do not exceed 3.0 inches gap at takeoff.

022191



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-9. Wet Take-off Power Available

022192

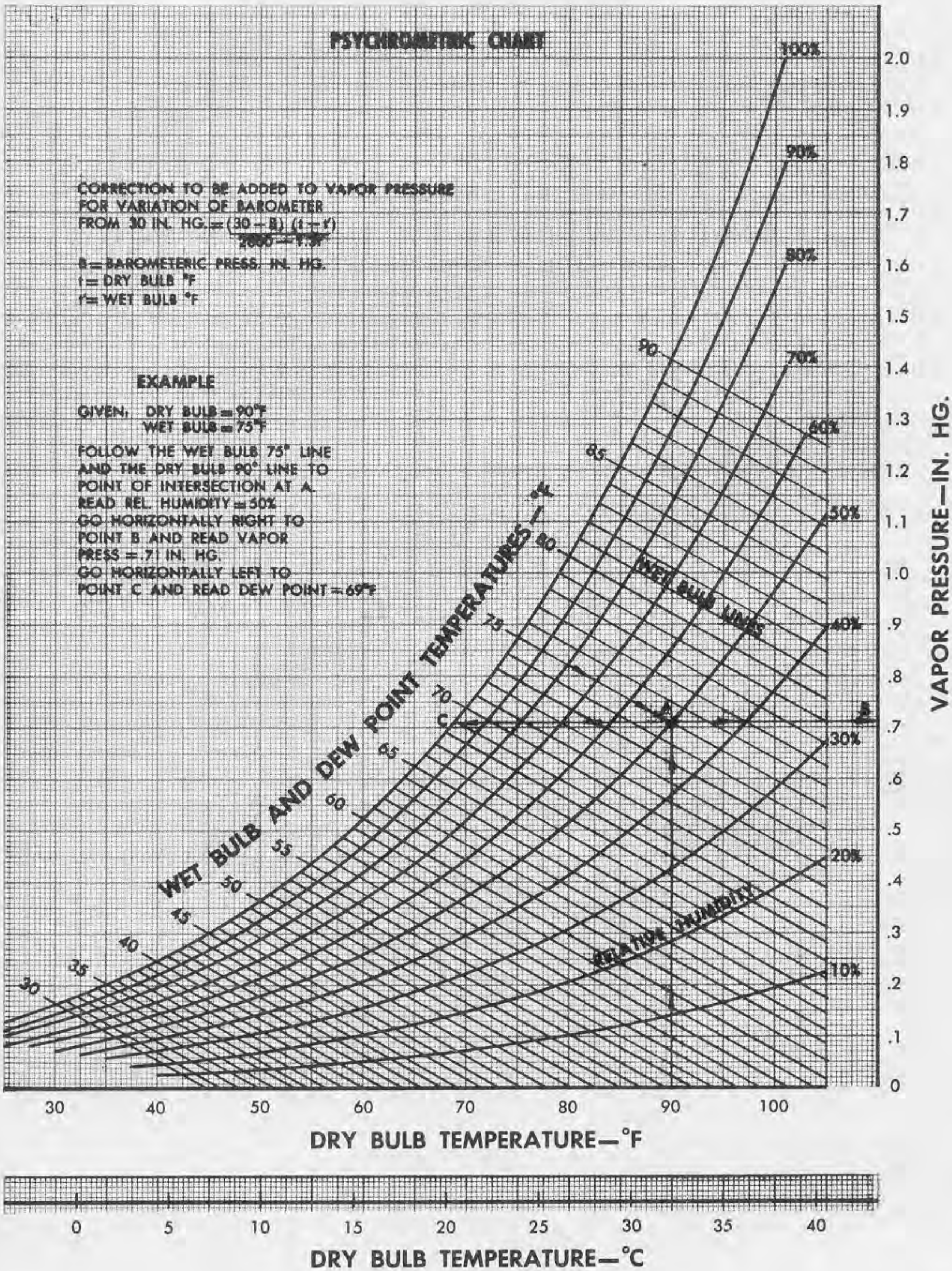


Figure A-10. Psychrometric Chart

022193

A-14. SPEEDS FOR TAKEOFF AND INITIAL CLIMB-OUT. One of the primary factors affecting safety and performance during takeoff is speed. Takeoff distance, stopping distance and climb angle are all affected by changes in speed.

A-15. A detailed study has been made to determine the optimum takeoff speeds, and the result is a compromise between the slowest practical speeds for the purpose of shortening field length and higher speeds (best angle of climb speed) for the purpose of obtaining best climb-out performance. On figures A-12 and A-13 are plotted rates of climb versus equivalent airspeed for several airplane weights, for the takeoff configuration, for 4 engines and 3 engines operating. The recommended takeoff speeds and flap retraction speeds were determined from these data. The equivalent airspeed for takeoff is shown on figure A-12.

A-16. The recommended takeoff, climb-out and flap retraction speeds are plotted on figure A-11 in terms of pilot's indicated airspeed. The takeoff procedure recommended with these speeds is to leave the weight on the nose wheel during the takeoff run until within 5 or 10 MPH of the recommended takeoff speed; then ease the weight off the nose wheel and, holding constant attitude, allow the airplane to fly off at the speed shown. Due to changing ground effects on the airspeed static system, as the airplane leaves the runway the indicated airspeed will increase even though the airplane does not accelerate. The airspeed reading should, therefore, be allowed to increase, while holding approximately constant attitude, to the values shown for climb-out by the time 50 to 100 feet height has been reached. The pilot's indicated airspeeds shown in figure A-11 are corrected for instrument error only, and represent a constant speed for climbout 12 to 14% above the power-off stall speed for flaps in takeoff position and a forward center-of-gravity position.

A-17. When field length is insufficient to conduct operations at the recommended speeds, the takeoff speed may be reduced a maximum of 5 MPH which will shorten the ground distances approximately 8%, but greater reductions will seriously impair the climb-out performance. This may be seen from figures A-12 and A-13. Performance-limited weight should be reduced 5000 pounds when using takeoff speeds 5 MPH lower than the recommended speeds. Recommended takeoff speeds should never be reduced when rough air prevails, in fact, added safety will result from increasing the takeoff speeds 5 to 10 MPH in rough air.

022194

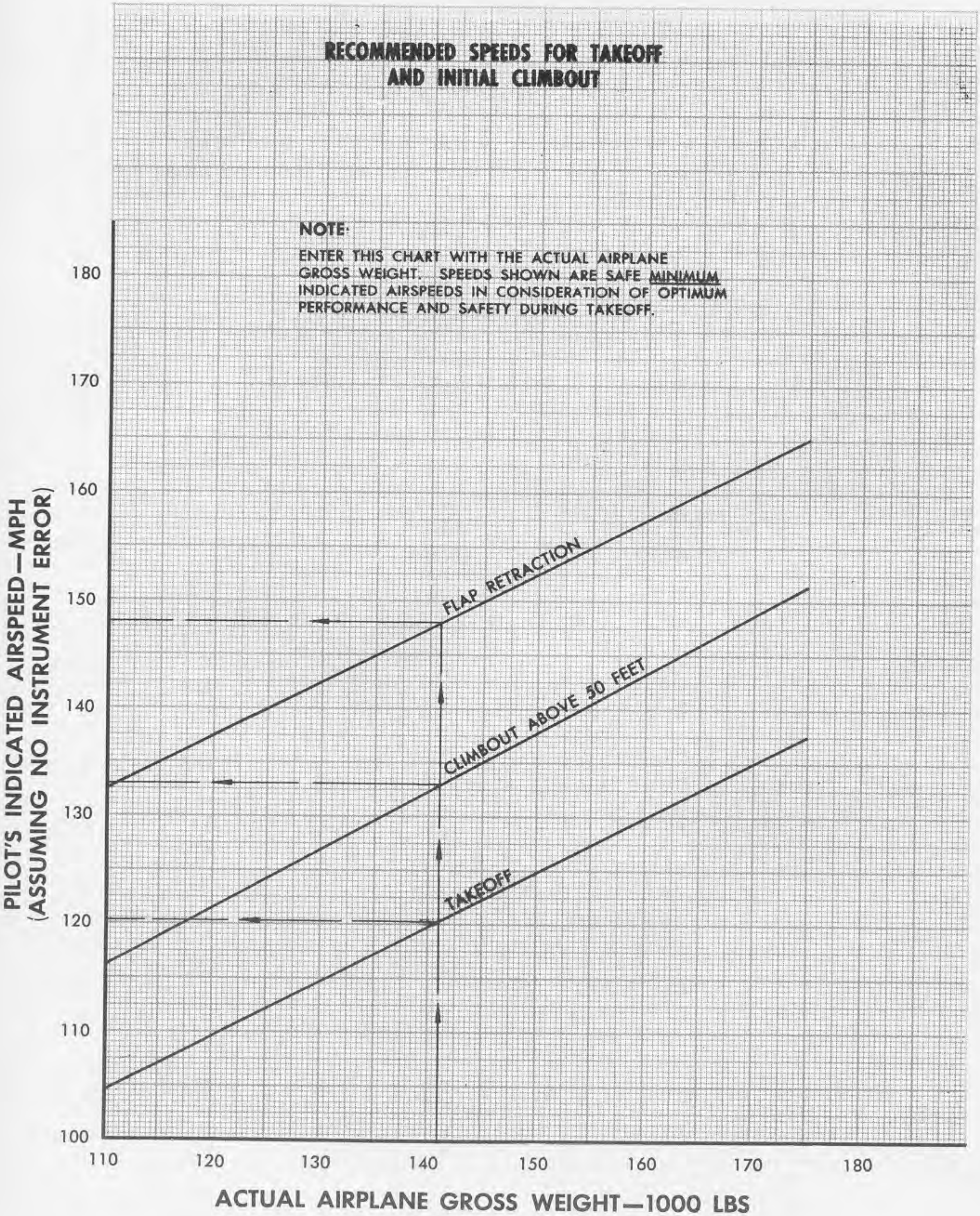


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Figure A-11. Recommended Speeds for Take-off and Initial Climbout

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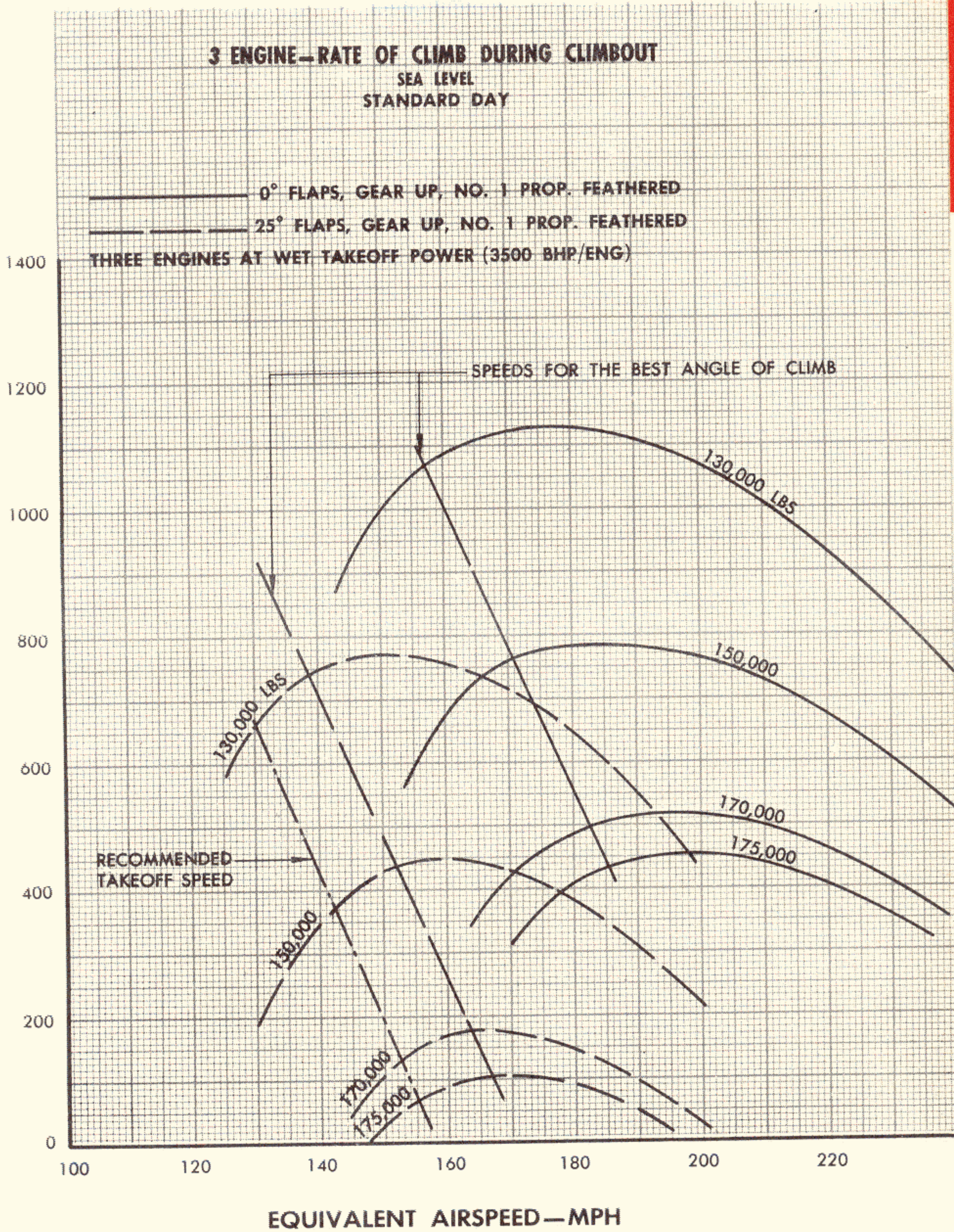

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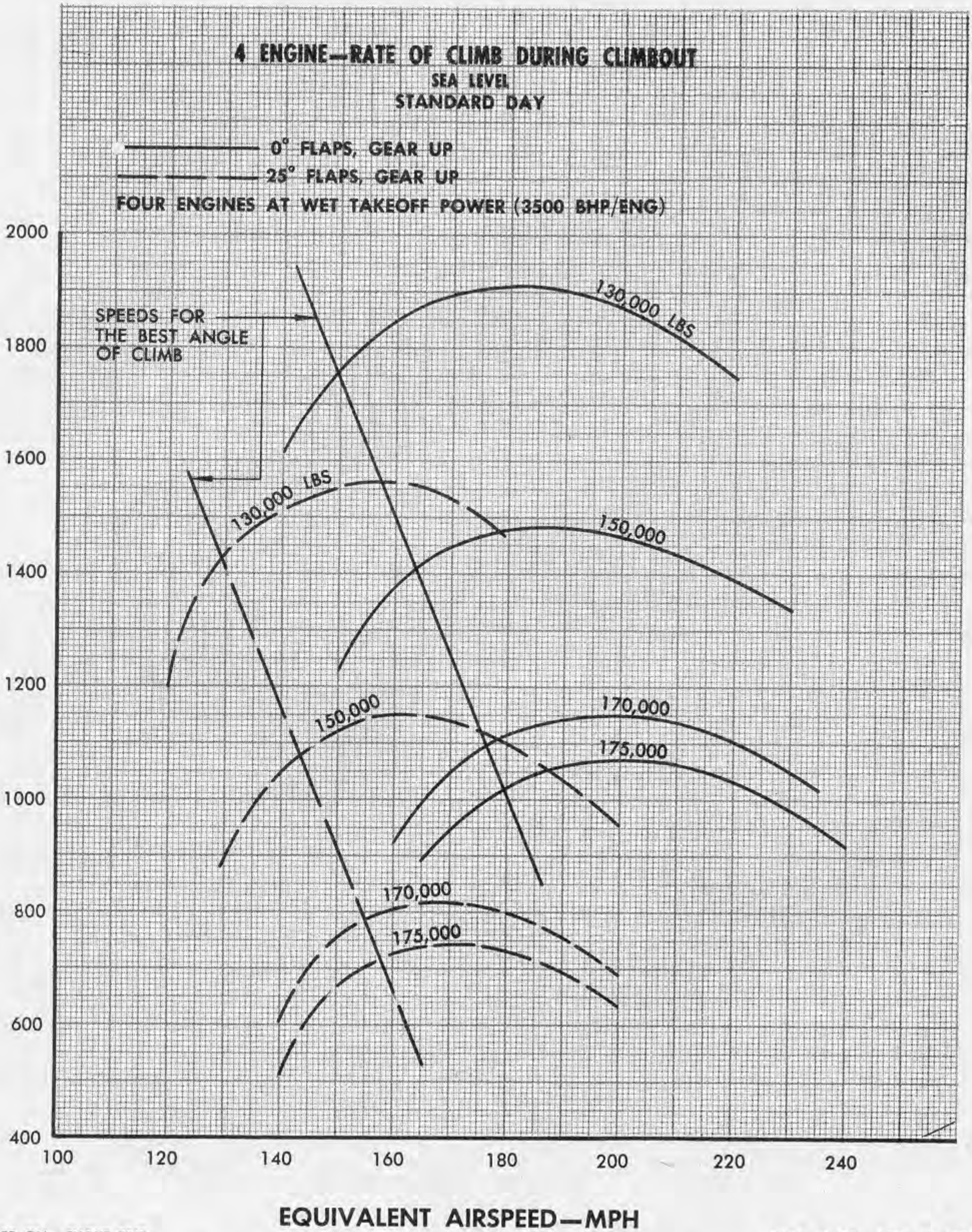
DATA AS OF: APRIL 10, 1951

Figure A-12. 3 Engine Rate of Climb During Climbout

022196



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-13. 4 Engine Rate of Climb During Climbout

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A-18. TAKEOFF WEIGHT LIMITATIONS. Takeoff gross weight is subject to both structural and performance limitations. Structurally the airplane meets a load factor of 2.5 at a maximum recommended weight of 153,000 pounds. At a weight of 175,000 pounds, the load factor is only 2.0. Thus, as weight increases, increased care in ground handling must be exercised as well as increased attention to runway smoothness and air turbulence, for takeoff. At 175,000 pounds smooth runways and non-turbulent air are essential for takeoff.

A-19. Takeoff weight limitations may be imposed by:
Length, condition and slope of runway.
Obstacles to be cleared after takeoff.
Pressure altitude at takeoff field.
Temperature, humidity and wind conditions.
Power output of engines.

A-20. Performance data are shown for weights up to 175,000 pounds. Weights below 120,000 pounds have been omitted since takeoff performance is no problem at lower weights. The maximum weight for a particular mission is controlled by the enumerated performance factors after a suitable safety level has been adopted. The takeoff performance charts show what the airplane may actually be expected to do with optimum pilot technique and other conditions as indicated, therefore adequate safety factors must be adopted depending on the tactical situation and experience with the airplane.

A-21. As previously mentioned, the presentation of takeoff performance is greatly simplified by consolidating the variables of gross weight, altitude, ambient temperature and power into a single variable by the equivalent performance weight method. For any conditions of actual weight, altitude, temperature and power available, the airplane will have takeoff acceleration and climb-out angles equivalent to those for another weight at sea level standard atmospheric conditions and 3460 BHP per engine. This latter weight may be used as a reference for the comparison of takeoff performance and is called "equivalent performance weight." The reference power, 3460 BHP, is that obtained at sea level standard conditions and 80% relative humidity.

A-22. Equivalent performance weight may be found from figure A-14. It is first necessary to find the power available from figure A-9, and entering the chart with this power correct for altitude and temperature, interpolate for actual gross weight and read the equivalent performance weight. The chart may also be used to find actual weight from equivalent weight.

A-23. By choosing a constant equivalent performance weight which represents the minimum desired level of takeoff performance the maximum actual gross weight for any altitude, outside air temperature or power may be obtained to satisfy this condition. At approximately 165,000 pounds equivalent performance weight the 3-engine rate of climb at takeoff power is 150 feet per minute which leaves an adequate margin of performance for acceleration to flap retraction speed. At 175,000 pounds equivalent performance weight the 3-engine climb-out performance is such that only airports with no obstacle or terrain clearance problems may be used.

022198

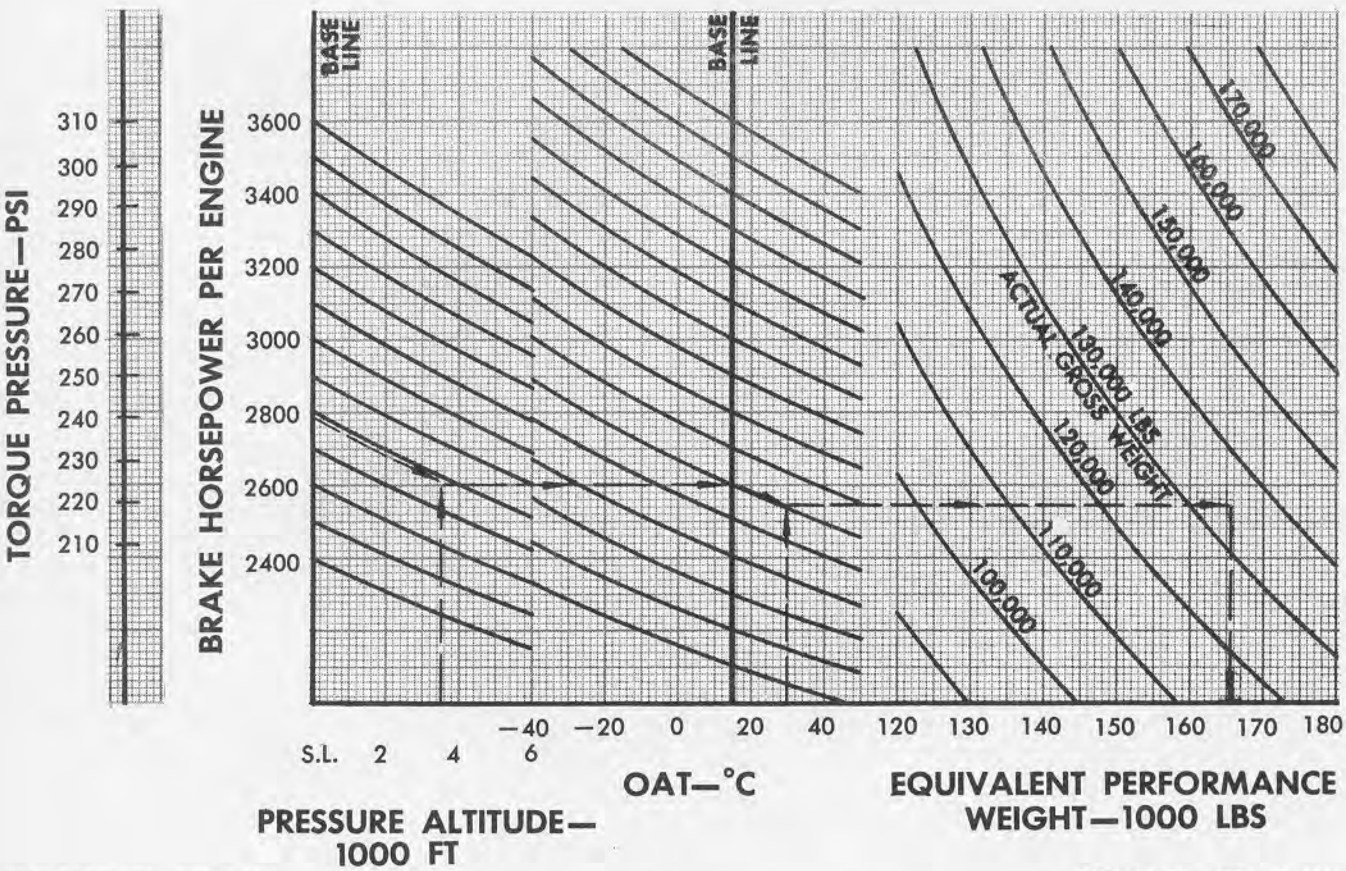
EQUIVALENT PERFORMANCE WEIGHT

TYPE A-13 CURVE

BASED ON:
SEA LEVEL—STANDARD DAY
3460 BHP/ENG

EXAMPLE: DETERMINE EQUIVALENT PERFORMANCE WEIGHT FOR BHP/ENG. = 2780, PRESS. ALT. = 3500 FT., O.A.T. = 30° C AND ACTUAL WEIGHT = 135,000 LBS.

1. ENTER CHART AT 2780 BHP, FOLLOW GUIDE LINES TO ALT. OF 3500 FT.
2. GO HORIZONTALLY TO O.A.T. BASE LINE THEN FOLLOW GUIDE LINES TO O.A.T. OF 30°C.
3. PROCEED HORIZONTALLY TO ACTUAL WEIGHT OF 135,000 LBS.
4. DROP VERTICALLY TO READ EQUIVALENT PERFORMANCE WEIGHT = 165,500 LBS.
5. NOTE TPSI IS APPROXIMATELY 240 AT 2780 BHP.

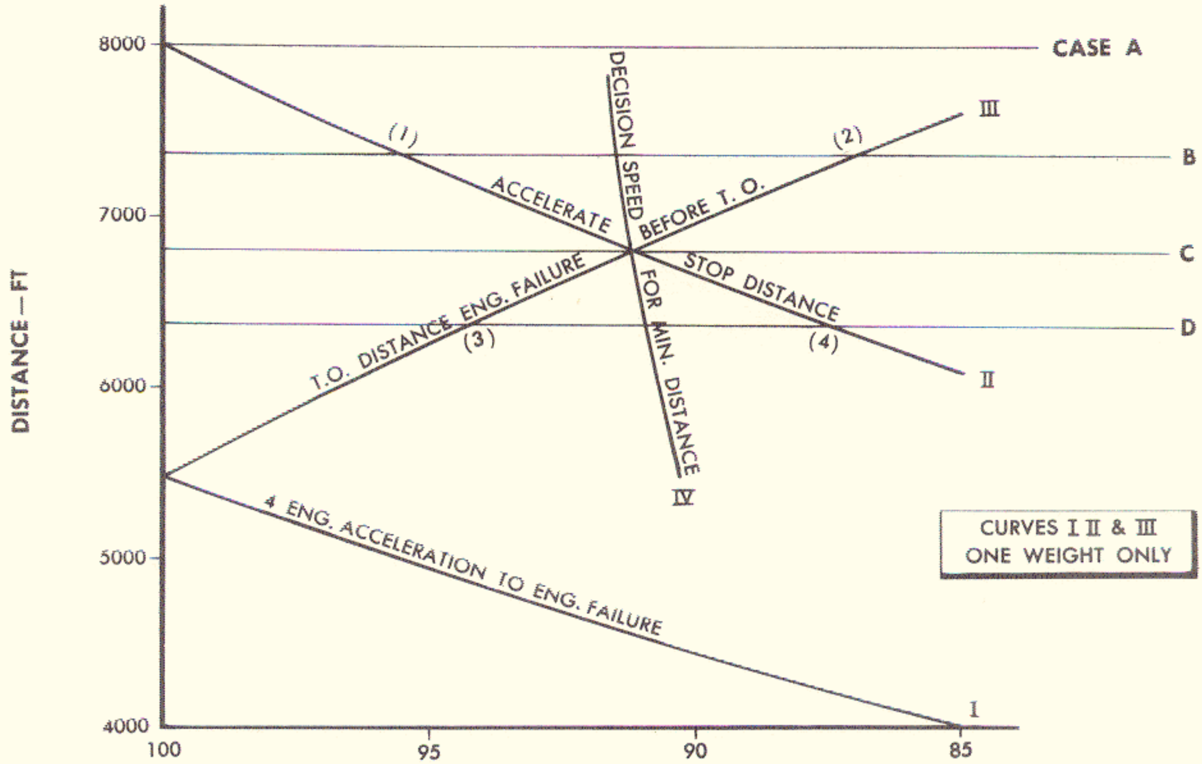


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-14. Equivalent Performance Weight

022199



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-15. Effect of Engine Failure Speed on Ground Run Distance

022211

A-24. TAKEOFF DISTANCE AND FLIGHT PATH. Having outlined the recommended takeoff procedure and speeds for takeoff and using equivalent performance weight to consolidate the major variables of weight, altitude, temperature and power, it is now possible to present such performance items as takeoff distance, stopping distance and flight path. These performance items, applied to the runway length and atmospheric conditions at an airfield, determine the maximum weight at which the airplane can safely operate from that airfield. Runway length requirements vary considerably with the level of safety desired. The following diagram and discussion explains the relation of runway length to takeoff distances considering an engine failure during the ground run. See figure A-15.

A-25. Curve I represents, for a particular weight, the 4-engine acceleration distance to some speed at which an engine failure occurs, expressed as a percent of takeoff speed. At 100 percent this is the normal distance to takeoff and as engine failure speed becomes less, so does the distance. The increment between curves I and II is the stopping distance so curve II represents the total accelerate-stop distance variation with engine failure speed. The increment between curves I and III is the 3-engine acceleration distance from engine failure to takeoff speed, so curve III represents the total distance to takeoff speed if takeoff is continued on 3 engines after engine failure. It should be noted that curves II and III will always cross at some engine failure speed for a particular gross weight.

A-26. Now consider various runway lengths in relation to these curves. In Case A the runway length is equal to (or greater than) the maximum accelerate-stop distance shown by curve II. This represents the highest possible safety level because the airplane may be accelerated right up to takeoff speed and still be stopped within the runway length. In case B the runway length intersects curve II at point (1) and curve III at point (2). Now between takeoff speed and the engine-failure speed represented by point (1) the accelerate-stop distance exceeds the runway length, but takeoff may be continued on 3 engines leaving a runway margin equal to the increment between curve III and line B. Between points (1) and (2) it would still be possible to take off on 3 engines but it would also be possible to stop within the runway length. Since stopping is the more desirable choice, point (1) can be called a "decision speed": if engine failure occurs below this speed the airplane will be stopped, but if an engine failure occurs after the "decision speed" has been reached, takeoff must be continued on 3 engines. This still represents a high level of safety since a decision speed could actually be chosen anywhere between points (1) and (2) and after the decision speed has been exceeded there is ample runway margin for a 3-engine takeoff.

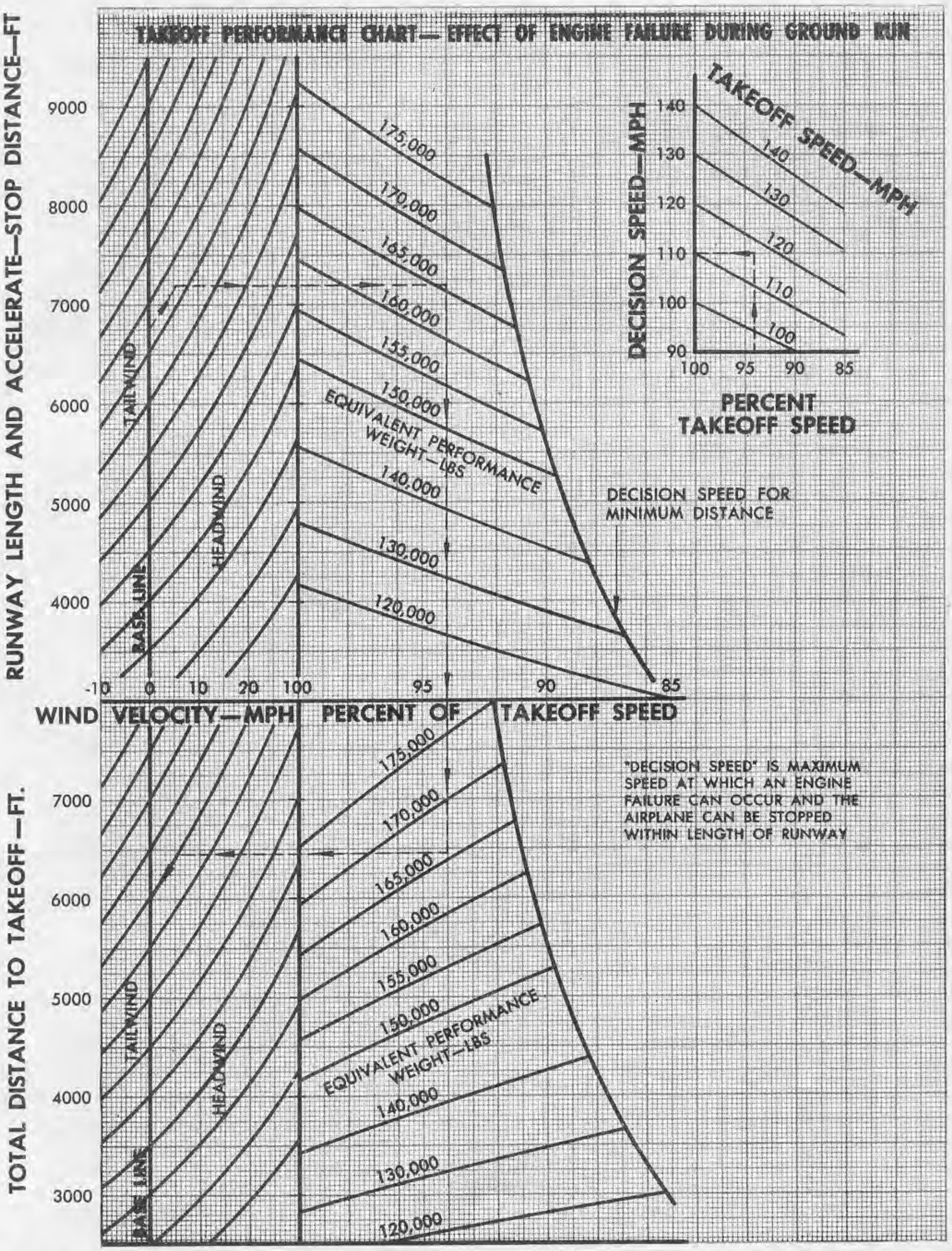
A-27. In Case C the runway length passes through the intersection of curves II and III. Here there is only one point of decision since the accelerate-stop distance exceeds the runway length at engine-failure speeds higher than that represented by the intersecting curves, and the 3-engine takeoff distance exceeds the runway length at lower speeds. Thus the point of intersection of curves II and III might be called the "decision speed for minimum distance" for the gross weight represented by these curves and the corresponding distance is the minimum runway length for safe takeoff for that weight. The critical region for an engine failure with this safety level is right at the decision speed, for if engine failure occurs near the decision speed the runway margins for stopping or 3-engine takeoff become quite small. Case D represents a condition which should not be considered except in extreme emergency. Here the runway is so short that if engine failure occurred between points (3) and (4) the airplane could neither take off on 3 engines nor stop within the runway length. If the decision speed were chosen at point (3) the airplane could take off above this speed but overrun equal to the distance increment between line D and curve II would be required to stop between points (3) and (4).

A-28. TAKEOFF DISTANCE. The Takeoff Performance Chart (figure A-16) is based on the principles discussed above. The curves of figure A-15 represent only one weight condition; for each weight there would be a corresponding pair of curves similar to II and III. Therefore it is possible to draw a line, curve IV, through the points of intersection of curves II and III for different weights. This is the line of decision speeds for minimum distance and since decision speeds should always be chosen on or to the left of this line it is unnecessary to continue the curves beyond it to lower engine-failure speeds. In figure A-16 the constant weight lines for accelerate-stop distance (curve II of figure A-15) have been separated from those for accelerate-to-takeoff distance (curve III of figure A-15) and they represent equivalent performance weights rather than actual gross weights so that all conditions of weight, power, altitude and ambient temperature can be considered. Wind correction grids for the distances are included; the recommendations given under "Wind and Runway Slope Corrections," paragraph A-35, discussing wind corrections should be observed. To convert engine failure or decision speed from percent of takeoff speed to pilot's indicated airspeed readings a separate graph appears on the chart. Use of this chart is further illustrated under "Examples for the Use of Takeoff Charts," paragraph A-38.

A-29. FLIGHT PATH. When obstacles beyond the field must be cleared on takeoff the climb-out performance becomes important. Figure A-17 shows both 4- and 3-engine flight paths for equivalent gross weights up to the 175,000 pounds maximum. For safety the 3-engine flight path should be used to determine obstacle clearance. The flight path distances are plotted from the takeoff point so the ground run distance should be added to obtain total distance from start of takeoff to the point at which obstacle clearance is desired. A conservative solution where takeoff distance is not immediately known is to consider the flight path beginning at the end of the runway. A wind correction grid is included on figure A-17 which should be used according to the recommendations given under paragraph A-35. These flight paths will be obtained provided that takeoff and climb-out are made at the recommended speeds with wing flaps 25°, that landing gear is fully retracted 15 seconds after takeoff, and in case of engine failure that the propeller is promptly feathered and cooling flaps closed on the dead engine. To make the flight paths more realistic "ground effect" was included up to a height of 50 feet which accounts for the curvature at high equivalent performance weights.

A-30. The accelerate-stop distances shown on figure A-16 are based on using brakes plus 3 engines in idle reverse power. The stopping distance is subject to considerable variation according to the procedure used; figure A-18 shows stopping distances for various procedures. Although airplane weight has a small effect on stopping distance when using reverse thrust this has been neglected for simplicity. The pilot's indicated airspeed from which stopping is initiated must be corrected for altitude and temperature by the nomograms on the chart before proceeding to the stopping distance curve appropriate to the procedure used. Additional stopping distance margin should be allowed when runways are wet or icy.

022212



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-16. Take-off Performance Chart

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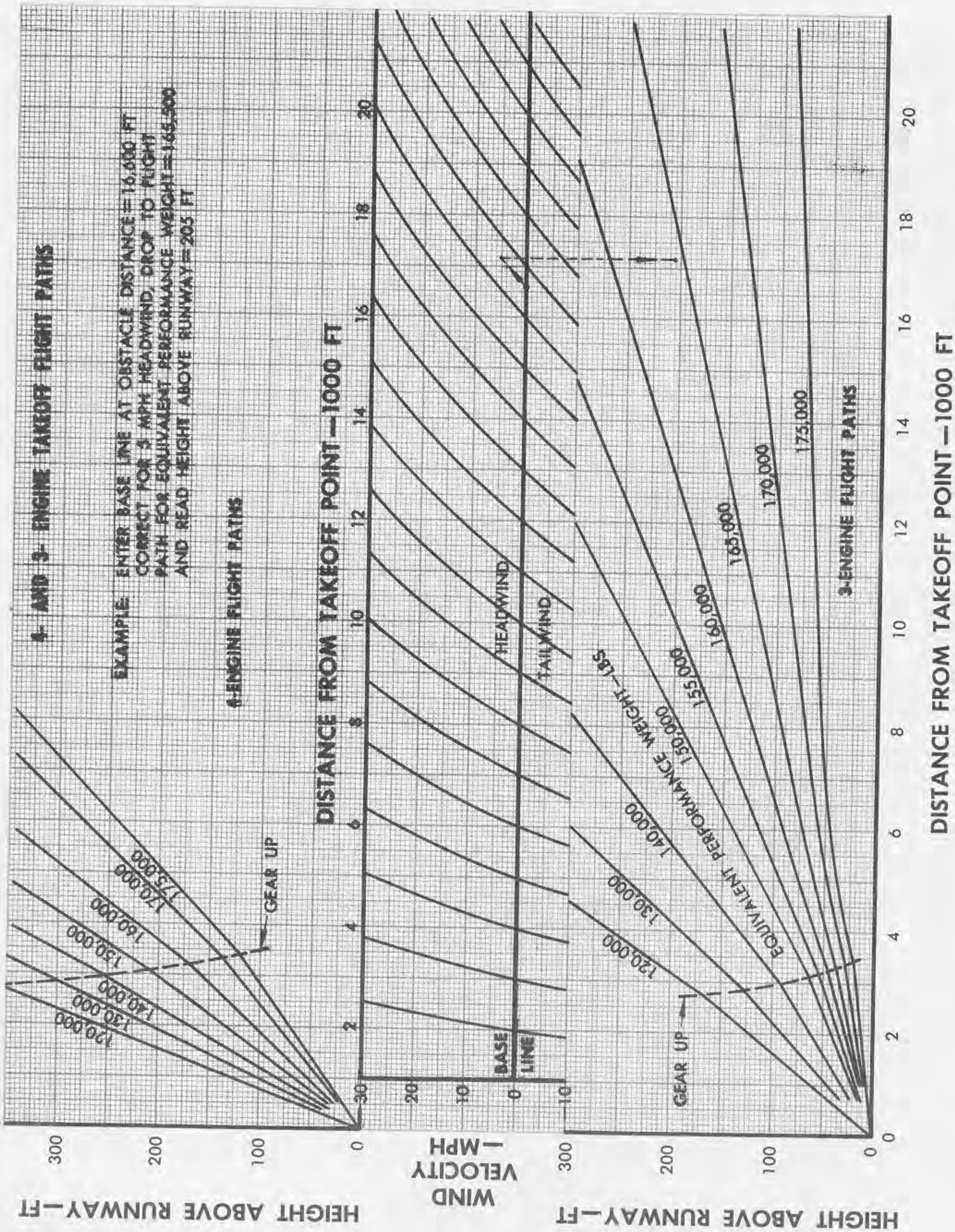

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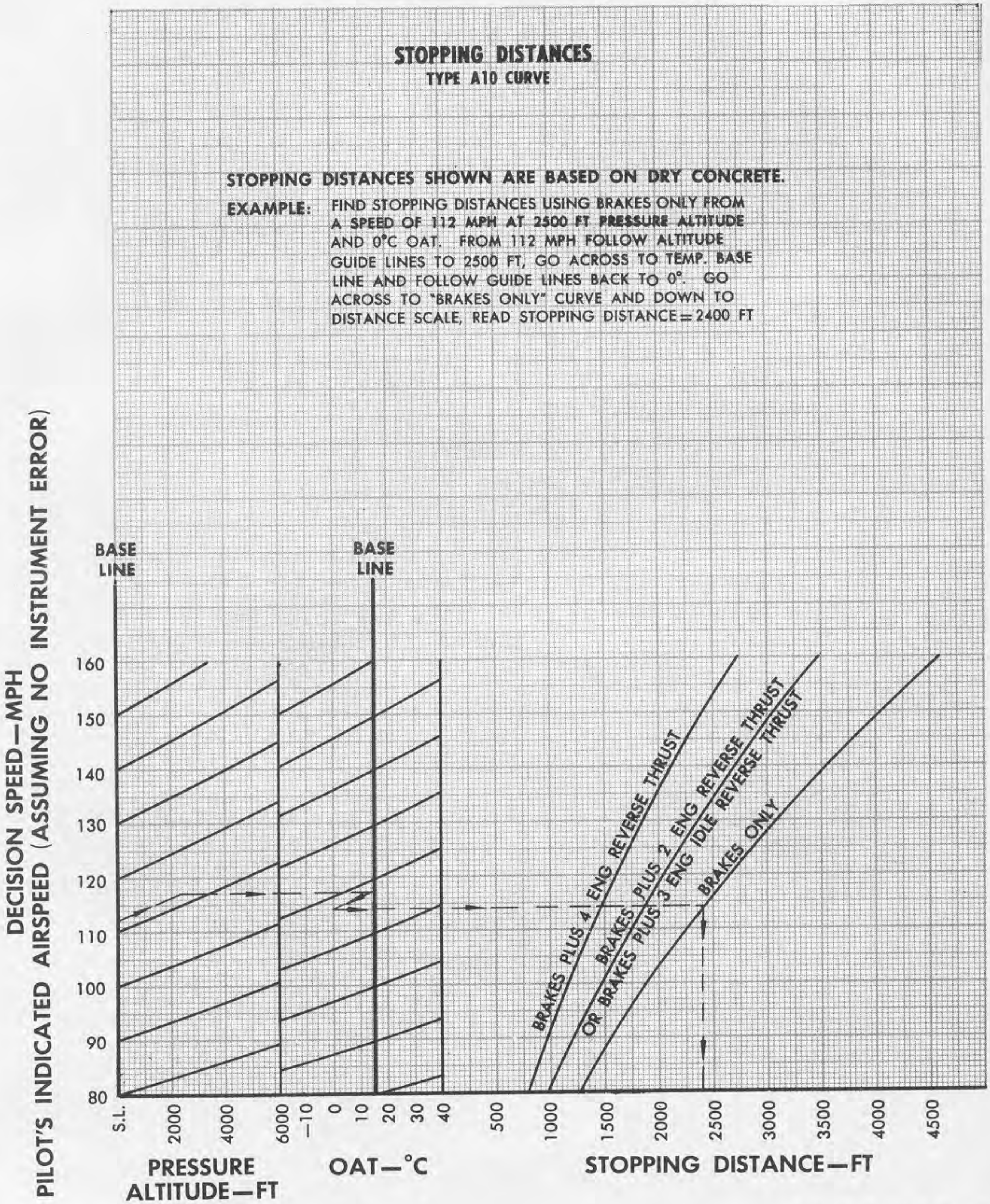
DATA AS OF: APRIL 10, 1951

Figure A-17. 4 and 3 Engine Take-off Flight Paths

022214

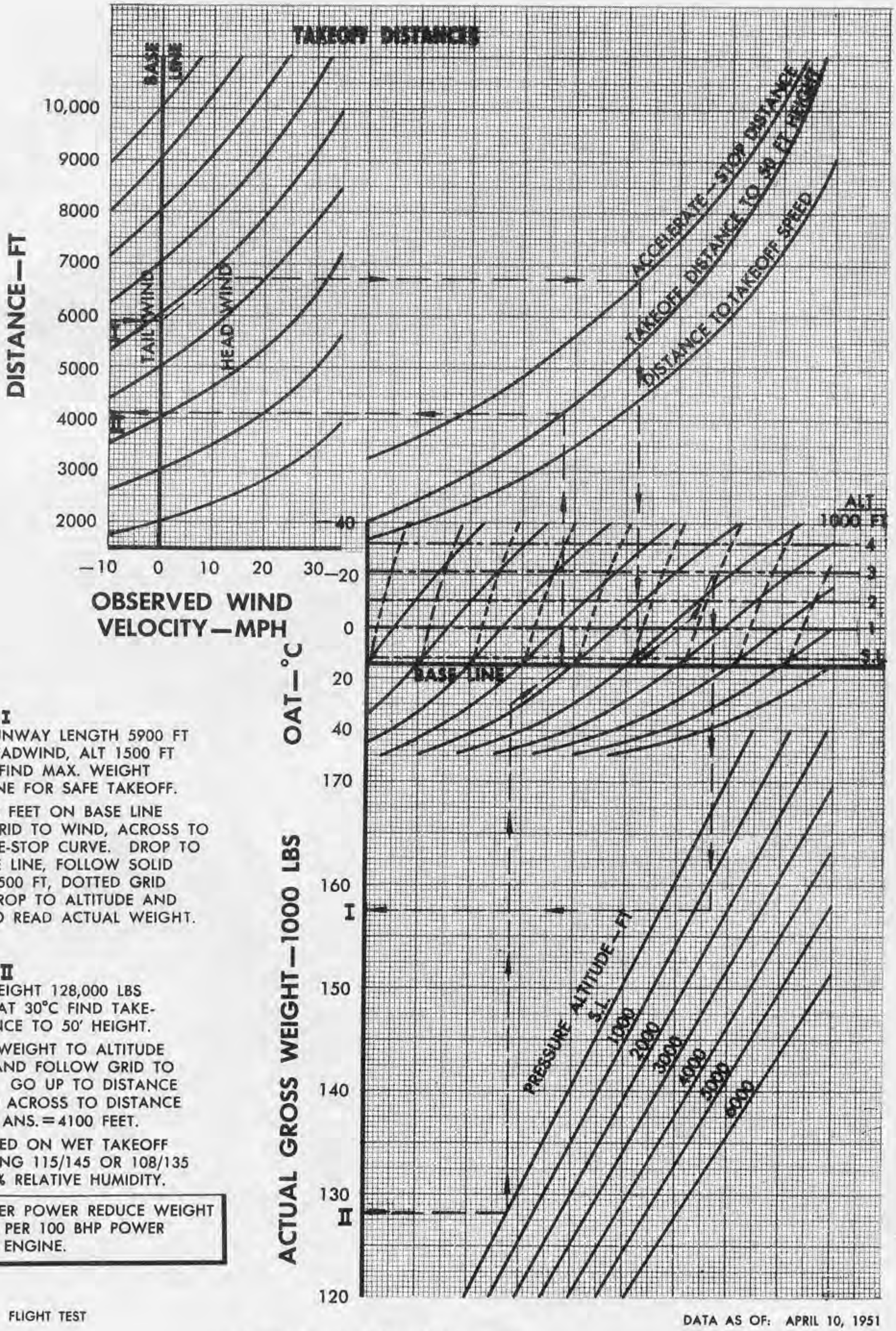


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-18. Stopping Distance

022215



EXAMPLE I
GIVEN: RUNWAY LENGTH 5900 FT 10 MPH HEADWIND, ALT 1500 FT OAT–20°C, FIND MAX. WEIGHT OF AIRPLANE FOR SAFE TAKEOFF.

FROM 5900 FEET ON BASE LINE FOLLOW GRID TO WIND, ACROSS TO ACCELERATE-STOP CURVE. DROP TO TEMP. BASE LINE, FOLLOW SOLID GRID TO 1500 FT, DOTTED GRID TO –20°, DROP TO ALTITUDE AND ACROSS TO READ ACTUAL WEIGHT.

EXAMPLE II
GIVEN: WEIGHT 128,000 LBS ALT S.L., OAT 30°C FIND TAKE-OFF DISTANCE TO 50' HEIGHT.

GO FROM WEIGHT TO ALTITUDE TO TEMP. AND FOLLOW GRID TO BASE LINE. GO UP TO DISTANCE CURVE AND ACROSS TO DISTANCE BASE LINE. ANS. = 4100 FEET.

CHART BASED ON WET TAKEOFF POWER USING 115/145 OR 108/135 FUEL, & 80% RELATIVE HUMIDITY.

FOR LOWER POWER REDUCE WEIGHT 3500 LBS, PER 100 BHP POWER LOSS PER ENGINE.

DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-19. Take-off Distances

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A-31. TAKEOFF DISTANCE AND FLIGHT PATH, SIMPLIFIED METHOD. For routine takeoffs the previous analysis would be somewhat tedious, therefore a chart has been prepared (figure A-19) from which takeoffs may be planned without consulting any other charts except the recommended speeds of figure A-11. This is for the case of a field with no obstacle clearance problem. Curves are shown for accelerate-stop distance, takeoff distance to a 50-foot height and 4-engine acceleration distance to takeoff speed. To provide maximum safety the accelerate-stop distance curve is used to determine runway length requirements, so no decision speed is necessary: if an engine failure occurs prior to takeoff the airplane will be stopped. The normal variation of wet takeoff power with altitude and temperature at 80% relative humidity is incorporated in the correction nomograms. As shown on figure A-9 the 3500 BHP power limit is encountered at a different temperature for each altitude which accounts for the double set of temperature correction lines on Figure A-19.

A-32. The chart may be used in two ways as shown by the examples: starting with runway length the maximum takeoff gross weight may be found, or starting with a known weight the takeoff distance and required runway length (accelerate-stop distance) may be determined. Any item, such as inoperative ADI, the use of low grade fuel, etc., resulting in a reduction of power will necessitate a reduction in maximum takeoff weight for a given runway length. As shown on figure A-19 the gross weight should be reduced 3500 pounds for every 100 BHP per engine the power is reduced.

A-33. If the limiting condition on a takeoff is obstacle clearance figure A-19 should not be used, but figures A-9 and A-14 should be used to determine the equivalent performance weight from the gross weight or the reverse as required. Figure A-20 may then be used to find the height at any distance from the start of the takeoff run, provided the runway length exceeds the accelerate-stop distance. The accelerate-stop distances are shown on figure A-20 corresponding to each flight path to make possible the determination of minimum runway length without going to another chart. Accelerate stop distances, figures A-19 and A-20 are based on 2 engine reverse thrust plus brakes or 3-engine idle reverse plus brakes. The use of figures A-19 and A-20 is illustrated by example II under "Examples for Use of Take-off Charts," paragraph A-38.

A-34. The ability of the airplane after takeoff to clear obstacles along the flight path and reach a safe altitude for flap retraction must be determined from the three and four engine flight path slope charts. It must be remembered that during this period the performance of the airplane is subject to its equivalent performance weight rather than its actual gross weight. This means, for example, that under a given atmospheric condition the actual gross weight of the airplane might be 150,000 pounds but the airplane would perform as though it weighed 170,000 pounds at standard conditions. To actually attain the flight paths shown in figure A-20, the indicated airspeeds for the actual gross weight shown in figure A-11 must be maintained until flap retraction altitude is reached. Upon reaching a safe altitude above the terrain allow the airplane to accelerate without loss in altitude to the recommended flap retraction speeds. Upon reaching the recommended flap retraction speeds the flaps should be started up and allowed to retract to the full up position in one continuous operation. The air speed for flap retraction is the same regardless of the number of engines operating. The minimum recommended altitude for flap retraction is an indicated altitude of 300 feet above the runway height. However, the above minimum should not apply under emergency conditions when obstacle clearance can be observed visually.

A-35. WIND AND RUNWAY SLOPE CORRECTIONS. Wind velocity has a marked effect on takeoff distances but caution should be exercised in depending on headwinds to gain increased takeoff performance. Wind velocity readings are generally obtained at some height above the ground whereas the actual velocity on the runway may be less, and possibly intermittent both in direction and velocity. Certain irregularities in terrain or obstacles such as a large building or closely spaced line of trees act as wind breaks; these should be considered especially in connection with the flight path during climbout. The most conservative approach is to neglect wind effect and accept any benefits of headwinds as an increased margin of safety, however, common practice is to use half the wind velocity component parallel to the runway for headwinds and the full velocity component for tailwinds. Wind correction graphs have been included for convenience on all applicable takeoff performance charts. Figure A-21 will be found useful for obtaining the wind component parallel to the runway when only the wind velocity and direction are known.

A-36. Runway slope is usually a minor concern since most fields are reasonably level, but an uphill takeoff imposes a severe penalty on takeoff performance, therefore figure A-22 is included to make suitable corrections to takeoff distances. Since slope effects acceleration and deceleration in opposite manners separate corrections must be applied to the two portions of an accelerate-stop distance correction as shown by the example on the chart.

A-37. A Fahrenheit-Centigrade temperature conversion chart is included (figure A-23) to facilitate the use of either system.

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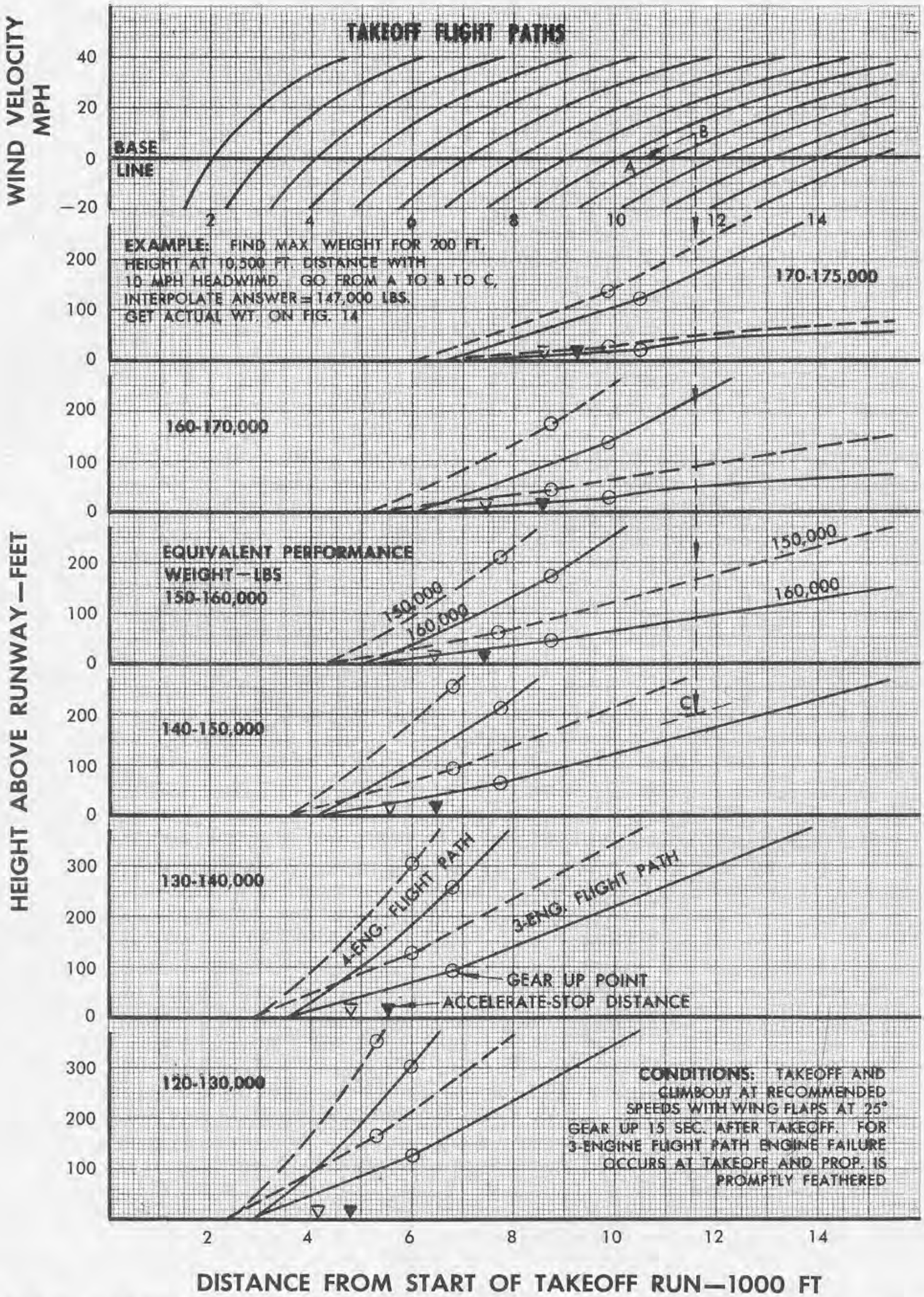

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Figure A-20. Take-off Flight Paths

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CROSSWIND CORRECTION CHART

THIS CHART DETERMINES WIND COMPONENTS PARALLEL TO AND ACROSS THE RUNWAY WHEN WIND VELOCITY AND DIRECTION RELATIVE TO THE RUNWAY ARE KNOWN.

EXAMPLE: GIVEN A 27 MPH WIND 35° OFF THE RUNWAY HEADING, FIND THE RUNWAY AND CROSSWIND COMPONENTS.

a. ENTER CHART AT A (27 MPH WIND VELOCITY AND 35° BEARING) AND PROCEED TO B WHERE A RUNWAY COMPONENT OF 22 MPH IS FOUND.

b. FROM A PROCEED TO C WHERE A CROSSWIND COMPONENT OF 15 1/2 MPH IS FOUND.

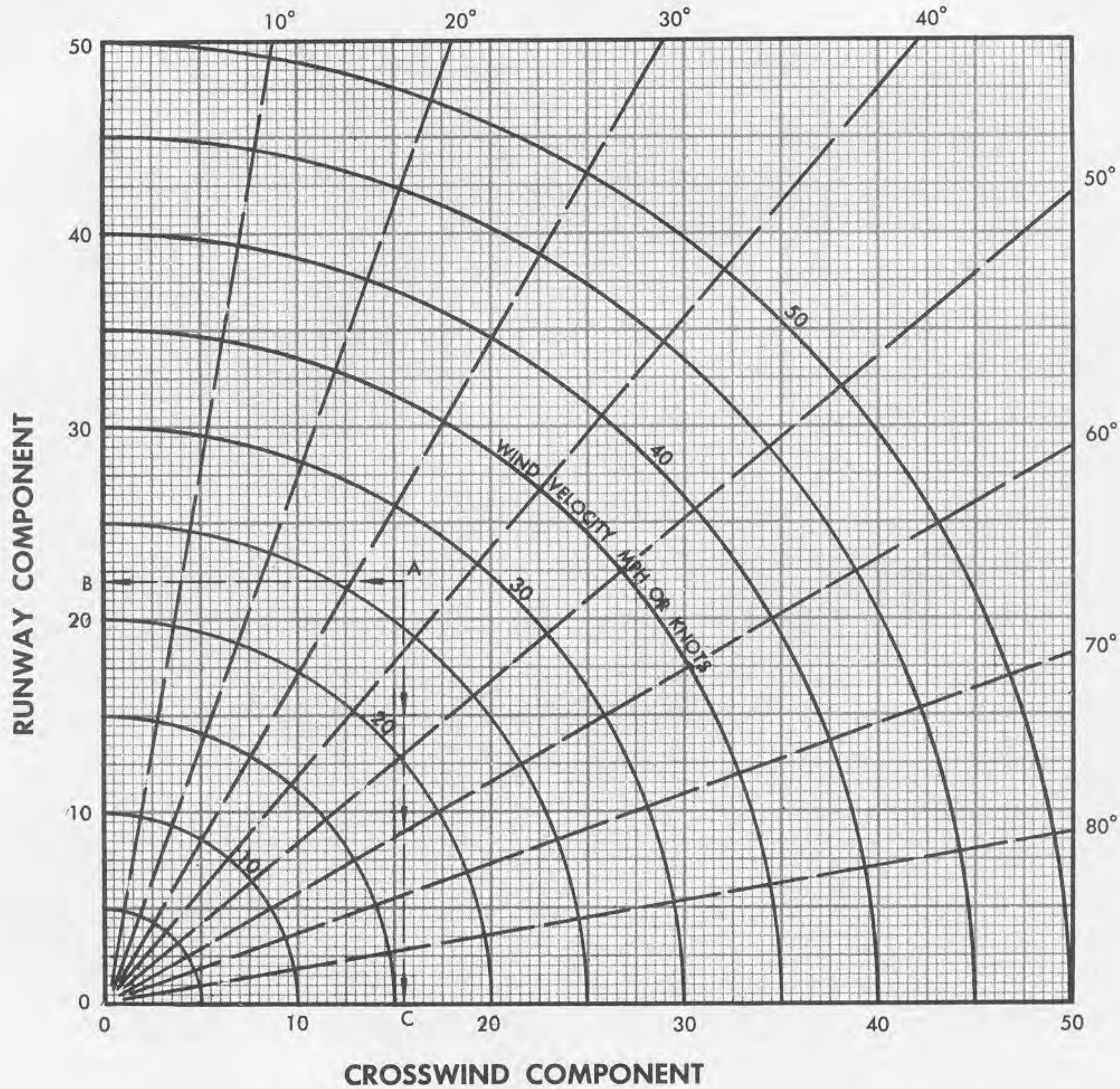

Figure A-21. Crosswind Correction Chart

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RUNWAY SLOPE CORRECTION TO GROUND DISTANCES

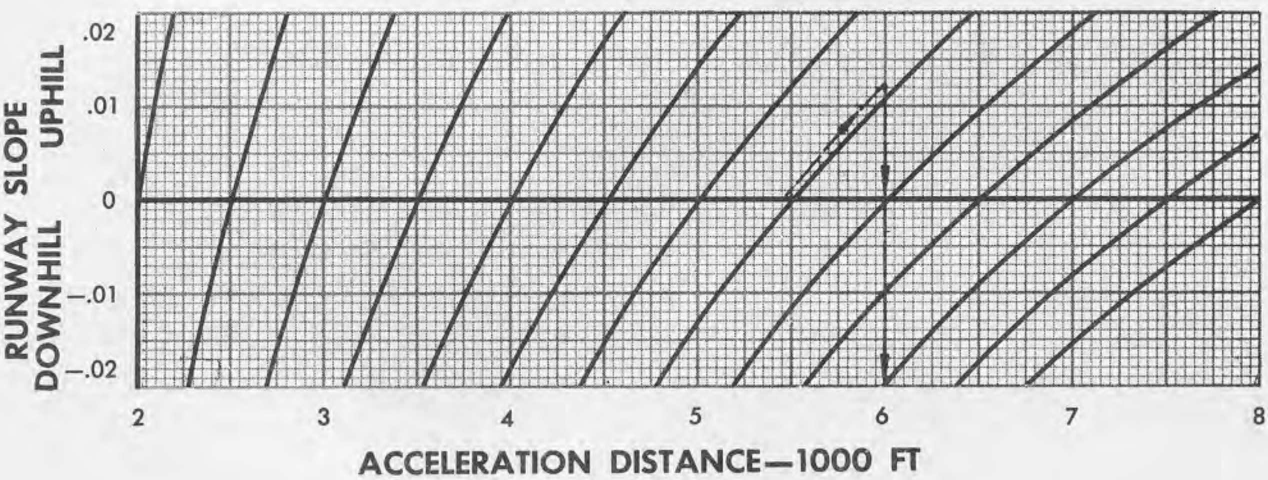
EXAMPLE:

THE ACCELERATE-STOP DISTANCE FOR A CERTAIN SET OF CONDITIONS IS 8000 FEET AND THE CORRESPONDING ACCELERATE-TO-TAKEOFF DISTANCE IS 5450 FEET. FIND THE RUNWAY LENGTH REQUIRED IF RUNWAY HAS AN UPHILL SLOPE OF 12 FEET PER 1000 (.012) IN THE TAKEOFF DIRECTION.

CORRECT ACCELERATION DISTANCE ON UPPER GRID. ENTER AT 5450 FEET AND FOLLOW GUIDE LINES TO .012 SLOPE. DROP VERTICALLY TO READ CORRECTED DISTANCE=6000 FEET.

DECELERATION DISTANCE IS 8000 − 5450 = 2550 FEET. ENTER LOWER GRID AT 2550, FOLLOW GUIDE LINES TO .012 SLOPE AND DROP VERTICALLY TO READ CORRECTED DISTANCE = 2450 FEET. TOTAL RUNWAY REQUIRED IS 6000 + 2450 = 8450 FEET.

RUNWAY SLOPE CORRECTION—ACCELERATION



RUNWAY SLOPE CORRECTION—DECELERATION

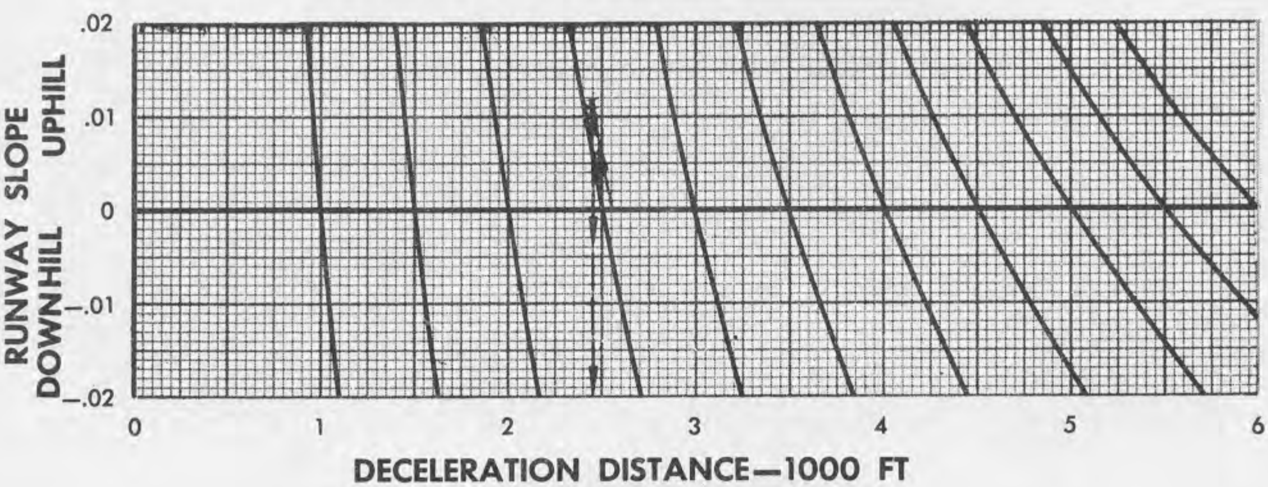


Figure A-22. Runway Slope Correction to Ground Distances

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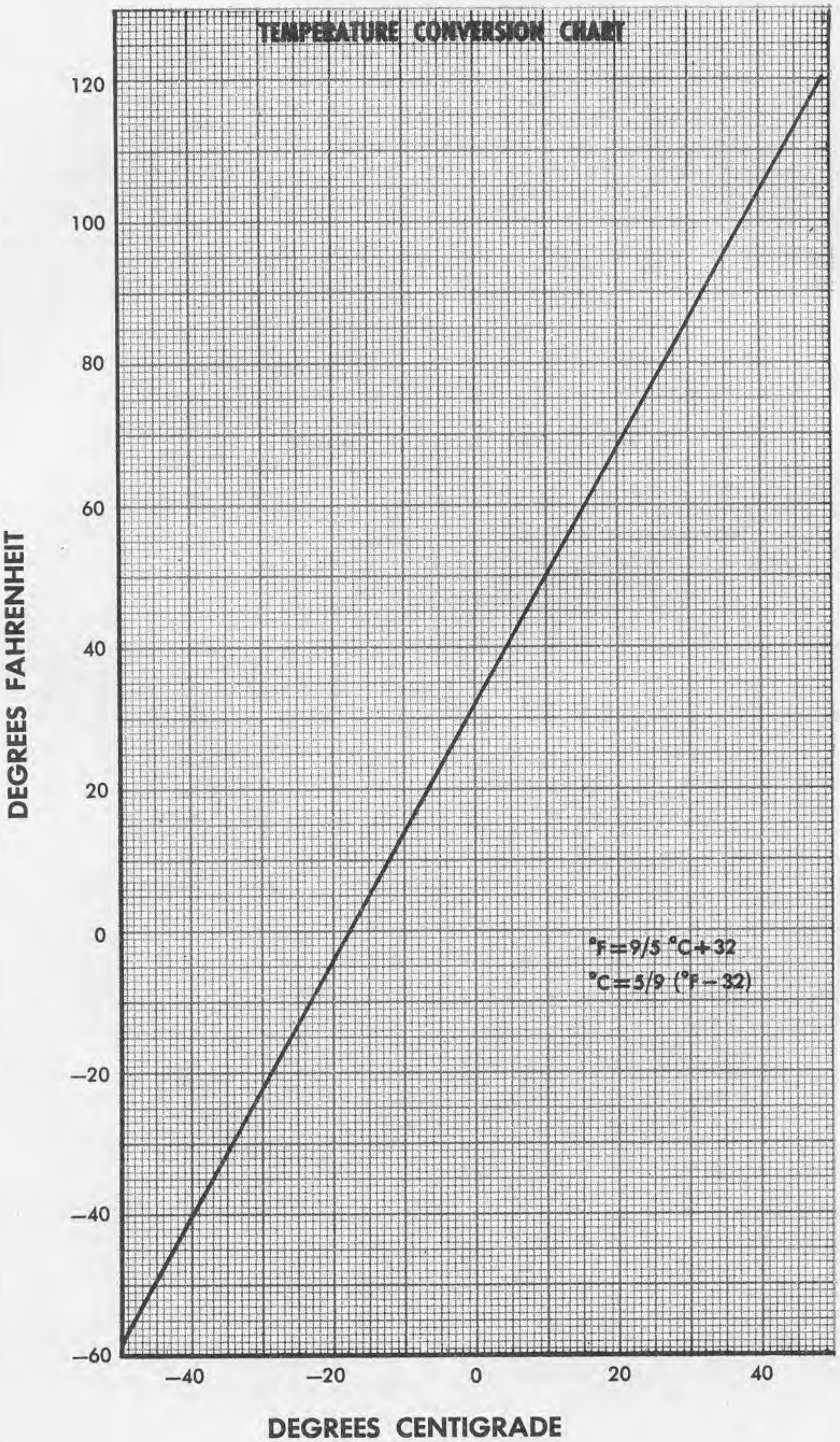

Figure A-23. Temperature Conversion Chart

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A-38. EXAMPLES FOR USE OF TAKEOFF CHARTS.

EXAMPLE I

A. Problem

Determine whether takeoff can be safely made under the following conditions if an engine failure occurs:

Gross weight	135,000 pounds
OAT	30° C
Pressure altitude	3500 feet
Runway length	6750 feet
Corrected wind component	5 MPH headwind

An obstacle 100 feet high is located 3 miles (15,850 feet) beyond end of runway.

B. Takeoff Speed, Power, and Equivalent Gross Weight.

1. From figure A-11 the recommended takeoff speed at 135,000 pounds gross weight is 117 MPH.
2. From figure A-9 the power available at 80% relative humidity (1.0 inches vapor pressure) is 2780 BHP/engine.
3. From figure A-14 the equivalent performance weight at 2780 BHP/engine, 3500 feet altitude, 30° C OAT and 135,000 pounds actual weight, is 165,500 pounds.

C. Runway Length and Decision Speed.

1. (a) Enter upper part of figure A-16 at runway length 6750 feet, on wind correction base line.
   (b) Follow guide lines to 5 MPH headwind.
   (c) Go horizontally to 165,500 pounds equivalent performance weight and read the critical engine failure speed as 94% of takeoff speed.
2. (a) Go down to 165,500 pounds on accelerate-to-takeoff distances.
   (b) Go across to 5 MPH headwind.
   (c) Follow guide lines to base line and read distance as 6000 feet.
3. (a) Enter decision speed graph at 94%.
   (b) Go vertically to 117 MPH takeoff speed and read decision speed as 110 MPH.

D. Obstacle Clearance.

1. (a) The amount of unused runway for engine failure at the decision speed would be 6750 - 6000 or 750 feet.
   (b) Add this to 15,850 to get 16,600 feet total air distance to obstacle.
2. (a) Enter figure A-17 at 16,600 feet on wind correction base line.
   (b) Follow guide lines to 5 MPH headwind.
   (c) Go vertically down to 3 engine flight paths to 165,500 pounds equivalent performance weight and read height above runway, 205 feet.

E. Solution.

The takeoff is possible, but if engine failure occurs above a pilot's indicated airspeed of 110 MPH the takeoff must be continued on 3 engines, in which case a minimum clearance of 205 - 100 or 105 feet will be obtained over the obstacle. This problem illustrates how a moderate field altitude and high ambient temperature may reduce an average airplane loading to a marginal takeoff condition even though the runway length seems adequate and obstacle clearance requirements low. By converting the actual weight to equivalent performance weight, however, it is obvious that these factors reduce the performance of the airplane to that of a much higher loading under standard conditions.

EXAMPLE II

A. Problem.

The airplane weight with a full gas and oil load, crew and miscellaneous equipment is approximately 130,000 pounds. Using this weight, determine the maximum cargo weight if takeoff is to be made under the following conditions:

The runway is 5750 feet long and taking off into the wind the slope is uphill 7 feet per 1000 feet. Also the wind is at an angle of 35° with the runway, its velocity is 27 MPH. A high-tension line 7250 feet beyond the end of the runway requires a height of 175 feet for safe clearance.

Pressure altitude = 1200 feet
Outside air temp. = 77° F
Relative humidity = 65%

Power checks have shown that one engine averages 60 BHP low and another 40 BHP low on takeoff power.

B. Power Available.

1. From the psychrometric chart (figure A-10) the vapor pressure at 77° F and 65% relative humidity is .61 inches of Hg.
2. From figure A-9 the power available at 1200 feet altitude, 77° F and .61 inches vapor pressure is 3165 BHP per engine. Since there is a total power deficiency of 100 BHP among the engines the net power available is:

$$3165 - \frac{100}{4} = 3140 \text{ BHP/engine}$$

C. Wind and Slope Corrections.

1. The wind direction relative to the runway is 35°. From figure A-21 this gives a headwind component of 22 MPH for the 27 MPH wind. In making headwind corrections half of this value or 11 MPH will be used.

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2. Since the actual runway slope correction cannot be made until the takeoff distance is known, an effective runway length will be used to allow for the slope. Enter figure A-22 at runway length 5750 feet and uphill slope .007 on the acceleration plot, follow guide lines to base line and read distance of 5450 feet.

D. Solution by Simplified Method.

1. Since an obstacle clearance problem is present solution may be attempted by means of figure A-20. Enter distance scale at 7250 + 5450 = 12,700 feet on wind correction base line, follow guide lines to 11 MPH headwind, and drop down to flight paths. The equivalent performance weight for 175 feet height is 156,000 pounds.

2. Note that the accelerate-stop distance for 156,000 pounds is about 7100 feet, therefore runway length is more critical than flight path, so figure A-19 should be used instead.

3. Enter figure A-19 at runway length 5450 feet, correct for 11 MPH headwind, go to accelerate-stop distance curve and drop to temperature base line. (From figure A-23, 77° F = 25° C). Follow guide lines to 25° C and drop to 1200 feet altitude. Read actual gross weight of 135,500 pounds.

4. Since power was 25 BHP/engine low, this weight should be reduced 3500 x 25/100 = 875 pounds, so actual weight is 134,625 pounds which means 4625 pounds of cargo could be carried.

E. Analysis by "Decision Speed" Method.

1. Enter figure A-16 at runway length 5450 feet, correct for 11 MPH wind and go across to minimum decision speed line. The equivalent performance weight is slightly greater than 160,000 pounds.

2. Enter figure A-17 at 7250 feet on wind correction base line, correct for 11 MPH wind and drop down to height of 175 feet on 3-engine flight paths. This corresponds to 152,000 pounds equivalent performance weight.

3. Since the flight path obtained in step 2 assumes all the runway is used on take-off, a higher weight is possible if the runway distance not used for take-off is added to the flight path distance. This can only be obtained by a "cut and try" process. A good figure to start with is half way between the values obtained by 1 and 2 or 156,000 pounds equivalent performance weight.

4. Going back to figure A-16, at 5450-foot runway length, 11 MPH-wind correction and 156,000 pounds the decision speed would be 94%. Dropping down to the take-off distance curves at this decision speed and 156,000 pounds, the take-off distance, with wind correction, is 4650 feet.

5. The flight path distance to obstacle then becomes:

5450 - 4650 + 7250 = 8050 feet

Entering figure A-17 again with this distance yields an equivalent performance weight just under 155,000 pounds at 175 feet height and 11 MPH wind. This is the maximum weight that will be used.

F. Solution.

1. From figure A-14 at 3140 BHP/engine, 1200 feet altitude, 25° C OAT, and 155,000 pounds equivalent performance weight, the actual weight, is 141,000 pounds.

2. From figure A-11 at 141,000 pounds the recommended takeoff speed is 120 MPH, climb-out speed 133 MPH, and flap retraction speed is 148 MPH.

3. From figure A-16 the decision speed for the 5450-foot runway, 11 MPH headwind and 155,000 pounds equivalent performance weight is 95%. Entering the decision speed graph at 95% and 120 MPH the decision speed is 114 MPH.

4. The amount of cargo that can be carried is 141,000 - 130,000 or 11,000 pounds.

5. Since a conservative assumption was made for the runway slope correction there should actually be a slight runway margin for stopping from the decision speed. From figure A-18 the stopping distance from 114 MPH at 1200 feet altitude and 25° C is 2000 feet using brakes plus 3-engine idle reverse thrust. Then the acceleration distance would be 5450 - 2000 or 3450 feet. Correcting the acceleration and deceleration portions separately by figure A-22, the total distance is 3600 + 1950 = 5550 feet. Since the runway was actually 5750 feet long, this leaves a 200-foot runway margin for stopping if engine failure occurs at the decision speed.

This example probably presents more complications than most actual takeoff conditions but is intended to illustrate the use and need for all the charts in the takeoff section. While the simplified method represents a higher safety level in case of engine failure note that the runway length is the limiting factor and the cargo load is only 4625 pounds. Using the decision speed analysis the obstacle clearance flight path is the limiting condition but the cargo load can be increased to 11,000 pounds

A-39. LANDING CHARACTERISTICS AND GO-AROUND. Landing distance is shown as the distance from a 50 foot height point to complete stop (figure A-24). The curve is based on an approach speed of 30% above the forward CG power-on stall speed for the landing configuration, and a stop using brakes only. These distances are appreciably reduced if reverse thrust is used during the stop. Using brakes plus idle reverse power reduces the total stopping distance by 27%. Using brakes plus full reverse power reduces the total stopping distance by 40%.

A-40. Final approach speeds (above fifty feet height) are shown on the landing distance weight lines. Speed should not be allowed to fall below these values until the landing flareout for the following reasons:

a. Control may become marginal during approach.

b. A proper flare requires the maintenance of a reasonable speed increment above stalling speed.

c. If for any reason a go-around must be initiated, the recommended approach speeds will permit immediate retraction of the flaps to the 25° position. This will result in much better climb-out performance.

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A-41. If the air is rough or crosswinds exist, the approach speed should be increased another 5 to 10 MPH for safe operation. Landings then can be made within the distances shown if two engine reverse thrust and brakes are used. If brakes alone are used, landing distances may be as much as 20% greater than those shown.

A-42. Use of the chart (figure A-24) is illustrated by the following example. Assume these conditions to exist:

Gross Weight	120,000 pounds
Field Pressure Altitude	2,000 feet
Outside Air Temperature	25° C
Headwind	10 MPH

Enter the chart at 25° C, follow parallel to the guide lines to 2,000 feet altitude, go horizontally to the 120,000 pound gross weight line, drop vertically to the base line of the wind correction nomogram, follow parallel to the guide lines to 10 MPH headwind and from this point drop vertically to landing distance scale and read 3,600 feet. Note on the 120,000 pound line that the approach speed should be 123 MPH.

A-43. Go-around in the event of a refused landing may be performance limited, especially if one engine is inoperative. Generally a go-around on four engines will not be limited by performance unless the airplane is at a low speed and nearing touch-down. However, depending on four engines for minimum safety requirements in go-around is not considered a sound procedure.

A-44. Before a go-around decision is made during an approach with one engine inoperative, careful consideration must be given the situation at the point go-around would be initiated. Speed, height, existance of obstacles, weather and atmospheric conditions, gross weight and expected power available should enter in the decision. The following items should be borne in mind before attempting a three engine go-around.

a. Never attempt a go-around when airspeed is below the recommended approach speeds (figure A-24) even on four engines.

b. At the moment a go-around decision is made, takeoff power should be applied, gear should be started up and wing flaps started up to 25°. Water should be used if available and cowl flaps should be adjusted as required. The airplane should be cleaned up as soon as possible before attempting another approach.

022224

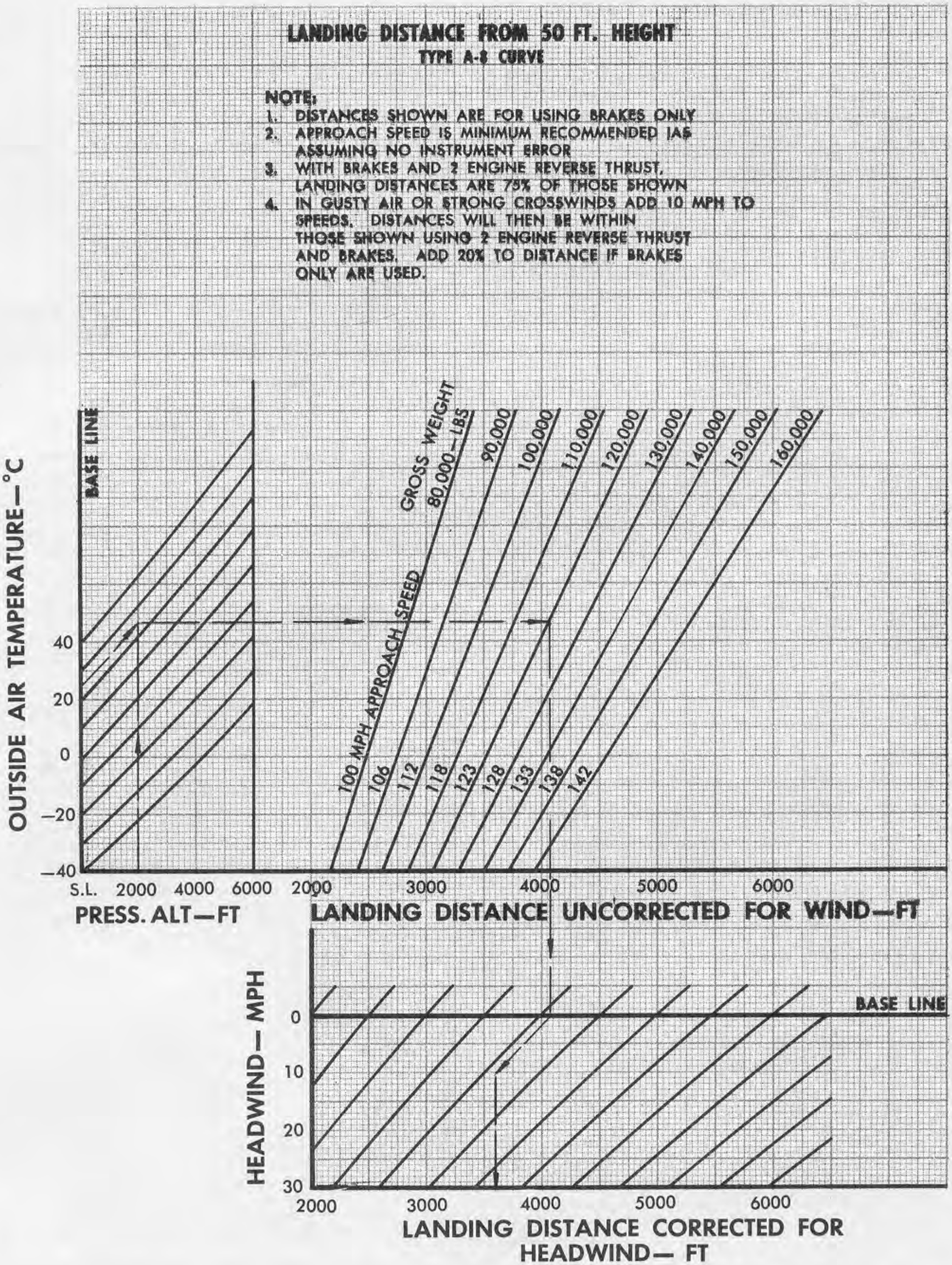

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Figure A-24. Landing Distance From 50 Feet Height

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A-45. POWER SCHEDULES AND FUEL FLOW CHARACTERISTICS.

A-46. GENERAL. Power plant performance for cruise and climb power operating schedules for altitudes from sea level to 30,000 feet, is shown on figures A-26 through A-33. Fuel flow and manifold pressure curves along with the RPM versus BHP operating schedule are shown. For a given value of BHP and altitude, the RPM and the approximate manifold pressure and fuel flow values can be determined as indicated by the dotted line and arrows on the curves. The manifold pressure curves shown are for a 20° C carburetor air temperature. To obtain the change in manifold pressure for other values of CAT, a line drawn from the base line value of 20° C, parallel to the slope of the nearest correction line to the CAT value being considered will give the new value of manifold pressure. The curves apply for full throttle or part throttle operation as required for cabin pressurization. See "Cruise Operation," paragraph 2-45, Section II.

A-47. Operations should be conducted using the mixtures, cylinder head temperature limits and power schedules shown on figures A-34 and A-35. Minimum power operation is at 1400 engine RPM or full throttle closed wastegate conditions. Above minimum power, operation is at 192 TPSI to 1900 BHP and 2300 RPM for both fuel grades. Above 1900 BHP operation is along a propeller load curve to 2650 BHP and 2550 RPM for 115/145 fuel (or along a straight line to 2500 BHP and 2550 RPM for 100/130 grade fuel). Basically, the power plant performance curves are for 115/145 fuel, and 108/135 fuel. However, they can be used for 100/130 fuel as the slight difference in the power schedule above 1900 BHP will not materially effect manifold pressure and fuel flow values.

A-48. Turbo life will be lengthened if powers are limited at high altitude so as to prevent operating the turbos above their continuous RPM rating. The following tables give the turbo operating limits and a power-altitude relationship which will assist in maintaining turbo RPM at the continuous speed rating.

Turbo Speed Rating	Limits
Up to 20,000 TRPM	None
Above 20,000 TRPM to 22,000 TRPM	15-minute periods of operation
Above 22,000 TRPM	Not available (governor setting)

The following power limitations may be observed at altitude to limit turbo speed to 20,000 RPM, the continuous speed rating.

Altitude (Feet)	BHP
23,500	2650
25,000	2450
26,000	2350
27,000	2250
28,000	2160
29,000	2070
30,000	1985

The above values result with 32° C carburetor air temperature and 180 MPH IAS. Higher carburetor air temperature and/or lower IAS increases turbo RPM for a selected altitude power combination. The above values assume no air duct leakage or engine malfunction. Engine instruments should be compared to avoid boosting any engine more than 2 inches MAP above the average of all engines.

A-49. MANUAL MIXTURE ADJUSTMENT - CRUISE POWER. The fuel flows shown on the performance curves and cruise charts, figures A-48 through A-79 are based upon auto-lean mixture settings. This nominally corresponds to the fuel flow achieved by adjusting fuel flow from best power until a 12 PSI torque pressure drop occurs. To obtain this setting use the following procedure:

a. Adjust power to obtain 204 TPSI with best power mixture (normally auto-rich).

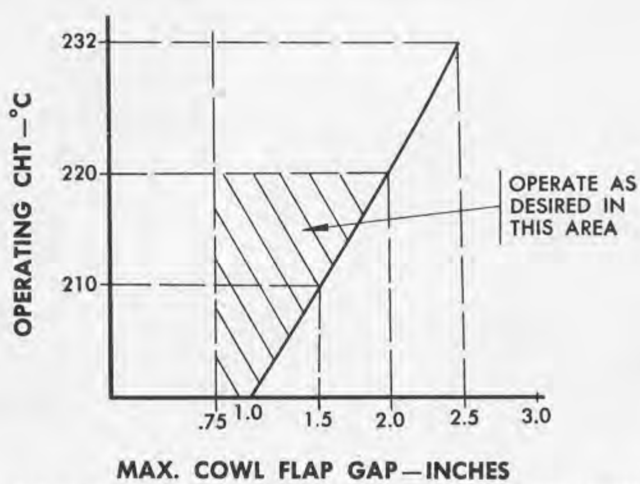
b. Manually adjust fuel flow to obtain 192 TPSI.

CAUTION

Do not adjust mixture manually at powers above 1900 BHP.

c. Note manifold pressure spread; if greater than 2 inches Hg., reduce MAP on highest engine, allowing TPSI to drop, until the spread is 2 inches Hg. This procedure will decrease the possibility of operating a malfunctioning or low output engine at abnormally high MAP in an effort to obtain uniform torque powers. The condition of such an engine should be checked, particularly with regard to ignition and cylinder compression, at the first opportunity.

A-50. CHT LIMITS. The cruise performance shown in this document is based upon operations at the limits shown on figures A-34 and A-35. To favor engine life, however, it is recommended that the cylinder head temperature be held at lower values. Figure A-25 represents the maximum cowl flap gap recommended for any chosen operating temperature and is a compromise between low cooling drag and low operating temperature. Use of this schedule will affect range as given in paragraph A-88.



DATA BASED ON: FLIGHT TEST DATA AS OF: APRIL 10, 1951

Figure A-25. Cruise Power CHT and Maximum CFG

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POWER SCHEDULE

TYPE M1 TABLE

20°C CARBURETOR AIR TEMPERATURE

FUEL GRADE AND MIXTURE	RPM	BHP	TPSI	APPROXIMATE MANIFOLD PRESSURE REQUIRED WITH ALTITUDE SL	5000	10000	15000	20000	25000	30000
115/145	2700	3500 (Max.)	301	(Max. available wet, do not exceed 60" Map)						
AUTO	2550	2650	242	52.0	50.8	50.3	50.3	50.7	*51.3	**
RICH	2500	2500	232	49.1	47.9	47.4	47.4	47.8	*48.4	**
	2450	2350	223	46.2	45.1	44.5	44.5	45.0	45.6	**
	2400	2200	212	43.3	42.3	41.6	41.6	42.1	42.7	43.2
	2350	2045	203	40.3	39.3	38.5	38.6	39.1	39.8	40.1
100/130	2700	3250 (Max.)	280	(Max. available wet, do not exceed 56.5" Map)						
AUTO	2550	2500	232	49.1	47.9	47.4	47.4	47.8	*48.4	**
RICH	2500	2385	222	46.8	45.7	45.2	45.1	45.6	46.2	**
	2450	2260	214	44.5	43.4	42.8	42.8	43.2	43.9	44.4
	2400	2140	207	42.2	41.2	40.5	40.5	41.0	41.6	42.1
	2350	2020	200	39.9	38.9	38.1	38.1	38.6	39.2	39.6
115/145	2300	1900	192	37.5	36.7	35.8	35.8	36.4	37.0	37.2
&	2250	1860	192	37.5	36.7	35.8	35.8	36.4	37.0	37.2
100/130	2200	1815	192	37.5	36.6	35.8	35.8	36.4	36.9	37.2
AUTO	2150	1775	192	37.4	36.6	35.7	35.8	36.3	36.8	37.1
RICH	2120	1750	192	37.4	36.5	35.7	35.7	36.3	36.8	37.1
115/145	2300	1900	192	39.0	38.1	37.7	37.7	37.8	38.2	38.8
&	2250	1860	192	39.0	38.1	37.6	37.7	37.8	38.2	38.7
100/130	2200	1815	192	39.0	38.0	37.6	37.7	37.8	38.1	38.7
AUTO	2150	1775	192	38.9	38.0	37.6	37.7	37.8	38.0	38.7
LEAN	2120	1750	192	38.9	37.9	37.5	37.6	37.8	38.0	38.7
	2100	1735	192	38.8	37.9	37.5	37.6	37.8	38.0	38.7
	2050	1690	192	38.8	37.8	37.4	37.6	37.7	37.8	38.6
	2000	1650	192	38.7	37.8	37.4	37.4	37.7	37.8	38.5
	1950	1610	192	38.5	37.7	37.2	37.3	37.6	37.6	38.5
	1900	1570	192	38.4	37.6	37.1	37.2	37.4	37.6	38.4
	1850	1530	192	38.2	37.4	36.9	37.0	37.2	37.4	38.2
	1800	1485	192	37.9	37.2	36.7	36.7	37.0	37.2	38.0
	1750	1445	192	37.7	37.0	36.5	36.5	36.8	37.0	37.8
	1700	1405	192	37.5	36.8	36.3	36.3	36.5	36.8	37.5
	1650	1360	192	37.2	36.6	36.1	36.1	36.3	36.6	37.2
	1600	1320	192	37.0	36.3	35.9	35.9	36.1	36.4	36.8
	1550	1280	192	36.8	36.1	35.7	35.7	35.8	36.1	36.5
	1500	1240	192	36.6	35.8	35.5	35.4	35.6	35.7	35.6
	1450	1200	192	36.3	35.6	35.3	35.2	35.3	34.9	34.8
	1400	1155	192	36.1	35.3	35.0	35.0	34.3	34.0	34.4
	1400	1100	183	34.8	34.1	33.8	33.8	33.3	32.9	32.8
	1400	1000	166	32.8	32.1	31.8	31.8	31.3	30.9	30.8
	1400	900	150	30.8	30.1	29.8	29.8	29.3	28.9	28.8
	1400	800	133	28.8	28.1	27.8	27.8	27.3	26.9	26.8

1400 RPM
1460 RPM
1520 RPM
1550 RPM

NOTE: 1. RPM and map values within the bracket are for the BHP shown where normal settings are limited by closed wastegate conditions.

2. Increase map .3" for each 5°C above 20°C CAT: decrease map .3" for each 5°C below 20°C CAT.

* Limited to 15 minute periods of operation due to high TRPM

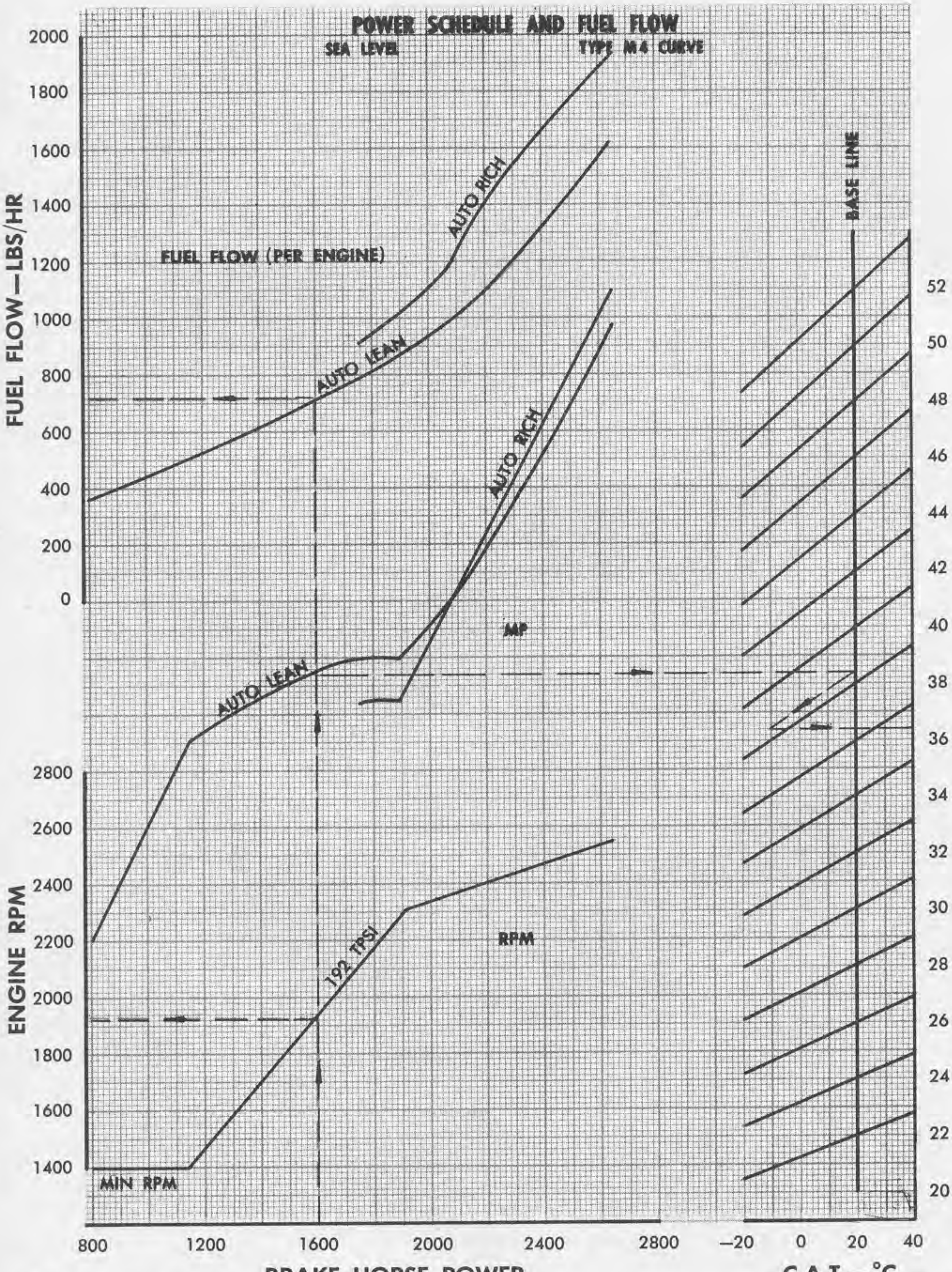
** 22000 TRPM critical altitude encountered in this power range

DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-26. Power Schedule Table

022227

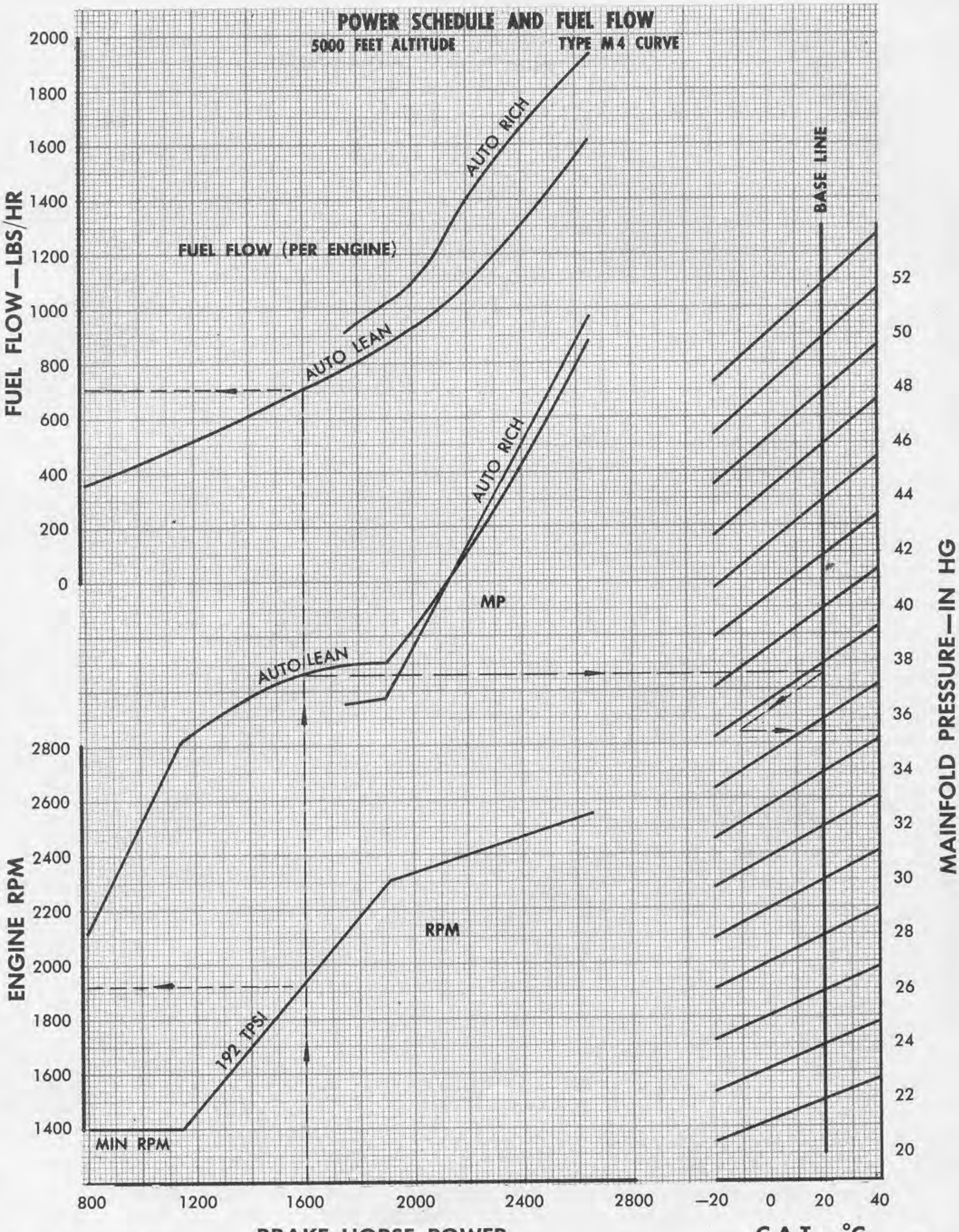


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-27. Power Schedule and Fuel Flow—Sea Level

022228

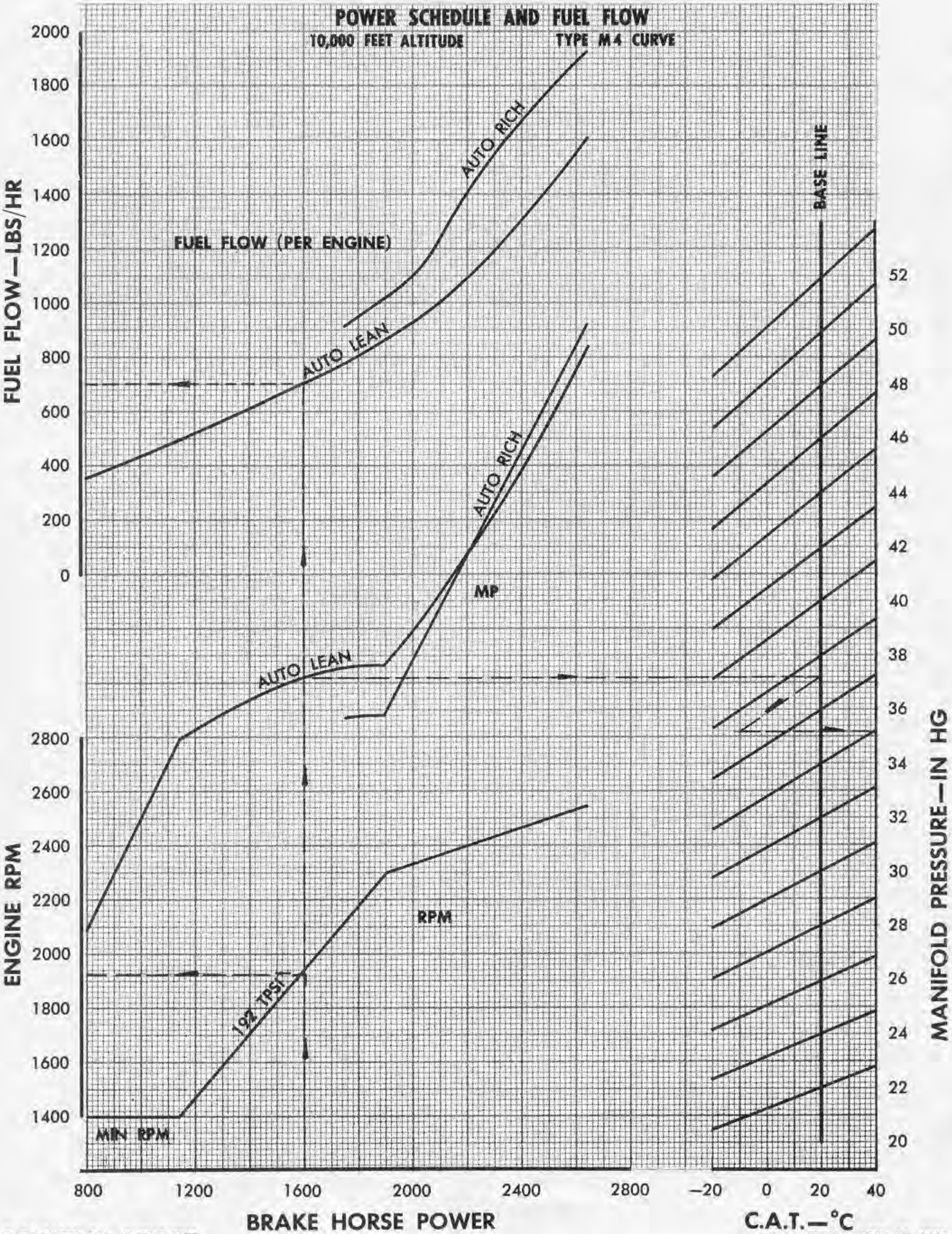


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-28. Power Schedule and Fuel Flow—5000 Ft.

022229

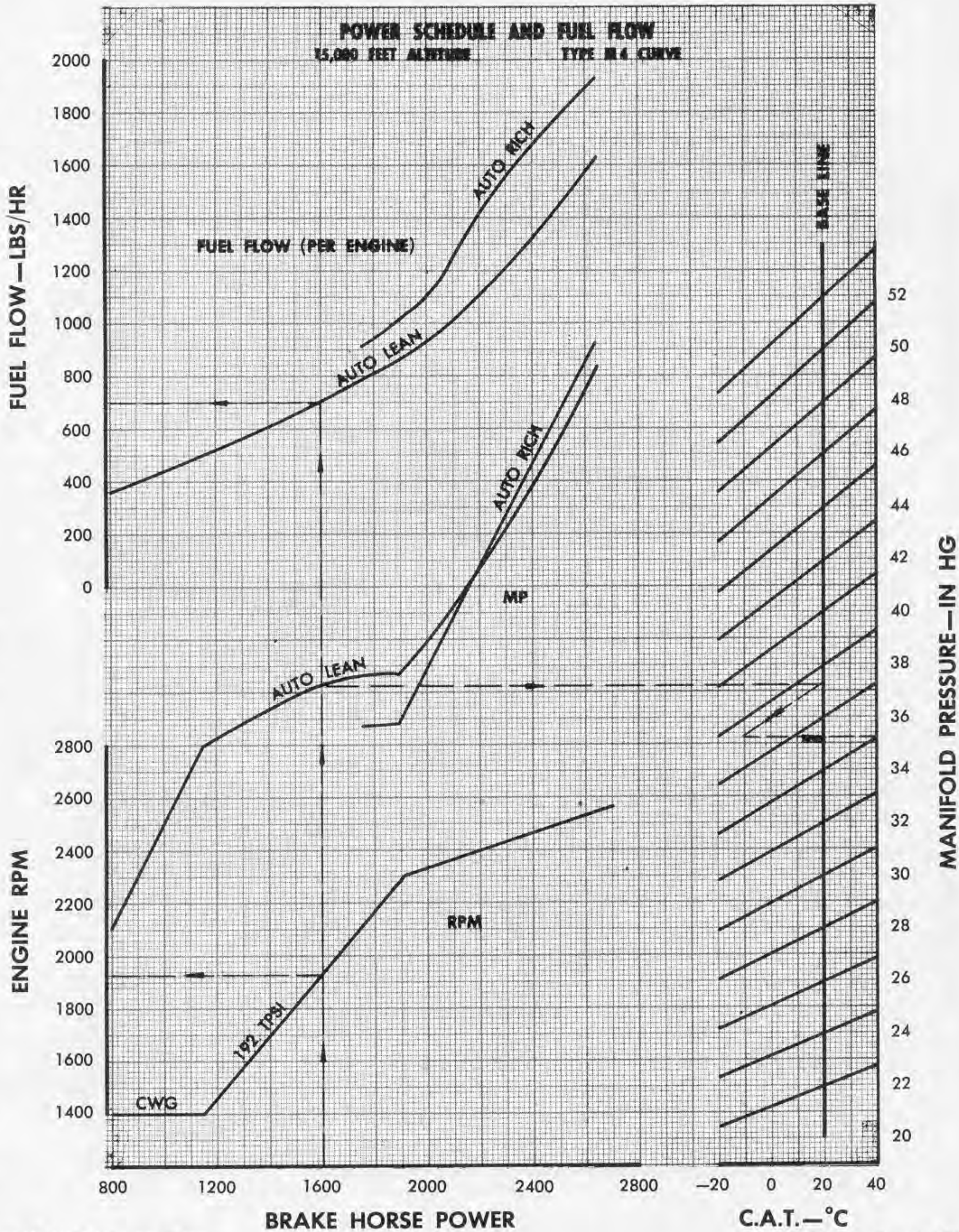


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-29. Power Schedule and Fuel Flow—10,000 Ft.

022230

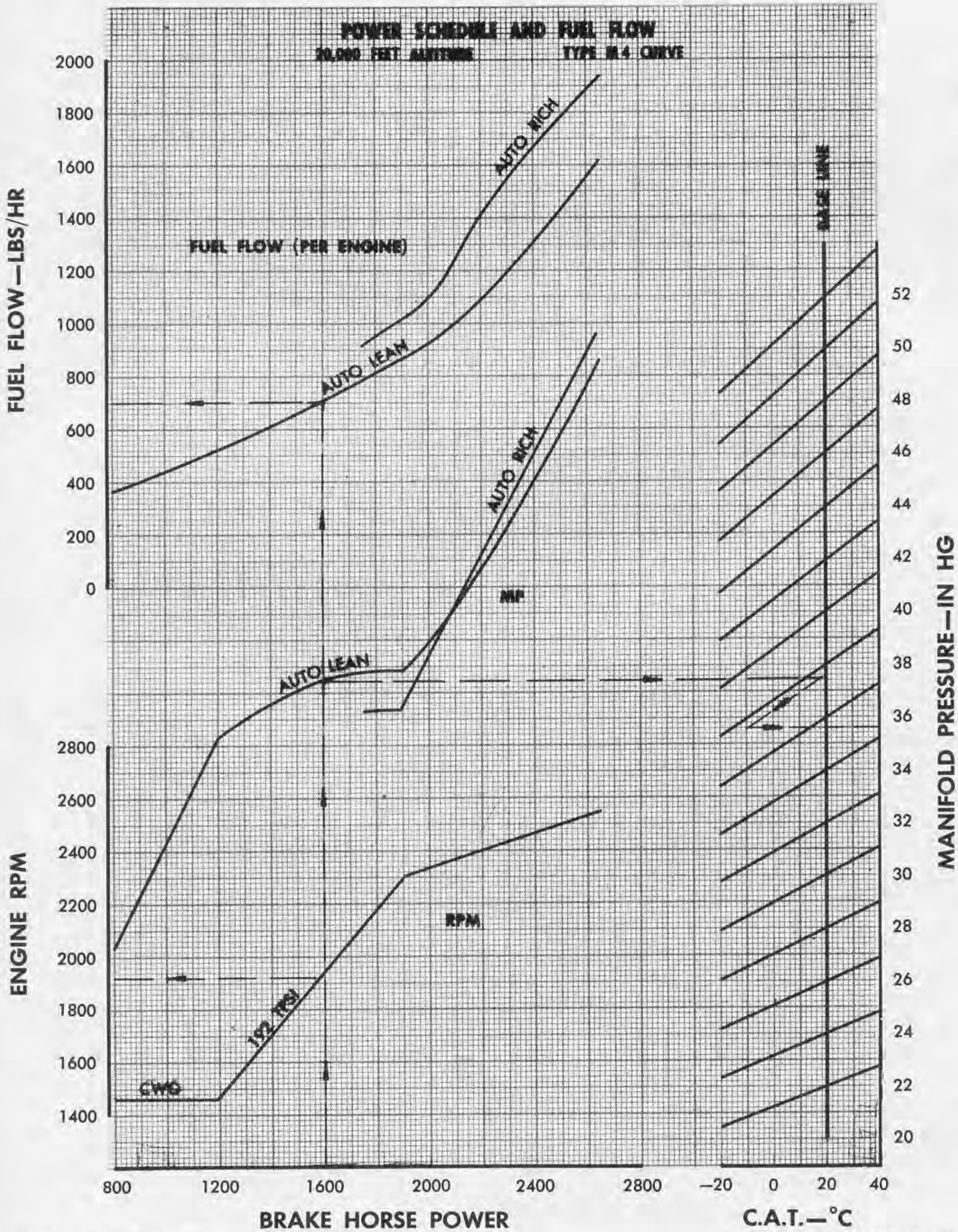


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-30. Power Schedule and Fuel Flow—15,000 Ft.

022231

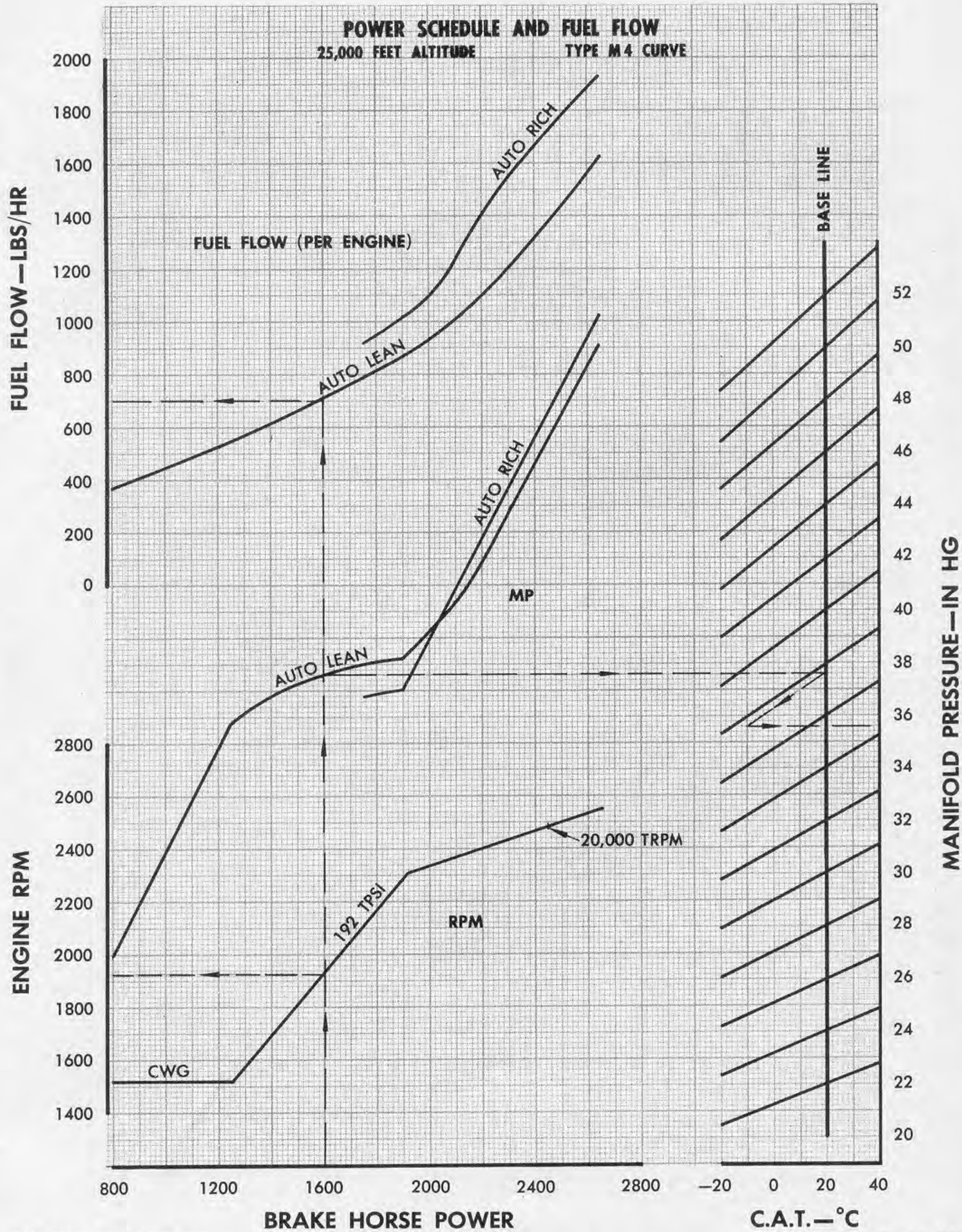


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-31. Power Schedule and Fuel Flow—20,000 Ft.

022232

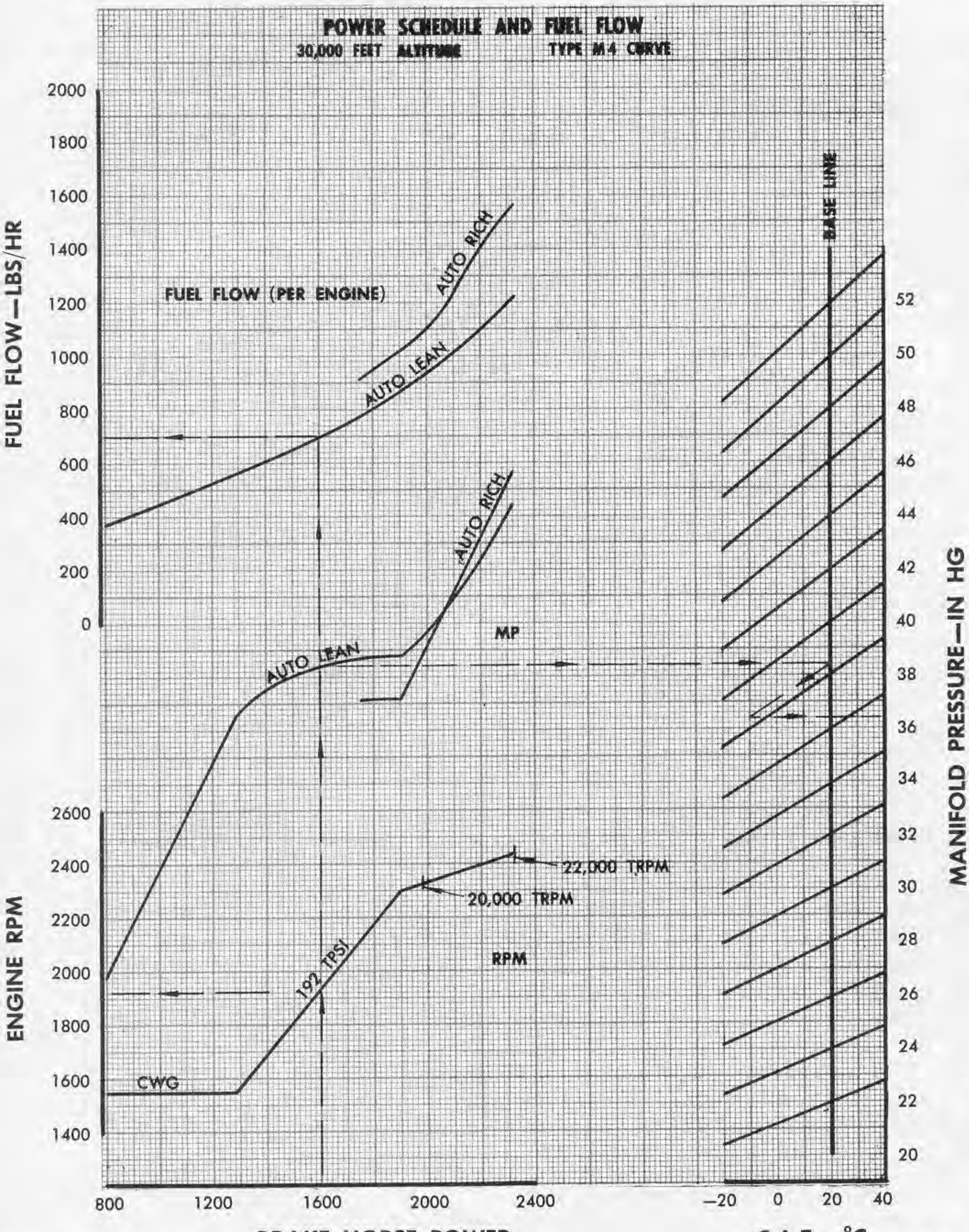


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-32. Power Schedule and Fuel Flow—25,000 Ft.

022233

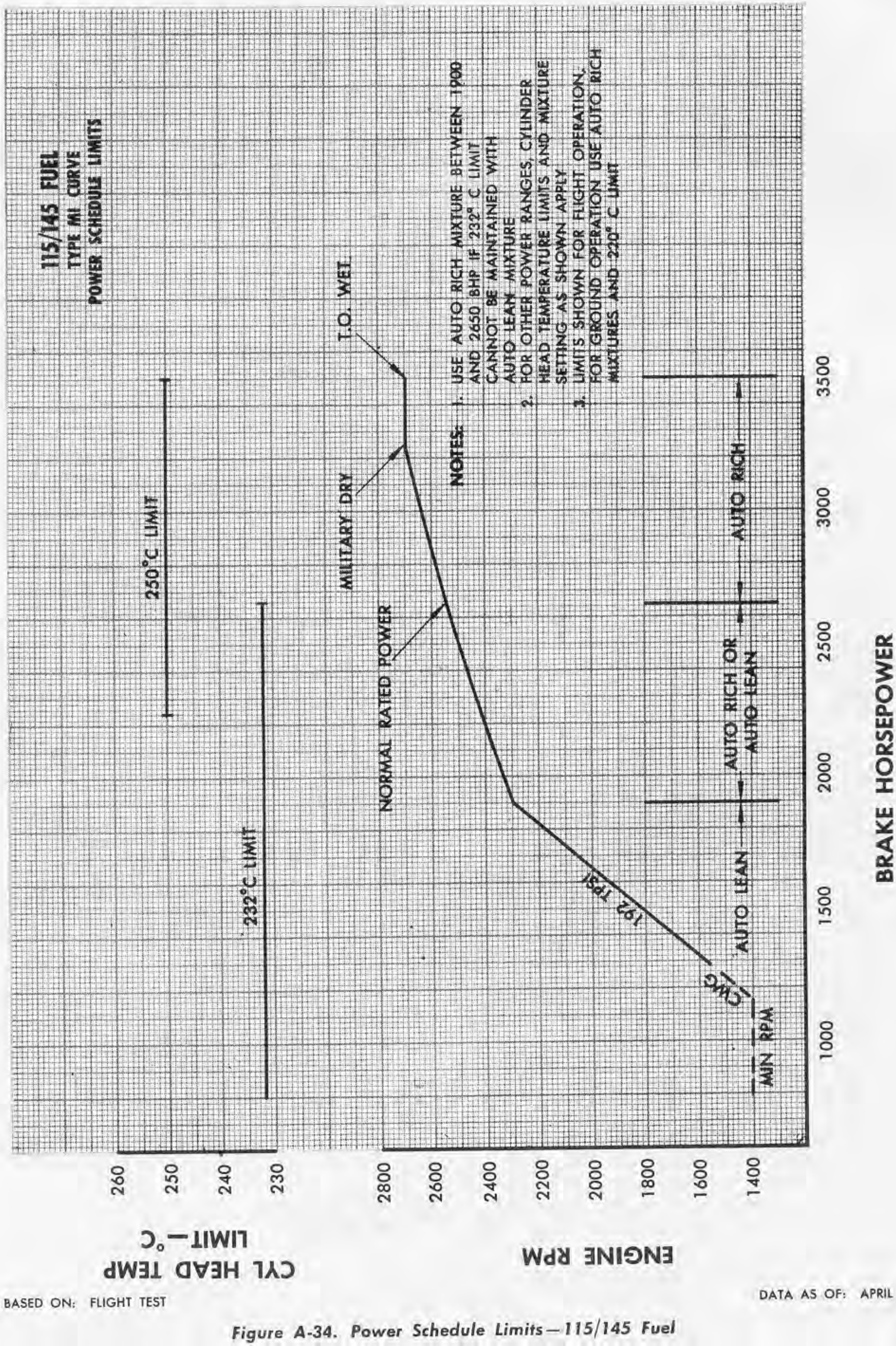


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-33. Power Schedule and Fuel Flow—30,000 Ft.

022234

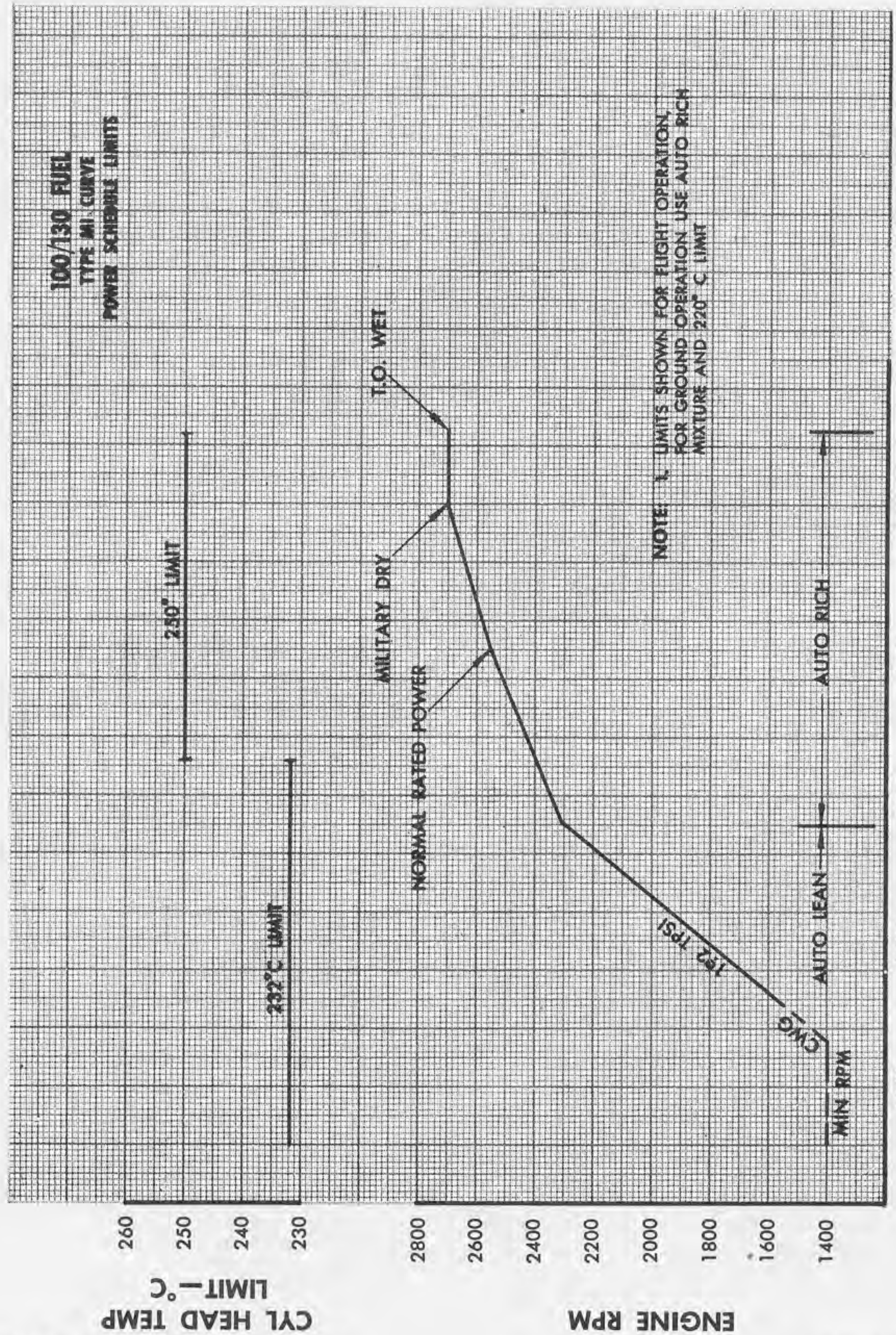


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-34. Power Schedule Limits—115/145 Fuel

022235



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-35. Power Schedule Limits—100/130 Fuel

022236

A-51. CLIMB CHARACTERISTICS.

A-52. Time, distance and fuel consumed during the climb to cruising altitudes must be known to accurately plan and execute a mission. These items may be determined from the applicable climb prediction chart. Three such charts (figures A-37, A-40 and A-43) are included, covering the following 4-engine power conditions.

a. Normal rated power 115/145 grade fuel.
b. 2500 BHP per engine (NRP) 100/130 grade fuel.
c. 2425 BHP per engine either fuel. See figure A-45 for tabular data. The 2425 BHP per engine climb power may be used to prolong useful engine accessory life.

A-53. The charts also include a table of recommended airspeeds at various gross weights for best rate of climb. Notation on the altitude lines indicate the normal cowl flap setting, and the dashed line curves indicate service and cruise ceilings, 100 and 300 feet-per-minute rates-of-climb.

A-54. Curves of 4-engine rates-of-climb versus altitude at constant gross weight, the basis from which the climb prediction charts were calculated, are presented as figures A-38, A-41 and A-44. Also shown, figures A-39 and A-42 are similar curves for 3 engines operating at normal rated power with 115/145 grade fuel and 100/130 grade fuel.

A-55. The general conditions considered for these climb charts for both three and four engines operating are summarized below:

a. Standard atmospheric conditions.
b. Climb speeds noted on charts.
c. Flaps and gear up.
d. .75 inch oil cooler gap (automatic).
e. Intercooler flap gap as required.
f. Cowl flap gap noted on charts.
g. Fuel flow noted on charts.
h. Normal rated power
   Auto rich mixture
   2550 engine RPM
   2650 BHP/engine using 115/145 grade fuel
   2500 BHP/engine using 100/130 grade fuel
i. Lowered power for increased accessory life.
   Auto rich mixture
   2350 engine RPM
   2425 BHP/engine either fuel

Deviations from these conditions whether arising from small drag changes, different atmospheric conditions or loss of power in a malfunctioning engine would make use of the charts unrealistic unless an adjustment is applied. This may be done in the form of a weight adjustment applied to the initial gross weight and resulting in an effective gross weight with which to enter the curves. Increments of weight adjustment to be applied for several variations are as follows:

Variation	Weight Adjustment
Drag changes	Add 1000 pounds for every square foot increase in drag area.
Engine power loss	Add 1250 pounds for each 100 BHP total reduction in power.
Outside Air Temperature	Add 350 pounds for each degree centigrade hotter than standard day.

See discussion of effective weight given under "Technique of Long Range Cruising," paragraph A-64.

A-56. The effect on climb of varying cooling flaps from recommended values is shown in figure A-36.

A-57. The climb prediction curves are plots of gross weight versus range in nautical miles with various altitude lines crossing the range guide lines. The range guide lines are constructed in a manner such that following a guide line from a beginning altitude and weight to the final altitude of a climb, shows the decrease in weight (fuel used) and the distance traveled as the climb progresses. Time in climb is also shown in a scale corresponding to the gross weight scale. The time scale is computed from fuel flow in pounds per minute and weight change. The variation of temperature with altitude for a standard day, the basis for all the climb charts, is included on the climb prediction curves. The compressibility temperature rise is not included in this curve since this factor varies with the two temperature bulb locations.

A-58. An example of the use of the Climb Prediction Charts should clarify their use. Suppose the following conditions exist for a climb to be made with the C-97A:

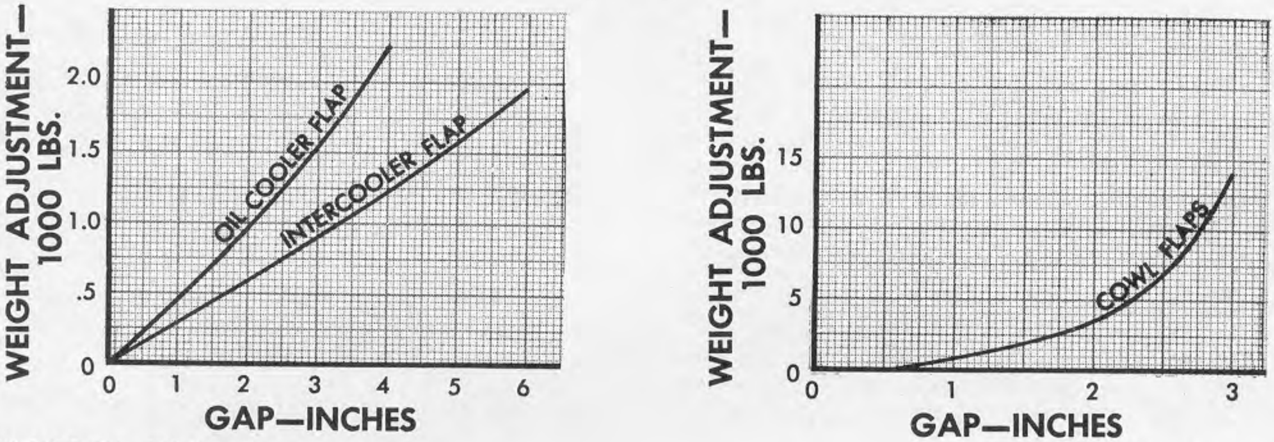
a. No extra drag items.
b. 115/145 grade fuel aboard.
c. Normal rated power setting.
d. Output of inboard engines is 40 BHP per engine less than normal rated power.
e. Gross weight at start of climb is 155,000 pounds.
f. Pressure altitude at beginning of climb is 5,000 feet.
g. Outside air temperature is expected to average 20° C hotter than standard between 5,000 and 20,000 feet.
h. Desired pressure altitude at the end of climb is 20,000 feet.

First determine the weight adjustment that must be applied because of the non-standard air temperature and power conditions.

An increase of 20 degrees centigrade from standard temperature results in a weight adjustment of:

$$20 \times 350 = +7{,}000 \text{ pounds.}$$

022237



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

022238

Figure A-36. Effect of Cooling Flap Changes on Climb Performance

The loss of 40 BHP on two engines results in a weight adjustment of:

80/100 x 1,250 = + 1,000 pounds.

The total weight adjustment is then:

1,000 + 7,000 = 8,000 pounds.

The effective weight will then be:

155,000 + 8,000 = 163,000 pounds.

Enter the four engine, normal rated power, 115/145 grade fuel, Climb Prediction Chart (figure A-37) at 163,000 pounds at point (1) on the 5,000 feet altitude line. Follow the dotted line parallel to the range guide lines to point (2) on the 20,000 feet altitude line. The distance flown will be the increment between points (1) and (2) on the range scale.

117 - 22 = 95 nautical miles

The fuel used is the increment on the weight scale:

163,000 - 159,400 = 3,600 pounds.

The time to climb is the increment on the time scale:

160 - 132 = 28 minutes.

Note that the fuel flow is 129 pounds per minute which for 28 minutes amounts to practically 3600 pounds. Thus the actual gross weight at the end of the climb is:

155,000 - 3,600 = 151,400 pounds.

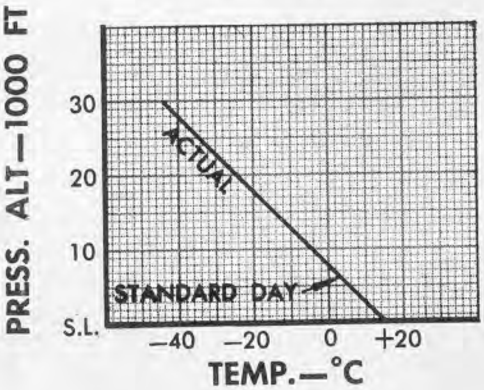
Climb speed is determined for the actual gross weights, and at the start of climb at 5000 feet is found, by interpolating in the climb speed table to be 191 MPH equivalent airspeed and at the end of the climb at 20,000 feet it should be 190 MPH equivalent airspeed.

4 ENGINE—NORMAL RATED POWER

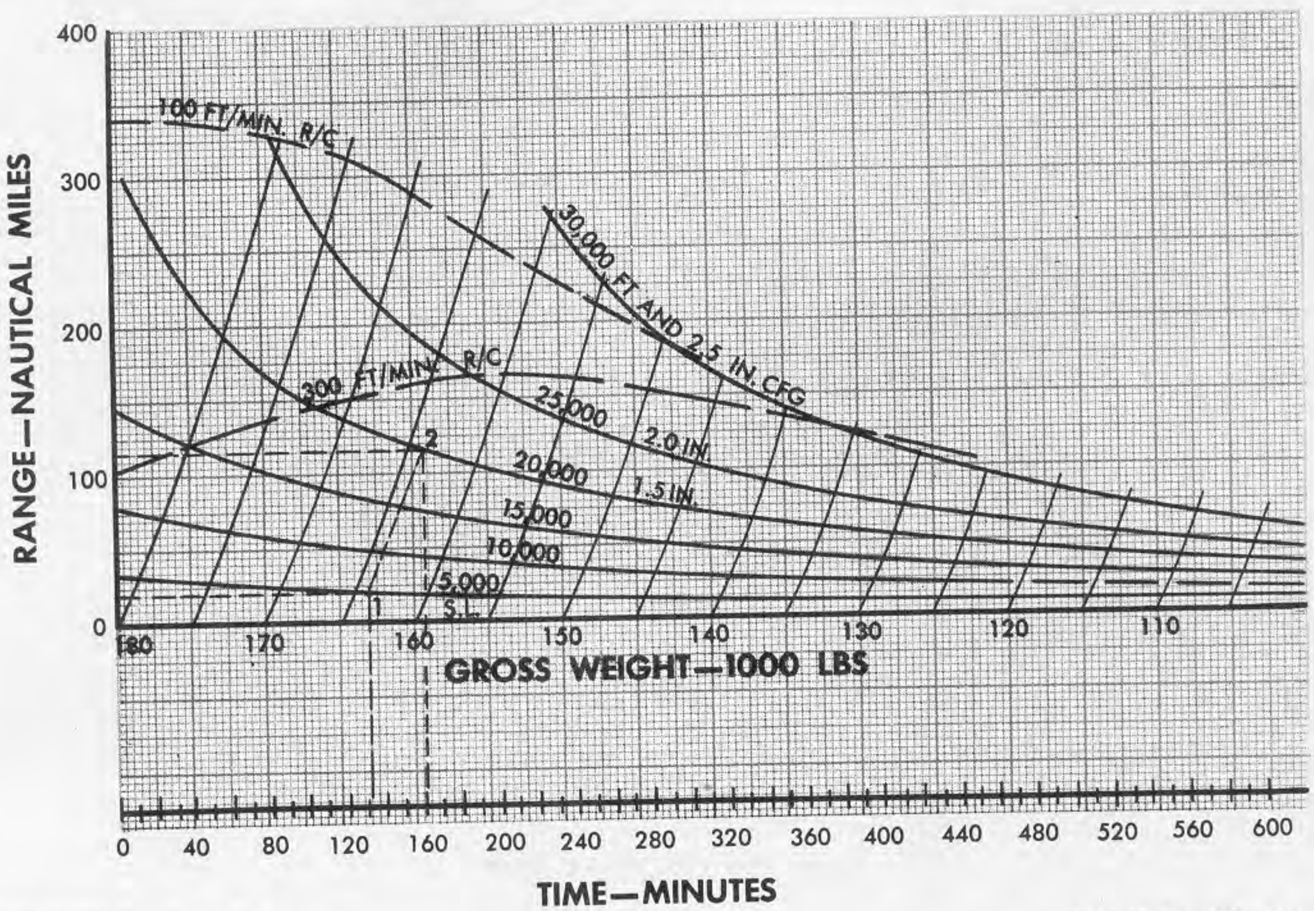
TYPE A6-4 CURVE
CLIMB PREDICTION
STANDARD DAY

BASED ON:
115/145 GRADE FUEL
AUTO RICH MIXTURE
NORMAL RATED POWER — 2650 BHP/ENG
2550 RPM
FUEL FLOW 129 LBS/MIN TO 26,000 FT — 114 LBS/MIN OVER 26,000 FT

.75 IN. OIL COOLER FLAP GAP (AUTOMATIC)
INTERCOOLER FLAP GAP AS REQUIRED
FOR EACH 1°C HOTTER THAN STANDARD DAY O.A.T. ADD 350 LBS TO AIRPLANE WEIGHT TO OBTAIN CLIMB PERFORMANCE



CLIMB SPEEDS	
GROSS WEIGHT — LBS	EQUIVALENT AIRSPEED — MPH
170,000	195
150,000	190
130,000	185
110,000	175

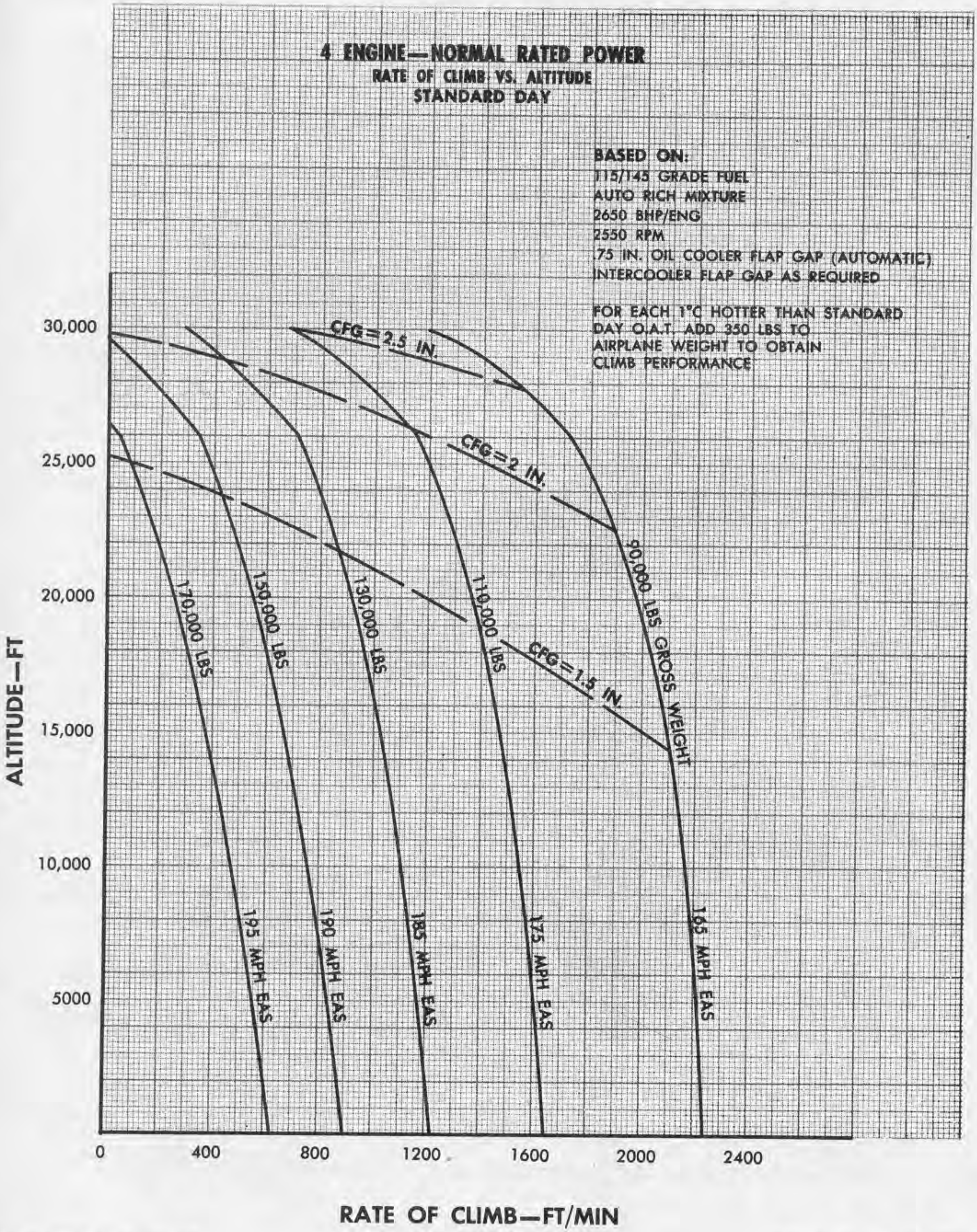


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-37. 4 Engine Climb Prediction—Normal Rated Power

022239

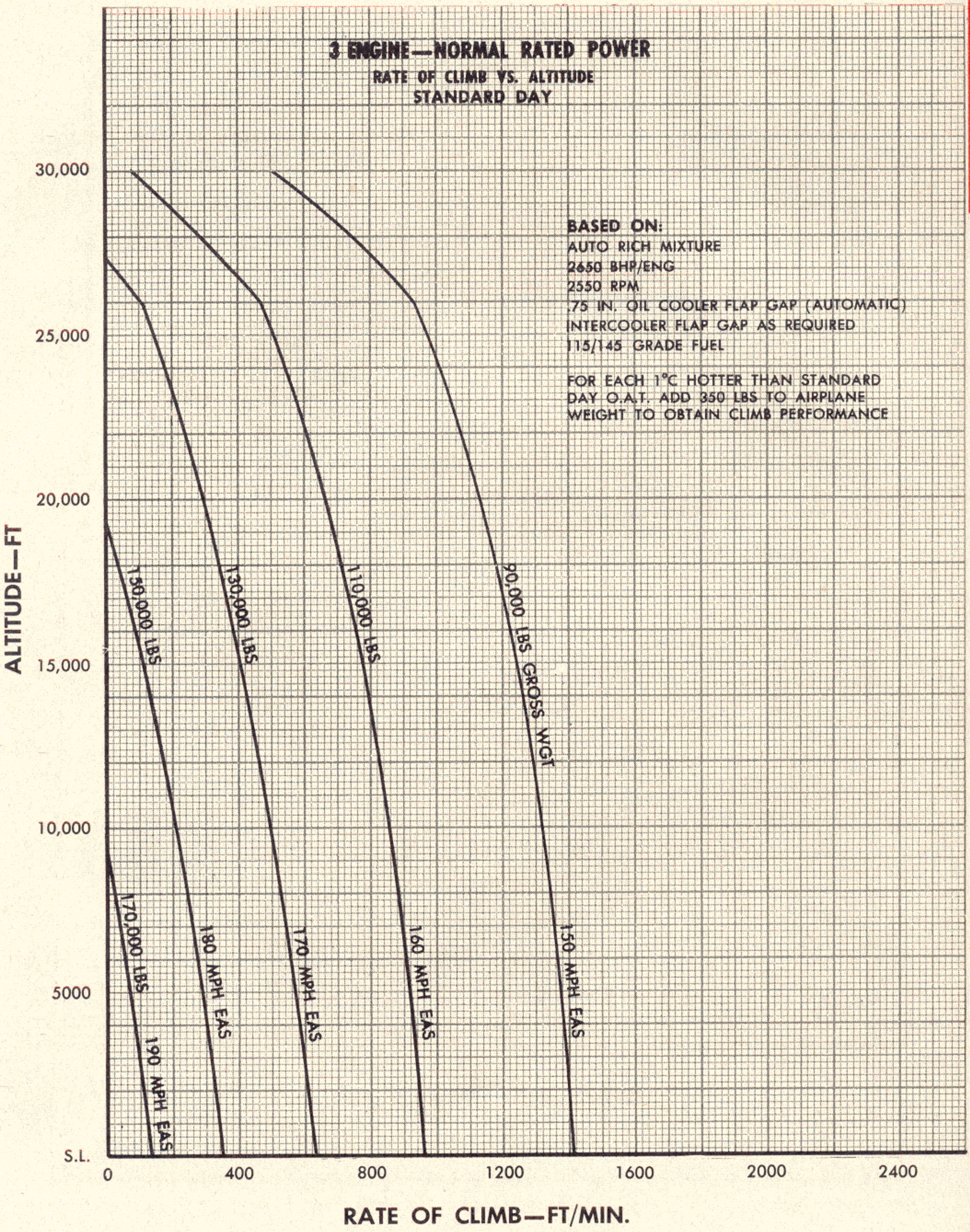


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-38. 4 Engine Rate of Climb Vs. Altitude—Normal Rated Power

022240



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-39. 3 Engine Rate of Climb Vs. Altitude—Normal Rated Power

022241

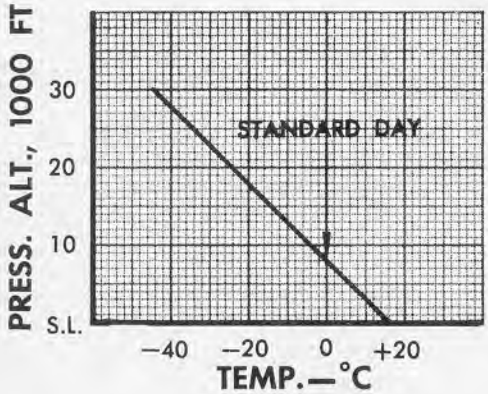
4 ENGINE—2500 BHP

TYPE A6-4 CURVE
CLIMB PREDICTION
STANDARD DAY

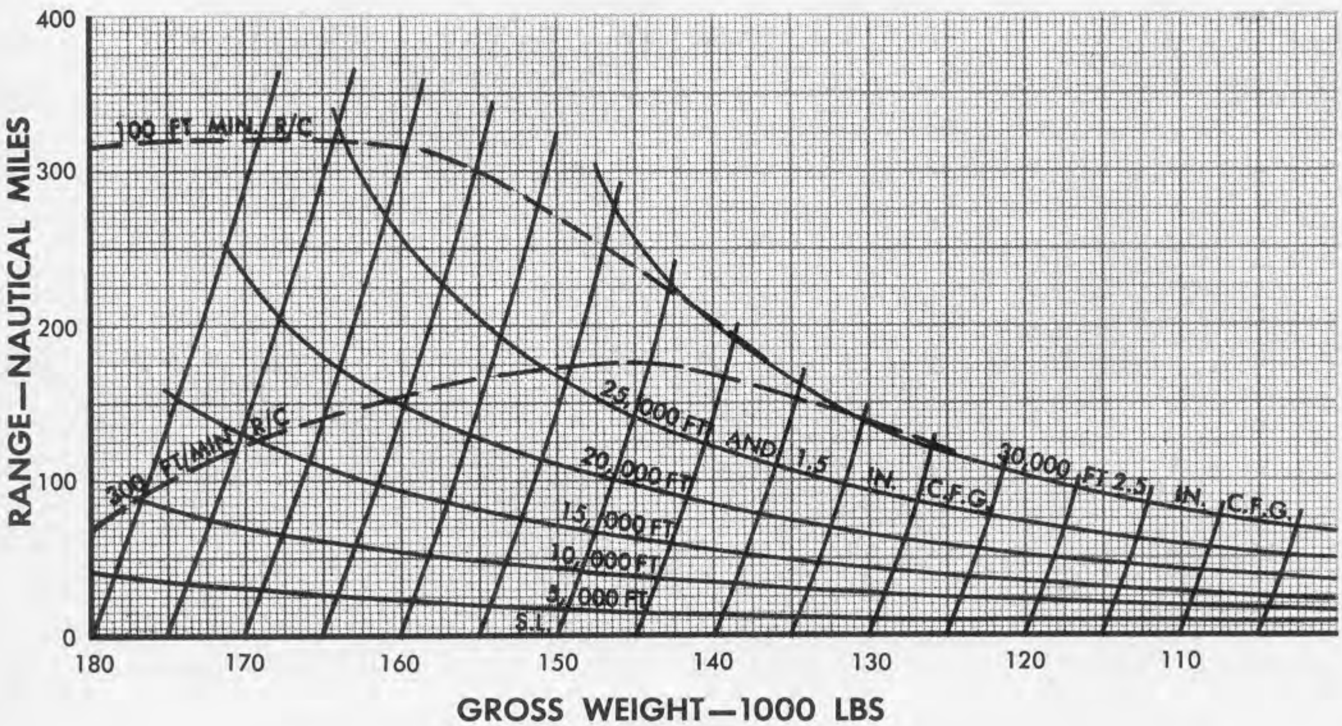
BASED ON:
100/130 GRADE FUEL
AUTO RICH MIXTURE
2500 BHP/ENGINE
2550 RPM
FUEL FLOW 119 LB/MIN UP TO 27,500 FT
108 LB/MIN AVE. OVER 27,500 FT

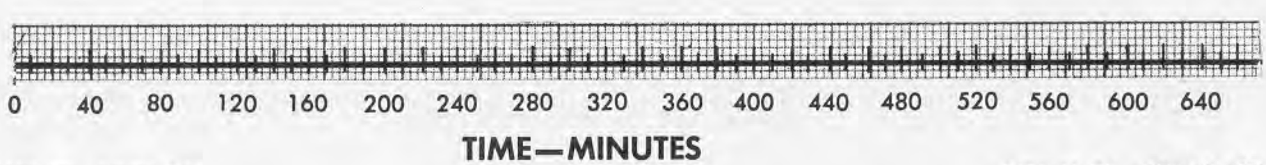
.75 INCH OIL COOLER FLAP GAP (AUTOMATIC)
INTERCOOLER FLAP GAP AS REQUIRED

FOR EACH 1°C HOTTER THAN STANDARD DAY O.A.T. ADD 350 LBS TO AIRPLANE WEIGHT TO OBTAIN CLIMB PERFORMANCE



CLIMB SPEEDS	
GROSS WEIGHT — LBS	EQUIVALENT AIRSPEED — MPH
170,000	195
150,000	190
130,000	185
110,000	175



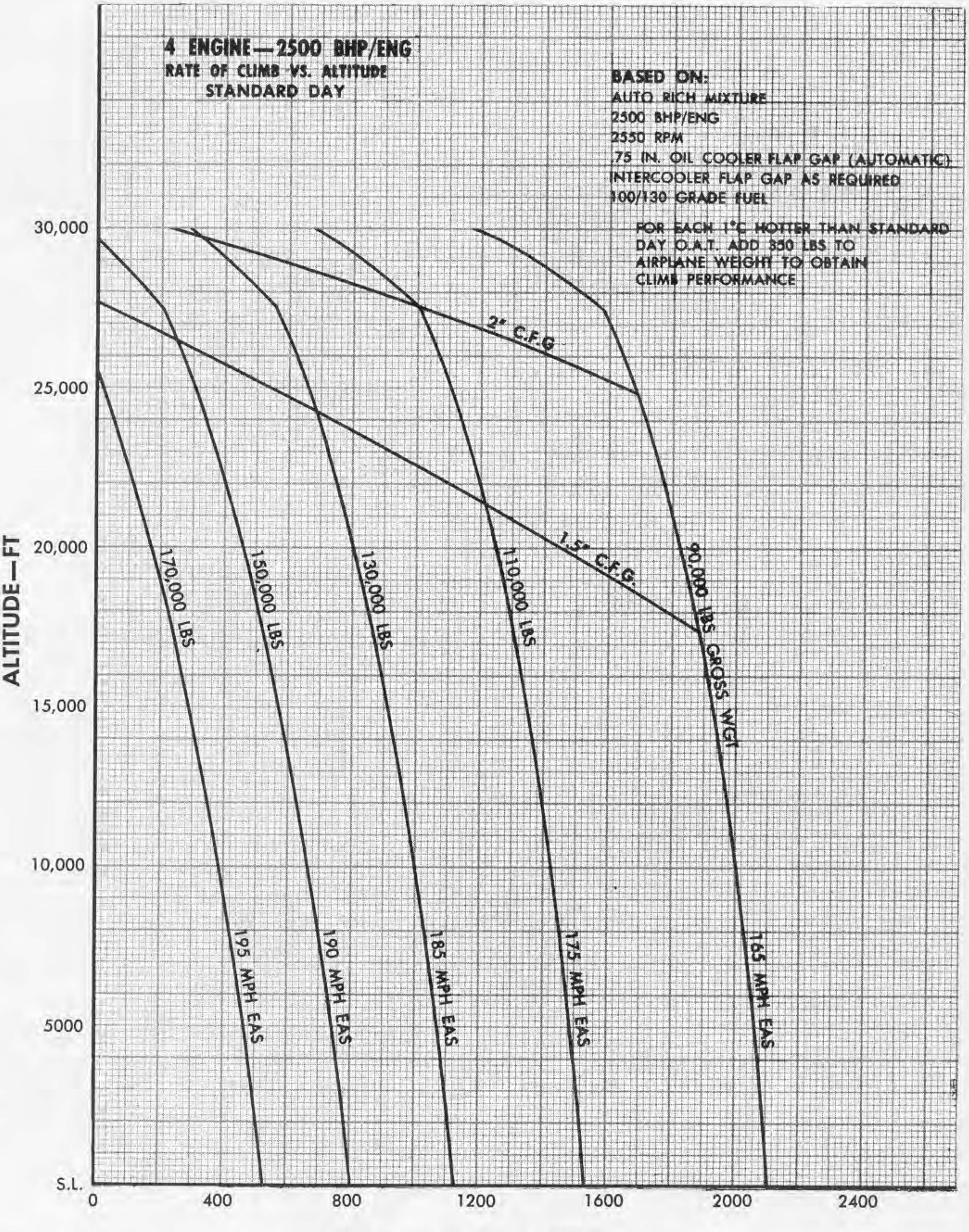


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-40. 4 Engine Climb Prediction—2500 BHP/Engine

022242

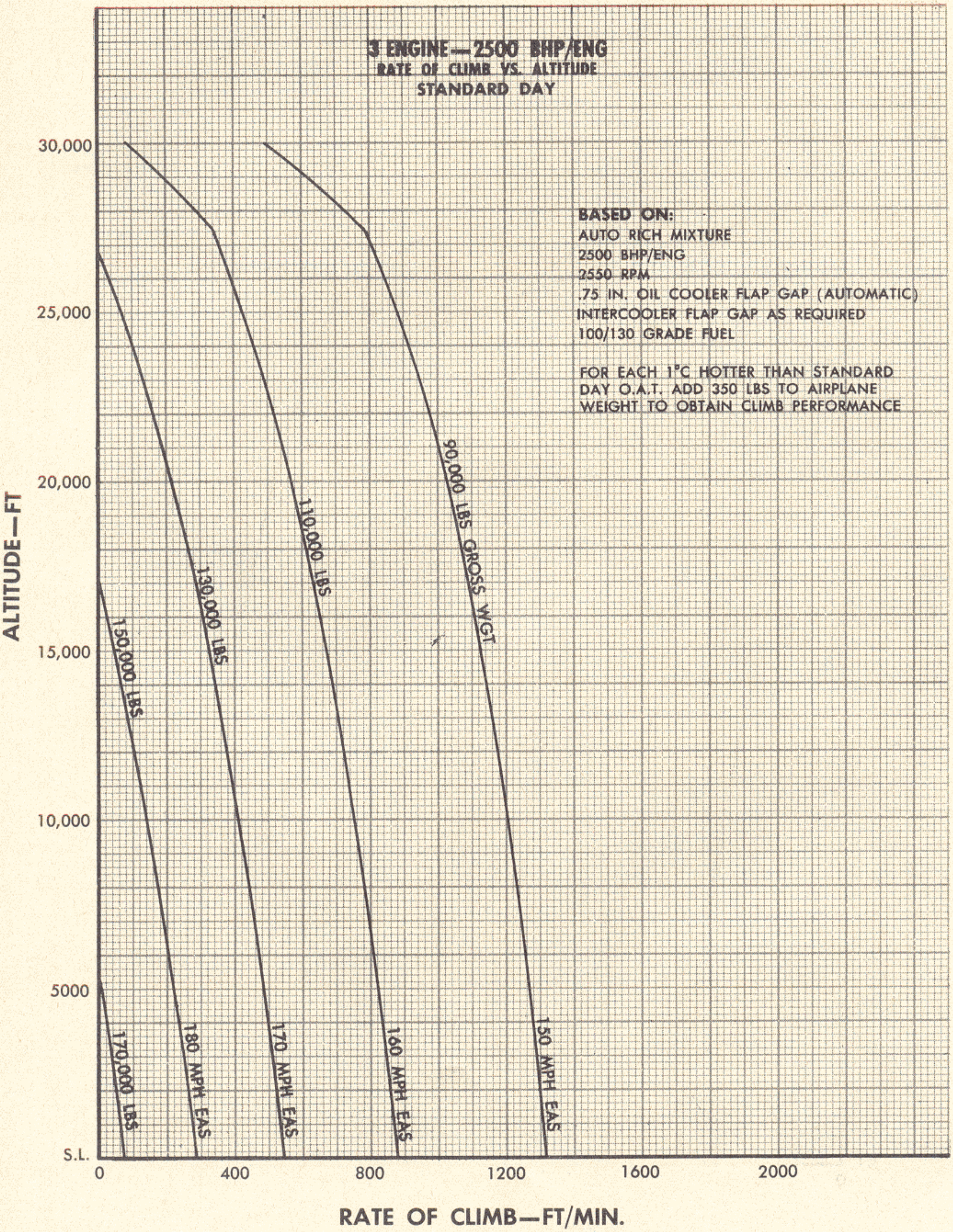


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-41. 4 Engine Rate of Climb Vs. Altitude—2500 BHP/Engine

022243



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-42. 3 Engine Rate of Climb Vs. Altitude—2500 BHP/Engine

022244

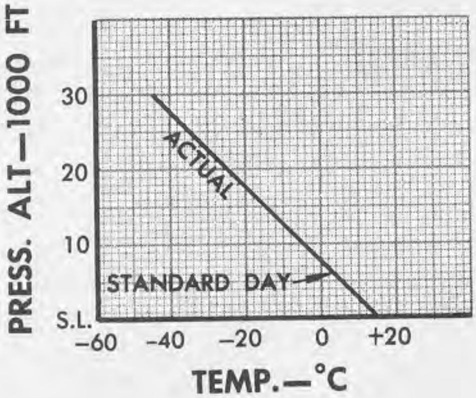
4 ENGINE—2425 BHP

TYPE A6-4 CURVE
CLIMB PREDICTION
STANDARD DAY

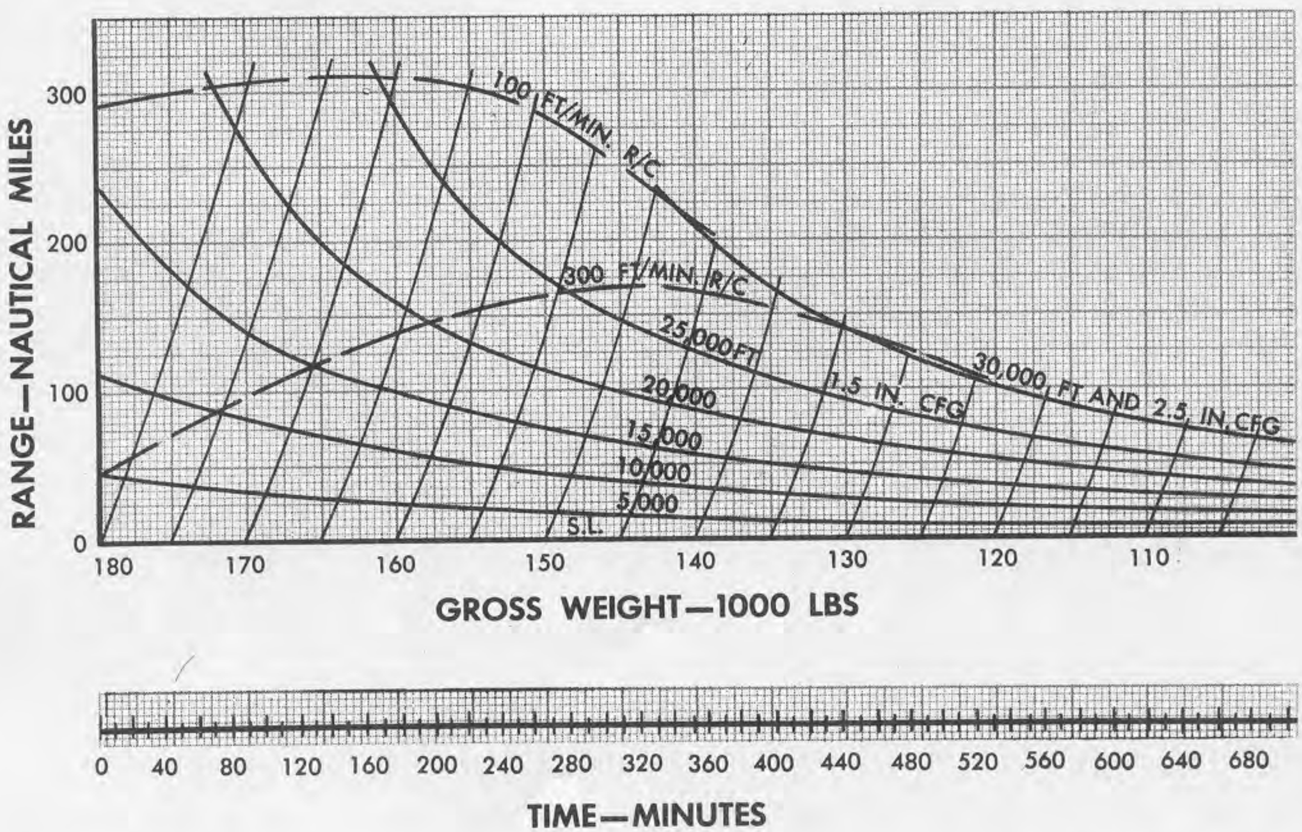
BASED ON:

115/145 AND 100/130 GRADE FUEL
AUTO RICH MIXTURE
2425 BHP/ENGINE
2350 RPM
FUEL FLOW 113 LBS/MIN. TO 28,000 FT
105 LBS/MIN AVERAGE OVER 28,000 FT

.75 IN. OIL COOLER FLAP GAP (AUTOMATIC)
INTERCOOLER FLAP GAP AS REQUIRED
FOR EACH 1°C HOTTER THAN STANDARD DAY O.A.T. ADD 350 LBS TO AIRPLANE WEIGHT TO OBTAIN CLIMB PERFORMANCE



CLIMB SPEEDS	
GROSS WEIGHT—LBS	**EQUIVALENT AIRSPEED—MPH**
170,000	195
150,000	190
130,000	185
110,000	175

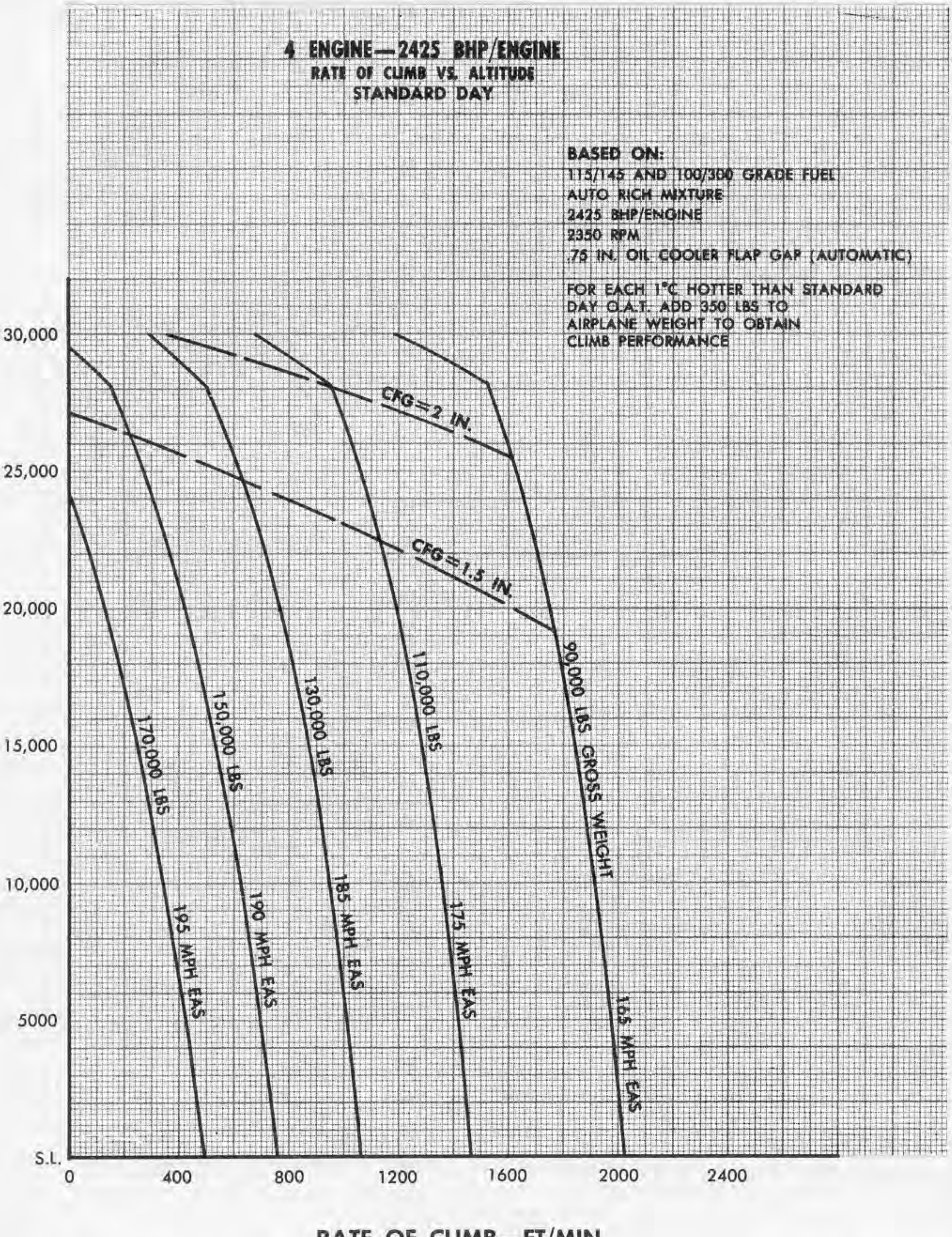


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-43. 4 Engine Climb Prediction—2425 BHP/Engine

022245



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-44. 4 Engine Rate of Climb Vs. Altitude—2425 BHP/Engine

022246

4 ENGINE CLIMB CHART—2425 BHP/ENG—2350 RPM—AUTO RICH

Time - minutes, Fuel - pounds (4 eng.), Distance - nautical miles. Standard Day

Equivalent Airspeed-MPH		195			190				185				175		
Pressure Altitude Ft.	Starting Gr. Wt. 1000 Lbs.	175	170	165	160	155	150	145	140	135	130	125	120	115	110
2,000	Time	5.5	4.5	4.0	3.5	3.0	2.5	2.5	2.0	2.0	2.0	1.5	1.5	1.0	1.0
	Fuel	610	530	450	390	340	300	270	240	220	200	180	160	140	130
	Dist.	16	14	12	10	9	8	7	6	5	4	4	3	3	3
4,000	Time	11.0	9.0	8.0	7.0	6.0	5.5	5.0	4.5	4.0	3.5	3.0	3.0	2.5	2.5
	Fuel	1230	1080	920	780	690	600	540	490	440	400	360	330	300	270
	Dist.	32	28	24	21	18	16	14	12	10	9	8	7	7	6
6,000	Time	16.5	14.5	12.5	10.5	9.0	8.0	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5
	Fuel	1870	1640	1410	1200	1050	910	820	750	680	620	560	500	460	420
	Dist.	48	43	38	33	28	24	21	18	16	14	12	11	11	10
8,000	Time	22.0	19.0	17.0	14.5	12.5	11.0	10.0	9.0	8.0	7.5	6.5	6.0	5.5	5.0
	Fuel	2520	2180	1900	1620	1420	1240	1120	1010	920	840	760	690	620	550
	Dist.	65	57	50	43	37	33	29	25	22	19	17	15	14	14
10,000	Time	28.5	24.5	21.0	18.0	16.0	14.0	12.5	11.0	10.0	9.5	8.5	7.5	7.0	6.0
	Fuel	3230	2760	2410	2060	1800	1590	1420	1270	1160	1060	960	870	780	690
	Dist.	85	73	64	55	47	42	37	32	28	24	22	20	19	18
12,000	Time	35.5	29.5	26.0	22.5	19.5	17.0	15.5	14.0	12.5	11.5	10.5	9.5	8.5	7.5
	Fuel	4000	3370	2940	2530	2220	1910	1750	1560	1420	1300	1180	1060	950	850
	Dist.	105	90	78	68	59	52	45	40	36	32	28	25	23	22
14,000	Time	42.0	35.5	31.0	27.0	23.5	21.0	18.5	16.5	15.0	13.5	12.5	11.0	10.0	9.0
	Fuel	4780	4000	3510	3050	2670	2350	2100	1870	1690	1550	1400	1270	1130	1000
	Dist.	127	107	94	81	71	63	55	48	43	38	35	31	28	26
16,000	Time	49.5	41.5	36.5	32.0	28.0	24.5	22.0	19.0	17.5	16.0	14.5	13.0	11.5	10.0
	Fuel	5630	4720	4130	3600	3170	2800	2470	2180	1980	1800	1640	1480	1320	1150
	Dist.	150	127	111	95	85	75	66	58	52	46	41	37	33	30
18,000	Time	58.0	49.0	42.5	37.0	32.5	29.0	25.0	22.0	20.0	18.5	16.5	15.0	13.0	11.5
	Fuel	6570	5570	4820	4200	3700	3280	2860	2520	2270	2070	1870	1680	1500	1320
	Dist.	180	152	131	111	98	87	77	68	61	54	48	43	38	34
20,000	Time	69.0	57.5	49.5	42.5	38.0	33.5	29.0	25.5	23.0	20.5	18.5	17.0	15.0	13.0
	Fuel	7800	6500	5600	4790	4290	3790	3300	2890	2590	2350	2120	1900	1690	1480
	Dist.	223	185	155	132	113	100	89	79	70	62	55	49	43	39
22,000	Time	81.5	68.0	57.5	49.5	43.5	38.0	33.0	29.0	26.0	23.5	21.0	19.0	17.0	14.5
	Fuel	9270	7680	6500	5630	4910	4320	3730	3270	2940	2650	2370	2130	1900	1660
	Dist.	277	224	185	156	130	115	102	91	80	71	63	55	49	44
24,000	Time		78.5	66.0	57.0	49.5	48.0	37.0	32.5	29.0	26.0	23.5	21.0	18.5	16.5
	Fuel		8920	7500	6480	5620	4890	4210	3670	3300	2960	2660	2370	2100	1850
	Dist.		268	220	184	152	133	117	103	92	81	70	62	55	49
26,000	Time				67.0	57.5	49.0	42.0	36.5	32.5	29.0	26.0	23.0	20.5	18.5
	Fuel				7570	6500	5550	4750	4150	3680	3270	2950	2630	2350	2070
	Dist.				220	186	159	138	119	105	92	80	71	63	55

DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-45. 4 Engine Climb Chart—2425 BHP/Engine

022247

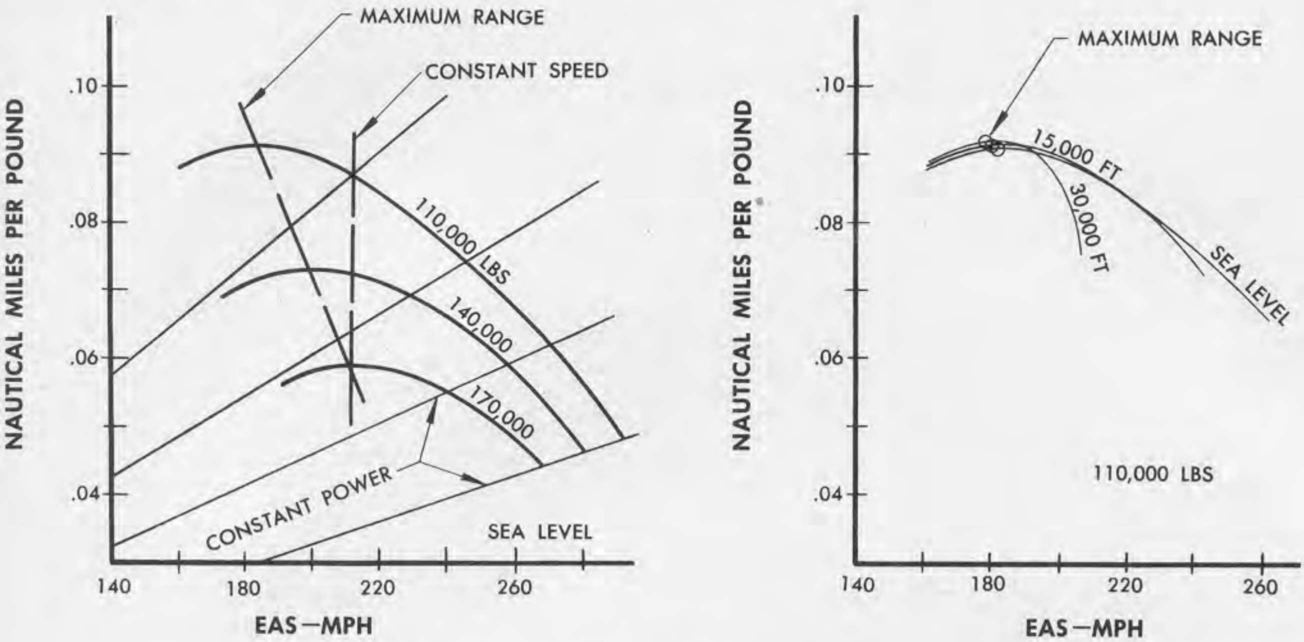


Figure A-46. Methods of Cruising the Airplane

022248

A-59. METHODS OF CRUISING THE AIRPLANE.

A-60. In general there are two ways of cruising the airplane in level flight; one, by selecting a desired power and obtaining resultant speeds which will vary with weight and altitude; and two, by selecting a desired speed or speed schedule and using power necessary to obtain these speed conditions.

A-61. The miles per pound vs. airspeed curves in figure A-46, show how the miles per pound vary with weight and with altitude at constant power operation. A high auto-lean power is ordinarily selected for constant power cruising because the most speed can be obtained in this manner without unduly hurting the engine or consuming an excessive amount of fuel. Although constant power cruising will usually reduce the time required in flight, it does so by sacrificing fuel economy and carrying capacity. Since this is not consistent with efficient use of the KC-97E airplane, constant power cruising will not be discussed further.

A-62. A more economical, but slower, way to cruise the airplane is by cruising it at constant speed at all gross weights and altitudes. The advantage of this system lies in the simplicity of establishing reasonably economical operation without complicating the instructions for the pilot. When large changes in weight or altitude are encountered this system may be modified to keep constant speed at all weights but to reduce this speed for the higher altitudes. However, again simplification of operating instructions is not sufficient reason for sacrificing economy and range.

A-63. Maximum range operation is simply a refinement of the second method, in which the speed must be varied with the weight and with the altitude to obtain the most economical type of operation. The advantage of such a system is the resulting increase in transferrable fuel and range which may be achieved. Saving a small percentage of the fuel used by the tanker may result in increasing the amount of transferrable fuel by a much larger percentage, especially when the fuel used by the tanker is considerably greater than the transferrable fuel. The disadvantages are that a more precise flying technique is required and that the presentation of flying information becomes much more complicated. Needless to say, it is very difficult to present the correct speed at which to fly the airplane at all weights and altitudes considering headwinds, rough weather, and climatic conditions without arriving at some compromises. These compromises usually involve a sacrifice of approximately one percent in range. Constant speed cruise operation and maximum range operation are also illustrated in figure A-46.

A-64. TECHNIQUE OF LONG RANGE CRUISING.

A-65. Obtaining the best cruise control requires the airplane to be flown on a predetermined speed schedule. These are usually speeds close to the maximum ratio of speed to power required. This schedule does not represent speeds resulting from predetermined power settings, rather, it is a schedule of speeds for optimum long range cruise conditions considering economy, time, ease of handling and atmospheric conditions including wind. The required power settings are then a result of the speed schedule. It is of prime importance for optimum range to cruise at the speed recommended for a particular flight condition, even when required power settings vary somewhat from those predicted. When maintaining long range cruising speeds, power settings should be adjusted as required to hold the desired altitude.

A-66. When selecting the airspeeds from the type A2 curve for a mission plan, the cruising periods should be divided into parts sufficiently small that a constant airspeed may be held for each period. These periods should be handled as increments of gross weight, selected so that they will represent approximately one hour periods, except that where recommended long range cruising speeds change more than 2 MPH during that time, the period should be reduced to a weight increment within a 2 MPH change in airspeed. The speeds selected for the plan should be the average speeds for these periods.

A-67. Accurate cruise control requires that during each cruise period the selected speed be held within ± 3 MPH, with as few exceptions as possible. This tolerance may appear rather small, but normally is not too difficult to maintain if the proper system of control is used. Remember that the elevator is basically the speed control and power is basically the altitude control. With this in mind it should not take an excessive amount of attention to hold airspeed within limits with the elevator. Altitude can then be controlled, without upsetting the established speed, by making minor adjustments to power as the flight progresses. These power adjustments must be made smoothly and gradually with either the throttle or RPM control as given under "Power Schedules and Fuel Flow Characteristics," paragraph A-45.

A-68. One exception to the above exists where operation at high altitude with high weights requires the use of a constant power of 2250 BHP in auto-rich with 250° C cylinder head temperature for a certain period of time during transition from the 250° C to the 232° C. Examination of the type A2 Long Range Summary Curves illustrates this.

A-69. Gradual changes in altitude during the long range cruising periods do not adversely affect range, since the slight loss in fuel mileage during climb is compensated for by improved fuel mileage as the airplane descends. When altitude must be held within very small limits, say ± 100 feet, quite frequent power adjustments may be necessary. Again this will not adversely affect range as the airplane will be flying in the optimum cruise condition and no improvement can be realized by deviating from this procedure.

A-70. Average power settings and fuel flows for each cruise period would be the most representative for entry in the flight log.

A-71. To obtain predicted fuel mileage it is also important, once the cruise condition has been established, to be sure that the fuel flows are within close limits of the predicted values for the actual power being used. The procedure for obtaining optimum fuel flow settings is given in the discussion of "Power Schedules and Fuel Flow Characteristics," paragraph A-45.

A-72. Maintaining the recommended speeds and minimum fuel flow will result in the most economical cruise the airplane can do regardless of whether the actual power settings and fuel flows are exactly as predicted or not. The following is a general procedure for setting up long range cruise conditions:

a. After reaching the desired cruise altitude, level out the airplane, allowing the speed to increase somewhat above expected cruising speed and reduce power to approximately the expected cruise power.
b. As soon as head temperatures have stabilized below cruise power limits, long range cruising airspeed should be established and maintained at that given on the mission plan.
c. Adjust power as necessary to maintain the required altitude.
d. Set up torque pressures for the normal operating schedule in auto-lean mixture or if manual mixture adjustment is employed follow procedures outlined in paragraph A-45.
e. Adjust cooling flaps as necessary to maintain the cylinder head and carburetor air temperatures within the maximum limitations.
f. Trim power to compensate for any mixture or cooling flap adjustment. Then adjust as necessary during cruise to maintain altitude within limits until this cruise period is completed.

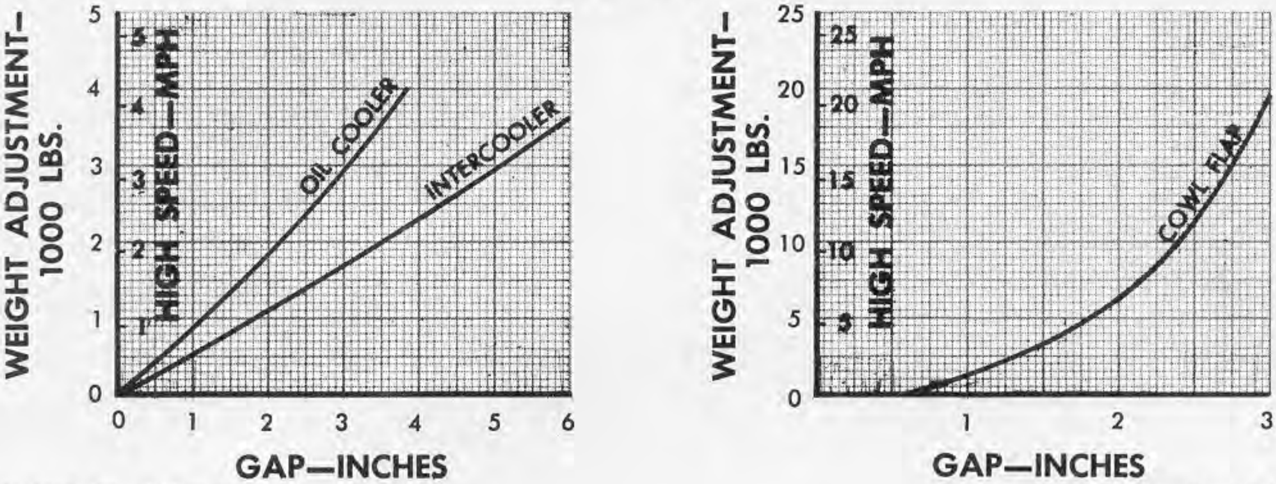
A-73. INSTRUMENT ERRORS. Apparent discrepancies between actual and predicted airplane performance may often be traced to malfunctioning instrumentation. Airspeed, altitude and power instruments must be accurate for good flight control. Likewise power instruments should be checked periodically for accuracy, particularly tachometer, manifold pressure, torquemeter, cylinder head temperature, fuel flow and carburetor air temperature gages.

A-74. The airspeed lines are short and arranged to avoid trapping any moisture which may get into them, either by driving rain or condensation. However, water has been known to get trapped in the lines in apparent disregard of arrangement and it should be checked as a possible source of airspeed and altimeter errors. Leaks in the system are more likely to develop and in the case of a pressurized airplane the errors resulting could be very large. Also the airspeed and altimeter meters themselves are hardly immune to internal troubles and erroneous indication. It is recommended that these systems be checked periodically.

A-75. EFFECT OF DRAG VARIATIONS. The cruise control charts as shown are based on flight tests of a standard C-97A airplane but are also applicable to the KC-97E airplane (refer to Introduction). Any variation from this configuration will affect performance from that shown in the charts. To obtain correct data based on a different configuration, drag corrections must be applied. Adding drag to the airplane will slow it down, reduce range or decrease rate of climb. Adding weight will have a similar effect. Decreasing drag will of course have the reverse effect.

A-76. The effects on cruise performance that occur as a result of drag variations from the basic airplane with its recommended cooling conditions may be accounted for by using an effective weight with which to enter certain of the charts. This effective weight is found by adding a weight adjustment increment to the actual gross weight of the airplane. Note that this procedure is the same as used in climb except that the weight adjustment per unit of drag is a different number for the cruise charts.

022249



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-47. Effect of Cooling Flap Changes on Cruise Performance

022250

A-77. The effect of drag differences are presented below as weight adjustment for level flight cruise and its relationship to climb weight adjustment and to changes in equivalent airspeed at constant power.

	△ EAS at constant power MPH	Climb wt. adjustment Pounds	Cruise wt. adjustment Pounds
Per sq. ft. of additional drag area	-2	+1000	+1850

The 1.5 square foot decrease in drag area from the C-97A for the C-97C would affect performance 1.5 times the values shown above, with opposite signs.

A-78. The effective weights obtained by the addition of a drag weight adjustment apply, except for airspeeds, to all of the following curves:

a. Long Range Distance Prediction
b. Long Range Time Prediction
c. Nautical Miles per Pound
d. Long Range Summary

Since weight adjustments are based on maintaining the airspeeds recommended for the actual gross weight of the airplane, an effective weight must not be used for determining airspeeds.

A-79. Example Using this Weight Adjustment Factor:
Given: A mission is being planned wherein a 4 engine cruise is to be made at 99% maximum range, auto-lean to 1750 BHP, auto-rich above 1750 BHP.
Actual weight after climb to 25,000 feet cruising altitude = 150,000 pounds.
A 2,000 nautical mile cruise is to be made at cruising altitude.
The airplane configuration has 1-1/2 square feet less drag than the KC-97E.

Required: Actual weight at end of cruise and the fuel used.

Solution:
a. The effective weight for cruise will be 150,000 - (1850 x 1.5) = 147,225 pounds.
b. Enter figure A-86 at 147,225 pounds, go to the 25,000 foot dotted line, read 1,410 nautical miles.
c. Add 2,000 nautical miles and obtain: 1,410 + 2,000 = 3,410 nautical miles.
d. Go vertically to the 3,410 nautical mile point, go right to the 25,000 foot line, drop vertically and read 117,525 pounds. This is an effective gross weight.
e. Then, actual airplane weight at end of cruise = 117,525 + 2,775 = 120,300 pounds. Fuel used = 147,225 - 117,525 = 29,700 pounds.

A-80. COOLING VARIATIONS. Variations in performance due to differences in apparent cooling may result in speed differences of several miles per hour. The largest cooling drag discrepancy is caused by cowl flap gap changes from predicted values. Incorrect cylinder head temperature or incorrect cowl flap gap readings (or indications) are quite likely to result in large amounts of unnecessary drag, since either of them will result in incorrect cowl flap settings. Secondary variations in drag may be caused by oil cooler or intercooler. The intercooler is the worst offender of the two since it may operate anywhere from closed to full open gaps while the automatic oil cooler flaps operate from one quarter to one half open. Both have about the same drag at full open position. It pays to keep the intercooler flaps as far closed as possible.

A-81. Engine seals and baffles should be checked to see that they are properly installed. Leakage through the seals will require excessive cowl flap opening with a resulting adverse effect upon range.

A-82. The curves of figure A-47 eliminate the need for finding the actual number of square feet of drag area change due to cooling variations by presenting weight adjustment versus cooling flap gap. If there are drag changes in addition to cooling drag, apply those weight adjustments first. Then enter the nautical mile per pound curve at the effective gross weight to obtain the recommended cowl flap gap.

A-83. Example Using figure A-47.
Assume the following conditions:
a. Actual gross weight = 125,000 pounds.

b. 20,000 feet altitude, four engines, auto-lean.
c. Cruise based on 99% maximum range speeds.
d. Recommended cowl flap gap, 0.8 inches (from figure A-56, entering at conditions 1 and 3).
e. Actual cowl flap gap = 1.5 inches.

From figure A-47 read:
600 pounds at 0.8 inch CFG
3200 pounds at 1.5 inch CFG

Then, weight adjustment = 3200 - 600 = 2600 pounds.

The effective weight is then 127,600 pounds. Use this weight as mentioned under "Effect of Drag Variations Other Than Cooling," paragraph A-75, remembering to use the actual gross weight to read the airspeeds.

A-84. CRUISE CONTROL CHARTS.

A-85. PRESENTATION OF CRUISE CONTROL INFORMATION. The cruise control data contained herein is presented in graphical form since experience has proven this presentation to be the most satisfactory for heavy multi-engine type airplanes. The main advantages thus realized are accuracy and continuity of the data with a better visualization of the relations of the various parameters involved.

A-86. The importance of maintaining the recommended cruise speeds and procedures for flying long range missions cannot be over emphasized. That being the case, the curves are invaluable since interpreting them is easily learned and they show so conclusively the tremendous loss of miles per pound of fuel when recommended speeds are not used.

A-87. NAUTICAL MILES PER POUND, TYPE A1 CURVES. These curves, figures A-48 through A-79, have been prepared for four, three and two engine operation. They are presented for auto-lean operation up to 2650 BHP per engine and from 1700 to 2650 BHP per engine in auto rich. The charts are based on standard day conditions from sea level to 30,000 feet altitude, and on the following maximum normal cylinder head temperatures:

232°C for all auto-lean operation up to 2650 BHP per engine.

232°C for all auto-rich operation up to 2250 BHP per engine.

250°C for all auto-rich operation above 2250 BHP per engine.

Lines of constant cowl flap gap are shown for cooling to these cylinder head temperatures with standard day conditions.

A-88. Recommendations as to head temperatures and cowl flap operation are noted previously in paragraph A-50. Use of these recommendations results in cowl flap settings approximately one-half inch greater than that shown on the curves. This results in a loss in range of about 1% for cruising at 15,000 feet and 2%, for cruising at 25,000 feet using cruise powers up to 1750 BHP during standard day operation.

A-89. Note on these charts that the low speed end of the weight lines becomes parallel to the neighboring power lines. The speed at which this occurs is the minimum fuel consumption (maximum endurance) speed and is therefore a good speed for loitering at a rendezvous.

CAUTION

Never allow airspeed to drop below that for minimum fuel consumption (approximately 20 percent above stall speed) when the wing flaps are up. Flight below this speed requires additional power, is difficult to fly, and will subject the airplane to inadvertent stalls when turning or in rough air.

A-90. The type A1 curves are presented to furnish a source of general cruise information such as discussed above. They are also the basis for the long range summary curves (type A2) and long range prediction curves (types A3D and A3T) which are much more convenient for mission planning. Nautical miles has been used as the primary scale on all curves involving distance, since this is the unit used for navigation and flight planning.

A-91. Airspeeds on the cruise charts are in miles per hour to correspond to the airspeed indicator scales. However, chart speeds are equivalent airspeeds and the instrument can show only indicated airspeed directly.

A-92. Since equivalent airspeed is indicated airspeed corrected for instrument error, position error and compressibility error, it is necessary to remove these corrections from the chart equivalent airspeeds to get the proper indicated airspeed readings at which to fly. Note that this is the reverse of the procedure normally used and illustrated under "Airspeed Altimeter and Outside Temperature Indicator Corrections," paragraph A-1, and exercise extreme care in the use of ± signs. The following example illustrates the procedures to get from equivalent airspeed to indicated airspeed. Assume:

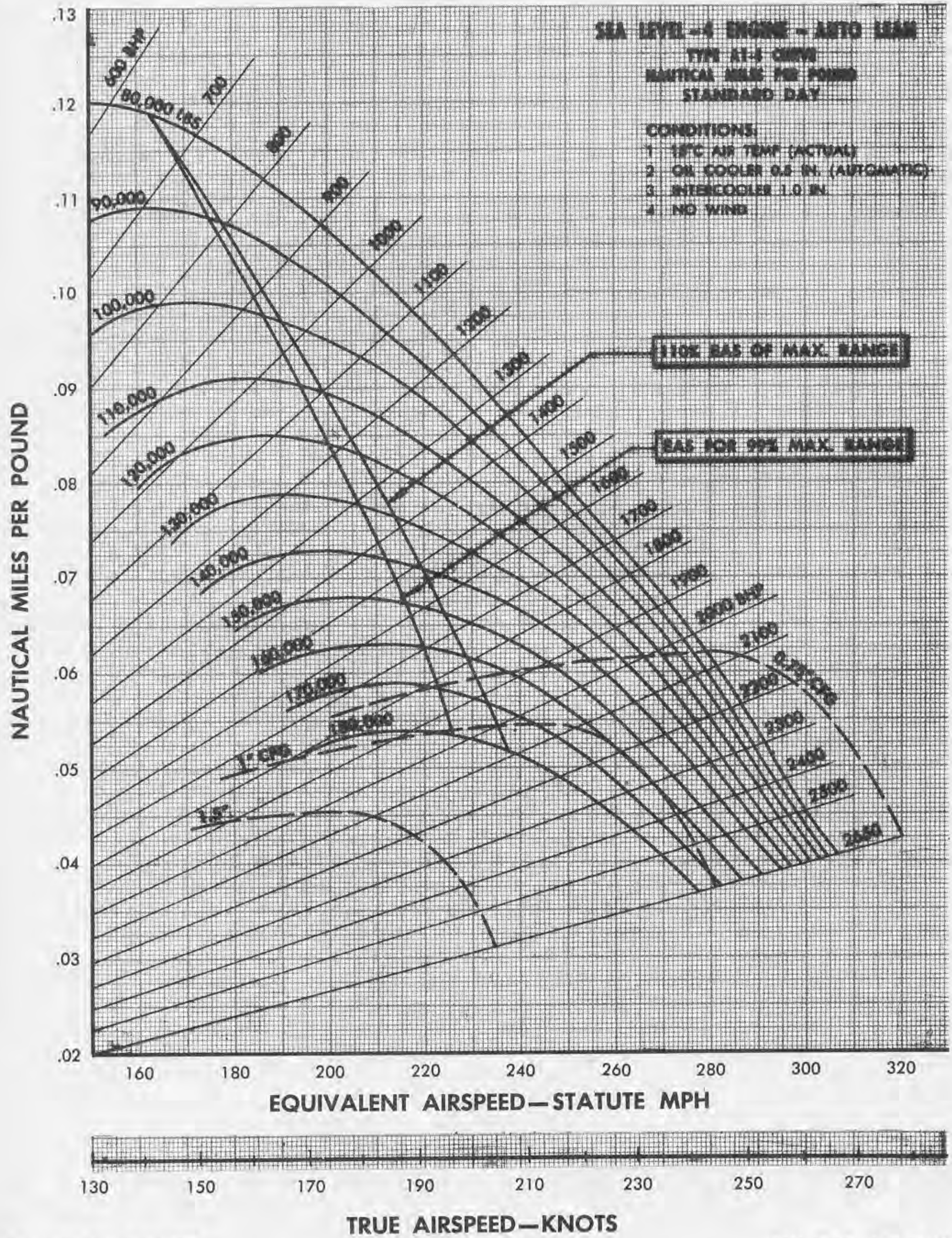
EAS	200 MPH
Gross Weight	125,000 pounds
Altitude	20,000 feet

Then, Compressibility Correction from figure A-7 = -2 MPH
Position Correction from figure A-3 = +3.5 MPH
Instrument Correction (assumed) = +2.5 MPH

EAS		Comp. Corr.		Pos. Corr.		Inst. Corr.	
200	+	2	-	3.5	-	2.5	= 196 MPH

A-93. The air temperatures noted on these miles per pound charts are free-air temperatures. These temperatures correspond to those which would be obtained from the airplane temperature gages after the readings are corrected for any instrument errors and for compressibility errors. Outside air temperature gages on airplanes usually indicate temperatures too high due to the speed of the air hitting the bulb. Indicated temperature readings must be corrected for this temperature rise due to compressibility. Temperature correction for compressibility is shown in figure A-8.

022251

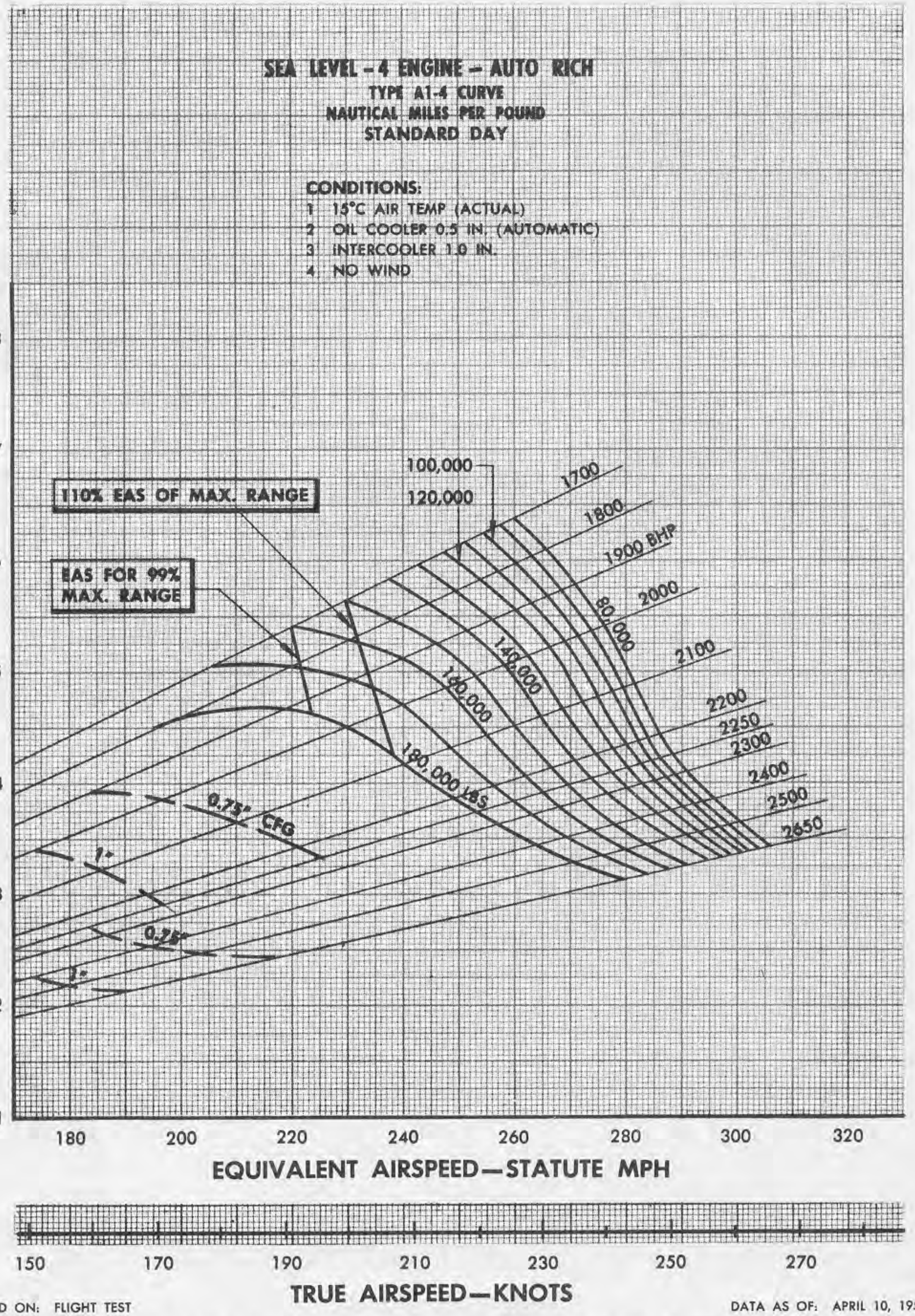


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-48. Nautical Miles per Pound, 4 Engine, Auto Lean, Sea Level

022252

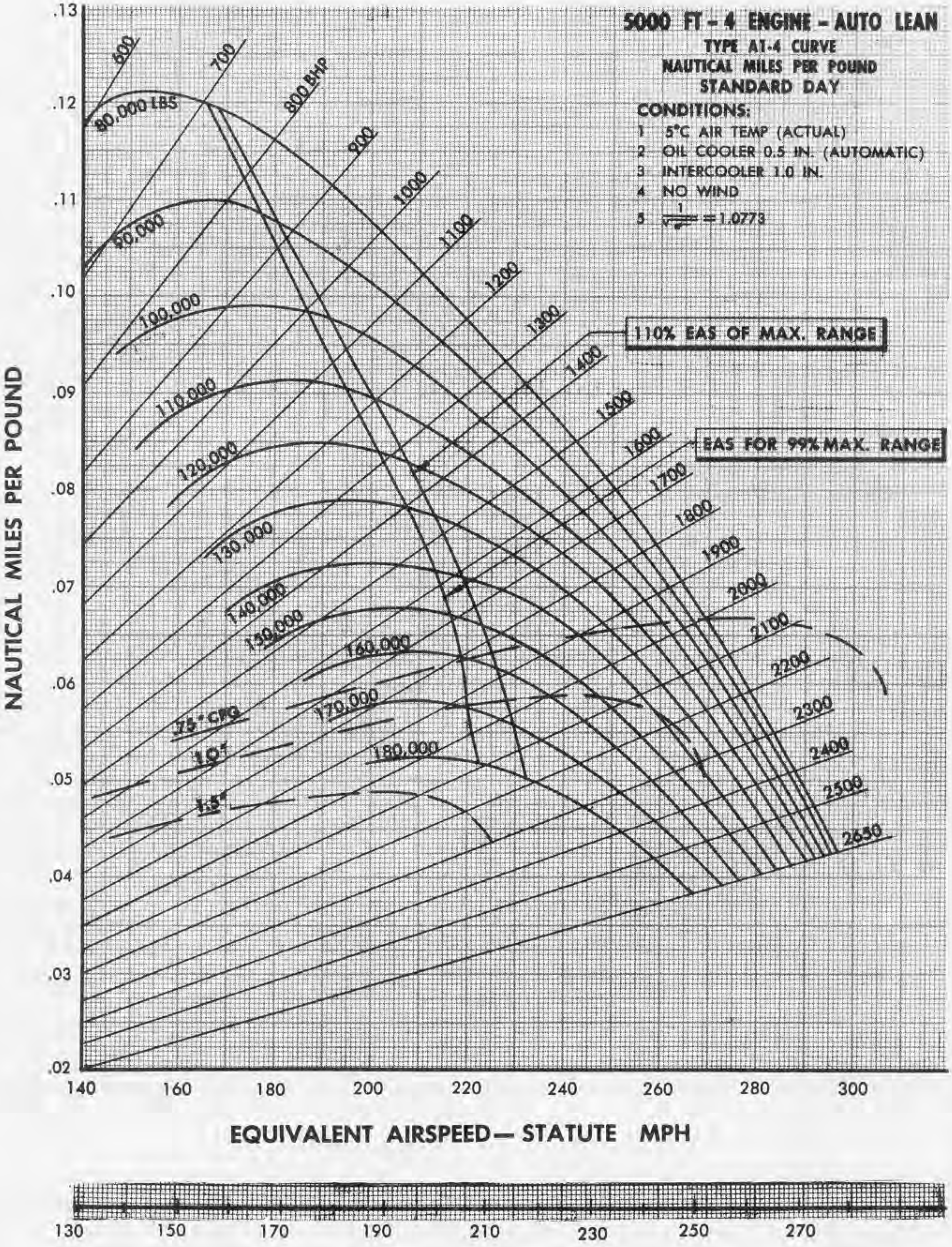


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-49. Nautical Miles per Pound, 4 Engine, Auto Rich, Sea Level

022253

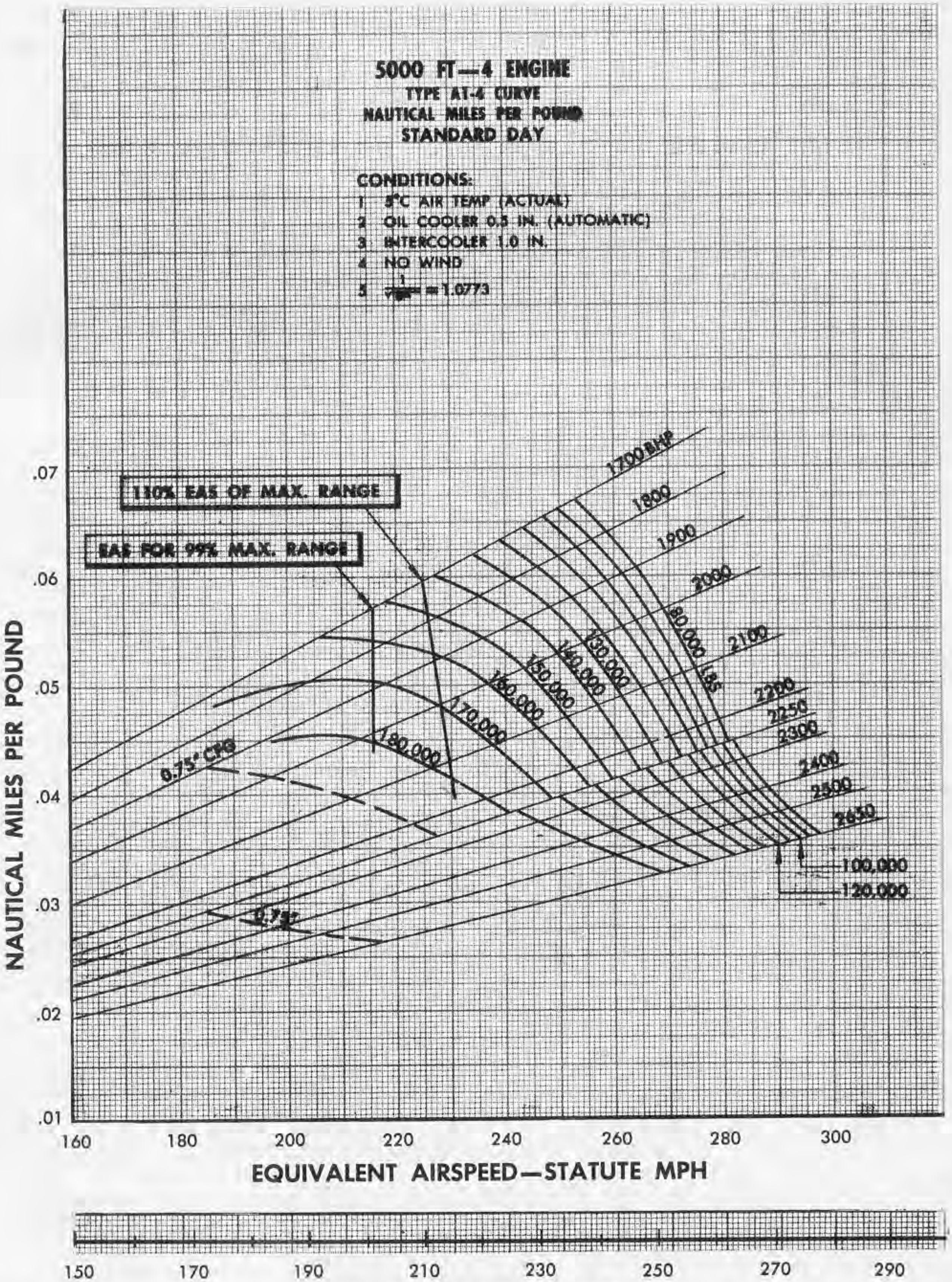


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-50. Nautical Miles per Pound, 4 Engine, Auto Lean, 5000 Ft.

022254

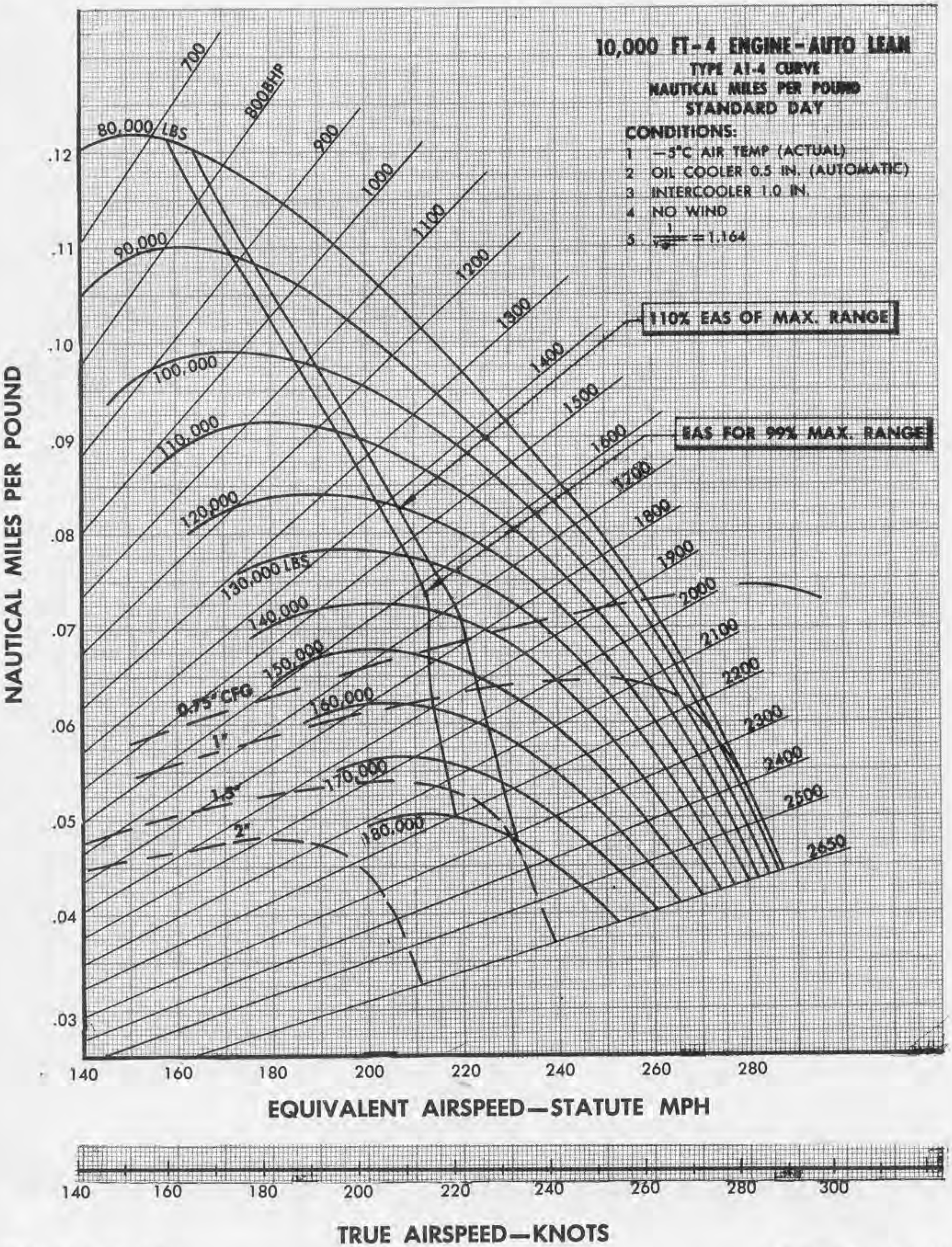


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-51. Nautical Miles per Pound, 4 Engine, Auto Rich, 5000 Ft.

022255

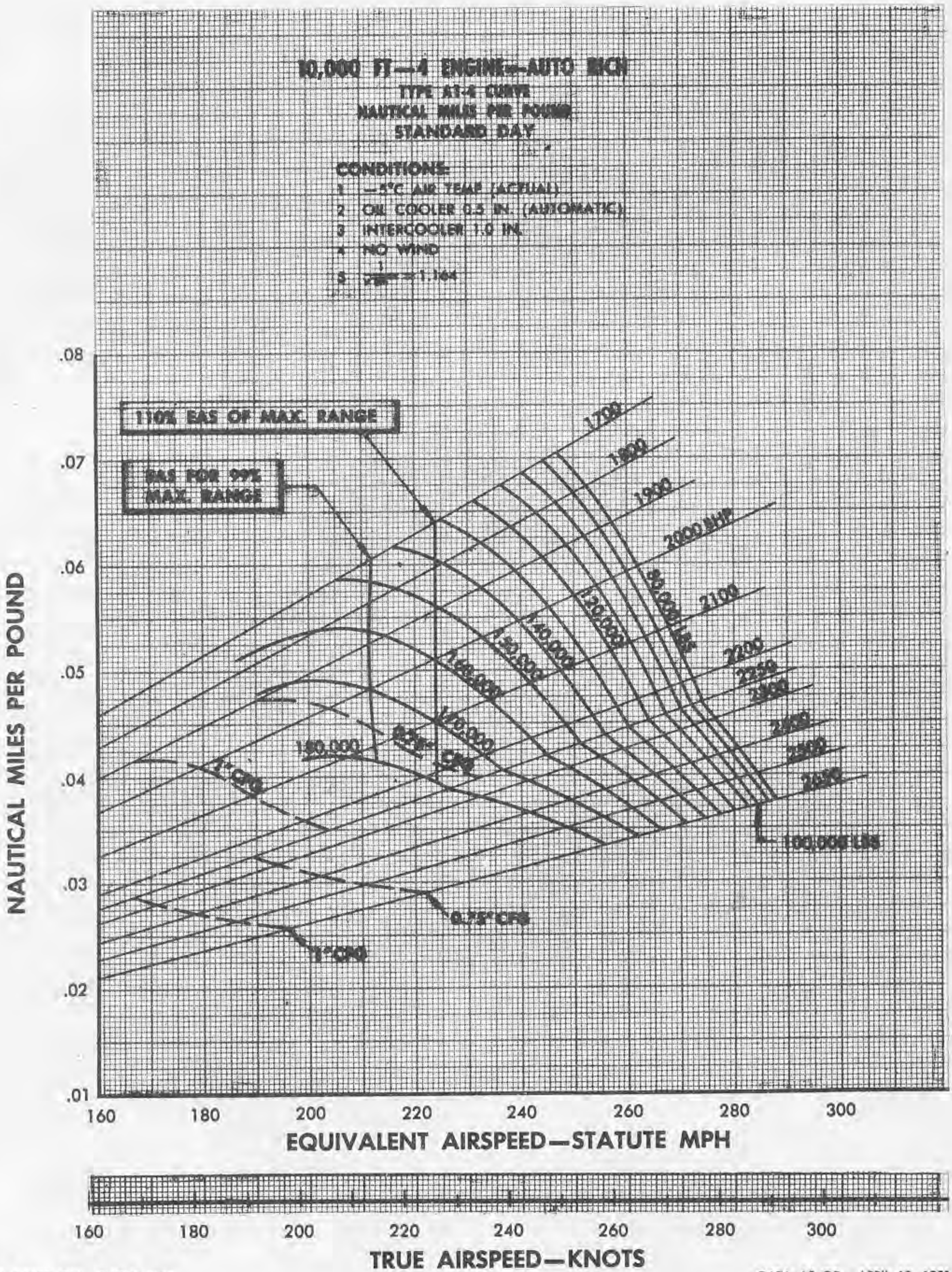


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-52. Nautical Miles per Pound, 4 Engine, Auto Lean 10,000 Ft.

022256

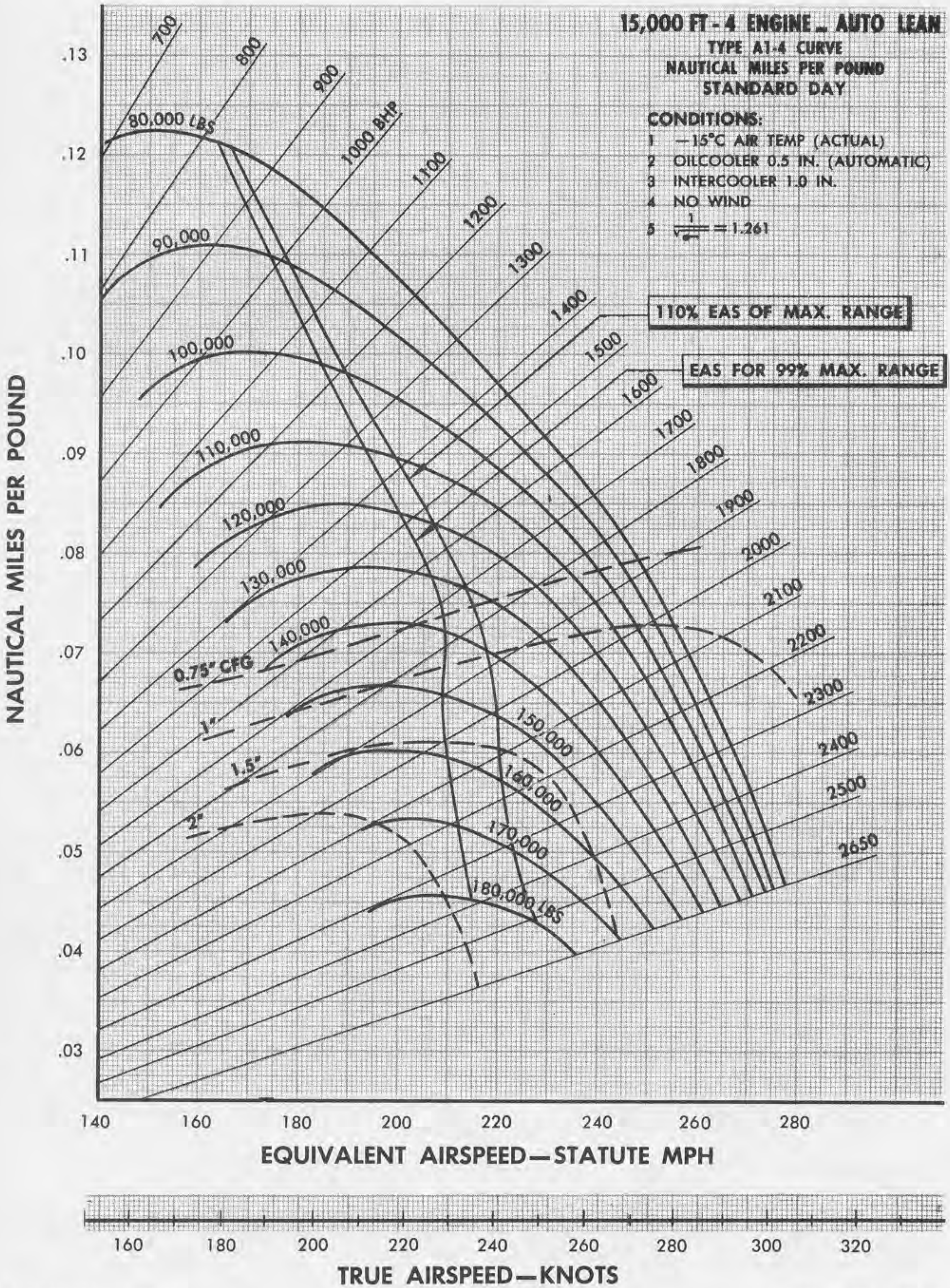


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-53. Nautical Miles per Pound, 4 Engine, Auto Rich, 10,000 Ft.

022257

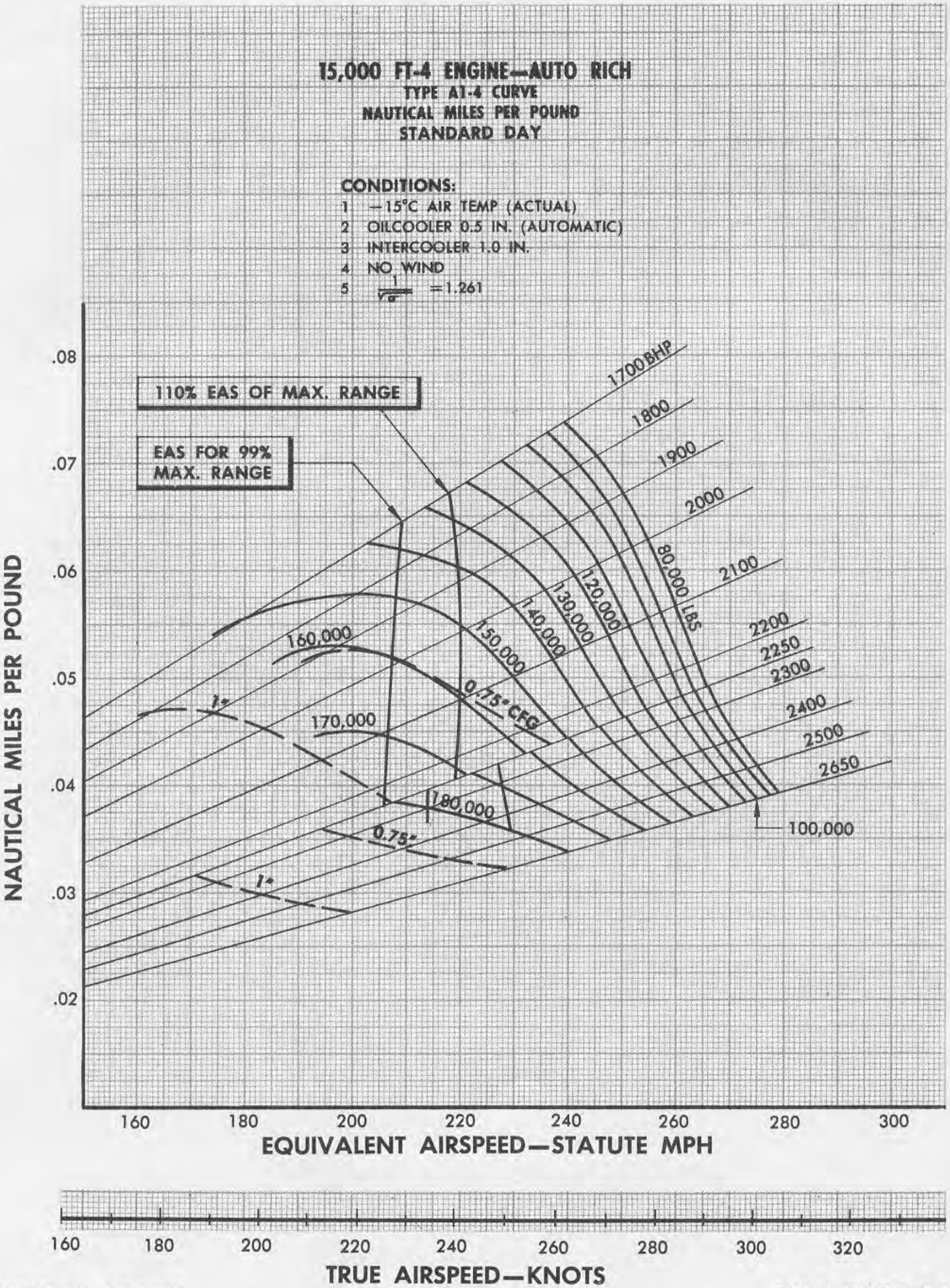


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-54. Nautical Miles per Pound, 4 Engine, Auto Lean 15,000 Ft.

022258

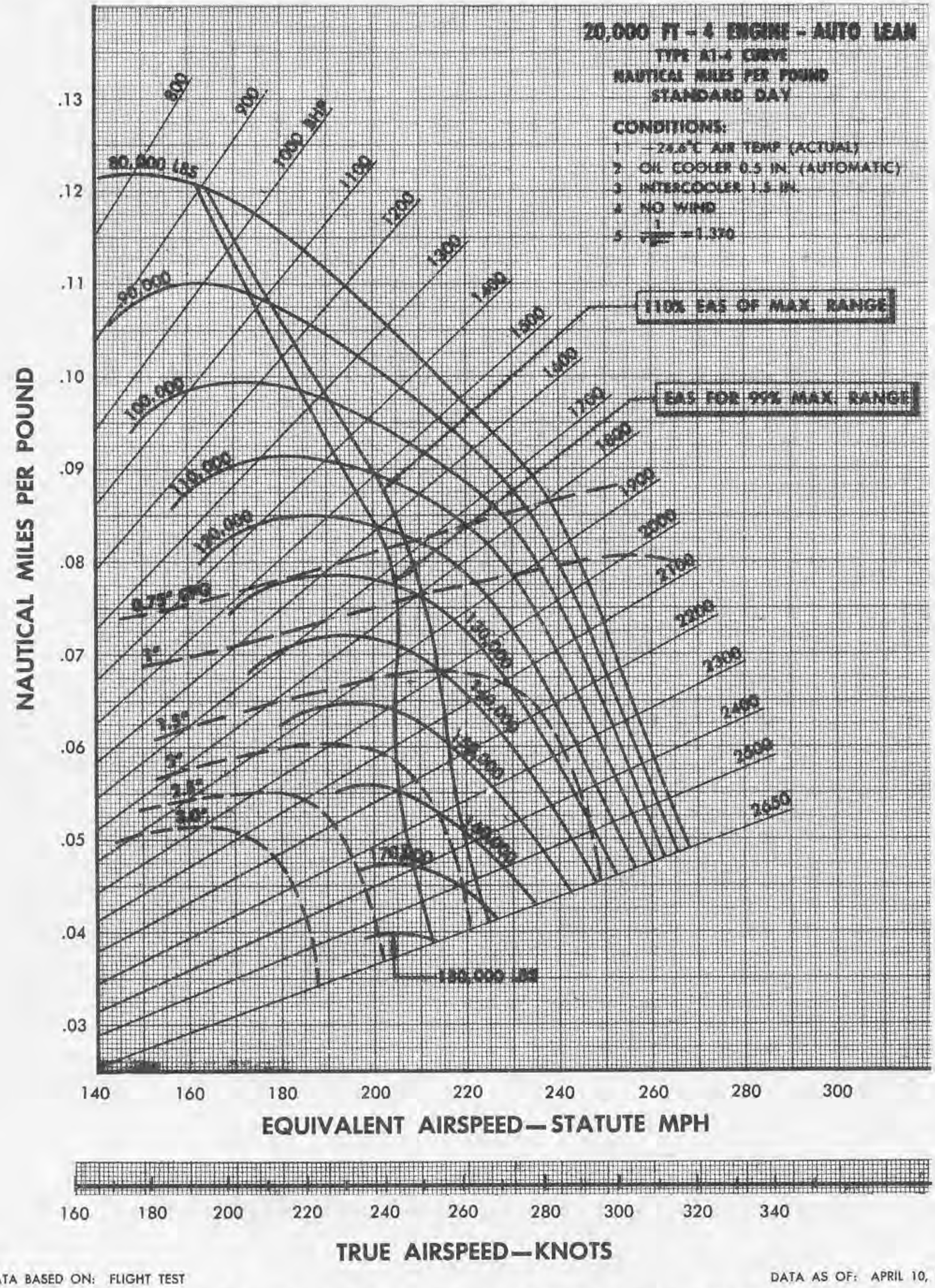


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-55. Nautical Miles per Pound, 4 Engine, Auto Rich 15,000 Ft.

022259

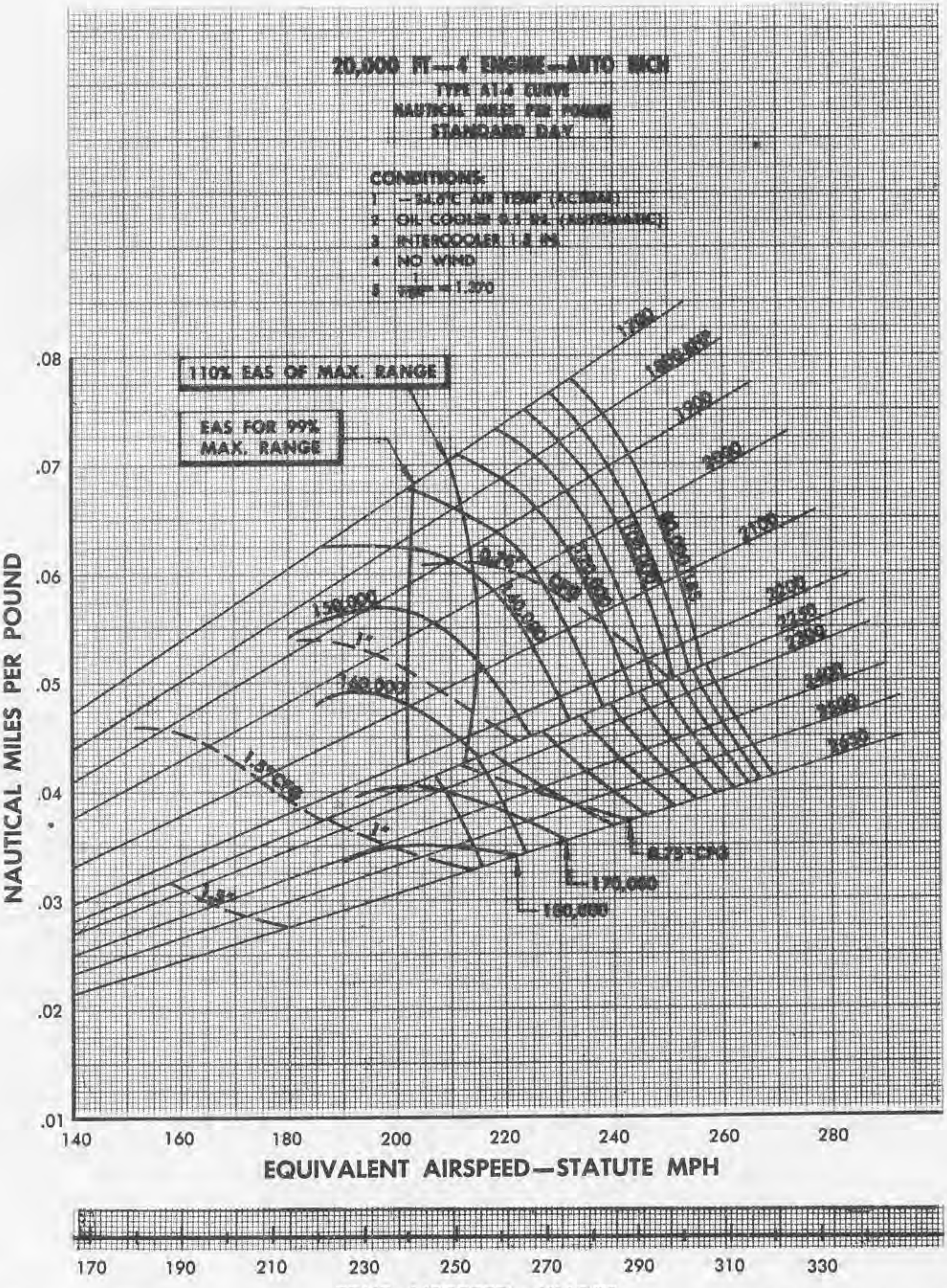


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-56. Nautical Miles per Pound, 4 Engine, Auto Lean, 20,000 Ft.

022260

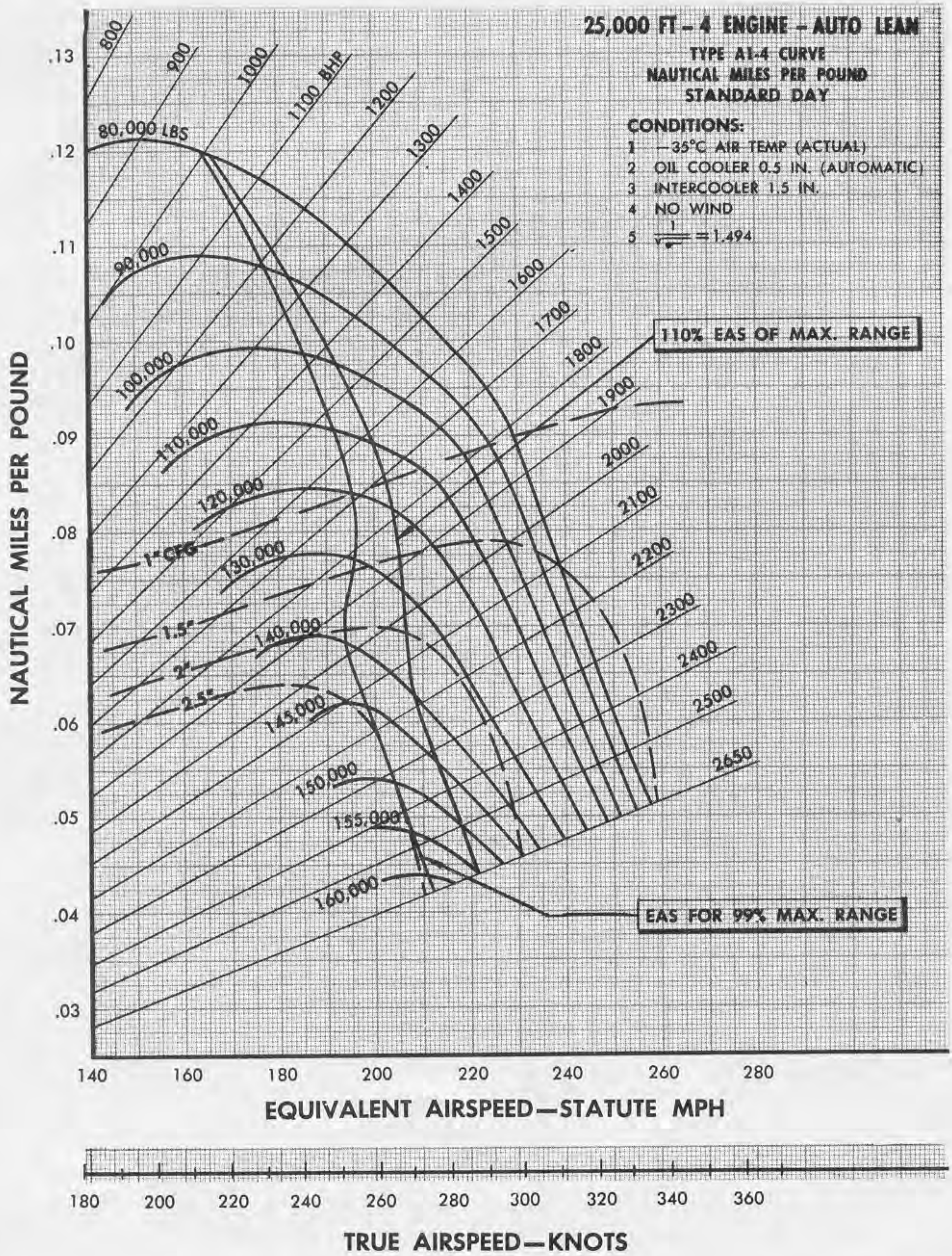


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-57. Nautical Miles per Pound, 4 Engine, Auto Rich, 20,000 Ft.

022261

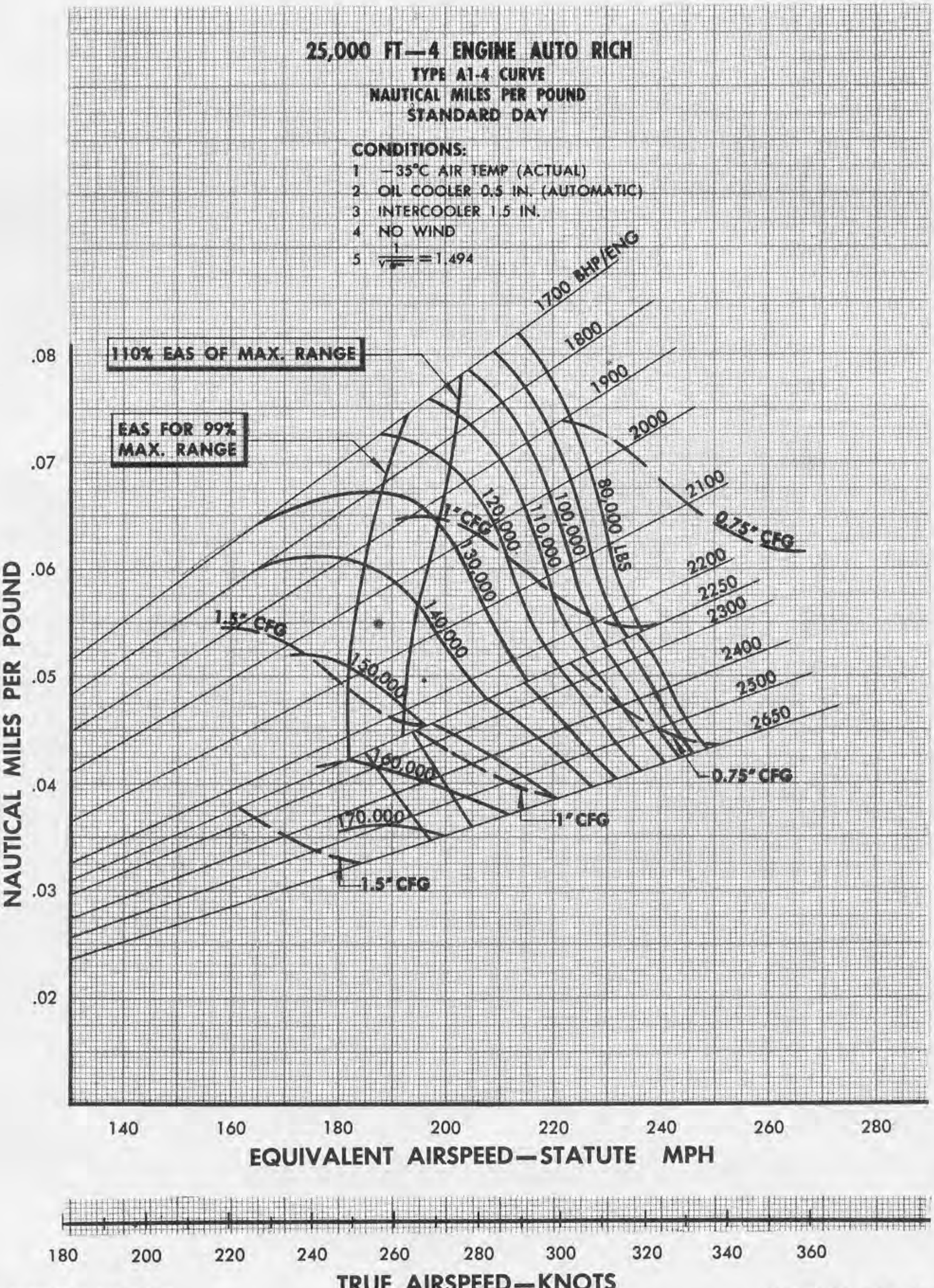


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-58. Nautical Miles per Pound, 4 Engine, Auto Lean 25,000 Ft.

022262

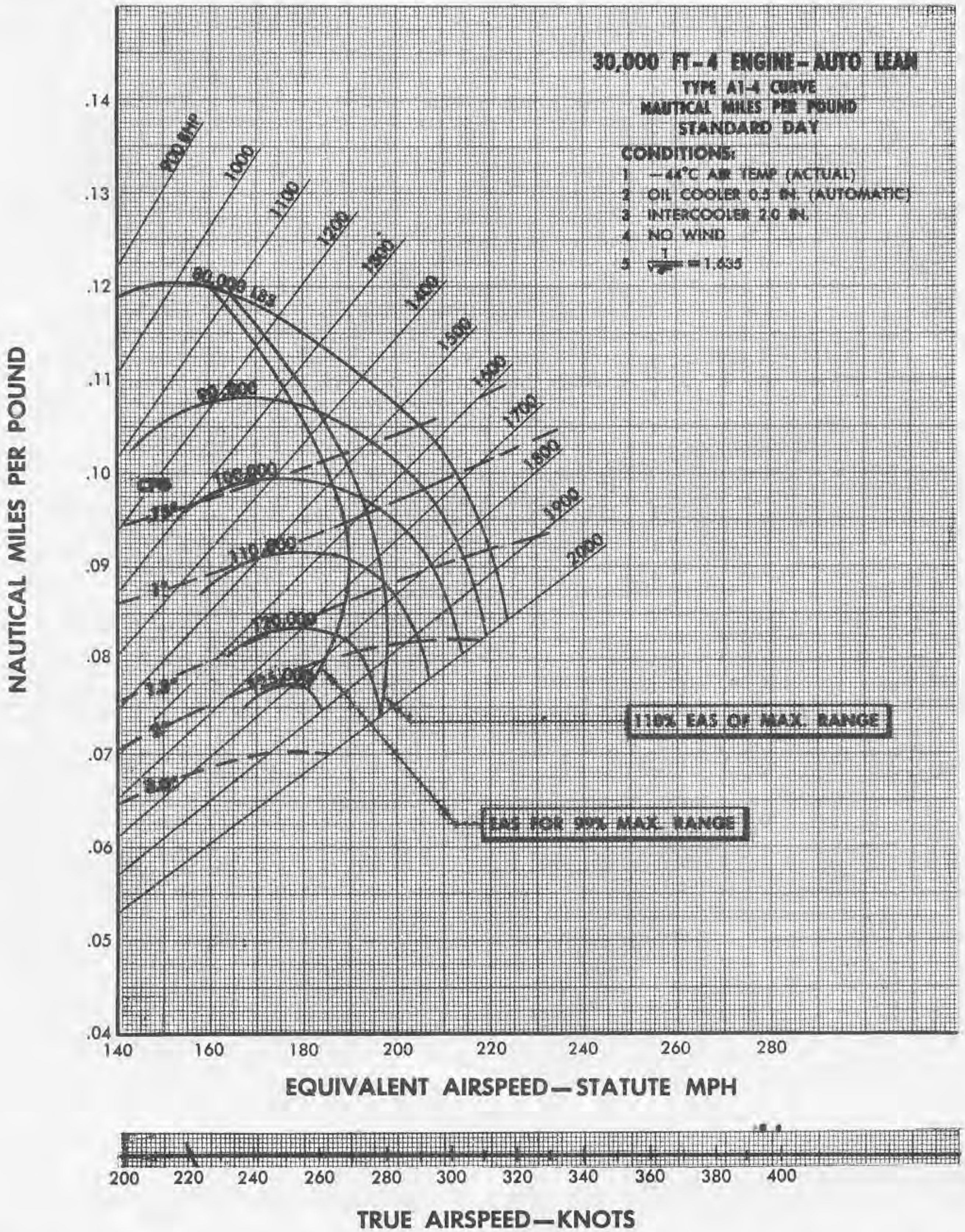


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-59. Nautical Miles per Pound, 4 Engine, Auto Rich, 25,000 Ft.

022263

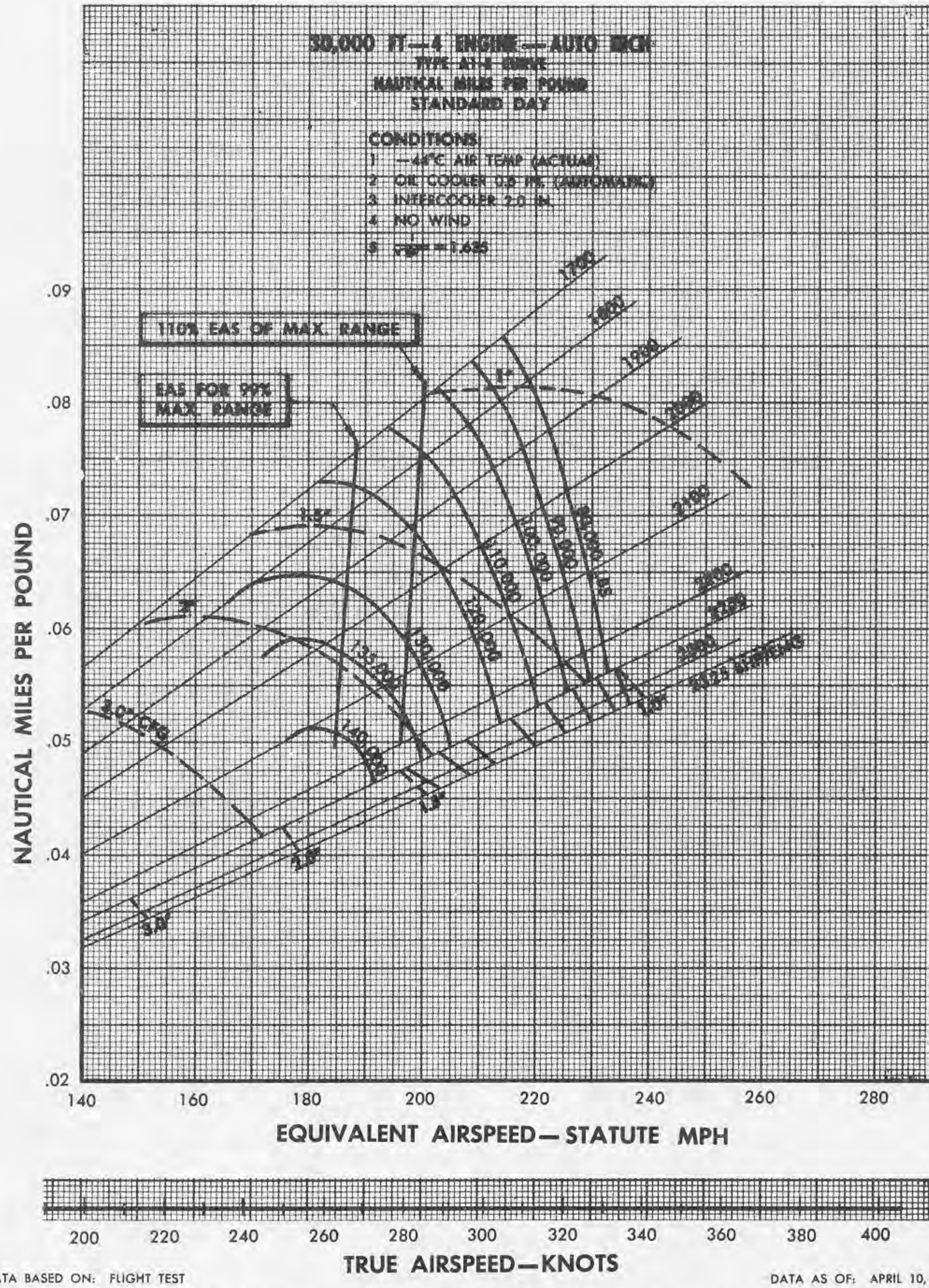


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-60. Nautical Miles per Pound, 4 Engine, Auto Lean 30,000 Ft.

022264

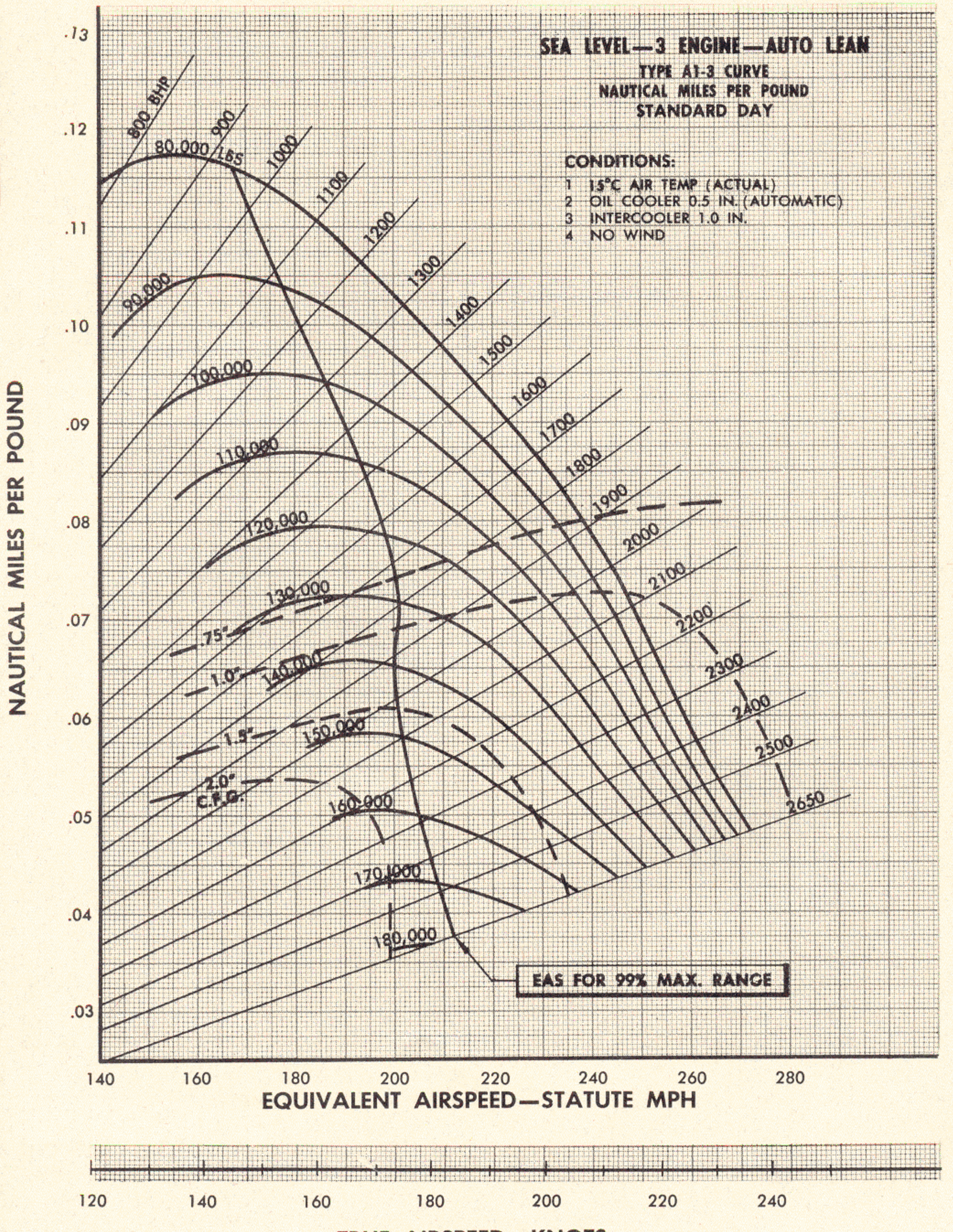


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-61. Nautical Miles per Pound, 4 Engine, Auto Rich 30,000 Ft.

022265

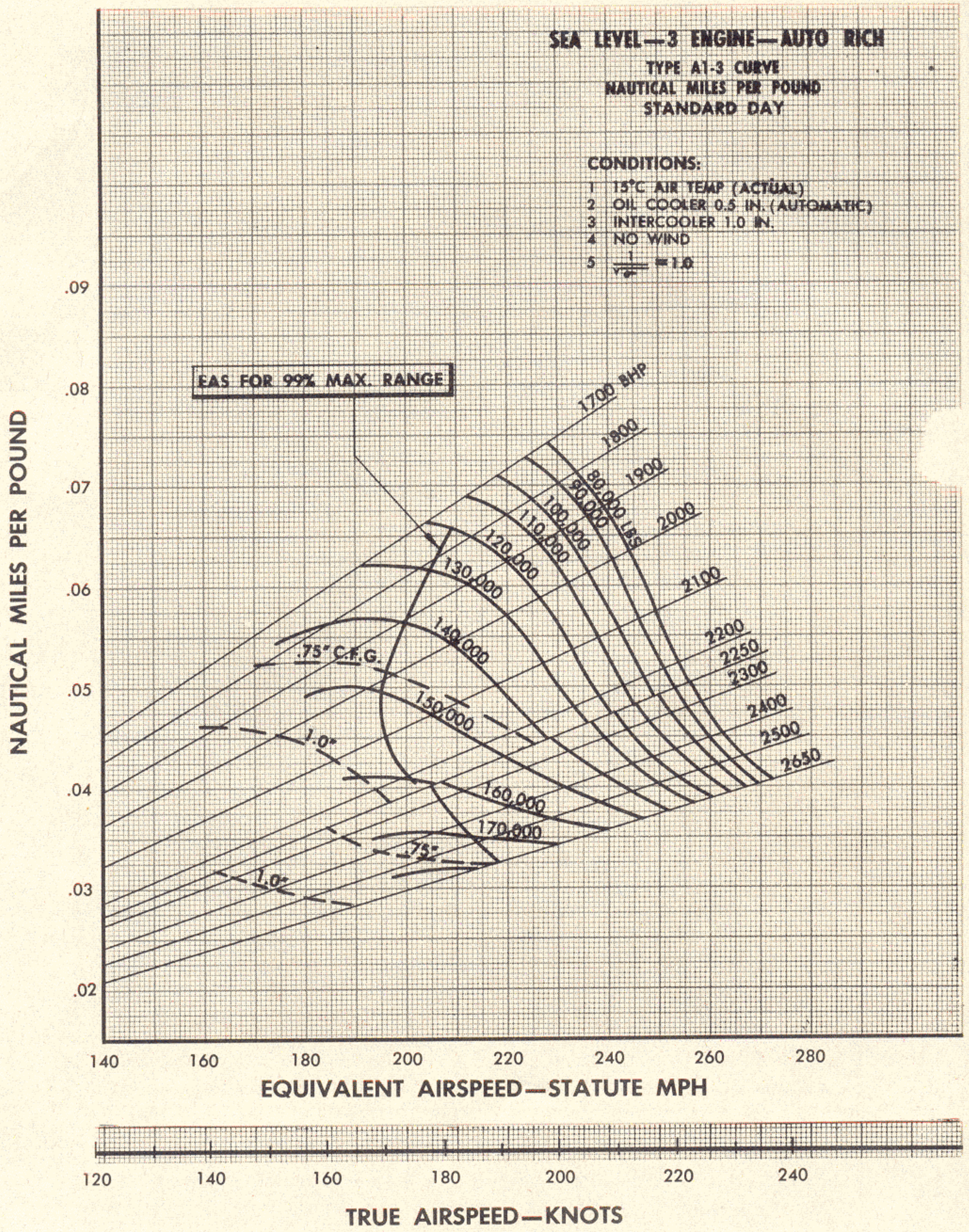


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-62. Nautical Miles per Pound, 3 Engine, Auto Lean, Sea Level

022266

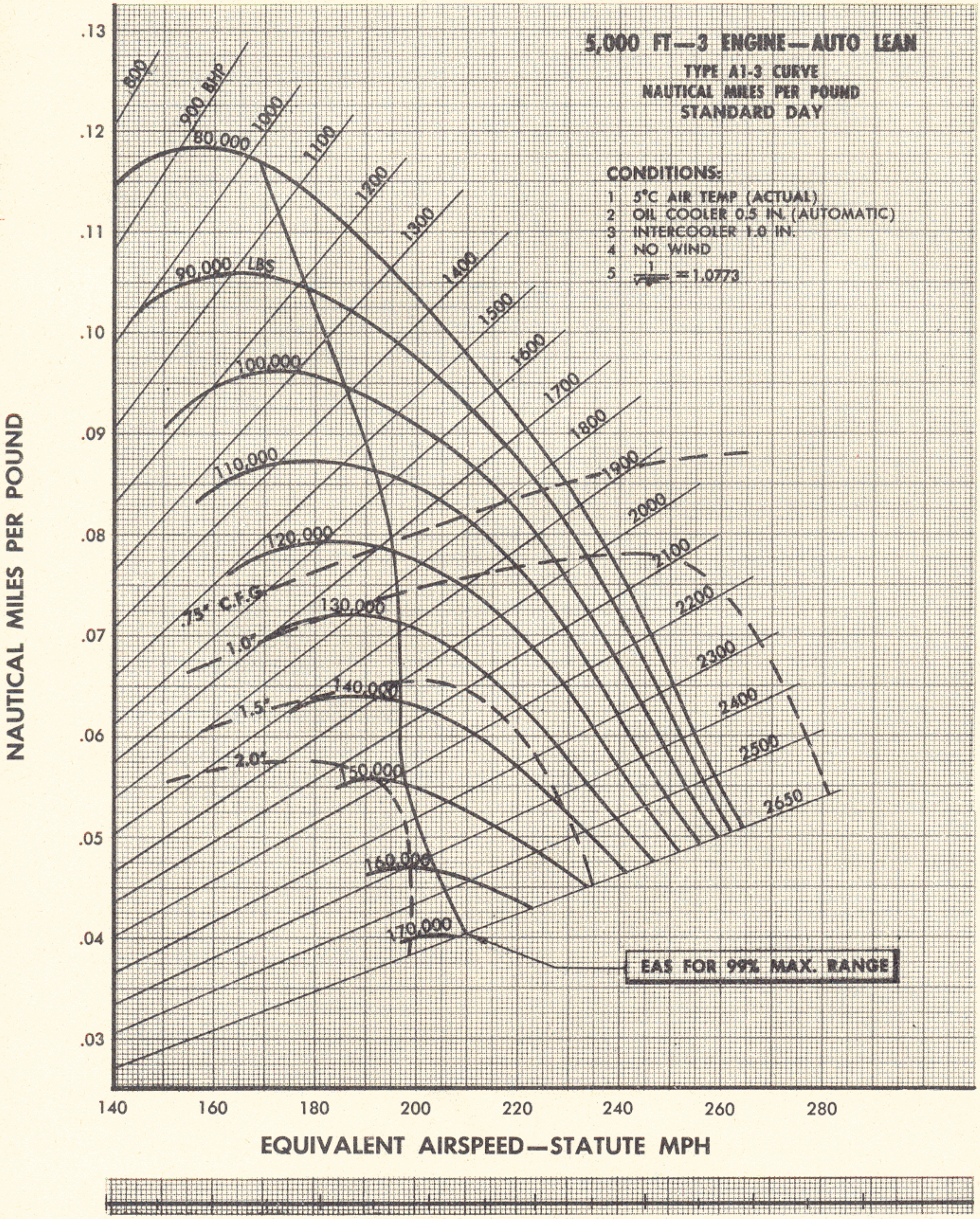


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-63. Nautical Miles per Pound, 3 Engine, Auto Rich, Sea Level

022267

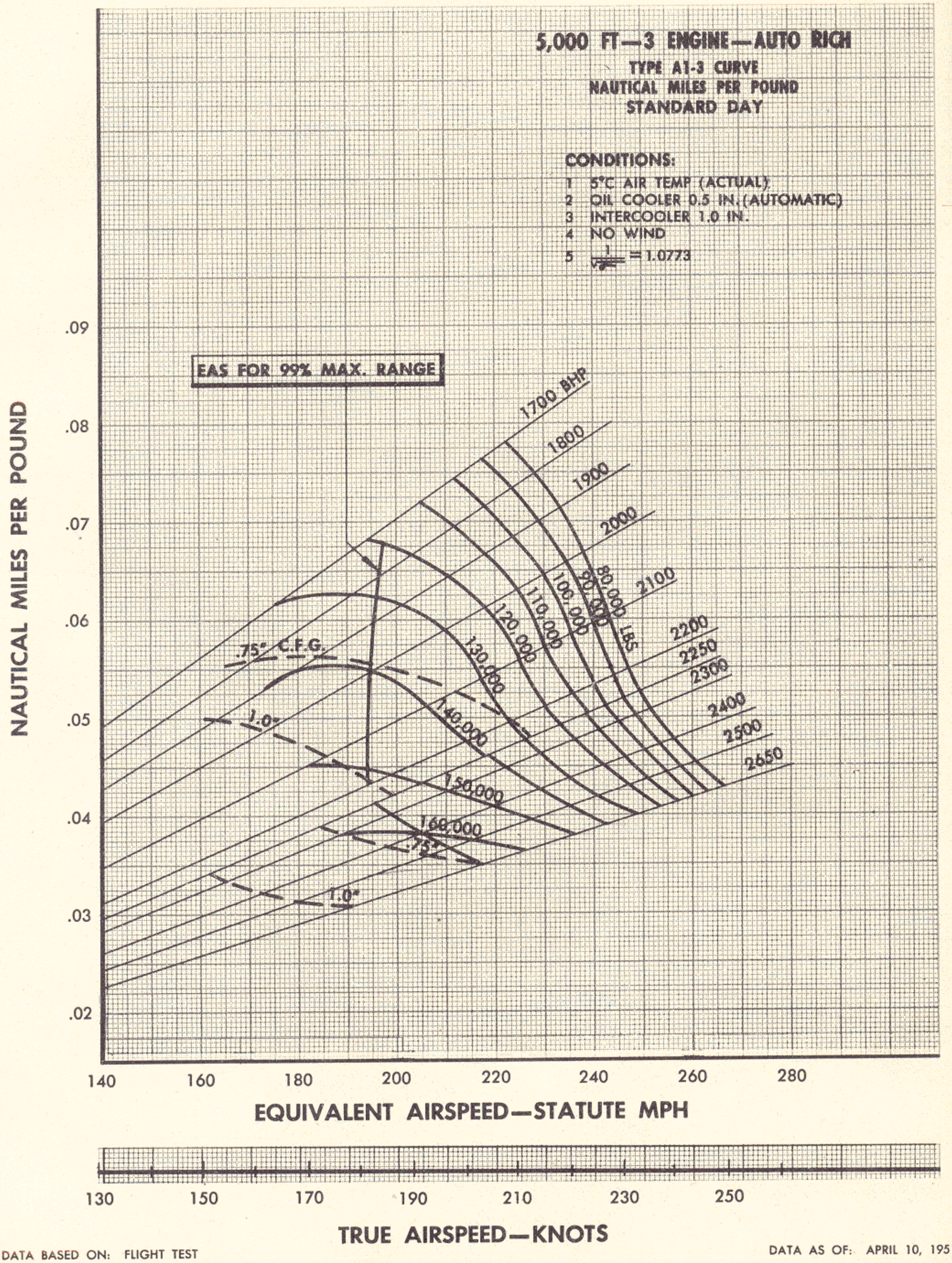


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-64. Nautical Miles per Pound, 3 Engine, Auto Lean 5000 Ft.

022268

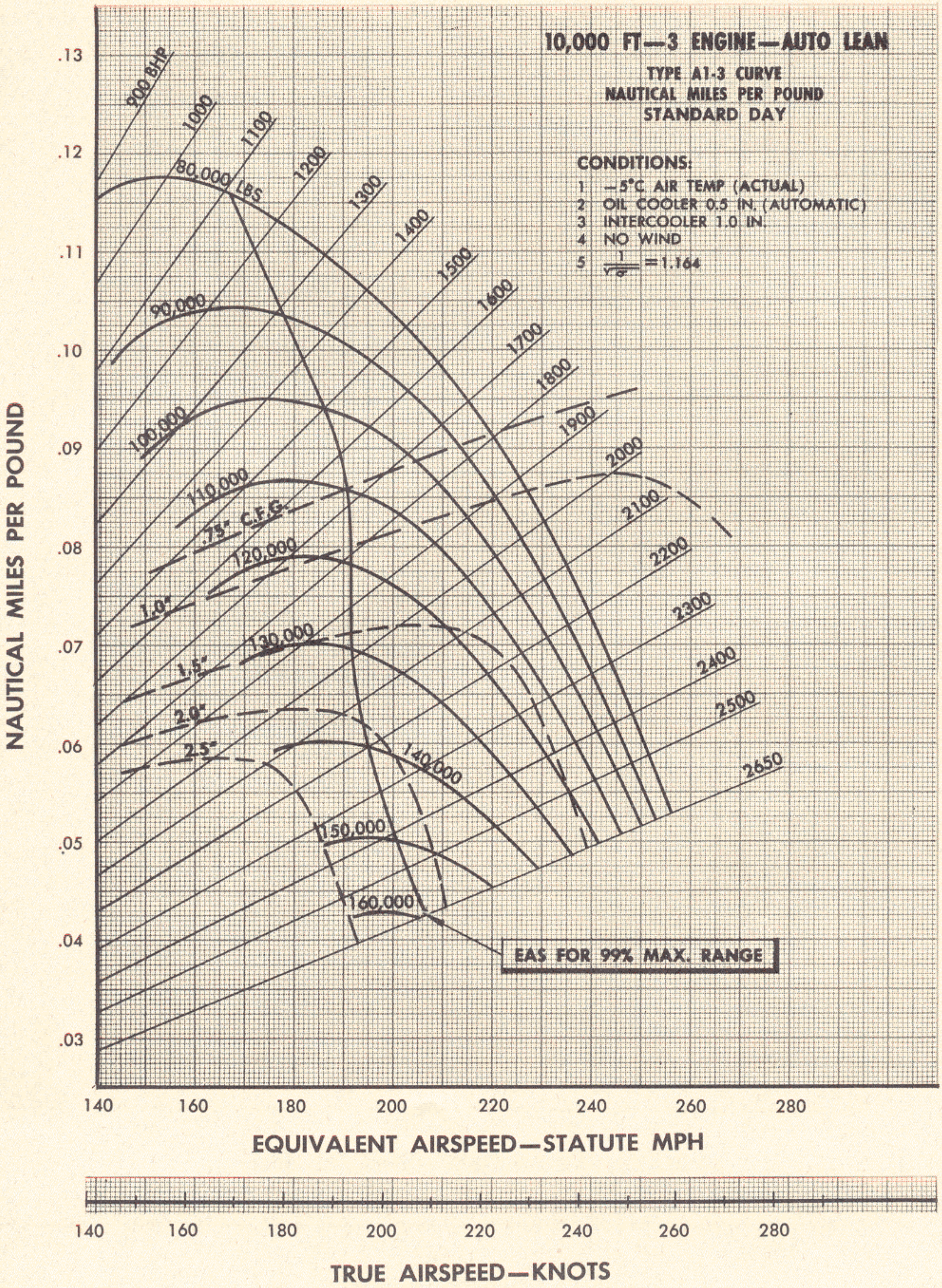


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-65. Nautical Miles per Pound, 3 Engine, Auto Rich, 5000 Ft.

022269

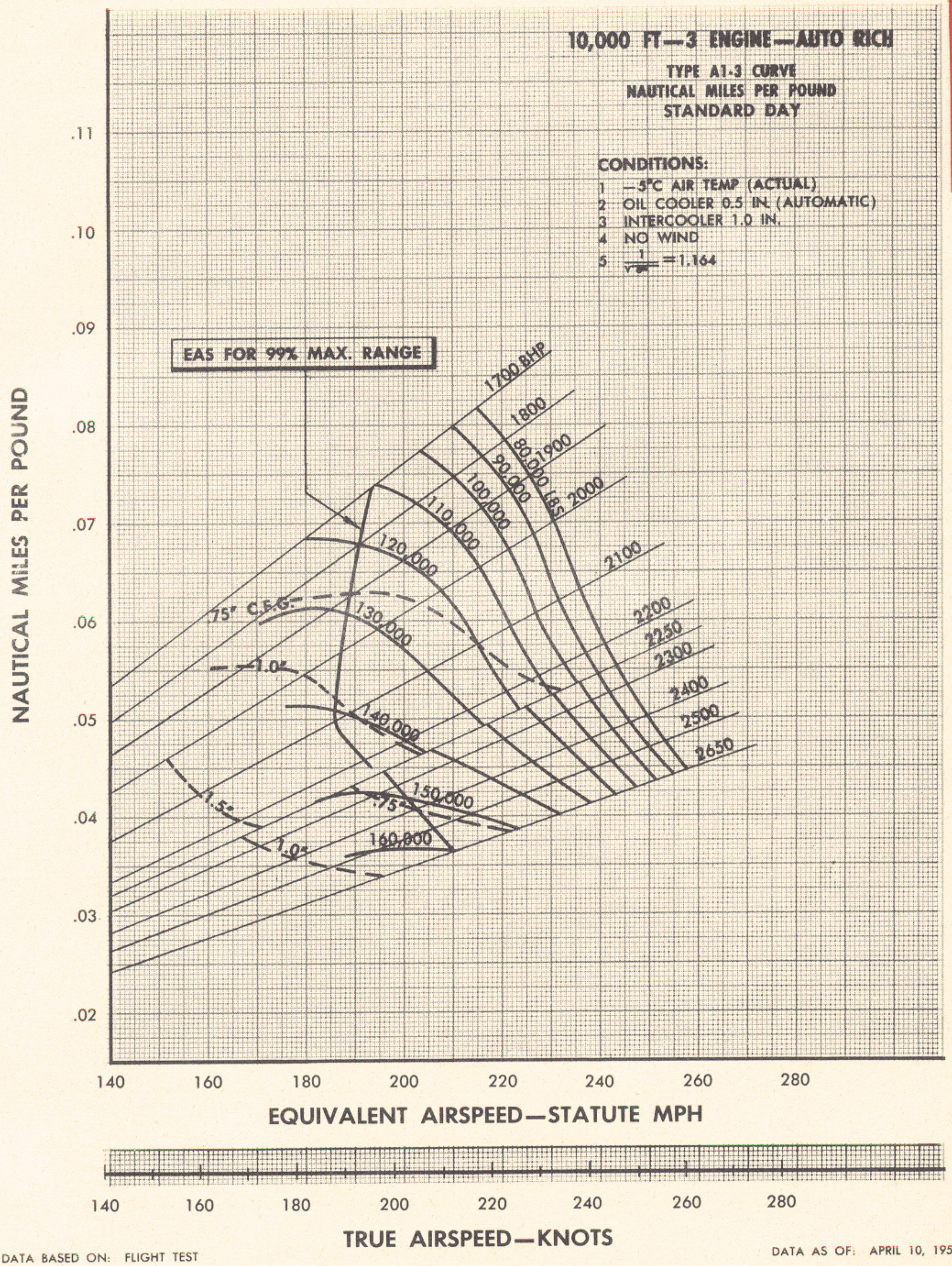


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-66. Nautical Miles per Pound, 3 Engine, Auto Lean 10,000 Ft.

022270

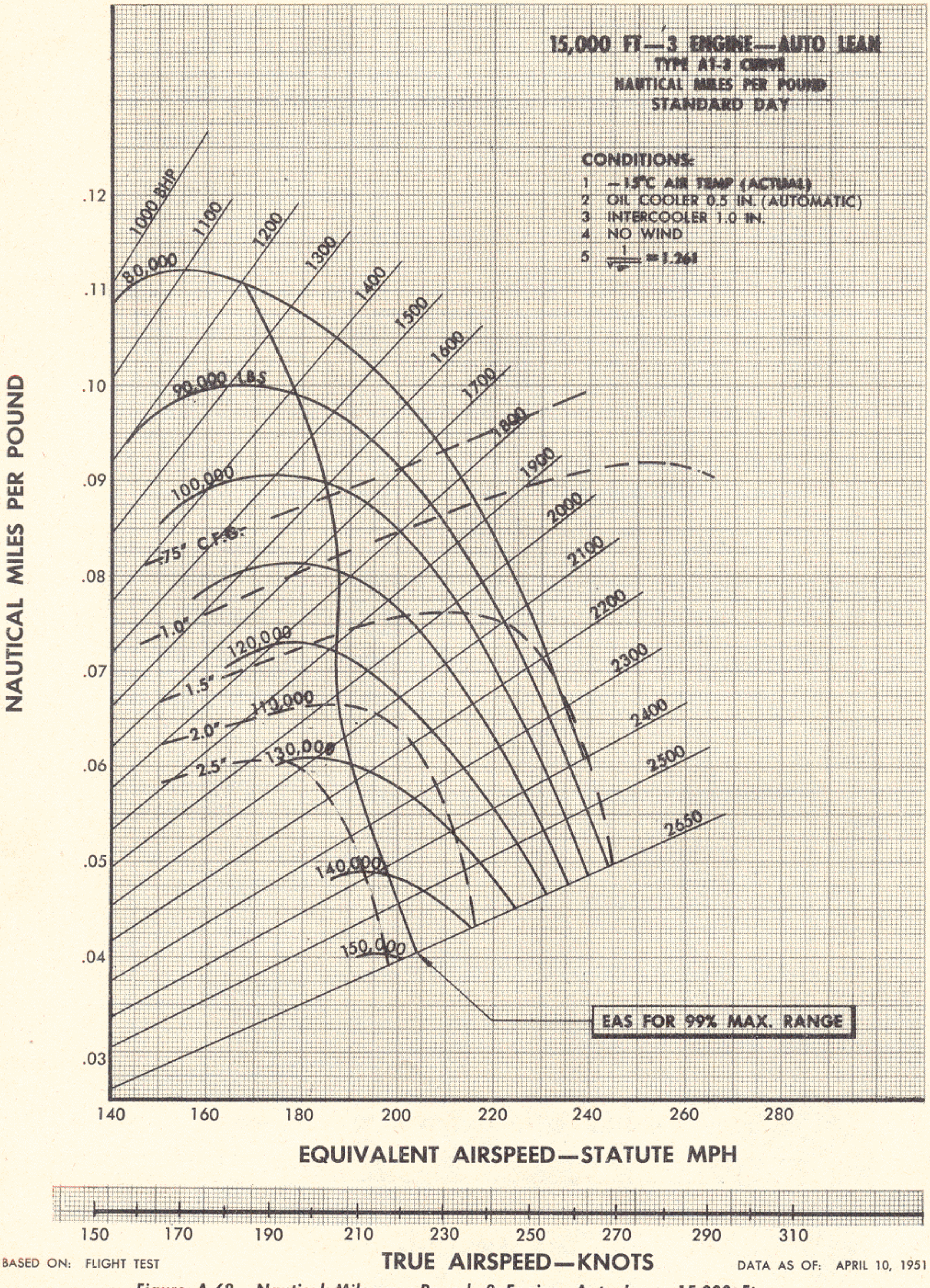


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-67. Nautical Miles per Pound, 3 Engine, Auto Rich 10,000 Ft.

022271

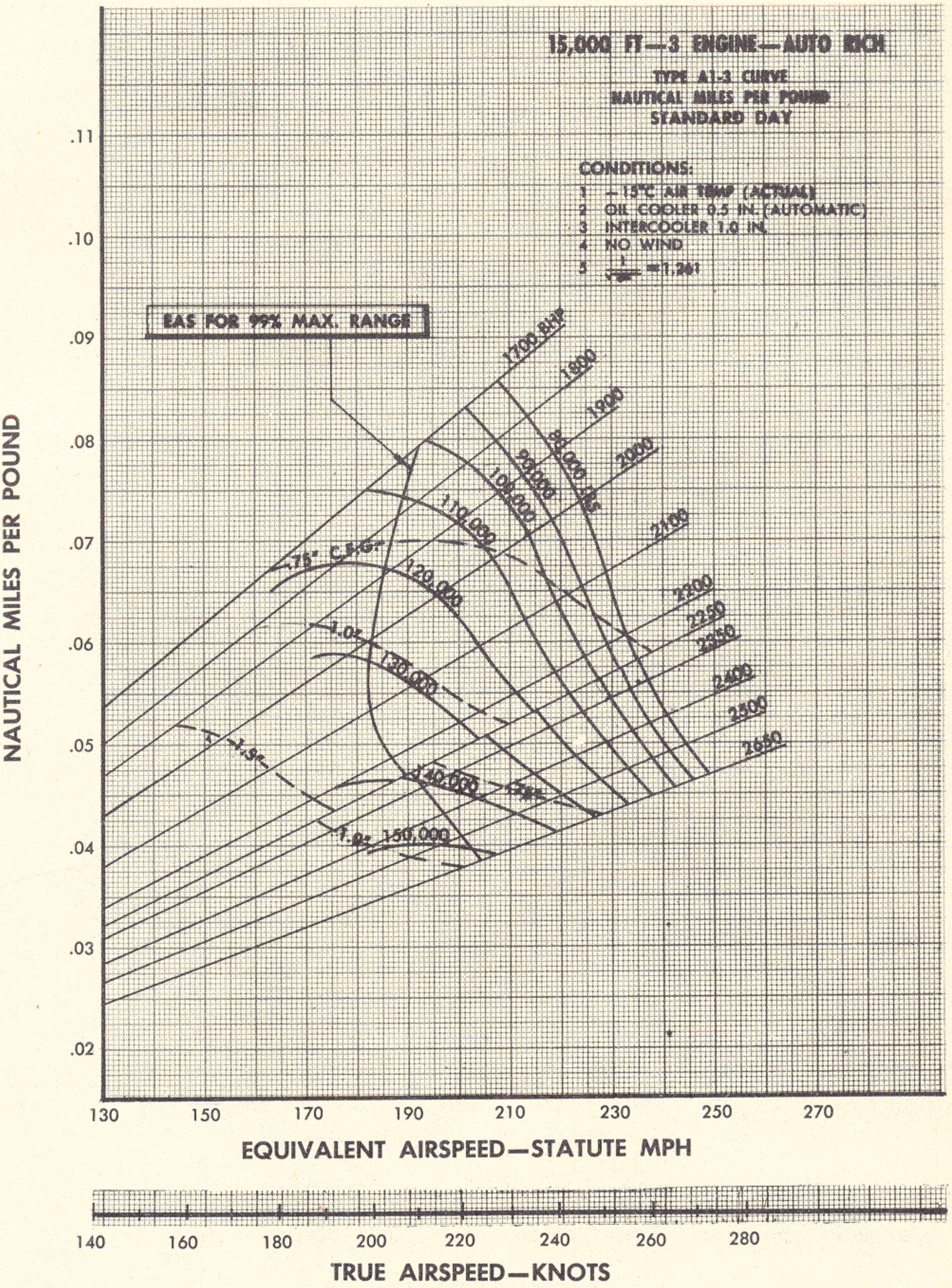


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-68. Nautical Miles per Pound, 3 Engine, Auto Lean, 15,000 Ft.

022272

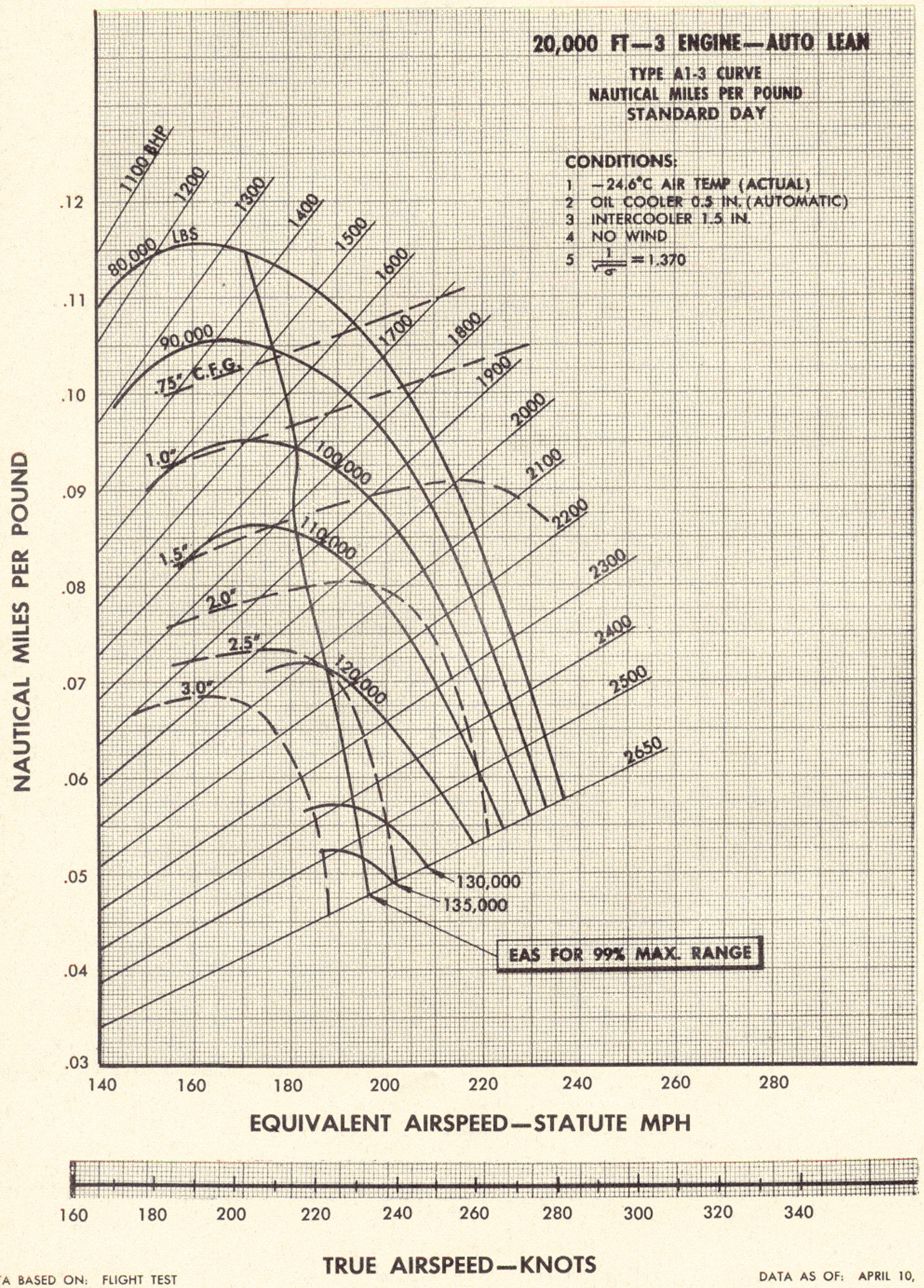


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-69. Nautical Miles per Pound, 3 Engine, Auto Rich, 15,000 Ft,

022273

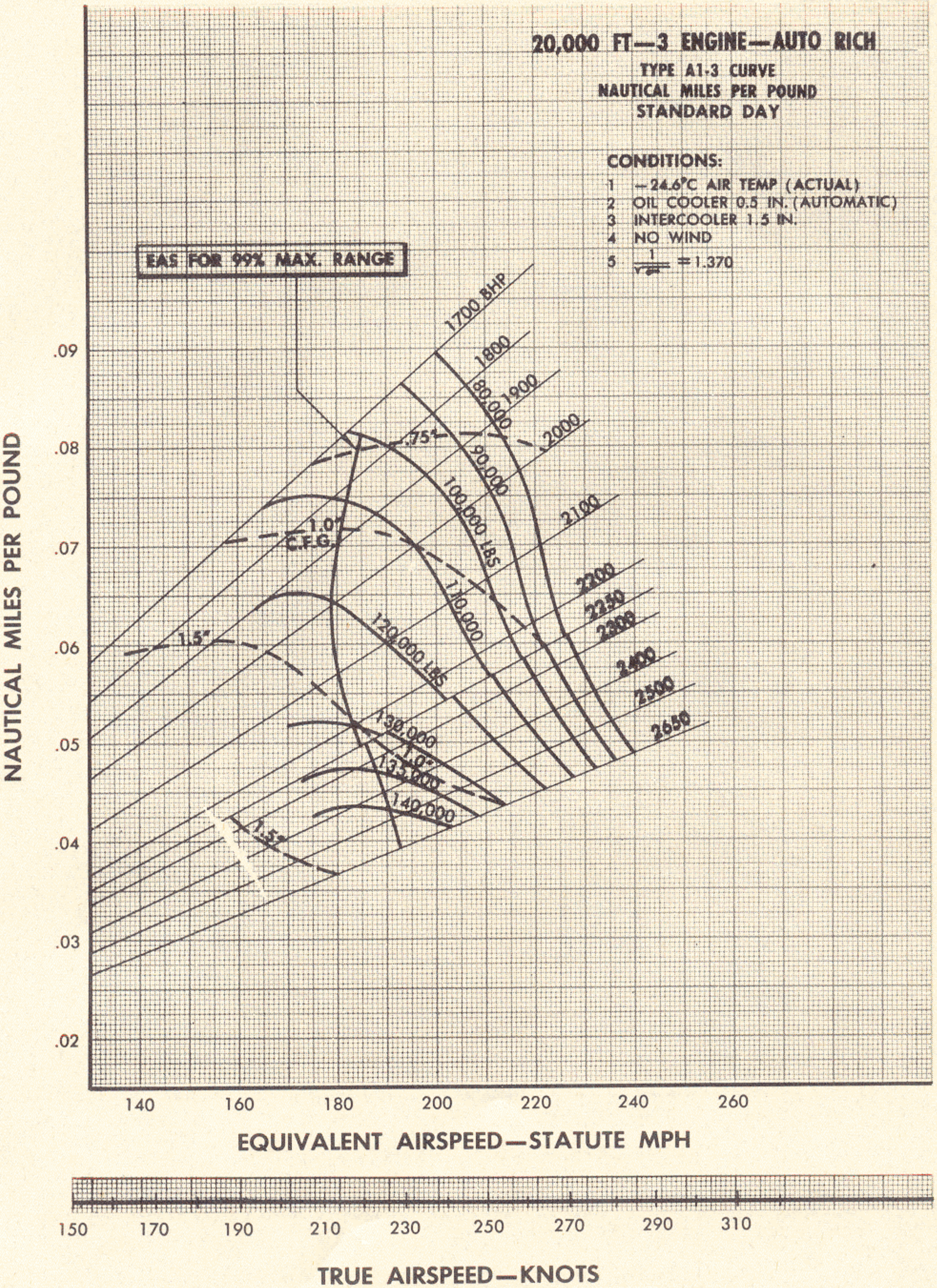


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-70. Nautical Miles per Pound, 3 Engine, Auto Lean, 20,000 Ft.

022274

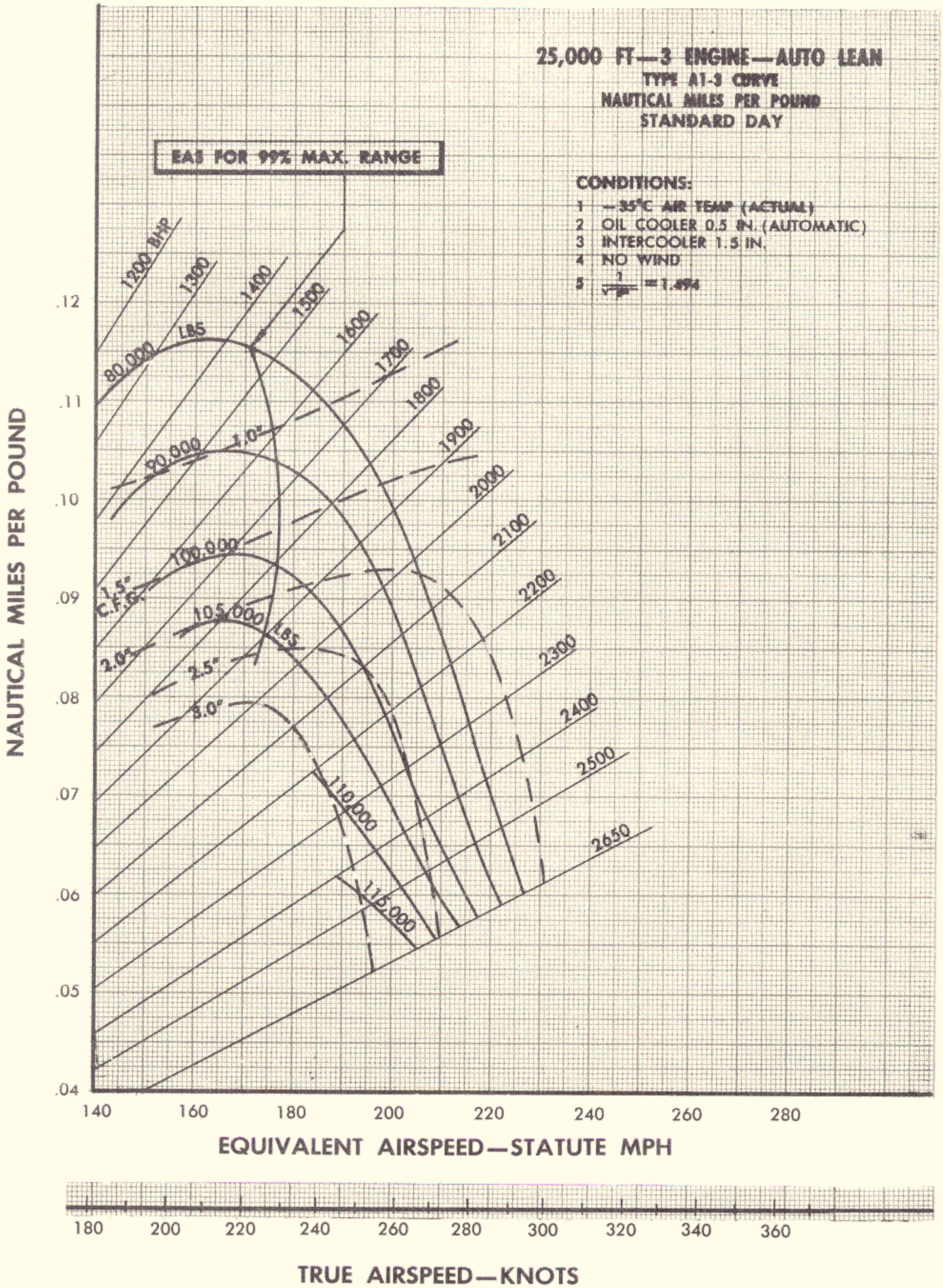


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-71. Nautical Miles per Pound, 3 Engine, Auto Rich, 20,000 Ft.

022275

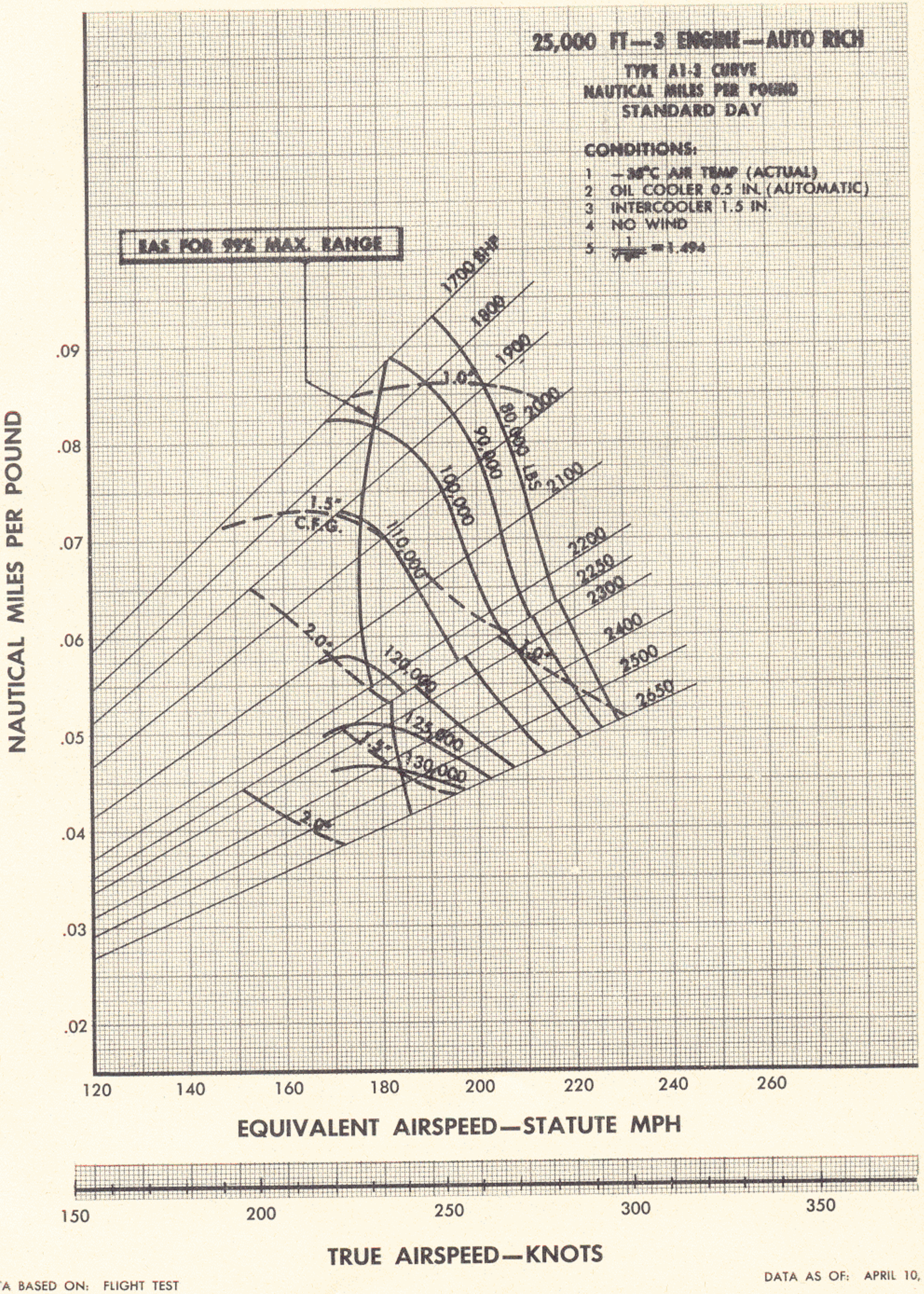


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-72. Nautical Miles per Pound, 3 Engine, Auto Lean, 25,000 Ft.

022276

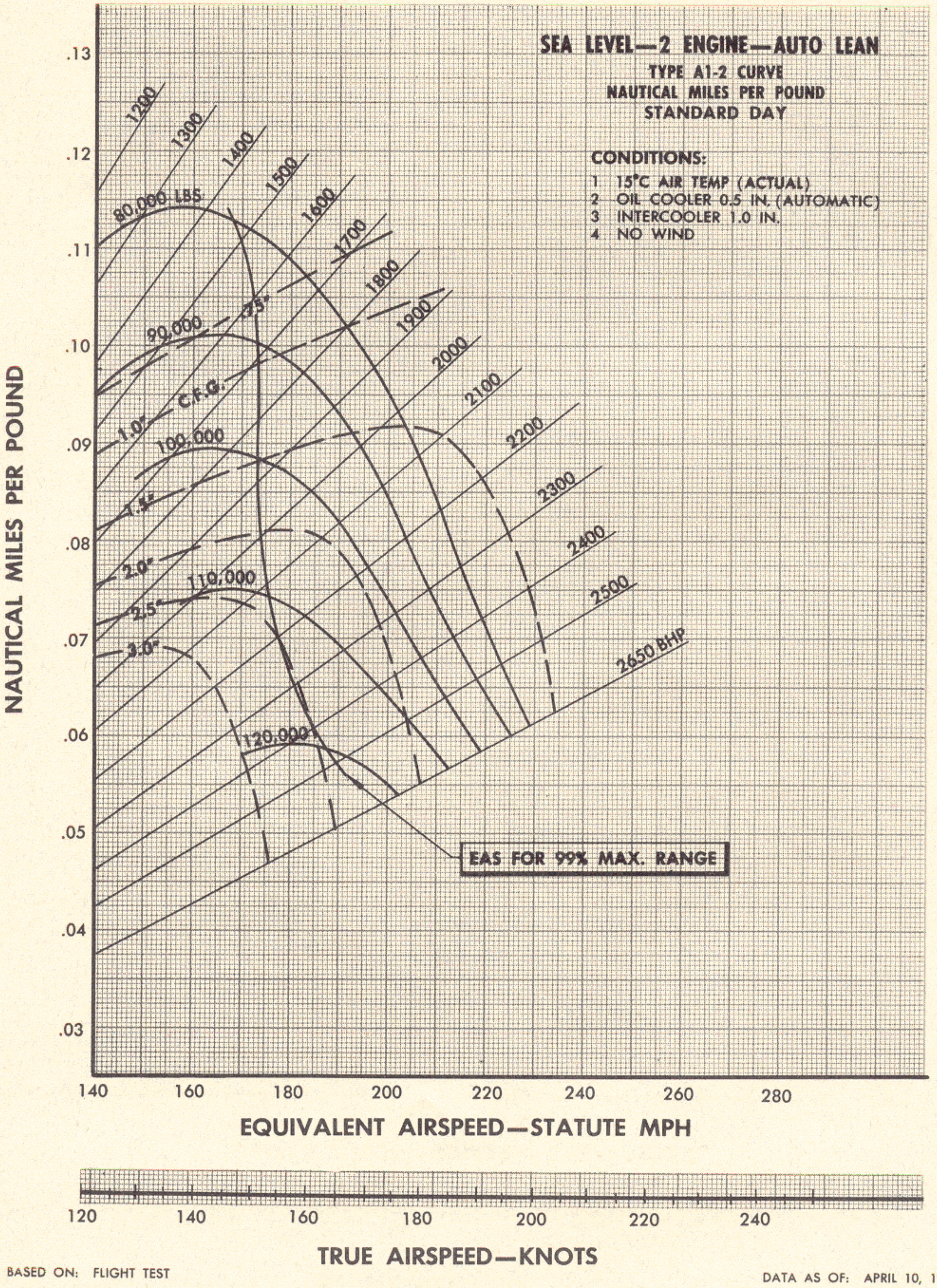


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-73. Nautical Miles per Pound, 3 Engine, Auto Rich, 25,000 Ft.

022277

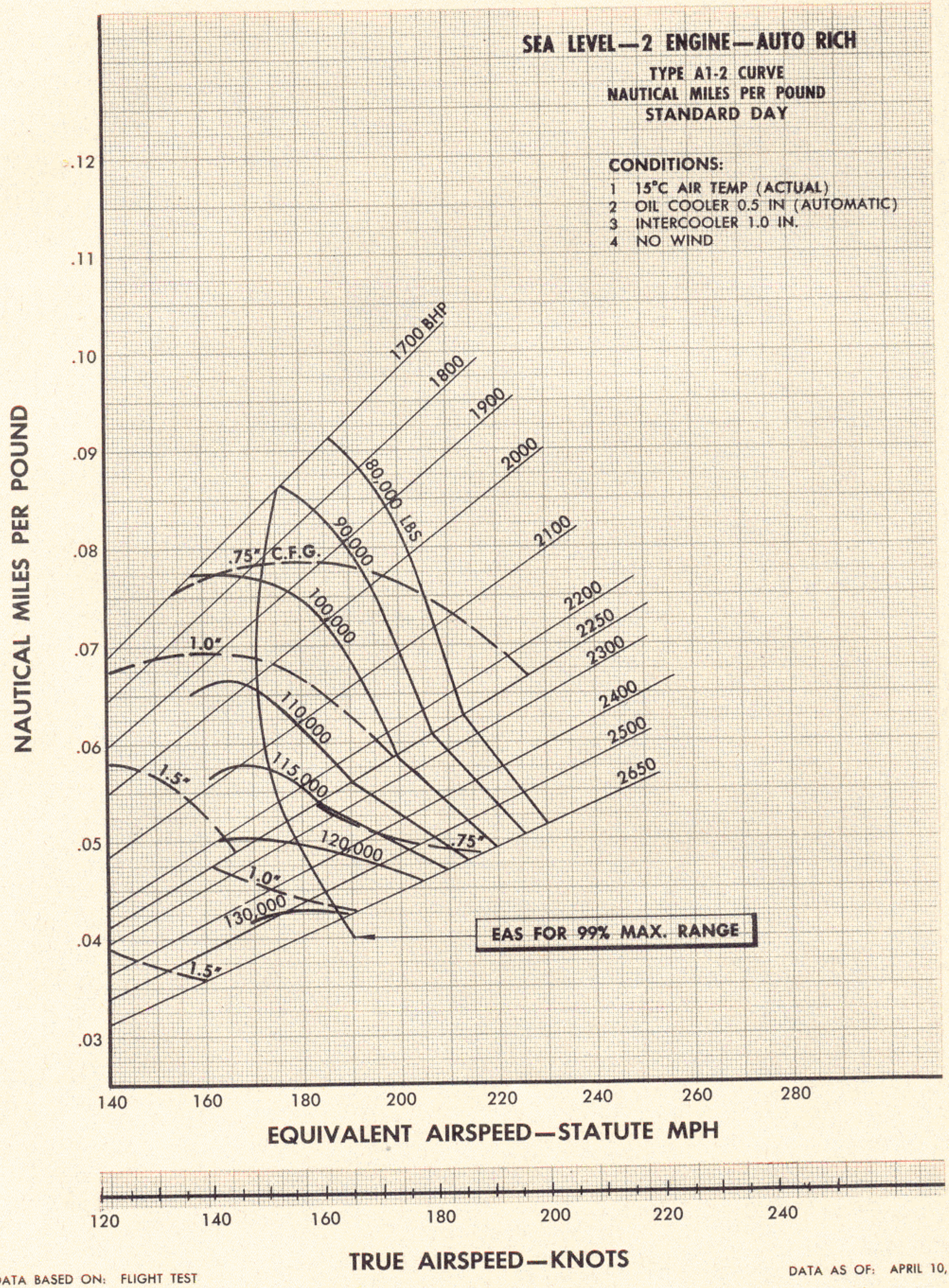


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-74. Nautical Miles per Pound, 2 Engine, Auto Lean, Sea Level

022278

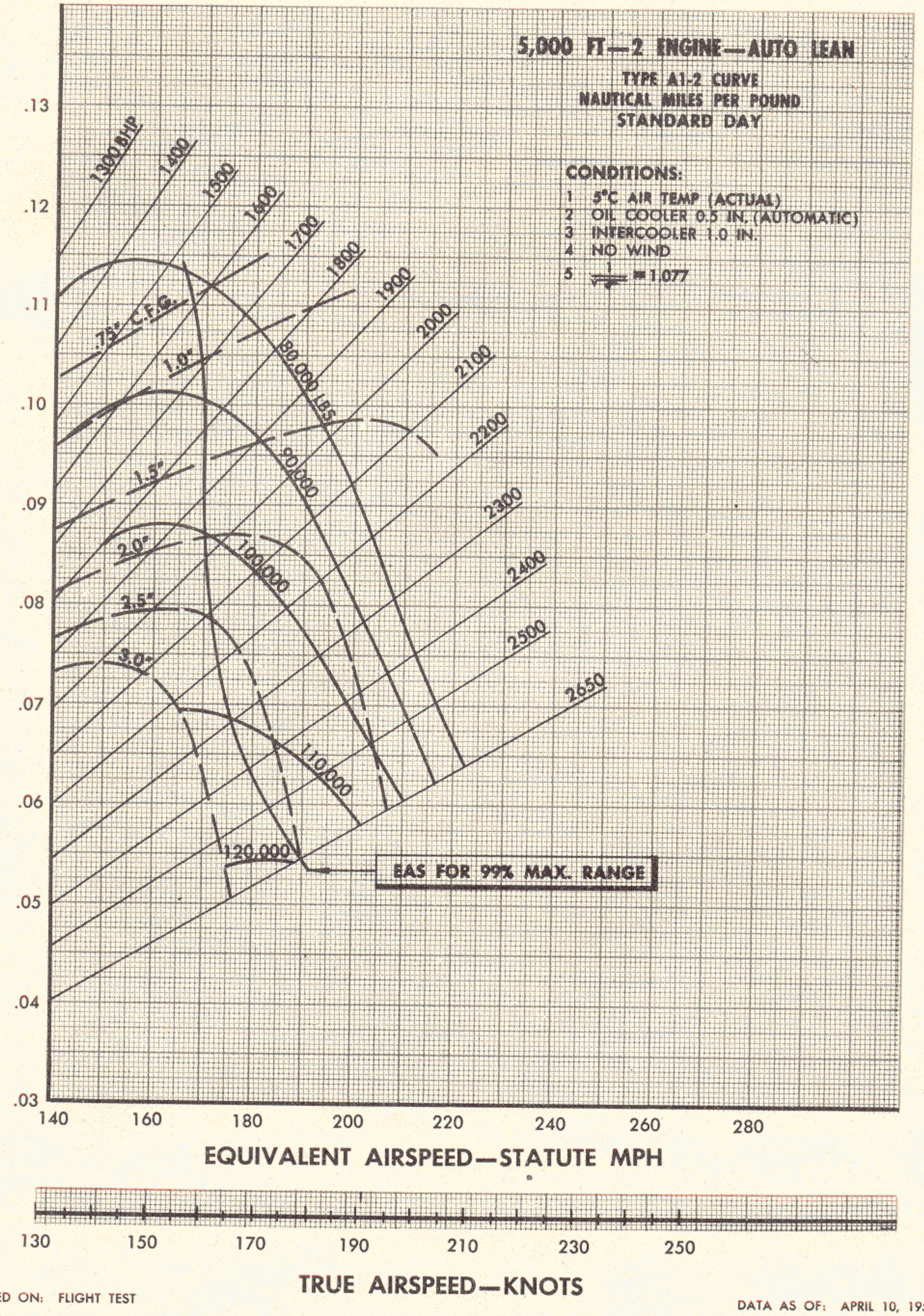


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-75. Nautical Miles per Pound, 2 Engine, Auto Rich, Sea Level

022279

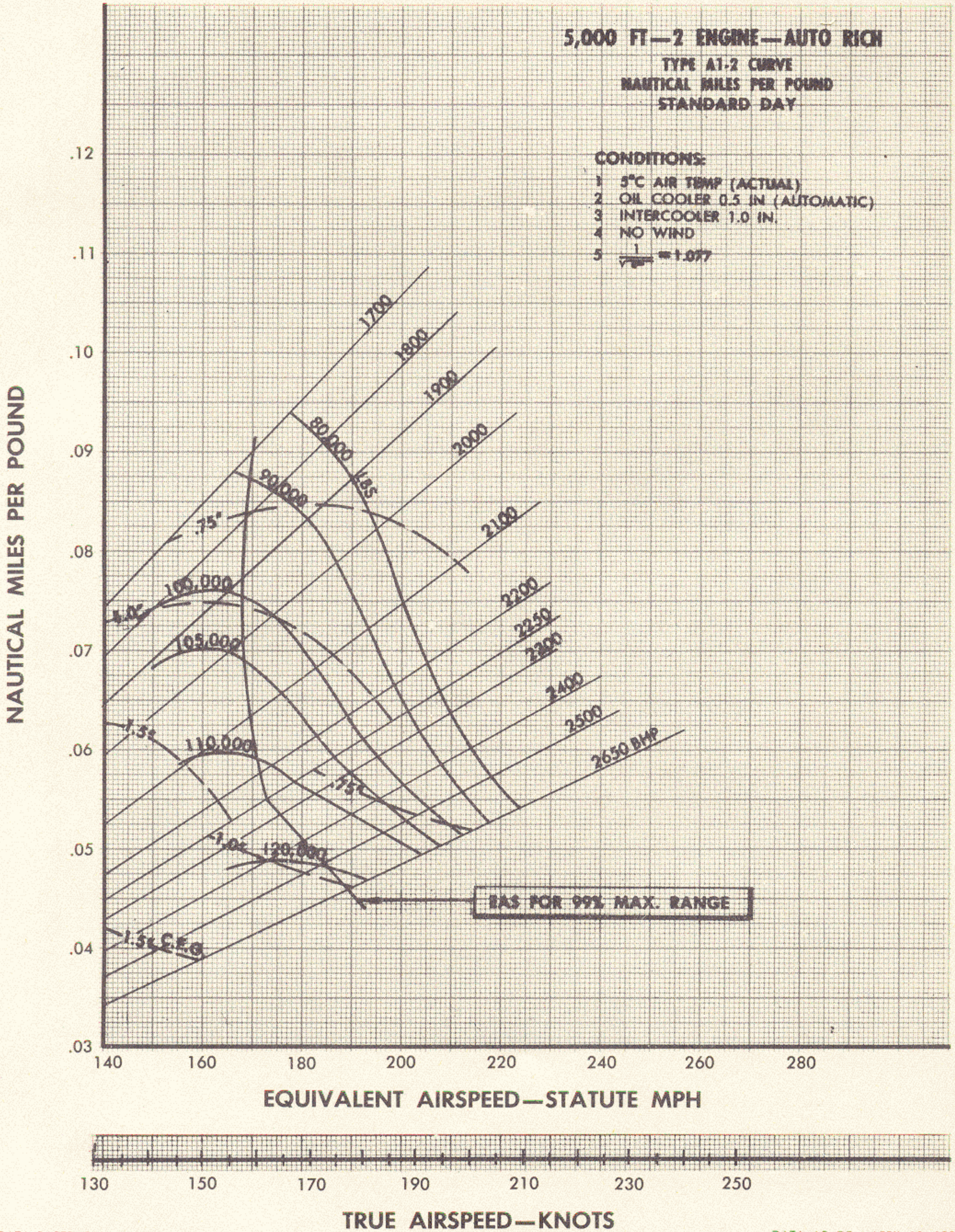


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-76. Nautical Miles per Pound, 2 Engine, Auto Lean, 5000 Ft.

022280

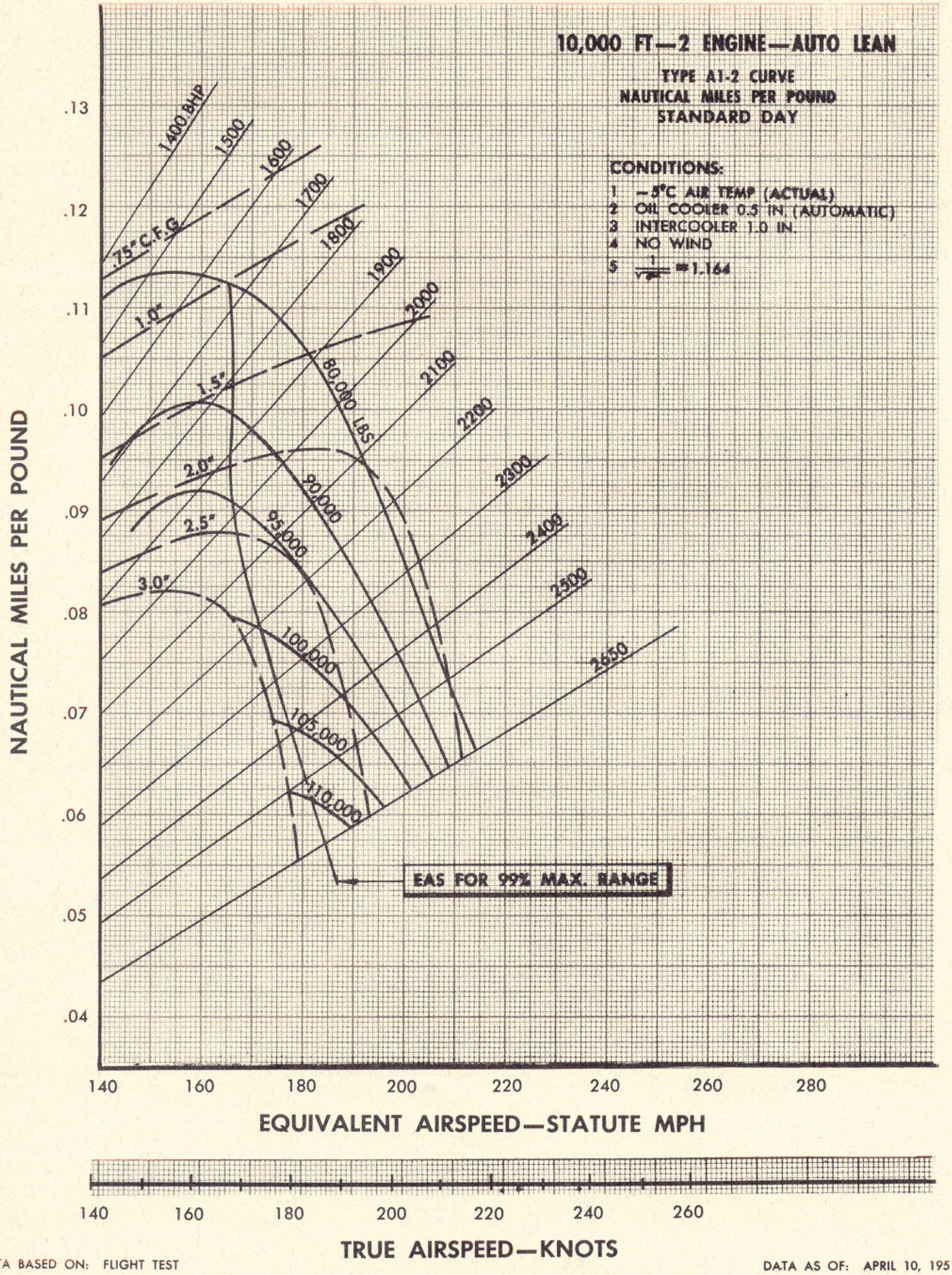


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-77. Nautical Miles per Pound, 2 Engine, Auto Rich, 5000 Ft.

022281

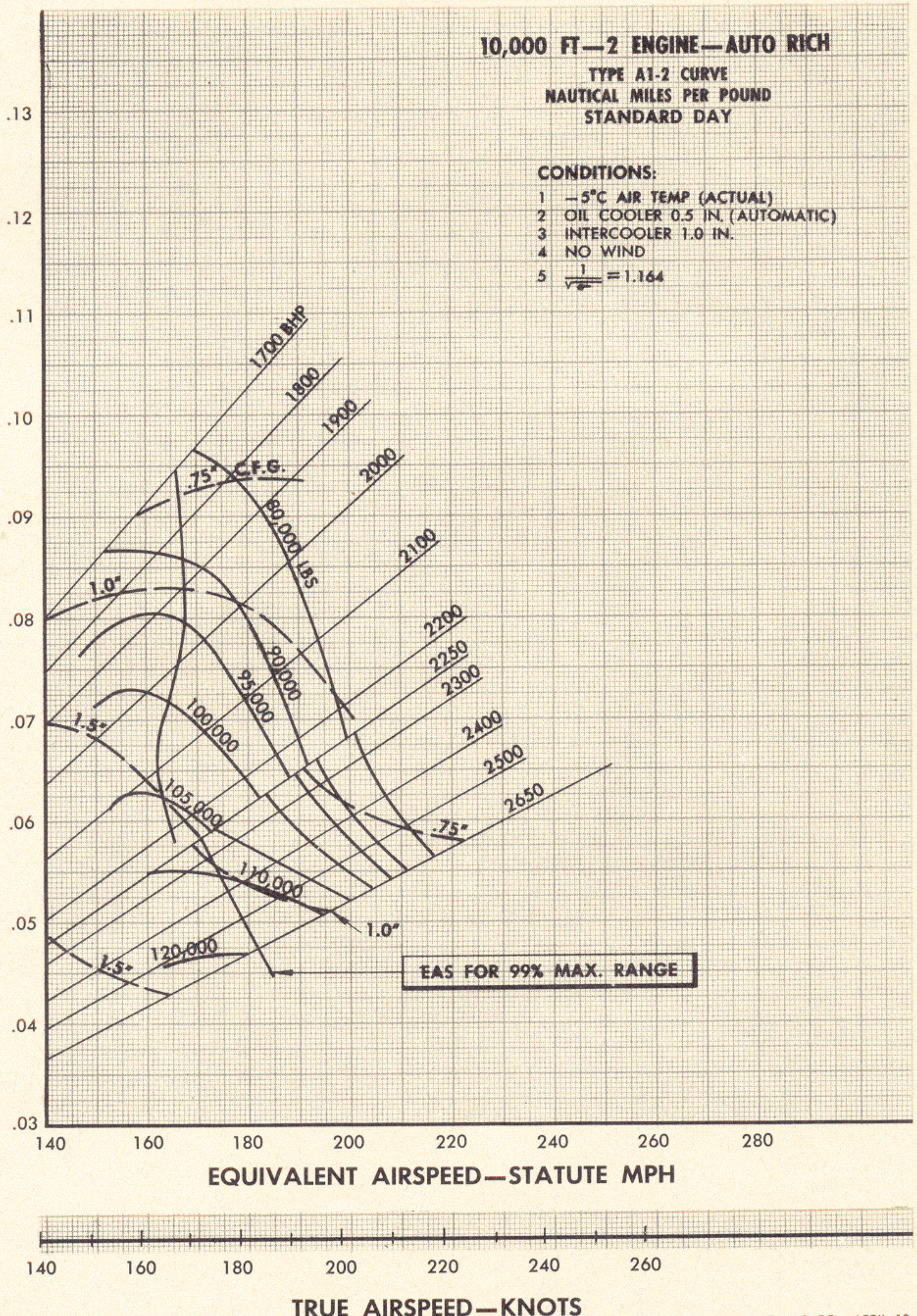


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-78. Nautical, Miles per Pound, 2 Engine, Auto Lean 10,000 Ft.

022282



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-79. Nautical Miles per Pound, 2 Engine, Auto Rich, 10,000 Ft

022283

022206

A-94. LONG RANGE SUMMARY (TYPE A2 CURVES). This type of curve is used as cruise control information for flight planning and for in-flight reference. It is obtained directly from the type A1 miles per pound curves and primarily shows the equivalent airspeed to be flown. Supplementary curves showing the expected RPM settings for the power required to maintain level flight at the corresponding airspeed and the resulting miles per pound are included on these charts. Curves for various altitudes are plotted versus gross weights for the following conditions:

a. Four engine cruise at speeds for 99% maximum range, operating engines auto-lean to 1750 BHP, auto-rich above 1750 BHP. See figure A-80.

b. Four engine cruise at speeds for 99% maximum range, operating engines auto-lean to 2650 BHP. See figure A-81.

c. Three engine cruise at speeds for 99% maximum range, operating engines auto-lean to 1750 BHP, auto-rich above 1750 BHP. See figure A-82.

d. Three engine cruise at speeds for 99% maximum range, operating engines auto-lean to 2650 BHP. See figure A-83.

e. Four engine cruise 110% EAS at maximum range, operating engines auto-lean to 1750 BHP, auto-rich above 1750 BHP. See figure A-84.

f. Four engine cruise 110% EAS at maximum range, operating engines auto-lean to 2650 BHP. See figure A-85.

A-95. The 99% maximum range recommended airspeed line is intended for all long range mission operation and will allow the operator to obtain about 99% of the maximum range. The 5 to 15 MPH-speed increase over that for the speed at maximum range results in:

a. A decrease in time required to fly a mission.

b. Greater ease of airplane handling, especially in rough air.

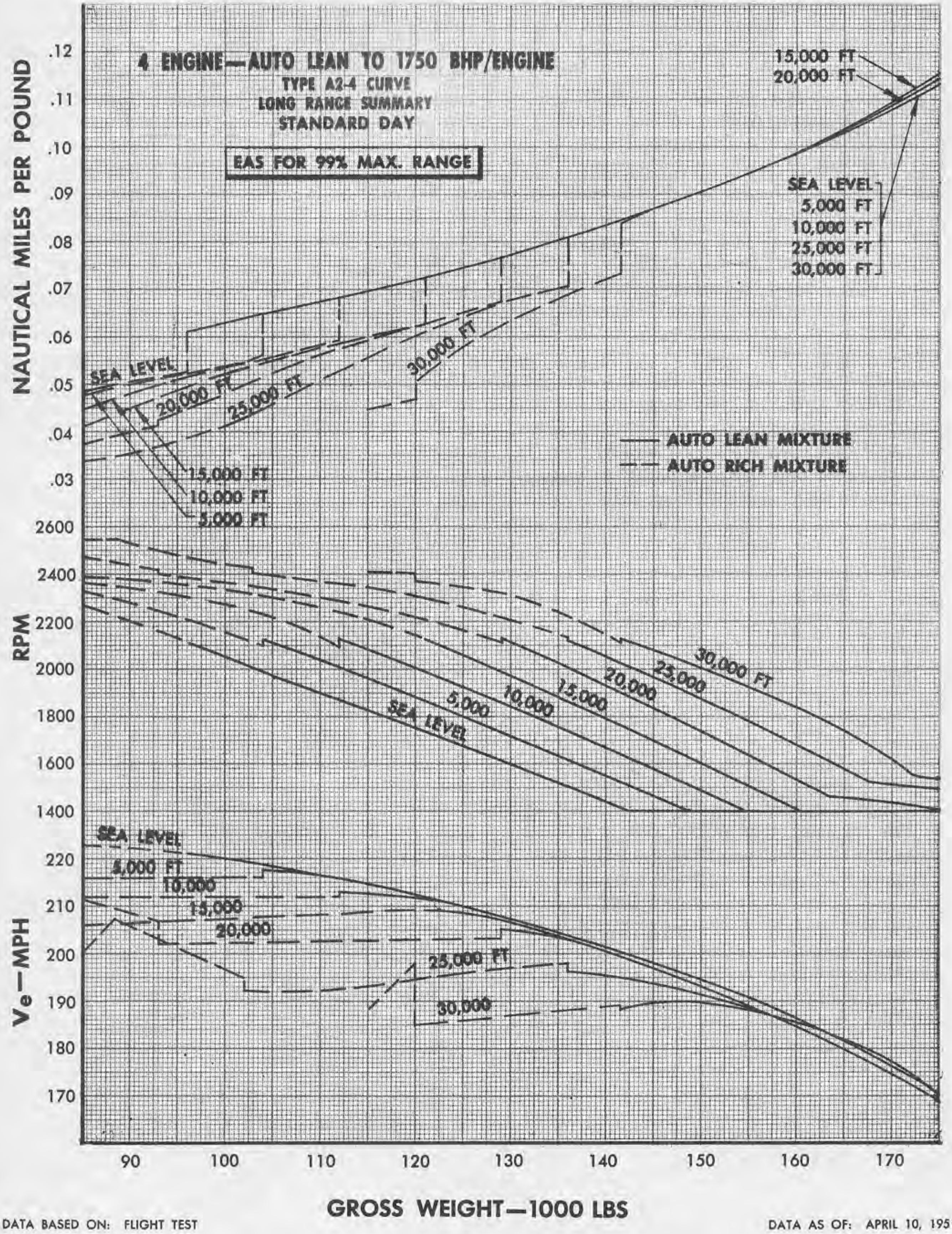
c. Automatic speed correction for headwinds up to approximately 50 knots.

A-96. Because of these advantages and better fuel mileage (over that obtained with 110% EAS at maximum range cruising condition) the importance of maintaining these speeds on a long range mission within a tolerance of ± 3 MPH cannot be over-emphasized.

A-97. The 110% maximum range airspeed is intended for use when time is considered more important than range or payload. Economy is still good at these speeds, ease of airplane handling is further increased and the time to cruise is reduced to about 97% of that required for 99% maximum range operation; also as pointed out under "Effect of Wind on Optimum Cruise Speeds," paragraph A-102, the 110% maximum range speed is very close to the maximum range speed for 100 knot headwinds.

A-98. Refer to "Technique of Long Range Cruising," paragraph A-64, and "Example Mission For Use of Charts," paragraph A-111, for the method of using these curves.

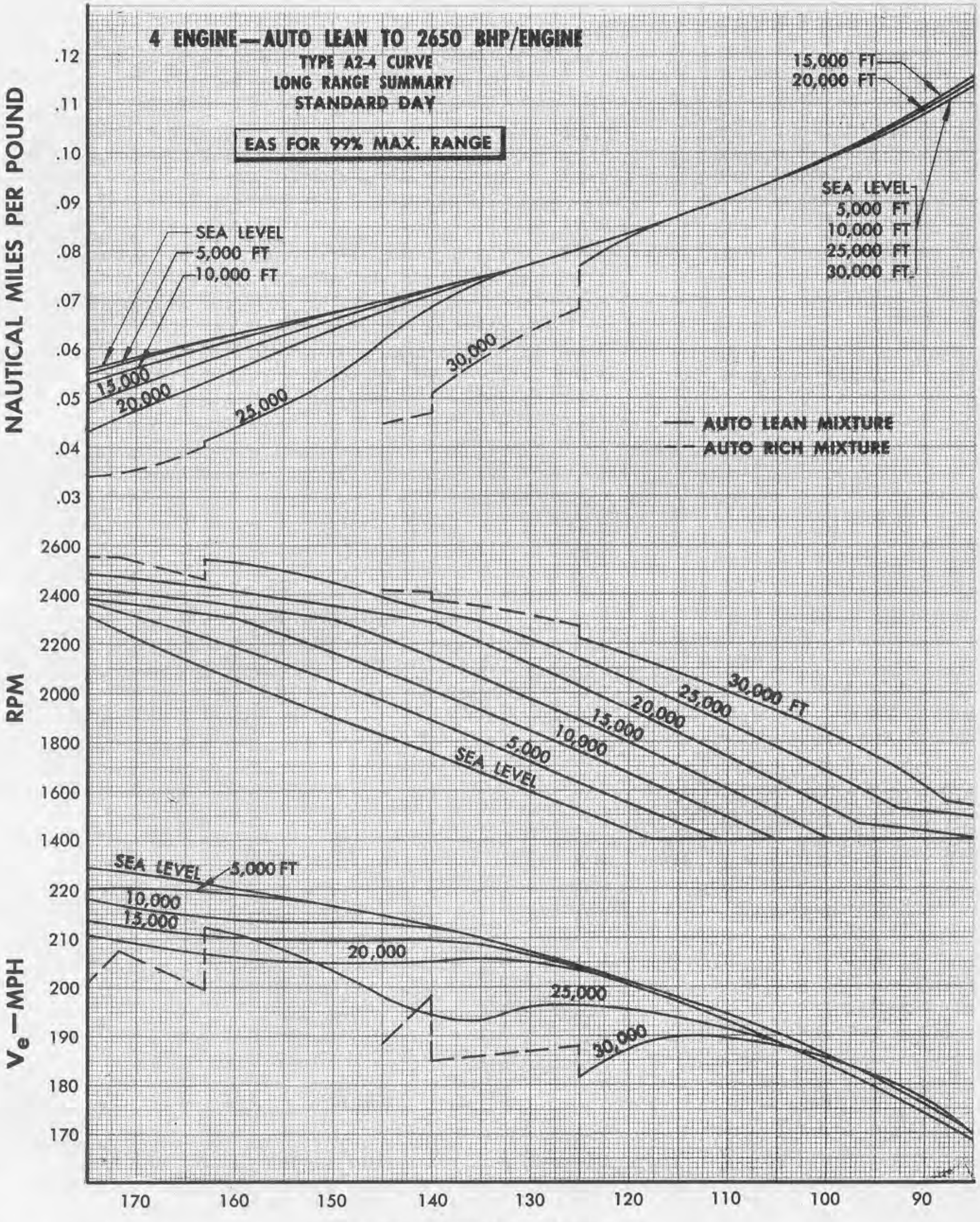
022284



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

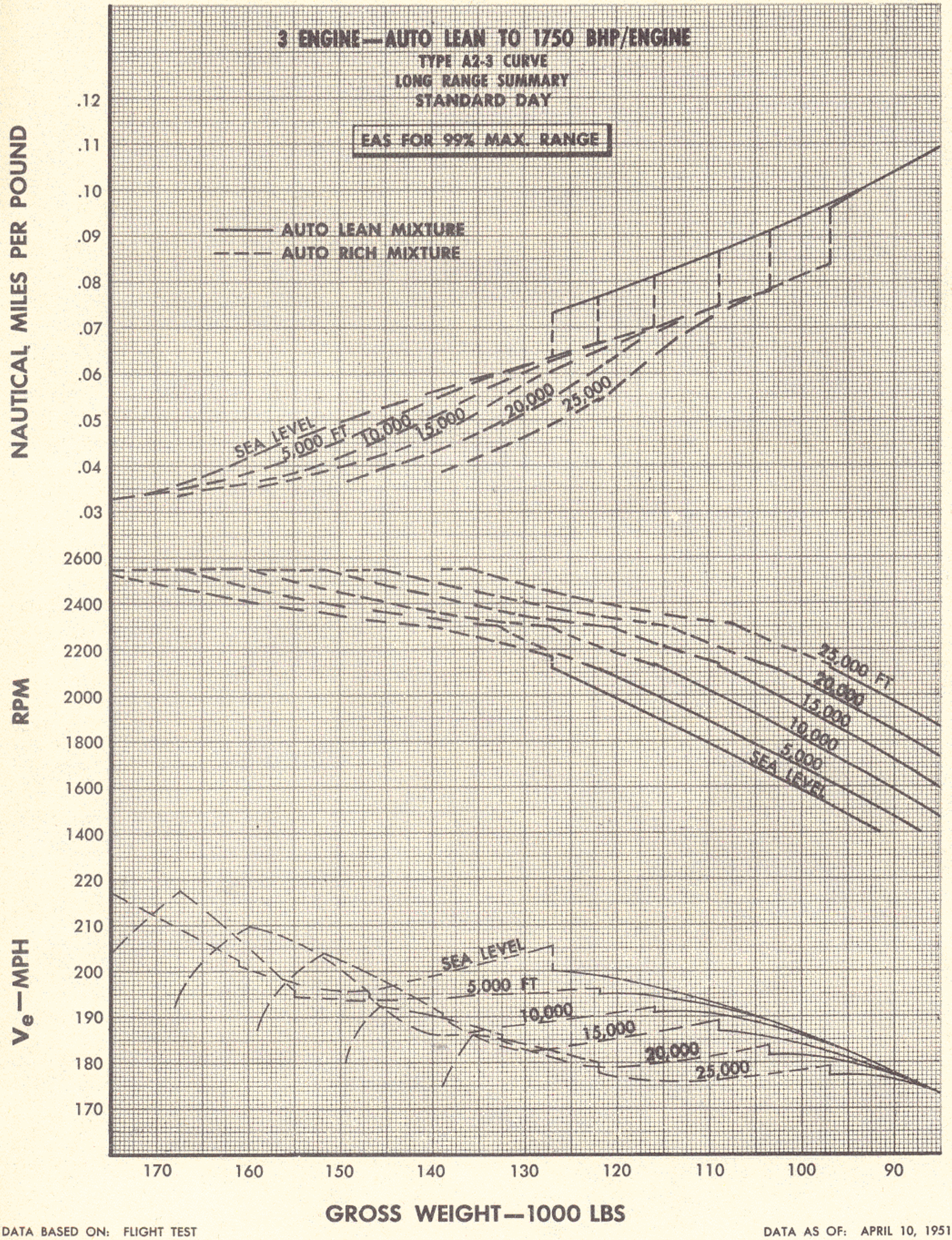
Figure A-80. Long Range Summary, 4 Engine, EAS for 99% Max. Range Auto Lean to 1750 BHP/Engine 022285



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

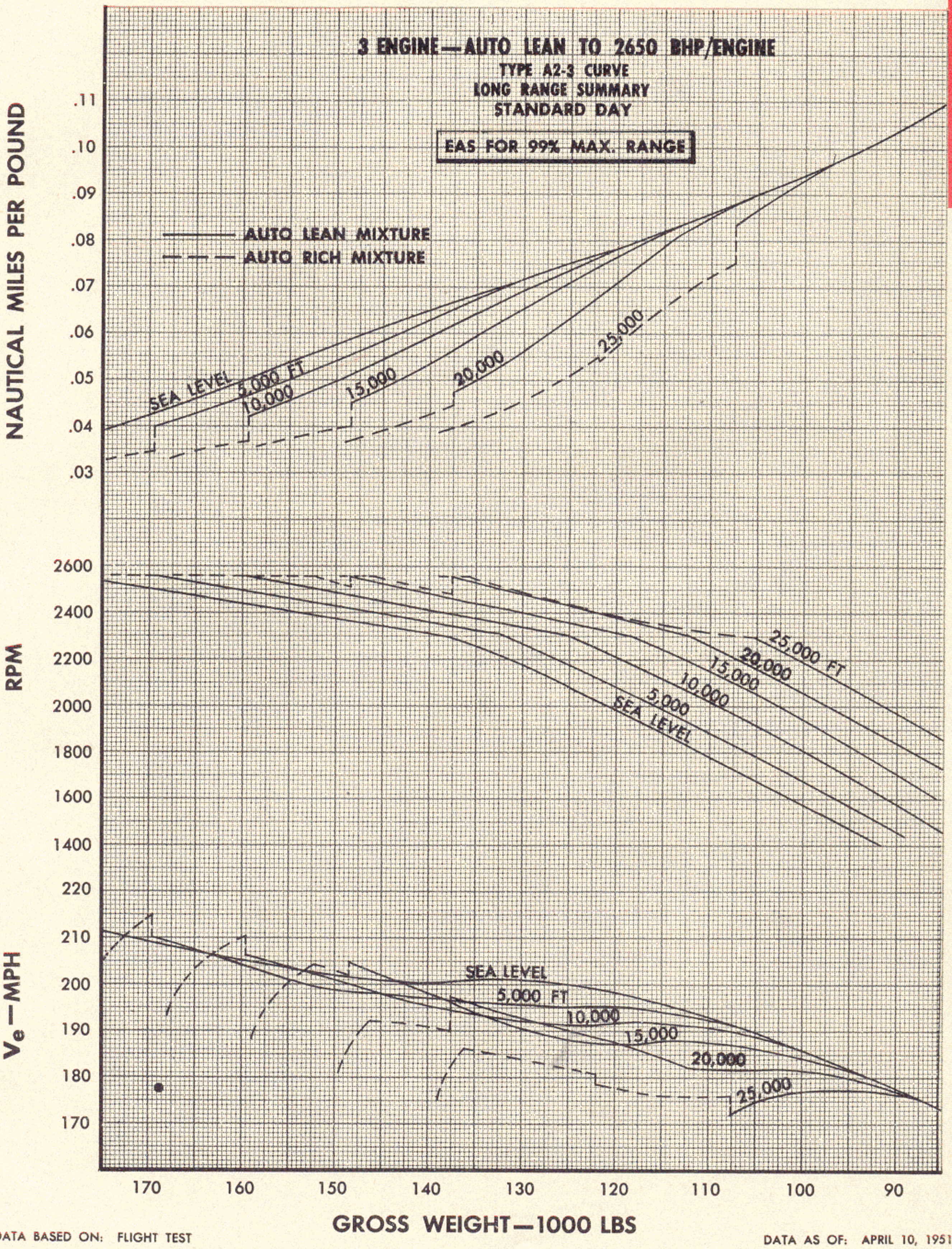
Figure A-81. Long Range Summary, 4 Engine, EAS for 99% Max. Range Auto Lean to 2650 BHP/Engine 022286



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

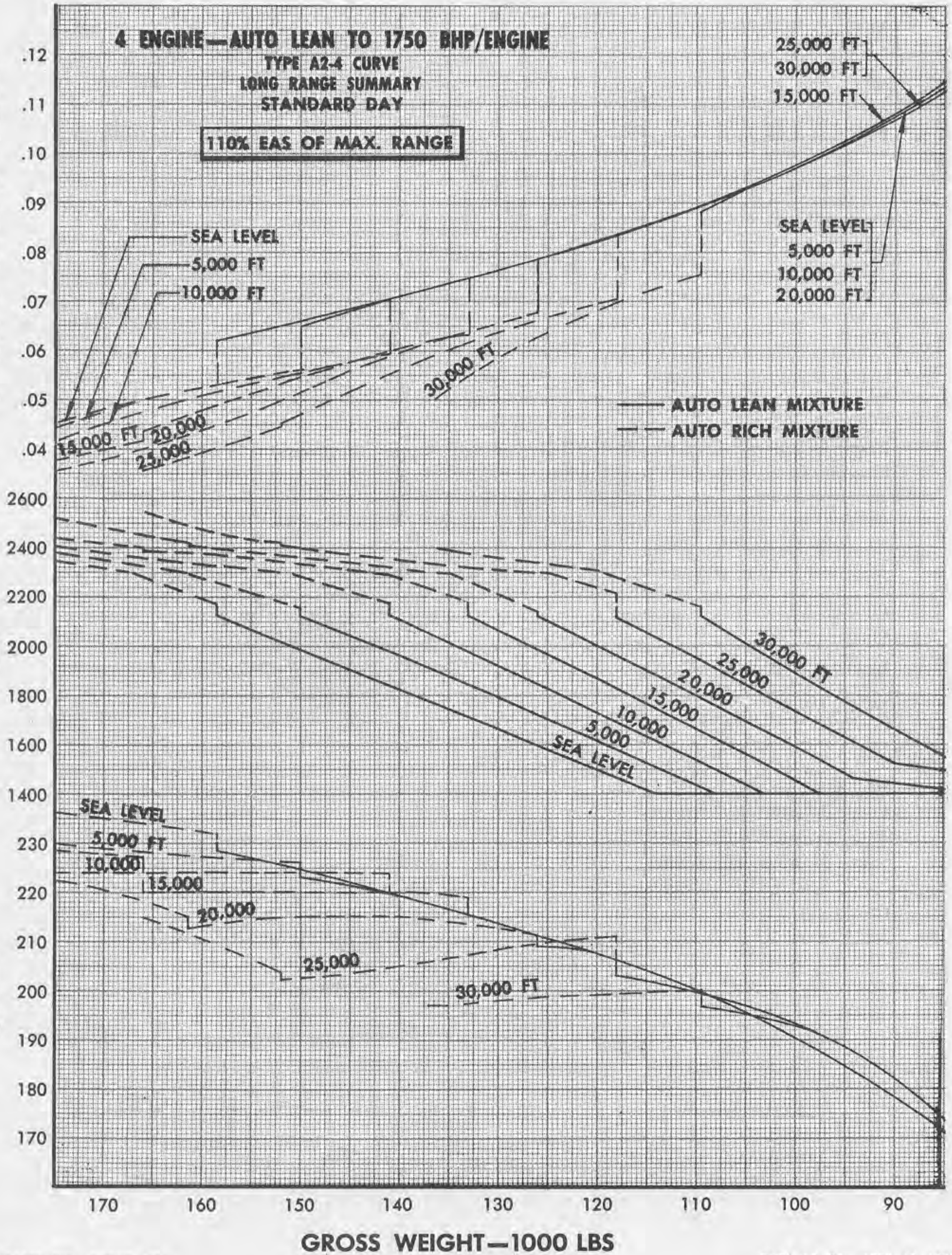
Figure A-82. Long Range Summary, 3 Engine, EAS for 99% Max. Range Auto Lean to 1750 BHP/Engine 022287



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

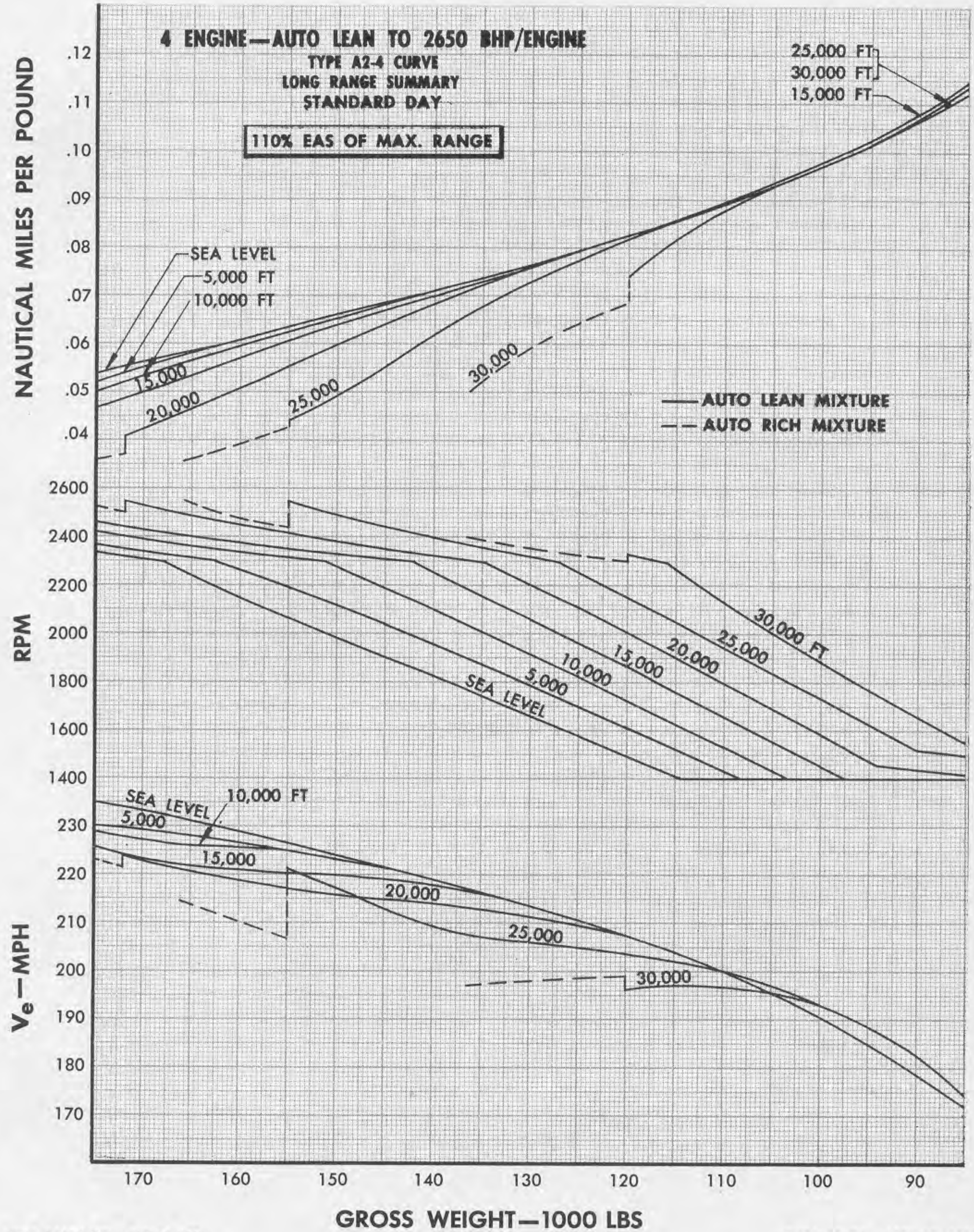
Figure A-83. Long Range Summary, 3 Engine, EAS for 99% Max. Range Auto Lean to 2650 BHP/Engine 022288



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-84. Long Range Summary, 4 Engine, 110% EAS at Max. Range Auto Lean to 1750 BHP/Engine



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-85. Long Range Summary, 4 Engine, 110% EAS at Max. Range Auto Lean to 2650 BHP/Engine 022290

022207

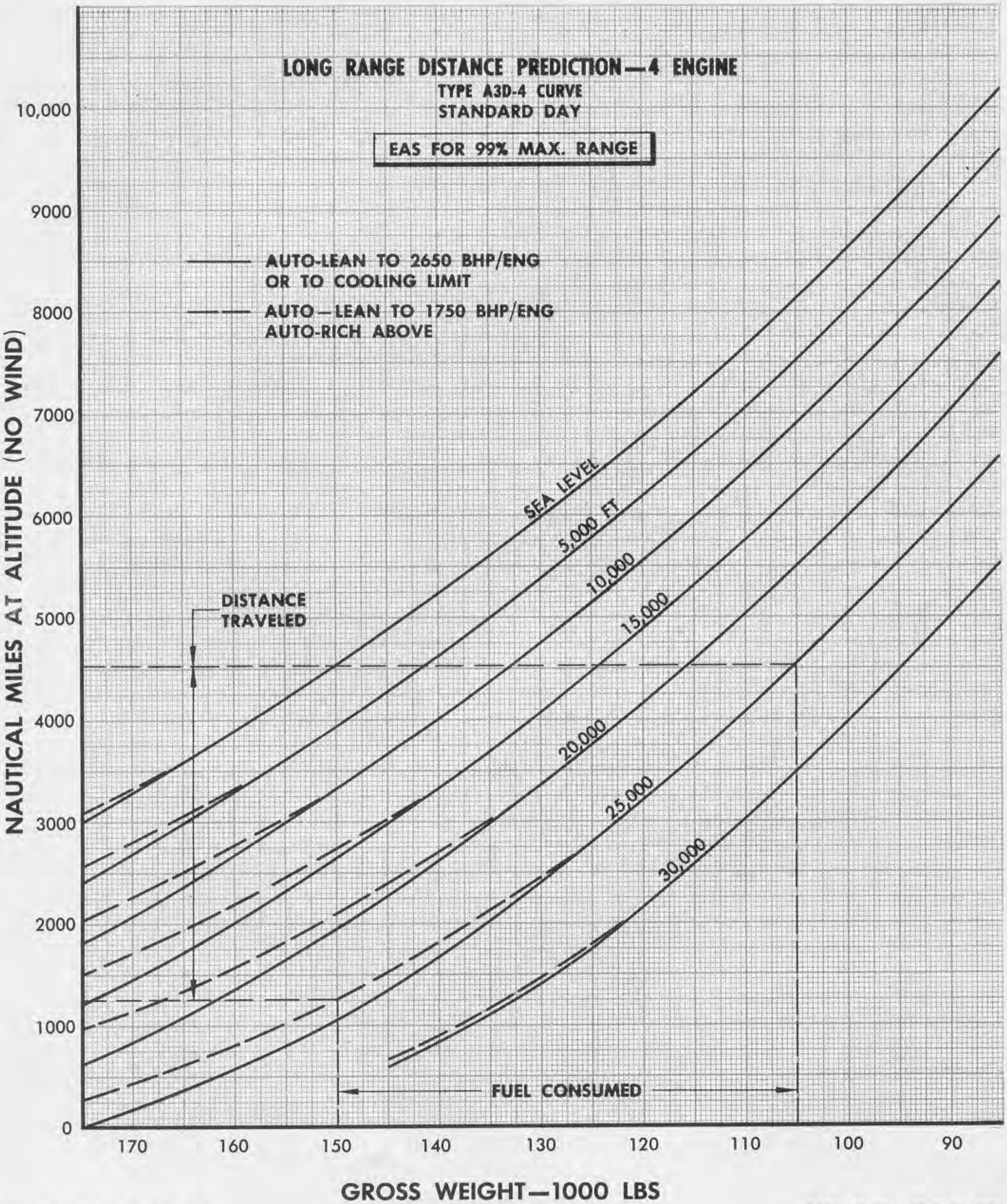
A-99. LONG RANGE PREDICTION (TYPE A3D AND A3T CURVES). Long range distance and time prediction curves, figures A-86 through A-91 are shown for the same cruising conditions as the previous section. They are prepared from information contained in the Nautical Miles Per Pound vs. Airspeed, Type A1 Curves. Their purpose is to present information for predicting distance and time of travel as the airplane's gross weight changes due to fuel used in long range cruise. The ability to obtain the predicted times and distances as set forth in these curves depends largely on the accuracy with which the pilot and flight engineer follow the cruise control procedures established for long range cruise. Setting up or flying a flight plan also requires accurate knowledge of airplane configuration, gross weight, and atmospheric conditions involved.

A-100. Example to illustrate the use of the prediction curves: Suppose at the beginning of cruise the gross weight is 150,000 pounds and a 2,290 nautical mile, 4 engine cruise, is to be made at 25,000 feet altitude using 99% maximum range airspeeds and auto-rich power settings above 1750 BHP per engine. Using this information find the fuel and time required for cruise.

a. First, locate the proper curves from the number of engines plus the speed and power conditions. In this case use figures A-86 and A-87.
b. Enter figure A-86 at 150,000 pounds, go to dashed 25,000 foot altitude line.
c. Proceed left and read 1,250 nautical miles.
d. Add 1,250 to 2,290 to get 4,540, then go right along the 4,540 nautical mile line to the 25,000 foot altitude line.
e. Drop vertically to the gross weight scale and read 105,000 pounds.
Then, fuel used is: 150,000 pounds - 105,000 pounds = 45,000 pounds.
f. To find the time required, enter figure A-87 at 150,000 pounds gross weight.
g. Go to dashed 25,000 foot altitude line and left to time scale and read 3.6 hours.
h. Enter at 105,000 pounds, go to 25,000 foot altitude line and left to read 16.6 hours.

Then, time to cruise is: 16.6 hours - 3.6 hours = 13 hours.

022291

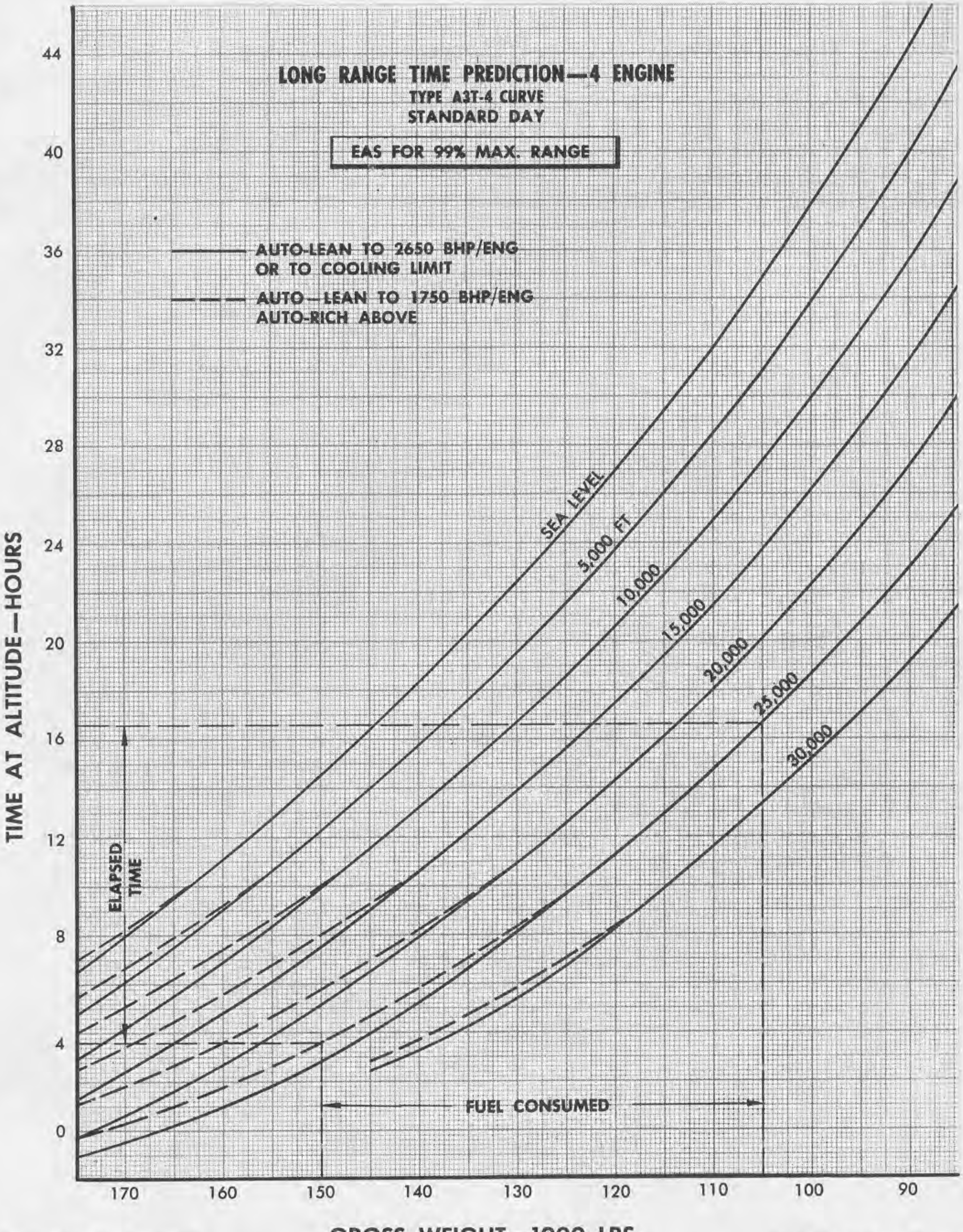


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-86. Long Range Distance Prediction, 4 Engine, EAS for 99% Max. Range

022292

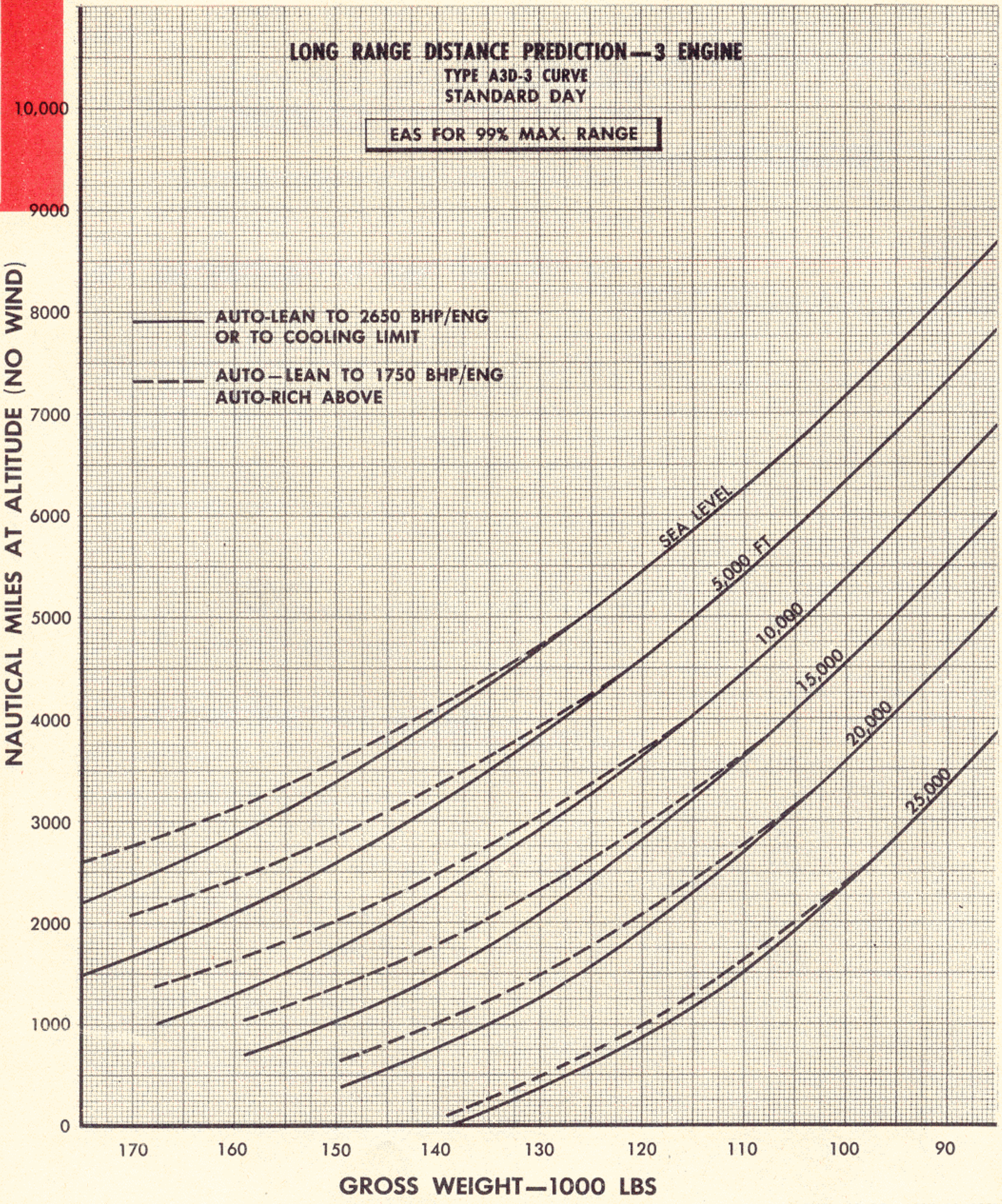


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-87. Long Range Time Prediction, 4 Engine, EAS for 99% Max. Range

022293

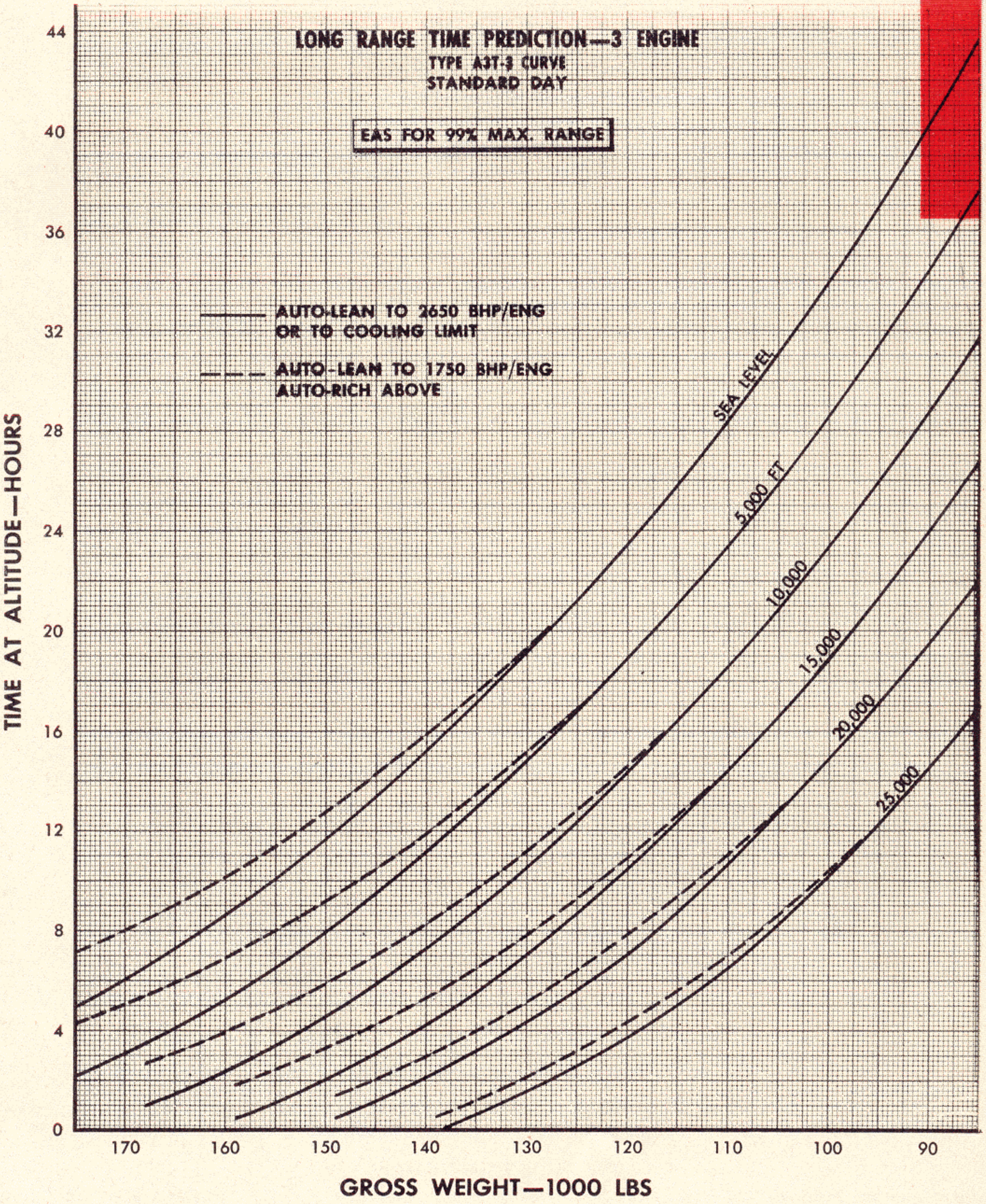


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-88. Long Range Distance Prediction, 3 Engine, EAS for 99% Max. Range

022294

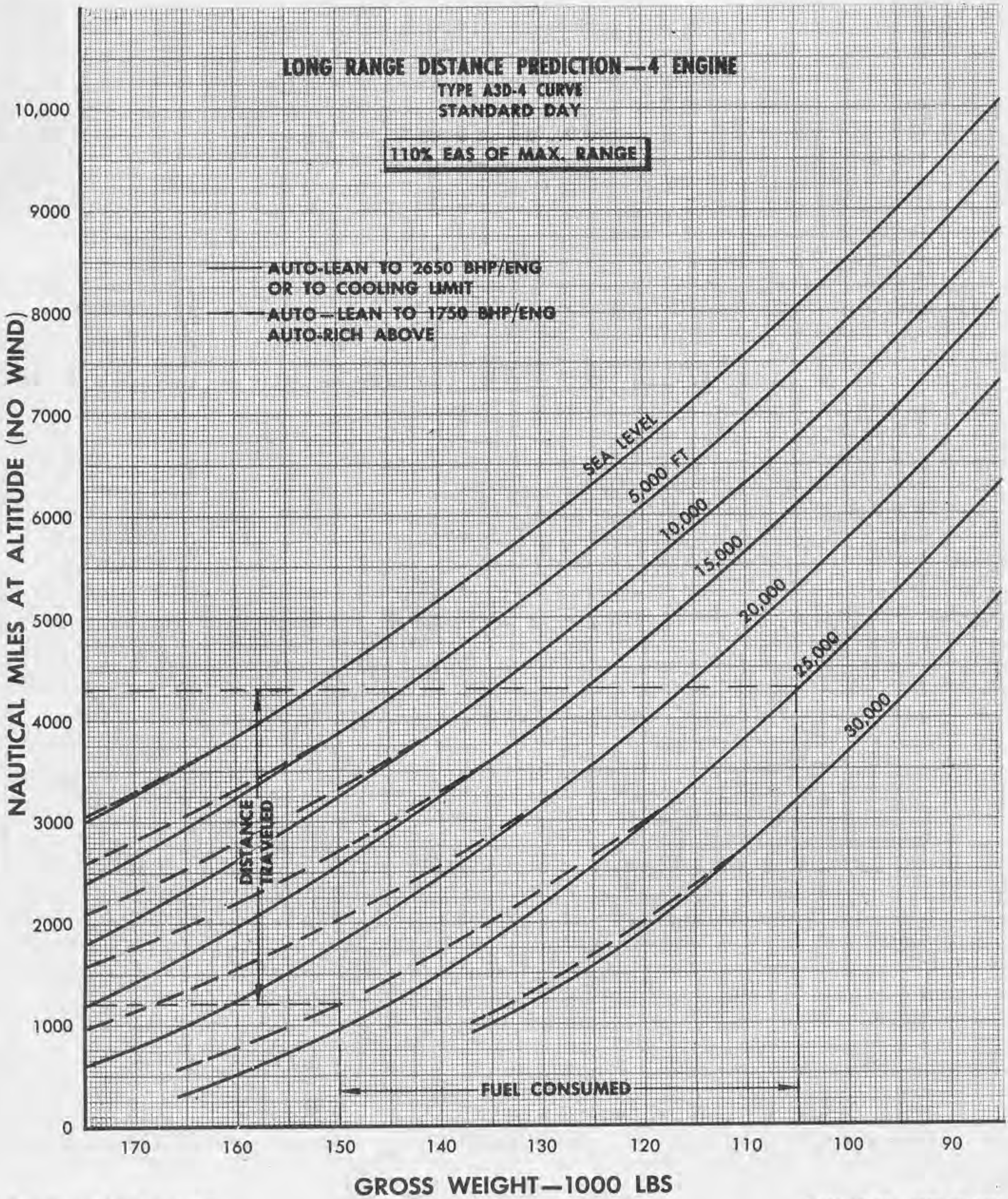


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-89. Long Range Time Prediction, 3 Engine, EAS for 99% Max. Range

022295

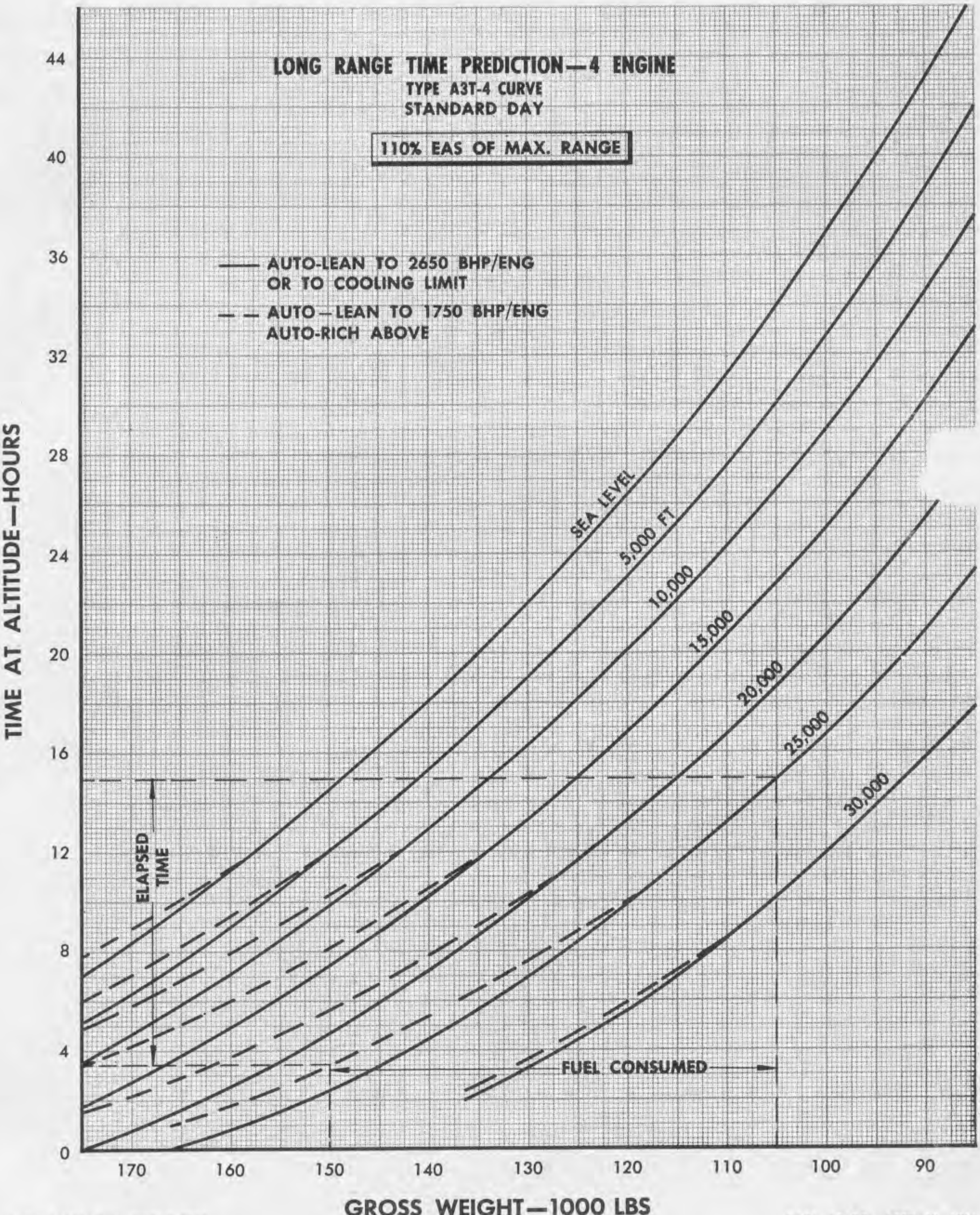


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-90. Long Range Distance Prediction, 4 Engine, 110% EAS at Max. Range

022296



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-91. Long Range Time Prediction, 4 Engine, 110% EAS at Max. Range

022297

A-101. LONG RANGE CRUISING TABLES. Long range cruising tables are presented in figures A-92, A-93, and A-94. They are simply a tabulation, for quick and easy reference, of Long Range Summary charts such as figure A-80 and figure A-83 combined with power schedules and fuel flow data as given in figures A-27 through A-33. These cruising tables show the airspeed, RPM, torque pressure (T.P.) and fuel flow per engine for 99% maximum range, standard day. The following mixtures were used:

for 99% maximum range, standard day. The following mixtures were used:

a. Four engines, auto-lean to 1750 BHP, auto-rich over 1750 BHP (for longer engine life).

b. Three and two engines, auto-lean to 2650 BHP (for fuel economy).

When flying at an odd-thousand feet altitude, interpolate for required values or use the next higher altitude.

022298

LONG RANGE CRUISING—4 ENGINES

IAS - statute MPH, TAS - knots, TP - psi, FF - lbs/hr./engine

AUTO RICH | AUTO LEAN

Density Altitude Ft.	Gr. Wt. Lbs.-1000	170 to 165	165 to 160	160 to 155	155 to 150	150 to 145	145 to 140	140 to 135	135 to 130	130 to 125	125 to 120	120 to 115	115 to 110	110 to 105	105 to 100
26,000	IAS	202	198	191	191	192	192	193	194	195	195	194	192	190	186
	TAS	268	263	253	253	255	255	255	256	257	257	256	258	251	247
	RPM	2510	2460	2430	2390	2370	2340	2300	2250	2200	2120	2030	1940	1860	1760
	TP	236	226	219	210	208	201	192	192	192	192	192	192	192	192
	FF	1820	1640	1520	1340	1240	1120	1020	990	960	915	745	710	675	635
24,000	IAS	203	197	192	192	192	193	196	196	197	196	194	192	189	186
	TAS	259	253	247	247	247	248	251	251	252	251	248	246	242	238
	RPM	2490	2440	2410	2370	2340	2310	2270	2210	2150	2070	1980	1890	1800	1700
	TP	233	222	217	208	201	195	192	192	192	192	192	192	192	192
	FF	1760	1570	1450	1240	1120	1040	1000	965	930	760	725	685	650	615
22,000	IAS	204	199	196	196	197	198	198	199	200	198	195	192	188	185
	TAS	253	247	243	243	244	246	246	247	248	246	242	238	234	230
	RPM	2450	2400	2380	2340	2300	2270	2230	2170	2100	2020	1930	1840	1740	1640
	TP	225	214	209	201	192	192	192	192	192	192	192	192	192	192
	FF	1620	1400	1280	1120	1020	1000	975	940	775	740	705	670	630	590
20,000	IAS	205	200	200	200	200	201	201	201	203	200	196	193	189	185
	TAS	246	240	240	240	240	241	241	241	243	240	235	231	227	222
	RPM	2420	2380	2350	2320	2280	2240	2190	2130	2070	1980	1880	1780	1680	1580
	TP	218	209	203	197	192	192	192	192	192	192	192	192	192	192
	FF	1490	1280	1170	1070	1010	980	950	920	760	725	680	645	605	570
18,000	IAS	205	202	202	202	203	203	204	204	204	201	197	194	190	185
	TAS	238	234	234	234	235	235	235	235	235	232	227	224	219	215
	RPM	2400	2370	2340	2300	2270	2220	2160	2090	2040	1940	1840	1740	1640	1540
	TP	214	208	201	192	192	192	192	192	192	192	192	192	192	192
	FF	1400	1240	1120	1020	1000	970	935	770	750	710	670	630	590	555
16,000	IAS	205	204	204	205	205	206	207	206	204	201	196	193	189	185
	TAS	230	229	229	230	230	231	231	230	228	225	220	217	213	208
	RPM	2370	2350	2320	2280	2240	2180	2120	2030	1960	1870	1780	1680	1580	1480
	TP	208	203	197	192	192	192	192	192	192	192	192	192	192	192
	FF	1240	1170	1070	1010	980	945	915	745	720	678	645	605	570	530
14,000	IAS	205	205	205	206	207	207	208	206	204	201	198	193	189	185
	TAS	224	224	224	225	226	226	226	224	219	218	215	210	206	202
	RPM	2360	2330	2300	2260	2210	2160	2070	1990	1900	1820	1720	1620	1530	1420
	TP	205	199	192	192	192	192	192	192	192	192	192	192	192	192
	FF	1210	1090	1020	995	965	935	760	730	690	660	620	585	550	510
12,000	IAS	207	207	207	208	208	206	208	206	204	201	198	194	190	186
	TAS	219	219	219	220	220	218	219	217	215	212	208	204	200	196
	RPM	2330	2310	2270	2220	2160	2100	2010	1950	1840	1760	1660	1570	1480	1400
	TP	199	195	192	192	192	192	192	192	192	192	192	192	192	192
	FF	1090	1040	1000	970	935	775	735	715	670	635	597	565	530	500
10,000	IAS	209	209	209	209	210	209	209	207	204	201	198	194	191	187
	TAS	214	214	214	214	215	214	213	211	208	205	202	198	195	191
	RPM	2320	2290	2250	2180	2120	2040	1960	1880	1800	1710	1620	1530	1440	1400
	TP	197	192	192	192	192	192	192	192	192	192	192	192	192	186
	FF	1070	1015	990	945	915	750	720	680	650	617	585	550	520	490
8,000	IAS	210	210	210	210	211	210	209	207	204	201	198	194	191	186
	TAS	208	208	208	208	209	208	206	204	201	198	195	191	188	184
	RPM	2300	2260	2210	2150	2080	2000	1920	1840	1750	1670	1580	1500	1410	1400
	TP	192	192	192	192	192	192	192	192	192	192	192	192	192	181
	FF	1020	995	965	930	765	733	700	670	632	600	570	540	510	480
6,000	IAS	211	211	211	212	211	209	208	206	203	200	197	193	190	186
	TAS	204	204	204	205	204	202	201	199	196	193	190	186	183	180
	RPM	2270	2220	2150	2110	2030	1940	1860	1770	1700	1620	1520	1440	1400	1400
	TP	192	192	192	192	192	192	192	192	192	192	192	192	187	175
	FF	1000	970	930	910	745	710	675	640	615	585	545	520	490	470
4,000	IAS	213	212	212	213	212	210	208	206	203	200	197	193	190	186
	TAS	200	199	199	200	199	197	194	193	190	187	184	181	178	174
	RPM	2240	2170	2090	2040	1970	1890	1810	1740	1650	1570	1480	1410	1400	1400
	TP	192	192	192	192	192	192	192	192	192	192	192	192	182	170
	FF	980	940	770	750	723	685	655	630	595	565	530	500	480	460
2,000	IAS	216	215	214	213	212	210	208	206	203	200	197	193	190	186
	TAS	197	196	195	194	193	191	189	187	184	182	179	175	173	169
	RPM	2200	2130	2050	1980	1910	1830	1750	1680	1600	1520	1440	1400	1400	1400
	TP	192	192	192	192	192	192	192	192	192	192	192	188	177	165
	FF	960	920	755	725	695	665	632	605	575	545	520	490	470	440

NOTE:
1. Data based on standard day conditions.
2. Auto Lean to 1750 BHP/Eng Auto Rich over 1750 BHP/Eng.
3. Manifold pressure may be determined by reference to figures A26 through A33.

DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-92. Long Range Cruising Tabulation, 4 Engine

022299

LONG RANGE CRUISING—3 ENGINES

IAS - statute MPH, TAS - knots, TP - psi, FF - lbs/hr./engine

Density Altitude Ft.	Gr. Wt. Lbs. x 1000	170 to 165	165 to 160	160 to 155	155 to 150	150 to 145	145 to 140	140 to 135	135 to 130	130 to 125	125 to 120	120 to 115	115 to 110	110 to 105	105 to 100
18,000	IAS							194	192	189	186	185	182	181	181
	TAS							224	222	218	216	215	211	210	210
	RPM							2520	2470	2420	2380	2330	2260	2170	2070
	TP							237	227	218	210	199	192	192	192
	FF							1500	1320	1160	1040	920	845	810	760
16,000	IAS						192	193	190	188	185	185	184	183	182
	TAS						217	217	214	211	209	208	207	206	205
	RPM						2510	2460	2430	2390	2350	2300	2220	2120	2020
	TP						235	225	219	211	203	192	192	192	192
	FF						1470	1280	1180	1070	960	870	825	790	740
14,000	IAS				201	197	196	193	190	189	186	186	187	186	184
	TAS				219	215	214	210	206	205	202	202	203	202	200
	RPM				2540	2530	2480	2440	2400	2360	2310	2250	2160	2070	1970
	TP				239	238	229	220	214	204	194	192	192	192	192
	FF				1580	1540	1360	1190	1100	970	890	840	800	760	720
12,000	IAS				200	197	194	193	190	189	188	188	188	187	184
	TAS				211	208	205	203	200	199	198	198	198	197	194
	RPM				2520	2490	2460	2420	2380	2340	2280	2210	2110	2020	1910
	TP				237	231	225	218	210	201	192	192	192	192	192
	FF				1500	1400	1280	1160	1040	940	850	820	780	740	700
10,000	IAS			202	199	196	193	192	191	189	189	189	189	188	185
	TAS			207	204	202	198	196	195	193	193	193	193	192	189
	RPM			2540	2500	2470	2430	2390	2350	2320	2250	2170	2070	1970	1860
	TP			239	233	227	219	211	203	197	192	192	192	192	192
	FF			1580	1440	1320	1180	1070	960	900	840	810	760	720	680
8,000	IAS			201	198	196	194	193	192	191	190	190	192	189	185
	TAS			199	196	194	193	191	190	189	188	188	190	187	184
	RPM			2520	2480	2450	2410	2370	2330	2280	2220	2120	2020	1910	1810
	TP			237	229	222	216	206	199	192	192	192	192	192	192
	FF			1500	1360	1250	1130	1000	920	850	825	790	740	700	660
6,000	IAS		202	199	196	195	193	193	192	191	191	191	191	188	185
	TAS		196	193	190	189	187	186	185	184	184	184	184	181	178
	RPM		2530	2490	2460	2420	2390	2350	2310	2240	2160	2060	1960	1860	1750
	TP		238	231	225	218	211	203	194	192	192	192	192	192	192
	FF		1540	1400	1280	1160	1070	960	890	830	800	750	710	680	630
4,000	IAS	204	202	199	196	195	194	195	194	193	193	192	191	188	185
	TAS	192	190	187	184	183	182	182	181	180	180	179	178	176	173
	RPM	2530	2500	2460	2430	2390	2360	2340	2290	2200	2100	2000	1900	1800	1700
	TP	238	233	225	219	211	204	201	192	192	192	192	192	192	192
	FF	1540	1440	1280	1180	1070	970	940	860	815	770	730	690	650	615
2,000	IAS	202	200	199	197	196	195	196	196	195	195	193	191	188	185
	TAS	184	182	181	180	179	178	178	178	177	177	175	174	171	168
	RPM	2500	2470	2440	2410	2380	2340	2310	2250	2160	2070	1970	1860	1760	1660
	TP	233	227	220	216	210	201	194	192	192	192	192	192	192	192
	FF	1440	1320	1190	1130	1040	940	890	840	800	760	720	680	640	600

NOTE:
1. Data based on standard day conditions.
2. Auto lean mixture.
3. Manifold pressure may be determined by reference to figures A26 through A33.

DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-93. Long Range Cruising Tabulation, 3 Engine

022300

LONG RANGE CRUISING—2 ENGINES

IAS - statute MPH, TAS - knots, TP - psi, FF - lbs/hr./engine

Density Altitude Ft.	Gr. Wt. Lbs. x 1000	125 to 120	120 to 115	115 to 110	110 to 105	105 to 100	100 to 95	95 to 90
10,000	IAS			182	177	172	167	165
	TAS			186	181	176	171	169
	RPM			2540	2480	2430	2360	2270
	TP			239	229	219	204	192
	FF			1580	1360	1180	970	850
8,000	IAS			178	174	170	166	165
	TAS			177	173	169	166	164
	RPM			2500	2450	2390	2340	2230
	TP			233	222	211	201	192
	FF			1440	1250	1070	940	830
6,000	IAS		180	176	172	169	166	166
	TAS		173	170	166	163	160	160
	RPM		2540	2470	2420	2360	2310	2190
	TP		239	227	218	204	194	192
	FF		1580	1320	1160	970	890	815
4,000	IAS		180	174	171	169	167	168
	TAS		169	163	161	159	157	158
	RPM		2500	2440	2390	2330	2270	2140
	TP		233	220	211	199	192	192
	FF		1440	1190	1070	920	850	790
2,000	IAS	187	180	174	172	170	169	169
	TAS	170	163	159	157	155	154	154
	RPM	2540	2480	2420	2370	2320	2210	2100
	TP	239	229	218	208	197	192	192
	FF	1580	1360	1160	1000	900	820	770

NOTE: 1. Data based on standard day conditions.
2. Auto Lean Mixture.
3. Manifold pressure may be determined by reference to figures A26 through A33.

DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-94. Long Range Cruising Tabulation, 2 Engine

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A-102. EFFECT OF WIND ON OPTIMUM CRUISE SPEEDS.

A-103. It can be readily seen that a headwind decreases ground range and a tailwind increases it. Not quite so apparent is the fact that operating in headwinds may require airspeeds greater than zero wind cruise speeds if unnecessary loss of range is to be avoided. The effect of wind on range for a given airspeed can be stated in the following simple equation:

$$\text{Ground mi/lb} = \text{Air mi/lb} \times \frac{V - V_W}{V}$$

V is airplane velocity and V_W is wind velocity, headwinds being considered positive values.

A-104. Figure A-95 illustrates why airspeed must sometimes be increased in headwinds to realize maximum ground miles per pound. It also illustrates a set of rule of thumb guides for operating in headwinds or tailwinds.

a. Flying at speeds recommended for 99% maximum range will result in maximum range for 50 knot headwind operation.

b. Flying at 110% of zero wind maximum range speeds results in maximum range for operation in 100 knot headwinds.

c. No change in speed from recommended zero wind cruise speeds is required for operation in tailwinds.

Where winds must be accounted for in cruise predictions, the ground distance will change in proportion to the effect of the wind on the average ground speed during cruise.

A-105. Consider a condition applicable to figure A-86 and zero wind:
If gross weight at start of a 10,000 feet altitude cruise is 141,500 pounds, and gross weight at end of cruise is 112,000 pounds, then:

Predicted distance traveled = 6250 - 3900 = 2350 naut. mi.

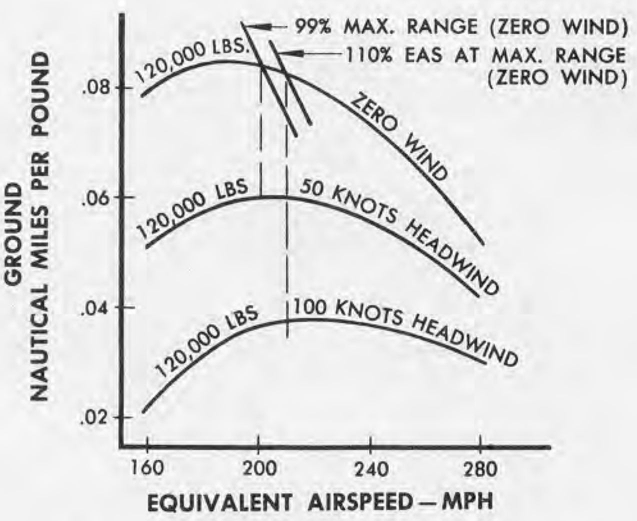

Figure A-95. Effect of Wind on Optimum Cruise Speeds 022302

From figure A-87 the time readings for 141,500 pounds and 112,000 pounds are 12.7 hours and 24.0 hours; therefore:

Predicted elapsed time in cruise = 24.0 - 12.7 = 11.3 hrs.

The average true airspeed (zero wind condition) is then:

$$\frac{2350 \text{ nautical miles}}{11.3 \text{ hours}} = 208 \text{ knots}$$

With a 15 knot headwind:

$$\text{Ground Distance} = 2350 \times \frac{193}{208} = 2180 \text{ nautical miles.}$$

The elapsed time will remain the same (11.3 hours).

A-106. DESCENT CONTROL.

A-107. Analysis shows that, compared to level flight, the energy derived from descent while maintaining long range cruising speeds provides 2.2 nautical miles additional range for every 1000 feet decrease in altitude. This is virtually independent of rate of descent used. This means that a close approximation of the airplane range in descent may be determined by finding the level flight range at cruise altitude and adding 2.2 nautical miles to this range for every 1000 feet of descent from cruise altitude.

A-108. At long range cruising speeds a rate of descent up to 1000 feet per minute may be used without affecting the range an appreciable amount. However, fast descents result in less economical engine operation because of the low power settings that must be used, but they are used for such a short time that no appreciable decrease in range results unless speeds appreciably higher than long range cruising are used.

A-109. During descent the cooling required is reduced and consequently the cowl flaps can be closed tighter than in level flight, thus tending to make 2.2 nautical miles per 1000 feet somewhat conservative.

A-110. When descending at speeds other than long range cruising speeds the factor of 2.2 nautical miles per 1000 feet, is, of course, not correct. It is apparent that descending at very high speeds would reduce this factor considerably.

A-111. EXAMPLE MISSION FOR USE OF CHARTS.

A-112. The KC-97E tanker airplane was designed to deliver fuel to a receiver airplane at a specified point in flight, thus extending the range of the receiver airplane. In general, the type of mission encountered with the tanker airplane will fall into one of the following three categories:

a. Determination of the maximum amount of fuel which may be transferred to a receiver airplane at a given distance. The solution to this problem requires starting with the maximum takeoff gross weight and computing the mission to the point of the contact with the receiver airplane, and then determining the landing condition and working backwards to the end of the fuel transfer. The difference between the formating weight at the end of the fuel transfer will be the amount of fuel transferred plus the fuel used by the tanker during the transfer. By trial and error the small percentage of the fuel used by the tanker may be determined and thus the actual fuel transferred to the receiver airplane has been computed. However, the fuel loading must be within the flight restrictions for overload gross weights and fuel distribution or concentration must be within structural, weight, and balance limits.

b. Determination of the maximum distance at which a given amount of fuel may be transferred to a receiver airplane. This is done by loading with the amount of fuel to be transferred plus the maximum amount of fuel that may be carried for tanker use up to the maximum takeoff weight. Then accounting for altitudes, winds, fuel used by tanker during transfer, etc., compute the mission in a normal manner, balancing the distance to and from the end of the fuel transfer.

c. Determination of the takeoff weight required to refuel a receiver airplane with a given amount of fuel at a given distance. The landing weight for this type of problem must either be known or estimated, and from this point the mission is worked backwards, from landing to the takeoff configuration.

The first type of problem has been chosen for presentation here because it is probably the most typical and at the same time demonstrates the use of the Appendix 1 charts.

A-113. Solution of any of these mission problems requires a schedule of operating procedures and methods. The following criteria will be assumed valid for this problem.

a. Warm-up and takeoff, allow 10 minutes at normal rated power.

b. Climb at normal rated power.

c. Initial cruise altitude, best combination of range and speed.

d. Cruise in auto rich for powers greater than 1750 BHP/engine.

e. Climb at normal rated power to formating altitude.

f. Rendezvous for one hour at airspeeds for long range cruising at formating altitude. (No distance credited for rendezvous).

g. Refuel at formating altitude at normal rated power on outbound course using maximum fuel transfer rate of 500 gallons per minute. Fuel transferred for jet bombers shall be MIL-F-5624 (AN-F-58) fuel until MIL-F-5624 transfer capacity of tanker is exhausted, then MIL-F-5572 (AN-F-48) fuel from the main fuel system of the tanker may be transferred.

h. Return at altitude for best combination of range and speed.

i. Allow 2.2 nautical miles per 1,000 feet altitude as range gain in descent.

j. Land with a fuel reserve of at least 5% of the initial fuel.

k. Account for cabin heater fuel at the rate of 50 pounds per hour.

l. Consider 6 pounds per gallon for MIL-F-5572 fuel and 6.5 pounds per gallon for MIL-F-5624 fuel.

A-114. Now, suppose that a jet bomber is to be refueled at the end of a 1,000 nautical mile tanker radius. The formating altitude will be 20,000 feet for the example. The tanker will be loaded to a maximum gross weight for takeoff of 175,000 pounds, and to a maximum equivalent gross weight for takeoff of 175,000 pounds as discussed in paragraph A-21. On the outbound leg there will be 10 knot headwinds from sea level to 10,000 feet and 15 knot headwinds at 20,000 feet. On the return leg the winds will be tailwinds of the same magnitudes. The atmosphere will be considered to be standard.

A typical maximum loading can be determined from the following information found in the Weight and Balance Handbook, AN 01-1B-40.

Basic Weight empty	81,647 pounds
Crew of 6 men	1,200
Miscellaneous equipment	160
Drinking water	83
A.D.I. Fluid, including system fluid	460
Supercharger lub. oil, including trapped oil	47
Trapped oil	533
Oil (196 gallons)	1,470
Unavailable fuel	492
Operating weight empty	86,092 pounds

For a maximum takeoff weight of 175,000 pounds the weight breakdown is as follows:

Operating weight empty	86,092 pounds
MIL-F-5624 fuel (IFR tanks full)	46,800
MIL-F-5572 fuel (outboard wing tanks)	21,240
MIL-F-5572 fuel (inboard wing tanks)	18,240
MIL-F-5572 fuel (center tanks)	2,628
Takeoff Weight	175,000 pounds

To obtain maximum performance, cruise altitudes must be chosen to obtain the best combination of range and speed. The Long Range Summary, type A2-4 curve, (figure A-80) shows that maximum fuel mileage occurs at the lower altitudes. Although the recommended equivalent airspeeds are also greater at the lower altitudes, they are not nearly enough greater to overcome the effect of altitude on corresponding true airspeeds. Since at high weights the difference in fuel mileage between sea level and 10,000 feet is insignificant, the initial cruise will be chosen at 10,000 feet. In this manner mission time can be reduced somewhat for an insignificant loss in range. Cruising after the fuel transfer will be at considerably lower weights. During lower weight operation fuel mileage is not significantly different at the formating altitude than at lower altitudes. Therefore, in order to decrease the mission time, the return cruise will be at the formating altitude of 20,000 feet. For simplicity, the required oil and water is included in the operating weight empty and the required heater fuel is assumed to be carried all the way.

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A-115. WARM-UP AND TAKEOFF (A - B, figure A-97). Experience will dictate the fuel needed for warm-up and takeoff. It is approximated by the amount of fuel used during 10 minutes operation at normal rated power. From figure A-27, fuel flow at 2650 BHP per engine and auto-rich mixture is 1930 pounds per hour per engine. Gross weight at the beginning of the climb after takeoff then appears to be:

$$\text{Gross weight} = 175{,}000 - \left(\frac{1930 \times 4}{6}\right) = 173{,}710 \text{ pounds.}$$

A-116. CLIMB TO 10,000 FEET (B - C, figure A-97). Using the weight of 173,710 pounds at the start of the climb, enter the Climb Prediction Chart, type A6-4 curve, (figure A-37) to find the fuel, time, and distance used in climbing from sea level to 10,000 feet.

	Altitude Feet	Weight Pounds	Dist. Naut. Mi.	Time Min.
Start of climb	S.L.	173,710	0	49
End of climb	10,000	171,000	59	70
Fuel, air distance and time in climb		2,710	59	21

Therefore, the weight at 10,000 feet at the end of the climb is 171,000 pounds.

The average EAS = 195 MPH is read also from figure A-37. Using an average altitude of 5000 feet the average true airspeed in knots is determined as follows:

$1/\sqrt{\sigma}$ at 5000 feet = 1.077

MPH/knot = 1.15

$$\text{Average true airspeed} = 195 \times \frac{1.077}{1.15} = 183 \text{ knots.}$$

The air distance traveled during the climb has been found to be 59 nautical miles.

The ground distance traveled, correcting for the 10 knots headwind, is then:

$$\text{Ground distance} = 59 \times \frac{183-10}{183} = 56 \text{ nautical miles.}$$

A-117. LONG RANGE CRUISE AT 10,000 FEET (C - D, figure A-97). It is now necessary to determine the distance to be flown at 10,000 feet. This distance is 1,000 nautical miles minus the distance in climb from sea level to 10,000 feet minus the distance in climb from 10,000 feet to 20,000 feet, and minus the distance flown during the fuel transfer. An estimate of 120 nautical miles will be used, for the present, for the distance in climb from 10,000 to 20,000 feet and for the fuel transfer. The ground distance which must be covered at 10,000 feet then becomes:

Ground distance = 1,000 - 56 - 120 = 824 nautical miles.

The cruising EAS is estimated from figure A-80 to be 212 MPH. The average true airspeed during the cruise at 10,000 feet is determined as follows:

$1/\sqrt{\sigma}$ at 10,000 feet = 1.164

MPH/knot = 1.15

$$\text{Average true airspeed} = 212 \times \frac{1.164}{1.15} = 215 \text{ knots.}$$

The air distance which must be covered at 10,000 feet, then becomes:

$$\text{Air distance} = 824 \times \frac{215}{215-10} = 864 \text{ nautical miles}$$

The fuel and time consumed during the cruise at 10,000 feet can be determined, now, from figures A-86 and A-87.

	Weight Pounds	Distance Naut. Mi. (fig. A-86)	Time Hours (fig. A-87)
Start of cruise	171,000	2,210	4.90
Add air distance		864	
End of cruise	154,300	3,074	8.90
Fuel and time consumed	16,700		4.00

Assuming that the estimates used during the cruise at 10,000 feet are very nearly correct, the calculations will be continued and these estimates will be checked again to balance the remainder of the mission.

A-118. CLIMB FROM 10,000 FEET TO FORMATING ALTITUDE OF 20,000 FEET (D - E, figure A-97). Fuel, distance, and time used in climb from 10,000 to 20,000 feet are determined from the weight determined at the end of the cruise at 10,000 feet and the Climb Preduction Chart, type A6-4 curve (figure A-37).

Entering figure A-37 with the starting weight of 154,300 pounds, the fuel and time consumed and the distance covered will be determined.

	Altitude Feet	Weight Pounds	Dist. Naut. Mi.	Time Min.
Start of climb	10,000	154,300	39	199
End of climb	20,000	152,150	95	216
Fuel, air distance and time in climb		2,150	56	17

Entering figure A-37 with the average weight during the climb of $\frac{152{,}150 + 154{,}300}{2} = 153{,}225$ pounds, the average EAS = 191 MPH is determined.

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Average headwind = 13 knots

$1/\sqrt{\sigma}$ at 15,000 feet = 1.261

MPH/knot = 1.15

Average true airspeed $= 191 \times \frac{1.261}{1.15} = 209$ knots

The ground distance then becomes:

Ground distance during climb $= 56 \times \frac{209 - 13}{209} = 53$ nautical miles.

A-119. RENDEZVOUS (E - F, figure A-97). The weight at the beginning of the one hour of rendezvous is the weight at the end of climb to 20,000 feet. Entering the Long Range Time Prediction, type A3T-4 curve, (figure A-87) at this weight of 152,150 pounds for 20,000 feet, move left and read 5.3 hours. Enter chart again at 5.3 + 1.0 = 6.3 hours and read the weight, 147,800 pounds at 20,000 feet.

Average weight during rendezvous $= \frac{152{,}150 + 147{,}800}{2} = 149{,}975$ pounds

Enter figure A-80 with 149,975 pounds and read EAS = 202 MPH.

$1/\sqrt{\sigma}$ at 20,000 feet = 1.370

MPH/knot = 1.15

Average true airspeed $= 202 \times \frac{1.370}{1.15} = 241$ knots.

The weight at the end of the rendezvous will be the weight at the start of the fuel transfer or 147,800 pounds. In order to determine how much fuel may be transferred, it will be necessary, now, to start at the landing weight and work backwards to the weight after the maximum fuel has been transferred with sufficient tanker fuel remaining to return to the tanker base.

A-120. LANDING WEIGHT. Assume the operating weight empty of the KC-97E airplane to be 86,400 pounds. According to our rules we should have remaining in the tanks upon landing a fuel reserve of 5% of the total weight of fuel on board available for tanker use. The total weight of MIL-F-5572 fuel on board is as follows:

Outboard wing tanks	21,240 pounds
Inboard wing tanks	18,240
Center tanks	2,628
Total MIL-F-5572 fuel	42,108 pounds

As much of this fuel as possible will be transferred after the MIL-F-5624 fuel capacity has been exhausted. A good estimate for the reserve would be 2000 pounds or 5% of 40,000 pounds. This will be checked after the remainder of the mission has been completed.

Cabin heater fuel requirements should be accounted for at the rate of 50 pounds per hour. Referring to the Long Range Summary, (figure A-80) a rough approximation of the average speed for the mission may be selected. Using this EAS of 207 MPH at an approximate average weight of 131,000 pounds and an average altitude of 15,000 feet the approximate flight time may be determined as follows:

Average $1/\sqrt{\sigma}$ = 1.261

MPH/knot = 1.15

TAS $= 207 \times \frac{1.261}{1.15} = 227$ knots

Total mission distance = 2000 nautical miles

Time $= \frac{2000}{227}$ + (1 hour for rendezvous) = 9.8 hours

Cabin heater fuel consumed = approximately 500 pounds

Throughout the mission the cabin heater fuel consumed will be disregarded. However, the total amount of 500 pounds consumed will be accounted for by including it in the landing weight.

Operating Weight Empty	86,400 pounds
Reserve	2,000
Cabin Heater Fuel	500
Landing Weight	88,900 pounds

A-121. DESCENT (H - I, figure A-97). As noted in paragraph A-106, compared to level flight, the energy derived from descent provides 2.2 nautical miles additional range for every 1000 feet decrease in altitude during descent at long range cruising speeds. This means that a close approximation of the airplane range may be determined by finding the level flight range at flight altitude and by adding 2.2 nautical miles to this range for every 1,000 feet of descent from flight altitude, as shown in figure A-96. The altitude for the return cruise is 20,000 feet as previously stated.

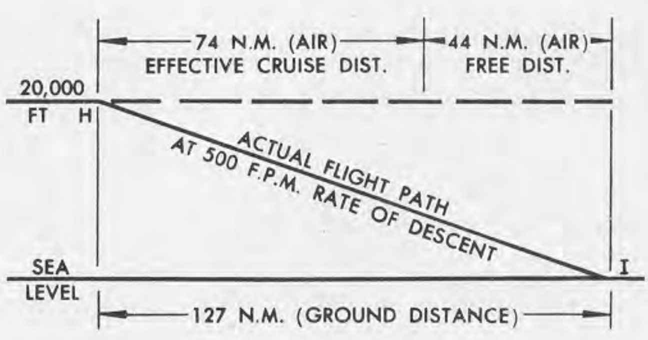

Figure A-96. Distance in Descent 022305

Additional descent range = 2.2 x 20 = 44 nautical miles

Time at 500 feet per minute descent = 40 minutes

Average descent altitude = 10,000 feet

From figure A-80 for an approximate average weight of 88,900 pounds at 10,000 feet:

Average cruising speed, EAS = 175 MPH

$1/\sqrt{\sigma}$ at 10,000 feet = 1.164

MPH/knot = 1.15

Average true airspeed = $175 \times \frac{1.164}{1.15} = 177$ knots

Descent distance = $177 \times \frac{40}{60} = 118$ nautical miles

Effective cruise distance at 20,000 feet = 118 - 44 = 74 nautical miles.

The effective cruise distance must be used to find the weight at the start of descent. Enter the Long Range Prediction, type A3D-4 curve, (figure A-86) at 20,000 feet and 88,592 pounds. Go left and read 7,180 nautical miles.

7,180 - 74 = 7,106 nautical miles

At 7106 nautical miles and 20,000 feet read the weight at the start of the descent which is equal to 89,200 pounds. The fuel used is 89,200 minus 88,592 or 608 pounds.

The actual ground distance covered in descent will be somewhat larger than the indicated distance because of the tailwinds which for the descent average out at about 13 knots. The average true airspeed was found to be 177 knots. Therefore, the actual ground miles will be:

Actual ground distance = $118 \times \frac{(177 + 13)}{177} = 127$ nautical miles.

A-122. OPERATION AT 20,000 FEET FROM END OF FUEL TRANSFER TO THE START OF THE DESCENT (G - H, figure A-97). The return distance in cruise at 20,000 feet after the fuel transfer has been completed will be the remainder of the 1000 nautical mile radius after the descent ground distance of 127 nautical miles has been subtracted.

Ground distance in cruise at 20,000 feet = 1000 - 127 = 873 nautical miles

The cruising EAS is estimated from figure A-80 to be 177 MPH. The average true airspeed during the cruise at 20,000 feet is determined as follows:

Tailwind = 15 knots

$1/\sqrt{\sigma}$ at 20,000 feet = 1.370

MPH/knot = 1.15

Average true airspeed = $177 \times \frac{1.370}{1.15} = 211$ knots

The air distance traveled in cruise at 20,000 feet is then:

Air distance in cruise at 20,000 ft. = $873 \times \frac{211}{211 + 15} = 815$ nautical mi.

Knowing that the weight at the end of this cruise is the same as the weight at the start of descent (89,200 pounds) enter the Long Range Prediction, type A3D-4 curve, (figure A-86) at 20,000 feet and find the weight at the start of the cruise.

	Weight Pounds	Distance Naut. Mi. (fig. A-86)	Time Hours (fig. A-87)
End of cruise	89,200	7,110	27.60
Subtract air distance		815	
Start of cruise	96,900	6,295	23.70
Fuel and time	7,700		3.90

The average true airspeed becomes:

Average true airspeed = $\frac{815}{3.90} = 209$ knots.

This checks closely enough with the original estimate.

The gross weight at the end of the fuel transfer is the weight at the start of the return cruise or 96,900 pounds.

A-123. TRANSFER OF FUEL AT FORMATING ALTITUDE OF 20,000 FEET WITH NORMAL RATED POWER (F - G, figure A-97). The weights at the beginning and the end of the fuel transfer have been determined. The difference in these weights is the maximum fuel transferrable plus any fuel consumed by the flight of the tanker itself.

Weight at start of transfer	147,800 pounds
Weight of MIL-F-5624 fuel transferred	46,800
Tanker weight + MIL-F-5572 fuel at start	101,000 pounds
Weight at end of transfer	96,900
MIL-F-5572 fuel to be disposed of during transfer	4,100 pounds

The MIL-F-5624 fuel is to be transferred first at the rate of 500 gallons per minute with the tanker oper-

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ating in normal rated power. MIL-F-5624 fuel will weigh 6.5 pounds per gallon.

Time for transfer of

$$\text{MIL-F-5624 fuel} = \frac{46{,}800}{500 \times 60 \times 6.5} = .24 \text{ hours}$$

From the Power Schedule and Fuel Flow, type M-4 curve, (figure A-31) the pounds per hour per engine of fuel used by the tanker during the transfer is determined as 1940 for normal rated power (2,650 BHP/engine in auto-rich).

Fuel used by tanker = 1940 x 4 x .24 = 1,864 pounds.

After the MIL-F-5624 fuel has been transferred from the tanker, MIL-F-5572 fuel may be transferred until only enough fuel is left to return to the tanker base with an adequate reserve.

MIL-F-5572 fuel
remaining = 4,100 - 1,864 = 2,236 pounds.

It will be estimated that 80 pounds of fuel will be used to transfer the remaining MIL-F-5572 fuel.

MIL-F-5572 fuel
to transfer = 2,236 - 80 = 2,156 pounds.

At the same rate of 500 gallons per minute the 2,156 pounds will be transferred. MIL-F-5572 fuel will weigh 6.0 pounds per gallon.

Time for transfer of

$$\text{MIL-F-5572 fuel} = \frac{2156}{500 \times 60 \times 6.0} = .01 \text{ hours}$$

Check the fuel used by the tanker:

1940 x 4 x .01 = 78 pounds.

This checks with the estimate of 80 pounds.

The time for the total transfer then becomes:

.24 + .01 = .25 hours = 15 minutes

The average weight during the transfer is:

$$\frac{147{,}800 + 96{,}900}{2} = 122{,}350 \text{ pounds.}$$

Entering the type A1-4 curve of figure A-57 with the average tanker weight during the fuel transfer, the average true airspeed is indicated as being 307 knots. To account for additional drag of the boom in the contact position rather than in the stowed position 9 knots (10 MPH) are subtracted giving the true airspeed as 298 knots. The distance traveled during the transfer is 298 x .25 = 75 nautical miles. The ground distance then becomes:

$$75 \times \frac{298 - 15}{298} = 71 \text{ nautical miles.}$$

The total fuel transferred = 46,800 + 2,156 = 48,956 lbs.

The distance of 71 nautical miles for the fuel transfer plus the distance of 53 nautical miles for the climb from 10,000 feet to 20,000 feet becomes 124 nautical miles which checks reasonably with the estimated distance of 120 nautical miles used in the first part of the mission.

The total amount of fuel available for use by the tanker was the total amount MIL-F-5572 fuel on board (42,108 pounds) minus the amount of MIL-F-5572 fuel transferred (2,156 pounds). This left 39,952 pounds of fuel used on the mission, including the 5% reserve. 5% of 39,952 pounds for reserve becomes 1,998 pounds, which checks almost exactly with the estimated reserve of 2000 pounds.

The mission profile and flight plan are represented by figure A-97.

A-124. PRE-FLIGHT PLANNING. Pre-flight planning for long range cruising periods must be based entirely upon the recommended equivalent airspeeds shown for a particular weight range and altitude on the Long Range Summary, type A2 curve. There are six different Long Range Summary sheets, and a little care is required to avoid use of one which does not fit conditions desired for the cruise. The following section of a preliminary flight log covering the cruise at 10,000 feet (points C to D) of the example is tabulated from the proper summary and prediction curves. A similar tabulation of the entire flight makes in-flight cruise and climb control much simpler.

Time Interval Hrs. Min.	Total Time Hrs. Min.	EAS MPH	Pilots' IAS MPH	Gross Weight Pounds	Fuel Used Pounds	Air Distance Nautical Miles	Total	Average RPM
	0			171,000			0	
1:00		212	209		4,550	230		2,340
	1:00			166,450			230	
1:00		212	209		4,250	220		2,300
	2:00			162,200			450	
1:00		212	209		4,050	210		2,270
	3:00			158,150			660	
1:00		212	209		3,850	204		2,240
	4:00			154,300			864	

NOTE: 1. No instrument error is assumed present in the airspeed indicator.

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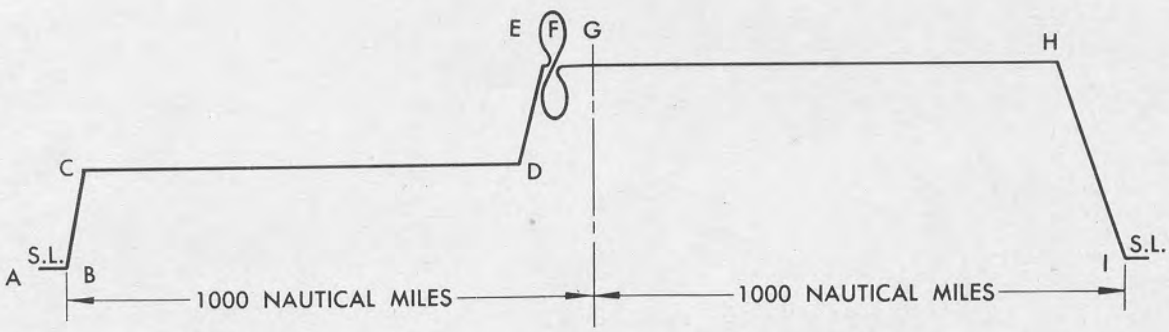
FUEL LOADING—LBS

DATE	ESTIMATE REQ'D 86,910	OUTBOARD WING 21,240	BASIC WEIGHT 81,647
MISSION	RESERVES 1,998	INBOARD WING 18,240	O.W.E. 86,092
SQUADRON	TOTAL ABOARD 88,908	CENTER TANK 2,628	T.O. GROSS WT. 175,000
		BODY TANKS 46,800	

FLIGHT PLAN

KC-97E TANKER FOR 1000 NAUTICAL MILE RADIUS



AVERAGE TAS	216 KNOTS	AVERAGE TAS	204 KNOTS
HEADWIND	10 KNOTS	TAILWIND	15 KNOTS
AIR DISTANCE	1054 NAUTICAL MILES	AIR DISTANCE	933 NAUTICAL MILES

FLIGHT STATIONS	A	B	C	D	E	F	G	H	I
GROSS WEIGHT (LBS.)	175,000	173,710	171,000	154,300	152,150	147,800	96,900	89,200	88,592
EAS (MPH)		195	212	191	202	247	182	175	
TAS (KNOTS)		169	215	193	241	294	217	207	
POWER SETTING	T.O.	2650	LRC	2650	LRC	2650	LRC	LRC	
TIME (HR. & MIN.)	0	:10	:21	4:00	:17	1:00	:15	3:54	:40
TOTAL TIME	0	:10	:31	4:31	4:48	5:48	6:03	9:57	10:37
FUEL USED (LBS.)	0	1290	2710	16,700	2150	4350	1944	7700	608
TOTAL FUEL USED	0	1290	4000	20,700	22,850	27,200	29,144	36,844	37,452
AIR DISTANCE (N. MI.)	0	0	59	864	56	0	75	815	118
TOTAL AIR DISTANCE	0	0	59	923	979	979	1054	1869	1987

Figure A-97. Example Mission

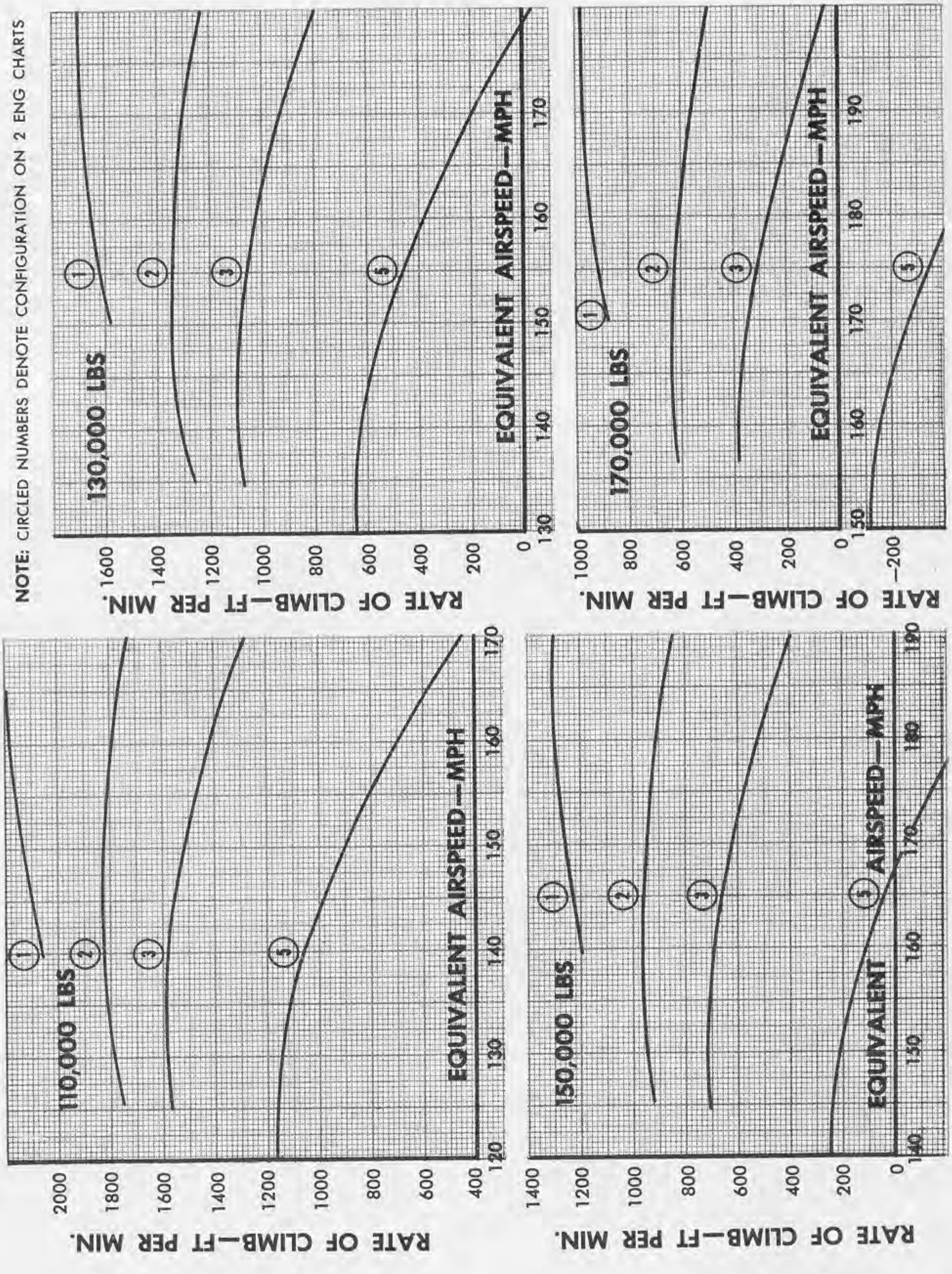
022308

A-125. EMERGENCY CLIMB.

A-126. Rates of climb are presented at various weights and sea level pressure altitude standard day for two, three and four engine operation in figures A-98 through A-100 using 3250 BHP on each operating engine and in figures A-101 through A-103 using normal rated power. Various configurations of the standard airplane, upon which corresponding curves are based, are itemized on figure A-100 for the 3250 BHP operation, and on figure A-103 for the normal rated power operation.

A-127. When flying with one or more engines inoperative, it is always best to maintain zero yaw if possible. The airplane drag is considerably less with the rudder deflected to hold zero yaw than it is if the whole airplane is allowed to yaw by reducing rudder deflection or leaving it in neutral.

4 ENGINE—3250 BHP—RATE OF CLIMB VS AIRSPEED
TYPE A9-4 CURVE
STANDARD DAY



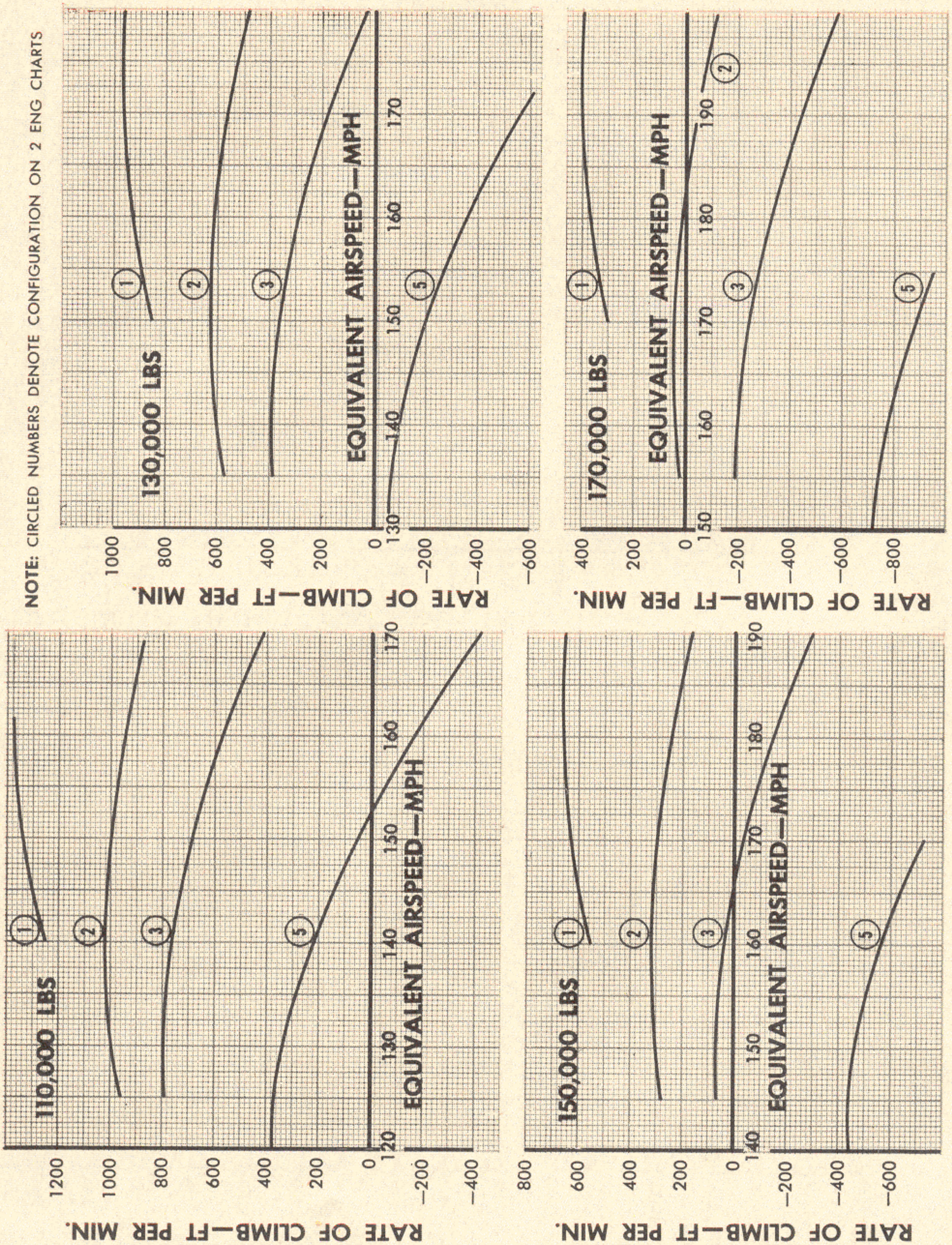
DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-98. 4 Engine Rate of Climb Vs. Airspeed, 3250 BHP

022310

3 ENGINE—3250 BHP—RATE OF CLIMB VS AIRSPEED
TYPE A9-3 CURVE
STANDARD DAY



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-99. 3 Engine Rate of Climb Vs. Airspeed, 3250 BHP

022311

2 ENGINE—3250 BHP—RATE OF CLIMB VS AIRSPEED

TYPE A9-2 CURVE
STANDARD DAY

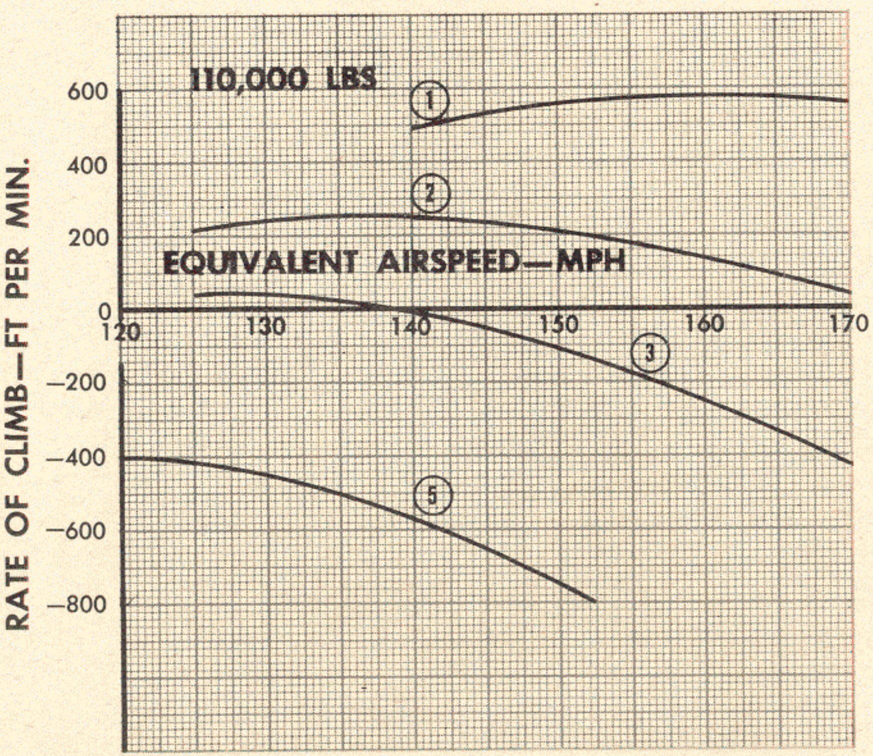
THE FOLLOWING INFORMATION APPLIES TO 4, 3 AND 2 ENGINE OPERATION

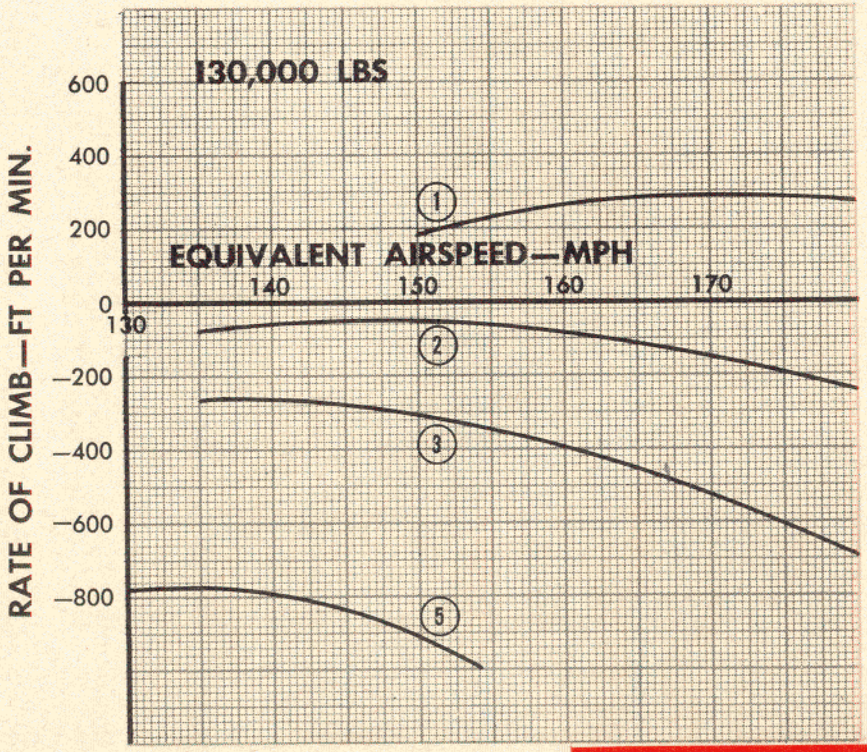
CONFIGURATION:

(1) STANDARD AIRPLANE—FLAPS UP, GEAR UP
(2) FLAPS 25°—GEAR UP
(3) FLAPS 25°—GEAR DOWN
(5) FLAPS 45°—GEAR DOWN

BASED ON:

3250 BHP/ENG AT 2700 RPM
SEA LEVEL
AUTO RICH MIXTURE—115/145 GRADE FUEL
0.75 IN. OIL COOLER FLAP GAP (AUTOMATIC)
2.0 IN. INTERCOOLER FLAP GAP
C.F.G. SET TO MAINTAIN CYLINDER HEAD TEMP LIMIT
INOPERATIVE PROPELLERS FEATHERED



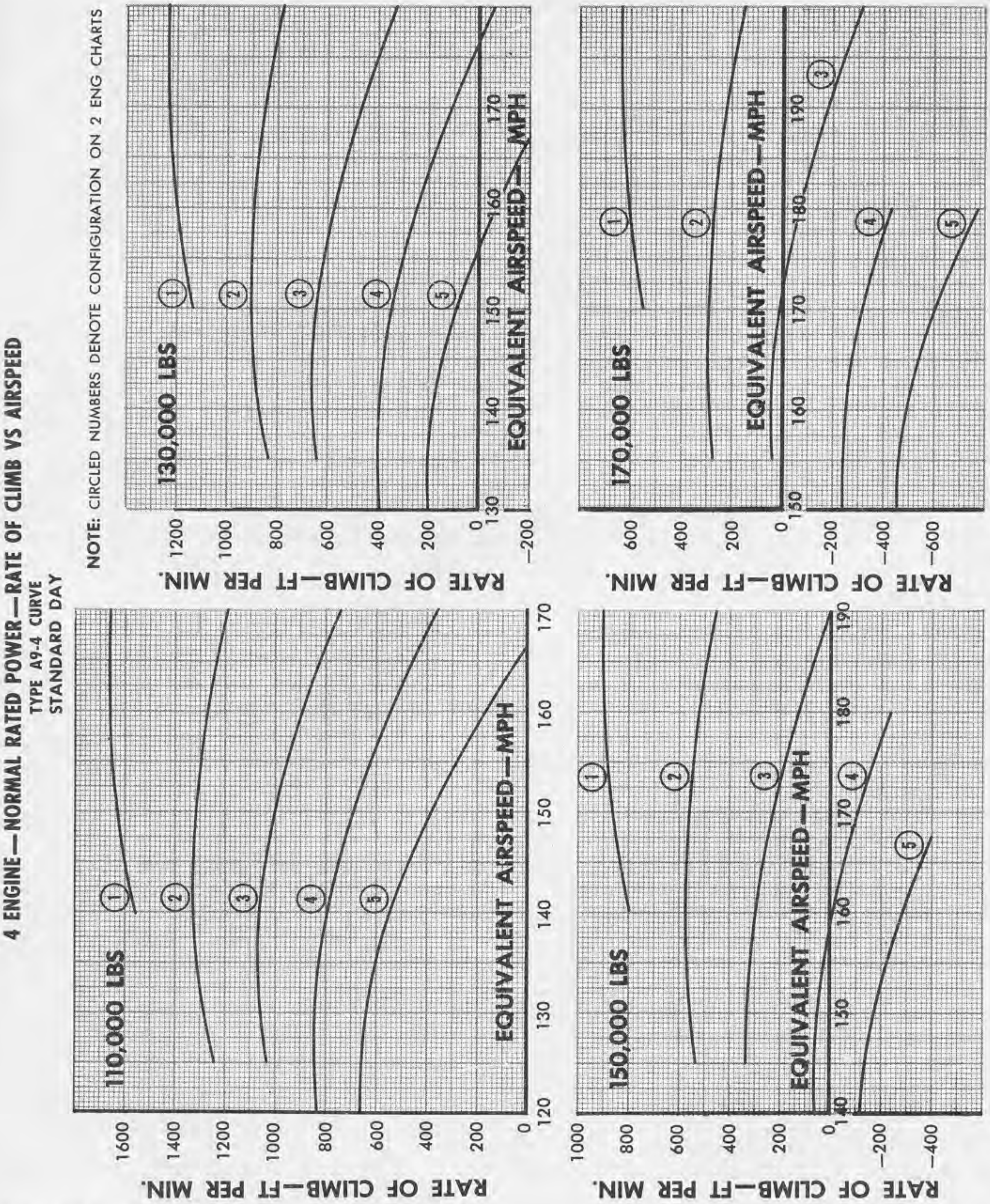


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

022312

Figure A-100. 2 Engine Rate of Climb Vs. Airspeed, 3250 BHP

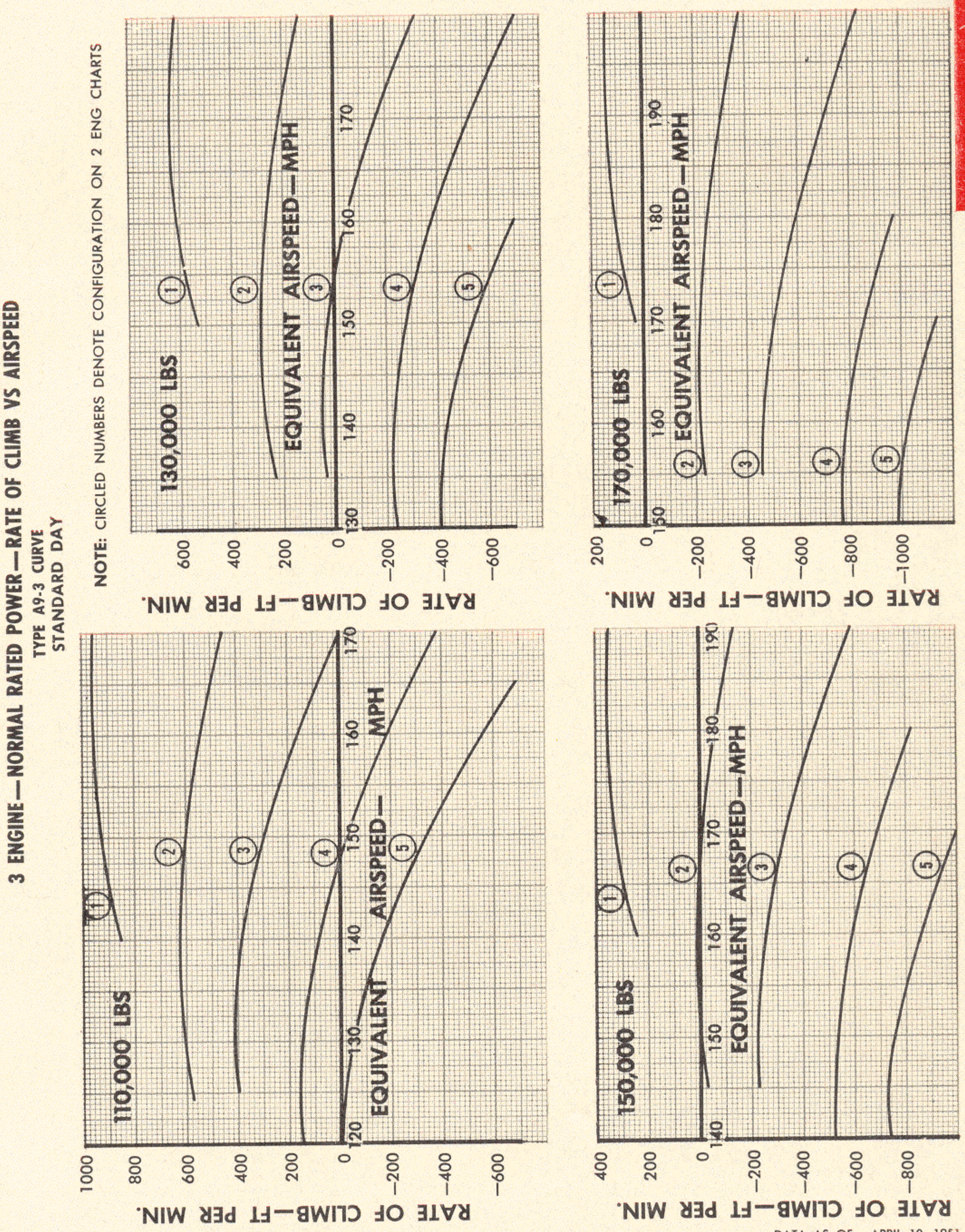


DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-101. 4 Engine Rate of Climb Vs. Airspeed, Normal Rated Power

022313



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-102. 3 Engine Rate of Climb Vs. Airspeed, Normal Rated Power

022314

U22209

2 ENGINE—NORMAL RATED POWER—RATE OF CLIMB VS AIRSPEED

TYPE A9-2 CURVE
STANDARD DAY

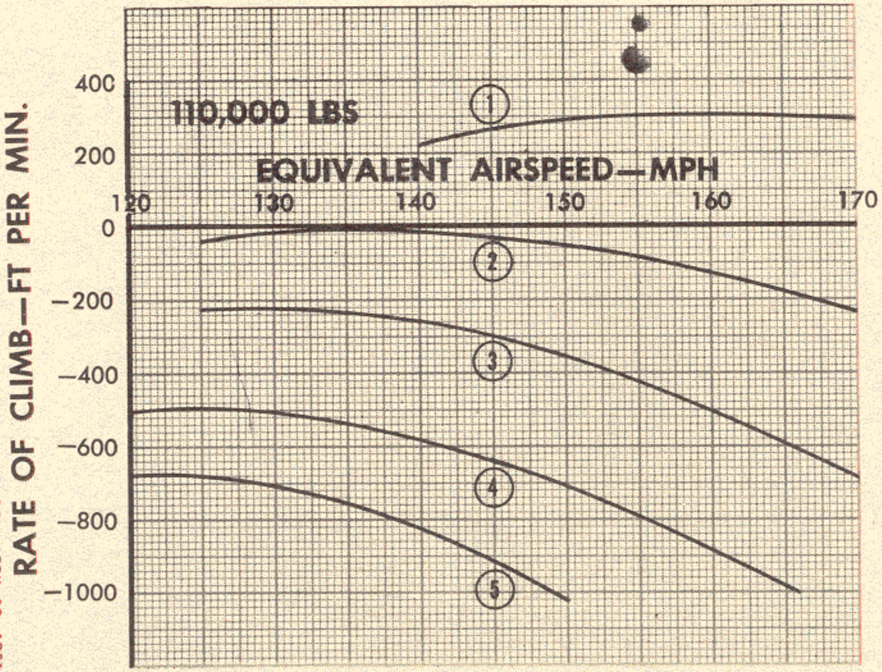
THE FOLLOWING INFORMATION APPLIES TO 4, 3 AND 2 ENGINE OPERATION

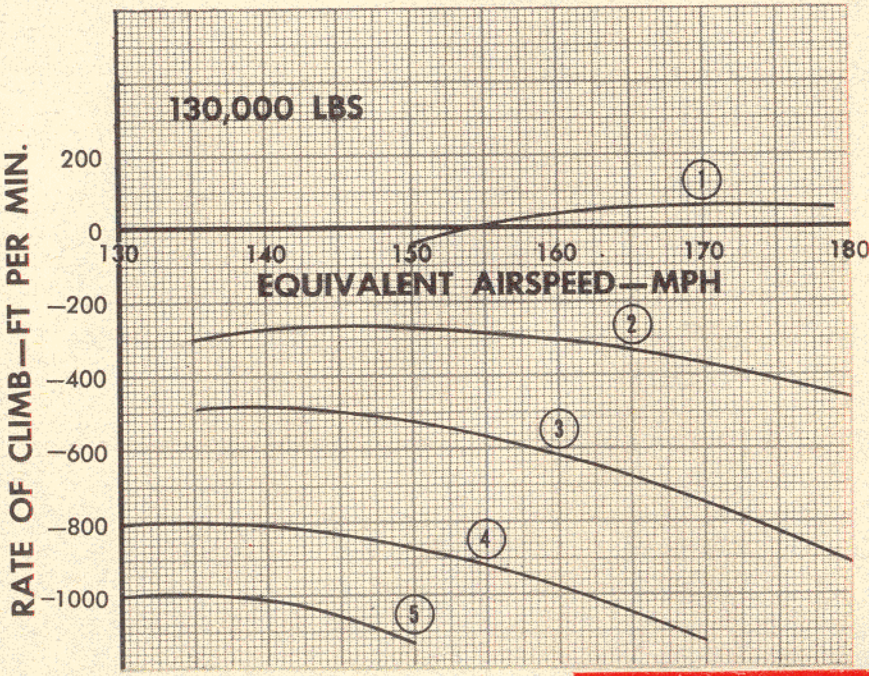
CONFIGURATION:

1. STANDARD AIRPLANE—FLAPS UP, GEAR UP
2. FLAPS 25°—GEAR UP
3. FLAPS 25°—GEAR DOWN
4. FLAPS 45°—GEAR UP
5. FLAPS 45°—GEAR DOWN

BASED ON:

2650 BHP/ENG AT 2550 RPM
SEA LEVEL
AUTO RICH MIXTURE—115/145 GRADE FUEL
0.75 IN. OIL COOLER FLAP GAP (AUTOMATIC)
2.0 IN. INTERCOOLER FLAP GAP
C.F.G. SET TO MAINTAIN CYLINDER HEAD TEMP LIMIT
INOPERATIVE PROPELLERS FEATHERED





DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

022315

Figure A-103. 2 Engine Rate of Climb Vs. Airspeed, Normal Rated Power

A-128. AERODYNAMIC AIRSPEED LIMITATIONS.

A-129. Pilot's indicated airspeed limitations are presented in figure A-104. The maximum indicated airspeeds permissible at any time are 348, 220, and 180 MPH for flaps up, 25° and 45° respectively. At higher altitudes maximum airspeeds are further limited by compressibility, as shown by the lines of .62, .52 and .48 Mach numbers applying to their respective flap settings.

A-130. The co-pilot's airspeed indicator has a placard pointer which is Mach limited and is set to approximately .62 Mach number. Where wing flap settings of 25° or 45° are used at high altitudes, a good rule of thumb for their respective Mach limits is 45 MPH and 55 MPH less than the reading of the placard pointer.

022316

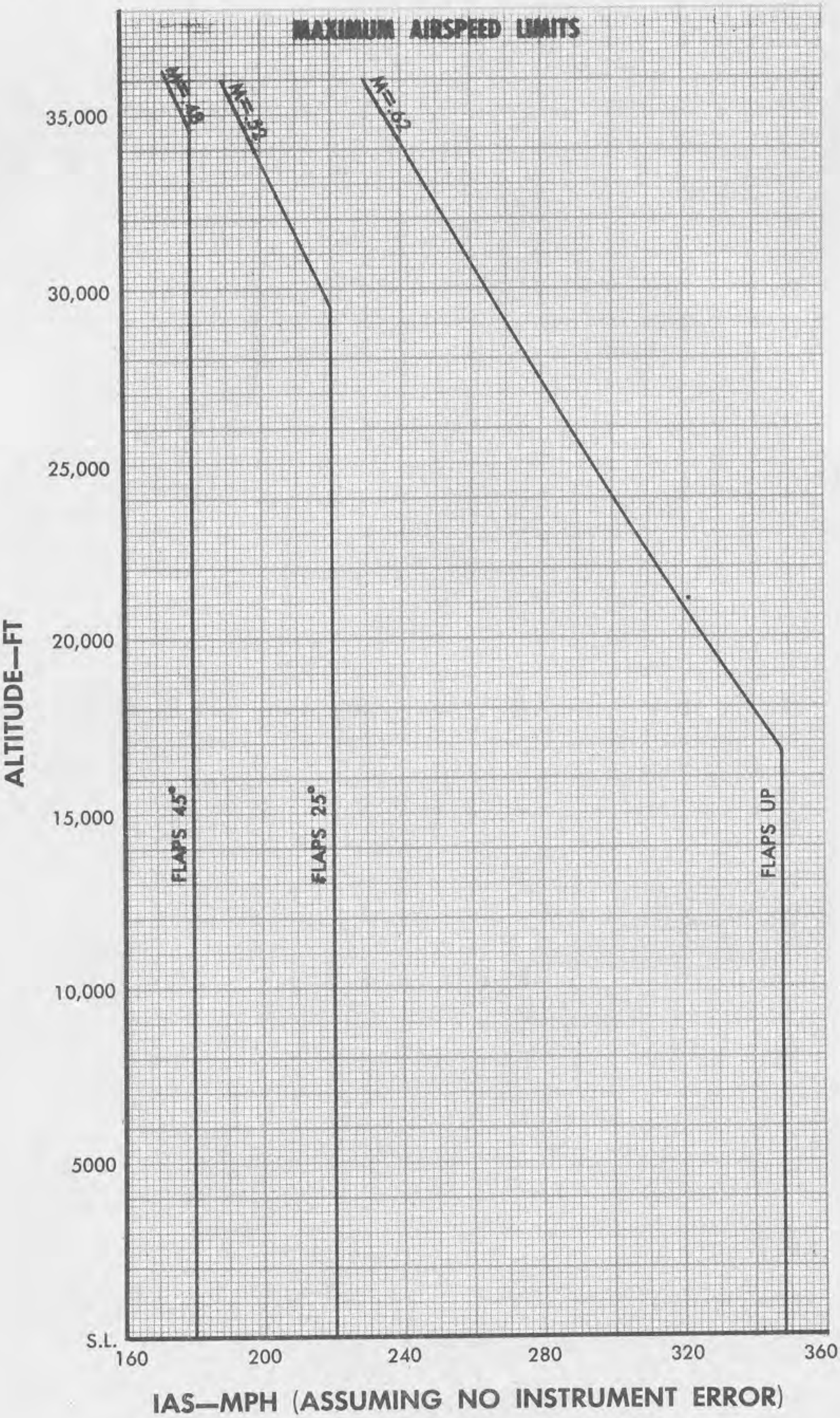


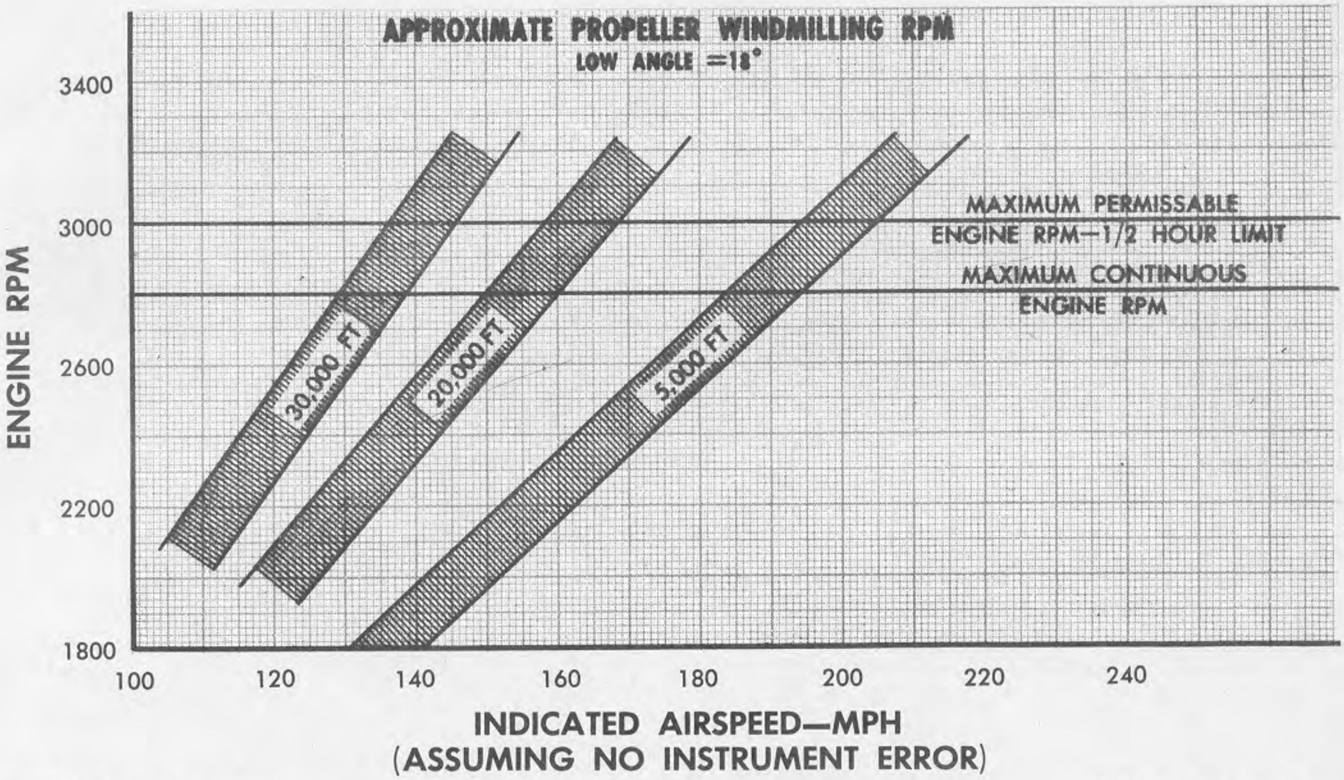
Figure A-104. Maximum Airspeed Limits

022317

A-131. WINDMILLING PROPELLER RPM LIMITS.

A-132. If a propeller RPM governor malfunctions the propeller may windmill against the low pitch angle stops. The engine might then be subjected to speeds beyond safe RPM limits. This becomes especially critical at the higher true airspeeds. Figure A-105 shows the approximate windmilling RPM, at the low pitch blade angle of 18°, versus the pilot's indicated airspeed for various altitudes. It is impossible to predict the exact windmilling RPM due to variation in atmospheric conditions, blade setting tolerances, engine friction, etc., but values will fall within the band shown for each altitude. If engine overspeed is encountered, the chart is useful for determining the windmilling RPM which will occur at various altitudes and airspeed combinations.

022318



DATA BASED ON: FLIGHT TEST

DATA AS OF: APRIL 10, 1951

Figure A-105. Approximate Propeller Windmilling RPM

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A-133. IN-FLIGHT REFUELING PERFORMANCE.

A-134. Obtaining optimum results with in-flight refueling requires careful mission planning supported by special flying techniques and coordination between receiver and tanker. In order to fit a refueling operation into the mission plans of both tanker and receiver, the usual cruise control data must be supplemented by additional operating information. The following is intended to provide the data on tanker performance in the formating condition and to supply information for predicting the necessary data on time, range, fuel consumed, and fuel transferred for certain most probable tanker-receiver combinations. Figure A-106 presents the KC-97E tanker airplane high speeds in level flight with normal rated power on a standard day when the boom is in the contact position. Because of the many variables affecting an operation of this kind it is first necessary to determine an operating schedule which will have the least tendency to restrict the operation of either airplane and therefore least restrict the combination. This schedule not only should result in optimum speeds and altitudes for the tanker-receiver combination but must also be practical for each airplane to adhere to.

A-135. Much of the necessary KC-97E tanker performance in the refueling condition can be obtained from the Nautical Miles per Pound curves, type A-1, by allowing for a 10 MPH loss in airspeed for the boom in contact position. This is only applicable, however, at speeds above long range cruising.

022320

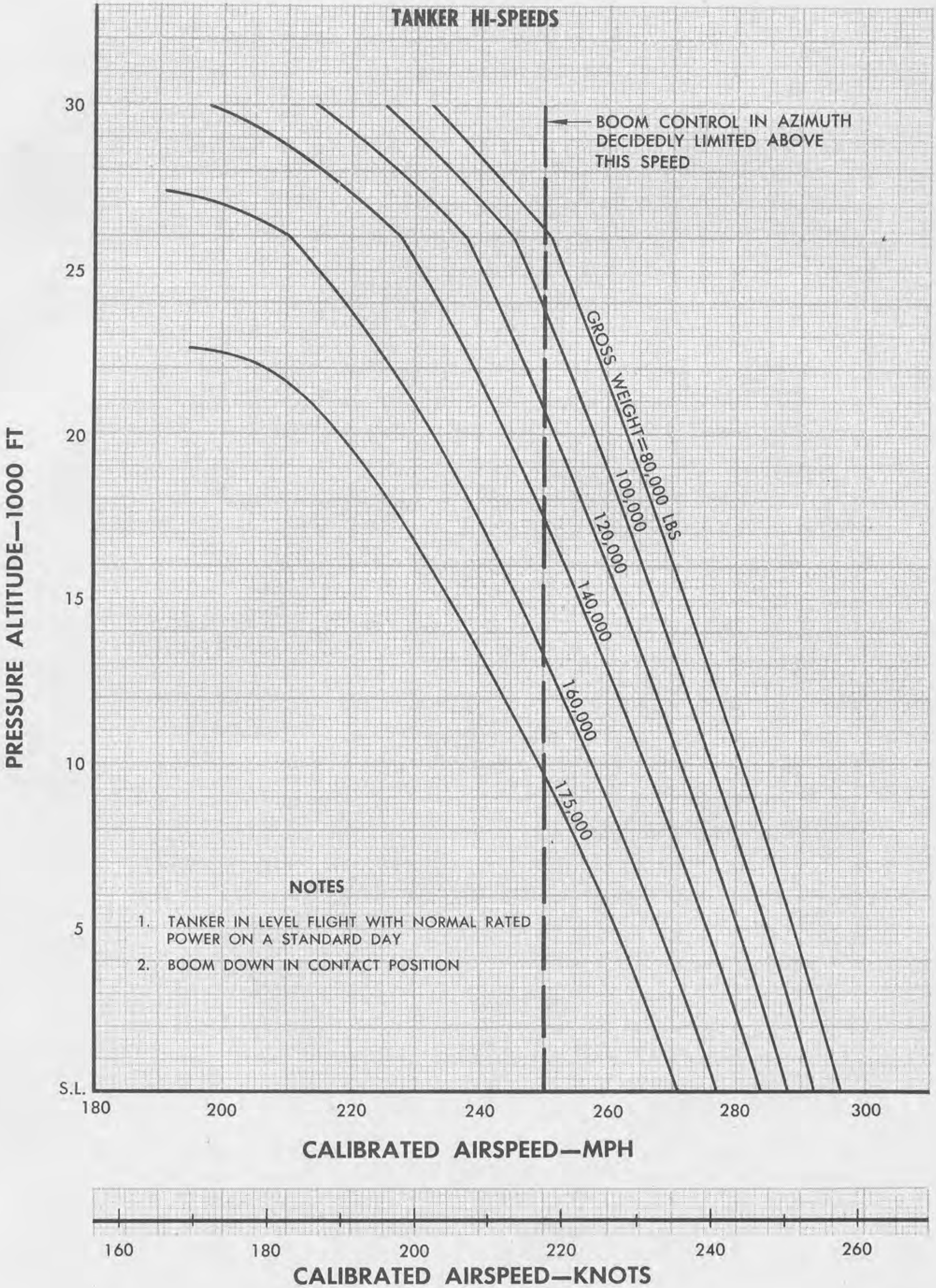


Figure A-106. Tanker Hi-Speeds

022321

A-136. REFUELING THE B-47B RECEIVER. Planning and operational data necessary for accomplishing an in-flight refueling of the B-47B receiver airplane with the KC-97E tanker airplane are presented in figures A-106 through A-110.

A-137. If refueling is made in level flight, the brake horsepower needed by the tanker to fly with the boom in the contact position may be obtained by entering the Nautical Miles per Pound curve, type A-1, at an equivalent airspeed of ten miles per hour greater than desired. The high speeds of the KC-97E tanker with boom in the contact position and with normal rated power are shown in figure A-106. Initial refueling altitudes appreciably higher than those possible in a level flight refueling operation may be attained by making contact and refueling while in a rate of descent, as shown in figure A-108. But, when large amounts of fuel are transferred this procedure results in only a slight increase in altitude at the end of refueling, compared with level flight refueling. Refueling in descent should be most useful when the level flight refueling altitudes are restricted by rough air conditions and/or cloud layers. While in the descent, the tanker will use normal rated power and fly the recommended speed schedule shown in figure A-107. This will result in rates of descent which will vary during the refueling.

A-138. REFUELING SPEEDS. The recommended schedule of airspeed for refueling B-47B airplanes is given in figure A-107. Knowing the B-47B weight at the beginning of the fuel transfer and the approximate time to refuel the B-47B from one weight to another from figure A-109, the increase in airspeed with time may be determined. These charts provide the airspeeds needed for mission planning, provide the contact speeds for the tanker and receiver pilots, indicate to the receiver pilot what airspeeds he should expect as the fuel is received, and dictate to the tanker pilot what airspeeds he must maintain throughout the refueling.

A-139. Once contact is made and fuel transfer begins the tanker pilot may maintain the proper airspeeds by increasing the calibrated airspeed about 2 MPH for every minute. However, at high receiver weights above 190,000 pounds this increase should be lowered to less than 1 MPH calibrated airspeed per minute. As a further check this should result in an increase in calibrated airspeed of approximately 6 MPH for every 10,000 pounds of fuel transferred. Caution must be employed to avoid an inadvertent disconnect at airspeeds greater than 250 MPH due to the increased difficulty of maintaining contact within the limits of boom control. Should disconnect occur, it would be extremely difficult to make contact again at those speeds because of reduced control effectiveness of the boom.

A-140. REFUELING ALTITUDES. Having established the airspeeds to be flown, depending upon the receiver weight, the altitude variations while maintaining these speeds with normal rated power applied to the tanker can be determined for a given tanker-receiver combination. Figure A-108 presents, for two tanker-receiver starting weight combinations, the variation in pressure altitude on a standard day versus B-47B receiver weight during refueling when the optimum speed schedule of figure A-107 is maintained with normal rated power. The fuel transfer rates of figure A-109 also have been used. The highest starting altitudes will be limited by the service ceiling of the KC-97E tanker airplane, less about 500 to 1500 feet to allow for accelerating to contact speed. Three minutes for making contact have been incorporated into the charts. The rates of descent shown are approximately those which are necessary to attain the scheduled airspeeds and altitudes with normal rated power on the tanker. It should be noted that at 20,000 feet or below, refueling for these weight combinations may take place in level flight. These charts are of particular interest in mission planning for determination of the altitudes at the beginning and the end of refueling. The tanker and receiver pilots are interested in the altitude lost and the rates of descent necessary while transferring a given quantity of fuel, particularly where cloud layers may restrict the altitudes available.

A-141. REFUELING TIME. Based on maximum fuel transfer rates the time to refuel the B-47B from the initial contact weight to the desired ending weight may be obtained from figure A-109. This time allows for the fuel used by the receiver. When using figures A-107 and A-108 three minutes should be added to the time from figure A-109 to account for making contact. It should be noted that an average refueling rate of 3450 pounds per minute has been used up to a receiver weight of 190,000 pounds. Above 190,000 pounds the average refueling rate has been reduced to 1250 pounds per minute to account for the decreased flow rates as the receiver tanks are filled while following an average typical fuel management plan.

A-142. FUEL CONSUMPTION DURING REFUELING. Due to the fact that the receiver must fly in the downwash of the tanker, additional power must be applied to the B-47B during the contact and fuel transfer to account for that absorbed by the downwash effects. Presented in figure A-110 are the normal fuel flows for the B-47B receiver and the correction factors by which the fuel flows must be multiplied to account for the additional power needed during refueling.

022322

REFUELING AIRSPEED SCHEDULE

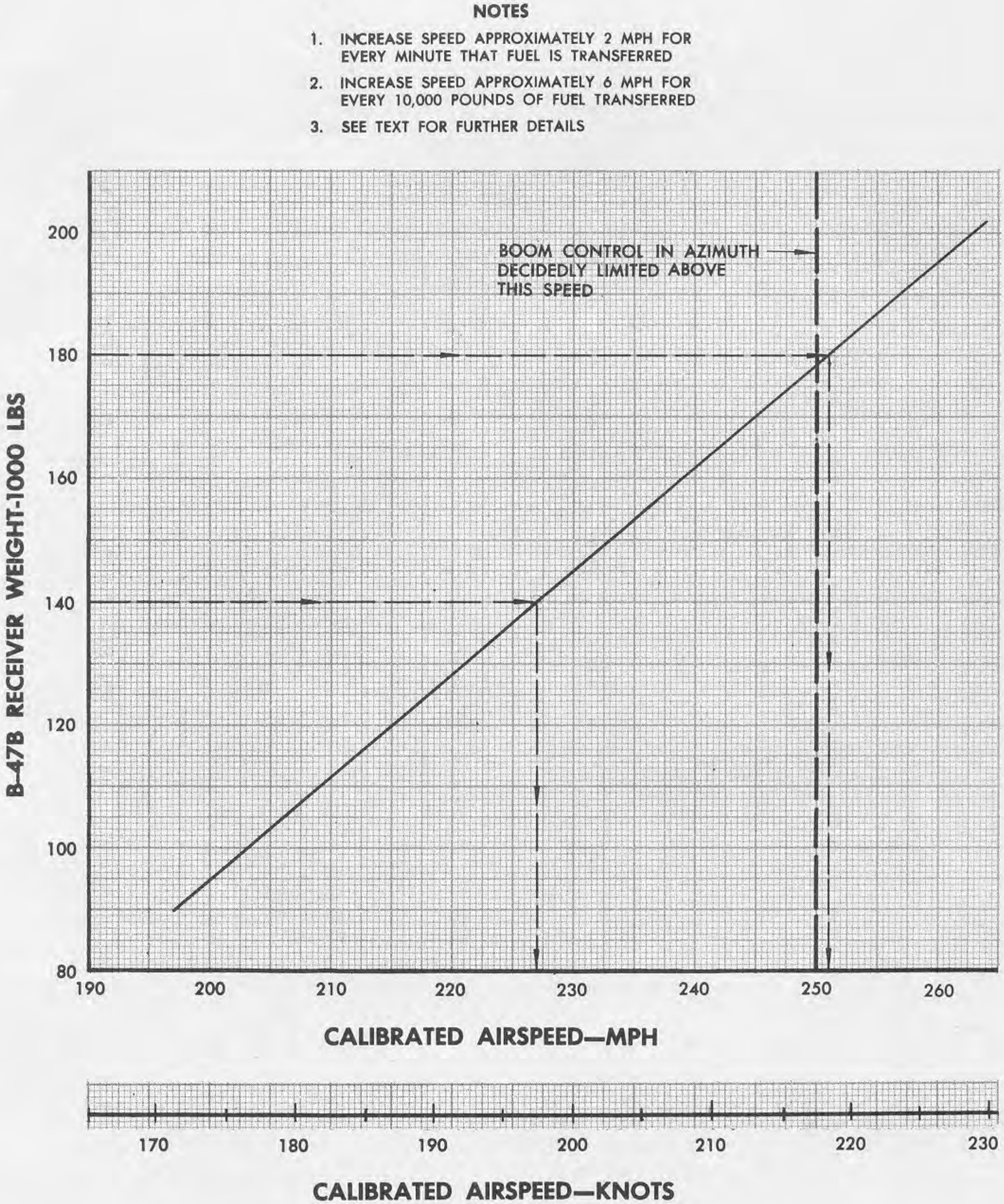


Figure A-107. Refueling Airspeed Schedule

022323

ALTITUDE VARIATION DURING REFUELING

STANDARD DAY

NOTES

1. ENTER THE CHART FOR THE PROPER TANKER-RECEIVER WEIGHT COMBINATION AT THE ALTITUDE DESIRED FOR STARTING REFUEL. FOLLOW SOLID LINES TO THE RIGHT FOR THE VARIATION IN ALTITUDE AS THE RECEIVER'S WEIGHT IS INCREASED BY THE FUEL TRANSFERRED.
   IF THE END CONDITIONS ARE KNOWN, THE PROCEDURE MAY BE REVERSED
2. RATES OF DESCENT NECESSARY DURING THE REFUEL ARE REPRESENTED BY THE DASHED LINES
3. CHARTS ARE BASED UPON THE REFUELING AIRSPEED SCHEDULE OF FIGURE A-107

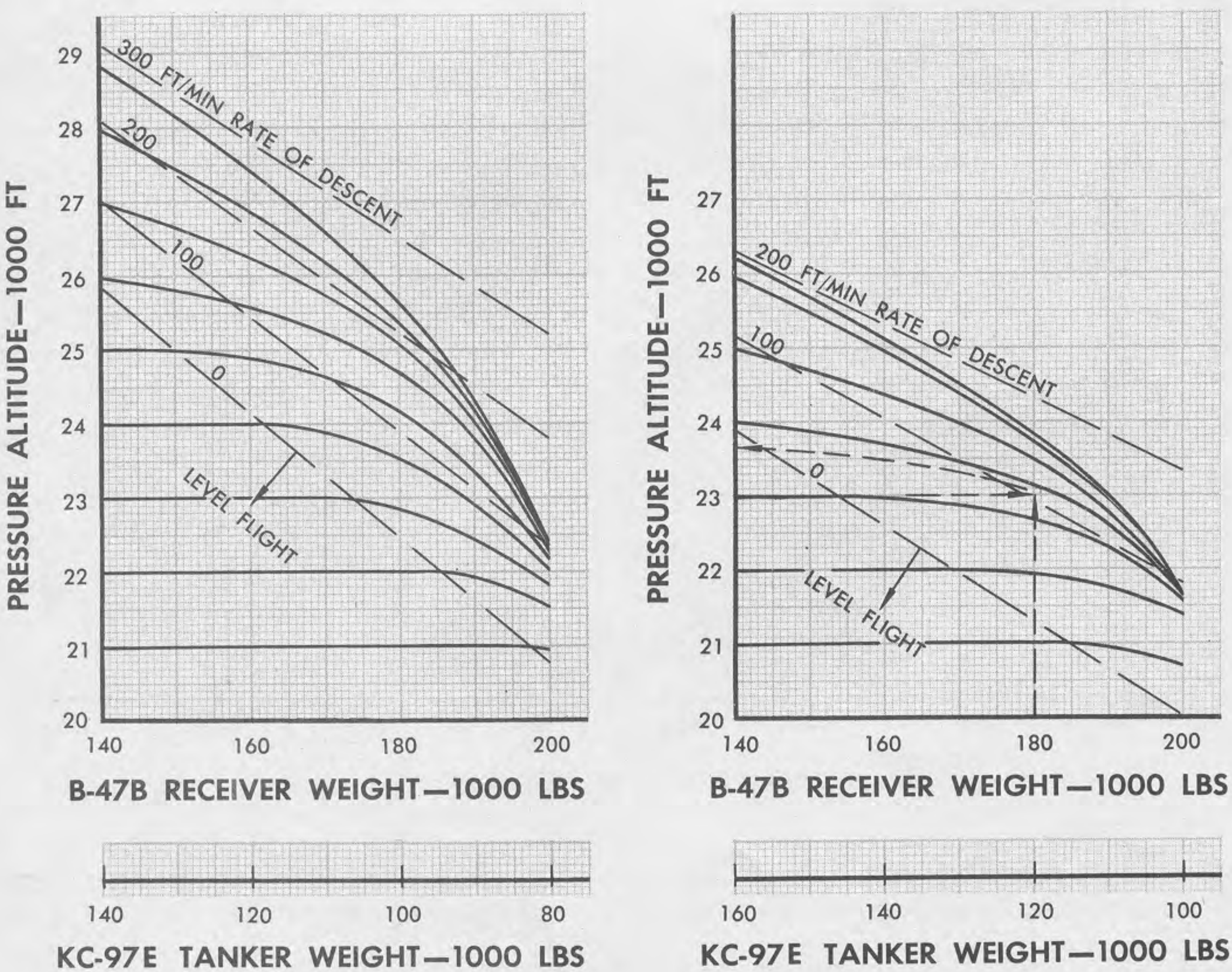


Figure A-108. Altitude Variation During Refueling

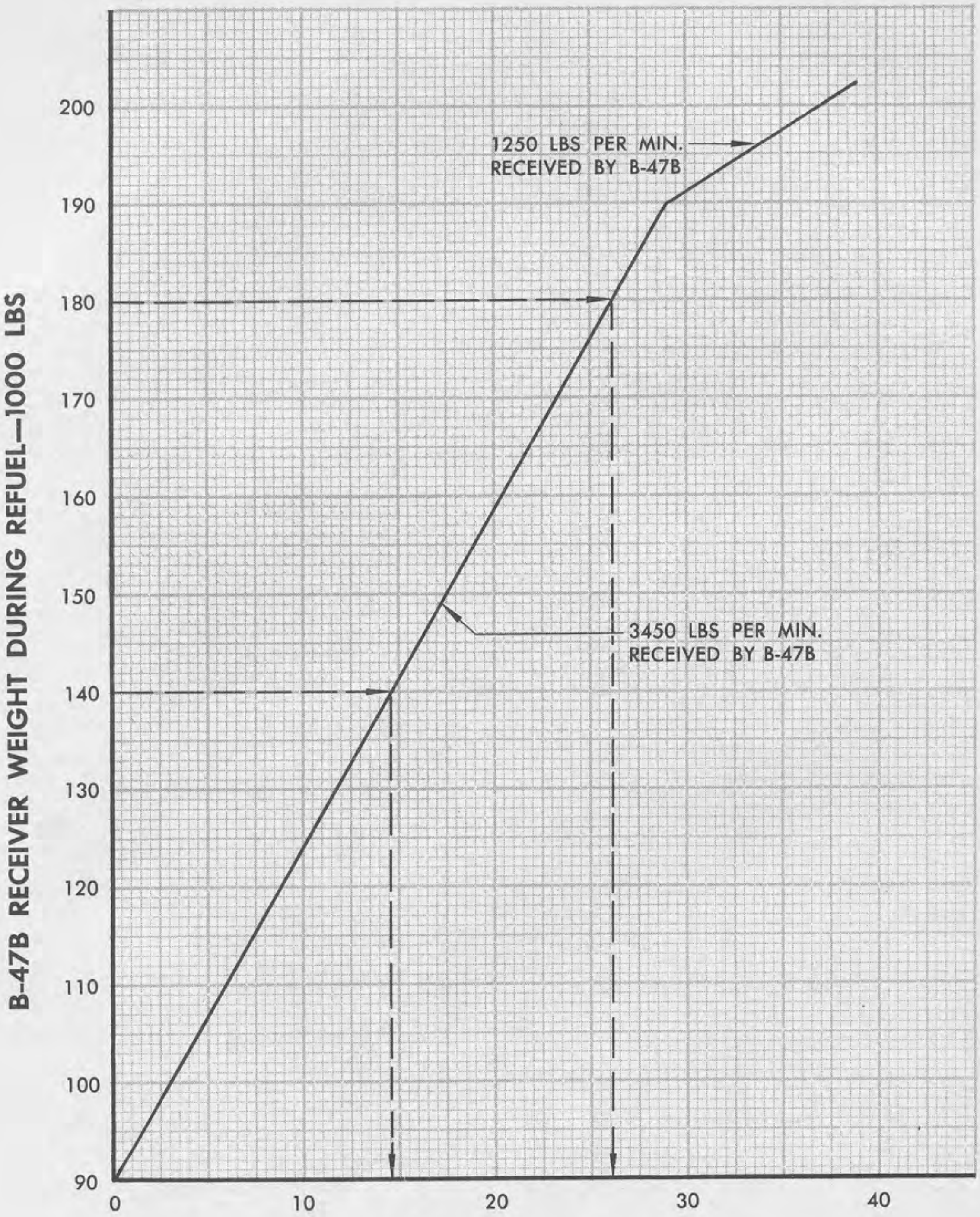
022324

TIME TO TRANSFER FUEL

NOTES 1. ADD 3 MINUTES FOR MAKING CONTACT

2. ADD FUEL CONSUMED BY RECEIVER TO OBTAIN FUEL TRANSFERED

3. APPROXIMATE OPTIMUM FUEL MANAGEMENT PLAN ASSUMED



022325

Figure A-109. Time to Transfer Fuel

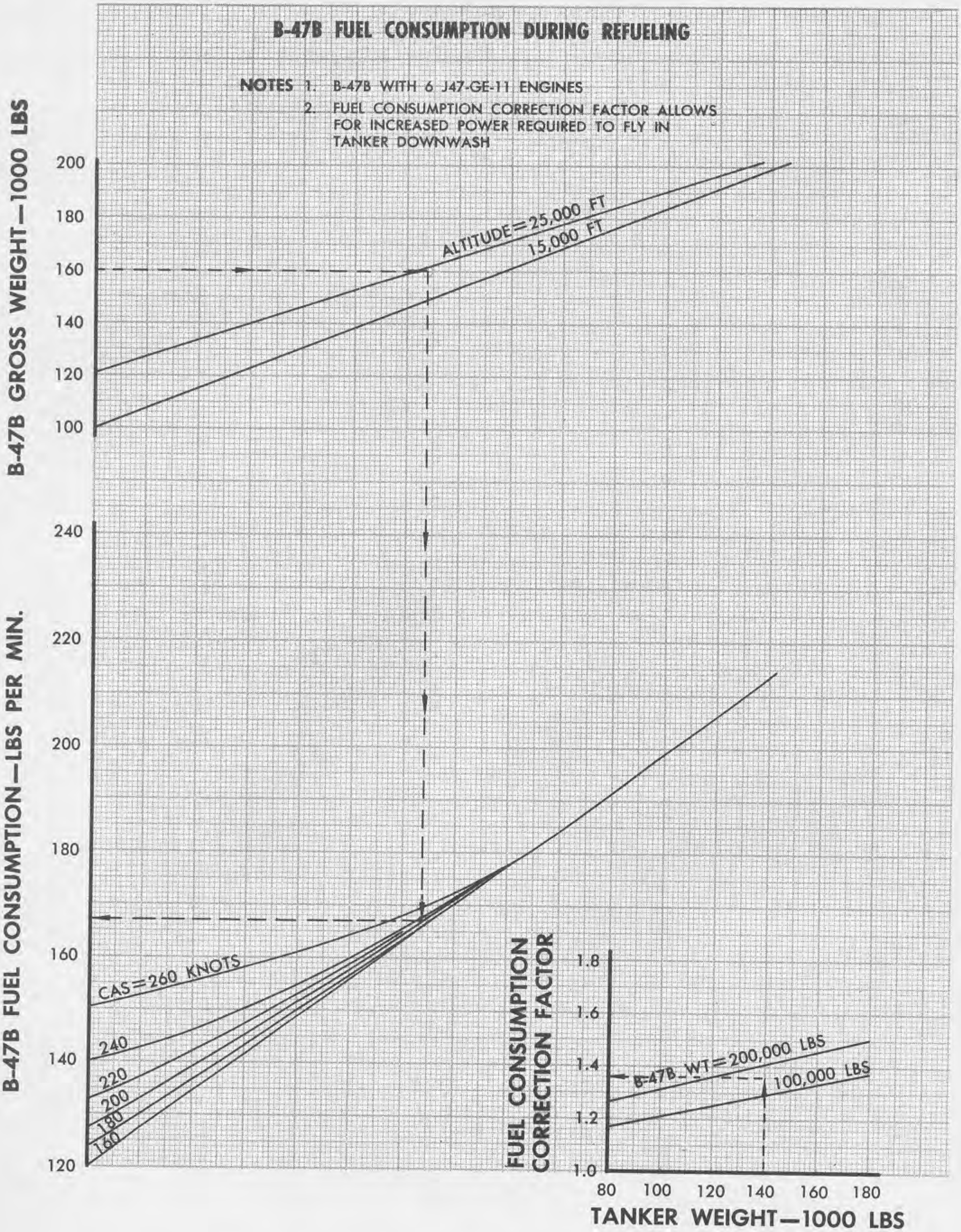


Figure A-110. B-47B Fuel Consumption During Refueling

022326

A-143. EXAMPLE OF MISSION PLANNING. A B-47B airplane is to be refueled by a KC-97E tanker airplane. Assume that the following is known:

KC-97E weight at start of refueling	160,000 pounds
B-47B weight at start of refueling	140,000 pounds
B-47B weight at end of refueling	180,000 pounds
Required pressure altitude at end of refueling	23,000 feet

Enter figure A-109 at the receiver weight, at initial contact, of 140,000 pounds and read 14.6 minutes. Enter figure A-109 again at the desired receiver weight of 180,000 pounds at the end of the refueling and read 26.2 minutes. The time to accomplish the refueling operation, provided approximately three minutes will be used for making contact, will be as follows:

Time for refueling = 26.2 - 14.6 + 3 = 14.6 (15 minutes)

In the same manner enter figure A-107 with the starting and ending receiver weights to obtain the initial contact and ending speeds.

	Receiver Weight Pounds	Calibrated Airspeed Knots	Calibrated Airspeed MPH
Initial Contact	140,000	197	227
End of refueling	180,000	218	251

The distance traveled during the refueling will be the average true airspeed times the time.

Average calibrated airspeed:
$$\frac{197 + 218}{2} = 208 \text{ knots}$$
Average equivalent airspeed:
208 - 3 = 205 knots

Average true airspeed:
1.45 x 205 = 297 knots

Distance during refueling:
$$\frac{297 \times 15}{60} = 74 \text{ nautical miles}$$

Since the starting receiver-tanker weight combination is 140,000 and 160,000 pounds, the right hand chart of figure A-108 will be used to determine the altitude at which contact must be made to complete the refueling at 23,000 feet. Enter the chart at a receiver gross weight of 180,000 pounds, go up to an altitude of 23,000 feet, and following the slope of the solid lines, proceed left to the starting altitude at a receiver weight of 140,000 pounds.

	Receiver Weight Pounds	Altitude Feet
Initial contact	140,000	23,650
End of refueling	180,000	23,000

Using average values of weight, altitude, and airspeed during the refueling, the fuel used by the receiver may be determined from figure A-110.

Average receiver weight = 160,000 pounds

Average tanker weight = approximately 140,000 lbs.

Average altitude = approximately 23,500 feet

Average calibrated airspeed = 208 knots

Enter figure A-110 with the receiver weight of 160,000 pounds. Go right to an altitude of 23,500 feet and then down to a calibrated airspeed of 208 knots. Proceed left and read an average normal B-47B fuel consumption of 167 pounds per minute. Enter the small correction chart of figure A-110 with the average tanker weight of 140,000 pounds, go up to the average receiver weight of 160,000 pounds, and then go left and read the fuel consumption correction factor of 1.36. The fuel consumed by the B-47B during the refueling then becomes:

Fuel consumed by B-47B:
$$(1.36 \times 167) \frac{\text{pounds}}{\text{minutes}} \times 15 \text{ minutes} = 3410 \text{ pounds}$$

The actual fuel transferred then becomes:

Fuel transferred:
180,000 - 140,000 + 3410 = 43,410 pounds.

Since the tanker is operating at normal rated power the brake horse-power per engine is 2650. Enter figure A-32 at 2650 brake horsepower per engine, auto rich, and read a fuel flow of 1940 pounds per hour. The fuel consumed by the tanker during refueling then becomes:

Fuel consumed by KC-97E:
$$\left(\frac{4 \times 1940}{60}\right) \frac{\text{pounds}}{\text{minutes}} \times 15 \text{ minutes} = 1940 \text{ pounds}$$

The weight of the tanker at the end of refueling may then be determined as follows:

Tanker weight at end of refueling:
160,000 - 43,410 - 1940 = 114,650 pounds

The data required for the mission plan is tabulated below:

	Initial Contact	End of Refueling
Receiver weight (lbs.)	140,000	180,000
Tanker weight (lbs.)	160,000	114,650
Calibrated Airspeed (knots)	197	218
Pressure altitude (ft.)	23,650	23,000
Time (minutes)	0	15
Distance (naut. mi.)	0	74
Fuel consumed by B-47B (lbs.)	0	3,410
Fuel consumed by KC-97E (lbs.)	0	1,940
Fuel transferred (lbs.)	0	43,410

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