

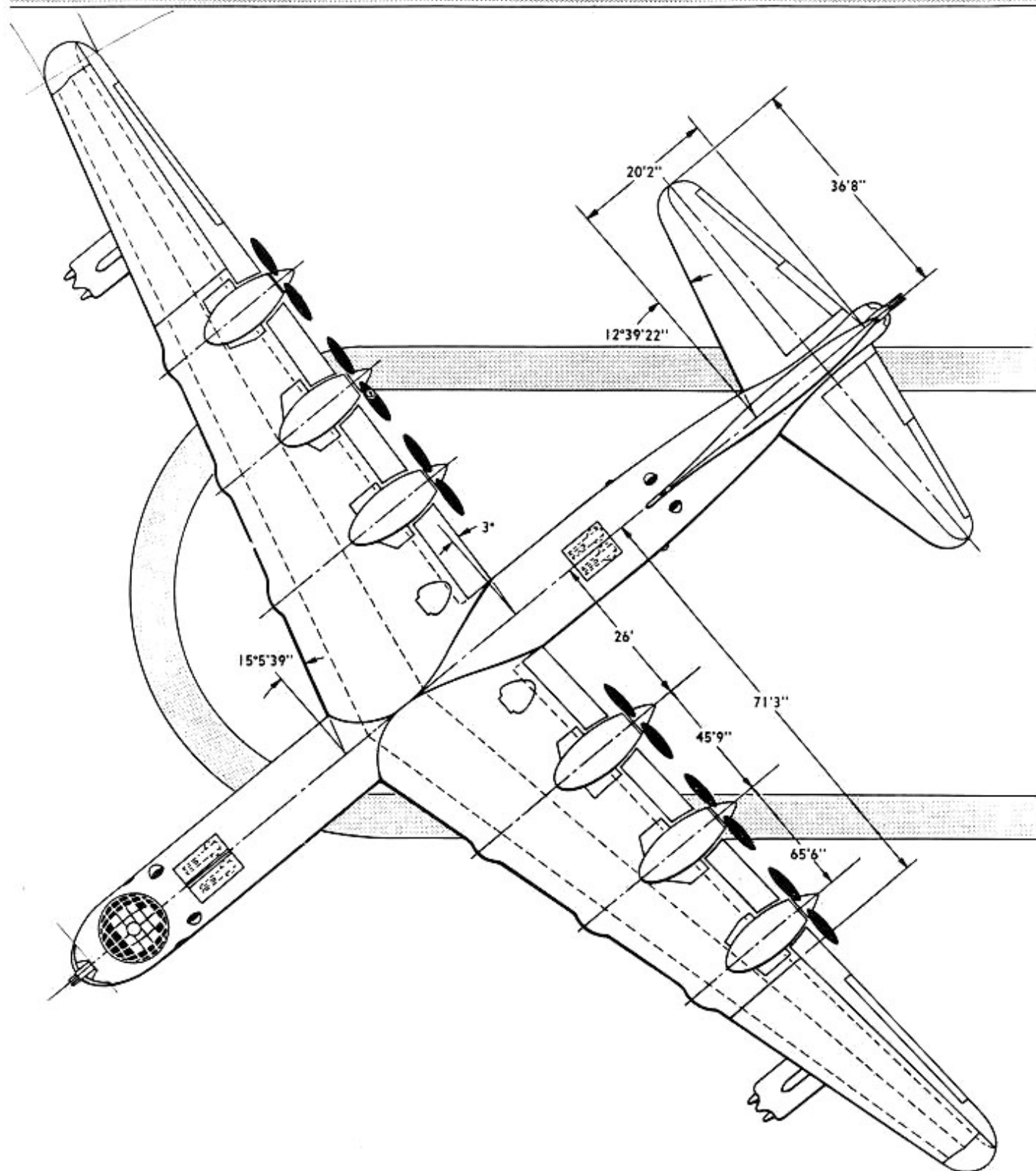
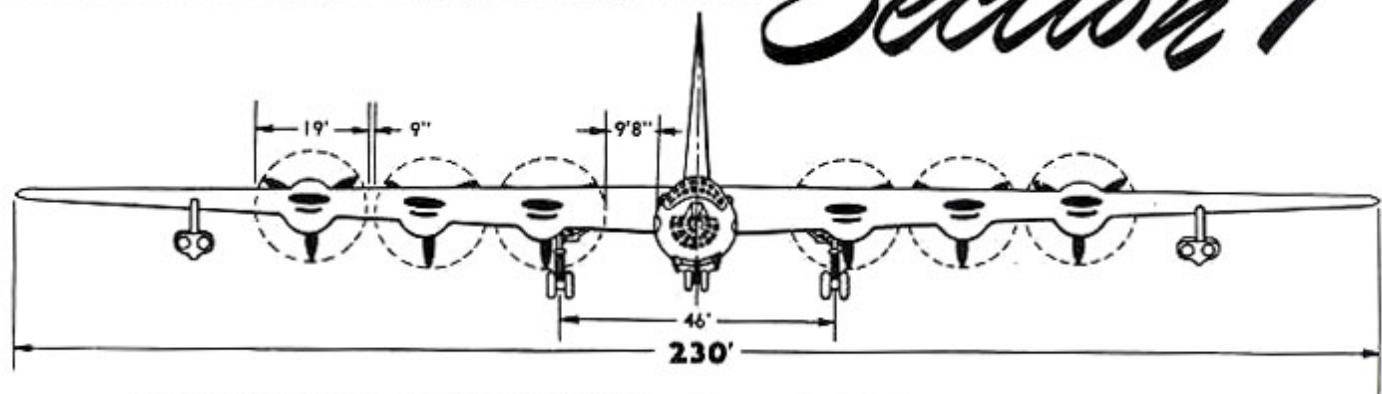


Figure 1-1. (Sheet 1 of 2 Sheets) Principal Dimensions

Section I



DESCRIPTION, DIMENSIONS AND LEADING PARTICULARS

1-1. DESCRIPTION.

1-2. The model B-36D, manufactured by Consolidated Vultee Aircraft Corporation, is a high-altitude, long-range, very heavy bombardment airplane.

1-3. The airplane is powered with four General Electric Model J47-GE-11 turbojet engines and six Pratt and Whitney Model R-4360-41 Wasp Major reciprocating engines. Each of the reciprocating engines is equipped with two General Electric Model B-1 exhaust-driven turbosuperchargers to provide a service ceiling of 40,000 feet. The R-4360-41 engines drive six Curtiss Model P-72B electric propellers. The propellers are constant-speed, full feathering reversible-type and can be synchronized in either normal or reverse pitch range.

1-4. The control surfaces consist of ailerons, elevators, and a rudder that are servo-tab operated, and three sets of flaps.

1-5. Crew compartments are pressurized, heated, and ventilated, and embody an oxygen system for use at altitude during unpressurized operation.

1-6. Four alternators, driven by four of the Wasp Major engines, furnish power to operate the electrical systems of the airplane. Alternating current is rectified to provide power for the various direct-current circuits.

1-7. Hydraulic power is used for operation of the landing gear, brakes, bomb doors, and nose gear steering.

1-8. Armament consists of eight remotely controlled turrets, each equipped with two twenty-millimeter cannons. The nose and tail turrets are nonretractable. All

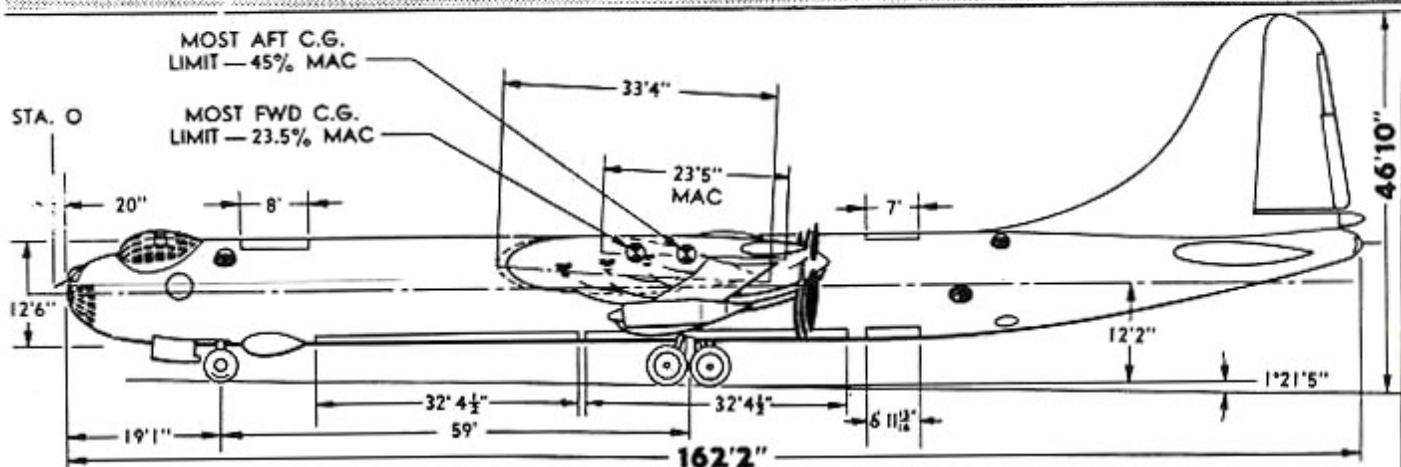


Figure 1-1 (Sheet 2 of 2 Sheets) Principal Dimensions

In order to gain the maximum benefits from this handbook, it is imperative that you read the foreword carefully.

SECTION I, DESCRIPTION—A detailed description of the airplane and all its systems and controls which

SECTION V, OPERATING LIMITATIONS—A section covering all airplane and engine operating limitations that must be observed during normal operation.

SECTION VI, FLIGHT CHARACTERISTICS—A section describing the flight characteristics of the airplane.

SECTION VII, SYSTEMS OPERATION—A discussion of the operation of the various airplane systems under all conditions of airplane operation.

SECTION VIII, CREW DUTIES—An amplified check list covering a discussion of the primary and alternate functions of each crew member.

SECTION IX, ALL WEATHER OPERATION—A supplement to Section II providing additional instructions for turbulent air and instrument flying; and for cold weather, desert, and tropical operation.

APPENDIX I, OPERATING DATA CHARTS—A section containing operating data essential to flight planning.

AIRPLANE GROUP NUMBER CODE.

Airplanes having a particular control or system in common have been assigned group numbers to avoid breaking the continuity of the text with the listing of airplane serial numbers. The groups with the airplanes they include and the items that are peculiar to each group are listed as follows:

GROUP 1—Water injection system with a manifold pressure switch—Airplanes USAF Serial No. 44-92095 through 49-2654

GROUP 2—Water injection system without a manifold pressure switch—Airplanes USAF Serial No. 44-92026 through 44-92087; 49-2656 and subsequent

GROUP 3—Round-tipped propellers—Airplanes USAF Serial No. 44-92026 through 44-92087; 44-92095 through 44-92098; 49-2647 through 49-2654

GROUP 4—Square-tipped propellers—Airplanes USAF Serial No. 49-2655 and subsequent

GROUP 5—Improved jet fuel and oil pressure gages—Airplanes USAF Serial No. 44-92032, 44-92033, 44-92037, 44-92042, 44-92046, 44-92047, 44-92050, 44-92055 through 44-92057; 44-92059 through 44-92063; 44-92065 through 44-92071; 44-92073, 44-92074, 44-92076 through 44-92078

GROUP 6—Improved crew comfort provisions and new crew positions for take-off and landing—Airplanes USAF Serial No. 44-92032, 44-92033, 44-92046, 44-92062, 44-92065 through 44-92071; 44-92073, 44-92074, 44-92076 through 44-92078; 44-92080 through 44-92087; and 49-2655

GROUP 7—Disc type brakes with one hydraulic accumulator—Airplanes USAF Serial No. 44-92026 through 44-92087; 44-92095 through 44-92098

GROUP 8—Expander tube brakes with two hydraulic accumulators—Airplane USAF Serial No. 49-2647 and subsequent

GROUP 9—Independent filament switch for landing lights—Airplanes USAF Serial No. 44-92032, 44-92033, 44-92037, 44-92042, 44-92046, 44-92047, 44-92050, 44-92055 through 44-92057; 44-92059 through 44-92063; 44-92065 through 44-92071; 44-92073 through 44-92087

GROUP 10—Special interphone system and wing interphone isolation lamp—Airplanes USAF Serial No. 44-92032, 44-92033, 44-92037, 44-92042, 44-92046, 44-92047, 44-92050, and 44-92055 through 44-92057; 44-92059 through 44-92063; 44-92065 through 44-92071; 44-92073, 44-92074, 44-92076 through 44-92078; 44-92080 through 44-92087; 49-2664 and subsequent

GROUP 11—Inspection windows in communication tube—Airplanes USAF Serial No. 44-92036, 44-92042, 44-92044 through 44-92047; 44-92050, 44-92052, and 44-92055 through 44-92057; 44-92059 through 44-92074; 44-92076 through 44-92078; 44-92080 through 44-92087; 49-2658 and subsequent

GROUP 12—Dual indicating instruments—Airplanes USAF Serial No. 44-92026 through 44-92087

GROUP 13—Single indicating instruments—Airplane USAF Serial No. 44-92095 and subsequent

GROUP 14—Type D-1 oxygen regulators, two sets of fire warning lamps—Airplanes USAF Serial No. 44-92032, 44-92033, 44-92037, 44-92041, 44-92042, 44-92046, 44-92047, 44-92050, and 44-92055 through 44-92057; 44-92059 through 44-92063, 44-92065 through 44-92071; 44-92073, 44-92074, and 44-92076 through 44-92078; 44-92080 through 44-92087

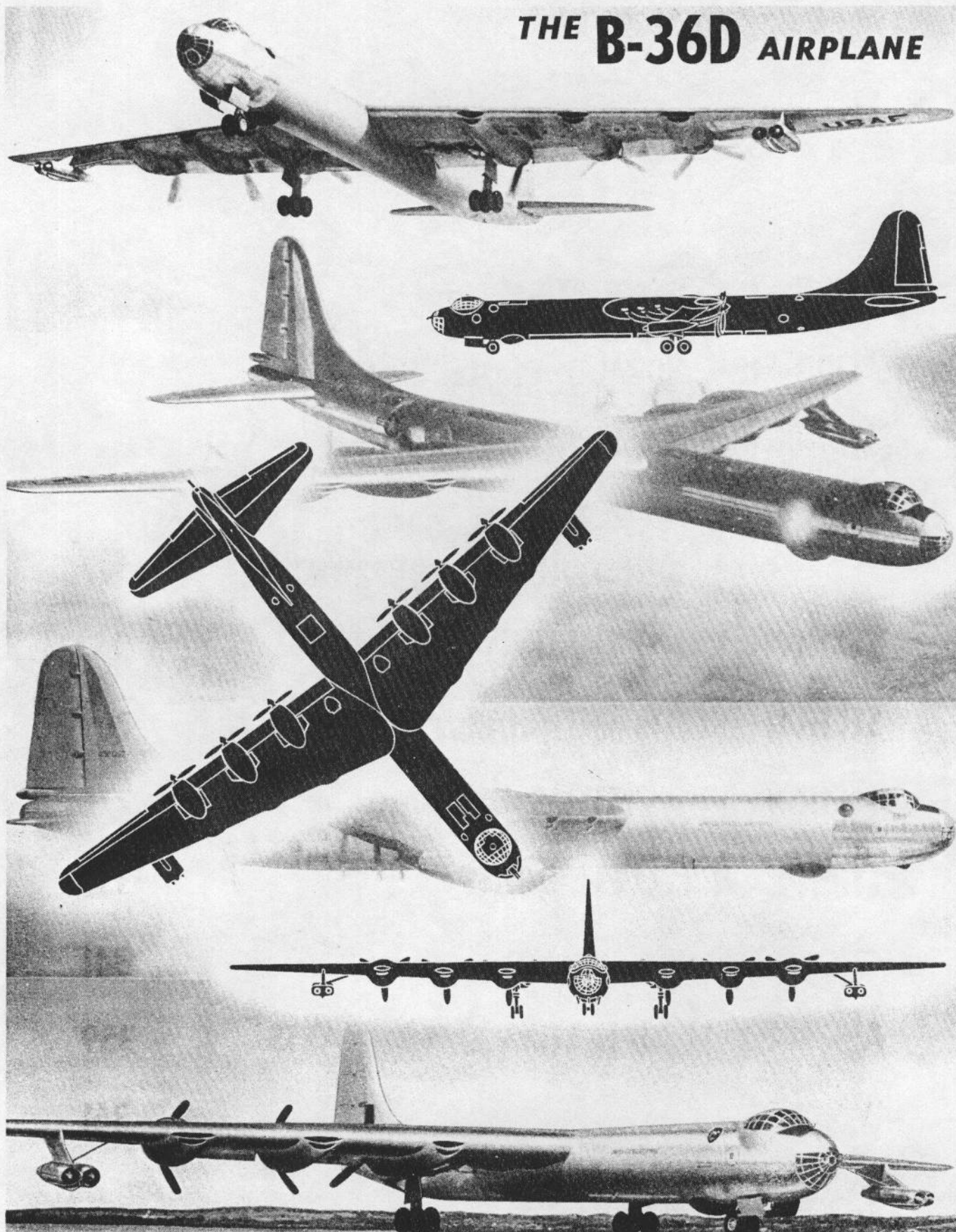
GROUP 15—Cylinder vibration provisions on engine analyzer—Airplanes USAF Serial No. 49-2657 through 49-2661

GROUP 16—Flight engineer's main instrument panel modified—Airplanes USAF Serial No. 44-92026 through 44-92031, 44-92034 through 44-92036; 44-92038 through 44-92041; 44-92043 through 44-92045; 44-92047 through 44-92049; 44-92051 through 44-92056; 44-92058 through 44-92066; 44-92072, 44-92074, and 44-92075

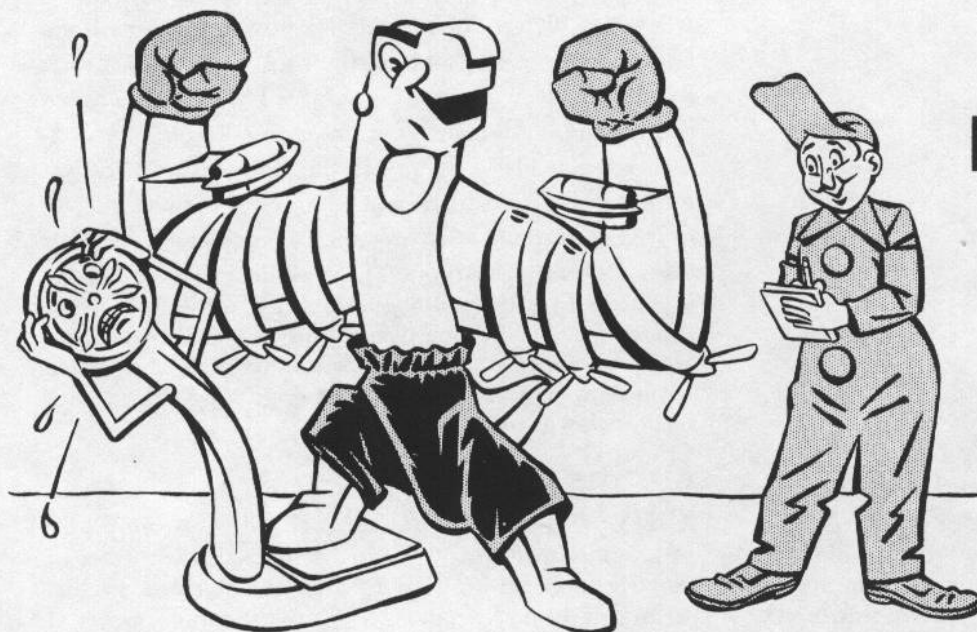
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THE B-36D AIRPLANE



CI-131-C



CI-304-C

SECTION I DESCRIPTION

THE AIRPLANE.

The B-36D, built by Consolidated Vultee Aircraft Corporation, is a long-range, high altitude, heavy, bombardment airplane. Its tactical mission is the destruction of land and naval objectives by bombing. Six Pratt and Whitney R4360-41 reciprocating engines drive pusher-type Curtiss propellers which can be synchronized in normal or reverse pitch. Additional power is provided by four General Electric J47 jet engines. The control surfaces consist of servo-tab-operated ailerons, elevators, and rudder. The flap system consists of three pairs of flaps. Four a-c alternators, driven by four of the reciprocating engines through constant speed drives, furnish the power to operate the airplane's electrical equipment. A portion of the a-c power is rectified to provide d-c power and electrical control. The landing gear, the brakes, the bomb bay doors, and the nose wheel steering system are hydraulically operated. The crew compartments are pressurized, heated, and ventilated, and are provided with an oxygen system for emergency use. Compartment heating; enclosure and blister defrosting; and propeller, wing, and tail anti-icing are accomplished by heated air. Heat for the air is obtained through the use of heat exchangers installed in the reciprocating engine exhaust systems. Offensive armament consists of four bomb bays which are designed to carry 500-, 1000-, 2000-, 4000-, 12,000-, 22,000-, and 43,000-pound bombs. In addition 100-, 115-, 125-, 250-, 325-, and 350-pound bombs can be carried at the 500-pound stations. Defensive armament consists of eight remotely controlled gun turrets, each containing two 20-millimeter guns. The nose and tail turrets are nonretractable. All other

turrets retract into turret bays which are faired with the fuselage by turret doors.

AIRPLANE DIMENSIONS.

The approximate over-all dimensions of the airplane are:

Length 162 feet 2 inches
Wing Span 230 feet
Height (to top of fin) 46 feet 10 inches
Wing Area 4772 square feet

DESIGN GROSS WEIGHT.

The design gross weight is approximately 357,500 pounds.

FLIGHT CREW.

The normal flight crew consists of 15 men as follows:

FORWARD CABIN

Aircraft Commander
Pilot
Copilot (Right Upper Forward Gunner)
First Engineer
Second Engineer (Left Upper Forward Gunner)
Navigator
Radar-Bombardier
Observer (Nose Gunner)
First Radio Operator (ECM Operator)
Second Radio Operator (ECM Operator)

AFT CABIN

Upper Aft Gunner (Right)
Upper Aft Gunner (Left)
Lower Aft Gunner (Right)
Lower Aft Gunner (Left)
Tail Gunner

MAIN DIFFERENCES.

The principal differences between the various models of the B-36 airplane are reflected in figure 1-1.

RECIPROCATING ENGINES.

The airplane is primarily powered by six pusher-type, Pratt and Whitney, R4360-41 Wasp Major engines. Each engine has 28 cylinders which are arranged helically in seven four-row banks around the crankshaft which rotates counterclockwise as viewed from aft of the wing. Each engine is equipped with a water injection system which permits the horsepower rating to increase from 3250 (dry) to 3500. A torquemeter sys-

tem for each engine measures the torque transmitted by the crankshaft to the propeller. This measurement is used to determine the actual power output of the engine. Carburetor and engine cooling air enters each nacelle at the wing leading edge. The flow of engine cooling air is augmented by an engine-driven fan. Controls are provided for varying the temperature of carburetor air and two turbosuperchargers maintain the required carburetor inlet pressure for each engine during high altitude operation. The cylinders of each engine are fired by a seven-magneto, high tension ignition system which is automatically pressurized for operation at high altitudes. A two-position controllable spark advance system permits efficient engine operation with certain power settings.

THROTTLE CONTROLS.

A set of throttle levers (13, figure 1-13) on the pilots' pedestal is mechanically interconnected with a set of throttle levers (16, figure 1-22) at the engineer's table. A lock lever (12, figure 1-13) on the pilots' pedestal will lock the throttle levers in any desired position. This lock can be overridden by the engineer.

BOMBERS

	B-36B	B-36D	B-36F	B-36H
CREW	15	15	15	15
ENGINEER'S STATION	SINGLE	SINGLE	SINGLE	DUAL
PRESSURIZED CREW COMPARTMENT	2	2	2	2
BOMB BAYS	4	4	4	4
BOMB BAY DOORS	SLOW ACTION ELECTRICAL	FAST ACTION HYDRAULIC	FAST ACTION HYDRAULIC	FAST ACTION HYDRAULIC
BOMBING SYSTEM	CONVENTIONAL	K ()	K ()	K ()
RECIPROCATING ENGINES (6)	R4360-41	R4360-41	R4360-53	R4360-53
JET ENGINES (4)	NONE	J47-19	J47-19	J47-19
ENGINE INSTRUMENTS	DUAL INDICATING	DUAL OR SINGLE INDICATING	SINGLE INDICATING	SINGLE INDICATING
TRANSFORMER RECTIFIERS	6	6	6	7

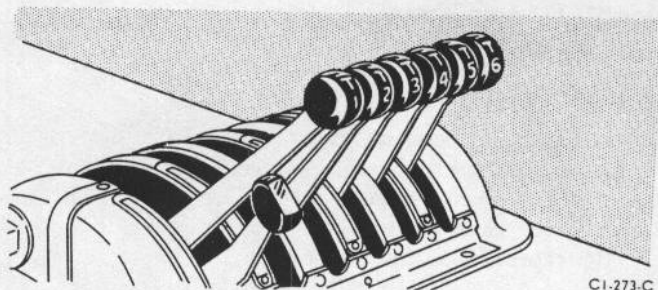
RECON. BOMBERS

	RB-36D&E	RB-36F	RB-36H
	21	21	21
	SINGLE	SINGLE	DUAL
	3	3	3
	2	2	2
	FAST ACTION HYDRAULIC	FAST ACTION HYDRAULIC	FAST ACTION HYDRAULIC
	CONVENTIONAL	CONVENTIONAL	CONVENTIONAL
	R4360-41	R4360-53	R4360-53
	J47-19	J47-19	J47-19
	DUAL OR SINGLE INDICATING	SINGLE INDICATING	SINGLE INDICATING
	8	8	9

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Figure 1-1. Main Differences Table

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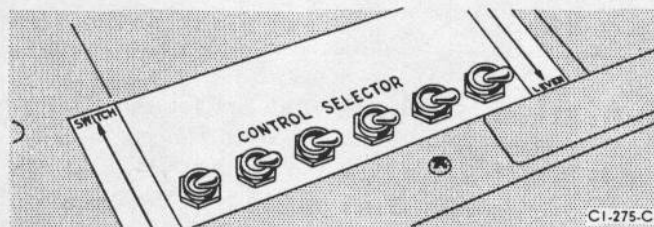
A warning horn provides an indication of an unsafe condition of the throttle levers with respect to the position of the flaps or landing gear. The horn will sound when all six reciprocating engine throttle levers are advanced for take-off and the flaps are not extended at least 20 degrees. The horn will also sound when the landing gear is up and locked and any throttle lever is retarded below minimum cruise. See "Landing Gear Warning Horn" and "Flap Warning Horn" of this section.

MIXTURE CONTROLS.

Two methods are available for controlling the mixture. Normally, control is accomplished electronically through the use of a set of control levers (13, figure 1-22) located on the flight engineer's table. Each lever is geared to a potentiometer which is located beneath the lever. Movement of the lever will move the potentiometer to originate a signal which is sent through an amplifier to an a-c actuator in the nacelle. The actuator positions the mixture control valve of the carburetor in response to the signal. In the event this method becomes inoperative, the mixture can be controlled by a set of override switches (7, figure 1-22) located on the engineer's table. These switches are connected directly to the mixture control actuators in the nacelles through an electrical circuit and provide emergency means of positioning the control valves. Both the normal and the override method of mixture control use 115-volt a-c power. No mixture controls are provided for the pilots.

Mixture Control Selector Switches.

Six two-position switches (8, figure 1-22), one for each engine, are provided to select the method of controlling the mixture. When these switches are placed

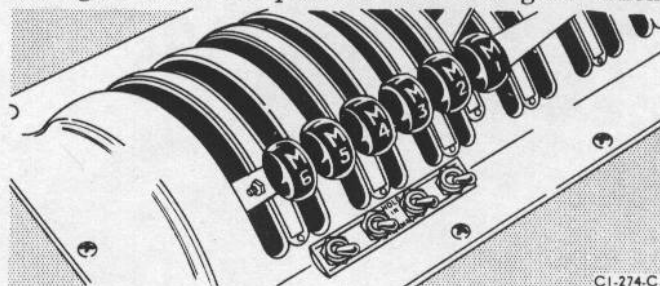


CI-275-C

in the LEVER position, the mixture control levers are effective for mixture control. When the switches are placed in the SWITCH position, the mixture control override switches become the means of controlling the mixture.

Mixture Control Levers.

Six mixture control levers (13, figure 1-22) are located on the flight engineer's table for normal control of the mixture. The positions on the control quadrant are IDLE CUT-OFF, NORMAL, and RICH. The NORMAL position, which is used for all normal operation, is a rich setting and the range between NORMAL and IDLE CUT-OFF provides manual lean settings. The range between NORMAL and RICH provides a mixture too rich for normal engine operation; however, settings in this range can be used effectively under certain operating conditions. (Refer to "Cooling," Section VII.) Six normal mixture indicator lamps (6, figure 1-22) are provided and will glow when



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the mixture controls are set for normal mixture. The control quadrant is graduated with index marks for reference in positioning the control levers.

CAUTION

Should an output tube of the electronic mixture control system fail while the selector switch is in the LEVER position, the mixture can be expected to go to the idle cut-off or rich position, depending on which tube fails.

Mixture Control Override Switches.

Six mixture control override switches (7, figure 1-22), located on the flight engineer's table, are provided for controlling the mixture in the event the normal mixture controls become inoperative. Each switch has a spring-loaded IDLE CUT-OFF position, a spring-loaded AUTO-RICH position, and a neutral center position. No NORMAL position is provided, but a normal setting can be obtained by jiggling the switches between IDLE CUT-OFF and AUTO-RICH until the normal mixture indicator lamps light.

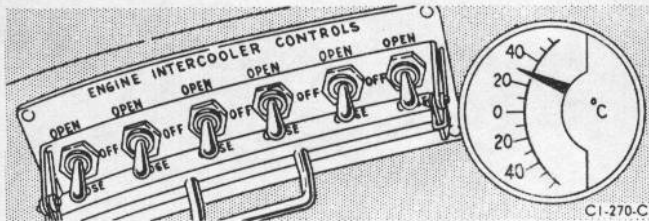
CARBURETOR AIR TEMPERATURE CONTROL.

Temperature control of carburetor air is accomplished by varying the volume of cooling air passing through the intercooler. This operation is accomplished through the use of intercooler shutters, which are controlled electrically from the flight engineer's station. Induction air may be heated before it enters the carburetor by diverting heated engine cooling air through the turbosuperchargers (figure 1-4) by means of the carburetor preheat switches.

Three dual indicating carburetor air temperature gages (17, figure 1-16) are located on the flight engineer's main instrument panel of group 12 airplanes. Six single indicating carburetor air temperature gages (10, figure 1-15) are located on the same panel of group 13 airplanes.

Intercooler Shutter Switches.

The six three-position intercooler shutter switches (1, figure 1-24) are on the flight engineer's auxiliary control panel. Each switch has a spring-loaded OPEN position, a spring-loaded CLOSE position, and a neutral OFF position. When a switch is held in the OPEN



or CLOSE position, a 28-volt d-c control circuit energizes relays to supply 115-volt alternating current to the intercooler shutter actuators to obtain the desired carburetor air temperature. The switches can be placed simultaneously in the OPEN position by means of a gang bar.

Carburetor Preheat Switches.

Three carburetor preheat switches (32, figure 1-20) are ganged together on the engineer's control panel. A 28-volt d-c control circuit supplies 115-volt alternating current to the carburetor preheat actuators. Placing the switches in the ON position closes valves in the turbo air inlet ducts and opens valves in the carburetor preheat ducts. This permits heated engine cooling air, which is obtained from the engine bay, to circulate through the turbos.



When the preheat valves open, the cabin pressure wing shutoff valves automatically close to prevent the possibility of carbon monoxide contamination of the cabin air.

Note

Additional control of carburetor air temperature is available when carburetor preheat is on, by use of the intercooler shutter control switches.

Carburetor Air Filter Switch.

Provisions have been made for the installation of carburetor air filters. When these filters are installed, filtered air is obtained by closing off the ram air to the turbosuperchargers and drawing air from the underside of the nacelle through the carburetor air filter. This action is accomplished by placing the carburetor air filter switch (15, figure 1-20) in the ON position.

The switch closes a 28-volt d-c control circuit which supplies a 115-volt alternating current to the carburetor air filter actuators.

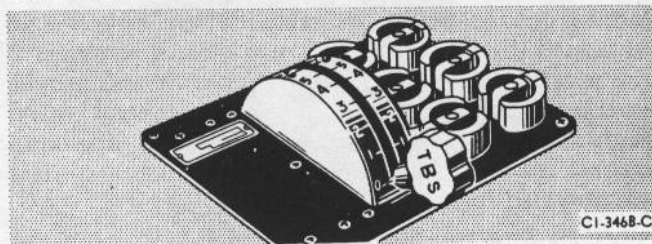
TURBO SYSTEM.

Each reciprocating engine has two exhaust-driven turbosuperchargers which are used to maintain a constant carburetor inlet pressure up to 35,000 feet. The right turbo for each engine also provides pressurized air for the cabins. (See figure 4-6.)

Turbo Controls.

Engine Supercharger Switches. Six two-position switches (12, figure 1-20), located on the engineer's control panel, are provided to select dual or single turbo operation. Placing the switch in R.H. ONLY will apply 115-volt a-c power to a turbo selector valve to divert all exhaust gases through the right turbo and will apply 115-volt a-c power to close a valve in the ram air duct between the cooling air tunnel and the left heat exchanger. Dual operation is provided when the switch is in the BOTH position.

Turbo Boost Selector. A Minneapolis-Honeywell electronic turbo regulator system is used to control the boost of the turbos and is regulated from a master control panel on the engineer's table. This panel contains a turbo boost selector lever (4, figure 1-21) and six calibration potentiometer knobs (5, figure 1-21). The knobs are used to make small individual adjustments of manifold pressures during flight to compensate for small differences in engine or turbo performances. Moving the knobs counterclockwise reduces manifold pressure. Once the system is calibrated, the engineer can control the boost of all engines simul-



taneously by operating the turbo boost selector lever. The lever has travel graduations from zero to ten. Normally, position 7 is used for take-off and contains a detent to hold the lever in that position. The lever can be forced past the detent toward position 10 to obtain additional boost. A turbo boost selector lever (21, figure 1-13) is also provided for the pilots and is mechanically interconnected to the engineer's lever. This lever is located on the pilots' pedestal. The regulator system operates on 115-volt alternating current.

WATER INJECTION SYSTEM.

Each reciprocating engine is equipped with a water injection system for permitting the development of additional power during take-off. The systems are of

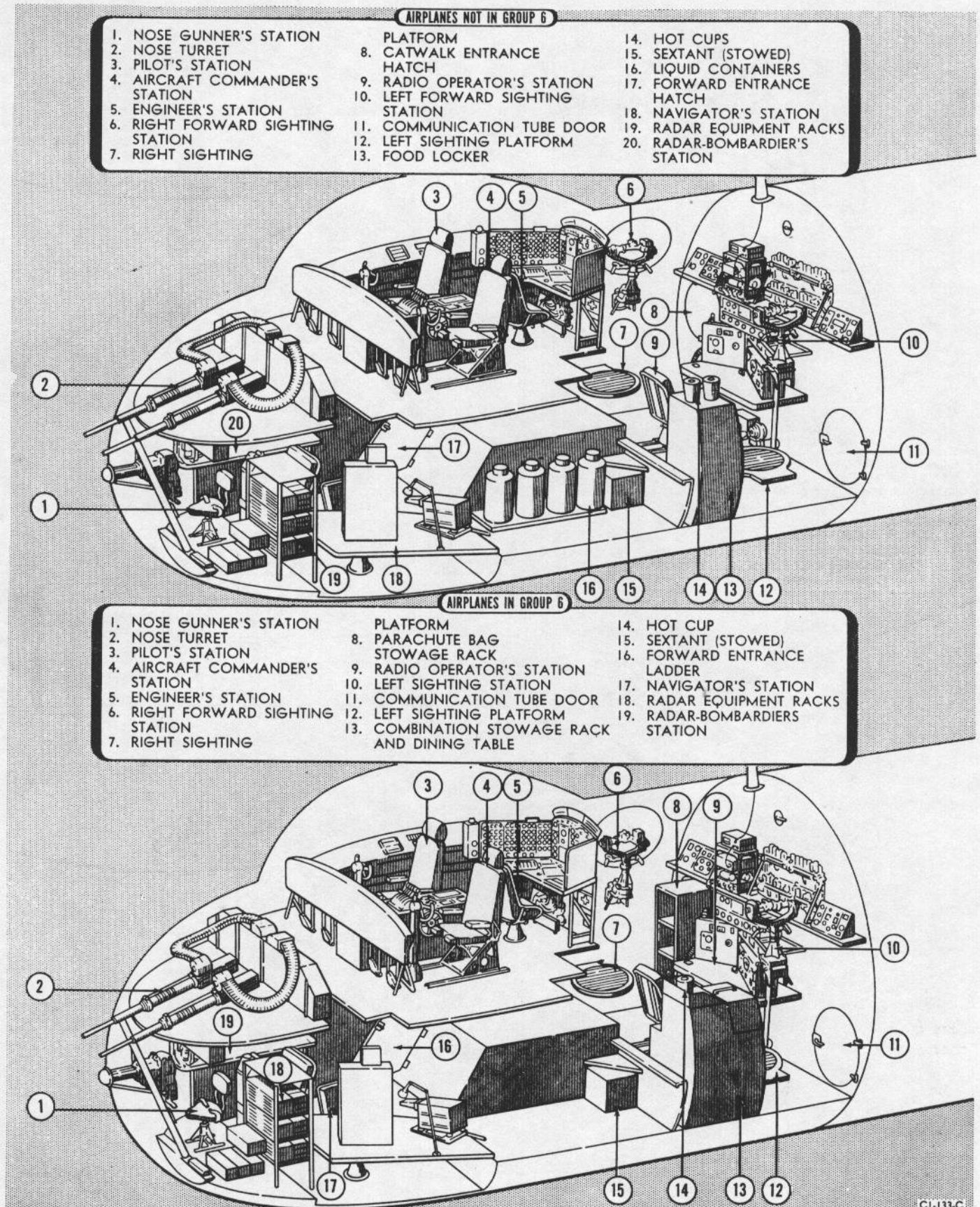
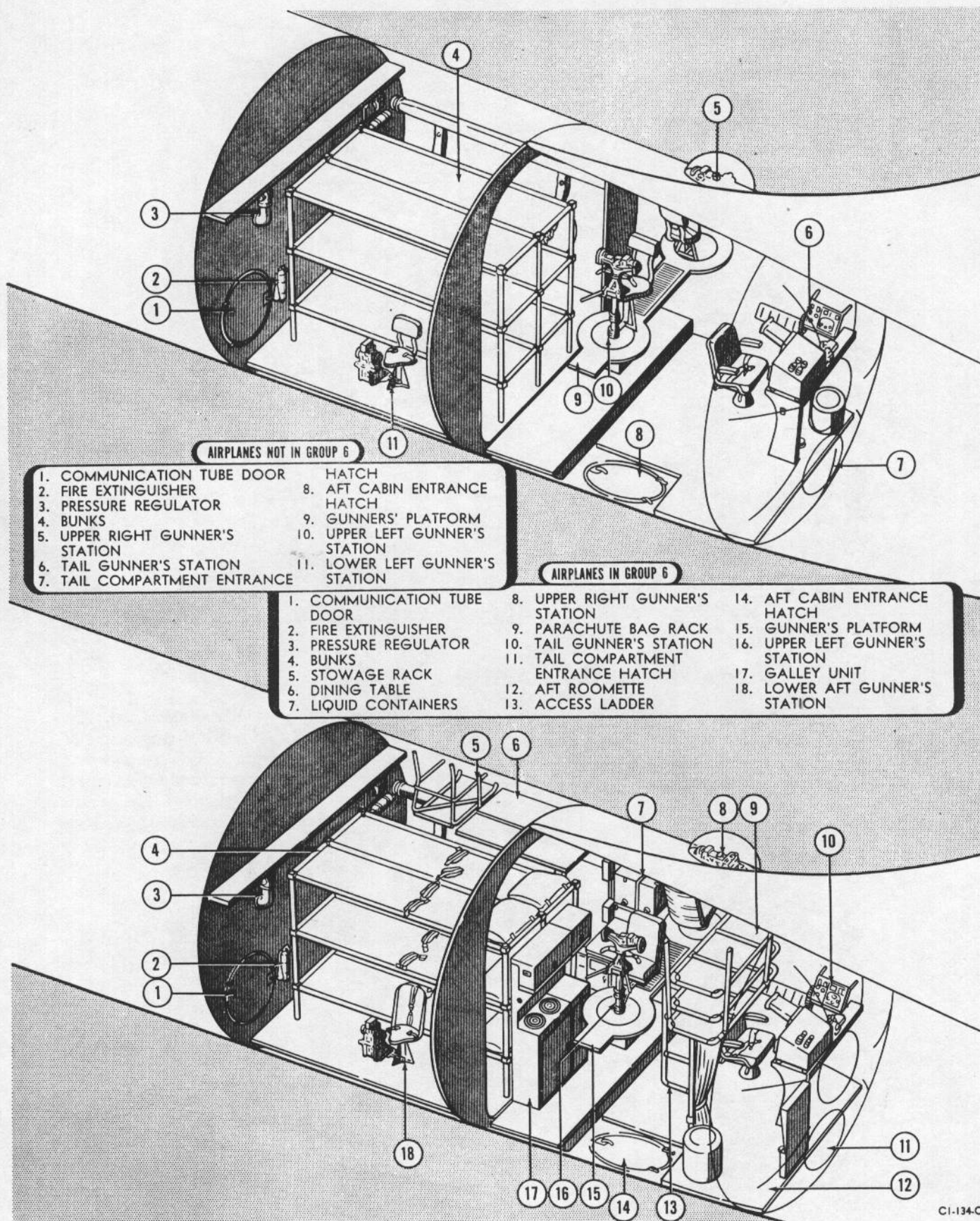


Figure 1-2. (Sheet 1) Airplane General Arrangement



CI-134-C

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

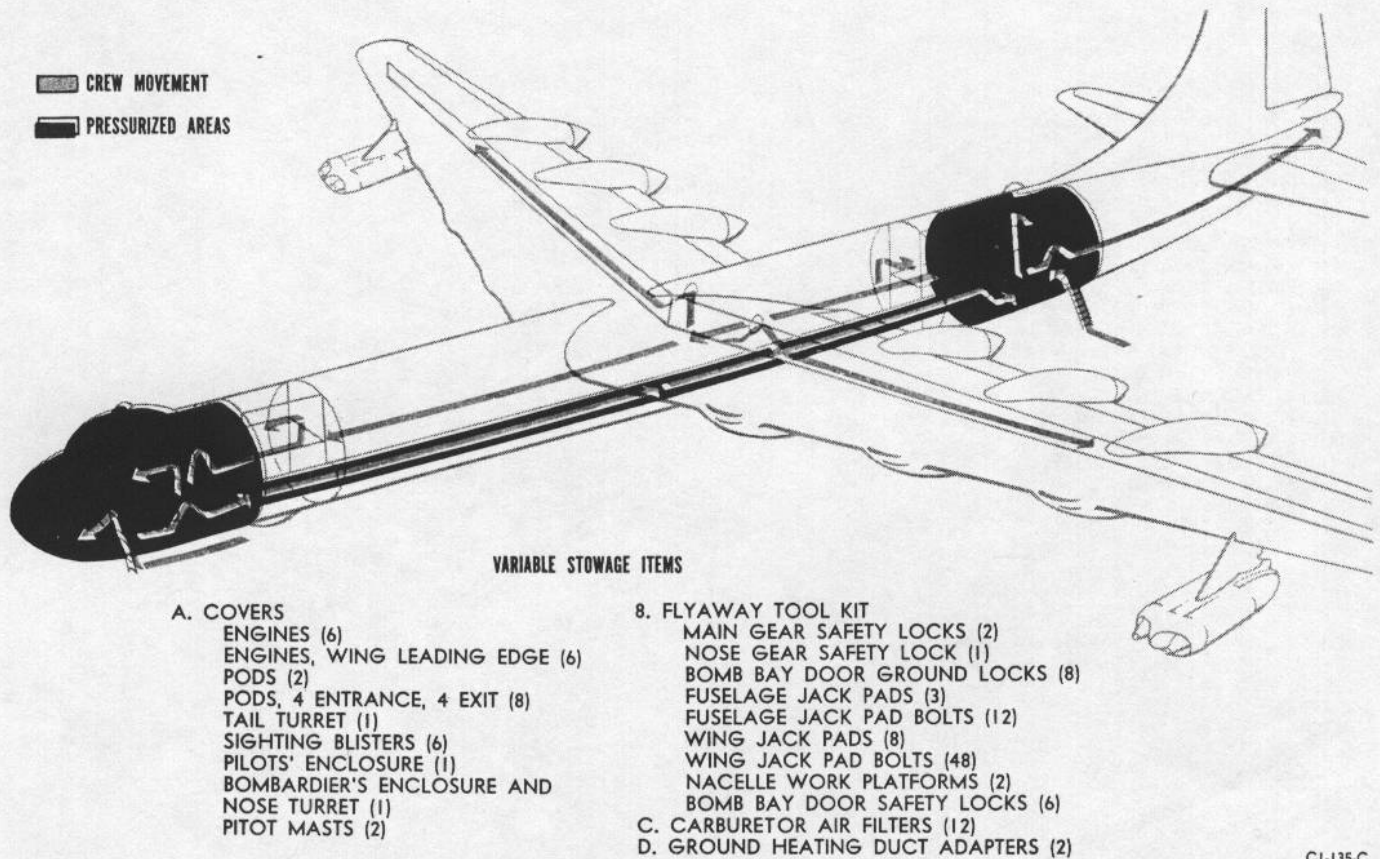


Figure 1-2. (Sheet 3) Airplane General Arrangement

CI-135-C

the nonhesitating type and include a nine-gallon water tank, a booster pump, and a water regulator. A 28-volt d-c circuit controls 200-volt alternating current for pump power. The regulator controls the flow of water as it is injected into the blower case to be mixed with fuel and air before entering the intake manifold. On group 1 airplanes, with the booster pumps operating, the regulators will automatically meter the water to the engines when a manifold pressure of 53.5 inches is reached. The systems will then operate continuously for approximately five minutes, after which time the water supply will be depleted and the booster pumps will automatically stop. On group 2 airplanes, water is injected into the engines by the actuation of the water injection control switches. This permits the use of water at any power setting. However, at manifold pressures less than 50 inches, the use of water has little net effect upon the power output of the engines.

Water Injection Switches.

These six on-off switches (10, figure 1-20) are located on the engineer's control panel. When the switches on group 1 airplanes are placed ON, the booster pumps are started and an electrical circuit is set up to solenoid valves in the water regulators. The valves will then open, when 53.5 inches manifold pressure is attained, permitting water to enter the engines. Placing the

switches OFF renders the systems inoperative. On group 2 airplanes, the switches are a direct means of injecting water into the engines. When the switches are placed ON, the pumps are started and water enters the regulator to be metered to the engines. The pumps on this group of airplanes will continue to operate after the five-minute water supply has been depleted. They are stopped only by moving the switches to OFF.

CAUTION

On group 2 airplanes if a water pressure pump is operating and no water pressure is indicated on the gage, the water supply is depleted and the control switch should be turned OFF. The pump should not be allowed to operate for more than 3 minutes without water, since water is required to cool the pump motor.

Water Pressure Gages.

There are three dual indicating water pressure gages (11, figure 1-16) on the flight engineer's main instrument panel of group 12 airplanes, and six single indicating water pressure gages on the same panel of group 13 airplanes, which indicate psi pressure in the water injection system.

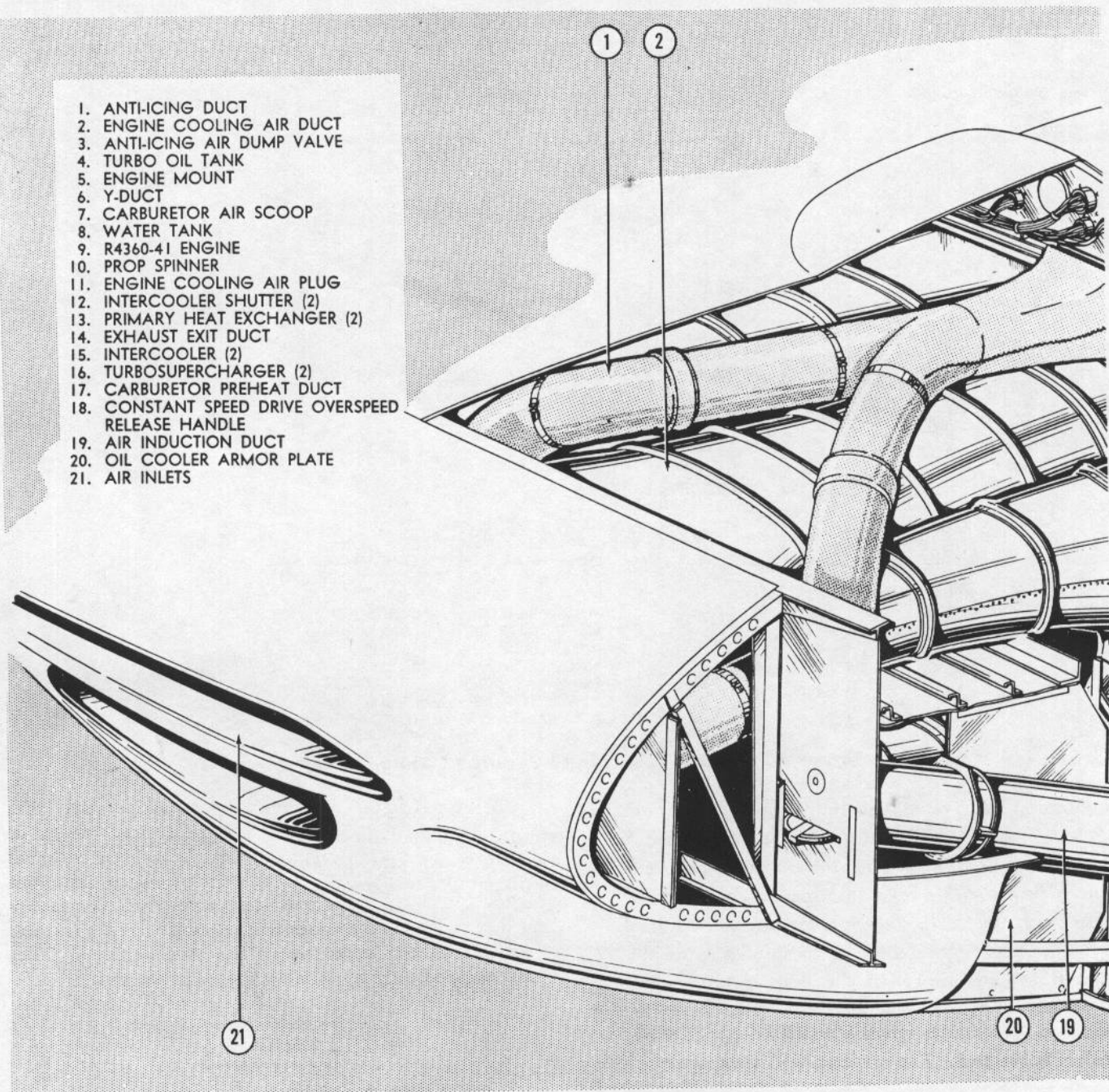


Figure 1-3. (Sheet 1) Reciprocating Engine Nacelle General Arrangement

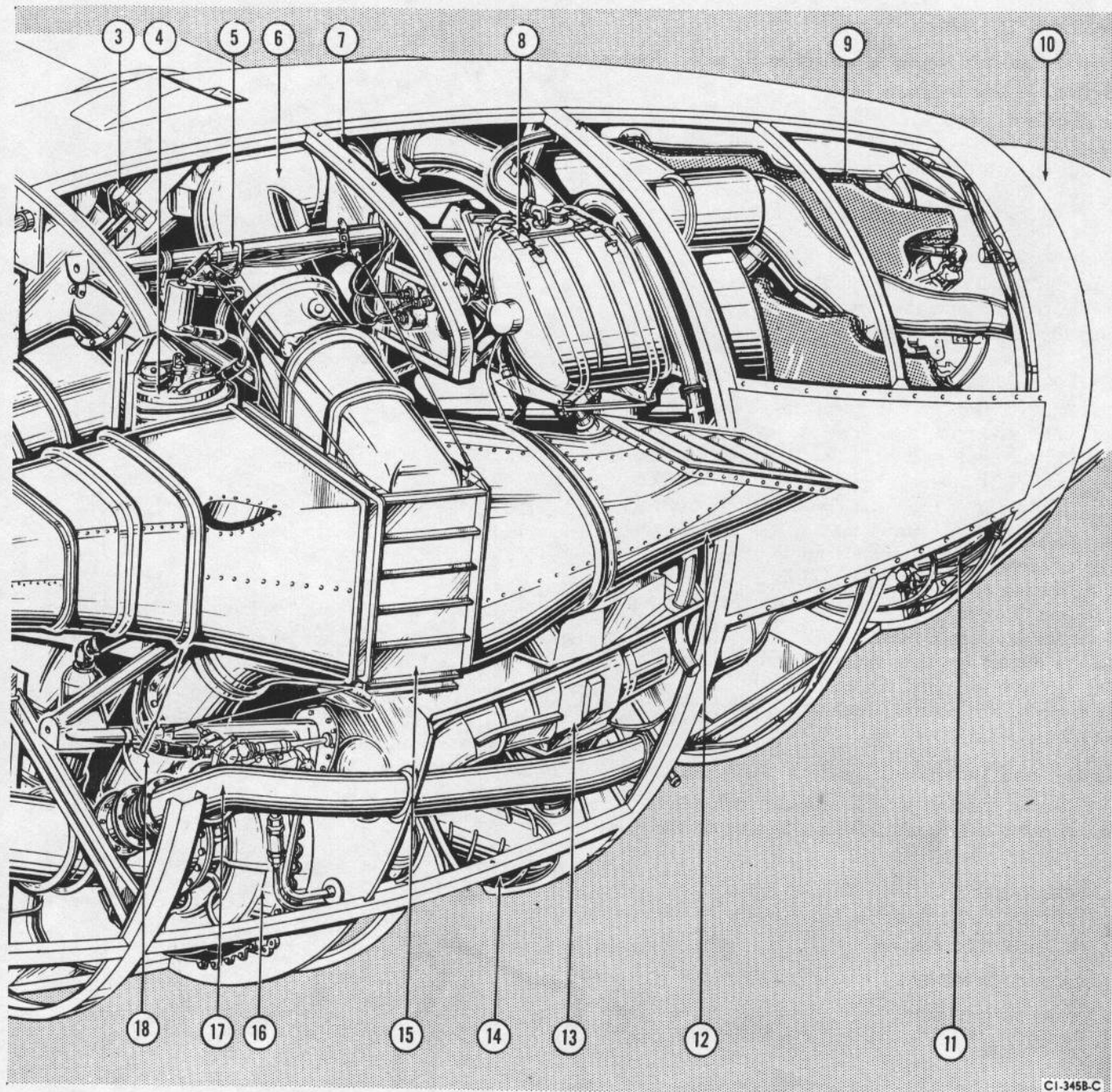
Note

With the control switches OFF, normal indication of the gages is approximately 10 psi. This reading indicates metered fuel pressure.

ENGINE COOLING SYSTEM.

Engine cooling air is introduced into the nacelle through a cooling air tunnel. Air is taken from the tunnel for cooling the turbosuperchargers, the exhaust system, the propeller mechanism, and various elec-

trically driven actuators. The flow of the remainder of cooling air is routed over the engine and is controlled by a ring-shaped air plug. Six switches on the flight engineer's auxiliary control panel are provided to control the air plugs in maintaining the proper cylinder head temperature. The position of the air plugs can be determined from the scanners' stations by observing the positions of the diamond-shaped markers painted on the air plugs. (See figure 1-6.) A two-speed engine-driven fan is installed in the air tunnel of each engine to increase the rate of cooling air flow.



CI-345B-C

Figure 1-3. (Sheet 2) Reciprocating Engine Nacelle General Arrangement

Air Plug Switches.

Six three-position switches (4, figure 1-24), located on the flight engineer's auxiliary control panel, control the engine air plugs. Each switch has a spring-loaded OPEN position, a spring-loaded CLOSE position, and a neutral center position marked OFF. The air plug is controlled by holding the switch in either the OPEN or CLOSE position to obtain the desired cylinder head temperature. The switches are provided with a gang bar for simultaneous operation in the OPEN position.

A 28-volt d-c circuit controls 200-volt alternating current, which operates the air plug actuator motor.

Fan Speed Switches.

Six two-position switches (14, figure 1-20), marked LOW RPM and HIGH RPM, control the speed of the engine cooling fans. The fan speed control actuators use 115-volt alternating current. For additional information on fan speed control see "Cooling Fan Control," Section II.

IGNITION SYSTEM.

Ignition for each engine is furnished by seven double magnetos — one for each bank of cylinders. Each of the double magnetos has a right and left system which supplies the electrical impulses to the right and left spark plug of each cylinder at the proper time of the engine cycle.

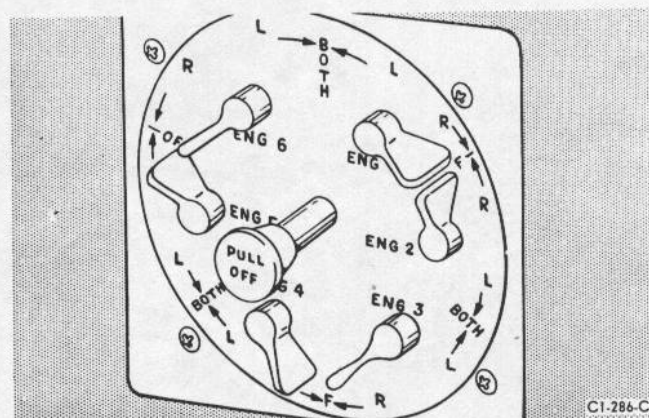
Note

The right spark plug is on the intake side of the cylinder and the left spark plug is on the exhaust side of the cylinder.

The engineer can set the spark to occur at either 20 degrees or 30 degrees before the piston reaches top-dead-center of the compression stroke by means of a set of spark advance switches. The 20-degree setting is used for normal operation. The spark advance setting of 30 degrees is used for certain cruise control configurations during manual leaning for greater engine efficiency (see Appendix 1) and to prevent back-firing during certain operating conditions at high altitude (see "Power Collapse," Section VII). In addition to the spark advance switches, the ignition controls include a master ignition switch and six individual engine ignition switches. An emergency ignition switch for stopping all engines simultaneously is provided for the pilots.

Master and Individual Ignition Switches.

The master ignition switch and the individual ignition switches (19, figure 1-20) are located on the flight



engineer's main control panel. The master switch sets up 28-volt d-c ignition circuits to the individual switches when pushed in.

Note

In an emergency the engineer can stop all engines simultaneously by pulling the master switch.

The individual ignition switches have positions marked OFF, L, R, and BOTH. The unmarked detent between L and R is another BOTH position. The L and R positions are used in checking the left and right magneto systems. When the switch is in the L position, the left magneto system is grounded and the right magneto system is the one being checked. Conversely, when the switch is in the R position, the left magneto system is being checked.

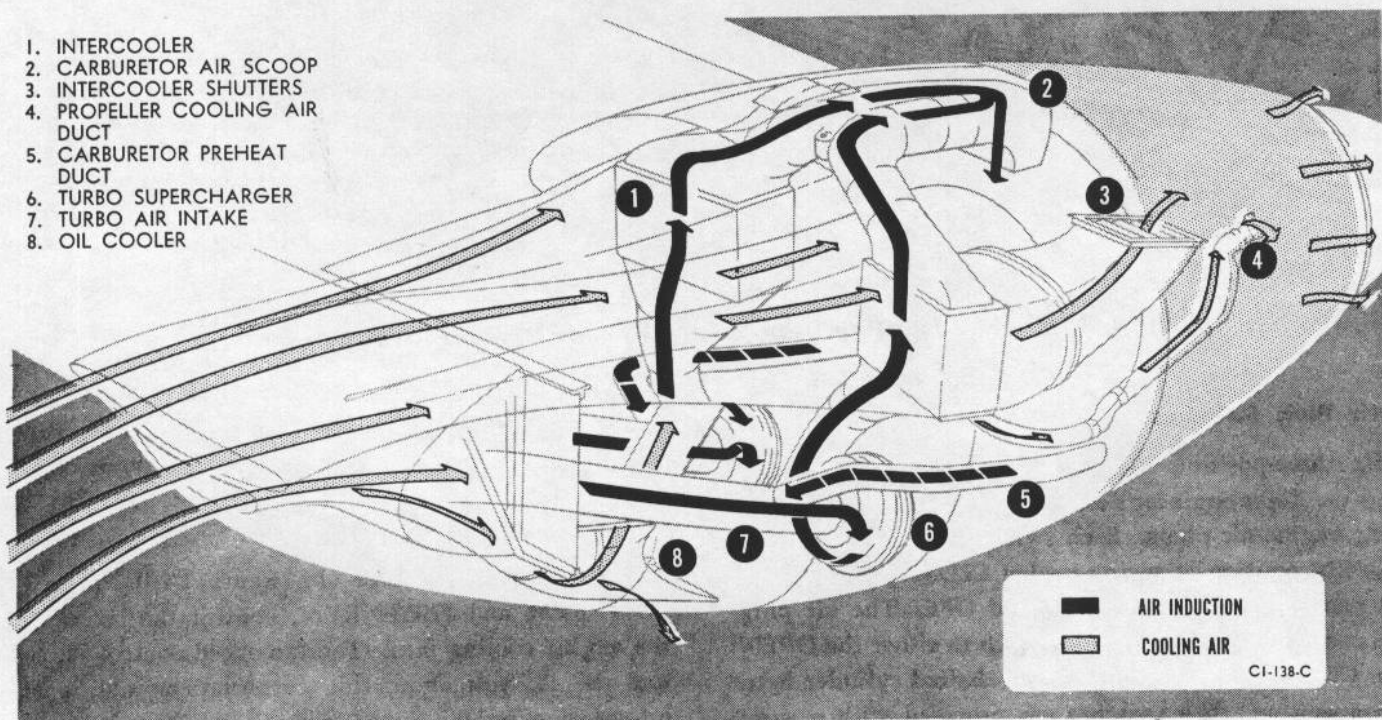


Figure 1-4. Air Induction and Engine Cooling

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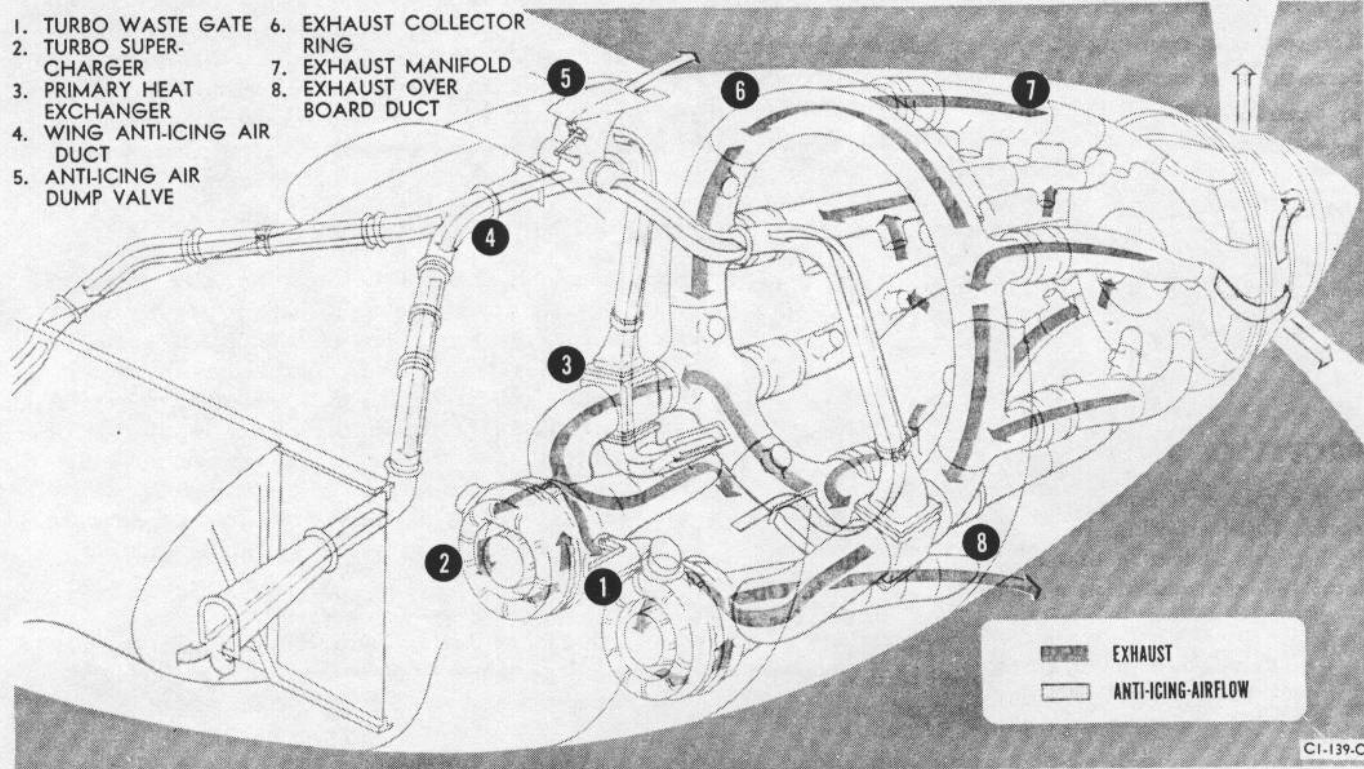


Figure 1-5. Exhaust and Anti-Icing Air Flow

Emergency Ignition Switch.

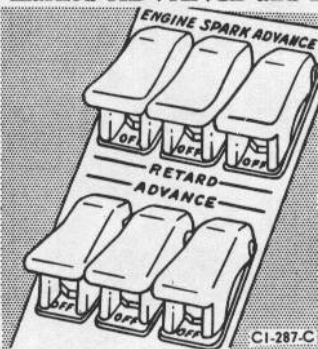
The emergency ignition switch (29, figure 1-12) is located on the pilots' instrument panel. Pulling the switch stops all engines.

CAUTION

This switch is to be used in emergency situations only. When testing the emergency ignition circuit, actuation of the switch must be instantaneous to prevent the possibility of backfiring.

Spark Advance Switches.

The six spark advance switches (9, figure 1-21) are located on the engineer's table and have positions marked ADVANCE and RETARD. When a switch is placed in the ADVANCE position, a 115-volt a-c circuit is completed to an actuator and the spark is advanced from the normal setting of 20 degrees to a setting of 30 degrees. Placing the switch in the RETARD position returns the spark to the normal 20-degree setting.

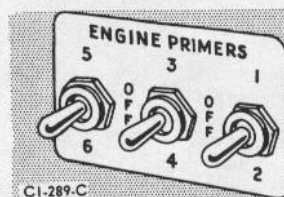


PRIMING SYSTEM.

Each reciprocating engine is equipped with a separate priming system to assist in starting whenever necessary. Priming is controlled by a solenoid-operated valve on the carburetor which allows fuel under booster pump pressure to pass into the intake manifold system of the engine.

Engine Primer Switches.

The six priming systems are controlled by three three-position switches (17, figure 1-20) located on the flight engineer's control panel. The switches are marked OFF in the center position with engine numbers above and below. When a primer switch is held in an engine position, a 28-volt d-c circuit is completed to a primer solenoid and fuel is injected directly into the blower case of the corresponding engine.

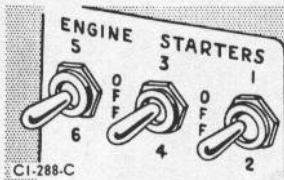


STARTING SYSTEM.

A heavy duty direct-cranking starter is mounted on the lower side of each reciprocating engine accessory case for cranking the engine. The starter cranks the engine through a planetary gear system, a dry-disc friction clutch, and a cranking jaw which engages the engine cranking jaw. The starter jaw automatically disengages when the engine starts. Engine damage due to hydraulic lock is prevented by the friction clutch which is preset to slip at 400-foot pounds of torque.

Engine Starter Switches.

The six direct-cranking starters are controlled by three three-position switches (18, figure 1-20). The switches are marked OFF in the center position with engine numbers above and below. Holding a starter switch in an engine position engages the starter and cranks the corresponding engine. A 28-volt d-c control circuit controls 200-volt alternating current which is applied to the engine starter.



PROPELLER SYSTEM.

The airplane is equipped with six Curtiss constant-speed, full-feathering, reversible propellers. The propellers are 19 feet in diameter and have three hollow steel blades installed in a one-piece steel hub. Openings are provided in the tip of each blade for the exit of propeller anti-icing air. The propellers of group 3 airplanes have round-tipped blades. Airplanes in group 4 have propellers equipped with square-

tipped blades. These blades have a thinner airfoil section which provides greater efficiency at higher speeds and altitudes than the blades with round tips. The control system of both propeller models is identical and is similar to that used on previous models of synchronizer-equipped propellers except that synchronization is possible in the reverse range.

PITCH CHANGE SYSTEM.

Pitch change is accomplished mechanically by power taken directly from propeller shaft rotation. Clutch engagement for operation of the pitch changing mechanism is accomplished hydraulically. The hydraulic power is controlled by small solenoid valves. A small electric motor drives the blades in the last of the feathering and the beginning of the unfeathering cycles when the engine is operating below 450 rpm and is unable to furnish sufficient power to operate the pitch changing mechanism.

Note

Pitch change during feathering and reversing is 45 degrees per second. Pitch change during normal operation is 2 1/2 degrees per second.

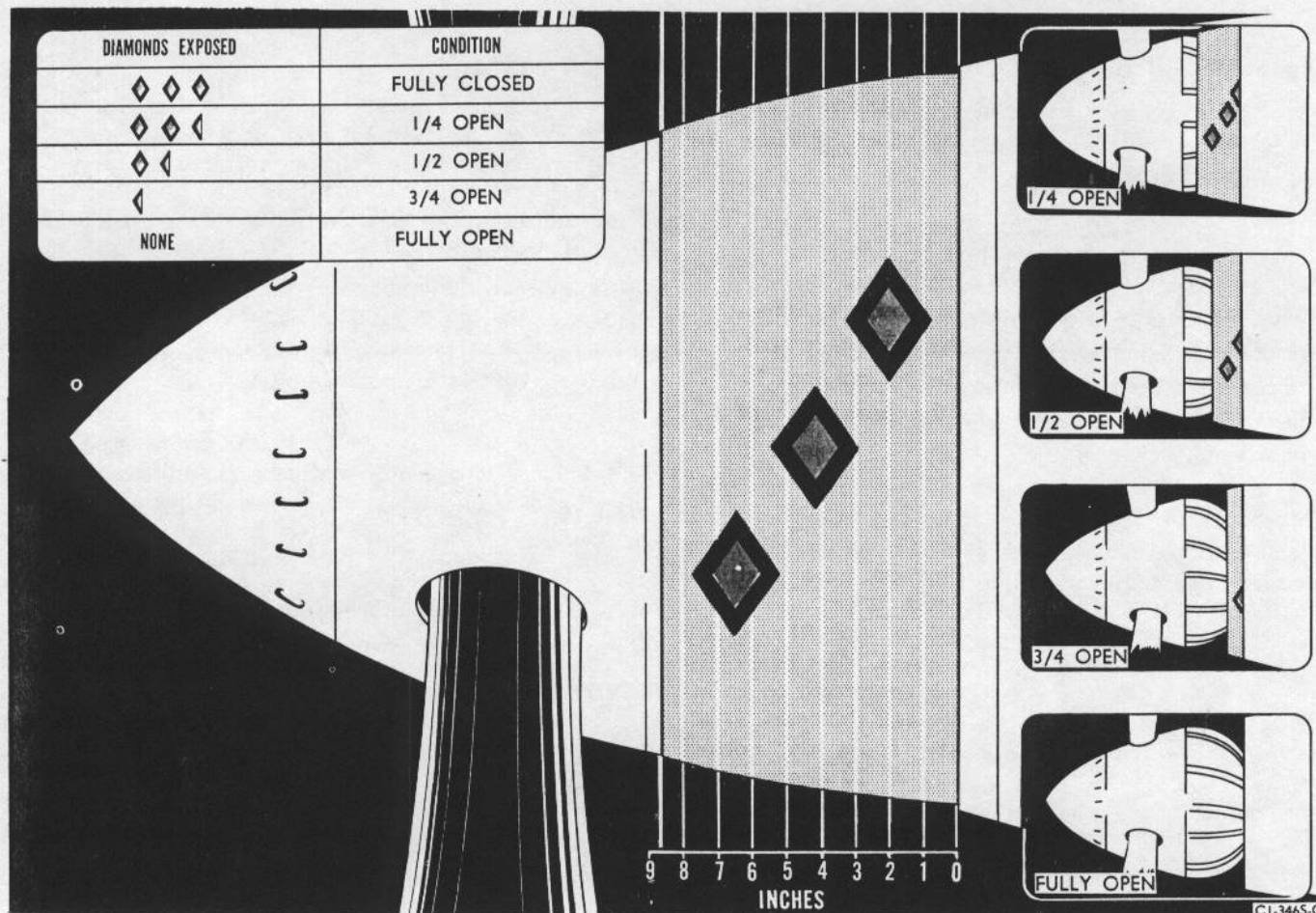


Figure 1-6. Reciprocating Engine Air Plug Position Indication

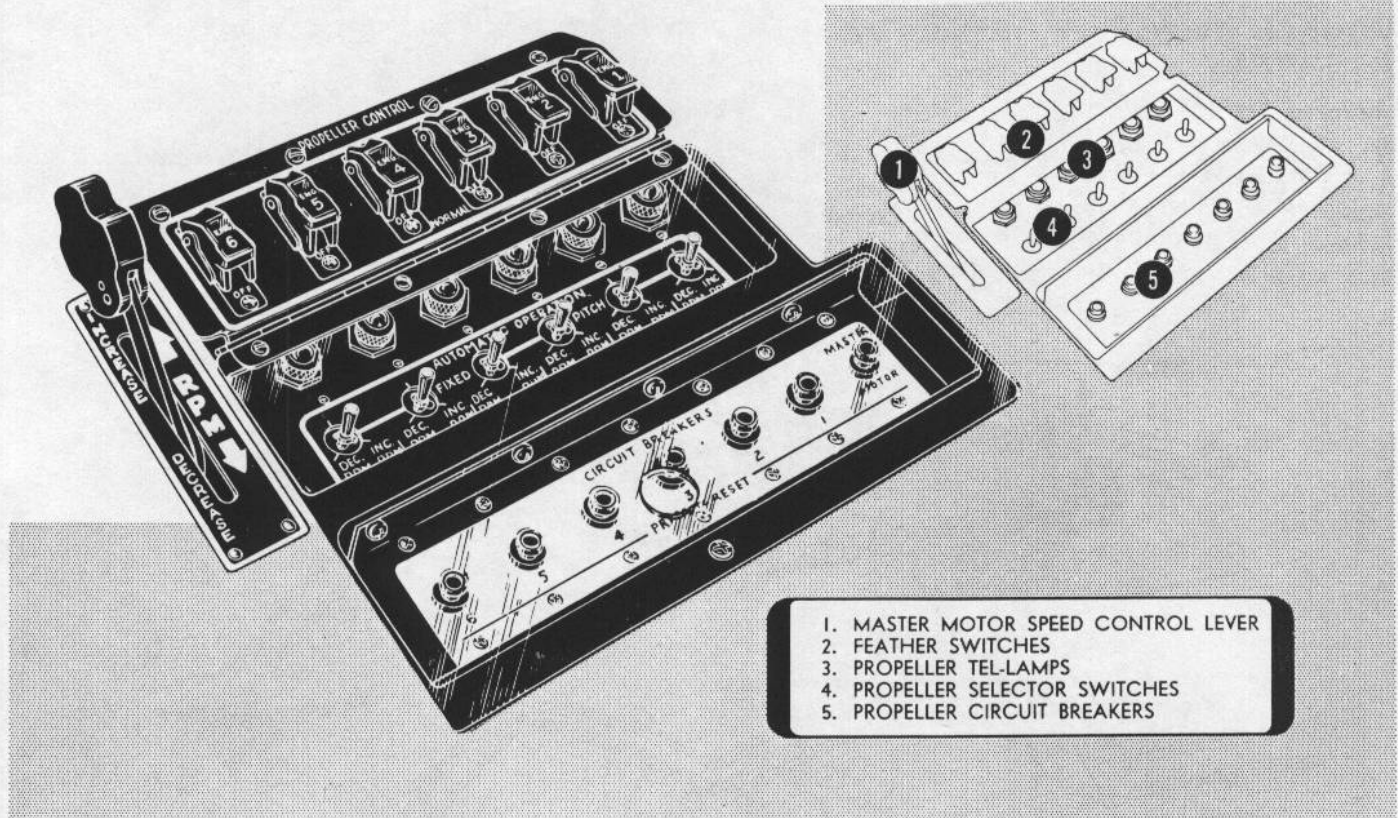


Figure 1-7. Engineer's Propeller Control Panel

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NORMAL PROPELLER CONTROLS AND INDICATORS.

Control of the propeller speed is conventional, but synchronization is accomplished by making the speed of all engines compare with the speed of an electrically driven master motor. A propeller alternator on each engine supplies an electrical indication of engine speed to a contactor assembly on the master motor. If the engine speed does not coincide with that of the master motor, corrective impulses are transmitted to the pitch changing mechanism until the engine is operating at master motor rpm. All engines operate at master motor rpm when their respective selector switches are placed in the AUTOMATIC OPERATION position and their throttles are advanced sufficiently for the engine to attain master motor rpm. In the event of master motor failure, the propeller will remain at the pitch in effect when the failure occurred. Pitch changes will then be accomplished by moving the selector switches to the INC. RPM or the DEC. RPM positions.

Propeller Selector Switches.

Six conventional propeller selector switches (4, figure 1-7) having four positions — AUTOMATIC OPERATION, DEC. RPM, INC. RPM, and FIXED PITCH — are provided on the flight engineer's table and operate on 28-volt d-c power.

Master Motor Control Lever.

(See 18, figure 1-13 and 1, figure 1-21.) Two control levers are provided to control the speed of the master motor. The lever located on the flight engineer's table is mechanically interconnected to the one on the pilots' pedestal. As well as controlling master motor rpm, these levers regulate the supply of 28-volt d-c power to operate the master motor.

Master Tachometers.

(See 7, figure 1-12 and 1, figure 1-15.) The master tachometers indicate master motor rpm. It should be noted that master motor rpm will not always coincide with engine rpm, since the master motor may be operating at any selected rpm during ground operations, even when the engines are not running.

Propeller Tel-Lamps

Six push-to-test tel-lamps (3, figure 1-7) are provided to indicate proper operation of the synchronization system. When the propeller selector switches are placed in the AUTOMATIC OPERATION position and the master motor is on-speed, the tel-lamps will light. If the master motor fails, all lamps will go out. Each lamp will go out when its corresponding selector switch is moved out of the AUTOMATIC OPERATION position.

PROPELLER REVERSE PITCH CONTROLS AND INDICATORS.

Reverse Selector Switches.

Three propeller reverse selector switches (10, figure 1-13) marked READY and SAFE are located on the pilots' pedestal. These switches are used to select symmetrical pairs of propellers to be reversed by setting up a 28-volt d-c circuit to the propellers. The

propellers are returned from reverse by placing the switches in the SAFE position.

Reverse Pitch Switch.

A push-button type reverse pitch switch (19, figure 1-13), located on the pilots' pedestal, completes a 28-volt d-c circuit which reverses the symmetrical pairs of propellers selected by the reverse selector switches.

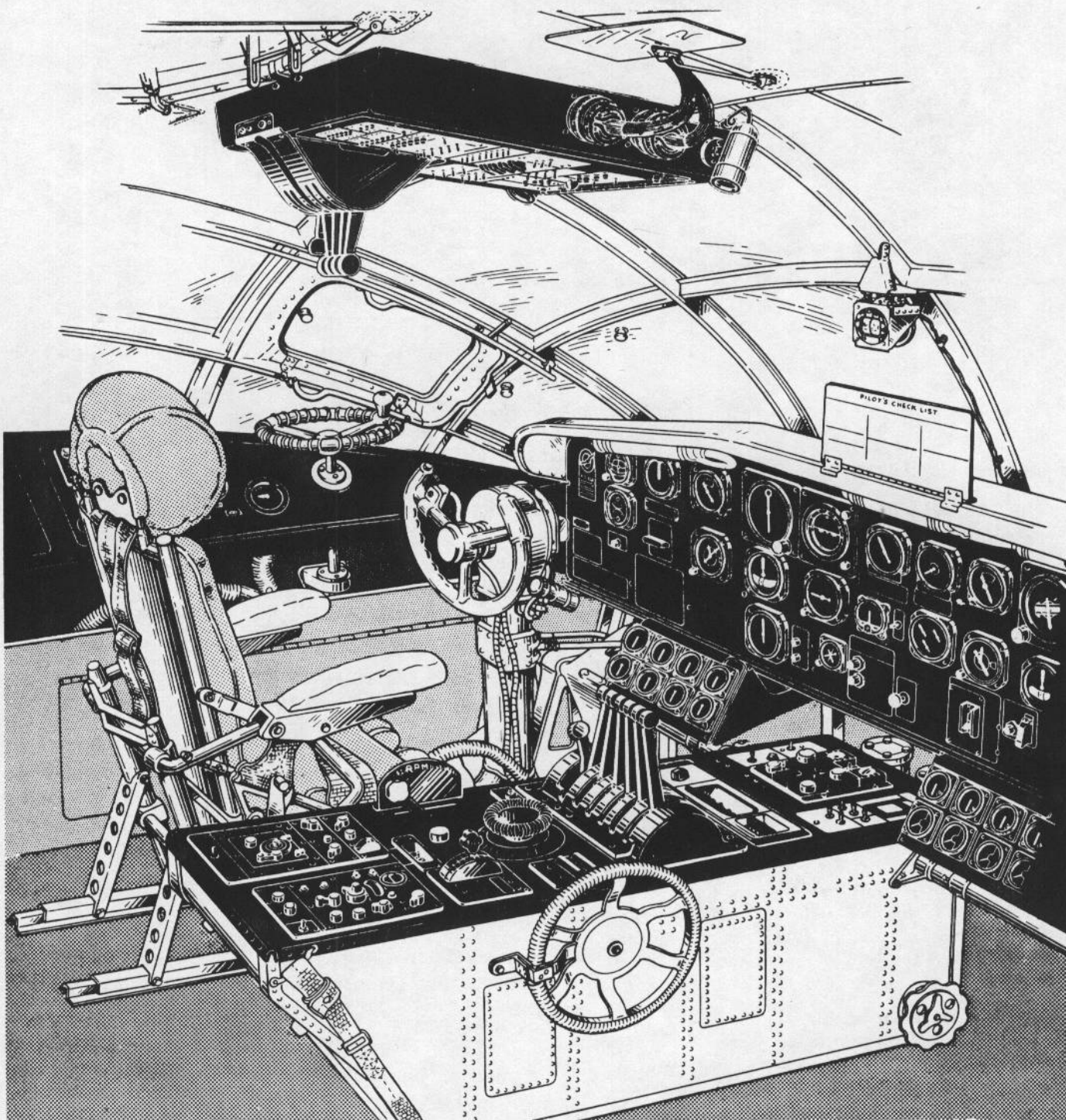


Figure 1-8. Aircraft Commander's Station

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Note

When one pair of propellers is in reverse pitch, the remaining pairs can be reversed by placing their reverse selector switches in the READY position.

WARNING

If an engine is shut down (propeller feathered), the propeller of the symmetrical opposite engine cannot be reversed unless the feather switch of the inoperative engine is returned to NORMAL.

Propeller Reverse Warning Lamps.

Six red warning lamps (40, figure 1-12) are located on the pilots' instrument panel. When any propeller is in reverse pitch, the corresponding red lamp will be lighted. The lamp will go out when the propeller is returned to normal pitch.

Note

The lamps will light when the propeller blades reach a positive pitch angle of 10.5 degrees going into reverse. Conversely, coming out of reverse, the lamps will go out at the 10.5-degree positive pitch angle.

Propeller Normal Pitch Indicator Lamps.

Six green lamps (19, figure 1-15) are located on the flight engineer's main instrument panel. These lamps indicate when the propellers are in normal pitch. When any propeller is in reverse pitch, the respective lamp will not burn.

Note

The lamps will light when the propeller blades reach a positive pitch angle of 10.5 degrees coming out of reverse. Going into reverse, the lamps will go out at the 10.5-degree positive pitch angle.

OIL TANK CAPACITIES, GALLONS

TANK	NO.	TOTAL VOLUME	*EXP. SPACE	MAX. USABLE	NORMAL LOADING
INBOARD	2	241	41	200	150
CENTER	2	248	48	200	150
OUTBOARD	2	262	62	200	150

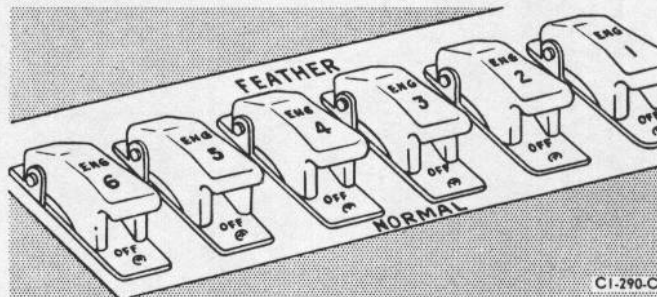
*EXPANSION SPACE CANNOT BE USED FOR ADDITIONAL OIL

CI-345T-C

Figure 1-9. Oil Tank Capacities

PROPELLER FEATHER CONTROLS.

Six two-position switches (2, figure 1-7), marked FEATHER and NORMAL, are located on the flight



engineer's table. The switches are guarded in the NORMAL position.

WARNING

The propellers cannot be reversed when their feather switches are in FEATHER.

RECIPROCATING ENGINE OIL SYSTEM.

Each reciprocating engine has an independent oil system which includes a tank, a shutoff valve, a means of oil dilution, and a cooling system. (See figure 1-23.) The capacity of each tank is given in figure 1-9.

An oil shutoff valve is located in the supply line between each tank and engine. A set of six switches at the engineer's station provide 115-volt a-c power for operation of the valves. To aid in oil scavenging and to prevent excessive loss of oil at altitude, the engine crankcase and the engine oil tank are pressurized for high altitude operation. A barometric type valve is located in the crankcase breather line to maintain a 1.4 psi differential between the ambient and crankcase pressure above an altitude of 30,000 feet. The oil tanks are pressurized by air taken from the cabin pressurization system and by the normal pressure input from the engine-driven scavenge pump. An aneroid type valve, which incorporates a relief valve, is installed in the tank vent lines to maintain a 2.75 psi differential between the ambient and oil tank pressure above approximately 20,000 feet. This pressurization is necessary to insure an adequate supply of oil to the engine oil pump and to minimize oil foaming. To obtain proper engine lubrication when low ground temperatures are experienced, the engineer can dilute the oil by injecting fuel into the oil supply line. (Refer to "Oil Dilution," Section IX for additional information.)

Electrical heating elements are provided for the tank vent lines and hoppers. For detailed information see "Oil Tank Vent Heaters" and "Oil Tank Hopper Heaters" in Section IV. Refer to figure 1-52 for servicing information.

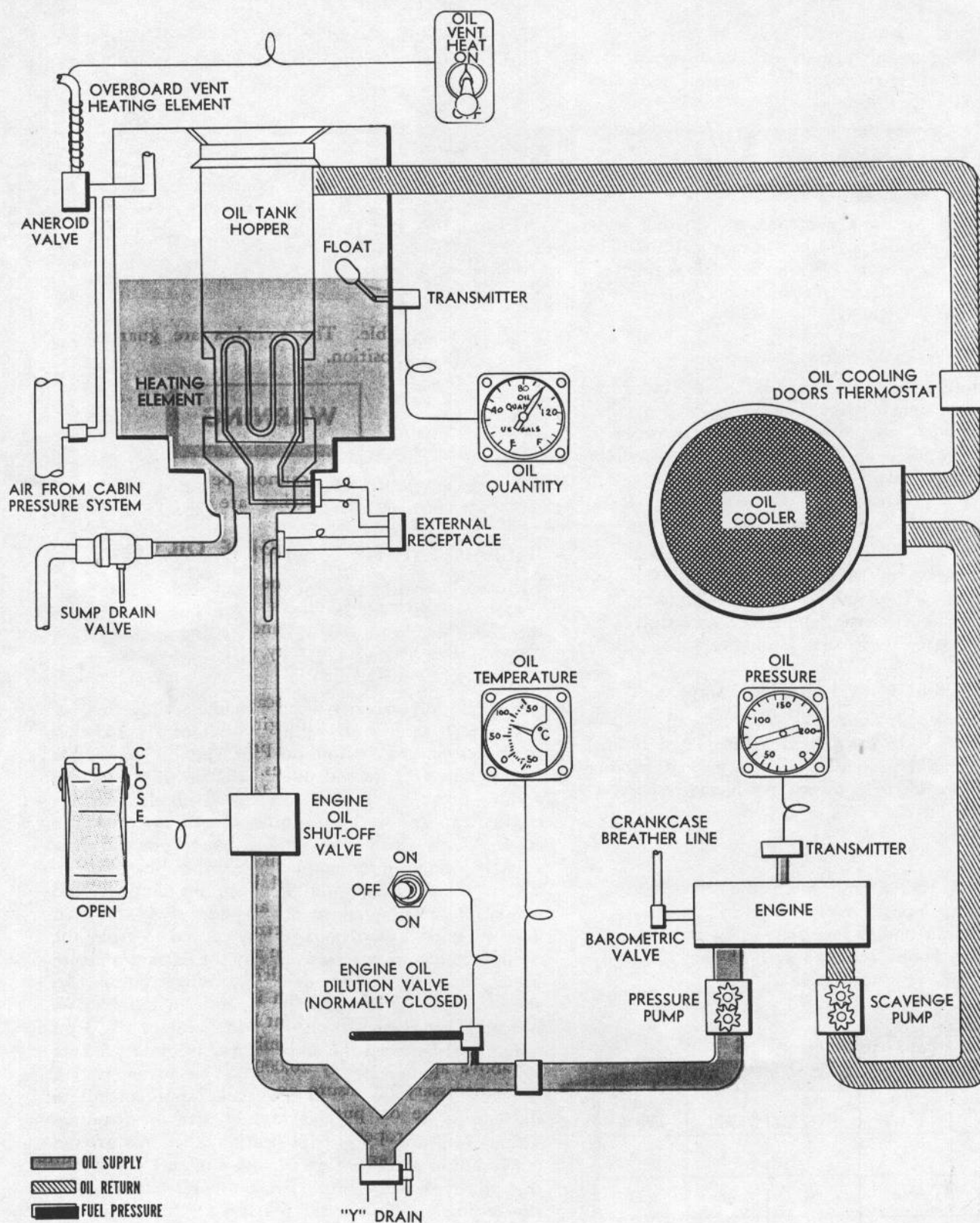


Figure 1-10. Reciprocating Engine Oil System Schematic

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OIL SYSTEM CONTROLS.

Oil Shutoff Valve Switches.

The engineer has six two-position switches (11, figure 1-20) on his main control panel for operating the oil shutoff valves. The switches have positions marked OPEN and CLOSE and are guarded in the OPEN position. With the exception of the valve for engine No. 6, the shutoff valves are accessible from the wing crawlways and can be operated manually.

Oil Dilution Switches.

There are six oil dilution switches (33, figure 1-20) on the engineer's main control panel. Each switch has two spring-loaded ON positions and a neutral OFF. One ON position is provided for using the switches individually. The other ON position permits gang bar operation for simultaneous dilution of the oil for all engines. When a switch is placed ON, a 28-volt d-c circuit is completed to an oil dilution solenoid.

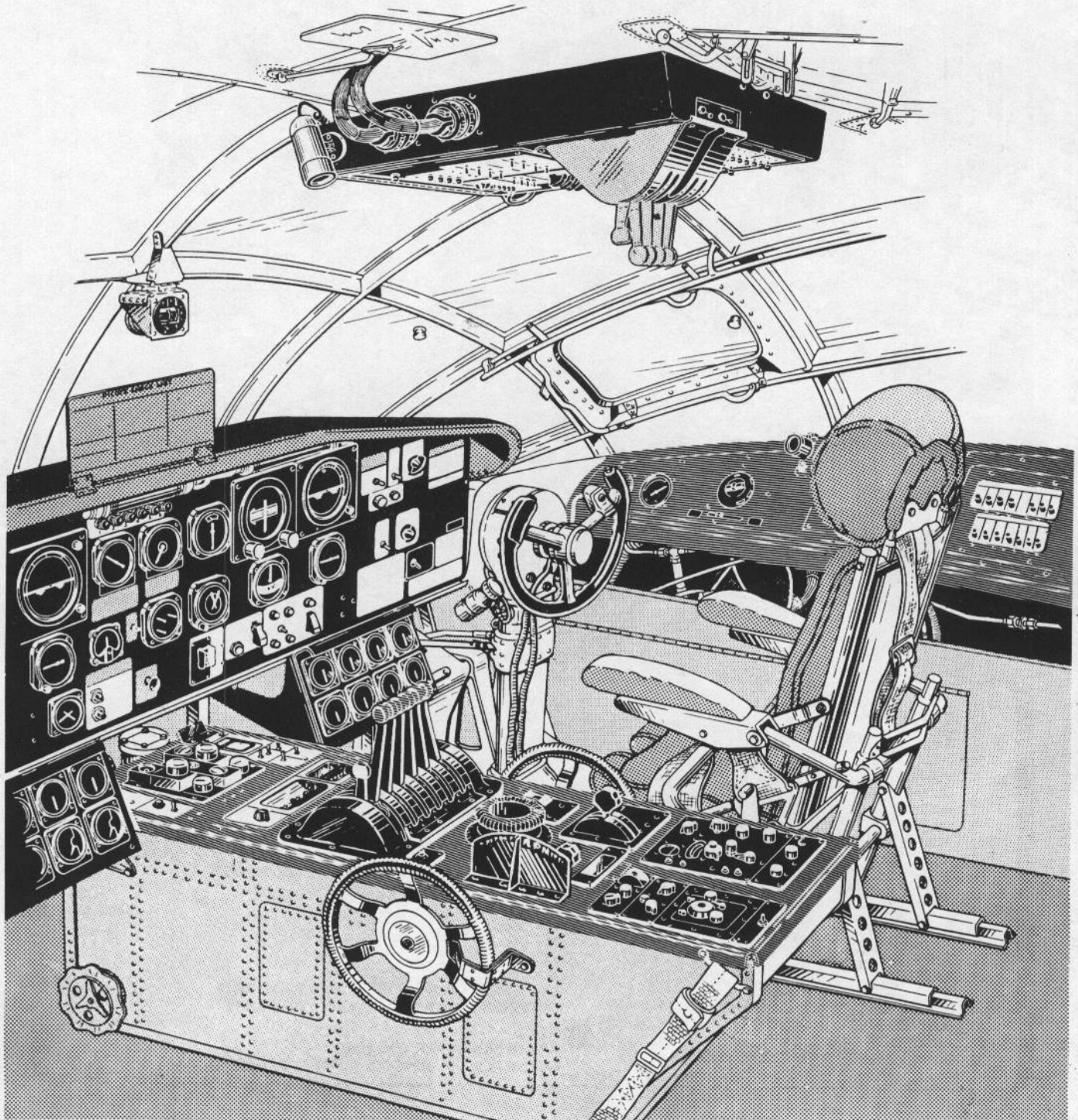
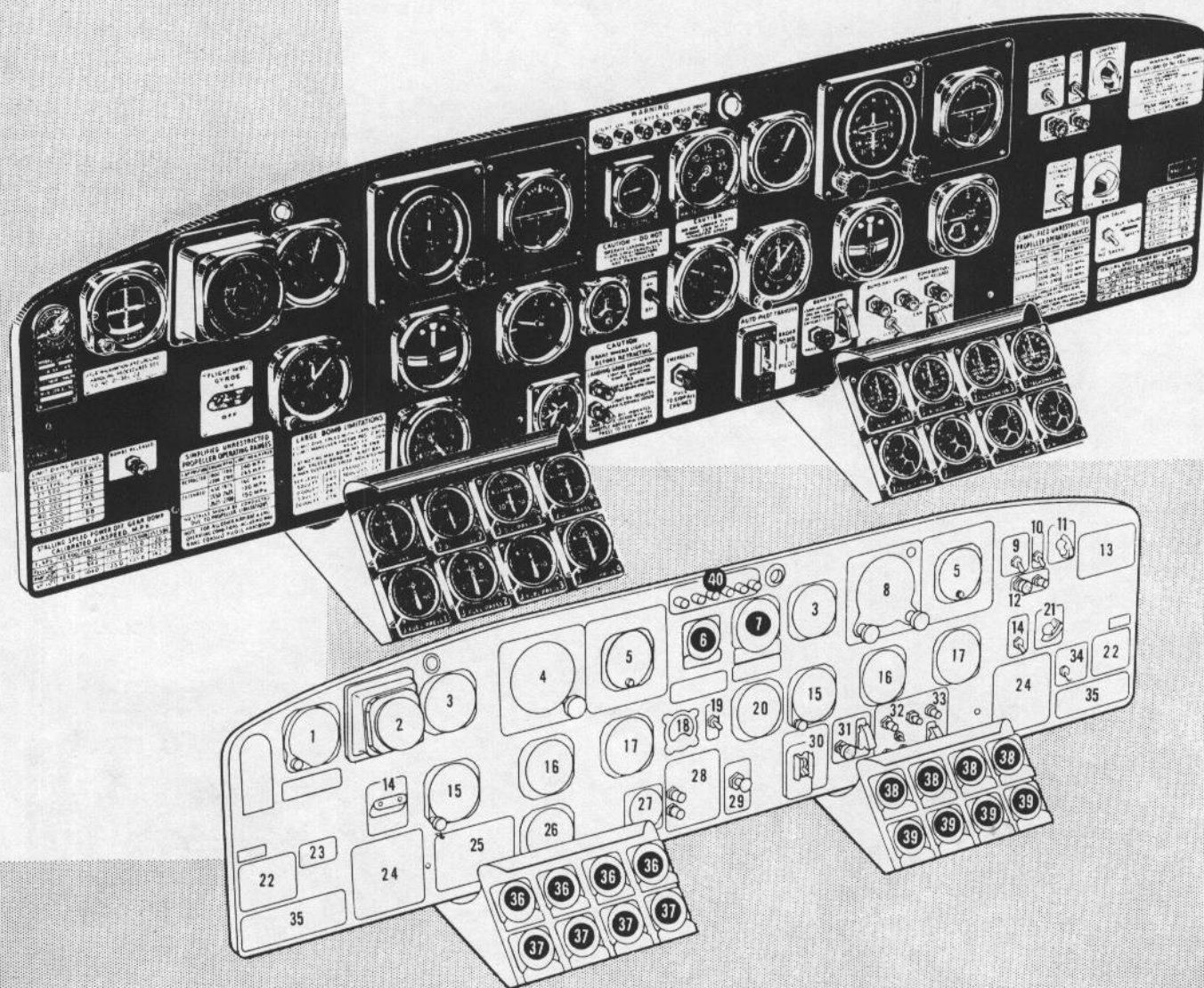


Figure 1-11. Pilot's Station

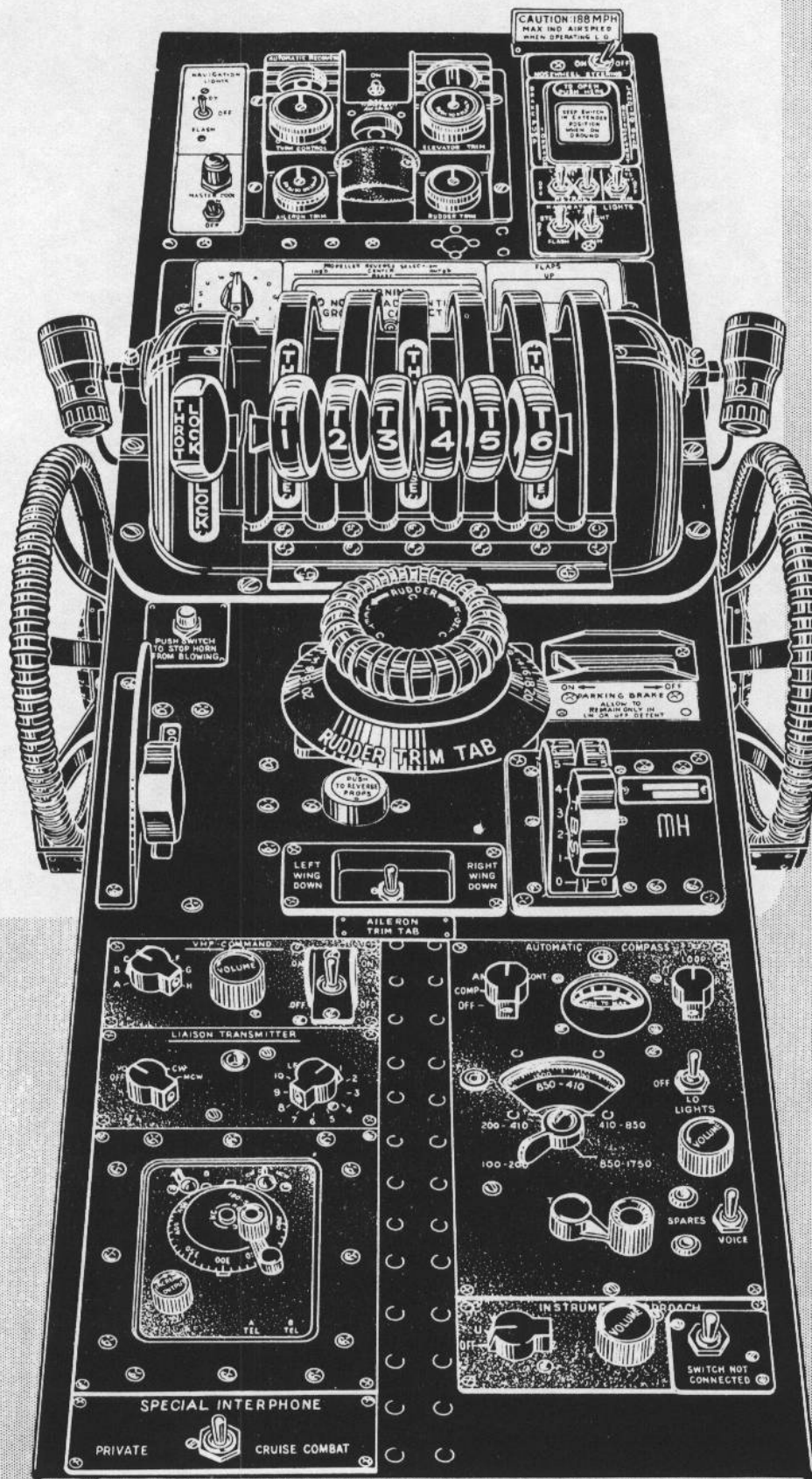
F1013



1. BLIND APPROACH INDICATOR
 2. PILOTS' DATA INDICATOR
 3. AIRSPEED INDICATOR
 4. DIRECTIONAL GYRO INDICATOR
 5. VERTICAL GYRO INDICATOR
 6. MANIFOLD PRESSURE GAGE
 7. MASTER TACHOMETER
 8. MASTER DIRECTIONAL INDICATOR
 9. WINDSHIELD WIPER CONTROL SWITCH
 10. FLUORESCENT LIGHTS CONTROL SWITCH
 11. COMPASS LIGHT CONTROL KNOB
 12. FLIGHT CONTROL LOCKS INDICATOR LAMPS
 13. WARNING HORN INSTRUCTION PLACARD
 14. FLIGHT INSTRUMENT SWITCHES
 15. ALTIMETER
 16. TURN AND BANK INDICATOR
 17. RATE OF CLIMB INDICATOR
 - 18.AILERON TRIM TAB INDICATOR
 19. ALARM BELL CONTROL SWITCH
 20. FLAP POSITION INDICATOR
 21. AUTOPILOT LAMPS SWITCH
 22. DIVING SPEED LIMITATIONS PLACARD
 23. BOMBS RELEASED INDICATOR LAMP
 24. PROPELLER OPERATING RANGES PLACARD
 25. LARGE BOMB LIMITATIONS PLACARD
 26. RADIO COMPASS
 27. CLOCK
 28. LANDING GEAR INDICATOR LAMPS
 29. EMERGENCY IGNITION SWITCH
 30. AUTOMATIC PILOT TRANSFER SWITCH
 31. BOMB SALVO INDICATOR LAMP AND CONTROL SWITCH
 32. BOMB BAY DOOR CONTROL SWITCH AND INDICATOR
 33. BOMB BAY FUEL TANK RELEASE SELECTOR SWITCH AND INDICATOR
 34. AUXILIARY BOMB SALVO SAFETY SWITCH
 35. STALLING SPEEDS PLACARD
 36. JET OIL PRESSURE GAGE
 37. JET FUEL PRESSURE GAGE
 38. JET ENGINE TACHOMETER
 39. JET TAIL PIPE TEMPERATURE INDICATOR
 40. PROPELLER REVERSE WARNING LAMPS
- NOTE:**
WHITE NUMERALS ON BLACK BACKGROUND DENOTES POWER CONTROLS.

Figure 1-12. Pilots' Instrument Panel

3-1012-2



1. NAVIGATION LIGHTS FLASHER SELECTOR SWITCH
 2. MASTER CODE CONTROLS
 3. AUTOPILOT CONTROL PANEL
 4. NOSE WHEEL STEERING SWITCH
 5. LANDING GEAR AND BRAKE PUMP SWITCHES
 6. LANDING LIGHT SWITCHES
 7. FORMATION LIGHT SWITCH
 8. NAVIGATION LIGHT SWITCHES
 9. NAVIGATION LIGHTS CODE SELECTOR SWITCH
 10. PROPELLER REVERSE SELECTOR SWITCHES
 11. FLAP CONTROL SWITCHES
 12. THROTTLE LOCK LEVER
 13. THROTTLE LEVERS
 14. ELEVATOR TRIM TAB CONTROL WHEEL
 15. WARNING HORN SHUT-OFF SWITCH
 16. RUDDER TRIM TAB CONTROL KNOB
 17. PARKING BRAKE LEVER
 18. MASTER MOTOR SPEED CONTROL LEVER
 19. PROPELLER REVERSE PITCH SWITCH
 20. AILERON TRIM TAB CONTROL SWITCH
 21. TURBO BOOST SELECTOR LEVER
 22. COMMAND RADIO CONTROL PANEL
 23. LIAISON RADIO CONTROL PANEL
 24. RADIO RANGE RECEIVER CONTROL PANEL
 - * 25. SPECIAL INTERPHONE SWITCH
 26. RADIO COMPASS CONTROL PANEL
 27. BLIND APPROACH CONTROL PANEL
- * (SOME AIRPLANES)

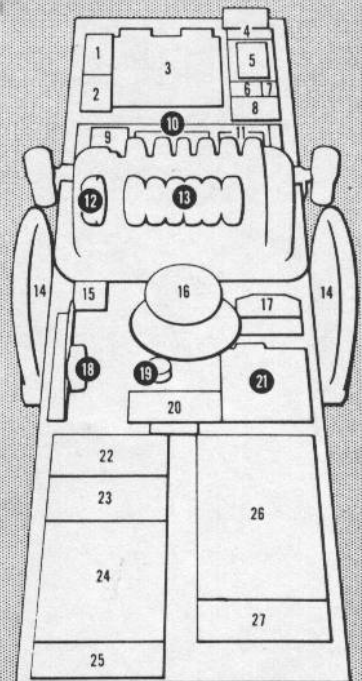


Figure 1-13. Pilots' Pedestal

3-1053-R

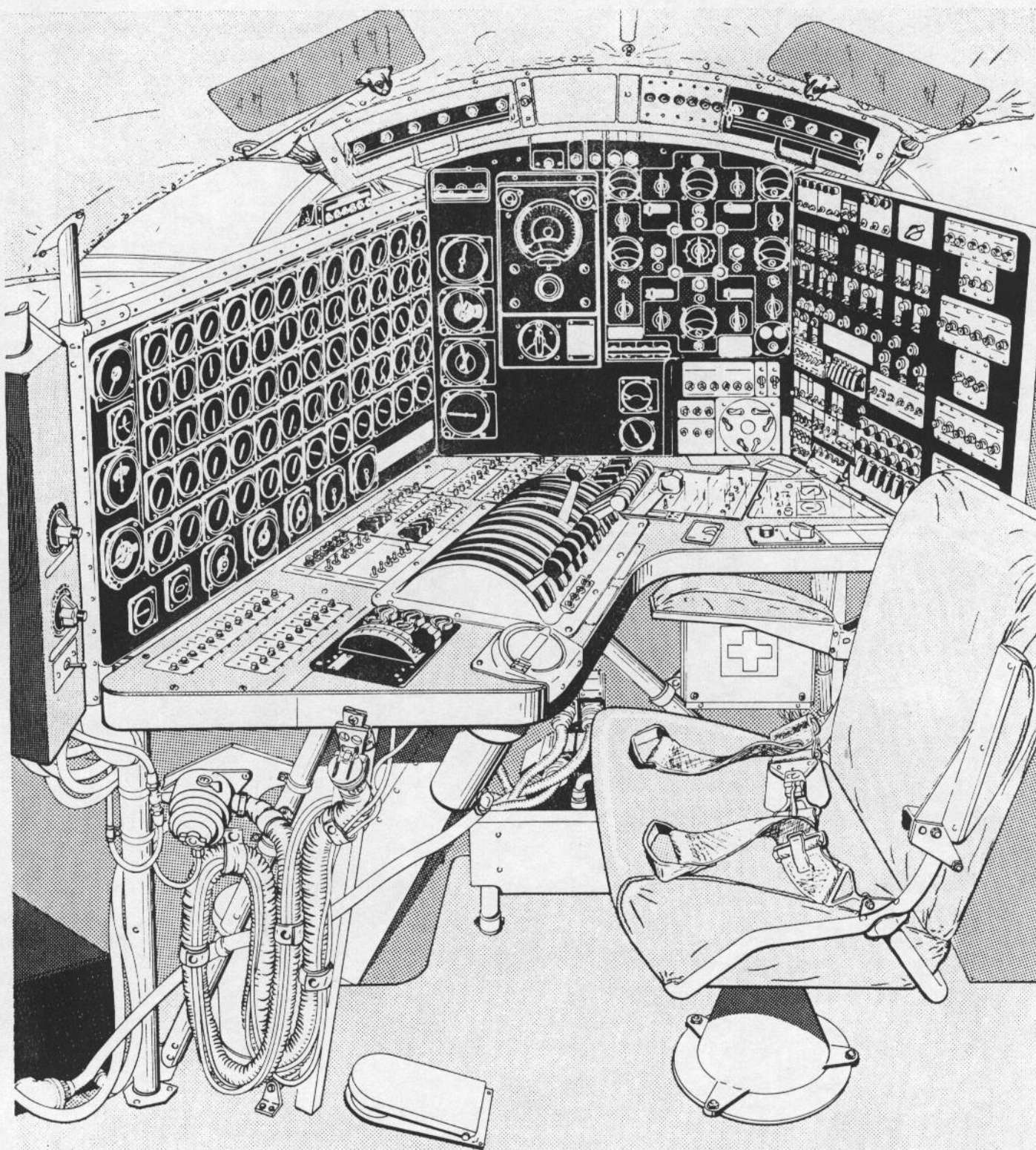


Figure 1-14. Engineer's Station

3-1023-R4

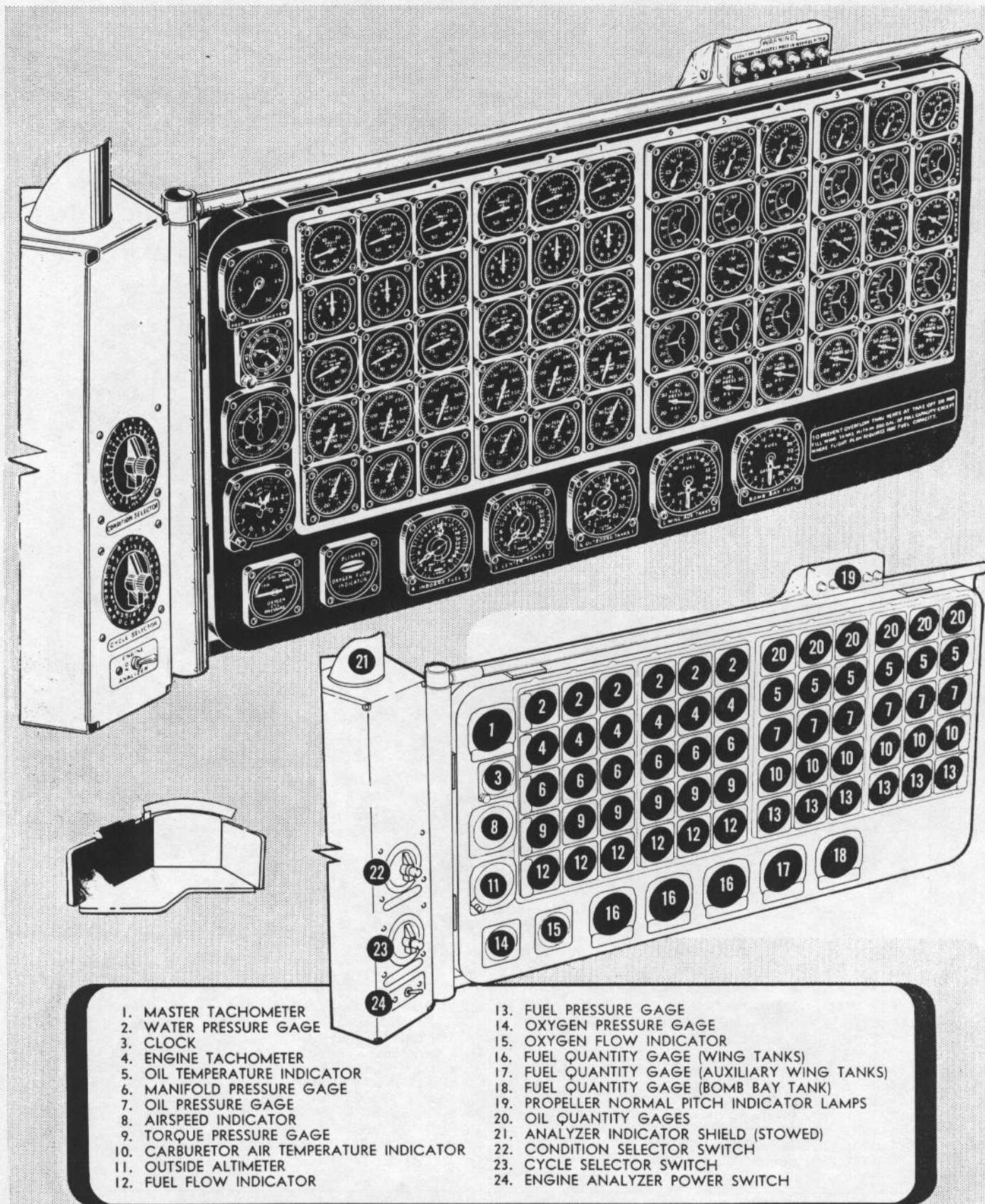
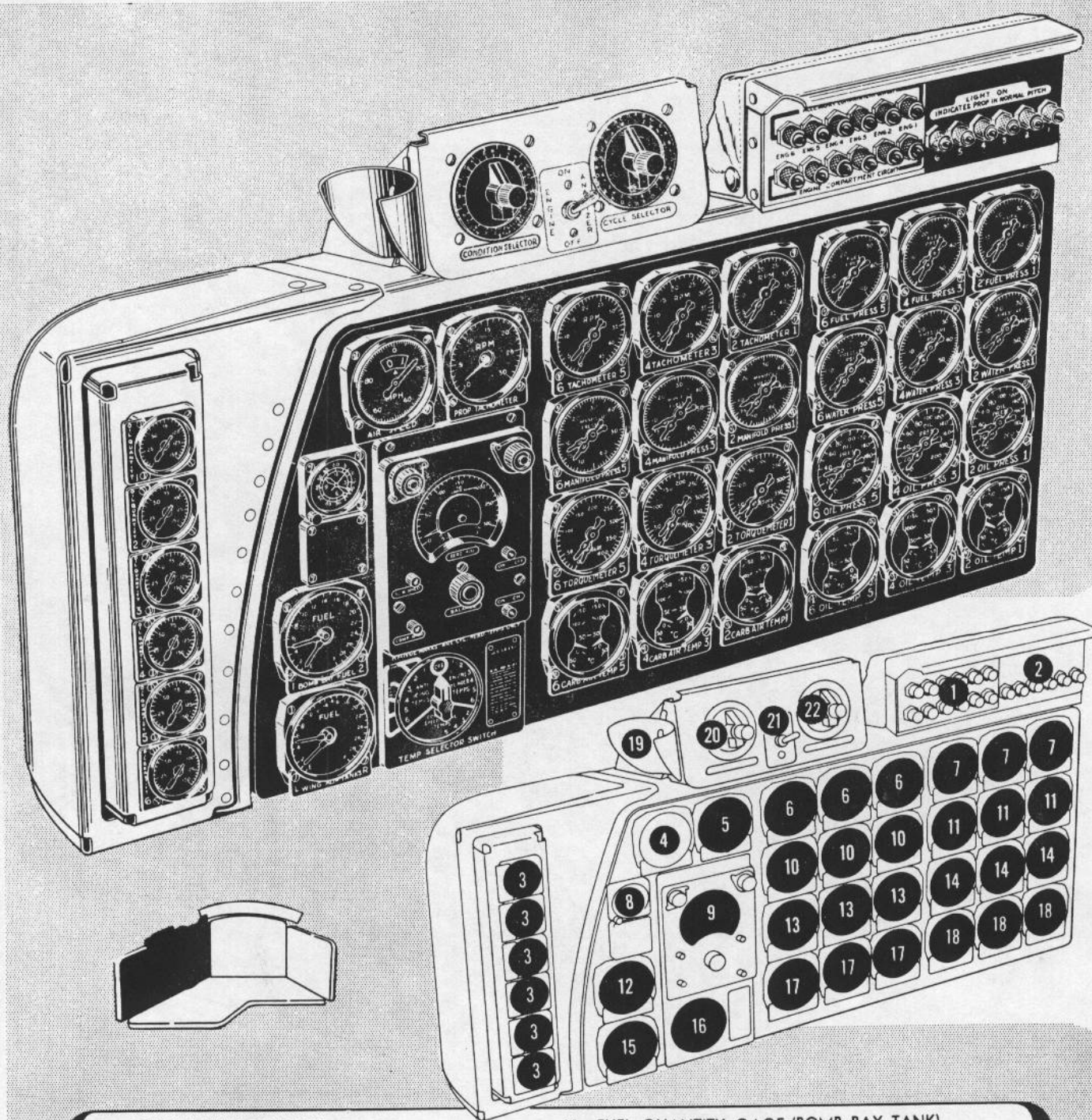


Figure 1-15. Engineer's Main Instrument Panel (Group 13 Airplanes)

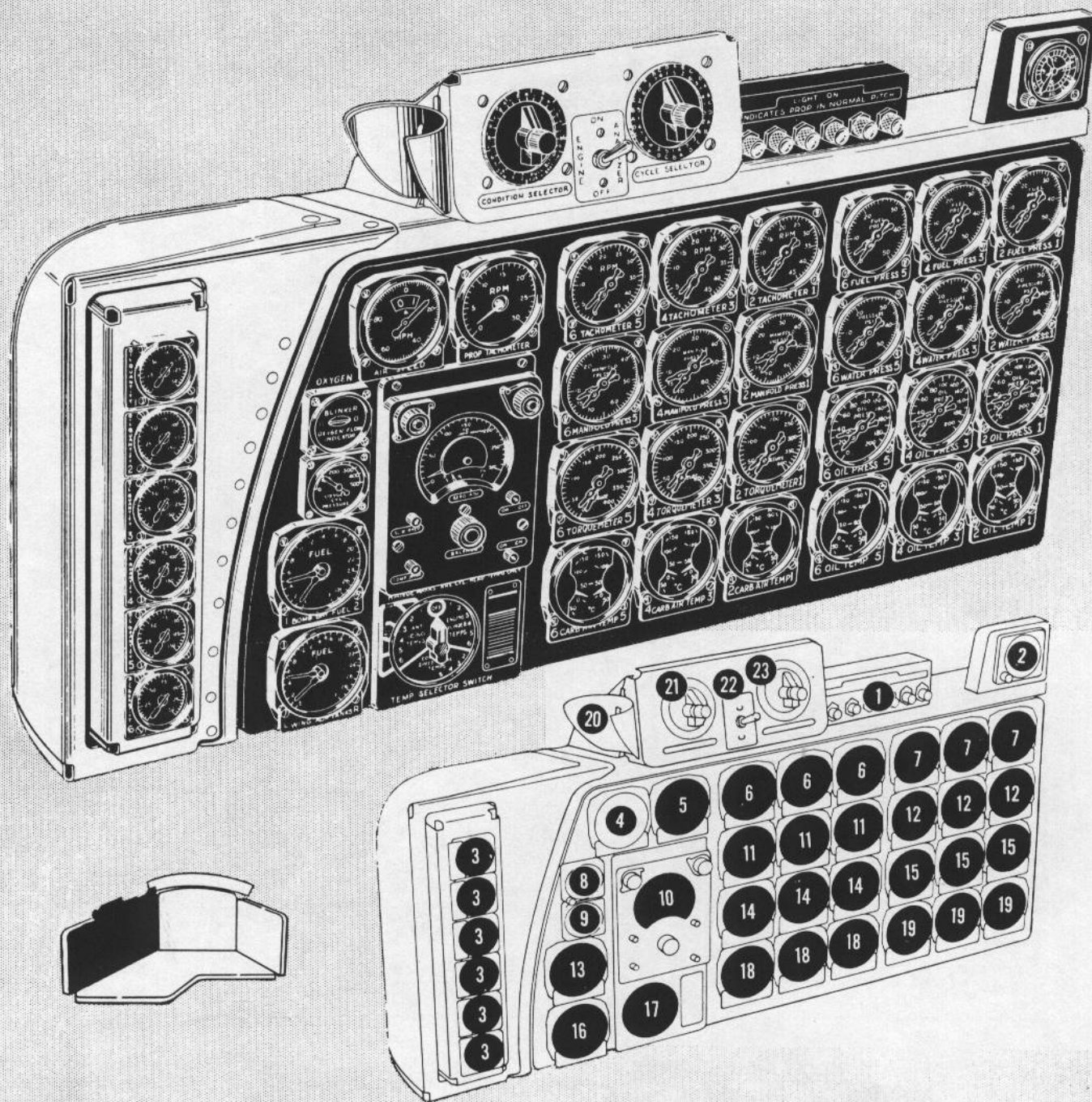


1. FIRE WARNING LAMPS
2. PROPELLER NORMAL PITCH INDICATOR LAMPS
3. OIL QUANTITY GAGES
4. AIRSPEED INDICATOR
5. MASTER TACHOMETER
6. ENGINE TACHOMETER
7. FUEL PRESSURE GAGE
8. CLOCK
9. MASTER TEMPERATURE INDICATOR
10. MANIFOLD PRESSURE GAGE
11. WATER PRESSURE GAGE

12. FUEL QUANTITY GAGE (BOMB BAY TANK)
13. TORQUEMETER PRESSURE GAGE
14. OIL PRESSURE GAGE
15. FUEL QUANTITY GAGE (AUXILIARY WING TANKS)
16. MASTER TEMPERATURE SELECTOR SWITCH
17. CARBURETOR AIR TEMPERATURE INDICATOR
18. OIL TEMPERATURE INDICATOR
19. ANALYZER INDICATOR SHIELD (STOWED)
20. CONDITION SELECTOR SWITCH
21. ENGINE ANALYZER POWER SWITCH
22. CYCLE SELECTOR SWITCH

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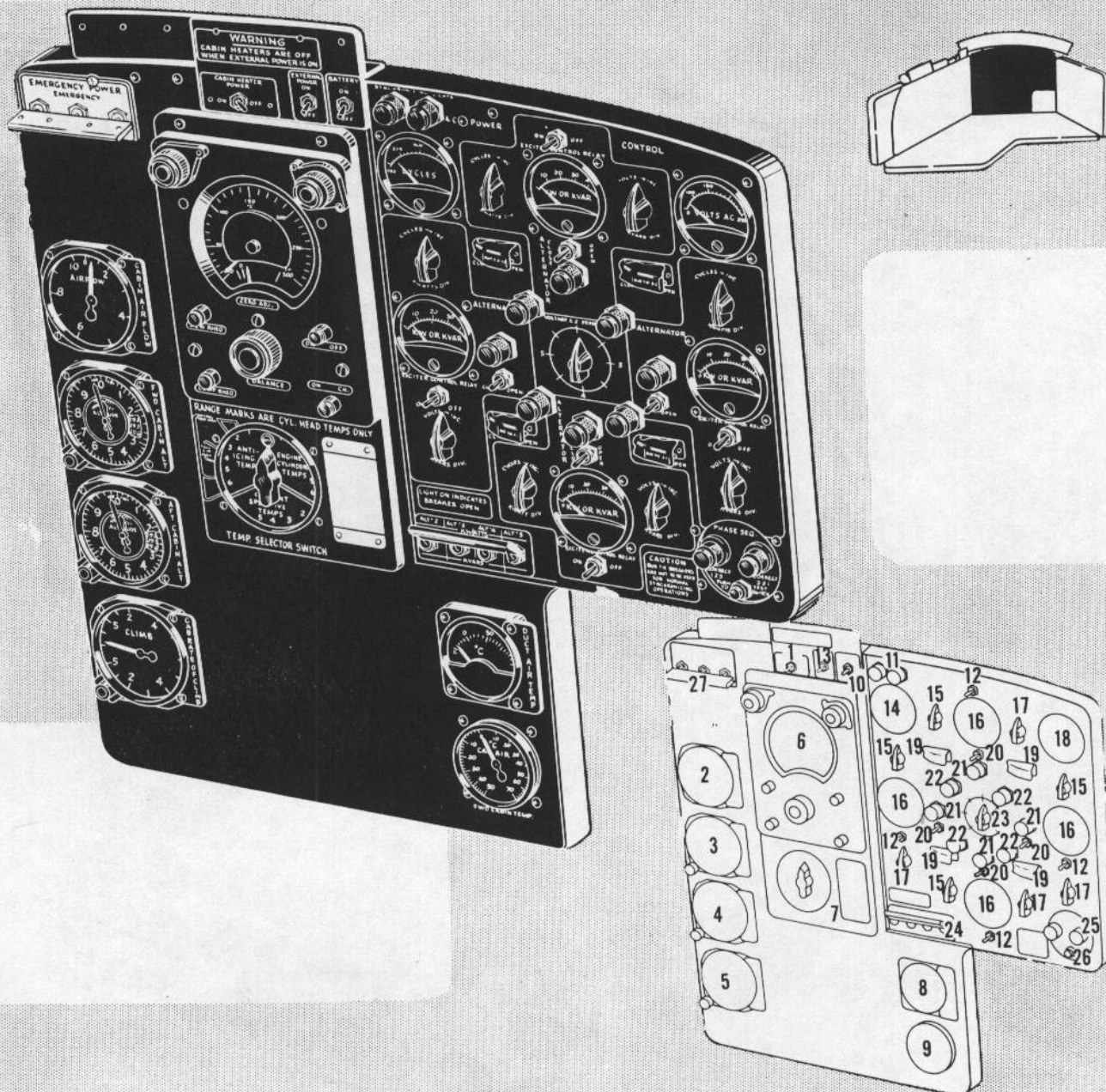
Figure 1-16. Engineer's Main Instrument Panel (Group 12 Airplanes)



- | | |
|---|---|
| 1. PROPELLER NORMAL PITCH INDICATOR LAMPS | 13. FUEL QUANTITY GAGE (BOMB BAY TANKS) |
| 2. CLOCK | 14. TORQUEMETER PRESSURE GAGE |
| 3. OIL QUANTITY GAGES | 15. OIL PRESSURE GAGE |
| 4. AIRSPEED INDICATOR | 16. FUEL QUANTITY GAGE (AUXILIARY WING TANKS) |
| 5. MASTER TACHOMETER | 17. MASTER TEMPERATURE SELECTOR SWITCH |
| 6. ENGINE TACHOMETER | 18. CARBURETOR AIR TEMPERATURE INDICATOR |
| 7. FUEL PRESSURE GAGE | 19. OIL TEMPERATURE INDICATOR |
| 8. OXYGEN FLOW INDICATOR | 20. ANALYZER INDICATOR SHIELD (STOWED) |
| 9. OXYGEN PRESSURE GAGE | 21. CONDITION SELECTOR SWITCH |
| 10. MASTER TEMPERATURE INDICATOR | 22. ENGINE ANALYZER POWER SWITCH |
| 11. MANIFOLD PRESSURE GAGE | 23. CYCLE SELECTOR SWITCH |
| 12. WATER PRESSURE GAGE | |

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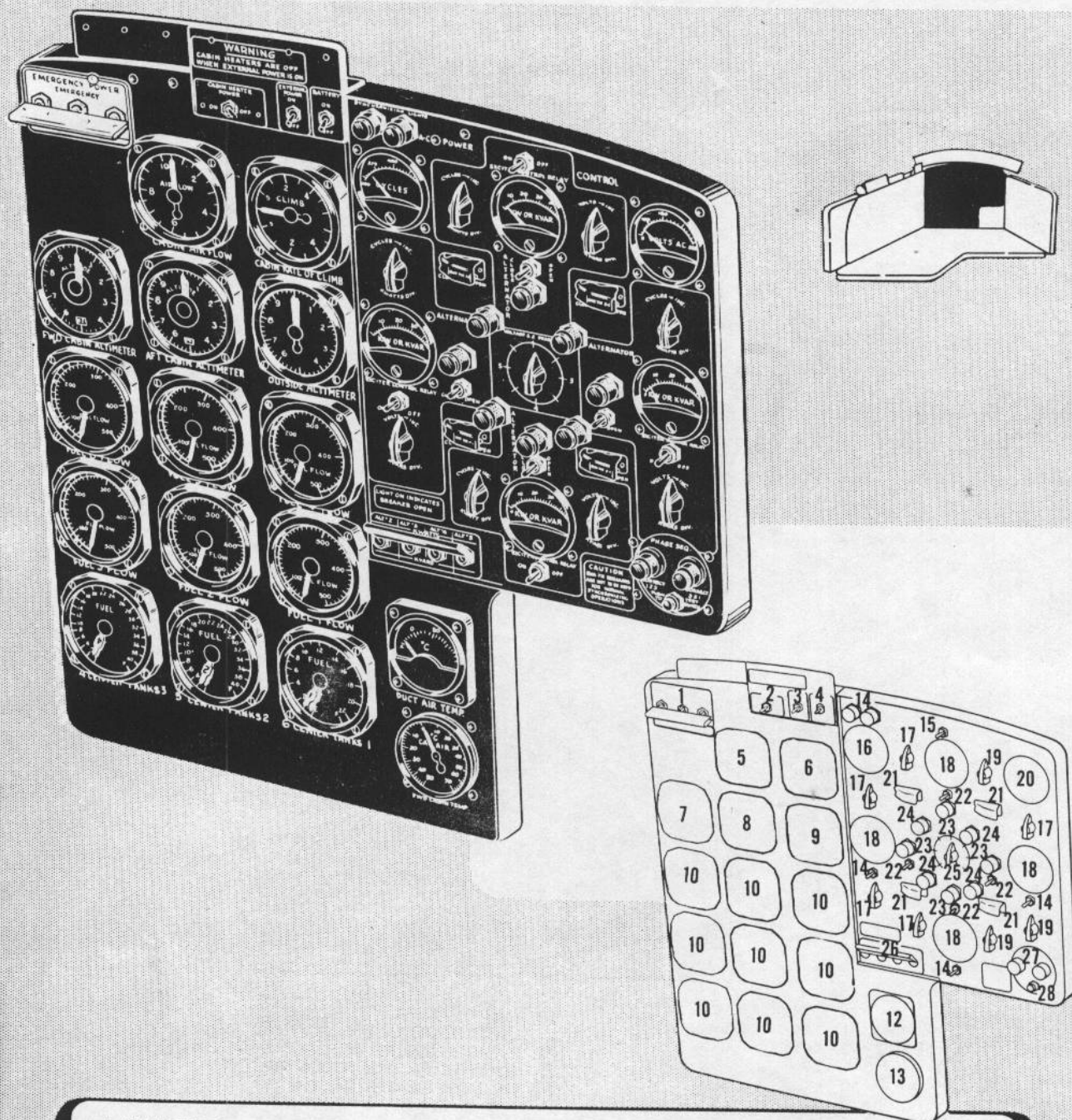
Figure 1-17. Engineer's Main Instrument Panel (Group 16 Airplanes)



- | | |
|---|---|
| 1. CABIN HEATER POWER SWITCH | 14. FREQUENCY METER |
| 2. CABIN AIRFLOW INDICATOR | 15. FREQUENCY CONTROL KNOB |
| 3. FORWARD CABIN ALTIMETER | 16. KILOWATT-KILOVAR METER |
| 4. AFT CABIN ALTIMETER | 17. VOLTAGE CONTROL KNOB |
| 5. CABIN RATE OF CLIMB INDICATOR | 18. VOLTMETER |
| 6. MASTER TEMPERATURE INDICATOR | 19. BUS TIE BREAKER CONTROL SWITCH |
| 7. MASTER TEMPERATURE SELECTOR SWITCH | 20. ALTERNATOR BREAKER CONTROL SWITCH |
| 8. DUCT AIR TEMPERATURE INDICATOR (FWD. CABIN PRESSURE) | 21. ALTERNATOR BREAKER INDICATOR LAMP |
| 9. FORWARD CABIN TEMPERATURE INDICATOR | 22. BUS TIE BREAKER INDICATOR LAMP |
| 10. BATTERY SWITCH | 23. VOLTAGE AND FREQUENCY SELECTOR SWITCH |
| 11. ALTERNATOR SYNCHRONIZING LAMPS | 24. KILOWATT-KILOVAR SELECTOR SWITCHES |
| 12. EXCITER CONTROL RELAY SWITCH | 25. PHASE SEQUENCE LAMPS |
| 13. EXTERNAL POWER SWITCH | 26. PHASE SEQUENCE LAMPS TEST SWITCH |
| | 27. EMERGENCY POWER SWITCH |

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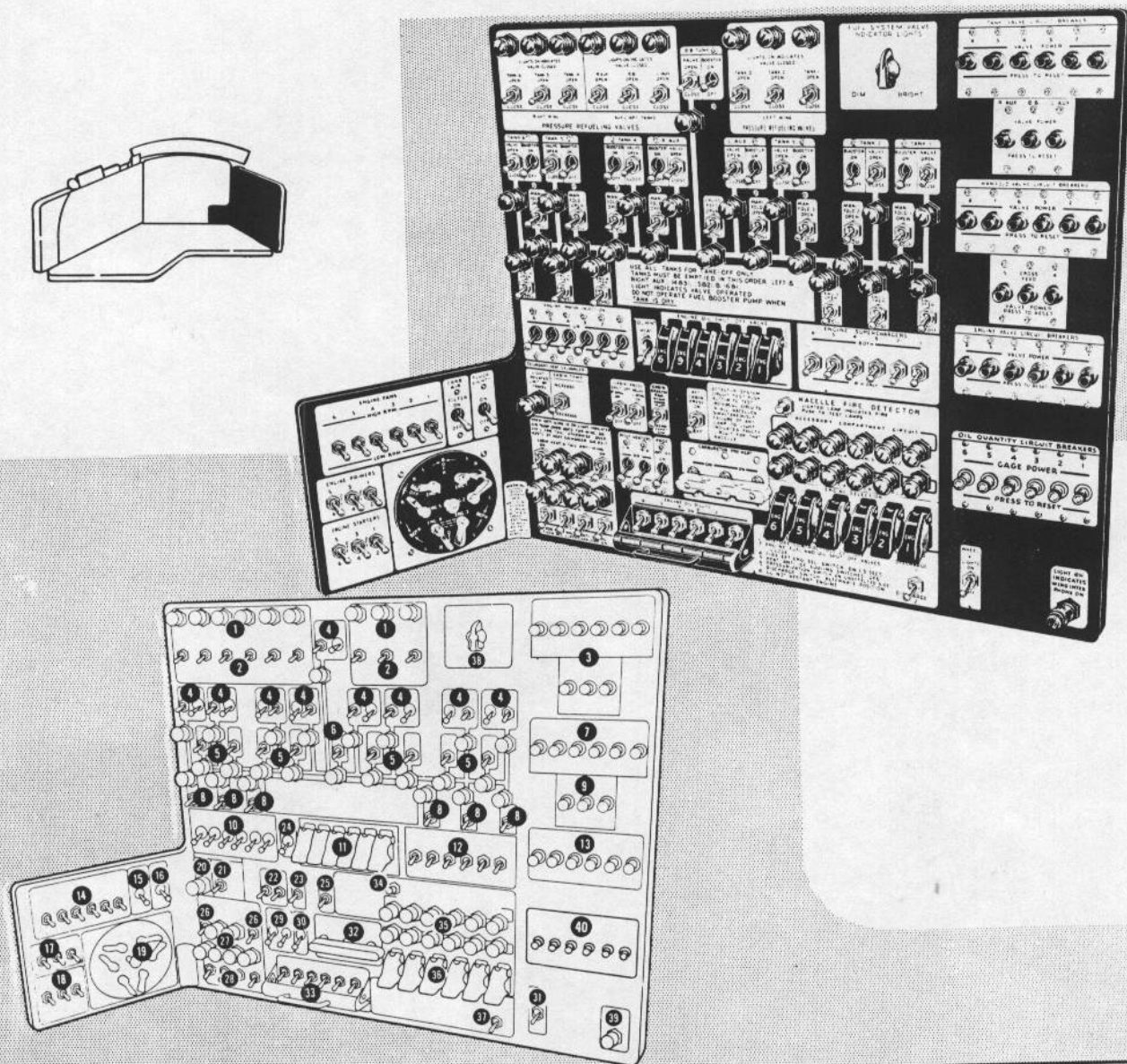
Figure 1-18. Engineer's Auxiliary Instrument Panel (Group 13 Airplanes)



- | | |
|---|--|
| 1. EMERGENCY POWER CONTROL | 15. EXCITER CONTROL RELAY SWITCH |
| 2. CABIN HEATER POWER SWITCH | 16. FREQUENCY METER |
| 3. EXTERNAL POWER SUPPLY SWITCH | 17. FREQUENCY CONTROL KNOB |
| 4. BATTERY SWITCH | 18. KILOWATT-KILOVAR METER |
| 5. CABIN AIRFLOW INDICATOR | 19. VOLTAGE CONTROL KNOB |
| 6. CABIN RATE OF CLIMB INDICATOR | 20. VOLTMETER |
| 7. FORWARD CABIN ALTIMETER | 21. BUS TIE BREAKER CONTROL SWITCH |
| 8. AFT CABIN ALTIMETER | 22. ALTERNATOR BREAKER SWITCH |
| 9. OUTSIDE ALTIMETER | 23. ALTERNATOR BREAKER INDICATOR LAMP |
| 10. FUEL FLOW INDICATOR | 24. BUS TIE BREAKER INDICATOR LAMP |
| 11. FUEL QUANTITY GAGE | 25. VOLTAGE AND FREQUENCY SELECTOR SWITCH |
| 12. DUCT AIR TEMPERATURE INDICATOR (FWD CABIN PRESSURE) | 26. KILOWATT-KILOVAR SELECTOR SWITCHES |
| 13. FORWARD CABIN TEMPERATURE INDICATOR | 27. PHASE SEQUENCE LAMPS |
| 14. ALTERNATOR SYNCHRONIZING LAMPS | 28. PHASE SEQUENCE LAMPS PUSH-TO-TEST SWITCH |

Figure 1-19. Engineer's Auxiliary Instrument Panel (Group 12 Airplanes)

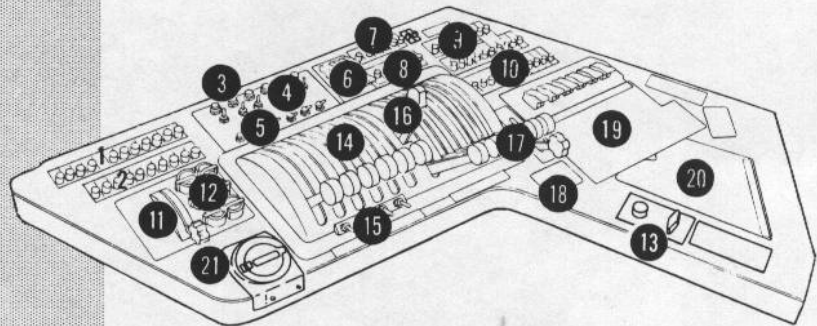
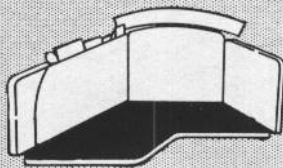
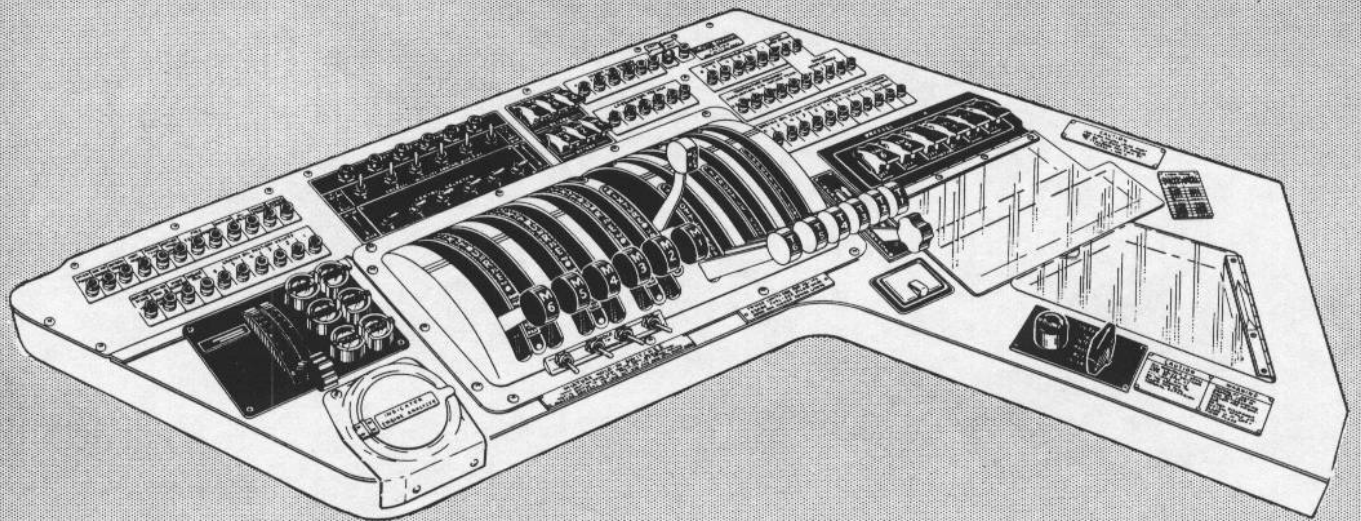
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1. PRESSURE REFUELING VALVE INDICATOR LAMPS
2. PRESSURE REFUELING VALVE SWITCHES
3. TANK VALVE CIRCUIT BREAKERS
4. TANK VALVE SWITCH
BOOSTER PUMP SWITCH
5. MANIFOLD VALVE SWITCH AND INDICATOR LAMPS
6. CROSS-FEED VALVE SWITCH
7. MANIFOLD VALVE CIRCUIT BREAKERS
8. ENGINE VALVE SWITCH
9. CROSS-FEED VALVE CIRCUIT BREAKERS
10. WATER INJECTION SWITCHES
11. OIL SHUT-OFF VALVE SWITCHES
12. ENGINE SUPERCHARGER SWITCHES
13. ENGINE VALVE CIRCUIT BREAKERS
14. FAN SPEED CONTROL SWITCHES
15. CARBURETOR AIR FILTER SWITCH
16. FLUORESCENT LIGHTS SWITCH
17. ENGINE PRIMER SWITCHES
18. ENGINE STARTER SWITCHES
19. MASTER AND INDIVIDUAL IGNITION SWITCHES
20. CABIN TEMPERATURE CONTROL VALVE INDICATOR LAMP
21. CABIN TEMPERATURE CONTROL SWITCH
22. CABIN PRESSURE SHUT-OFF VALVE SWITCHES
23. BOOSTER FAN CONTROL SWITCH
24. OIL VENT HEATER SWITCH
25. AFT CABIN PRESSURE SWITCH
26. CABIN HEAT AND TAIL ANTI-ICING SWITCHES
27. CABIN HEAT AND ANTI-ICING WARNING LAMPS
28. WING ANTI-ICE SWITCHES
29. PITOT HEATER SWITCHES
30. PROPELLER ANTI-ICE SWITCH
31. WHEEL LIGHTS SWITCH
32. CARBURETOR PREHEAT SWITCHES
33. OIL DILUTION SWITCHES
34. FIRE DETECTOR PUSH-TO-TEST SWITCH
35. FIRE WARNING LAMPS
36. FIRE EXTINGUISHER ENGINE SELECTOR SWITCHES
37. FIRE EXTINGUISHER DISCHARGE SELECTOR SWITCH
38. FUEL INDICATOR LAMPS DIM-BRIGHT KNOB
39. WING INTERPHONE INDICATOR LAMP
40. OIL QUANTITY CIRCUIT BREAKERS

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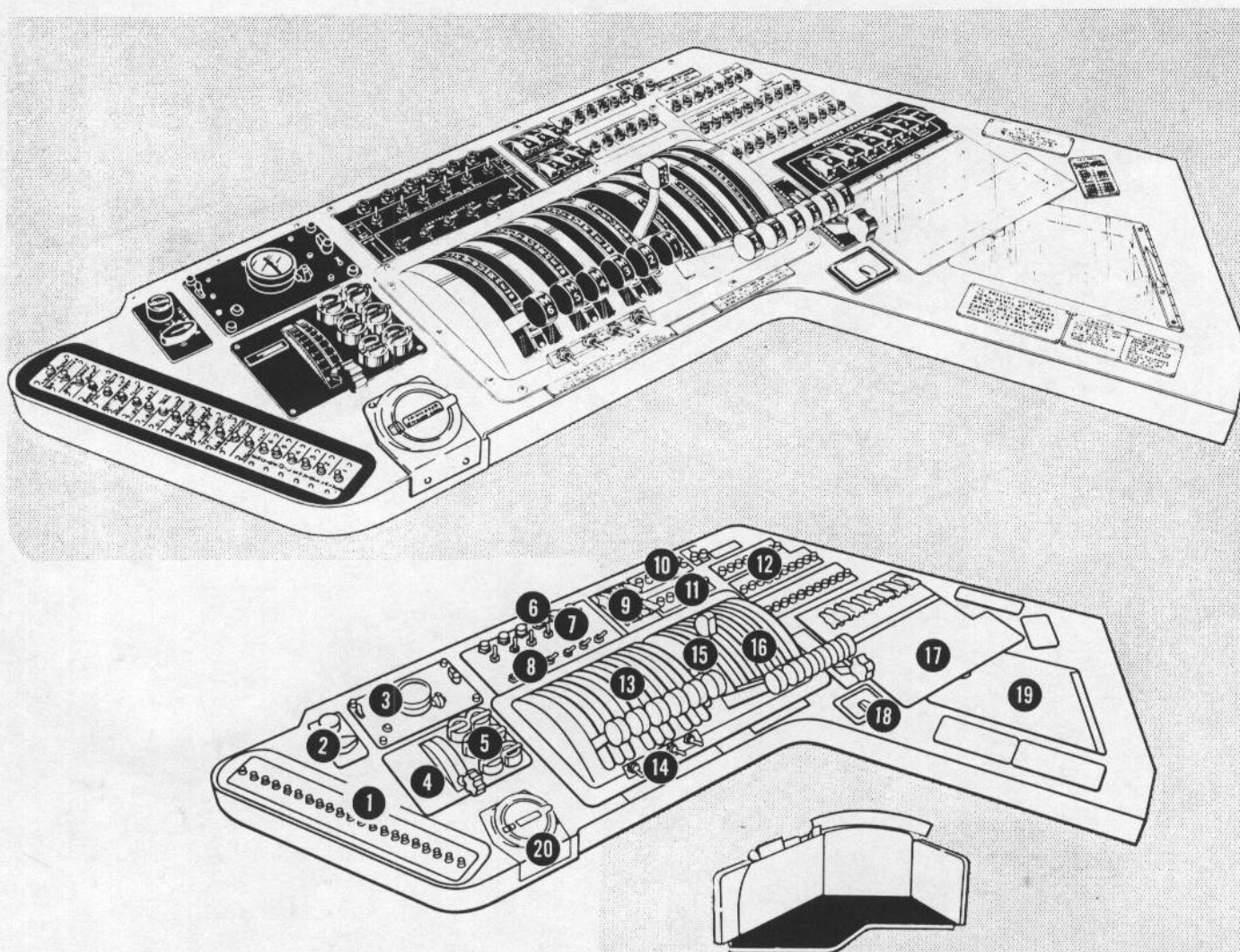
Figure 1-20. Engineer's Main Control Panel



- | | |
|---|--|
| <p>1. CIRCUIT BREAKERS
INTERPHONE
BUS TIE BREAKER CONTROL
EMERGENCY BRAKE PUMP
BOOSTER FAN
ENGINE TEMPERATURE INDICATOR
ANTI-ICE DUCT TEMPERATURE
FIRE EXTINGUISHER
FIRE DETECTOR
IGNITION
OIL DILUTION
ENGINE PRIMER
ENGINE STARTER</p> <p>2. CIRCUIT BREAKERS
WING ANTI-ICE
TAIL ANTI-ICE AND CABIN HEAT
WING SHUT-OFF VALVES
ENGINE FAN
ENGINE OIL SHUT-OFF VALVES (6)</p> <p>3. NORMAL MIXTURE INDICATOR LAMPS</p> <p>4. MIXTURE CONTROL OVERRIDE SWITCHES</p> <p>5. MIXTURE CONTROL SELECTOR SWITCHES</p> <p>6. MANUAL SPARK ADVANCE SWITCHES</p> <p>7. ENGINE FUEL MIXTURE CIRCUIT BREAKERS</p> | <p>8. CARBURETOR PREHEAT CIRCUIT BREAKERS</p> <p>9. CIRCUIT BREAKERS
CABIN DUCT TEMPERATURE
PROP PITCH INDICATOR
ENGINE SUPERCHARGER SELECTOR (6)
ENGINE SPARK ADVANCE (6)
CARBURETOR AIR TEMPERATURE INDICATOR (6)</p> <p>10. CIRCUIT BREAKERS
ENGINE OIL TEMPERATURE INDICATORS (6)
MAIN FUEL TANK LEVEL INDICATORS (3)
LEFT & RIGHT AUXILIARY WING TANK LEVEL INDICATORS
BOMB BAY FUEL TANK LEVEL INDICATOR</p> <p>11. TURBO BOOST SELECTOR LEVER</p> <p>12. TURBO CALIBRATION POTENTIOMETER KNOBS</p> <p>13. INTERPHONE CONTROL PANEL</p> <p>14. MIXTURE CONTROL LEVERS</p> <p>15. ALTERNATOR BREAKER HOLD-IN SWITCHES</p> <p>16. MIXTURE CONTROL LOCK LEVER</p> <p>17. THROTTLE LEVERS</p> <p>18. ASH RECEIVER</p> <p>19. PROPELLER CONTROL PANEL</p> <p>20. HYDRAULIC CONTROL PANEL</p> <p>21. ENGINE ANALYZER INDICATOR</p> |
|---|--|

CI-345K-C

Figure 1-21. Engineer's Table (Airplanes not in Group 14)



- | | |
|---|--|
| <p>1. CIRCUIT BREAKERS
INTERPHONE
BUS TIE BREAKER CONTROL
EMERGENCY BRAKE PUMP
BOOSTER FAN
ENGINE TEMPERATURE INDICATOR
ANTI-ICE DUCT TEMPERATURE
FIRE EXTINGUISHER
FIRE DETECTOR
OIL DILUTION
ENGINE PRIMER
ENGINE STARTER
WING ANTI-ICE
TAIL ANTI-ICE
WING SHUT-OFF VALVES
ENGINE FAN
ENGINE OIL SHUT-OFF VALVE (6)</p> <p>2. INTERPHONE CONTROL PANEL</p> <p>3. OXYGEN CONTROL PANEL</p> <p>4. TURBO BOOST SELECTOR LEVER</p> <p>5. TURBO CALIBRATION POTENTIOMETER KNOBS</p> <p>6. NORMAL MIXTURE INDICATOR LAMPS</p> | <p>7. MIXTURE CONTROL OVERRIDE SWITCHES</p> <p>8. MIXTURE CONTROL SELECTOR SWITCHES</p> <p>9. SPARK ADVANCE SWITCHES</p> <p>10. ENGINE FUEL MIXTURE CIRCUIT BREAKERS</p> <p>11. CARBURETOR PREHEAT CIRCUIT BREAKERS</p> <p>12. CIRCUIT BREAKERS
CABIN DUCT TEMPERATURE
PROP PITCH INDICATOR
ENGINE SUPERCHARGER SELECTOR (6)
ENGINE SPARK ADVANCE (6)
CARBURETOR AIR TEMPERATURE INDICATOR (6)
ENGINE OIL TEMPERATURE INDICATOR (6)
FUEL TANK LEVEL INDICATOR (5)</p> <p>13. MIXTURE CONTROL LEVERS</p> <p>14. ALTERNATOR BREAKER HOLD-IN SWITCHES</p> <p>15. MIXTURE CONTROL LOCK LEVER</p> <p>16. THROTTLE LEVERS</p> <p>17. PROPELLER CONTROL PANEL</p> <p>18. ASH RECEIVER</p> <p>19. HYDRAULIC CONTROL PANEL</p> <p>20. ENGINE ANALYZER INDICATOR</p> |
|---|--|

CI-345J-C

Figure 1-22. Engineer's Table (Group 14 Airplanes)

OIL SYSTEM INDICATORS.

Oil Temperature Gages.

Oil temperature gages (5, figure 1-15) are located on the engineer's main instrument panel and indicate, in centigrade, reciprocating engine oil temperatures.

Oil Pressure Gages.

Oil pressure gages (7, figure 1-15), located on the engineer's main instrument panel, indicate the nose oil pressure of the reciprocating engines.

Oil Quantity Gages.

There are six single-indicating oil quantity gages (20, figure 1-15 and 3, figure 1-16) located on the engineer's main instrument panel. The gages indicate oil quantity in US gallons.

OIL COOLING.

Oil cooling is completely automatic. Thermostatically controlled valves regulate the flow of oil and cooling air through the oil cooler to keep the temperature within the desired operating range. Two methods of routing the cooling air through the cooler are provided to insure proper operating temperatures in both ground and flight operations. On the ground, air is drawn through the oil cooler by the engine-driven fan. During flight ram air independent of the fan passes through the oil cooler. Two doors in the air inlet ducts control the routing of the oil cooling air. The door actuators operate on 115-volt alternating current and are energized through a switch actuated by the movement of the left main gear oleo strut during take-off and landing. (See figure 1-23.)

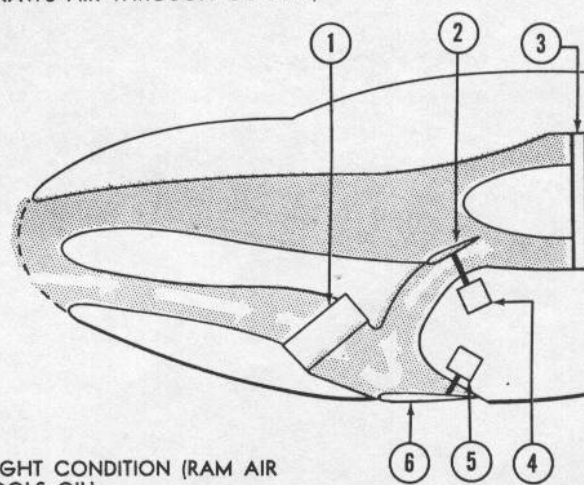
JET ENGINES.

In addition to the six reciprocating engines, the airplane is equipped with four General Electric J47-19 jet engines to provide extra power for take-off, climb, target area operation, and other instances where extra power is required.

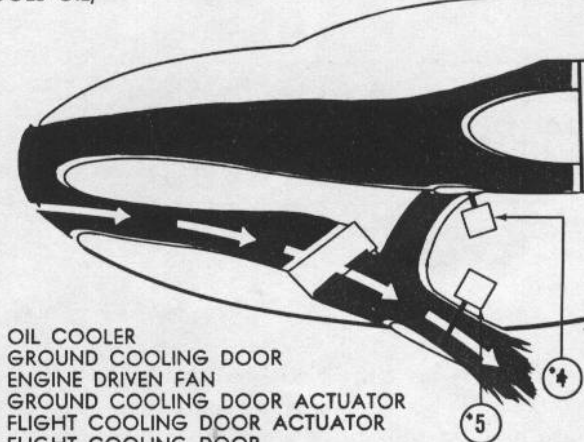
A pod nacelle containing two jet engines is suspended from each wing outer panel. Each engine is rated to deliver 5200 thrust pounds at sea level static conditions when operating at 100 per cent rpm with tail pipe temperature at 690°C.

The main components of the jet engine include an accessory section, a 12-stage axial flow compressor, eight can-type combustion chambers, and a single stage turbine. A tail cone and tail pipe serve to conduct the hot exhaust gases away from the engines. Fuel used is the same grade as that used by the reciprocating engines and is taken from the same system. Oil for each jet is supplied from an individual oil tank. The oil is of a different specification than that used by the reciprocating engines. See figure 1-52 for servicing information on the oil system. A

GROUND CONDITION (ENGINE FAN
DRAWS AIR THROUGH COOLER)



FLIGHT CONDITION (RAM AIR
COOLS OIL)



1. OIL COOLER
 2. GROUND COOLING DOOR
 3. ENGINE DRIVEN FAN
 4. GROUND COOLING DOOR ACTUATOR
 5. FLIGHT COOLING DOOR ACTUATOR
 6. FLIGHT COOLING DOOR
- *CONTROLLED BY THE THERMOSTAT IN THE OIL RETURN LINE AND THE LANDING GEAR SAFETY SWITCH.

■ FAN DRAWN AIR
■ RAM AIR

CI-188-C

Figure 1-23. Reciprocating Engine Oil Cooling

heating element is incorporated in each oil tank to heat the oil while the engines are not operating during flight.

All jet engine controls are grouped on an overhead panel which is located directly above the pilots' pedestal. Jet engine instruments are grouped below the pilots' main instrument panel on each side of the pedestal. Each jet is controlled by a throttle lever which acts through a fuel regulator mounted on the engine accessory section. The regulator controls a fuel control valve to meter the amount of fuel to the engine called for by the throttle lever after automatically compensating for engine rpm and air density.

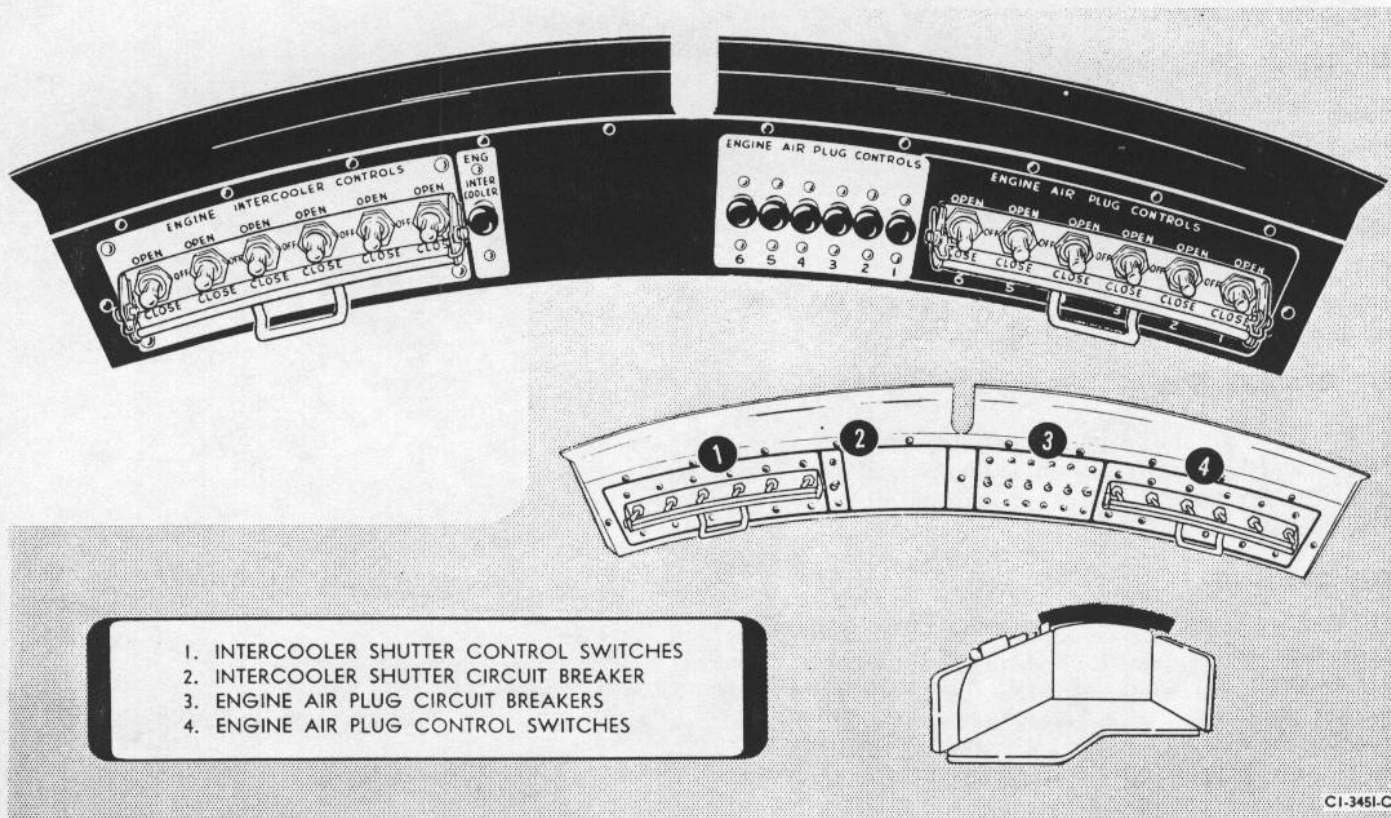


Figure 1-24. Engineer's Auxiliary Control Panel

The airplane can fly with or without the jets in operation, according to the conditions of flight. Jet air plugs are used to shut off the engine air flow when the engines are inoperative. When the air plug doors are fully closed, enough air will flow through to windmill the engines at approximately 5 per cent rpm. This low windmilling speed allows heated oil to circulate through the engines so the oil will not congeal at low temperatures. If additional heat is needed for the oil, heated anti-icing air can be taken from the wing anti-icing system and circulated around the oil lines and the oil cooler or the oil tank heaters may be turned on. A special ignition circuit which by-passes the starters is provided to start the jet engines in flight.

FUEL REGULATOR CONTROLS.

Throttle Control Levers.

Four throttle levers (1, figure 1-25) and a friction lock lever (2, figure 1-25) are located on the pilots' overhead jet control panel. The lock lever will lock the throttles in any desired position. The throttle lever positions are CLOSE, IDLE, and OPEN. Throttle control employs an electronic system similar to the reciprocating engine mixture control. Movement of a lever originates a 115-volt a-c signal which ultimately positions the fuel regulator and the stopcock of the corresponding engine. The stopcock acts as a fuel

shutoff valve when the throttle is closed and functions as a fuel metering valve for engine starting before the fuel regulator becomes effective. The initial movement of a lever also completes the related ignition circuit for ground starting.

Throttle Control Selector Switches.

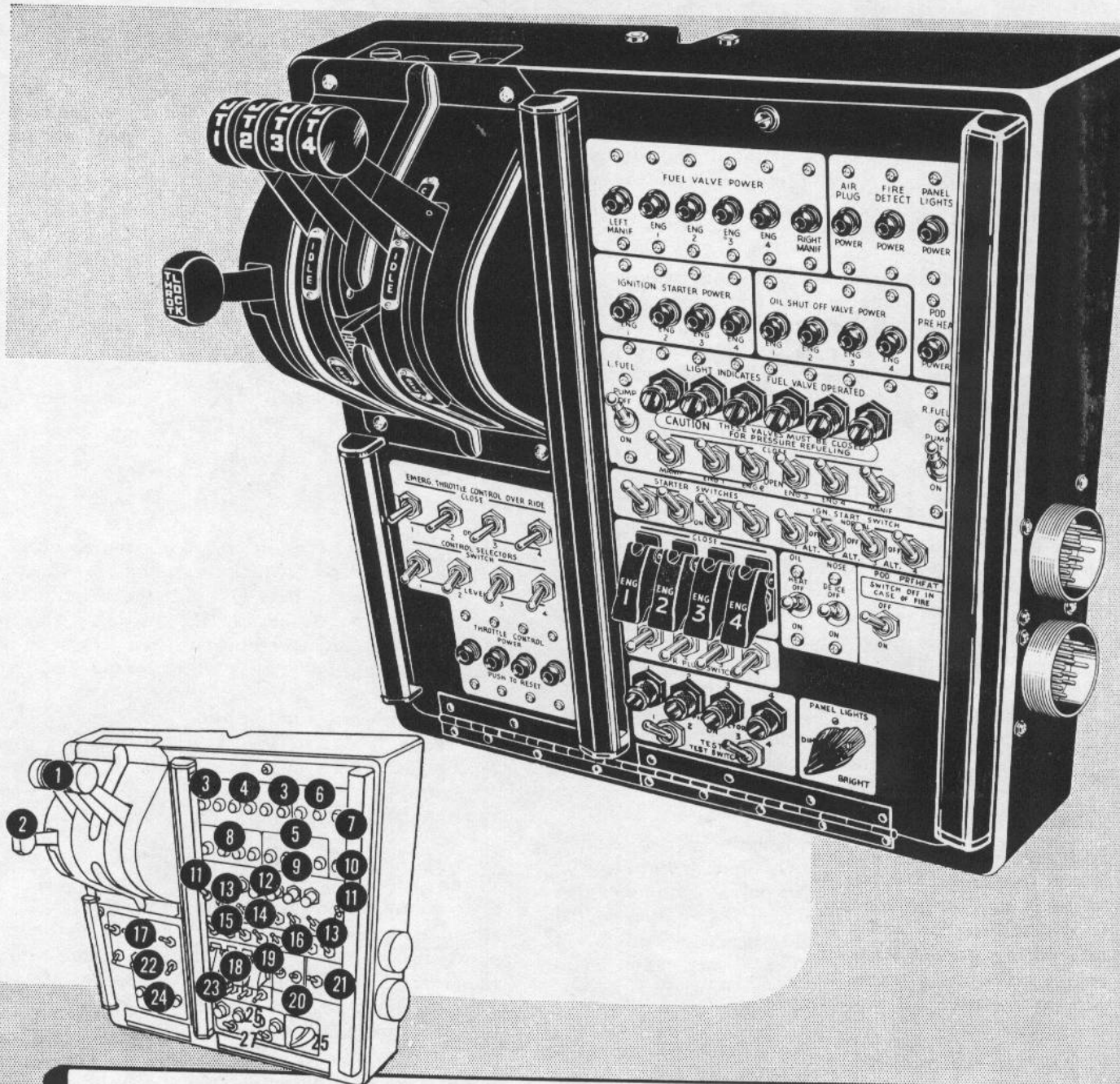
Four two-position switches (22, figure 1-25), located on the overhead control panel are used to select the type of throttle control desired. When the switches are in the LEVER position, the throttle levers provide throttle control. When the switches are placed in the SWITCH position, throttle control with a set of override switches is effective.

Emergency Throttle Control Override Switches.

Four three-position switches (17, figure 1-25), located on the overhead control panel, are provided in the event the electronic throttle controls become inoperative. The switches are connected directly to actuators on the engines by electrical circuits and have spring-loaded OPEN and CLOSE positions and a neutral OFF position. Intermediate settings of the fuel regulator can be obtained by jiggling the override switches.



Throttle control is very sensitive when using the emergency throttle override switches.



- | | |
|---|--|
| 1. THROTTLE LEVERS | 15. ENGINE STARTER SWITCHES |
| 2. THROTTLE LOCK LEVER | 16. IGNITION SWITCHES |
| 3. MANIFOLD FUEL VALVE CIRCUIT BREAKERS | 17. THROTTLE CONTROL OVERRIDE SWITCHES |
| 4. ENGINE FUEL VALVE CIRCUIT BREAKERS | 18. OIL SHUT-OFF VALVE SWITCHES |
| 5. AIR PLUG CIRCUIT BREAKER | 19. OIL HEATER SWITCH |
| 6. FIRE DETECTION CIRCUIT BREAKER | 20. NOSE DE-ICE CONTROL SWITCH |
| 7. CONTROL PANEL LIGHTS CIRCUIT BREAKER | 21. POD PREHEAT CONTROL SWITCH |
| 8. IGNITION CIRCUIT BREAKERS | 22. THROTTLE CONTROL SELECTOR SWITCHES |
| 9. OIL SHUT OFF VALVE CIRCUIT BREAKERS | 23. AIR PLUG CONTROL SWITCHES |
| 10. POD PREHEAT CIRCUIT BREAKER | 24. THROTTLE CONTROL CIRCUIT BREAKERS |
| 11. BOOSTER PUMP SWITCHES | 25. PANEL LIGHTS CONTROL SWITCH |
| 12. FUEL VALVE INDICATOR LAMPS | 26. FIRE WARNING LAMPS |
| 13. MANIFOLD VALVE SWITCHES | 27. FIRE DETECTION SWITCHES |
| 14. ENGINE VALVE SWITCHES | |

Figure 1-25. Jet Engine Control Panel

3-1021-R4

AIR INTAKE CONTROL.

The air intake of each jet engine is controlled by eight leaf-type doors (plugs) which are operated by an actuator mounted in the nose cone. During jet engine operation the plugs must always be open. When the jets are shut down, the plugs should be closed to prevent excessive windmilling, minimize drag, and keep foreign objects from entering the air intake.

Note

When the plugs are fully closed, the engine will windmill at approximately 5 per cent rpm to maintain oil circulation. If low temperatures cause a drop in windmilling rpm, the doors can be opened enough to attain the desired rpm.

Air Plug Control Switches.

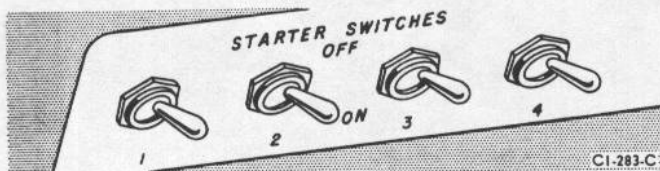
Four three-position switches (23, figure 1-25), located on the pilots' overhead jet control panel, provide control for the electrically operated engine air plugs. The switches have full-on positions marked OPEN and CLOSE and a neutral OFF position. The switches receive 28-volt direct current from a single circuit breaker to close relays which supply 115-volt a-c power to the air plug actuators. In the event of a short in one air plug control circuit, placing the switch of the defective circuit in neutral and resetting the circuit breaker will allow continued operation of the other three circuits. The neutral OFF position can also be used for intermediate positioning of the air plugs.

STARTING SYSTEM.

Each jet engine is equipped with an a-c starting system containing a starter switch and a starter. The starter is used for ground starts only, as the jet engine is windmilled for aerial starts. After the engine fires during ground starts, the starter is used to aid engine acceleration up to 20 to 25 per cent rpm to prevent excessive tail pipe temperatures and possible compressor stall.

Engine Starter Switches.

Four spring-loaded switches (15, figure 1-25), located on the overhead control panel, are provided for ground starting only. When the switches are held ON,



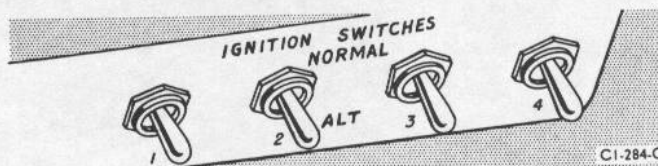
28-volt direct current closes relays to supply 200-volt a-c power to the starters. Closing the switches also sets up the ignition circuits. When the switches are released, the starters are de-energized and the ignition is cut off.

IGNITION SYSTEM.

Ignition start switches supply electrical energy to ignition electrodes which are mounted in combustion chambers No. 3 and 7 of each jet engine. Complete combustion is carried out by flame propagation through the crossfire tubes. Ignition is used only for starting as combustion in the chambers is self-sustaining once it has been started, except when flame-out conditions occur.

Ignition Start Switches.

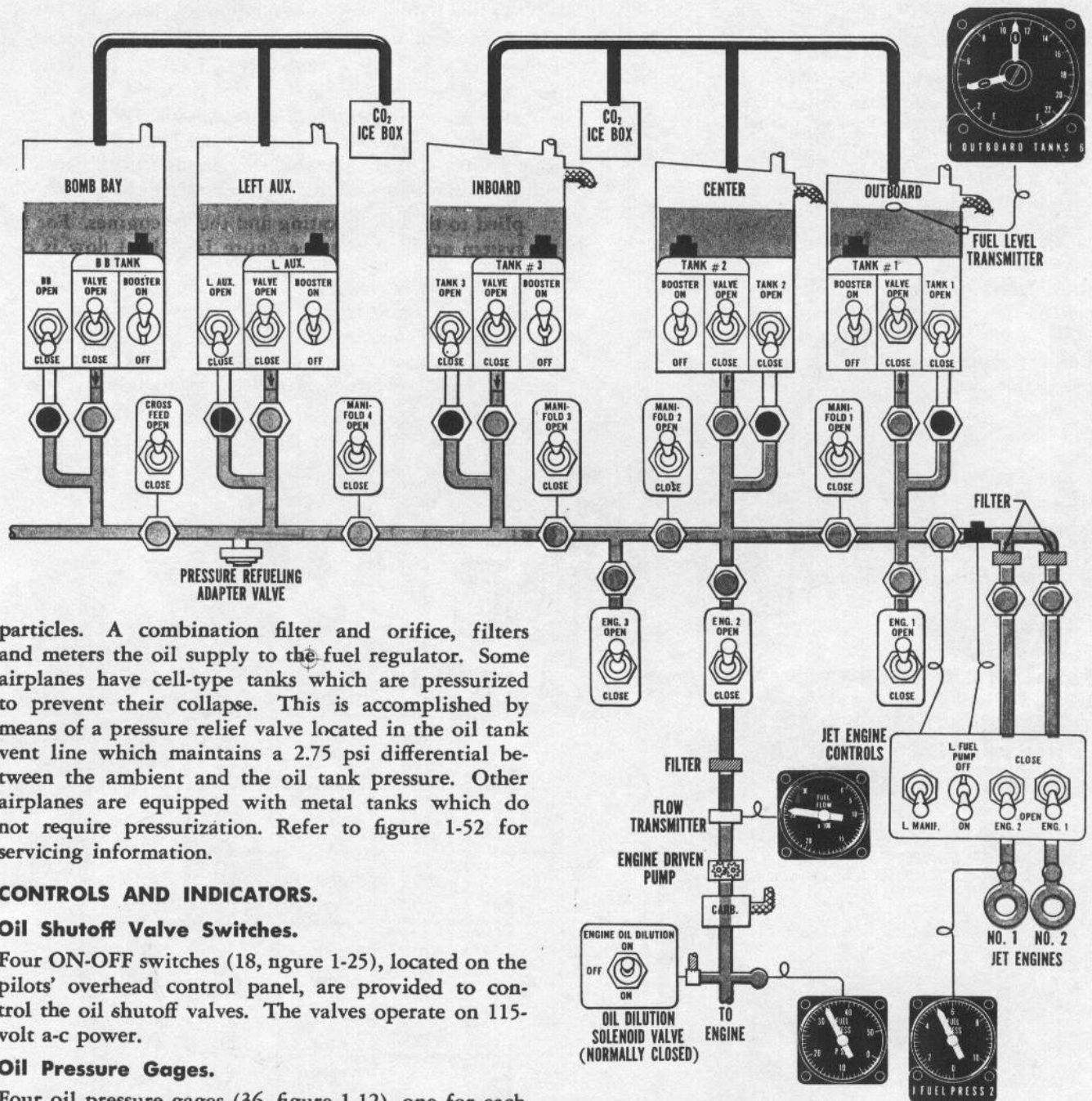
Four three-position switches (16, figure 1-25), located on the overhead control panel, are provided for starting the engines during flight. Each switch has a neutral OFF position, a NORMAL position, and a



spring-loaded ALT position. With the switches in the NORMAL position, ignition occurs when the starter switches are held ON and the throttle levers are advanced from the CLOSE position. This prevents flooding the combustion chambers with raw fuel before ignition occurs which would result in a hot start. For aerial starts where the starter is not used because sufficient windmilling rpm is available, the switches are held in the ALT position and supply a-c current directly to the electrodes.

JET ENGINE OIL SYSTEM.

Each jet engine has an independent oil system consisting principally of a 20-gallon supply tank, lines, pressure and scavenge pumps, a filter, an oil cooler, and an oil tank heater. The tanks, installed in the wing above the jets, will hold 13 gallons of oil with the remaining 7-gallon space reserved for oil foaming. The oil flows from the tank to a gear-driven combination pressure and scavenge pump mounted on the accessory section and is pumped to the lubrication points and to the fuel regulator. A filter mounted on the compressor case filters the oil passing through the line from the pressure pump to the aft bearings. A scavenge pump in the mid-frame returns the oil in the aft section through the cooler to the tank. The cooler is mounted on the compressor casing and uses fuel as a cooling medium. The oil cooling is fully automatic with a thermostatically controlled by-pass and relief valve regulating the flow of oil through the cooler. Lubricating oil pumped to the forward section of the engine is scavenged and returned to the supply tank by the scavenge side of the combination pressure and scavenge pump. This oil is not cooled, as temperatures are not high in the section it lubricates. Strainers within the accessory section gear case clean the oil of any large foreign



particles. A combination filter and orifice, filters and meters the oil supply to the fuel regulator. Some airplanes have cell-type tanks which are pressurized to prevent their collapse. This is accomplished by means of a pressure relief valve located in the oil tank vent line which maintains a 2.75 psi differential between the ambient and the oil tank pressure. Other airplanes are equipped with metal tanks which do not require pressurization. Refer to figure 1-52 for servicing information.

CONTROLS AND INDICATORS.

Oil Shutoff Valve Switches.

Four ON-OFF switches (18, figure 1-25), located on the pilots' overhead control panel, are provided to control the oil shutoff valves. The valves operate on 115-volt a-c power.

Oil Pressure Gages.

Four oil pressure gages (36, figure 1-12), one for each jet engine, are located on the pilot's jet instrument panel.

FUEL SYSTEM.

Fuel is supplied to the reciprocating and the jet engines from six main wing tanks and two auxiliary wing tanks. An additional tank can be installed in bomb bay No. 3. The main wing tanks are formed by compartments between the front and rear spars inboard of each reciprocating engine nacelle. Bullet sealing panels are attached to the forward, aft, bottom, and side surfaces of the two outboard tanks in each wing. The auxiliary wing tanks are formed by a compart-

Figure 1-26. Fuel System Schematic

ment on each side of the fuselage center line between the front and rear spars. Each auxiliary wing tank compartment contains four interconnected bladder-type cells which are nonself-sealing and are made of rubber impregnated nylon fabric. The bomb bay tank is self-sealing and is equipped with quick disconnect fittings so it can be dropped in flight. It is supported within the bomb bay by bomb shackles. The capacity of each tank is given in figure 1-27.

Note

The capacity of each auxiliary wing tank varies from airplane to airplane because of small differences in the size of the bladder-type cells. For the sake of uniformity all auxiliary wing tanks are rated at 4788.5 gallons usable fuel.

All tanks are interconnected, making it possible to supply fuel from any combination of tanks to any combination of engines. Each fuel tank has an inlet and outlet line with a fuel valve in each. The inlet line is a provision for single point pressure refueling which is accomplished from a special adapter valve in the bomb bay. The outlet line connects the tanks to the main manifold fuel line which interconnects all of the wing fuel tanks. From this main manifold, fuel is supplied to the reciprocating and the jet engines. For fuel system arrangement, see figure 1-26. Fuel flow is controlled by tank, manifold, cross-feed, and engine fuel valves. Normally these valves are electrically operated by 28-volt direct current. With the exception of the manifold and engine valves for the jet engines, the valves can be positioned manually for emergency operation. Fuel pressure is provided by an engine-driven

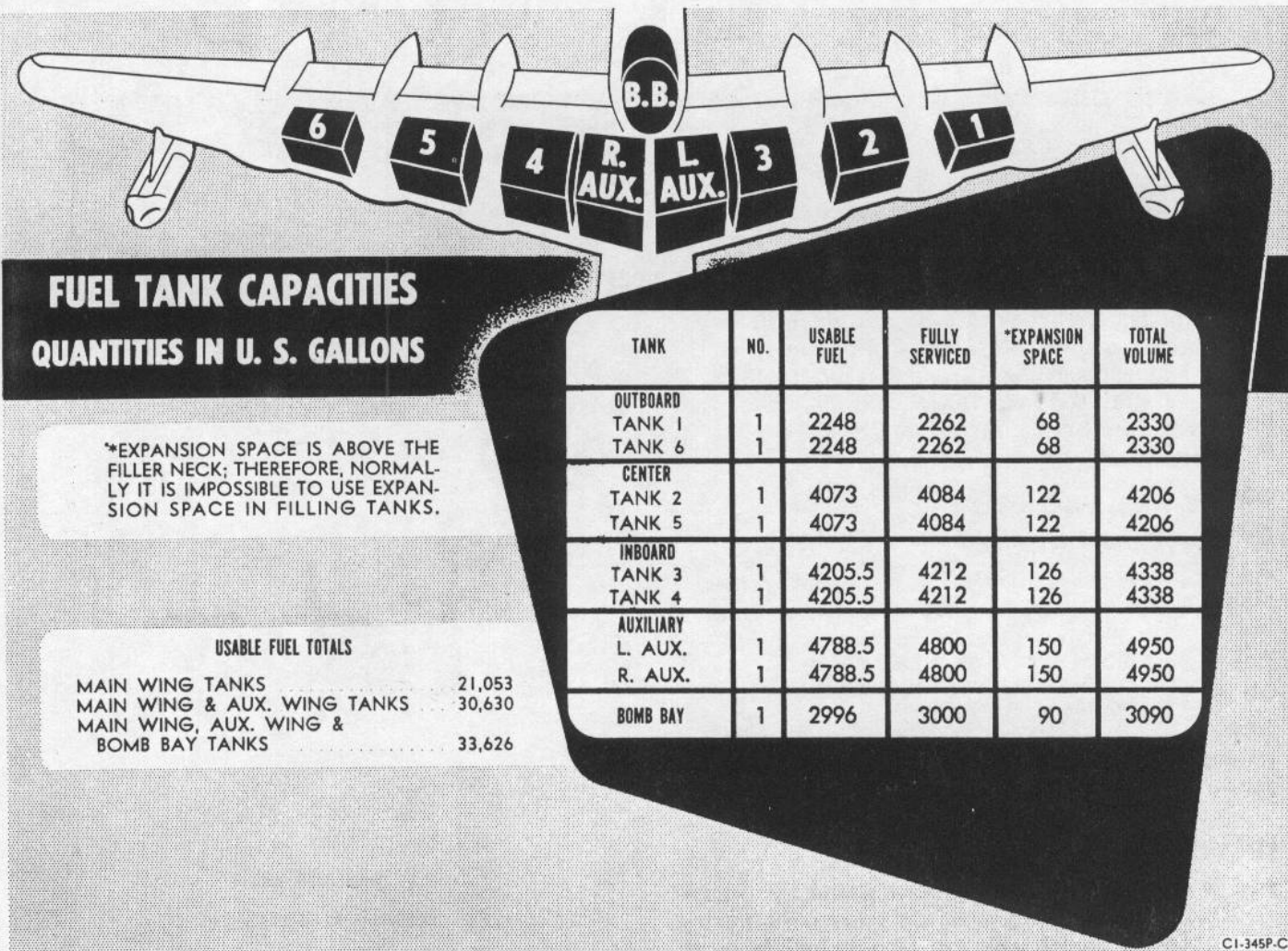


Figure 1-27. Fuel Tank Capacities

pump on each engine and a booster pump in each tank. An additional booster pump is installed in the fuel line leading to each pair of jet engines. The booster pumps operate on 208-volts alternating current. For fuel system management, refer to Section VII.

Fuel conforming to Specification No. MIL-F-5572 (AN-F-48), grade 115/145, is used. Grade 100/130 may be used as an alternate fuel.

CAUTION

When an alternate fuel is used, engine limitations differ from those established for the recommended fuel grade. Refer to Section V for all operating limits.

For additional fuel servicing information, see figure 1-52.

FUEL SYSTEM CONTROLS.

Tank Valve Switches.

Each tank valve is provided with a control switch (4, figure 1-20) located on the main control panel at the flight engineer's station. The switches have positions marked OPEN and CLOSE, and are used to control fuel flow from the tanks.

Engine Valve Switches.

Six reciprocating engine valve switches (8, figure 1-20) are located on the main control panel. Four jet engine valve switches (14, figure 1-25) are located on the pilots' overhead control panel. Each switch operates an engine valve to control the flow of fuel to its corresponding engine. Each of these switches has an OPEN and CLOSE position.

Manifold Valve Switches.

Eight manifold valve switches (5, figure 1-20) are located on the main control panel and each switch controls a manifold valve. These manifold valves control fuel flow through the main manifold line. Two additional switches (13, figure 1-25) are located on the pilots' overhead control panel. Each of these switches operates a valve which controls the flow to each pair of jet engines. All manifold valve switches are marked OPEN and CLOSE.

Cross-Feed Valve Switch.

One cross-feed valve switch (6, figure 1-20) is located on the engineer's main control panel. The switch is marked OPEN and CLOSE, and is used to operate the cross-feed valve which controls fuel flow from one wing system to the other.

Booster Pump Switches.

Nine booster pump switches (4, figure 1-20) are located on the engineer's main control panel. Each

switch controls a fuel tank booster pump. Two additional switches (11, figure 1-25), located on the pilots' overhead control panel, operate the booster pumps for the jet engines. The booster pump switch positions are ON and OFF.

Fuel Indicator Lamps Dim-Bright Knob.

This rheostat knob (38, figure 1-20), located on the engineer's main control panel, controls the brilliance of the fuel valve indicator lamps on the fuel control panel except those for the pressure refueling valves.

FUEL INDICATORS.

Fuel Flow Indicators.

Six fuel flow indicators (10, figure 1-19) are located on the flight engineer's auxiliary instrument panel of group 12 airplanes. Each indicator is electrically connected to its respective flowmeter transmitter, which is located in the fuel line upstream from the engine-driven pump on each reciprocating engine. The indicators register fuel flow in gallons and pounds per hour. Six fuel flow indicators (12, figure 1-15) for the reciprocating engines are located on the engineer's main instrument panel of group 13 airplanes and indicate fuel flow in pounds per hour. There are no indicators to register fuel flow to the jet engines.

Fuel Pressure Gages.

Three dual indicating fuel pressure gages (7, figure 1-16) for the reciprocating engines are located on the engineer's main instrument panel of group 12 airplanes. Six single indicating fuel pressure gages, (13, figure 1-15) for the reciprocating engines are located on the engineer's main instrument panel of group 13 airplanes. Four gages (37, figure 1-12) for the jet engines are mounted on the pilot's jet instrument panel.

Fuel Quantity Gages.

For group 12 airplanes, three dual indicating fuel quantity gages (11, figure 1-19) for the main wing tanks are located on the flight engineer's auxiliary instrument panel and a dual indicating gage (15, figure 1-16) for the auxiliary wing tanks is located on the flight engineer's main instrument panel. A single indicating instrument (12, figure 1-16) for the bomb bay tank is also located on the flight engineer's main instrument panel. For group 13 airplanes, three dual indicating fuel quantity gages (16, figure 1-15) for the main wing tanks and a dual indicating gage for the auxiliary wing tanks are located on the flight engineer's main instrument panel. A single indicating gage (18, figure 1-15) for the bomb bay tank is located on the flight engineer's main instrument panel.

Fuel Valve Indicator Lamps.

Fuel valve indicator lamps (5, figure 1-20 and 12, figure 1-25) are located on the engineer's main control panel and the pilots' overhead jet control panel.

pump on each engine and a booster pump in each tank. An additional booster pump is installed in the fuel line leading to each pair of jet engines. The booster pumps operate on 208-volts alternating current. For fuel system management, refer to Section VII.

Fuel conforming to Specification No. MIL-F-5572 (AN-F-48), grade 115/145, is used. Grade 100/130 may be used as an alternate fuel.

CAUTION

When an alternate fuel is used, engine limitations differ from those established for the recommended fuel grade. Refer to Section V for all operating limits.

For additional fuel servicing information, see figure 1-52.

FUEL SYSTEM CONTROLS.

Tank Valve Switches.

Each tank valve is provided with a control switch (4, figure 1-20) located on the main control panel at the flight engineer's station. The switches have positions marked OPEN and CLOSE, and are used to control fuel flow from the tanks.

Engine Valve Switches.

Six reciprocating engine valve switches (8, figure 1-20) are located on the main control panel. Four jet engine valve switches (14, figure 1-25) are located on the pilots' overhead control panel. Each switch operates an engine valve to control the flow of fuel to its corresponding engine. Each of these switches has an OPEN and CLOSE position.

Manifold Valve Switches.

Eight manifold valve switches (5, figure 1-20) are located on the main control panel and each switch controls a manifold valve. These manifold valves control fuel flow through the main manifold line. Two additional switches (13, figure 1-25) are located on the pilots' overhead control panel. Each of these switches operates a valve which controls the flow to each pair of jet engines. All manifold valve switches are marked OPEN and CLOSE.

Cross-Feed Valve Switch.

One cross-feed valve switch (6, figure 1-20) is located on the engineer's main control panel. The switch is marked OPEN and CLOSE, and is used to operate the cross-feed valve which controls fuel flow from one wing system to the other.

Booster Pump Switches.

Nine booster pump switches (4, figure 1-20) are located on the engineer's main control panel. Each

switch controls a fuel tank booster pump. Two additional switches (11, figure 1-25), located on the pilots' overhead control panel, operate the booster pumps for the jet engines. The booster pump switch positions are ON and OFF.

Fuel Indicator Lamps Dim-Bright Knob.

This rheostat knob (38, figure 1-20), located on the engineer's main control panel, controls the brilliance of the fuel valve indicator lamps on the fuel control panel except those for the pressure refueling valves.

FUEL INDICATORS.

Fuel Flow Indicators.

Six fuel flow indicators (10, figure 1-19) are located on the flight engineer's auxiliary instrument panel of group 12 airplanes. Each indicator is electrically connected to its respective flowmeter transmitter, which is located in the fuel line upstream from the engine-driven pump on each reciprocating engine. The indicators register fuel flow in gallons and pounds per hour. Six fuel flow indicators (12, figure 1-15) for the reciprocating engines are located on the engineer's main instrument panel of group 13 airplanes and indicate fuel flow in pounds per hour. There are no indicators to register fuel flow to the jet engines.

Fuel Pressure Gages.

Three dual indicating fuel pressure gages (7, figure 1-16) for the reciprocating engines are located on the engineer's main instrument panel of group 12 airplanes. Six single indicating fuel pressure gages, (13, figure 1-15) for the reciprocating engines are located on the engineer's main instrument panel of group 13 airplanes. Four gages (37, figure 1-12) for the jet engines are mounted on the pilot's jet instrument panel.

Fuel Quantity Gages.

For group 12 airplanes, three dual indicating fuel quantity gages (11, figure 1-19) for the main wing tanks are located on the flight engineer's auxiliary instrument panel and a dual indicating gage (15, figure 1-16) for the auxiliary wing tanks is located on the flight engineer's main instrument panel. A single indicating instrument (12, figure 1-16) for the bomb bay tank is also located on the flight engineer's main instrument panel. For group 13 airplanes, three dual indicating fuel quantity gages (16, figure 1-15) for the main wing tanks and a dual indicating gage for the auxiliary wing tanks are located on the flight engineer's main instrument panel. A single indicating gage (18, figure 1-15) for the bomb bay tank is located on the flight engineer's main instrument panel.

Fuel Valve Indicator Lamps.

Fuel valve indicator lamps (5, figure 1-20 and 12, figure 1-25) are located on the engineer's main control panel and the pilots' overhead jet control panel.



Figure 1-28. Alternating Current Power Distribution

the power distribution system. A multicircuit feeder will provide continued service after one of its conductors has been broken, causing an open circuit. To furnish the necessary protection against faults or shorts occurring on a feeder section, fuses are located on each end of the conductors. Should a conductor break and the two loose ends cause a short circuit, the fuses at each end will clear, isolating the fault and permitting continued operation of the feeder section through the remaining conductors. Any one of the four alternators will supply sufficient electrical power for routine operations provided all auxiliary cabin heaters are turned off.

EXTERNAL POWER SOURCE.

When the airplane is on the ground, electric power is obtained from a B-10 portable power cart on which is mounted an alternator driven by a gasoline engine. During normal operation the cart is connected to the airplane through a six-prong external power receptacle located on the under side of the fuselage below the wing. The power cart supplies 200-volt, 3-phase, 400-cycle, alternating current, part of which energizes the airplane's transformer-rectifier units and furnishes 28-volt direct current. When the portable power cart is connected to the airplane, it is imperative that the 3-phase power supplied has the same phase sequence as the alternators installed in the airplane. The direction of rotation of a 3-phase electric motor is entirely dependent on the phase sequence of its power supply. If two of the three power lines to a motor are interchanged, resulting in reversed phase sequence, the direction of motor rotation reverses. Therefore, if the power leads from the cart are interchanged so that the phase sequence of the power output is incorrect, motors on the airplane will run in the wrong direction when energized from the portable power cart. To prevent this error, indicator lamps for determining phase sequence are provided.



Fuel booster pump motors will be damaged when operated in reverse.

External Power Supply Switch.

This two-position ON-OFF switch (13, figure 1-18), when placed in the ON position, completes the circuit from the portable power cart to the airplane's electrical system. At the same time it breaks the circuits to all cabin heaters and to the electric hot plates on the galley unit. The switch is located on the engineer's auxiliary instrument panel.

Phase Sequence Lamp Test Switch.

A push-to-test switch (26, figure 1-18) is located adjacent to the phase sequence lamps to test their operation.

Phase Sequence Lamps.

Two lamps (25, figure 1-18), are provided on the engineer's auxiliary instrument panel to indicate phase sequence. If the phase sequence of the cart is correct, the lamp marked CORRECT 1, 2, 3 will light. If the phase sequence is incorrect, the lamp marked INCORRECT 3, 2, 1 will light.

Note

If both lamps light, the indication of the brightest lamp should be followed.

ALTERNATING-CURRENT SYSTEM.

The a-c power supply consists of four 40-kva, 208/115-volt, 3-phase, neutral grounded, 400-cycle alternators. One alternator each is installed on engines No. 2, 3, 4, and 5. Each alternator feeds into the main power panels in the fuselage, from where the power is distributed to the various electrical loads in the airplane.

In the event of complete loss of a-c power, the reciprocating engine instruments will react as follows:

1. The fuel, oil, water, and manifold pressure gages, the fuel flow indicators; and the torque meters will fail but will remain in the approximate positions they were in when the failure took place.
2. The master temperature indicator and engine tachometers will continue to operate.
3. The oil quantity gages will fail and return to zero.
4. The fuel quantity gages will fail going either up or down.
5. The carburetor air, and oil temperature gages will continue to operate on battery power if required. The master tachometer will operate when the master motor is in use.

Alternator Controls and Indicators.

Power output of any alternator is possible only when the alternator field is excited by d-c current supplied by a generator built into the alternator. This d-c flow is controlled by a three-position, spring-loaded, on-off exciter control relay switch (12, figure 1-18). Voltage output of the alternator is controlled by regulating the voltage of the exciter field. The real load output is measured in kilowatts. The real load output is accompanied by a reactive current during inductive load output; this reactive current is measured in kilovars.

One of the most important devices in the a-c power supply system is the unit used to drive the alternator at a constant speed throughout the range of various engine speeds. Alternator frequency varies with alternator speed; therefore, in order to generate a constant frequency, which is necessary for correct operation of much of the electrical equipment as well as being a prerequisite to parallel operation of alterna-

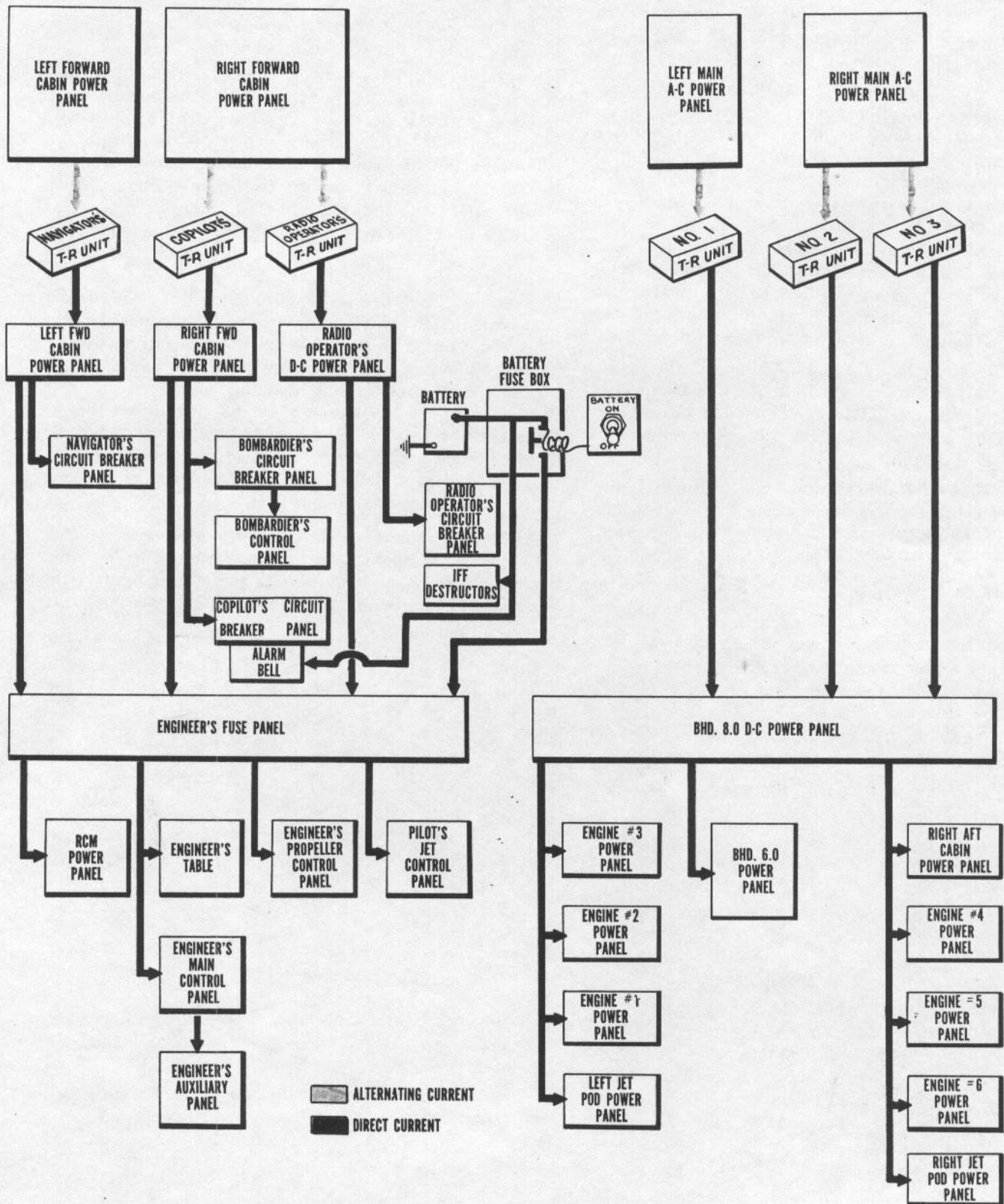


Figure 1-29. Direct-Current Power Distribution

tors, a reliable constant speed source is required. The constant-speed drive used is a mechanical-hydro-electric governor and drive unit. The drive unit, a variable ratio hydraulic transmission, delivers power to the alternator at a speed which is held constant through controlling action applied to the drive by the governor equipment.

Parallel operation (all alternators supplying a common bus) is desirable, since it will give greater stability to the electrical system; and in the event one alternator is inoperative, the entire power supply will not be cut off. One kilowatt-kilovar meter (16, figure 1-18) is supplied for each alternator to indicate its power output. Although it is desirable that all alternators divide the load as much as possible, the free-wheeling feature of the constant-speed drive permits alternator motoring for periods up to 5 minutes without damage to the drive. (See "Alternator Motoring," Section III.)

Exciter Control Relay Switch. Holding this switch (12, figure 1-18), momentarily in the ON position excites the alternator. Holding the switch momentarily in the OFF position de-excites the alternator and discontinues its output.

Voltage Control Knob. Voltage control of each alternator is controlled by its associated voltage control knob (17, figure 1-18).

Frequency Control Knob. This knob (15, figure 1-18) is connected to the governor control circuit and provides a means of controlling the speed of the constant-

speed drive. Controlling the speed at which the alternator is driven directly controls the frequency of its output.

Voltage and Frequency Selector Switch. An eight-position selector switch (23, figure 1-18), is located on the engineer's main instrument panel. Four of these positions are marked 2, 3, 4, and 5, with respect to the four alternators. With the switch in any of these positions, the voltmeter and frequency meter will indicate the voltage and frequency of the selected alternator. Also, the kilowatt-kilovar meter (16, figure 1-18), for each alternator will indicate the power output of the selected alternator when its alternator breaker is closed and electric power is being used. The four unmarked positions are connected to the four main bus bars. The position between 2 and 3 is connected to bus 201, the position between 3 and 4 to bus 301; the position between 4 and 5 to bus 401, and the position between 5 and 2 to bus 501. With the switch in any of these positions, the voltmeter and frequency meter will indicate the voltage and frequency of the current on the selected bus, provided the bus tie breakers are open. If the bus tie breakers are closed, any of these four positions will give the voltage and frequency of the current on the connected bus bars.

Alternator Breaker Switch. Each alternator is connected to the power distribution network by an alternator breaker. A three-position switch (20, figure 1-18) spring-loaded in the OPEN and CLOSE positions con-

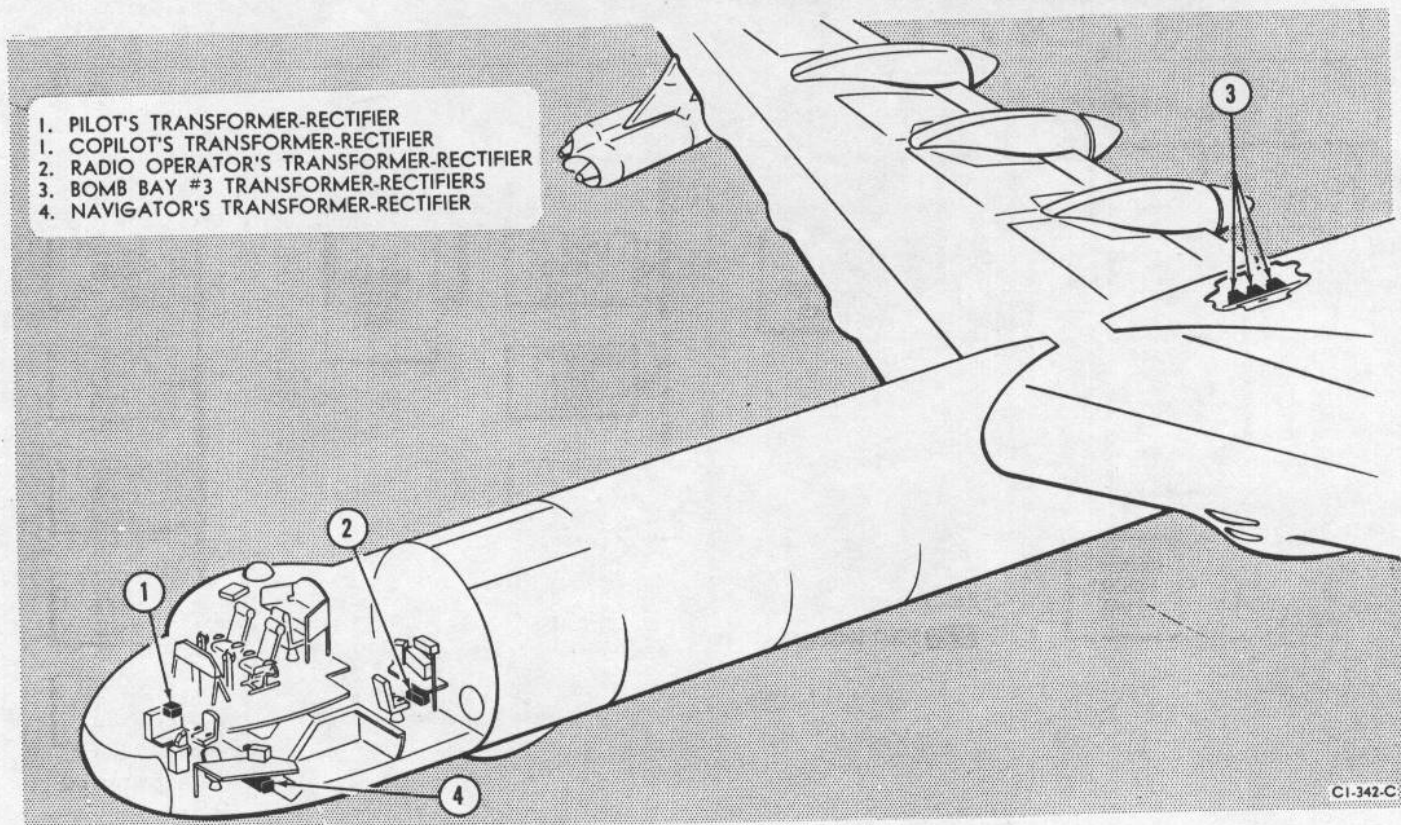


Figure 1-30. Location of Transformer-Rectifier Units

trols the breaker which is a d-c operated solenoid. Individual alternator breaker indicator lamps (21, figure 1-18), are located adjacent to each alternator breaker switch. These red lamps glow when the breaker is in the OPEN position. In the event an alternator breaker of a particular alternator is closed and the mixture control lever of that engine is moved to the IDLE CUT-OFF position, the breaker will automatically be opened through the action of a switch located on the lever.

Alternator Breaker Hold-In Switches. A hold-in switch (14, figure 1-21) for each alternator is provided to prevent the alternator breaker from opening when the corresponding mixture control lever is moved to the IDLE CUT-OFF position. The switches are used during normal engine shutdown when it is necessary to keep the alternator breaker of the last engine being shut down closed so that electrical power will be available to properly position the mixture control. The switches each have a spring-loaded HOLD IN position and a full-on NORMAL position and are located on the flight engineer's table.

Kilowatt and Kilovar Selector Switches. A bank of four kilowatt-kilovar selector switches (24, figure 1-18) is used to determine the power output of the alternators. These switches, which are ganged together, are used to select the desired reading by placing them in either the KWATTS or KVARS position. Indicators (16, figure 1-18) are provided for use with the kilowatt-kilovar selector switches. During parallel operation the division of real load is indicated by these meters when the selector switches are in the KWATTS position. When the switches are in the KVARS position, the meters register the reactive current measured in vars being put out by each alternator.

Bus Controls and Indicators. When in parallel operation, the individual alternators are all interconnected to a common bus. This bus is divisible by means of tie breakers. The tie breakers are controlled by four three-position bus tie breaker control switches (9, figure 1-18), which are spring-loaded in the OPEN and CLOSE positions. The switches have guards which identify the bus segments they interconnect. The arrangement of the main a-c power bus and the individual bus tie breakers is illustrated in figure 1-28. A red indicator lamp (21, figure 1-18), is located adjacent to each bus tie breaker switch and glows when the bus tie breaker is open.

Synchronizer Lamps. The synchronization controls and indicators are provided to equalize the output and frequency of each alternator so that they may be put in parallel. Two lamps (11, figure 1-18) on the engineer's panel are used to synchronize alternators. These lamps are connected so that by means of the voltage and frequency selector switch each lamp is placed between one phase of the power bus and the corresponding phase of the alternator to be paralleled with the bus. There-

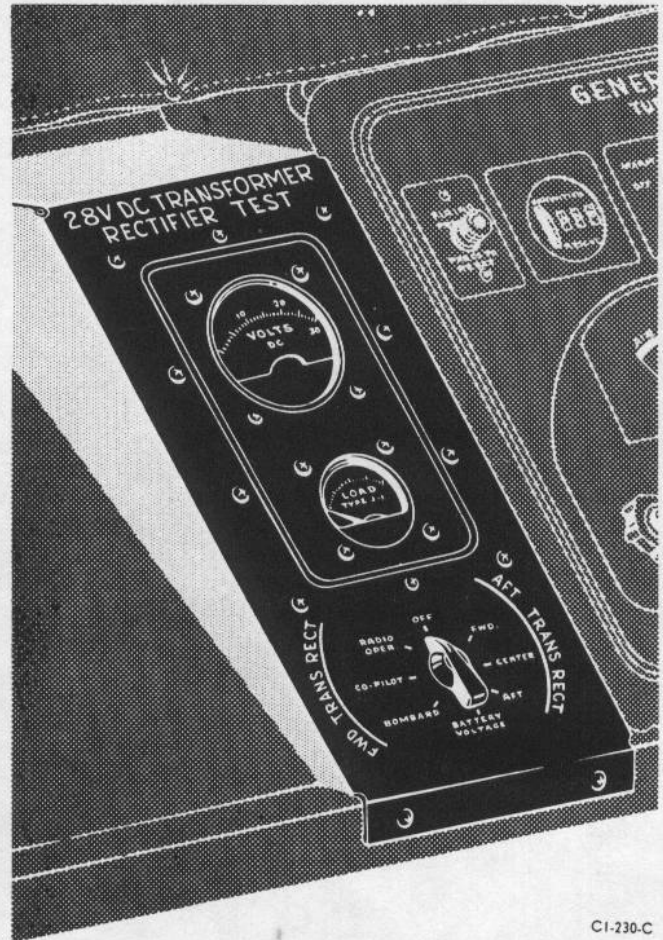
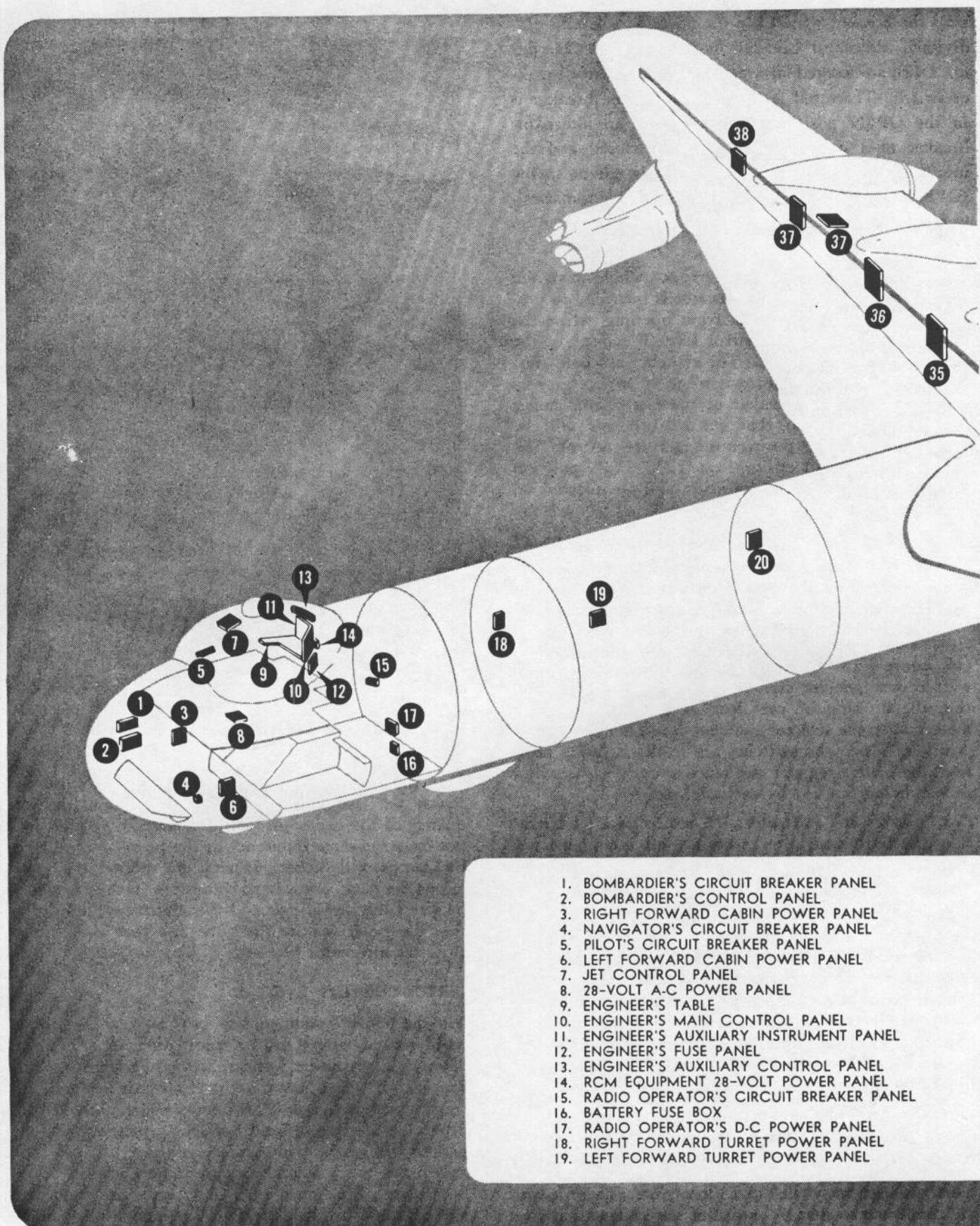


Figure 1-31. Transformer-Rectifier Test Unit

fore, the lamps will light when a difference exists between the frequency of the power bus and the frequency of the alternator. If the alternator voltage does not have the same frequency as the power bus voltage, the lamps will flicker. During the period that both lamps are dark, there is no difference in the frequency between the power bus and the alternator, indicating that the polarities are the same and that it is safe to close the alternator breaker.

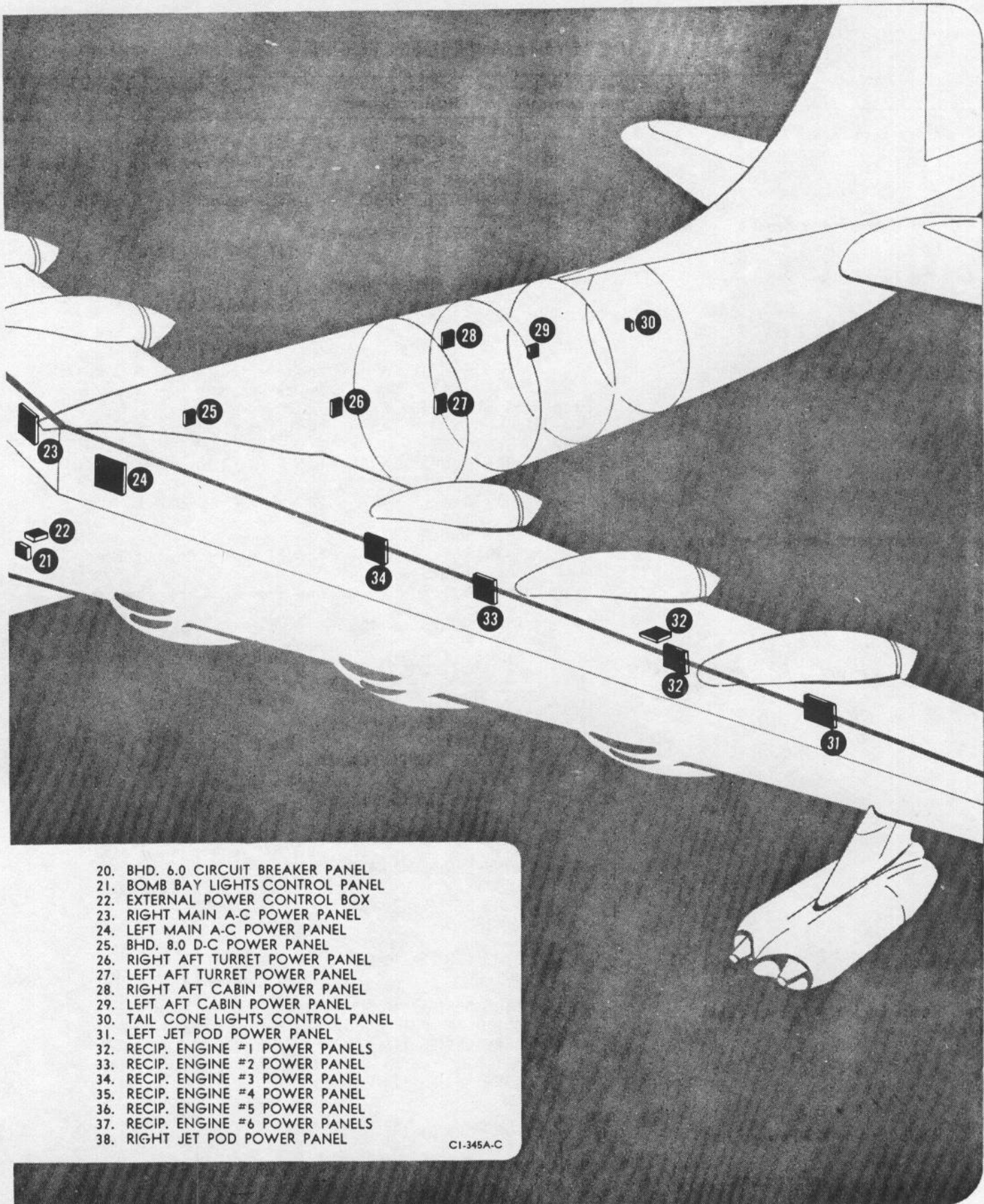
DIRECT-CURRENT SYSTEM.

The d-c power system consists of a 24-volt, 17 ampere-hour storage battery and six transformer-rectifier units. The t-r units convert 3-phase, 208-volt, alternating current into 28-volt direct current. Each unit is rated for a continuous output of 50 amperes. The units are located as follows: one under the navigator's table, one behind the radar-bombardier's control panel, one under the radio operator's table, and three in No. 3 bomb bay. (See figure 1-30.) The units are connected through fuses to the a-c system and operate in parallel to deliver direct current when power is on the a-c bus. The total load of the system is automatically shared by the units.



1. BOMBARDIER'S CIRCUIT BREAKER PANEL
2. BOMBARDIER'S CONTROL PANEL
3. RIGHT FORWARD CABIN POWER PANEL
4. NAVIGATOR'S CIRCUIT BREAKER PANEL
5. PILOT'S CIRCUIT BREAKER PANEL
6. LEFT FORWARD CABIN POWER PANEL
7. JET CONTROL PANEL
8. 28-VOLT A-C POWER PANEL
9. ENGINEER'S TABLE
10. ENGINEER'S MAIN CONTROL PANEL
11. ENGINEER'S AUXILIARY INSTRUMENT PANEL
12. ENGINEER'S FUSE PANEL
13. ENGINEER'S AUXILIARY CONTROL PANEL
14. RCM EQUIPMENT 28-VOLT POWER PANEL
15. RADIO OPERATOR'S CIRCUIT BREAKER PANEL
16. BATTERY FUSE BOX
17. RADIO OPERATOR'S D-C POWER PANEL
18. RIGHT FORWARD TURRET POWER PANEL
19. LEFT FORWARD TURRET POWER PANEL
20. [Panel location on fuselage]
18. [Panel location on fuselage]
19. [Panel location on fuselage]
20. [Panel location on fuselage]
35. [Panel location on tail]
36. [Panel location on tail]
37. [Panel location on tail]
37. [Panel location on tail]
38. [Panel location on tail]

Figure 1-32. (Sheet 1) Fuse and Circuit Breaker Panel Location



- 20. BHD. 6.0 CIRCUIT BREAKER PANEL
- 21. BOMB BAY LIGHTS CONTROL PANEL
- 22. EXTERNAL POWER CONTROL BOX
- 23. RIGHT MAIN A-C POWER PANEL
- 24. LEFT MAIN A-C POWER PANEL
- 25. BHD. 8.0 D-C POWER PANEL
- 26. RIGHT AFT TURRET POWER PANEL
- 27. LEFT AFT TURRET POWER PANEL
- 28. RIGHT AFT CABIN POWER PANEL
- 29. LEFT AFT CABIN POWER PANEL
- 30. TAIL CONE LIGHTS CONTROL PANEL
- 31. LEFT JET POD POWER PANEL
- 32. RECIP. ENGINE #1 POWER PANELS
- 33. RECIP. ENGINE #2 POWER PANEL
- 34. RECIP. ENGINE #3 POWER PANEL
- 35. RECIP. ENGINE #4 POWER PANEL
- 36. RECIP. ENGINE #5 POWER PANEL
- 37. RECIP. ENGINE #6 POWER PANELS
- 38. RIGHT JET POD POWER PANEL

CI-345A-C

Figure 1-32. (Sheet 2) Fuse and Circuit Breaker Location

AC SYSTEM FEEDER FUSES

LOCATION	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE	CONNECTED TO
Engineer's Fuse Panel	2	30	"ENGINEER'S PANEL"	Engineer's Table
	3	30	"ENGR'S PANEL POWER INPUT"	Engineer's Fuse Panel A-C Power Switch
	1	20	"MASTER TURBO"	Turbosupercharger Regulator Control
Left Aft Cabin Power Panel	9	30	"WIRE SERIES 450-451- 452"	Left Aft Turret Power Panel
Left Aft Turret Power Panel	12	40	"WIRE SERIES 400-401- 402-403"	Left Main A-C Power Panel
	9	30	"WIRE SERIES 450-451- 452"	Left Aft Cabin Power Panel
Left Forward Cabin Power Panel	3	30	"ENGR'S ALT POWER"	Engineer's Fuse Panel A-C Power Switch
	* 3	20	"LH TRANS RECT UNIT"	Navigator's Transformer-Rectifier
	2	40	"RCM POWER PANEL"	RCM Equipment 28 Volt Power Panel
	12	40	"WIRE SERIES 307-308- 309-329"	Left Forward Turret Power Panel
	1	20	"28 V TRANS"	28 Volt A-C Power Panel
Left Forward Turret Power Panel	12	40	"WIRE SERIES 300-301- 302-303"	Left Main A-C Power Panel
	12	40	"WIRE SERIES 307-308- 309-329"	Left Forward Cabin Power Panel
Left Jet Pod Power Panel	9	60	"WIRE SERIES 124-125- 126"	Recip. Engine #2 Power Panel
Left Main A-C Power Panel	* 3	20	"BOMB BAY TRANSF RECT UNIT"	Transformer-Rectifier #1
	12	60	"WIRE SERIES 110-111- 112-113"	Recip. Engine #2 Power Panel
	12	60	"WIRE SERIES 140-141- 142-143"	Recip. Engine #3 Power Panel
	12	40	"WIRE SERIES 300-301- 302-303"	Left Forward Turret Power Panel
	12	40	"WIRE SERIES 400-401- 402-403"	Left Aft Turret Power Panel
	12	40	"WIRE SERIES 420-421- 422-423"	Right Main A-C Power Panel
	12	40	"WIRE SERIES 430-431- 432-433"	Right Main A-C Power Panel
Recip. Engine #1 Power Panel	12	60	"WIRE SERIES 116-117- 118-119"	Recip. Engine #2 Power Panel
Recip. Engine #2 Power Panel	12	60	"WIRE SERIES 110-111- 112-113"	Left Main A-C Power Panel
	12	30	"WIRE SERIES 116-117- 118-119"	Recip. Engine #1 Power Panel
	9	60	"WIRE SERIES 124-125- 126"	Left Jet Pod Power Panel
Recip. Engine #3 Power Panel	12	60	"WIRE SERIES 140-141- 142-143"	Left Main A-C Power Panel
Recip. Engine #4 Power Panel	12	60	"WIRE SERIES 240-241- 242-243"	Right Main A-C Power Panel

Figure 1-33. (Sheet 1) Fuse and Circuit Breaker List

AC SYSTEM FEEDER FUSES (Continued)

LOCATION	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE	CONNECTED TO
Recip. Engine #5 Power Panel	12	60	"WIRE SERIES 210-211-212-213"	Right Main A-C Power Panel
	12	30	"WIRE SERIES 216-217-218-219"	Recip. Engine #6 Power Panel
	9	60	"WIRE SERIES 224-225-226"	Right Jet Pod Power Panel
Recip. Engine #6 Power Panel	12	30	"WIRE SERIES 216-217-218-219"	Recip. Engine #5 Power Panel
Right Aft Cabin Power Panel	9	30	"WIRE SERIES 440-441-442"	Right Aft Turret Power Panel
Right Aft Turret Power Panel	12	40	"WIRE SERIES 410-411-412-413"	Right Main A-C Power Panel
	9	30	"WIRE SERIES 440-441-442"	Right Aft Cabin Power Panel
Right Forward Cabin Power Panel	* 3	20	"BLKHD 4.0 TRANS RECT UNIT"	Radio Operator's Transformer-Rectifier
	3	30	"ENGR'S FUSE PANEL"	Engineer's Fuse Panel A-C Power Switch
	* 3	20	"RH TRANS RECT UNIT"	Copilot's Transformer-Rectifier
	12	40	"WIRE SERIES 317-318-319-339"	Right Forward Turret Power Panel
Right Forward Turret Power Panel	12	40	"WIRE SERIES 310-311-312-313"	Right Main A-C Power Panel
	12	40	"WIRE SERIES 317-318-319-339"	Right Forward Cabin Power Panel
Right Jet Pod Power Panel	9	60	"WIRE SERIES 224-225-226"	Recip. Engine #5 Power Panel
Right Main A-C Power Panel	* 3	20	"BOMB BAY TRANSF RECT CENTER"	Transformer-Rectifier #2
	* 3	20	"BOMB BAY TRANSF RECT AFT"	Transformer-Rectifier #3
	12	60	"WIRE SERIES 210-211-212-213"	Recip. Engine #5 Power Panel
	12	60	"WIRE SERIES 240-241-242-243"	Recip. Engine #4 Power Panel
	12	40	"WIRE SERIES 310-311-312-313"	Right Forward Turret Power Panel
	12	40	"WIRE SERIES 410-411-412-413"	Right Aft Turret Power Panel
	12	40	"WIRE SERIES 420-421-422-423"	Left Main A-C Power Panel
	12	40	"WIRE SERIES 430-431-432-433"	Left Main A-C Power Panel
	12	40	"WIRE SERIES 475-476-477-478"	External Power Control Box
	1	20	"28V TRANSF"	Bomb Bay Lights Control Panel
	1	30	"BOMBARDIER'S PANEL"	Bombardier's Circuit Breaker Panel
	3	20	"COPILOT'S PANEL"	Copilot's Circuit Breaker Panel
28 Volt A-C Power Panel	1	30	"NAVIG'S PANEL"	Navigator's Circuit Breaker Panel
	1	30	"RADIO OPER'S PANEL"	Radio Operator's Circuit Breaker Panel

*Denotes A-C System feeder fuses which appear on the Direct Current Distribution System Schematic.

Figure 1-33. (Sheet 2) Fuse and Circuit Breaker List

DC SYSTEM FEEDER FUSES

LOCATION	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE	CONNECTED TO
Battery Fuse Box	1	30	"ALARM BELL"	Copilot's Circuit Breaker Panel
	3	40	"ENGINEER'S PANEL"	Engineer's Fuse Panel
	2	30	"SCR695 DETONA- TOR"	Radio Operator's Circuit Breaker Panel
Bhd. 6.0 D-C Power Panel	3	50	"50 AMP FUSE"	Bhd. 8.0 D-C Power Panel
Bhd. 8.0 D-C Power Panel	3	50	"AFT CABIN"	Right Aft Cabin Power Panel
	3	40	"AFT TRANSF RECT"	Transformer-Rectifier #3
	3	50	"BLKHD 6.0 CIRCUIT BREAKER PANEL"	Bhd. 6.0 D-C Power Panel
	3	40	"CENTER TRANSF RECT"	Transformer-Rectifier #2
	3	30	"FWD CABIN"	Engineer's Fuse Panel
	3	40	"FWD TRANSF RECT"	Transformer-Rectifier #1
	3	20	"LEFT WING"	Recip. Engine #1, 2 & 3, AND Left Jet Pod Power Panels
	3	20	"RIGHT WING"	Recip. Engines #4, 5 & 6, AND Right Jet Pod Power Panels
Engineer's Fuse Panel	3	40	"BATTERY"	Battery Fuse Box
	3	30	"BOMB BAY"	Bhd. 8.0 D-C Power Panel
	3	30	"L.H. FWD PANEL"	Left Forward Cabin Power Panel
	3	30	"RADIO OPER'S PANEL"	Radio Operator's D-C Power Panel
	3	30	"R.H. FWD PANEL"	Right Forward Cabin Power Panel
Left Forward Cabin Power Panel	3	30	"ENGR'S PANEL"	Engineer's Fuse Panel
	3	40	"LH TRANS RECT UNIT"	Navigator's Transformer-Rectifier
	3	30	"NAVIG PANEL"	Navigator's Circuit Breaker Panel
	3	30	"RH POWER PANEL"	Right Forward Cabin Power Panel
Left Jet Pod Power Panel	3	10	"28V DC POWER"	Bhd. 8.0 D-C Power Panel
Radio Operator's D-C Power Panel	3	40	"BLKHD 4.0 CONVR'T"	Radio Operator's Transformer- Rectifier
	3	30	"ENGR'S PANEL"	Engineer's Fuse Panel
	3	30	"RADIO OPER'S PANEL"	Radio Operator's Circuit Breaker Panel
Recip. Engine #1 Power Panel	3	10	"28V DC POWER"	Bhd. 8.0 D-C Power Panel
Recip. Engine #2 Power Panel	3	10	"28V DC POWER"	Bhd. 8.0 D-C Power Panel
Recip. Engine #3 Power Panel	3	10	"28V DC POWER"	Bhd. 8.0 D-C Power Panel
Recip. Engine #4 Power Panel	3	10	"28V DC POWER"	Bhd. 8.0 D-C Power Panel
Recip. Engine #5 Power Panel	3	10	"28V DC POWER"	Bhd. 8.0 D-C Power Panel
Recip. Engine #6 Power Panel	3	10	"28V DC POWER"	Bhd. 8.0 D-C Power Panel
Right Aft Cabin Power Panel	3	50	"BHD 8.0 DC POWER PANEL"	Bhd. 8.0 D-C Power Panel
Right Forward Cabin Power Panel	3	30	"BOMB'S CIRCUIT BREAKER PANEL"	Bombardier's Circuit Breaker Panel
	3	30	"COPILOT'S CIRCUIT BREAKER PANEL"	Copilot's Circuit Breaker Panel
	3	30	"ENGR'S PANEL"	Engineer's Fuse Panel
	3	30	"LH POWER PANEL"	Left Forward Cabin Power Panel
	3	40	"RH TRANS RECT UNIT"	Copilot's Transformer-Rectifier
Right Jet Pod Power Panel	3	10	"28V DC POWER"	Bhd. 8.0 D-C Power Panel

Figure 1-33. (Sheet 3) Fuse and Circuit Breaker List

AC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS

*Push-Pull Type Circuit Breaker

†Switch Type Circuit Breaker

The words "Power" and "Control," in parenthesis, are used in conjunction with certain "Equipment or Circuit" designations in both the AC and DC Equipment Fuse and Circuit Breaker lists. The word "Power" is used to indicate an electrical circuit which is completed through a relay. "Control" indicates an energizing circuit for a relay. For each power circuit, or groups of similar power circuits, there is a corresponding control circuit. For example, in the a-c system you will find:

Aileron Trim Tab (Power):

Left

Right

The corresponding control circuit appears in the d-c system as:

Aileron Trim Tab (Control),

Left and Right

Normally, a-c power has d-c control. However, some equipment has d-c power with d-c control. Any equipment or circuit designation which does not contain either of the specified words, indicates a power circuit without a controlling relay.

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Aileron Trim Tab (Power):				
Left	32	3	10	"AILERON TRIM TAB"
Right	37	3	10	"AILERON TRIM TAB"
Air Plug (Power):				
Jet Engine 1	31	1	10	"#1 AIR SHUT OFF DOORS"
Jet Engine 2	31	1	10	"#2 AIR SHUT OFF DOORS"
Jet Engine 3	38	1	10	"#3 AIR SHUT OFF DOORS"
Jet Engine 4	38	1	10	"#4 AIR SHUT OFF DOORS"
Recip. Engine 1	32	3	10	"ENGINE AIR PLUG"
Recip. Engine 2	33	3	10	"ENGINE AIR PLUG"
Recip. Engine 3	34	3	10	"ENGINE AIR PLUG"
Recip. Engine 4	35	3	10	"ENGINE AIR PLUG"
Recip. Engine 5	36	3	10	"ENGINE AIR PLUG"
Recip. Engine 6	37	3	10	"ENGINE AIR PLUG"
Alternating Current Phase Sequence Indicator Lamps	22	3	10	"EXTERNAL POWER PHASE SE- QUENCE INDICATOR FUSE"
Anti-Icing:				
Jet Pod Heaters (Power):				
Left	31	3	30	"NOSE DOORS DE-ICE"
Right	38	3	30	"NOSE DOORS DE-ICE"
Propellers (Power):				
Recip. Engines 1, 2, & 3	34	1	10	"PROP ANTI ICE"
Recip. Engines 4, 5, & 6	35	1	10	"PROP ANTI ICE"
Tail, AND Cabin Air Temperature Control Valve	9	1	* 5	"ANTI-ICE TAIL AND CABIN HEAT"
Wing	9	1	* 5	"ANTI-ICE WING IND."
Autopilot (Power), E6	3	1	20	"AUTO PILOT"
Bomb Station Indicator Lights	3	1	10	"BOMB ST. IND. LTS."
Brake Pump	See: "Hydraulic Pump (Power), Brake"			
Cabin Air Temperature Control Valve	See: "Anti-Icing, Tail, AND Cabin Air Temperature Control Valve"			
Cabin Pressurization	See: "Pressure Shut Off Valves, Aft Cabin AND Wing"			
Camera Door (Power)	27	3	10	"CAMERA DOOR MOTOR"
Carburetor Air Filters (Power):				
Recip. Engines 1, 2, & 3	34	1	10	"CARB. AIR FLTR."
Recip. Engines 4, 5, & 6	35	1	10	"CARB. AIR FLTR."

Figure 1-33. (Sheet 4) Fuse and Circuit Breaker List

AC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Carburetor Air Preheat (Power):				
Recip. Engine 1	32	1	10	"CARB. PREHEAT"
Recip. Engine 2	33	1	10	"CARB. PREHEAT"
Recip. Engine 3	34	1	10	"CARB. PREHEAT"
Recip. Engine 4	35	1	10	"CARB. PREHEAT"
Recip. Engine 5	36	1	10	"CARB. PREHEAT"
Recip. Engine 6	37	1	10	"CARB. PREHEAT"
Compass, Radio-AN/ARN-7	6	1	10	"RADIO COMPASS"
Compass, Slaved Gyro Magnetic	6	3	10	"GYROSYN COMPASS"
Control Surface Locks (Power)	23	3	10	"CONT. SURF. LOCK R.H. AIL. L.H. AIL. TAIL"
Engine Analyzer Relay				
Box:				
Left	33	1	10	"ENG. ANALYZER"
Right	36	1	10	"ENG. ANALYZER"
Fan:				
Cabin Air Booster (Power)	23	6	40	"CABIN PRES. BOOST. FAN"
Forward Cabin Ventilating	6	3	10	"CABIN VENT. FAN"
Fans, Engine Cooling — Recip. Engines 1, 2, 3, 4, 5, & 6	9	1	* 5	"ENGINE FAN"
Flap (Power):				
Center, Left	33	3	20	"CENTER FLAPS"
Center, Right	36	3	20	"CENTER FLAPS"
Inboard, Left	34	3	20	"INBOARD FLAPS"
Inboard, Right	35	3	20	"INBOARD FLAPS"
Outboard, Left	32	3	20	"OUTBOARD FLAPS"
Outboard, Right	37	3	20	"OUTBOARD FLAPS"
Fuel:				
Pump (Power), Booster:				
Auxiliary Tank, Left	24	3	10	"LEFT WING AUX. BOOST PUMP"
Auxiliary Tank, Right	23	3	10	"RIGHT WING AUXIL. BOOST PUMP"
Bomb Bay Tank	27	3	10	"BB #3 FUEL BOOST PUMP"
Jet Engines 1 & 2	31	3	10	"FUEL PUMP"
Jet Engines 3 & 4	38	3	10	"FUEL PUMP"
Wing Tank 1	33	3	10	"FUEL BOOSTER PUMP"
Wing Tank 2	34	3	10	"FUEL BOOSTER PUMP"
Wing Tank 3	34	3	10	"FUEL BOOSTER PUMP"
Wing Tank 4	35	3	10	"FUEL BOOSTER PUMP"
Wing Tank 5	35	3	10	"FUEL BOOSTER PUMP"
Wing Tank 6	36	3	10	"FUEL BOOSTER PUMP"
Mixture — Recip. Engines 1, 2, 3, 4, 5, & 6	9	6	* 5	"ENGINE FUEL MIXTURE 1, 2, 3, 4, 5, & 6"
Gyro Indicator:				
Type C-5, Navigator's	3	3	10	"PILOTS GYRO HORIZON"
Type E-1, Copilot's	6	3	10	"NAVIG DIRECTIONAL GYRO"
Gyro Indicators, Type B-1 AND E-1 — Pilot's	6	3	10	"PILOTS GYRO HORIZON"
Heater, Pitot Tube:				
Left	10	1	† 5	"PITOT TUBE HEATER L.H."
Right	10	1	† 5	"PITOT TUBE HEATER R.H."
Heater (Power), Auxiliary Cabin:				
Aft Cabin, Left	29	3	30	"CABIN HEAT"
Aft Cabin, Right (Airplanes not in Group 20)	28	3	30	"CABIN HEAT"
Aft Cabin, Right AND Galley Hot Plates (Group 20 Airplanes)	28	3	30	"COMPT HEATER OR GALLEY"

Figure 1-33. (Sheet 5) Fuse and Circuit Breaker List

AC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Bombardier's	6	3	30	"CABIN HEAT"
Radio Operator's	3	3	30	"RADIO OPERATOR'S COMPT."
Heater (Power), Oil:				
Jet Engine 1	31	1	10	"OIL CELL HEATER #1"
Jet Engine 2	31	1	10	"OIL CELL HEATER #2"
Jet Engine 3	38	1	10	"OIL CELL HEATER #3"
Jet Engine 4	38	1	10	"OIL CELL HEATER #4"
Heater (Power), Oil Vent Line:				
Recip. Engine 1	32	1	10	"OIL VENT HEAT"
Recip. Engine 2	33	1	10	"OIL VENT HEAT"
Recip. Engine 3	34	1	10	"OIL VENT HEAT"
Recip. Engine 4	35	1	10	"OIL VENT HEAT"
Recip. Engine 5	36	1	10	"OIL VENT HEAT"
Recip. Engine 6	37	1	10	"OIL VENT HEAT"
Heaters (Power), Fuel Purging:				
Bomb Bay Tanks, Auxiliary Tanks, AND Wing Tanks, 1, 2, & 3	24	1	10	"FUEL TANK PURGE"
Wing Tanks, 4, 5, & 6	23	1	10	"FUEL TANK PURGE"
Hot Cup Receptacle:				
Aft Cabin (Airplanes not in Group 20)	28	1	20	"HOT CUPS"
Aft Cabin (Group 20 Airplanes)	See: "Oven, Hot Cups Aft"			
Forward Cabin (Airplanes not in Group 20)	6	1	20	"HOT CUP"
Forward Cabin and Liquid Container, Forward (Group 20 Airplanes)	3	1	10	"HOT CUP"
Hydraulic Pump (Power):				
Brake	24	6	60	"BRAKE PUMP"
#1	23	6	60	"HYDRO PUMP MOTOR"
#2	24	6	60	"HYDRO PUMP MOTOR #2"
Ignition (Power): (J47-19 Engines)				
Jet Engine 1	31	1	10	"#1 IGN."
Jet Engine 2	31	1	10	"#2 IGN."
Jet Engine 3	38	1	10	"#3 IGN."
Jet Engine 4	38	1	10	"#4 IGN."
Intercooler (Power):				
Close:				
Recip. Engine 1	32	1	10	"INTR COOL CLOSE"
Recip. Engine 2	33	1	10	"INTR COOL CLOSE"
Recip. Engine 3	34	1	10	"INTR COOL CLOSE"
Recip. Engine 4	35	1	10	"INTR COOL CLOSE"
Recip. Engine 5	36	1	10	"INTR COOL CLOSE"
Recip. Engine 6	37	1	10	"INTR COOL CLOSE"
Open:				
Recip. Engine 1	32	1	10	"INTR COOL OPEN"
Recip. Engine 2	33	1	10	"INTR COOL OPEN"
Recip. Engine 3	34	1	10	"INTR COOL OPEN"
Recip. Engine 4	35	1	10	"INTR COOL OPEN"
Recip. Engine 5	36	1	10	"INTR COOL OPEN"
Recip. Engine 6	37	1	10	"INTR COOL OPEN"
K-1 Bombing System:				
Amplifier — Computer, Type A-2	6	1	10	"K-1 SYS. REG."
Amplifier — Computer, Type A-2	6	1	30	"K-1 SYS. UNREG."

Figure 1-33. (Sheet 6) Fuse and Circuit Breaker List

AC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Filter, F-67/APS-23	6	1	20	"BOMB'G RADAR"
Relay, Aft Heater Junction Box	3	3	30	"K-I SYS. HEATERS"
Relay, Forward Heater Junction Box	6	3	30	"K-I SYS. HEATERS"
Transformer, Forward Heater Junction Box	6	3	10	"K-I SYS. GYROS"
Lights:				
Cockpit, Sub Flight Deck	15	1	† 5	"SUB FLT. DECK LT."
Communication Tube — Forward	15	1	* 5	"TUBE. LIGHT"
Dome, Radio Compartment	15	1	† 5	"DOME LIGHT"
Landing, Left (Filament Power)	8	1	30	"L.H. LAND LIGHT"
Landing, Right (Filament Power)	8	1	30	"R.H. LAND LIGHT"
Table, Navigator's	4	1	* 5	"TABLE LIGHTS"
Lights:				
Aft Cabin AND Tail Cone (Airplanes not in Group 20)	21	1	† 10	"AFT CABIN"
Aft Roomette, Dining Table, and Tail Cone Dome (Group 20 Airplanes)	28	1	† 5	"T CONE. COUNTER & ROOM LTS"
Cockpit, Aft Gunners'	28	1	* 5	"COCKPIT LIGHTS"
Dome, Tail Cone	30	1	† 5	"DOME LIGHTS TAIL CONE"
Fluorescent, Engineer's	10	1	† 5	"FLUOR LIGHTS"
Fluorescent, Pilots' Instrument Panel	3	1	10	"PILOTS INST LIGHTS"
Formation	5	1	* 5	"LIGHTS FORM"
Lights:				
Cockpit, Forward Gunners' AND Radio Operator's (Group 1 Airplanes)	15	1	* 5	"COCKPIT LIGHTS"
Cockpit, Forward Gunners' Radio Operator's AND Roomette (Group 2 Airplanes)	15	1	* 5	"COCKPIT & ROOMETTE LIGHTS"
Lights:	8	1	10	"ENGR'S DOME LIGHTS"
1. Cockpit, Engineer's				
2. Cockpit, Pilots'				
3. Dome, Engineer's				
Lights:	1	1	* 5	"FLUOR LIGHTS"
1. Cockpit, Bombardier's				
2. Dome (Red AND White), Bombardier's				
3. Fluorescent, Bombardier's				
4. Instrument, Right Forward Cabin Power Panel				
Lights:	4	1	* 5	"FLUORESCENT LIGHTS"
1. Cockpit, Navigator's				
2. Fluorescent, Navigator's				
Lights:	5	1	* 10	"LIGHTS COCKPIT"
1. Cockpit, Copilot's Circuit Breaker Panel				
2. Fluorescent, Pilot's Control Column				
3. Inter-Aircraft Signal, Copilot's				
Lights:	1	1	* 5	"TABLE LIGHT"
1. Cockpit, Nose Gunners'				
2. Fluorescent, Bombardier's				
3. Table, Bombardier's				

Figure 1-33. (Sheet 7) Fuse and Circuit Breaker List

AC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Lights:	28	1	* 5	"DOME LIGHTS"
1. Communication Tube — Aft				
2. Dome, Aft Cabin				
Lights:	5	1	* 5	"LIGHTS COCKPIT"
1. Cockpit, Pilot's				
2. Dome, Nose Wheel Well Entrance Hatch				
3. Fluorescent, Copilot's Control Column				
4. Fluorescent, Jet Instrument Panels				
5. Instrument, Pilots' Instrument Panel				
Lights (Power):	21	1	†15	"BOMB BAY LIGHTS 3 & 4"
1. Dome, Aft Turret Bay				
2. Dome, Aft Turret Passageway				
3. Dome, Bomb Bay 3				
4. Dome, Bomb Bay 4				
5. Dome, Main A-C Power Panels				
6. Instrument, Flap Control Panel				
Lights (Power):	21	1	†15	"BOMB BAY LIGHTS 1 & 2"
1. Dome, Bomb Bay 1				
2. Dome, Bomb Bay 2				
3. Dome, Forward Turret Bay				
4. Dome, Forward Turret Passageway				
5. Dome, Station 7.0				
6. Instrument, Left Forward Turret Power Panel				
7. Instrument, Right Forward Turret Power Panel				
Lights (Power):	8	1	10	"WING TIP LIGHTS"
1. Navigation, Wing (Red AND Green)				
2. Navigation, Tail (Yellow)				
Liquid Container, Aft (Group 20 Airplanes)	See "Oven, B-4 AND Liquid Container"			
Liquid Container, Forward (Group 20 Airplanes)	See "Hot Cup Receptacle"			
Meters, Voltage AND Frequency, Watt AND Var. AND Phase Sequence				
Lamps from:				
Alternator 2	33	3	10	"AC INST"
Alternator 3	34	3	10	"AC INST"
Alternator 4	35	3	10	"AC INST"
Alternator 5	36	3	10	"AC INST"

NOTE

The above fuses are in the circuits which lead from each alternator to the positions marked "2," "3," "4," and "5" of the Voltage and Frequency Selector Switch. THESE CIRCUITS ARE ALSO THE SOURCE OF EMERGENCY POWER, when the selector switch is positioned for any alternator which will excite, and when the Emergency Power Switch is in the "EMERGENCY" position.

Figure 1-33. (Sheet 8) Fuse and Circuit Breaker List

AC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Meters, Voltage AND Frequency from:				
Bus 201	24	2	10	"AC INST"
Bus 301	24	2	10	"AC INST"
Bus 401	23	2	10	"AC INST"
Bus 501	23	2	10	"AC INST"
Oil Cooler (Power):				
Recip. Engine 1	32	1	10	"ENG. OIL COOL"
Recip. Engine 2	33	1	10	"ENG. OIL COOL"
Recip. Engine 3	34	1	10	"ENG. OIL COOL"
Recip. Engine 4	35	1	10	"ENG. OIL COOL"
Recip. Engine 5	36	1	10	"ENG. OIL COOL"
Recip. Engine 6	37	1	10	"ENG. OIL COOL"
Oil Shut Off Valves — Jet Engines 1, 2, 3, & 4	7	4	* 5	"OIL SHUT OFF VALVE POWER ENG. 1, 2, 3, & 4"
Oil Shut Off Valves — Recip. Engines 1, 2, 3, 4, 5, & 6	9	6	* 5	"ENGINE OIL SHUT OFF VALVES 1, 2, 3, 4, 5, & 6"
Oven, B-4 AND Liquid Container, Aft (Group 20 Airplanes)	28	1	20	"BEV. TANKS & OVEN"
Oven, B-4 AND Hot Cups, Aft (Group 20 Airplanes)	28	2	10	"HOT CUPS & OVEN"
Preheat, Jet Pod	7	1	* 5	"POD PREHEAT POWER"
Pressure Shut Off Valves, Aft Cabin AND Wing	9	1	* 5	"WING SHUT OFF VALVES"

NOTE

Either one of the following groups of RCM equipment
may be installed in the aircraft.

Radar Countermeasures Equipment,
Group I:

AN/ALA-2, or	14	1	5	"RACK POSIT. #5A"
AN/APA-38	14	1	10	"RACK POSIT. #5A"
AN/APR-4	14	1	10	"RACK POSIT. #2"
AN/APT-4 — Rack Position 1	14	1	20	"RACK POSIT. #1"
AN/APT-4 — Rack Position 4	14	1	20	"RACK POSIT. #4"
AN/APT-4 — Rack Position 5	14	1	20	"RACK POSIT. #5"

Radar Countermeasures Equipment,
Group II:

AN/ALA-2, or	14	1	5	"RACK POSIT. #5A"
AN/ALA-38	14	1	10	"RACK POSIT. #5A"
AN/APR-4	14	1	10	"RACK POSIT. #2"
AN/APT-1	14	1	20	"RACK POSIT. #4"
AN/APT-5A	14	1	10	"RACK POSIT. #1"
AN/ARQ-8	14	1	20	"RACK POSIT. #5"

Radar Set:

AN/APG-32	28	1	20	"APG-3"
AN/APN-9A — Loran	6	1	10	"LORAN RECVR"
AN/APX-6	6	1	10	"APX-6 I.F.F."

Radar Set Pressurization:

AN/APG-32	28	1	10	"APG-3 PUMP"
AN/APQ-31	3	1	10	"RADAR PRESS PUMP"

Spark Advance — Recip. Engines
1, 2, 3, 4, 5, & 6

9	6	* 5	"ENGINE SPARK ADVANCE 1, 2, 3, 4, 5, & 6"
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Figure 1-33. (Sheet 9) Fuse and Circuit Breaker List

AC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Special Bombing Equipment:				
FTC Junction Box	3	1	10	"SPECIAL BOMBING"
Special Bombing Transformer	19	1	10	"SPECIAL BOMBING"
Starter (Power) — Jet Engines 1, 2, 3, & 4 (Connected Direct to Bus Bar — No Fuses)				
Starter (Power):				
Recip. Engine 1	32	3	60	"STARTER"
Recip. Engine 2	33	3	60	"STARTER"
Recip. Engine 3	34	3	60	"STARTER"
Recip. Engine 4	35	3	60	"STARTER"
Recip. Engine 5	36	3	60	"STARTER"
Recip. Engine 6	37	3	60	"STARTER"
Throttle — Jet Engines 1, 2, 3, & 4	7	4	* 5	"THROTTLE CONTROL POWER 1, 2, 3, & 4"
Transmitter, Autosyn:				
Jet Engine 1	31	1	10	"#1 AUT. TRANS."
Jet Engine 2	31	1	10	"#2 AUT. TRANS."
Jet Engine 3	38	1	10	"#3 AUT. TRANS."
Jet Engine 4	38	1	10	"#4 AUT. TRANS."
Transmitter, Autosyn:				
Recip. Engine 1	32	1	10	"ATOSN. TRANS."
Recip. Engine 2	33	1	10	"ATOSN. TRANS."
Recip. Engine 3	34	1	10	"ATOSN. TRANS."
Recip. Engine 4	35	1	10	"ATOSN. TRANS."
Recip. Engine 5	36	1	10	"ATOSN. TRANS."
Recip. Engine 6	37	1	10	"ATOSN. TRANS."
Turbosupercharger Regulator — Recip. Engines 1, 2, 3, 4, 5, & 6	12	6	10	"ENGINE 1, 2, 3, 4, 5, & 6 TURBO"
Turbosupercharger Selection — Recip. Engines 1, 2, 3, 4, 5, & 6	9	6	* 5	"ENGINE SUPERCHARGER SELEC- TION 1, 2, 3, 4, 5, & 6"
Turret Computer Heater, AND Thyratron Energizing (Control):				
Aft Lower, Left	27	1	10	"LOW LH TURRET"
Aft Lower, Right	26	1	10	"LOW RH TURRET"
Aft Upper, Left	27	1	10	"UP LH TURRET"
Aft Upper, Right	26	1	10	"UP RH TURRET"
Forward, Left	19	1	10	"UPPER LH TURRET"
Forward, Right	18	1	10	"UPPER RH TURRET"
Nose	3	1	10	"NOSE TUR"
Tail	28	1	10	"TAIL TUR"
Turret Desiccator, Nose	3	3	10	"NOSE TURRET DESICCATOR"
Turret Door:				
Aft Lower	27	3	10	"LOWER TURRET DOOR MOTOR"
Aft Upper	26	3	10	"UPPER TURRET DOOR MOTOR"
Forward, Left	19	3	10	"UPPER LH TURRET DOOR MOTOR"
Forward, Right	18	3	10	"UPPER RH TURRET DOOR MOTOR"
Turret (Power):				
Aft Lower, Left	27	3	50	"LOWER LH TURRET"
Aft Lower, Right	26	3	50	"LOWER RH TURRET"
Aft Upper, Left	27	3	50	"UPPER LH TURRET"

Figure 1-33. (Sheet 10) Fuse and Circuit Breaker List

AC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Aft Upper, Right	26	3	50	"UPPER RH TURRET"
Forward, Left	19	3	50	"UPPER LH TURRET"
Forward, Right	18	3	50	"UPPER RH TURRET"
Nose	3	3	40	"NOSE TURRET"
Tail	28	3	40	"TAIL TURRET POWER"
Voltage Regulator:				
Alternator 2	33	3	10	"AC PWR. EQUIP."
Alternator 3	34	3	10	"AC PWR. EQUIP."
Alternator 4	35	3	10	"AC PWR. EQUIP."
Alternator 5	36	3	10	"AC PWR. EQUIP."
Water Injection (Power):				
Recip. Engine 1	32	3	10	"WATER INJECTION PUMP"
Recip. Engine 2	33	3	10	"WATER INJECTION PUMP"
Recip. Engine 3	34	3	10	"WATER INJECTION PUMP"
Recip. Engine 4	35	3	10	"WATER INJECTION PUMP"
Recip. Engine 5	36	3	10	"WATER INJECTION PUMP"
Recip. Engine 6	37	3	10	"WATER INJECTION PUMP"
Water Tank Heater, Aft (Group 20 Airplanes)	29	1	10	"WATER HEATER"
Water Tank Heater, Forward (Group 20 Airplanes)	3	1	10	"WATER HEATER"
Windshield Wiper (Power), Pilots'	3	3	10	"PILOTS WINDSHIELD WIPER"

DC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Aileron Trim Tab (Control), Left AND Right	5	1	* 5	"TABS AILERON"
Aileron Trim Tab Position Indicator:				
Left	32	1	10	"AIL. TAB"
Right	37	1	10	"AILERON TRIM TAB"
Air Plug (Control):				
Jet Engines 1, 2, 3, & 4	7	1	* 5	"AIR PLUG POWER"
Recip. Engines 1, 2, 3, 4, 5, & 6	13	6	* 5	"ENGINES AIR PLUG CONTROLS 1, 2, 3, 4, 5, & 6"
Alarm Bell	5	1	* 5	"ALARM BELL"
Alternator:				
Exciter Relay 2	33	1	10	"ALT. CONT."
Exciter Relay 3	34	1	10	"ALT. CONT."
Exciter Relay 4	35	1	10	"ALT. CONT."
Exciter Relay 5	36	1	10	"ALT. CONT."
Governor 2	33	1	10	"GOV. CONT."
Governor 3	34	1	10	"GOV. CONT."
Governor 4	35	1	10	"GOV. CONT."
Governor 5	36	1	10	"GOV. CONT."
Anti-Icing:				
Air Temperature Warning Lamps	9	1	* 5	"ANTI-ICE HEAT DUCT TEMP."
Jet Pod Heaters (Control), AND Thermal Valves (Control)	7	1	† 5	"NOSE DE-ICE"

Figure 1-33. (Sheet 11) Fuse and Circuit Breaker List

DC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Jet Pod Thermal Valves (Power), Left	31	1	10	"POD DE-ICE"
Jet Pod Thermal Valves (Power), Right	38	1	10	"POD DE-ICE"
Propellers (Control) — Recip. Engines 1, 2, 3, 4, 5, & 6	10	1	† 5	"PROP ANTI-ICE"
Autopilot (Control), E-6	5	1	*10	"AUTO PILOT"
Bomb Bay Doors (Control): Bombardier's	1	1	* 5	"BOMB BAY DOOR"
Pilots'	5	1	* 5	"BOMB DOORS"
Bomb Master Switch	2	1	†25	"MASTER POWER"
Bomb Nose Arming (Control) — Bomb Bays 1, 2, 3, & 4	1	1	* 5	"NOSE FUSING"
Bomb Nose Arming (Power): Bomb Bay 1	20	1	†25	"BOMB NOSE FUSING B.B. 1"
Bomb Bay 2	20	1	†25	"BOMB NOSE FUSING B.B. 2"
Bomb Bay 3	25	1	†55	"BOMB NOSE FUSING B.B. 3"
Bomb Bay 4	25	1	†25	"BOMB NOSE FUSING B.B. 4"
Bomb Rack Compressor, Pneumatic: Left	20	1	†25	"PNEUMATIC BOMB RACK LEFT COMP."
Right	20	1	†25	"PNEUMATIC BOMB RACK RIGHT COMP."
Bomb Rack Junction Box, Pneumatic	20	1	†25	"PNEUMATIC BOMB RACK JUNCT. BOX"
Bomb Rack Selector: Bomb Bay 2	20	1	† 5	"B.B. 2 RACK SELECTOR"
Bomb Bay 3	25	1	† 5	"RACK SELECTOR B.B. 3"
Bomb Bays 1 & 4	25	1	† 5	"RACK SELECTOR B.B. 1 & 4"
Bomb Release Switch	1	1	*10	"BOMB RELEASE"
Bomb Release Intervalometer	1	1	* 5	"INTER HEATER"
Bomb Salvo (Control) — Bomb Bays 1, 2, 3, & 4: Bombardier's	1	1	*10	"BOMB SALVO"
Pilots'	5	1	* 5	"BOMB SALVO"
Radio Operator's	15	1	*10	"BOMB SALVO"
Bomb Salvo (Power): Bomb Bay 1	20	1	†25	"BOMB SALVO B.B. 1"
Bomb Bay 2	20	1	†25	"BOMB SALVO B.B. 2"
Bomb Bay 3	25	1	†25	"BOMB SALVO B.B. 3"
Bomb Bay 4	25	1	†25	"BOMB SALVO B.B. 4"
Bomb Scoring Tone Relay	1	1	* 5	"BOMB SCORING TONE"
Brake Pump	See: "Hydraulic Pump (Controls), Brake"			
Bus Tie Breakers	9	1	* 5	"BUS TIE BREAKERS CONTROL"
Cabin Air Duct Temperature Indicator	9	1	* 5	"CABIN DUCT TEMP."
Camera Door (Control), AND Camera Initiation, Aerial	25	1	†25	"CAMERA"

Figure 1-33. (Sheet 12) Fuse and Circuit Breaker List

DC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Camera Initiation, O-15	1	1	*10	"RADAR CAMERA"
Carburetor Air Filter (Control) — Recip. Engines 1, 2, 3, 4, 5, & 6	10	1	† 5	"CARB. AIR FILTER"
Carburetor Air Preheat (Control) — Recip. Engines 1, 2, 3, 4, 5, & 6	9	6	* 5	"CARBURETOR PREHEAT 1, 2, 3, 4, 5 & 6"
Carburetor Air Temperature Indi- cators — Recip. Engines 1, 2, 3, 4, 5, & 6	9	6	* 5	"TEMPERATURE INDICATORS CAR- BURETOR AIR 1, 2, 3, 4, 5, & 6"
Compass, Radio — AN/ARN-7	4	1	* 5	"RADIO COMPASS"
Compass, Slaved Gyro Magnetic	5	1	* 5	"GYROSYN COMPASS"
Control Surface Locks (Control)	5	1	* 5	"CONTROL SURFACE LOCKS"
Fan, Air Circulating:				
Copilot's	3	1	20	"CO-PILOTS FAN"
Pilot's	6	1	20	"PILOTS FAN"
Fan (Control), Cabin Air Booster	9	1	* 5	"BOOST FAN"
Fire Detection:				
Recip. Engine 1	32	1	10	"FIRE DETECT"
Recip. Engine 2	33	1	10	"FIRE DETECT"
Recip. Engine 3	34	1	10	"FIRE DETECT"
Recip. Engine 4	35	1	10	"FIRE DETECT"
Recip. Engine 5	36	1	10	"FIRE DETECT"
Recip. Engine 6	37	1	10	"FIRE DETECT"
Fire Detection AND Test — Jet Engines 1, 2, 3, & 4	7	1	* 5	"FIRE DETECT POWER"
Fire Detection Test — Recip. Engines 1, 2, 3, 4, 5, & 6	9	1	*10	"FIRE DETECT"
Fire Extinguisher	9	1	*15	"FIRE EXT."
Flaps (Control), Alternate	25	1	* 5	"ALTER. FLAP CONTROL"
Flaps (Control), Normal:				
Center	5	1	* 5	"FLAPS CENTER"
Inboard	5	1	* 5	"FLAPS INB'D."
Outboard	5	1	* 5	"FLAPS OUTB'D."
Flaps Position Indicator	5	1	* 5	"FLAP POSITION IND."
Flaps Position Transmitters, Center, Inboard, AND Outboard	25	1	† 5	"FLAP TRANS"
Fuel:				
Gage, Quantity:				
Bomb Bay Tank	9	1	* 5	"FUEL TANK LEVEL INDICATORS BOMB BAY"
Auxiliary Tanks, Left AND Right	9	1	* 5	"FUEL TANK LEVEL INDICATORS L. & R. AUX."
Wing Tanks, 1 & 6	9	1	* 5	"FUEL TANK LEVEL INDICATORS 1 & 6"
Wing Tanks, 2 & 5	9	1	* 5	"FUEL TANK LEVEL INDICATORS 2 & 5"
Wing Tanks, 3 & 4	9	1	* 5	"FUEL TANK LEVEL INDICATORS 3 & 4"

Figure 1-33. (Sheet 13) Fuse and Circuit Breaker List

DC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Pump (Control), Booster:				
Bomb Bay Tank	10	1	† 5	"BB TANK BOOSTER"
Jet Engines 1 & 2	7	1	† 5	"L. FUEL PUMP"
Jet Engines 3 & 4	7	1	† 5	"R. FUEL PUMP"
Pumps (Control), Booster:				
Auxiliary Tanks, Left	10	2	† 5	"TANKS L. & R. AUX. BOOSTER"
Wing Tanks 1, 2, 3, 4, 5, & 6	10	6	† 5	"TANKS 1, 2, 3, 4, 5, & 6 BOOSTER"
Tanks, Bomb Bay:	10	1	* 5	"BB TANK VALVE POWER"
1. Heater (Control), Purging				
2. Transmitter, Quantity				
3. Valve				
4. Valve, Pressure Refueling				
Tanks, Auxiliary — Left AND Right:	10	2	* 5	"L. & R. AUX. TANK VALVE POWER"
1. Heaters (Control), Purging (2)				
2. Transmitter, Quantity (2)				
3. Valves (2)				
4. Valves Pressures Refueling (2)				
Tanks, Wing — 1, 2, 3, 4, 5, & 6	10	6	* 5	"1, 2, 3, 4, 5, & 6 TANK VALVE POWER"
1. Heaters (Control), Purging (6)				
2. Transmitters, Quantity (6)				
3. Valves (6)				
4. Valves, Pressure Refueling (6)				
Valve:				
Cross-Feed	10	1	* 5	"CROSS FEED MANIFOLD VALVE POWER"
Manifold — Jet Pod, Left	7	1	* 5	"FUEL VALVE POWER LEFT MANI- FOLD"
Valve:				
Manifold — Jet Pod, Right	7	1	* 5	"FUEL VALVE POWER RIGHT MANI- FOLD"
Jet Engines 1, 2, 3, & 4	7	4	* 5	"FUEL VALVE POWER ENG. 1, 2, 3, & 4"
Manifold — 1, 2, 3, 4, 5, 6, 7, & 8	10	8	* 5	"FUEL MANIFOLD VALVE POWER 1, 2, 3, 4, 5, 6, 7, & 8"
Recip. Engines 1, 2, 3, 4, 5, & 6 AND Oil Cooler (Control) — Flight Cooling — Recip. Engines 1, 2, 3, 4, 5, & 6	10	6	* 5	"ENGINE VALVE POWER 1, 2, 3, 4, 5, & 6"
Gyro Indicator, Pilot's — Type B-1	6	1	10	"PILOT'S GYRO HORIZON"
Heaters (Control), Auxiliary Cabin	11	1	† 5	"CABIN HEATER POWER"
Heaters (Control), Fuel Purging	See: "Fuel Tank, Bomb Bay, AND Fuel Tanks, Auxiliary AND Wing"			
Heaters (Control), Oil — Jet Engines 1, 2, 3, & 4	7	1	† 5	"OIL HEAT"
Heaters (Control), Oil Vent Line — Recip. Engines 1, 2, 3, 4, 5, & 6	10	1	† 5	"OIL VENT HEAT"
Hydraulic Fluid Temperature (Control)	9	1	† 5	"HYD. PUMP FLUID TEMP."
Hydraulic Pump (Control): Brake	5	1	* 5	"BRAKE PUMP"

Figure 1-33. (Sheet 14) Fuse and Circuit Breaker List)

Section I
Description

SECURITY INFORMATION — RESTRICTED
AN 01-5EUC-1

DC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Brake — Emergency	9	1	* 5	"EMERG. BRAKE PUMP"
#2 — Emergency	9	1	† 5	"HYD. PUMP OVERRIDE"
Hydraulic Pump (Controls):				
Brake	See: 1. "Hydraulic Pump (Control), Brake"			
	2. "Hydraulic Pump (Control), Brake — Emergency"			
#1	See: 1. "Bomb Bay Doors (Control), Bombardier's"			
	2. "Bomb Bay Doors (Control), Pilots"			
	3. "Hydraulic Fluid Temperature (Control)"			
	4. "Landing Gear Extension AND Retraction (Control)"			
	5. "Landing Gear Steering (Control), Nose"			
#2	See: 1. "Hydraulic Pump (Control), #2 — Emergency"			
	2. "Landing Gear Extension AND Retraction (Control)"			
H-1 Accessory Equipment:				
Air Pump	20	1	†25	"H-1 EQUIPMENT AIR PUMPS"
Suit Heater Receptacle AND Test Receptacle	20	1	†25	"H-1 EQUIPMENT TEST REC HEAT SUIT"
Ignition (Control), AND Starter (Control), AND Starter Engaging (Control) — Jet Engines 1, 2, 3, & 4	7	4	* 5	"IGNITION STARTER POWER ENG. 1, 2, 3, & 4"
Ignition (Power): (J47-11 Engines)				
Jet Engine 1	31	1	10	"#1 IGN."
Jet Engine 2	31	1	10	"#2 IGN."
Jet Engine 3	38	1	10	"#3 IGN."
Jet Engine 4	38	1	10	"#4 IGN."
Instrument Approach System — Glide Path AND Localizer Receivers	1	1	*10	"INST. APPROACH"
Intercoolers Close AND Open (Control) — Recip. Engines 1, 2, 3, 4, 5, & 6	13	1	* 5	"ENG. INTERCOOLER"
Interphone:				
Amplifier, Mixer:				
Copilot's	5	1	* 5	"COMBAT INTERPHONE"
Pilot's	5	1	* 5	"PILOT INTERPHONE"
Radio Operator's	15	1	* 5	"MIXER AMP"
Amplifier — Normal Channel	15	1	* 5	"INTERPHONE"
Amplifier — Private Channel				
(Through Audio Input Relays "A" & "C")	9	1	* 5	"INTERPHONE"
K-1 Bombing System:				
Amplifier — Computer, Type A-2	6	1	30	"K-1 SYSTEM"
Filter, F-67/APS-23	6	1	30	"BOMB'G RADAR"
Landing Gear Extension AND Re- traction (Control), AND Oil Cooler (Control) — Ground Cooling — Recip. Engines 1, 2, 3, 4, 5, & 6	5	1	* 5	"LANDING GEAR CONTROL"
Landing Gear Steering (Control), Nose	5	1	* 5	"LANDING GEAR NOSE STEER"
Light:				
Inter-Aircraft Signal:				
Bombardier's	6	1	10	"ALDIS RECP."
Nose Gunner's	3	1	10	"ALDIS RECP."

Figure 1-33. (Sheet 15) Fuse and Circuit Breaker List

Section I
Description

SECURITY INFORMATION — RESTRICTED
AN 01-5EUC-1

DC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Lights:				
Instrument — Jet Control Panel	7	1	* 5	"PANEL LIGHTS POWER"
Inter-Aircraft Signal:				
Aft Lower Gunners'	28	1	*10	"LOWER ALDIS"
Aft Upper Gunners'	28	1	*10	"UPPER ALDIS"
Forward Gunners'	17	1	10	"ALDIS RECP."
Landing — Extension AND Re- traction, AND Filament (Control), Left AND Right	5	1	* 5	"LANDING LIGHTS CONTROL"
Landing Gear Wheel Well	10	1	† 5	"WHEEL LIGHTS"
Navigation, Fuselage, AND Code Flashing	5	1	*10	"LIGHTS NAVIGATION FUSELAGE"
Navigation, Tail (Yellow)	See: "Lights (Control), Navigation — Wing (Red AND Green) AND Tail (White), AND Lights, Navigation — Tail (Yellow)"			
Wing Internal	25	1	†10	"WING TE LIGHTS"
Lights (Control), Navigation — Wing (Red AND Green) AND Tail (White), AND Lights, Navigation — Tail (Yellow)	5	1	* 5	"LIGHTS NAVIGATION WING & TAIL"
Lights (Control):	28	1	* 5	"TURRET & BB LIGHTS"
1. Dome, Aft Turret Bay				
2. Dome, Aft Turret Passageway				
3. Dome, Bomb Bay 3				
4. Dome, Bomb Bay 4				
5. Dome, Main A-C Power Panels				
6. Instrument, Flap Control Panel				
Lights (Control):	15	1	* 5	"LIGHTS TURRET BB 1 & 2"
1. Dome, Bomb Bay 1				
2. Dome, Bomb Bay 2				
3. Dome, Forward Turret Bay				
4. Dome, Forward Turret Passage- way				
5. Dome, Station 7.0				
6. Instrument, Forward Turret Power Panels				
Lights (Control) — (Alternate Control Circuit for the Two Preceding Groups)	25	1	* 5	"TURRET & BB LIGHTS"
Marker Beacon Set, AN/ARN-12	15	1	* 5	"MARKER BEACON"
Master Temperature Indicator	9	1	* 5	"ENG TEMP IND"
Oil Cooler (Control) — Flight Cooling — Recip. Engines 1, 2, 3, 4, 5, & 6	See: "Fuel Valves — Recip. Engines 1, 2, 3, 4, 5, & 6, AND Oil Cooler (Control) — Flight Cooling — Recip. Engines 1, 2, 3, 4, 5, & 6"			
Oil Cooler (Control) — Ground Cooling — Recip. Engines 1, 2, 3, 4, 5, & 6	See: "Landing Gear Extension AND Retraction (Control), AND Oil Cooler (Control) — Ground Cooling — Recip. Engines 1, 2, 3, 4, 5, & 6"			
Oil Dilution — Recip. Engines 1, 2, 3, 4, 5, & 6	9	1	*15	"OIL DILUTE"
Oil Quantity Gages — Recip. En- gines 1, 2, 3, 4, 5, & 6	10	6	* 5	"OIL QUANTITY GAGE POWER 1, 2, 3, 4, 5, & 6"
Oil Temperature Indicators — Recip. Engines 1, 2, 3, 4, 5, & 6	9	6	* 5	"TEMPERATURE INDICATORS EN- GINE OIL 1, 2, 3, 4, 5, & 6"
Phantom Target, RF-3/AP	1	1	* 5	"PHANTOM TARGET"

Figure 1-33. (Sheet 16) Fuse and Circuit Breaker List

RESTRICTED

DC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Primers — Recip. Engines 1, 2, 3, 4, 5, & 6	9	1	* 5	"ENGINE PRIMER"
Propellers Feathering, Reversing, AND Pitch Changing — Recip. 1, 2, 3, 4, 5, & 6	9	6	*15	"PROPELLER CONTROL 1, 2, 3, 4, 5, & 6"
Propeller Master Motor	9	1	*10	"PROPELLER CONTROL MASTER MOTOR"
Propeller Pitch Indicator Lamps, Engineer's AND Pilot's	9	1	* 5	"PROP PITCH IND"

NOTE

Either of the following groups of RCM equipment may be
installed in the aircraft.

**Radar Countermeasures Equipment,
Group I:**

AN/APR-4	16	1	* 5	"RACK POSIT. #2"
AN/APT-4 — Rack Position #1	16	1	*10	"RACK POSIT. #1"
AN/APT-4 — Rack Position #4	16	1	*10	"RACK POSIT. #4"
AN/APT-4 — Rack Position #5	16	1	*10	"RACK POSIT. #5"

**Radar Countermeasures Equipment,
Group II:**

AN/APR-4	16	1	* 5	"RACK POSIT. #2"
AN/APT-1	16	1	*10	"RACK POSIT. #4"
AN/APT-5A	16	1	* 5	"RACK POSIT. #1"
AN/ARQ-8	16	1	*10	"RACK POSIT. #5"

Radar Set:

AN/APG-32	28	1	*15	"TAIL RADAR POWER"
AN/APN-9A — Loran	4	1	* 5	"LORAN"
AN/APX-6	15	1	* 5	"IDENT. REC'R"
AN/APX-6 Detonator	15	1	*10	"IDENT. DETONT'R."

Radio Range Receiver, BC-453

	5	1	* 5	"RANGE RECEIVER"
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Radio Set:

AN/ARC-3 — Command	17	1	30	"COMMAND AN/ARC-3"
AN/ARC-8 — Liaison (Dynamotor)	17	3	20	"LIAISON RADIO DYN"
AN/ARC-8 — Liaison (Receiver)	15	1	* 5	"LIAISON REC'R"

**Starters (Control) — Jet Engines
1, 2, 3, & 4**

See: "Ignition (Control), AND Starter (Control), AND Starter Engaging
(Control) — Jet Engines 1, 2, 3, & 4"

**Starters (Control) — Recip. Engines
1, 2, 3, 4, 5, & 6**

9	1	* 5	"ENGINE STARTER"
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**Starter Engaging (Control) — Jet
Engines 1, 2, 3, & 4**

See: "Ignition (Control), AND Starter (Control), AND Starter Engaging
(Control) — Jet Engines 1, 2, 3, & 4"

Starter Engaging (Power):

Jet Engine 1	31	1	10	"#1 STARTER ENGAGING"
Jet Engine 2	31	1	10	"#2 STARTER ENGAGING"
Jet Engine 3	38	1	10	"#3 STARTER ENGAGING"
Jet Engine 4	38	1	10	"#4 STARTER ENGAGING"

Test Power Terminal:

Recip. Engine 1	32	1	10	"TEST POWER"
Recip. Engine 2	33	1	10	"TEST POWER"

Figure 1-33. (Sheet 17) Fuse and Circuit Breaker List

DC SYSTEM EQUIPMENT FUSES AND CIRCUIT BREAKERS (Continued)

EQUIPMENT OR CIRCUIT	LOCATION (PANEL NO.)	QUAN- TITY	SIZE (AMPERES)	DECAL NOMENCLATURE
Recip. Engine 3	34	1	10	"TEST POWER"
Recip. Engine 4	35	1	10	"TEST POWER"
Recip. Engine 5	36	1	10	"TEST POWER"
Recip. Engine 6	37	1	10	"TEST POWER"
Turn AND Bank Indicator				
Copilot's	5	1	* 5	"TURN & BANK IND. COPILOT"
Pilot's	5	1	* 5	"TURN & BANK IND. COPILOT"
Turret Interlocking Relay	25	1	† 5	"TURRET DOOR IN'LOCK"
Turret Sight Test Receptacle:				
Aft	28	1	*10	"28V DC RECP."
Forward	17	1	20	"GUNSIGHT CHECKER"
Water Injection (Control) — Recip. Engines 1, 2, 3, 4, 5, & 6	10	6	† 5	"ENGINE WATER INJECTION 1, 2, 3, 4, 5, & 6"
Windshield Wiper (Control), Pilots'	5	1	* 5	"WINDSHIELD WIPER"

Figure 1-33.(Sheet 18) Fuse and Circuit Breaker List

The battery is located in the aft end of the nose wheel well. The battery is connected to the d-c system through a relay which is controlled by a switch (10, figure 1-18) on the engineer's panel. Power for the relay is taken from the battery. During normal operation of the bus the relay is closed, permitting the battery to be charged by the transformer-rectifier units. The battery supplies a continuous source of d-c power to the alarm bell control switch on the pilots' instrument panel and to the destructor unit of the AN/APX-6 identification set at the radio operator's station. This feature permits direct operation of these units, regardless of the position of the battery switch.

A complete loss of a-c power will result in a loss of d-c power except for that stored in the battery. If a failure of this nature is encountered, it is recommended that battery power be conserved as much as conditions will allow so that systems requiring dc, such as the propeller reverse pitch and feathering systems, can be operated in the event of an emergency. Refer to Section III for emergency electrical power operation.

Battery Switch.

This two-position ON-OFF switch controls the battery relay which connects the battery to the d-c power distribution system.

Transformer-Rectifier Test Unit.

A transformer-rectifier test unit (figure 1-31), installed on the radio operator's equipment shelf, is provided to check the voltage and amperage output of the six transformer-rectifier units. It is also used to check the voltage of the battery. The unit consists of a selector switch, a voltmeter, and an ammeter.

Transformer-Rectifier Test Unit Selector Switch. A selector switch having eight positions — RADIO OPER, CO-PILOT, BOMBARD, BATTERY VOLTAGE, AFT, CENTER, FWD, and OFF—is provided to select the t-r unit to be tested. Placing the switch in the RADIO OPER, CO-PILOT, or BOMBARD position selects the t-r unit to be tested in the forward cabin. Placing the switch in the AFT, CENTER, or FWD position selects the t-r unit to be tested in the bomb bay. The BATTERY VOLTAGE position is provided to check the voltage of the battery.

Transformer-Rectifier Test Unit Voltmeter. Voltage output of the unit being tested is indicated by the voltmeter.

Transformer-Rectifier Test Unit Ammeter. This meter is provided to indicate the amperage output load of the unit being tested. A reading of 1.0 on the meter indicates 100 per cent (50 amperes) output.

EMERGENCY ELECTRICAL SYSTEM.

In the event all alternators "jump" off the line, an emergency circuit is provided to restore enough power to operate essential electrical equipment. The emergency circuit begins at the terminals of each alternator and goes through the voltage and frequency selector switch to an emergency power switch. By use of the emergency switch, a-c power is fed to the pilot's flight instrument switch and the radio operator's transformer-rectifier. The d-c output of the t-r unit can be used to close the alternator breaker when attempting to get an alternator back on the line or, if such attempts fail, to operate essential d-c equipment (See figure 1-34.)

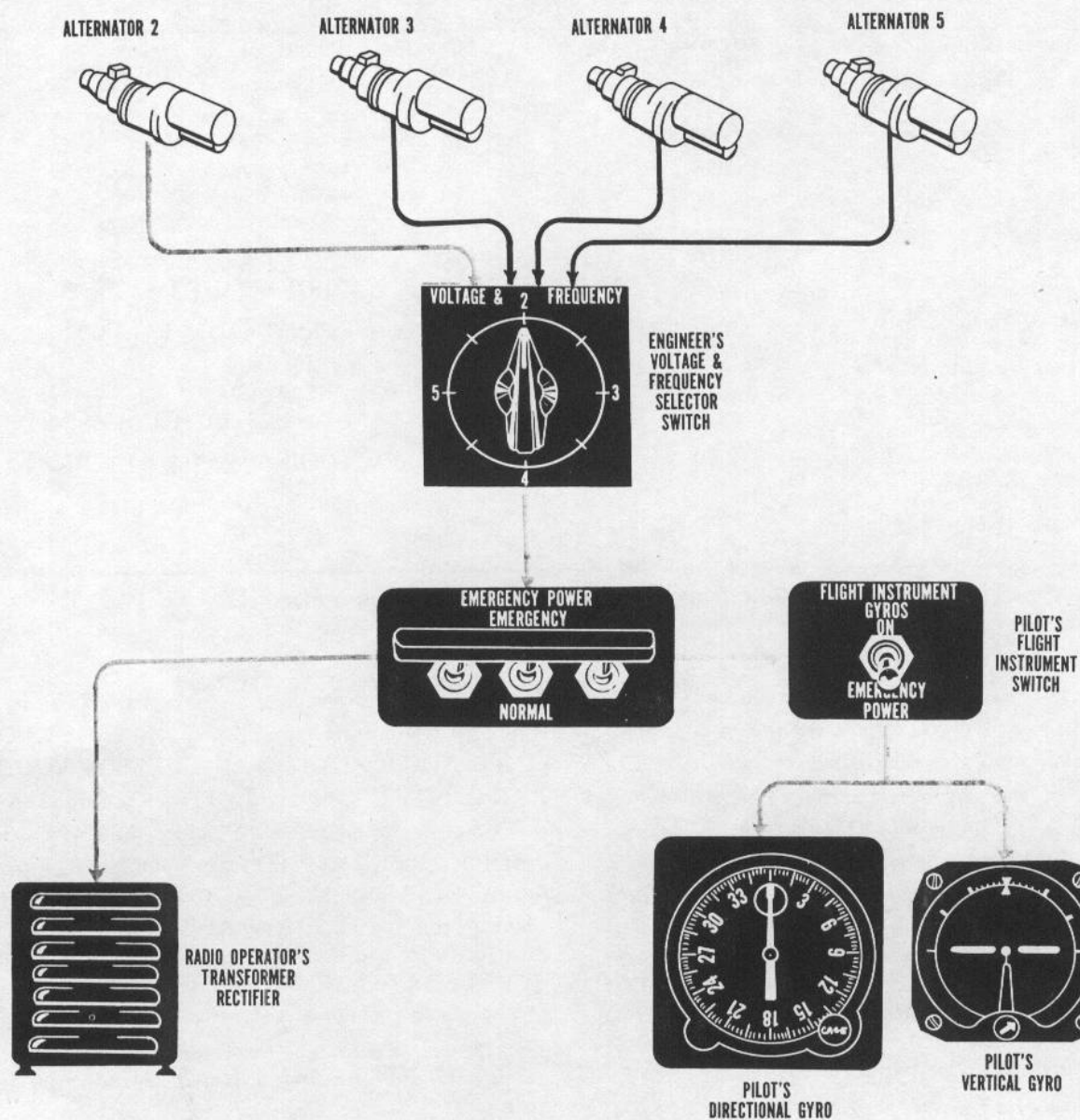


Figure 1-34. Emergency Electrical Power Distribution

CI-339-C

WARNING

Do not permit the d-c load to exceed 1.0 (50 amperes) as indicated on the load meter of the transformer-rectifier test unit, when selected to the RADIO OPER position. An overload can damage the t-r unit with a resulting loss of all emergency power.

Emergency Power Control.

The emergency power control (27, figure 1-18) consists of three two-position switches ganged together on the engineer's auxiliary instrument panel. Placing the switches in EMERGENCY completes the emergency power circuit; moving the switches to NORMAL breaks the circuit. During normal operation the switches should always be in the NORMAL position.

ALTERNATE SOURCE OF A-C POWER TO ENGINEER'S FUSE PANEL.

A two-position switch (figure 1-35), is located on the engineer's fuse panel. This switch has positions marked NORMAL and ALTERNATE and is used to select one of two sources of a-c power for the engineer's fuse panel. This switch is wired in the NORMAL position, and power is supplied from the right forward cabin panel. The ALTERNATE position provides power from the left forward cabin power panel. Adjacent to this switch is a lamp which indicates when power from either source is being supplied to the engineer's fuse panel.

HYDRAULIC SYSTEM.

The hydraulic system is composed of four independent systems: a main system, a brake system, and two emergency systems. Each system has its own reservoir and selector valve. Main system pressure is supplied by two electrically driven pumps. Hand pumps provide pressure for the emergency systems. The main system operates the landing gear, bomb bay doors, and nose wheel steering. Pressure from one emergency system can be used to extend the landing gear or to charge the brake system accumulators.

Note

Normally, brake pressure is supplied by an independent hydraulic system. For detailed information refer to "Brake System" of this section.

The other emergency system can be used to open or close the bomb bay doors.

MAIN HYDRAULIC SYSTEM.

The main hydraulic system supplies fluid pressure for landing gear, nose wheel steering, and bomb bay door operation. The system consists of a reservoir, two elec-

trically driven hydraulic pumps, and a main selector valve.

The main system reservoir, located on the wing front spar inside the fuselage, is provided with a sight level gage and filler neck. Fluid can be added during flight. For servicing information, refer to figure 1-52.

The main hydraulic system pumps operate whenever the associated control switch for landing gear operation, nose wheel steering, or bomb bay door operation is actuated.

Note

For information concerning these switches refer to "Landing Gear Switch" and "Steering Switch" of this section and "Bomb Bay Door Switch" of Section IV.

Both pumps operate for landing gear retraction and bomb bay door operation. Only one pump operates during landing gear extension and nose wheel steering. The pumps operate on 200-volt a-c power received through relays which are controlled by 28-volt direct current and deliver approximately 3100 psi fluid pressure to the system.

CAUTION

To prevent overheating of the hydraulic fluid,

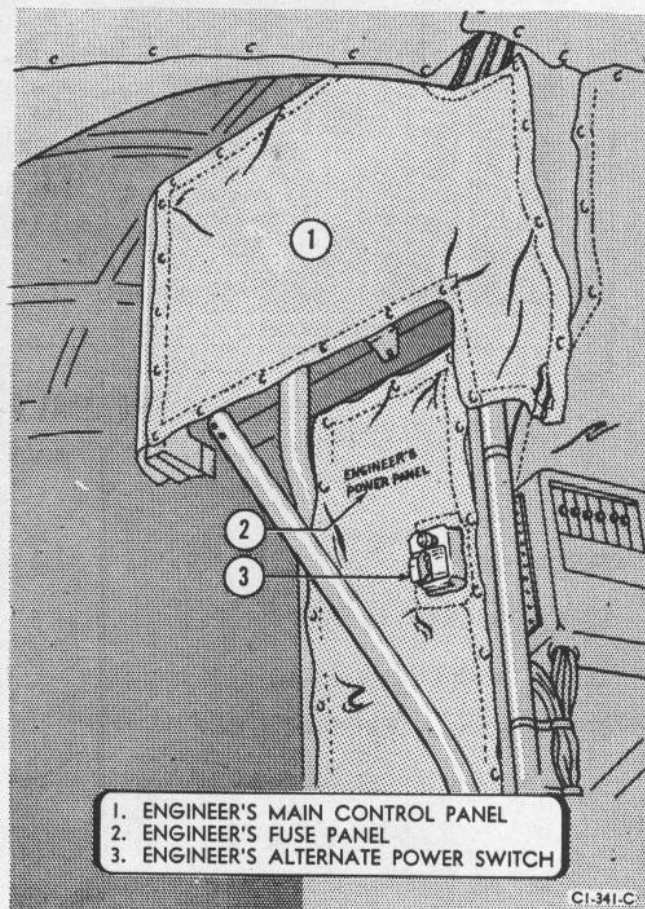
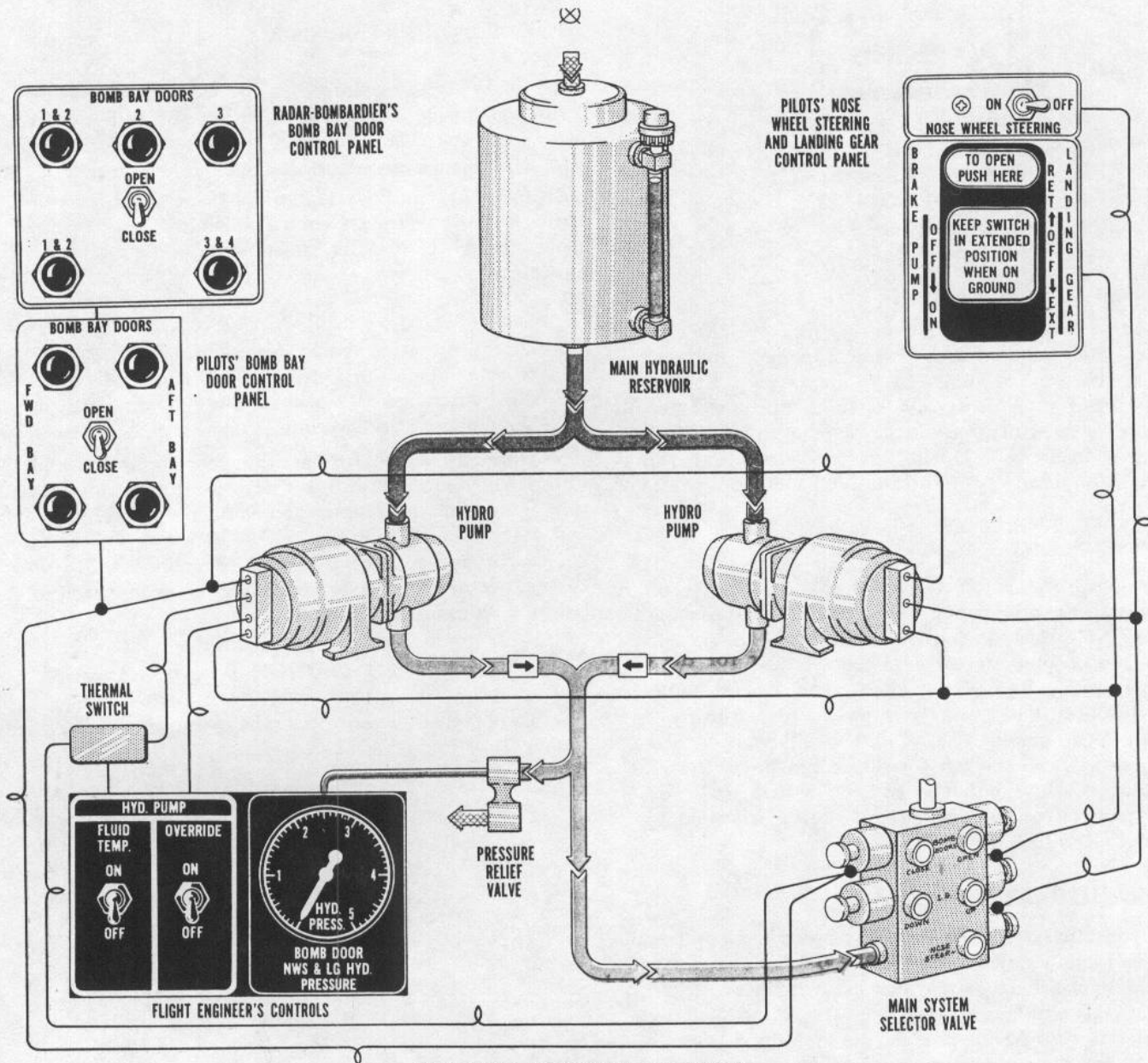
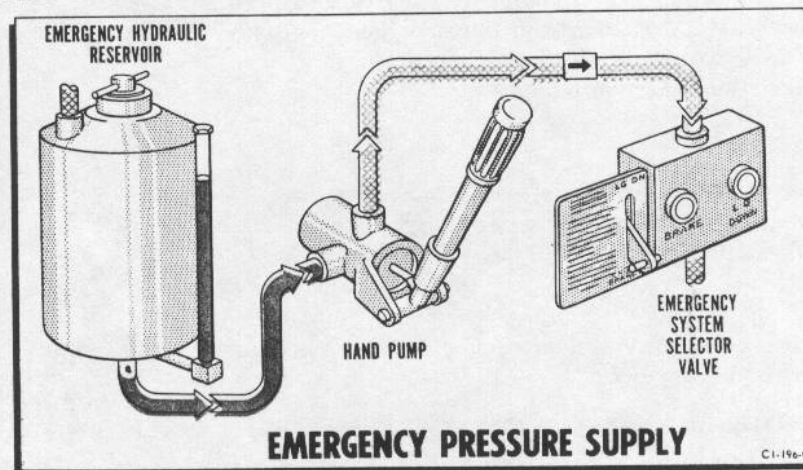


Figure 1-35. Alternate Power Switch



NORMAL PRESSURE SUPPLY

- SUPPLY
- PRESSURE
- RETURN
- EMERGENCY PRESSURE
- CHECK VALVE



EMERGENCY PRESSURE SUPPLY

Figure 1-36. Hydraulic Power Supply Schematic

limit pump operation to one retract or extend cycle in each 5-minute period.

The main system selector valve, located on the wing front spar inside the fuselage, is controlled by 28-volt direct current. The valve controls fluid pressure from the main pumps to the landing gear, nose wheel steering, and bomb bay door mechanisms. In the event of an electrical failure, the valve for the selected system can be operated manually as directed in "Manual Operation of Main Selector Valve," Section III.

Hydraulic Pump Override Switch.

This spring-loaded switch (2, figure 1-37), is used to control one pump motor during emergency manual operation of the main system selector valve. Holding the switch in the ON position energizes a main hydraulic pump motor.

Hydraulic Fluid Temperature Switch.

This switch (1, figure 1-37) at the engineer's station is used to set up a temperature control circuit for bomb bay door system hydraulic fluid. (Refer to "Hydraulic Fluid Temperature Control," Section IV.)

Hydraulic Pressure Gage.

A pressure gage (6, figure 1-37), at the flight engineer's station indicates the hydraulic pressure for the landing gear, bomb bay door, and nose wheel steering operation.

LANDING GEAR AND BRAKE EMERGENCY HYDRAULIC SYSTEM.

This system consists of a reservoir, a hand pump, and a selector valve, figure 1-36). Since the system serves for emergency operation of both landing gear and brakes, the selector valve is provided so that fluid pressure can be directed to the proper system. The emergency system hydraulic lines are separate from the main system. Shuttle valves are installed between the normal and emergency hydraulic lines so that pressure from either side can close the other line, directing fluid pressure into the actuating units. With the selector valve in LANDING GEAR DOWN position, hand pump operation extends and locks the landing gear. Hand pump operation with the selector valve in CHARGE BRAKE ACCUMULATOR position will supply fluid pressure to charge the brake accumulator. A fully charged accumulator will provide three full brake applications. Refer to "Emergency Hydraulic Landing Gear Extension" and "Emergency Brake Pressure," Section III, for operating instructions.

Note

When the emergency hydraulic system is used for landing gear extension, the main landing gear wheel well doors will not retract after the landing gear is lowered.

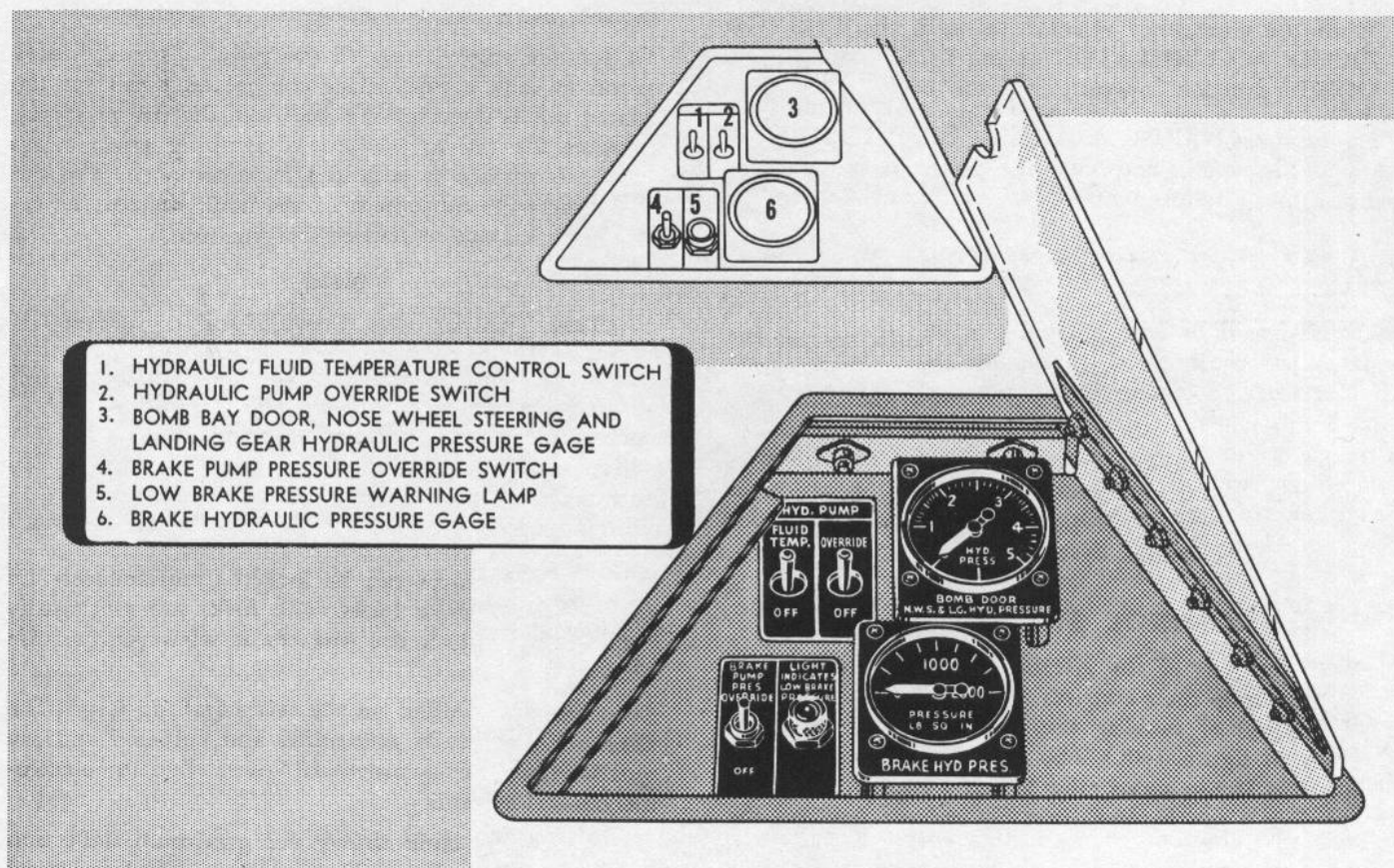


Figure 1-37. Engineer's Hydraulic Control Panel

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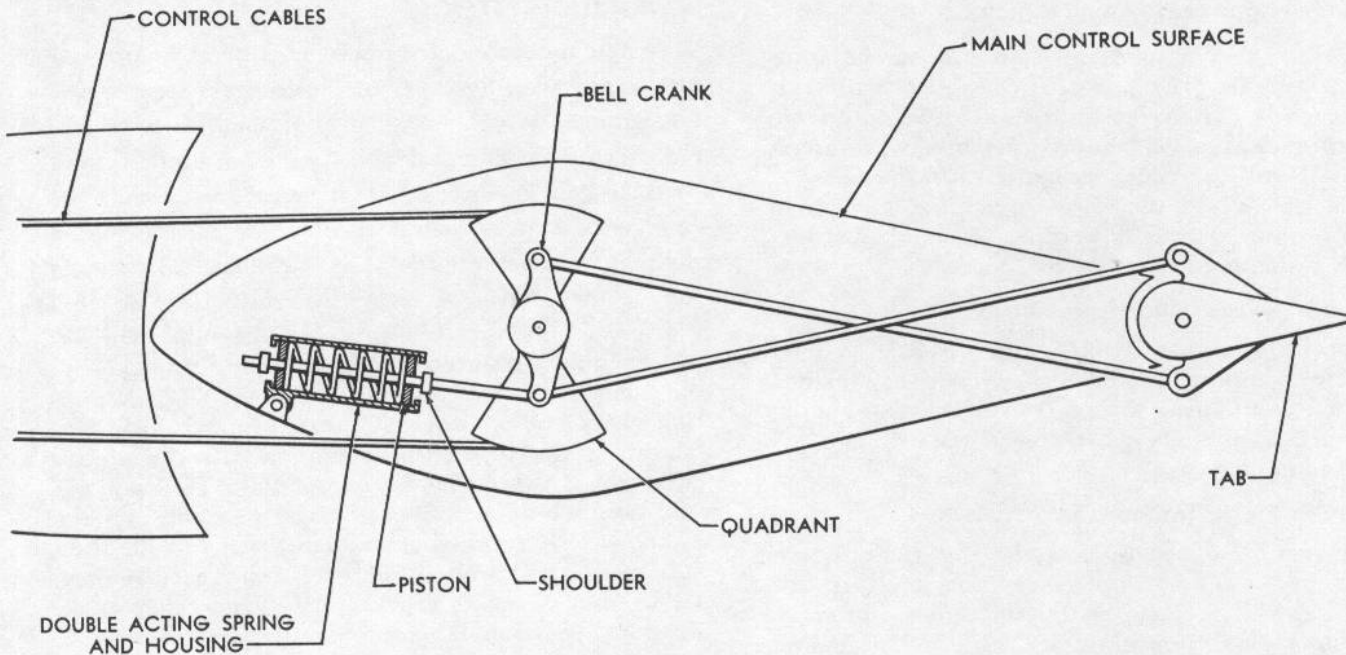


Figure 1-38. Rudder and Elevator Operation

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Emergency Selector Valve Control.

With the emergency selector valve in the CHARGE BRAKE ACCUMULATOR or the LANDING GEAR DOWN position, operation of the hand pump produces the selected action. Normally the valve should be left in the CHARGE BRAKE ACCUMULATOR position. This permits any pressures caused by thermal expansion to be relieved in the accumulators.

BOMB BAY DOOR EMERGENCY HYDRAULIC SYSTEM.

The bomb bay door emergency hydraulic system has a separate reservoir, hand pump, selector valve, and hydraulic lines. The emergency lines are connected to the bomb bay door main actuating units through shuttle valves in an arrangement similar to that in the landing gear emergency system. For operation of this system, refer to "Operation of Bomb Bay Door Emergency Hydraulic System," Section IV.

FLIGHT CONTROL SYSTEM.

The movement of the ailerons, elevators, and rudder in response to their controls is conventional; however, the method of moving the main surfaces is unique. (Refer to figure 1-38.) The control are mechanically linked to flying servo tabs. When a control is moved to deflect a tab in one direction, the air load on the displaced tab causes the main surface to be deflected in the opposite direction. Even though an extra stage of action is involved between the control movement

and the main surface movement in this method, response time is less than one-tenth of a second.

To provide control feel to the pilot, a spring-loaded piston in each main surface compresses whenever the related tab is deflected. In addition, the piston spring operates the tab to produce a damping effect when the main surface is deflected by turbulence. The tab counteracts the movement of the main surface and restores the surface to its original position.

Note

These pistons also provide for movement of the main surfaces when the airplane is on the ground and there are no air loads on the surfaces. When a tab is moved, the piston spring compresses until the spring load is sufficient to overcome the friction at the main surface pivot points; then the main surface will move.

All control surfaces can be locked simultaneously by means of hydraulic locks. The locks are electrically controlled and lock the surfaces at whatever position they are in.

Six flaps are installed on the wing trailing edge. The flaps are electrically controlled and actuated and are synchronized in symmetrical pairs by an electro-mechanical system.

The following table shows the maximum deflection of all control surfaces. The reference point for these deflections is the chord plane of the surface.

Control Surface	Deflection (Degrees)	
	UP	DOWN
Ailerons	20	20
Aileron Servo Tabs	25	25
Elevators	25	20
Elevator Servo Tabs	20	20
Elevator Trim Tabs	24	12
Flaps	—	30
	RIGHT	LEFT
Rudder	16	16
Rudder Servo Tab	14	14
Rudder Trim Tab	20	20

SURFACE CONTROLS.

Control Columns and Rudder Pedals.

The aircraft commander's and pilot's stations are each provided with a control column (figure 1-8) and a set of rudder pedals. Operation of the columns and pedals is conventional.

Aileron Trim Tab Switch.

The aileron tab acts as a trim tab as well as a servo tab. A spring-loaded switch (20, figure 1-13), located on the pilots' pedestal, supplies 28-volt direct current to relays which supply 200-volt a-c power to the trim tab actuators. The switch positions are LEFT WING DOWN, RIGHT WING DOWN, and neutral OFF.

Aileron Trim Indicator.

An indicator (18, figure 1-12), on the pilots' instrument panel, shows the degree of aileron trim. The indicator operates on 28-volt direct current in response to a signal from potentiometers on the trim tab actuators.

Elevator Trim Tab Control Wheels and Indicators.

The elevator trim tabs are set by a pair of dual-operating control wheels (14, figure 1-13) on the pilots' pedestal. A rotatable dial on the hub of each wheel indicates the trim condition of the tabs.

Rudder Trim Tab Control Knob and Indicator.

Rudder trim is set by a control knob (16, figure 1-13) located on the pilots' pedestal. A rotatable dial around the base of the knob indicates the trim setting of the rudder trim tab.

CONTROL SURFACE LOCKS.

The flight control surfaces are hydraulically locked in the position they are in when the locks are engaged. The locks prevent any sudden movement of the surfaces, but allow the surfaces to creep under load; therefore, locked controls will not restrict small movements of the control columns or rudder pedals. A safety switch, actuated by the movement of the right main oleo strut, automatically unlocks the controls as soon as the weight of the airplane is removed from the gear.

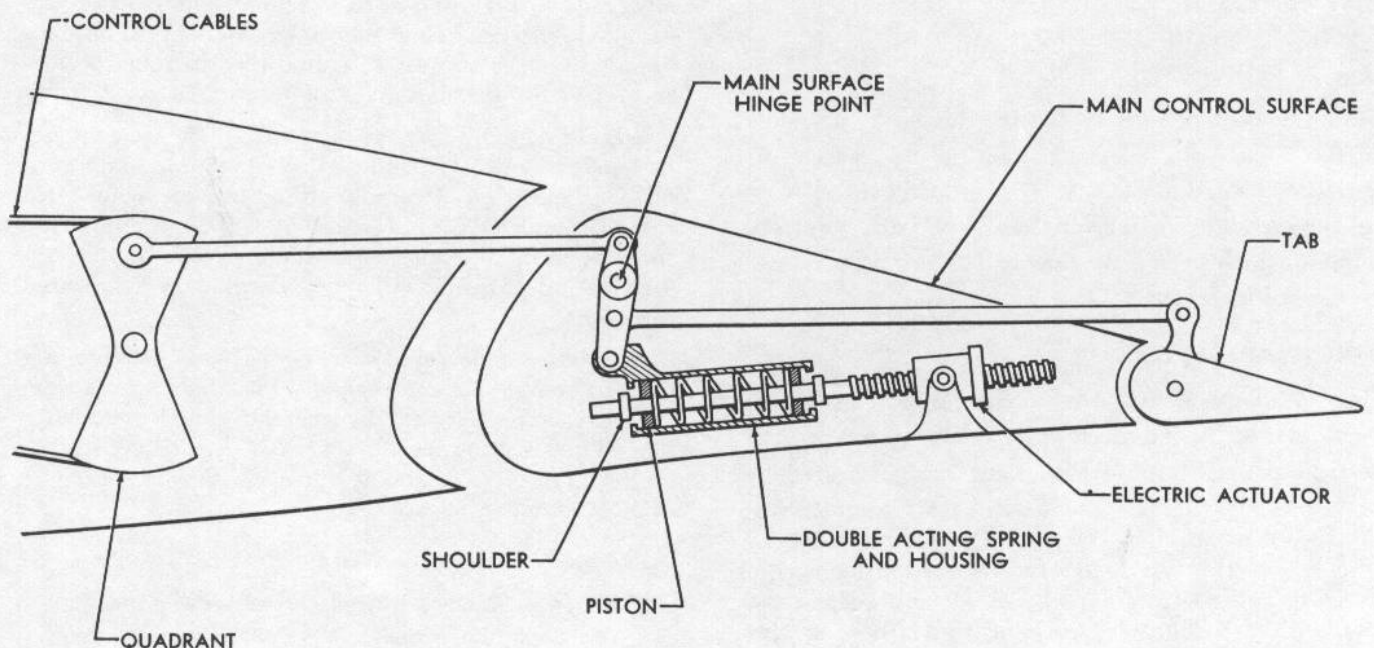


Figure 1-39. Aileron Trim and Flying Servo Tab Operation

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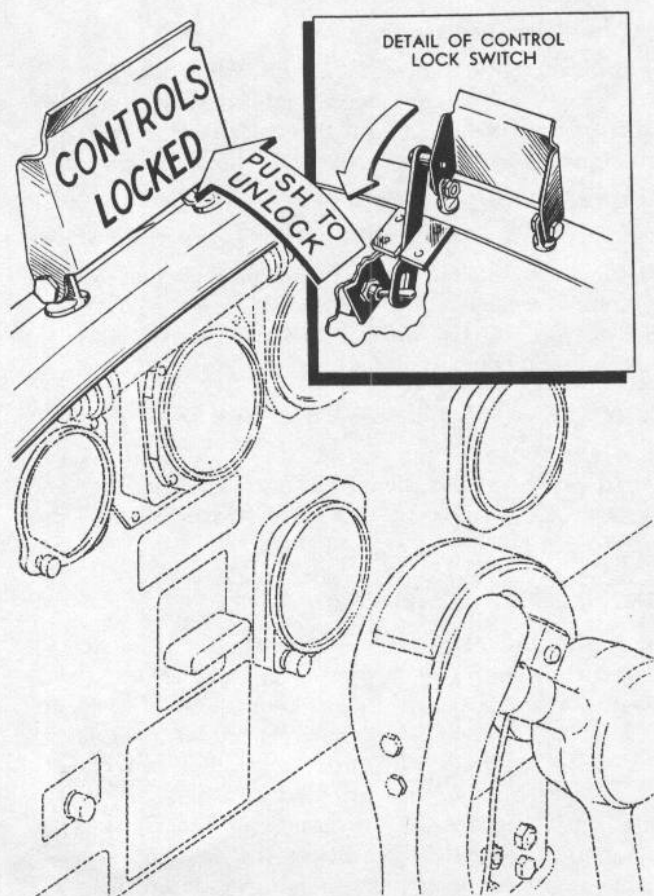


Figure 1-40. Flight Control Lock Switch

Indicator lamps show when the surfaces are locked or unlocked.

Control Lock Switch.

The flight control lock switch is actuated by a yellow flag on the pilot's coaming. Raising the flag to its vertical **CONTROLS LOCKED** position locks all control surfaces. The switch supplies 28-volt direct current to relays which permit the flow of 115-volt a-c power to the control lock actuators.

WING FLAP SYSTEM.

The wing flap system consists of six slotted flaps which are mechanically and electrically synchronized in symmetrical pairs. Normally, all flaps are controlled by three ganged switches. These switches supply 28-volt direct current to close relays which provide 200-volt a-c power to the flap actuators. A synchronizer is connected to each pair of flaps by cables and keeps these flaps within 2 degree of each other. If the flaps become misaligned by 3 degrees, the normal flap control for the unsynchronized pair becomes inoperative. Emergency controls are provided for adjusting each flap individually if the normal control system fails.

Note

When one pair of flaps is inoperative because of misalignment, normal operation of the remaining pairs is unaffected.

Normal Controls.

Flap Switch. This switch (11, figure 1-13) is actually three switches ganged together and is located on the pilots' pedestal. The switch has spring-loaded UP and DOWN positions and a center OFF position.

Indicators.

Flap Position Indicator. This indicator (20, figure 1-12) is located on the pilots' instrument panel and consists of three separate indicators. Each individual indicator reflects the position of one pair of flaps as transmitted from the associated flap synchronizer.

Warning Horn. A warning horn, which is also used for landing gear warning, is provided for the flap system. The horn is electrically connected to the synchronizers and the throttles and indicates an unsafe condition of the flaps with respect to throttle position.

If all throttles are advanced to take-off power and the flaps are not extended at least 20 degrees, the horn will sound. No silencing button is provided for this circuit; therefore, the throttles must be retarded or the flaps extended to shut off the horn.

Emergency Controls.

An emergency flap control panel is located on the right side of the fuselage near the wing crawlway hatch. A separate 28-volt d-c source (bulkhead 8.0 power panel) is provided for this emergency panel. Three master selector switches are mounted at the top of the emergency panel, and six individual flap switches are grouped by pairs below the master switches. The individual switches supply 28-volt direct current to close the relays for the flap actuator motors.

Emergency Flap Switches. Each of these six switches has spring-loaded UP and DOWN positions and a center OFF position. Holding either of the switches in the UP or DOWN position and then holding the corresponding flap master selector switch in the **ALTERNATE** position will move the flap in the desired direction.

Flap Master Selector Switches. These switches are used to complete the emergency circuit for the system that has been "set up" by the individual emergency flap switches. Each master switch is marked **NORMAL** and **ALTERNATE**, and is spring-loaded to return to **NORMAL** when released.

Note

When a flap is adjusted to the same position as its symmetrical flap, the synchronizing system (if operative) will maintain synchronization; therefore, any further actuation of the selector switch will result in the movement of both flaps.

LANDING GEAR SYSTEM.

The airplane has a tricycle landing gear consisting of two four-wheel main gears and a two-wheel nose gear. The nose and main gear and the main gear wheel well doors are hydraulically operated. The other fairings are mechanically operated by the movement of the gear.

The main landing gear is designed so a single oleo strut on each main gear cushions the taxiing, take-off, and landing shocks. Each set of dual wheels in the tandem arrangement is attached to the bottom of the main column by a separate axle beam which permits it to pivot up and down independent of the other set. These separate axles will permit one set of duals to pass over an obstacle approximately 16 inches high while the other set remains in contact with the runway. To permit even distribution of loads, the sets of duals in tandem are linked together through an equalizer which pivots on the main column; the aft set of duals is linked to the aft end of the equalizer by the oleo strut and the forward set is linked to the forward end by a fixed link. This system transfers the shocks taken by either set of duals to the oleo strut.

Hydraulic pressure for landing gear operation is furnished by the main hydraulic system pumps. The pumps supply fluid under pressure to the main selector valve where the fluid is directed to either the extension or retraction mechanism. The landing gear is normally operated by a single switch located on the pilots' pedestal. In the event the normal system fails, emergency controls are provided for gear operation. These include a means of manually positioning

the main selector valve for retraction or extension of the gear, an emergency hydraulic landing gear extension system, and a method of releasing the gear for a free fall extension.

A safety switch, actuated by the oleo strut on the left main gear, prevents gear retraction while the airplane is on the ground. Ground safety locks (figure 2-7) are provided in the flyaway tool kit. When installed they prevent unlatching of the gear.

NORMAL CONTROLS.

Landing Gear Switch.

The landing gear switch (5, figure 1-13) is located on the pilots' pedestal and has positions marked EXTEND and RETRACT on either side of a center OFF position. When the switch is moved from OFF to RETRACT, both main system hydraulic pumps are started and the main selector valve is positioned to retract the landing gear. When moved from OFF to EXTEND, the switch starts one hydraulic pump and positions the selector valve for landing gear extension.

Note

When the landing gear control switch is moved to EXTEND, a gang bar automatically turns on a brake pump control switch to prevent landing with low brake pressure. Refer to "Brake Pump Switch" of this section.

Landing Gear Indicator Lamps.

Two landing gear indicator lamps (28, figure 1-12) are located on the pilots' instrument panel. One lamp is red and the other is green, and they indicate a

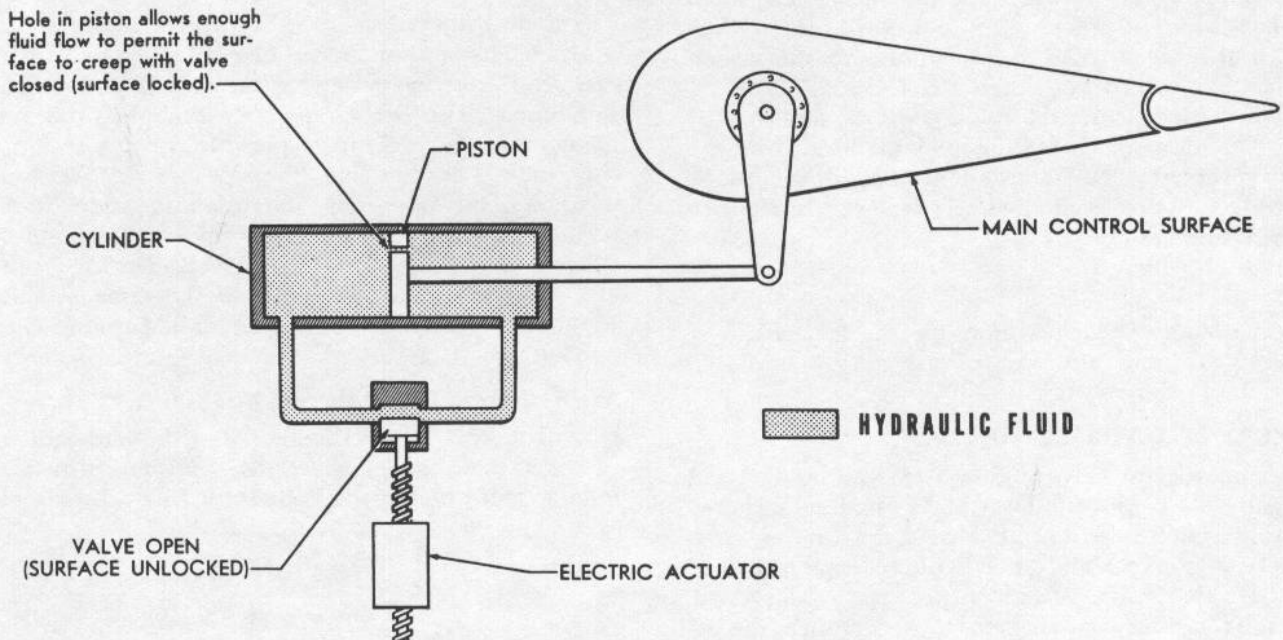


Figure 1-41. Flight Control Lock Operation

RESTRICTED

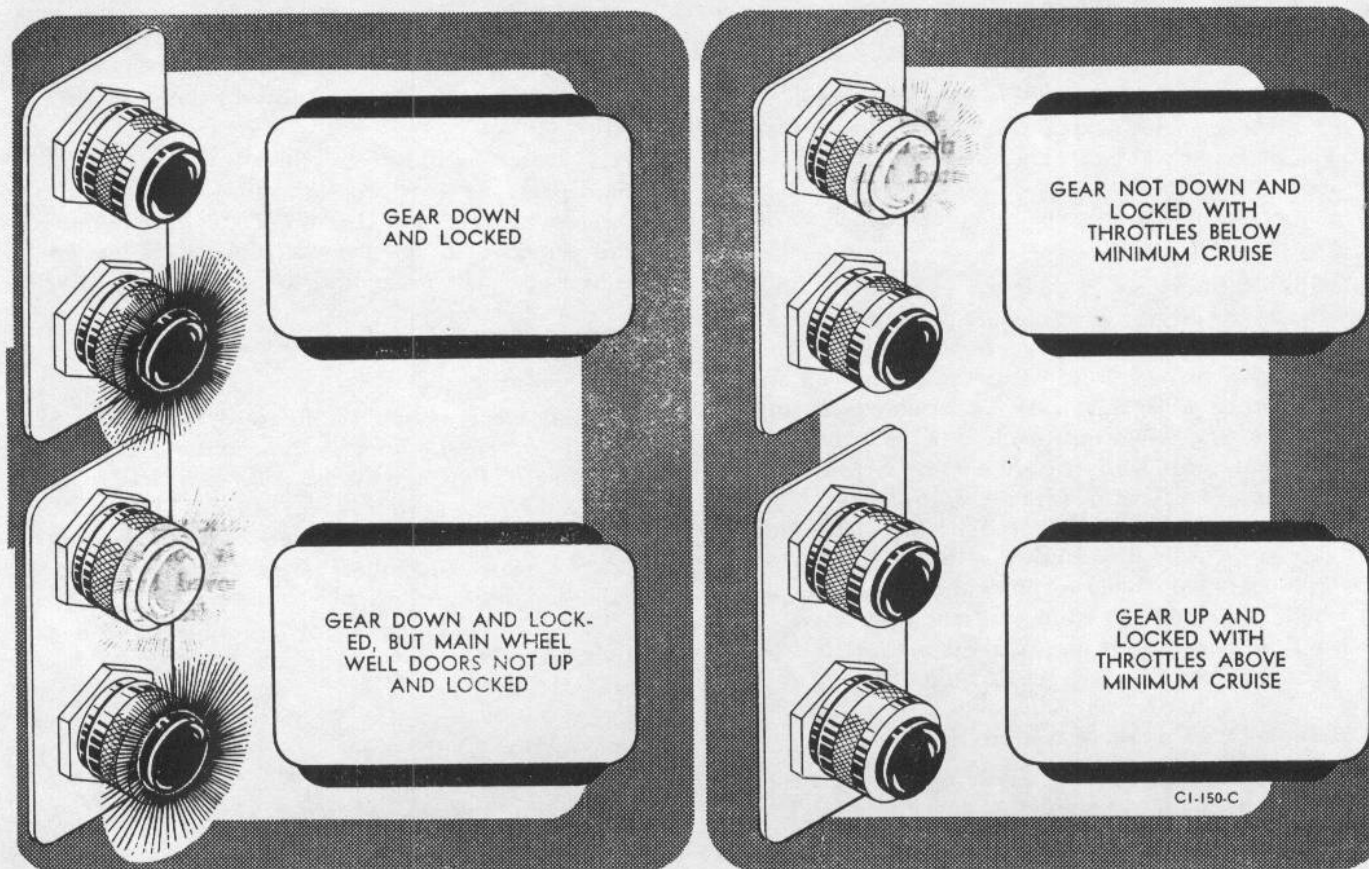


Figure 1-42. Landing Gear Position Indications

safe or unsafe condition of the landing gear. See figure 1-42.

Warning Horn.

The landing gear warning horn, which is also used for flap position warning, provides warning when any throttle is retarded below minimum cruise and the landing gear is not down and locked. The warning horn is located on the pilots' pedestal and may be shut off with a switch (15, figure 1-13) located on the pilots' pedestal. The sounding of the horn must be stopped each time a single throttle lever is retarded below minimum cruise.

Note

The landing gear warning and the flap position warning are connected to the horn through different circuits.

MANUAL SELECTOR CONTROLS.

The main selector valve (figure 3-13) can be operated manually in conjunction with the hydraulic pump override switch to extend or retract the landing gear. A DOWN plunger and an UP plunger are provided on the valve body. When a plunger is depressed, hydraulic pressure is directed to accomplish the selected action. Plungers are also provided for operating the bomb bay doors and nose wheel steering.

MAIN GEAR MANUAL EXTENSION CONTROL.

The main gear may be released manually for a free fall extension through the use of manual controls (figure 3-14) located in each main gear wheel well.

The main gear is locked in both the UP and DOWN positions by a side brace. The side brace pivots on each end, and has a latch-secured breaking point in the center. The breaking point is slightly off-center from the ends, making it possible for the weight of the landing gear to hold the side brace in its locked position. During normal extension the side brace is unlatched and pulled off center by linkage connected to the side brace unlatching jack. During manual extension the hoist accomplishes the same actuation. Refer to "Manual Extension of Main Landing Gear," Section III.

Main Gear Door Release Handle.

One of these T-handles is located at the outboard edge of each main gear wheel door. When turned, the handle will unlatch the door for a free fall extension.

WARNING

The handle is attached to the door and will fall when the door is unlatched.

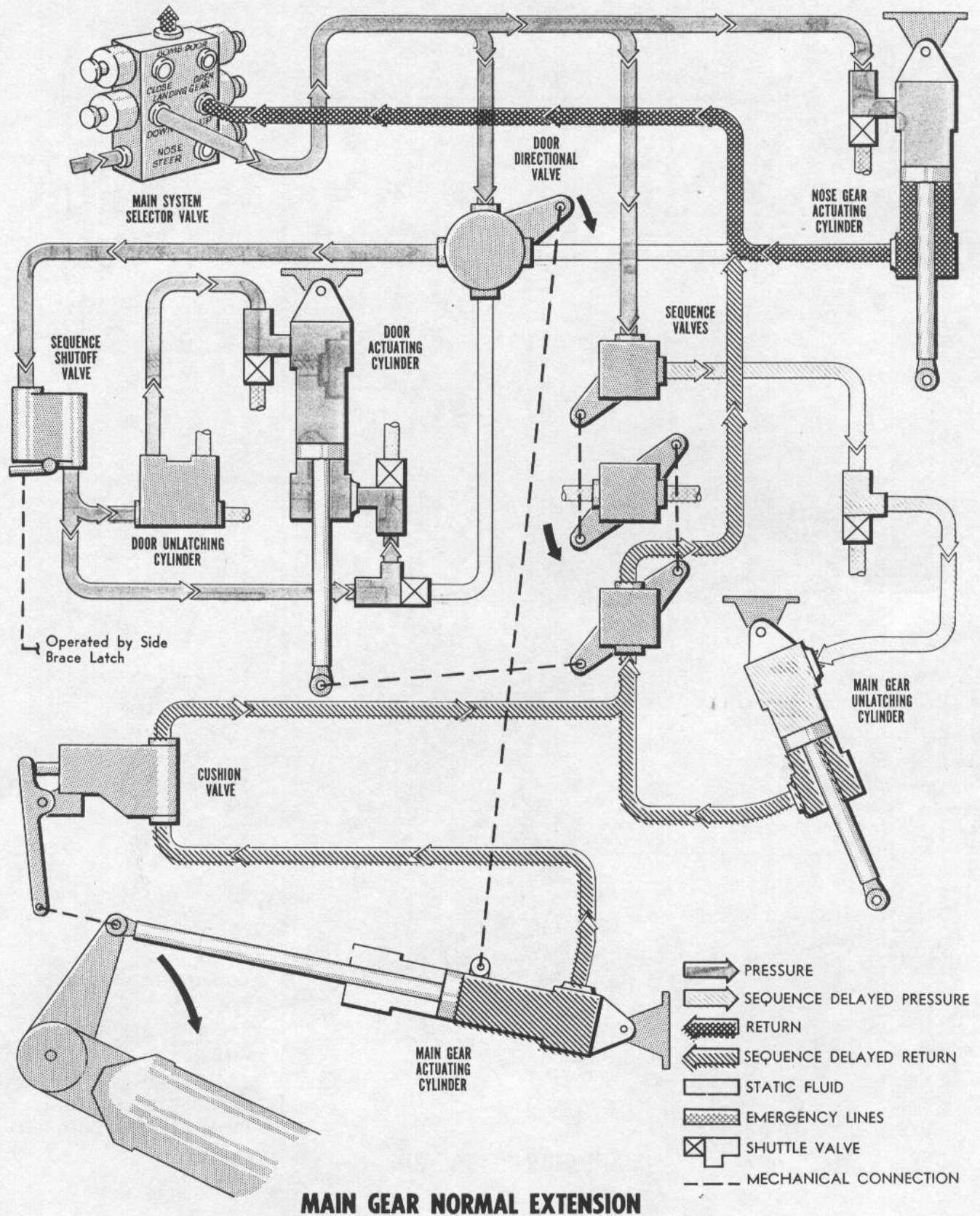


Figure 1-43. Landing Gear Normal Extension Schematic

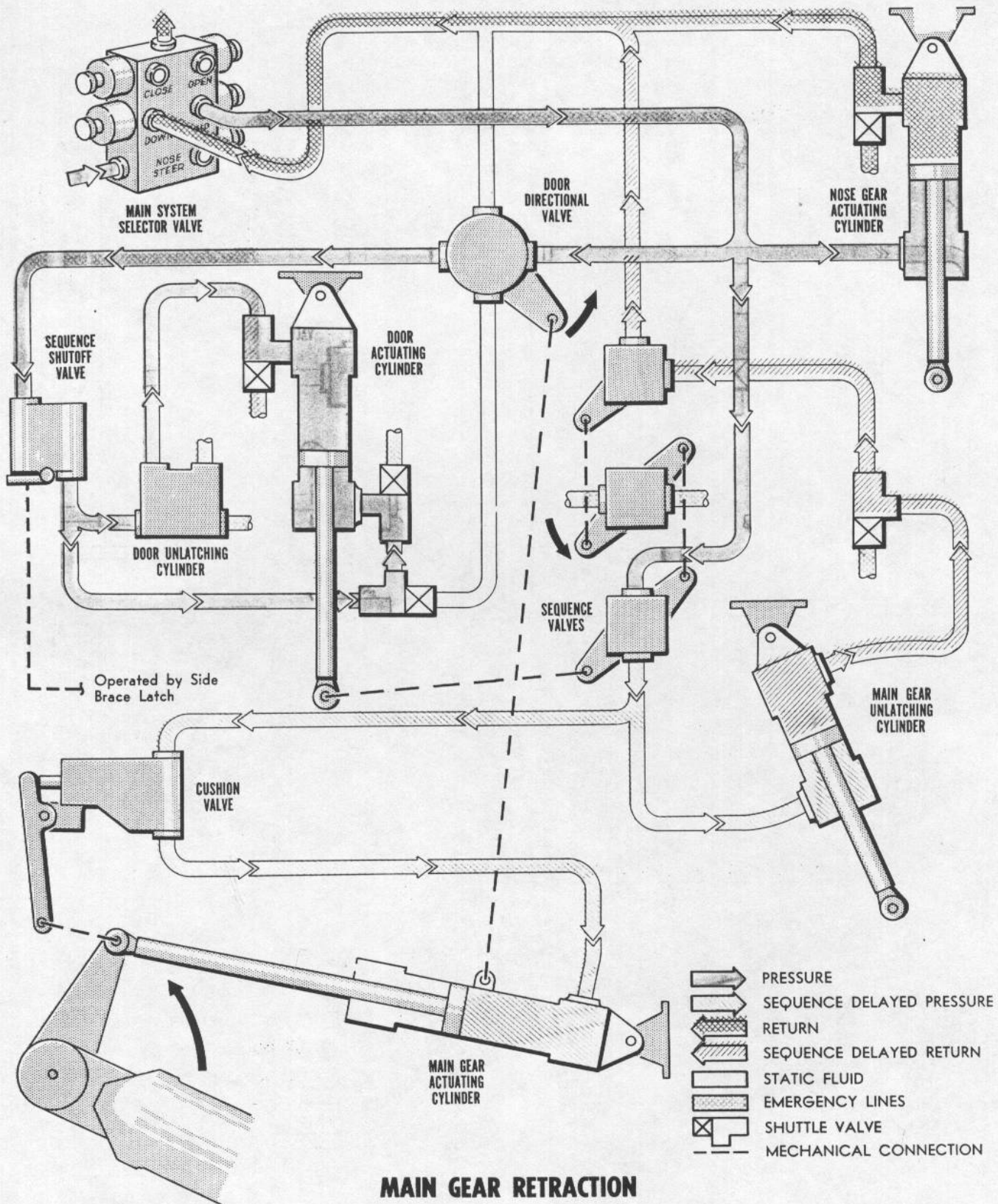
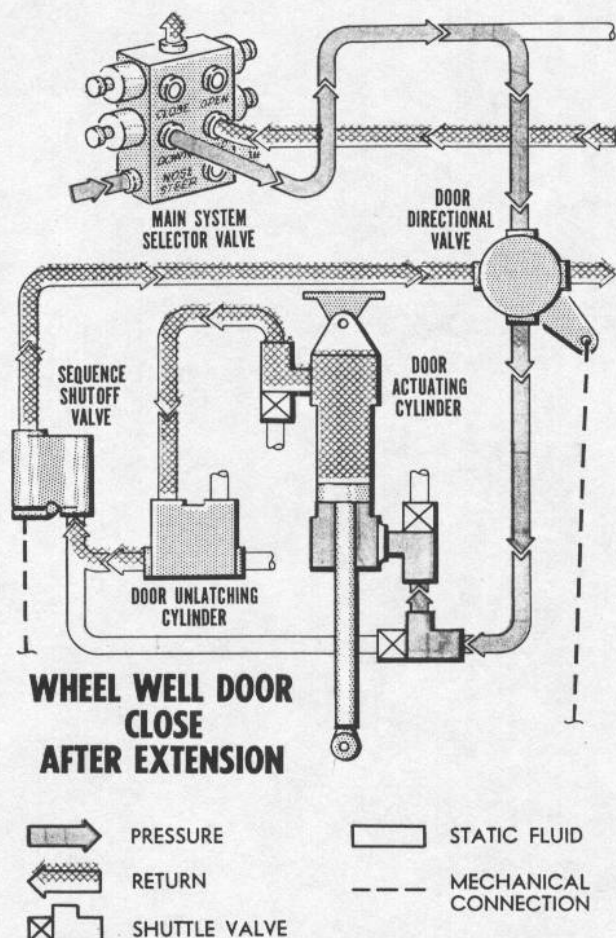


Figure 1-44. Main Gear Retraction Schematic

CI-197-C



**WHEEL WELL DOOR
CLOSE
AFTER EXTENSION**

C1-346C-C

Figure 1-45. (Sheet 1) Main Wheel Well Door Actuation Schematic

Latch Link Pin.

This pin is painted red and is in the side brace unlatching linkage. Normally this linkage is operated by a hydraulic unlatching jack; however, during manual extension the unlatching linkage is disconnected by pulling out the latch link pin. This prevents the possibility of pressure in the hydraulic system interfering with manual unlatching.

Manual Hoist.

A manual hoist is located above the side brace of each main landing gear. The hoist is operated by a ratchet handle and is rigged with a cable which is attached to a hoist hook. To unlatch and raise the side brace the hoist hook is engaged with a latch release lever and the hoist is operated until the side brace is unlocked.

Latch Release Lever.

A latch release lever is located on the side brace latching mechanism of each main gear. The lever has a fitting to which the manual hoist hook is engaged for unlocking the side brace.

NOSE GEAR MANUAL EXTENSION CONTROLS.

Nose Gear Release Handle.

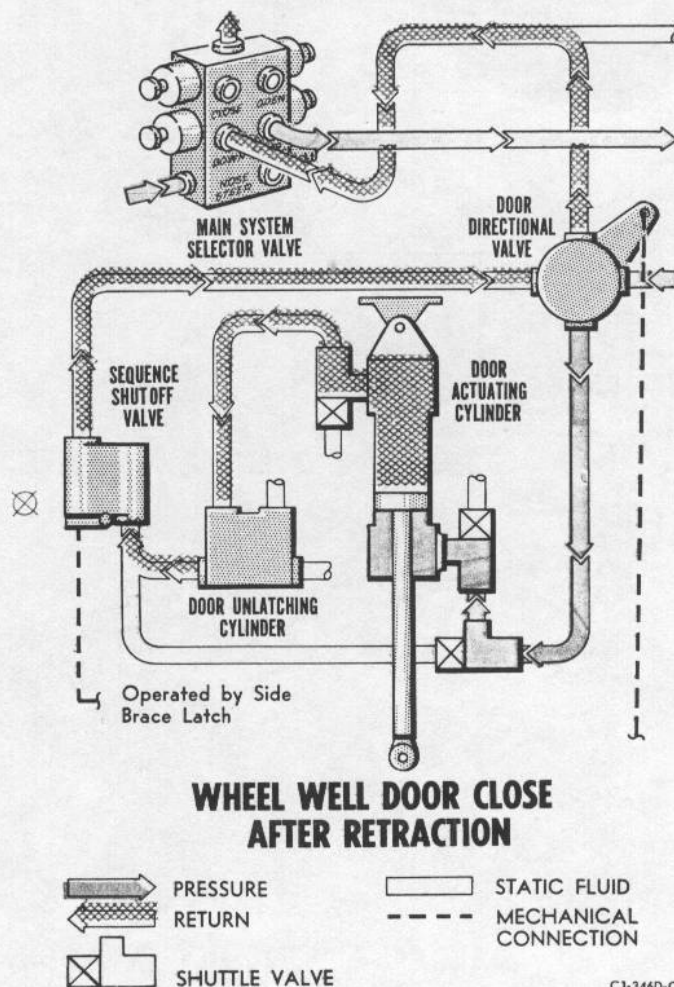
This release handle (figure 3-17) is located on the floor near the radio operator's station, and when pulled will unlock and allow a free fall extension of the nose gear. (Refer to "Manual Extension of Nose Landing Gear," Section III.)

Nose Landing Gear Emergency Latch Hook.

This latch hook (figure 3-17) stowed on the side of the food locker, is used to operate the latch after an emergency manual extension of the nose gear has been effected.

NOSE WHEEL STEERING SYSTEM.

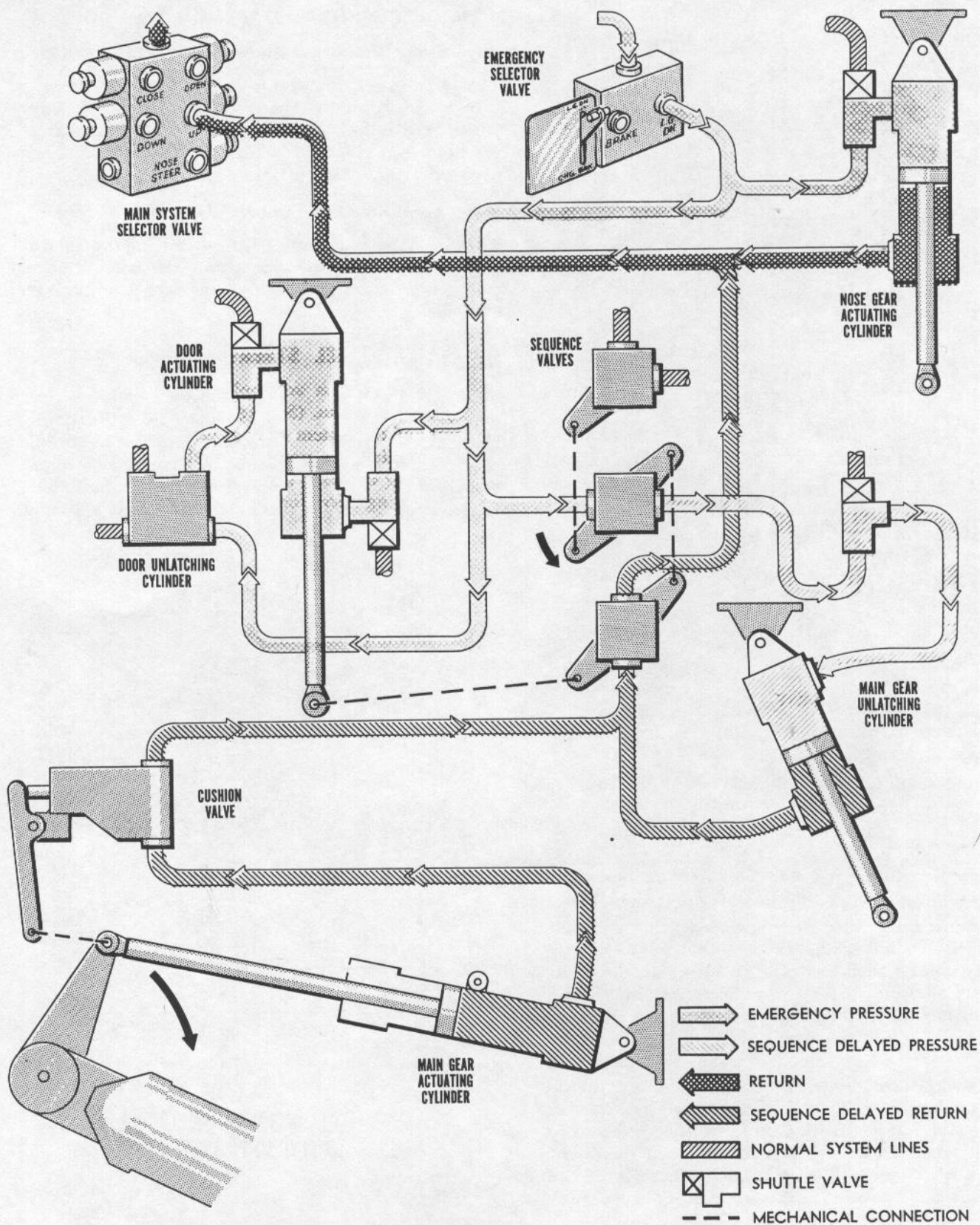
Nose steering is accomplished by a cable-controlled hydraulic system. (See figure 1-48.) The main components of the system are a steering switch, a 28-volt d-c control circuit, a steering wheel, a directional valve, an actuating cylinder, and control cables. Hydraulic fluid for steering operation is supplied by the main hydraulic



**WHEEL WELL DOOR CLOSE
AFTER RETRACTION**

C1-346D-C

Figure 1-45. (Sheet 2) Main Wheel Well Door Actuation Schematic



MAIN GEAR EMERGENCY EXTENSION

C1-200-C

Figure 1-46. Landing Gear Emergency Extension Schematic

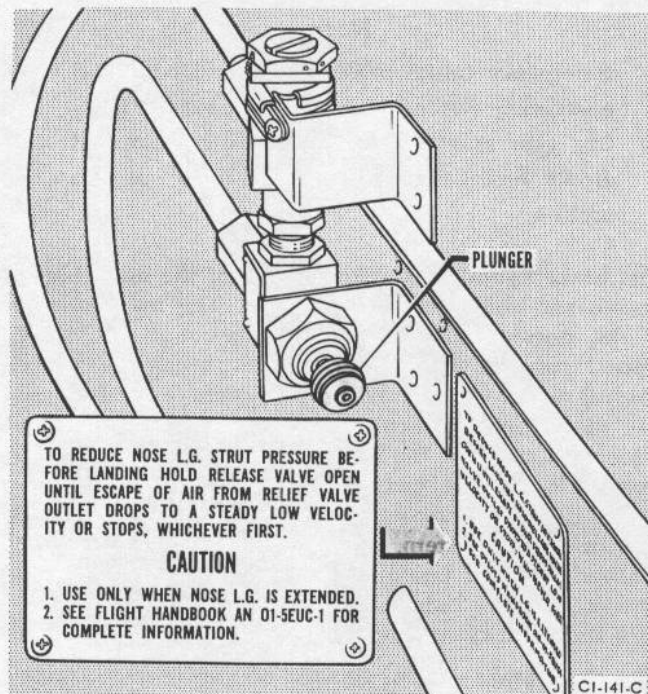


Figure 1-47. Nose Gear Strut Pressure Release Valve

system, and pressure is provided by one of the main system pumps. Movement of the steering wheel directs the pressure into the geared actuator which turns the nose wheel. Nose steering hydraulic pressure is indicated on the main hydraulic system pressure gage. A safety switch installed on the nose gear scissors renders the steering system inoperative when the nose gear is off the ground.

Note

A safety switch on the left main landing gear also prevents steering when the main gear is off the ground.

When the nose gear leaves the ground and the nose gear strut extends, centering cams are engaged to keep the nose wheel straight during retraction. Upon landing, the cams disengage when the weight of the airplane compresses the strut three inches or more. If the nose gear strut has been heavily charged with air to support a large gross weight at take-off, the weight of the airplane at landing may not be sufficient to compress the strut the required three inches for disengaging the cams. In this condition, the nose gear will remain locked in its center position. Before landing, the strut must be depressurized by the nose gear strut pressure release valve located in the forward turret bay.

CONTROLS AND INDICATORS.

Steering Wheel.

This wheel (figure 1-8) is located on the aircraft commander's fairing to the left of the aircraft commander's control column and directs the action of the nose gear.

Steering Switch.

This ON-OFF switch (4, figure 1-13) is located on the pilots' pedestal. This switch energizes one of the main hydraulic system pump motors and actuates the main hydraulic system selector valve to provide the pressure required for nose gear steering.

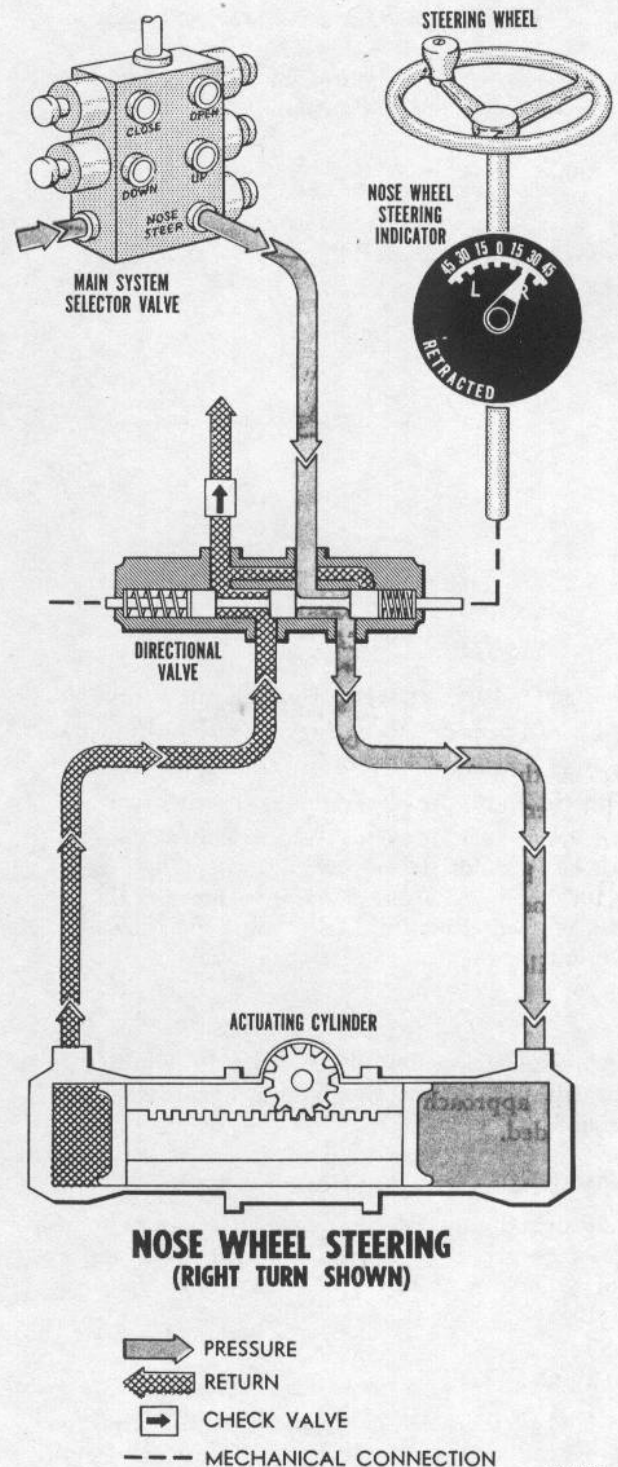
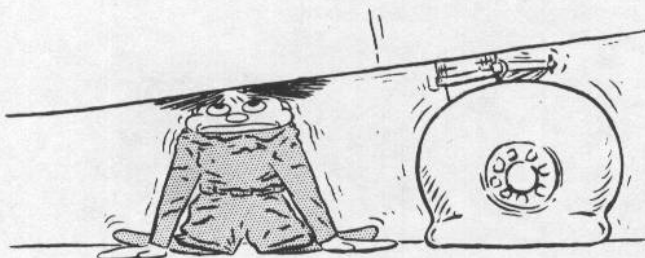


Figure 1-48. Nose Wheel Steering Schematic

Nose Strut Pressure Release Valve.

The manually operated pressure release valve is provided to reduce the pressure in the nose gear strut in flight. (Refer to "Nose Gear Strut Depressurization," Section VII.) The valve is located just aft and to the right of the forward catwalk entrance hatch and is operated by means of a spring-loaded plunger on the valve body. (See figure 1-47.) When the plunger is held in, pressure will be bled from the strut. When strut pressure has dropped to a value which will permit steering, a relief valve automatically closes. This prevents depressurization below the amount necessary to sustain the weight of the airplane.



CI-246-C

CAUTION

The relief valve is set to shut off the escape of air at a pressure occurring when the weight of the airplane is NOT on the nose gear. Therefore, to prevent damage to the strut, the nose gear pressure release valve must not be used for depressurizing when the airplane is on the ground. Also, to prevent the loss of hydraulic fluid, do not depressurize while the nose gear is retracted.

Note

Depressurization should be accomplished during approach after the landing gear is extended.

Nose Wheel Steering Indicator.

An indicator (figure 1-8) is provided adjacent to the nose steering wheel to indicate the direction and degree of deflection of the nose wheel from its center position.

BRAKE SYSTEM.

Each wheel of the main gear on the B-36 is equipped with a hydraulically operated brake. The normal brake system is an independent hydraulic system. (See figure 1-49.)

Note

Emergency brake pressure is provided by an emergency system which is also used for landing gear extension. See "Landing Gear and Brake Emergency Hydraulic System" of this section.

The brake hydraulic system consists of the main brake system and the slave brake system. The main system is the power source for the brakes, and the slave system controls the power source through a brake control valve. The slave brake system extends from the flight deck controls to the main brake system which is located in the bomb bay directly between the two main landing gears. Since the slave system operates on low pressure as compared with the high pressure main system, considerable weight saving is realized and the possibilities of leakage in the main system lines are reduced by the use of long low-pressure lines and comparatively short high-pressure lines.

The slave brake system consists of two pressure reservoirs, a master cylinder mechanically connected to each brake pedal, and a slave cylinder which is located in the control valve. When a brake pedal is depressed, the pressure is transmitted from the master cylinder to the slave cylinder. The slave cylinder is positioned by this pressure, allowing main system pressure to pass through the control valve to the brake.

The main brake system consists of a reservoir, a pump, an accumulator, and a brake control valve. The accumulator stores pressure for the main system, and accumulator pressure is maintained by the 200-volt a-c motor-driven pump. Pump motor power is controlled by a 28-volt d-c circuit through the brake pump switch on the pilots' pedestal. A pressure switch installed in the control circuit holds the circuit open when accumulator pressure is within limits; therefore, the pump will operate only when accumulator pressure drops below limits. In the event of a malfunction in the control circuit, the pump can be operated by the pump pressure override switch, located on the flight engineer's table.

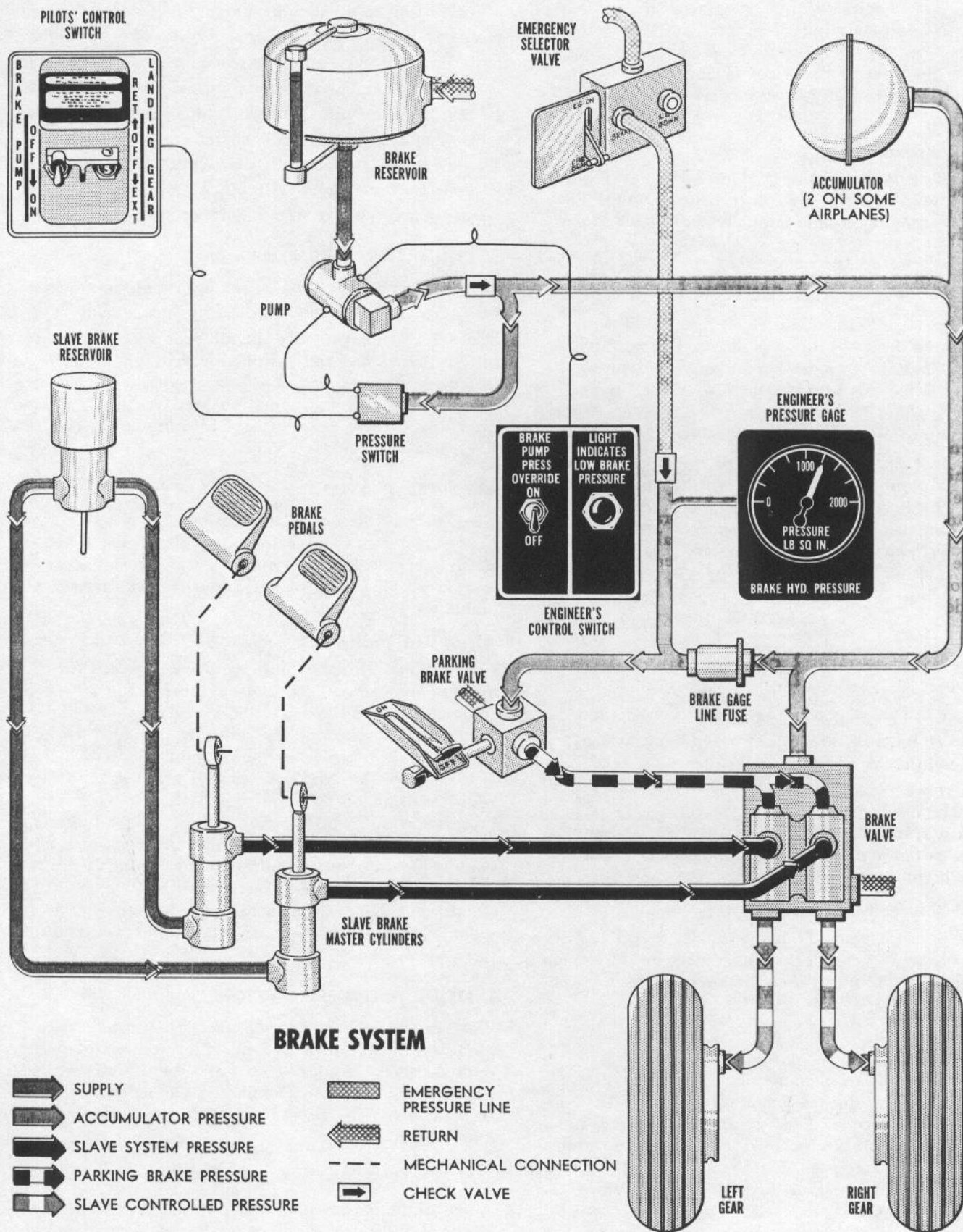
Note

Group 7 airplanes are equipped with disc-type brakes utilizing a system pressure of from 850 to 1025 psi. Group 8 airplanes are equipped with expander tube brakes which require a system pressure of from 1125 to 1500 psi, necessitating two accumulators instead of one.

BRAKE CONTROLS AND INDICATORS.

Brake Pump Switch.

This switch (5, figure 1-13) controls the normal operation of the brake pump motor. To prevent landing with low brake pressure, a gang bar will move the



BRAKE SYSTEM

Figure 1-49. Brake System Schematic

brake pump switch to the ON position when the landing gear control switch is placed in the EX-TEND position. In flight, however, the switch must be moved to the OFF position to minimize pump wear, as the gang bar control is not effective when the landing gear control switch is moved to RE-TRACT.

Parking Brake Lever.

The parking brake lever (17, figure 1-13) is located on the pilots' pedestal and controls the parking brake valve for applying accumulator pressure to the brakes.

CAUTION

When the brake line gage fuse is blown *parking brakes* are inoperative. Pressure is available for foot brakes although no pressure is indicated on the gage.

Brake Pump Pressure Override Switch.

This switch (4, figure 1-37) is provided to energize the brake pump motor in the event the normal brake pump control circuit fails. If the brake pressure gage or warning lamp indicates low brake pressure when the brake pump switch is ON, system pressure can be brought within operating range by placing the override switch in the ON position.

CAUTION

Since the brake pump will operate continuously when the override switch is ON, the switch must be turned OFF when the pressure is within operating range.

Pressure Gage.

Hydraulic pressure for the brake system is indicated on the hydraulic pressure gage (6, figure 1-37) located on the flight engineer's table.

Low Pressure Warning Lamp.

A low pressure warning lamp (5, figure 1-37) is located adjacent to the brake hydraulic pressure gage and gives a warning when brake pressure falls below normal.

INSTRUMENTS.

Fuel, water, oil, torquemeter, and manifold pressure indications are supplied by autosyn transmitters located in each nacelle. The transmitters and indicators operate on 26-volt alternating current fed from transformers which receive 115-volt alternating current. The reciprocating engine instruments are located at the engineer's station. In addition, a master tachometer and a manifold pressure gage are provided for the pilots. The pilots' manifold pressure gage is for No. 4 engine only. Anti-icing air, cylinder head, and con-

stant speed drive (alternator) oil temperature readings are obtained at the engineer's station from a master temperature indicator powered by its own flashlight batteries. All gyroscopic instruments are electrically operated. Control switches are provided to disconnect power from the pilots' vertical and directional gyros when they are not in use. A switch is also provided at the navigator's station to disconnect 200-volt a-c power to his directional gyro. All other gyros operate only when their respective system is turned on.

TORQUEMETER INDICATORS.

Torquemeters are located on the flight engineer's main instrument panel. Dual indicating instruments (13, figure 1-16) are provided in all group 12 airplanes; group 13 airplanes are equipped with single indicating instruments. These torquemeters provide a convenient and accurate bhp determination based on easily measured quantities. For further information refer to "Torquemeter," Section VII.

AIR-SPEED SYSTEM.

The air-speed system is conventional in design. Pitot heads are located on each lower side of the forward portion of the fuselage, and a static pressure port is located on each side of the fuselage just forward of bomb bay No. 1.

Air-Speed Indicators.

Conventional air-speed indicators are provided for the aircraft commander and the engineer. True air-speed indicators are located at the navigator's and radar-bombardier's stations. The pilot is provided with a maximum allowable air-speed indicator which has two pointers. The red pointer indicates the limit dive speed in mph or the limiting Mach number whichever is lower. These limiting air speeds are indicated by the red line in figure 6-2. The other pointer is a conventional air-speed indicator and a window in the instrument shows the Mach setting. The pointers should not be permitted to cross each other, as it would be an indication of operation in excess of safe speeds.

OUTSIDE AIR THERMOMETERS.

Two direct-reading outside air thermometers are mounted in the airplane. One is located on the flight deck above the flight engineer and the other is located on the left side of the bombardier's enclosure. These instruments give direct readings of the outside air temperature.

MASTER TEMPERATURE INDICATOR.

A flashlight battery-operated potentiometer-type temperature indicator (9, figure 1-16) is located on the flight engineer's main instrument panel in group 12 airplanes. In group 13 airplanes, this instrument (6,

figure 1-18) is mounted on the flight engineer's auxiliary instrument panel. This instrument is used to obtain temperature readings from cylinder heads, anti-icing air ducts, and alternator constant speed drive oil.

Master Temperature Indicator Selector Switch.

This switch is used to select the particular engine for which the cylinder head, anti-icing air, or constant speed drive oil temperature is to be determined.

Master Temperature Indicator Switch.

This ON-OFF switch controls the power from the flashlight batteries.

Check Switch.

This two-position switch, marked CH and ON, places the galvanometer in the check circuit.

Compensating Rheostat Knob.

This rheostat marked COMP. RHEO. adjusts compensating current when the check switch is in the CH position.

Balance Knob.

The balance knob is used to zero the galvanometer pointer when the check switch is in the ON position.

Slide Wire Rheostat Knob.

This rheostat marked SL. W. RHEO. is turned clockwise when the galvanometer cannot be zeroed with the balance knob. Normally, it is adjusted to remain as far counterclockwise as possible while still maintaining full scale balancing with the balance knob.

Galvanometer Pointer.

When the check switch is placed in the CH position, the galvanometer pointer functions as a milliammeter and measures the necessary amount of compensating current required to obtain an accurate temperature indication on the potentiometer. When the check switch is in the ON position, the galvanometer mechanism is in series with the thermocouple circuit and serves as a galvanometer.

Main Indicator Pointer.

This pointer acts as a direct reading temperature gage.

Battery Receptacles.

The master temperature indicator receives its power from the flashlight batteries installed in receptacles located in the upper corners of the instrument. Two spare batteries are stored in a container in back of the indicator.

FLIGHT INSTRUMENT SWITCHES.

A pair of ON-OFF switches (14, figure 1-12) is located on the left side of the pilots' instrument panel, and one three-position switch (14, figure 1-12) is on the right side. The double switch on the left side of the panel

can be used to disconnect the aircraft commander's gyro horizon from 200-volt alternating current while airplane is not being flown.

Note

Both turn and bank indicator needles operate automatically on 28-volt dc through the pilot's circuit breaker panel. Fundamental flight instruments (needle, ball, and air-speed) should therefore be available as long as battery power exists.

The single switch on the right side of the panel connects the directional gyro and the pilot's gyro horizon with 200-volt ac. When this switch is ON the power comes through the right forward cabin power panel; when the EMERGENCY position is used, power comes through the engineer's auxiliary instrument panel. Both instruments can be disconnected by the OFF position when they are not in use.

NAVIGATOR'S DIRECTIONAL GYRO CONTROL SWITCH.

This two-position ON-OFF switch (10, figure 4-14) controls the operation of the directional gyro on the navigator's instrument panel.

JET ENGINE INSTRUMENTS.

Tail Pipe Temperature Indicators.

Four tail pipe temperature indicators (39, figure 1-12), one for each jet engine, are located on the pilot's jet instrument panel.

Engine Tachometers.

Four engine tachometers (38, figure 1-12), one for each jet engine, are located on the pilot's jet instrument panel.

ENGINE ANALYZER.

Ignition Analysis.

The engine analyzer is designed to detect, locate, and identify abnormalities in the operation of the reciprocating engines. It performs these functions by presenting patterns on the screen of a cathode ray tube, of voltages across the primary circuits of the magnetos. By use of the analyzer, the engineer can keep the reciprocating engines under constant surveillance during flight and thereby determine the severity of any engine malfunctions and make the required adjustments. He can also detect and analyze troubles peculiar to high altitude which could not be normally discovered during ground checks. Any decision on the feathering of an engine as a result of analyzer observations should include consideration of normal engine instrument indications. The engine analyzer checks the performance of the magneto coils, condensers, and breaker points; it checks magneto timing, breaker point synchronization, and spark ad-

vance; it checks the operation of the spark plugs and distributors; and it checks the condition of the spark plug leads and ignition harnesses. During normal operation, an ignition system establishes a characteristic pattern and any malfunction in the system will alter this pattern. Since malfunction patterns are also characteristic of the malfunction, they serve to identify the specific nature of the trouble.

The basic components of the engine analyzer consist of a synchronizing generator for each engine, a condition selector switch, a cycle switch, two relay boxes, a power supply-amplifier, and an indicator. The analyzer control panel is located adjacent to the engineer's main instrument panel and the indicator is flush mounted in his table. (See figure 1-14.)

Note

Resistors are provided in analyzer electrical circuits to automatically isolate the analyzer system from the engine, so that a malfunction in the analyzer will not interfere with engine operation.

Cylinder Vibration Analysis (Group 15 Airplanes).

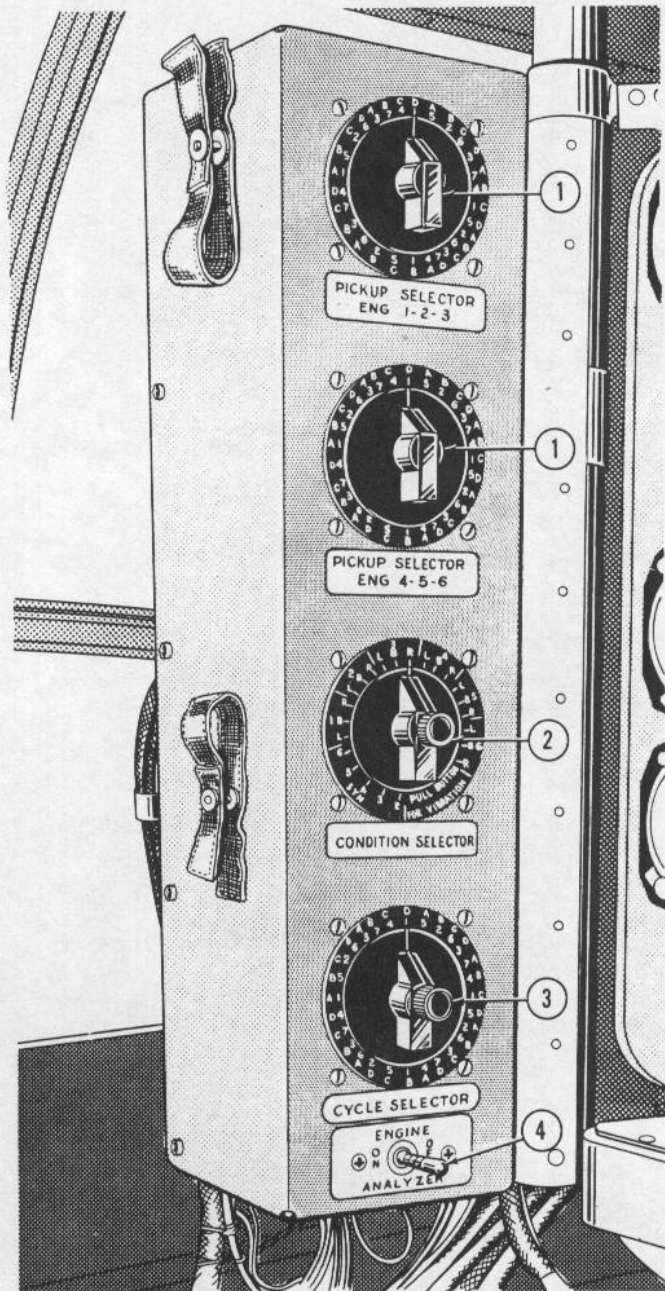
In addition to the ignition analysis provisions, airplanes in group 15 have provisions for analyzing cylinder vibration. This is accomplished by presenting patterns on the indicator scope of voltages generated in vibration pickups by cylinder vibration. By inspecting these vibration patterns, the engineer can analyze the performance of the valves, pistons, wrist pins, and many other engine parts; he can also detect the presence of detonation. In addition to the other analyzer components, airplanes in this group have two pickup selector switches (1, figure 1-50) mounted on the analyzer control panel, and a vibration pickup unit mounted on each engine cylinder.

Controls.

Condition Selector Switch. A condition selector switch (2, figure 1-50) located on the engine analyzer control panel is used to select the particular engine to be analyzed and the type of analysis; ignition (left, right, or both magnetos), or engine rpm synchronization. In group 15 airplanes it is also used to select vibration analysis and the engine to be analyzed. The condition selector switch consists of a fixed index ring surrounding a rotatable switch dial. The index ring is divided into three general sectors which are engraved as follows:

1. The first sector is marked SYN, 2, 3, 4, 5, and 6, for selecting any of these engines to check their rpm synchronization with the rpm of engine No. 1.

2. The second sector, marked 1, 2, 3, 4, 5, and 6, is used for selecting an engine. The inner radius of this sector has designations L, B, and R opposite each engine number for selecting left, both, or right mag-



1. PICKUP SELECTOR SWITCH
2. CONDITION SELECTOR SWITCH
3. CYCLE SELECTOR SWITCH
4. ENGINE ANALYZER POWER SWITCH

3-1023-R3

**Figure 1-50. Engine Analyzer Control Panel,
Group 15 Airplanes**

netos when making an ignition analysis. On group 15 airplanes this sector is used for selecting a particular engine for either vibration or ignition analysis. For vibration analysis the switch dial may be indexed to either L, B, or R within the engine sector.

3. The third sector, marked PULL BUTTON FOR VIBRATION, is not used except for this notation

which refers to the push-pull knob centrally located on the switch dial. This knob must be pushed IN to select ignition analysis. The pull out position is inoperative except in group 15 airplanes, where the pulled out position selects vibration and the pushed in position selects ignition analysis.

Pickup Selector Switches (Group 15 Airplanes). Airplanes in this group have two pickup selector switches (2, figure 1-50). One for engines 1, 2, and 3, and the other for engines 4, 5, and 6, are used to select a specific cylinder for vibration analysis. These switches each have a fixed index ring engraved with cylinder designations which are arranged in the firing order of an engine. A switch dial with a single index line moves relative to these designations to select the cylinder to be checked. They are not involved in ignition analysis.

Cycle Selector Switch. The cycle selector switch (3, figure 1-50) located on the analyzer control panel is marked as follows:

1. A fixed index ring is inscribed with symbols corresponding to cylinder designations of an engine.
2. A rotatable switch dial, with an index line labeled IGN, is divided into four quadrants representing the four strokes of a reciprocating engine. Around the periphery of the dial at specific points are designations EC, IO, IC, and EO which are abbreviations for valve operations occurring during the engine cycle. For ignition analysis, only the IGN index line is used.
3. A push-pull knob, located in the center of the rotatable switch dial, selects a fast sweep when pushed IN, and a slow sweep when pulled OUT. To select a cylinder for ignition analysis, place the IGN index line opposite the cylinder designation. If the push-pull knob is OUT for a slow sweep, all four ignition patterns for one magneto will appear. The pattern of the selected cylinder will appear first in the series followed by the others in the order of firing of that magneto. If the knob is pushed IN for a fast sweep, only the significant oscillatory portion of a single ignition pattern will appear. This pattern is expanded at the expense of eliminating some of the trailing portion of the pattern including the section at which the breaker points close. In group 15 airplanes, the cycle switch is used in conjunction with the other switches to set up the analyzer for vibration analysis. When performing vibration analysis, the cycle switch is used to select the specific point of the engine cycle at which the horizontal time sweep across the scope is to be initiated. Positioning one of the designations, such as EC (exhaust valve closing), of the rotatable dial adjacent to a cylinder number on the fixed ring will cause that engine event to appear first in a slow sweep pattern. Exact alignment of the dial with a cylinder designation is not necessary; instead, the detent nearest to alignment which

does not split a given pattern should be used. A slow sweep pattern covers all vibration-producing events in the selected cylinder for 720 degrees of crankshaft rotation. A fast sweep shows a horizontally expanded pattern of vibration events for a selected 80 degrees of crankshaft rotation.

Note

The cylinder selected on the cycle switch must correspond to the cylinder selected on the pickup selector or an inaccurate pattern will be shown.

Engine Analyzer Power Switch. This ON-OFF switch-type circuit breaker (4, figure 1-50) located on the analyzer control panel is used to turn the system ON and OFF.

Indicators.

Engine Analyzer Indicator. The engine analyzer indicator consists of a three-inch cathode ray tube mounted in the engineer's table.

EMERGENCY EQUIPMENT.

RECIPROCATING ENGINE FIRE EXTINGUISHER SYSTEM.

An electrically operated, two-shot fire extinguisher system (figure 1-51) is provided for combating reciprocating engine fires. The system is controlled by 28-volt direct current and uses either methyl bromide or bromochloromethane as the extinguishing agent. The extinguishing agent is stored in four metal containers, two in each main gear wheel well; and each pair or bank of containers constitutes a discharge.

All of the controls for the system are located at the engineer's station. The bank of containers to be discharged is determined by the position of a discharge selector switch. Six engine selector switches are provided to discharge the containers and direct the discharge to the proper engine. Since the supply lines extend to engines No. 1 and 6, directional valves are provided for diverting the discharge to engines No. 2, 3, 4, and 5. Normally, the supply line to the left wing is open; therefore, when engine No. 4, 5, or 6 is selected, a directional valve opens the line to the right wing and closes the line to the left wing.

Note

The four engine directional valves and the wing directional valve are spring-loaded and are first positioned electrically then held in that position by the force of the discharge. For this reason, an engine selector switch should be held for approximately 5 seconds to assure pressure at the valves.

A relay is provided to delay the discharge of extinguishing agent for approximately one-tenth of a second to give the directional valves sufficient time to complete their operation.

Note

The jet engines are not equipped with an extinguisher system.

Discharge Selector Switch.

The discharge selector switch (37, figure 1-20) marked DISCHARGE 1 and DISCHARGE 2, permits the selection of either of the two banks of extinguishing agent containers for discharge.

Reciprocating Engine Selector Switches.

Six reciprocating engine selector switches (36, figure 1-20) are located on the engineer's control panel. The switches are used to discharge the selected containers and, at the same time, to position the directional valves to direct the flow of extinguishing agent to the proper reciprocating engine.

RECIPROCATING ENGINE FIRE DETECTOR SYSTEM.

Each reciprocating engine nacelle is furnished with equipment for detecting the presence of fire. Thermocouples, located in potential fire areas of the nacelle, are the fire-sensitive units of the system. If a thermocouple is subjected to an abnormally rapid rise in temperature, it generates a very low voltage. This voltage energizes a relay which connects 28-volt direct current to an indicator lamp on the engineer's panel, lighting the lamp. Since the thermocouples are sensitive only to rapid rates of change in temperature, gradual temperature increases resulting from engine warm-up or power runs will not cause a warning indication.

Reciprocating Engine Fire Warning Lamps.

Twelve fire warning lamps (35, figure 1-20), two for each nacelle, are located on the engineer's main control panel to give a visual indication of a nacelle fire. On group 12 airplanes, an identical set of lamps (1, figure 1-16), is also located on the main instrument panel. A push-to-test switch (34, figure 1-20) is provided to test simultaneously the continuity of the detector circuit in each nacelle to the fire warning lamps.

WARNING

Never ignore an alarm indication. Inability to obtain a warning during test proves only that the system is not in perfect condition, but not necessarily that it is completely inoperative.

JET ENGINE FIRE DETECTOR SYSTEM.

The fire detector system on each jet engine consists of ten cartridge-type detector units strategically located in potential fire zones. The units are calibrated to close electrical contacts when subjected to a predetermined temperature. In event of a fire, when this temperature is reached, the 28-volt d-c circuit to a warning lamp on the jet control panel will be completed and the lamp will light.

Jet Engine Fire Detection Switches.

Two two-position switches (27, figure 1-25), one for each pair of jet engines, are located on the pilots' overhead control panel. When the switches are in the ON position, the fire detector circuits to the jet nacelles are set up. Placing the switches in the TEST position checks the continuity of the circuits from the nacelles to the warning lamps.

Jet Engine Fire Warning Lamps.

Four fire warning lamps (26, figure 1-25), one for each jet engine, are located on the pilots' overhead jet control panel. The lamps give a visual indication of jet engine-nacelle fires.

ALARM BELLS.

An alarm bell is located in each crew compartment. The bells are controlled by an ON-OFF switch (19, figure 1-12) on the pilots' instrument panel and use d-c power from the airplane's battery.

PARACHUTE STATIC LINES.

Parachute static lines are located forward of the forward hatch in the forward cabin and forward of the entrance hatch in the aft cabin.

SURVIVAL SUITS.

Hooks are provided at each crew station for the stowage of survival suits.

LIFE RAFTS.

No emergency sea equipment is provided. When the mission requires such equipment, individual life rafts will be issued to the crew.

HAND FIRE EXTINGUISHERS.

The airplane is equipped with four hand fire extinguishers. In the forward cabin one type 4-TB extinguisher is left of the engineer's station and one type A-20 is right of the ECM equipment. In the aft cabin a 4-TB extinguisher is mounted on the left side, and a type A-20 on the right side.

HAND AXES AND KNIVES.

A panel containing a hand axe and a knife is installed in each crew compartment. One panel is above

seats. In addition each seat is equipped with an inertia reel lock-type shoulder harness for the protection of the occupant.

Shoulder Harness Control.

A two-position LOCKED-UNLOCKED shoulder harness inertia reel lock control is located on the left side of the pilots' seats. A latch is provided for positively retaining the control handle at either position of the quadrant. By pressing down on the top of the control handle, the latch is released and the control handle may then be moved freely from one position to another. When the control is in the UNLOCKED position, the reel harness cable will extend to allow the pilot 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 control handle is moved to the LOCKED and then returned to the UNLOCKED position. When the control is in the LOCKED position, the reel harness cable is manually locked so that the pilot is prevented from bending forward. The LOCKED position is used only when

Two battle splint and blood plasma kits are located as follows: one near the left escape hatch in the forward cabin and one at the left end of the bunks in the aft cabin.

The pilots' seats are provided with fore-and-aft, vertical, and angular adjustments and have arm rests which retract to permit easy movement into and out of the



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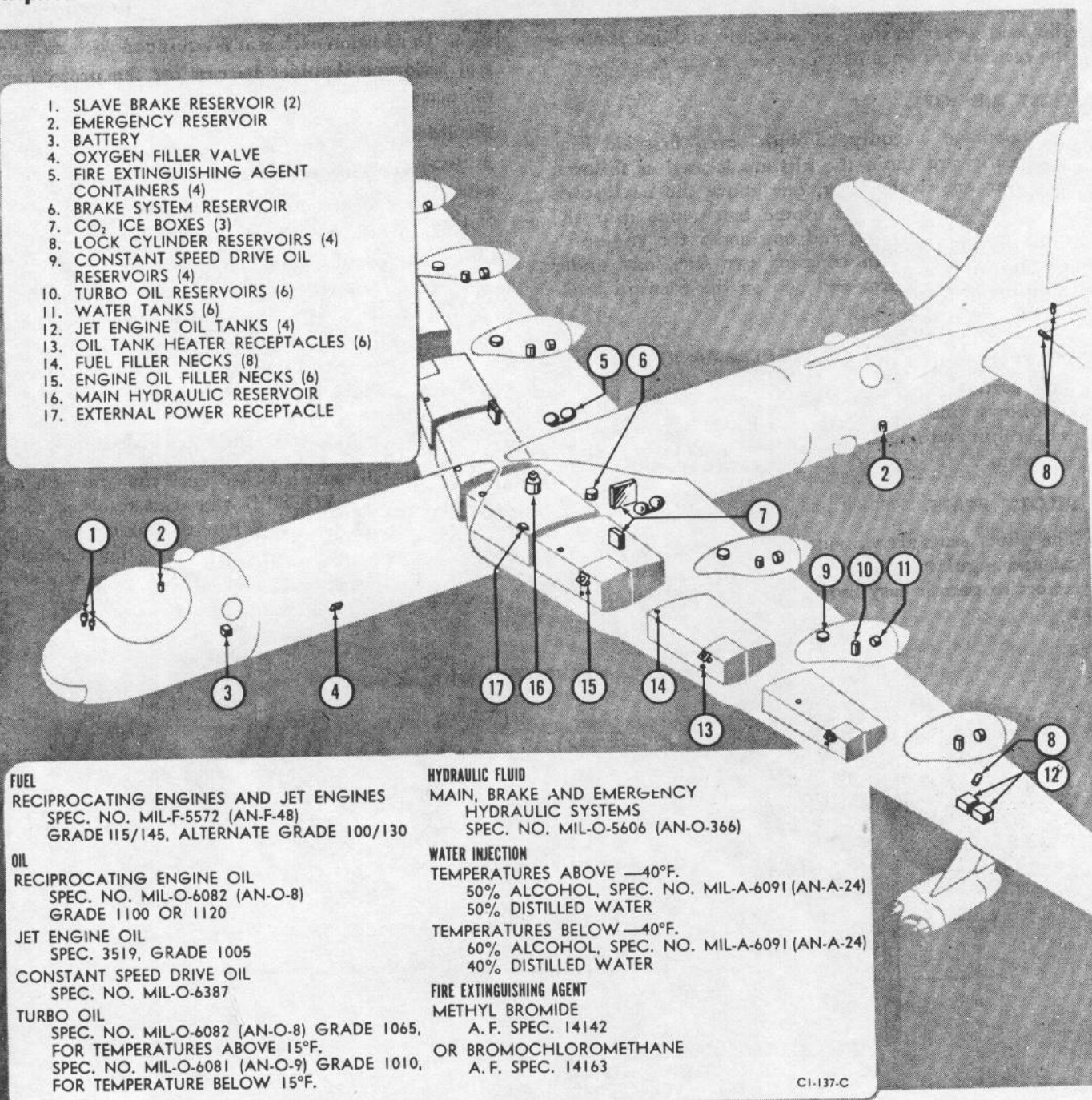


Figure 1-52. Service Diagram

a crash landing is anticipated. This position provides an added safety precaution over and above that of the automatic safety lock.

ENGINEER'S SEAT.

A swivel-type seat mounted on a fixed conical base is provided for the engineer. The seat can be rotated approximately 60 degrees to the right and 110 degrees to the left. Adjustments can also be made fore and aft and vertically. Fore-and-aft movement is controlled

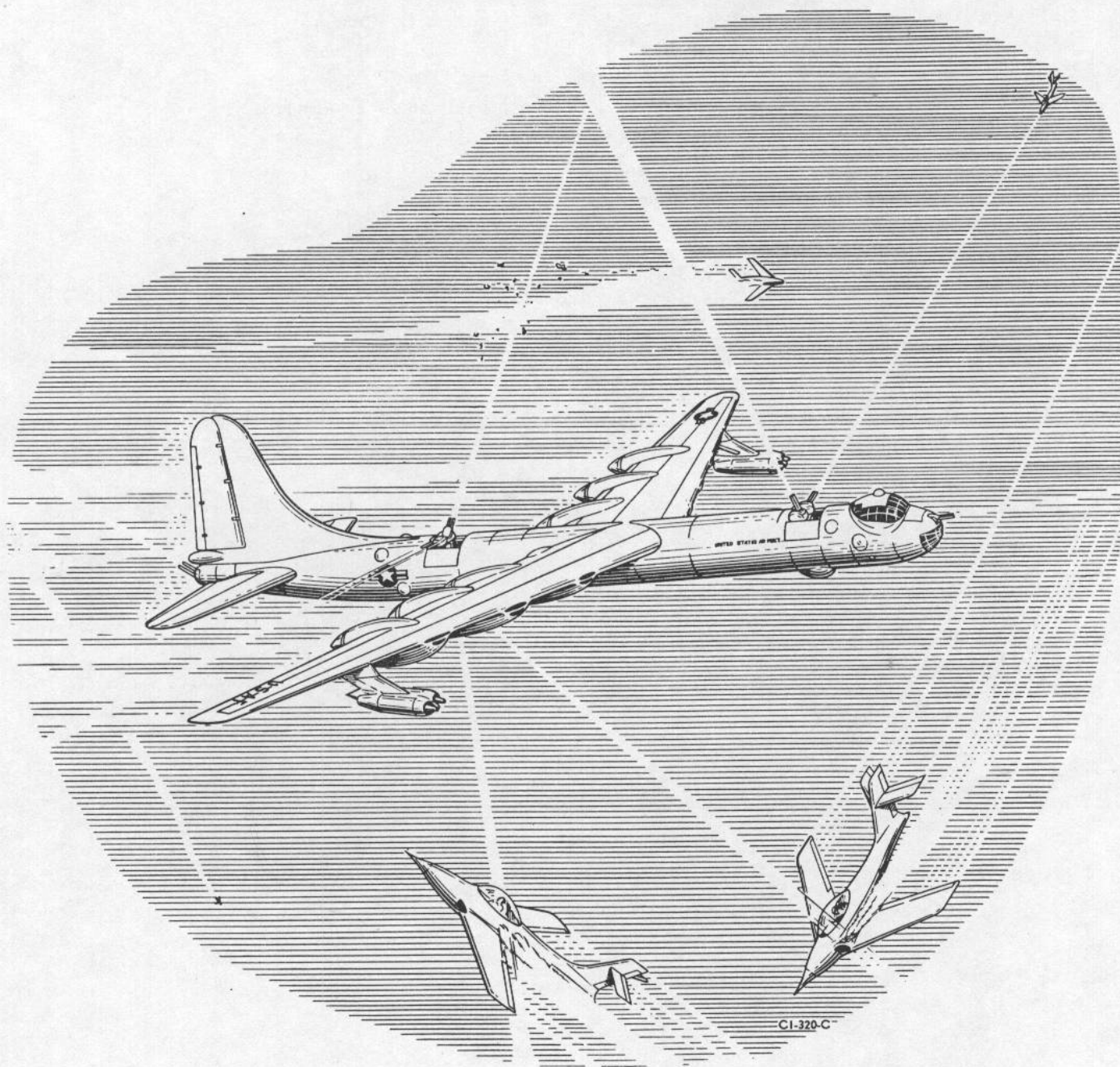
by a knob located on the right side of the seat support. A pedal, located on the forward side of the support, controls vertical movement. The seat is equipped with a folding arm rest and a safety belt.

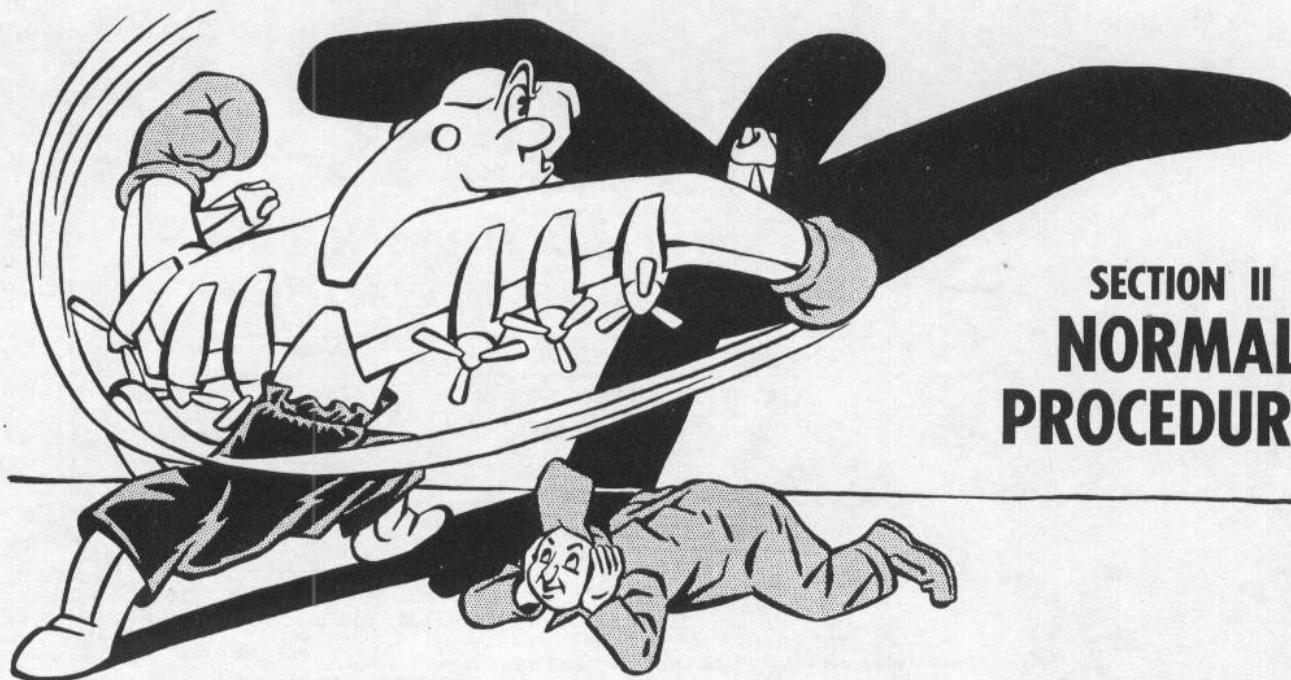
AUXILIARY EQUIPMENT.

Information concerning the following equipment and systems is given in Section IV.

1. Heating and Anti-Icing System.
2. Pressurization System.

- | | |
|---|------------------------------|
| 3. Cabin Ventilating Equipment. | 11. Lighting System. |
| 4. Auxiliary Cabin Heaters. | 12. Oxygen System. |
| 5. Jet Pod Heating and Anti-Icing System. | 13. Autopilot. |
| 6. Propeller Anti-Icing System. | 14. Navigation Equipment. |
| 7. Pitot Tube Heaters. | 15. Portable D-C Power Unit. |
| 8. Oil System Heaters. | 16. Gunnery Equipment. |
| 9. Hand-Operated Heater. | 17. Bombing Equipment. |
| 10. Communication and Associated Electronic Equip-
ment. | 18. Photographic Equipment. |
| | 19. Miscellaneous Equipment. |





SECTION II NORMAL PROCEDURES

CI-305-C

INTRODUCTION.

In general, the purpose of this section is to establish a proper sequence of events and to set forth those procedures and techniques which must be performed in a prescribed manner during a complete flight under normal conditions. The scope has been expanded to include as much training information and normal operating procedures as practical. The sequence begins when the flight is conceived and does not end until the crew has completed their postflight duties. This provides a comprehensive picture of the requirements of a typical mission.

The arrangement of the data presented in this section has been devised by experienced personnel. It reflects the best information obtainable from all available sources including the using tactical organizations. It is only natural to expect that, from time to time, new and revised procedures will be necessary due to modifications of the systems and the development of new techniques. Revisions will be published from time to time to cover these changes.

To prevent undue complication of this section it will only include normal operating procedures applicable to the aircraft commander, pilot, copilot, first flight engineer, and second flight engineer. Procedures for other crew members will be dealt with only so far as coordination requires to properly execute a particular function. For the specific duties of other crew members see Section VIII, "Crew Duties." For emergency procedures refer to Section III, "Emergency Procedures." Other sections in this publication will deal with various aspects of the aircraft and equipment

from the standpoint of basic operation, and peculiarities characteristic of the equipment under various conditions. If information is desired on any particular phase of operation not covered in this section, reference to the other sections should provide the answer. If any question should arise that is not covered in this handbook, check with the standardization board. They will help you evaluate the situation and submit recommended changes to this publication through the proper channels.

The phases of operation covered in this section will follow a normal sequence as though you were actually planning and flying the mission. The sequence recommended is based upon the experience of tactical organizations in actual operation and constitutes the best compromise to reduce mission failures, crew fatigue, and maintenance to an acceptable minimum. Certain local considerations may require that the exact sequence be varied to meet the situation. However, the amplified procedures and techniques described herein are mandatory to provide a complete check and must be performed in the prescribed manner.

A unique innovation in normal operating procedures of the complex B-36 might be called a dual preflight run-up system. The first preflight run-up is called a "Preflight Operational Equipment Check" and is designed to check every piece of equipment aboard the aircraft from the safety standpoint as well as reasonably assuring its successful operation during any phase of the mission. This is known as a *complete* preflight check of all operational equipment and normally is accomplished as early as possible within a 24-hour period prior to estimated take-off time. The second

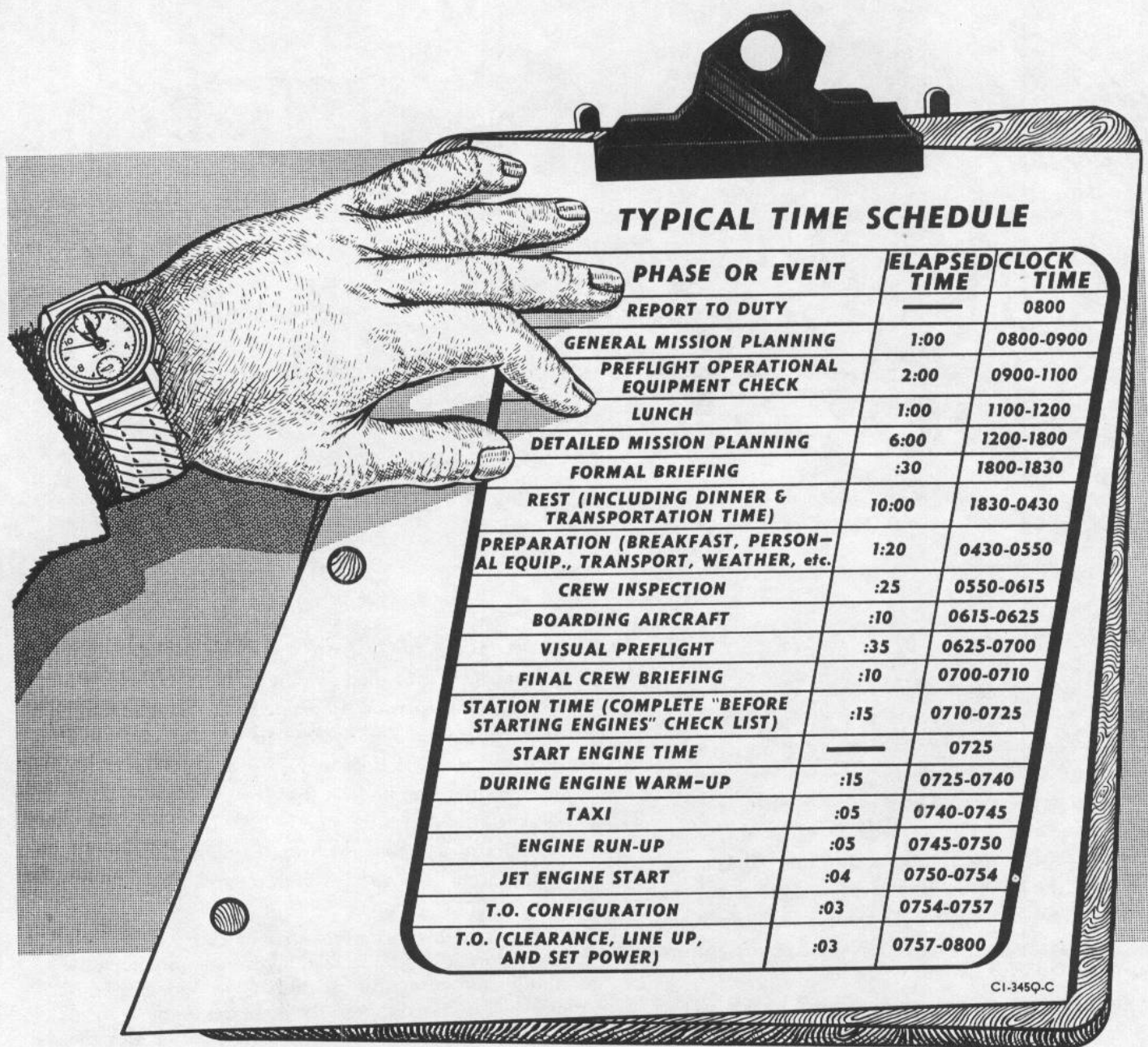


Figure 2-1. Typical Time Schedule

preflight run-up occurs just after the visual preflight inspection and is known as a *minimum* safety check just prior to the actual take-off. Experienced B-36 units have found that this system, coupled with good maintenance, has reduced their mission failure rate from very excessive to almost negligible. It has also reduced the ground time required on the reciprocating engines, although an unqualified inspection of the

dual run-up system would not make this fact apparent to the inexperienced operator or maintenance representative.

A typical time schedule following the sequence of events recommended in this section is shown in figure 2-1 for the pilots and engineers. The time schedule for other crew members will vary with mission requirements but normally will not exceed this total.

B-36D PILOTS' STANDARD CHECK LIST

BEFORE STARTING

1. Landing Gear Control Switch..... EXTEND
2. Visual Inspection — Form I, F, And Loading List..... COMPLETED
3. Pitot Covers And Ground Locks..... REMOVED
4. Nose Wheel Scissors..... CONNECTED
5. Personal Equipment..... CHECK—IN PLACE
6. Seats And Pedals..... ADJUSTED
7. All Circuit Breakers..... IN
8. All Indicator Lamps..... PUSH-TO-TEST
- *9. Radio Checks..... COMPLETED
10. Autopilot..... ON
11. Flight Instrument Switches..... ON
12. Propeller Reverse Selector Switches..... SAFE, LIGHTS OUT
- *13. Nose Steering And Brakes..... CHECKED AND SET
14. Surface Controls And Trim Tabs..... CHECKED
15. Autopilot..... CHECKED AND OFF
16. Surface Controls..... LOCKED
17. Bomb Bay Door Locks..... REMOVED
18. Interphone, Alarm Bell Check..... COMPLETED
19. Fire Equipment..... IN PLACE
20. Emergency Ignition Switch..... IN
- *21. Receive Engineer's Report And Notify Engineer,
"BRAKES SET, FIRE GUARD STANDING BY, IGNITION IN,
START ENGINES."

STARTING RECIPROCATING ENGINES

A/C Observes Engineer's Reciprocating Engine Starts and Handles Throttles On Idling Engines. Maintain Approximately 1100 RPM.

DURING ENGINE WARM-UP

- *1. Emergency Ignition Switch..... CHECKED
2. Pilot's Manifold Pressure Gage..... CHECKED
3. Master Tachometer..... CHECKED
- *4. Propeller Reverse Check..... COMPLETED (LIGHTS OUT)
5. Bomb Bay And Camera Doors..... CLOSED
6. Observe Engineer's Barometric Pressure Checks

TAXIING

1. Nose Wheel Steering Switch..... ON
2. Engineer's Taxi Configuration..... CHECKED
3. Check Ground Man..... ALL CLEAR SIGNAL
4. Call Control Tower..... TAXI INSTRUCTIONS
5. Inboard Propeller Reverse Selector Switch..... READY
6. "Ready To Taxi" — Parking Brakes..... OFF

ENGINE RUN-UP

1. Parking Brake Lever..... ON
2. Nose Wheel Steering Switch..... OFF
3. Propeller Reverse Selector Switches..... SAFE (LIGHTS OUT)
4. Observe Engineer's Power Checks

STARTING JET ENGINES (GROUND-AIR)

1. All Circuit Breakers..... IN
2. Fire Detector Test Switches..... TEST AND RELEASE
3. Throttle Selector Switches..... LEVER
4. Throttles..... CLOSED
5. Pod Preheat Switch..... AS REQUIRED
6. Nose De-Ice Switch..... AS REQUIRED
7. Oil Heater Switch..... AS REQUIRED
8. Oil Shutoff Valve Switches..... OPEN
- *9. Notify Engineer..... "SET UP JET START CONFIGURATION."
10. Danger Area Clear And Fire Equipment Standing By.
11. Air Plug Switches..... OPEN (CHECK PLUGS VISUALLY)
12. Manifold Valve Switches (L & R)..... OPEN
13. Booster Pump Switches (L & R)..... ON
14. (Ground Start) Ignition Start Switches..... NORMAL
15. J-1 Engine Fuel Valve..... OPEN
16. J-1 Fuel And Oil Pressure Gages..... ZERO
17. Notify Ground Observer Or Aft Gunner..... "STARTING J-1."
18. (Ground Start) J-1 Starter Switch..... HOLD ON
- 18A. (Air Start) J-1 Ignition Start Switch..... HOLD IN ALT.
19. J-1 Throttle ——— OPEN AT 6-10 PER CENT RPM TO OBTAIN 25-30 PSI FUEL PRESSURE

CAUTION: WHEN IGNITION OCCURS, ADJUST THROTTLE TO MAINTAIN A CONSTANT TAIL PIPE TEMPERATURE. DO NOT EXCEED 690°C TPT.

20. J-1 Oil Pressure..... REPORT INDICATION ON INTERPHONE
21. (Ground Start) J-1 Starter Switch..... RELEASE AT 20% RPM
- 21A. (Air Start) J-1 Ignition Start Switch..... RELEASE AT IDLE
22. J-1 Throttle..... ADJUST TO MAINTAIN IDLE RPM
23. J-4, J-2, J-3 — Repeat Steps 15 Thru 22
24. (Ground Start) All Ignition Start Switches..... OFF

BEFORE TAKE-OFF

1. Parking Brake Lever..... ON
2. Propeller Reverse Selector Switches..... SAFE AND LIGHTS OUT
3. Flight Instrument Switches..... ON
4. Gyros..... SET AND UNCAGED
5. Nose Wheel Steering Switch..... ON
6. Landing Gear Control Switch..... EXTEND
7. Autopilot..... OFF
8. Flaps And Indicator..... CHECKED AND SET AT 20°
9. Trim Tabs..... SET
10. Entrance Ladders..... STOWED
11. Windows And Hatches..... CLOSED
12. Forward And Aft Cabins..... READY FOR TAKE-OFF
- *13. Engineer's Take-Off Configuration..... PILOT READS —
ENGINEER ANSWERS:
"ALTERNATORS — PARALLELED; BOOSTER PUMPS — ON;
TURBOS — BOTH; SPARK — RETARDED; MIXTURES — NORMAL;
BRAKE AND STEERING PRESSURE — NORMAL; TAKE-OFF
CONFIGURATION COMPLETED, STANDING BY FOR
PROPELLER REVERSE SAFETY CHECK AND TAKE-OFF
POWER."
14. Notify Crew..... "STAND BY FOR TAKE-OFF"
15. Surface Controls..... UNLOCKED AND CHECKED
16. Salvo Circuits..... AS REQUIRED
17. Safety Belts..... FASTENED
18. Read Pilot's Take-Off Configuration To Engineer:
"CONTROLS — UNLOCKED; FLIGHT INSTRUMENT SWITCHES — ON; FLAPS — 20°; AUTOPILOT — OFF; NOSE STEERING — ON; PROPELLERS — SAFE, LIGHTS OUT."

* PILOT-ENGINEER COORDINATION ITEM

Figure 2-2. (Sheet 1) Pilot's Standard Check List

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B-36D PILOT'S STANDARD CHECK LIST (Cont'd)

TAKE-OFF

- *1. Jets 90 Per Cent RPM..... PROPELLER REVERSE SAFETY CHECK
- *2. Set Take-Off Power..... JETS 100 PER CENT RPM
- 3. Parking Brakes..... RELEASED

AFTER TAKE-OFF

- 1. Foot Brakes..... APPLY TO STOP WHEEL ROTATION
- 2. Nose Steering Switch..... OFF
- *3. Landing Gear Control Switch..... RETRACT
- 4. Flaps Up..... AFTER 130 MPH IAS BUT NOT LESS THAN 125% OF STALL SPEED

INITIAL CLIMB

- *1. Power Condition Two (2)..... AFTER GEAR AND FLAPS UP
- 2. Landing Gear And Brake Pump Switch..... OFF
- 3. Hold Best Climb IAS..... SEE APPENDIX

STOPPING JET ENGINES (GROUND-AIR)

- 1. (Ground) Throttles..... IDLE THREE MINUTES, THEN CLOSE
- 1A. (Air) Throttles..... IDLE ONE MINUTE, THEN CLOSE
- 2. Booster Pumps..... OFF
- 3. (Ground) Air Plugs..... CLOSE BELOW 100°C TPT AND ZERO PER CENT RPM
- 3A. (Air) Air Plugs..... CLOSED BELOW 100°C TPT AND 30 PER CENT RPM
- 4. Manifold Valves..... CLOSED BELOW 20 PER CENT RPM
- 5. Engine Fuel Valves..... CLOSED BELOW 10 PER CENT RPM
- 6. Nose De-Ice..... AS REQUIRED
- 7. Pod Preheat..... AS REQUIRED
- 8. Oil Heater Switch..... AS REQUIRED
- 9. Oil Shutoff Valves..... ALWAYS OPEN DURING FLIGHT
- 10. Throttle Circuit Breakers..... OUT

BEFORE LANDING

- 1. Notify Crew..... "PREPARE TO LAND."
- 2. Autopilot..... OFF
- 3. Jet Air Plug Switches..... OPEN
- *4. Engineer's Landing Configuration..... PILOT READS — ENGINEER ANSWERS:

"ALTERNATORS — PARALLELED; BOOSTER PUMPS — ON; TURBOS — BOTH; SPARK — RETARDED; MIXTURES — NORMAL; TBS — ZERO; PROPELLERS — AUTOMATIC; LANDING GROSS WT. _____ POUNDS; CG _____ PER CENT; BEFORE LANDING CHECK LIST COMPLETED, STANDING BY ON RPM FOR LANDING GEAR AND BRAKE CHECK."

- 5. Stalling Speed..... CHECKED
- 6. Master Tachometer..... 2550 RPM
- 7. Landing Gear Control Switch..... EXTEND
- 8. Parking Brake Lever..... OFF

* PILOT-ENGINEER COORDINATION ITEM

BEFORE LANDING (Continued)

- *9. Left And Right Brakes..... CHECKED
- 10. Nose Gear Strut..... BLED
- 11. Nose Steering Switch..... ON
- 12. Read Pilot's Landing Configuration To Engineer:
"GEAR DOWN AND LOCKED, AUTOPILOT — OFF, NOSE WHEEL STEERING SWITCH — ON, STANDING BY ON FLAPS."
- 13. Flaps..... 10 DEGREES

BASE LEG

- 1. Flaps..... 20 DEGREES
- 2. Jet Air Plug Switches..... CLOSE

FINAL APPROACH

At High Gross Weights, High Field Elevation, And In Emergencies 2700 RPM And No. 7 TBS Setting May Be Used.

- 1. Flaps..... 30 DEGREES

LANDING

- 1. Propeller Reverse Selector Switches..... READY ON MAIN GEAR CONTACT
- 2. Propeller Reverse Pitch Switch..... DEPRESS ON A/C'S COMMAND
- 3. Control Surfaces..... LOCKED AT 50 MPH
- 4. Propeller Reverse Selector Switches..... SAFE
- 5. Flaps..... RETRACTED
- 6. Jet Oil Shutoff Valve Switches..... CLOSED AT ZERO PER CENT RPM

POSTFLIGHT RUN-UP

- 1. Parking Brake Lever..... ON
- 2. Nose Wheel Steering Switch..... OFF
- 3. Propeller Reverse Selector Switches..... SAFE (LIGHTS OUT)
- 4. Observe Engineer's Power Checks

STOPPING RECIPROCATING ENGINES

- 1. Parking Brake Lever..... ON
- 2. Propeller Reverse Selector Switches..... SAFE (LIGHTS OUT)
- 3. Nose Wheel Steering Switch..... OFF
- 4. Flight Instrument Switches..... OFF
- 5. Contact Engineer..... "READY TO STOP ENGINES"
- *6. Emergency Ignition Switch..... PULL OFF
- 7. Radio Equipment..... OFF

BEFORE LEAVING AIRCRAFT

- 1. All Control Switches..... PROPERLY POSITIONED
- 2. Wheel Chocks..... IN PLACE
- 3. Parking Brake Lever..... OFF
- 4. Postflight Visual Inspection..... COMPLETED
- 5. Aircraft Forms..... COMPLETED
- 6. Pitot Head Covers..... IN PLACE
- 7. Security Of Aircraft..... ESTABLISHED

Figure 2-2. (Sheet 2) Pilot's Standard Check List

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B-36D FLIGHT ENGINEER'S STANDARD CHECK LIST

BEFORE STARTING

1. Required Forms.....ABOARD AND CHECKED
2. All Circuit Breakers and Control Switches.....PROPERLY POSITIONED
3. Emergency Power Switch.....NORMAL
4. Cabin Heater Power Switch.....OFF
5. External Power Supply Switch.....OFF
6. Battery Switch.....ON
7. Alternator Panel Configuration.....CHECKED
8. Call Ground Observer For External Power
9. Correct A-C Phase Sequence Lamp.....LIGHTED
- *10. External Power Supply Switch.....ON
(Liquid Lock Check, If Required, With Ignition Switches Off)
11. Fuel Panel Configuration.....CHECKED
12. Water Injection Switches.....OFF
13. Oil Vent Heater Switch.....AS REQUIRED
14. Oil Shutoff Valve Switch Guards.....DOWN
15. Engine Supercharger Switches.....BOTH
16. Cabin Pressure Shutoff Valve Switches.....OFF
17. Cabin Booster Fan Switch.....OFF
18. Aft Cabin Pressure Switch.....ON
19. Cabin Heat, Wing And Tail Anti-Ice Switches.....OFF
20. Pitot Heater And Propeller Anti-Ice Switches.....OFF
21. Carburetor Preheat Switches.....OFF
22. Nacelle Fire Detector And Extinguisher.....CHECKED
23. Wheel Well Lights Switch.....AS REQUIRED
- *24. Hydraulic Control Panel.....CHECKED
25. Propeller Control Panel.....CHECKED
26. Fan Speed Control Switches.....LOW RPM
27. Carburetor Air Filter Switch.....AS REQUIRED
28. Fluorescent Lights Switch.....AS REQUIRED
29. Spark Advance Switches.....RETARD (GUARD DOWN)
30. Mixture Control Check.....COMPLETED
31. TBS.....ZERO
32. Turbo Calibration Knobs.....FULL COUNTERCLOCKWISE
33. Master Temperature Indicator.....ON AND COMPENSATED
34. Intercoolers And Air Plugs.....AS REQUIRED
35. Instrument Check.....NORMAL
36. Master Ignition Switch.....ON
- *37. Report to A/C, "Check List Completed, Master Ignition In, Ready To Start Engines."

STARTING RECIPROCATING ENGINES

1. Fuel Tank Valve Switches.....OPEN
2. Respective Booster Pumps.....ON
3. Inform Ground Observer, "Ready To Start Engines, Clear No. 4."
4. Voltage And Frequency Selector Switch.....NO. 4 POSITION
5. Throttle Levers.....POSITIONED
6. Engine Fuel Valves.....OPEN
7. Fuel Pressures.....10-14 PSI
8. Locate No. 4 Starter, Primer, And Ignition Switches
9. No. 4 Engine Starter Switch.....ON
10. No. 4 Engine Ignition Switch.....BOTH
11. No. 4 Engine Primer Switch.....ON
12. No. 4 Mixture Control Lever.....NORMAL
13. Report, "Oil Pressure Normal, Alternator Excited."
14. Repeat Steps 8 Thru 13 For Starting Engines 5, 6, 3, 2, And 1

* PILOT-ENGINEER COORDINATION ITEM

DURING ENGINE WARM-UP

- *1. Ignition Safety Check.....IDLE RPM
2. Engine Oil-In Temperature.....MINIMUM 40°C
3. All Booster Pump Switches.....OFF
- *4. Propeller Control System.....CHECKED
5. Idle Speed.....CHECKED
6. In-Flight Oil Cooling Doors.....CHECKED
7. Barometric Pressure Checks.....COMPLETED
8. Alternator Checks.....COMPLETED

TAXIING

1. Taxi Configuration, "Alternators On The Line And Paralleled, Brake And Nose Steering Pressure Normal, Ready To Taxi."

ENGINE RUN-UP

1. Full Power No Boost Checks.....COMPLETED
2. Full Power With Boost Checks.....COMPLETED
3. Cabin Pressurization And Carburetor Preheat Checks.....COMPLETED

STARTING JET ENGINES (GROUND-AIR)

- *1. Jet Start Configuration.....CHECKED AND "STANDING BY FOR JET ENGINE START."

BEFORE TAKE-OFF

1. Air Plugs And Intercoolers.....AS REQUIRED
2. Cabin Heater Power Switch.....OFF
3. All Alternators On Line.....PARALLELED
4. Fuel Panel Checked.....BOOSTER PUMPS ON
5. Engine Supercharger Switches.....BOTH
6. Cabin Pressure Shutoff Valve Switches.....OFF
7. Booster Fan Control Switch.....OFF
8. Pitot Heater Switches.....AS REQUIRED
9. Propeller Anti-Ice Switch.....OFF
10. Carburetor Preheat Switches.....OFF
11. Cabin Heat, Wing And Tail Anti-Ice Switches.....OFF
12. Engine Fan Speed Control Switches.....LOW RPM
13. Temperatures.....CHECKED AND WITHIN LIMITS
14. Spark Advance Switches.....RETARD
15. Mixture Control Selector Switches.....LEVER
16. Mixture Control Levers.....NORMAL
17. Propeller Selector Switches.....AUTOMATIC OPERATION
18. Propeller Normal Pitch Indicator And Tel-Lamps.....LIGHTED
19. Brake And Nose Steering Pressure.....NORMAL
- *20. Engineer's Take-Off Configuration.....PILOT READS — ENGINEER ANSWERS:

"ALTERNATORS — PARALLELED; BOOSTER PUMPS — ON; TURBOS — BOTH; SPARK — RETARDED; MIXTURES — NORMAL; BRAKE AND STEERING PRESSURE — NORMAL; TAKE-OFF CONFIGURATION COMPLETED, STANDING BY FOR PROPELLER REVERSE SAFETY CHECK AND TAKE-OFF POWER."

Figure 2-3. (Sheet 1) Engineer's Standard Check List

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B-36D FLIGHT ENGINEER'S STANDARD CHECK LIST (Cont'd)

TAKE-OFF

- *1. Propeller Reverse Safety Check As Jets Reach 90 Per Cent RPM.
- *2. Set Take-Off Power and Report the Following to A/C as Performed, "Advancing Throttle to 35 Inches, Master Tachometer 2000 RPM, Propellers Governing, Master Tachometer 2700 RPM, Tel-Lamps Operating, Engine RPM Normal, Throttles Full Open, Water Injection On, TBS 7, Power Stabilized, Ready For Take-Off."
- 3. Report, "Power Stabilized, Propellers Governing," 10 MPH Prior to Nose-Up Speed.

AFTER TAKE-OFF

- 1. Report, "Main Hydraulic Pressure Relieved."

INITIAL CLIMB

- 1. Power Condition No. 2.....UPON PILOT'S REQUEST
- 2. TBS.....REDUCE M.P. TO 55 INCHES
- 3. Water Injection Switches.....OFF
- 4. Reduce Power.....2550 RPM, 51.5 INCHES M.P.
- 5. Torque, Fuel Flow, CHT, CAT.....WITHIN LIMITS

CRUISE

For Specific Cruise Data, See Appendix I and Amplified Check List.

BEFORE CLIMB (HIGH POWER OPERATION, AFTER A MANUAL LEAN SPARK ADVANCE CRUISE)

- 1. Air Plugs And Intercoolers.....OPEN
- 2. Spark Advance Switches.....RETARD
- 3. Mixture Controls.....NORMAL (LIGHTS ON)
- 4. Engine Supercharger Switches.....BOTH
- 5. Desired Power.....SET

BEFORE LANDING

- 1. Air Plugs And Intercoolers.....AS REQUIRED
- 2. Cabin Heater Power Switch.....OFF
- 3. Electrical System.....CHECKED
- 4. Fuel Panel Checked.....BOOSTER PUMPS ON
- 5. Engine Supercharger Switches.....BOTH
- 6. Cabin Pressure Shutoff Valve Switches.....OFF
- 7. Booster Fan Control Switch.....OFF
- 8. Pitot Heater Switches.....AS REQUIRED
- 9. Propeller Anti-Ice Switch.....OFF
- 10. Carburetor Preheat Switches.....AS REQUIRED
- 11. Cabin Heat, Wing And Tail Anti-Ice Switches.....OFF
- 12. Fan Speed Control Switches.....LOW RPM
- 13. Spark Advance Switches.....RETARD
- 14. Mixture Control Selector Switches.....LEVER
- 15. Mixture Control Levers.....NORMAL
- 16. TBS.....ZERO
- 17. Propeller Selector Switches.....AUTOMATIC
- 18. Propeller Normal Pitch Indicator And Tel-Lamps.....LIGHTED

* PILOT-ENGINEER COORDINATION ITEM

BEFORE LANDING (Continued)

- *19. Engineer's Landing Configuration.....PILOT READS —
ENGINEER ANSWERS:
"ALTERNATORS — PARALLELED; BOOSTER PUMPS — ON; TURBOS — BOTH; SPARK — RETARDED; MIXTURES — NORMAL; TBS — ZERO; PROPELLERS — AUTOMATIC; LANDING GROSS WT. _____ POUNDS; CG _____ PER CENT; BEFORE LANDING CHECK LIST COMPLETED, STANDING BY ON RPM FOR LANDING GEAR AND BRAKE CHECK."
- 20. Master Tachometer.....2550 RPM
AT HIGH GROSS WEIGHTS, HIGH FIELD ELEVATIONS, AND IN EMERGENCIES, 2700 RPM AND 7 TBS SETTING MAY BE USED.
- *21. Brakes Checked.....PRESSURE NORMAL

LANDING

- 1. Brake and Nose Steering Pressure.....NORMAL AFTER NOSE WHEEL CONTACTS GROUND
- 2. RPM and M.P. Checked.....AFTER PROPS REVERSE DO NOT EXCEED 30 INCHES M.P. EXCEPT IN EMERGENCY

TAXI

- 1. Alternators (Minimum Of Two On The Line).....PARALLELED
- 2. Brake and Nose Steering Pressure.....NORMAL

POSTFLIGHT RUN-UP

- 1. Barometric Pressure Engine Checks.....COMPLETED
- 2. Full Power No Boost Check.....COMPLETED

STOPPING RECIPROCATING ENGINES

- 1. Air Plugs.....OPEN
- 2. Intercooler Shutters.....CLOSED
- 3. Master Motor Speed Control Lever.....FULL DECREASE
- 4. Booster Pumps.....OFF
- 5. Alternator Control Checks.....COMPLETED
- 6. Idle Speed And Mixture Checks.....COMPLETED
- 7. Fuel Tank Valve Switches.....CLOSED
- 8. Cross-Feed, Manifold, And Engine Valve Switches.....OPEN
- 9. Individual Ignition Switches.....OFF
- *10. Master Ignition Switch.....PULL OFF
- 11. Battery Switch.....OFF
- 12. Master Temperature Indicator.....OFF

BEFORE LEAVING AIRCRAFT

- 1. Postflight Visual Inspection.....COMPLETED
- 2. Dip Stick Readings.....RECORDED
- 3. Forms And Reports.....COMPLETED

Figure 2-3. (Sheet 2) Engineer's Standard Check List

C1-345U-C

GENERAL MISSION PLANNING.

The mission may be conceived at any level of command. Each lower level of command must do a certain amount of planning upon receipt of the operations order. However, the final details of any mission plan and the execution of the individual mission is always up to the individual crew. The exact requirements for mission planning are set forth in Air Force, major command, and local directives with which your crew should be familiar.

Receipt of an operations order dictates a multitude of tasks that must be performed by the combat crew as a team with time being a limiting factor. The crew must be assembled by the aircraft commander and notified of the impending flight. At this time the crew learns which aircraft is to be flown and approximately what is to be accomplished on the mission. Since time is a limiting factor and crew fatigue must be held to a minimum prior to a lengthy mission, a logical sequence of events must take place to make sure that everything required is accomplished with absolute efficiency.

The responsibility for insuring efficient teamwork is the aircraft commander's. Through coordination with the engineering section, it should be determined when the assigned aircraft will be ready for preflight. Normally a mission is not scheduled until the aircraft is in commission. If there is to be some delay, notify your crew so that they may continue with the next phase, "Detailed Mission Planning," while standing by for the "Preflight Operational Equipment Check." As soon as the aircraft is declared ready, see that all crew members proceed directly to the aircraft to perform their portion of the "Preflight Operational Equipment Check." This will allow maintenance maximum time to correct any discrepancies noted during this check and assures your crew that their aircraft is prepared to perform the anticipated mission before they proceed with other time-consuming requirements.

PREFLIGHT OPERATIONAL EQUIPMENT CHECK.

This preflight check is designated to be a thorough, comprehensive, and complete check of each crew member's operational equipment. This check constitutes the first of two preflight run-ups for pilots and engineers. Many items not directly affecting safety of flight, but promoting successful accomplishment of the mission, need not be rechecked during the second preflight run-up just prior to take-off, unless a recheck is dictated by inclement weather conditions, additional maintenance repairs after preflight operational check, or an unusual delay before take-off. This operational equipment check is amplified and aligned in such a manner that it can be used to replace both run-ups and still provide a complete check in event only one

run-up is desired due to the nature of the mission such as aircraft ferry flights, maintenance test flights, or time factor.

In order that any deficiencies may be corrected and defective equipment replaced prior to flight, this check should be accomplished as soon as possible within a 24-hour period prior to estimated take-off time. The aircraft commander should coordinate his mission planning with all sections concerned and order the necessary equipment for accomplishment of the mission. Each crew member should have a definite duty to perform in connection with the preflight and should know what his responsibilities are. Equipment to be checked includes radar, bombing, and navigation equipment; radio and ECM equipment; and the complete gunnery system. If the entire crew performs their required checks together, better coordination and teamwork exist and the routine of the ground maintenance crew is less disrupted. Actually the ground maintenance crew is soon accustomed to flight crew requirements and it becomes an expected portion of their routine. Various equipment checks require that electrical power be established and that engines be running with the alternators paralleled to see that the available power supply provides proper equipment operation, such as radar equipment. Wing flap, hydraulic system, gunnery system, and jet engine starter operation demand high electrical loads and will not be operated during the radar equipment preflight check.

In addition to an operational check of normal and specially installed equipment, this preflight includes a complete reciprocating engine run-up. The jet engines should only be run to make sure that known deficiencies have been cleared since the preceding flight. All newly installed jet equipment must be thoroughly checked.

Since this preflight is an operational check of equipment and should be completed as soon as possible, the pilots' and engineers' visual preflight inspection is performed later as outlined in this section under "Visual Preflight Inspection." There will of necessity be some duplication of effort with this system; however, those preflight procedures which are duplicated are necessary to insure the best interests of flying safety. Locate the crew chief and determine what maintenance has been performed. Make sure the proper status of the aircraft is reflected in Parts II and III of AF Form 1.

The ground crew will aid in making preparations for the preflight operational equipment check and run-up. By a quick visual inspection assure yourself that the wheel chocks are in place, maintenance stands are out of the path of the aircraft and propeller blast, and that all installed cowling is secure.

Before deciding where the aircraft is to be parked for run-up, check the wind direction and velocity. The aircraft should be headed directly into the wind for

several reasons. Considerable difficulty may be experienced in moving the rudder in strong cross winds. Tail winds can cause excessive or erratic tail pipe temperatures during jet engine starting and operation. A direct head wind provides maximum ground cooling and even propeller loading during engine run-up and single magneto check. Wind velocity affects the idle speed setting of the reciprocating engines. Other considerations also affect the choice of a proper parking spot for run-up. Park the aircraft on a clean, hard surface to prevent pick-up and throwing of gravel and debris by the jet intakes or propeller blast. Avoid tailing the aircraft toward other aircraft, buildings, close taxi strips or runways to prevent damage from propeller or jet engine blast and to allow the run-up to progress as rapidly as possible without interruptions.

Before entering the aircraft, know who is to handle the ground interphone and that he understands proper ground reporting procedures on engine starts, control checks, propeller checks, etc.

The aircraft commander, pilot, and engineers proceed to their stations with their headsets and microphones and check the interphone systems to be used with the ground observer. At this point the pilot will read the "Before Starting Engines" check list to the aircraft commander, who will complete the checks. In the same manner the second engineer will assist the first engineer. Coordination items between aircraft commander and first engineer are indicated on the check list and must be checked as indicated in the amplified check list.

Proceed with the applicable entries of the pilots' and engineers' check lists as amplified below:

BEFORE STARTING ENGINES.

PILOTS

1. Landing Gear Control Switch—EXTEND. The landing gear control switch should be in the EXTEND position for all ground operations. With the switch in this position, a gang bar arrangement holds the brake pump switch ON.

2. Visual inspection; Forms 1, F, and Loading List—Completed.

Before flight the visual inspections, loading lists, and Forms 1 and F must be complete. Visual inspection should be completed to the aircraft commander's satisfaction. Discrepancies noted in the Form 1 which have been corrected should be particularly checked to insure that those items of equipment are in proper working order.

The Form F which was filled out by the pilot must be thoroughly checked for accuracy and signed by the aircraft commander. Figures on gross weight of aircraft, nose-up speed, unstick speed, take-off distance over a 50-foot obstacle, refusal speed, stopping distance using both brakes and reverse pitch, and stopping dis-

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1. Required Forms—Aboard and Checked. Check the AF Form 1 before any preflight or flight operations. Before flight also check the Form F for accuracy and completion; the Flight Log initiated with proper headings, correct gross weight and fuel load in pounds, and predicted take-off and climb power settings indicated; and other required forms aboard such as flight engineers' reports, prediction forms, or test flight reports as required by local directives.

2. All Circuit Breakers and Control Switches—Properly Positioned. To make certain control circuits are connected to their respective power source and to prevent inadvertent operation of systems when power is applied to the aircraft.

3. Emergency Power Switch—NORMAL. To insure that the normal power distribution system is not partially blocked out; for example, the radio operator's unit would be blocked out except when fed by an excited alternator which has been selected by the engineer's voltage and frequency selector switch.

PILOTS

tance with brakes only must be memorized by the aircraft commander prior to take-off. The original copy Form F must be filed with Operations. Loading list must be checked to insure that the name, rank, serial number, and organization of every person on the flight is on the loading list. One copy of the loading list must be filed with the aircraft clearance at base operations.

3. Pitot Covers and Ground Locks—Removed. (Not to be accomplished during "Preflight Operational Equipment Check.")

The aircraft commander will personally check just before he enters the aircraft to see that all down locks (main landing gear, nose gear, and rudder locks) have been removed and that the pitot covers have been removed.

4. Nose Wheel Scissors—Connected. The aircraft commander will also check just before he enters the aircraft to insure that the nose wheel scissors have been connected. The nose wheel scissors will only be disconnected when it is necessary to move the aircraft by use of a tug or towing equipment.

The aircraft should be in proper taxi position when the crew boards the aircraft so that it is unnecessary to have the nose wheel scissors disconnected for any further towing operations.

5. Personal Equipment—Checked in place. (Not to be accomplished during "Preflight Operational Equipment Check.")

Oxygen equipment, headset, and throat mike should be in place and plugged in. Other equipment necessary for the immediate flight should be readily available at each station. All other personal equipment should be in the A-3 bag and properly stowed.

6. Seats and Pedals—Adjusted. Make certain that the seat and rudder pedals are in proper position for the most efficient use of brakes and rudder.

7. All Circuit Breakers—In. To make sure that various indicator lamps, instruments, and control circuits are connected to the electrical power distribution systems.

8. All Indicator Lamps—Push to test. To see that the indicator lamps are not burned out.

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4. Cabin Heater Power Switch—OFF. The circuit is automatically de-energized when the external power is ON. However, the switch will be OFF during engine starting to prevent overload of the a-c system after external power is turned off and the engine alternator is placed on the line.

5. External Power Supply Switch—OFF. To prevent inadvertent connection of the external power supply to the bus before correct phase sequence has been established and the alternator breakers checked open.

6. Battery Switch—ON. To energize the d-c bus system, providing power for the indicator lamp and control circuits.

7. Alternator Panel Configuration—Checked.

a. Frequency Control Knobs — Full DECREASE. This is the normal position for these controls when the alternators are not operating. It provides a safety precaution against constant-speed drive surging and overspeeding and probably latching in underdrive during engine start.

b. Bus Tie Breaker Switches—CLOSED. Check the action of these breakers at this time. Raise the switch guards and open each breaker — lamp on indicates breaker is open. Close each breaker and place switch guards down — lamp out indicates breaker closed. All breakers closed insures that a-c power is feeding all four bus systems. Push to test any lamps that do not appear to be operating to make sure lamp is not burned out. Any controls that do not indicate normal indication must be investigated by an electrical specialist.

c. Exciter Control Relay Switch—ON. Exciting the alternators prior to engine start allows the operator to see that the alternator control circuits are functioning normally as each engine is started by watching the voltage and frequency indications. To effectively excite the alternators prior to engine start it will be necessary to momentarily remove the mixture control levers from the IDLE CUT-OFF position because a micro switch behind each mixture control lever for alternator-equipped engines keeps the exciter relay control circuit broken.

d. Alternator Breaker Switches — OPEN (lamps lighted). To insure that alternator breakers are open prior to placing the external power switch ON, thus placing a-c power on the bus system. The open position prevents "motorizing" of the engine-driven alternators and subsequent excessive loads on the auxiliary power unit. Check the operation of these breakers and hold-in switch effectiveness by continuing where you left off in step c above.

CAUTION

Never close alternator breakers while external power is ON.

PILOTS

9. Radio Checks—Completed. Coordinate with the engineer at this point to insure that he has external power available to operate radio equipment.

Contact the control tower on the VHF command set and receive taxi instructions, OAT., altimeter setting, and dew point. While the aircraft commander is making this check, the pilot will check the operation of the radio compass. If instrument conditions are to be encountered immediately after take-off, have radio compass tuned to local range station and on compass position for take-off. Either the aircraft commander or pilot will monitor interphone at all times.

10. Autopilot—ON. Turn the autopilot switch ON so that the gyros may be warming up for a later operational check. The autopilot should be given an operational check on the ground if it is to be used during the flight. There will be ample time to perform this check before taxiing if the pilot schedules his time.

11. Flight Instrument Switches—ON. These switches are provided so that the flight instruments may be spared hours of ground operation during maintenance of the airplane. These switches must be ON approximately fifteen minutes before take-off so that the gyros can stabilize and so that flight instrument operation can be checked. During the preflight operational equipment check, place the pilot's flight instrument switch to EMERGENCY until the emergency electrical power system check has been completed.

12. Propeller Reverse Selector Switches—SAFE, Lights Out. This will prevent inadvertent operation in reverse pitch. The red propeller reverse warning lamps indicate when the propellers are in reverse pitch. The lamps should go out when the propeller reverse selector switches are in the SAFE position.

ENGINEERS

All alternator breakers — CLOSED (lamps out). All alternator hold-in switches—HOLD IN. Return mixture control levers to IDLE CUT-OFF. See that alternator breaker lamps are still out. Release all alternator hold-in switches and see that all alternator breakers open as indicated by the four alternator breaker lamps.

8. Call ground observer for external power.

The ground observer can either close the APU circuit breaker or plug in the external power, depending upon type of power unit involved. You also know he is standing by on interphone to make any adjustments to power found necessary by aircraft instrumentation.

9. Correct A-C Phase Sequence Lamp—Lighted. To insure that external power is in correct phase (1, 2, 3) with the aircraft wiring system. If *incorrect phase* external power were placed on the aircraft a-c power distribution system, it would cause all three phase motors to operate in reverse, nullifying limit switches on electrical actuators and resulting in immediate damage to aircraft structure and equipment.

10. External Power Supply Switch—ON. Check bus voltage (208V) and frequency (405 cycles ± 5). Have the ground observer adjust if necessary.

Note

If the engine has not been started within a two-hour period or if the engine was started and shut down for 30 minutes, perform a liquid lock check at this time with the ignition switches OFF. This check normally occurs during the engineer's "Visual Preflight Inspection" and the procedure is amplified under that heading.

11. Fuel Panel Configuration—Checked.

a. Pressure Refueling Valve Switches—CLOSE. These valves should always be closed except when fuel is being transferred. Normally closed, these valves prevent inadvertent fuel transfer; open valves would also cause abnormally low fuel pressures during checks and operations.

b. Fuel Booster Pumps—OFF. Always OFF except when fuel is to be used from tank and respective tank valve is open.

c. Fuel Tank Valves — CLOSE. Normal position when fuel is not being used or transferred and engines are not running.

d. Engine Fuel, Manifold, and Cross-Feed Valves—OPEN. The normal position of these valves is open at all times except when checking valve operation or during fuel system emergencies. In the OPEN position these valves permit any fuel tank to feed any engine plus allowing for temperature expansion of fuel in the long manifold system.

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Note

Steps a, b, c, and d above constitute the normal fuel panel configuration any time the engines are not operating, refueling or fuel transfer is not being accomplished, or operation of the fuel system is not being checked. Set up this configuration before and after conducting any of these operations to establish a known condition from which to start or end any operation.

e. Fuel System Operational Check.

Note

The following check should be made during the "Operational Equipment Check" to assure that all valves and booster pumps in the fuel system perform their designated functions. It should only be necessary to perform one complete check prior to any flight to prevent wear from added operation of these components, but additional checks may be made any time it is deemed advisable and in every case where a recheck is dictated by repair or replacement of equipment.

- (1) No. 1 Tank Valve—OPEN (all others closed).
- (2) No. 1 Booster Pump—ON (all others OFF).
- (3) No. 6 Engine Valve—OPEN (all others OFF).
No. 6 engine fuel pressure gage should register 10-14 psi.
- (4) No. 1 Manifold Valve—CLOSED (all others OPEN).
- (5) No. 4, 5, or 6 Pressure Refueling Valve momentarily OPEN then CLOSED to drop No. 6 engine fuel pressure to zero.

Note

After pressure refueling valve is closed, no fuel pressure should register after 10 seconds on No. 6 engine fuel pressure gage.

- (6) Close No. 2 Manifold Valve and Open No. 1 Manifold Valve. No fuel pressure on No. 6 engine.
- (7) Close No. 3 Manifold Valve and Open No. 2 Manifold Valve. No fuel pressure should register on No. 6 engine.
- (8) Continue above procedure on remaining manifold and cross-feed valves until all have been checked.

Note

At any time a pressure is indicated on No. 6 engine, the valve that was last operated to closed position is leaking or inoperative. When No. 8 manifold valve is opened, a fuel pressure of 10-14 psi should be registered again. If a pressure is not indicated, one of the

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cross-feed or manifold valves is stuck in the closed position. Detection of the one that is not operating can be narrowed down by opening engine fuel valves 5 and 4, etc., across the panel until a fuel pressure is finally obtained.

(9) No. 1 Booster Pump OFF and one pressure refueling valve open momentarily to kill fuel pressure on No. 6 engine as before.

(10) Close pressure refueling and engine valves.

(11) No. 1 Tank Valve OPEN and Booster Pump ON. (No pressure should register.)

(12) No. 1 Engine Valve OPEN (pressure should register on No. 1 Engine); then CLOSE No. 1 Engine Valve.

(13) No. 1 Tank Booster Pump OFF and Tank Valve CLOSED.

(14) Repeat steps 11, 12, and 13 using individual tank and booster pump for each engine as for No. 1 engine.

Note

Pressure should build up on the corresponding gage as each engine valve is opened. The booster pump pressure (10-14 psi) should remain up for at least 10 seconds.

(15) Bleed off engine fuel pressure again for reuse as an indication of fuel valve operation and booster pump pressure on other tanks which contain fuel and are to be used.

12. Water Injection Switches—OFF. To prevent water injection pumps from operating.

13. Oil Vent Heater Switches—As Required. To prevent vapors from congealing, freezing, and consequently plugging the engine oil tank vent lines. This switch should be placed in the ON position for ground and flight operations when the ambient air temperature is at 0°C (32°F) and below.

14. Oil Shutoff Valve Switch Guards—DOWN. This is the normal position for these controls to prevent starvation of oil to engine when started.

15. Engine Supercharger Switches—BOTH. Normal position for all ground operation to prevent abnormal manifold pressure during run-up and possible damage to right turbo system if backfire occurs during starting.

16. Cabin Pressure Shutoff Valve Switches—OFF. Normal position for these valves prior to engine start prevents drainage of manifold pressure during full power checks.

17. Cabin Booster Fan Switch—OFF. Prevents overloading of a-c system.

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13. Nose Steering & Brakes—Checked and Set. This check must be made in coordination with the engineer. It includes a check of the nose steering system, a complete brake check, and setting of the parking brake prior to engine start.

ENGINEERS

18. Aft Cabin Pressure Switch—ON. Sets up aft cabin for pressurization. There is no reason for this valve to be closed except when it is desired to depressurize the aft cabin during flight or to check cabin air flow.

19. Cabin Heat, Wing and Tail Anti-Ice Switches—OFF.

a. Cabin Heat and Tail Anti-Ice Switch—FULL DECREASE until lamp lights.

b. Cabin Heat, Wing and Tail Anti-Ice Switches—OFF. (Push to test warning lamps.) This opens the engine dump valves and prevents heating the leading edges of wings and empennage during engine run-up. If leading edges are heated over 50°C above OAT, during ground operation damage, such as permanent wrinkling of the leading edges (oilcanning), will probably result.

20. Pitot Heat and Propeller Anti-Ice Switches—OFF.

Normal position for these valves except during operational checks or when icing is anticipated during flight. Leaving pitot heat switch ON on the ground will burn out the heater element, while ground operation of engines with propeller anti-ice switch will damage oil seals in the propeller power unit, causing loss of propeller oil and subsequent loss of propeller control.

21. Carburetor Preheat Switches—OFF.

These switches should be OFF at all times except when checking system or when icing is anticipated. If left ON, excessive carburetor temperatures will be experienced during run-up and control of cabin pressure wing shutoff valves will be lost, since these valves automatically close when carburetor preheat is ON.

22. Nacelle Fire Detector and Extinguisher—Checked.

a. Fire Extinguisher Engine Selector Switches—OFF, (guards down). To prevent accidental discharge of the fire extinguisher system.

b. Fire Detector Push-to-Test Switch—Push to test circuit. This tests the complete warning circuit for continuity and normal operation from a rapid rate heat rise. If any one lamp does not light within 10 seconds, the circuit is defective and must be checked.

23. Wheel Well Lights Switch—As Required. This switch should be OFF except during gear operation at night, when a crew member is in the wing, or when a crew member is checking the nose gear latch. It controls three lamps that shine directly upon the landing gear locks.

24. Hydraulic Control Panel—Checked.

a. Hydraulic Fluid Temperature Control Switch—As required. Use to keep bomb bay door fluid temperature between -18°C (0°F) and 38°C (100°F) to insure proper operation of the bomb bay door system. Turn ON when ambient air temperature is below -18°C (0°F) if bomb bay door operation is anticipated.

PILOTS

- a. Steering Control Switch—ON. Apply slight pressure in both directions with the nose steering wheel.

CAUTION

Do not force nose wheel to move while the aircraft is static. This would cause undue stress and strain on nose gear components and scrubbing abrasions of the tires.

- b. Steering Control Switch—OFF.

c. Brake Pump Switch—OFF. The brake check will be made with the brake pump switch OFF and the parking brake lever OFF.

d. Announce, "Left brake," and firmly depress left brake pedal and release. Then announce, "Right brake," and firmly depress right brake pedal and release. The engineer will check for pressure drop.

e. Depress and release both brake pedals until brake pressure drops.

- f. Brake Pump Switch—ON.

g. Parking Brake Lever—ON. Announce, "Parking brake set."

Brake pedals should be fully extended. Normal pressure on the brake pedals should not cause any depression.

If the brake pedals move spongily, the slave brake system must be bled and rechecked.

In the event pressure does not force the foot pedals out, the brake gage line fuse is probably blown. If this has happened, hold the aircraft with the foot brakes, have the radio operator or the second engineer place the emergency hydraulic selector valve in the CHARGE BRAKE ACCUMULATOR position, and operate the hand pump four or five strokes. This will reset the brake fuse and the parking brakes should operate normally. The aircraft must be completely stopped for normal parking brake setting because of

ENGINEERS

b. Hydraulic Pump Override Switch—OFF. Turn ON momentarily (approx. 1/4 sec.) and then OFF. Observe surge of main system hydraulic pressure and electrical load. Main system hydraulic pressure should return to zero with override switch OFF. The above check with the override switch assures that the override circuit and relay and No. 2 hydro pump and motor are operational.

c. Request pilot to perform a nose steering check and note pressures. If OK, report, "Nose steering pressure normal."

d. Brake System Check—Completed. Contact pilot and announce "Ready for brake check." Report pressures during check.

e. As pilot depresses and releases brake pedals, report remaining pressure, "—psi."

f. Note and report, "Accumulator pressure — psi." Accumulator pressure should be approximately 250 psi.

g. Brake Pump Pressure Override Switch—Hold ON until pressure is 500-600 psi; then release and announce, "—psi with override."

h. Observe low brake pressure warning lamp lighted and then pressure build-up until lamp goes out. Observe continued build-up of pressure to normal. Report, "Brake pressure normal."

i. Observe and announce, "Pressure down, building up, normal."

25. Propeller Control Panel—Checked.

a. Propeller Feather Switch — NORMAL (guards down). To prevent accidental feathering of propeller. All normal circuits pass through each propeller feather switch.

b. Propeller Circuit Breakers — In. Connects all propeller controls to d-c power distribution.

c. Propeller Selector Switches—AUTOMATIC OPERATION. Sets up system for eventual run-up and for a check on the protective relay tel-lamps as master motor speed is increased.

d. Master Motor Speed Control Lever—Full INCREASE rpm. Note that full increase stop is set for a master tachometer indication of 2700 rpm.

PILOTS

the instantaneous locking action of the system. The foot brakes will be used to hold the airplane when releasing the parking brakes to prevent excessive wear on the brake system due to drag during brake release. Rapid successive movement of the parking brake will cause the brake gage line fuse to move and drop the brake pressure, rendering the parking brakes inoperative. If this condition exists, place the emergency selector valve in the CHARGE BRAKE ACCUMULATOR position and operate the hand pump four or five strokes. This action will position the fuse to give the proper pressure. The emergency selector valve should be allowed to remain in the CHARGE BRAKE ACCUMULATOR position at all times except during emergency hydraulic extension of the landing gear.

14. Surface Controls and Trim Tabs—Checked.

Before unlocking the controls, check for wind velocity and direction. Considerable difficulty may be experienced in moving the rudder in strong cross winds. Under these conditions it will be necessary to head the airplane into the wind before a rudder movement check can be made.

A ground observer will check proper movement of the control surfaces and tabs. The controls should be checked in the following order: elevators, rudder, and ailerons. To expedite this check it is recommended that the trim control be moved in the same direction as the control surface and that the surfaces, servo tabs, and trim tabs be checked simultaneously. For example, elevator trim full nose-up and control column full back gives elevator surface up with servo and trim tab down.

It should be remembered that aileron trim tabs are electrically operated and that a few minutes cooling period should be allowed to cool the electric motor between full left trim deflection and full right trim deflection. Check the coordination between trim tab indication on the pilots' trim tab indicator and the reported setting given by the ground observers.

Set trim tabs for take-off, using 30 per cent MAC as neutral elevator; set 1 degree elevator trim for each 1 per cent variation from 30 per cent MAC. If nose is heavy (30 per cent minus), trim nose up; if tail is heavy (30 per cent plus), trim nose down.

Surface controls locked. After the surface control check is completed, the lock will be engaged. A red lamp will burn for controls in the locked position, and a green lamp will burn for controls in the unlocked position. If neither green nor red lamp burns, the condition can be caused from the lamps being burned out.

15. Autopilot—Checked and OFF.

- a. Turn autopilot on.
- b. Pilot's turn control in detent.

ENGINEERS

e. Propeller Tel-Lamps — Lighted. Tel-lamps indicate that contactors are properly grounded through the master motor protective relay and that control panel is set up for automatic operation.

26. Fan Speed Control Switches—LOW RPM. Normal position for all operation below 13,500 feet except when checking engine cooling fan for shift from low rpm to high rpm and then back to low rpm. The LOW RPM position, being normal, prevents low torque readings during run-up and prevents damage to fan, cooling tunnel, accessory case, and sheer couplings during full power checks.

27. Carburetor Air Filter Switch—As Required. Used only under extreme dust conditions. Switch is inoperative and filters not installed on most aircraft under normal conditions.

28. Fluorescent Lights Switch—As Required. Controls engineer's fluorescent lights. See that all three operate normally before any anticipated night operation.

29. Spark Advance Switches—RETARD (guards down). This places engine ignition timing in retard position (20°BTC), which is normal for all ground and high power operation except when checking the ADVANCE position during engine run-up for proper operation.

30. Mixture Control Check—Completed.

a. Mixture Control Lever—Move from IDLE CUT-OFF to RICH and note that the indicator lamps light and go out as mixture control travels through NORMAL.

b. Move mixture control lever back to NORMAL—Lights on.

c. Selector Switches—SWITCH.

d. Override Switches—Hold to RICH and note that the indicator lamps go dark as mixture control travels toward RICH.

e. Override Switches—Hold to IDLE CUT-OFF and note that the indicator lamps light and go out as mixture control travels through NORMAL.

f. Selector Switches—LEVER, and note that the indicator lamps light as mixture control travels to NORMAL.

g. Mixture Control Lever—IDLE CUT-OFF, and note that indicator lamps go dark as mixture control moves to IDLE CUT-OFF.

31. Turbo Boost Selector—ZERO. Waste gates should be full open to prevent damage due to backfire during starting and excessive back pressures and overheating during run-up. Use only to check full power on the ground.

32. Turbo Calibration Knobs—Fully Counterclockwise.

PILOTS

c. Slaved gyro magnetic compass annunciator cleared.

d. Unlock surface controls and position them to approximately level flight.

e. Engage the autopilot when the green lamps come on. If only one green lamp burns, the other lamp is merely burned out and will not hinder operation of the autopilot.

CAUTION

Do not engage the autopilot with a heavy pre-load on the controls due to high winds. This will result in clutch slippage with consequent overheating and burning out.

f. Turn each trim knob (aileron, rudder, and elevator) and check control movement for proper direction.

g. Turn pilot's turn control and check control movement for proper direction.

h. Turn slaved gyro magnetic compass push-to-set-pointer knob and check control movement for proper direction. Controls should move to make a turn in a direction opposite to that in which the pointer moved. Only a slight movement is necessary to produce control movement.

i. In turn, disengage the aileron, the rudder, and the elevator trim knobs. The green lamps should blink when any one surface is disengaged, and normal manual control should be obtained in that axis.

j. Re-engage the autopilot and depress each autopilot release switch to ascertain proper operation. Then check for freedom of movement of the controls.

k. Turn the autopilot off.

16. Surface Controls—Locked. After autopilot check is complete and autopilot is turned off, engage the surface control lock.

17. Bomb Bay Door Locks—Removed. Bomb bay door locks should be removed at this point so that the doors can be closed before engine start. The locks have been left on up to this point so ground crew personnel could safely observe any fuel leaks in the bomb bays and to make the interior of the bomb bays readily accessible to fire fighting equipment in the event of a fire in the bomb bays.

18. Interphone, Alarm Bell Check—Completed.

The compartment commanders will check in with the aircraft commander and report, "Normal interphone check complete and alarm bell loud and clear," for his compartment. The radio operator will also report results of the private interphone check which was completed when the crew initially boarded the aircraft.

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A "must" unless you have personal knowledge that they are properly indexed. This prevents staggered indications and probable excessive manifold pressures when setting TBS for full take-off power.

33. Master Temperature Indicator—ON and Compensated. Adjust master temperature indicator as follows:

a. Selector Switch—OFF.

b. Control Switch—ON.

c. Adjust slide wire rheostat to obtain full scale deflection with balance knob.

d. Turn Check Switch to CH position.

e. Adjust Comp. Rheo. Knob until galvanometer needle is directly over CH line.

f. Turn check switch to the ON position.

g. Move selector switch through all positions checking for open circuits and ambient temperature indications. Leave selector switch on first engine to be started (normally No. 4 engine).

34. Intercoolers and Air Plugs—As Required. Normal position for all ground and high power operation is full open. However, the desired position should be dictated by good reasoning after due consideration of such factors as weather, accelerated warm-up, etc. A complete cycle of operation of these controls is described in the engineer's preflight inspection, but may be performed at this time if desired. It should not be necessary to check cycle of operation more than once prior to any flight. This will prevent undue wear on actuators and linkage.

35. Instrument Check—Normal. This can be accomplished while manipulating air plugs and intercoolers. See that all temperature indicators check against ambient air. RPM, torque, and fuel flow indicators for zero reading. Fuel, oil, and water pressures normal. Have second engineer record static M.P. for future use during check at field barometric pressure.

36. Master Ignition Switch—ON.

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19. Fire Equipment—In Place.

A fire truck or an officially authorized equivalent will be in place accessible to the engine being started before attempting to start engines.

20. Emergency Ignition Switch—IN. When the engineer has completed his check list up to putting his master ignition switch on, he will inform the aircraft commander to push in his emergency ignition switch.

21. Receive engineer's report and notify engineer, "Brakes set, fire guard standing by, ignition in, start engines."

37. Report to aircraft commander, "Check list completed, master ignition in, ready to start engines."

STARTING RECIPROCATING ENGINES.

When starting engines, a ground observer (an experienced member of the ground crew or the flight crew) must be in constant communication with the engineer. A qualified pilot will be in his seat and a qualified crew member will be standing by on interphone at the emergency brake station. The engineer should announce what he is doing at all times during ground operation so that the aircraft commander, ground observer, and scanners will be able to anticipate their activities where coordination is required. Ground fire equipment of adequate capacity to combat any anticipated fire should be properly manned and standing by. See "Reciprocating Engine Fire on the Ground," Section III, for instructions on combating engine fires. As each of the engines is turned over, any observation of abnormal operation must be reported to the engineer immediately. The engine starting sequence is 4, 5, 6, 3, 2, 1. The aircraft commander will observe the engineer's procedure during reciprocating engine starts. The aircraft commander can assist the engineer during starts by handling the throttle of each engine to maintain specified idling speeds after the engineer has it started.

Starting Don'ts.

1. Don't start the engines until the "Before Starting Engines" check list has been completely covered.
2. Don't start the engines until the propellers have been pulled through to eliminate the possibility of a liquid lock.
3. Don't jam the throttles forward at any time, especially during the starting procedure.
4. Don't start the engines without a fire guard being posted.
5. Don't continue to run an engine if the oil pressure does not build up to 50 psi within thirty seconds.

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1. Fuel Tank Valve Switches—OPEN. Use the most inboard symmetrical pair of wing fuel tanks containing fuel. This checks positive fuel feed through the maximum number of manifold valves.

2. Respective Booster Pumps—ON. To provide positive fuel pressure to engine-driven fuel pump and

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fuel under pressure to primer. The primer is effectively inoperative without pressure.

3. Inform ground observer, "Ready to start engines, clear No. 4."

4. Voltage and Frequency Selector Switch—No. 4 Position. See that bus voltage provided by external power source is within limits by moving the selector switch to the bus position. Then move it to the No. 4 position. This will allow you to observe voltage and frequency of engine being started.

5. Throttle Levers—Position. Retard throttle checking "springback" or "cushion"; then advance throttle approximately one inch. If it becomes necessary to restart a relatively "hot" engine, a more open throttle setting may be required.

6. Engine Fuel Valves—OPEN. Opens fuel supply to engine carburetors, fuel pressure gages, and primers.

7. Fuel pressures 10-14 psi. This is normal booster pump pressure. Pressure varies with altitude, cycles, fuel density, and condition of booster pump.

8. Locate No. 4 starter, primer, and ignition switches. Operate starter and primer switches with right hand and ignition switch with left hand (left hand crossed over). Starter and primer switches are spring-loaded OFF.

9. No. 4 Engine Starter Switch—ON. Energize starter continuously through six blades of propeller rotation. If any indication of a hydraulic lock is noted, discontinue the starting procedure. The above procedure lessens the possibility of the engine firing against a lock, causing extensive engine damage.

10. No. 4 Engine Ignition Switch—BOTH after 6 blades of propeller rotation.

11. No. 4 Engine Primer Switch—ON, after ignition switch is turned to BOTH. This lessens possibility of a hydraulic lock and allows fuel-air ratio to build up from the lean side to a combustible mixture. This should produce a good start without "flooding" the induction system, provided other controls are handled properly. Listen to the ground observer and watch No. 4 engine tachometer to determine progress of the start. After turning the ignition switch on, move left hand to No. 4 throttle to control rpm as engine begins firing. Flicking the primer OFF for a fraction of a second may be required for hot weather starts to prevent overpriming. Release starter switch at 500 rpm. Adjust the throttle and prime until engine is running smoothly at the recommended idle rpm (1000-1200 rpm).

CAUTION

The carburetor accelerating pump is controlled by movement of the throttle and bypasses the mixture control IDLE CUT-OFF

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1. As the engineer starts other engines, control the throttles of the engines that have been started to maintain the recommended idle speed (1000-1200 rpm).

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position. Rapid movements of the throttle will cause overpriming of the induction system, thus prolonging or preventing initial starting or causing too rapid acceleration and subsequent backfiring and induction fires after engine is partially started.

12. No. 4 Mixture Control Lever—NORMAL. As the mixture moves from IDLE CUT-OFF to NORMAL and the idle features in the carburetor take over, the engine has a tendency to "load up" as indicated by a drop-off in rpm. Wait until a definite drop-off in rpm is noted; then release the primer switch and re-adjust the throttle to obtain idle speed, if necessary.

CAUTION

Maximum continuous cranking time is one minute; then allow the starter to cool a minimum of THREE MINUTES.

13. Report, "Oil pressure normal, alternator excited."

CAUTION

If excitation is not immediately apparent, shut down the engine. With no meter indication, malfunctions which might cause alternator damage would not be evident.

Adjust voltage to 208 volts and frequency to 375 cycles to allow control circuits to stabilize. Move the voltage and frequency selector switch to the number of the next alternator-equipped engine to be started.

Note

Do not adjust frequency above 375 cycles at this time, since the frequency will increase with the temperature of the control circuit resistor.

CAUTION

- a. If oil pressure does not register 50 psi within 30 seconds, the engine will be shut down and the cause investigated.
- b. Alternators must be excited and properly governed before advancing the throttles above 1200 rpm. This is necessary so that the alternators can be checked when the engines are run up. If the frequency of any alternator increases with an increase in engine rpm and cannot be adjusted, then the affected engine must be shut down and the constant-speed drive unit checked. Otherwise an overspeed condition may be reached, causing the units to disintegrate and cause a serious fire.

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14. Repeat steps 8 thru 13 for starting engines 5, 6, 3, 2, and 1. Since No. 1 and 6 engines are not alternator-equipped, references to alternators in the starting procedure should be disregarded.

Note

If the engine stops running with the mixture control in NORMAL, the lever should be returned to the IDLE CUT-OFF position. After the starter has been allowed to cool, the starting procedure may be repeated.

RECIPROCATING ENGINE GROUND OPERATION.

The ground operation of each engine must be held to 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. Spark plug fouling occurs very rapidly during ground idling, particularly if the idle mixture setting is too rich. This type fouling can be minimized by using the following procedures:

When it is necessary to run an engine on the ground for an extended time, it shall be run up to 2200 rpm, 37 inches manifold pressure, for a one minute period every 15 minutes. This procedure will act to clear away the fouling deposits in their early stages.

Every hour during a prolonged period of ground running or if fouling is observed, the foregoing procedure will be supplemented by wet take-off power. The thermal shock of water injection will act to clear away lead deposits before they reach the dangerous stage.

1. Operate the engine at 2000 rpm and bring the cylinder head temperature to 200-220°C.
2. Increase to take-off power with water on and hold for 30 seconds.
3. At the end of 30 seconds operate for one minute at dry take-off power and then repeat wet take-off power for 30 seconds.

4. Reduce manifold pressure to 55 inches, turn water injection switches OFF, and reduce rpm to idle.

DURING ENGINE WARM-UP.

The reciprocating engines are now all started and operating at idle speed. Do not exceed idle rpm until the engine oil-in temperature reaches 40°C. Make all ground operations with the mixture controls in the NORMAL position. The following procedure calls for an ignition safety check; a propeller, idle, and in-flight oil cooling door check; barometric pressure checks; and alternator checks. To reduce engine ground test time, these checks can be made on all six engines at once. Check heat and anti-ice, fan speed, spark advance, and single ignition at barometric pressure.

While the engines are warming up, you will have sufficient time to make the ignition safety check at idle rpm. It should only be necessary to perform this check once prior to any flight. Normally it will be made after engine start of the initial complete reciprocating engine run-up during the "Preflight Operational Equipment Check."

While the engineer makes the ignition safety check, the aircraft commander should maintain idle rpm on the engines the engineer is not working on. Proceed with the checks as follows:

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1. Ignition Safety Check—Idle Rpm.

a. Individual Ignition Switches—L, Detent, R, Detent, L, BOTH. Make this check starting with engine No. 1 and continuing with engines 2, 3, 4, 5, and 6. With your left hand on the throttle of the engine being checked, use your right hand to move the ignition switch from BOTH to 1 and then to the detent position between L and R; then switch from the detent position to R and finally back to BOTH.

The L position of the ignition switches grounds out the left (exhaust side) bank of spark plugs and checks the right (intake side) bank and vice versa.

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CAUTION

Never leave the ignition switches in the detent position between L and R. If they are left in this position and the pilots' emergency ignition switch or the engineer's master ignition switch was pulled out (off), the ignition relays would chatter, causing severe backfiring.

Do not investigate the OFF position with the individual ignition switches. A slight drop-off of engine rpm on each single magneto position indicates wiring continuity from the switches to the solenoids, proper operation of the solenoids, and proper connection of the ignition leads.

1. Emergency Ignition Switch—Checked.

Upon the engineer's request, the aircraft commander will move the emergency ignition switch momentarily OFF. Place your hands over this push-pull type switch so that you can get a positive and straight "out-back in" action without any side force. Do not allow the switch to be cut (off) for more than a split second. If the switch remains OFF too long, DO NOT TURN IT BACK ON, for severe backfire will occur on all engines.

2. Pilot's Manifold Pressure Gage—Checked.

This is a check to insure that the instrument is functioning normally by cross checking the indication on the engineer's No. 4 engine manifold pressure gage with the pilot's manifold pressure gage. The pilot's manifold pressure gage gives an indication of No. 4 engine only and is used as master indicator for the pilot's observation.

3. Master Tachometer—Checked. Cross check the pilot's master tachometer setting with the setting on the engineer's master tachometer during all propeller automatic checks. This check should be made when the engineer sets 1400 rpm with the propeller master motor. When this check is complete, stand by for a propeller reverse check.

4. Propeller Reverse Check—Completed, lights out. The propeller reverse check will be made at the same time as the engineer's propeller control system check. The engineer will notify the aircraft commander when he has 1700 rpm set and is ready to check propeller reversing.

Propellers will be checked in symmetrical pairs (inboard, centers, and outboards) in that order. It is important that this propeller reverse check be made before taxiing to assure a means of stopping the aircraft in the event of brake failure.

b. Request the aircraft commander to momentarily pull out his emergency ignition switch. As this is done, a momentary drop-off of rpm on all engines indicates proper operation. Let the ground observer know what is going on. He can hear engines cut out and watch for backfire from his vantage point.

c. Master Ignition Switch—Momentarily Off.

2. Engine Oil-In Temperature—Minimum 40°C.

Check all engine and constant-speed drive temperatures in limits, paying particular attention to oil-in temperatures prior to advancing throttles for engine run-up.

3. All Booster Pump Switches—OFF. To allow fuel to gravity feed to engine-driven fuel pumps. Check fuel pressures to see that they remain within limits (24-28 psi). Erratic fuel pressure readings indicate a faulty engine-driven fuel pump which must be investigated before flight.

4. Propeller Control System—Checked.

This is to provide a complete operational check of the automatic, reversing, manual increase and decrease, and feather control circuits.

a. Throttle Levers—Set to obtain approximately 1700 rpm.

b. Master Motor Speed Control Lever—1400 rpm. Decrease until master tachometer indicates 1400 rpm. The rpm of all engines should decrease until engine tachometers indicate 1400 rpm $\pm$ 50. This step checks automatic decrease rpm controls and resets propeller low limit blade angle limit switches.

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a. After the engineer reports that engines are ready for propeller reverse check, place the inboard reverse selector switch in READY.

b. Announce over the interphone, "Reversing inboards." This alerts the engineer and the ground observer. Then depress the propeller reverse pitch switch, thereby energizing the circuit and reversing the selected pair of propellers. After the circuit has been energized, it is not necessary to depress the reverse pitch switch again as long as one pair of propellers remain reversed. As each pair of propellers is reversed, check to see that the corresponding red propeller reverse warning lamps light. The engineer and ground observer should report each symmetrical pair as "Reversed" or "Normal," as the case may be during the propeller reversing check.

c. Announce, "Reversing centers," and place the center reverse selector switch in READY. Check corresponding red propeller reverse warning lamp.

d. Announce, "Reversing outboards," and place the outboard reverse selector switch in READY. Check corresponding red propeller reverse warning lamp.

e. The propellers will be brought out of reverse in symmetrical pairs (outboards, centers, and inboards) in that order. Move outboard reverse selector switch to SAFE and announce, "Outboards safe, lights out."

f. Move center reverse selector switch to SAFE and announce, "Centers safe, lights out."

g. Move inboard reverse selector switch to SAFE and announce, "Inboards safe, lights out."

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c. Master Motor Speed Control Lever—2700 rpm full INCREASE rpm position. This step checks automatic increase rpm controls and the master motor protective relay circuit as indicated by the tel-lamps. The tel-lamps should go out during any rapid change of the master motor speed control lever and come on again as the master motor begins governing at this new setting. This indicates that the master motor protective relay is breaking the ground of each contactor, thus preventing undesired rpm changes in event of a master motor failure. Any time the tel-lamps are out (provided the bulbs are good), the automatic control circuit is disrupted and the propellers assume a fixed pitch position until the system is again in balance and the tel-lamps come back on. During this step report, "Tel-lamps out, back on, rpm approximately 1700 rpm."

d. Reset all engines to 1700 rpm, if necessary, and advise pilot, "Ready for propeller reverse check."

e. Announce, "Inboards reversed, normal pitch lamp is out." Observe No. 3 and No. 4 engine tachometers and corresponding green normal pitch indicator lamps. Normally the engine tachometers indicate an erratic action, finally settling down at a noticeably higher rpm. The manifold pressure gages show a reverse indication, settling at a noticeably lower value. The corresponding green normal pitch indicator lamps should go out.

f. Announce, "Centers reversed, normal pitch lamp is out."

g. Announce, "Outboards reversed, normal pitch lamp is out."

h. Master Motor Speed Control Lever—1400 rpm.

i. Engine Tachometers—1400 rpm (± 50).

j. Master Motor Speed Control Lever—2700 rpm.

k. Engine Tachometers—1700-1900 rpm.

Note

This checks automatic propeller control in reverse operation.

l. Announce, "Outboards normal, green light on." As the propellers are returned from reverse pitch, the indications will be just the opposite of those observed in step 4e above.

m. Announce, "Centers normal, green light on."

n. Announce, "Inboards normal, green light on."

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5. Bomb Bay and Camera Doors—Closed.

Closing the camera doors as soon as possible will eliminate the possibility of the windows being splattered with mud, snow, or slush during taxi and engine run-up. Bomb bay doors will be closed before taxiing to prevent anything from being blown into the bomb bays by the propeller blast.

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Note

After the propellers are returned to normal pitch, the engine rpms will be staggered considerably. This is due to the necessary tolerance allowed in setting the "return from reverse" limit switches which, in most cases, bring the blade angle back within the normal control ranges even though the angle is less than the low pitch stop. Normal settings will be regained the next time the propellers receive a decrease rpm signal either manually, automatically, or from the feather system. Don't bother the throttles at this time because after the next check the rpms should return to the original 1700 rpm setting.

o. No. 1 and 6 Propeller Selector Switches—DEC. RPM until engine speed drops to 1400 rpm, then INC. RPM until engine speed reaches 1500 rpm. Finally, place selector switches in AUTOMATIC OPERATION. Engine speed should return to 1700 rpm. Repeat this procedure on remaining engines, working inboard on symmetrical pairs—ie., 2 and 5, 3 and 4. RPM's quoted are approximate. You are looking for direction of control primarily and not for specific rpm. However, when switches are released, pitch change must stop and rpm should not overshoot over 100 rpm unless the propeller selector switches are sticking. Anticipate instrument lag, power build up, and power drop; release the switches about 50-100 rpm shy of the value you are shooting for. All engine rpm's should return to 1700 rpm after this check.

p. Momentary Feather Check—Completed. Perform check in this order: Engines 1, 2, 3, 4, 5, and 6. All engines should return to 1700 rpm after this check. Using the right hand, raise the propeller feather switch guard. Place your fingers behind the switch guard, actuate the switch with your thumb, and immediately slap the guard down with your fingers. Shoot for a 100-rpm drop-off and automatic return to 1700 rpm. This checks the fast rate feather operation.

CAUTION

Do not leave the propeller feather switch in FEATHER longer than 1/4 of a second, or the propellers will go into full feather. Stand by on the mixture control levers and, in the event of a malfunction, move to IDLE CUT-OFF immediately to lessen the possibility of an induction fire.

5. Idle Speed—Checked. Should be set for 1100 rpm with throttles fully retarded, approximately 180° CHT, no wind condition, and average barometric pressure for seasonal conditions at the base at which your aircraft is primarily stationed. Allow a 30-rpm variation for each 10 mph effective head wind. (See "Stopping Reciprocating Engines" of this section for idle mixture check.)

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Note

Pull the pilot's landing gear circuit breaker upon engineer's request. Close the circuit breaker as soon as the engineer requests it.

6. Observe engineer's barometric pressure checks.

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6. In-Flight Oil Cooling Doors—Checked. Request the pilot, "Pull landing gear circuit breaker." Ask the ground observer to let you know when all in-flight oil cooling doors are open. Keep a close watch on oil temperatures during this check. The doors will be visibly open at approximately 90°C oil-in temperature. Ask the pilot, "Close the landing gear circuit breaker," as soon as the ground observer reports or as soon as any oil-in temperature reaches 98°C. While the oil temperature is increasing, you can continue with your other checks.

7. Barometric Pressure Checks—Completed. Advance throttles until all engines indicate 37 inches M.P. Advance throttles with a reasonable speed to check for normal acceleration tendencies of all engines. Allow engines to operate at this power for approximately one minute to clear away early lead deposits which will foul spark plugs. While clearing engines check alternator paralleling and constant-speed drive oil temperatures. Check cylinder head temperatures and leave master temperature selector switch set on hot-test indicating engine. Reduce master motor speed to 2000 rpm, watch engine rpm govern, and return master motor speed to 2700 rpm. See that engine rpm's return in proper alignment to within ± 50 rpm of one another. Retard throttles to manifold pressure values recorded by second engineer prior to engine start and proceed with the following check:

a. Heat and Anti-Icing Check. Use master temperature selector switch to check wing and tail anti-icing temperatures. Zero the highest indication and turn ON all cabin heat and tail and wing anti-ice switches for five seconds and turn OFF. Move the master temperature selector switch through the anti-icing positions. A galvanometer needle deflection left of zero indicates a temperature rise.

CAUTION

Do not allow temperatures to exceed 50°C above ambient air temperature.

Check a little later to see that temperatures have receded to normal, indicating that the engine dump valves have operated through one complete cycle and are in the open position. Have your second engineer record the rpm, torque, and fuel flow of all engines while you are making this check. You will need those figures as a positive check of return from high fan drive and spark advance checks before proceeding to higher powers. These records will be turned over to maintenance after the flight for use in their engine conditioning program.

b. Engine Cooling Fan Speed Check. Fan Speed Control Switches—HIGH RPM and check torque pressure and rpm drop (approximately 100 rpm). Normal

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torque pressure drop is 10-15 psi. Fan Speed Control Switches—LOW RPM and check torque pressure and rpm return to normal. After return to normal, check the anti-icing temperature again to see that the dump valves are open and temperatures have receded. Return master temperature selector switch to engine with highest CHT. Torque pressure and rpm should now be stabilized, so proceed with next check.

c. Spark Advance Check. Spark Advance Switches—ADVANCE and check for a rise of 2 to 6 psi torque pressure and 25 to 50 rpm.

Note

Indications in excess of this range indicate an engine out of time and must be adjusted prior to flight.

Spark Advance Switches—RETARD and check for a drop in torque pressure to normal.

CAUTION

Spark must be retarded before going to higher power. If in doubt of spark position, make a single ignition check. If the spark is still advanced, the rpm drop will be negligible.

Note

Note oil, cylinder head, and constant speed drive temperatures and alternator paralleling before proceeding with next check.

d. Single Ignition Check. This check should be performed first on engines 1 and 6, recording rpm drop, then retarding throttles to idle; second, engines 2 and 5, recording rpm drop, then retarding throttles to idle; and third, engines 3 and 4, recording rpm drop, then retarding throttles to idle. Keep your left hand on the throttle of the engine being checked so that it may be retarded in the event of "cutting-out" of the engine due to a faulty ignition system or inadvertant turning off of the ignition switch. If either occurs, retard the throttle immediately and return the ignition switch to BOTH at about 1000 rpm. If the engine quits completely, move the mixture control to IDLE CUT-OFF, to shut off flow of fuel, and take the alternator off the line.

Use your right hand to manipulate the ignition switches. Normal engine drop-off when operating on one magneto is 35 to 75 rpm; maximum permissible is 100 rpm. Normal torque drop is 10 to 15 psi.

CAUTION

Drop-offs lower than these indications must be corrected prior to take-off.

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Note

When altitudes above 34,000 feet are anticipated, maximum rpm drop-off is 60.

Use the following procedure to check individual engines in the recommended sequence:

(1) No. 1 Ignition Switch—L and note rpm drop-off.

(2) No. 1 Ignition Switch—To detent between L and R and note rpm return to normal.

(3) No. 1 Ignition Switch—R and note rpm drop-off.

(4) No. 1 Ignition Switch—Detent L, and back to BOTH and note rpm return to normal. Do not switch from R back to BOTH too rapidly or the ignition relays will chatter causing violent backfiring.

(5) Repeat steps (1) thru (4) on remaining engines in the recommended sequence. When the above procedure is completed on the last symmetrical pair of engines, the first pair that was checked will be cool enough to continue with the next check.

e. The engine analyzer should be used to perform the following checks:

(1) Slow sweep check of all magnetos and spark plugs.

(2) Ignition grounding system.

(3) Breaker point synchronization.

(4) Spark advance.

(5) Fast sweep check of ignition at magneto check point.

(6) Vibration check on all cylinders (group 15 airplanes).

8. Alternator Checks—Completed. No constant speed drive oil warm-up is required. Proceed with the following checks:

a. Special Check. During "Preflight Operational Equipment Check," the alternator will be checked by using the emergency method of restoring normal electrical power. The in-flight procedure is given in Section III, "Emergency Procedures." This ground check will vary slightly. Proceed as follows:

(1) De-excite all alternators.

(2) External Power Switch—OFF.

(3) Battery Switch—OFF.

(4) Reduce a-c and d-c electrical loads to a minimum.

(5) Turn the voltage and frequency selector switch to the selected alternator.

(6) Move the emergency power switch to EMERGENCY.

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- a. Pilot's Flight Instrument Switch—EMERGENCY.

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(7) Hold the respective exciter control relay switch ON momentarily and adjust to 208 volts and 405 cycles.

(8) Request the pilot to move his flight instrument switch to EMERGENCY and to check that his flight instruments are functioning properly.

CAUTION

Do not permit the d-c load to exceed 50 amperes as indicated on the t-r test unit, with the selector switch in the RADIO OPER position.

(9) Repeat steps 8a(5) thru 8a(7) for other alternator-equipped engines.

(10) Close the alternator breaker switch of the last selected alternator.

Note

If you find that the alternator functions normally on the line, return the emergency power switch to NORMAL and readjust voltage and frequency.

(11) Request pilot to place his flight instrument switch back to ON.

(12) Battery Switch—ON.

(13) Parallel remaining alternators in the normal manner starting with steps 8b(6) below.

b. Normal Check. If the above "Special Check" was satisfactory during the "Preflight Operational Equipment Check," then the electrical panel will be set up using the normal method during the preflight prior to take-off.

(1) Voltage and Frequency Selector Switch—No. 4 position.

(2) No. 4 Voltage and Frequency—Adjust to 208 volts and 405 cycles.

(3) Voltage and Frequency Selector Switch—Bus position. (Detent between 4 and 5.)

(4) External Power Supply Switch—OFF. Watch bus voltage and frequency drop-off.

(5) No. 4 Alternator Breaker Switch—CLOSE. Watch bus voltage and frequency build-up. Adjust frequency if necessary.

(6) Voltage and Frequency Selector Switch—No. 5 position.

(7) No. 5 Voltage and Frequency—Adjust to 208 volts and 405 cycles. Make fine adjustment on frequency until alternator synchronizing lamps blink at slowest rate possible to obtain.

(8) No. 5 Alternator Breaker Switch—CLOSE. (When alternator synchronizing lamps are out.) The

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synchronizing lamps indicate three things. First, when both lamps are blinking simultaneously, they indicate correct phase sequence. Second, alternately blinking lamps indicate a crossed phase sequence; very serious damage will result if two alternators with opposing phase sequences are paralleled. It would amount to a direct short of the total output of both units. Third, the lamps indicate when two alternators of correct phase sequence are in or out of step. Lamps out indicate "in step" and lamps on indicate "out of step."

(9) Adjust the kilowatt and kilovar load division as indicated on the kilowatt-kilovar meters. These meters read kilowatts when the kilowatt-kilovar selector switches are in the KWATTS position. Use the frequency control knobs to divide the kilowatt load. Move the kilowatt-kilovar selector switch to the KVAR position and use the voltage control knobs to divide the kilovar load.

(10) Repeat steps (6) thru (9) to parallel No. 3 and No. 2 alternators.

(11) Voltage and Frequency Selector Switch—Detent position between any two alternator positions. This will allow you to read bus voltage on the voltmeter. Selection of any alternator position enables you to read individual frequency and voltage of alternators on stand-by.

(12) Instruct ground crew to unplug the external power supply if the aircraft is to be taxied. When it is unplugged, the correct-incorrect phase sequence lamps will go out.

TAXIING.

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1. Nose Wheel Steering Switch—ON. This switch energizes the main hydraulic system pump motor and actuates the main hydraulic system selector valve to provide pressure for nose wheel steering. This pressure is indicated on the engineer's hydraulic pressure gage and is indicated only when the airplane is on the ground.

2. Engineer's Taxi Configuration—Checked. Check the pressure in the brake system and nose wheel steering hydraulic system. These readings are obtained from the engineer. Never release the parking brake before checking for normal brake pressure. Never start to taxi until the engineer tells you he is prepared. Request, "Engineer's taxi configuration," over interphone.

3. Check Ground Man—"All Clear" Signal. After all checks are completed on the "During Engine Warm-Up" check list and the engineer is ready to taxi, have the ground observer check to be certain that all obstructions have been removed and that the aircraft is clear. Before the aircraft commander clears the ground observer off interphone, the ground observer will check and report, "Down locks removed, nose scissors

ENGINEERS

1. Taxi configuration, "Alternators on the line and paralleled, brake and nose steering pressure normal, ready to taxi."

a. A minimum of two alternators must be on the line and paralleled (four recommended).

b. Note and report brake and steering pressures at 30-second intervals during all taxi operations in congested areas and prior to turns.

c. Maintain all engine speeds slightly above idle speed, for taxi operations, in conjunction with reversing of selected pairs of propellers by the aircraft commander. An even manifold pressure setting across the board usually provides desired taxi speeds with two pairs of propellers in reverse. Exact conditions will vary with terrain features, wind conditions, and taxi obstructions.

PILOTS

ENGINEERS

connected, nose door latching arm down, pitot and static ports clear, camera and bomb bay doors closed, ladder up, and chocks removed." The ground observer then passes the ground communications cord into the forward compartment, comes forward, and signals to the aircraft commander that he is clear to taxi.

4. Call Control Tower—Taxi Instructions. While the aircraft commander is clearing with the ground observer, the pilot will contact the control tower and receive taxi instructions and clearance to taxi.

5. Inboard Propeller Reverse Selector Switch—READY. Propeller reverse thrust will be used to aid in controlling taxi speed. This reduces the use of brakes and increases their usefulness. Continuous cycling of the propellers will not be used; slight adjustments of throttle to control the forward speed will be used instead. For normal taxi operation, No. 3 and 4 propellers will be used in reverse pitch. When taxiing with tail winds or when taxiing down slopes, it may be necessary to have two pairs of propellers in reverse. The aircraft commander will move the inboard propeller reverse selector switch to READY and stand by to reverse.

6. "Ready to taxi" — Parking Brakes — OFF. Announce, "Ready to taxi," over interphone and receive acknowledgement from each crew compartment. Allow the aircraft to roll forward from its parked position before pushing the reverse pitch switch to reverse the inboard propellers. This will eliminate the necessity for additional power on the center and outboard engines in order to get the aircraft in motion. Announce over interphone, "Reversing Inboards."

Note

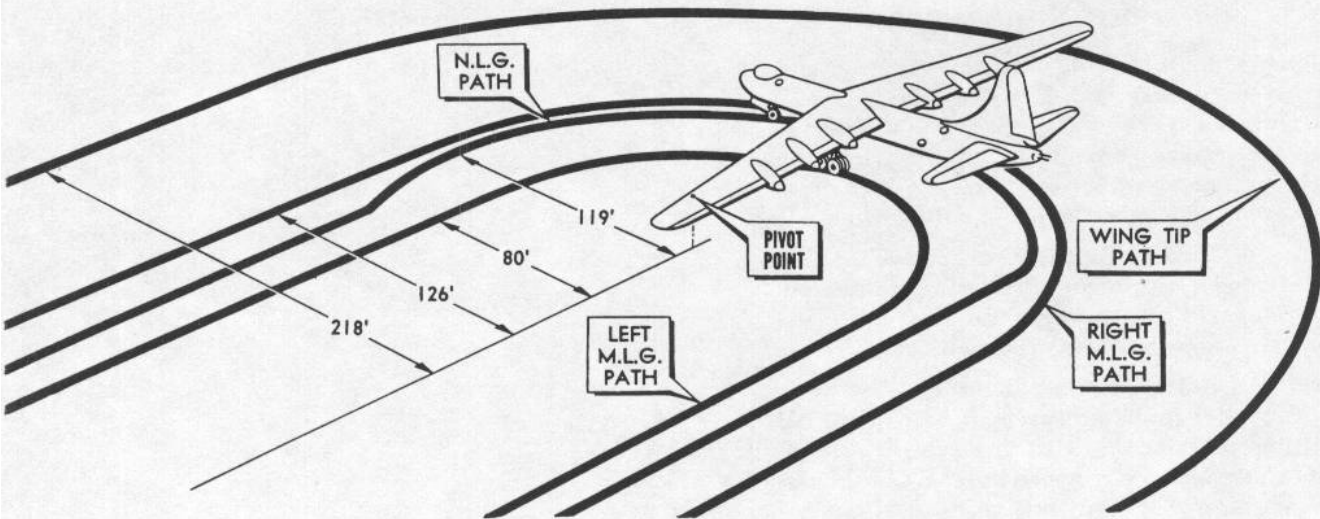
There will be an observer in each forward blister on interphone during all taxi operations. At night these observers will be equipped with Aldis lamps.

Brake applications should be light to prevent skidding of the tires. The control surfaces must be locked at all times during taxiing. The B-36 has a normal nose-down attitude while on the ground. Don't let this attitude bother you; you'll become accustomed to it.

Directional control while taxiing is accomplished hydraulically through the use of the steering wheel. Under certain conditions it will be necessary to supplement hydraulic steering with differential braking or differential throttling.

In the event nose steering becomes inoperative, the aircraft may be steered effectively and without damage to the nose gear by differential throttling and braking.

This airplane is the largest that you have yet encountered, and several new techniques must be learned before becoming adjusted to its size. One of these is the procedure used to make turns. Because of the make-up



3-1043-R

Figure 2-4. Minimum Turning Radius

PILOTS

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of the main gear "skate," the aircraft must be turned with caution to prevent skidding of tires. The airplane must be in motion before executing turns; use the largest turning radius possible and limit taxi speed to approximately 12 mph while turning in order to minimize tire wear and landing gear stress. Make alternate right and left turns, when practical, to equalize tire wear. The minimum turning radius recommended for the nose gear is 119 feet. The pivot point is about two-thirds from the outboard engine toward the wing tip. It must be remembered that you are about 50 feet in front of your main gear so that when lining up with the runway you must over turn and then bring the nose wheel back to the center line. A runway width of 300 feet is adequate for executing normal turns. After making a turn allow a short roll and stop with the nose wheel in line with the fuselage center line, thereby reducing nose wheel stresses at the start of take-off.

Aircraft clearances are especially important during taxiing. The B-36's wing span of 230 feet will in many cases overlap on both sides of the taxi strip. Along taxi strips be careful to avoid damaging obstacles such as boundary lights, vehicles, etc. Use particular care at night; both the aircraft commander and pilot must be alert to avoid any obstructions. Use your landing lights when you are taxiing and have Aldis lamps available in both the forward and aft compartments. Partial retraction and extension of landing lights will throw some light in the desired direction when trying to see obstructions on the sides of the taxi strips. When in doubt about aircraft clearance, send out crew members with flashlights to act as "wing walkers." A tip for use during twilight hours is to use shadows cast by the aircraft to judge aircraft clearance while taxiing. Remember, be safety-conscious while taxiing as well as when flying.

ENGINE RUN-UP.

The following procedure calls for power checks which include full power with no boost, single turbo shift, full power with boost, water injection, cabin pressurization, and carburetor preheat checks to be made on symmetrical pairs of engines. After power checks are completed on any pair of engines, they should be shut down as soon as their cylinder head temperatures cool to 180°C, provided take-off is not to follow and provided they are not needed for taxiing or for jet engine starts. Run-up procedures are as follows:

PILOTS

1. Parking Brake Lever — ON. The aircraft commander will set the parking brakes and both he and the pilot will stand by on the foot brakes in case the aircraft creeps forward during engine run-up or in case of parking brake failure.
2. Nose Wheel Steering Switch — OFF. This switch must be in the OFF position during all ground operation — except when you are taxiing — to eliminate unnecessary hydraulic pump operation.
3. Propeller Reverse Selector Switches — SAFE (Lights Out). When the aircraft commander has the aircraft in position for engine run-up he should announce over interphone, "Nose steering switch off, all propeller reverse selector switches safe, parking brakes set, ready for engine run-up." As each item is announced, the aircraft commander should check each one by putting his hand on the item being checked. The propeller reverse selector switches have a gang bar to move all three switches to the READY position, but in order to place them in the SAFE position, each of the three switches must be moved individually.
4. Observe Engineer's Power Checks. Pay particular attention to the following: Acceleration, power relationships at full throttle with no boost, and torque pressure and engine stability at take-off power. Study the engineer's amplified check list so that you may understand exact run-up procedures. Learn acceptable values of rpm, manifold pressure, torque pressure, and fuel flow during each check.

ENGINEERS

1. Full Power No Boost Checks — Completed.
 - a. Advance throttle levers of coolest symmetrical pair of engines to full open and check for proper acceleration. Allow this full throttle no boost power to stabilize for approximately 30 seconds. Note and record rpm, M.P., torque, and fuel flow (to be checked against prior readings as a standard for engine condition). If manifold pressure varies more than 2 inches between engines with a corresponding variation in torque reading (approximately 10 psi) the engine is not operating correctly or the propeller low pitch stop setting is incorrect.
 - b. Engine Supercharger Switches — R.H. ONLY and check manifold pressure rise (approximately 3 to 5 inches).
 - c. Engine Supercharger Switches — BOTH — and check manifold pressure drop.
 - d. Throttle lever of above symmetrical pair. Retard to idle and repeat steps 1a, b, and c of above procedure for remaining pairs of symmetrical engines.
2. Full Power With Boost Checks — Completed.
 - a. Advance throttle levers of coolest pair of symmetrical engines to full open and check for normal acceleration.
 - b. Turbo Boost Selector — Advance smoothly to position 7. To avoid sudden overboost of engines, always exercise due caution when moving turbosupercharger controls or when moving throttles of an engine if turbosupercharger controls are set.
 - c. Turbo Calibration Knobs — Indexed at 60 inches M.P. and note rpm, M.P., torque, and fuel flow. Calibration knobs should always be indexed 2 inches below take-off manifold pressure. On standard day conditions, take-off M.P. is 62 inches, so you trim to 60 inches. The other 2 inches are picked up by ram air during the take-off roll. Refer to the "Humidity Correction for Take-Off" chart in the appendix for the correct manifold pressure under atmospheric conditions other than standard. Check turbo calibration knob indexing after manifold pressure is set up. If index marks do not line up, hold the center screw in place with a screw driver and move outer plastic knob until indexes are lined up.

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- d. Turbo Boost Selector—Reduce M.P. to 55 inches.
- e. Water Injection Switches—ON and note increase in water pressure to 24-28 psi. If there is not a proper rise in water pressure, the water injection switches must be turned off immediately, because the water pumps depend upon their own fluid supply for lubrication.
- f. Turbo Boost Selector—Advance to position 7 and note water pressure, rpm, M.P., torque, and fuel flow. Then return TBS to 55 inches M.P.
- g. Water Injection Switches—OFF and note rise in fuel flow.
- h. Turbo Boost Selector—Zero and note M.P. drop.
- i. Throttle Levers—Retard to idle.
- j. Repeat steps 2a thru 2i for remaining pairs of symmetrical engines.

3. Cabin Pressurization and Carburetor Preheat Checks—Completed.

- a. Aft cabin pressure shutoff valve switch—OFF.
- b. Master motor speed control lever—Set master tachometer at 1700 rpm.
- c. Turbo boost selector lever—10 position.
- d. Throttle levers—Adjust to obtain 35 inches M.P.
- e. Cabin pressure wing shutoff valve switches—L. WING ON and note slight increase of cabin pressure air flow; then R. WING ON and note further increase in air flow.
- f. Carburetor preheat switches—ON and check the following:
 - (1) Decrease of cabin pressure air flow to zero.
 - (2) M.P. drop of 2 to 4 inches.
 - (3) Rapid increase in carburetor air temperature.

CAUTION

Do not allow CAT. to rise more than 20°C or exceed 43°C, whichever occurs first.

- g. Carburetor preheat switches—OFF and check the following:
 - (1) Increase in cabin pressure air flow.
 - (2) Rise in M.P.
 - (3) Decrease in carburetor air temperature.
- h. Cabin pressure wing shutoff switches—L. WING OFF and note decrease in air flow; then R. WING OFF and note further decrease in air flow to zero.
- i. Throttles—Idle.
- j. Repeat steps 3a thru 3i on other symmetrical engines.
- k. TBS—Zero.
- l. Master Motor—2700 rpm.

Note

If this complete reciprocating engine check is performed as a part of the first run-up

PILOTS

ENGINEERS

STARTING JET ENGINES.

Jet engines are considered to be supplementary power for the B-36. They provide an ease of operation never before experienced in heavy gross weight take-offs and high altitude performance of a basically reciprocating engine-powered aircraft. Due to their relatively high specific fuel consumption, the jet engines should not be used unwisely.

Unlike the complex reciprocating engines, your jet engines are mechanically simple. Although a preflight run-up of the jets cannot be omitted, they need not be run during the "Preflight Operational Equipment Check" except to ground-check a new installation or to clear previous discrepancies. Ordinarily, if your jet engines were satisfactory on the last flight and the required visual inspections reveal nothing of any consequence, they may be started immediately prior to take-off with a power check constituting the preflight run-up.

Consult the maintenance records and the crew chief to find out which jet engines, if any, must be checked. Let your engineer know before engine start whether or not any jet engines are to be run so that he may arrange his run-up accordingly.

After the engineer starts his run-up, it will be necessary for him to utilize the interphone and the ground observer if ground time is to be held to a minimum. Probably the best time to start the jet engines is after the engineer is through with all power checks and has shut down No. 1 and No. 6 engines. If it is not necessary to taxi the aircraft and the auxiliary power plant is still standing by, the engineer can complete his engine shutdown as soon as the jets have been started and are idling satisfactorily. Even without auxiliary power he would be able to shut down all but one alternator-equipped engine. When starting jet engines it is recommended that the engine with the least time be started first so that engine operation may be equalized. Record the starting times, temperature of each hot start, and the number of minutes at each power setting. The "Time Today" and "Hot Starts" are recorded in the Part II, AF Form 1, along with other noted discrepancies. The number of minutes at each power setting affects fuel consumption and should be given to your engineer.

PILOTS

1. All Circuit Breakers—IN. Push in all circuit breakers on the pilots' jet control panel. Don't forget the throttle circuit breakers.

of the "Preflight Operational Equipment Check," No. 1 and 6 engines are not required for additional checks and may be shut down as soon as the CHT is 180°C or less. Note "Stopping Reciprocating Engines" of this section for idle mixture check to be made during shutdown.

By the time you have taxied into position for reciprocating engine run-up, the control tower should have dispatched a fire truck to the area so that you can start your jet engines.

Before starting jet engines, make certain that the danger areas, as shown in figure 2-5, are clear of personnel and ground equipment. When a jet engine instrument is read during starting or during changes of power and rpm, the instrument panel must be vibrated slightly so as to get accurate readings from the instrument.

Cautions To Observe During Jet Engine Starting.

Throttle Sensitivity. The throttles are very sensitive to throttle lever movement; therefore, extreme care must be used when operating the throttle levers.

Hot Starts. For information on hot starts, refer to "Jet Engines," Section V.

Failure to Start. If the engine fails to start before 11 per cent rpm is reached, close the throttle, close the engine fuel valve, and release the starter switch. Allow 3 minutes for fuel to drain from the combustion chambers before attempting another start.

Engine Starter Limitations. Operation of the engine starter is limited to three false starts of 45 seconds duration each. If more than three starts are required, allow the starter to cool one hour. Do not attempt a start until the engine has come to a complete stop.

Accelerations and Decelerations. The engine should accelerate from 50 to 100 per cent rpm in approximately 12 seconds. When 100 per cent rpm is obtained, the high rpm stop should prevent overspeeding. If time permits, accelerations and decelerations should be slow in order to save unnecessary wear and tear on the engine. If time does not permit, then rapid throttle movements can be accomplished and the fuel regulator will control the acceleration rate. The exhaust temperature during rapid acceleration may climb momentarily to a value over 690°C but not over 870°C.

Starting Procedure.

The jet engines are simple to start and easy to operate, but always use your check list and complete it in the following sequence:

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2. Fire Detection Test Switches—TEST and Release. This will test the continuity of the fire detection circuits from the jet pods to the lamps.
3. Throttle Selector Switches—LEVER.
4. Throttles—Closed.
5. Pod Preheat Switch—As required.
6. Nose De-Ice Switch—As required.
7. Oil Heater Switch—As required. Turn this switch ON to heat the jet engine oil if the ambient air temperature is below 50°C (41°F).
8. Oil Shutoff Valve Switches—OPEN.
9. Notify engineer, "Set up jet start configuration." When engineer reports configuration set up, be sure that in each wing two tank valves are open and two booster pumps are on. The high rate of fuel consumption by the jet engines demand this configuration.
10. Danger area clear and fire equipment standing by. Clear the starting area of personnel and equipment. If the jet engines cannot be started in the parking position, have the aft gunners clear the danger area and have a fire truck proceed to the starting position.

1. Jet Start Configuration—Checked and, "Standing by for jet engine start."
 - a. At least two (four recommended) alternators paralleled on the line.
 - b. Engines with alternators, which are on the line, operating above 1200 rpm for heavy electrical loads to minimize wear on the constant-speed drives.
 - c. Two tank valve switches OPEN and two booster pump switches ON in each wing.

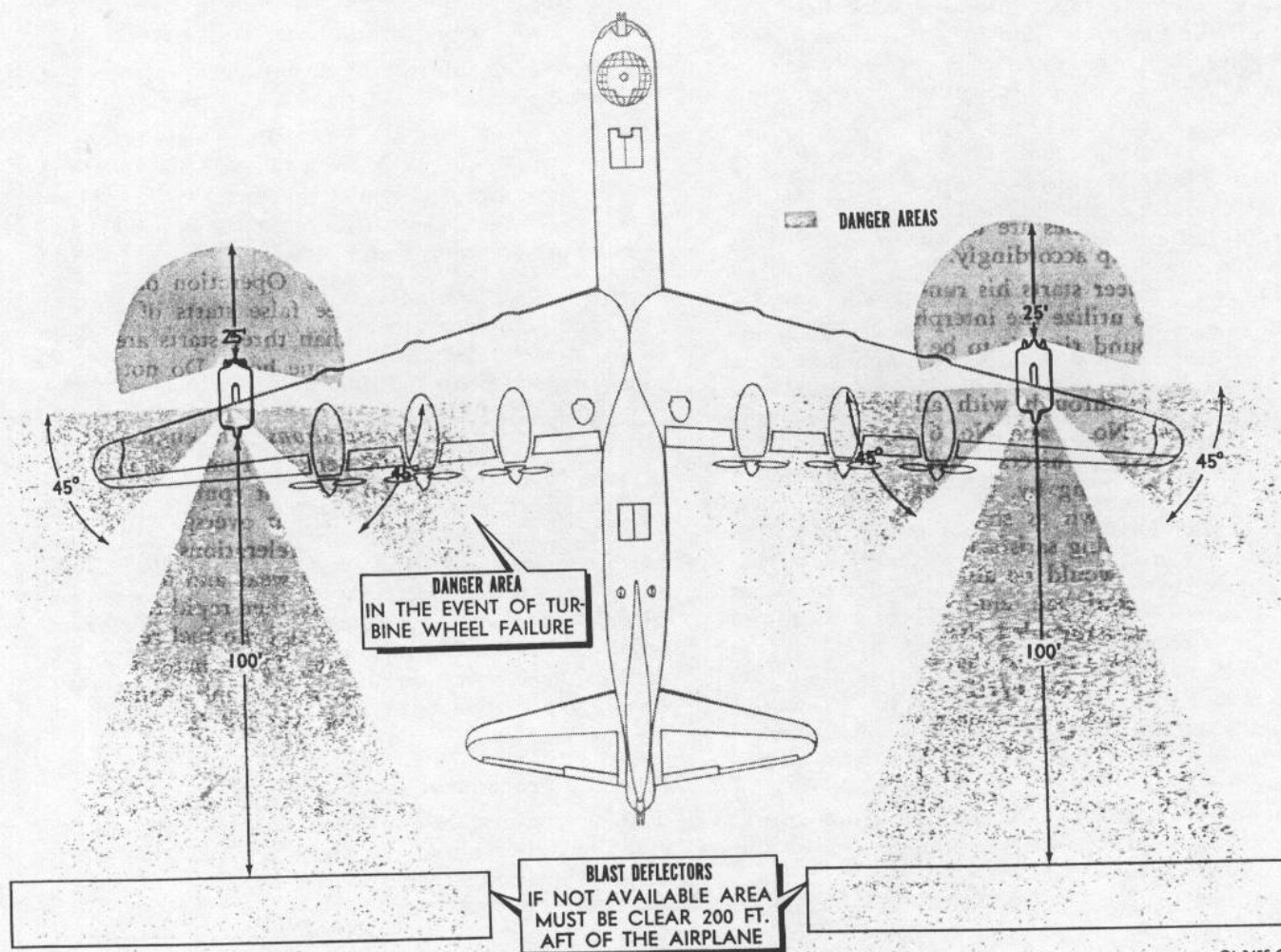


Figure 2-5. Jet Engine Danger Areas

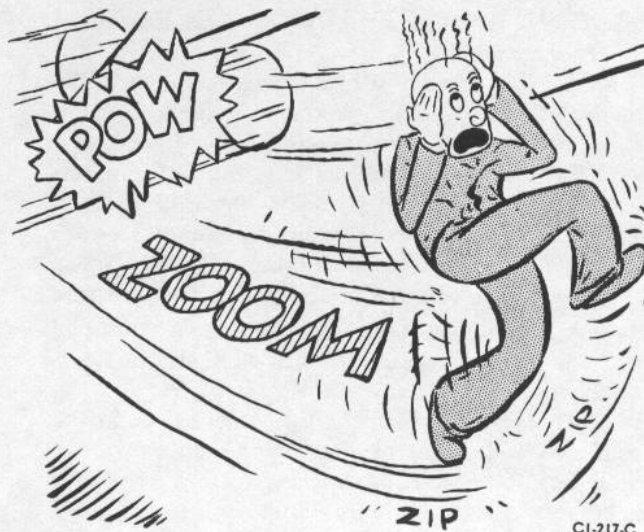
RESTRICTED

PILOTS

11. Air Plug Switches—OPEN. Check plugs visually. The aircraft commander will make a visual check of J-1 and J-2 while the pilot is visually checking J-3 and J-4 to see if the doors are open. At night have a crew member make this check from the forward sighting blisters with the aid of an Aldis lamp.
12. Manifold Valve Switches (L and R)—OPEN. The valve indicator lamps should go out and come on again, indicating successful valve operation.
13. Booster Pump Switches (L and R)—ON. No pressure will be indicated on the fuel pressure gage until the throttles are advanced to open the stopcock.
14. Ignition Start Switches—NORMAL.
15. J-1 Engine Fuel Valve—OPEN.
16. J-1 Fuel and Oil Pressure Gages—Zero. These pressures should be checked just before starting because of the low idling oil pressure and because of the sluggishness of these instruments.
17. Notify ground observers or aft gunner—"Starting J-1." If a ground observer is present, he stands by the nose of the engine being started. As the starter is engaged, the observer will report when the engine is turning over; then he will move to a position where he can see the exhaust heat waves and report when combustion occurs.
18. J-1 Starter Switch—Hold ON until the engine attains 20 per cent rpm.
19. J-1 Throttle—OPEN at 6 to 10 per cent rpm to obtain 25 to 30 psi fuel pressure. Move the throttle slowly to prevent overshooting due to the lag in the pressure indication. Maintain 25 to 30 psi during initial acceleration to avoid excessive temperatures in the tail pipe and around the shroud ring and shroud ring binding which are caused by higher fuel pressures. Although the engine will probably start at 6 to 10 per cent rpm, the starter switch should be held ON to aid the engine until 20 per cent rpm is reached so that good flame propagation can be obtained. During a normal start, combustion will occur immediately after fuel pressure is indicated. Adjust the throttle to maintain tail pipe temperature between 600 and 650°C. Although the maximum allowable limit is well beyond this range, the life of the engine will be increased by staying within the recommended range.
20. J-1 Oil Pressure—Report indication on interphone. This precludes the possibility of operating an engine with no oil pressure and also permits the crew member keeping the jet engine log to maintain an accurate record of operating time.
21. J-1 Starter Switch—Release at 20 per cent rpm.
22. J-1 Throttle—Adjust to maintain idle rpm, keeping the tail pipe temperature below maximum allowable used for normal flight operation. Since there are no idle detents on J47-19 jet engines, these engines must be idled according to fuel pressure and rpm indications.
23. J-2, J-3, and J-4—Repeat steps 15 thru 22.
24. All Ignition Start Switches—OFF.

ENGINEERS

**OBIE OBSERVER WAS CHECKING A JET.
HE'LL WATCH WHAT HE'S DOING NEXT TIME--
YOU CAN BET.
HE WAS IN THE WRONG PLACE WHEN
COMBUSTION OCCURRED,
AND RAN AWAY SHOUTING--
"MY GAD, I'M DE-FURRED"!!**



CI-217-C

STOPPING RECIPROCATING ENGINES.

The engineer will stop the reciprocating engines as follows:

1. Air Plug Switches—OPEN until air plugs are fully open. This will allow the engines to cool below 180°C before shutdown and will allow heat to dissipate after shutdown.
2. Intercooler Shutter Switches—CLOSE until intercooler shutters are closed. This will prevent damage to intercooler shutters when maintenance is being performed on the top of the wing.
3. Master Motor Speed Control Lever—Full DECREASE.
4. Booster Pump Switches—OFF.
5. Alternator Control Checks—Completed. Perform the following alternator control checks while engines are cooling for shutdown (190°C or less).
 - a. Voltage and Frequency Selector Switch—To position of alternator-equipped engine to be shut down.
 - b. Exciter Control Relay Switch—Momentarily OFF. Observe that the alternator breaker lamp comes on and the voltage and frequency drops off to zero. This is a check to make sure that the exciter control relay switch will remove the alternator from the line as well as de-excite it. A faulty exciter switch or relay will override the differential protection relay in the event of a short within the alternator, thus creating a fire hazard.
 - c. Exciter Control Relay Switch—Momentarily ON. If normal excitation occurs, frequency should return to 405 cycles and voltage should return to 208 volts.
 - d. Voltage Control Knob—Check voltage range. The voltage range should be at least 195 to 215 volts by adjustment of the engineer's voltage control knob. Reset voltage to 208 volts.
 - e. Frequency Control Knob—Check frequency range. The maximum frequency should be 440 ± 5 cycles. DO NOT go above 445 cycles. If the limit (440 ± 5 cycles) is not obtained, adjustment should be made to the frequency control rheostat located in the governor control "J" box on the respective engine distribution panel. While adjustments are being made, the engineer's frequency control knob should be turned to full decrease to preclude the possibility of the constant-speed drive going into under-drive. After the adjustment is made, the minimum indication with the engineer's knob in the FULL DECREASE position will be approximately 370 cycles, depending upon the constant-speed drive temperature.
 - f. Repeat the above steps on alternator-equipped engines, one at a time, until only one alternator is left. After completing the above steps on the last alternator, re-establish electrical power by reclosing the alternator breaker or by placing the external power switch ON if an auxiliary power unit is available. If the correct phase sequence lamp is on, the APU is plugged in and standing by.

6. Perform idle mixture check as engines are shut down as follows:

- a. Check to see that cylinder head temperature is at or below 180°C.
- b. Engine Primer Switch—Hold ON momentarily and observe engine rpm. Rpm should drop off immediately. If the rpm increases before it drops off, the idle mixture is too lean.
- c. Throttle Lever—Advance to 1500 rpm or above to clear cylinders. Then return to idle and allow rpm to stabilize.
- d. Mixture Control Lever—IDLE CUT-OFF. When the mixture control is moved to IDLE CUT-OFF, check the idle mixture setting for a minimum 5-rpm rise and a maximum 10-rpm rise as indicated on the respective engine tachometer. Record the readings that do not fall within these limits so proper settings may be made at the earliest possible convenience. A minimum 5-rpm rise when leaning the mixture assures that the idle mixture is not too lean while the 10-rpm maximum rise prevents idling in the "too rich" range. When resetting idle mixtures, an additional check may be made by enriching the mixture with the primer after it is believed that the desired mixture is correct. For use of the primer, see step 6b above.

Note

When making the idle mixture check on the last alternator-equipped engine, the hold-in switch must be actuated until the engine cuts out. Release the hold-in switch as soon as the engine cuts out and observe that the alternator breaker lamp comes on, indicating that the alternator breaker has opened.

7. Fuel Tank Valve Switches—CLOSE.
8. Cross-Feed, Manifold, and Engine Valve Switches—OPEN.

Note

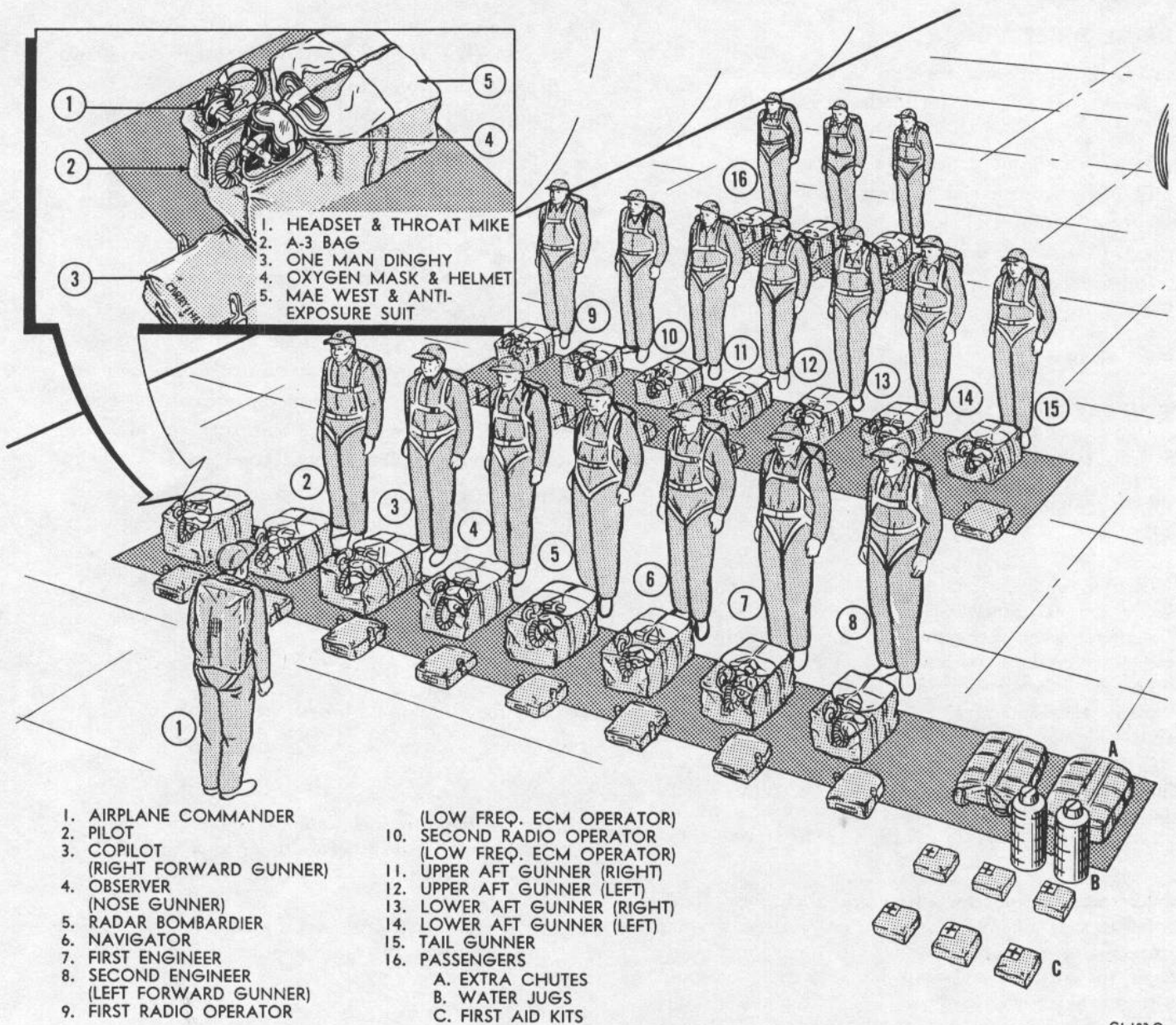
Allowing these valves to remain open will prevent fuel expansion damage to the main manifold line.

9. Individual Ignition Switches—OFF after propellers have stopped.
10. Master Ignition Switch—Pull Off.
11. Battery Switch—OFF.
12. Master Temperature Indicator—OFF.

STOPPING JET ENGINES (GROUND).

The pilots will shut down the jet engine as follows:

1. Throttles—Idle for 3 minutes; then CLOSE. The 3-minute idle period will stabilize temperatures throughout the engines, preventing malfunctions due to differential expansion and contraction of engine parts. Remember that the tail pipe temperature indicator takes the temperature at the tail pipe only.



CI-183-C

Figure 2-6. Crew Inspection

2. Jet Booster Pump Switches—OFF.

3. Jet Air Plug Switches—CLOSE when tail pipe temperature is 100°C and engine rpm is 30 per cent. Before closing the doors check for zero fuel pressure. Also, watch the tail pipe temperatures while the doors are closing. If there is a sudden temperature rise, open the doors of the affected engine immediately, because the engine is still operating. In this case, attempt to shut down the engine by using the throttle override controls. If engine operation persists, close the engine fuel valve.

4. Manifold Valve Switches—CLOSE below 20 per cent rpm.

5. Engine Valve Switches—CLOSE below 20 per cent rpm.

6. Nose De-Ice Switch—OFF.

7. Pod Preheat Switch—OFF.

8. Oil Heater Switch—OFF.

9. Oil Shutoff Valve Switches—CLOSE.

DETAILED MISSION PLANNING

Mandatory requirements for detailed mission planning are set forth in Air Force, major command, and local directives. The purpose here is to maintain a proper sequence of events and to remind the aircraft commander that a study of the proper directives and a common sense application of the principles involved will promote better teamwork in developing good flight planning techniques.

FORMAL BRIEFING.

As in "Detailed Mission Planning," the requirements for a formal briefing are set forth in other directives with which you must be familiar. Again, it is mentioned here to maintain proper sequence of events to provide ready information pertaining to the aircraft commander's responsibilities as pertaining specifically to the B-36 aircraft, and to provide helpful suggestions or hints based on principles derived from experience gained in managing the B-36 combat crew. For aircraft commander's responsibilities see "Crew Duties," Section VIII.

CREW INSPECTION.

The time for crew inspection shall be established during formal briefing. Normally, the crew will report to the airplane for this inspection.

Note

During inclement weather, the inspection may be accomplished under any available shelter. After such an inspection, all equipment should be packed in A-3 bags, transported to the airplane, and loaded aboard immediately on arrival.

In addition to the personal equipment required, each crew member will wear dog tags on each flight. The information on these tags must be kept current. All crew members will wear tags on a chain around their necks.

Crew formation for crew inspection should be standardized so that all crew members know exactly what is expected of them. The crew will form on the left side of the aircraft and will lay out their personal equipment as shown in figure 2-6. Then the aircraft commander will accomplish the inspection as follows:

1. Give command, "Attention," and call the roll.
2. Give commands, "Right face," "At ease," and "Inspect parachutes." Each crew member shall check the parachute of the man in front of him. The aircraft commander's parachute shall be checked by the pilot. After checking the parachutes of the men in front of them, the crew members standing next to last in each line shall turn around and check the parachute of the men on the end of each line. As each crew member completes his part of the parachute check, he shall assume the "at ease" position.

Note

If both chest-type and back-type parachutes are worn, each crew member must check his own chest pack in addition to checking the back pack as indicated in the preceding paragraph.

3. Give commands, "Attention" and "Left face." Check each crew member's equipment for completeness, fit, and condition. In addition check professional equipment, such as sextant, technical orders, each individual's sop's, etc., as required for the mission.

4. Give command, "At ease" and read discrepancies noted in Parts II and III of Form I.

5. Have the navigator give the crew a time "hack."

6. Establish the time for final crew briefing.

7. Designate specific crew members for command of each compartment. Each of these men will command his compartment under all conditions. He will be responsible for the execution of all normal and emergency instructions affecting his compartment, and will subsequently notify the aircraft commander.

8. Give the crew any special instructions not previously covered and order any special checks necessary on preflight. Also, answer any questions the crew may have.

9. Give commands, "Attention" and "Dismissed."

BOARDING AIRCRAFT.

All crew members must board the aircraft with their equipment.

Note

The second engineer should start the auxiliary power unit before boarding the airplane.

Each crew member should accomplish a combat station check and report to the radio operator on private interphone as follows:

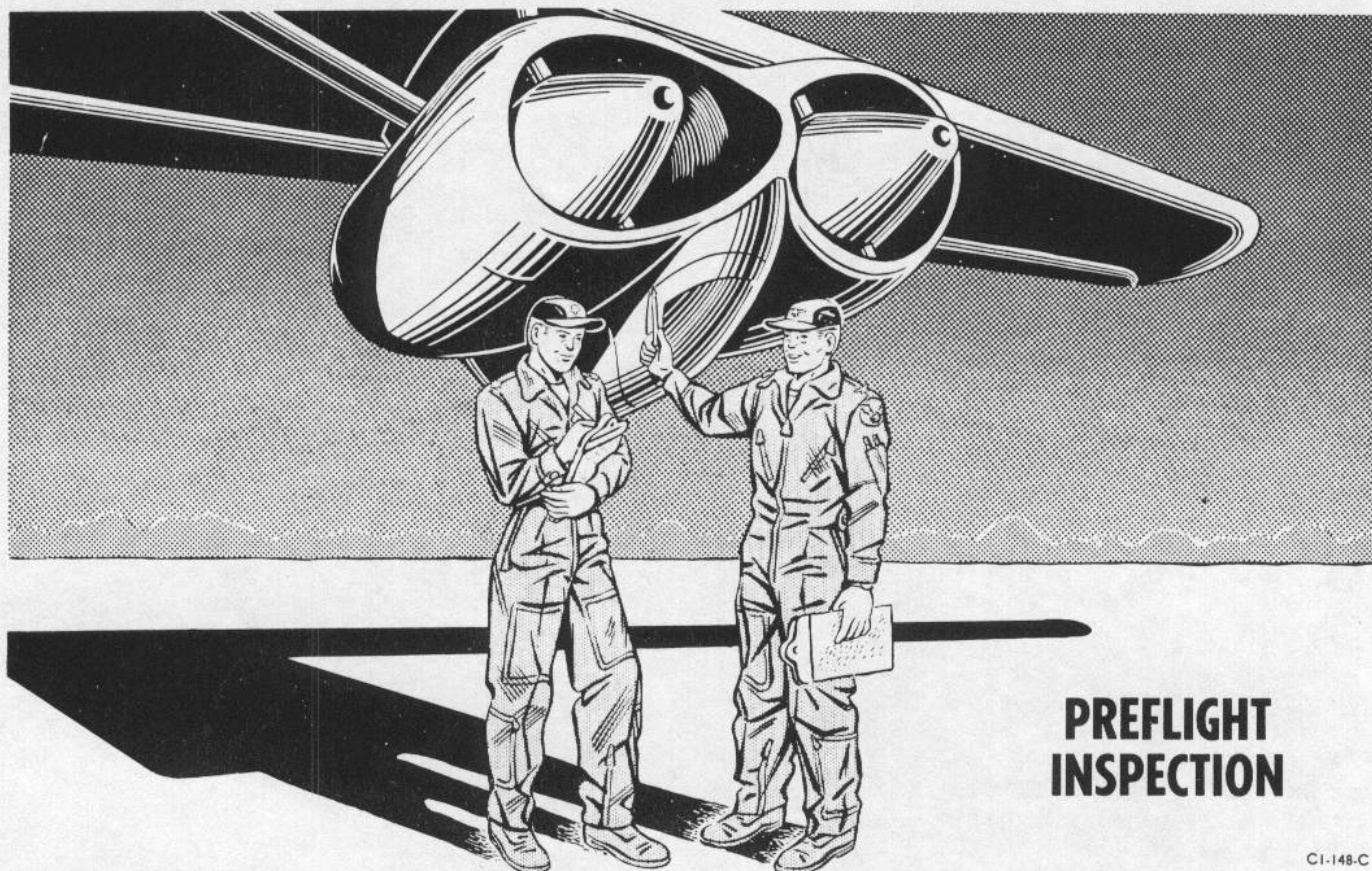
1. Combat equipment at station.
2. Oxygen equipment checked.
3. Oxygen pressure 400 to 450 psi with diluter handle and altitude dial set at NORMAL.

Note

Oxygen panels on group 14 airplanes are equipped to automatically compensate for altitude and therefore do not have altitude dials.

4. Circuit breakers in.

As each crew member completes his report the radio operator will note the station; and when all crew members have reported, he will notify the aircraft commander. After checking in with the radio operator, all crew members will switch back to normal interphone and proceed in accordance with their preflight check lists.



PREFLIGHT INSPECTION

CI-148-C

AIRCRAFT COMMANDER'S VISUAL PREFLIGHT INSPECTION.

HOW TO MAKE A GOOD PREFLIGHT.

The aircraft commander is responsible for performance of preflight inspections; however, the complexity of the aircraft and the detailed check lists make it necessary for the aircraft commander to delegate some of these preflight duties to the pilot and copilot as well as to other crew members. Being a teamwork airplane, close coordination and wise planning are required to effect a good preflight in a minimum amount of time. A good aircraft commander guards against fatiguing himself or his crew before starting on the mission. At the same time, he does not make a sketchy preflight inspection and risk an aircraft accident. Plan wisely and delegate responsibility.

A good aircraft commander will want to make the complete visual preflight inspection by himself so that he knows all preflight maintenance, service, and inspection procedures have been accomplished and the airplane is ready to fly. Make the checks listed in figure 2-7 carefully and completely. Omit nothing. Follow the route shown in this figure. As your training and familiarization with the airplane progress, you will be able to speed up this inspection so that it does not hold up your preparation for flight, but still accomplishes its purpose. It is the aircraft commander's responsibility to see that the inspection is actually made and not just signed off on the AF Form I.

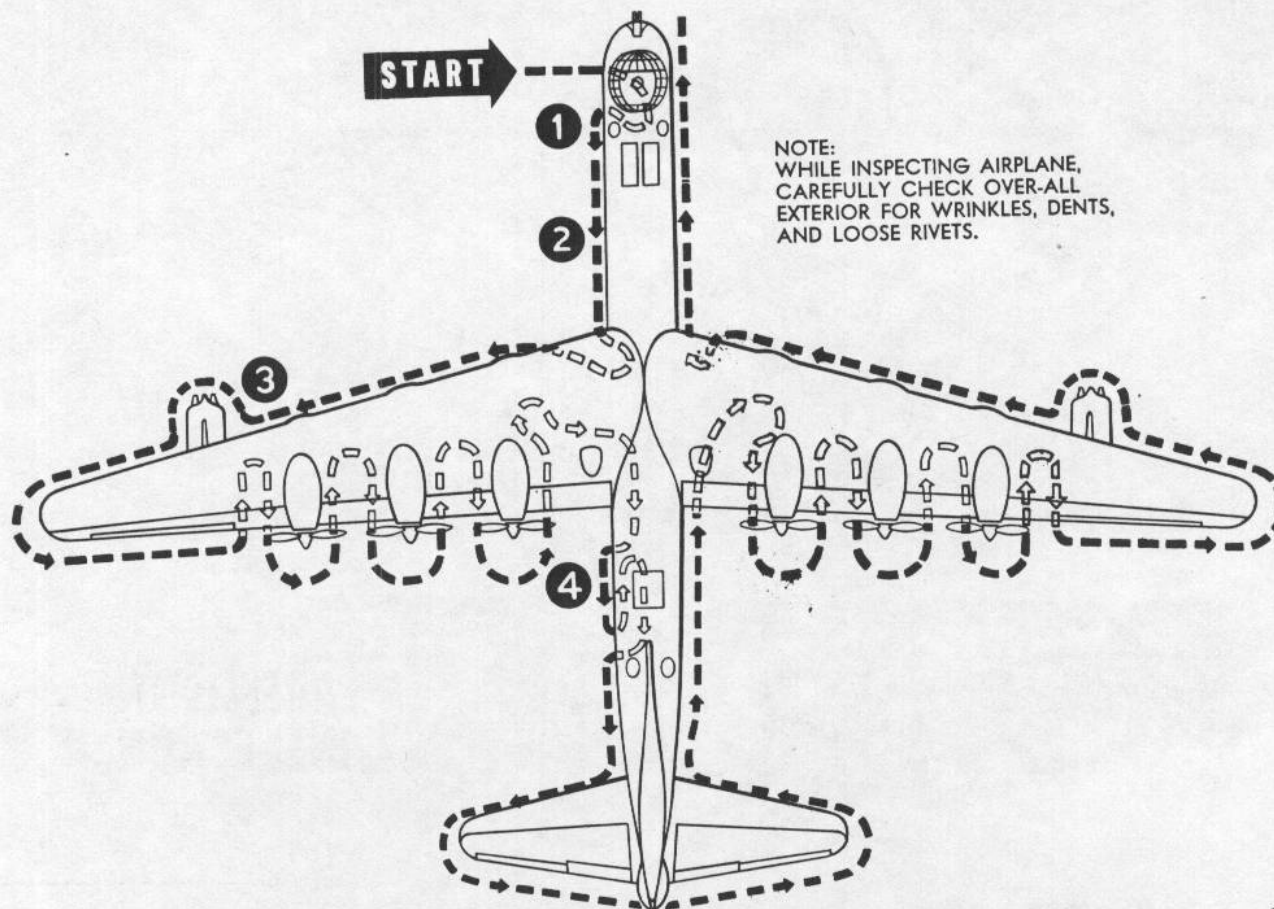
Normally about two hours before take-off, it is necessary to complete all phases of the aircraft preflight and final crew briefing. This time will vary with the crew experience. In order to accomplish the preflight inspection in minimum time, it is well to delegate certain duties to the pilot and copilot. As aircraft commander you are personally responsible for the entire preflight inspection, but that does not mean you will accomplish the entire inspection yourself. Delegate the responsibility of certain portions of the aircraft preflight inspection to each pilot.

Have your pilots accompany you on preflight inspections until they become thoroughly familiar with inspection procedures and can be relied upon to make an inspection by themselves. Then you will be able to divide the aircraft up in sections, having one pilot inspect the top of the wings and the other pilot inspect one side of the aircraft while you inspect the other side. This will expedite the inspection and reduce the individual time and effort expended to accomplish a full preflight.

In addition to assisting the aircraft commander in the regular preflight inspection, the pilot and copilot will check the following:

PILOT.

1. Proceed to pilot's station and stow personal equipment. Use oxygen mask and helmet to make initial interphone check.



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Figure 2-7. (Sheet 1) Aircraft Commander's Visual Preflight Inspection

2. Check oxygen panel. Note oxygen system pressure and report to radio operator on interphone, "Radio this is pilot, combat crew equipment at station, oxygen pressure _____ pounds."

3. Check stowage of astrodome, pressure guard, and vent fan.

4. Check parking brake pressure on flight engineer's panel and set parking brakes.

5. Check the nose steering by putting slight pressure on the steering wheel control while moving the Nose Steering Switch to the ON and OFF positions.

6. Check the flight deck lights for operation.

7. Turn on and check landing, formation, and position lights. Have another crew member on the ground signal to you whether these lights are operating properly.

8. Be sure that the pilots' night flying curtain is stowed in forward cabin.

9. Check instrument panel and flight deck flood lights and see that spare bulbs are available.

10. Turn pitot heater switch on engineer's panel ON and check to determine if the heaters are warming up. Turn pitot heater switch OFF.

11. Check that pilot's side windows open and close properly.

12. Check throttle controls for proper movement, indexing, and rigging.

13. Check mechanical movement of TBS, indexing, and rigging.

14. Check mechanical movement, indexing, and rigging of propeller master motor controls.

15. Jet Engine Fuel System Pressure Check.

a. Throttle Selector Switches—LEVER.

b. Throttle Levers—Closed.

c. All Circuit Breakers—In.

d. Fuel Manifold Valve Switches (L & R)—OPEN.

e. All Jet Engine Fuel Valve Switches—OPEN.

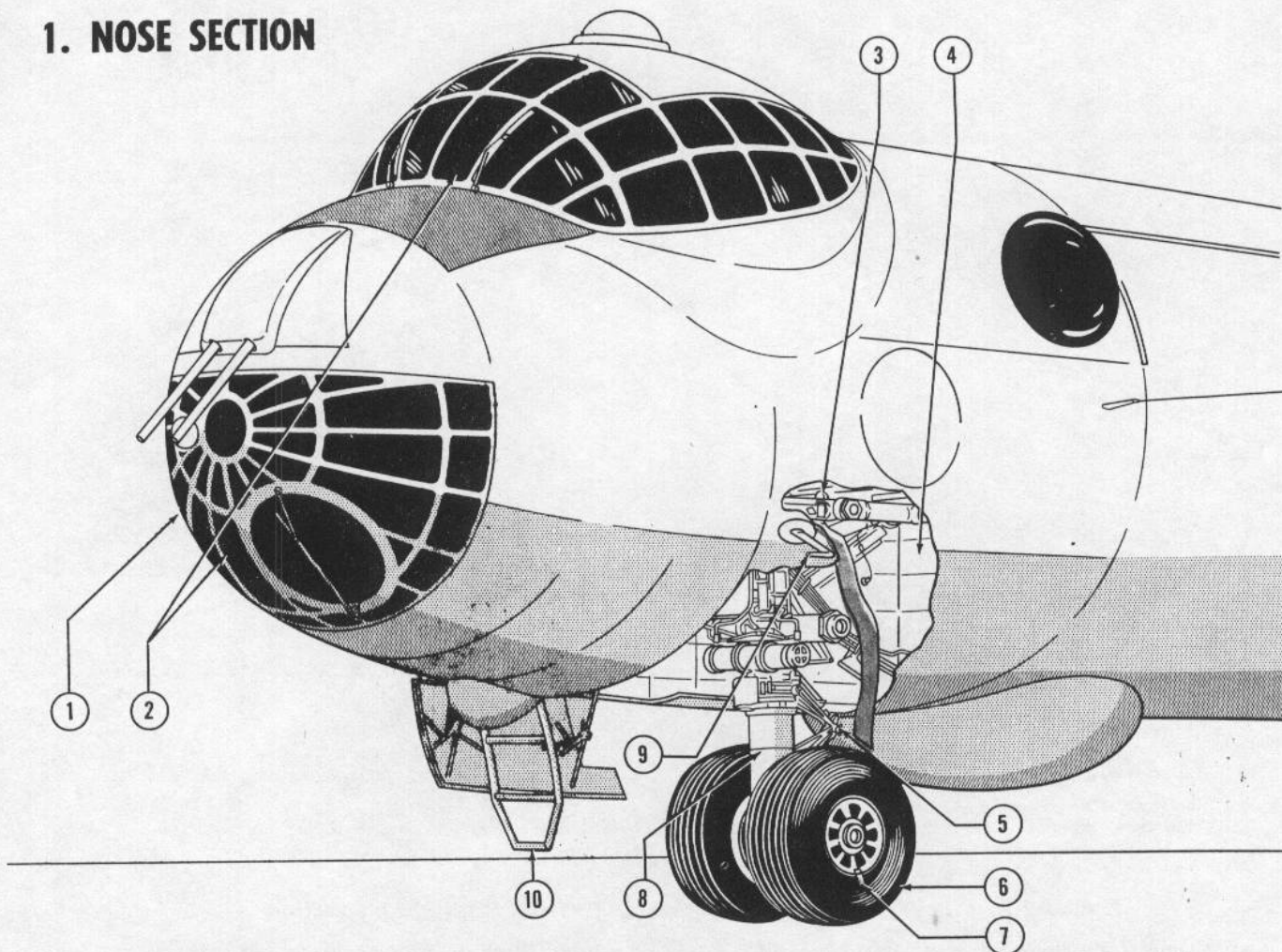
f. Fuel Booster Pump Switches—ON.

g. Jet Air Plug Switches—OPEN.

Note

This jet panel configuration will be maintained for 5 minutes unless excessive fuel leaks are reported by the ground observer. This procedure allows an adequate fuel pressure check of the entire jet engine fuel system down to the jet engine fuel stopcock. Slow

1. NOSE SECTION



1. While approaching the nose section, note the general over-all appearance of the airplane.
2. Nose glass & pilot's windshield for cleanliness.
3. Nose gear safety lock in place.
4. Nose wheel well area for hydraulic leaks.
5. Nose gear scissors up and engaged.
6. Tires for cuts, blisters, and proper inflation.

- (Roll radius — 20 inches).
7. Red tire slip marks for alignment.
8. Nose wheel oleo strut for cleanliness and proper inflation (Inches plus or minus 1/4 inch).
9. Pitot mast covers removed and tubes clear.
10. Entrance ladder for condition.

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Figure 2-7. (Sheet 2) Aircraft Commander's Visual Preflight Inspection

dripping of fuel from each jet engine manifold drain is normal because of the bleed bypass. Leakage from the combustion chamber drain system or pressure regulator (nose section) is not normal and an engine start must not be attempted until the source of difficulty is located and corrected.

h. Obtain ground observer's report—Fuel Pressure Check—Normal.

- i. Jet Fuel Booster Pump Switches (L & R)—OFF.
- j. All Jet Engine Fuel Valve Switches—Closed.
- k. Jet Fuel Manifold Valve Switches—Closed.
- l. Jet Throttle Circuit Breakers—Out.

16. Proceed to top of the wing and check for loose rivets, condition of control surfaces, turret doors, blisters, and general condition of top of the aircraft.

17. Check fuel level, using the dip stick, and record the amount in each tank.

18. Check oil level, using the dip stick, and record the amount of oil in each tank.

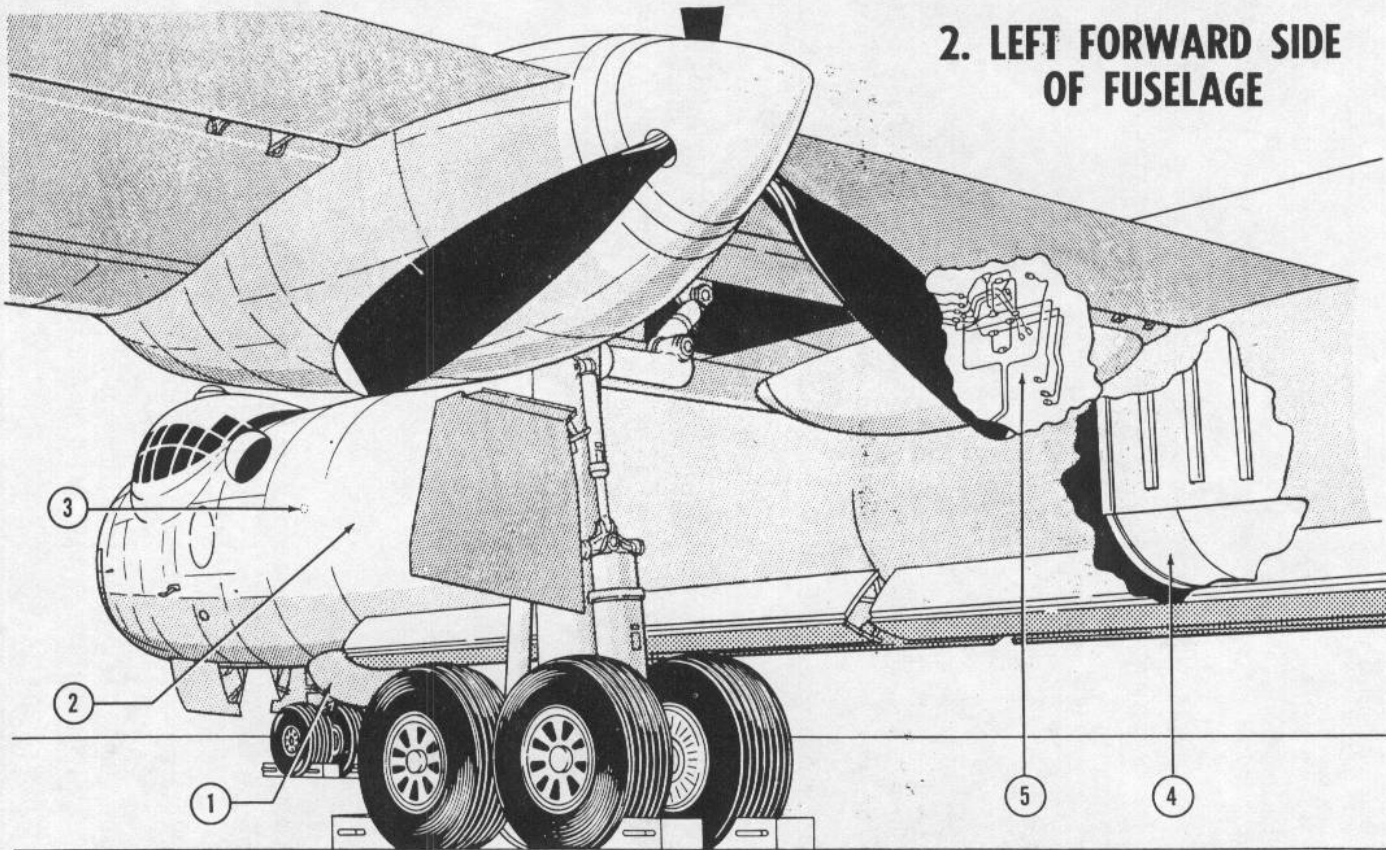
19. Check all fairing and cowlings, ailerons, tabs, flaps, and antennas.

20. Check propellers and spinners, air plugs, inter-coolers, and anti-icing dump valve.

21. Check evidence of duct cracking or leaking.

22. Fill out Form F and return to the aircraft commander, who will check it for accuracy and sign. It is your responsibility to see that the airplane is properly loaded and balanced; you should know enough about this work to be able to check the weight and balance. Obtain the take-off and the anticipated landing gross weights and cg locations. Also make a check to assure yourself that the required amounts of fuel, ammuni-

2. LEFT FORWARD SIDE OF FUSELAGE



1. Radar dome for cracks.
2. Fuselage for cracks.
3. Static ports clear.
4. If bomb bay tanks are installed, check for leaks and

- general condition.
5. With bomb bays 2 & 3 open, check the wing center section area for hydraulic and fuel leaks.

CI-153-C

Figure 2-7. (Sheet 3) Aircraft Commander's Visual Preflight Inspection

tion, and bombs have been loaded. Loading information can be obtained from the *Handbook of Weight and Balance*, AN 01-1B-40. Refer to "Operating Limits," Section V for operational weight limitations.

Check the basic weight of your B-36 carefully. Remember, your airplane probably has undergone modification affecting the weight. Make absolutely sure that the basic weight you are using applies to the airplane that you are going to fly.

COPILOT.

1. Check flight lunches to insure that the proper number have been received and that they are properly distributed and stowed in the forward and aft cabins.
2. Preflight right forward sighting stations. (See "Crew Duties," Section VIII.)
3. Supervise loading of radio compartment.

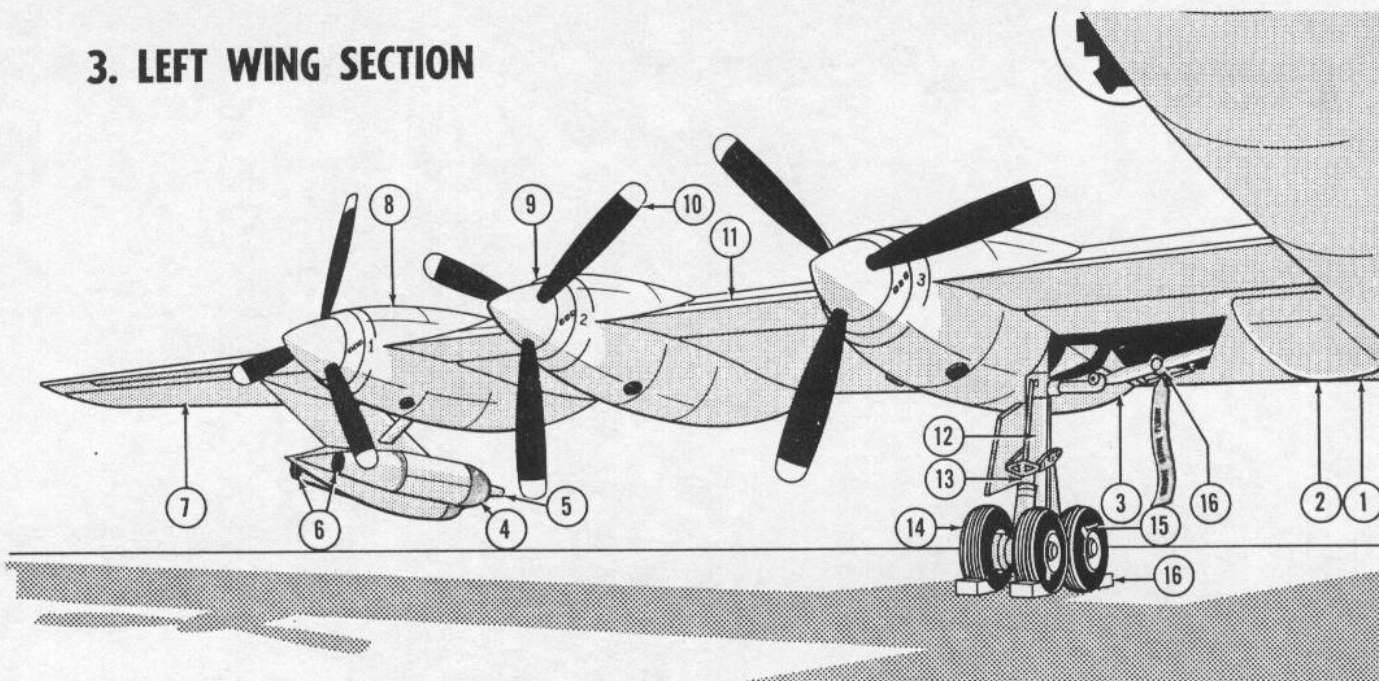
ENGINEERS' PREFLIGHT INSPECTION.

This inspection will be accomplished with a minimum of two flight engineers. Although the first flight engineer will be assisted in the inspection, this in no way relieves him of the responsibility of insuring that every step is properly completed. He is expected to know the B-36 and to determine its condition before flight.

The procedure contained herein comprises an inspection route arranged in a sequence which will allow greatest efficiency. The procedure results in a thorough inspection. Various factors may force it to be modified slightly. Additional items may be inspected as warranted by local conditions and requirements; but all the items listed below must be performed in the prescribed manner.

Actually your preflight inspection begins as you and the second engineer approach the aircraft. You should have immediately noticed if any obvious maintenance was still in progress and if adequate stands, auxiliary power units, lighting, towing equipment, fire equipment, etc., are standing by for use. Recheck the status of the aircraft with the crew chief as reflected by the Parts II and III of the AF Form 1. Pay particular attention to the corrective action taken on all discrepancies noted by the crew during the operational equipment check. The Part II of the AF Form 1 should indicate that the daily inspection has been completed, the amounts of fuel and oil serviced, and the totals of fuel and oil by location. If it does not interfere with a specific maintenance operation, shut off the auxiliary power unit in event it is operating, so that some of the distracting noise is not present during crew inspection. Be ready to report the aircraft status to the aircraft commander and stand by for crew inspection.

3. LEFT WING SECTION



- | | |
|--|--|
| <ol style="list-style-type: none"> 1. Underside of wing for loose rivets, fuel leaks, oil leaks, and cracks. 2. Proceed along leading edge and check for excessive dents and warpings. 3. Air inlets for damage and obstructions. 4. Jet engines 1 & 2 for loose cowling and general condition. 5. Jet engine starter cooling inlet plugs removed. 6. Jet engine tail pipe for damage and obstructions. 7. Wing tips, ailerons, and trim tabs for general condition. 8. Engine 1, 2, & 3 for loose cowling and oil leaks. 9. Air plugs for condition. | <ol style="list-style-type: none"> 10. Propeller blades for general condition. 11. Flaps for general condition. 12. Left main gear hydraulic lines, struts, and positioning jacks for leaks. 13. Oleo strut for cleanliness and proper inflation (3-1/2 inches plus or minus 1-1/4 inches). 14. Tires for cuts, blisters, and proper inflation (Roll radius 24.3 inches plus or minus 1/8 inch). 15. Red tire slip marks for alignment. 16. M.L.G. safety lock in place. Chocks in place. |
|--|--|

CI-154-C

Figure 2-7. (Sheet 4) Aircraft Commander's Visual Preflight Inspection

After dismissal from crew inspection the first and second engineer will proceed with their preflight inspection duties as follows:

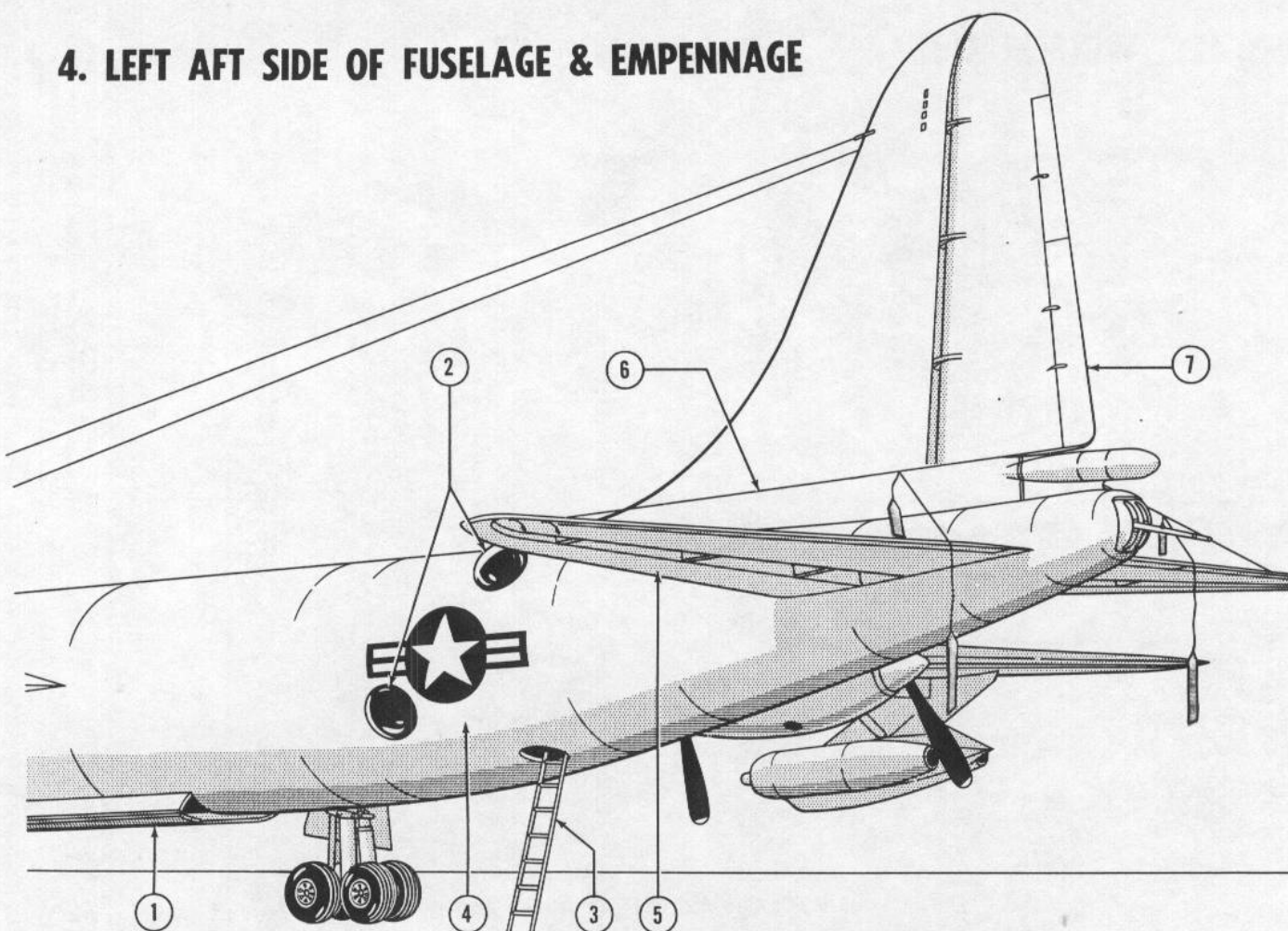
FIRST ENGINEER

1. Proceed to the flight engineer's station. Stow personal equipment not immediately required in an out-of-the-way place and arrange it at your station in the order you will need it. Use your oxygen mask and helmet to make your initial interphone check.
2. Complete items 1 thru 10 of the "Before Starting Engines" check list.
3. Check your oxygen panel, note oxygen system pressure, and report results to the radio operator on the private interphone. Report, "Radio, this is engineer, combat crew equipment at station, oxygen panel checked, pressure _____ pounds."
4. Check all ignition switches OFF and stand by for a call from the second engineer who will be acting as your ground observer for a static propeller feather check and an engine liquid lock check.
5. Static propeller feather check completed as follows:

SECOND ENGINEER

1. Locate crew chief and ground observer and assist in starting the auxiliary power unit, adjusting its output, and see that ground observer is standing by on interphone.
2. Correct auxiliary power source upon request from engineer. Stand by to make final power adjustments.
3. After electrical power has been established, go aboard and stow your equipment. Check your assigned oxygen station, note system pressure, and report results to the radio operator on private interphone. "Radio, this is second engineer at the left forward sighting station, combat crew equipment at station, oxygen panel checked, pressure _____ pounds."
4. Return to the servicing bulkhead (Sta. 7.0) and stand by on ground interphone to assist first engineer with a static propeller feather and engine liquid lock check. Let first engineer know as soon as you are on interphone.
5. Static propeller feather check observed as follows:

4. LEFT AFT SIDE OF FUSELAGE & EMPENNAGE



1. Proceed to check bomb bays 3 & 4, repeating the procedure followed for bomb bays 1 & 2.
2. Sighting blisters for cleanliness.
3. Enter the aft cabin through aft entrance hatch and check for cleanliness, stowage of equipment, and general appearance.
4. Leave the aft cabin and check the fuselage skin for general condition.

5. Horizontal stabilizers for general condition.
6. Rudder ground locks installed.
7. Rudder for proper alignment.

NOTE

Proceed along the right side of the airplane and repeat applicable checks which were followed on the left side.

C1-155-C

Figure 2-7. (Sheet 5) Aircraft Commander's Visual Preflight Inspection

FIRST ENGINEER

Note

If you performed a satisfactory static propeller feather check after engine run-up during the "Operational Equipment Check," it may be omitted at this time. The propeller static feather check will be performed immediately after engine shutdown of the "Pre-flight Operational Equipment Check" so that the propeller oil and mechanism will be at best operating temperature for all weather conditions.

a. Propeller Selector Switches—FIXED PITCH.

b. All propeller feather switches FEATHER position for 30 seconds then return to NORMAL position (Feather Switch Guards Down).

SECOND ENGINEER

a. Check and report all blade angles in the approximate feather position. Any propeller that will not reach the feather position on this check will not feather in the air and must be repaired or changed.

FIRST ENGINEER

Note

If longer than 30 seconds is required to feather any propeller (i.e., cold weather operation), wait at least two minutes before attempting to complete the feather operation. Allow feather motors to cool a minimum of two minutes between feather and unfeather operation. Allow a minimum of five minutes before attempting to complete another cycle if a recheck is required.

c. Propeller Selector Switches—INC. RPM. Hold in INC. RPM until normal low pitch position is reached.

6. Liquid Lock Check—Pull propellers through 6 blades with starters. Sequence 4, 5, 6, 3, 2, 1.

CAUTION

Energize starter intermittently for 3 blades (60 degree increments) and continuously for 3 blades. Maintain contact with observer for reports of propeller movement. This procedure must be followed to minimize the possibility of damage in the event of a liquid (hydraulic) lock.

7. Fuel Panel Configuration—Checked.

8. Mixture Control Check—Completed.

Note

For amplification of steps 7 and 8 above, see items 11 and 30 under "Before Starting Engines" of this section.

9. Fuel Panel Configuration—Set to obtain system pressure.

a. Minimum of two tank valves OPEN and booster pumps ON (one on each wing to provide system fuel pressure).

b. All engine fuel valves—OPEN to allow pressure up to carburetor and cause oil cool control motors to operate.

10. Complete remaining items of the engineer's "Before Starting Engines" check list, with the exception of items 36 and 37.

11. Check engineer's panel lighting.

12. Adjust seat (if necessary).

13. Spare flashlight batteries—Check.

14. First Aid Kit in Position—Check.

15. Portable oxygen bottle filled to 400 psi and stowed.

16. Engineer's Fuse Panel—Fuses of proper ratings installed and spares available.

17. Engineer's Fuse Panel Alternate A-C Power Switch—NORMAL position and indicator lamp on.

18. CO₂ hand fire extinguisher and axe checked and in place.

SECOND ENGINEER

b. Check and report all blade angles returning to normal low pitch position.

6. Check area of propeller arcs for freedom from obstructions and personnel. Announce "All Clear" and report all propeller movements on interphone to the first engineer.

7. Be ready to turn ground observer position over to ground crew member and proceed with second engineer's normal preflight inspection as soon as pressure is reported on the fuel system.

8. Check under bomb bay catwalks and wings from ground for any obvious fuel leaks. If none are apparent, proceed to the left main landing gear.

INSPECTION OF LEFT MAIN LANDING GEAR

1. Inspect general condition of wheels and tires for obvious defects, inflation, tire slippage, and wear.

2. Check exposed portion of brakes and brake hydraulic lines for proper mounting, condition, and evidence of leakage.

3. Check extension ($3\frac{1}{2} \pm 1/4$ inches) and condition of the oleo strut, equalizer assembly, and main column.

4. Check security and condition of wheel fairings and safety switches.

5. Check security and condition of the landing gear positioning jack, including proper connection of the flex line and evidence of leakage.

6. Inspect inside of hollow main landing gear pivot shaft for evidence of fuel leakage from wing fuel tank.

7. Check main side brace for general condition of latching mechanism, proper connecting and alignment of latch release arm at both ends, and security and condition of the hydraulic snubber. See that ground safety lock is in place.

8. Check for security, condition, and evidence of leakage of the main landing gear hydraulic actuating mechanism, lines, and connections.

FIRST ENGINEER

RADIO OPERATOR'S COMPARTMENT

1. Emergency dump valve pedal reset in untripped position and valve closed (manual modulating knob full clockwise).
2. Cabin Pressure Regulator—On.
3. Vacuum Relief Valve—Freedom of movement and for obstructions.
4. Pressure relief and dump valve handle safetied in NORMAL position.
5. Forward Cabin Pressurization Manual Shutoff Valve—OPEN.
6. Security and condition of the forward cabin pressurization ducting.
7. Heat, Anti-Ice, and Diffuser Valves—As required.
8. Emergency Hydraulic Reservoir—Check level.
9. Emergency Hydraulic Hand Pump and Selector Valve—Check latch and operation.
10. Emergency Hydraulic Selector Valve—CHARGE BRAKE ACCUMULATOR POSITION.
11. Radio Operator's Transformer-Rectifier — Check for security, foreign material, wiring, and fan output.
12. Visually inspect condition and rigging of normally accessible control cables and pulleys.
13. Red Nose Gear Release Handle—Connected to cable and stowed in recess.
14. Lift nose gear latch observation window. Observe condition of window and visually inspect the nose gear latching mechanism and replace cover.
15. Nose Gear Emergency Latching Hook—Normally stowed on food locker.
16. T-R Test Unit—Check voltage and load output of each transformer-rectifier and the battery; return selector switch to OFF.
17. Turbo, jet throttle, and mixture control amplifiers—Check wiring, mounting, and presence of two spares.
18. Propeller Synchronizer and Junction Box—Check wiring and security of mounting.

RADAR-BOMBARDIER'S COMPARTMENT

1. Remove sufficient overhead upholstery (under flight deck) to visually inspect control column and brake pedal rigging. Depress the plunger on the slave brake reservoirs. If these plungers can be pushed full in, the reservoir is fully serviced. If these plungers extend over 3/4 inch when depressed, the slave brake system should be bled of all air and the reservoirs reserviced. Empty the slave brake reservoir overflow cups if necessary and replace the upholstery.
2. 28-Volt A-C Power Panel (overhead)—Check connections, fuses, transformers, and relays.
3. Instrument Transformer—Check security and wiring.
4. Transformer-Rectifiers — Check for security, foreign material, wiring, and fan output.

SECOND ENGINEER

9. Inspect condition of all hinges, levers, and actuating linkages for the landing gear fairings, doors, and sequence valves.
10. Inspect the latch mechanism and main landing gear wheel well door limit switches for proper condition, security of mounting, proper electrical connections, and corrosion or binding of the micro-switch actuating mechanism.
11. Make the following inspection of the main landing gear manual extension controls:
 - a. Cable wound correctly on large drum approximately 2 turns.
 - b. Hoist hook properly stowed after operational check.

INSPECTION INSIDE LEFT WING

The second engineer will perform the same check inside the left wing as the first engineer performs in the right wing.

INSPECTION OF NO. 3 AND NO. 4 BOMB BAYS

1. Zip closed the wing crawlway access port.
2. Turn off the wing crawlway lights.
3. Inspect the visible portion of the fuel manifold and wing center section for general condition and evidence of fuel leakage.
4. Check condition, security of mounting, and rigging of all accessible control cables and pulleys passing through bomb bays.
5. Check the left wing splice terminal strips for condition of wiring, insulation, and connections—Replace covers.
6. Note the A, B, C phase power-on indicator lamps on left main a-c power panel. Open this panel and check for proper installation and rating of active and spare fuses, general condition of buses and bus tie breakers, condition of wiring; then reclose the panel doors.
7. Visually inspect the wing flap synchronizer system for condition and security of mounting of the synchronizer units, and the control cables, and electrical wiring.
8. Check the outer walls of the communication tube for cracks or imperfections.
9. Auxiliary Fuel Tank—Check fittings, seams, fuel and vent lines for leaks, routing, proper connections, etc.
10. Visually inspect heating and pressurization ducting for alignment, cracks, or obvious damage which may cause pressure leaks.
11. Transformer-Rectifiers—Check for security, foreign material, wiring, and fan output.
12. CO₂ Icebox—Check interior for presence of gasoline vapors. Check purging lines, check valves, and electrical wiring.
13. Bulkhead 8.0 D-C Power Panel—Check condition

FIRST ENGINEER

5. Check the A, B, C phase power-on indicator lamp on the following panels:

- a. Left Forward Cabin Power Panel.
- b. Right Forward Cabin Power Panel.
- c. Forward R.H. (Nose Turret) Power Panel.

NOSE LANDING GEAR INSPECTION

1. Condition of the nose entrance ladder, linkage, and stowage provisions.
2. Condition of the nose wheel well doors, linkage, and pick up arm.
3. Inspect tires and wheels for general condition, proper inflation, slippage, and wear.
4. Check extension ($3\pm 1/4$ inches) and condition of the oleo strut.
5. Nose Gear Scissors—Connected.
6. Check nose steering unit and equipment, including cable system.
7. Check hydraulic lines for proper connections, routing, and evidence of leakage.
8. Nose Landing Gear Latch Spot Light—Proper operation and security of mounting.
9. Emergency release cables and pulleys for proper rigging.
10. Nose landing gear latch mechanism and latch release link in place.
11. Ground Lock—In place.
12. Battery—Mounting, connections, and signs of corrosion.
13. On group 6 airplanes, check forward roomette waste tank drain valve in vertical up position (closed).
14. On group 6 airplanes, check that the overflow and filler plugs for the forward roomette water tank are tight.

EXTERIOR INSPECTION

1. See that the bomb bay doors are open and safety locks in place. Check bomb bay door actuators for leakage, linkage, and security of mounting.
2. Check for fuel leaks along the manifold lines under the bomb bay catwalk, the servicing bulkhead or wing center section, and any installed auxiliary fuel tanks.
3. Check under the wings and engine nacelles for open vents, proper installation of cowlings, and evidence of fuel or oil leaks.
4. Check condition of propellers, approximate blade angles, and the position of the air plugs and inter-cooler shutters.

INSPECTION OF RIGHT MAIN LANDING GEAR

The first engineer will perform the same checks of the right main landing gear as the second engineer performs on the left main landing gear.

SECOND ENGINEER

and note position of circuit breakers. Make sure circuit is closed to the emergency flap control box.

14. Emergency Flap Control Switches—NORMAL, panel light operative.
15. Interphone jackboxes in bomb bays disconnected.

CAUTION

The wing interphone control switch must always be in the OFF position and the remote interphone jackboxes disconnected when these channels are not in use. Isolation of these channels will prevent disruption of the basic interphone system in event a fire or some other cause short circuits these channels.

16. Oxygen Bottles and Connections—Check leaks and security.
17. Check the A, B, C phase power-on indicator lamps and proper rating and installation of fuses in the following:
 - a. Right Aft Turret Power Panel.
 - b. Left Aft Turret Power Panel.
18. Check turret and bomb bay light.

INSPECTION OF AFT CABIN AND TAIL CONE

1. Aft Cabin Pressurization Manual Shutoff Valve—OPEN.
2. Cabin Pressure Regulator—ON.
3. Cabin Pressure Relief and Dump Valve—Handle safetied in NORMAL position.
4. Vacuum Relief Valve—Freedom of motion and obstruction, and presence of quick-release strap.
5. Security and condition of the aft cabin heat and pressurization ducting.
6. Check the aft cabin power and circuit breaker panels.
7. Visually inspect condition and rigging of normally accessible control cables and pulleys.
8. Emergency Bomb Bay Door Hydraulic Reservoir—Check fluid level and selector valve OFF
9. Tail Cone Lights—ON to check operation and OFF when tail cone inspection is complete.
10. Tail Anti-Icing Ducts—Check for condition and cracks.
11. Remote interphone jackbox plugs disconnected.
12. Visually inspect the condition and rigging of the elevator and rudder control system.
13. Check the condition and servicing of the rudder.

FIRST ENGINEER

INSPECTION INSIDE RIGHT WING (AS
INSPECTION PROGRESSES OUTBOARD)

1. Open the wing crawlway access port.
2. Turn ON the wing crawlway lights.
3. Methyl Bromide Cylinders, Lines, and Valves—Check pressure, wiring, and security.
4. Inspect all accessible portions of the fuel manifold lines, valves, and tanks.
5. CO₂ Icebox—Check interior for presence of gasoline vapors. Check purging lines, check valves, and electrical wiring.
6. Check wheel well and wing crawlway lights.
7. Check tank-to-engine oil lines and connections for leaks, oil thermostats for proper operation, and manual crank stowed on the engine oil shutoff valves.
8. Check throttle and flap synchronizer cables for condition and rigging.
9. Check wing auxiliary spar forging for cracks.
10. Fuel Level Transmitters—Check mounting and wiring.
11. Inspect the following at each engine nacelle and K-truss cutout.
 - a. Alternator and turbo oil tanks for leaks and caps for security.
 - b. K-truss cutout and accessible engine mounts for cracks.
 - c. Accessible ducting for alignment, cracks, breaks, connections, etc.
 - d. Turbosupercharger and Waste Gate Actuator and Linkage—Check condition.
12. Inspect each engine power distribution panel for the following:
 - a. Check the A, B, C phase power-on indicator lamps and proper rating and installation of the active and spare fuses.
 - b. Check the 28-volt d-c power lamp on and the alternator control fuses.
 - c. Check the relays for proper wiring and security of mounting.
 - d. Visually inspect the wiring and mounting of the alternator control units.

AS INSPECTION PROGRESSES INBOARD

13. Check routing, connections, and security of mounting of the fuel tank vent lines, vapor return lines, and fuel tank purging lines.
14. Check pressurization ducting and flow limiters for alignment, cracks, breaks, connections, and routing.
15. Check condition of wing flap relays and attachments.
16. Check all wing internal bracing for cracks, loose rivets, loose members, and general condition.

SECOND ENGINEER

and elevator control locks, making sure that cylinders have been properly filled.

14. Check the mounting, linkage, electrical connections, and rigging of the autopilot servos.

LOADING AND SERVICING

1. Check the Form F with the pilot who inspected the top of the wing. See that all entries agree with known loading arrangements.
2. Initiate the engineers' Flight Log with the actual gross weight and fuel load figures.
3. Stand by at the nose of the aircraft to report results of the preflight inspection to the first engineer and aircraft commander.

FIRST ENGINEER

17. Visually inspect accessible internal wiring for proper insulation, wiring, routing, and general condition.

18. Check condition of miscellaneous crawlway equipment.

INSPECTION OF NO. 1, 2, AND 3 BOMB BAYS

The first engineer will inspect applicable related items on the right side forward as the second engineer did on the left side aft in the bomb bays with the following additions:

- Check the brake hydraulic control panel for general condition, leaks, and fluid level in reservoir.
- Check the main hydraulic panel for general condition, leaks, and fluid level in main reservoir.
- Check aileron crossover cables, pulleys, and autopilot servo for interference, condition, rigging, and proper alignment.
- Hydraulic Relay Panel—Check wiring and security.

ENGINEER'S STATION

- Fuel Panel Configuration—Booster pumps OFF, relieve pressure, and close all tank and refueling valves—all other valves OPEN.
- Note fuel quantity as indicated on tank gages and check this later with quantities dip sticked by the pilot.
- If no one is using the external power, turn OFF the external power and battery switches.

MISCELLANEOUS

- Recheck conditions outside the aircraft. See that auxiliary power unit has sufficient fuel remaining to meet your needs. Check status of all last-minute repairs with the crew chief.
- Balance the fuel tank gage readings against the fuel dip stick figures.
- Check results of the preflight inspection with your second engineer. You and the second engineer will then meet with the aircraft commander at the nose of the airplane and go over all discrepancies noted.

SECOND ENGINEER

- BUS 301
- BUS 201
- LEADS TO BUS TIE BREAKER 5-2
- LEADS TO BUS TIE BREAKER 4-5
- SPARE FUSES
- FUSES
- LEADS TO LEFT FORWARD TURRET POWER PANEL
- LEADS TO LEFT AFT TURRET POWER PANEL
- BUS TIE BREAKER 2-3
- BUS TIE BREAKER 3-4

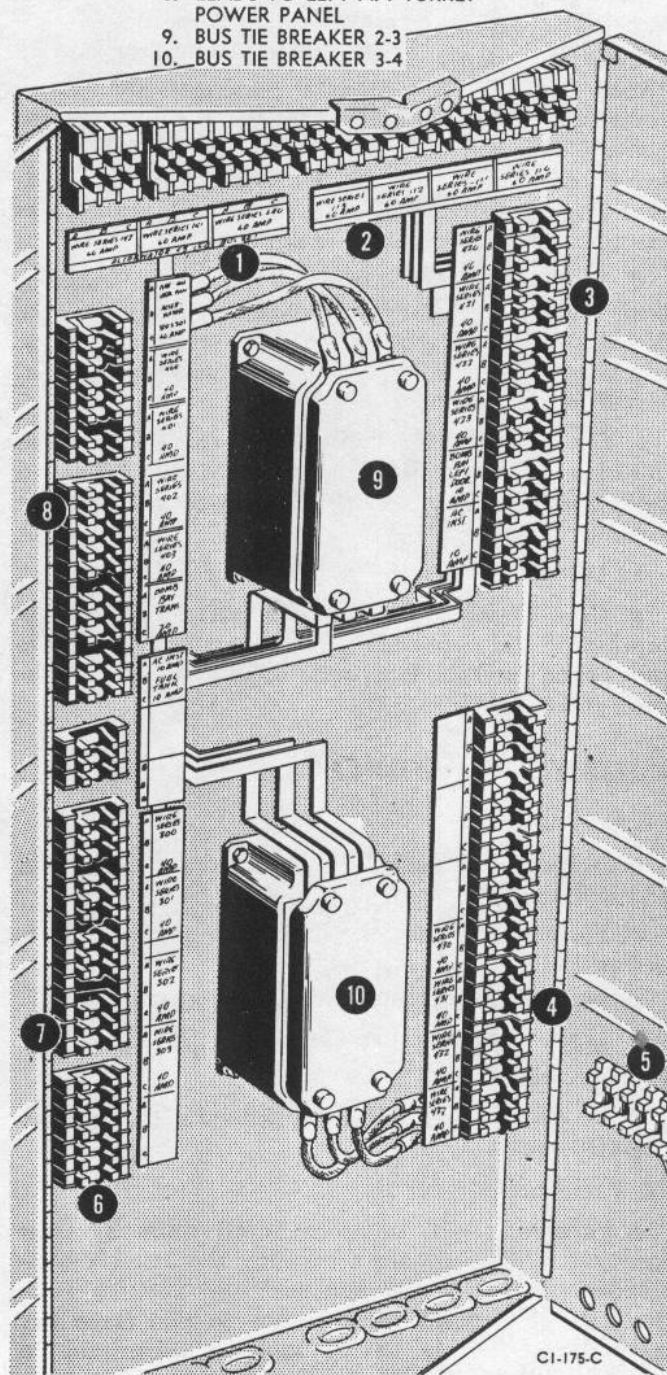


Figure 2-8. Left Main A-C Power Panel
Fuse Arrangement

FINAL CREW BRIEFING.

When all crew members have completed their preflight and the aircraft commander is satisfied that a thorough preflight inspection has been completed, he will conduct an informal final crew briefing.

a. Call the roll, and have each crew member give preflight report; down locks (except bomb bay door locks) removed.

b. Check Form 1 to see that specialized equipment has been signed off after preflight.

c. Check on crew knowledge of emergency signals, emergency positions, and oxygen outlets. Aircraft commander will personally brief pilot and engineer on "Abort Take-Off" procedure. If passengers are aboard, make sure they know emergency signals, positions for take-off, landing, crash landing, oxygen outlets, primary and secondary exits for bail-out, crash landing, and ditching; proper operation of their parachute, bail-out bottle, oxygen equipment, etc.

d. State time interval at which gunners in scanning positions are to render visual engine check during the flight. During daylight, it will be every hour; during night, high altitude cruise, weather, and high power, it will be every 30 minutes.

e. Cover route, altitudes to be flown, weather, and duration of flight. If information has not changed since formal briefing, it is unnecessary to cover it again at this point.

f. Answer any questions crew may have.

g. Crew members board the aircraft. With the exception of the upper aft gunners, all crew members will go on interphone as soon as they board the aircraft and stand by.

RULES TO BE ENFORCED ON EACH FLIGHT.

1. Smoking.

a. No smoking during ground operation, take-off, and landing.

b. No smoking at any time when gas fumes are detected.

c. No smoking in unpressurized compartments.

d. Make sure all cigarettes are completely out before throwing away.

e. Do not attempt to throw a lighted cigarette from the airplane.

2. Parachutes.

a. Parachutes will be worn at all times by crew members while they are occupying the aircraft commander's, pilots', flight engineers', and gunners' positions. This is considered necessary so that these key crew members may devote complete attention to coping with any emergency situation that may arise, without being distracted by the necessity of putting on parachutes prior to abandoning the aircraft.

b. All crew members will wear parachutes at all times under the following conditions:

(1) When above 25,000 feet pressure altitude with the aircraft pressurized, with the exception that parachute may be removed temporarily when it is necessary for proper performance of duty.

(2) During take-off, landing, formation flying, fighter passes, gunnery practice, when emergency conditions exist, when gas fumes are detected, or any time danger is imminent.

(3) While occupying positions when the aircraft is pressurized and there is imminent danger of explosive decompression.

c. At all other times parachutes need not be worn, but will be kept close by at all times.

d. Stow an extra parachute in each pressurized compartment.

e. Make sure all parachutes have been properly inspected and packed before take-off.

3. Safety Belts.

a. One pilot, flight engineer, and blister gunners will have safety belts fastened at all times.

b. Above 25,000 feet altitude aircraft commander, pilot, engineer, and gunners at blister positions will have safety belts fastened when the cabins are pressurized.

4. Oxygen. (See "Oxygen System," Section IV.)

STATION TIME.

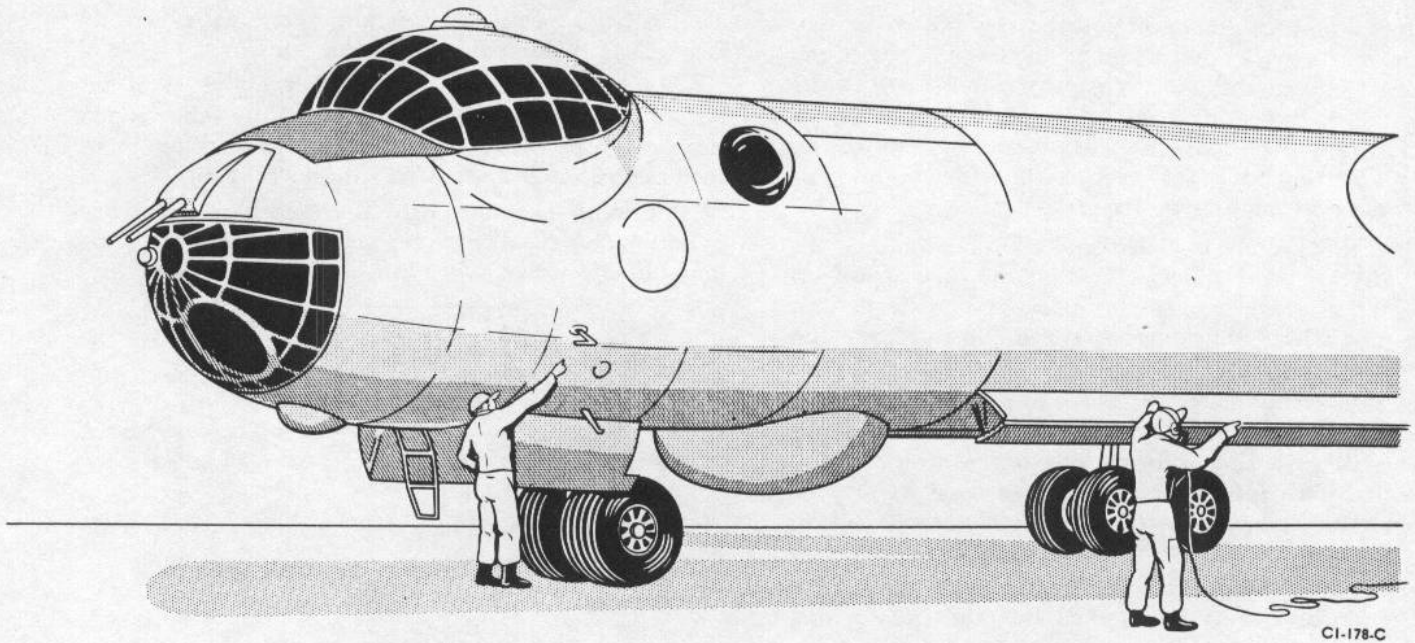
Station time is designated by the aircraft commander to make sure that each crew member knows the exact time he should be at his assigned station aboard the aircraft ready for engine start, taxi, and take-off. The pilots and engineers have several duties to perform between "Station Time" and "Starting Engines" and should be allowed approximately 15 minutes between these times to make sure the remaining schedule is not interrupted. "Station Time" immediately follows "Final Crew Briefing." Since the pilot and first engineer have the most duties to perform before engine start, they should be first to enter the aircraft after dismissal from final briefing. The aircraft commander will want to be last for several reasons:

a. To see that all personnel and equipment are aboard.

b. To make a last visual check to see that ground safety locks and pitot covers are removed.

c. To see that the area is clear of obstructions and adequate fire equipment is available preparatory to engine start.

The second engineer will see that the auxiliary power unit and the ground observer are standing by before proceeding to his station. The aircraft commander, pilot, and engineers will recheck and complete applicable items of the "Before Starting Engines" check list and stand by for starting engines.



Meanwhile other crew members will proceed to their stations as orderly as possible, check in with their compartment commander on normal interphone, and proceed with any other required preparations. Compartment commanders will report the results of this normal interphone-alarm bell check to the aircraft commander when it is indicated that they should do so by one sustained ring of the alarm bell.

STARTING RECIPROCATING ENGINES.

The reciprocating engines will be started in accordance with the instructions given under "Preflight Operational Equipment Check, Starting Reciprocating Engines" of this section. An effort should be made to start the engines as close to take-off time as the situation and the experience of the crew permits in order to conserve fuel and engine life.

DURING ENGINE WARM-UP.

If a complete "Preflight Operational Equipment Check" was accomplished, the only checks that must be made during this engine warm-up are listed below:

1. Check oil-in temperatures at 40°C or above.
2. Perform complete propeller check.
3. Barometric pressure checks—Completed.
4. Parallel alternators on the line.

TAXIING.

Taxiing shall be accomplished in accordance with the instructions given under "Preflight Operational Equipment Check, Taxiing," of this section.

ENGINE RUN-UP.

This run-up shall include minimum safety checks consistent with the results of the power checks conducted during the "Preflight Operational Equipment Check." Checks must include full power with no boost checks and full power with boost checks.

STARTING JET ENGINES.

Start the jet engines in accordance with the instructions given under "Preflight Operational Equipment Check, Starting Jet Engines" of this section. The jet should be started as close to take-off as remaining time will allow to conserve fuel and engine life.

BEFORE TAKE-OFF.

This airplane, like a medium bomber, requires close coordination between the aircraft commander and the flight engineer. Although fewer reciprocating engine controls are available to the pilots, adding to the engineer's responsibility for engine operation, the pilots have an added task of controlling the jet engines.

Because of this airplane's size, the responsibility for its operation is naturally greater than that for medium bombers. The amount of equipment has increased and operation of the equipment is more complex. Although a larger crew is provided to absorb some of the added duties, this does not alleviate the increased responsibilities of the aircraft commander, pilot, and flight engineer during such operations as take-off. They are the "key three" during take-off and must perform with precision and perfect coordination.

Before and during take-off your perspective will differ from that experienced on other airplanes. Your flight deck is higher, the wing is approximately 40 feet aft, and the reciprocating engines are pusher type. Therefore, you will not have the customary reference to the wings and engines. However, with a few flights you will develop the proper perspective.

When the aircraft is taxied into position for take-off, the aircraft commander will align the nose wheel on the center marker of the runway and make certain the nose wheel indicator reads zero before setting the parking brakes.

The pilot, who makes out Form F, will use this information to obtain the necessary basic data for take-off and will give this information to the aircraft commander. This information should be fixed in the aircraft commander's mind and will include the following items:

1. Gross Weight—This is computed on Form F by the pilot and must be checked by the aircraft commander.
2. Per Cent of MAC Forward or Aft of CG—The elevator trim tabs are set according to MAC location. The recommended tab setting at take-off for the cg employed, is one degree nose-up for each one per cent forward of 30 per cent MAC, and vice versa.
3. Nose-Up Speed—This is the speed at which the nose should be raised to establish a deck angle of 7 to 9 degrees for the most efficient lift on the wings.
4. Length of Take-Off Roll—This will vary with the gross weight of the airplane.

5. Unstick Speed—This is the speed at which the airplane is calculated to leave the runway.

6. Stopping Distance with Brakes Only—It is important that the aircraft commander know how much runway is required for stopping the airplane with the brakes should he decide to abort a take-off.

7. Stopping Distance with Brakes and Reverse Propellers—This information is vital in the event the take-off is aborted.

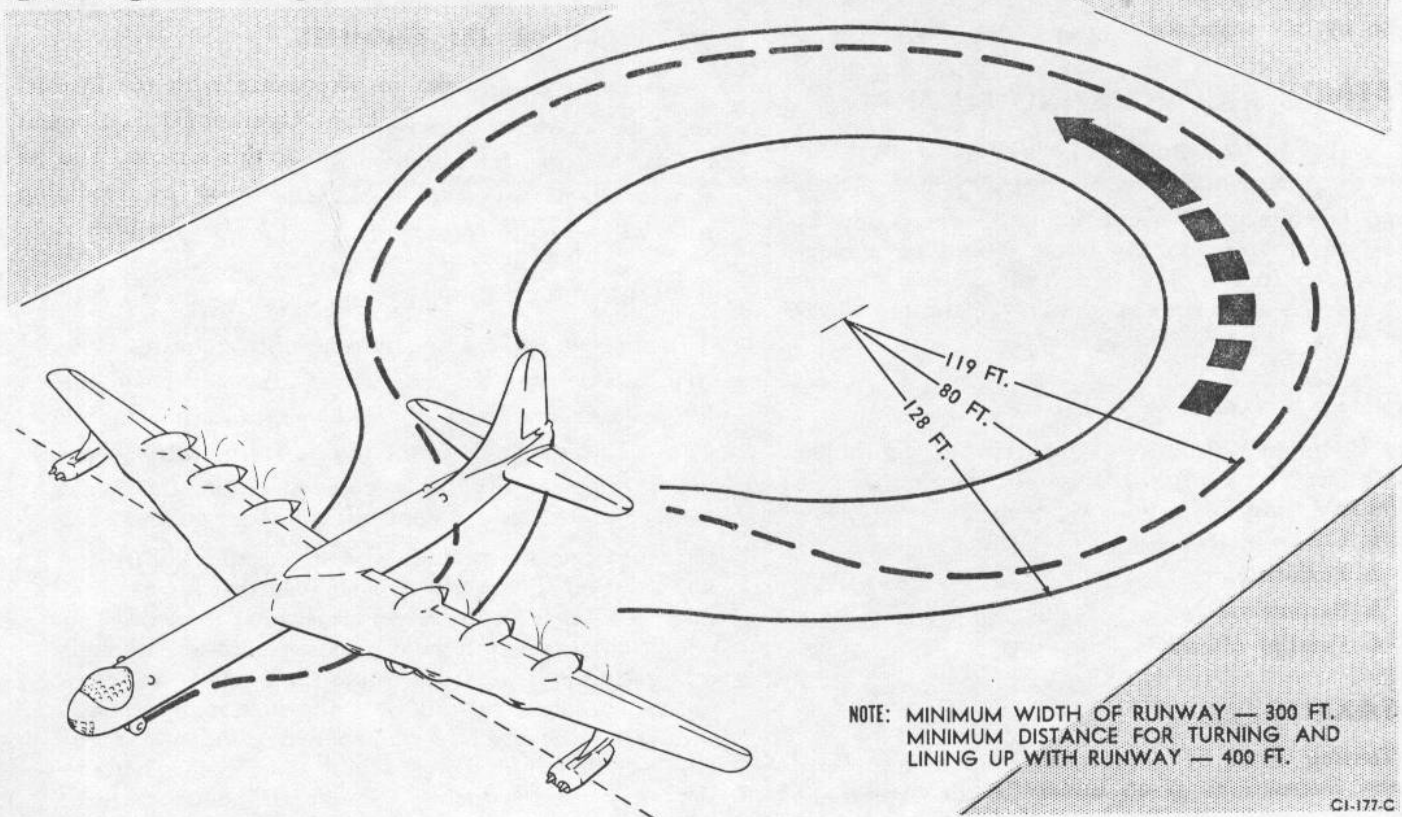
WARNING

Line up as near the end of the runway as possible prior to take-off. You may need it for an emergency stop.

8. Refusal Speed—The highest ground speed at which it will be possible to stop the airplane on the remaining runway.

9. Take-Off Distance to Clear a 50-Foot Obstacle—With this knowledge, the aircraft commander can determine whether the airplane will clear obstacles at the end of the runway.

10. Best Climb Speed—This information will be furnished by the flight engineer. This figure has been calculated to give you optimum performance for the gross weight of your airplane, with consideration given to efficient engine operation and cooling, and allows for a safe margin of air speed in case of engine failure. This climbing air speed will decrease approximately three mph for each 5000 feet of climb up to 35,000 feet.

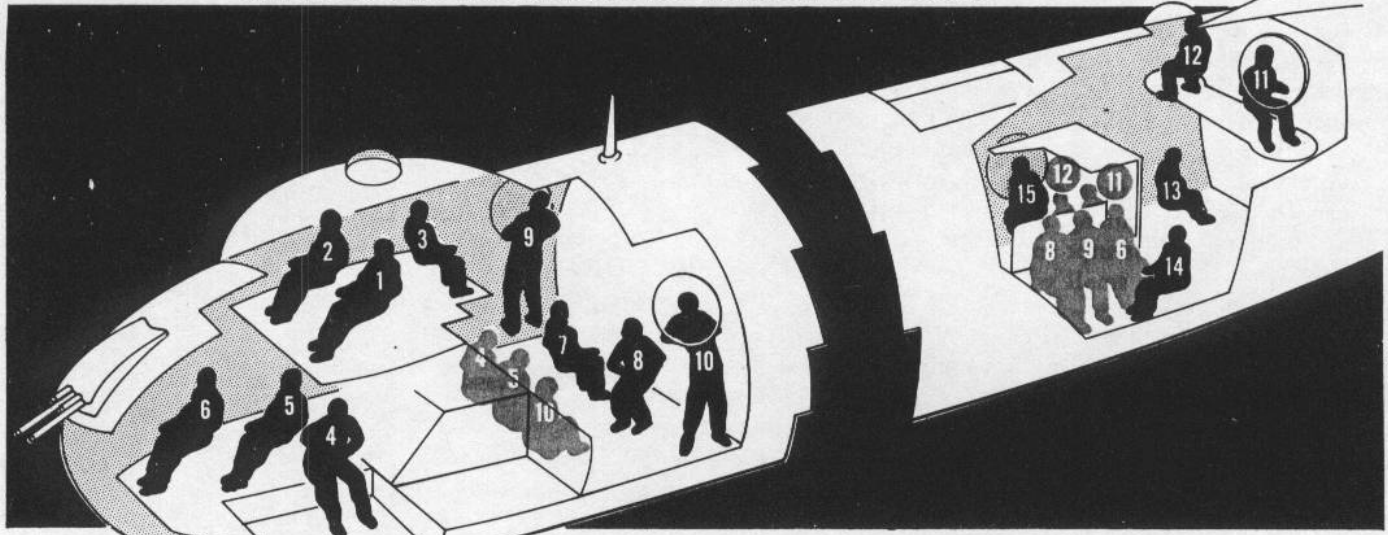


● ORIGINAL STATION

● UNCHANGED CREW POSITION

● CHANGED CREW POSITION

NOTE: BLUE AND RED INDICATE POSITIONS FOR TAKE-OFF AND LANDING



1. AIRCRAFT COMMANDER
2. PILOT
3. FIRST ENGINEER
4. NAVIGATOR
5. RADAR-BOMBARDIER
6. OBSERVER (NOSE GUNNER)
7. FIRST RADIO OPERATOR

8. SECOND RADIO OPERATOR
9. COPILOT (RIGHT FORWARD GUNNER)
10. SECOND ENGINEER (LEFT FORWARD GUNNER)
11. UPPER AFT GUNNER (LEFT)

12. UPPER AFT GUNNER (RIGHT)
13. TAIL GUNNER
14. LOWER AFT GUNNER (LEFT)
15. LOWER AFT GUNNER (RIGHT)

SHEET 1
C1-345A-C

Figure 2-9. Crew Positions For Take-Off and Landing (Airplanes Not In Group 6)

While the flight engineer is completing his final engine checks, the aircraft commander and the pilot will be going through the "Before Take-Off" check list.

CAUTION

Use your check list and follow it carefully. No matter how proficient you are or how well you know your procedures, you are inviting trouble when you fail to use your check list.

The aircraft commander will have the jet engines started at this point and will keep them in stand-by until the engineer is ready to set take-off power on the reciprocating engines. When the engineer sets take-off power, the aircraft commander will advance all jet engines to 100 per cent rpm for take-off.

PILOTS

1. Parking Brake Lever—ON. The parking brakes will be used until take-off power is established on the reciprocating and jet engines; then the airplane will be restrained with the foot brakes, and the parking brakes will be released.
2. Propeller Reverse Selector Switches—SAFE (lights out). Observe that all propeller reverse warning lights are out, indicating all propellers are in normal pitch.
3. Flight Instrument Switches—ON. These switches should be turned ON while accomplishing "Before

ENGINEERS

1. Air Plugs and Intercoolers—As required.
2. Cabin Heater Power Switch—OFF.
3. All Alternators on the Line—Paralleled.
4. Fuel Panel Checked—Booster pumps on.
5. Engine Supercharger Switches—BOTH.
6. Cabin Pressure Shutoff Valve Switches—OFF.
7. Booster Fan Control Switch—OFF.
8. Pitot Heater Switches—As required.
9. Propeller Anti-Ice Switch—OFF.

PILOTS

Starting Check List." This is a double check to insure that it is done.

4. Gyros—Set and uncaged. Observe the indications of the directional gyro, vertical gyros, turn and bank indicators, and slaved gyro magnetic compass. Set the directional gyro with the magnetic compass, and set the vertical gyros with the turn and bank indicators. The accuracy of the turn and bank indicators should have been checked during taxiing. When setting the magnetic compass, attempt to remove the white dot or white cross from the small window at the upper right corner of the compass.

5. Nose Wheel Steering Switch—ON. This will turn on one hydraulic pump and circulate fluid through the system at approximately 600 psi.

6. Landing Gear Control Switch—EXTEND. This action will position the brake pump switch ON.

7. Autopilot—OFF.

8. Flaps and Indicator—Checked and set at 20 degrees. Fully extend the flaps and have the aft gunners report their position. Check the flap indicators for 30 degrees. Raise the flaps to 20 degrees for take-off and check the gunners' reports with the indicators. To avoid overheating the flap actuators, limit their operation to one cycle of operation per minute or two cycles in two minutes with a 10-minute cooling period.

ENGINEERS

10. Carburetor Preheat Switches—OFF.

11. Cabin Heat, Tail, and Wing Anti-Ice Switches—OFF.

12. Engine Fan Speed Control Switches—LOW RPM.

13. Temperatures—Checked and within limits.

14. Spark Advance Switches—RETARD.

15. Mixture Control Selector Switches—LEVER.

16. Mixture Control Levers—NORMAL.

17. Propeller Selector Switches—AUTOMATIC OPERATION.

18. Propeller Normal Pitch Indicator and Tel-Lamps—Lighted.

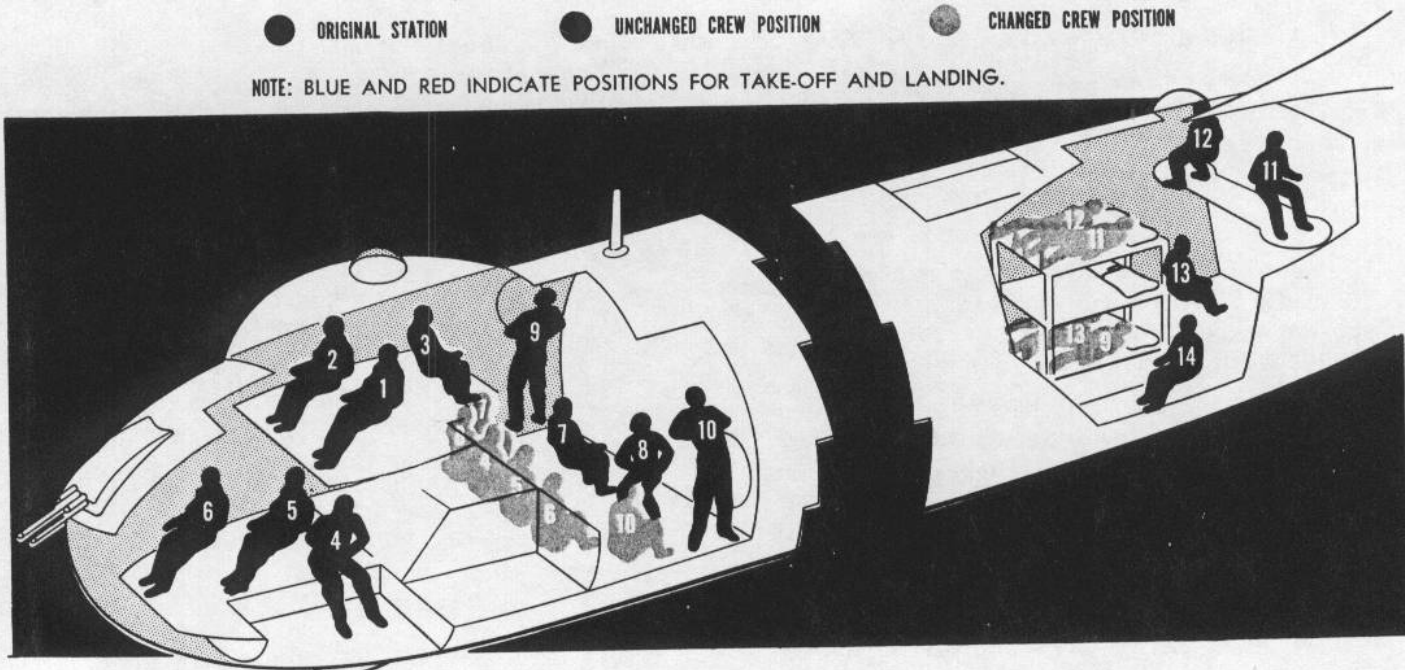
19. Brake Pressure and Nose Steering Pressure—Normal.

● ORIGINAL STATION

● UNCHANGED CREW POSITION

● CHANGED CREW POSITION

NOTE: BLUE AND RED INDICATE POSITIONS FOR TAKE-OFF AND LANDING.



1. AIRCRAFT COMMANDER
2. PILOT
3. FIRST ENGINEER
4. NAVIGATOR
5. RADAR-BOMBARDIER
6. OBSERVER (NOSE GUNNER)
7. FIRST RADIO OPERATOR

8. SECOND RADIO OPERATOR
9. COPILOT (RIGHT FORWARD GUNNER)
10. SECOND ENGINEER (LEFT FORWARD GUNNER)
11. UPPER AFT GUNNER (LEFT)

12. UPPER AFT GUNNER (RIGHT)
13. TAIL GUNNER
14. LOWER AFT GUNNER (LEFT)
15. LOWER AFT GUNNER (RIGHT)

SHEET 2
CI-345A-C

Figure 2-10. Crew Positions For Take-Off and Landing (Group 6 Airplanes)

PILOTS

ENGINEERS

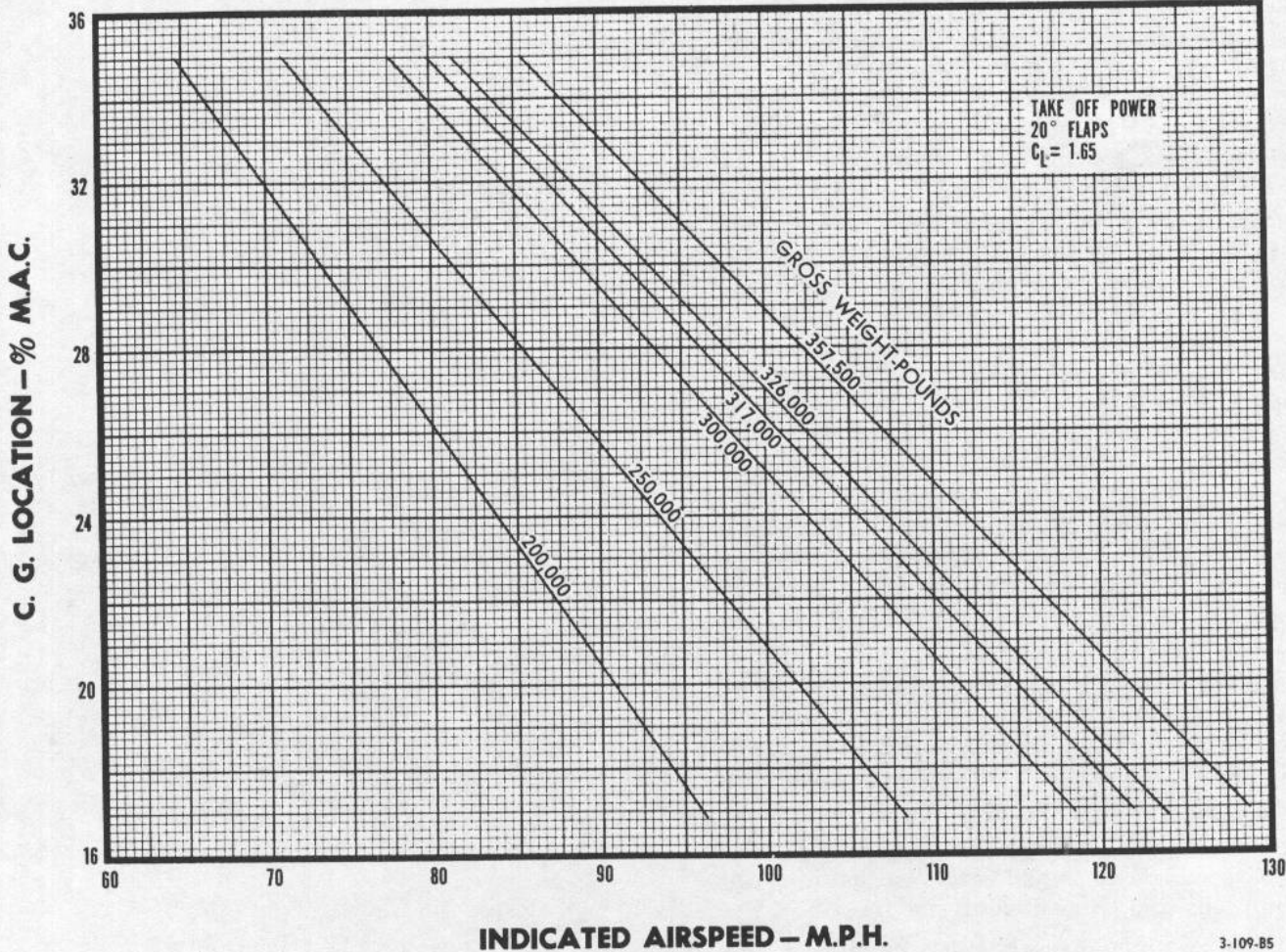
9. Trim Tabs—Set.
10. Entrance Ladders—Stowed. The radar-bombardier will make sure that the forward entrance ladder is retracted and strapped securely, and that the forward entrance door is closed. He will report this information to the radio operator when he assumes crash landing position.
11. Windows and Hatches—Closed. Notify the crew to close all windows and hatches. The aircraft commander and pilot will close their emergency exits, and the engineer will close the astrodome hatch, if open.
12. Forward and Aft Cabins—Ready for take-off. Check with compartment commanders that the entrance ladders are stowed, all hatches closed and all crew members have assumed their take-off positions. (See figures 2-9 and 2-10.) The radio operator will report this information to the aircraft commander.
13. Engineer's Take-Off Configuration—Pilot reads—Engineer answers: "Alternators—Paralleled; Booster Pumps—ON; Turbos—BOTH; Spark—RETARDED; Mixtures—NORMAL; Brake and Steering Pressure—Normal; Take-Off Configuration Completed, Standing by for Propeller Reverse Safety Check and Take-Off Power."

This is not just a list of items to be read from a piece of paper, nor is it a reflection on the ability of the engineer. The intent is to recheck each item as he reads it off to assure the aircraft commander and himself that his panels are properly set up for take-off.

14. Notify crew—"Stand by for take-off." Each compartment commander should acknowledge this call and report his compartment ready for take-off.
15. Surface Controls—Unlocked and checked. Check the control lock indicator lamps; the green lamp should be on and the red lamp out. If the green lamp is out and the red lamp is on, check the toggle switch which is actuated by the flag on the pilots' instrument panel. This switch may not have been actuated by the flag. Move the control surfaces and have the aft gunners report the movement of all visible surfaces. The aircraft commander can make a visual check of rudder movement.
16. Salvo Circuits—As required. Have salvo circuits set for salvo if heavily loaded for take-off.
17. Safety Belts—Fastened. Crew members will be in their take-off positions. Safety belts and shoulder harnesses will be fastened.
18. Read pilot's take-off configuration to engineer. This will insure that all checks made by the aircraft commander before take-off are completed. The pilot should recheck each item when he calls it off as follows: "Controls—Unlocked; Flight Instrument Switches—ON; Flaps —20 degrees; Autopilot — OFF; Nose Steering—ON; Propellers—SAFE, Lights Out."

20. Engineer's Take-Off Configuration—Pilot reads—Engineer answers: "Alternators — Paralleled; Booster Pumps—ON; Turbos—BOTH; Spark—RETARDED; Mixtures—NORMAL; Brake and Steering Pressure—Normal; Take-Off Configuration Completed, Standing by for Propeller Reverse Safety Check and Take-Off Power."

**AIRSPPEED-TAKE-OFF ATTITUDE
20° "UP" ELEVATOR DEFLECTION**



3-109-85

Figure 2-11. Nose-Up Air-Speed Chart

PILOTS

ENGINEERS

The aircraft commander will be sure the jet booster pumps are on, all jet manifold and engine valves are open, pod preheat and nose de-ice switches are off, and the jet engine oil tank heater switch is as required. It will take about 30 seconds to read and visually check the entire take-off configuration.

TAKE-OFF.

PILOTS

ENGINEERS

1. Jets 90 per cent rpm—Propeller Reverse Safety Check. Make propeller check at 35 inches M.P. with jets at 90 per cent rpm. When the aircraft commander has completed his take-off configuration check, he will instruct the pilot to bring the jets up to 90 per cent rpm. Then the engineer should be instructed to obtain 35 inches M.P. on all reciprocating engines, decrease the

1. Propeller reverse safety check as jets reach 90 per cent rpm.

PILOTS

master motor rpm to 2000 and check propeller governing, and increase the master motor rpm to 2700. The aircraft commander should make the final check of his manifold pressure gage and master tachometer.

2. Set take-off power—Jets 100 per cent rpm. When the engineer reports, "Thirty-five inch check complete—standing by to set take-off power," and tower clearance has been received for take-off, advance the jets to 100 per cent rpm. Then instruct the engineer to set take-off power on the reciprocating engines and to report, "Take-off power established and propellers governing." Be sure the engineer turns on the water injection switches at approximately 55 inches M.P. Water injection will be used on all engines during take-off with a gross weight of 300,000 pounds or more. Initial take-off with a gross weight of less than 300,000 pounds is permitted if not more than one engine water injection system is malfunctioning. Subsequent transitional take-off below 250,000 pounds gross weight is permitted without water injection, provided dry take-off power is used.

3. Parking Brakes—Released.

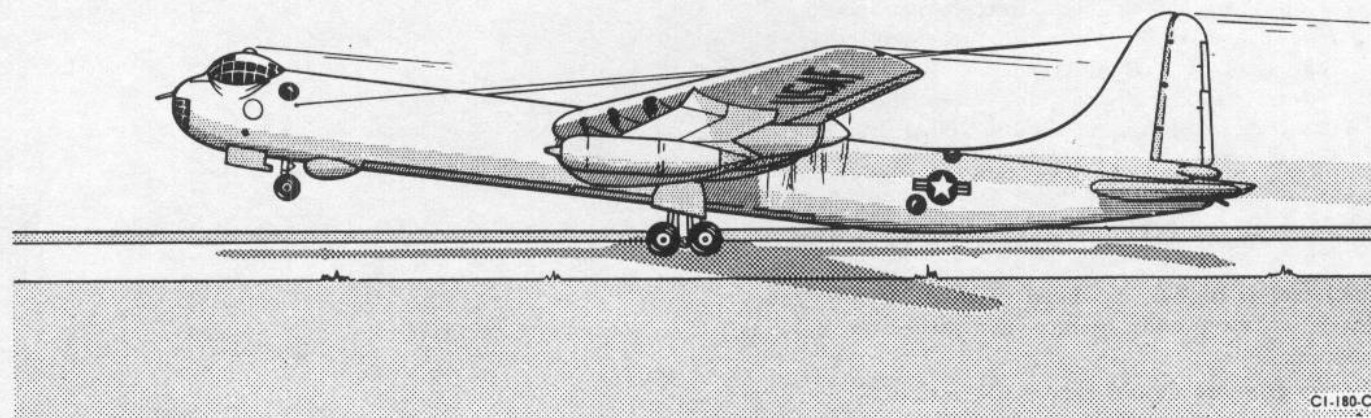
When the brakes are released, directional control will be maintained by use of nose steering until the rudder becomes effective at 50 to 60 mph. As soon as power has been stabilized during take-off roll, the engineer will report this fact to the aircraft commander.

The pilot should keep his hand on the jet throttles during the take-off run in order to handle immediately any jet emergency on take-off. Start applying elevator pressure at approximately 10 mph below nose-up speed.

When approximately 80 per cent take-off air speed has been attained, apply and maintain 50 to 75 pounds pull on the elevator control wheel. If control wheel pull is maintained until approximately 85 per cent of take-off air speed is attained, the airplane will begin to move to the take-off attitude.

ENGINEERS

2. Set take-off power and report the following to the aircraft commander as performed. "Advancing throttle to 35 inches, master tachometer 2000 rpm, propellers governing, master tachometer 2700, tel-lamps operating, engine rpm normal, throttles full open, water injection on, TBS at 7, power stabilized, ready for take-off."



CI-180-C

PILOTS

As take-off air speed is approached, the 50 to 75-pound pull requirement of the control wheel will subside and, at the instant of take-off "get-away," the force required will be reduced to zero, essentially.

As the airplane emerges from ground effect to climb, a normal tendency of the airplane to nose up will be experienced. This tendency must be countered by elevator control wheel "push force" and retrimming of the elevator trim tabs.

Initiate landing gear retraction as soon as the airplane is positively air-borne.

Retraction and extension of the landing gear induces a mild change in longitudinal trim of the airplane. The sweepback of the wing causes flap movement to exercise a great effect on longitudinal stability. The resultant effect of flap movement can be reduced by operating the flaps in increments of 5 degrees.

AFTER TAKE-OFF.

PILOTS

1. Foot Brakes—Apply to stop wheel rotation. If the wheels are allowed to spin during gear retraction, unnecessary loads will be imposed on the retraction mechanism because of the gyro effect of the spinning wheels. The tires could also be damaged if the wheels were allowed to rotate in the wheel wells.

2. Nose Steering Switch—OFF. This will minimize pump wear.

3. Landing Gear Control Switch—RETRACT. The aircraft commander will give the order, "Gear up," over the interphone in addition to a visual order for gear up to the pilot. Make certain the aft gunners report both main gears air-borne before retracting the gear. It will take approximately 60 seconds to retract the gear.

4. Flap Switch—UP. At the verbal order from the aircraft commander, the pilot will begin to retract the flaps. Retraction should be accomplished in 5-degree increments to allow the pilot to trim the airplane as the flaps are raised.

The flaps should not be retracted until 130 mph IAS or 125 per cent of stalling speed, whichever is higher, has been obtained. (See "Flap Retraction Speeds," figure 6-5.) Since drag with the gear and flaps down is excessive, if it is practical, the landing gear should be retracted immediately and retraction of the flaps begun at 130 mph, even though the gear is not completely retracted. At least two alternators on the line is a requirement for simultaneous operation of the gear and flaps. Do not fully retract the flaps until 140 mph IAS or 125 per cent of stalling speed, whichever is higher, has been reached. If emergency power is being used, reduce the power as soon as possible.

The aft gunners should report the action of the flaps as they are raised to be sure that all flaps operate in

ENGINEERS

3. Report, "Power stabilized, propellers governing," 10 mph prior to nose-up speed.

ENGINEERS

1. Report, "Main hydraulic pressure relieved."

PILOTS

unison. If either the inboard or outboard flaps fail to rise, the attitude of the airplane will be affected. If the inboard flaps fail, the aircraft will have a tendency to nose up; if the outboard flaps fail, the tendency will be to nose down. With any pair of flaps fully extended, the stalling speed is reduced approximately 6 mph.

To operate one pair of flaps, open the circuit breakers for the other two pairs and operate the flap control switch. In the event the normal flap controls fail, use the alternate flap controls as described in "Wing Flaps." Section III.

INITIAL CLIMB.

PILOTS

1. Power Condition No. 2—After gear and flaps up and a minimum of 500 feet above terrain has been reached. Unless some abnormality arises this should serve as a notification to the pilot and engineer that you consider the aircraft safely air-borne and that power may be reduced as predicted for the flight. At the aircraft commander's discretion, each take-off is usually predicted to last from 3 to 5 minutes. At the end of the predicted period the pilot will reduce the jet engines to rated climb power.

2. Landing Gear and Brake Pump Switch—OFF. An added precaution against inadvertent operation of hydraulic motors and subsequent loss of system operation.

3. Hold Best Climb IAS—(See Appendix 1.) Climb performance has been tested and charted for all normal operation. Request the climb speed for your configuration from the flight engineer. Climb speed varies with gross weight and altitude and the initial indicated air speed will drop off approximately 3 mph for each 5000 feet of altitude up to 35,000 feet and slightly more thereafter. Hold the correct air speed during climb—then performance should equal the engineer's and navigator's prediction. Charted climb air speed values result in stable operation under all weather conditions and the best compromise between power available from jet and reciprocating engines. This results in the best rate of climb consistent with efficient operation. If the jet engines are not to be used after level off, they should be reduced to idle speed, preparatory to shutdown, the instant the planned altitude is reached. Regardless of level-off technique, the engineer has sufficient power available from the reciprocating engines, at less cost in fuel consumption, to complete this maneuver.

ENGINEERS

ENGINEERS

1. Power Condition No. 2—Upon Pilot's Request.
2. Turbo Boost Selector—Reduce M.P. to 55 inches.
3. Water Injection Switches—OFF. Use individual switches to cut off one water injection pump at a time. Note fuel flow increase, water pressure decrease to static value, and slight torque pressure drop-off.
4. Reduce Power—2550 rpm, 51.5 inches M.P.
5. Torque, Fuel Flow, CHT, CAT.—Within Limits. Manually adjust controls to obtain specifications desired. Specified fuel flow for climb is indicated in "M-2 Fuel Flow Curve." (See Appendix 1.)

Note

Engine fuel flow meters should be calibrated.

Torque varies with altitude due to engine cooling fans absorption of bhp. Once set, torque will increase approximately 0.3 psi for each 1000 feet of altitude. CHT and CAT. should be held constant throughout the climb at near maximum allowable to decrease cooling drag. To hold the above values constant, it will be necessary to vary manifold pressure. However, do not exceed M-1 charted values over 2 inches M.P. on engines which show evidence of substandard engine conditioning. On poorly conditioned or malfunctioning engines, a lower torque value must be accepted. During any manual adjust power setting, engine overheating can be combatted by opening intercoolers and air plugs to lower CAT. and CHT; by enriching fuel flow; by reducing bmep; and, as a last resort, by increasing air speed. As the planned cruising altitude is reached, climb 500 feet above cruise altitude and then allow the air speed to build up to cruise value and reduce power cautiously until the desired air speed and altitude have stabilized.

Note

Normally the alternator frequency will decrease during an extended climb and increase during descent because OAT. affects the resistance of the control circuit. So you must remember to adjust alternator frequency to compensate for these variations.

STOPPING JET ENGINES (AIR).

After climb when the flight plan calls for shutting down the jet engines, the pilot will shut down the jet engines as follows:

1A. Throttles—Idle one minute and then close. This procedure is followed in order to let temperatures throughout the jet engine stabilize. Because of the close tolerances involved and the fact that metals with different expansion and contraction factors were used in manufacturing the various parts of the engines and shroud ring, binding can result unless temperatures are stabilized. Remember that the tail pipe temperature indicator shows the temperature of the tail pipe only.

2. Booster Pumps—OFF.

3A. Air Plugs—Closed at or below 100°C tail pipe temperature and 30 per cent rpm. Check the fuel pressure and see that it reads zero before closing the air plugs. Watch tail pipe temperatures as the air plugs are closing; if temperatures rise sharply, open the air plugs on the affected jet immediately. Tail pipe temperature rise is an indication that the jet is still running. Attempt to shut off the affected jet by using the switch position of the throttle. If the jet still continues to run, close the engine valve.

4. Manifold Valves—Closed below 20 per cent rpm.

5. Engine Fuel Valves—Closed below 10 per cent rpm.

6. Nose De-Ice—As required. (Should be ON if ice is visible or if flying in icing conditions.)

7. Pod Preheat—As required. Since pod preheat must be off when wing anti-icing is being used, in order to give adequate heat for wing anti-icing, preheating the jet pod must be handled with care when flying in icing conditions. Keep wing anti-icing heat on until the wings are free of ice, turn on pod preheat long enough to free the strut of ice, start the jets, and then turn pod preheat off and route the heat back to the wing. Icing conditions should not hinder operation of the jets once they are started.

8. Oil Heater Switch—As required. (Leave on at 15,000 feet and above or when OAT. is 5°C and below.)

9. Oil Shutoff Valves—Always open during flight.

10. Throttle Circuit Breakers—Out, to prevent unnecessary operation of jet throttle amplifiers and inadvertent opening of the throttles.

CRUISE NO. 1. (LOW ALTITUDE—HEAVY GROSS WEIGHT.)

Cruising at any altitude calls for real cruise control. The responsibility for cruise control rests heavily with the flight engineer. By working closely with his aircraft commander and navigator, the flight engineer must base his operations on calculations derived from

a series of performance charts and curves. In addition he must develop operational techniques such as *manual adjustment* and *manual leaning*, and *dual* and *single* turbo operation. While maintaining a reasonable balance of the many operational variables and techniques involved, he must develop, in coordination with his aircraft commander and the navigation team, definite procedures in conjunction with the *Long Range Cruise* problem to compromise with other problems such as navigation, bombing, gunnery, etc.

Cruise No. 1 is the initial leg of the normal mission after take-off at maximum gross weight. At this time the long range air speed is, no necessity, relatively fast. The combination of gross weight, air speed, and altitude demands power settings which are above the manual leaning range. With perfect carburetion, operation would simply be in NORMAL mixture setting, but reasonable manufacturing tolerances do not allow such simplicity. To correct for this variable it is necessary to manually adjust the mixture controls until a specified fuel flow is obtained. These specified fuel flows are furnished the aircraft manufacturer by the engine manufacturer and in turn are plotted on M-2 type fuel flow curves, which are found in the appendix along with other operational data. For further information on manual adjustment refer to "Mixture Control," Section VII.

Proper manual adjusting calls for accurate instrumentation; however, it must be noted by the operator that when operating below rated power, manually adjusted power settings are just slightly leaner than best power. Investigate and observe the fuel flow at which best power is obtained. Common sense application of these observations will serve as a check of instrument calibration when compared with the average engine and will prevent marginal operation which might be detrimental to engine life.

Propeller restrictions should be observed when cruising at any altitude. Characteristically, these restrictions are more severe at altitudes from sea level to approximately 24,000 feet. Propeller restrictions represent a vibration range which is created by various combinations of rpm, altitude, and air speed. By avoiding the restricted areas you will prevent undue stress, strain, and fatigue of various metallic components of which your aircraft is constructed—especially such items as wing skin and bracing, engine mounts, and propeller installations.

After two or three cruises at this altitude, your gross weight and air-speed requirements will decrease to such a point that subsequent operation will phase into the manual leaning power range. Manual leaning procedures for altitudes from sea level to 35,000 feet and above 35,000 feet are given in Section VII, "Manual Leaning." Study these procedures carefully, for manual leaning is the "heart" of the overall operation of the B-36. It is one procedure that must be precise. Study the entire Section VII, "Reciprocating Engines" care-

fully, for it contains valuable information which will assist you in understanding various operational techniques and procedures.

As your operation phases into manual leaning at lower altitudes, do not forget to record the mixture control quadrant settings which gave you best economy, for these settings will be required for initial manual lean settings above 35,000 feet altitude.

BEFORE CLIMB OR HIGH POWER OPERATION.

Normally the first leg of the mission is accomplished with the jet engines off and the initial high reciprocating powers have phased into lean operation. On some long initial cruises it may become necessary to resort to single turbo operation if rpm's below 1850 in manual lean are attempted. You must anticipate the end of this leg for several important steps must be taken before establishing a climb to a higher altitude. The engineer should know whether jet engines will be required for additional power, and will inform the aircraft commander of the required power configuration including the indicated air speeds to be maintained during the climb. In addition, the engineer and aircraft commander should allow themselves sufficient time to perform the items included in the following check lists when coordinating with the other crew members and establishing a time at which the climb should start.

STARTING JET ENGINES (AIR).

PILOTS

1. All Circuit Breakers—In. To connect control and actuator circuits to their respective power sources.
2. Fire Detector Test Switches—TEST and Release. All warning lamps should light in approximately 10 seconds. This action checks the continuity of the detector system. Failure of any lamp to light within a reasonable length of time, or any light that flickers indicates a detector system malfunction and any later indications may not be reliable.
3. Throttle Selector Switches—LEVER.
4. Throttles—Closed.
5. Pod Preheat Switch—As Required. ON when icing is anticipated or 10 minutes prior to jet engine start when OAT. is -30°C or colder. When jets are inoperative, pod preheat will not be effective unless the engineer's wing anti-icing switches are ON. Pod preheat should be turned off any time there is suspicion of fire so that fire may not enter the wing area.
6. Nose De-Ice Switch—As Required. ON only to prevent ice forming on the jet air plugs.
7. Oil Heater Switch—As Required. To maintain jet engine oil temperature when the ambient air temperature is below 5°C (41°F).

ENGINEERS

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8. Oil Shutoff Valve Switches—OPEN. Always open during normal flight.
9. Notify engineer, "Set up jet start configuration."
10. (Not applicable for air start.)
11. Air Plug Switches—OPEN (check plugs visually). The aircraft commander and pilots will visually check their respective sides to see that air plugs are opening. At night, station an observer with an Aldis lamp at each forward blister to make certain that air plugs are open. The jet engines should start windmilling as the jet air plugs open. Approximately 185 mph IAS should result in a windmill speed of about 15 per cent rpm at any altitude. After jet air plugs are opened and the initial rpm build up has stabilized, the desired 6-10 per cent starting speed may be controlled by varying the indicated air speed.
12. Manifold Valve Switches (L & R)—OPEN.
13. Booster Pump Switches (L & R)—ON.
14. (Not applicable for air start.)
15. J-1 Engine Fuel Valve—OPEN.
16. J-1 Fuel and Oil Pressure Gages—Zero. Notice where these pressure instruments zero so that you can tell when a pressure indication is obtained as rpm increases and the throttles are opened for a start.
17. Notify Ground Observer or Aft Gunner—"Starting J-1." The scanners should be able to detect and report any unusual leaks or fire noted. With experience they will let you know when combustion occurs by observing the heat waves.
18. (Not applicable for air start.)
- 18A. (Air Start) J-1 Ignition Switch—Hold in ALT. This operation sets up the spark action which will ignite a combustible mixture as the proper fuel-air ratio is obtained when opening the throttle. Do not release the ignition switch until idle rpm for your specific altitude is stabilized.
19. (Air Start) J-1 Throttle—Open to obtain 25-30 psi fuel pressure at 6-10 per cent rpm. Use 6-8 rpm for starts above 30,000 feet altitude. RPM begins to develop as the jet air plugs are opened. Use of the starter is not required for an air start. In the air, substitute the ignition switch for the starter-ignition switch combination used on the ground. Then by cracking the throttle at the proper rpm to obtain 25-30 psi fuel pressure, ignition should occur as the mixture reaches a combustible fuel-air ratio. Ignition is primarily indicated by a sharp increase in tail pipe temperature.

Note

If ignition does not occur within 20 seconds after opening throttle, slowly retard throttle to reduce fuel pressure to 20 psi; then advance the throttle to increase fuel pressure to

ENGINEERS

1. Jet Start Configuration—Checked and, "Standing by for jet engine start."

The in-flight jet start configuration requires a minimum of two tank valve switches OPEN and respective booster pumps ON in each wing. The appropriate rpm and the best available alternator configuration should already be established.

BEFORE CLIMB (HIGH POWER OPERATION, AFTER A MANUAL LEAN SPARK ADVANCE CRUISE).

A tremendous amount of reciprocating engine damage can result if you fail to properly prepare the engine for high power operation. A good engineer should always remember the following items which must be checked, but even the best are prone to forget or overlook an item under certain conditions of stress or fatigue. By actually using the following check list, any oversight will be avoided and the transition from low to high power operational configurations will be successful.

1. Air Plugs and Intercoolers—OPEN. To prevent engine overheating during subsequent operation at higher bmep and increased fuel-air ratio.
2. Spark Advance Switches—RETARD. All normal engine operation above 1940 bhp, 2200 rpm, and 160 bmep must be in retarded spark.

Note

See Section VII, "Spark Selection" for the specific procedure for return from manual lean spark advance operation to retard spark.

3. Mixture Controls—NORMAL (Lights On). To provide an adequate fuel flow for any condition until the desired power is set.
4. Engine Supercharger Switches—BOTH. Dual turbo and high power operation go hand in hand. Use of single turbo in conjunction with a dual turbo power setting will result in overheating, turbo overspeeding, and, if allowed to continue at high bmep, severe engine damage. Abnormally high CAT. is a prime indication of an engine stuck in single turbo in flight when setting up a dual turbo power setting. See Section VII, "Supercharging" for further information on use of single and dual turbo and shifting procedures. If a malfunction of the system forces single turbo operation on one or more engines they may be safely operated at sufficiently reduced powers to prevent excessive CAT. In an emergency, such as a go-around when landing, power may be increased until an absolute limiting value of 55°C CAT. (wet) or 38°C CAT. (dry) is reached, but must be reduced as soon as the situation will permit.

PILOTS

35 psi and again retard the throttle to 20 psi. Continue this operation until ignition occurs or until 60 seconds total time has elapsed. If ignition still does not occur, close the throttle and do not attempt another start until adequate time has been allowed for fuel to drain.

When ignition occurs, as evidenced by an increase in tail pipe temperature, maintain 25-30 psi fuel pressure until tail pipe temperatures begin to stabilize. Then advance the throttle lever smoothly to idle. This throttle adjustment should maintain 450 to 500°C tail pipe temperature until altitude idle rpm is reached.

CAUTION

DO NOT exceed 870°C tail pipe temperature when starting or 690°C tail pipe temperature during acceleration or operation.

20. J-1 Oil Pressure—Report Indication on Interphone. The oil pressure should increase with rpm. If a positive increase has not been observed by the time a start has been effected, the engine should be shut down to prevent damage from lack of lubrication.

21. (Not applicable for air start.)

21A. (Air Start) J-1 Ignition Switch—Release at Idle. When idle rpm for your specific altitude is stabilized, flame propagation should be complete and self-sustaining. Release the ignition switch, which is spring-loaded, to the OFF position.

22. J-1 Throttle—Adjust to Maintain Idle Rpm. Allow the initial engines started to idle while starting subsequent engines. This allows a more complete warm-up period before higher power operation and aids in preventing a more asymmetrical power condition while starting the corresponding symmetrical jet engine.

23. J-4, J-2, J-3—Repeat steps 15 thru 22. As for a ground start, begin the start procedure with the engines which have accumulated the least time. However, subsequent starts will be from side to side in order to maintain the best balanced power condition. In order to even up the logged time when operating only two jets, you may operate any combination of J-1 and J-4, J-1 and J-3, J-2 and J-3, or J-2 and J-4 with no noticeable affect. One or two engines may be started at any time to offset loss of reciprocating engines if sufficient fuel remains or safety is a factor.

CLIMB TO HIGH ALTITUDE.

Crew coordination is very important during climb to altitude, particularly coordination between the aircraft commander, the engineer, and the scanners. The scanners must keep an accurate check of air plug and

ENGINEERS

5. Desired Power—SET. Procedure for setting powers, after observing the above steps, is normal.

intercooler settings, evidences of overheating, oil leaking or spewing, or any other sign of malfunction of the airplane. The engineer must be aware of all malfunctions as indicated by the engine instruments and reported by the scanners so as to effectively control the engines at peak efficiency during the climb. The aircraft commander must fly the correct air speed, maintaining the rate of climb steady for the given air speed, and retrim the airplane frequently to obtain best climb performance. The engineer should also insure that the windows in the flight compartment are kept defrosted as much as possible by controlling the cabin air temperature and air flow.

The engineer will maintain a close surveillance on the engine instruments and keep the air plugs adjusted to maximum allowable cylinder head temperatures, thereby obtaining minimum drag. The air plug is a direct control over cooling air flow and can be considered a throttle to the cooling passages. When the combination of air speed and fan results in an excess of air being pumped over that required to maintain satisfactory temperatures, considerable drag is eliminated by restricting the passage and, consequently, the weight of air being pumped.

The entire crew must be well trained, properly disciplined, and prepared to operate as a coordinated team if safety and efficiency are to be obtained at high altitudes. The B-36 has been operated consistently at extreme altitudes where the greatest strain is placed upon both the airplane and the individual. How well it will perform for you depends upon all the preparation, training, checking, and planning thus far — plus an alert ability to anticipate the requirements that will provide an ease of operation with a reasonable margin of safety. Any time operation is to be above 35,000 feet altitude, each crew member should have some specific task to perform that will aid the operation. All crew members should be notified and prepared for altitude operation before the climb begins until after the descent below critical altitude. The engineer's log should be up-to-date and the climb and initial cruise powers and air speeds should have already been entered in appropriate columns for ready reference and information to the aircraft commander and navigator when requested. Last minute preparations for pressurization, heating, and anti-icing should be considered. Any equipment needed must be accessible to your oxygen station.

The navigation team should be prepared to keep the pilot informed of correct headings to fly and to make frequent position reports.

You will normally use the jet engines for climb to high altitude, in order to increase the rate of climb. Climb at normal rated power and rpm on the reciprocating engines is standard with this airplane. While reduced power climbs are employed on other aircraft to attain commercial standards of durability, the use of maximum continuous rating is specified for this airplane for best over-all mission efficiency.

CREW SAFETY AT ALTITUDE.

Crew safety at altitude is extremely important. The aircraft commander should be on guard at all times while flying at high altitude in seeing that his crew is doing the right thing at the right time. One of the most important aspects of altitude flying is oxygen discipline. Refer to "Oxygen System," Section IV.

HIGH ALTITUDE CRUISE.

Cruise at high altitude is normally defined in two categories: Cruise No. 2, which is cruising at high altitude with the jet engines operating, and Cruise No. 3, which is cruising at high altitude without the use of jet engines. Again the main factor is manual leaning, and the engineer must concern himself with the many problems that will confront him during these operations.

As cruise control extends the range of the airplane, so does it amplify the duties and responsibilities of the flight engineer. Complete proficiency in the use of the charts and curves will be attained only by understanding them and working with them. Conscientious study of the pages to follow and of Appendix I is essential.

Obviously, the term cruise control cannot be applied exclusively to any single operation. Actually, it consists of five interrelated operational steps as follows:

1. Preflight planning
2. In-flight operations
3. In-flight replanning
4. Operations after failure of one or more engines
5. Postflight analysis

These steps are founded on a series of performance curves and charts. Since these charts and the use of them are basic to the other operations, they will be discussed first. However, before considering the charts and curves at length, let's have a brief explanation of "Equivalent Air Speed," "Nautical Miles," "Drag Factors," and "Air Speed Versus Gross Weight and Altitudes," since doing so will make certain features of the charts and curves more readily understandable.

EQUIVALENT AIR SPEED.

Equivalent air speed is calibrated air speed corrected for compressibility effects.

NAUTICAL MILES.

The nautical mile (6080 feet) rather than the statute mile (5280 feet) is used on all cruise control charts and curves in which distance is a factor. This is consistent with the use of nautical miles in all B-36 operations and eliminates the possibility of confusion between the flight engineer and the navigator. It must be noted however, that equivalent air speed is read in terms of statute miles since the instruments themselves are thus marked.

DRAG FACTORS.

Unnecessary drag is a very detrimental factor in planning proper cruise control. It can be caused by improper trimming of the airplane or by improper settings of air plugs or cooling doors.

To combat improper trim of the aircraft, it is recommended that a definite schedule of trimming be set up. For instance, if the engineer is on a 2-hour power schedule, the aircraft should be retrimmed every 30 minutes on the elevator axis. In all cases of power changes the aircraft should be retrimmed to conform with the new air speed, and it should also be retrimmed after all fuel transfers and changes in cg of the aircraft.

A second cause of drag to be reckoned with is the settings of the air plugs and cooling doors. From their fully open to fully closed positions the air plugs on all six engines can vary the air speed as much as six mph EAS and the intercoolers as much as four mph EAS. Open doors and hatches also cause drag. Keep them closed. When an air speed is given, it should be maintained as closely as possible to get maximum cooling of the engine with air plugs and cooling doors shut down as far as possible so as to maintain the engine temperatures within limits. The opening of these doors and plugs will reduce air speed considerably by increasing the drag.

Fuel is used from the inboard tanks first, because of structural considerations. In normal operation the practice of using fuel from inboard to outboard produces a more stable airplane in turbulent air. This added stability results from the fact that the fuel is outboard in the wings and the added weight so far out in the wing produces a dampening effect on roll tendencies in turbulent air and decreases the flight load factor.

AIR SPEED VERSUS GROSS WEIGHT AND ALTITUDE

Air speed versus gross weight and altitude is the basis for the development of the nautical mile per pound charts which determine long-range cruising plans. In the nautical mile per pound charts a recommended EAS is obtained for a given weight and altitude. Through proper power setting and proper trimming of the airplane, the flight engineer and pilot maintain these recommended air speeds.

Since long-range flying is based on cruise control, it is necessary to see the effect of gross weight and altitude in air speed. Air speed is the starting point for the flight engineer in setting proper power, while the pilot must maintain level flight through correct trimming of the aircraft. The final goal, nautical miles per pound, can then be attained.

Level off for cruising altitude should be made from an altitude 500 feet above cruising altitude. The engineer should set up cruise power commensurate with aircraft weight and altitude, less the extra 500 feet, to help establish cruising air speed and trim the aircraft cruise

ing straight and level. Efficient cruising requires maintaining a recommended air speed which can be obtained from the "Type A-1 Nautical Miles Per Pound Curves." Maintain the desired air speed by use of the elevators and vary power settings slightly to maintain altitude. Do not allow air speed to drop; if it is impossible to maintain altitude with a given air speed, check trim and then add power as necessary.

SYSTEMS OPERATION.

Operation of the various systems during flight is given in Section VII, "Systems Operation."

FLIGHT CHARACTERISTICS.

Refer to Section VI, "Flight Characteristics," for the characteristics of the aircraft during flight.

DESCENT FROM HIGH ALTITUDE.

After cruising at high altitudes, the next phase will be to descend to a medium altitude. For information concerning descents, refer to "Normal Descent" of this section.

CRUISE NO. 4. (MEDIUM ALTITUDE — LOW GROSS WEIGHT.)

Cruising at a medium altitude at low gross weight on the last leg of the journey home is known as cruise No. 4. Again the flight engineer concerns himself with manual leaning.

DESCENT.

NORMAL DESCENT.

Descent in every case should be governed by the air speed and propeller limitations specified in operating limits, Section V. Air speed is the more critical limit because undetected flutter could cause structural failure. Propeller vibration, however, usually means a sharp reduction in blade life rather than an immediate failure.

Descents should always be made at long-range air speed. Most long-range flights are made with the airplane on automatic pilot, and the rate of descent will be approximately 300 feet per minute. When necessary, power reduction will be made in accordance with the bmepp power schedule of the Appendix in order to maintain efficient and economical engine operation.

CAUTION

Do not throttle reciprocating engines except for emergency descent. This procedure is discussed in Section III.

Under no-wind conditions, approximately 2.2 nautical miles of range can be gained for every 1000 feet of al-

titude. For example, descent from 25,000 feet to sea level will add about 55 miles to the range. However, this is a small factor compared with the magnitude of winds at altitude. Consequently, wind conditions must be given primary consideration in making a descent.

If there is a strong head wind at a high altitude and a tail wind is predicted for a lower altitude, obviously descent should be made to the lower altitude to take advantage of the tail wind. On the other hand, if the winds at all altitudes are the same but the nautical miles per gallon at the higher cruising altitude is greater than that which would be obtained at the lower altitude, the higher altitude should be maintained since the airplane is already at altitude. Another factor entering into the descent picture is crew fatigue. If there is only a slight difference in nautical miles per gallon obtainable at high and low altitude, the decision would probably be made to remain at the higher altitude so as to reduce the time required to complete the mission.

RAPID DESCENT.

When head winds are encountered, it is best to descend rapidly through the regions of high adverse winds and cruise at altitudes where wind conditions are more favorable. Regardless of these factors, however, you should in no case descend below the altitude you will have to maintain for the remainder of the flight because of topographic conditions.

Rapid descent like normal descent should also be governed by the air speed and propeller limits specified in Section V. In this case, however, power settings are reduced to minimum values required to prevent excessive wear and stress from reverse bearing loads. The absolute minimum setting is 1550 rpm and 15.5 inches M.P. Settings above this minimum should be computed on the basis of 1 inch M.P. for each 100 rpm increase.

CAUTION

Manifold pressures below these minimum values will be limited to 30 seconds or less. Gas pressure is needed inside the cylinder to prevent stress and wear caused by windmilling.

NORMAL LANDING.

This airplane is not difficult to land after you've made a few landings to adjust yourself to its landing attitude. This adjustment is necessary because your station is so far forward of the wing; and, with the nose-up condition of a normal landing, you are about 40 to 50 feet in the air. Since this airplane has such a large wing span, you must realize that somewhat less control response can be expected at the slower air speeds encountered during final approach. However, if you use good judgment and apply the knowledge gained from landing other airplanes, you can land this airplane without difficulty.

NOSE GEAR STRUT DEPRESSURIZATION.

The requirements for depressurization of the nose strut are based on the relationship of nose strut loads at take-off and at landing. This relationship can be obtained from the charts in figure 2-12 to determine whether depressurization of the nose gear strut is necessary. The charts are used in the following manner:

1. Using Chart A, determine the strut load at take-off by finding the point of intersection of the lines representing take-off gross weight and cg location. From this point, follow the vertical line to the bottom of the chart and read the strut load.
2. To determine the strut load at landing, repeat step 1, using landing gross weight and cg location.
3. Using Chart B, follow the lines representing the strut loads at landing and at take-off until they intersect. The area in which the lines intersect will indicate whether or not depressurization is required.

TRAFFIC PATTERN.

Because of the high stability of the airplane, considerable longitudinal retrimming will be necessary when executing steep turns. This trimming must be accomplished during the entry and exit periods of the turns to maintain constant air speed and nominal elevator control forces. For normal traffic pattern use single needle-width turns, which will be two-minute turns at 90 degrees per minute. This airplane has a four-minute turn indicator; therefore, single needle-width turns are equal to half needle-width turns on other aircraft. Because of this slower turning rate, the traffic pattern for this airplane will be somewhat larger than for other aircraft.

The traffic pattern should be entered by flying upwind over the landing runway at about 1000 feet above traffic altitudes. This will give you an opportunity to observe airdrome traffic and space your aircraft in the traffic pattern accordingly. Then descent can be made to the traffic pattern altitude of 2500 feet above the terrain on the down wind leg approximately two or three miles out from the landing runway. A 500-foot descent should be made on the down wind leg so that the turn on the base leg is accomplished at 2000 feet. Before turning on the base leg, the "Before Landing" check list should be complete and the landing configuration should be received from the engineer. Another 500-foot descent should be made on the base leg and a 200-foot descent should be made during the turn into the final approach. This will permit a correct approach speed with a 500-foot per minute descent on the final leg.

A minimum air speed of 150 mph IAS should be maintained on the down wind leg during normal landings. The landing gear should not be extended until you are halfway through the down wind leg or when opposite the end of the landing runway. When the gear is extended and checked, the flaps should be

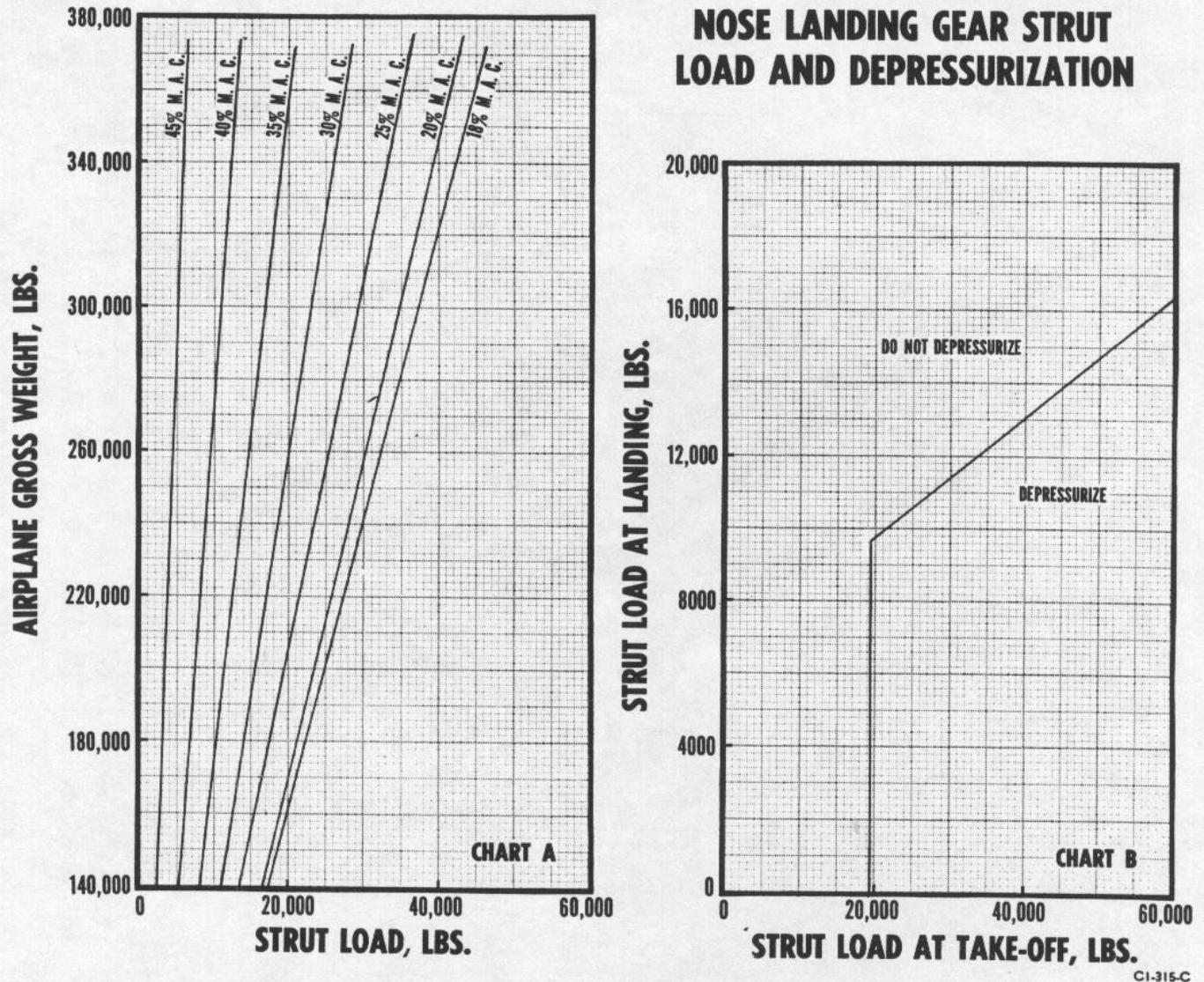


Figure 2-12. Nose Gear Strut Load and Depressurization Chart

lowered to 10 degrees. The minimum air speed for the down wind leg will be maintained for the base leg, and the flaps will be extended to 20 degrees. On the final approach, air speed should be maintained at 135 per cent of the stalling speed and the flaps should be lowered to 30 degrees.

Cross-wind landings should be avoided whenever possible. If at any point during final approach lateral corrections of appreciable magnitude are required, an immediate go-around will be executed in order to avoid the dangerous condition of having a wing drop in the proximity of the ground.

When the flaps are lowered, the airplane tends to nose up and gain altitude. Therefore when the flaps are lowered, anticipate this change in attitude and roll in enough nose-down elevator trim to counteract this tendency. Each successive lowering of the flaps on the base and final legs will require further down-elevator trim.

When the aircraft is at an average landing weight of about 200,000 to 230,000 pounds, a power setting of about 30 inches manifold pressure should maintain sufficient air speed and altitude on the down wind leg. When the gear is lowered and flaps set at 10 degrees, an increase in power to about 37 inches manifold pressure is necessary to maintain correct air speed and altitude.

Control effectiveness versus air speed is very important during the final approach while trying to maintain a constant IAS. Excessive aileron movement, cross trim, improper throttle settings, or overcontrolling tend to increase stall characteristics and decrease control effectiveness, with a resultant loss of air speed. On the final approach, keep the wings as level as possible. For directional control, minimize the use of aileron control. During cross-wind landings, employ rudder control rather than aileron control to correct for drift.



Figure 2-13. Traffic Pattern

When the main gear is on the runway, the pilot will ready the propellers on the order of the aircraft commander. The nose should be held off and directional control maintained with the rudder. Rudder control is effective down to speeds of 60 mph. If directional control cannot be maintained with rudder alone, unbalanced power should be used. The nose should be

Caution should be taken not to use the nose steering to make any large corrections until the airplane has slowed down considerably. Severe oscillations or buffeting of the nose section will occur if you use over-control of the nose wheel steering on fast ground rolls.

WARNING

Flight crew will not be stationed in the lower nose section during landing because of the likelihood of personnel being trapped in event of a crash landing.

BEFORE LANDING.

PILOTS

1. Notify crew—"Prepare to land." The landing check should be started 8 to 10 minutes before landing.

2. Autopilot—Off.

3. Jet Air Plug Switches—OPEN. Although the 2 to 4 per cent windmilling rpm experienced in flight with the jet nose doors closed will scavenge most of the jet oil, a certain amount will tend to collect in the engine. To scavenge all of the oil, it is necessary to open the jet air plugs to increase windmilling rpm when entering the landing pattern.

4. Engineer's Landing Configuration—Pilot reads—Engineer answers: "Alternators—Paralleled; Booster Pumps—ON; Turbos—BOTH; Spark—RETARDED; Mixtures—NORMAL; TBS—ZERO; Propellers—AUTOMATIC; Landing Gross Wt. _____ Pounds; CG _____ Per Cent; Before Landing Check List Complete, standing by on rpm for landing gear and brake check."

5. Stalling Speeds—Checked. A check of the placard on your instrument panel will give you the stalling speeds at various flap settings for the landing gross weight.

6. Master Tachometer—2550 rpm.

7. Landing Gear Control Switch—EXTEND. The gang bar arrangement will turn the brake pump switch ON. The pilot will report on the interphone, "Gear coming down," and will place the landing gear and brake pump switches in EXTEND and ON, respectively. The aft gunners will watch gear operation through the complete cycle and will report on interphone as follows: "Left canoe door coming open." "Right canoe door coming open." "Left canoe door fully open, left gear coming down." "Right canoe door fully open, right gear coming down." "Left gear down and locked, left canoe door coming closed." "Right gear down and locked, right door coming closed." "Left canoe door fully closed." "Right canoe door fully closed." The radio operator will check the nose gear

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1. Air Plugs and Intercoolers—As required.

2. Cabin Heater Power Switch—OFF.

3. Electrical System—Checked.

4. Fuel Panel Checked—Booster Pumps ON.

5. Engine Supercharger Switches—BOTH.

6. Cabin Pressure Shutoff Valve Switches—OFF.

7. Booster Fan Control Switch—OFF.

8. Pitot Heater Switches—As required.

9. Propeller Anti-Ice Switch—OFF.

10. Carburetor Preheat Switches—As required. (See "Emergency Use of Carburetor Preheat," Section IX.)

11. Cabin Heat, Wing and Tail Anti-Ice Switches—OFF.

12. Fan Speed Control Switches—LOW RPM.

13. Spark Advance Switches—RETARD.

14. Mixture Control Selector Switches—LEVER.

15. Mixture Control Levers—NORMAL.

16. TBS—ZERO.

17. Propeller Selector Switches—AUTOMATIC OPERATION.

18. Propeller Normal Pitch Indicator and Tel-Lamps—Lighted.

19. Engineer's Landing Configuration—Pilot reads—Engineer answers: "Alternators—Paralleled; Booster Pumps—ON; Turbos—BOTH; Spark—RETARDED; Mixtures—NORMAL; TBS—ZERO; Propellers—AUTOMATIC; Landing Gross Wt. _____ Pounds; CG _____ Per Cent; Before Landing Check List Complete, Standing by on rpm for landing gear and brake check."

20. Master Tachometer—2550 rpm. At high gross weights, high field elevations, or in emergencies, 2700 rpm and 7 TBS setting may be used.



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through the inspection window and will report, "Nose gear down and locked." The pilot will observe the landing gear indicator lamps and note whether the warning horn is sounding; also he will receive the engineer's report that main hydraulic system pressure is relieved. Complete extension of the gear normally takes approximately 50 seconds. After receiving the pilot's report that the gear is down and locked, the aircraft commander will check to see that the red landing gear indicator lamp is out and the green lamp is lighted.

The indicated air speed must not exceed 188 mph during landing gear extension. A visual check of the landing gear by the gunners is very important. The red "unsafe to land" indicator lamp is operated by canoe door limit switches and is not a positive check. The green lamp is operated by the main gear limit switches. The aft gunners' check of the flags on the main gear side braces together with the hydraulic pressure relief noted by the engineer is a positive check.

8. Parking Brake Lever—OFF. The parking brakes can be set accidentally by personnel moving about on the flight deck. Be sure this lever is OFF.

9. Left and Right Brakes—Checked. After the gear is down and locked, check the brakes. The pilot should depress the foot pedals one at a time, and the engineer will report a drop in brake pressure as each pedal is operated. After both pedals are operated and the pressure has returned to normal, the engineer will report the fact on interphone.

10. Nose Gear Strut—Bled. See figure 2-12 to determine whether depressurization is necessary. If landing gross weight exceeds 300,000 pounds, start the jet engines and have them standing by at idle.

11. Nose Steering Switch—ON. No steering pressure will be indicated until the nose strut is compressed below 10 inches after landing.

12. Read pilots' landing configuration to engineer: "Gear down and locked, autopilot OFF, nose wheel steering switch ON, standing by on flaps."

13. Flaps—10 degrees.

WARNING

Do not extend flaps at indicated air speeds in excess of those shown for propeller and flap limitation in figure 5-3.

21. Brakes Checked—Pressure normal.

BASE LEG.

PILOTS

ENGINEERS

1. Flaps—20 degrees.
2. Jet Air Plug Switches—CLOSE.

FINAL APPROACH.

PILOTS

CAUTION

When the gross weight demands an approach speed in excess of 138 mph IAS, use 2700 rpm before full flap extension.

CAUTION

Check propeller and flap vibration limitations in figure 5-3 when gross weight demands high approach speed.

1. Flaps—30 degrees.

WARNING

Flaps are subject to structural failure at the following air speeds:

10°.....	189 mph
20°.....	189 mph
30°.....	189 mph

Check propeller limitations against flap setting as shown in figure 5-3.

Maintain 135 per cent of stalling speed or a minimum of 120 mph IAS, whichever is higher. Lift with 30-degree flap setting is sufficient to allow a very steep landing approach with power off; however, normal approach is made with power on to prevent overcooling of the engines.

LANDING.

PILOTS

1. Propeller Reverse Selector Switches—READY, on main gear contact. The pilot will place these switches in READY at the order of the aircraft commander.

CAUTION

Do not ready the propellers until ground contact has been made.

2. Propeller Reverse Pitch Switch—Depressed on aircraft commander's command. The pilot will actuate this switch at the order of the aircraft commander after the nose wheel has contacted the runway. When the pilot actuates the switch, the aircraft commander will increase the throttles to the desired power. With the propellers in reverse during normal landings, 30 inches M.P. is maximum; however, in emergencies full

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1. If a go-around becomes necessary, smoothly increase M.P. to 51.5 inches. Then increase master motor cautiously to 2700 rpm and 63 inches M.P. if additional power is required.

ENGINEERS

1. Brake and Nose Steering Pressure—Normal after nose wheel contacts ground.
2. Rpm and Manifold Pressure Checked—After propellers are reversed, do not exceed 30 inches M.P. except in an emergency.

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power application is acceptable. The pilot will stand by on the controls and will hold them in neutral while reversing. The effect of reverse thrust from the propellers is greater at high speeds; thus, it is desirable to use reverse thrust as soon as possible after landing.

3. Control Surfaces—Locked at 50 mph. On normal landing the flight controls should not be locked until the forward speed reaches 50 mph. This will permit the use of the rudder for directional control for as long as it is effective. Since gusty winds can cause serious rudder damage when the airplane's speed is less than 50 mph, the controls must be locked at 50 mph on all landings. If more than 30 inches M.P. is used during reverse pitch, controls must be locked at all speeds.

4. Propeller Reverse Selector Switches—SAFE. The aircraft commander will return the desired pairs of propellers to the normal position after the landing. The engines should be reduced to idle before returning the reverse selector switches to SAFE.

5. Flaps—Retracted. Flaps will be retracted after turning off the runway.

6. Jet Oil Shutoff Valve Switches—CLOSE, at zero per cent rpm. These valves should be closed at zero per cent rpm to trap all of the oil in the tanks. If this is not done and the oil tanks are filled before the next flight, the excess oil trapped in the engine will be forced out the vent lines on the next jet start. When closing the valves, be sure the associated circuit breakers are pushed in.

Note

One of the symmetrical pairs of engines will be stopped on command of the aircraft commander after landing has been completed, after the airplane has been turned off the active runway, and after the engines have been checked for proper operation.

MINIMUM RUN LANDINGS.

Use the same procedure as that used in normal landing with the following exceptions: Reverse the propellers after the main landing gear touches the ground and before the nose wheel touches the ground. When reversing the propellers with the nose still in the air, the nose must not be at too high a deck angle and must be held steady. To increase the effects of reverse thrust, reduce rpm to 2000 with the master motor as power is applied.

CAUTION

Since the airplane has a very responsive brake system and is equipped with four-wheel main gears, extra care must be used to avoid skidding the rear wheels. Scanners should be alert for such observations and should notify the aircraft commander.

CROSS-WIND LANDINGS.

Cross-wind landings will be avoided if at all possible. If, at any point during final approach, lateral corrections of an appreciable magnitude are required, an immediate go-around will be executed in order to avoid having a wing drop while near the ground. Avoid dropping one wing to correct for a cross wind. The recommended procedure for making a cross-wind approach and landing is to head into the wind (crab) just enough to keep a straight ground path and hold the wing level. Take out the crab with the rudder after flare-out and before touch down, being careful not to inadvertently drop a wing.

GO-AROUND.

The procedure for a normal go-around is not complicated. Raise the flaps from the full-down position to 20 degrees as power is applied and continue on the same approach angle until safe flying speed is reached.

CAUTION

To avoid overspeeding the propellers when increasing power in a go-around, advance throttles to full open before advancing the TBS lever to position 7. If additional power is needed, advance the master motor control lever to 2700 rpm.

CAUTION

Drag with full flaps is excessive. Raise the flaps to 20 degrees as quickly as possible after a decision to go around has been made. *Do not* raise flaps past 20 degrees until a safe IAS is obtained. Flaps should not be completely retracted below 140 mph IAS or 125 per cent of stalling speed (whichever is greater). The landing gear will not be raised un-

til it is certain that touch down will not be made. Remember that the airplane will continue to settle for a short period after full power has been applied.

TAXIING.

For taxiing instructions refer to "Preflight Operational Equipment Check, Taxiing." When taxiing after landing and after postflight engine checks, one symmetrical pair of engines may be shut down.

STOPPING RECIPROCATING ENGINES.

The engineer will stop engines in accordance with the instructions given in "Preflight Operational Equipment Check, Stopping Reciprocating Engines." The aircraft commander will accomplish the following during engine shutdown:

CAUTION

Make sure the wheels are chocked if engine run-up is performed in a congested area.

1. Parking Brake Lever—ON.
2. Propeller Reverse Selector Switches—SAFE (lights out).
3. Nose Wheel Steering Switch—OFF.
4. Flight Instrument Switches—OFF.
5. Contact engineer, "Ready to stop engines."

CAUTION

Aircraft commander, pilot, engineer, and lower aft gunners will remain on interphone. Radio will be tuned to tower frequency until the last propeller has stopped turning.

6. Emergency Ignition Switch—Pull OFF.
7. Radio Equipment—OFF.

BEFORE LEAVING AIRCRAFT.

Check and accomplish the following before leaving the aircraft:

PILOTS

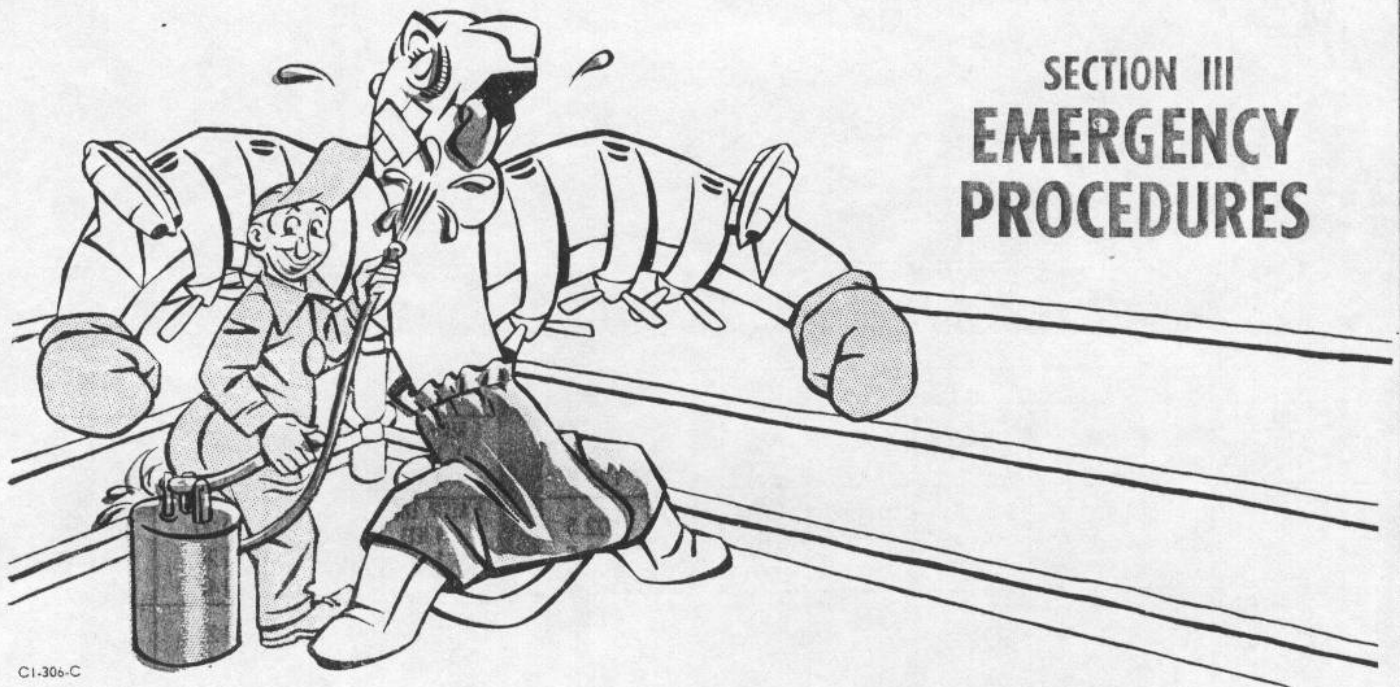
1. All Control Switches—Properly positioned.
2. Wheel Chocks—In place.
3. Parking Brake Lever—OFF after wheels are chocked.
4. Postflight Visual Inspection—Completed. Visual inspection of interior for proper condition and stowage of equipment. All ground locks in place.
5. Aircraft forms—Completed. Coordinate forms and reports with maintenance and operations.
7. Security of the aircraft—Established.

ENGINEERS

1. Postflight Visual Inspection—Complete.
2. Dip Stick Readings—Recorded.
3. Forms and Reports—Completed. Coordinate with maintenance and operations.



C1-346L-C



Survival in an emergency requires the fully coordinated effort of each crew member. A well trained crew will know what to do and, if properly disciplined, will react with efficiency. Since procedure drills are the nearest approach to reality, they should be conducted at every opportunity so that the crew will be familiar with each procedure and will learn to accomplish it in a minimum of time. If time and circumstances permit, planning for an impending bail-out or forced landing will increase the chances for survival. The chances of survival depend critically on communication equipment; water, food and medical supplies; and crew discipline.

Note

Crew discipline is especially important in rationing food and water and dispensing medical supplies.

Emergency signals are given on the alarm bells and are as follows:

1. Prepare to bail out—Three short rings.
2. Bail-out—One long ring.
3. Prepare to ditch or crash land—Six short rings.
4. Ditching or crash landing—One long ring.

Note

If possible the crew should be warned and acknowledgement received by interphone.

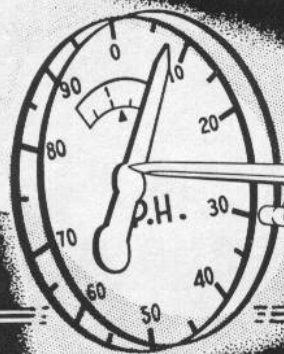
ENGINE FAILURE.

FLIGHT CHARACTERISTICS WITH PARTIAL POWER.

The airplane is not difficult to maneuver under conditions where some engines are inoperative. The ease of maneuverability results from the free-floating characteristic of the servo-operated control surfaces and the positive means of trimming the airplane. Do not be apprehensive about normal turns into dead engines. Remember too, that in case of critical power failure, the jet engines are there to supplement the remaining power.

It is important to be familiar with the appendix which gives rate of climb versus air speed for various flap and gear positions with engines inoperative. With asymmetrical power, the drag of the inoperative engine and the thrust of the opposite engine combine to form a powerful turning effect. Any resulting turn increases the lift of the faster moving wing, causing a roll into the dead engine. Normal aileron correction tends to bring up the low wing but at the same time adds adverse yaw into the inoperative engine. With speed reduction the drag of the inoperative engine decreases, but the thrust of the opposite engine (at constant power setting) increases. As speed is decreased, both ailerons and rudder become less effective. Above the safety speeds listed in figure 3-1, full control of the airplane can be maintained with high asymmetrical power. When cruising on four or five engines, all en-

MINIMUM IAS (MPH) FOR ZERO YAW FULL RUDDER DEFLECTION



INDICATED AIRSPEEDS, MPH
(ALL OPERATING ENGINES AT T. O. POWER)

	76.6° F (OAT)	100° F (OAT)	NACA DAY			
	SEA LEVEL	SEA LEVEL	SEA LEVEL	3000'	6000'	9000'
6 RECIP. ENG. + 3 JETS + 2 JETS	99.5 138	97.5 135	101.5 144	98 138	94.5 132	91.0 125.5
5 RECIP. ENG. + 4 JETS + 3 JETS + 2 JETS	105 138.5 167	102.5 133.5 162	107 141 173	105.5 137 167	104 133 160.5	102.5 129.5 154.5
4 RECIP. ENG. + 4 JETS + 3 JETS + 2 JETS	128 155 181.5	124.5 151.5 175.5	131 160.5 188	129 156 181	127 151 175	124.5 147 169
3 RECIP. ENG. + 4 JETS	139	135	142	139	136	133.5

INDICATED AIRSPEEDS, MPH
(ALL OPERATING ENGINES AT MRP)

	SEA LEVEL	10,000'	20,000'
6 RECIP. ENG. + 3 JETS + 2 JETS	98 136	87 118	77 101
5 RECIP. ENG. + 4 JETS + 3 JETS + 2 JETS	105 136 165	100 124 147	95 113 130
4 RECIP. ENG. + 4 JETS + 3 JETS + 2 JETS	128 154 180	121 142 162	115 131 145
3 RECIP. ENG. + 4 JETS	137	130	123

Speeds quoted are for the most asymmetric engine configuration, i.e., inoperative engines are those most outboard on one side.

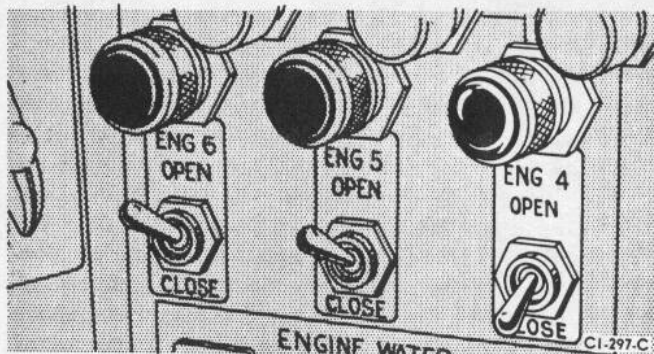
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Figure 3-1. Minimum Indicated Airspeeds for Zero Yaw

gines should be kept operating at the same power setting. At low speeds, however, it is necessary to throttle back to more symmetrical power conditions in order to maintain control. The charts shown in figure 3-1 represent the best available information until such time as the stall and lateral control tests are completed.

RECIPROCATING ENGINE SHUTDOWN IN FLIGHT.

The flight engineer shall position controls of the affected engine as follows:



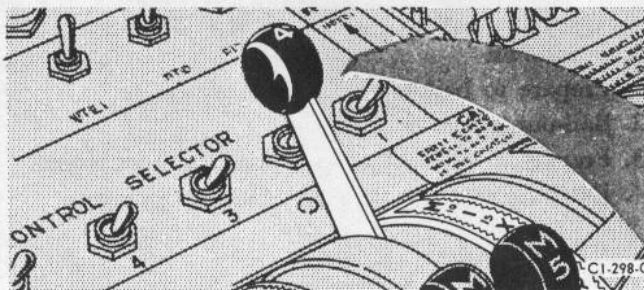
1. Engine fuel valve switch—CLOSE.

WARNING

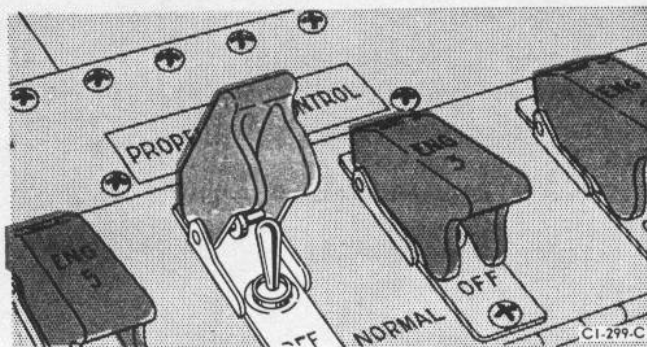
Do not, without forethought, close other fuel valves or shut off fuel booster pumps, since other engines may be dependent on their position or operation.

CAUTION

Do not close oil shutoff valves unless engine is being feathered because of fire.



2. Mixture control lever—IDLE CUT-OFF.



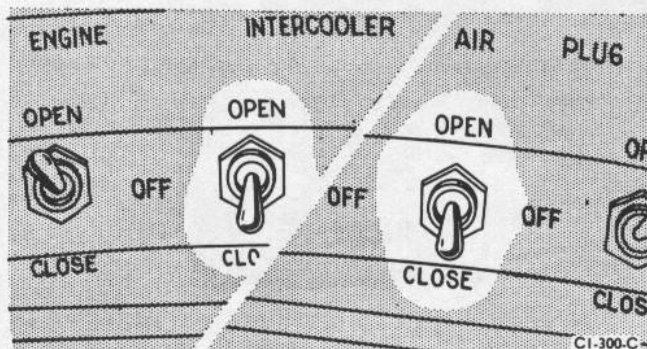
3. Propeller feather switch—FEATHER, simultaneously with idle cut-off.

Note

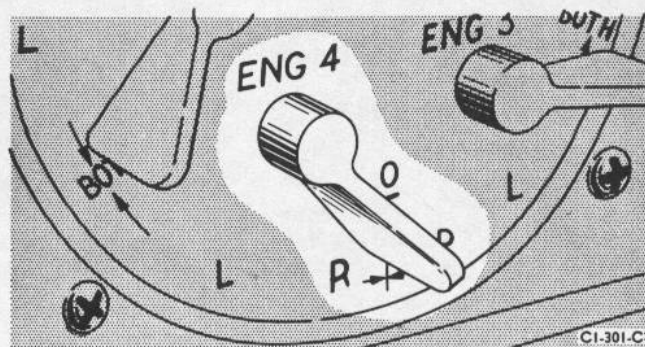
Because of an aerodynamic characteristic slight windmilling in reverse will occur on completion of the feathering cycle of propeller No. 1, 2, or 3. To remedy this condition, place the propeller selector switch of the affected propeller in FIXED PITCH, return the feather switch to NORMAL, and then jiggle the selector switch in the INC. RPM position until the windmilling has ceased. Leave the selector switch in FIXED PITCH position. If the propeller is inadvertently moved through the feather position and begins to windmill in the normal direction, actuate the feather switch and repeat the above procedure.

CAUTION

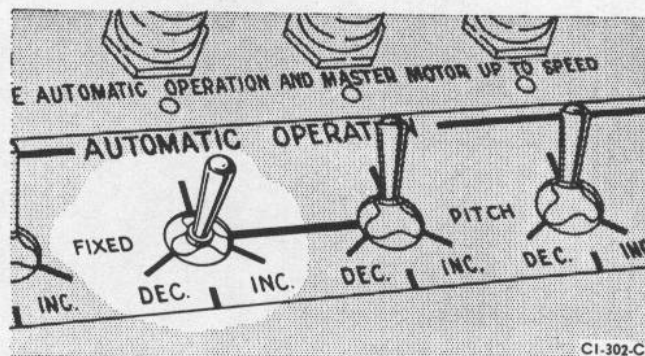
Do not allow a propeller to windmill in reverse, because the engine may be damaged because of inadequate lubrication. If an engine is subjected to reverse windmilling for an appreciable length of time, it should be thoroughly checked after the flight.



4. Intercoolers and airplug control switches—Hold in CLOSE position until intercoolers and air plug are fully closed.



5. Ignition switch—OFF.



6. Propeller selector switch—FIXED PITCH.

Note

Turn the voltage and frequency selector switch to the number of the feathered engine and check for zero readings on the frequency meter and the voltmeter.

7. Frequency Control Knob—Full DECREASE.

OIL DILUTION AFTER ENGINE SHUTDOWN.

After engine shutdown, if it is anticipated to restart the engine at a later time, the following procedures will be used:

1. Allow the engine to cool to an oil temperature of 30 to 40°C.
2. Oil shutoff valve—check OPEN.
3. Windmill engine to 800 rpm.
4. Use normal oil dilution procedure. Refer to the oil dilution table, "Oil Dilution," Section IX.

PROPELLER UNFEATHERING DURING FLIGHT.

CAUTION

If a propeller has been feathered for 5 minutes or more in low temperatures requiring oil dilution as given in Section IX, "Oil Dilution," and the oil was not diluted at engine shutdown, do NOT unfeather.

1. Mixture control lever—IDLE CUT-OFF.
2. Throttle lever—Approximately 1/4 open.
3. Engine oil shutoff valve control switch—OPEN.
4. Engine fuel valve switch—OPEN.
5. Fuel pressure—10-14 psi.
6. Starter switch—Engage through eight blades.

CAUTION

Energize starter in blade travel increments not to exceed 60 degrees in order to minimize the possibility of damage in event of a hydraulic lock.

7. Propeller selector switch—FIXED PITCH.
8. Propeller feather switch—NORMAL (guard down).
9. Propeller selector switch—INC. RPM, until engine turns over 500 to 600 rpm; then return to FIXED PITCH.

CAUTION

If there is no oil pressure indication within 30 seconds, refeather the engine.

10. Ignition switch—ON.
11. Mixture control—NORMAL.

Note

The torquemeter will indicate a successful engine start. When the mixture is brought to NORMAL, if the torque oil has congealed in the line to the autosyn transmitter, a power surge and a normal rise in CHT indicates a successful start.

CAUTION

Check for an indication of oil pressure and alternator excitation. If there is no oil pressure indication, refer to the oil temperature to see whether normal indications are evident. If there is no indication of an increase in oil temperature or if the oil temperature goes too high, the oil supply to the engine may be impaired and the engine should be immediately refeathered.

12. Propeller selector switch—INC. RPM, until 1400 rpm; then return to FIXED PITCH.
13. Throttle lever—Advance until M.P. is approximately 25 inches.
14. Propeller selector switch—As required to maintain 1400 rpm during throttle advance.

CAUTION

Warm up the engine at 1400 rpm and 25

inches M.P. until engine oil temperature reaches 40°C.

15. Propeller selector switch—INC. RPM, until rpm nearly matches rpm of the other engines.
16. Propeller selector switch—AUTOMATIC OPERATION.
17. Throttle lever—Advance as required for power setting.
18. Alternator—Parallel on bus. (Engines No. 2, 3, 4, or 5.)

ENGINE FAILURE DURING TAKE-OFF.

In the event of engine failure on take-off, accomplish these steps:

1. First obtain directional control by using rudder with a minimum of aileron.
2. Pick up at least minimum control air speed before attempting to climb. (See figure 3-1.)
3. Raise the landing gear immediately, if practical, and start retracting the flaps at 125 per cent of stalling speed, even though the gear is not completely up. (See figure 6-5.)
4. If emergency power is being used, reduce this power as soon as possible.
5. Determine which engine or engines have failed and whether or not they are delivering enough power to carry themselves; if they are not, feather their propellers and make a normal landing approach.

CAUTION

Failure of an output tube of the electronic mixture control system may cause the mixture control to be driven to the IDLE CUT-OFF position. If there is evidence of such a failure as shown by complete loss of power with a sharp decrease in fuel flow and torque, with fuel pressure normal, retard throttle to prevent power surge and back firing and use the mixture control override switch to reset the mixture. If power is not restored, then feather the propeller.

Note

If sufficient power is not available to execute the landing pattern, prepare to crash land straight ahead. Refer to "Crash Landings" of this section.

WARNING

Never attempt a turn before directional control is obtained and a safe flying speed is reached.

ABORTING TAKE-OFF.

If the aircraft commander should decide to abort a

take-off after take-off power has been established, he should notify the crew by announcing over the interphone "Aborting Take-Off." Immediately following this announcement, the crew members concerned will comply with the following procedure:

1. Engineer—Water Injection Switches—OFF.

WARNING

If the water injection is not shut off before reducing power on the reciprocating engines, the excess water may "drown" the engines causing a rapid drop to an extremely low rpm with loss of all a-c power and subsequent loss of control of jet engines. If this condition exists, the jet engines must be shut down by closing the jet engine fuel valves.

2. Engineer—TBS—ZERO.
3. Pilot—Jet Throttles—OFF.
4. Pilot—Propeller Reverse Selector Switches—READY.
5. Aircraft Commander—Throttles—Retarded.
6. Pilot—Propeller Reverse Pitch Switch—DEPRESSED.
7. Aircraft Commander—Throttles—ADVANCED as required, and use maximum braking without skidding.

Note

Prior to each take-off the aircraft commander will personally brief the pilot and flight engineer on the above "Aborting Take-Off" procedure.

PARTIAL POWER TAKE-OFF.

This procedure should be used when some engines are inoperative and the airplane must be flown from a base where repair facilities are inadequate.

Note

If symmetrical engines are inoperative, use the normal take-off procedure. See Appendix 1 for take-off performance.

CAUTION

This procedure does not apply in the event of engine failure on take-off or reduced power take-off.

Study the applicable portion of the "Take-off and Distance Curve" in the appendix. Prepare the airplane by closing the air plug doors of the inoperative jets and sealing the air intakes of the inoperative reciprocating engines, but do not seal any exhaust or air outlets. One point to consider in this type of take-off is the unbalanced thrust created by asymmetrical pow-

er. With take-off power, full opposite rudder will not be sufficient to counteract the yaw at low speeds. Therefore, with all operative engines idling and the airplane restrained with the foot brakes, the take-off should be accomplished as follows:

1. Apply full take-off power to the symmetrical engines.
2. Release the foot brakes, but hold the rudder at full deflection.
3. As the airplane accelerates and the rudder becomes more effective, apply full power to the remaining engines.

CAUTION

At no time should full power be applied to a strong side engine until all engines inboard from it are operating at full power.

4. When all operative engines are at full power, reduce rudder deflection to maintain zero yaw.

Note

Use rudder trim and hold the nose wheel on the ground as long as possible to aid in maintaining directional control.

5. As soon as take-off air speed is reached, make a rapid pull-off followed by level flight to accelerate to a safe climbing speed; retract the land gear as soon as the airplane is positively air-borne.

WARNING

Remember that minimum safe climb speed is 120 per cent of stalling speed. See figure 3-1 for minimum yaw.

OIL SPEWING.

Oil spewing at altitudes of approximately 37,000 feet and above is caused by insufficient crankcase scavenging. This condition can become a serious problem. A dangerous amount of oil may be lost, making it necessary to feather engines to prevent seizing. Also, oil spewing from the breather vent congeals on the wing trailing edge and is thrown into the propellers by the slipstream, damaging the propellers and the fuselage. If conditions allow, attempt to stop oil spewing by reducing rpm. If this does not alleviate the condition, reduce altitude. For further information, refer to "Oil Spewing" of Section VII.

PARTIAL POWER LANDING.

It may sometimes be necessary to land with two or more engines inoperative; however, with careful planning there is seldom cause for alarm. When operating with asymmetric reciprocating engines inoperative, the resulting conditions of unbalanced thrust and lift great-

ly affect directional control at low air speeds with high powers on the remaining engines. For the critical air speeds below which effective control cannot be maintained with a given asymmetrical power configuration, refer to figure 3-1. There are many factors that must be considered in attempting a partial power landing. The aircraft commander should weigh these factors and determine the subsequent action. After alerting the crew to prepare for a possible crash landing, proceed as follows:

1. Make sure that the cg location is within proper limits for landing.
2. Based on expected landing gross weight, determine whether jet engine thrust is required to replace the loss of the reciprocating engines. (Refer to the appendix for determining sustained flight power requirements.)

It is recommended that one or both symmetrical pairs of jet engines be started so that adequate power is available to maintain level flight at 135 per cent of stalling speed with gear down and flaps at 20 degrees, allowing for the loss of one additional reciprocating engine.

3. If the jet engines are to be used, they should be operated at 90 per cent rpm, maintaining pattern speeds and final approach glide angle by retarding the reciprocating engine throttles.

Note

The jet engines are maintained at 90 per cent rpm to eliminate the possibility of compressor stall or flame-out due to rapid power changes.

4. The jets should be started as early as practical prior to entering the traffic pattern, based on estimated power requirements, fuel reserve, jet engine life, etc. (For starting procedure see "Starting Jet Engines in Flight," Section II.)

5. During the landing approach, maintain a safe air speed of 135 per cent of stalling speed.

6. Leave the gear up as long as practical before entering the final approach, thereby eliminating the need for high engine power to overcome landing gear drag. Care must be used to insure that gear is fully down and locked prior to turning on final approach. Normal gear extension requires approximately 45 seconds.

7. Adjust power on operating engines to maintain the desired approach speed.

Note

If the reciprocating engines are retarded, clear them by advancing the throttles every two minutes and prior to turning on the final approach.

8. Adjust directional trim with the rudder trim tabs during final approach.

9. Position flaps at 20 degrees until there is no possi-

bility of under shooting; then extend full flaps.

10. Just prior to touch down, if conditions permit, fully retard throttles on live reciprocating engines and simultaneously neutralize the rudder trim controls. Do not reduce jet power until a safe landing is assured; however, slight reductions may be necessary to maintain correct final approach air speeds even after reciprocating engines have been fully retarded.

CAUTION

Jet engines do not provide as rapid acceleration and deceleration of the aircraft as do reciprocating engines; therefore, required jet engine power changes must be anticipated earlier.

11. After the airplane contacts the runway, place the propeller reverse selector switches in the READY position in preparation for thrust reversal.

12. Shut down the jet engines and reverse the propellers simultaneously.

PROPELLER FAILURE.

RUNAWAY PROPELLER (OVERSPEEDING ENGINE).

Failure of the propeller synchronizing system may result in a runaway propeller. When such a failure occurs, the engine may exceed allowable limits. Attempt to reduce rpm as follows:

1. Retard the throttle if the runaway is violent.
2. Hold the propeller selector switch in the DEC. RPM position.

WARNING

Never use the propeller feather switch to decrease rpm because of the fast pitch change rate of 45 degrees per second.

3. If the above procedure does not reduce rpm, feather the engine. See "Reciprocating Engine Shutdown," of this section.

Note

If the propeller will not feather, engine overspeeding can be reduced by decreasing air speed and/or altitude.

CAUTION

All conditions of overspeeding should be noted on Form 1. If engine rpm was between 3100 and 3300 rpm, the engine must be inspected before the next flight. If the engine speed exceeded 3300 rpm, the engine must be changed.

EMERGENCY PITCH SETTING BEFORE LANDING.

When a landing is to be made in fixed pitch because of synchronizer failure, set the propeller blades to insure full power in the event of a go-around. This can be done before entering the final approach by using the following procedure:

1. Pilot—Maintain 135 per cent of stalling speed and remain at traffic altitude while the engineer performs the following steps on one engine at a time.

Note

The pilot can use remaining throttles to maintain 135 per cent of stalling speed. It is important that a constant air speed and altitude be maintained while the engineer is setting this power to assure adequate and balanced power for go-around.

2. Engineer — Propeller Selector Switch — FIXED PITCH.
3. Engineer—Turbo Calibration Trim Knobs—Full Decrease.
4. Engineer—TBS—7.

Note

Accomplish the remaining steps on one engine at a time for engines No. 1, 6, 2, 5, 3, and 4 respectively.

5. Throttle Lever—Full Open.
6. Propeller Selector Switch—Increase rpm to 2600.
7. Propeller Selector Switch—FIXED PITCH.
8. Turbo Calibration Knob—Increase to 60 inches M.P.

Note

As the turbo calibration knobs are increased to 60 inches M.P., the rpm will automatically increase to approximately 2700 with no adjustment to the fixed pitch setting. The final values desired are 2700 rpm and 60 inches M.P. which is adequate power for normal landing weights. At any rate, more power should be used only in an emergency since maximum dry engine power would be exceeded. When stabilized at 2700 rpm and 60 inches M.P., retard the throttle to the average power of the other engines and proceed with the next engine. After all engines have been trimmed, subsequent power changes should be made with the throttles only.

CAUTION

Advance throttles slowly while applying power to avoid overspeeding engines. Advancing the throttles too rapidly will cause the waste gates to slam shut, probably stick-

ing and creating an uncontrollable turbo and an engine overspeed condition and possible backfire.

9. After ground contact return TBS to ZERO to prevent backfiring and overboosting during reversing.

FIRE.

RECIPROCATING ENGINE FIRE ON THE GROUND.

If your aft gunners report a flaming exhaust stack, the fire is probably a torching turbo and may be put out by increasing the throttle momentarily. For other fires on the ground immediately warn the crew, signal to the fire truck and the ground crew for portable equipment, and notify the control tower. The flight engineer should meanwhile carry out this procedure:

1. Affected engine fuel and oil shutoff valve switches—CLOSE.
2. Alternator breaker hold-in switches—Hold in one switch.

Note

This step is applicable only when the alternators are furnishing electrical power to the airplane.

3. All mixture control levers—IDLE CUT-OFF.

Note

There are instances where the fire will burn itself out after the fuel has been shut off; therefore, before proceeding to the next step check to see whether the fire is out.

4. Proper engine fire extinguisher selector switch—Hold ON for at least five seconds as soon as the engine stops.
5. Fire extinguisher discharge selector switch — Place in the alternate position—Discharge if fire is still burning.
6. All ignition switches—OFF.

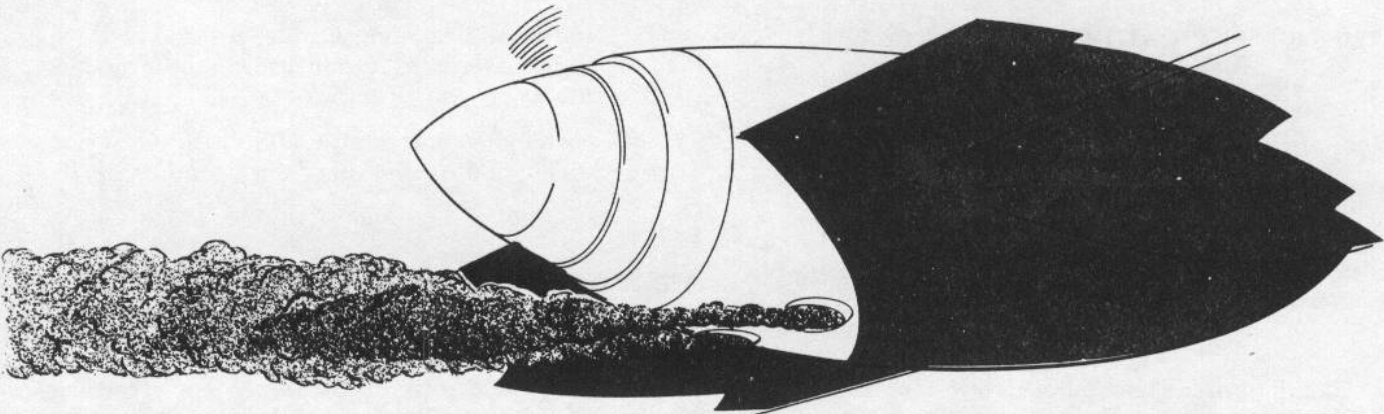
Note

Prolonged exposure to methyl bromide may prove toxic to personnel; however, since exposure is usually for a short period there is little possibility of ill effects from it.

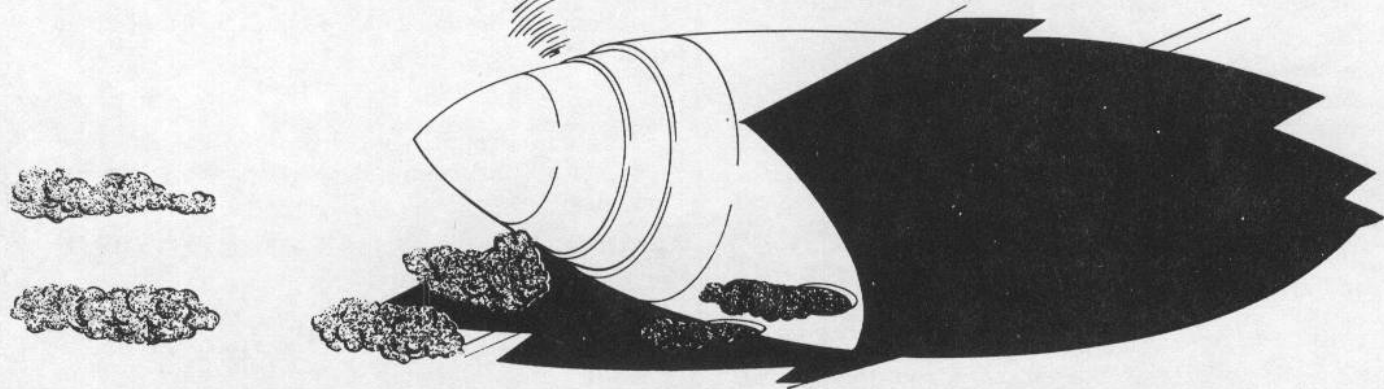
JET ENGINE FIRE ON THE GROUND.

In event of a jet engine ground fire, the pilot must call the tower and position his controls as follows:

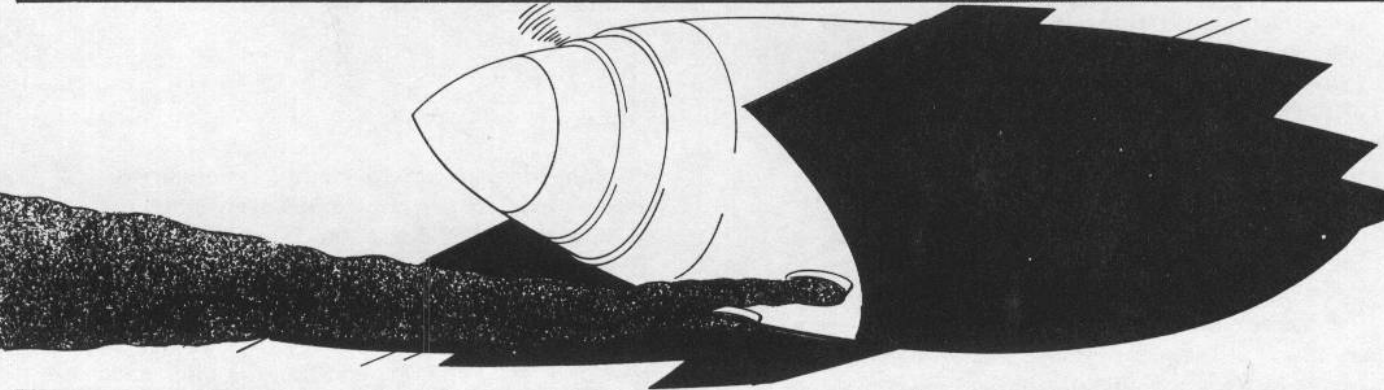
1. Throttle—CLOSE.
2. Proper engine fuel valve switches—CLOSE.
3. Proper manifold fuel valve switch—CLOSE.
4. Proper fuel booster pump switch—OFF.
5. Oil shutoff valve switches—CLOSE.
6. Pod preheat switch—OFF.



SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
THIN BLACK SMOKE FROM EXHAUST	1. RICH MIXTURE AT HIGH POWER 2. RICH MIXTURE AT HIGH RPM AND LOW MANIFOLD PRESSURE 3. LEAKY PRIMER	1. NONE 2. ADJUST POWER SETTING 3. NONE

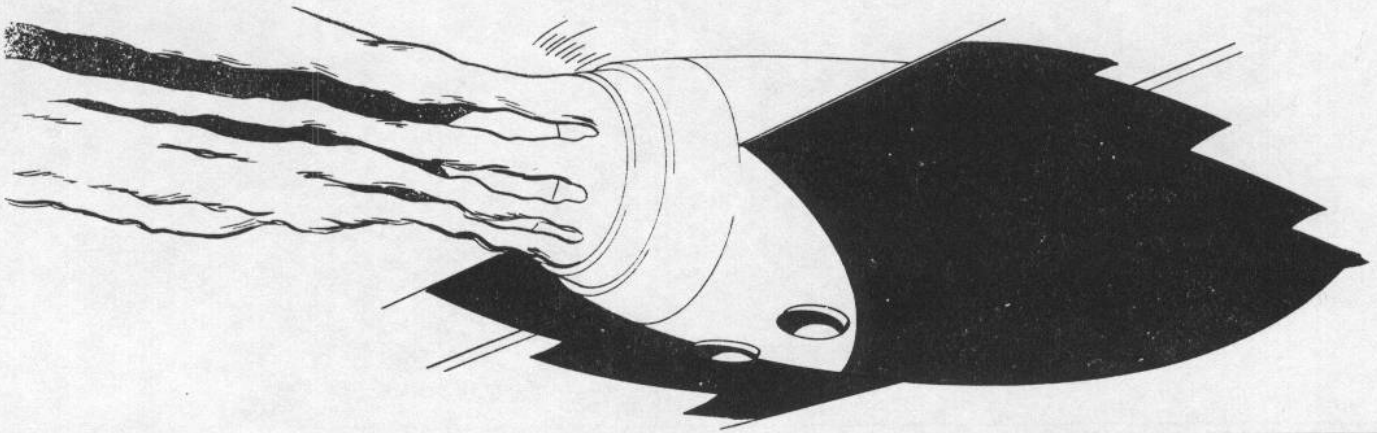


SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
PUFFS OF BLACK SMOKE FROM EXHAUST	1. DETONATION 2. CYLINDER MALFUNCTION 3. FOULED SPARK PLUGS	1. CHECK FUEL PRESSURE. CHECK MIXTURE CONTROL SETTING. RICHEN MIXTURE. REDUCE MANIFOLD PRESSURE. REDUCE CYLINDER HEAD TEMPERATURE. 2. REDUCE POWER. WATCH FOR FIRE. 3. INCREASE CYLINDER HEAD TEMPERATURE TO LIMIT.

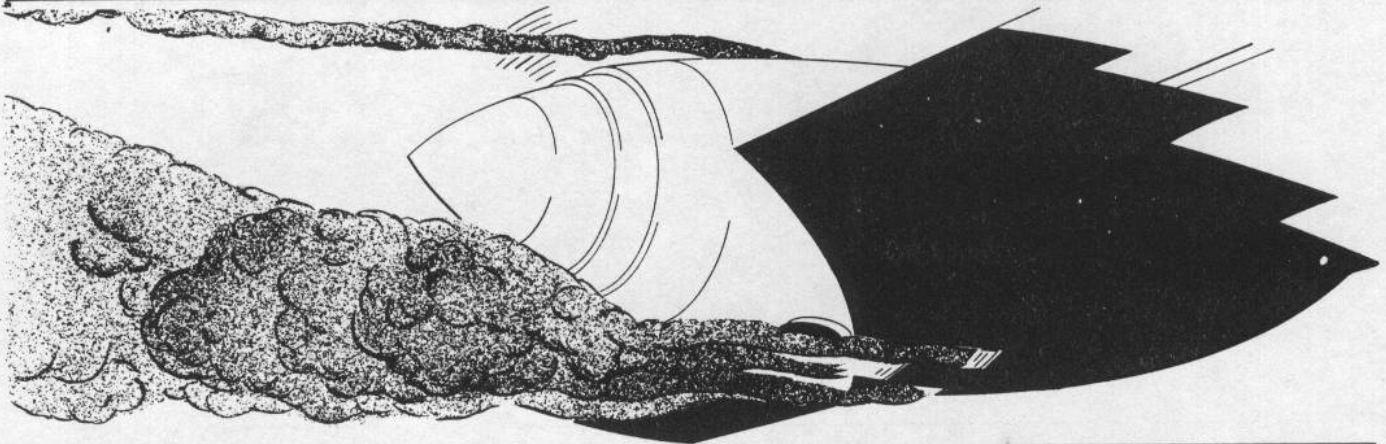


SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
THIN BLUISH WHITE SMOKE FROM EXHAUST	1. INTERNAL FAILURE—RINGS 2. IMPELLER SEAL OR TURBO SEAL OIL LEAKAGE	1. CHECK OIL PRESSURE. CHECK OIL QUANTITY.

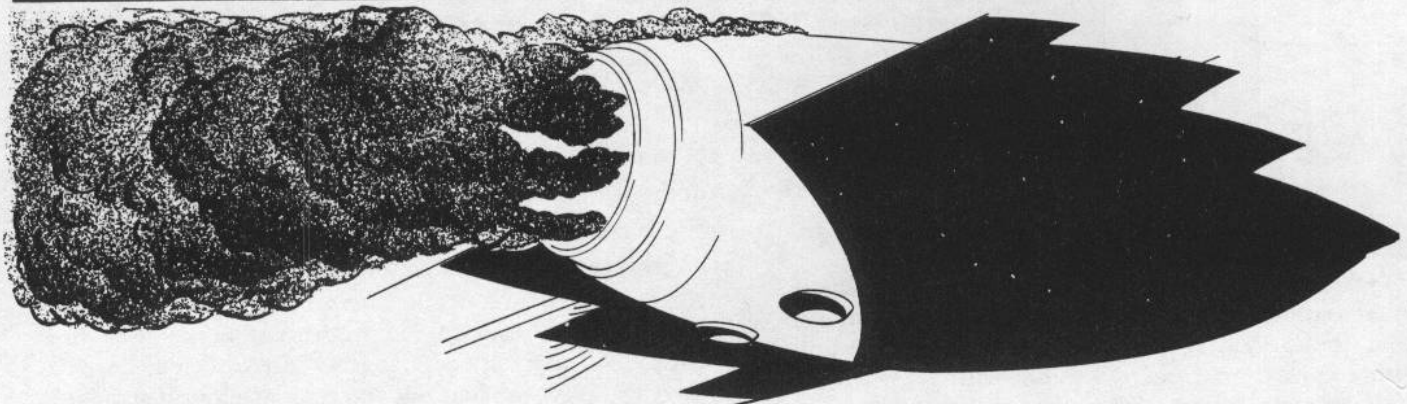
Figure 3-2. (Sheet 1) Diagnosing Smoke and Fire



SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
WHITE SMOKE FROM AIR PLUG OPENING	1. EXHAUST SYSTEM FAILURE	1. CUT OFF FUEL. FEATHER PROPELLER. WATCH FOR FIRE.

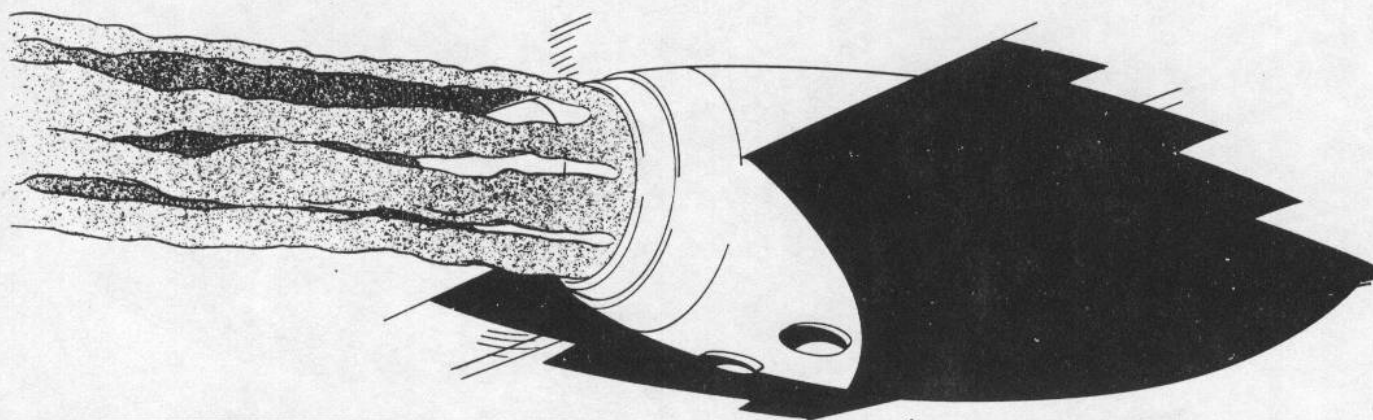


SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
BLACK SMOKE FROM LOUVERS. BLUISH WHITE SMOKE FROM LOUVERS OR OIL COOLER DOOR.	1. FUEL LINE AFIRE 2. OIL LEAK	1. CUT OFF FUEL. FEATHER PROPELLER. USE FIRE PROCEDURE. 2. CHECK OIL PRESSURE. CHECK OIL QUANTITY. WATCH FOR FIRE.

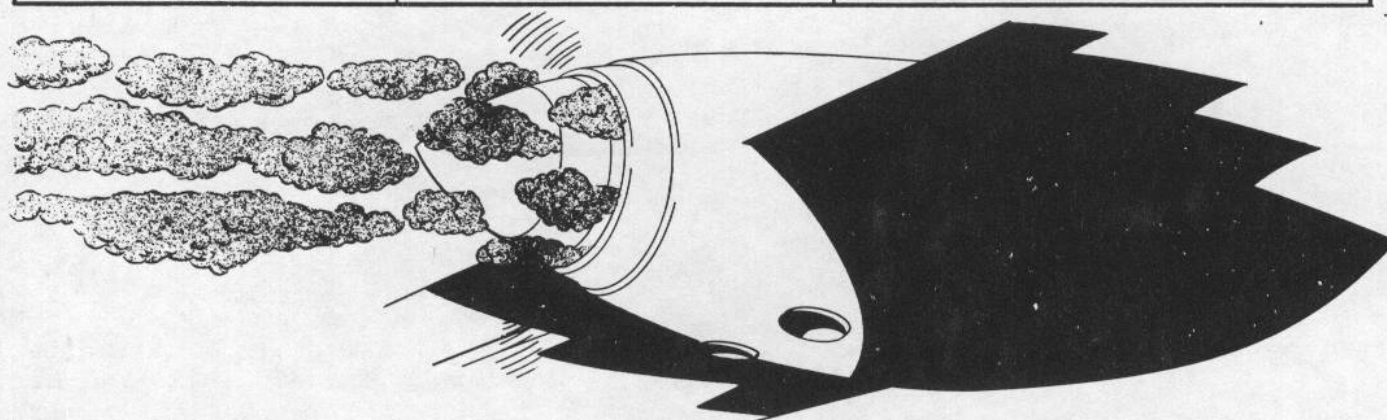


SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
DENSE BLACK SMOKE AND FLAME FROM AIR PLUG OPENING. FIRE MAY IMMEDIATELY BURN THROUGH UPPER COWLING OF NACELLE	1. BROKEN FUEL LINE OR ACCESSORY SECTION FIRE	1. CUT OFF FUEL. FEATHER PROPELLER. USE FIRE PROCEDURE.

Figure 3-2. (Sheet 2) Diagnosing Smoke and Fire



SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
THIN BLUISH WHITE SMOKE FROM AIR PLUG OPENING	1. OIL LEAK	1. CHECK OIL PRESSURE. CHECK OIL QUANTITY. WATCH FOR FIRE.



SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
PUFFS OF BLUISH WHITE SMOKE FROM AIR PLUG OPENING	1. OIL LEAK	1. CHECK OIL PRESSURE. CHECK OIL QUANTITY. WATCH FOR INTERNAL ENGINE FAILURE. WATCH FOR FIRE.

Figure 3-2. (Sheet 3) Diagnosing Smoke and Fire

CAUTION

In the event fuel is burning on the ground, move the the airplane upwind.

RECIPROCATING ENGINE FIRE IN FLIGHT.

Engine abnormalities are often difficult to diagnose either rapidly or accurately while in flight; however, from indications of the engine instruments coupled with information from the gunners in the aft cabin, fairly effective action can be taken in a minimum time. Engine malfunctions are often indicated by smoke or fire as shown in figure 3-2. Torching exhaust stacks are observed sometimes when the engine is operating on excessively rich mixtures. In some instances flame may extend through the air plug opening and the propeller. Effective leaning of the mixture will stop this condition almost immediately. When a crew member spots a fire he will place his interphone selector switch

in the CALL position and report "Flame" or "Smoke," whichever is applicable, "From No. ____ engine." If possible, the crew member will identify the type and location of the flame or smoke. When a warning is received from the fire detection system, the flight engineer will inform the aircraft commander. When the location of the fire is determined, the aircraft commander will instruct the flight engineer, "Use fire procedure on No. ____ engine." In addition, he will alert the crew for bail out in accordance with standard bail-out procedure. After receiving this instruction, the flight engineer will use the following procedure:

1. Affected engine's fuel shutoff switch—CLOSE.
2. Mixture control lever—IDLE CUT-OFF.
3. Propeller feather switch — FEATHER, simultaneously with idle cut-off.
4. Affected engine's oil shutoff switch—CLOSE.

Note

There are cases when the fire will burn itself out after the engine is feathered and the fuel is cut off. Therefore, before continuing with the fire fighting procedure, check to see whether the fire is extinguished.

5. Proper fire extinguisher engine selector switch—Hold ON for at least five seconds as soon as engine stops.
6. Air plug and intercooler switches—OPEN.
7. Proper cabin pressure wing shutoff valve switch—OFF. Use pressure from unaffected wing.
8. Proper cabin heat and tail anti-ice control switch—OFF, if fire is in engine No. 3 or No. 4.
9. Proper wing anti-ice control switch—OFF, if fire is in engine No. 1, 2, 5, or 6.
10. Fire extinguisher discharge selector switch—Place in alternate position.
11. Proper ignition switch—OFF.
12. Do not restart engine.

JET ENGINE FIRE IN FLIGHT.

In the event of a jet engine fire in flight, the pilot will position the jet engine controls as follows:

1. Throttle—CLOSE.
2. Proper engine fuel valve switch—CLOSE.
3. Proper oil shutoff valve switch—CLOSE (OPEN, after fire is extinguished).
4. Pod preheat switch—OFF.
5. Nose de-ice switch—OFF.

Note

If fire is not extinguished, repeat steps 1 through 5 on remaining jet engine in affected pod and proceed with steps 6 and 7.

6. Proper manifold fuel valve switch—CLOSE.
7. Proper fuel booster pump switch—OFF.

WING FIRE.

A wing fire involving fuel and oil tanks may be difficult to identify, because the smoke and flames will probably emerge from the engine nacelle. A wing fire will, therefore, probably be reported as an engine fire by the aft cabin gunners and should be fought as such until all the extinguishing agent is exhausted. The engineer will turn off the anti-icing system and stop the flow of cabin pressurizing air from the wing on fire. Check that the other wing is furnishing pressurization. After the fire is out, a reasonable length of time must be allowed for the fumes to dissipate before investigating the damage via the wing crawlway.

FUSELAGE FIRE.

Reduce the draft by shutting off pressurized or ventilating air. Isolate the fire by use of valves and doors. Know the locations and limitations of the hand fire extinguishers.

1. Crew—Don oxygen masks and goggles and set diluter lever of oxygen regulator to 100% OXYGEN. On A-14 regulator, set dial according to altitude. On D-1 regulator, push emergency toggle lever to left or right.
2. Crew—Locate cause of fire.
3. Crew—If it is an electrical fire, isolate the circuit.
4. Crew—If the fire is caused by fluid leak, stop the fluid flow.
5. Engineer—Aft cabin pressure control—OFF, if necessary.
6. Engineer—Cabin pressure wing shut-off valve switches—OFF, if necessary.
7. Crew—Aft cabin manual pressure shutoff valve—CLOSED, if necessary.
8. Crew—Use hand fire extinguishers.

WARNING

Do not increase ventilation until the flames are extinguished. Use oxygen masks for protection against fumes.

9. Crew—Open dump valves, doors, or blisters as required *after* the fire is out.

ELECTRICAL FIRE.

Fuses and circuit breakers protect most of the electrical circuits and tend to isolate an electrical fire. However, there are cases where fuses of high capacity will permit a short sufficient to cause a fire. In such instances use A-20 or CO₂ fire extinguisher and attempt to isolate the circuit containing the short.

EMERGENCY DESCENT.

Emergency descent should be used only when circumstances call for maximum rate of letdown. Engine wear and propeller vibration must be tolerated under these conditions, but air-speed limits should be observed to avoid immediate structural failure.

Throttles on six engines should be fully retarded, engine speed 2700 rpm, gear down, bomb bay doors open, turret extended, flaps 30 degrees, and maximum allowable IAS should be maintained for maximum drag. The degree of emergency will be the governing factor, but engines 3 and 4 can be maintained at sufficient power to provide pressure and heat.

EMERGENCY LANDING FIELDS.

In the event of an emergency where a landing at other than the home base is necessary, the aircraft commander will make every attempt, consistent with safety, to land at a *Primary Field*. If it is not possible, he should try to land on an *Alternate Field*. All *Primary Fields* have fuel, adequate maintenance, and the proper type of runway for B-36 operation. All *Alternate Fields* are adequate for limited B-36 opera-

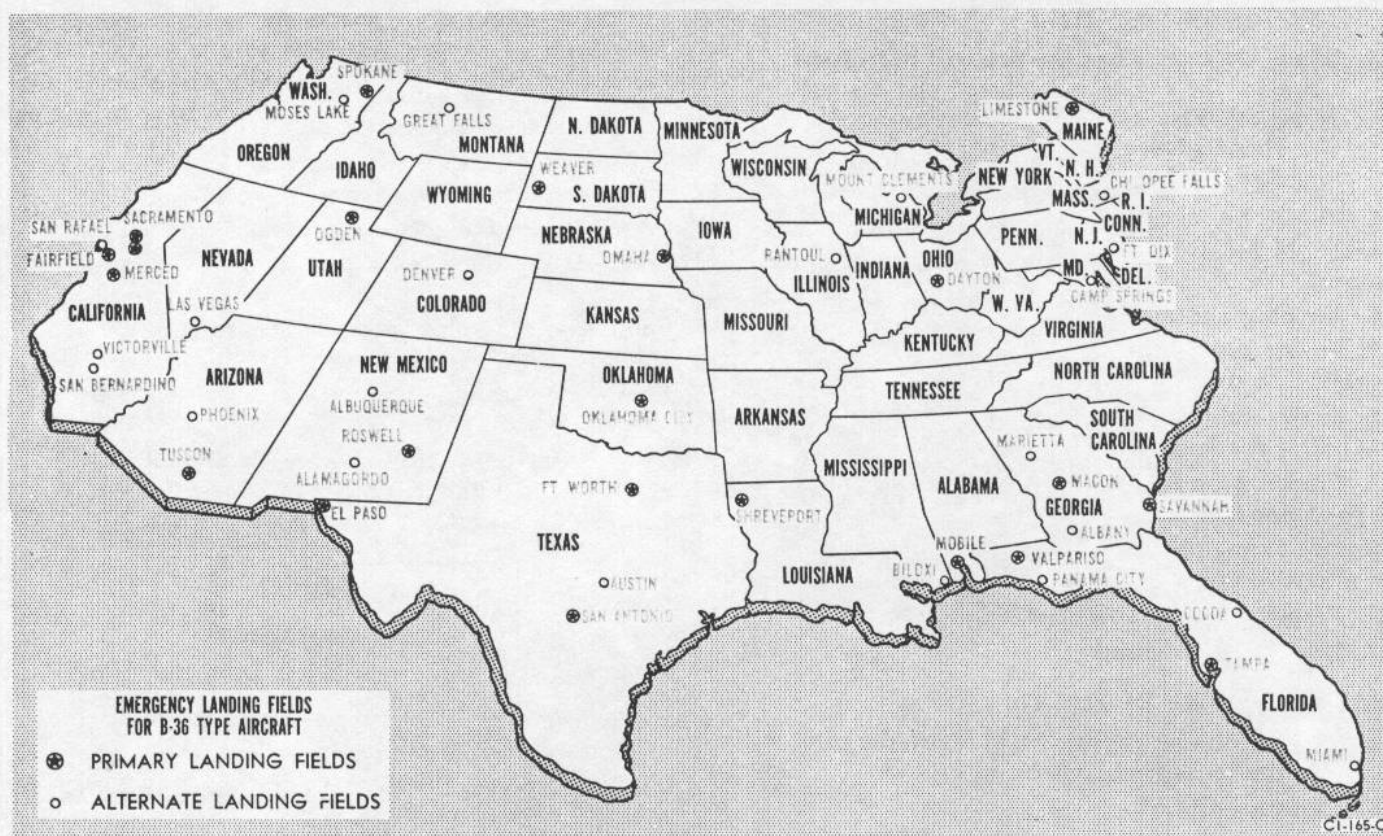


Figure 3-3. Emergency Landing Fields

tion only. They cannot refuel or perform major maintenance on B-36 type aircraft, and the runways are not stressed for continuous B-36 operation. For geographic locations see figure 3-3.

PRIMARY FIELDS

Location	Base	Longest Runway
Alabama, Mobile	Brookley AFB	8900
Arizona, Tucson	Davis Monathan AFB	7900
California, Fairfield	Travis AFB	8100
California, Merced	Castel AFB	7000
California, Sacramento	Mather AFB	7500
California, Sacramento	McClellan AFB	7000
Florida, Tampa	MacDill AFB	10,000
Florida, Valpariso	Eglin AFB	8000
Georgia, Macon	Robins AFB	7000
Georgia, Savannah	Hunter AFB	7000
Louisiana, Shreveport	Barksdale AFB	10,000
Maine, Limestone	Limestone AFB	9200
Nebraska, Omaha	Offutt AFB	6100
New Mexico, Roswell	Walker AFB	8500
Ohio, Dayton	Wright-Patterson AFB	8000
Oklahoma, Oklahoma City	Tinker AFB	7800
South Dakota, Weaver	Rapid City AFB	8000
Texas, Fort Worth	Carswell AFB	8200
Texas, El Paso	Biggs AFB	9600
Texas, San Antonio	Kelly AFB	7500
Utah, Ogden	Hill AFB	7500
Washington, Spokane	Fairchild AFB	8000

ALTERNATE FIELDS

Location	Base	Longest Runway
Arizona, Phoenix	Williams AFB	6100
California, San Bernardino	Norton AFB	7600
California, San Rafael	Hamilton AFB	6300
California, Victorville	George AFB	7400
Colorado, Denver	Lowry AFB	8300
Florida, Cocoa	Patrick AFB	7000
Florida, Miami	Miami International	8400
Florida, Panama City	Tyndall AFB	8000
Georgia, Albany	Turner AFB	7500
Georgia, Marietta	Robbins AFB	7500
Illinois, Rantoul	Chanute AFB	6300
Maryland, Camp Springs	Andrews AFB	7000
Massachusetts, Chicopee Falls	Westover AFB	7300
Michigan, Mt. Clemens	Selfridge AFB	6000
Mississippi, Biloxi	Kessler AFB	6500
Montana, Great Falls	Great Falls AFB	8900
Nevada, Las Vegas	Nellis AFB	6400
New Jersey, Fort Dix	McGuire AFB	8200
New Mexico, Alamogordo	Holloman AFB	8400
New Mexico, Albuquerque	Kirtland AFB	10,200
Texas, Austin	Bergstrom AFB	7100
Washington, Moses Lake	Larson AFB	10,000

FORCED LANDINGS.

Successful forced landings depend on the crews familiarity with the proper procedures. One crew member will be designated for the command of each compartment during emergencies and will be responsible for reporting the compartment clear of personnel before leaving. Frequent dry-run drills should be conducted so that the crew will be prepared for this emergency. The instructions contained in the following paragraphs deal with crash landings and ditching.

CRASH LANDINGS.

Crash Landing On Take-Off.

In case of an impending crash landing immediately after take-off, proceed as follows:

1. Pilot—Warn crew to brace for the impact and land straight ahead.
2. Crew—Remain in crash landing positions. (See figures 2-9 and 2-10.)

Note

On airplanes not in group 6, the crew members sitting next to the bulkhead on the aft cabin bunks must turn and brace themselves against the bulkhead.

3. After the impact and deceleration, the lower aft gunners should remove their respective sighting blisters and make their exit.

4. The tail gunner and crew members on the right bunk exit through the right blister port; those on the left bunk exit through the left blister port.

5. The pilots exit through their hatches in the canopy.

6. The engineer may escape through the astrodome opening after removing the guard and the astrodome.

7. All personnel in the radio operator's compartment must use the left escape hatch if possible; however, if jamming prevents removal of the hatch, use the right and left blister ports.

Controlled Crash Landing.

When it is possible, the decision to crash land should be made early enough to allow the crew time for adequate preparation. These general instructions must be remembered in case of a crash landing:

1. Land the airplane with the gear up on any type of terrain except a hard smooth surface or a known airfield.

2. If it is possible, crash land near a road, a telephone line, or a small settlement to assure quick communication and immediate medical aid.

3. The crew must brace for the impact and remain braced until the airplane has come to rest. The forces generated during deceleration are enough to cause serious injury to any unprepared crew member.

Before Approach. When the decision to crash land is made, warn the crew by interphone and by six short

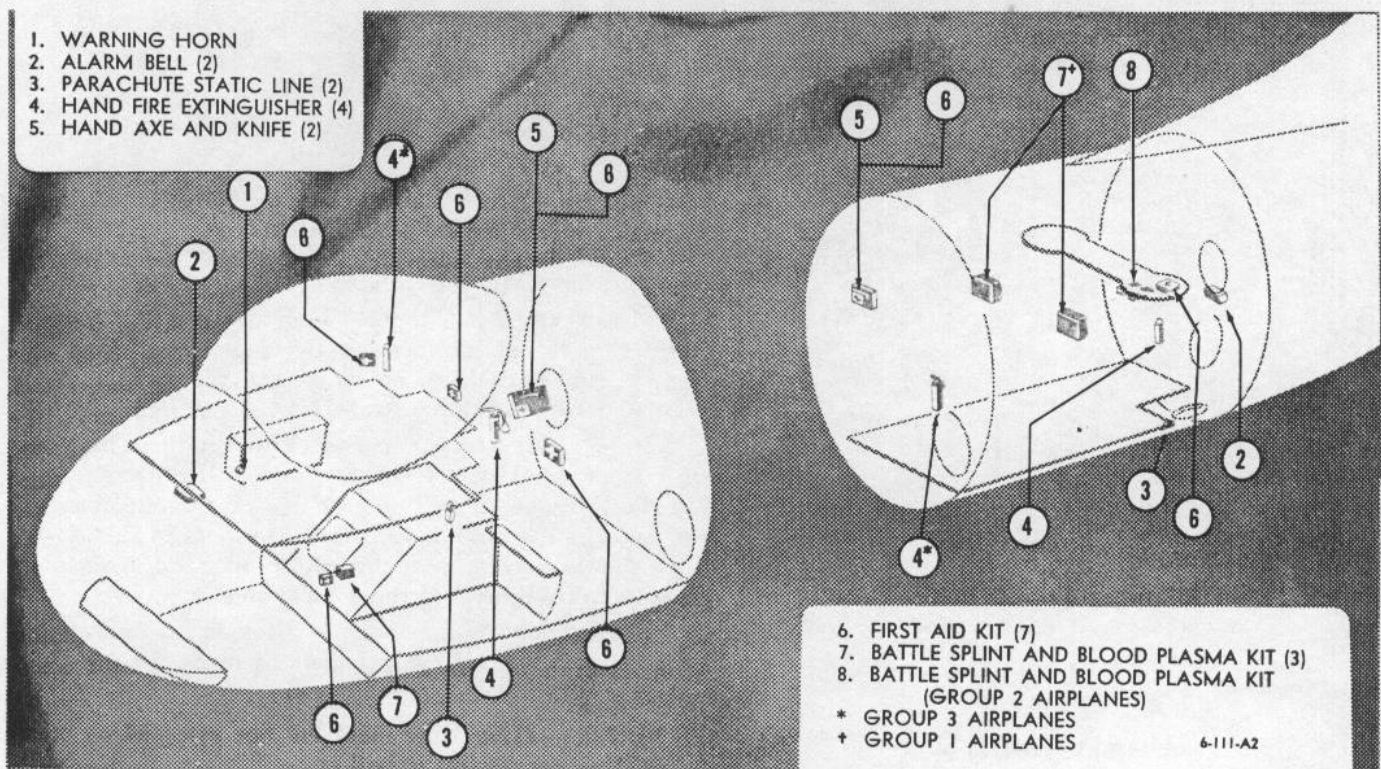


Figure 3-4. Miscellaneous Emergency Equipment

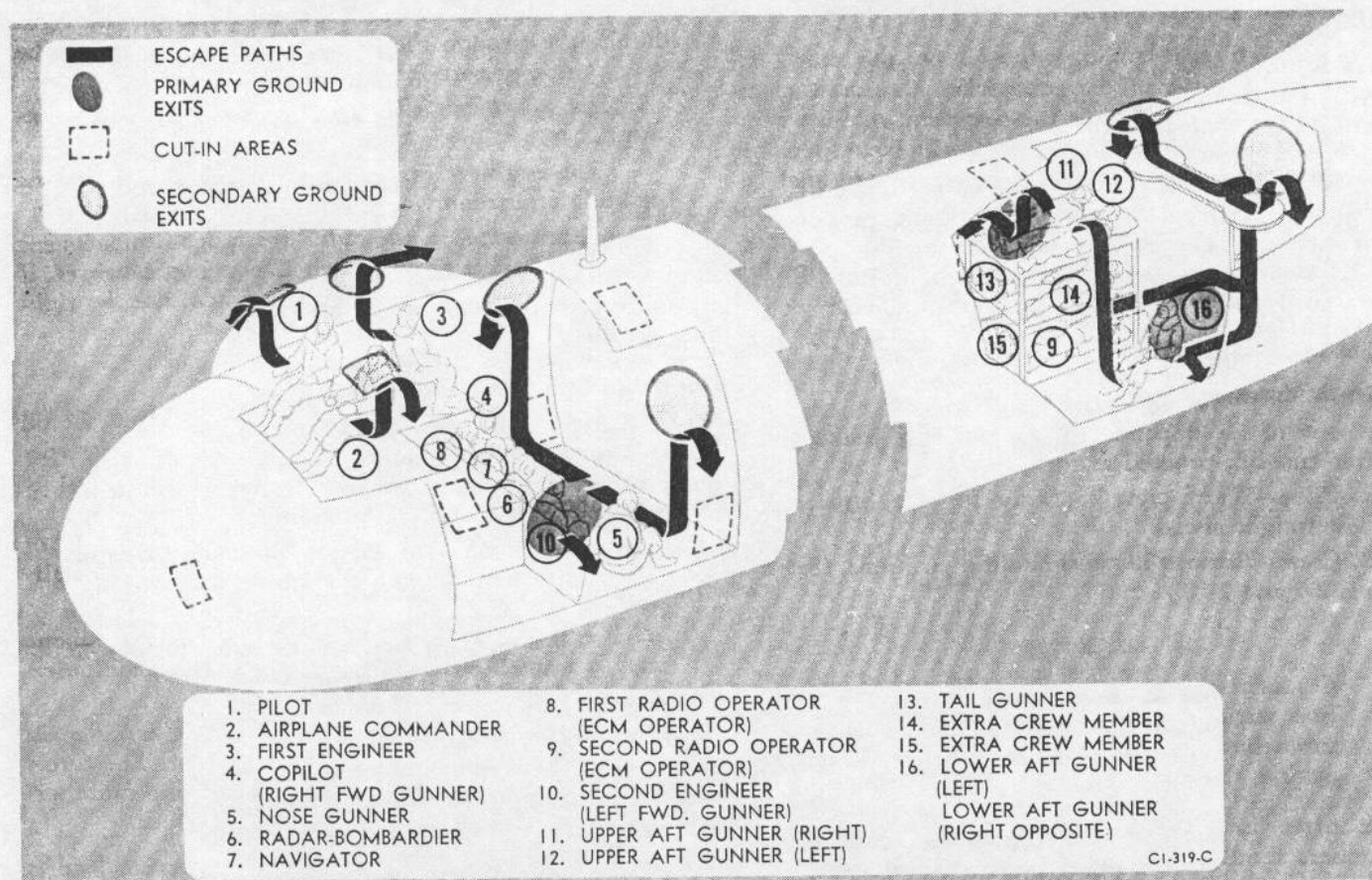


Figure 3-5. Emergency Escape Routes and Ground Exits (Group 6 Airplanes)

rings of the alarm bells. The crew must immediately make the following preparations:

1. Pilot—Salvo all bombs and bomb bay tanks over an unpopulated area if possible.



WARNING

Do not jettison the hand axes, because they may be needed to cut through the fuselage.

2. Bomb bay door switches—CLOSE.

3. Radio Operator—Transmit course, altitude, ground speed, and position; and turn IFF to EMERGENCY.

4. Navigator—Remove left forward escape hatch and stow in nose of airplane.

5. Crew—Jettison all loose equipment and items which might fly loose on impact.

6. To prevent jamming, leave all emergency hatches open, but leave bomb bay doors closed.

7. Forward and Aft Gunners—Unlock the gun sights by rotating the yellow handles 180 degrees; then un-snap the rubber cushions at the base of the sights and pivot sights in and down to the stowed position.

8. Forward and Aft Gunners—Release the three locking clamps on respective blisters and pull blisters inside the fuselage. Blisters in the forward cabin must be placed in the nose of the airplane; those in the aft cabin should be secured under the bunks and against the forward bulkhead of the compartment.

9. Compartment Commander — Report to aircraft commander when his compartment is ready for crash landing.

10. Pilot—Give crew members not essential to crash landing permission to bail out.

11. Pilot—If practical, circle the landing area until the remaining fuel supply is 200 gallons in each wing.

12. Pilot—If the landing is to be made on a known airfield, notify the tower to clear traffic and have crash equipment standing by.

Approach and Contact. Begin the approach far enough from the landing area to allow the remaining crew members time to make last minute preparations. The pilot and the engineer must accomplish the following:

1. Engineer—Obtain a fuel configuration in each wing of one tank feeding three engines and CLOSE the fuel cross-feed valve.

2. Pilot—Fully extend the flaps and maintain a very flat approach.

3. Pilot—By one long ring of the alarm bell and by interphone warn the crew to brace for the impact.

4. Pilots—Tighten safety belts and shoulder harnesses and lock inertia reel lock controls.

CAUTION

The pilots are prevented from bending forward when the inertia reel is locked; therefore, all switches not readily accessible must be "cut" before moving the control to the LOCKED position.

5. Engineer—Mixture control lever—IDLE CUT-OFF on pilot's request. Use hold-in switch for last engine.

6. Engineer—Engine ignition switches—OFF.

7. Engineer—All fuel valve switches CLOSE and battery switch OFF on impact.

Emergency Entrance.

If it becomes necessary to enter the airplane to rescue trapped crew members, use the emergency entrances as shown in figure 3-6. The left and right escape hatches in the forward cabin can be released from the outside if they are not jammed. Otherwise, it is necessary to chop through the fuselage at one of the marked cut-in areas.

DITCHING.

At the present time the B-36 has no permanently installed ditching equipment, but recommendations have been made to provide it with adequate equipment. In the meantime, the aircraft should not be ditched unless water temperatures make living after bail-out improbable, and the position of the aircraft precludes the possibility of immediate rescue of crew members.

Note

The following ditching procedure is for a 15-man crew and is meant to be used as a guide only until adequate provisions are made for ditching the aircraft.

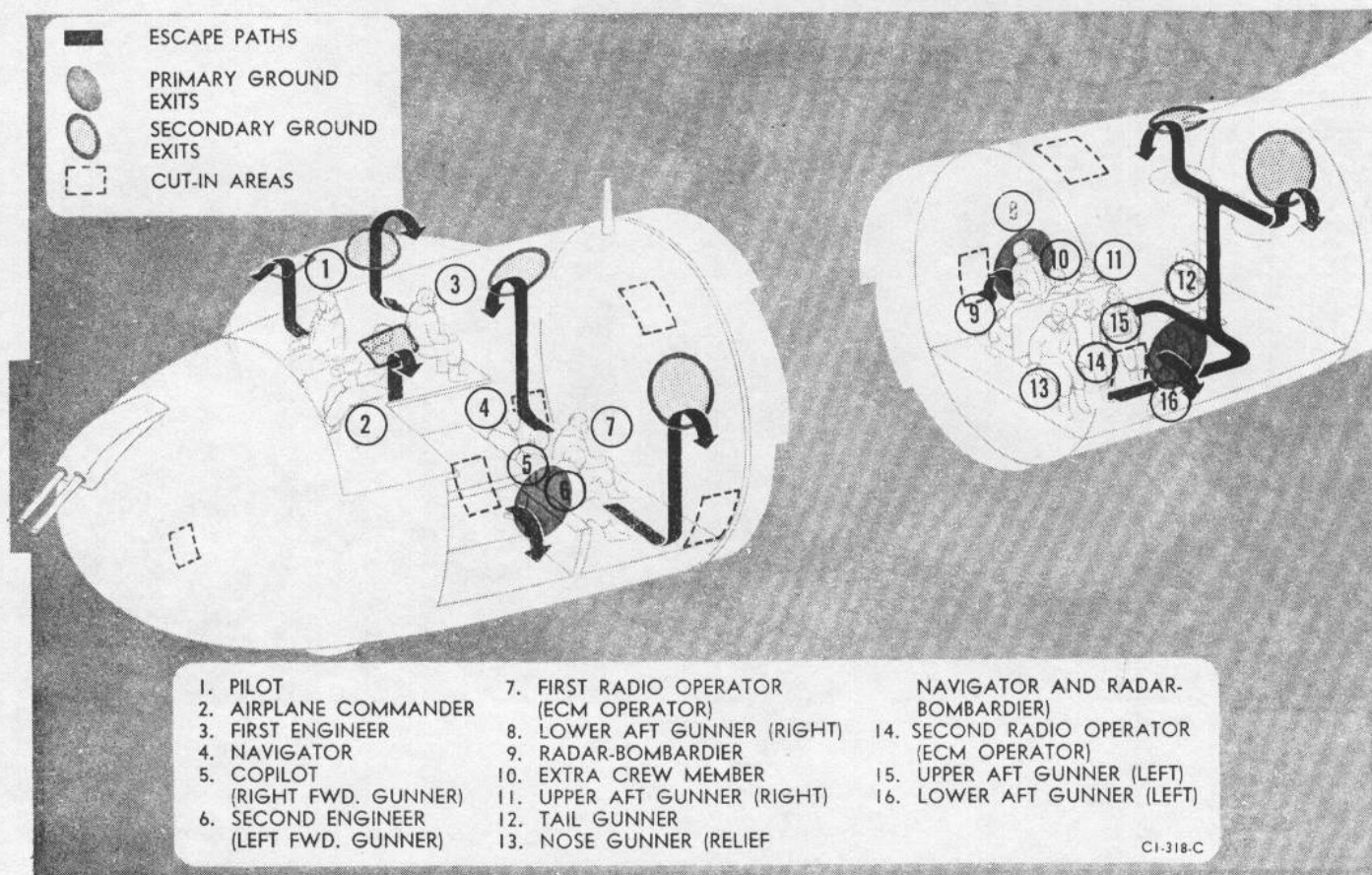


Figure 3-6. Emergency Escape Routes and Ground Exits (Airplanes not in Group 6)

Ditching drills should be performed until each crew member is thoroughly familiar with the procedure and the specific duties for which he is responsible. Make an equipment check before each overwater flight. Kits should be complete and crew life vests, survival suits, and life rafts should be in good condition.

Preparation For Overwater Flight.

Spare emergency equipment for crew members using the turret bay positions for ditching shall be stowed in the bay to eliminate any hindrance in assuming positions. A long interphone cord should also be provided for communication with these crew members.

One type E-2 six-man life raft should be stowed in the radio compartment and two should be tied to the floor of the forward turret bay. A parachute pack with a 25-foot static line must be attached to each life raft with the other end of the static line secured to the airplane. This insures the availability of life rafts in the event a

decision is made to bail out rather than ditch. Another static line 30 feet in length should be provided for each raft to prevent its drifting free from the airplane after ditching. Each of these static lines must be attached to a raft in a manner that will cause the discharge of the inflating bottle when the line is pulled.

WARNING

The 30-foot static lines must be cut after the life rafts are fully loaded and crew members are aboard in order to prevent the sinking airplane from pulling the rafts under.

CAUTION

Be careful to prevent entanglement of static lines which might result in inflation of the life rafts before their ejection.

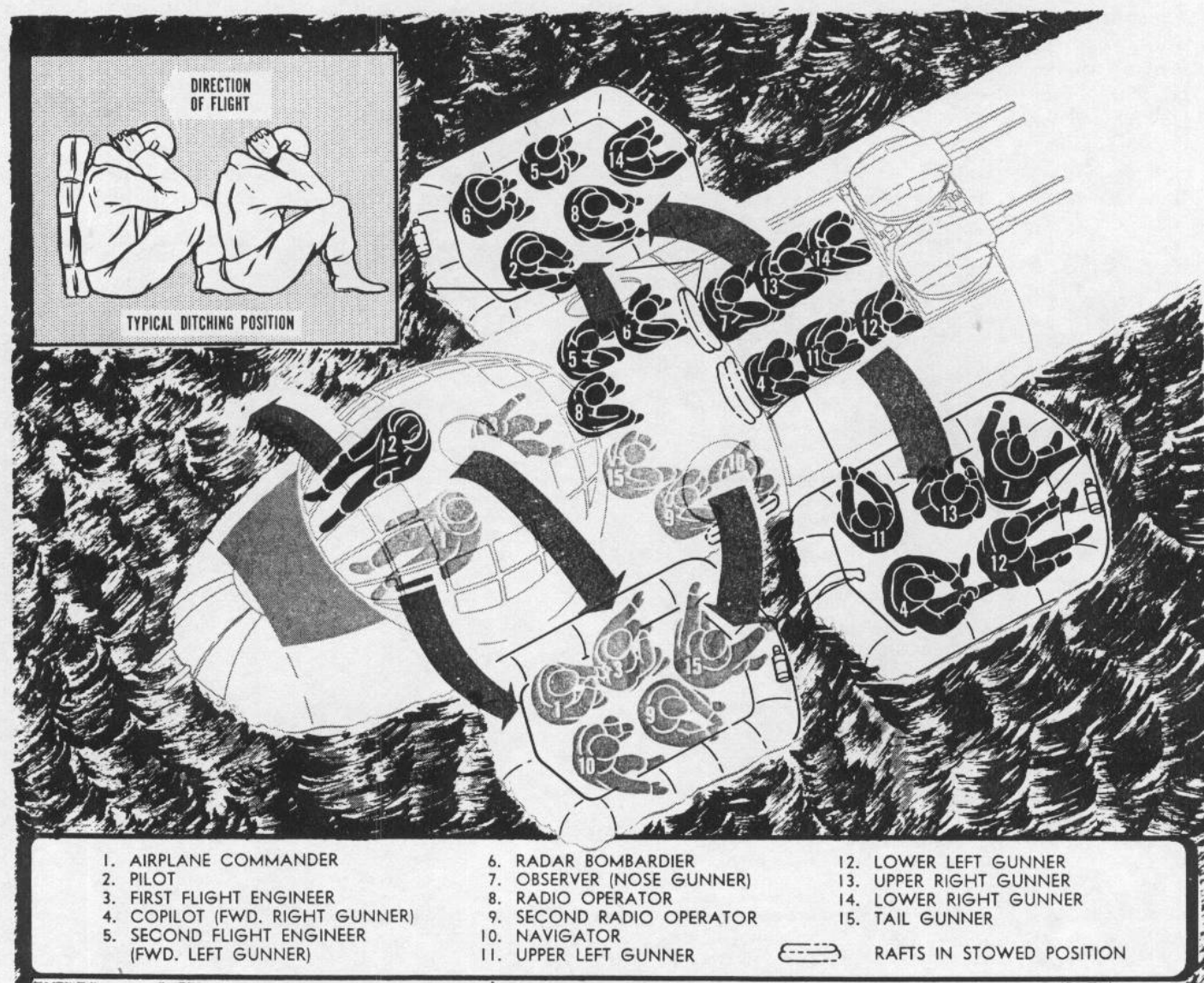


Figure 3-7. Ditching Positions and Exits

A Gibson Girl radio should be stowed on the floor of the radio operator's compartment. Two static lines and a G-8 aerial delivery type parachute shall be provided for the radio. The static lines serve the same purpose as those provided for the life rafts.

Before Approach.

When ditching becomes imperative, give the crew a warning over the interphone and also by six short rings of the alarm bells. Crew members not actively engaged in controlling the airplane should jettison loose equipment and any objects which might fly loose on impact. When jettisoning is completed, crew members must assume the positions shown in figure 3-7 for ditching.

CAUTION

Make sure that the forward turrets are extended and that the guns are stowed aft before the gun sights are stowed. The guns must be stowed aft to provide clearance for the men using the turret bay.

All crew members should remove their flak suits and parachutes. The one-man rafts should be removed from the parachutes and stowed for later use. The crew must don R-1 anti-exposure suits, flak helmets, emergency kits, life vests, and gloves. Neckties should be loosened. The life raft in the radio operator's compartment should be placed against the wall just forward of the communication tube door.

CAUTION

All aft cabin personnel should be forward prior to stowing this raft, since the communication tube door will be blocked.

The copilot, observer, and upper and lower aft gunners must use the forward turret bay positions for ditching. Entrance to the turret bay is made through the catwalk entrance hatch, into the forward bomb bay, and up the ladder just aft of the turret bay. The life rafts in the turret bay must be placed vertically against the forward wall of the turret bay so that they will cushion the shock of the impact for the crew members.

All crew members except the aircraft commander and the pilot shall sit facing aft with their hands clasped behind their heads to prevent snapping their necks on impact. They should use their parachutes and all available padding for their backs. The crew members in the turret bay should sit in three-man tandems, with the back men braced against the life rafts. All upper blisters, pilots' windows, and the astrodome must be removed and the blisters stowed prior to impact. After the impact each man must take his one-man life raft when he leaves the airplane.

Crew Responsibilities.

When a decision is made to ditch the airplane, each crew member must follow the procedures established in the following paragraphs:

Aircraft Commander.

1. Duties before impact:

- a. Warn pilot—"Prepare for ditching in ____ minutes."
- b. Give 6 short rings on the alarm bells.
- c. Order pilot—"Open emergency exits and jettison loose equipment." Open canopy windows and jettison if possible.
- d. Fasten safety belt and shoulder harness.
- e. Radio other craft of your distress, giving position and time. Have the radio operator broadcast a position report and turn the IFF emergency switch ON.
- f. Order pilot—"Stations for ditching. Impact in ____ seconds." Have pilot obtain weight from engineer and figure the stalling speed.
- g. About five seconds before impact, give order: "Brace for impact." Have the pilot give one long ring on the alarm bell.

h. Instruct engineer to complete ditching configuration.

2. Position:

- a. Lower seat and push rearward. Brace feet on rudder pedals with knees flexed and hands on control wheel after locking inertia reel.



CAUTION

The pilots are prevented from bending forward when the inertia reel is locked; therefore, all switches not readily accessible must be "cut" before moving the control to the LOCKED position.

3. Duties after ditching:

- a. Check to see that the crew is clear, and exit through the left canopy window.
- b. Take command of the left forward raft. Supervise removal of injured crew members and the securing of emergency equipment aboard the rafts. Guide the raft from the airplane and, when at a safe distance, order the life rafts tied together.

Pilot.

1. Duties before impact:

- a. Relay the aircraft commander's instructions to the crew. Receive acknowledgements and notify the aircraft commander, "Crew notified."
- b. Open the window; jettison if possible.
- c. Fasten shoulder harness and safety belt.
- d. Stand by on interphone to relay aircraft commander's orders to crew. Check progress of crew in jettisoning equipment. A minimum of one minute before impact, order radio operator to clamp down key and assume ditching position. Relay command, "Brace for impact." Send one long ring on the alarm bell.

2. Ditching position:

- a. Lower seat and push rearward. Brace feet on rudder pedal stand with knees flexed, left hand on left knee, and right hand braced against the right window frame after locking inertia reel.

CAUTION

The pilots are prevented from bending forward when the inertia reel is locked; therefore, all switches not readily accessible must be "cut" before moving the control to the LOCKED position.

3. Duties after ditching:

- a. Exit through the right window.
- b. Take command of the right raft. Direct removal of emergency equipment. Guide the raft away from the airplane; and then at a safe distance, join other rafts and assist in tying ALL rafts together.

Flight Engineer.

1. Duties before impact:

- a. Acknowledge ditching order.
- b. If ditching is necessary because of insufficient fuel, estimate the remaining time aloft and inform aircraft commander and the navigator.
- c. Take the first aid kit from under the table and pass it to the second engineer.
- d. Fasten safety belt.
- e. On command, open the astrodome hatch and pass it to the nose compartment. If possible, obtain a fuel configuration in each wing of a single tank feeding three engines.

f. On aircraft commander's command, "Complete ditching configuration": CLOSE the tank valves; hold-in switch — IN; mixture control — IDLE CUT-OFF; master ignition switch—OFF; battery switch—OFF.

2. Ditching position:

- a. In the engineer's seat facing aft with hands clasped behind head to prevent snapping the neck on impact.

3. Duties after ditching:

- a. Take all necessary equipment and exit through the engineer's escape hatch to left forward raft.
- b. Assist injured crew members and aid in stowing equipment aboard raft.

Navigator.

1. Duties before impact:

- a. Acknowledge ditching order.
- b. Through coordination with the aircraft commander and the engineer calculate the course, altitude, ground speed, and position of ditching. Give this information and an accurate Loran line to the radio operator so that he may broadcast a position report.

c. Inform aircraft commander of surface wind speed and direction.

d. Destroy classified documents and material and aid in jettisoning all loose equipment. Gather essential maps and navigation equipment into watertight bags or tuck into clothing.

2. Ditching position:

- a. Sitting on radio compartment floor on left side of fuselage.

3. Duties after ditching:

- a. Assist in ejecting life raft through left blister.
- b. Take necessary equipment and exit from blister to left forward raft.
- c. Assist injured crew members and aid in stowing equipment aboard the raft.

Second Radio Operator.

1. Duties before impact:

- a. Acknowledge ditching order.
- b. Assist radio operator in jettisoning all unnecessary equipment.
- c. Secure first aid kit to arm.
- d. Destroy all classified documents.

2. Ditching position:

- a. Between navigator and tail gunner facing aft on radio compartment floor.

3. Duties after ditching:

- a. Assist in ejecting life raft through left blister.
- b. Take CRC-7 VHF transmitter-receiver into left forward life raft.

Tail Gunner.

1. Duties before impact:

- a. Acknowledge ditching order.
- b. Destroy all secret equipment.
- c. Proceed through communication tube to forward ditching position with first aid kit secured to arm.

2. Ditching position:

- a. Seated on floor in radio compartment between first and second radio operators.

3. Duties after ditching:

- a. Assist in ejecting life raft and other emergency equipment through left blister and board left forward life raft.

First Radio Operator.

1. Duties before impact:

- a. Acknowledge ditching order.
- b. Check IFF emergency switch ON, if installed.
- c. Transmit position, course, altitude, and ground speed as received from navigator. Relay fix or bearings and estimated time and position of ditching.
- d. Jettison radio operator's chair.
- e. Remain on interphone.
- f. On command of pilot, screw down key.

2. Ditching position:

- a. Seated on floor in radio compartment between tail gunner and second engineer.

3. Duties after ditching:

- a. Proceed to right forward raft through right blister with Gibson Girl radio.
- b. Assist injured crew members and aid in stowing equipment aboard raft.

Second Flight Engineer.

1. Duties before ditching:

- a. Acknowledge ditching order.
- b. Leave turret doors open and guns pointed aft.
- c. Assist first engineer.
- d. Assist in jettisoning loose equipment.
- e. Get first aid kit from first engineer and secure it to arm.
- f. Remove upper left blister and pass to nose section.

2. Ditching position:

- a. Seated facing aft between radio operator and radar operator.

3. Duties after ditching:

- a. Obtain necessary emergency equipment.
- b. Exit through upper right blister to right raft.

Radar-Bombardier.

1. Duties before ditching:

- a. Acknowledge ditching order.
- b. Salvo bombs on command of aircraft commander. Do not salvo bomb bay fuel tank if empty. Close the bomb bay doors.

- c. Take first aid kit from nose compartment and secure it to arm.

2. Ditching Position:

- a. Seated to the right of the second engineer, facing aft.

3. Duties after ditching:

- a. Obtain necessary emergency equipment and exit through upper right blister to right raft.

Copilot.

1. Duties before impact:

- a. Acknowledge ditching order on interphone.
- b. Leave turret doors open with guns stowed aft. Remove upper right blister and pass it to the nose section.

- c. Proceed directly to forward turret bay and connect the interphone cord to the jack box in the forward bomb bay for contact with other compartments.

2. Ditching position:

- a. Sitting against forward bulkhead on left side of forward turret bay. Use parachute and one-man raft for padding.

3. Duties after ditching:

- a. Assist in lowering the lift rafts into the water.
- b. Proceed from turret bay and take command of left aft raft.
- c. Assist injured crew members and aid in stowing equipment in raft. Maintain contact with other rafts.

Observer (Nose Gunner).

1. Duties before impact:

- a. Acknowledge ditching order.
- b. Proceed directly to forward turret bay.

2. Ditching position:

- a. Sitting against forward bulkhead on right side of forward turret bay.

3. Duties after ditching:

- a. Assist in lowering the right life raft into the water.
- b. Proceed across the turret bay to the left aft raft.

Upper and Lower Aft Gunners.

1. Duties before impact:

- a. Acknowledge ditching order.
- b. Proceed through the tunnel to the radio compartment and then through catwalk entrance to forward upper turret bay to ditching positions.
- c. The two left aft gunners secure first aid kits to arms.

2. Ditching position:

- a. Left gunners on left side and right gunners on right side of turret bay seated facing aft.

3. Duties after ditching:

- a. Assist in ejecting life rafts.

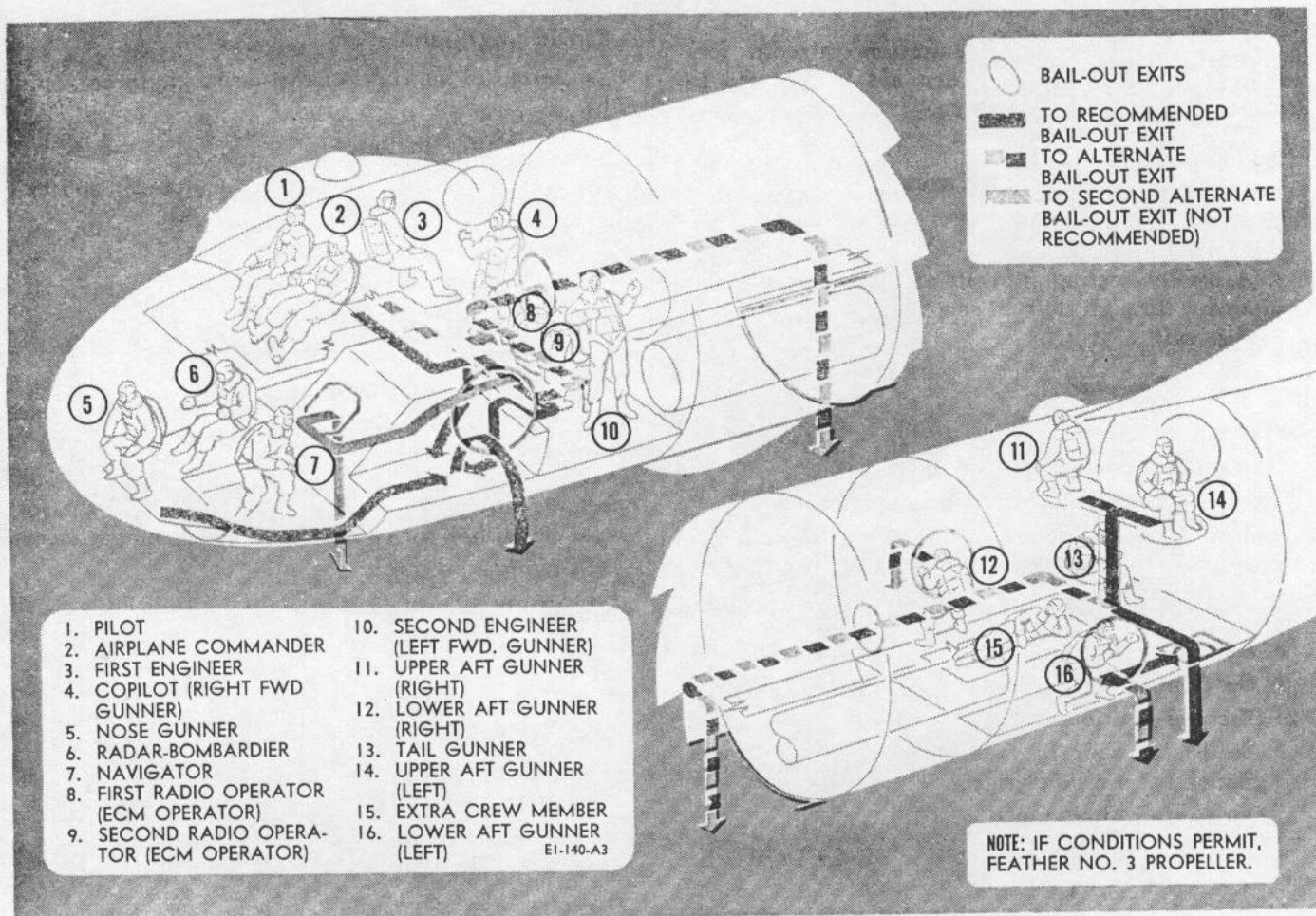


Figure 3-8. Bail-Out Routes and Exits

b. After ejecting life raft, the upper right aft gunner will join the left gunners in the left aft life raft. The lower right aft gunner will go with the right raft.

Approach and Contact.

It is believed that ditching the airplane with 30 degrees flaps while maintaining 9 degree nose-high attitude at a low air speed will result in the most satisfactory procedure. This must be accomplished while power is still available in order to maintain the lowest possible rate of descent. The landing gear should be up and the bomb bay doors closed. Head the airplane parallel to uniform waves or swells. If the sea is irregular and confused, make the ditching into the wind. Aim for contact along the swell crest or just after the crest has passed.

BAIL-OUT.

If over uninhabited territory, all bail-outs should be made so that the crew will land in the same vicinity. If over water and surface vessels are below, the airplane should be headed so that crew members will

drift onto the course of the vessel. A slow turn may be executed or two bail-out runs made, if necessary, to place the men close together. See figure 3-8 for emergency exits. Procedure will vary according to conditions. If circumstances requiring bail-out permit, descend to at least 10,000 feet and minimize forward speed. Steps given below apply to standard unpresurized bail-out procedure.

1. Pilot—Give "prepare to bail-out" emergency signal on aircraft commander's direction: three short rings on the alarm bells, amplified interphone warning.

2. Pilot—Actuate salvo switch to open bomb doors and salvo.

3. Radio Operator—Transmit course, altitude, ground speed, and estimated position of bail-out as received from the navigator, turn IFF emergency switch ON.

4. Navigator—Remove left escape hatch and place it in the nose compartment.

5. Crew—If time permits, destroy classified equipment.

6. Tail Gunner—Open aft compartment entrance hatch.

7. Pilot—Give bail-out emergency signal on aircraft commander's direction: one long sustained ring on the alarm bells, amplified by interphone warning. Direct engineer to feather No. 3 propeller and position the most inboard blade of propeller parallel to the wing.

8. The order of bail-out from the forward compartment should be as follows: Navigator, observer, radar-bombardier (compartment commander), second radio operator, second flight engineer, copilot, radio operator, pilot, flight engineer, and aircraft commander.

9. The order of bail-out in the aft compartment is as follows: tail gunner and upper left, upper right, lower right, and lower left gunner (compartment commander).

10. To bail out of the recommended exit in the forward or aft cabin, the crew members sit at the escape hatch in a tight ball and roll out of the exit. This procedure will eliminate the possibility of being caught on the edge of the hatch.

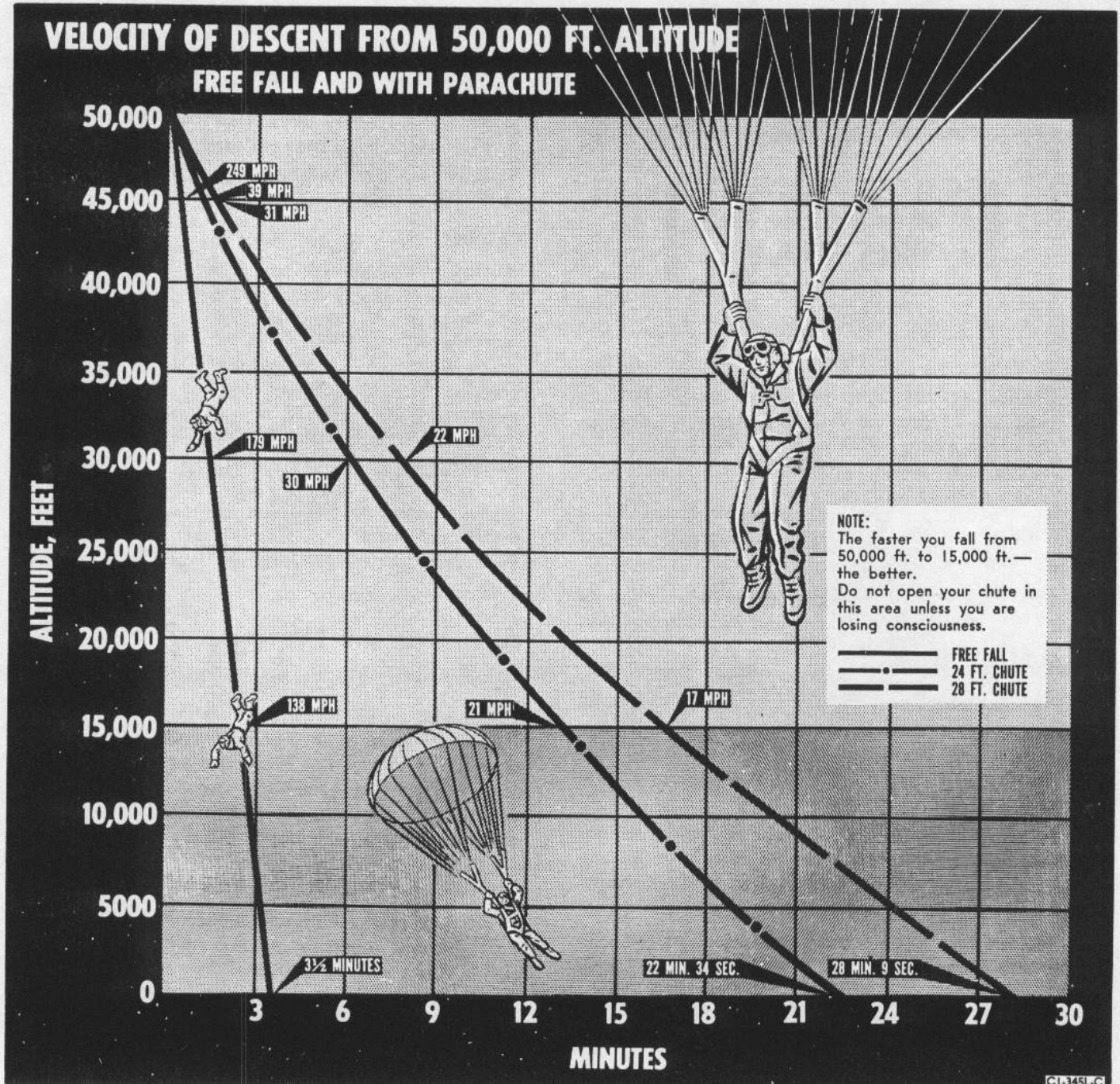
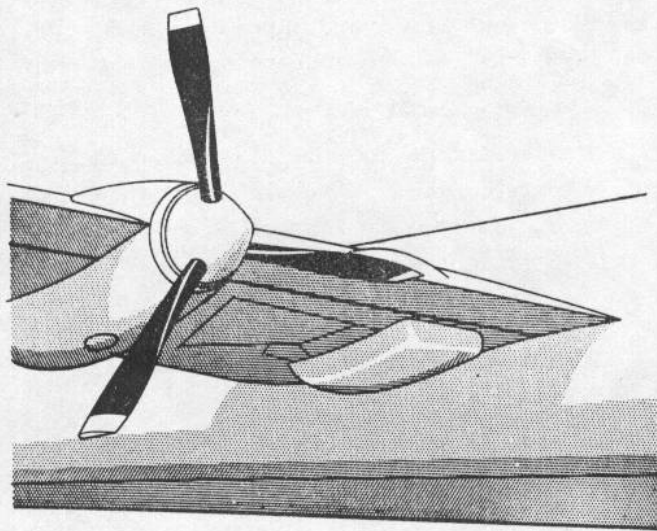


Figure 3-9. Bail-Out Descent Chart

RESTRICTED



WHEN ENGINE 3 IS FEATHERED,
CRANK UNTIL BLADES ARE
THIS WAY!

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Note

If time and conditions permit, as many crew members as possible should bail out of the aft cabin escape hatch as it is considered to be the safest bail-out exit.

11. When using the bomb bay for bail-out, crew members should sit at forward end of the bay and "roll" out head first.

12. Personnel using the wheel well for bail-out should climb down the entrance ladder and jump from there.

HIGH ALTITUDE BAIL-OUT.

If it becomes necessary to bail out at high altitude, every attempt should be made to ride the airplane down to at least 30,000 feet before bail-out is attempted. During this descent, the following steps should be taken:

1. If possible while the airplane is being depressurized, each crew member should remain at his station and breathe 100 per cent oxygen at the required setting for the corresponding altitude.

2. Helmet chin straps should be cinched, mask straps tightened, flying clothes and gloves secured, and goggles put in place.

3. Bail-out bottles should be fastened to parachutes and connected to oxygen masks with oxygen hose under parachute harnesses.

4. Portable oxygen bottles should be used by crew members opening the emergency exits.

WARNING

Each crew member using a portable oxygen bottle will be closely watched by another crew member. At the first sign of anoxia, he will be returned to the ship's system and replaced by another man.

When the alarm bell rings and the interphone command is received for bail-out, each crew member should proceed as follows:

1. Take several deep breaths from the airplane's oxygen system.
2. Pull out the safety pin, actuate the bail-out bottle, and disconnect from the aircraft's oxygen system.
3. Go quickly to the designated escape hatch.
4. Place right hand near rip cord but not on it.
5. With the left hand holding mask to the face and with chin on chest, bail out.

Free Fall. (See figure 3-9.)

Remember, the average useful consciousness is about 15 seconds at 40,000 feet without oxygen. After clearing the airplane, straighten the body and keep the knees flexed and the elbows at the sides. The right hand should remain near the rip cord and the left hand on the mask as during bail-out. If the ground is visible, pull the rip cord to open the chute between 10,000 and 5,000 feet approximately two minutes after bail-out from 40,000 feet. At night or in weather conditions where the terrain is not visible, attempt to free fall for one minute before pulling the rip cord if bail-out is made from above 35,000 feet. When the parachute has opened, readjust and tighten the oxygen mask.

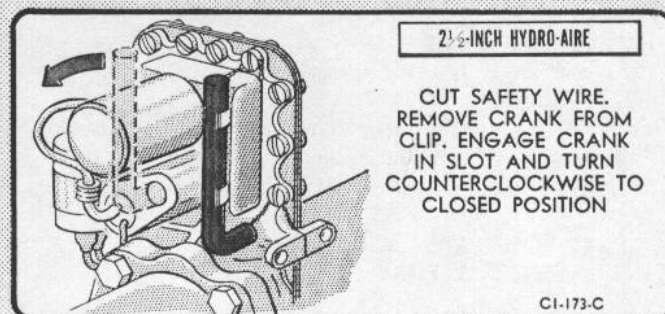
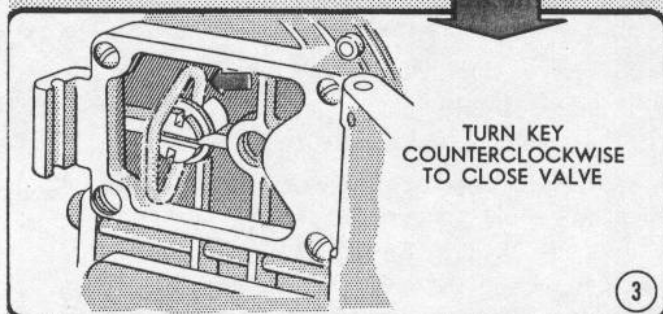
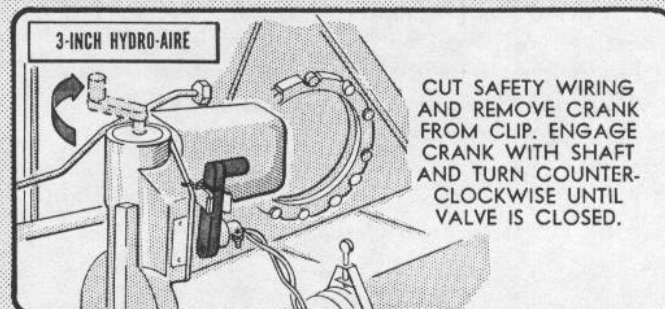
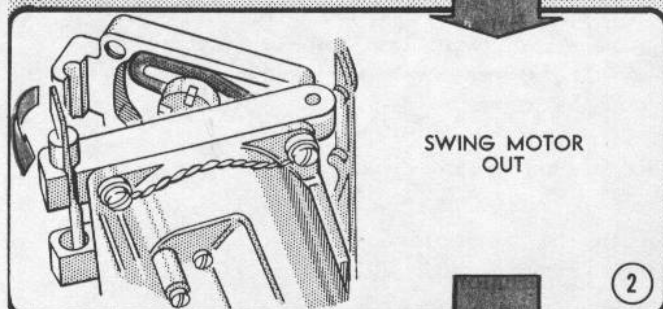
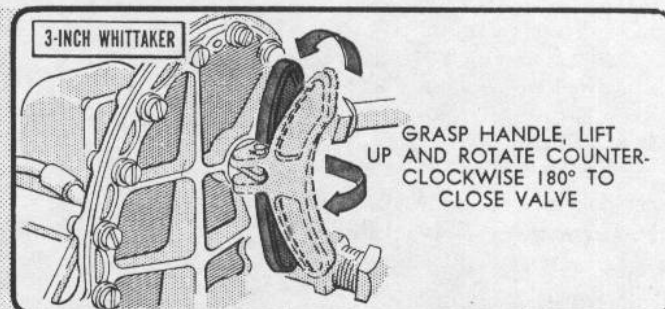
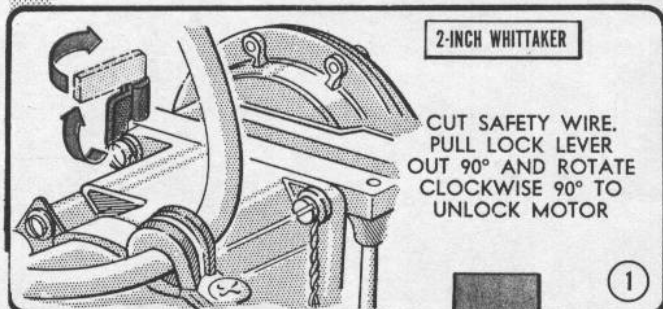
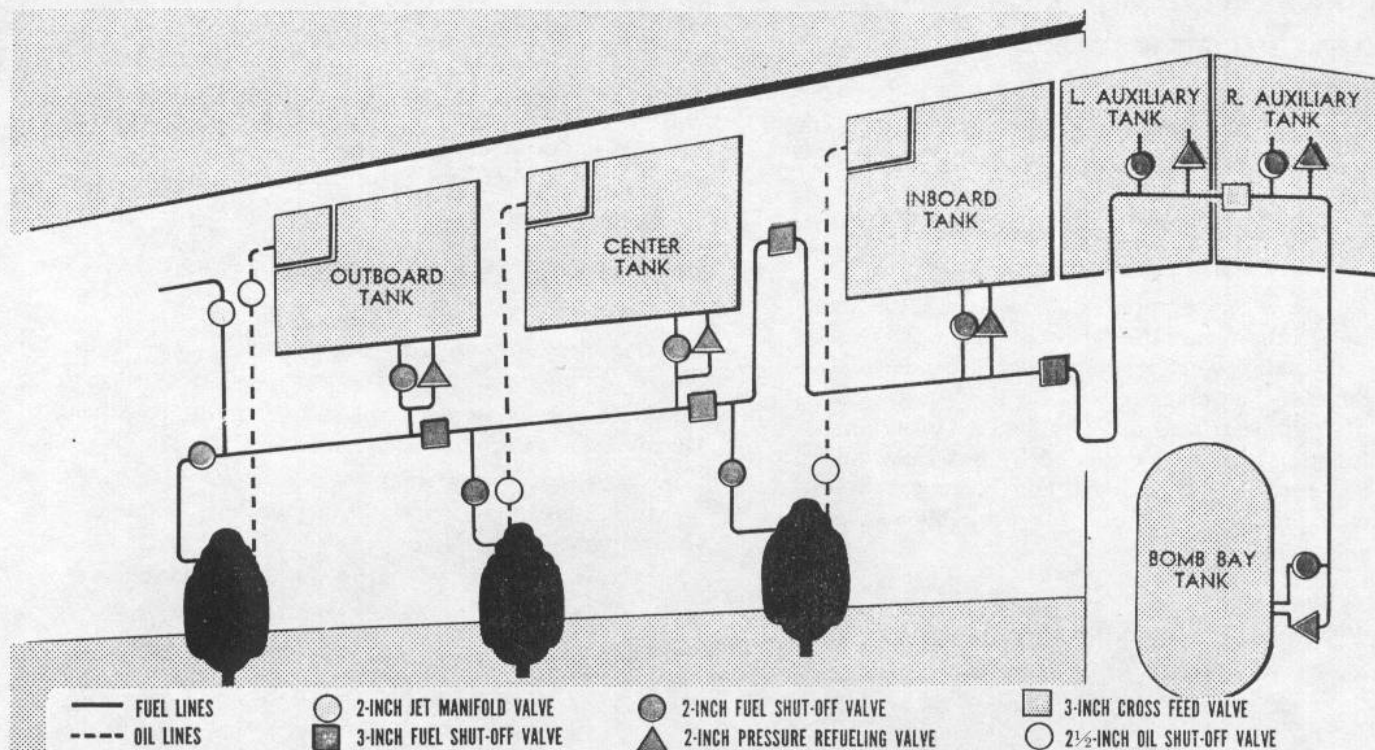
FUEL AND OIL SYSTEMS.

ENGINE-DRIVEN FUEL PUMP FAILURE.

The loss of an engine-driven fuel pump will result in a sharp decrease in fuel pressure and a loss in torque pressure. If this occurs, determine whether or not the engine is delivering enough power to carry itself; if not, feather the propeller. Additional power may be obtained by use of the engine primer in an emergency.

MANUAL OPERATION OF FUEL AND OIL VALVES.

If electrical failure or unit malfunction should prevent normal operation of the fuel and oil shutoff valves, they can be operated manually. (See figure 3-10.) The jet engine fuel and oil shutoff valves and the oil shutoff valve for reciprocating engine No. 6 are inaccessible during flight. The cross-feed valve and the bomb bay tank valves are accessible from the catwalk. The other valves are accessible from the wing crawlway.



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Figure 3-10. Manual Operation of Fuel and Oil Valves

ELECTRICAL SYSTEM.

EXCESSIVE ELECTRICAL LOADS.

At the first indication of an unusual or excessive electrical load for which no correction is immediately evident, perform the following steps as rapidly as possible:

1. All four bus tie breaker switches—OPEN.

Note

To allow more rapid diagnosis, completely isolate the four buses. Bus isolation will insure that power is still available on normal buses. A faulted bus will be indicated by a high kilowatt reading. Any load division malfunction will be eliminated by bus isolation. See Section VII, "Chart For Electrical System Trouble Shooting" for probable causes and remedies.

2. Immediately de-excite any alternator that is carrying too much load, (KWATT or KVAR), or that is fluctuating over 10 cycles or volts.

CAUTION

If it becomes necessary to de-excite No. 5 alternator (which feeds bus 501), the engineer's fuse panel a-c power switch must be placed in the ALTERNATE position. (Check indicator light.)

3. Check the frequency and voltage control and stability of remaining isolated buses.

4. Reduce all electrical loads to a practical minimum until diagnosis is complete.

5. Connect adjacent operative bus to the dead bus and note for excessive loads or fluctuations. If the dead bus is clear of fault, allow the bus to remain energized. If excessive loads or fluctuations are noted, isolate immediately and do not restore power to the affected bus.

6. Use the bus tie breaker switches and the synchronizing lamps to parallel remaining buses.

CAUTION

Restore only essential electrical loads to prevent overloading remaining alternators.

7. If check as stated in step 5 reveals a faulted bus, that bus and its alternator must be left isolated and must not be used until the fault is cleared.

ALTERNATE SOURCE OF A-C POWER FOR THE FLIGHT ENGINEER'S FUSE PANEL.

Should it be determined that a-c power for the engineer's fuse panel has been disrupted, as indicated by the lack of power for such critical items as mixture

controls, spark advance, turbosuperchargers, anti-icing, cabin pressure, etc., check the indicator lamp on the flight engineer's fuse panel to see whether power is being supplied to that panel. If the lamp is not burning, place the fuse panel a-c power switch in the ALTERNATE position. If there is still no indication of power, check the feeder fuses in the left and right cabin power panels.

EMERGENCY ELECTRICAL POWER OPERATION.

Restoring Normal Electrical Power.

If a complete loss of normal alternator power occurs, the following operating procedure will be followed:

1. Place the exciter control switch of all paralleled alternators OFF immediately.
2. Recheck to insure that the alternator breaker indicating lamps of all previously paralleled alternators are lighted.
3. Place the battery switch in the OFF position.



CAUTION

If the battery switch is left ON, the d-c load requirements will drain battery power which should be conserved for operation of essential equipment.

4. Reduce a-c and d-c electrical loads to a minimum.
5. Turn the voltage and frequency selector switch to any alternator which will excite.
6. Re-excite this alternator as follows:
 - a. Momentarily hold the exciter control switch ON.
 - b. Place the emergency power control in the EMERGENCY position.
 - c. Adjust voltage and frequency to normal.
 - d. If voltage and frequency cannot be adjusted, momentarily hold the exciter control switch in the OFF position and proceed to another alternator.
7. If voltage and frequency can be adjusted to normal, connect the alternator to the main bus by holding the alternator breaker switch in the CLOSE position until the indicator lamp goes out.

CAUTION

The kilowatt-kilovar meter should be observed closely while connecting the alternator to the main bus to assure that an overload condition does not exist. An overload reading on the meter indicates either an overload or a fault condition and the alternator should be immediately removed from the line.

8. If the alternator functions normally on the bus, adjust voltage and frequency and return the emergency power control to **NORMAL**.

9. If an overload reading is observed, **OPEN** the alternator breaker switch immediately and then **OPEN** all four bus tie breaker switches.

10. Connect the alternator back to the isolated bus by closing the alternator breaker switch.

Note

If the kilowatt-kilovar meter indicates that the overload condition still exists the bus is faulted and cannot be used until fault is cleared. In this case the alternator should be removed from the line immediately and care exercised to keep the faulted bus disconnected from the rest of the electrical system.

11. After the above procedure is accomplished for each alternator, parallel all working alternators using the bus tie breakers. Use normal paralleling procedures except connect the voltage and frequency selector switch between the two buses to be paralleled. When the alternator synchronizing lamps are dark, **CLOSE** the bus tie breaker switch connecting these two buses.

Obtaining Emergency Electrical Power.

If attempts to get an alternator back on the line fail and there is an alternator capable of being excited, enough a-c and d-c power can be obtained to operate all d-c units and the pilot's attitude and directional gyros. Proceed as follows:

1. Position the voltage and frequency selector switch to any alternator which will excite or which appears to be in underdrive.

Note

An underdrive condition may be verified by increasing or decreasing engine speed and noting that the voltage is proportional to engine rpm.

2. Momentarily hold the exciter control relay switch **ON**.

3. Place the emergency power control in the **EMERGENCY** position.

4. Place the pilot's flight instrument switch in the **EMERGENCY** position.

5. Restore only essential d-c loads.

WARNING

Do not permit the d-c load to exceed 1.0 (50 amperes) as indicated on the loadmeter of the transformer-rectifier test unit, when selected to the **RADIO OPER** position. An overload can damage the t-r unit with a resulting loss of emergency power.

6. If the constant-speed drive is in underdrive, proceed with the following steps:

a. Increase engine rpm to 2000 or above.

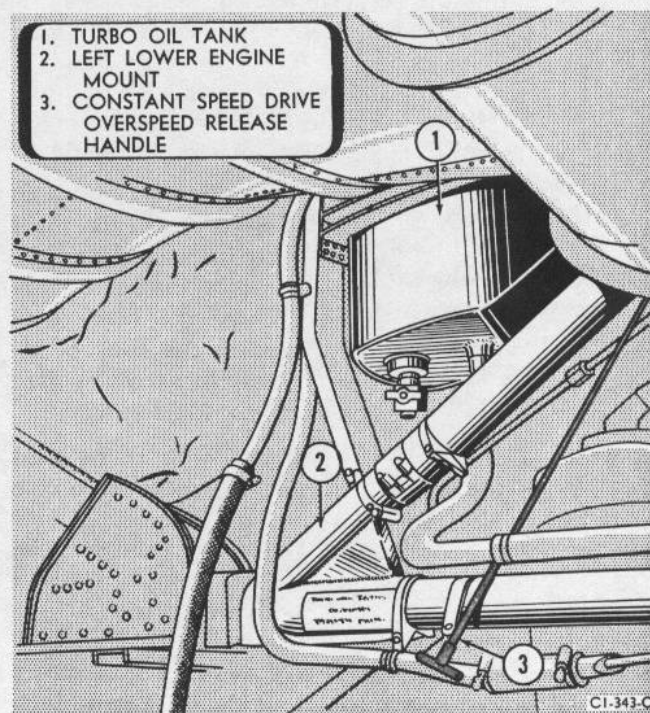
b. Have a crew member proceed to the wing crawlway and pull the underdrive release handle. (See figure 3-11.)

Note

If drive cannot be tripped out of underdrive, full rated alternator power may be obtained by increasing engine rpm to approximately 2700 to obtain a minimum of 380 cycles.

ALTERNATOR MOTORING.

The free-wheeling element in the constant-speed drive permits motoring of the alternators, for short periods of time, as indicated by high kilovar loads and low or negative kilowatt loads; however, if the alternator has motored continuously for approximately 5 minutes and attempts at adjusting the alternator have failed, **OPEN** the affected alternator breaker.



**Figure 3-11. Constant Speed Drive
Overspeed Trip Release**

CAUTION

Do not feather the affected engine. This action is not necessary since opening the alternator breaker protects the electrical system and the shear section of the constant-speed drive protects the engine in the event that the motoring was caused by internal drive failure.

EMERGENCY FLIGHT PROCEDURES IN THE EVENT OF COMPLETE FAILURE OF A-C POWER.

A complete failure of all four alternators to the extent that not even one could be excited through the emergency electrical system or by use of the battery constitutes an extreme emergency. The battery switch must be placed in the OFF position immediately and only be turned to the ON position when an engine rpm change is desired. All electrical switches throughout the aircraft must be placed to the OFF or neutral position in order to conserve the battery.

This electrical failure would most probably occur during a cruise condition, but regardless of when it occurs, every precaution must be taken by the aircraft commander and the flight engineer to control the engines so as not to cause engine failures before a successful landing is accomplished.

If a cruise is required before reaching a landing field, and the electrical failure occurred when a cruise power was set, leave the engine controls as they were when the electrical failure occurred. The engineer would have no indication of the engine power since all auto-syn instruments (torque pressure, manifold pressure, and fuel flow) would be inoperative. Air speed would be the best indication of the power settings of the engines. If the air speed gets excessive, retard the throttles. If the air speed gets too low increase the engine rpm gradually by intermittent use of the battery and propeller selector switches. Because the waste gates should remain where they were at the time of the electrical failure, engine power may be varied by gradual changes in engine rpm and throttle settings.

If a descent of several thousand feet is to be made and a relatively low engine rpm was set at the time of electrical failure, the rpm must be increased occasionally by intermittent use of the battery and the propeller selector switches in the descent. This is due to the more dense air at lower altitudes which would tend to automatically decrease the engine rpm (approximately 50 rpm decrease for each 1000 foot descent). Continue to hold the desired rpm throughout the descent by intermittent use of the battery and propeller selector switches at 5000-foot increments and control air speed by use of the throttles. As the aircraft approaches the landing

pattern altitude, *gradually increase* the rpm to 2600 and continue to adjust the throttles to maintain the desired air speed. This procedure will prevent exceeding the engine limitations to destructive values even if the waste gates are closed more than they normally would be. Extreme care must be exercised when increasing the engine rpm since the manifold pressure is dependent upon the waste gate position as the rpm is increased. As the rpm is increased RETARD the throttle at the same time and cross reference cylinder head temperature. A safe landing can be accomplished even if the engines were in advanced spark and manual lean at the time of the complete electrical failure. By constant surveillance of air speed and adjustment of the throttles, the engines would be operating at a reasonably low bmep which would "cushion" the manual lean and spark advance settings.

The aircraft commander will order the landing gear extended by use of the emergency hand pump and selector valve in the radio compartment.

CAUTION

The emergency reservoir must be reserviced after the landing gear is extended. If this method of extension is unsuccessful the aircraft commander will order a mechanical drop of the landing gear. The aircraft commander will accomplish the landing without the aid of the wing flaps and a "go-around" should not be attempted due to the high engine power requirements with these adverse conditions.

Reverse propellers may be used after touch down by use of the battery and reverse pitch switches. A crew member will be standing by at the emergency hand pump in the radio compartment with the selector to the CHARGE BRAKE ACCUMULATOR position. The aircraft commander must use steady pressure on the brake pedals to conserve brake accumulator pressure. After the aircraft has stopped the engineer will shut down all engines by CLOSING all engine fuel valves and then turning the battery switch OFF.

WING FLAPS.

At any time a pair of flaps fails to extend or retract normally it will be necessary for someone to operate the emergency switches on the alternate flap control panel near the right wing crawlway entrance. The following steps should be accomplished to raise or lower the flaps in an emergency:

1. Plug in a headset at the alternate flap control panel to establish interphone contact with the pilots and gunners.

Note

In some airplanes it will be necessary to turn the wing crawlway lights and interphone

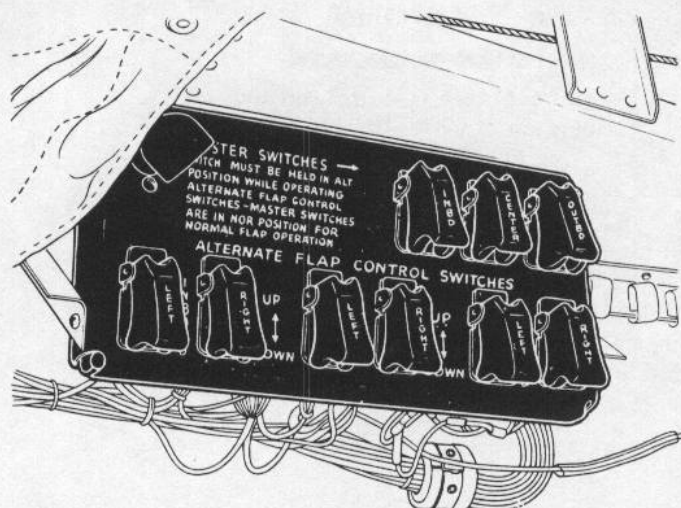


Figure 3-12. Emergency Flap Controls

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switches to the ON position to utilize this jackbox.

2. Hold the proper alternate flap control selector switch in the UP or DOWN position, depending on the flap movement desired.

3. With the aft cabin gunners checking flap position, hold the proper alternate flap control selector switch in the spring-loaded ALTERNATE position.

4. Have the gunners stop you when the flaps are approximately equal. If the synchronizing system is completely inoperative, proper flap positioning will depend on the judgment of the gunners.

If the synchronizing system is operative and you move the lagging flap approximately two and one-half degrees past the position of the symmetrical good flap, the gunner will notice that the good flap will follow with a jumping motion. To keep the flap settings at the required deflection, the gunner must inform you to release the switch at the first movement of the good flap. At this point, both flaps will be equal in deflection.

Note

If the emergency flap control system is inoperative, check alternate flap panel circuit breaker switch at bulkhead 8.0 D.C. power panel then check the fuses at the respective engine power panel of each flap. If the fuses are blown, replace them and attempt the emergency switches again before trying the normal system. If the emergency system works, do not use the normal system until maintenance can be accomplished.

EMERGENCY LANDING GEAR OPERATION.

If the landing gear fails to respond to the positioning of the landing gear control switch, three emergency

methods are provided to effect landing gear operation. These methods are as follows:

1. Manual Operation of Main Selector Valve.
2. Emergency Hydraulic Landing Gear Extension.
3. Manual Extension of Main and Nose Landing Gear.

Note

Gear retraction can be accomplished by the first method only. Extension can be accomplished by any of the three methods.

For emergency gear extension these procedures should be attempted in the order listed, except when the main hydraulic reservoir is empty; in this case the first procedure should be omitted. To determine the probable cause of normal control failure, proceed as follows:

1. Place the landing gear control switch in EXTEND or RETRACT as required.

Note

If no hydraulic pressure is indicated, the landing gear extend or retract relays may be inoperative.

2. Hold the hydraulic pump override switch ON.

Note

- a. If there is no hydraulic pressure, check the main hydraulic reservoir fluid level and the main hydro pump fuses in the main a-c power panel.
- b. If pressure is indicated, but the gear does not operate, a faulty electrical circuit to the selector valve may be the source of trouble.
3. Turn the landing gear control switch OFF and release the hydraulic pump override switch to OFF.

CAUTION

Do not operate the main hydraulic pumps more than two out of every ten minutes at maximum pressure since sustained operation will damage the pump motors.

MANUAL OPERATION OF MAIN SELECTOR VALVE.

1. Landing gear control switch—OFF.
2. Landing gear control circuit breaker—Pull out.

CAUTION

The preceding steps should be accomplished to prevent inadvertent operation of the gear.

3. Main selector valve—Push in and hold the UP or DOWN landing gear plunger, as desired.

CAUTION

The crew member operating the selector valve must be in interphone contact with

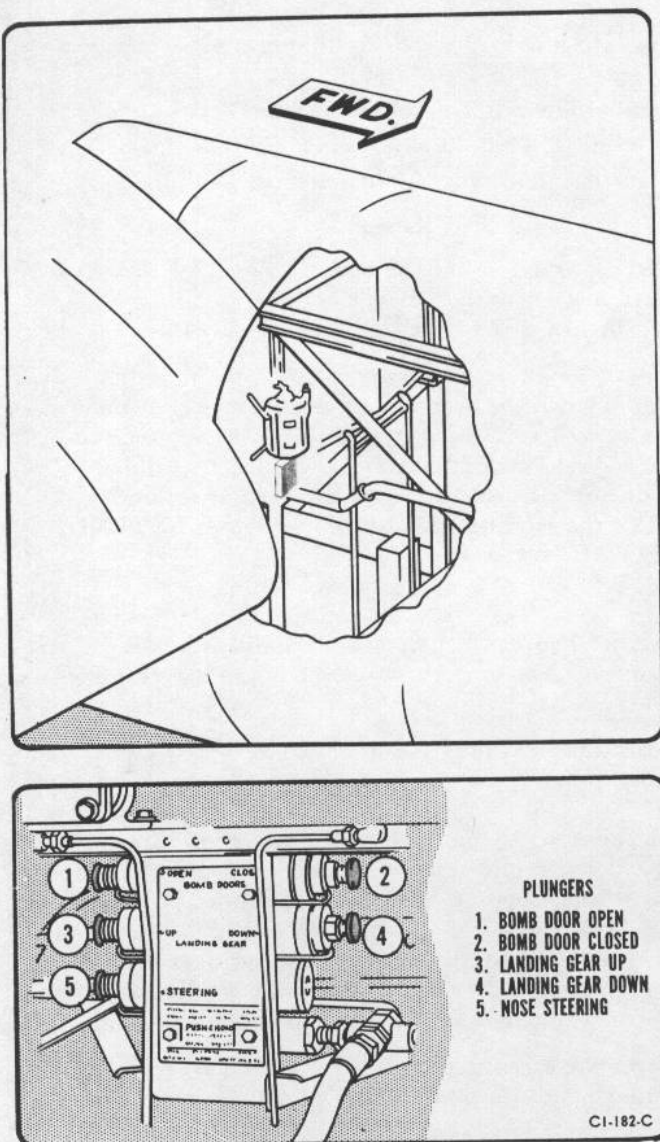


Figure 3-13. Main Hydraulic Selector Valve Controls

the aircraft commander, engineer, and gunners, and must notify the engineer when he has positioned the valve plunger.

4. Hydraulic pump override switch—Hold ON until lower aft gunners report that the desired gear action has been completed, then turn OFF.

CAUTION

To prevent pump motor damage, limit the operation of the main hydraulic pumps to two minutes out of every ten minutes at maximum pressure.

5. Main selector valve—Release plunger when notified that gear action has been completed.

WARNING

To be sure the gear is down and locked, the aft gunners should visually check the position of the pink fluorescent flag (figure 3-14) on each main gear side brace. The flags will not be visible when the gear is down and locked. Gunners will also notice a snapping motion of the latch link rod as it goes into the locked position.

6. Landing gear control circuit breaker—IN and check gear position indicator lights.

7. Nose gear—Checked visually down and locked by the radio operator.

EMERGENCY HYDRAULIC EXTENSION.

If the main hydraulic pumps fail to operate in response to the landing gear control switch or the pump override switch, use the following procedure to extend the landing gear:

1. Landing gear control switch—OFF.
2. Landing gear control circuit breaker—Pull OUT.

CAUTION

The preceding steps will prevent inadvertent operation of the gear. The crew member pumping the gear down must establish interphone contact with the aircraft commander and the gunners.

3. Emergency selector valve—Position at EXTEND LANDING GEAR.

4. Hand pump—Operate until the gear is down and locked. The nose gear usually extends first, the main gear doors open, and then the main gear extends.

Note

The main gear doors will remain down since they cannot be retracted by hand pump operation.

WARNING

If the green landing gear indicator light does not come ON when the landing gear control circuit breaker is pushed IN, make a visual check at the wing crawlway entrances to be sure the gear is down and locked.

5. Emergency selector valve lever—Return to the CHARGE BRAKE ACCUMULATOR position.

CAUTION

The emergency selector valve must be placed in the CHARGE BRAKE ACCUMULATOR position before operating the normal brake hydraulic system. Otherwise, fluid will be transferred into the emergency reservoir if the emergency brake check valve between the emergency selector valve and the hydraulic gage line is leaking.

CAUTION

If fluid begins to overflow in the emergency reservoir during gear extension, the emergency selector valve must be placed in EXTEND LANDING GEAR to prevent further loss of fluid.

WARNING

If the normal gear system is operated after an emergency extension of the gear, the landing

gear control switch must first be moved to EXTEND to properly position shuttle valves and close canoe doors. Because the landing gear doors remain down after a hand-pump extension of the gear, the gear and the doors might retract simultaneously if the landing gear control switch was moved to RETRACT first.

CAUTION

If during hand pump extension of the gear, the landing gear control switch is inadvertently moved to RETRACT, a hydraulic lock will be created between the nose gear emergency extension line and the emergency hand pump. To overcome this condition, momentarily place the landing gear control switch in EXTEND. This action will reposition a shuttle valve in the nose gear emergency line and remove the hydraulic lock. There will be no loss of hydraulic fluid and the resulting pressure will be normal.

6. Reservice emergency hydraulic reservoir prior to landing.

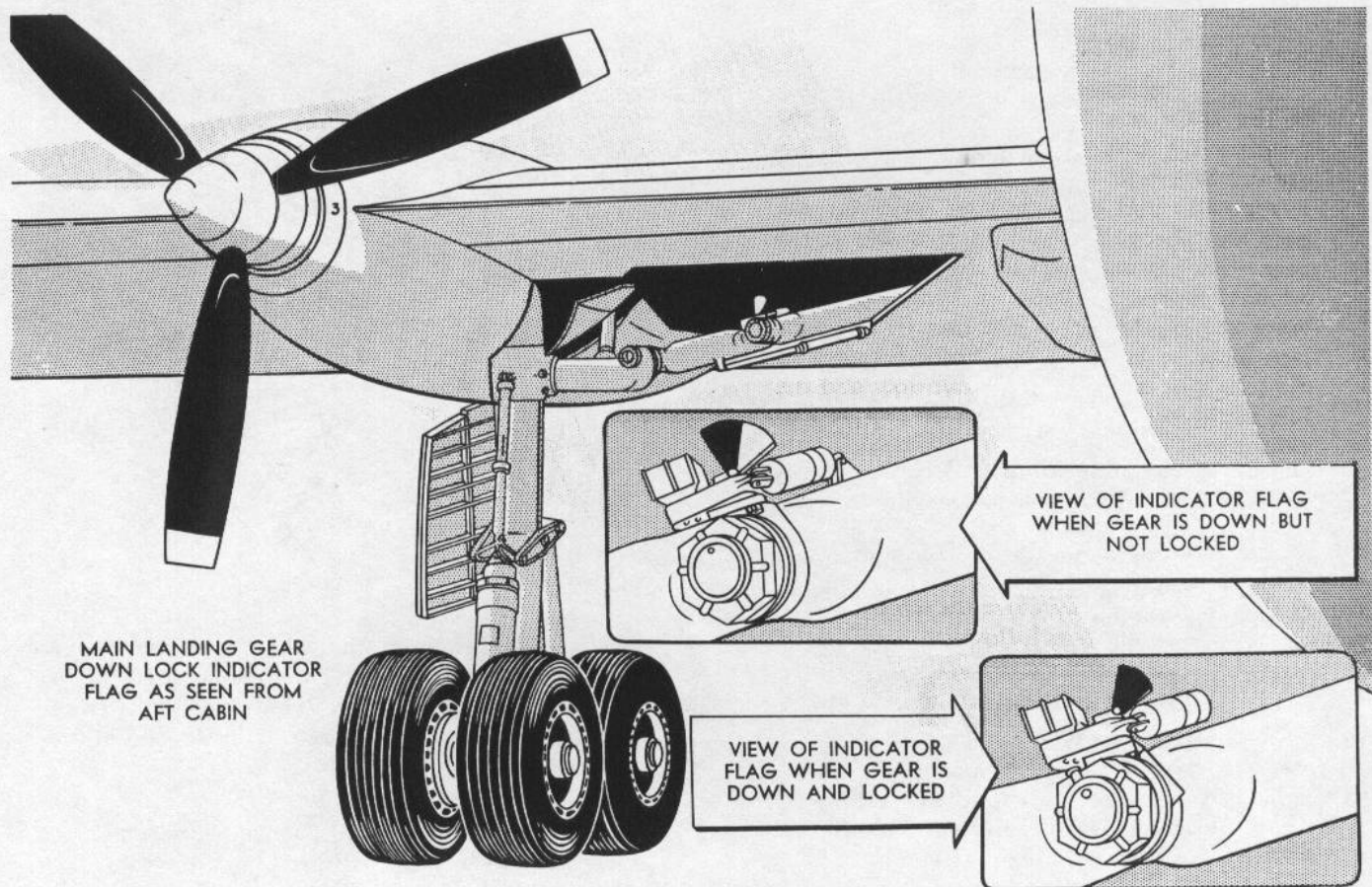


Figure 3-14. Side Brace Latch Indicator Flag

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1. HOIST HOOK STOWAGE STRAP
2. HOIST LOCK PIN
3. HOIST RATCHET HANDLE
4. WHEEL WELL DOOR RELEASE HANDLE
5. HOIST HOOK
6. LATCH LINK PIN

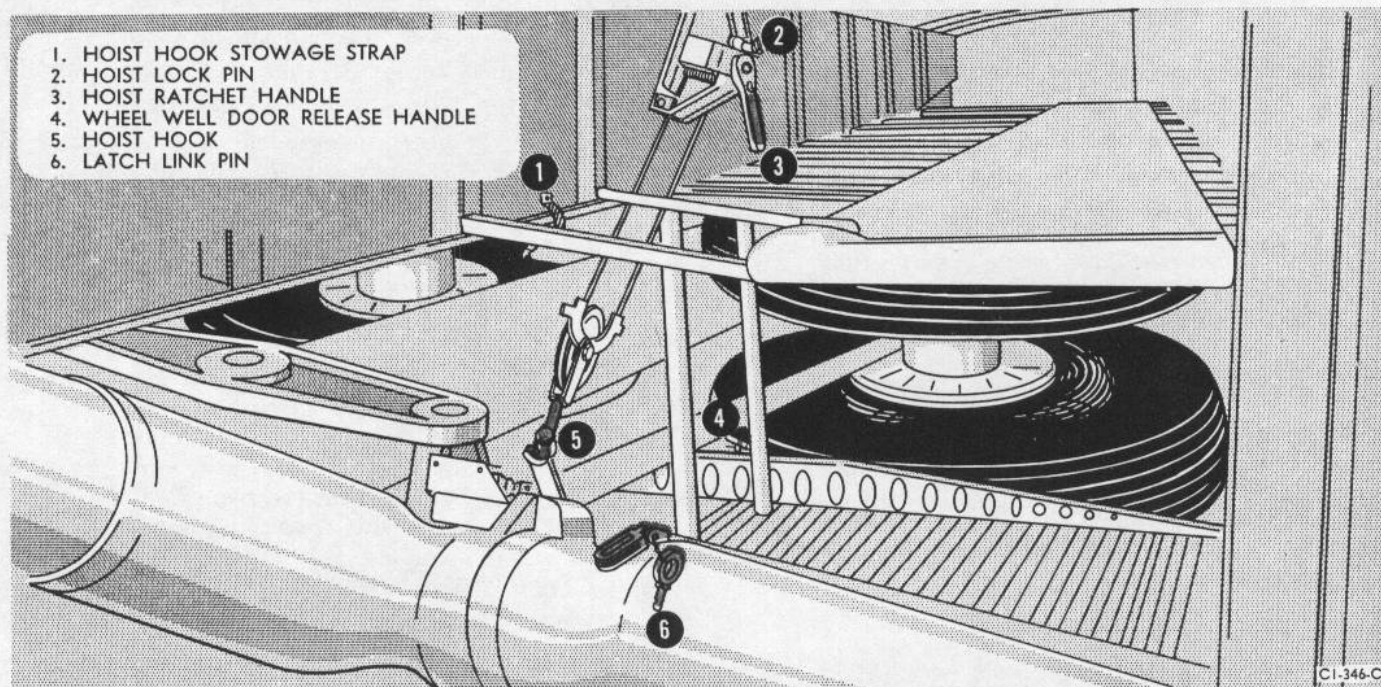


Figure 3-15. Main Landing Gear Manual Extension Controls

MANUAL EXTENSION OF MAIN LANDING GEAR.

WARNING

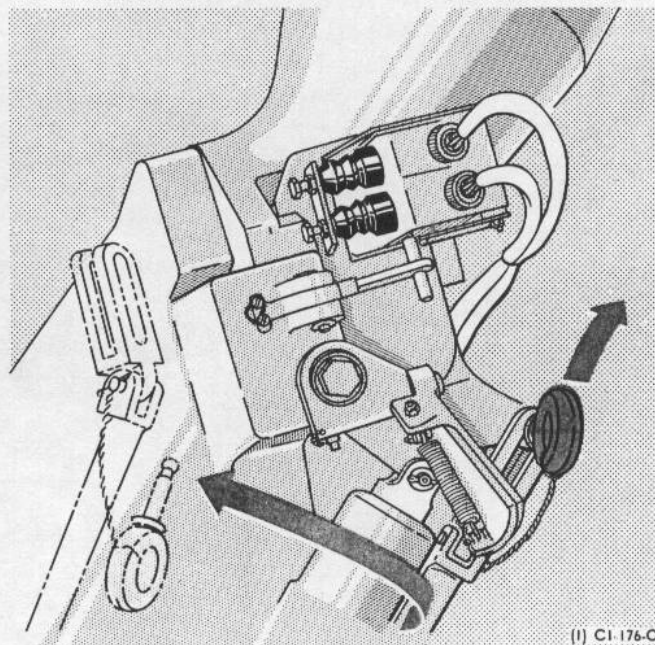
If the main selector valve is stuck in the position for landing gear retraction, a hydraulic lock will be created between the selector valve and the actuating jacks for the gear and the gear door. In this event, the gear cannot be extended by the manual method until hydraulic lines are loosened to remove the liquid lock. The line to the door jack must be loosened at a point forward of the restrictor to allow door extension, and the line to the cushion valve must be loosened to permit gear extension.

Each main gear is accessible from the wing crawlway. The locations of manual controls are shown in figure 3-15.

One crew member should be on the interphone system at the wing crawlway entrance while another accomplishes the extension as follows:

WARNING

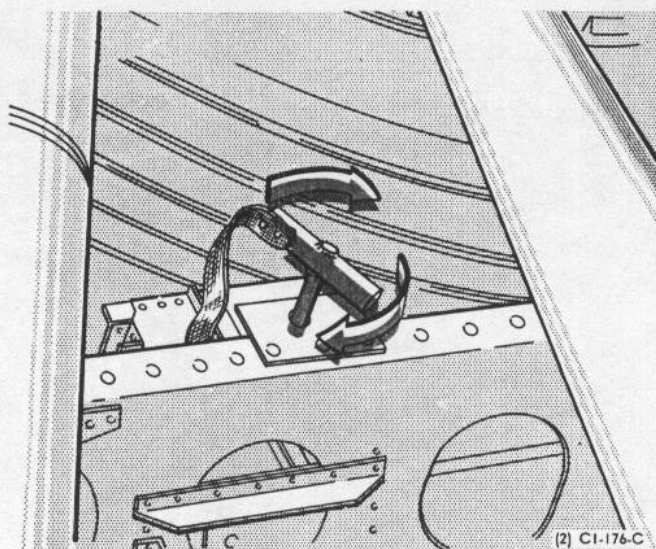
Before attempting manual extension of the main landing gear, be sure that the landing gear control switch is OFF and the landing gear circuit breaker is pulled. If conditions permit, the inboard engine behind the gear to be extended must be feathered and the most inboard blade placed parallel with wing.



1. Assume a position on the wheel well stationary structure from where it will be possible for you to reach the red latch link pin. Remove this pin from the latch link rod located on the side brace, and allow the rod to drop free of the latch.

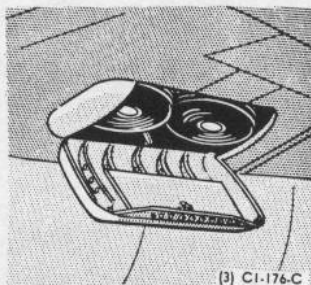
Note

With the latch link rod disconnected, normal operation of the gear will be impossible thus eliminating the hazard of someone operating the gear while you are working in the wheel well.



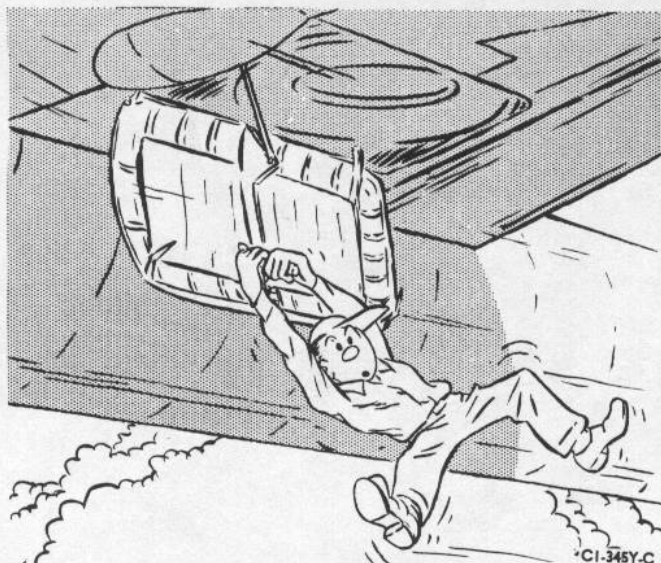
2. Remove the safety from the main gear door release T-handle.

3. Turn the T-handle clockwise until the door latches are disengaged. The door should then fall open.

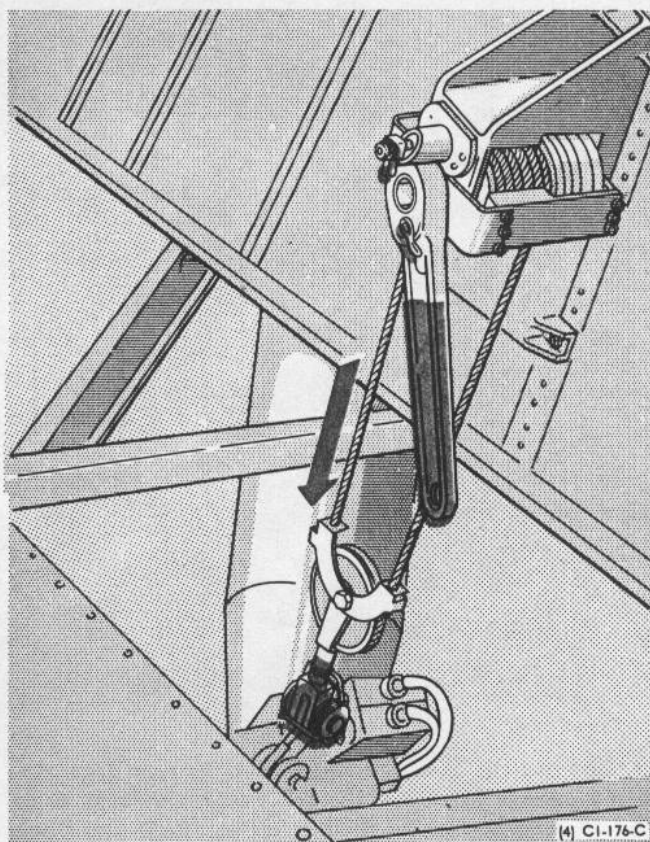


WARNING

The handle goes with the door; do not hold onto it.



4. Assume a position on the wheel well stationary structure, remove the hoist hook from its stowage straps, and extend the hoist cable by pulling downward.



Note

The hoist lock pin, which is located above the ratchet handle on the cable drum, must be disengaged from the ratchet drum to extend the cable. The pin is disengaged by pulling out the pin and turning it until its wing grip fits into the notch at the top of the cam. The ratchet handle pawl must be set to allow unreeling of the cable (counterclockwise turning of the drum). The cable extends by unwinding from the large drum and winding onto the small drum.

5. Attach the hoist hook over the latch release lever.

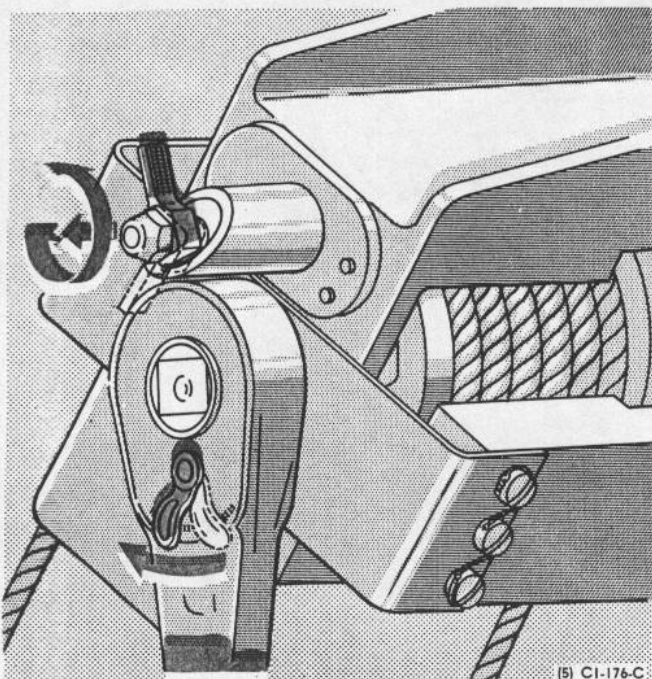
CAUTION

Be sure that the spring release on the hoist hook is behind the latch release lever to insure positive release of the hoist hook when the side brace is unlatched and raised.

CAUTION

Do not cross the cables.

6. Engage the hoist lock pin with the drum by pulling and turning the pin 180 degrees out of the cam notch.



(5) C1-176-C

7. Reverse the ratchet handle pawl so that operation of the ratchet will wind the cable onto the large drum (force being applied to the ratchet handle in the clockwise direction).

8. Tighten the cable by a clockwise movement of the ratchet handle while holding the hoist hook on the latch release lever until the cable slack is taken up.

Note

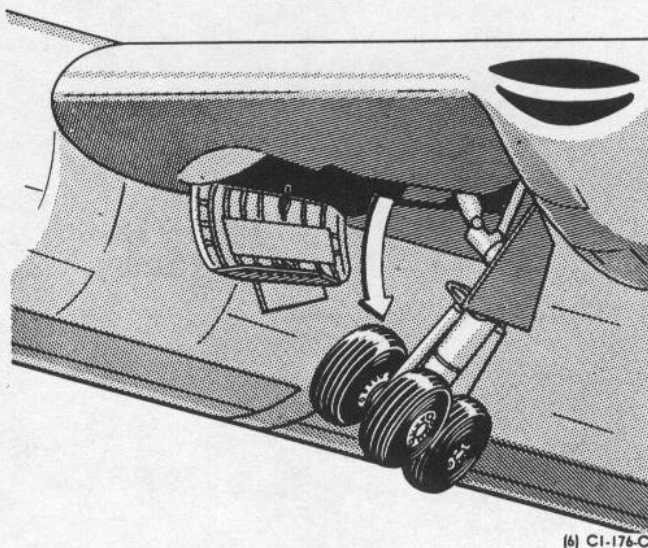
When the hoist lock pin is engaged, the only movement that can be made is in the clockwise direction (cable unwinding from the small drum and winding onto the large drum).

CAUTION

For right main gear, lying on catwalk facing aft, *push* ratchet handle for clockwise movement of the drum. For left main gear, lying on the catwalk facing aft, *pull* ratchet handle for clockwise movement of the drum.

9. Continue applying force to the ratchet handle in the clockwise direction to apply tension to the cable, and turning the handle in the counterclockwise direction to obtain a new "bite" on the drum. This ratcheting is necessary because of the limited space and leverage when in a prone position.

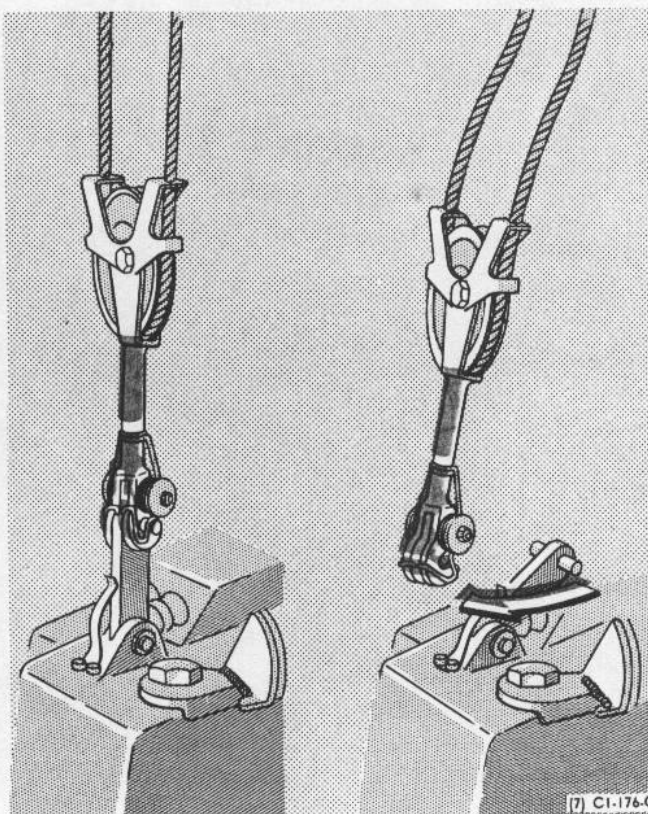
10. When the latch release lever unlatches the side brace and the side brace begins to rise, the gear will fall away under its own weight. The side brace will continue to rise, and as the tension is relieved the hook should spring free of the latch release lever.



(6) C1-176-C

Note

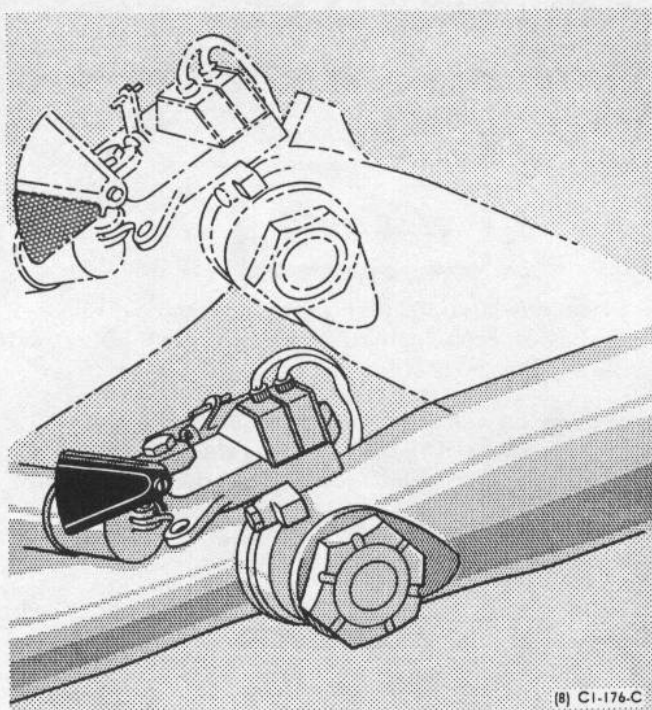
If the hoist hook does not spring free, disengage it by hand after cable tension is released.



(7) C1-176-C

Note

If the landing gear does not lock in the down position, a slight kicking of the latching link bracket should engage the lock.



Note

To be sure that the gear is locked, check the position of the pink fluorescent flag on each main gear side brace. When the gear is locked the flag will not be visible.

EMERGENCY RETRACTION OF NOSE LANDING GEAR.

In the event the nose gear fails to retract with the main landing gear, use the inspection window in the floor of the radio operator's compartment to determine whether the emergency release pin is in place. If this pin has been inadvertently pulled or not properly installed, the latch will not unlock. When this occurs, the nose gear can be retracted by either of two methods.

Method No. 1.

If the emergency release pin is still available but not installed, the latch rod and pin can be reassembled as follows: (See figure 3-16.)

WARNING

DO NOT operate radar equipment or landing gear while the crew member is performing this operation.

Note

To reach the equipment, a crew member must enter the radar equipment bay beneath the forward turrets and use the access hole in the forward bulkhead.

1. Pilot—Place landing gear control switch in the OFF position to relieve hydraulic pressure and pull landing gear control circuit breaker.

2. Crew member—Insert the release pin through the latch assembly beneath the forward end of the latch release rod.

CAUTION

To connect the unlocking arm with the main gear retracted, the unlocking arm collar must be rotated slightly. Do not attempt to adjust the rod length.

3. Pilot—After crew member is clear, retract the gear in the normal manner.

Method No. 2.

If the emergency release pin is missing completely, the gear can be retracted as follows:

WARNING

Be sure the landing gear control switch is OFF and the hydraulic pressure is zero.

1. Apply a steady pull of approximately 150 pounds on the nose gear release handle. The latch will open and the cable will pull through the floor another two or three inches.

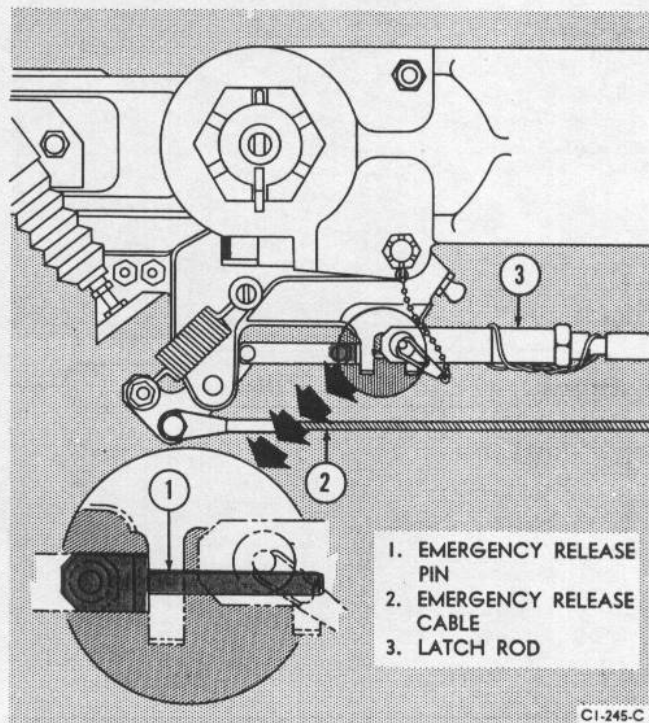


Figure 3-16. Nose Landing Gear Latch Mechanism

Note

Check the position of the latch through the inspection window.

2. Hold the cable tight to keep the latch open while the landing gear control switch is placed in RETRACT.

3. When the gear begins to retract, release the handle; the gear should lock in the retracted position.

WARNING

If the gear is retracted by this method, be sure the release cable is properly seated over the pulleys; this will be necessary for gear extension.

Note

When gear extension is required, the manual

extension method must be used.

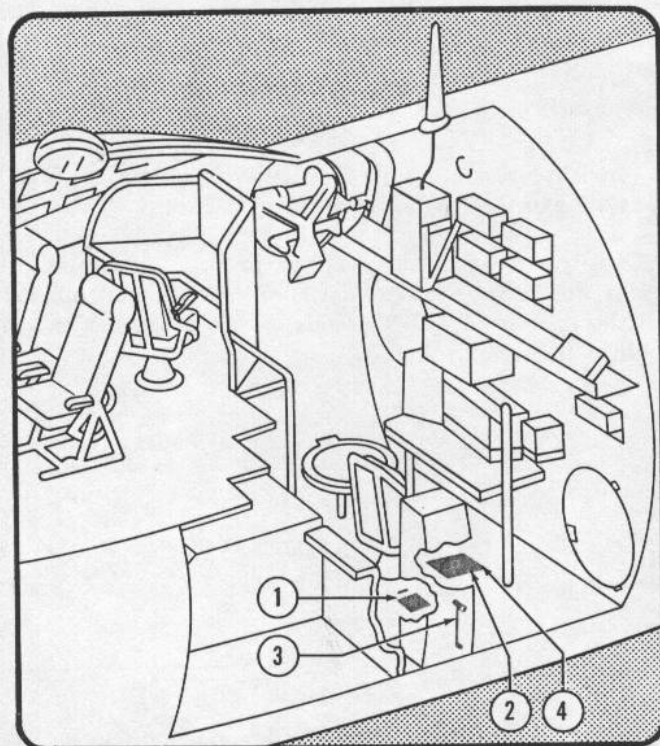
MANUAL EXTENSION OF NOSE LANDING GEAR.

If the nose landing gear fails to extend by hydraulic means, use the following procedure:

WARNING

Place the landing gear control switch OFF, check for zero hydraulic pressure, and pull the landing gear circuit breaker.

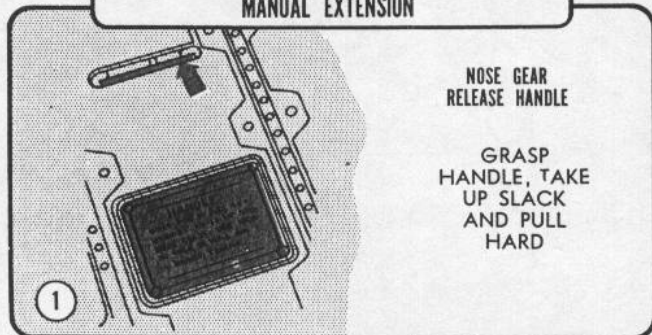
1. Pull up on the nose gear release handle with 50 pounds tension until the cable comes through the floor approximately ten inches and release the handle immediately when all the cable slack is taken up, because the gear will extend and rapidly retract the handle.



MANUAL EXTENSION

NOSE GEAR
RELEASE HANDLE

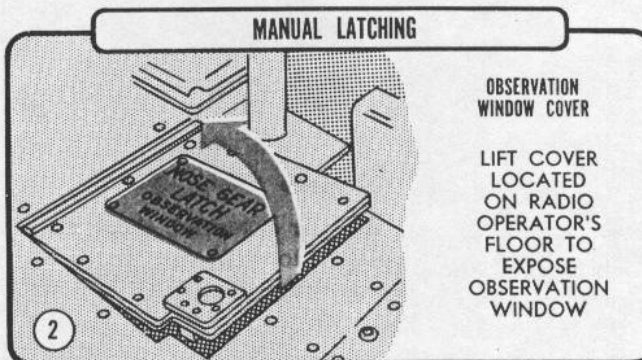
GRASP
HANDLE, TAKE
UP SLACK
AND PULL
HARD



MANUAL LATCHING

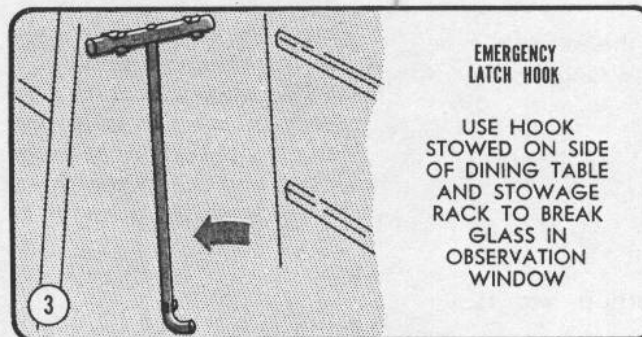
OBSERVATION
WINDOW COVER

LIFT COVER
LOCATED
ON RADIO
OPERATOR'S
FLOOR TO
EXPOSE
OBSERVATION
WINDOW



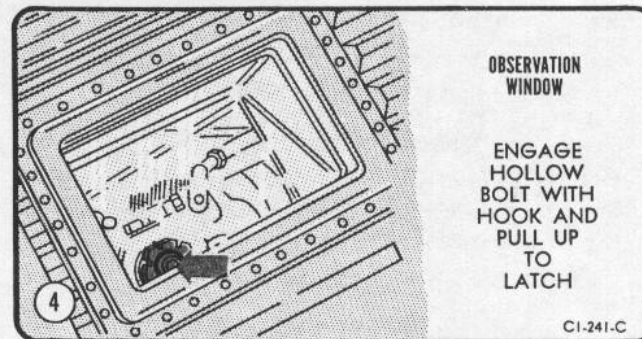
EMERGENCY
LATCH HOOK

USE HOOK
STOWED ON SIDE
OF DINING TABLE
AND STOWAGE
RACK TO BREAK
GLASS IN
OBSERVATION
WINDOW



OBSERVATION
WINDOW

ENGAGE
HOLLOW
BOLT WITH
HOOK AND
PULL UP
TO
LATCH



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Figure 3-17. Nose Gear Manual Extension and Latching Controls

CAUTION

Failure to release the handle might result in injury to the hands.

Note

Look through the inspection window to see if the gear is locked; if it is not, perform steps 2 and 3.

2. Break the inspection window with the nose landing gear emergency latching hook.

CAUTION

Wear goggles to prevent eye injury caused by glass fragments.

3. Lower the latching hook through the broken inspection window and hook it into the hollow pivot bolt; then pull up until the latch is locked.

EMERGENCY STOPPING.

The aircraft commander or pilot handling the controls on take-off is charged with the responsibility of making the decision on whether to abort a take-off. There will not be time to make a delayed decision. No one can tell you what to do in these situations; however, you can equip yourself with knowledge on which to base your decision by knowing your REFUSAL SPEED, your STOPPING DISTANCE WITH BRAKES ONLY, and your STOPPING DISTANCE WITH BRAKES AND REVERSE PROPS. Then if you have sufficient runway left when the decision is made to abort the take-off, you will know what to do.

USE OF BRAKES AND PROPELLERS.

For normal stopping of the aircraft, reverse pitch of the six reciprocating engines is sufficient to slow down or stop the aircraft with little or no brake action required. However, for emergency stopping after the decision to abort the take-off has been made, you are concerned only with stopping the aircraft in as short a space as possible without going off the runway. Therefore all normal restrictions on use of brakes and props will not apply. To increase the effects of reverse thrust, reduce rpm to 2000 with the master motor as power is applied.

You will not be concerned with burning out a set of brakes, blowing out tires, or exceeding prop restrictions in reverse. Your main concern is to save the crew and the aircraft. The brakes have an independent hydraulic system which keeps pressure available in two accumulators. The accumulators are kept automatically charged by an a-c motor-driven pump; however, if the automatic operation fails the flight engineer has an override switch to maintain the necessary pressure in the accumulators. If neither of these systems are available, an emergency hand pump method is available.

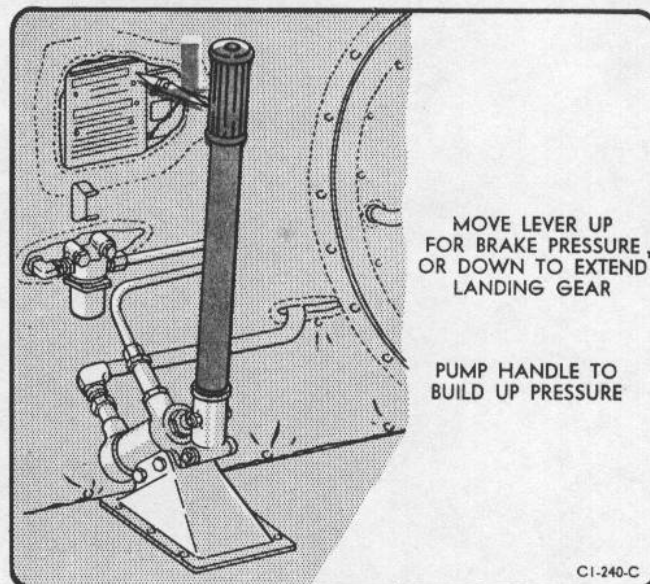
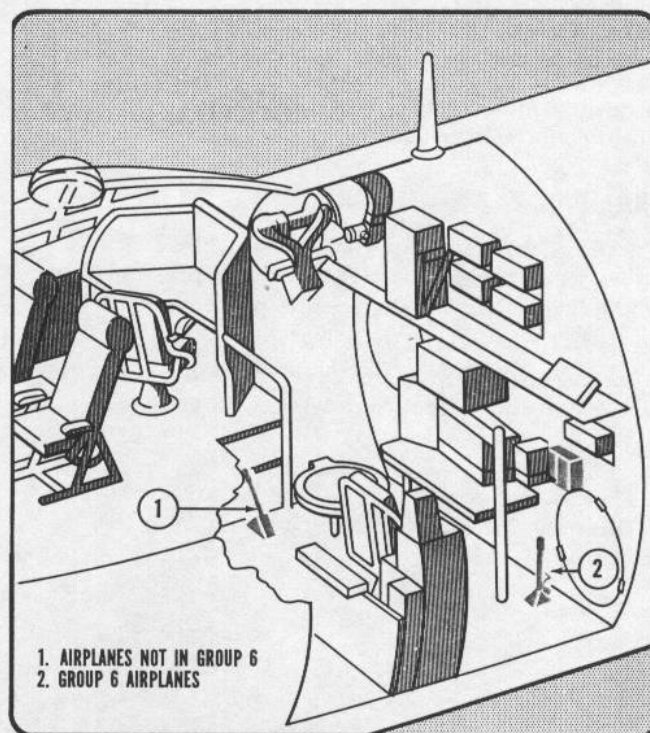


Figure 3-18. Brake and Landing Gear Emergency Hydraulic Controls

CAUTION

With the brake system off, a fully-charged accumulator will furnish enough pressure for three brake applications. In order to obtain the most effective braking action with a minimum of three applications available, keep the brake pedals depressed as long as the action is required.

The normal operating limits of 30 inches M.P. for use in reverse pitch may be exceeded if necessary for emergency stopping. When this limitation is exceeded, the controls must be LOCKED to prevent damage to the control surfaces.

EMERGENCY BRAKE PRESSURE.

If the pilots' brake pump switch is on, the brake low pressure warning lamp is lighted, and a pressure gage check indicates low brake pressure, proceed as follows:

1. Pilot—Brake pump switch—ON.
2. Engineer—Brake pump pressure override switch—ON; hold until pressure is within range.

Note

Should step 2 fail to produce pressure, perform the following as shown in figure 3-18.

3. Crew — Emergency selector valve — CHARGE BRAKE ACCUMULATOR.

4. Crew—Operate hand pump until pressure is within normal range.

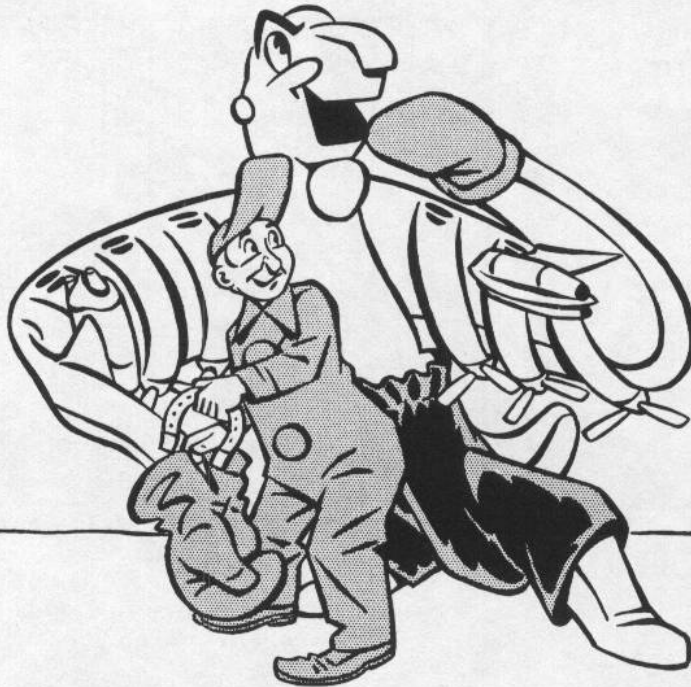
Note

Fully charged accumulators will supply brake pressure for three full brake applications.

To obtain maximum efficiency from fully charged accumulators, apply the brakes moderately and hold them using differential braking as required.

CAUTION

Don't fully release the brake pedals. If you do, the efficiency of the brake system will be decreased.



SECTION IV DESCRIPTION AND OPERATION OF AUXILIARY EQUIPMENT

CI-307-C

HEAT AND ANTI-ICING SYSTEM.

Heated air for wing and tail anti-icing and for heating pressurized air is obtained by ducting ram air from the nacelle cooling air tunnel through the two primary exhaust gas heat exchangers in each nacelle. The heated air from engines 1, 2, 5, and 6 is used for wing anti-icing. Engines 3 and 4 provide the air which is used as required in the secondary heat exchanger to heat the pressurized air for cabin heating. The air from engines 3 and 4 is also used to provide tail anti-icing. A duct system routes the air from the nacelles to the leading edges of the wing and tail. Flow is controlled by electrically operated valves located in the duct system. These valves are controlled from the engineer's station and operate on 115-volt a-c power. See figure 4-6 for system arrangement.

Note

During operation of the anti-icing system, the leading edge of the wing and tail surfaces may "oilcan." The "oilcanning" is a normal occurrence and will not have any damaging effects.

HEATING AND ANTI-ICING CONTROLS.

Cabin Heat and Tail Anti-Icing Switches.

For operating the modulating dump valves in the in-board nacelles there are two three-position switches (26, figure 1-20) on the engineer's control panel. These switches are spring-loaded to the neutral position and enable you to regulate the amount of heated air going to the tail for anti-icing or to supply the secondary heat exchanger for cabin heat. When the switches

are held ON, the valves are positioned for full cabin heat and tail anti-icing; when they are held OFF, the valves are positioned for full dump.

Cabin Temperature Control Switch.

This three-position switch (21, figure 1-20) controls a modulating valve which regulates the amount of heated air passing through the secondary heat exchanger on its way to the tail for anti-icing. When the switch is held in the INCREASE position, the tail anti-icing air is routed through the secondary heat exchanger to heat the cabin air. In the DECREASE position, the tail anti-icing air by-passes the secondary heat exchanger and no heat is supplied to the cabins other than that provided by the heat of compression of the pressurized air from the turbos. An indicator lamp (20, figure 1-20) glows when the valve has reached either of its extreme travel limits.

Wing Anti-Icing Switches.

Four three-position switches (28, figure 1-20) are located on the engineer's control panel to control the dump valves for engines 1, 2, 5, and 6. These switches have operating positions marked ON and OFF and a neutral center position which is not marked. Placing the switches in the ON position actuates the valves in a direction which permits heated air to enter the anti-icing ducts. With the switches in the OFF position, the valves are actuated in the opposite direction to route the heated air overboard. The valves may be stopped at any intermediate position by returning the switches to the neutral center position. In this manner the anti-icing air temperature is controlled by regulating the volume of heated air which enters the system.

INDICATORS.

Duct Air Temperature Gage.

The temperature of air entering the forward cabin through the pressure duct is read from a gage (12, figure 1-19) at the engineer's station. Temperature indications are supplied by a temperature bulb located in the pressure duct.

Cabin Heat and Anti-Icing Air Maximum Temperature Warning Lamps.

Cabin heat and anti-icing temperature warning lamps (27, figure 1-20) are located at the engineer's station. The thermal switches which relay temperature indications to the warning lamps are located as follows: one thermal switch in the anti-icing duct downstream from each nacelle dump valve, and two fire detector thermal switches in the heating ducts between the dump valve and the primary heat exchanger. When the thermal switch downstream from the dump valve is subjected to temperatures in the range of 210 to 221°C for the tail air and 171 to 182°C for the wing air, the corresponding warning lamp will light. The lamp will also light when the corresponding fire detector thermal switches are subjected to temperatures in excess of 425°C.

CAUTION

For two or three minutes after turning the system on, you may get erroneous indications from the maximum temperature warning lamps of the wing and tail anti-icing system. This false reading is caused by the time lapse required for the internal temperature of the thermal switches to stabilize.

Master Temperature Indicator.

The master temperature indicator (9, figure 1-16 for group 12 airplanes and 6, figure 1-18 for group 13 airplanes) receives temperature indications from a thermocouple located downstream of the dump valve, adjacent to the thermal switch in each nacelle. For a description of the master temperature indicator refer to "Master Temperature Indicator," Section I.

Cabin and Tail Air Modulating Valve Indicator Lamp.

This lamp (20, figure 1-20) glows when the valve has reached either of its extreme travel limits.

PRESSURIZATION SYSTEM.

The forward and aft cabins and the interconnecting communication tube are pressurized by a controllable system which utilizes air from the right turbosupercharger in each nacelle. Pressure regulators are located in each cabin to maintain cabin pressure automatically.

CABIN PRESSURE VS. ATMOSPHERIC PRESSURE

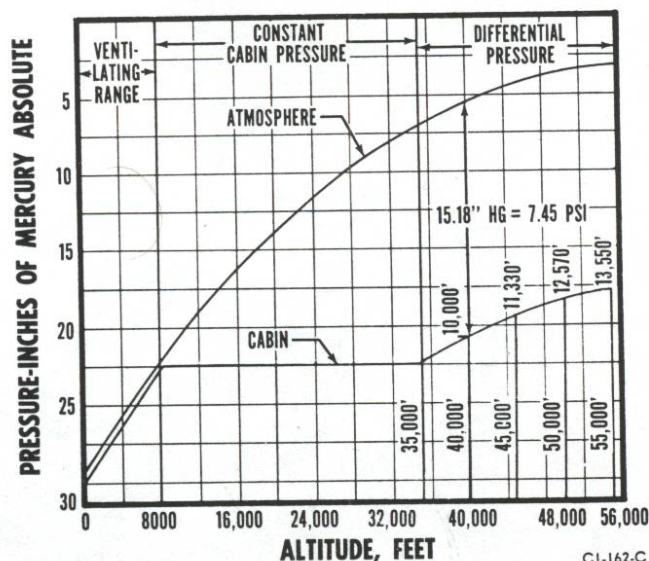


Figure 4-1. Cabin Pressure Versus Atmospheric Pressure

The pressure regulators are set to allow an unpressurized condition from sea level to 8000 feet, to permit a constant pressure altitude of 8000 feet from 8000 to 35,000 feet, and to hold a constant differential pressure of 7.45 psi above 35,000 feet. (See figure 4-1.) In pressurized flight the aft cabin can be depressurized while maintaining pressure in the forward cabin. A booster fan is provided to draw ambient air into the duct system when an auxiliary source of ventilating and pressurizing air is required. See figure 4-6 for system arrangement.

CAUTION

Cabin pressurization is not available when carburetor preheat is used. Some pressurization and cabin heat can be made available at low altitudes by turning on the cabin booster fan. However, as altitude is increased the efficiency of the booster fan will be reduced at an increased rate. Above 12,000 feet the booster fan operates at such low efficiency that cabin pressure can decrease to the extent that some airplane equipment becomes inoperative. Normal cabin pressurization will be available above 12,000 feet in most cases however, since carburetor preheat is seldom required above this altitude because of the heat provided by turbo boost. Above 12,000 feet altitude carburetor preheat should be used only as an emergency measure.

NORMAL CONTROLS.

Cabin Pressure Shutoff Valve Switches.

The flow of pressurized air from the nacelles to the fuselage is controlled by two three-position switches (22, figure 1-20) located on the engineer's control panel. These switches operate two modulating shutoff valves which control the flow of pressurized air from each wing system by connecting 115-volt a-c power to the valve actuators. The switches have a neutral off position and positions marked ON and OFF.

Note

The cabin pressure shutoff valves are automatically turned off when the carburetor preheat system is turned on. In this condition the cabin booster fan should be turned on.

Aft Cabin Pressure Switch.

The flow of pressure air to the aft cabin is controlled by a two-position switch (25, figure 1-20) located on the engineer's control panel. This switch completes 115-volt a-c circuit to the aft cabin pressure shutoff valve for valve operation.

CABIN AIR BOOSTER FAN.

A two-speed booster fan is located in the ventilating air duct and supplies air independent of the turbos to the cabins. The fan is operated on LOW when it is used to ventilate the cabins during ground operation and flight altitudes up to 8000 feet. For pressurized flight above 8000 feet it is operated in the HIGH position to furnish additional boost to the cabins for more positive pressurization and heating. The fan can also be used in conjunction with the secondary heat exchanger to supply heated air to the cabins independently of the cabin pressure system in unpressurized flight. A three-position switch (23, figure 1-20) located on the engineer's main control panel controls the operation of the fan. The switch positions are HIGH ABOVE 8000 FEET, OFF, and BE-LOW 8000 FEET LOW.

CAUTION

You must never turn the fan on HIGH when below 8000 feet except to check its operation for a few seconds. The air density below 8000 feet will cause the motor to burn out.

Note

The HIGH ABOVE 8000 FEET position is temporarily inoperative.

INDICATORS.

Cabin Pressure Air Flow Indicator.

A pitot-static head in the pressure duct leading to the forward cabin is connected to an air-flow indicator (5, figure 1-19) on the engineer's auxiliary instrument panel.

Note

The graduations on the face of the indicator have no quantitative value; instead, they merely indicate an increase or decrease of air flow in the duct. The cabin altimeters and the cabin rate-of-climb indicator should be used to determine whether the cabins are obtaining the proper amount of air. An increase of 1.0 on the air-flow indicator is normal during ground check.

Cabin Altimeters.

Two altimeters located at the engineer's station, one for the forward cabin (7, figure 1-19) and one for the aft cabin (8, figure 1-19) indicate the pressure altitude for each cabin. Some airplanes have an additional cabin altimeter located at the tail gunner's station for the convenience of the aft cabin personnel.

Note

The engineer's aft cabin altimeter static port is located in the forward end of the communication tube. Any condition causing loss of pressurization in the communication tube will cause the aft cabin altimeter to read incorrectly.

EMERGENCY CONTROLS.

Manual Shutoff Valves.

In the event of failure of the electrical pressurization shutoff valves, which are controlled by the cabin pressure shutoff valve switches, manual shutoff valves are provided in each cabin. The extreme positions of the valve handles are OPEN and CLOSED. The forward shutoff valve (3, figure 4-2) is located in the pressure duct inlet just forward of the aft bulkhead in the forward cabin. The valve (4, figure 4-3) in the aft cabin is located in the pressure duct inlet near the forward bulkhead.

Forward Cabin Dump Valve.

The forward cabin dump valve (4, figure 4-2) located under the flight deck step, has a foot-operated dump pedal provided on the valve body. This valve can be used to decrease the pressure in all cabins simultaneously, provided the communication tube doors are open. Release of the pressurized air is obtained by depressing the quick-release pedal on the valve body. The dump valve hand knob located on the floor near the engineer's station can be used to control the pressure in the forward cabin manually.

Note

To reset the valve after using the pedal for depressurizing, the knob must be rotated counterclockwise several times and pulled up until the release pedal locks in its untripped position. Then the knob must be turned clockwise until the valve is closed.

Pressure Relief and Dump Valves.

To supplement the forward cabin dump valve in cabin depressurization, the forward and aft cabins are equipped with pressure relief and dump valves (4, figure 4-2 and 2, figure 4-3). The normal function of these valves is to automatically relieve excess cabin pressure; however, each valve is equipped with a handle for emergency depressurization. By cutting the safety wire and moving the handle from NORMAL to DUMP, the valve is opened to release cabin pressure.

Vacuum Relief Valves.

A vacuum relief valve is provided in each crew compartment; however, only the valve (3, figure 4-3) in

the aft cabin is used for emergency depressurization, since the forward cabin valve has no strap attached. The strap on the aft cabin valve is pulled for emergency depressurization.

Pressure Regulator Control.

In the event of a pressure regulator failure which would allow the escape of pressurized air, a manual shutoff valve on the side of the regulator (5, figure 4-2 and 1, figure 4-3) can be used to close off its air exit provisions; the forward cabin dump valve hand knob can be used to modulate air pressure.

CABIN HEATING, DEFROSTING, AND ENCLOSURE ANTI-ICING.

After heated air is ducted into the cabins, it can be regulated by manual controls. These controls consist of selector valves, restrictor dampers, and various types of outlets. (See figures 4-4 and 4-5.) The defroster outlets, which are nonadjustable, provide heating as well as defrosting. Adjustable heating outlets provide heated air when defrosting is not required.

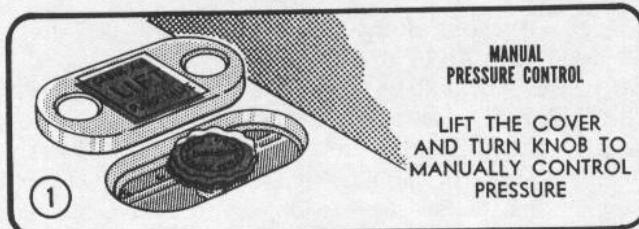
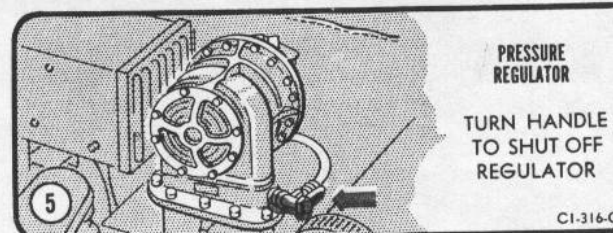
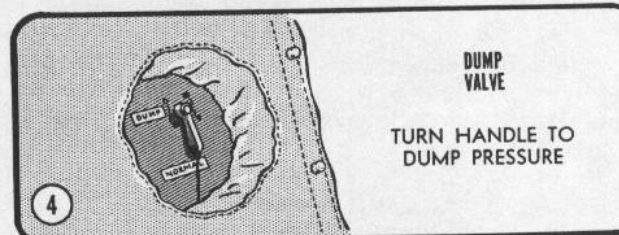
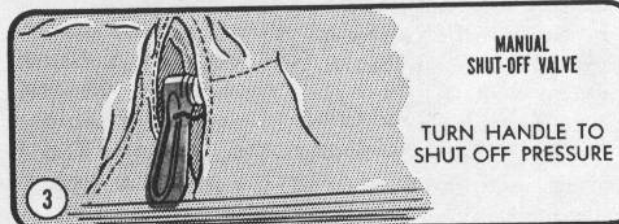
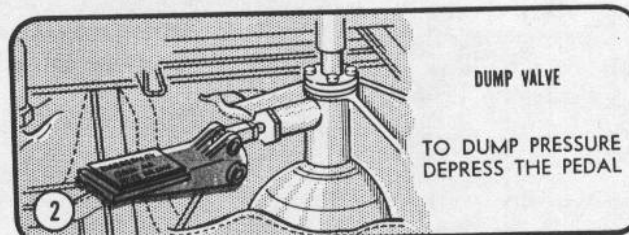
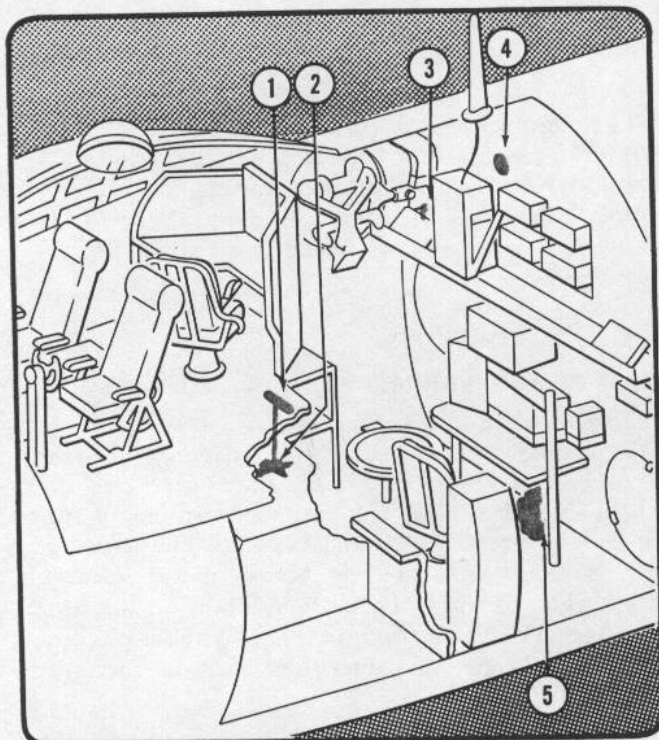


Figure 4-2. Forward Cabin Manual Pressurization Controls

RESTRICTED

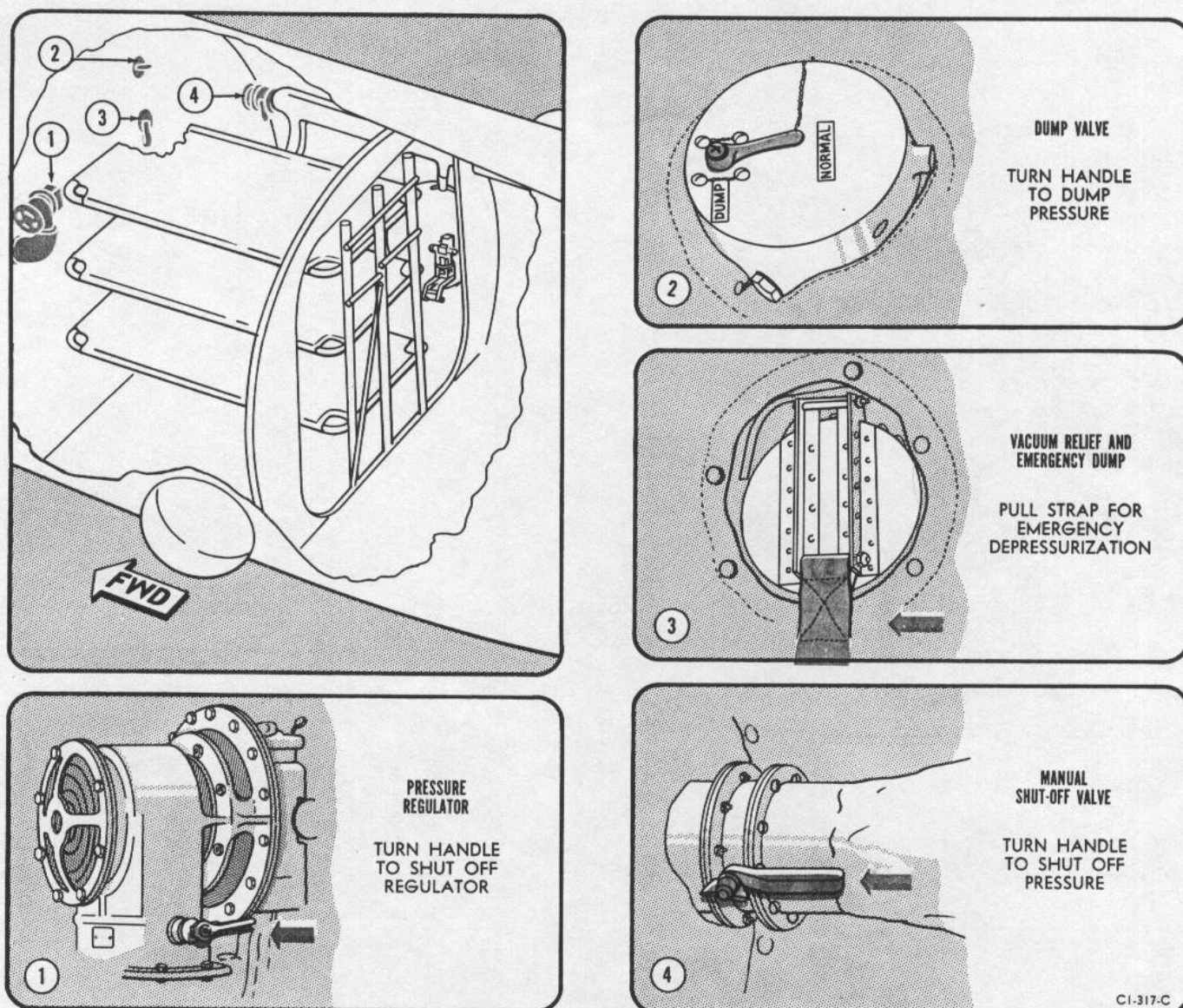


Figure 4-3. Aft Cabin Manual Pressurization Controls

CONTROLS.

Heat and Anti-Ice Selector Valve.

This valve (1, figure 4-4) is located in the heating duct in the right forward side of the radio operator's compartment. Double ducting is installed from the valve forward into the flight compartment. One section carries air to the enclosure defrosting and anti-icing outlets; the other carries it to the heating outlets. The valve control knob can be moved to the **HEAT** position when cabin heating alone is required or the **ANTI-ICE** position if both heating and defrosting are required.

CAUTION

Place the selector valve in its center position to prevent excessive pressure in the forward

cabin ducts at high altitude in an unpressurized high airflow condition.

Selector Valves.

Two selector valves are installed in the Y-duct sections in the nose compartment. The pilot-bombardier selector valve (2, figure 4-4) is located forward and to the right of the pilot's rudder pedals. This valve can be positioned to route heated air to the pilots' defroster outlets or to divert the flow to the bombardier-gunner selector valve (3, figure 4-4) in the observers' compartment. At this point the flow can be routed either to the radar-bombardier's optical flat and/or the nose gunner's scanning window. Selector valves are also installed in the various Y-duct sections in the aft cabin.

Restrictor Dampers.

Restrictor dampers (figures 4-4 and 4-5) are installed in

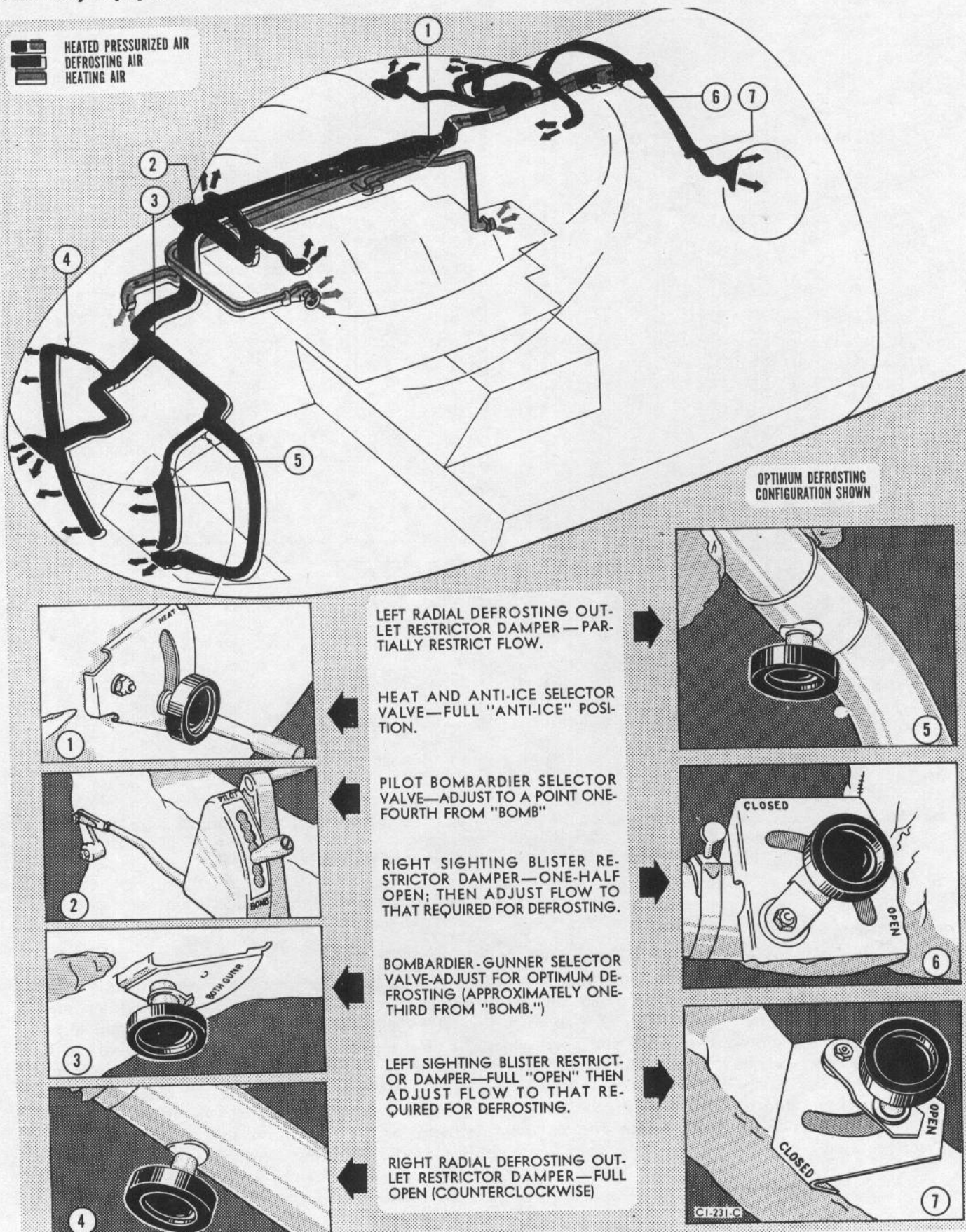


Figure 4-4. Forward Cabin Heating and Defrosting Controls

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the heating ducts which lead to the following locations in the forward cabin: the defrosting nozzles at the sighting blisters, the heating outlets in the radio operator's compartment, the pilots' heating outlets, and the radar-bombardier's heating outlet. A restrictor damper is also installed in the duct leading to the right forward heating outlet in the aft cabin. These dampers are used to regulate the flow of heating air to the various outlets noted.

Heating Outlets.

Seven outlets are installed in the heating ducts—four (figure 4-4) in the forward cabin and three (5, figure 4-5) in the aft cabin. In the forward cabin an outlet is located at the aircraft commander's station, the pilot's station, the right side of the radio operator's compartment, and the nose gunner's station. In the aft cabin, heating outlets are located just aft of each lower sighting blister and in the right forward side

of the cabin near the catwalk entrance. Each outlet has five manually controlled positions which provide five different flow patterns.

OPERATION OF CABIN HEATING, ANTI-ICING, AND PRESSURIZATION SYSTEMS.

CREW RESPONSIBILITY.

Obtaining optimum cabin heating and defrosting requires the cooperative effort of every crew member. When heating and defrosting are required, the crew members are responsible for the duties listed in the following paragraphs.

Aircraft Commander and Pilot.

Before flight the aircraft commander will assure himself that a periodic check of the cabin pressure duct system has been made with the cabin pressure test machine. From the results of the test he will determine

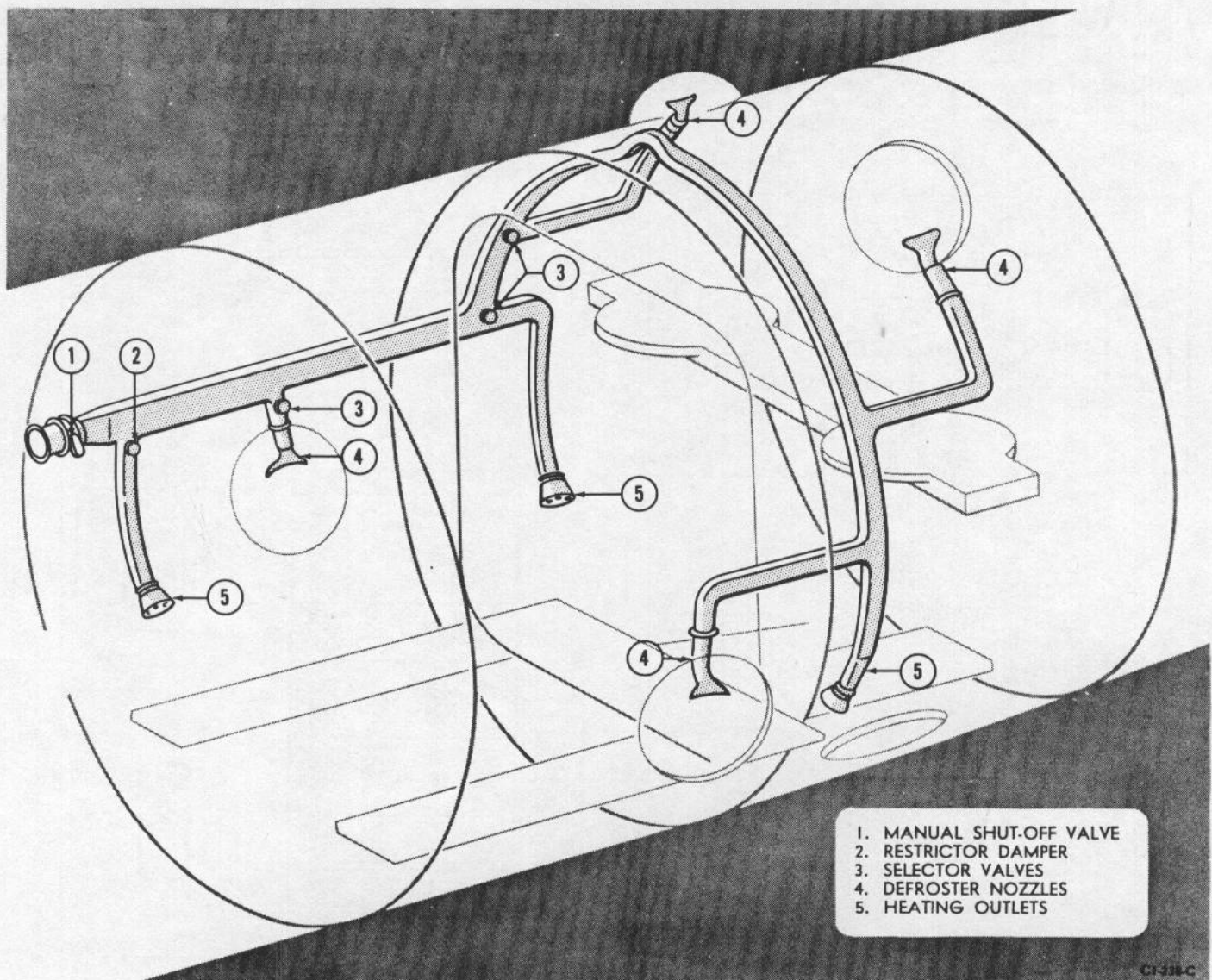


Figure 4-5. Aft Cabin Heating and Defrosting Controls

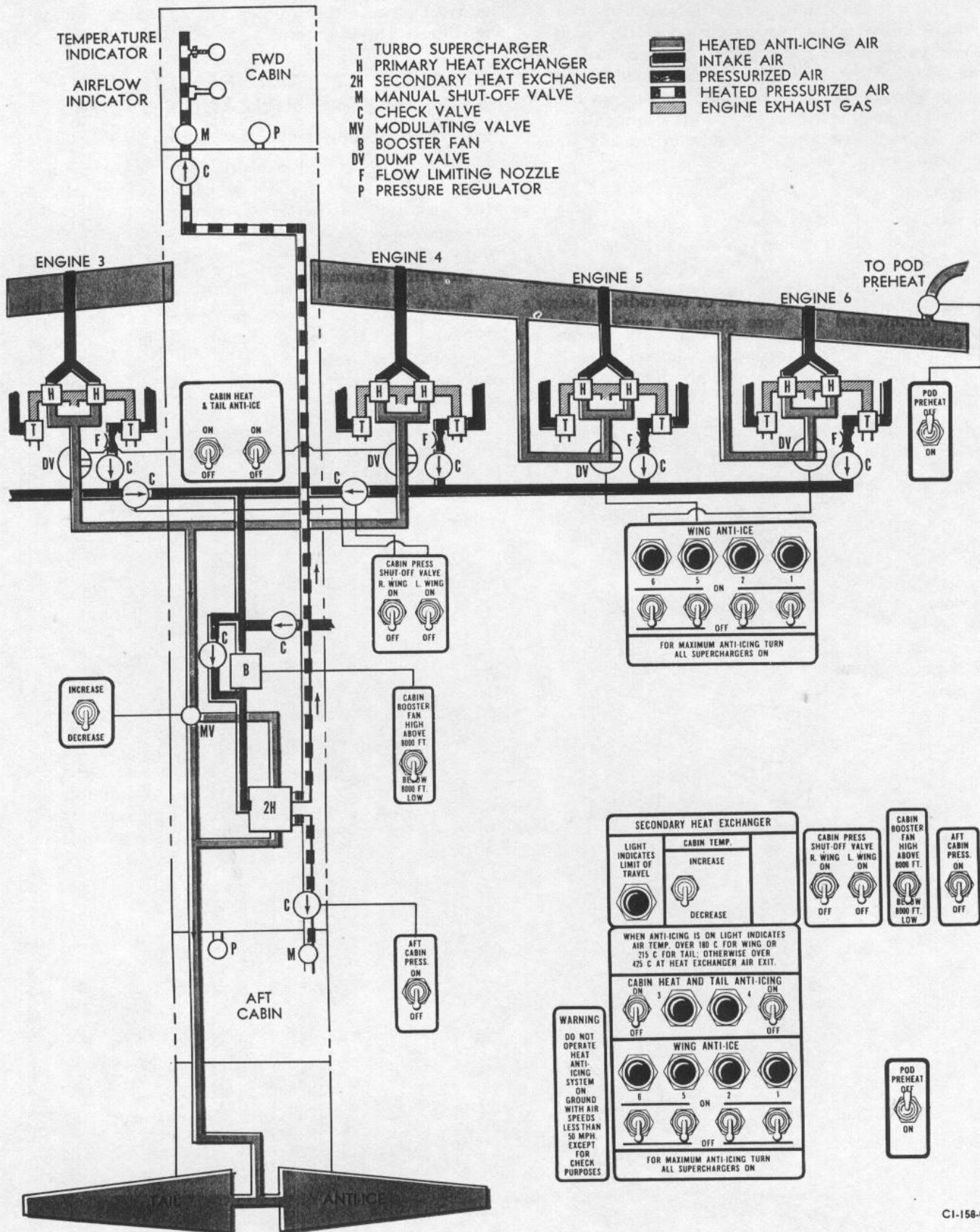


Figure 4-6. Heating, Anti-Icing, and Pressurization Systems Schematic

CI-158-C

what the capabilities of his system will be.

Engineer.

The engineer is responsible for the control of his valves and will maintain optimum duct temperatures and air flow. To achieve this he will receive reports from other crew members as to the results of his configuration. If a crew member becomes uncomfortable because of the temperature, it is the engineer's responsibility to correct the condition as nearly as possible.

Radar-Bombardier.

The pilot will control the pilot-bombardier valve. The radar-bombardier will control the bombardier-gunner valve, the radial radar-bombardier enclosure defrosting valve, and the auxiliary cabin heater.

Note

For airplanes having radar-bombardier's enclosure defrosting, the pilot-bombardier valve is normally placed about the 3/4 position toward BOMBARDIER CONTROL.

Radio Operator.

The radio operator will set the two sighting blister valves, the heat anti-ice valve, and the engineer's clear vision double pane, and the astrodome valve. He will also control the auxiliary cabin heater.

Note

If trouble is encountered in obtaining enough heat for defrosting, place the heat anti-ice valve in the full ANTI-ICE position.

Aft Cabin.

The compartment commander in the aft cabin will have the duty of obtaining optimum valve settings, through cooperation with other crew members, for defrosting and for the operation of the auxiliary cabin heaters. He will also keep the engineer informed as to the cabin temperature and the condition of the sighting blisters.

Note

If defrosting of the sighting blisters becomes critical, completely shut off the heating outlets, allowing all air to flow from the blister defroster nozzles.

NORMAL OPERATION.

Cabin Heating and Defrosting.

To obtain heat for the forward and aft cabins use the following procedure:

1. Place the aft cabin pressure switch in the ON position.
2. Check to determine that the forward and aft cabin manual shutoff valves are open.
3. Place the left and right cabin pressure wing shut-

off valve switches in the ON position.

CAUTION

If the carburetor preheat is being used, the wing shutoff valves cannot be opened. In this condition the cabin booster fan should be turned on to supply some heat. However, heat will be reduced as altitude is increased.

4. Hold the cabin temperature control switch in the DECREASE position until the lamp lights.

5. Place the cabin heat and tail anti-ice control switches in the ON position.

Note

These dump valves may be modulated if necessary to prevent exceeding a temperature of 215°C as read on the flight engineer's master temperature indicator.

6. Jiggle the cabin temperature control switch in the INCREASE position until the temperature of the air is suitable for cabin heating.

CAUTION

Do not exceed 105°C as read on the flight engineer's duct air temperature indicator.

Note

As an alternate method for controlling the cabin air temperature, hold the cabin temperature control switch in the INCREASE position until the lamp lights. Then jiggle the cabin heat and tail anti-ice switches until the desired cabin air temperature is obtained. During icing conditions the procedure as outlined in steps 4, 5, and 6 should be used to insure maximum air flow for anti-icing the tail.

7. In the forward cabin perform the following:
 - a. Place the right sighting blister defrosting restrictor valve in the 1/2 OPEN position.
 - b. Place the left sighting blister defrosting restrictor valve in the full OPEN position.
 - c. Close the astrodome defrosting duct restrictor valve unless it is necessary to defrost the astrodome.
 - d. For those airplanes equipped with a defrosting system for the flight engineer's two clear vision panes, restrict the flow to the amount required for vision.
 - e. Place the heat anti-ice valve located behind the flight engineer's panel in full ANTI-ICE position, thus diverting all of the air from the heating outlets to the pilots' and observers' enclosure for defrosting purposes.
 - f. Place the pilot-bombardier enclosure defrosting control located near the pilot's rudder pedals 3/4

from PILOT toward BOMB.

g. In the observers' compartment place the bombardier-gunner selector valve on BOTH.

h. In those airplanes having defrosting nozzles for the side radial panes on the observers' enclosure, adjust the selector valves in the ducts for optimum defrosting.

i. As a refinement to the above system, provided acceptable defrosting is obtained, the valve listed under step e above may be moved slightly off the ANTI-ICE position toward HEAT. After this has been done, the restrictor valves in the ducts to the radio operator's compartment, the observers' compartment, and the pilot's station should be adjusted, as well as the heating outlets to these stations and to the copilot's station.

j. Adjust the blister defrosting restrictor valves to the minimum flow position for acceptable defrosting.

8. In the aft cabin the restrictor and selector valves should be adjusted so that optimum blister defrosting and cabin heating are obtained. Generally this will require restricting or closing the heating outlets to obtain acceptable defrosting of the blisters. It may be necessary to restrict the flow to the right sighting blisters to force air to the left sighting blisters.

9. Turn the auxiliary cabin heater switches to LOW or HIGH as required.

CAUTION

Do not turn the heaters on if the pressure altitude of the cabin exceeds 12,000 feet, because the cooling air supplied by the heater fan would be insufficient to cool the fan motor, causing rotor seizure.

10. Turn on cabin booster fan.

CAUTION

The flight engineer's cabin air-flow indicator should be observed when the fan is turned on, and if the duct flow is not increased the fan should be turned off. The fan will not increase cabin air flow when high turbo compressor discharge pressures are being obtained.

Enclosure Anti-Icing.

For optimum enclosure anti-icing under severe icing conditions, it will be necessary to obtain maximum flow of heated air to the pilots' and observers' enclosures. Maximum flow is accomplished as follows:

1. Place the heat anti-ice selector control knob in the ANTI-ICE position.
2. Place both cabin pressure wing shutoff valve switches in the ON position.
3. Restrict flow to the aft cabin to that required for pressurization.

4. Obtain high manifold pressure by placing the engine supercharger switches on BOTH. (See "Shifting Turbos," Section VII.) Also advance the turbo boost selector lever as near to position 10 as conditions permit.

5. Place the cabin heat and tail anti-icing control switches in the ON position.

6. Hold the cabin temperature control switch in the INCREASE position until the indicator lamp lights.

CAUTION

To forestall damage to the enclosure panes, the duct temperature must not be allowed to exceed 105°C.

7. Close or restrict the flow to the forward cabin sighting blisters.

8. Turn on the cabin booster fan.

9. Adjust the flow between the observers' and pilots' enclosures as required.

When frosting or icing of a certain enclosure becomes critical, such as the pilots' enclosure during landing, it may be necessary to direct the entire flow of heated air to that area by adjusting the selector provided in the heating ducts for these stations. When the entire supply of heating air is being used for defrosting purposes, the auxiliary cabin heaters can be used for cabin heating if required.

Under certain atmospheric conditions, moisture will form between the inner and outer panes of the enclosures. This condition can be alleviated by obtaining a maximum flow of heating air to the enclosure as described in the preceding paragraphs. The pilots' ventilating fans, located on each outboard frame of the rudder pedal, can be used to obtain a more uniform and lower temperature on the flight deck, since they tend to replace the hot air with cooler air from the lower portion of the cabin.

Cabin Pressurization.

The pressurization system is put in operation by placing the cabin pressure shutoff valve switches ON. The aft pressure switch must be ON for aft cabin pressurization.

EMERGENCY OPERATION.

Anti-Icing System Overheating.

When any of the warning lamps indicate an excessive temperature, check this temperature immediately and govern any subsequent action on the basis of the master temperature indicator rather than the warning lamps. If an excessive temperature is indicated, proceed as follows:

1. Pilot—If climbing, increase the air speed without increasing power.
2. Engineer—Proper wing or tail anti-ice switch—Momentarily OFF, routing some of the heated air overboard, until the temperature is within limits.

3. Engineer—Reduce power of the engine in the nacelle indicated. Opening the air plugs will also aid in diminishing heat.

WARNING

If none of the above efforts reduce the excessive temperature satisfactorily, position the proper wing or tail anti-ice switch to OFF for full dump. Observe the warning lamp; if it still burns, a temperature in excess of 425°C between one of the heat exchangers and the dump valve in the affected nacelle is indicated. The only known cause of this condition is a ruptured heat exchanger which permits exhaust gases to enter the anti-icing duct. If operating on both superchargers, switch the affected engine to single turbo operation to isolate the exhaust gases from the left heat exchanger. If the left heat exchanger is ruptured, this action will eliminate the source of heat and be effective in reducing the temperature. If results are not obtained, or if operating on single turbo when the emergency occurs, observe the fire warning lamps, because a fire is imminent and engine shutdown may be necessary.

Cabin Pressure Control.

If a pressure regulator fails, shut off the unit and let the other regulator control the pressure air exit for both compartments. If a single regulator proves insufficient, the engineer must assist the single regulator by manual operation of the pressure dump valve. In case of aft cabin shutoff valve failure, shut off the pressure by closing the manual shutoff valve in the compartment.

EMERGENCY DEPRESSURIZATION.

If it becomes necessary to depressurize the cabins so that escape hatches can be opened in an emergency, all crew members must go on 100 per cent oxygen and the airplane must be depressurized as soon as possible. The engineer must cut off cabin air flow, and the compartment commander of each cabin must see that all dump valves are opened. In the aft cabin the strap on the vacuum relief valve should be pulled and held open to speed depressurization. If the dump valves do not do the job, use the hand axes and cut through the fuselage along the stringers. The stringers will act as barriers to any objects being sucked out of the airplane.

WARNING

Do not attempt to break the sighting blisters to depressurize the cabins.

VENTILATION EQUIPMENT.

The cabin air can be circulated for ventilation by means of eight electrically operated fans. The main source of ventilation is provided by the cabin air booster fan, which can be used to pull outside air through the pressurizing ducts into the forward and aft cabins. (Refer to "Cabin Air Booster Fan" of this section.) Two circulating fans are located at the pilots' station to aid in ventilating the flight compartment. The fans of the four auxiliary cabin heaters can be used independently of the heating elements to provide additional air circulation in the cabins. (Refer to "Auxiliary Cabin Heaters" of this section.) During ground operations a flight compartment ventilating fan can be installed in the astrodome.

PILOTS' AIR CIRCULATING FANS.

The pilots' two air circulating fans are installed on the outboard frames of the rudder pedals. The fans are adjustable and are operated by an ON-OFF switch located on each mounting bracket.

FLIGHT COMPARTMENT VENTILATING FAN.

The flight compartment ventilating fan is provided in the airplane for air circulation during ground operations. The fan is stowed on the pilot's fairing and is installed in the astrodome opening for operation. The electrical receptacle and control switch are located on the flight compartment ceiling above the engineer's seat. The control switch has positions marked OFF, OUT, and IN. When the switch is placed in the OUT or IN position, the fan will operate as an exhaust or intake fan, respectively.

OBTAINING CABIN VENTILATION ON GROUND.

For ventilation during ground operations, accomplish the following:

1. Open the communication tube doors.
2. Turn the cabin heat and tail anti-icing control switches OFF.
3. Place the cabin air booster fan switch in the low speed position and control the air flow with the selector valves and restrictor dampers.
4. Install the flight compartment ventilating fan.
5. Utilize the pilots' air circulating fans and the auxiliary cabin heater fans for ventilating local areas.

OBTAINING CABIN VENTILATION IN FLIGHT.

For ventilation during flight, perform the following steps:

1. Turn the cabin pressure shutoff valve switches—OFF.
2. Turn the cabin heat and tail anti-icing switches—OFF.
3. Turn the aft cabin pressure switch—ON.

4. Place the cabin air booster fan switch in the low speed position and control the air flow with the selector valves and restrictor dampers.
5. Utilize the pilots' air circulating fans and the auxiliary cabin heater fans for ventilating local areas.
6. Open the communication tube doors.
7. If a small quantity of heat is desired, perform the preceding steps, with one exception: Place the cabin pressure shutoff valve switches ON. In this manner the heat of compression can be utilized, eliminating use of the tail anti-icing system to obtain cabin heat.

AUXILIARY CABIN HEATERS.

In addition to the regular cabin heating system, four portable cabin heaters are stowed in the airplane. (See figure 4-7.) One is located under the flight deck step in the forward cabin, and one is on the radio operator's floor just below the catwalk entrance hatch. In the aft cabin a heater is stowed at the forward bulkhead and the other is at the aft bulkhead. Each heater is comprised of a heating element and a motor-driven fan which operate on 208-volt, 3-phase alternating current. Each heater is equipped with an electric cord of sufficient length to allow the heater to be moved about the cabin.

CONTROLS.

Heater Control Switch.

Each heater is controlled by a three-position switch marked HIGH, LOW, and OFF. The HIGH and LOW positions are provided to control the output of the heating element. The heater power circuit is provided with power from the fan control circuit; therefore, the fan switch must be ON before the heater will operate.

Fan Control Switch.

When cabin heating is not required, the fan of each heater may be operated independently to provide additional air circulation. Independent operation is made possible by a fan control switch located on each unit. This on-off switch controls the fan motor and applies power to the heater control switch.

Cabin Heater Power Switch.

This two-position switch (2, figure 1-19) located on the engineer's auxiliary instrument panel, is used to shut off all auxiliary cabin heaters. During engine starting or when a partial loss of alternator power occurs, this switch should be placed in the OFF position. With either of these conditions existent there is a possibility of overloading the a-c system because of the high power requirements of the heaters. On group 6 airplanes the circuit to the electric hot plates on the galley unit is also broken when the heater power switch is placed in the OFF position. In addition, when the power switch on the galley unit is ON, the right aft cabin heater circuit is de-energized.

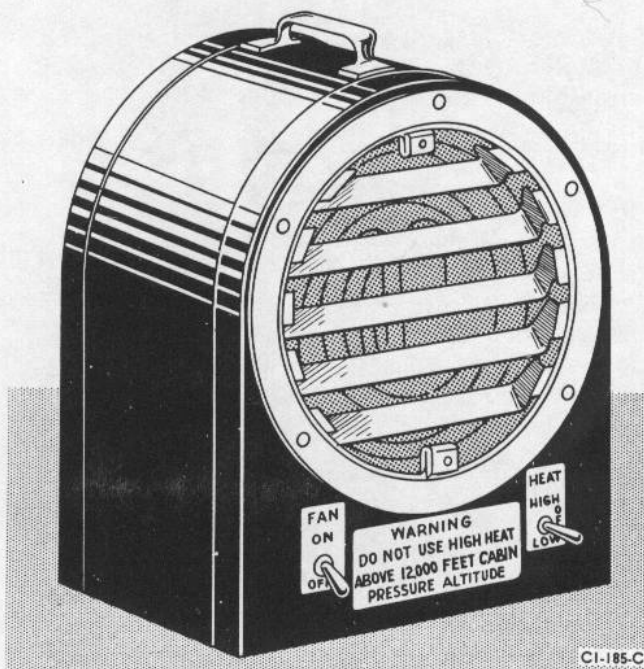


Figure 4-7. Auxiliary Cabin Heater

Note

When external power is on the airplane, the heater power circuit is automatically de-energized, regardless of the position of heater power switch.

JET POD HEATING AND ANTI-ICING SYSTEM.

The jet pod heating and anti-icing system employs three independent sources of heat and is designed to perform the following functions: to prevent icing of the nacelle and the strut leading edges, to prevent the formation of ice on the nose cones and air plugs, and to provide heat for the jet oil system prior to starting the engines during flight.

CAUTION

There are no provisions for internal anti-icing of the jet engine. Internal icing is indicated by an increase in tail pipe temperature which can be alleviated by reducing the rpm.

JET NACELLE AND STRUT ANTI-ICING.

For nacelle and strut anti-icing when the jet engines are operating, hot air is bled through a port at the 12th stage of each compressor and is controlled by a valve, which operates in conjunction with the nose cone and air plug anti-icing facilities. A portion of the heated air is ducted to the nacelle leading edge where it flows aft between the inner and outer skins and exits from the nacelle through louvers in the cowl forward of the fire wall. The remainder of the

air is used for anti-icing of the strut leading edge and is ducted through the double skin passages of the leading edge to the top of the strut. The air then flows aft to the strut trailing edge where it exits through louvers.

NOSE CONE AND AIR PLUG ANTI-ICING.

The air plug and nose cone of each engine are provided with electrical heating elements to prevent the formation of ice on these sections. The system should be turned on in icing conditions, whether the engines are in operation or not.

PREHEATING.

Wing anti-icing air is used to provide heat for the jet engine oil system prior to starting the engines during flight. The flow of this air is controlled by a valve located in the duct which conveys the air from the wing leading edge to each jet pod. A portion of this air is used for heating the oil cooler and oil lines in each nacelle. The remainder of the air is ducted into the strut to heat the lines which lead from the oil tank to the engines.

Note

The wing anti-icing system must be in operation before jet pod preheating can be accomplished.

CONTROLS.

Nose De-Ice Control Switch.

This on-off switch-type circuit breaker (20, figure 1-25) located on the jet control panel, controls the nose cone and air plug heating elements and the internal anti-icing valve for nacelle and strut anti-icing. When this switch is placed ON, 28-volt direct current energizes a relay which connects 200-volt a-c power to electrical heating elements of the nose cone and air plug doors. Also, 28-volt direct current opens a valve which permits heated air from the engine compressor to be routed into the pod nacelle and strut for anti-icing.

Pod Preheat Control Switch.

This on-off switch (21, figure 1-25) operates a valve in the duct leading from each wing leading edge to the jet nacelles and their strut. When the switch is placed ON, 115-volt alternating current is routed to the pod preheat valve actuators which opens the valves. Wing anti-icing air is then routed to the nacelles and struts for pod preheating, provided the wing anti-icing system is in operation.

WARNING

In the event of a jet engine fire, this switch must be placed in the OFF position to prevent

fire from passing through the duct to the interior of strut and wing.

Note

When the wing anti-icing system is being used during severe icing conditions, the pod preheat control switch must be in the OFF position to obtain maximum heat for wing anti-icing.

PROPELLER ANTI-ICING SYSTEM.

Anti-icing of the propeller blades is accomplished by ducting heated air from the exhaust manifold shrouds through the hollow steel blades. Two valves in each nacelle control the flow of this air and they may be positioned for anti-icing or for routing the air overboard. The system should be put into operation as soon as possible when icing conditions are encountered and left on for the duration of the icing condition.

WARNING

Because of possible damage to the propeller or its oil seals due to excessive anti-icing temperatures, the system should never be operated when the ambient air temperature is above 5°C or during flight above 30,000 feet.

Propeller Anti-Icing Switch.

A two-position switch-type circuit breaker (30, figure 1-20) actuates the anti-icing air valves for all six propellers. When it is in the ON position, 28-volt d-c energizes relays which connect 115-volt a-c power to the anti-icing air valve actuators and the valves are positioned for anti-icing.

PITOT TUBE HEATERS.

Pitot tube heat is controlled by two ON-OFF switches (29, figure 1-20) located on the flight engineer's control panel. When the switches are in the ON position 115-volt a-c power is routed to the heaters.

OIL HEATERS.

OIL TANK VENT LINE HEATERS.

Each reciprocating engine oil tank vent line is equipped with a heating element to prevent vapors from congealing, freezing, and consequently plugging the vent lines. The heaters are controlled by a single switch (24, figure 1-20) located on the engineer's control panel. The switch positions are ON and OFF. When the switch is in the ON position, 28-volt direct current is routed to a relay which in turn energizes the heater element circuit with 115-volt alternating current. This switch should be placed in the ON position for ground and flight operations when the ambient air temperature is at 0°C (32°F) and below.

OIL TANK HOPPER HEATERS.

Electrical heating elements for each oil hopper and outlet line are provided for preheating the reciprocating engine oil prior to starting. The heating elements require a power output of 5250 watts and operate on 115 volts—either alternating or direct current. Because the portable power cart of the airplane does not have sufficient output, the power must be supplied by ground facilities. A receptacle (12, figure 1-52) for plugging in the external power source is located beneath each oil tank. Access to the receptacles is gained through panels on the lower surface of the wing. Time required for the oil to become properly heated is approximately one minute for each degree below 0°F.

JET ENGINE OIL HEATERS.

The jet engine oil tanks are equipped with 28-volt d-c controlled, 115-volt a-c actuated heating elements for maintaining the oil temperature above an operating minimum. A thermal switch located in each tank closes when the oil temperature drops to 5°C. If the jet engine oil heater switch is turned ON, the oil is heated automatically when the thermal switch closes. For additional information regarding the heating of jet engine oil, refer to "Jet Pod Heating and Anti-Icing System," of this section.

Jet Engine Oil Heater Switch.

A two-position switch-type circuit breaker (19, figure 1-25) located on the pilots' overhead jet control panel controls the action of both oil heaters. When it is in the ON position, power is supplied to each heating element.

HAND-OPERATED HEATER.

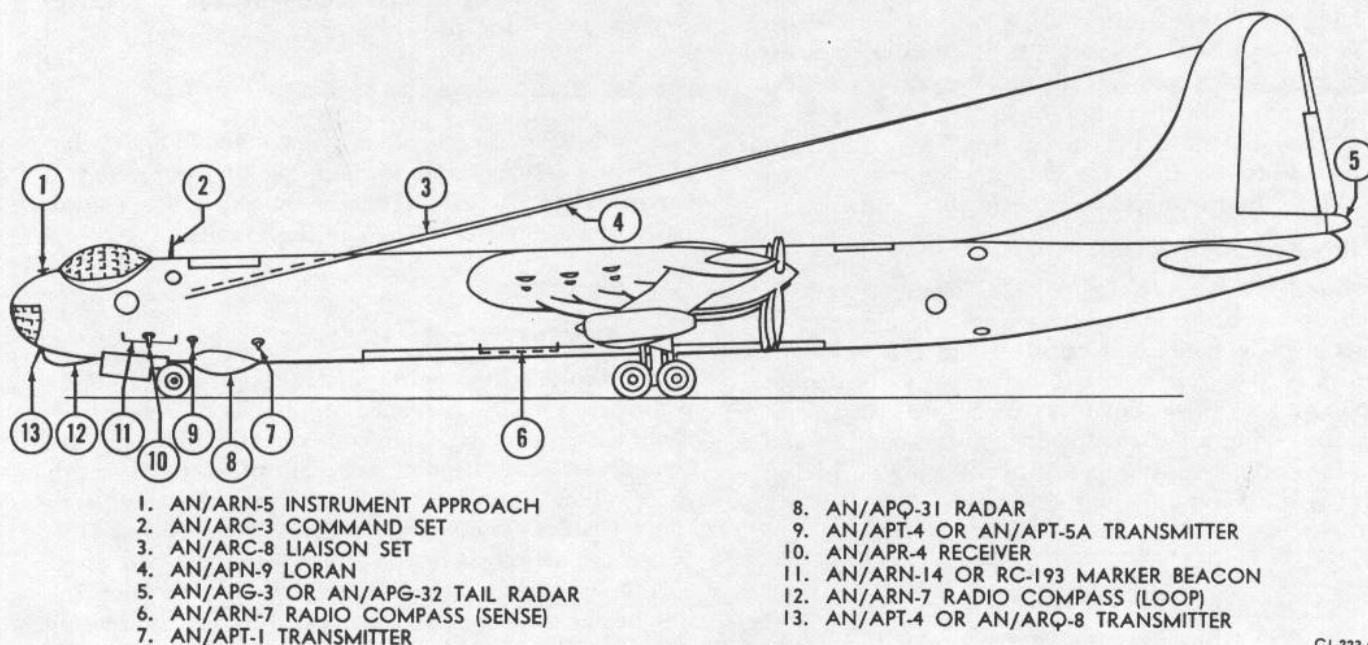
Provisions are made in the aft turret bay for the stowage of a type F-2 hand-operated heater for use in preheating the cylinder of the portable d-c power unit. (Refer to "Portable D-C Power Unit" of this section. A duct used in connecting the heater to the cylinder is stowed adjacent to the heater. The heater has a two-hour gasoline supply tank, is ignited manually, and has an output of 20,000 BTU per hour at 60 rpm. A blower is incorporated in the heater for forcing the heated air through the duct to the power unit. The blower is manually rotated by a hand crank located on the side of the heater. At -29°C (-20°F) or below, the heater will not burn any fuel other than 100-octane aviation gasoline.

WARNING

Under no conditions should the hand-operated heater be used to heat shelters or occupied enclosures, because air delivered by this heater is NOT free from carbon monoxide.

CAUTION

The exhaust gases discharged from the type F-2 heater reach temperatures as high as 583°C (1000°F). Therefore it should not be used to heat any equipment which will be damaged at this temperature.



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Figure 4-8. Antenna Locations

1. LIAISON TRANSMITTER
2. INTERPHONE CONTROL PANEL
3. CIRCUIT BREAKER PANEL
4. RADIO RANGE RECEIVER
5. LIAISON RECEIVER
6. TRANSMITTER KEY
7. INTERPHONE AMPLIFIER
8. LIAISON SET DYNAMOTOR
9. PRESSURE REGULATOR
10. MICROPHONE SWITCH
11. NOSE GEAR LATCH OBSERVATION WINDOW
12. CLOCK
13. OXYGEN CONTROLS
14. COMMUNICATION TUBE LIGHT SWITCH
15. DOME LIGHT SWITCH
16. SUB FLIGHT DECK LIGHT SWITCH
17. TURRET LIGHTS SWITCH
18. LIAISON MONITOR SWITCH

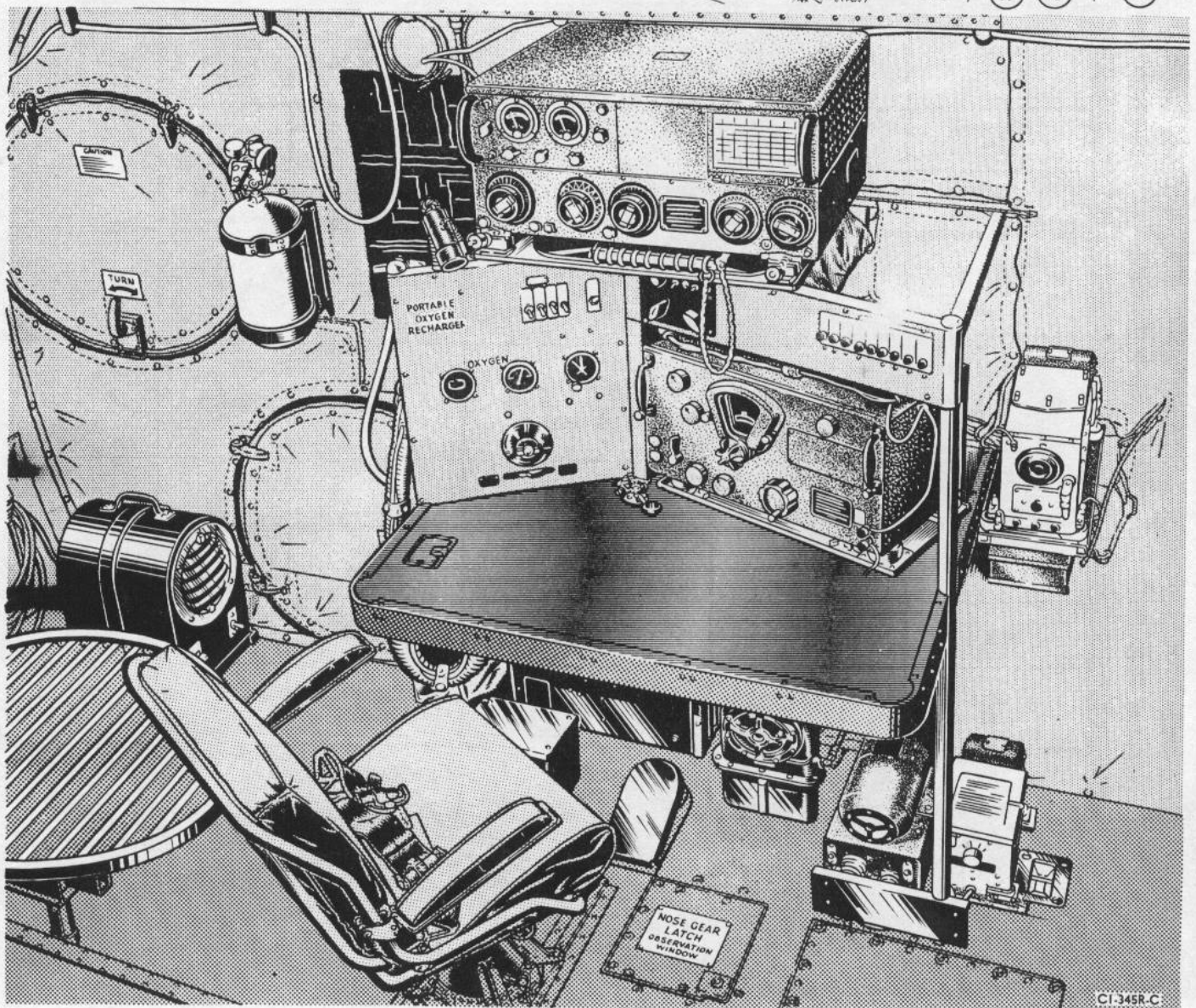
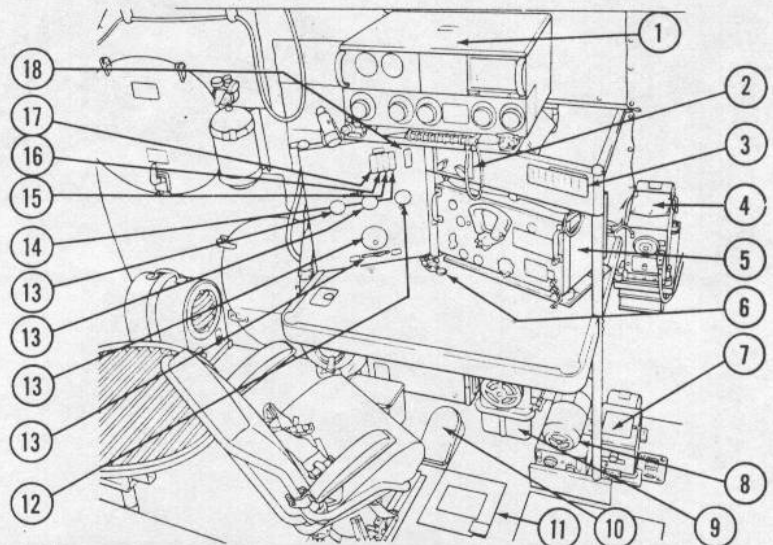


Figure 4-9. Radio Operator's Station

COMMUNICATION AND ASSOCIATED ELECTRONIC EQUIPMENT

	TYPE	DESIGNATION	USE	PRIMARY OPERATOR	RANGE	LOCATION
COMMUNICATION EQUIPMENT	INTERPHONE	USAF COMBAT	CREW COMMUNICATION	CREW		ALL CREW STATIONS
	FILTER	F21/ARA-9	TO SEPERATE VOICE AND RANGE SIGNALS	PILOTS		(FIGURE 4-11)
	COMMAND RADIO	AN/ARC-3	PLANE-TO-PLANE OR PLANE-TO-GROUND COMMUNICATION	PILOTS	30 MILES AT 1000 FEET	(4, FIGURE 4-15)
	LIAISON RADIO	AN/ARC-8	CODE OR VOICE TRANSMISSION AND RECEPTION	RADIO OPERATOR AND PILOTS	5000 MILES HIGH FREQUENCY	(1 AND 5, FIGURE 4-9 AND 3, FIGURE 4-15)
	RADIO RANGE RECEIVER	BC-453-B	RECEPTION OF CODE RANGE SIGNALS	PILOTS		(2, FIGURE 4-15)
	RADIO SET (WALKIE-TALKIE)	AN/CRC-7	EMERGENCY USE	CREW	15 MILES AT 2000 FEET	
NAVIGATION EQUIPMENT	INSTRUMENT APPROACH EQUIPMENT	AN/ARN-5B AND RC-103-D	LATERAL AND VERTICAL PATH INDICATOR DURING INSTRUMENT LANDINGS	PILOTS	LOCAL	(6, FIGURE 4-15)
	RADIO COMPASS	AN/ARN-7A	RECEPTION OF CODE OR VOICE SIGNALS, DIRECTION BEARING, AND HOMING	PILOTS	200 MILES	(5, FIGURE 4-15 AND 6, FIGURE 4-13)
	MARKER BEACON SET	AN/ARN-12 OR RC-193A	TO OBTAIN FIX ON NAVIGATION BEAM		LOCAL	
RADAR EQUIPMENT	IDENTIFICATION SET	AN/APX-6	IDENTIFICATION	RADIO OPERATOR		
	LORAN SET	AN/APN-9 OR 9 A	LONG RANGE NAVIGATION	NAVIGATOR	750 MILES	(1, FIGURE 4-13)
	RADAR SET	AN/APQ-31	HIGH ALTITUDE BOMBING AND NAVIGATION AID	RADAR-BOMBARDIER	200 MILES	(FIGURE 4-35)
	AUTOMATIC GUN LAYING	AN/APG-3 OR AN/APG-32	TO CONTROL THE TAIL TURRET	TAIL GUNNER		

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SHEET 1

Figure 4-10. (Sheet 1) Communication and Associated Electronic Equipment

ECM EQUIPMENT	TYPE	DESIGNATION	USE	PRIMARY OPERATOR	RANGE	LOCATION
	RADAR COUNTER-MEASURE	AN/APT-4	TO JAM RADAR SIGNALS	RADIO OPERATOR		(1, FIGURE 4-12)
	RADAR COUNTER-MEASURE	AN/APT-5A	TO JAM RADAR SIGNALS	RADIO OPERATOR		(5, FIGURE 4-12)
	RADAR COUNTER-MEASURE	AN/APR-4	TO DETECT AND MEASURE FREQUENCY OF RADIO AND RADAR SIGNALS	RADIO OPERATOR		(2, FIGURE 4-12)
	RADAR COUNTER-MEASURE	AN/APT-1	TO JAM RADAR SIGNALS	RADIO OPERATOR		(6, FIGURE 4-12)
	RADAR COUNTER-MEASURE	AN/ARQ-8	TRANSMITTING ONLY TO JAM RADAR SIGNALS	RADIO OPERATOR		(4, FIGURE 4-12)
	PANORAMIC ADAPTER	AN/APA-38	TO PROVIDE VISUAL INDICATION OF RECEIVED RADIO AND RADAR SIGNALS	RADIO OPERATOR		(3, FIGURE 4-12)

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SHEET 2

Figure 4-10. (Sheet 2) Communication and Associated Electronic Equipment

COMMUNICATION AND ASSOCIATED ELECTRONIC EQUIPMENT.

The communication and associated electronic equipment consists of radio and interphone equipment to provide airplane-to-airplane communication, airplane-to-ground communication, and intraplane communication between crew members; navigation sets for guidance and blind landing; and radar sets for identification, long range navigation, radar defense, radar bombing, and tail turret control. Equipment is provided on each wing and on the rudder and elevators to discharge static electricity. For antenna arrangement see figure 4-8. A functional breakdown of the installed equipment of the airplane is listed in figure 4-10.

COMBAT INTERPHONE SYSTEM.

The interphone system provides interphone communication between all crew stations. In addition, remote interphone jackboxes are located in the wing crawlways between the nacelles, in the tail section, in the bomb bays, and outside under the fuselage between No. 2 and No. 3 bomb bays.

The basic interphone system is conventional. The system, however, has been modified to include a private

interphone channel; a call circuit; and provisions for either the aircraft commander or pilot, or both, to mix command radio, radio compass, interphone, marker beacon, and localizer audio signals into one output.

To start the interphone amplifier, turn on the airplane's main power supply. Make sure the ON-OFF switch on the amplifier is in the ON position.

Note

Normally this switch is safety-wired in the ON position.

Private Interphone Channel.

The private interphone channel employs a private interphone amplifier and can be used in the event of normal interphone channel failure. Two variations of the private interphone channel are used. On airplanes not included in group 10, a special interphone switch (1, figure 4-15) on the pilots' pedestal provides primary control of the private interphone channel. When this switch is in the normal CRUISE COMBAT position and the private interphone channel is in use, communication between all crew stations is available. Placing the switch in the PRIVATE position removes all crew stations from the channel except those for the aircraft commander, pilot, navigator, and radar-

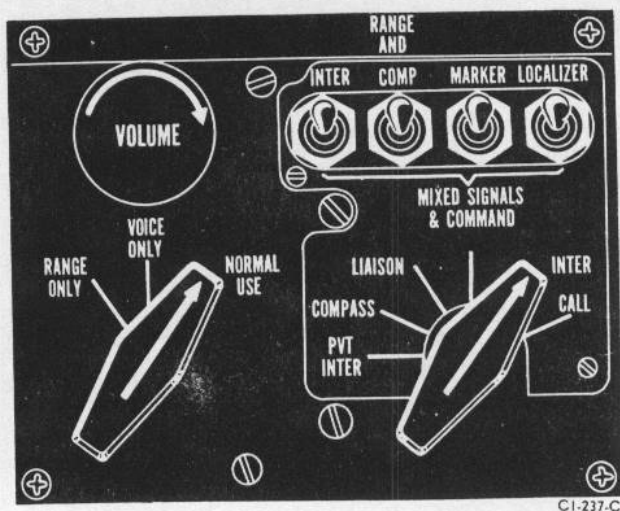


Figure 4-11. Pilot's Interphone Panel

bombardier. Thus a private communication channel is available for close coordination between these stations and the remainder of the crew can still use the normal interphone system.

On airplanes not included in group 10, when it is desired to restrict the private interphone channel to any of the four designated stations, the following steps must be performed by the aircraft commander or the pilot:

1. Place the special interphone switch in the PRIVATE position.
2. Hold the selector switch on the interphone control panel in the spring-loaded CALL position.
3. Direct the crew members with whom communication is desired to place their selector switches in the PVT. INTER position.
4. Release the selector switch, place it in the PVT. INTER position, and continue the conversation on the private interphone channel.

On group 10 airplanes the special interphone switch for the private interphone channel has not been incorporated, thereby eliminating the restrictions on the private interphone channel use except those imposed by crew discipline. Use of the special interphone switch in the PRIVATE position prevents communication between aft cabin crew members and the flight deck if the normal interphone channel becomes inoperative.

When use of the private interphone channel is desired, the following steps must be performed:

1. Hold the selector switch on the interphone control panel in the spring-loaded CALL position.
2. Close the microphone switch and speak into the microphone, directing the crew members with whom communication is desired to place their selector switches in the PVT. INTER position.

3. Release the selector switch, place it in the PVT. INTER position, and continue the conversation on the private interphone channel.

Emergency Interphone Operation (Excluding Group 10 Airplanes).

When it is apparent that the normal interphone system has become inoperative, the crew member first noticing the deficiency will alert the remainder of the crew to switch to PVT. INTER. The special interphone switch on the pilots' pedestal must be in the CRUISE COMBAT position at all times, except in instances when close coordination is required between the five crew members on the private circuit. Three amplifiers are provided; one each in the normal, private; and special interphone systems. In case of amplifier failure, any one of the three amplifiers can be interchanged.

Emergency Interphone Operation (Group 10 Airplanes).

When it is apparent that the normal interphone system has become inoperative, the crew member first noticing the deficiency will alert the other crew members to switch to PVT. INTER.

Note

The call circuit operates through the normal interphone amplifier only.

Wing Interphone Control Switch.

An on-off wing interphone control switch is provided at each wing crawlway entrance hatch. This switch is used to isolate the wing interphone channel from the basic interphone channel so that, in the event a nacelle fire short circuits the wing interphone channel, the basic interphone channel will remain operative. Each switch is mechanically ganged to a wing crawlway light switch.

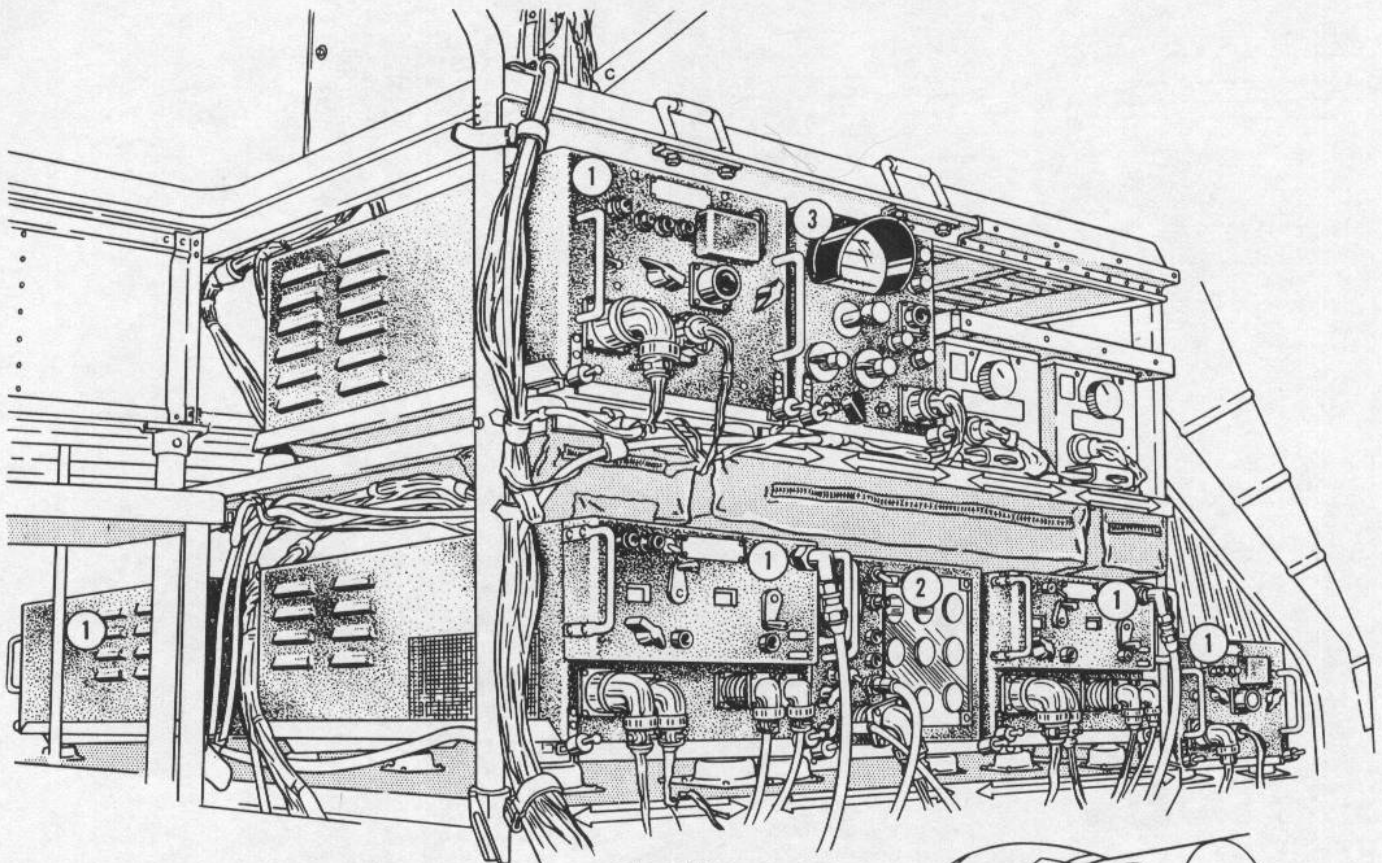
CAUTION

The wing interphone control switch must always be in the OFF position when the wing interphone channel is not in use.

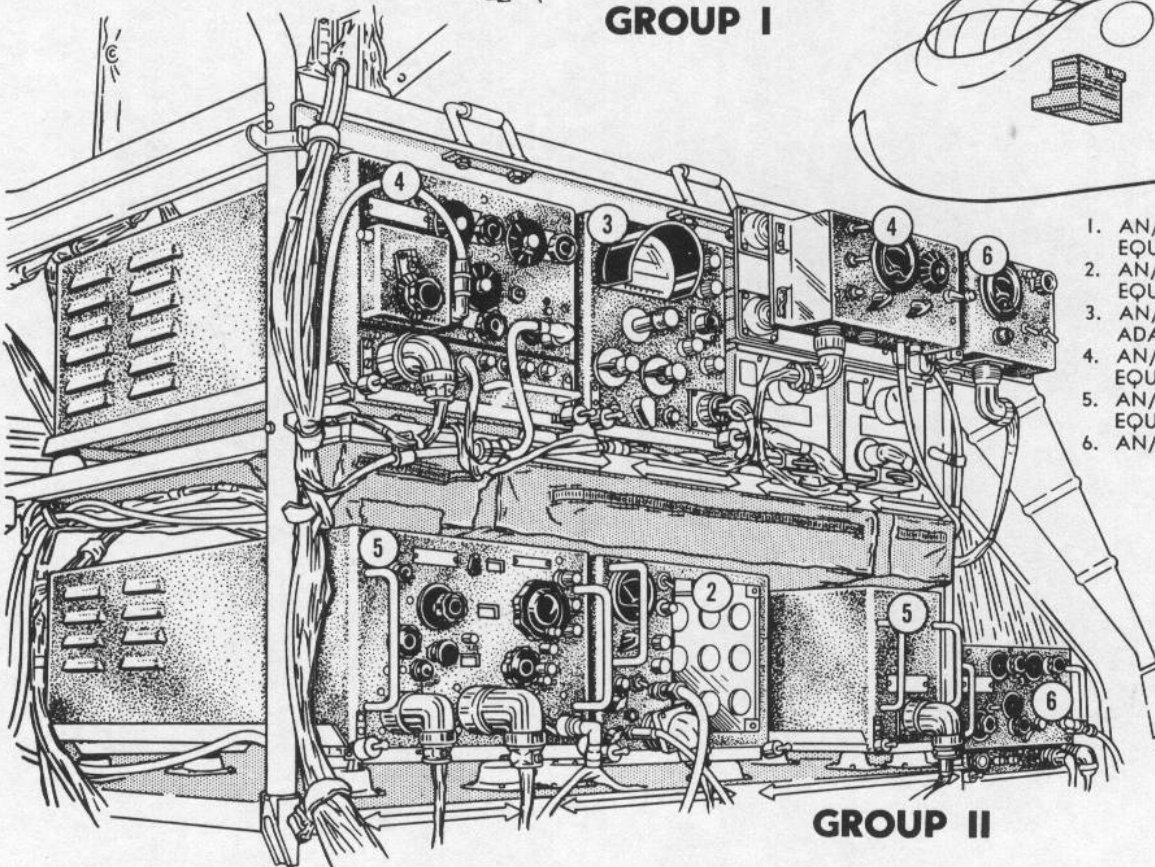
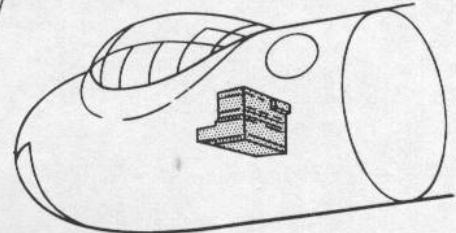
On group 10 airplanes an indicator lamp (39, figure 1-20) located on the flight engineer's panel lights when one or both of the wing interphone control switches are on.

Call Circuit.

A call circuit is provided to enable a crew member at any crew station to interrupt the reception of the other stations provided the normal interphone channel is operative. When the call circuit is selected by holding a selector switch in the spring-loaded CALL position, all other interphone controls are switched from any facility being used to the output of the normal interphone amplifier.



GROUP I

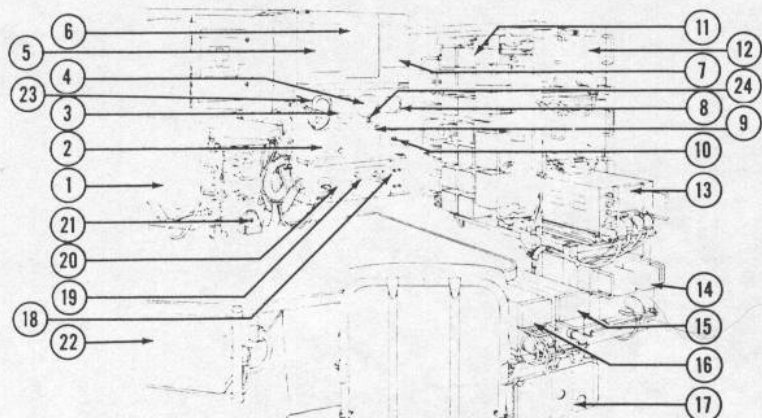


GROUP II

1. AN/APT-4 RADAR EQUIPMENT
2. AN/APR-4 RECEIVING EQUIPMENT
3. AN/APA-38 PANORAMIC ADAPTER
4. AN/ARQ-8 RADIO EQUIPMENT
5. AN/APT-5A RADAR EQUIPMENT
6. AN/APT-1 TRANSMITTER

Figure 4-12. ECM General Arrangement

3-1029



1. LORAN SET AN/APN-9A
2. DIRECTIONAL GYRO INDICATOR—TYPE C-5
3. OUTSIDE ALTIMETER
4. GYRO COMPASS REPEATER—TYPE V-2
5. RADIO COMPASS INSTRUCTION PLACARD
6. RADIO COMPASS CONTROL PANEL
7. CHECK LIST
8. CLOCK
9. RADIO COMPASS
10. DIRECTIONAL GYRO CONTROL SWITCH
11. SERVO AMPLIFIERS
12. COMPUTER POWER SUPPLY—TYPE A-1
13. SN-57/APQ-31 RADAR SYNCHRONIZER
14. CP-53/APQ-31 AZIMUTH COMPUTER
15. PP-352/APQ-31 POWER SUPPLY
16. PP-353/APQ-31 POWER SUPPLY
17. COMPUTER TRANSMITTER—TYPE B-1
18. CIRCUIT BREAKER ANEL
19. INTERPHONE CONTROL PANEL
20. OXYGEN CONTROLS
21. TABLE LAMP CONTROL KNOB
22. RADIO COMPASS RECEIVER R-5A/ARN-7
23. TRUE AIRSPEED INDICATOR
24. COMPASS SLAVING SWITCH

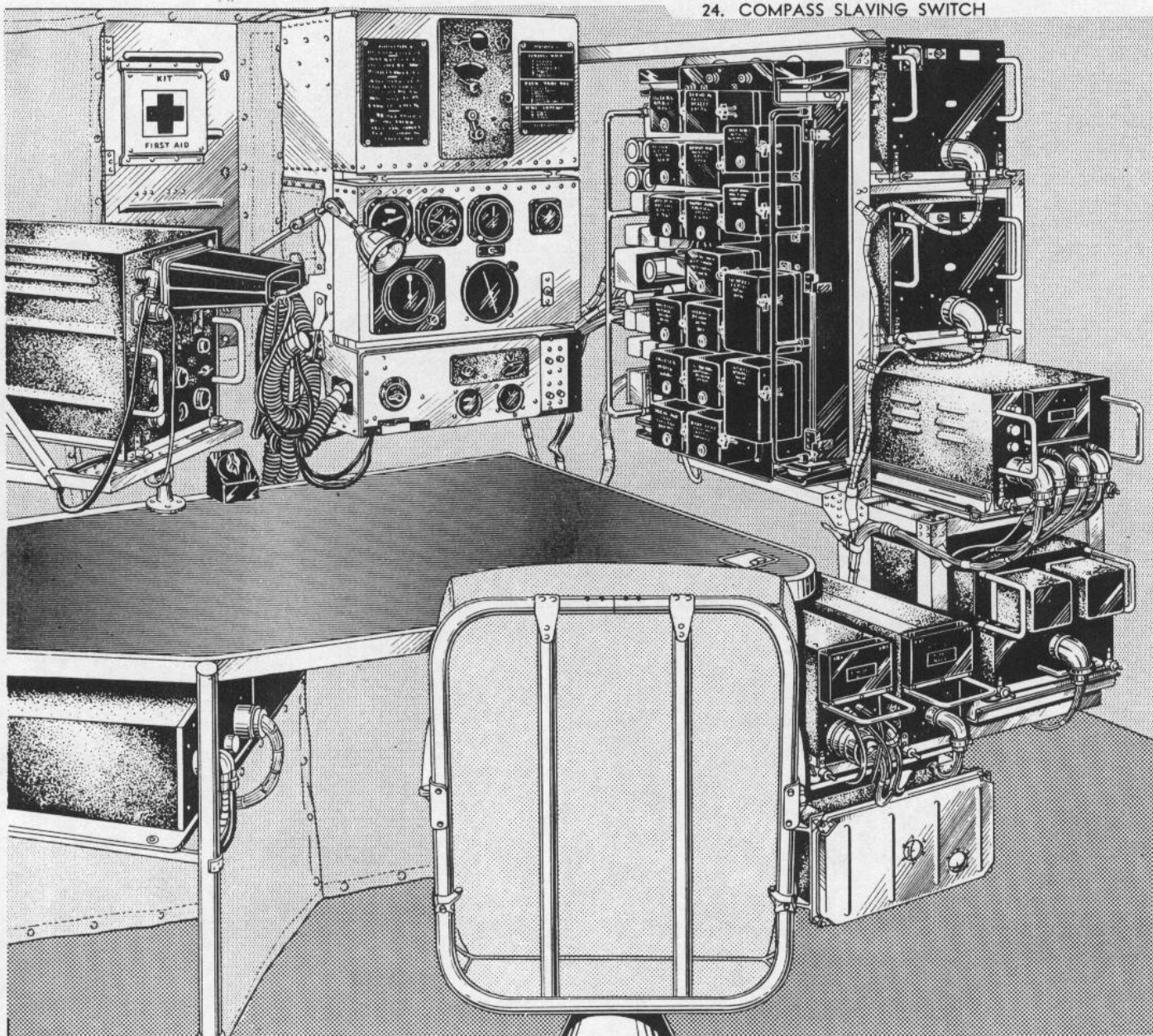


Figure 4-13. Navigator's Station

3-1022-R3

Mixed Signals and Command.

This feature of the interphone system is provided for the aircraft commander and pilot only. (See figure 4-11.) It allows either or both of them to mix any combination of radio compass, interphone, marker beacon, and localizer audio signals with command radio signals, affording close coordination for take-off or landing operation. To use the mixed signals and command feature, proceed as follows:

1. Place the selector switch on the interphone control panel in the MIXED SIGNALS & COMMAND position. The command radio signals will be received in the headset, provided the set is in operation and its volume is properly adjusted.
2. Adjust the volume control on the interphone control panel for the desired output level.
3. To transmit on the command radio set, close the microphone switch and speak into the microphone.
4. To receive signals from other sets in conjunction with command radio signals, place any combination of the toggle switches marked INTER-COMP-MARKER-LOCALIZER in the ON position. The INTER switch is for the interphone channel, and the COMP switch is for the radio compass channel. The MARKER switch is for the marker beacon channel, and the LOCALIZER switch is for the localizer channel.

Note

These four channels are operative only when their switches are on and the interphone selector switch is set at MIXED SIGNALS & COMMAND.

Mixed Signals and Liaison.

This facility is provided for the radio operator only and is utilized as follows:

1. Place the selector switch on the interphone control panel in the MIXED SIGNALS & LIAISON position. The liaison radio signals will be received in the headset, provided the set is in operation and its volume is properly adjusted.
2. Adjust the volume control on the interphone panel to the desired output volume.
3. To transmit on the liaison radio set, close the microphone switch and speak into the microphone. The VOICE-CW-MCW switch on the liaison transmitter must be in the VOICE position.

Note

Other crew members can hear the liaison set by placing their selector switches in the LIAISON position.

Radio Operator's Interphone Control Panel.

This panel is a modified pilots' interphone control panel. Its operation is conventional except that it permits the radio operator to receive AN/APR-4 audio

signals. To receive these signals, place the second switch from the right in the gang of four switches in the up position. (The three adjacent switches are inoperative.) Then place the selector switch on MIXED SIGNALS & LIAISON.

COMMAND RADIO AN/ARC-3.

Operation of this equipment is accomplished from the control panel (4, figure 4-15) on the pilots' pedestal. Operate as follows:

1. Place the selector switch on the interphone control panel to MIXED SIGNALS & COMMAND.
2. Place the ON-OFF switch on the command set control unit to the ON position and turn the channel selector switch to any one of the positions designated A through H on the control unit. This action applies power to the unit, which then automatically tunes itself to the channel selected.
3. To stop the equipment, place the ON-OFF switch in the OFF position.

LIAISON RADIO SET AN/ARC-8.

Control of transmitting equipment is accomplished from the radio operator's table. (See figure 4-9.) The equipment is started by placing the LOCAL-REMOTE switch to the LOCAL position and setting the emission switch to VOICE. A remote control panel (3, figure 4-15) is located on the pilots' pedestal for use by the aircraft commander or pilot. Control of this panel is attained when the radio operator places the LOCAL-REMOTE switch to REMOTE. A green light on the pilots' remote control panel will indicate that the transmitter is ready for remote control. To stop the transmitter, place the EMISSION switch in the OFF position.

RADIO RANGE RECEIVER BC-453-B.

Operation of this equipment is accomplished from a remote control panel (2, figure 4-15) on the pilots'

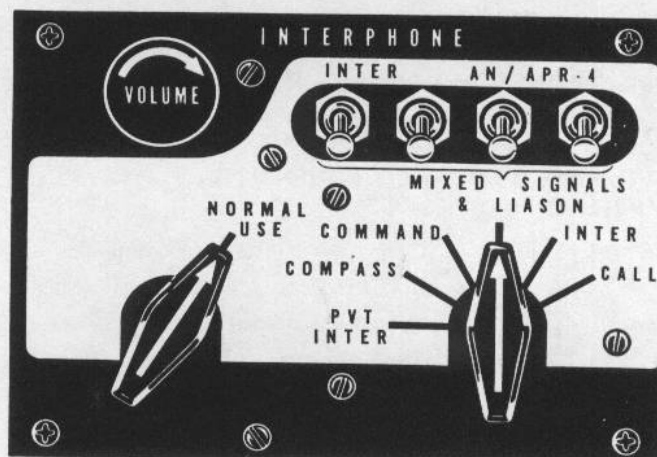
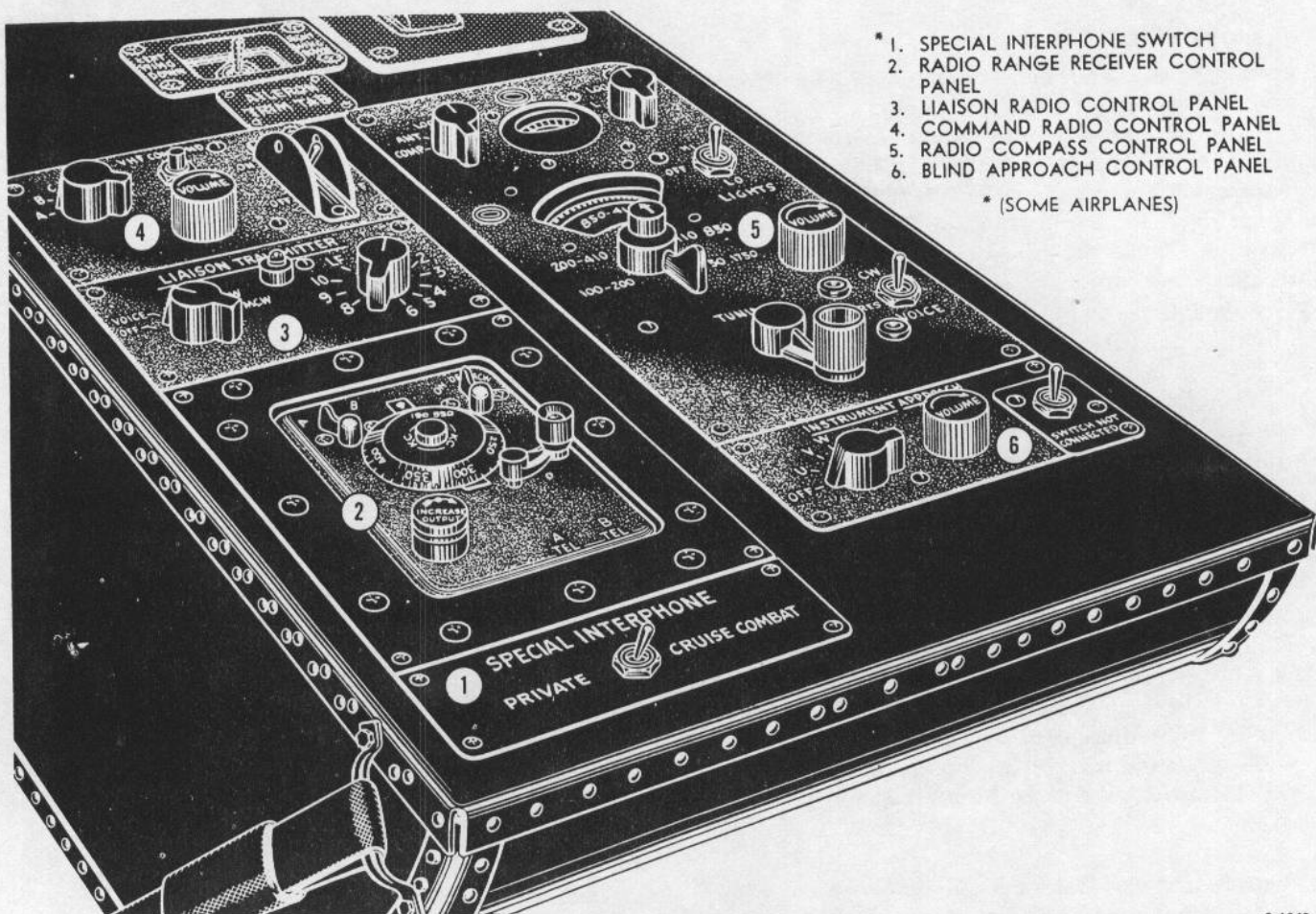


Figure 4-14. Radio Operator's Interphone Panel

3-1050-R



- * 1. SPECIAL INTERPHONE SWITCH
- 2. RADIO RANGE RECEIVER CONTROL PANEL
- 3. LIAISON RADIO CONTROL PANEL
- 4. COMMAND RADIO CONTROL PANEL
- 5. RADIO COMPASS CONTROL PANEL
- 6. BLIND APPROACH CONTROL PANEL

* (SOME AIRPLANES)

Figure 4-15. Pilots' Radio Controls

3-1049-R

pedestal. The receiver is started by placing the CW-OFF-MCW switch on the control panel in either the CW or MCW position. To turn the equipment off, place the CW-OFF-MCW switch in the OFF position.

RADIO SET AN/CRC-7 ("WALKIE-TALKIE").

This set is stowed on the left side of the radio operator's compartment adjacent to the food locker and is provided for emergency use. To start the unit, remove the lock pin from the three switch keys marked TONE, TRAN, and REC and press the desired key. To stop the set, release the keys.

INSTRUMENT APPROACH EQUIPMENT AN/ARN-5A AND RC-103-A.

A control panel (6, figure 4-15) installed on the pilots' pedestal is provided to control this equipment. An indicator (1, figure 1-12) located on the pilots' instrument panel gives the pilots a visual indication of the signals received by both receiving sets. About 20 minutes before approaching the runway, turn the selector switch to the appropriate channel and allow the receivers to warm up.

RADIO COMPASS AN/ARN-7.

This equipment is used by the pilots and navigator; each has a control panel and an indicator. The pilots' control panel (5, figure 4-15) is located on the pilots' pedestal; the pilots' indicator (26, figure 1-12) is installed on the pilots' instrument panel. The navigator's control panel and indicator (9, figure 4-13) are located at the navigator's station. To start the equipment, momentarily hold the function switch on the control panel in the spring-loaded CONT position and then move the function switch to the COMP or ANT position. To stop the equipment, turn the function switch to OFF.

MARKER BEACON SET AN/ARN-12 OR RC-193A.

Some airplanes are equipped with the RC-193A set, while other airplanes have the AN/ARN-12 set. The operation of this equipment is automatic when the ship's d-c power is on and its circuit breaker is closed. Marker beacon signals are indicated by a lamp at the corner of the instrument approach indicator on the pilot's instrument panel. To receive signals aurally the interphone control panel marker switch must be on MARKER and the selector switch must be on MIXED SIGNALS & COMMAND.

IDENTIFICATION SET AN/APX-6.

Provisions have been made for the installation of an AN/APX-6 identification set at the radio operator's station.

LORAN SET AN APN-9A.

The receiver-indicator (1, figure 4-13) of this set is installed on the navigator's table. A control panel incorporated on the front of the receiver-indicator in conjunction with a detachable visor provides all of the manual controls. To start the set, proceed as follows:

1. Set the AMPLITUDE BALANCE control at its center position.
2. Turn the FINE DELAY control to its center position of rotation.
3. Set the DRIFT control at its center position of rotation.
4. Turn the RECEIVER GAIN control clockwise until the STATION rate identification (pilot light) illuminates. Wait at least five minutes to allow the equipment to warm up. The set is now ready for operation.
5. To stop the equipment, turn the RECEIVER GAIN control to POWER OFF and check to see the pilot light is not illuminated. Also check to see that the pattern on the indicator screen has disappeared.

PHANTOM TARGET RF-3A/AP.

Phantom target RF-3A/AP is air-borne equipment designed to test the overall effectiveness of radar transmitting and receiving equipment. This test equipment serves as an artificial target which simulates echoes to a radar-transmitted signal. By measuring the duration of the echo, the radar-bombardier is able to judge the effectiveness of the system. A spring-loaded push-type switch (4, figure 4-35) is provided at the radar-bombardier's station for operating the equipment.

RADAR SET AN/APQ-31.

For reasons of security classification, no information on control and operation of this equipment is given in this publication.

RADAR PRESSURIZATION.

A 115-volt, a-c, motor-driven pressure pump located in the lower section of the forward cabin provides pressurized air for the radio frequency unit, the radio frequency line (wave guide), and the modulating unit of the AN/APQ-31 radar set. The pressure pump draws cabin air through a dehydrator to remove all moisture and then pressurizes it before it is routed to the units. The system incorporates a pressure pump switch, a pressure gage, an indicator lamp, and a pressure drain valve located on the radar-bombardier's

K-() control panel. The system is controlled by the pressure pump switch which has three positions—AUTOMATIC ON, OFF, and MANUAL ON. When the switch is in the AUTOMATIC ON position, operation of the pump is controlled automatically by the action of a pressure switch. The indicator lamp lights when the pump is in operation.

CAUTION

If the pressure begins to exceed its specified limits, as indicated on the pressure gage, and the indicator lamp indicates that the pump is still operating, the pump should be stopped by placing the switch in the OFF position.

If the pressure begins to drop to a critically low point and the indicator lamp indicates that the pump is not in operation, hold the switch in the spring-loaded MANUAL ON position until the pressure is back to normal.

CAUTION

Do not operate the radar set until radar t-r unit air pressure is above minimum limits.

LIGHTING SYSTEM.

The lighting system is composed of two groups of lights, exterior and interior. These lights operate on both 28-volt alternating and direct current, as well as 115-volt alternating current. The exterior group includes landing lights, formation lights, navigation lights, and code-signalling lights. Interior lighting is accomplished by means of dome, cockpit, and other miscellaneous lights. Receptacles for operating Aldis signals lights are located at the navigator's station, on the pilot's fairing, and at each sighting station.

EXTERIOR LIGHTS.

Landing Lights.

Two retractable landing lights are mounted flush with the fuselage, one on each side of the nose section just above the lower flight deck floor. In airplanes other than group 9, each landing light as a three-position switch that controls extension, illumination, and retraction. In group 9 airplanes, a three-position switch controls the extension and retraction of each light, and an additional ON-OFF switch energizes the filaments of both lamps.

CAUTION

When operating in extremely cold temperatures, or during icing conditions, the filament control switch should be placed ON

for a short time before extending the light. This action will preheat the light assemblies and remove any ice that might interfere with proper extension of the lights.

Navigation Lights.

The navigation light system consists of a red light assembly on the left wing tip, a green light assembly on the right wing tip, two yellow and two white lights on the stabilizer close to the fuselage, and two white light assemblies, one on the upper fuselage approximately in line with the wing trailing edge and one on the lower fuselage forward of the wing leading edge. The white fuselage light assemblies each consist of one small and one large light. The system is used to indicate the position and direction of motion of the airplane and to relay Morse code signals. All of the control switches for the system are mounted on the pilots' pedestal. A fuselage light switch (8, figure 1-13) controls the two small white fuselage lights when turned from OFF to either DIM or

BRIGHT, and the master code switch (2, figure 1-13) sets up the circuit for flashing code signals with the two large white fuselage lights. The code selector switch is used to select the desired code signals, and the code indicator on the pilots' pedestal provides the pilots with a visual indication of the signal being sent. The position light switch controls the wing and tail lights with OFF, STEADY, and FLASH positions. The lights can be operated either dim or bright in both the STEADY and FLASH conditions by use of the dimming switch.

Formation Lights.

Nine blue formation light assemblies are installed on the airplane. Three are mounted on the left wing, three on the right wing, and three on the aft part of the upper fuselage. The lights are controlled by a switch (7, figure 1-13) on the pilots' pedestal. The three positions of the switch are OFF, DIM, and BRIGHT.

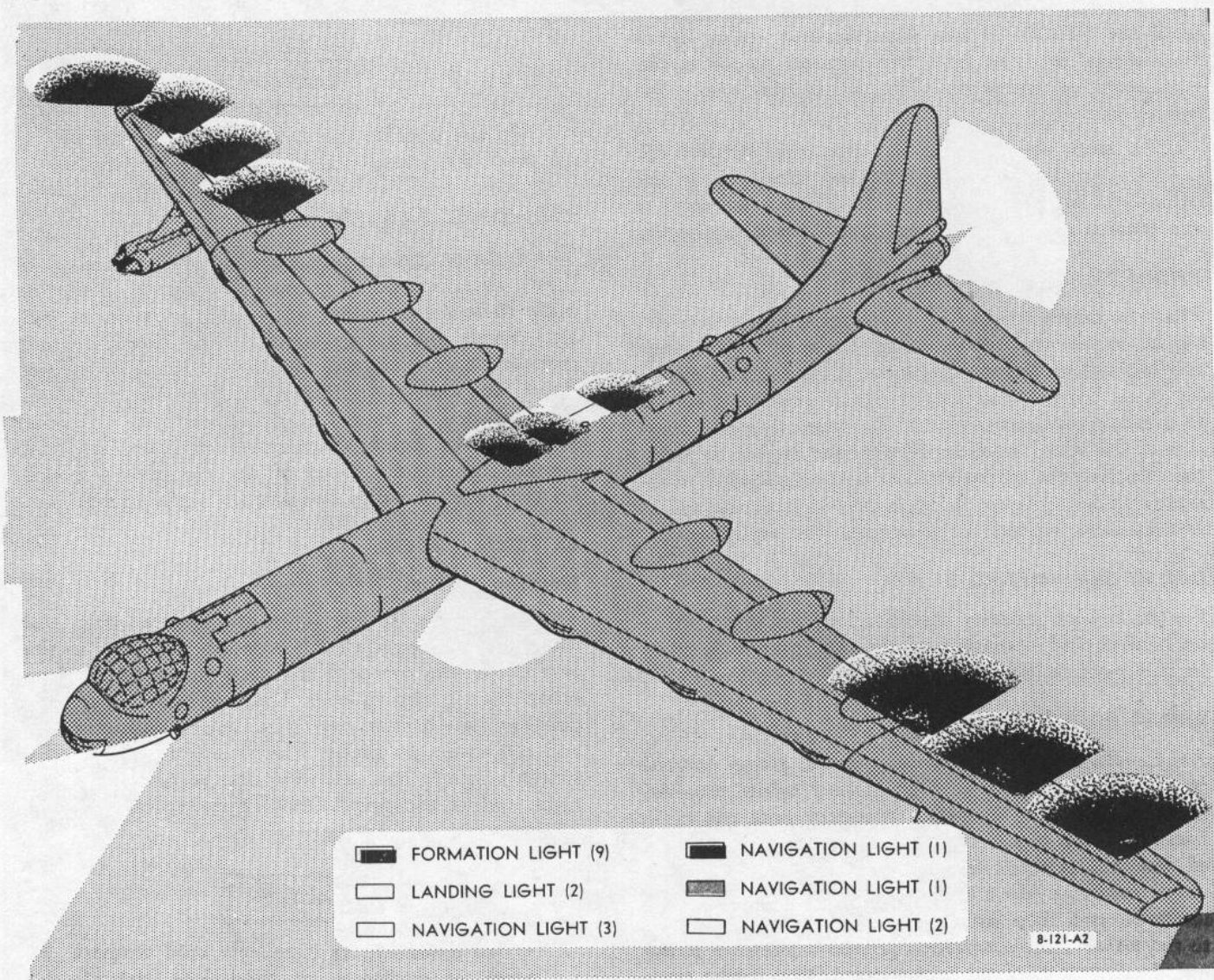


Figure 4-16. Exterior Lights Arrangement

RESTRICTED

CREW MEMBERS OXYGEN DURATION-HRS.

CABIN ALT., FT.	GAGE PRESSURE, P.S.I.							BELOW 100
	400	350	300	250	200	150	100	
40,000	10.3	8.8	7.4	5.9	4.4	2.9	1.5	EMERGENCY DESCEND TO ALTITUDE NOT REQUIRING OXYGEN
	10.3	8.8	7.4	5.9	4.4	2.9	1.5	
35,000	10.3	8.8	7.4	5.9	4.4	2.9	1.5	
	10.3	8.8	7.4	5.9	4.4	2.9	1.5	
30,000	7.6	6.5	5.5	4.4	3.3	2.2	1.1	
	7.6	6.5	5.5	4.4	3.3	2.2	1.1	
25,000	6.1	5.3	4.4	3.5	2.6	1.8	0.9	
	7.2	6.2	5.2	4.1	3.1	2.1	1.0	
20,000	4.9	4.2	3.5	2.8	2.1	1.4	0.7	
	8.2	7.0	5.8	4.7	3.5	2.3	1.2	
15,000	3.9	3.3	2.8	2.2	1.7	1.1	0.6	
	10.0	8.5	7.1	5.7	4.2	2.8	1.4	
10,000	3.3	2.8	2.4	1.9	1.4	1.0	0.5	
	13.2	11.3	9.4	7.5	5.7	3.8	1.9	

RED FIGURES INDICATE DILUTER LEVER IN 100% POSITION
BLACK FIGURES INDICATE DILUTER LEVER IN NORMAL POSITION
CYLINDERS — 26 EA. G-1
CREW — 15
WHEN 11 MAN CREW IS USED DURATION INCREASES APPROXIMATELY 25%

CI-345W.C

Figure 4-17. Oxygen Consumption Table

INTERIOR LIGHTS.

Dome, instrument, control panel, cockpit, table, and crew station lights are located throughout the forward cabin to provide the crew with adequate illumination. The lights are controlled by built-in dimmer and switch units, panel switches, and rheostats. Lights in the forward turret bay and dome and passage lights in bomb bays No. 1 and 2 are controlled by either of two switches, one on the radio operator's control panel and the other on the bomb bay lights control panel. The aft turret bay and bomb bays No. 3 and 4 dome and passage lights are controlled by either of two switches, one on the bunk equipment panel in the aft cabin and the other on the bomb bay lights control panel.

The aft cabin dome light is controlled by two switches, one on the left side of the cabin near the communication tube and the other at the entrance hatch. The gunners' cockpit lights are controlled by built-in dimmer and switch units. The switch for the tail cone and tail turret dome lights is a switch-type circuit breaker located above the tail cone entrance hatch. A switch at each wing crawlway entrance controls the wing crawlway lights. Mounted on the engineer's circuit breaker panel is one switch-type circuit breaker for control of the nose and main landing gear wheel well lights. Receptacles for operating the Aldis

lamps are located at the navigator's station, the pilot's station, and at each sighting station.

OXYGEN SYSTEM.

The airplane is equipped with a low pressure oxygen system consisting of 26 type G-1 oxygen cylinders (airplanes in group 14 have 24 oxygen cylinders), 5 portable diluter oxygen units, 8 recharger hoses, and oxygen controls at each crew station. Two types of oxygen regulators are installed on B-36D airplanes. Airplanes in group 14 are equipped with the D-1 automatic pressure-breathing diluter-demand regulator; all other airplanes have an A-14 pressure-breathing diluter-demand regulator. The oxygen cylinders are located on the left side of the bomb bay area, and the system is serviced through a single filler valve located on the lower left side of the fuselage near the radar dome. (See figure 1-52.) For combat safety each crew oxygen station is supplied from two distribution lines through automatic check valves. The approximate duration of the oxygen system is given in figure 4-17. Only a pressure-breathing demand oxygen mask will be used above 34,000 feet pressure altitude.

D-1 REGULATOR CONTROLS AND INDICATORS. (Group 14 Airplanes)

An automatic pressure-breathing, diluter-demand oxy-

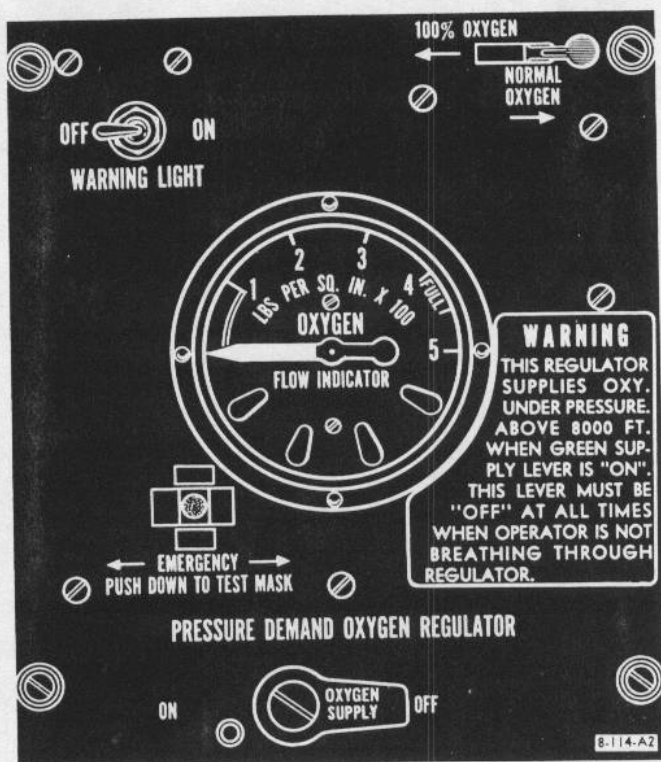


Figure 4-18. Typical Oxygen Panel
(Group 14 Airplanes)

gen regulator (figure 4-18) is installed at each crew station and in each roomette. One additional regulator is located on the bunk equipment panel on the forward bulkhead of the aft cabin and one is located on the forward bulkhead in bomb bay No. 1. An oxygen flow indicator and a pressure gage are incorporated in the regulator.

Regulator Diluter Control.

A diluter lever is provided on each oxygen regulator. In the NORMAL OXYGEN position the lever opens the air inlet valve so that the regulator automatically supplies a proper mixture of air and oxygen to the mask at all altitudes. The lever at the 100% OXYGEN position closes the air inlet valve so that the regulator supplies 100 per cent oxygen to the mask for emergency use.

Regulator Supply Valve Lever.

An oxygen supply valve lever is located at the bottom of each regulator panel. The lever, when turned to the ON position, opens the oxygen supply to the regulator. The lever, when turned to the OFF position, cuts off the oxygen supply.

WARNING

If the oxygen supply valve is left turned on at an unused station, the oxygen supply will be depleted.

Regulator Emergency Toggle Lever.

The emergency toggle lever provides a means of manually supplying positive pressure to the mask for emergency purposes. Pushing the lever in gives a positive pressure to the mask. This pressure is automatically stopped when the lever is released. Pushing the lever to either side (right or left) locks the lever to give a continuous positive pressure to the mask.

Note

The oxygen mask fit may be tested at any altitude by pushing the emergency toggle lever.

Regulator Warning System Switch.

This switch is inoperative because the oxygen system warning signals are not incorporated in this airplane.

Pressure Gage.

A pressure gage is incorporated in each regulator to indicate the pressure in the oxygen system. It is used to determine oxygen duration.

Flow Indicator.

A flow indicator is incorporated in each regulator to indicate when oxygen is flowing through the regulator.

OXYGEN PANELS.

(Airplanes not in Group 14)

Oxygen equipment panels are installed at each crew station and on the forward wall of the aft cabin for personnel using the bunks. Each panel consists of a type A-14 pressure-breathing diluter-demand regulator, a type A-3 flow indicator, and a type K-1 pressure gage. Each panel is furnished oxygen through two lines from two different sources so that in the event a line ruptures or one of the sources fails the panel will not be deprived of oxygen.

PORTABLE OXYGEN EQUIPMENT.

The five portable oxygen units are provided to furnish the crew with oxygen when entering the unpressurized areas in the airplane while at high altitude, as well as serving as an emergency system in case of failure of an oxygen panel. Three of these units are located in the forward cabin and two in the aft cabin. The units consist of an A-6 walk-around oxygen cylinder and an A-15 regulator. Eight portable recharger assemblies are installed in the airplane; four are located in the forward cabin, two above the catwalk in the bomb bay, and two in the aft cabin. Any of the eight recharger hoses may be used to fill the portable cylinders.

NORMAL OXYGEN PROCEDURE.

The following rules will be followed on every high altitude flight:

1. Mask will be worn at all times when *cabin* altitude is 10,000 feet or above.

2. *Pressure altitude 25,000 to 30,000 feet.*

Mask and helmet not worn but near person. Mask should be connected to oxygen supply and ready for use.

3. *Pressure altitude 30,000 to 35,000 feet.*

Helmets must be worn, mask not on face but attached to helmet and connected to oxygen supply.

4. *Pressure altitude above 35,000 feet.*

All crew members will have helmet and mask on with mask connected to oxygen supply. No crew member will remove oxygen mask without approval of the airplane commander.

5.

<i>Cabin Altitude</i>	<i>Regulator Setting (A-14 Pressure Demand)</i>
10 - 34,000 feet	Normal
34 - 38,000 feet	Safety
38 - 41,000 feet	41 M
41 - 43,000 feet	43 M
43,000 feet and above	45 M

6.

<i>Cabin Altitude</i>	<i>Regulator Setting (D-1 Regulator)</i>
0 - 10,000 feet	Oxygen Supply Lever OFF
10,000 feet and above	Oxygen Supply Lever ON

WARNING

No flights will be made over 43,000 feet unless the aircraft is equipped with the D-1 regulator. Also, the supply lever of the D-1 regulator must be in the OFF position when not in use.

OXYGEN SYSTEM EMERGENCY OPERATION.

With symptoms of the onset of anoxia, or if smoke or fuel fumes should enter the cabin, set the diluter lever of the oxygen regulator to the 100% OXYGEN position. In the event of accidental loss of cabin pressure on airplanes not in group 14, immediately turn the pressure dial of the oxygen regulator to the ABOVE 45M position and tighten the mask to hold pressure. On group 14 airplanes, set the diluter lever of the regulator to 100% OXYGEN and push the emergency toggle lever to the right or left.

CAUTION

When use of 100% OXYGEN or EMERGENCY becomes necessary, the aircraft commander will be informed of this action. Use

of 100% OXYGEN or EMERGENCY will reduce oxygen duration of the airplane. After the emergency is over, set the diluter lever to NORMAL OXYGEN and, on group 14 airplanes, push the emergency toggle lever to the center position.

If the regulator should become inoperative, disconnect the mask from the airplane oxygen system and connect it to a portable oxygen unit. If an adequately filled portable unit is not available, pull the cord of the H-2 emergency oxygen cylinder.

WARNING

When use of the H-2 emergency oxygen cylinder becomes necessary, the aircraft commander will be informed of this action so that he can immediately descend to an altitude at which oxygen is not required.

OXYGEN DISCIPLINE.

Oxygen discipline is extremely important at high altitude because of the very short period of useful consciousness in the event of an oxygen system malfunction, improperly used oxygen equipment, or an explosive decompression. Training in the altitude chamber should be taken very seriously and practiced religiously during all high altitude flights. In fact the aircraft commander must enforce good oxygen discipline. This discipline should not begin in the air, but on the ground during personal equipment inspection. See to it that every crew member has properly fitted equipment, knows how to use his oxygen equipment, and knows how to handle any emergency situation. Lack of oxygen discipline in a crew could destroy it as surely as an anti-aircraft shell.

Loss of Cabin Pressure.

Explosive decompression or sudden loss of cabin pressurization results in an equalization of cabin altitude and airplane altitude within a few seconds time. In aircraft hulls with large cabin volumes, this explosive type of decompression occurs only with the sudden and complete blowout of a large blister or panel. Since time is all-important in preventing anoxia or hypoxia after explosive decompression, every crew member must immediately report any defect appearing in the hull which may lead to rapid pressure loss. If sudden decompression occurs without warning, the emergency condition must be transmitted immediately over the interphone, since crew members at duty stations remote from the compartment in which the panel or blister has blown may not realize what has occurred and may not carry out the necessary oxygen procedure to prevent unconsciousness.

The crew members in the damaged compartment will recognize explosive decompression by the following

events: dull booming sound with forceful out-rush of air and usually a formation of fog; forceful expiration of breath with mask chattering back and forth on face; passage of gas and belching; rapid popping of ears or plugging of ears; rasping or screeching in interphone.

Crew members in remote areas of hull may not hear or feel anything except a rapid popping and plugging of ears, which of itself alone should be sufficient warning to crewmen that cabin pressure has been lost. Warning bells and horns in remote areas are not reliable warning signals.

Mechanical effects of the explosive decompression result in considerable suction being exerted toward the blown hull area. Therefore crew members at duty stations near structures which might blow out must keep their seat belt or safety straps fastened when the cabin is pressurized. The communication tube should not be used except in cases of emergency at altitudes above 30,000 feet when cabin pressurization is being used.

The extent and severity of physical effects on personnel following explosive decompression depend on the following factors:

1. Rapidity of decompression.
2. Final cabin altitude resulting from decompression.
3. Range of altitude differential or pressure gradient through which cabin decompression has occurred.
4. Duration of time spent without oxygen at resultant altitude.
5. Individual physical condition.

The important physical effects of explosive decompression on personnel are anoxia and decompression sickness such as bends or chokes (altitude dysbarism). Anoxia is the most immediate, potentially dangerous, and disabling threat to the air crew. The average useful conscious time is indicated in the following table:

<i>Altitude</i>	<i>Average Useful Conscious Time</i>
20,000 feet	15 minutes
25,000 feet	3-4 minutes
30,000 feet	1 minute
35,000 feet	45 seconds
40,000 feet	15-20 seconds
45,000 feet	15 seconds
50,000 feet	10 seconds

When explosive decompression occurs, perform the following steps as rapidly as possible:

1. If mask is not on face, turn A-14 oxygen regulator to 43M first and then apply mask to face, tightening face straps to hold pressure.
2. If mask is being worn, turn A-14 regulator to the proper altitude setting and then tighten face straps

on mask. The D-1 regulator operates automatically if the oxygen supply switch is turned ON.

3. Check oxygen hose connections and blinker activity at regulator.

4. Aircraft commander will begin descent of aircraft immediately to 35,000 feet and make a thorough check of all crew members.

5. Check the condition of all occupants in your compartment. If any individual appears to be in difficulty or has already lost consciousness, the crew member nearest him should go to his aid without detaching himself from his own hose and station.

6. In case a crewman cannot be reached by a rescuer while still attached to his outlet, the rescuer will act as follows:

- a. Signal to other crew member in compartment or report over interphone his intended rescue action.



Figure 4-19. Oxygen Station in Use

CI-167-C

b. Pull his bail-out bottle release (if above 35,000 feet or altitude unknown) and detach hose from oxygen station.

c. Go immediately to the stricken airman, turn his A-14 regulator to 43M or above, and push his mask forcibly in his face until he regains consciousness and signals that he can take care of himself. If type D-1 regulators are used, push the stricken airman's emergency toggle lever either to the right or left. This will supply a positive pressure to the mask. Hold in this position until crew member signals that he can take care of himself.

WARNING

Extreme care must be exercised in handling stricken crew members as they regain consciousness. In some instances they will become violent.

If stricken airman's oxygen equipment appears not to be functioning properly and no other outlets are available in the compartment, fasten mask on face tightly and pull his bail-out bottle. Return then immediately to own station, reconnect to the oxygen system, and notify the aircraft commander of the emergency situation. Do not remain disconnected from your station for more than five minutes using the bail-out bottles.

d. Return to own station, reconnect, check blinker, and check in on interphone or by visual signal, indicating your return and condition of rescued airman.

Use of Pressure Oxygen Breathing Following Cabin Decompression.

The pressure oxygen system is designed primarily for emergency use and will provide adequate oxygen to the crew during descent of the airplane from an altitude of 50,000 feet down to 35,000 feet or below, where normal diluter-demand oxygen can be used from the regulator. Pressure breathing requires a forceful expiration against an oxygen pressure resistance which increases as the regulator settings are increased from SAFETY through 41M to ABOVE 45M. At the higher pressure settings the individual not conditioned to and practiced in pressure breathing will become fatigued, but there is no discomfort or injury inflicted on him as the result of pressure breathing during the time of descent after cabin decompression. Likewise, no damage to the lungs will occur as a result of having the mask on the face and breathing normal or 100 per cent oxygen at the time of descent after cabin decompression or at the time explosive decompression occurs.

Bends, chokes, and creeps; decompression sickness; and altitude dysbarism are synonymous terms and indicate

a condition of the body in which nitrogen bubbles are released into the tissue spaces and blood stream as a result of the sudden loss of pressure surrounding the body. This physical effect seldom occurs except after prolonged exposure at cabin altitudes in excess of 35 to 40,000 feet, or after explosive decompression through large pressure differentials to resultant cabin altitudes above 40,000 feet.

The condition is relieved upon descent of the airplane to 30,000 feet or below, or upon repressurization of the cabin. When decompression sickness occurs after decompression, it is seldom disabling and has no permanent after-effects on the body. The incidence and severity of decompression sickness at any given altitude can be markedly reduced by preliminary denitrogenization or by wearing a pressure suit.

Denitrogenization Procedure For Prevention of Decompression Sickness.

Tactical considerations may require that the aircraft complete a specific portion of the mission at an altitude of 40,000 feet without descending to a lower altitude, even though complete pressurization is lost. This requires that the crew receive maximum possible protection against potential decompression sickness. To accomplish this protection the following procedure is outlined:

1. One hour prior to reaching the critical point in the flight the aircraft commander will order all crew members to put on oxygen masks, if not already being worn, and to turn regulator to 100% OXYGEN.

2. Cabin pressure will be maintained at or below 10,000 feet for 30 minutes, during which time the crew will be breathing 100 per cent oxygen.

3. Cabin pressure will then be gradually decreased during the next 30 minutes until a cabin altitude of 30,000 feet is reached. At this point cabin altitude is leveled off and maintained there with crew on 100 per cent oxygen through the critical period of the flight. If cabin pressure is completely lost during the critical period, the airplane may be maintained at 40,000 feet altitude with crew breathing oxygen at a regulator setting of 41M with a maximum margin of safety against the appearance of disabling decompression sickness among the air crew.

Use of Walk-Around Bottles.

When moving around the cabin, walk-around bottles should be used at all times at *cabin* altitudes above 10,000 feet. Walk-around bottles that do not deliver pressure oxygen will not be used above 35,000 feet. Oxygen bottles that deliver pressure oxygen may be used at any altitude.

When *airplane* altitude exceeds 25,000 feet, a walk-around bottle must be taken on any movement by crew members from one pressurized compartment to another.

Precautions in Using Walk-Around Bottles.

1. Keep charged to at least 400 psi when not in use.
2. If recharger hose leaks, keep it attached to a walk-around bottle to conserve oxygen.
3. When using a walk-around bottle, check the pressure gage regularly and recharge when gage reads 100 psi.

AUTOPILOT.

The airplane is equipped with a type E-6 autopilot. This electro-mechanical device automatically positions the control surfaces for level flight, coordinated turns, or flight paths based on information provided by other equipment.

Note

E-6 autopilot modifications are discussed in "Autopilot System" Section VII. Do not interchange calibration control settings between modified and unmodified systems.

Primary control of the system is accomplished from the autopilot control panel (3, figure 1-13) located on the pilots' pedestal. "Second station" turn control operation can be transferred to the radar-bombardier at the discretion of the aircraft commander.

Calibration controls are also provided for the adjustment of autopilot response through the wide variations in gross weight, cg, air speed, and altitude. These calibration controls are located in the observer's compartment.

PRIMARY CONTROLS.

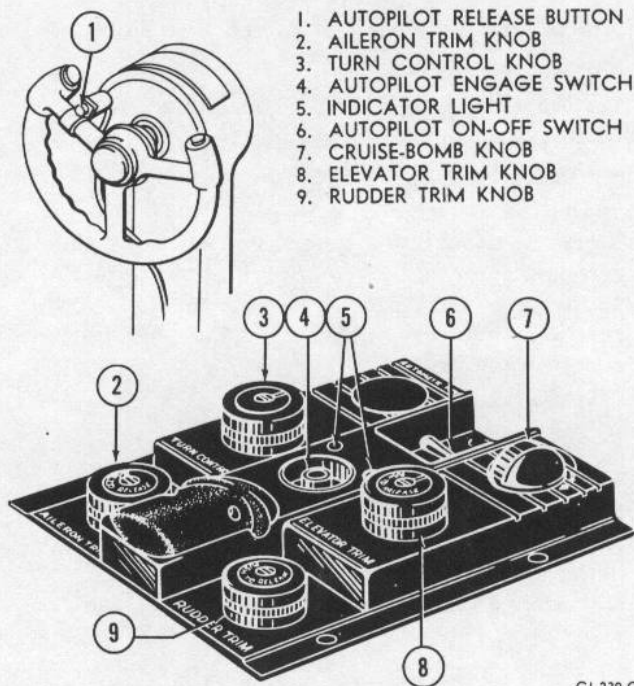
The primary controls of the autopilot are located on the autopilot control panel (figure 4-20). Individual controls on the autopilot control panel are discussed in the following paragraphs.

Autopilot On-Off Switch.

This switch (6, figure 4-20) controls 115-volt alternating current from the right forward power panel. The autopilot is normally ready for operation one minute after this switch is placed in the ON position.

Elevator, Rudder, and Aileron Trim Knobs.

These knobs (8, 9, and 2, figure 4-20) are used to apply electrical trim to the autopilot while it is engaged. If the autopilot is ON but not engaged, these knobs will normally oscillate in order to maintain a neutral position with respect to the movement of the control surfaces. Each knob has a push-button-type switch located in its center. These push-button switches can be used to disengage the three axes individually. If an axis is disengaged by one of these switches, the autopilot engage switch must be pressed to re-engage the axis.



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Figure 4-20. Autopilot Control Panel

Autopilot Engage Switch.

A push-button type switch (4, figure 4-20) is provided to engage the autopilot after the green lights on the autopilot control panel begin to flicker. After the autopilot is engaged, the green lamps will burn steadily.

Turn Control Knob.

The turn control knob (3, figure 4-20) is used to establish a coordinated automatic turn in the direction of knob rotation. Maximum bank obtainable is 32 degrees.

Cruise-Bomb Knob.

This knob is not used as a functional control.

Automatic Recovery Switch.

The automatic recovery switch should not be used because airplane response is too violent. This control is covered by a plate on the modified panel.

Note

An obstructed automatic recovery switch is not always a valid indication that the autopilot has been modified.

Autopilot Release Switches.

Both control wheels are equipped with an autopilot release switch (1, figure 4-20). Either switch will release all three control axes simultaneously.

TRANSFER CONTROLS.

The following controls are used during remote or "second station" turn control operation by the radar-bombardier.

N-2 Transfer Switch.

This switch (30, figure 1-12), located on the pilots' instrument panel, is provided to enable the radar-bombardier to utilize the turn control feature of the autopilot. The switch has two positions, RADAR BOMB and PILOT. Normally it is left in the PILOT position and the turn control is operated from the autopilot control panel on the pilots' pedestal. When the switch is placed in the RADAR BOMB position, the autopilot turn control is made available to the radar-bombardier as well as the pilots.

E-2 Turn Control Unit.

The E-2 turn control unit (25, figure 4-37) located at the radar-bombardier's station consists of a turn control knob, a two-position mode selector switch, and an indicator light. When the aircraft commander transfers control to the radar-bombardier, the indicator light will glow. If the mode selector is in MANUAL, the radar-bombardier can maneuver the aircraft with his turn control knob. If the mode selector is in AUTOMATIC, the radar-bombardier can maneuver the aircraft with the tracking handle of the K-() system.

CALIBRATION CONTROLS.

All calibration controls are located in the observer's compartment. The directional coupler amplifier assembly is located beneath the radar-bombardier's table. Four calibration control knobs are located under the cover plate of this unit as shown in figure 4-22. The remainder of the calibration controls are located on the main chassis (figure 4-21) above the nose wheel well. Access to the control knobs is gained by remov-

ing the covers on the face of the units.

Note

Modified autopilots have three additional knobs located on top of the auxiliary calibrator. This unit is mounted in the middle of the chassis as viewed from the top.

Sensitivity Knobs.

The sensitivity knobs establish the minimum signal level for which the amplifier will call for correction. In most cases, input signals come from the reference gyros which detect deviations in the attitude of the aircraft. They may, however, come from the autopilot control panel or from "second station" corrections. Under these conditions the induced signal is "nulled" by the gyros whenever the aircraft reaches the steady state of the maneuver. The sensitivity setting of the amplifier determines the amount the aircraft can deviate from a steady attitude before a corrective maneuver is applied. The range of this adjustment is very small, and it should be carried as high as possible on each axis.

Ratio Knobs.

The settings on these knobs determine the amount of control surface deflection applied for each unit signal that goes into the amplifier or the dynamic response of the aircraft. The range of adjustment on these knobs is great and their settings are quite delicate under most conditions.

Throttling Knobs.

The settings on these knobs determine the speed at

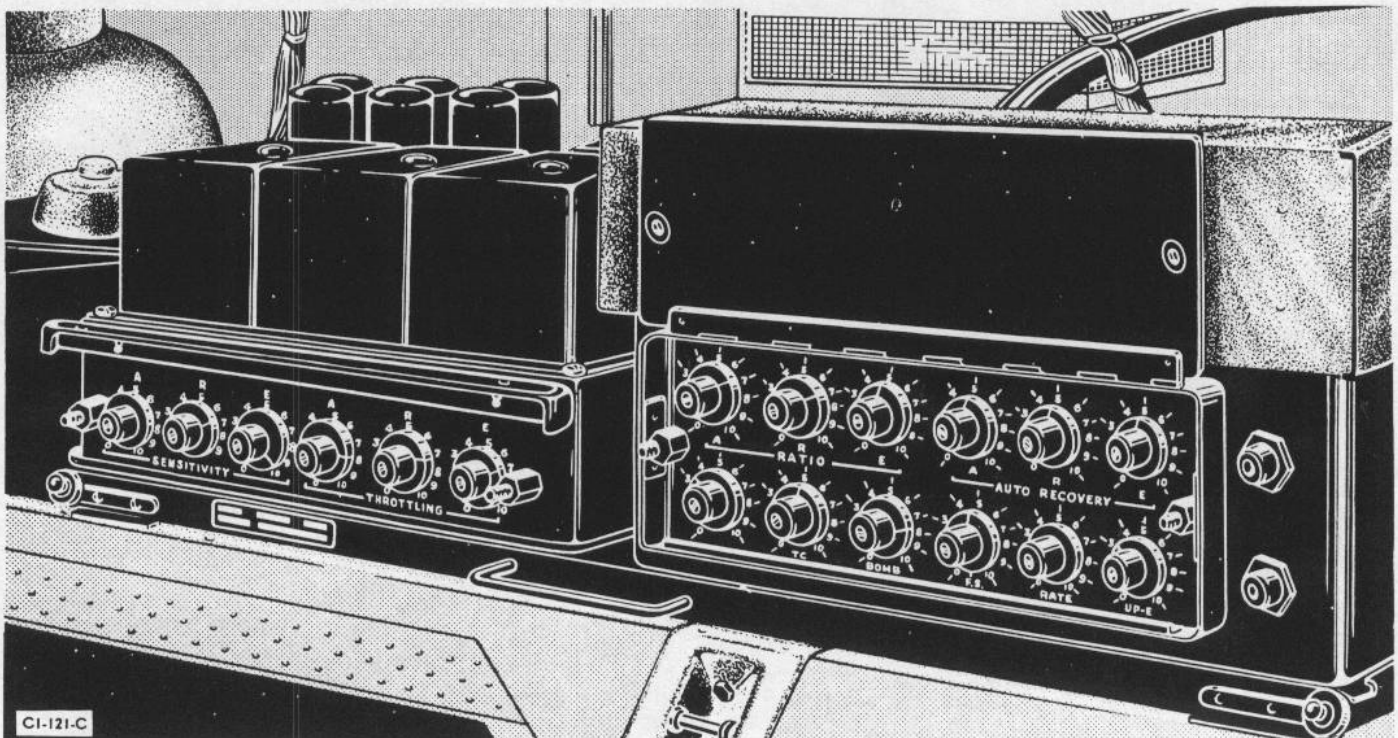
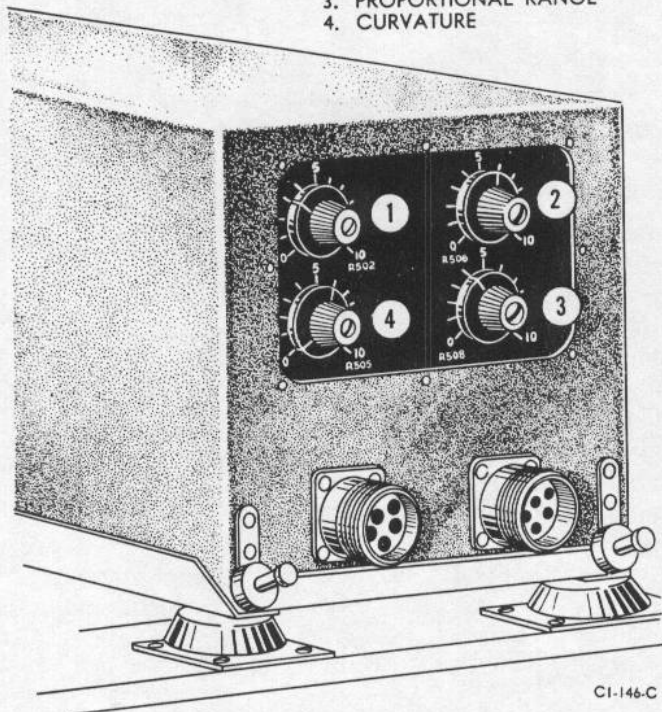


Figure 4-21. Autopilot Amplifier and Main Calibration Unit

1. COMPASS MAXIMUM BANK
2. COMPUTER MAXIMUM BANK
3. PROPORTIONAL RANGE
4. CURVATURE



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Figure 4-22. A-11 Directional Coupler Amplifier Assembly.

which the servos drive and consequently the speed with which the control surfaces move. They are in effect electronic brakes. The higher the setting, the greater the braking action, and the slower the movement of control surfaces.

Automatic Recovery Knobs.

The auto-recovery switch is covered and taken out of the circuit on most of the aircraft. The knobs are still carried at five to maintain bridge balance in the circuit.

E-FS and FS Knobs.

These knobs were used to coordinate formation stick turns. They are still in the circuit. Moving E-FS will change the pitch attitude of the aircraft.

TC Coordination Knob (Unmodified Systems).

This knob is used to coordinate turns made either by the pilots' turn control knob or "second station." Its setting determines the amount and direction of rudder applied per degree of bank. With the knob at zero, the autopilot puts in its maximum value of bottom rudder; with the knob at ten, the autopilot puts in its maximum value of top rudder.

TC Coordination Knob (Modified Systems).

This knob is carried at zero. Turns are coordinated with rudder gain in the auxiliary calibrator.

Bomb Coordination Knob.

This knob was used to coordinate turns made from the Norden bombsight. It is still in the circuit but has little or no dynamic effect.

Rate Coordination Knob.

This knob is used to "damp" the action of the rudder. It is the electrical equivalent of a mechanical "dash-pot." Rudder ratio must be kept high enough to insure flying a good heading. It is a characteristic of most aircraft that rudder ratio must be so high that the aircraft is on the verge of overcorrecting. For this reason the rudder needs "damping."

Up-Elevator Coordination Knob.

This knob is used to control the pitch attitude of the aircraft while it is in a bank.

Rudder Gain Knob.

This knob is used to coordinate all turns. It operates in much the same way as the TC coordination knob does in the unmodified autopilot.

Aileron Roll Rate Knob.

This control acts the same way in the aileron axis as the rate coordination control acts in the rudder axis. It damps the action of the ailerons while the aircraft is rolling in or out of turns. It also helps to keep the ailerons from overcorrecting when in straight and level flight. Its action puts in opposite aileron for any roll.

Rudder Roll Rate Knob.

This control attempts to coordinate the rudder while rolling in and out of turns. While the effect of this control is not too obvious, it aids in smoothing out turns, particularly at higher airspeeds.

Compass Maximum Bank Knob.

This control determines the directional stiffness of the system or the amount of corrective bank angle applied per degree of heading error.

Computer Maximum Bank Knob.

This control sets the maximum bank angle the airplane can reach in correcting for a large steering signal from the ground position computer.

Curvature Knob.

The effect of this control is similar to the throttling control on the E-6 amplifier. This knob setting should be carried as high as possible to keep course corrections proportional to the amount of remaining error.

Proportional Range Knob.

This control sets the heading correctional signal required for the airplane to reach the maximum bank angle established by compass maximum bank or computer maximum bank. This could also be considered as the rate of amplifier response to the input signal.

CALIBRATION CONTROL SETTINGS.

The following calibration control settings are based on an average weight, airspeed, cg, and altitude. They will probably work acceptably for the first ten hours. Procedure for inflight adjustments appears in "Autopilot System", Section VII.

CAUTION

Do not interchange settings between modified and unmodified autopilots. Modifications are discussed in "Systems Operation," Section VII.

Basic Calibration Control Settings (Modified System).

Main Calibrator

Sensitivity	A-8	R-9	E-10
Throttling	A-2	R-5.5	E-5.5
Ratio	A-5	R-5	E-6.5

Note

When in second station "automatic" operation, set aileron ratio at:

10,000 feet	5
25,000 feet	4
35,000 feet	2
40,000 feet	1

Automatic Recovery		A-5	R-5	E-5
Coordination	TC	0	EFS	3
	Bomb	1.8	FS	5
	Rate	10	Up-E	3 to 4

A-8 Amplifier

Compass Max. Bank	2.5
Computer Max. Bank	
below 25,000 feet	5
above 25,000 feet	6
Curvature	10
Proportional Range	
10,000 feet	8
25,000 feet	10
35,000 feet	10
40,000 feet	10

A-11 Amplifier

Compass Max. Bank	2.5
Computer Max. Bank	
below 25,000 feet	5
above 25,000 feet	6
Curvature	10
Proportional Range	
10,000 feet	3.5
25,000 feet	6.0
35,000 feet	6.0
40,000 feet	7.5

Auxiliary Calibrator

Rudder Gain	2.8
Aileron Roll Rate	6.0
Rudder Roll Rate	3.0

Basic Calibration Control Settings (Unmodified System).

Main Calibrator

Sensitivity	A-8	R-9	E-10
Throttling	A-2	R-8	E-7.5
Ratio	A-3.5	R-5	E-5

Note

Above 30,000 feet, reduce aileron ratio to 1 when in second station "automatic."

Automatic Recovery	A-5	R-5	E-5	
Coordination	TC	5.5	ES	5
	EFS	3	Rate	10
	Bomb	8	Up-E	3-4

A-6 Directional Coupler

Compass Max. Bank	2.5
Computer Max. Bank	
above 25,000 feet	5
below 25,000 feet	6
Curvature	10
Proportional Range	
10,000 feet	4
25,000 feet	8
35,000 feet	6
40,000 feet	9

A-11 Directional Coupler

Compass Max. Bank	2.5
Computer Max. Bank	
above 25,000 feet	5
below 25,000 feet	6
Curvature	10
Proportional Range	
10,000 feet	3.5
25,000 feet	6.0
35,000 feet	6.0
40,000 feet	7.5

OPERATION.

Before Engaging the Autopilot.

1. Attain a safe altitude and manually trim the airplane for straight and level flight. Check with flight instruments.
2. Autopilot on-off switch—OFF.
3. Turn control knob—In detent.
4. Rudder, elevator, and aileron trim knobs—Center.

Engaging the Autopilot.

1. Place the autopilot on-off switch in the ON position; then wait until the two green indicator lamps begin to flicker before performing step 2 below.

Note

The autopilot will be ready for operation approximately one minute after it is turned on.

2. Autopilot engage switch—Press firmly.

Note

Clear the annunciator window of the slaved gyro magnetic compass before engaging the autopilot. Also, do not adjust the PUSH TO SET POINTER knob of the compass while the autopilot is engaged, because it will affect the directional stability of the airplane.

CAUTION

Do not engage the autopilot while the airplane is turning.

3. After the autopilot is engaged, check the flight instruments. Carefully readjust the autopilot trim knobs on the control panel until the airplane is flying straight and level.

WARNING

Never adjust the manual trim tab on any axis while that axis is engaged.

4. To make coordinated automatic turns, rotate the turn control knob in the desired direction.

Note

If the airplane turns in the opposite direction when the turn control knob is moved out of detent, check manual trim. If it is found to be satisfactory, remove the undesired trim with the autopilot trim knobs.

Disengaging the Autopilot.

1. To temporarily disengage the autopilot, press the release button on either the aircraft commander's or the pilot's control column. This action will release all servo motors simultaneously, but the autopilot will remain on.
2. To disengage the servo motors individually, press the center of the autopilot trim knob for the axis to be disengaged.
3. To stop autopilot operation, place the autopilot on-off switch in the OFF position.

Retrimming.

1. If extensive retrimming of the airplane is required, push the center of the electrical trim knob on the axis to be retrimmed. This will release the servo motor.

2. Trim the surface manually.
3. Re-engage the servo motor by pressing the engage switch.

Operation From Radar-Bombardier's Station.

1. Wait for the indicator light to glow indicating that aircraft commander's transfer switch is in the RADAR BOMB position.

CAUTION

Do not attempt to move mode selector switch to AUTOMATIC until light comes on indicating that the aircraft commander has transferred control.

2. Leave mode selector switch in MANUAL to maneuver aircraft with the turn control knob.
3. Move the mode selector switch to AUTOMATIC to maneuver aircraft with the K-() tracking handle.

Regaining Control From Radar-Bombardier's Station.

To regain control, the aircraft commander must do one of the following:

1. Move the N-2 transfer switch back to PILOT.
2. Disengage the autopilot.
3. Disengage the aileron axis.
4. Shut the autopilot off.

Note

The N-2 transfer switch will automatically move back to PILOT when either step 2, 3, or 4 is accomplished, and the autopilot must be re-engaged before the N-2 transfer switch can again be placed on RADAR BOMB.

NAVIGATION EQUIPMENT.

MAGNETIC COMPASS.

A magnetic compass is located directly above the pilots' instrument panel.

SLAVED GYRO MAGNETIC COMPASS SYSTEM.

A J-1 slaved gyro magnetic compass system is incorporated in the airplane. It provides a gyro-stabilized compass which indicates the airplane's magnetic heading without northerly turning error. The gyro is free from drift and tilt, and therefore requires no resetting. The system consists of a master directional indicator (8, figure 1-12) located on the pilot's instrument panel, a flux valve located in the left wing tip, and a repeater indicator located on the navigator's instrument panel. When the compass is slaved (electrically connected) to the flux valve the compass is a directional gyro with a magnetic sense. Operating in this condition, the flux valve senses its position with respect to the earth's magnetic meridian.

Any difference between the indicated heading of the compass and the magnetic heading sensed by the flux valve will be detected by a voltage which will apply a torque to the gyro to align it with the magnetic heading. In the unslaved condition, the compass acts as a directional gyro. A compass slaving switch (24, figure 4-14) is located on the navigator's instrument panel and permits the navigator to deslave the compass when the flux valve sends erroneous signals to the gyro. This condition will occur in certain sections of the polar regions where a magnetic compass becomes unreliable.

The slaved gyro magnetic system is connected to the autopilot system and furnishes it with the directional reference signals required to keep the airplane on course during normal autopilot operation.

Slaved Gyro Magnetic Compass Operation.

The slaved gyro magnetic compass system is connected directly to 200-volt alternating current. Therefore, it is on at all times when the airplane power is on. A PUSH TO SET POINTER knob on the master directional indicator is used to quickly synchronize the compass indicator to the heading detected by the flux valve before take-off, or when resetting the indicator after exceeding the operating limits of the gyro.

Note

The gyro is free to operate within 60 degrees of climb or dive (from level flight) and 60 degrees right or left bank.

An annunciator window on the upper right of the master indicator shows whether the gyro is aligned with the heading detected by the flux valve. When they are aligned, the window is clear of any image. If they are not aligned, the discrepancy is evidenced by the appearance of a dot or cross in the window, depending on the direction of misalignment. During flight it is normal for the dot and cross to appear alternately in the window. If either the dot or cross appear steadily in straight flight (except for a minute or two following a turn) the system is not operating properly.

Note

If it is necessary to adjust the master indicator pointer during flight, make certain that the automatic pilot is off and that the airplane is in a straight and level attitude.

CELESTIAL NAVIGATION PROVISIONS.

Astro Compass.

Provisions have been made for stowing an astro compass on the floor beneath the flight engineer's table. The bar on which the astro compass is mounted when in use, is stowed on the bulkhead under the radio operator's table.

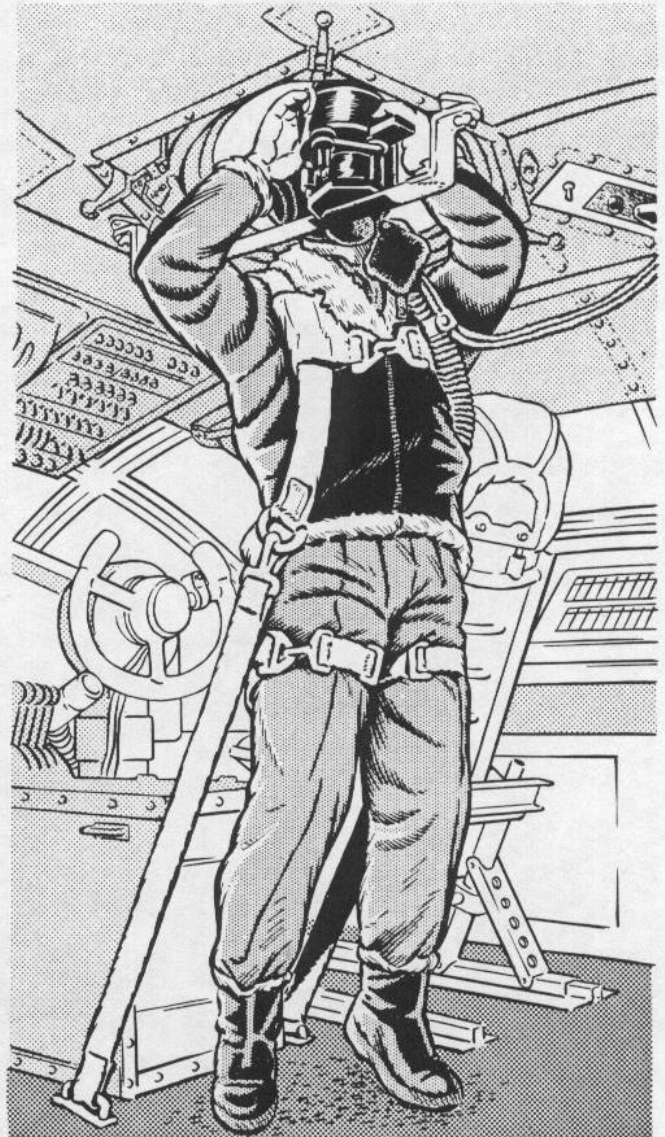


Figure 4-23. Using the Astrodome

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Sextant.

Provisions have been made for stowing a sextant and its support bracket under the flight deck step.

Astrodome.

The airplane is provided with an astrodome for making celestial observations with the sextant and astro compass. The dome is protected by a pressure guard when not in use. The dome can be removed and a fan installed for ventilation of the flight deck during ground operations. The pressure guard and ventilating fan are stowed on the pilot's fairing.

PORTABLE D-C POWER UNIT.

Provisions have been made in the aft turret bay for the stowage of a 28-volt d-c power unit consisting of a generator driven by a one-cylinder gasoline engine.

The function of the unit is to furnish electric power to the airplane's d-c system for the purpose of operating the communications equipment in the event of a crash landing in a remote region. During operation the unit is connected to the airplane through a power receptacle located at the radio operator's station. The unit is started through the use of a starter plate and a rope. The output of the generator is controlled automatically.

GUNNERY EQUIPMENT.

The airplane is equipped with eight remote-controlled gun turrets, six of which are retractable. Of the six retractable turrets, two are located on the forward

top side of the fuselage, two are on the aft top side, and two are on the aft bottom side. The other two turrets are located at the nose and tail and are non-retractable. Each turret is equipped with two 20-mm cannons. The nose turret has provisions for 400 rounds of ammunition per cannon; the other turrets have provisions for 600 rounds per cannon. The turrets, except the one for the tail, are controlled from corresponding remote sighting stations; the tail turret is operated through radar controls located in the aft cabin. (See figure 4-24.) There is no transfer of turret control between sighting stations. Each sighting station is furnished with a remote gun sight, equipped with a gun camera, a turret control panel, and oxygen and interphone controls. The turret control panels

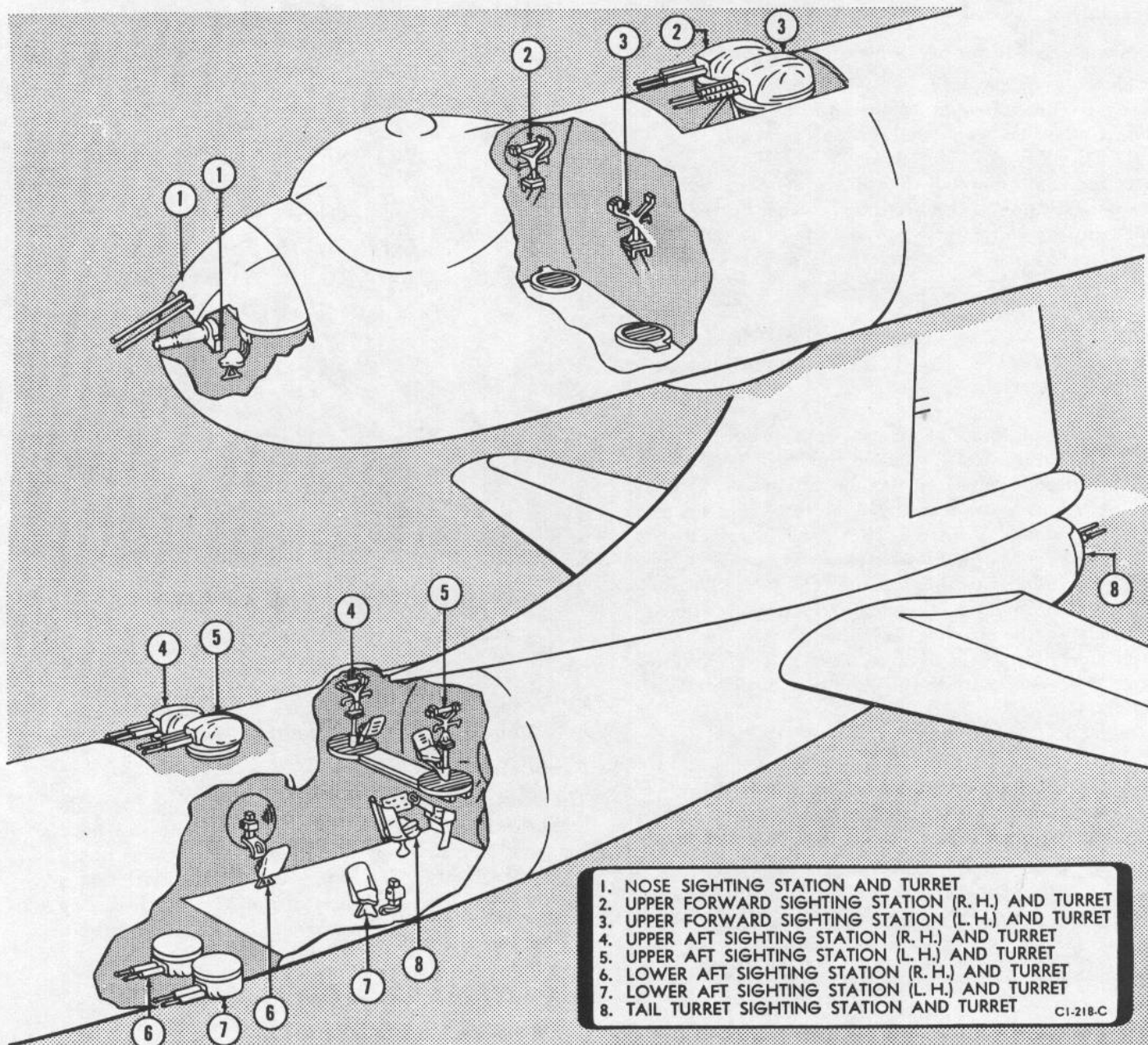


Figure 4-24. Turret and Sighting Station Locations

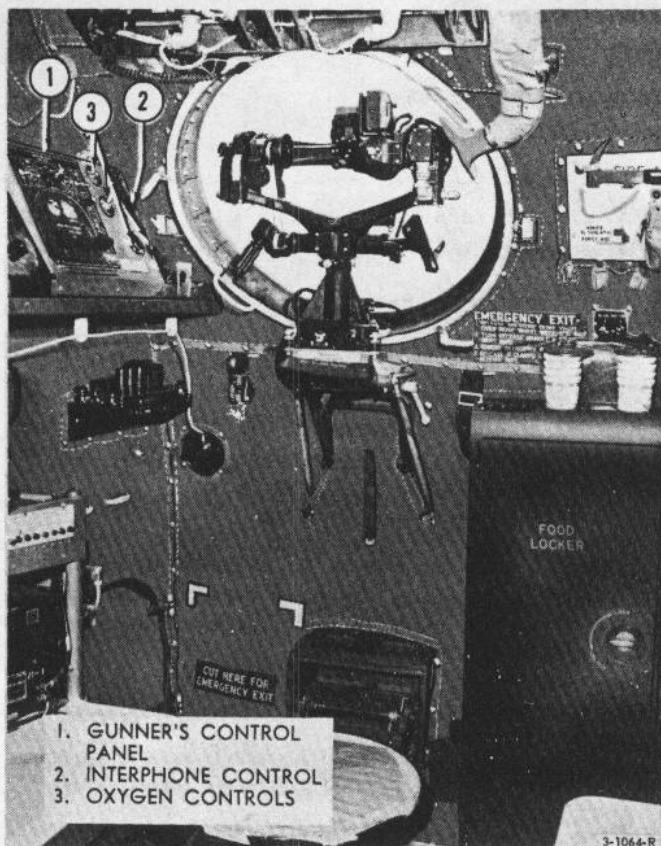


Figure 4-25. Typical Forward Sighting Station

are identical for the various stations except the ones for the nose and tail turrets. (See figures 4-28 and 4-31.)

NORMAL CONTROLS.

Turret Safety Switch.

This two-position switch is located on each turret junction box. When it is ON, the 28-volt d-c circuit from the thyatron controller to the turret power switch is closed.

Turret Power Switch.

This two-position d-c switch-type circuit breaker on the turret control panel is in series with a turret safety switch in the system junction box; these switches control all d-c power to the turret system.

Turret System Uni-Switch.

A five-position turret system uni-switch on the control panel for each retractable turret controls the turret circuits. The five positions on the switch are OFF, WARM UP, STAND BY, DOOR OPEN, and OPERATION. The WARM UP position supplies 120-volt, single-phase, a-c power to the gun, feeder, and computer heaters. When the uni-switch is in the STAND BY position, a-c power is supplied to the turret control circuits. The DOOR OPEN position completes the circuit to the turret door motor, opening the tur-

ret doors. Placing the uni-switch in the OPERATION position extends the turret and, when the turret is fully extended, supplies d-c control voltage to the turret control circuits.

Warm-Up and D-C Power Switches (Safe-Fire).

These switches, ganged together on the control panel, have positions marked SAFE and FIRE. When the warm-up switch is placed in the FIRE position, it allows a-c power to be supplied to the firing control box circuits. When the d-c power switch is placed in the FIRE position, it turns on the gun firing circuit. Placing this switch in SAFE turns off the gun firing circuit.

Note

The gang bar simultaneously places both switches in the SAFE position only.

Gun Camera Switch.

When this switch is placed in the ON position, the camera operates when the guns are fired. This switch is located on each sighting mechanism except for the radar-controlled tail turret where the switch is located on the tail turret control panel.

Altitude-Airspeed Handset Unit.

This unit (figure 4-28), located on the turret control

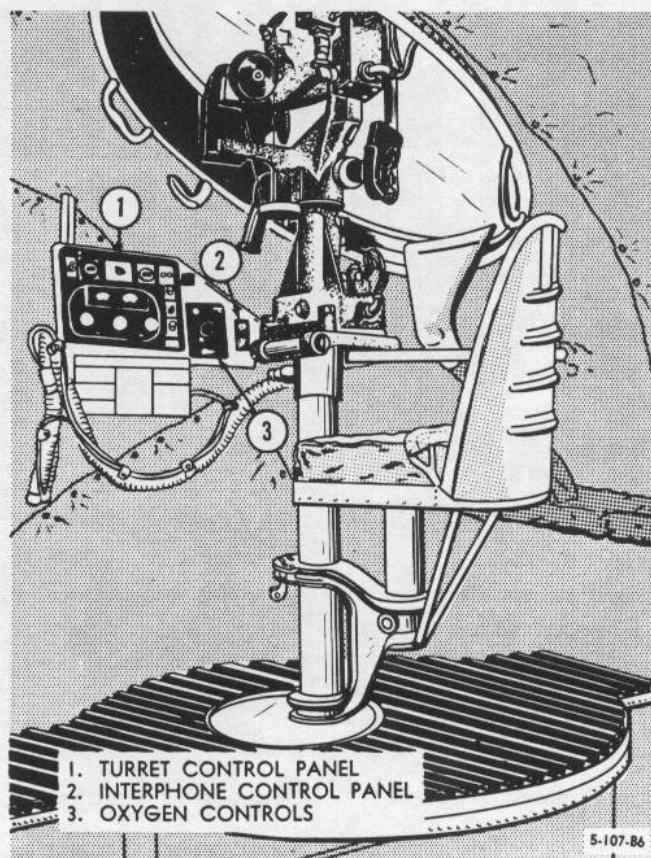


Figure 4-26. Typical Upper Aft Sighting Station

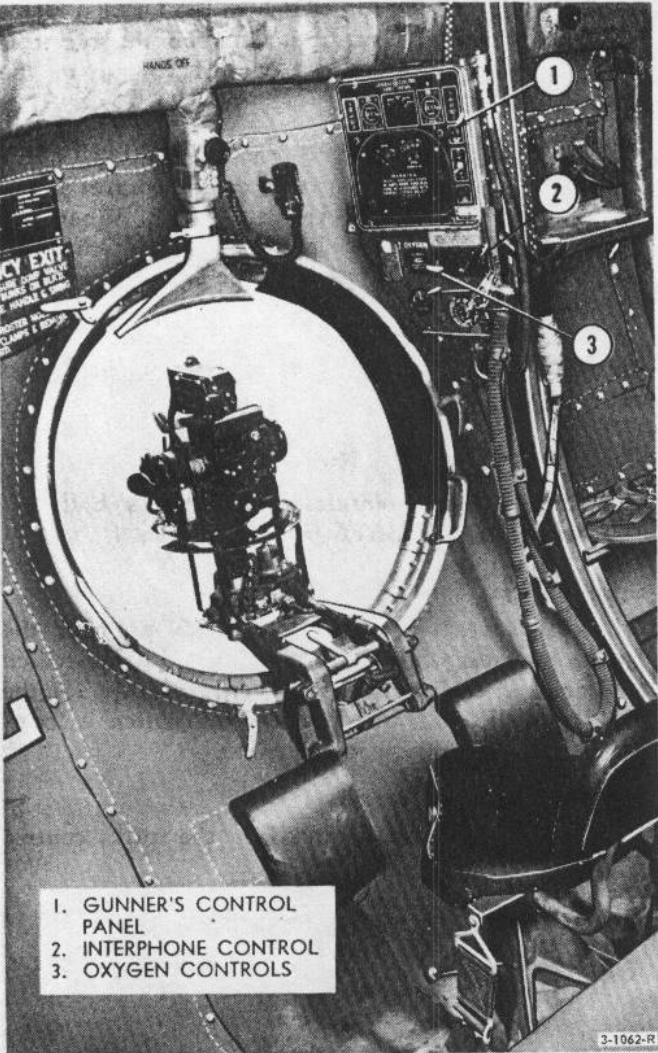


Figure 4-27. Typical Lower Aft Sighting Station

panel, incorporates three knobs and three dials to be used in setting up data for the computer so that it will compute the proper lead and ballistic corrections during turret operation.

Action Switch.

An action switch is located on the right hand control of each gun sighting mechanism. Actuating this switch controls the movement of the turret to follow the sight in tracking a target. Also, this switch must be depressed to complete the firing circuit. When the switch is released the turret will automatically return to the position for retracting.

INDICATORS.

Turret-Extended Lamp.

This lamp will glow when the turret is extended and ready for operation.

Turret Door Closed Lamp.

This lamp will glow continuously when the turret is retracted and the doors are closed, provided the uni-switch is not in the OFF or WARM UP position.

Ammunition Counter Dials.

Two dials on each turret control panel will indicate reserve ammunition for each group in that turret.

EMERGENCY CONTROLS.

Hand Crank.

In case of an emergency the turret can be extended or retracted manually, provided the turret doors are open, by use of a hand crank stowed in the proximity of each turret. The rotor shaft of the turret extend-and-retract motors has a fitting for the crank. The turrets can also be moved in azimuth or elevation manually by applying the hand crank at the fittings provided on the azimuth and elevation drive assemblies. (See figure 4-29.)

OPERATION.

Operation of the retractable turrets from the sighting stations is discussed in the following paragraphs.

Before Entering A Combat Zone.

Perform the following steps before entering a combat zone.

1. Make certain the warm-up and d-c power switches are in the SAFE position.
2. Move the uni-switch to the WARM UP position to supply power to the gun feeder and computer heaters.

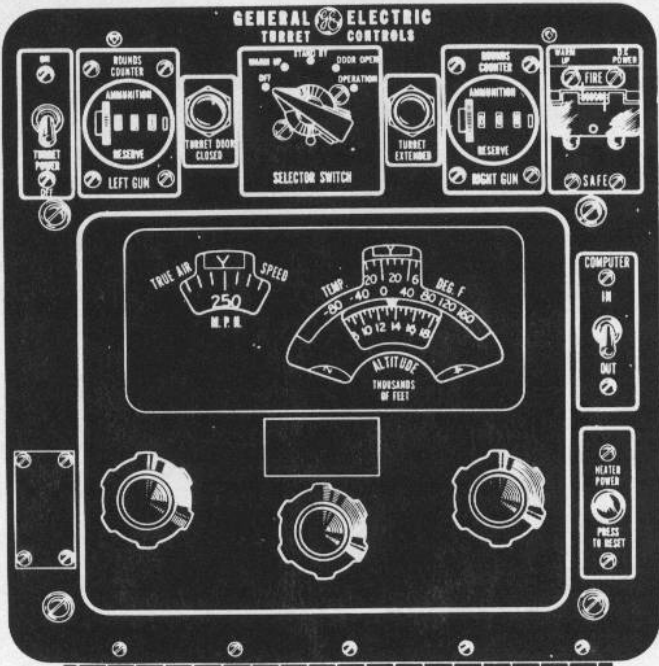


Figure 4-28. Typical Gunner's Control Panel

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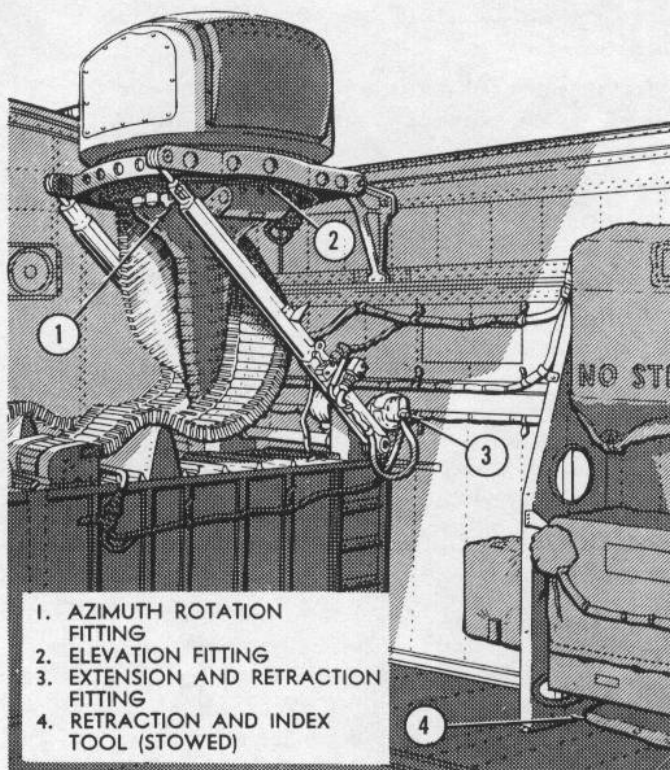


Figure 4-29. Typical Turret

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Note

Allow a warm-up period of approximately fifteen minutes.

3. Move the uni-switch to the STAND BY position to apply a-c voltage to the turret control circuits.

4. After 90 seconds time delay, the turret door closed lamps will light unless the door has already been opened by the opposite gunner. During this time set up the airspeed-altitude handset unit on the control panel according to the information furnished by the navigator.

Note

Before entering a zone in which turret use is anticipated, the navigator will furnish to all gunners the equivalent airspeed, the pressure altitude, and the corrected outside air temperature. The dials on the handset must be set accordingly so that the computer will make the proper lead and ballistic corrections during turret operation. The navigator will inform the gunners when dial adjustments on the handset need readjusting. It is recommended that dial settings be checked every 10 minutes when in a combat zone.

5. Place the turret power switch in the ON position prior to opening the turret door. The turret safety switch in the system junction box should have been placed ON prior to placing power on the airplane.

6. Move the uni-switch to the DOOR OPEN position and observe that the turret door indicator lamp goes out.

7. Move the uni-switch to the OPERATION position and see that when the turret extends, the turret extended lamp is on.

8. Place the warm-up and d-c power switches in the FIRE position.

Note

The warm-up and d-c power switches should be in FIRE only when ready to fire. Return them to SAFE when not firing.

9. If corrected gun aiming is to be used, place the computer in-out switch on the base of the sighting station in the IN position.

10. To fire the guns, unlock the sight, grasp the control grip firmly closing the action switch, and depress the trigger switch when the target is correctly framed.

CAUTION

To avoid damage from possible "cook-offs," do not allow the guns to point to any part of the aircraft or at other aircraft in the formation until at least fifteen minutes cooling time has elapsed after firing.

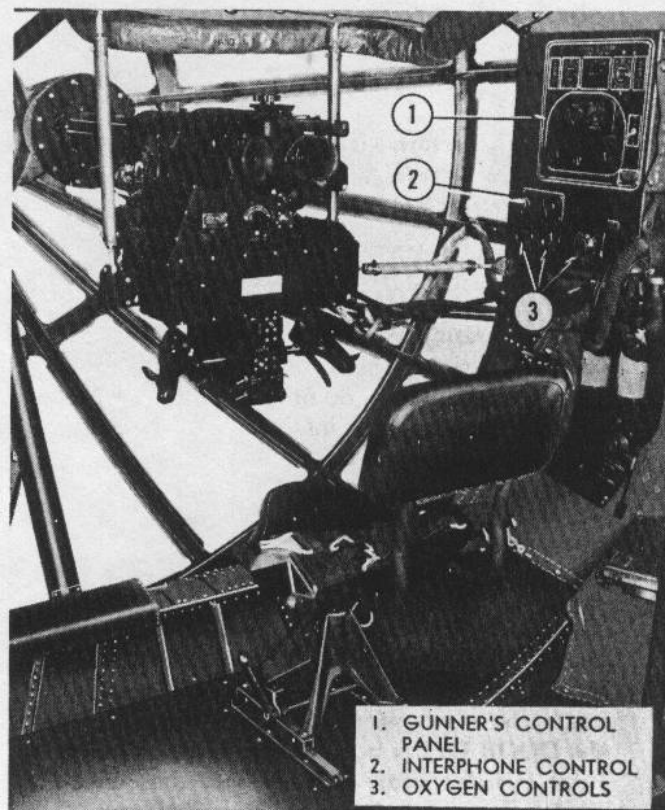


Figure 4-30. Nose Sighting Station

3-1038-R

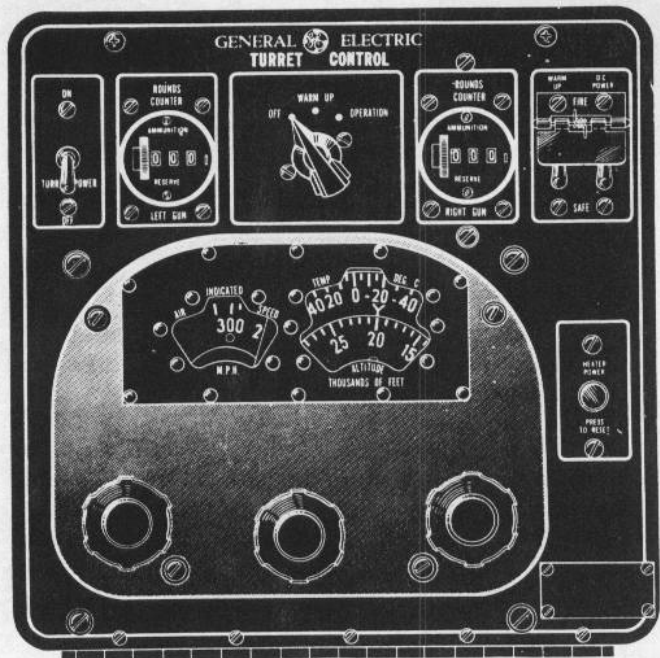


Figure 4-31. Nose Gunner's Control Panel

11. If operation of the computer at extreme low temperature is anticipated, the uni-switch should be placed in STAND BY position prior to arrival at these conditions so that the tube heaters may aid the computer heaters in maintaining an adequate internal temperature in the computer.

Leaving A Combat Zone.

On leaving a combat zone perform the following:

1. Place the warm-up and d-c power switches in the SAFE position.
2. Release the action switch at the sighting station and wait a few seconds for the turret to return to the position for retraction.



Before releasing the action switch, move the turret to the approximate stowing position. If the turret is not at or near the stowing position when the action switch is released, the rapid movement and sudden stopping could cause damage to the turret.



The uni-switch should not be turned to the DOOR OPEN position when turret stowing is intended until the turret has had time to reach the stow position. This is because in the DOOR OPEN position the turret contour limit switch circuit is by-passed, thus effectively giving the turret no electrical stop.

3. Place the uni-switch in the DOOR OPEN position to retract the turret.

tion to retract the turret.

4. Place the uni-switch in the STAND BY position to close the door.

5. After it is assured that the turret is stowed and the doors are closed, move the uni-switch to the OFF position.

6. Place the turret power switch in the OFF position.

Note

When the uni-switch is OFF, all power to the turret circuits is broken.

7. Heater power circuit breaker—Pull out.

Nose Turret.

Nose turret operation and control is identical to the retractable turrets except that the control panel does not have the uni-switch positions marked STAND BY and DOOR OPEN, and the door closed and turret extend lamps.

Tail Turret.

The radar-controlled tail turret is operated from the tail gunner's station located in the aft cabin. The tail turret control panel is identical to the control panels of the retractable turrets except that it has uni-switch positions marked RADAR and RADAR AND COMPUTER instead of DOOR OPEN and OPERATION. Placing the switch in the RADAR AND COMPUTER positions puts the equipment into full operation. With the switch in the RADAR position, the equipment is completely operative but the computer does not function.

The equipment is started by turning the uni-switch on the control panel from OFF or WARM UP to STAND BY. The switch is then turned from STAND BY to RADAR or RADAR AND COMPUTER for complete operation. The equipment will begin to operate after a 3 1/2-minute warm-up period. The equipment is completely stopped by turning the switch to the OFF position.



Before turning the uni-switch to OFF, place the altitude knob in the maximum altitude position.

Radar Pressurization.

A 115-volt, a-c, motor-driven pressure pump located under the upper right sighting platform in the aft cabin provides pressurized air for the radio frequency unit, the modulating unit, and the radio frequency line (wave guide) of the AN/APG set. The system is controlled by a pressure pump switch located at the tail gunner's station. Operation of the system is identical to that of the AN/APQ-31 radar set. (Refer to "Radar Set AN/APQ-31" of this section.)

BOMBING EQUIPMENT.

The airplane incorporates four bomb bays designed to carry varied bomb loads and various sized bombs. Provisions are made for carrying a fuel tank in bomb bay No. 3. The double-folding, gate-action bomb bay doors are hydraulically operated. (See figure 4-33.) Thirty-six removable bomb racks of 15 different types are furnished with each airplane, allowing a number of bomb loading conditions. Design of the bombing equipment is based on 500-, 1000-, 2000-, 4000-, 12,000-, 22,000-, and 43,000-pound bombs. However, 100-, 115-, 125-, 250-, 325-, and 350- pound bombs can be carried at the 500-pound stations. The forward section, comprising bomb bays No. 1 and No. 2, and the aft section, comprising bomb bays No. 3 and No. 4, are fitted for carrying the various 12,000-, 22,000-, and 43,000-pound bomb loads. The all-electric bomb release system, based on the type A-5 and S-4 bomb rack releases with controls at the radar-bombardier's station (figure 4-37), consists of five individual circuits: a 28-volt d-c nose fuse arming circuit, a 115-volt a-c bomb indicator lamp circuit, a 28-volt d-c circuit for normal release with tail fuse automatically armed, a 28-volt d-c circuit for salvo release with tail fuse automatically safe, and a 28-volt d-c bomb bay door opening circuit. A K-() system, consisting of

a vertical periscopic bomb sight and the AN/APQ-31 radar-computer equipment, is installed in the airplane. On group 11 airplanes, seven inspection windows are provided in the communication tube for checking to see if any bombs have hung or jammed in the bomb bay during a bomb drop.

BOMB RELEASE SEQUENCE.

The tables in figure 4-32 give the general release sequences for dropping bombs from all four bays with all releases installed and cocked. Beginning at the top of the first column, as shown, the sequence passes from rack to rack, firing the lowest release in each rack. When the first layer has been fired in this manner, the rack sequence is repeated again, firing the second release in each rack and so on until all releases have been operated. The sequence is always from rack to rack; two releases on the same rack are never fired in succession, and a rack is not by-passed in the sequence until all releases on that rack have been fired. Although all the releases installed in the airplane are not cocked simultaneously in any normal loading condition, the sequence is given in this manner to cover all conditions. For any particular loading configuration, only the releases to be used will be cocked. In using the tables, whenever an uncocked release is en-

500 AND 1000 POUND BOMB RACK INSTALLATION

START DOWN THIS COLUMN

SEQUENCE OF RELEASES ON EACH RACK

RACK TO RACK SEQUENCE

BAY	LOC. OF RACK IN BAY	RELEASE STATION NUMBERS															
4	RT. AFT	13	14	15	16	17	18	19	20	21	22	*28	23	*29	24	*30	
1	RT. FWD.	13	14	15	16	17	18	19	20	21	22	*28	23	*29	24	*30	
4	LT. AFT.	1	2	3	4	5	6	7	8	9	10	11	12				
1	LT. FWD.	1	2	3	4	5	6	7	8	9	10	11	12				
4	RT. FWD.	13	14	15	16	17	18	19	20	21	22	*28	23	*29	24	*30	
1	RT. AFT	13	14	15	16	17	18	19	20	21	22	*28	23	*29	24	*30	
4	LT. FWD.	1	2	3	4	5	6	7	8	9	10	11	12				
1	LT. AFT	1	2	3	4	5	6	7	8	9	10	11	12				
2	RT. AFT	13	14	*25	*26	15	16	17	*27								
2	LT. AFT	1	2	3	4	5											
3	RT. FWD.	13	14	*25	*26	15	16	17	*27								
3	LT. FWD.	1	2	3	4	5											
2	RT. FWD.	13	14	15	16	17	18	19	20	21	22	*28	23	*29	24	*30	
2	LT. FWD.	1	2	3	4	5	6	7	8	9	10	11	12				
3	RT. AFT	13	14	15	16	17	18	19	20	21	22	*28	23	*29	24	*30	
3	LT. AFT	1	2	3	4	5	6	7	8	9	10	11	12			END	

*RELEASE IN ADJACENT CENTER RACK

*RELEASE IN ADJACENT CENTER RACK

Figure 4-32. (Sheet 1) Bomb Sequence Tables

2000 AND 4000 POUND BOMB RACK INSTALLATION

1000 AND 4000 SECOND BOMB RACK INSTALLATION

START DOWN THIS COLUMN

SEQUENCE OF RELEASES ON EACH RACK

RACK TO RACK SEQUENCE

BAY	LOC. OF RACK IN BAY	RELEASE STATION NUMBERS						
4	RIGHT	35	36	37	38	39	40	
1	RIGHT	35	36	37	38	39	40	
4	LEFT	31	32	33	34			
1	LEFT	31	32	33	34			
2	RIGHT	35	36	37	38	39	40	
2	LEFT	31	32	33	34			
3	RIGHT	35	36	37	38	39	40	
3	LEFT	31	32	33	34		END	

Figure 4-32. (Sheet 2) Bomb Sequence Tables

1-1018

countered, pass on to the next release in that rack. If any of the four bays are not used, the racks in the unused bays will be by-passed in the sequence. For a mixed load, the sequence can be determined by combining information from the two tables.

As an example in using the tables, suppose it is desired to drop fifty-six 500-pound bombs from bays No. 2 and 3 only. In this case stations 2, 4, 8, and 10 in the LH racks and stations 14, 16, 20, and 22 in the RH racks would not be cocked, and the bomb group selector switch for bays No. 1 and 4 would be left open. Then the sequence for the first four layers would be as follows: Bay 2 rt aft 13, 2 lt aft 1, 3 rt fwd 13, 3 lt fwd 1, 2 rt fwd 13, 2 lt fwd 1, 3 rt aft 13, 3 lt aft 1, (end of first layer); 2 center aft 25, 2 lt aft 3, 3 center fwd 25, 3 lt fwd 3, 2 rt fwd 15, 2 lt fwd 3, 3 rt aft 15, 3 lt aft 3, (end of second layer); 2 center aft 26, 2 lt aft 5, 3 center fwd 26, 3 lt fwd 5, 2 rt fwd 17, 2 lt fwd 5, 3 rt aft 17, 3 lt aft 5, (end of third layer); 2 rt aft 15, 3 rt fwd 15, 2 rt fwd 18, 2 lt fwd 6, 3 rt aft 18, 3 lt aft 6, (end of fourth layer). The remainder of the sequence continues in like manner.

Large Bomb Sequence.

With four 12,000-pound bombs loaded, the sequence is forward, aft, forward, aft. For three 22,000-pound bombs, the sequence is forward, aft, aft. For two 43,000-pound bombs the sequence is forward, aft.

NORMAL CONTROLS.

Master Power Switch.

The master power switch, with its two positions marked ON and OFF, controls the electric power to the bombing control panel.

Bomb Release Selector Switch.

This switch has three positions—K-1, RADIO, and

OFF; but the RADIO position is inoperative. When the switch is in the K-1 position, the K-() system is effective for bomb release.

Bomb Bay Door Switch.

A spring-loaded switch, marked OPEN and CLOSE and located on the bombing control panel, is provided to control the bomb bay doors. The doors are operated by holding the switch in the desired position until the corresponding indicator lamps light. To prevent damage by buffeting when the bomb bay doors are open, the aft turret doors open and close in conjunction with the bomb bay doors. A bomb bay door switch (32, figure 1-12) is also provided in the pilot's instrument panel.

Bomb Bay Selector Switches.

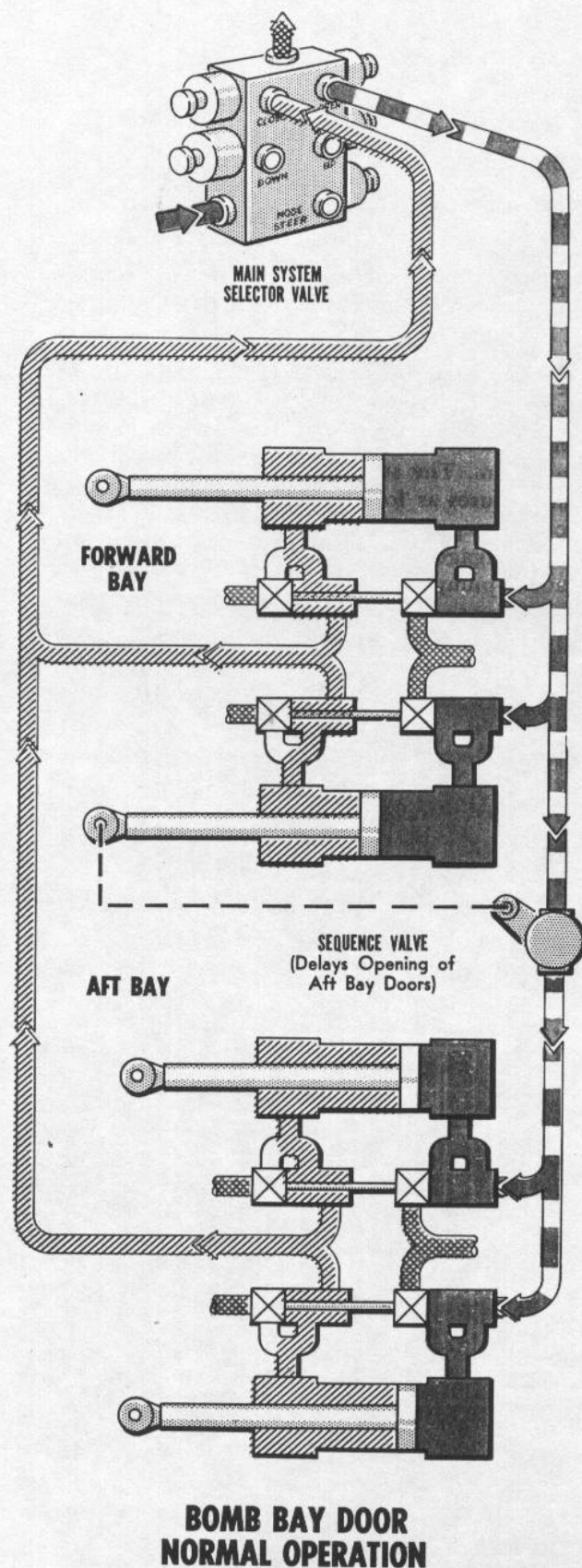
Three on-off switches, one each for bomb bays No. 2 and 3 and a single switch for bomb bays No. 1 and 4, are provided to set up the release circuit to the bomb racks when a normal bomb load is being carried. When large bombs are being carried, the No. 2 switch is used for the forward section, which includes bomb bays No. 1 and 2; and the No. 3 switch is used for the aft section, which includes bomb bays No. 3 and 4.

Nose Fuse Switch.

The switch, marked SAFE and ARM is provided for the arming of the nose fuses. All bombs can be armed simultaneously with this switch. When the switch is in the SAFE position during normal release, only the tail fuses will be armed. During salvo the tail fuse will be automatically safe and the nose fuse will either be armed or safe, depending on the position in which the nose fuse switch is placed.

Bomb Station Indicator Lights Switch.

When this switch is placed ON, each indicator light



-  PRESSURE
-  DOOR OPEN PRESSURE, ALTERNATE RETURN
-  DOOR OPEN RETURN, ALTERNATE PRESSURE
-  RETURN TO RESERVOIR
-  EMERGENCY LINES
-  MECHANICAL CONNECTION

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will burn as long as its bomb rack release unit is cocked.

Bomb Station Indicator Light Test Switch.

This switch is provided to test all bomb station indicator lights.

Bomb Interval Control Panel.

A type B-3A intervalometer (11, figure 4-35) is located adjacent to the bombing control panel.

Bomb Bay Door Safety Switch.

A two-position, on-off, safety switch is provided at the radar-bombardier's station to prevent injury to personnel by the inadvertent closing of the bomb bay doors during ground checking of the K-() system. The guarded safety position is marked OFF. When the switch is in this position, the K-() bombing system will not operate the bomb bay doors. When the switch is ON, operation of the bomb bay doors is automatically controlled by the K-() system.

CAUTION

Except during a bombing run, the switch must always be in the guarded OFF position. If left ON and an attempt is made to open the bomb bay doors with the bomb door switch, the doors will go to an intermediate position. If this condition occurs and is not immediately recognized, the hydraulic pumps will burn out as the pump motors will continue to operate even after the bomb bay door switch is released. To correct this condition, place the safety switch in the OFF position.

Note

The above condition is caused by the following electrical configuration. When in the ON position, the bomb bay door safety switch produces a continuous door-closed signal unless broken by the door-closed limit switches. If the bomb bay door switch is actuated, the doors will start to open and will make contact with the closed limit switches. This causes a door-closed and a door-open signal to be sent simultaneously which results in the doors stopping at an intermediate position. In this condition, the pumps will operate continuously.

Figure 4-33. Bomb Bay Door Normal Hydraulic System Schematic

INDICATORS.

Bomb Bay Door Lamps.

Five bomb bay door lamps, three for OPEN and two for CLOSED, give visual indication of bomb bay door position.

Note

If the CLOSED indicator lamps continue to burn after the bomb bay door switch has been released, check the position of the bomb bay door safety switch at the radar-bombardier's station.

Nose Fuse Lights.

This light when on, indicates that the bomb nose fuses are armed.

Bomb Station Indicator Lights.

One hundred and thirty-two bomb station indicator lights, one for each station, are located on the bombing control panel. Each light will burn as long as its bomb

rack release unit is cocked. Each light will go out as the bomb at its station is released.

Bomb-Size Indicator.

Four bomb-size indicators, one for each bomb bay, can be set manually to show the size of bombs loaded in each bay.

HYDRAULIC FLUID TEMPERATURE CONTROL.

Provisions for maintaining proper hydraulic fluid temperatures for operation of the bomb bay doors are incorporated in the main hydraulic system.

Operation of the system is fully automatic, provided the switch-type circuit breaker (1, figure 1-37) on the engineer's table is in the ON position. In this condition, a circuit is set up to a thermal switch located in the system. The switch then reacts to hydraulic fluid temperatures as follows: When the fluid temperature drops to approximately -18°C (0°F), the thermal switch engages. This in turn starts one of the main hydraulic pump motors and energizes the door-close

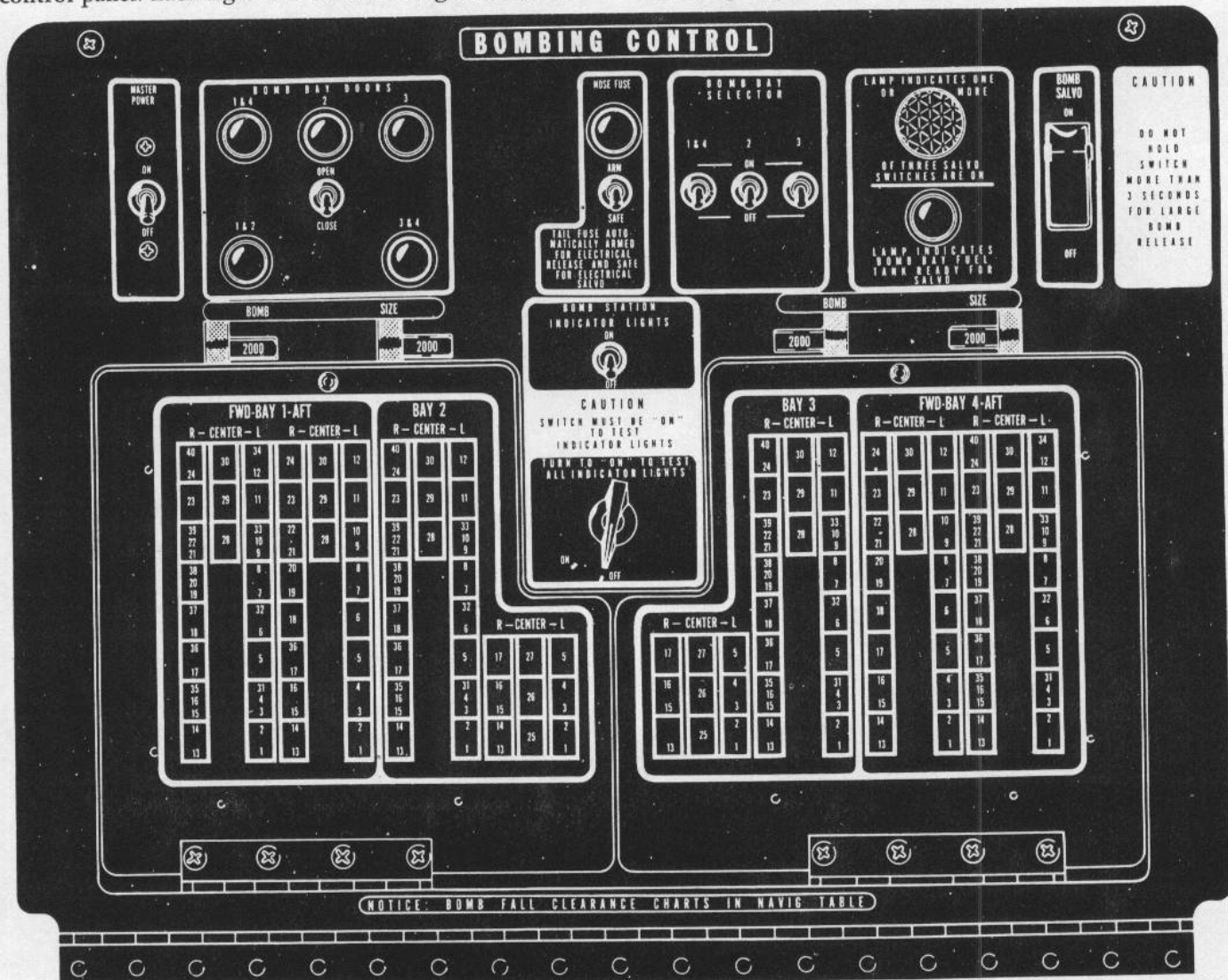


Figure 4-34. Bombing Control Panel

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1. INTERPHONE CONTROLS
2. TABLE LIGHT CONTROL SWITCH
3. OXYGEN PANEL
4. PHANTOM TARGET SWITCH
5. RADAR PRESSURIZATION CONTROLS
6. GYRO COMPASS
7. TRUE AIRSPEED INDICATOR
8. C-1 BALLISTICS CONTROL
9. BOMBING CONTROL PANEL
10. CIRCUIT BREAKER PANEL
11. BOMB INTERVAL CONTROL PANEL
12. CAMERA SYSTEM CIRCUIT BREAKERS
13. CAMERA DOOR INDICATOR LAMP
14. CAMERA DOOR SWITCH
15. CAMERA POWER-ON INDICATOR LAMP
16. CAMERA OPERATION INDICATOR LAMP
17. CAMERA MODE SELECTOR SWITCH
18. CAMERA MASTER POWER SWITCH
19. POLAR NAVIGATION CONTROL
20. AUXILIARY BOMBING CONTROL
21. NAVIGATION CONTROL
22. C-413/APS-23 CONTROL UNIT
23. TRACKING CONTROL
24. D-2 BOMB RELEASE
25. E-2 TURN CONTROLLER
26. O-15 CAMERA
27. D-218/APS INDICATOR
28. TIME-TO-GO INDICATOR
29. RADAR PRESSURE GAGE
30. P-3B CONTROL PANEL

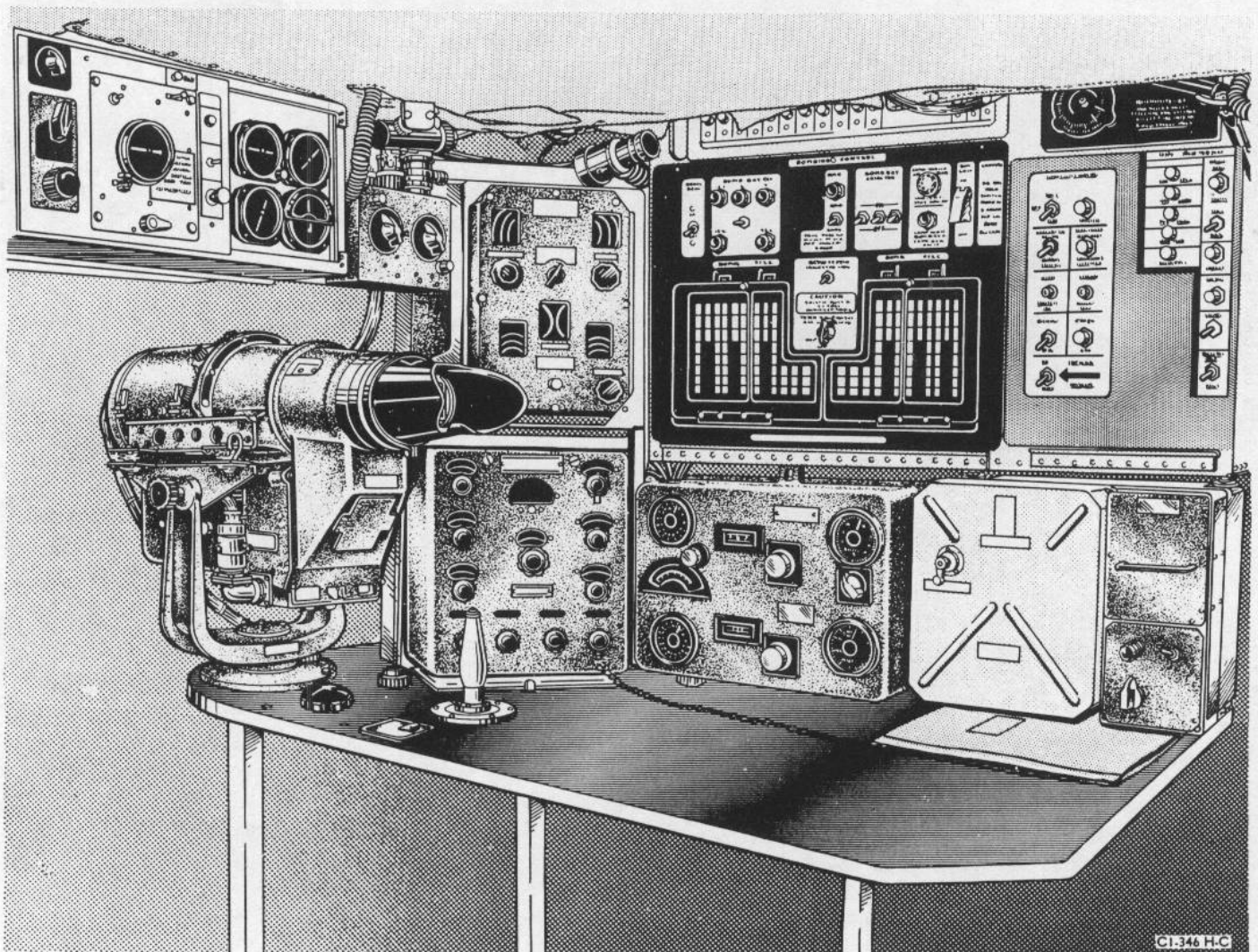
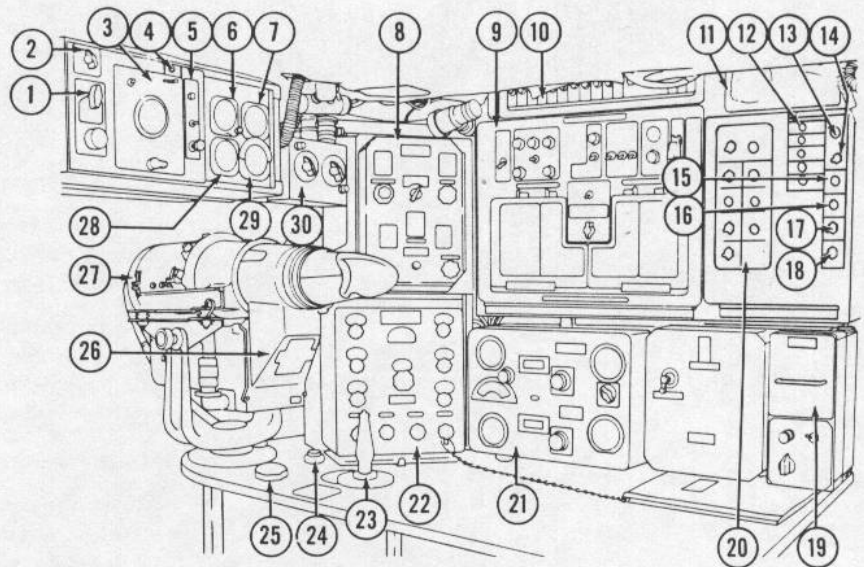


Figure 4-35. Radar-Bombardier's Controls

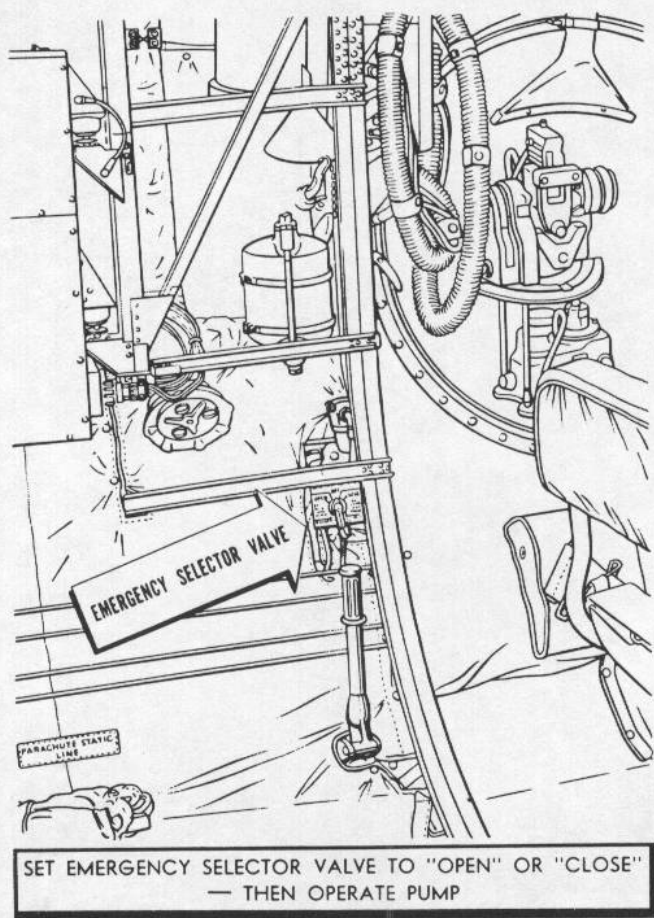


Figure 4-36. Bomb Bay Door Emergency Hydraulic System Controls

3-1067

solenoid of the main selector valve. Fluid is then circulated through the system until it reaches a temperature of approximately 38°C (100°F) at which time the thermal switch opens, the pump stops, and the door-close solenoid is de-energized.

Note

Actuation of a bomb bay door switch will render the hydraulic fluid temperature control inoperative.

EMERGENCY RELEASE CONTROLS.

Bomb Salvo Switches.

Two bomb salvo switches are provided: one each at the pilots' and the radar-bombardier's stations. Each switch has a spring-loaded ON position and OFF position; any one of the switches can be momentarily held ON to salvo the bombs. If a bomb bay fuel tank is being carried, it can be salvoed with the bombs, provided the bomb bay tank release selector switch (33, figure 1-12) is in the CAN SALVO position. A lamp, adjacent to each salvo switch, will light when the salvo cycle begins and will go out when the bombs are salvoed and the bomb bay doors are closed.

Note

The bomb bay doors must be closed with the bomb bay door switches after salvo.

BOMB RELEASE.

The bombs can be released individually, in train, in salvo, by radar, and pneumatically. During bomb release, to maintain airplane trim, the release circuits in bays 1 and 4 are set up so that if bombs are released from either bay, an equivalent is released from the other. Because of this arrangement, when single release is desired, it is necessary to select either bay 2 or 3. For train release any of the four bays can be used.

The bombs can be salvoed from either the pilots' or the radar-bombardier's station. If desired, the bomb bay fuel tank can be salvoed in conjunction with the bombs.

Single Release.

To set up the radar-bombardier's station for single release, proceed as follows:

1. Master Power Switch—ON.
2. Bomb Bay Selector Switch (No. 2 and 3)—ON.
3. Release Transfer Switch (located on the auxiliary bomb control panel)—BOMB RACK RELEASE.
4. Intervalometer Switch—SEL.
5. Nose Fuse Switch—ARM.
6. Bomb Bay Door Switch—OPEN.
7. D-2 Release Switch—Depress to release bombs.

Train Release.

To release the bombs in train, proceed as follows:

1. Master Power Switch—ON.
2. Bomb Bay Selector Switch—ON for desired bays.
3. Release Transfer Switch (located on the auxiliary control panel)—BOMB RACK RELEASES.
4. Intervalometer Switch—TRAIN, and set in desired spacing and number of bombs.
5. Nose Fuse Switch—ARM.
6. Bomb Bay Door Switch—OPEN.
7. D-2 Bomb Release Switch — Depress to release bombs.

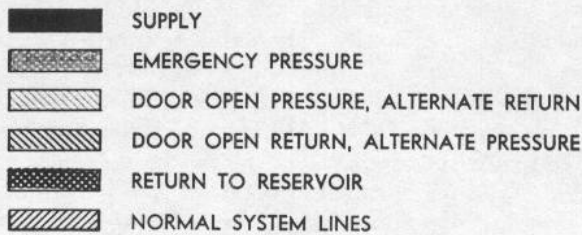
Salvo Release.

To salvo the bombs and fuel tank, proceed as follows:

1. Pilots' and Radar-Bombardier's Salvo Circuit Breakers—Pushed in.
2. Bomb Bay Fuel Tank Release Switch—CAN SALVO.
3. Bomb Salvo Switch—Momentarily ON.

Note

Once the salvo circuit is completed, it takes approximately 3 seconds to salvo the bombs. To stop the salvo cycle, reactuate the salvo switch.



4. Bomb Bay Door Switch—CLOSE.

WARNING

The bomb salvo switch-type circuit breakers in the bomb bay must be ON because all electrical impulses to the racks go through these switches.

Radar Release.

For reasons of security classification, no information on control and operation of the K-() bombing equipment is given in this publication.

Pneumatic Release.

For reasons of security classification, no information on control and operation of this equipment is given in this publication.

BOMB BAY DOOR EMERGENCY CONTROLS.

Manual Selector Controls.

The hydraulic system main selector valve is provided with an OPEN and CLOSE plunger for operation of the bomb bay doors. The plungers are used in conjunction with the hydraulic pump override switch.

Manual Operation of Main Selector Valve.

(See figure 3-13.)

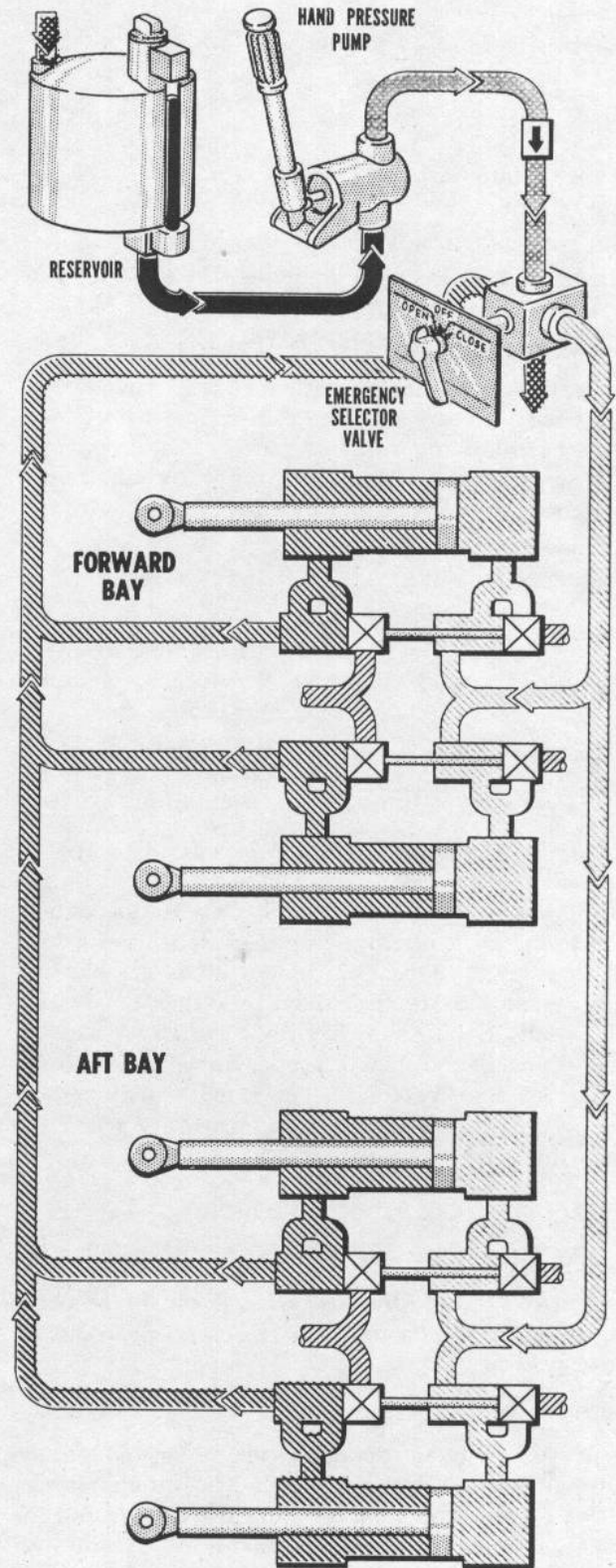
1. Engineer — Hydraulic Pump Override Switch — ON.
2. Crew — Main Selector Valve OPEN or CLOSE Plunger — Hold in until desired action is completed.
3. Engineer — Hydraulic Pump Override Switch — OFF.

Bomb Bay Door Emergency Hydraulic System.

A fluid supply, a hand pump, and a bomb bay door emergency selector valve (figure 4-36) are the main components of the emergency bomb bay door system. With the selector valve in the OPEN or CLOSE position, operation of the hand pump produces the selected action.

CAUTION

When not in use, the lever will be left in the OFF position.



**BOMB BAY DOOR
EMERGENCY OPERATION**

Figure 4-37. Bomb Bay Door Emergency Hydraulic System Schematic

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Operation of Bomb Bay Door Emergency Hydraulic System (See figure 4-37.)

1. Hydraulic Fluid Temperature Control Switch—OFF.
2. Emergency Selector Valve—OPEN or CLOSE, as desired.
3. Hand Pump—Operate until doors are in the desired position.
4. Emergency Selector Valve—OFF.
5. Bomb Bay Door Safety Switch—OFF.

PHOTOGRAPHIC EQUIPMENT.

The airplane is equipped with an aerial camera station located just forward of the lower aft turret. Any one of the following cameras can be installed at the station for use in both day and night reconnaissance and orientation and in bomb spotting.

Type	Focal Length— Inches	Use
K-17	6, 12, or 24	Bomb Spotting and Reconnaissance
K-22	6, 12, 24, or 40	Bomb Spotting and Reconnaissance
K-18	24	Reconnaissance
K-19B	12	Night Photography
K-24	7, 12, or 20	Orientation

Each of these cameras, with the exception of the K-19B, is controlled by an intervalometer located on the radar-bombardier's control panel. The K-19B camera is controlled by a photocell unit located just forward of the camera station. The camera doors are electrically operated and are controlled by either the camera door switch or the bomb bay door switch. A vacuum system is provided to insure proper film position in the camera magazine. Vacuum is generated by a d-c motor-driven pump which operates automatically when the camera doors are opened.

CAMERA CONTROLS.

Camera Master Power Switch.

When placed in the ON position, 28-volt d-c power is supplied to the switch and signal circuits of the camera control system.

Intervalometer.

A type B-7 camera intervalometer is located on the radar-bombardier's control panel. The intervalometer controls the automatic operation of the camera and the interval between exposures. Controls of the intervalometer include a single-exposure switch, a start-stop switch, a recycle switch, an exposure counter dial, an interval selector, and a mode selector switch for setting up the electrical circuit for the type of camera operation to be used. The positions of the mode selector switch are NT. RECON. BOMB SPT., NT. ORIEN., DAY ORIEN., DAY RECON., and OFF.

Camera Mode Selector Switch.

A mode selector switch (17, figure 4-35) having an AUTO position and a spring-loaded MANUAL position is provided on the auxiliary bombing control panel. When the switch is in the AUTO position, the operation of the camera is controlled by the intervalometer and camera operation is initiated when the bomb release switch is actuated. When the switch is held in the MANUAL position, camera operation will be initiated and the rate of exposure will be determined by the cycling speed of the camera.

Camera Door Switch.

A three-position camera door switch (14, figure 4-35) is provided on the auxiliary bombing control panel for opening and closing the camera doors. The switch has a spring-loaded OPEN position, a spring-loaded CLOSE position, and a neutral center position. The OPEN and CLOSE positions provide manual electrical control of the doors. When the switch is in the neutral center position, the camera doors will open when the bomb bay door switch is actuated.

Note

The camera doors can be closed only by means of the camera door switch.

INDICATORS.

Camera Operation Indicator Lamps.

A green indicator lamp (16, figure 4-35) is located on the auxiliary bombing control panel. When the camera is operating, the lamp will blink at the rate of exposure.

Camera Door Indicator Lamps.

Two camera door indicator lamps (13, figure 4-35), an amber lamp for OPEN and a red lamp for CLOSED, give visual indication of the camera door position.

OPERATION.

Operation of the aerial camera is accomplished as follows:

1. Camera Master Power Switch—ON.
2. Camera Door Switch—OPEN when camera is not to be used in conjunction with bomb dropping operations.

Note

The camera doors open automatically when the bomb bay doors open.

3. Intervalometer Mode Selector Switch—NT. RECON. BOMB SPT. when camera is to be used in conjunction with bomb dropping operations; otherwise, set as required if automatic operation of the camera is to be used.

Note

When the camera is used in conjunction with

bomb dropping operations, intervalometer operation will be initiated automatically with the release of a bomb; otherwise the intervalometer operation is started by depressing the START button.

4. Mode Selector Switch—AUTO for automatic operation in hold or in MANUAL for manual operation of the camera.

5. Camera Door Switch—Hold in CLOSE position upon completion of photography.

Note

For night photography, it is only necessary to have the camera master switch ON and the camera doors open as the K-19B camera is tripped automatically when the flash from the bomb strikes the photocell.

MISCELLANEOUS EQUIPMENT.

COMMUNICATION TUBE CART.

The communication tube cart provides transportation through the communication tube which connects the pressurized compartments. Rollers on the cart are mounted on a track laid in the tube. The user lies face-up on the cart and pulls himself along by means of an overhanging rope. The cart is automatically locked in place when it reaches its end of travel. It can be unlocked by pulling the ring on the top surface of the cart. It can be unlocked and brought from the opposite end of the communication tube by turning the handle on the cart return carriage pulley between the tracks. The cart is equipped with brakes for controlling its speed during changes in airplane attitude.

ENTRANCE LADDERS.

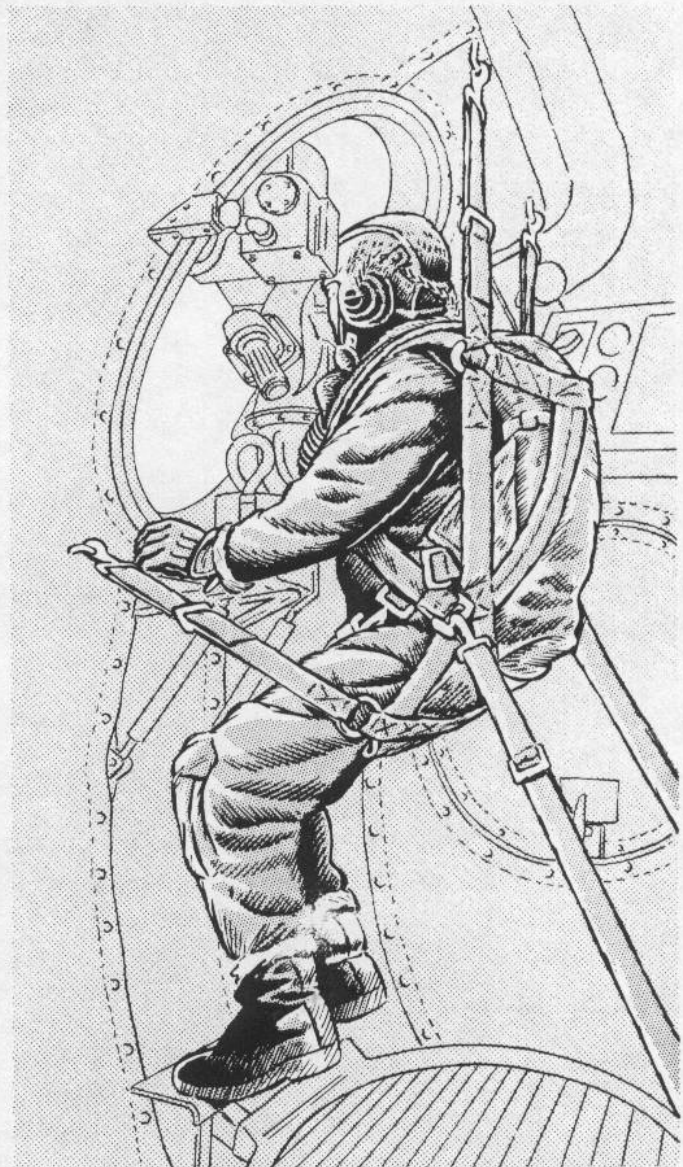
Two ladders are provided for access to the crew compartments. The forward cabin entrance ladder is permanently attached to the forward bulkhead of the nose wheel well and swings up into the well to its stowed position. On airplanes not in group 6, the aft cabin entrance ladder stows inside the cabin and provides access to the upper bunks and the sighting platform. On group 6 airplanes the aft cabin entrance ladder is stowed in the tail compartment and a permanent ladder provides access to the bunks and the sighting platform.

PILOTS' NIGHT-FLYING CURTAIN.

When in use, the night-flying curtain is snapped into position between the pilots' and the flight engineer's stations. The curtain is stowed in the copilot's fairing.

SPARE LAMP STOWAGE BOX.

Stowage for spare electric lamp bulbs is provided by a box located aft of the left escape hatch in the forward cabin.



2-1016-R

**Figure 4-38. Forward Sighting Station
Sling-Type Seat**

NAVIGATOR'S SEAT.

The navigator's seat rotates approximately 90 degrees right or left and is equipped with a safety belt and control knob lock. (See figure 4-14.)

RADAR-BOMBARDIER'S SEAT.

The radar-bombardier's seat is mounted on tracks which permit the seat to be adjusted fore and aft. It rotates sufficiently on its base to allow access to the bombsight and control panel. The seat is equipped with a control knob lock and safety belt.

RADIO OPERATOR'S SEAT.

The radio operator's seat rotates approximately 90 de-

grees in each direction. It moves fore and aft on a fixed track and is equipped with a control knob lock and safety belt. Both arm rests fold up, giving ample freedom of movement in and out of the seat.

NOSE GUNNER'S SEAT.

The nose gunner is provided with a bicycle-type seat which is adjustable fore and aft and vertically. The seat is equipped with a padded back rest, a safety belt, and a control lock lever which governs fore-and-aft movement. Vertical movement is controlled by a manual elevation adjustment pin.

FORWARD GUNNERS' SEATS.

The forward sighting stations are not equipped with stationary seats as are the other stations, but are provided with fabric sling-type seats. See figure 4-38. These seats can be rigged into position for scanning and sighting purposes or they may be stowed.

WARNING

The sling-type seats are not to be occupied during take-off and landing; the forward gunners must assume the positions indicated in figures 2-9 and 2-10.

UPPER AFT GUNNERS' SEATS.

Bicycle-type seats similar to those of the nose gunner are provided at these stations. The seats are located on the upper aft gunners' platform and pivot about the base of the sighting support column.

LOWER AFT GUNNERS' SEATS.

On airplanes not in group 6 the lower aft gunners' seats are the same as the nose gunner's. Knee pads installed on the bulkhead below the sight provide protection when the sighting position is assumed. On group 6 airplanes the lower aft gunners' seats are designed so they can be used during take-off and landing. For this reason the seats are equipped with inertia reel lock-type shoulder harnesses identical to those provided for the pilots. For further information on this type shoulder harness, refer to "Shoulder Harness Control" in Section I.

WINDSHIELD WIPERS.

The pilots are provided with two windshield wipers. Both wipers are controlled by a single ON-OFF switch (9, figure 1-12) on the pilots' instrument panel. When the switch is placed in the ON position, 28-volt direct current actuates a relay which completes a 200-volt a-c circuit to the windshield wiper motors.

CREW COMFORT PROVISIONS.

(Group 6 Airplanes.)

Bunks.

Six bunks, complete with mattresses, pillows, and blankets, are provided in the aft cabin of the airplane. The bunks are equipped with foot braces, safety harnesses, and safety belts, and are to be used for crew positions during take-off and landing.

Auxiliary Bunks. Provisions are made for the installation of two bunks in the forward cabin. When installed, one is located above the nose wheel well entrance hatch and the other is located aft of the flight engineer's station in the radio operator's compartment. The bunk above the wheel well entrance hatch may be swung forward and up into a stowed position beneath the flight deck floor; the other bunk has no stowed position. Both bunks can be readily installed or removed.

Miscellaneous Personal Gear Stowage.

Small hammock-type mesh bags for the stowage of personal gear are located adjacent to each bunk. Small racks are provided on each side of the bunks in the aft cabin for parachute stowage.

Parachute Bag Stowage.

Provisions are made to stow parachute bags in the following locations: two in a folding rack on the nose wheel well in the navigator's compartment, one under the step in the left walkway of the forward cabin, two in each combination dining table and stowage rack (4, figure 4-39) located on each side of the radio operator's compartment, and four in a vertical rack adjacent to the radio operator's table. In the aft cabin, a rack (11, figure 4-40) for accommodating eight bags is located on the aft bulkhead.

Hot Cups.

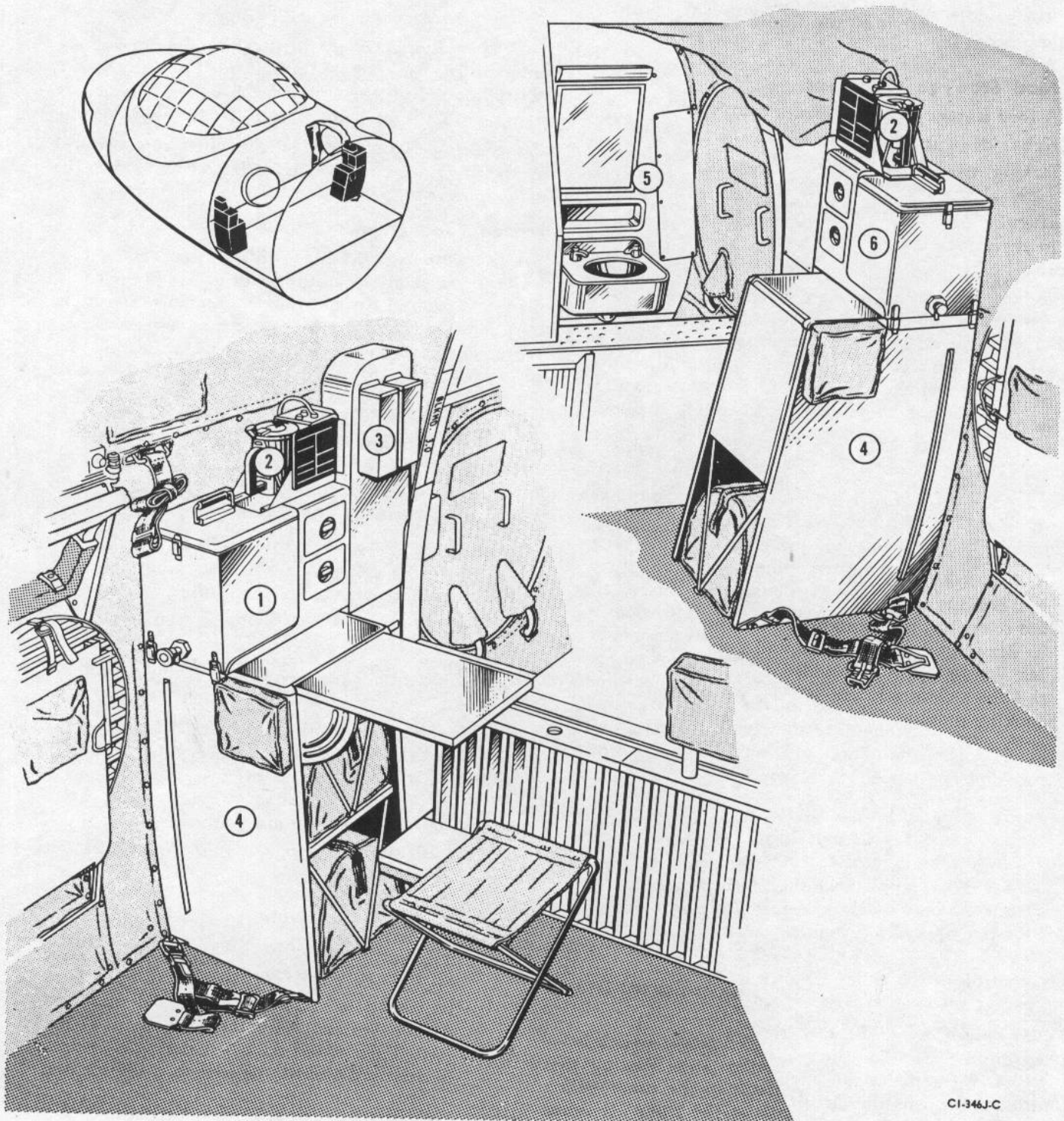
Four hot cups are provided for crew use. One (2, figure 4-39) is located above each combination stowage rack and dining table in the radio operator's compartment. The other two (10, figure 4-40) are located adjacent to the food stowage locker on the right side of the aft cabin.

Liquid Containers.

A four-gallon, electrically heated, liquid container (1, figure 4-39) is located on the combination stowage rack and dining table on the left side of the radio operator's compartment. A four-gallon insulated drinking water container (6, figure 4-39) is mounted in a similar location on the right side of the compartment. In the aft cabin, a four-gallon insulated drinking water container (7, figure 4-40) and a two-gallon, electrically heated container (8, figure 4-40) are located above the food storage locker.

1. HEATED LIQUID CONTAINER
2. HOT CUP
3. PAPER CUP DISPENSERS
4. COMBINATION STOWAGE RACK AND DINING TABLE
5. FORWARD ROOMETTE
6. INSULATED LIQUID CONTAINER

NOTE: COMPLETE CREW COMFORT PROVISIONS ARE NOT SHOWN IN THIS ILLUSTRATION. FOR DETAILS REFER TO "MISCELLANEOUS EQUIPMENT (GROUP 6 AIRPLANES)," OF THIS SECTION.



CI-346J-C

Figure 4-39. Crew Comfort Provisions In Forward Cabin (Group 6 Airplanes)

Note

The electrically heated containers operate automatically when they are plugged in and power is available in the airplane.

Cup Dispensers.

Paper cup dispensers (3, figure 4-39 and 6, figure 4-40) are located adjacent to the liquid containers in each compartment.

Food Stowage Provisions.

A food storage locker (3, figure 4-40) is located on the right side of the aft cabin. Provisions are made for attaching two portable food storage units (3, figure 4-40) to the underside of the sighting platform in the aft cabin. Three additional portable units are located in the galley.

Icebox.

An icebox for stowing perishable food is located below the hot plates. The icebox is suitable for use with either wet or dry ice and has a capacity for 50 pounds of wet ice. When wet ice is used, the water drains into the garbage container. For best efficiency, ice should be placed in the box 24 hours prior to a flight to allow it to prechill.

Galley Unit.

A galley unit (4, figure 4-40) located aft of the bunks in the aft cabin is equipped with all the necessary conveniences for preparing hot meals and for stowing both perishable and nonperishable foods. The galley unit consists of two electric hot plates, an icebox, a re-use container, two portable food stowage units, a utility drawer, a work platform, and a centrifugal air filter fan. Storage space is provided on an overhead shelf for the food conveyor and a stowage compartment for cooking utensils. On the back of the galley is located both a bracket for mounting the can opener and two electrical outlets for plugging in any 110-volt a-c resistance-type appliances.

CAUTION

Do not use appliances that incorporate an electric motor unless it is specifically wound for the 400-cycle current.

The controls of the galley are described in the following paragraphs.

Galley Power Switch. An ON-OFF power switch is located on the front of the galley unit. Placing this switch ON completes the circuit to the other galley controls and opens the circuit to the right aft cabin heater. Placing the switch OFF completes the circuit to the right aft cabin heater and de-energizes the galley circuits.

Note

Both of these circuits are de-energized when either of the cabin heater power switch is OFF or when the external power switch is ON.

Hot Plate Control Knobs. The two hot plates on the galley unit are controlled by individual knobs marked OFF, LOW, MED, and HIGH. These controls receive their power through the galley power switch.

Galley Fan Switch. The centrifugal fan for filtering the air about the cooking area is controlled by an ON-OFF switch located on the front of the galley. The galley power switch must be on before the fan will operate.

Galley Light Switch. The galley lights are controlled by an ON-OFF switch which is effective only when the galley power switch is ON.

Frozen Food Oven.

An electric oven (9, figure 4-40) located on the food locker on the right side of the aft cabin is provided for heating prepared frozen meals or canned rations. The oven is thermostatically controlled and contains six removable shelves, each with detachable heating elements. Two push-to-reset buttons above the oven door are used to turn the oven on, and the thermostatic controls automatically break the circuit when the proper temperature is reached. The thermostats may be reset after the oven partially cools by pushing the push-to-reset buttons. A pilot light located below the door lights when the oven is heating.

Operation. To warm frozen foods, proceed as follows:

1. Remove the cellophane wrappers from the packages, but do not remove the metal foil.
2. Place one meal on each shelf.

CAUTION

The oven accommodates six meals; however, if less than six are to be heated, remove the unused shelves from the oven.

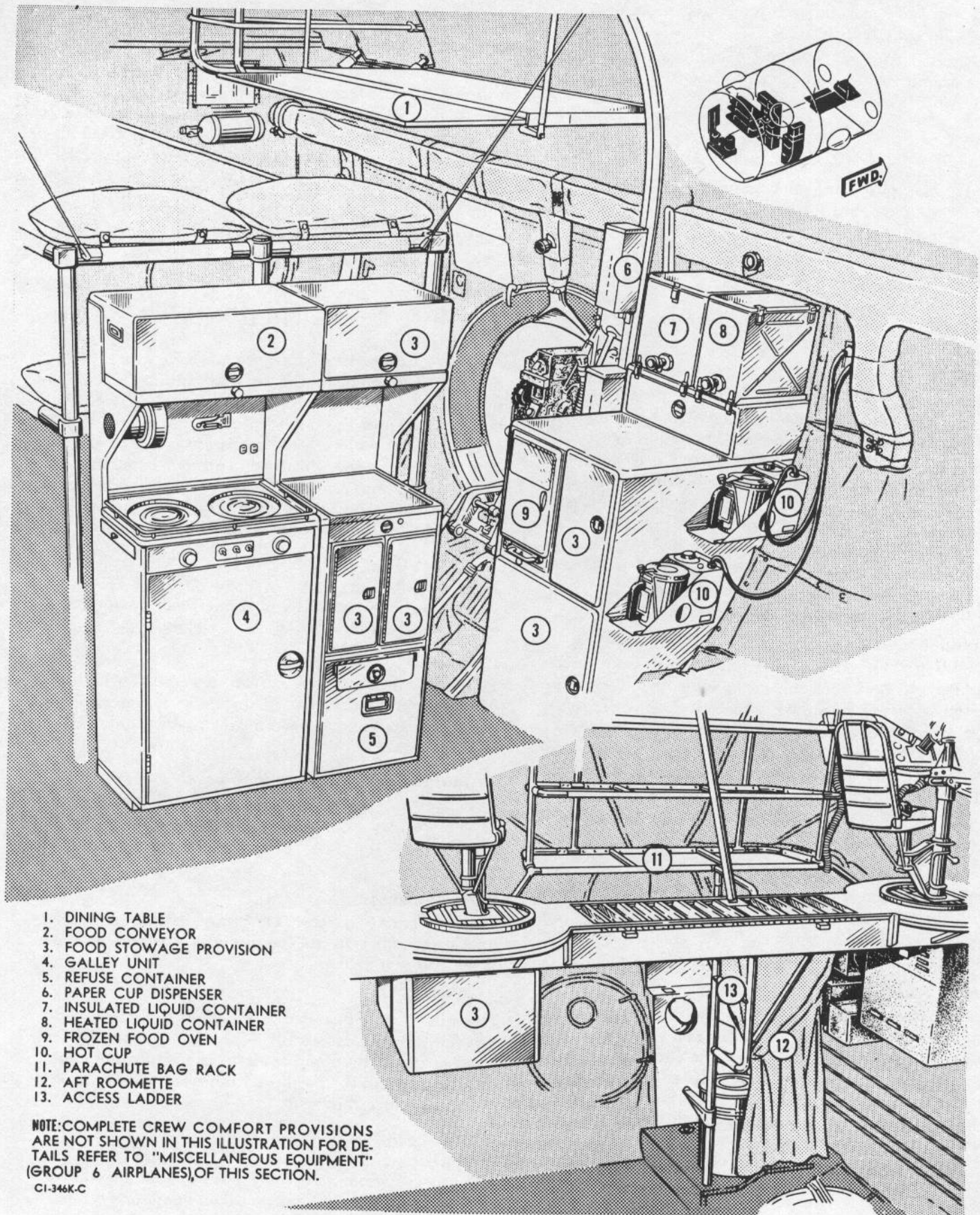
3. Push in both reset buttons.
4. Wait 10 minutes after the pilot light goes out; then remove the meals.

Note

The oven must partially cool before the reset buttons are effective again. If the oven is to be reused immediately, place cold meals on the shelves and leave the door open. If the pilot light comes on when the push-to-reset buttons are pushed, the oven is ready for use.

Canned rations can be heated as follows:

1. Remove shelves 1, 3, and 5 (counting from the top) from the oven.



1. DINING TABLE
2. FOOD CONVEYOR
3. FOOD STOWAGE PROVISION
4. GALLEY UNIT
5. REFUSE CONTAINER
6. PAPER CUP DISPENSER
7. INSULATED LIQUID CONTAINER
8. HEATED LIQUID CONTAINER
9. FROZEN FOOD OVEN
10. HOT CUP
11. PARACHUTE BAG RACK
12. AFT ROOMETTE
13. ACCESS LADDER

NOTE: COMPLETE CREW COMFORT PROVISIONS ARE NOT SHOWN IN THIS ILLUSTRATION FOR DETAILS REFER TO "MISCELLANEOUS EQUIPMENT" (GROUP 6 AIRPLANES), OF THIS SECTION.

CI-346K-C

Figure 4-40. Crew Comfort Provisions In Aft Cabin (Group 6 Airplanes)

2. Place 4 to 5 cans on each remaining shelf.
3. Push in the reset buttons.
4. If small cans of food are being heated, remove them when the pilot light goes out. Large cans should be left in the oven a little longer.

CAUTION

Do not push the reset buttons unless cold (room temperature) cans are placed on the shelves.

CAUTION

Always remove the heating elements before cleaning the shelves in water.

Food Conveyor.

An insulated food conveyor (2, figure 4-40) is provided for transporting prepared hot meals to personnel in the forward cabin. The conveyor is locked in its stowed position on the top of the galley unit. To release from the stowed position, pull conveyor release knob, lift unit up and out to disengage from the galley. Place the conveyor on the communication tube cart for transporting it between compartments. To prevent the conveyor from slipping off the cart, it should be placed in the center of the cart with brake handle in the recess on the bottom edge of the conveyor.

Dining Provisions.

A folding shelf on the parachute bag stowage racks (4, figure 4-39) on each side of the radio operator's compartment serves as dining table space. A collapsible stool, provided for each table, is stowed in each rack. Folding dining tables (1, figure 4-40) are mounted on the fuselage adjacent to the upper bunks in the aft cabin. The tables can be folded up and stowed when not in use. When extended they may be used by crew members sitting on the top bunks.

Refuse Containers.

A fifteen-gallon garbage container is mounted flush with the floor of the radio operator's compartment. In the aft cabin, a refuse bin (5, figure 4-40) is located in the galley unit.

Toilet Facilities.

Two enclosed roomettes equipped with complete toilet facilities are provided in the airplane. One roomette (12, figure 4-40) is located aft of the entrance hatch in the aft cabin. The aft roomette facilities include a toilet which is vented to the outside, a urinal which drains overboard when the button on the floor below is depressed, a lavatory equipped with a liquid soap dispenser and hot water from an automatic water heater located behind the roomette. Other features include an oxygen panel, holders for paper towels and toilet paper, and roomette lights. The forward roomette (5, figure 4-39), located forward and to the left of the radio

operator's compartment, has similar facilities except that a relief tube is provided instead of a urinal. The relief tube and lavatory each drain into a tank built around the toilet instead of draining overboard.

Water Heater Safety Switch. A push-to-reset button located on the sump of each automatic water heater prevents the water temperature from exceeding 150°F. In the event the tank runs dry, the safety switch breaks the circuit at 150°F and must be reset after the tank is refilled.

CREW COMFORT PROVISIONS.

(Airplanes not in Group 6.)

Bunks.

Six bunks are provided for the crew and are located in the aft cabin.

Auxiliary Bunks. Provisions are made for the installation of two bunks in the forward cabin. When installed, one is located above the nose wheel well entrance hatch and the other is located aft of the flight engineer's station in the radio operator's compartment. The bunk above the wheel well entrance hatch may be swung forward and up into a stowed position beneath the flight deck floor; the other bunk has no stowed position. Both bunks can be readily installed or removed.

Food Locker.

A food locker is installed in the left side of the radio operator's compartment.

Hot Cups.

Four hot cups are provided for crew use. Two are located on the food locker in the radio operator's compartment, and two are mounted on the right side of the aft cabin.

Insulated Liquid Containers.

Six insulated liquid containers are provided for the crew. Four are located near the navigator's station in the forward cabin, and two are on the right side of the aft cabin.

Cup Dispensers.

Two paper cup dispensers are provided. One dispenser is located adjacent to the liquid containers in each crew compartment.

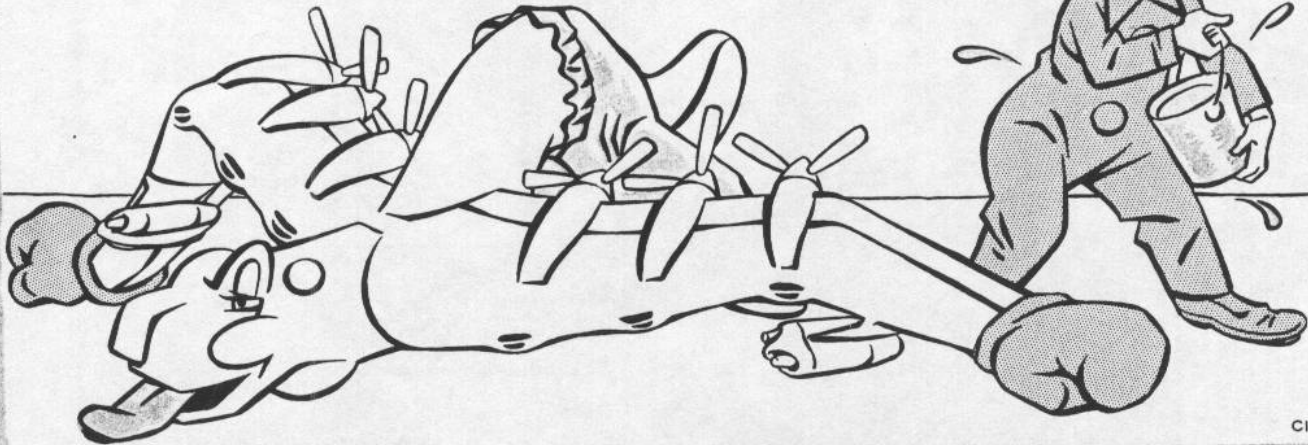
Wash Basin.

A wash basin is installed in the right side of the radio operator's compartment. A drainage tube connected to the bottom of the basin routes waste water into a tank located beneath the basin. A fresh water supply tank is installed above the basin.

Toilet Facilities.

A relief tube and tank and a toilet are installed in each crew compartment. In the forward cabin they are located on the right side of the radio operator's compartment. In the aft cabin these facilities are located near the aft bulkhead.

SECTION V OPERATING LIMITATIONS



CI-308-C

The purpose of this section is to cover all important limitations that must be observed during normal operation. Special attention should be given to the instrument markings (figure 5-1) since these limitations are not necessarily repeated in the text. When necessary, an additional explanation of instrument markings is covered in the text under appropriate headings.

MINIMUM CREW REQUIREMENTS.

The minimum crew requirements for this airplane are the aircraft commander, pilot, and the engineer. Additional crew members will be added at the discretion of the Commanding Officer.

INSTRUMENT LIMITATIONS.

The limits marked on the airplane instruments are shown in figure 5-1.

ENGINE LIMITATIONS.

RECIPROCATING ENGINES.

In addition to the limitations indicated in figure 5-1, the limits discussed in the following paragraphs are imposed on reciprocating engine operation.

Maximum Overspeed.

Maximum overspeed is 3300 rpm. However, if engine speed has reached between 3100 and 3300 rpm the engine must be inspected before the next flight. If the

engine speed exceeded 3300 rpm, the engine must be changed. All conditions of overspeeding are to be noted on the Form 1.

Minimum Idle Speed.

Minimum idling speed is 1100 rpm.

Note

During ground operation of the flaps or jet engine starting, the alternator-equipped engines (2, 3, 4, and 5) must be idled at 1200 rpm.

Engine Limitations with Advanced Spark.

Operation of the reciprocating engines at high cylinder head and carburetor air temperatures with advanced spark will result in detonation and subsequent engine failure. Operation has been found most critical at 160 bmep in the range of 1900 to 2200 rpm. To eliminate the possibility of encountering detonation in the critical range, the following instructions and limits will be strictly adhered to when operating in the advanced spark position.

1. Cylinder head temperature will be maintained at or below 220°C. The desired range for advanced spark operation is 210° to 220°C.

2. Carburetor air temperature will be maintained at or below 20°C. The desired range for advanced spark operation is 15° to 20°C.

Should icing conditions prevail and it is necessary to raise the CAT., all operation in advanced spark will be

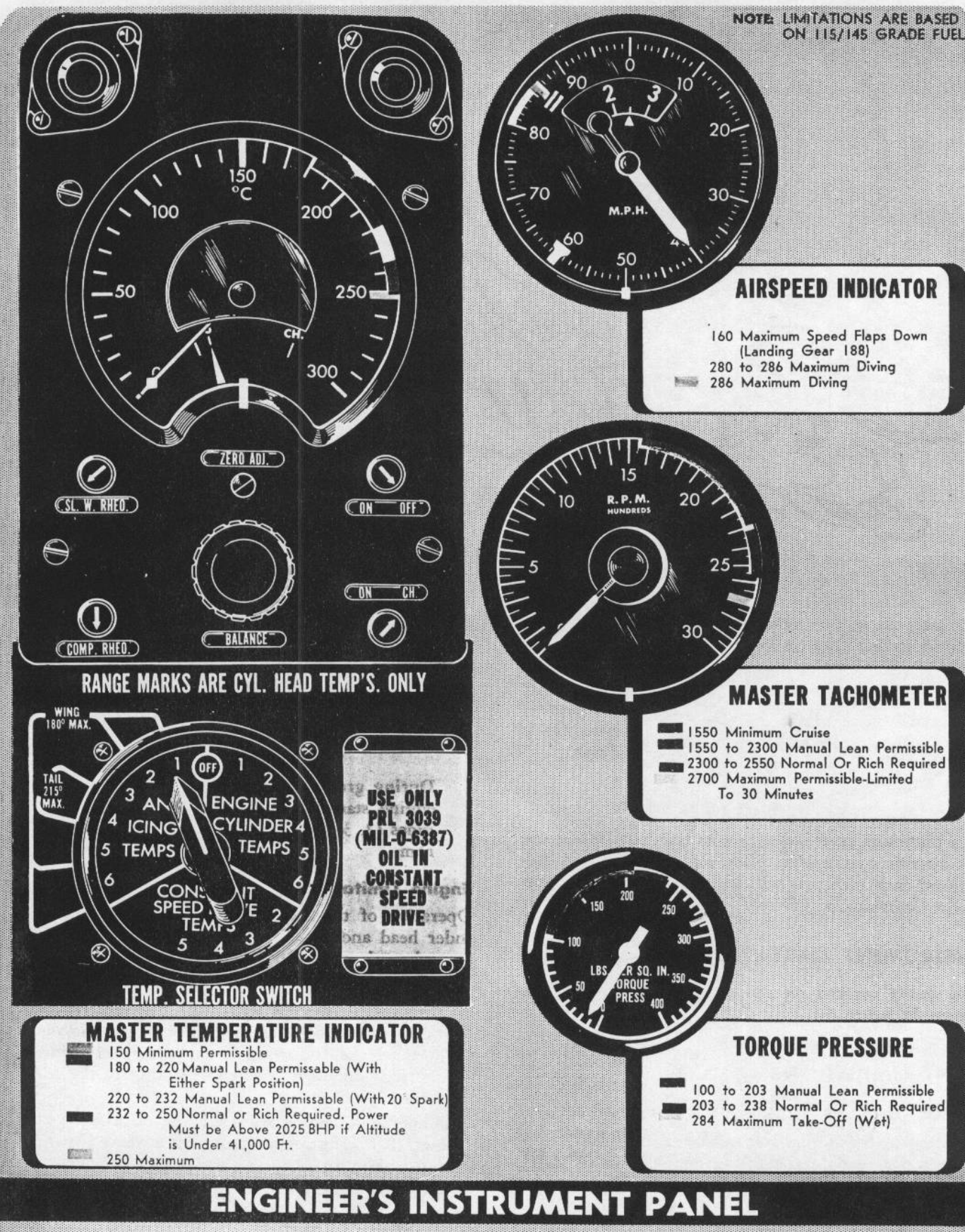


Figure 5-1. (Sheet 1) Instrument Limitations

3-1053-004



FREQUENCY METER

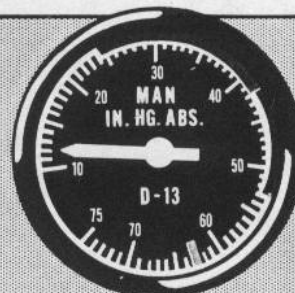
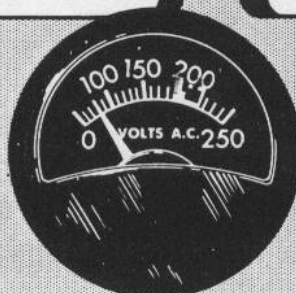
- 375 Minimum Permissible
- 380 to 420 Desired Operating Range
- 425 Maximum Permissible

VOLT METER

- 190 Minimum Permissible
- 190 to 210 Desired Operating Range
- 210 Maximum Permissible

MANIFOLD PRESSURE

- 24 to 42 Manual Lean Permissible
- 42 to 53 Normal Or Rich Required
- 63 Take-Off (0 Humidity Correction)



OIL PRESSURE

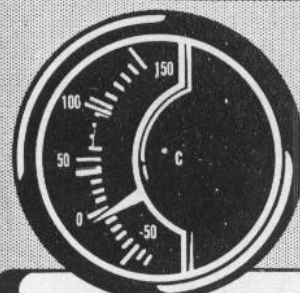
- 45 Minimum For Speed Below 2000 RPM
- 50 Minimum For Speeds Of 2000 RPM Or Above
- 55 to 80 Desired Operating Range
- 80 Maximum

TACHOMETER

- 1550 Minimum Cruise
- 1550 to 2300 Manual Lean Permissible
- 2300 to 2550 Normal Or Rich Required
- 2700 Maximum Permissible-Limited To 30 Minutes

WATER PRESSURE

- 24 Minimum
- 24 to 27 Desired Operating Range
- 28 Maximum



DUCT AIR TEMPERATURE

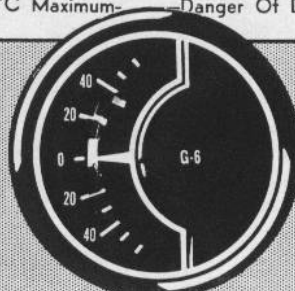
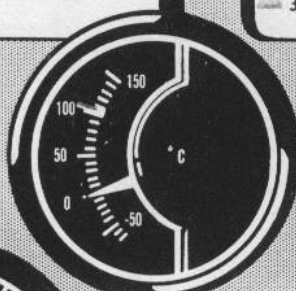
- 105°C Maximum

CARBURETOR AIR TEMP.

- 20° to -5°C Continuous Operation
- 5° to 10°C Danger of Icing
- 10° to 20°C Manual Lean Permissible (With Either Spark Position)
- 20° to 38°C Any Mixture With Either Spark Position Between 1900 And 2200 RPM
- 38°C Maximum—Danger Of Detonation

OIL TEMPERATURE

- 40°C Minimum
- 60 to 85°C Desired Operating Range
- 98°C Maximum Permissible



NOTE: LIMITATIONS ARE BASED ON 115/145 GRADE FUEL

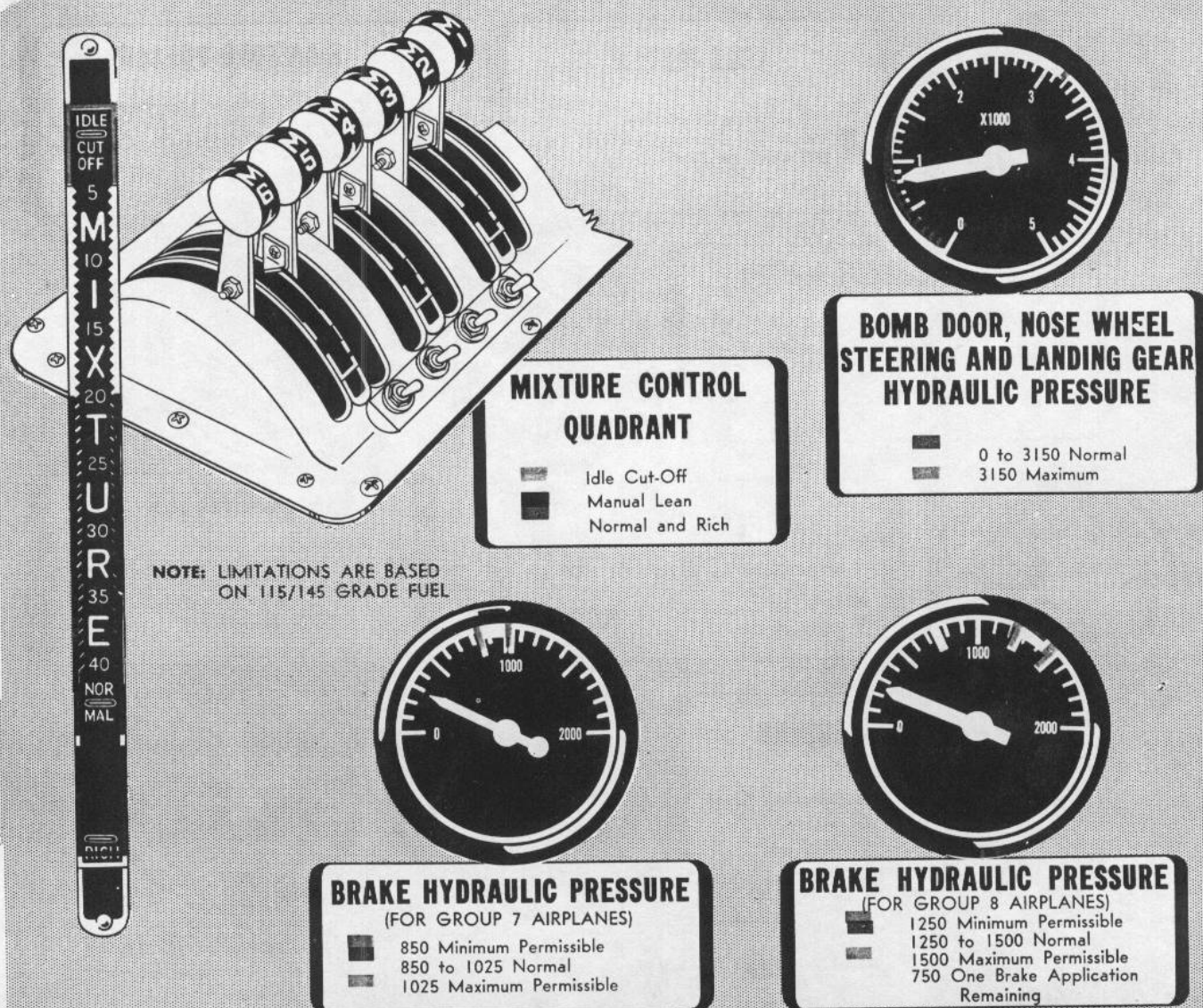


FUEL PRESSURE

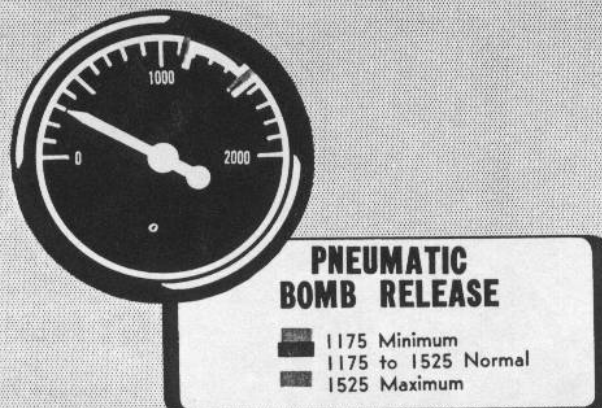
- 24 Minimum For Flight
- 24 to 26 Normal
- 28 Maximum

Figure 5-1. (Sheet 2) Instrument Limitations

3-1613-04



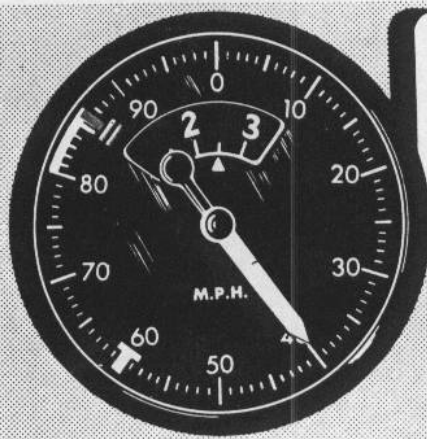
ENGINEER'S TABLE



BOMB BAY NO. 1

3-1033-14

Figure 5-1. (Sheet 3) Instrument Limitations

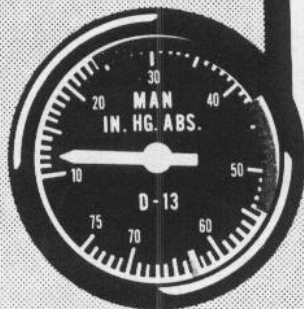
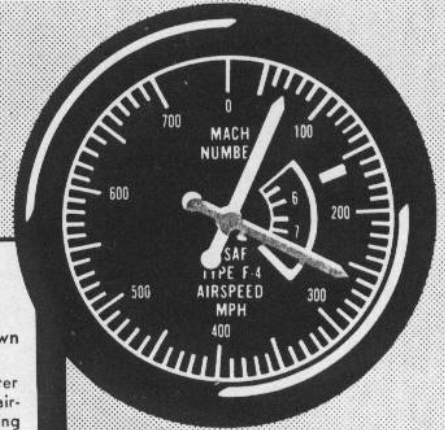


AIRSPPEED INDICATOR

160 Maximum Speed Flaps Down
(Landing Gear—188)
280 to 286 Max. Diving (357,500 Lbs.)
286 Maximum Diving

F-4 OR F-5 AIRSPPEED INDICATOR

160 Maximum Speed Flaps Down
(Landing Gear 188)
The instrument setting is such that the red pointer
will move to indicate the limiting structural air-
speed of 286 mph or the airspeed representing
the limiting Mach No. of .66, whichever is less.

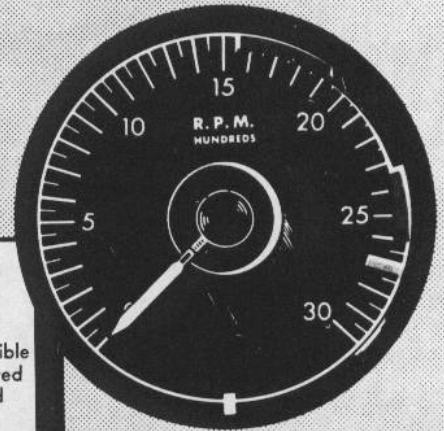


MANIFOLD PRESSURE

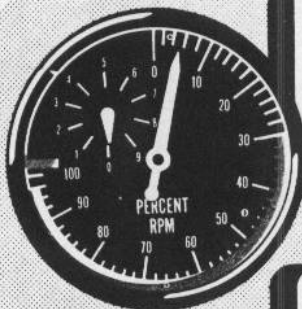
24 to 42 Manual Lean Permissible
42 to 53 Normal or Rich Required
63 Take-Off (0 Humidity Correction)

MASTER TACHOMETER

1550 Minimum Cruise
1550 to 2300 Manual Lean Permissible
2300 to 2550 Normal or Rich Required
2700 Maximum Permissible—Limited
To 30 Minutes



PILOTS' INSTRUMENT PANEL



TACHOMETER

30 to 96% Best Cruising
100% Maximum

TAIL PIPE TEMPERATURE

315°C Minimum For Flight
315° to 655°C Continuous Operation
690°C Maximum For Flight
870°C Maximum During Start
And Acceleration Only



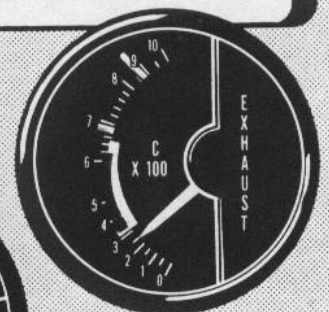
OIL PRESSURE

2 Minimum
2 to 50 Continuous Operation
50 Maximum

(AIRPLANES NOT IN GROUP 19)

FUEL PRESSURE

20 Minimum For Flight
20 to 400 Desired Operating Range
400 to 500 Permissible At High Speed
At Low Altitude With Low
Ambient Temperatures
500 Maximum
(AIRPLANES NOT IN GROUP 19)



NOTE: LIMITATIONS ARE BASED
ON 115/145 GRADE FUEL

PILOTS' JET

INSTRUMENT PANEL

Figure 5-1. (Sheet 4) Instrument Limitations

3-1033-R4

NOTE: LIMITATIONS ARE BASED
ON 115/145 GRADE FUEL

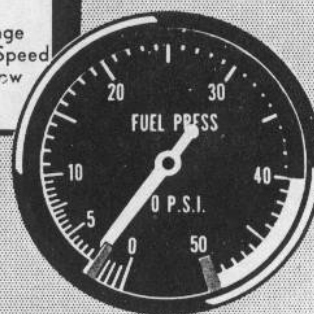


OIL PRESSURE (GROUP 19 AIRPLANES)

- 2 Minimum
- 2 to 50 Continuous Operation
- 50 Maximum

FUEL PRESSURE (GROUP 19 AIRPLANES)

- 20 Minimum For Flight
- 20 to 400 Desired Operating Range
- 400 to 500 Permissible At High Speed
- At Low Altitude With Low Ambient Temperatures
- 500 Maximum



PILOTS' JET

INSTRUMENT PANEL

Figure 5-1. (Sheet 5) Instrument Limitations

3-1033-R4

discontinued. The CHT with retarded spark and 160 bmeP will be maintained at or below 220°C. The desired range is 210° to 220°C. When using retarded spark at 189 bmeP for powers in excess of 2020 bhp, the maximum allowable CHT is 250°C with a normal mixture setting or a manual adjust setting.

Fan Speed Limitations.

Because of structural limitations of the fan, high ratio will not be used below 13,500 feet if the engine speed exceeds 2000 rpm. Between 13,500 and 20,000 feet, the high ratio may be used when engine speeds are below 2200 rpm. Either drive may be used above 20,000 feet.

Operating Limits with Alternate Fuel Grade (100/130).

Manual Lean Permissible

Manifold Pressure	25 to 37.5 inches
RPM	1240 to 2230 rpm
Cylinder Head Temperature	150° to 218°C
Carburetor Air Temperature	20°C maximum

Normal Mixture

Manifold Pressure	37.5 to 45.5 inches
RPM	2230 to 2550 rpm
Cylinder Head Temperature	218° to 232°C
Carburetor Air Temperature	38°C maximum

Maximum Allowable

Manifold Pressure	53.5 inches
RPM	2700 rpm
Cylinder Head Temperature	232° C
Carburetor Air Temperature	38°C

CAUTION

When using alternate grade fuel the spark advance setting will not be used.

JET ENGINES.

The limits for jet engine operation which are not shown in figure 5-1 are given in the following paragraphs.

Maximum Overspeed.

Maximum overspeed is 104 per cent rpm. Engine over-speed operation exceeding 104 per cent rpm requires that the engine be changed even though over-temperature limits were not encountered.

Minimum Idle Speed.

Minimum idle speed is 25 per cent rpm.

Note

Rapid advancement of the throttle on an engine idling below 25 per cent rpm will probably cause a flame-out.

Over-Temperature Operation.

Any start or acceleration during which the tail pipe temperature exceeds 1000°C or any ten starts or accelerations during which the tail pipe temperature exceeds 870°C constitutes over-temperature operation and requires that the engine be removed from the airplane and returned to overhaul.

Note

This is required in case of ten hot starts regardless of time lapse between starts.

The temperature and duration of all over-temperature operation (870°C) shall be entered on Form 1.

Five starts or accelerations during which the tail pipe temperature exceeds 870°C requires that the engine be carefully inspected prior to flight for possible damage.

AIR-SPEED LIMITATIONS.

The maximum continuous indicated speeds and limit dive speeds are shown in figure 5-2. Other limiting air speeds are as follows:

1. The maximum IAS for the following operations is 188 mph because of structural limitations.

- Landing gear extension.
- Landing gear retraction.
- Landing light extension.
- Full aileron deflection.
- Flap extension.

2. The maximum IAS for bomb bay door operation is 286 mph.

PROPELLER AND FLAP LIMITATIONS.

The operating limits for propellers and flaps are reflected in figure 5-3.

PROHIBITED MANEUVERS.

All acrobatics including spins and stalls are prohibited. The maximum permissible bank while turning is 60 degrees at a gross weight of 357,500 pounds.

MAXIMUM INDICATED AIRSPEEDS

Maximum continuous speeds are based on structural ability to withstand an indicated gust of 50k feet per second velocity.

Limit dive speeds are based on flutter and

dynamic pressure restrictions. Gusts are not considered; but in general, indicated gusts of 30k feet per second or better can be withstood at these speeds.

The limit diving speeds shown in this chart are based on structural limitations of the airframe. Normal diving speeds must be based on propeller limitations.

WITH PODS				
ALTITUDE, FT.	MAXIMUM CONTINUOUS IAS-MPH			LIMIT DIVE SPEEDS , MPH-ALL BOMB LOADS ALL GROSS WEIGHTS
	TWO 43,000 LB. BOMBS ALL GROSS WEIGHTS	ALL BOMB LOADS EXCEPT TWO 43,000 LB. BOMBS		
		357,500 LBS. G.W.	280,000 LBS. G.W. OR LESS	
SEA LEVEL	250	250	266	286
10,000	245	245	266	286
20,000	236	236	266	286
27,500	228	228	266	286
30,000	225	225	266	272
35,000	220	220	245	245
40,000	212	212	216	216
45,000	182	182	188	188
50,000	151	151	162	167

INTERPOLATE FOR INTERMEDIATE GROSS WEIGHTS

INTERPOLATE FOR INTERMEDIATE GROSS WEIGHTS

WITHOUT PODS				
ALTITUDE, FT.	MAXIMUM CONTINUOUS IAS-MPH			LIMIT DIVE SPEEDS , MPH-ALL BOMB LOADS ALL GROSS WEIGHTS
	TWO 43,000 LB. BOMBS ALL GROSS WEIGHTS	ALL BOMB LOADS EXCEPT TWO 43,000 LB. BOMBS		
		328,000 LBS. G.W.	280,000 LBS. G.W. OR LESS	
SEA LEVEL	230	250	266	286
10,000	227	245	266	280
20,000	220	236	266	266
25,000	216	230	257	257
30,000	210	223	248	248
35,000	203	214	240	240
40,000	195	204	213	213
45,000	184	184	187	187

INTERPOLATE FOR INTERMEDIATE GROSS WEIGHTS

CI-345N-C

Figure 5-2. Maximum Indicated Air Speeds

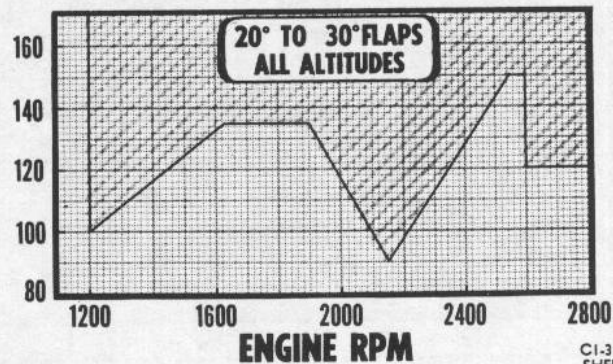
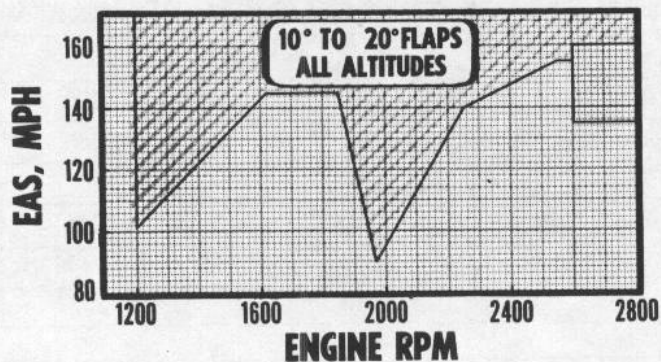
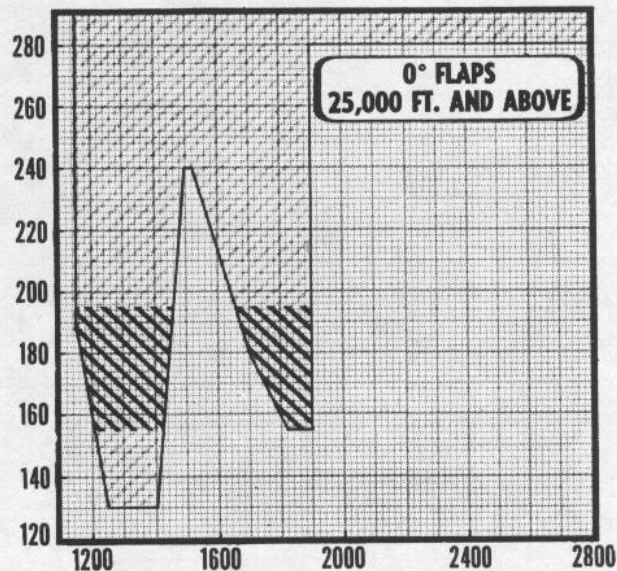
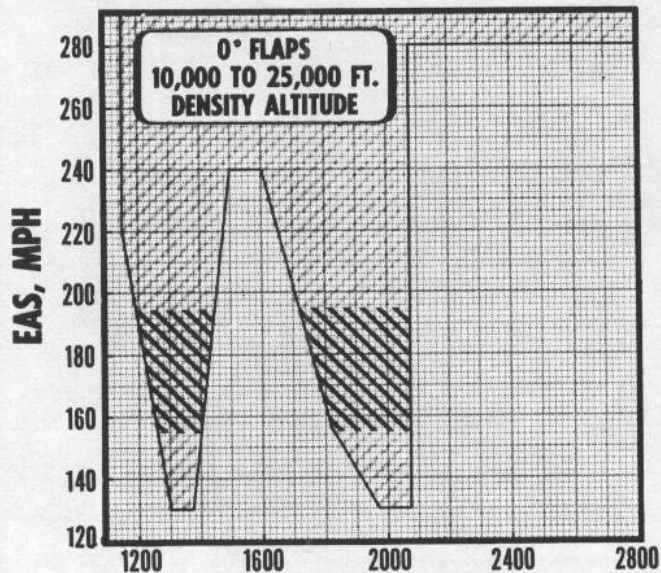
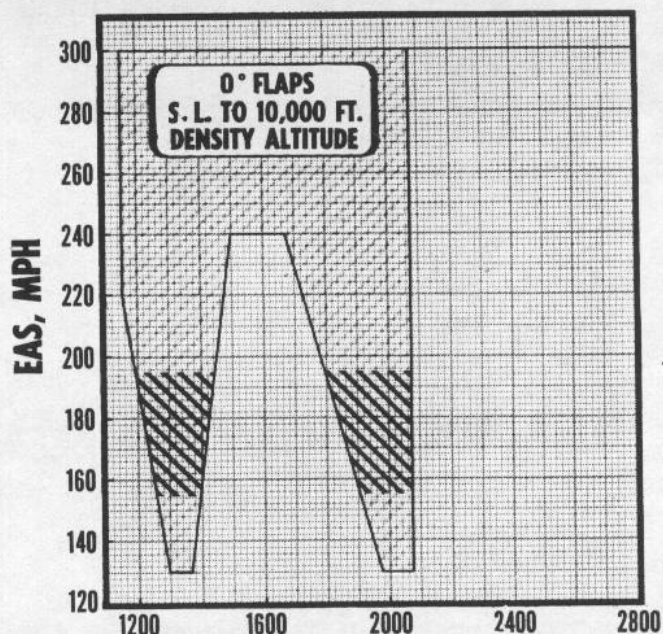
RESTRICTED

R4360-41 ENGINE
SQUARE TIP PROPELLER
LIMITATIONS

-  RESTRICTED DUE TO PROPELLER VIBRATION LIMITATIONS
-  SEE SHEET 2 FOR CRUISE RESTRICTIONS IN THIS AREA
-  OPERATION IN THIS AREA WILL REDUCE PROPELLER LIFE

NOTE:
Check airplane, gear, and
flap structural limitations.

DATA AS OF: 1-1-52
DATA BASED ON: FLIGHT TEST



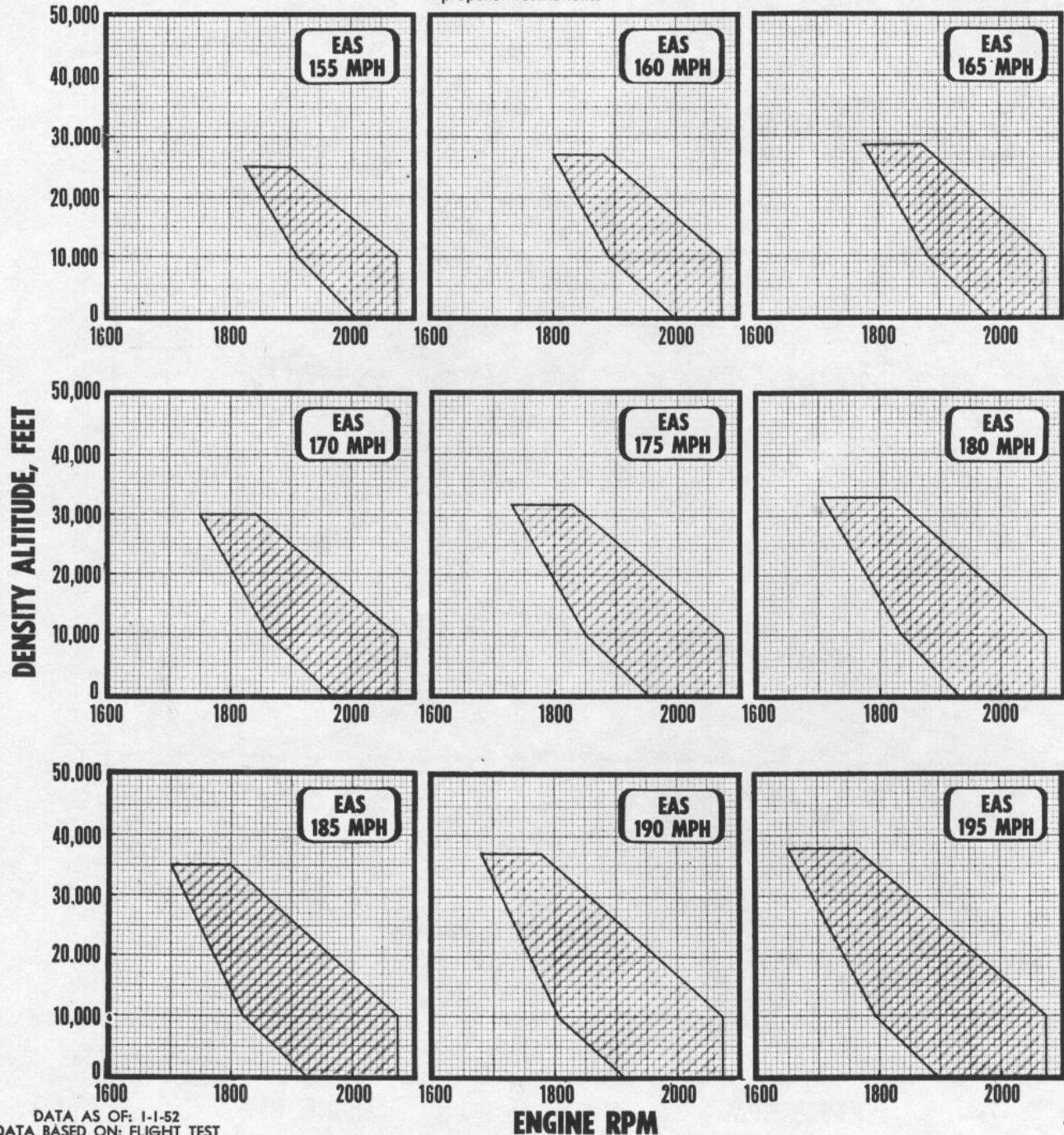
C1-314-C
SHEET 1

Figure 5-3. (Sheet 1) Propeller and Flap Limitations

R4360-41 ENGINE
**SQUARE TIP PROPELLER
LIMITATIONS**

□ CRUISE OPERATION IN THIS AREA
RESTRICTED DUE TO PROPELLER
VIBRATION LIMITS.

NOTE:
Refer to Sheet 1 for complete
propeller restrictions.



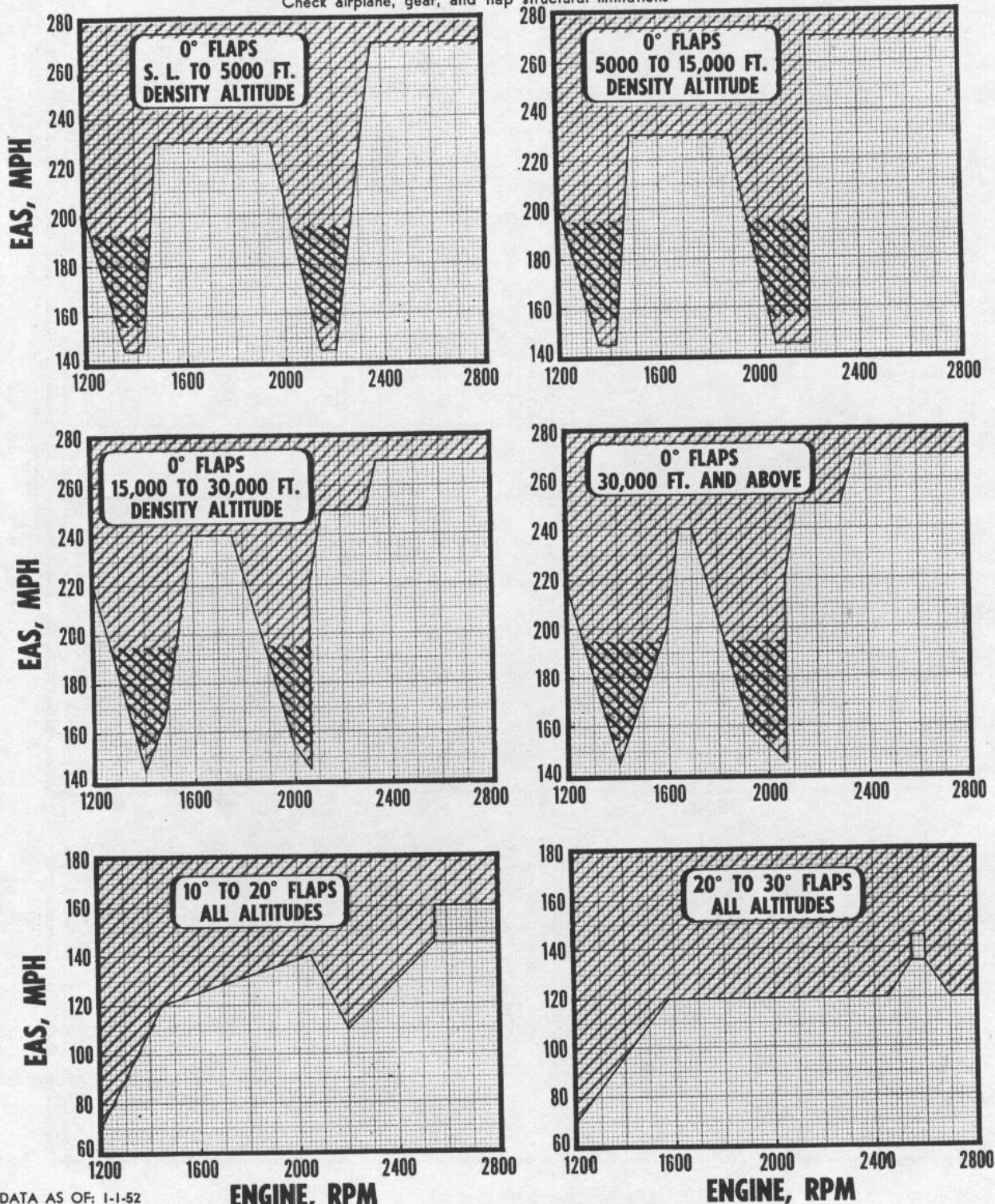
C1-314-C
SHEET 2

Figure 5-3. (Sheet 2) Propeller and Flap Limitations

R4360-41 ENGINE
ROUND TIP PROPELLER LIMITATIONS

 RESTRICTED DUE TO PROPELLER VIBRATION LIMITATIONS
 SEE SHEET 4 FOR CRUISE RESTRICTIONS IN THIS AREA
 OPERATION IN THIS AREA WILL REDUCE PROPELLER LIFE

NOTE:
Check airplane, gear, and flap structural limitations



DATA AS OF: 1-1-52
DATA BASED ON: FLIGHT TEST

ENGINE, RPM

ENGINE, RPM

C1-314-C
SHEET 3

Figure 5-3. (Sheet 3) Propeller and Flap Limitations

R4360-41 ENGINE ROUND TIP PROPELLER LIMITATIONS

 CRUISE OPERATION IN THIS AREA
RESTRICTED DUE TO PROPELLER
VIBRATION LIMITS.

NOTE:
Refer to Sheet 3 for complete
propeller restrictions.

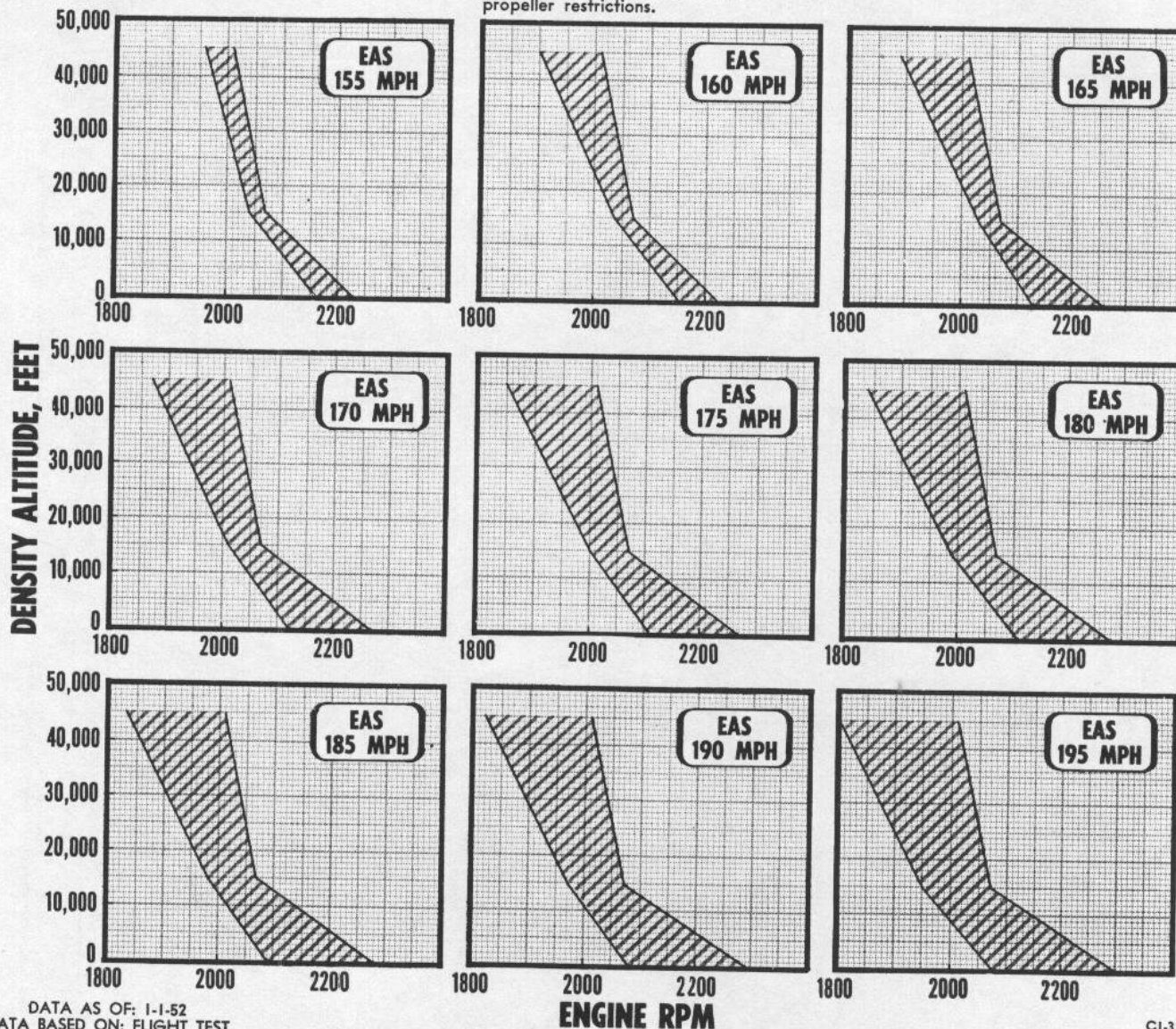


Figure 5-3. (Sheet 4) Propeller and Flap Limitations

ACCELERATION LIMITATIONS.

The diagrams in figure 5-4 show the airplane acceleration limits vs. air speed for altitudes from 10,000 to 45,000 feet for two gross weight conditions. The accelerations as shown represent the limit design factors for the aircraft structure. The airplane must operate within the boundaries of the appropriate curve corresponding to its weight and altitude at all times.

Each of the curves is an envelope of several limiting

curves and is the maximum allowable acceleration for any given speed. These limiting curves include maximum wing lift, specified maneuver factors, positive and negative gust factors, buffet boundaries (characterized at low speeds by small buffeting and at high speeds by lift divergence), and the airplane limit diving speeds.

CENTER OF GRAVITY LIMITATIONS.

The cg limits are from 17 to 45 per cent MAC.

OPERATING FLIGHT STRENGTH DIAGRAM **GROSS WEIGHT 320,000 LBS.**

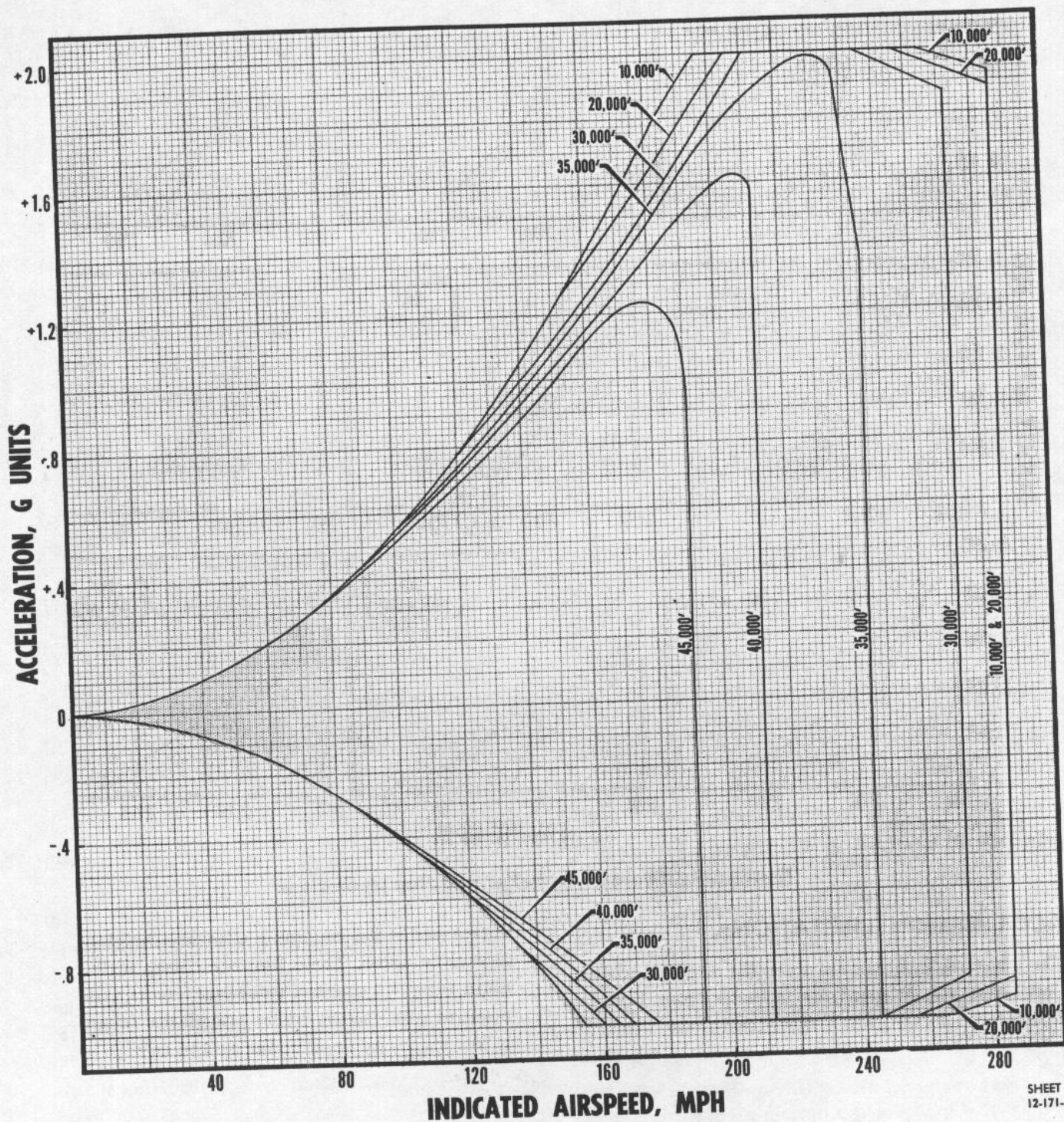
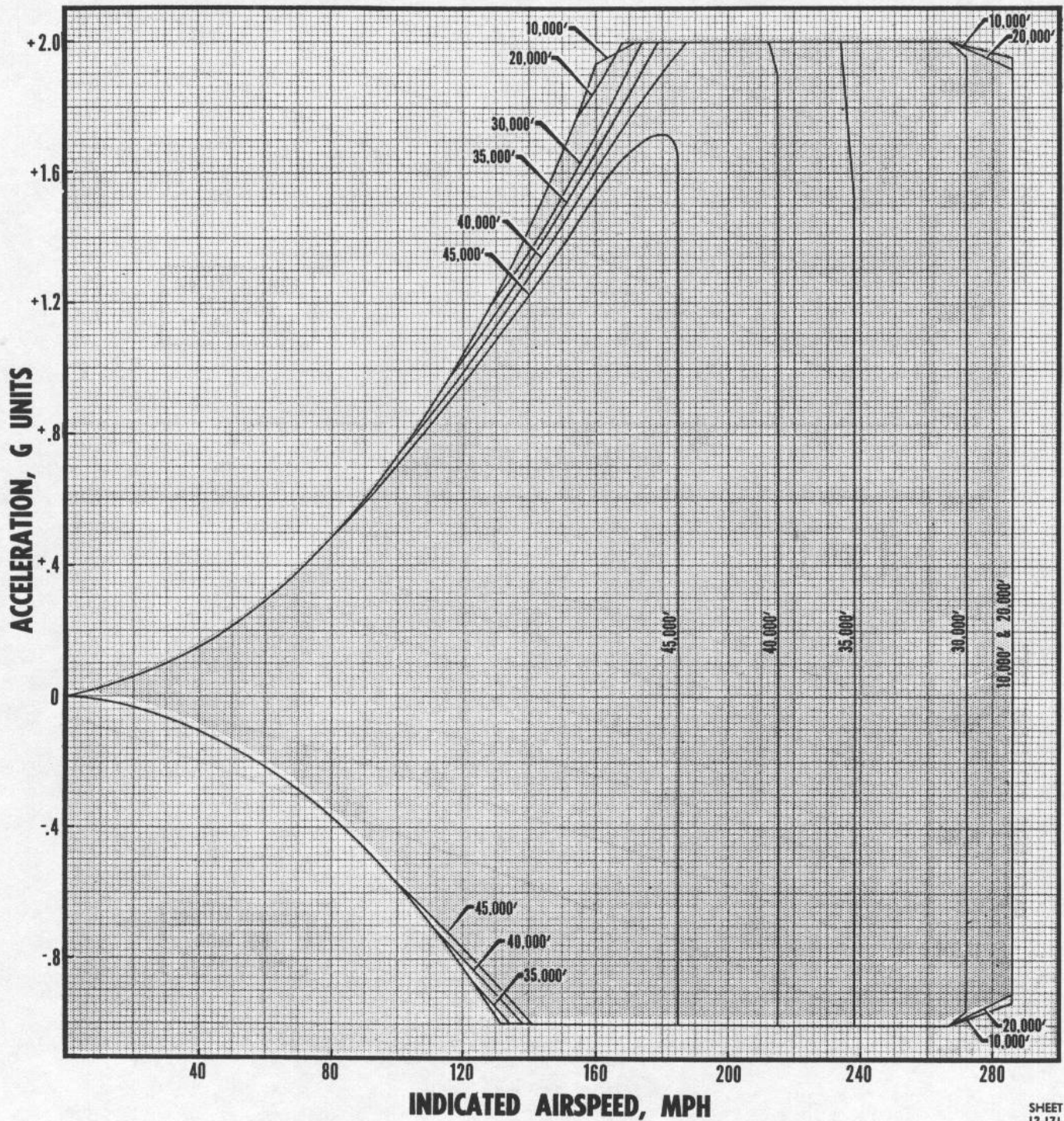


Figure 5-4. (Sheet 1) Flight Strength Diagram

SHEET 1
12-171-A

OPERATING FLIGHT STRENGTH DIAGRAM

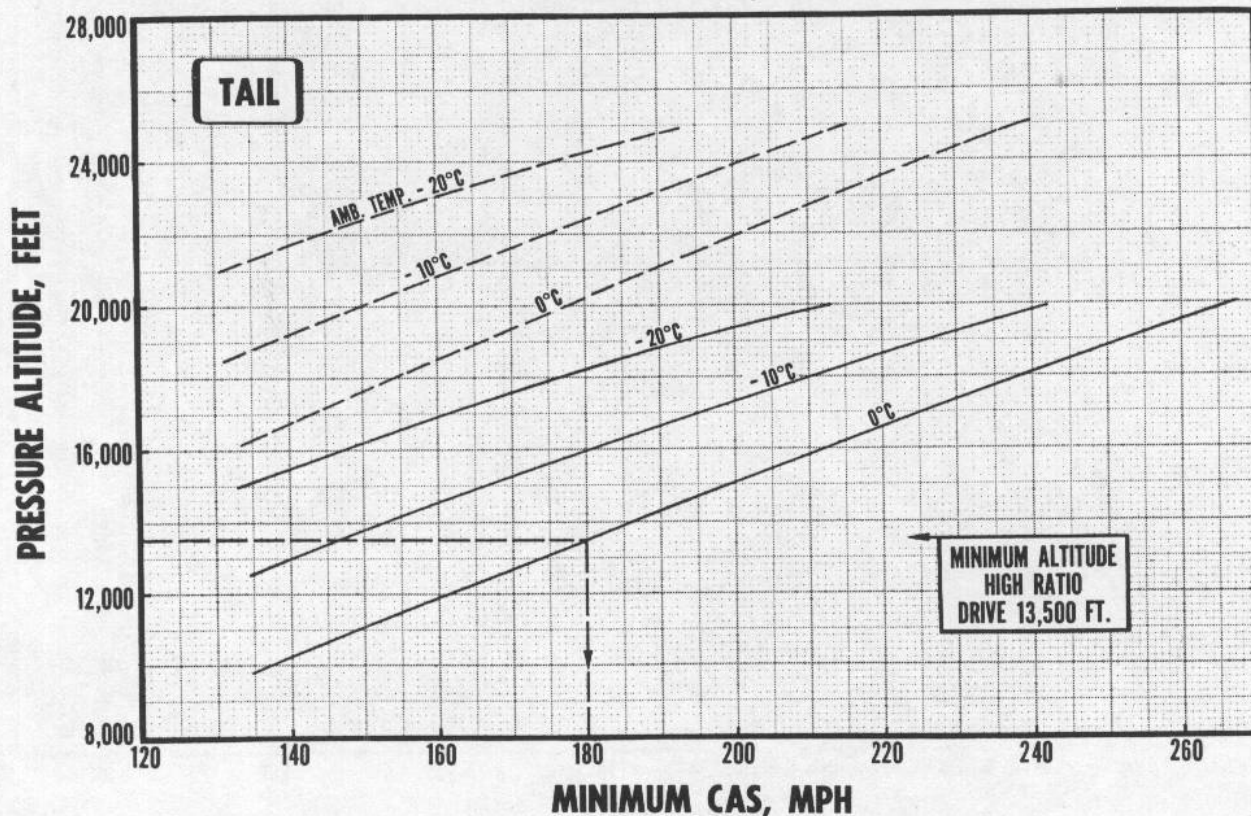
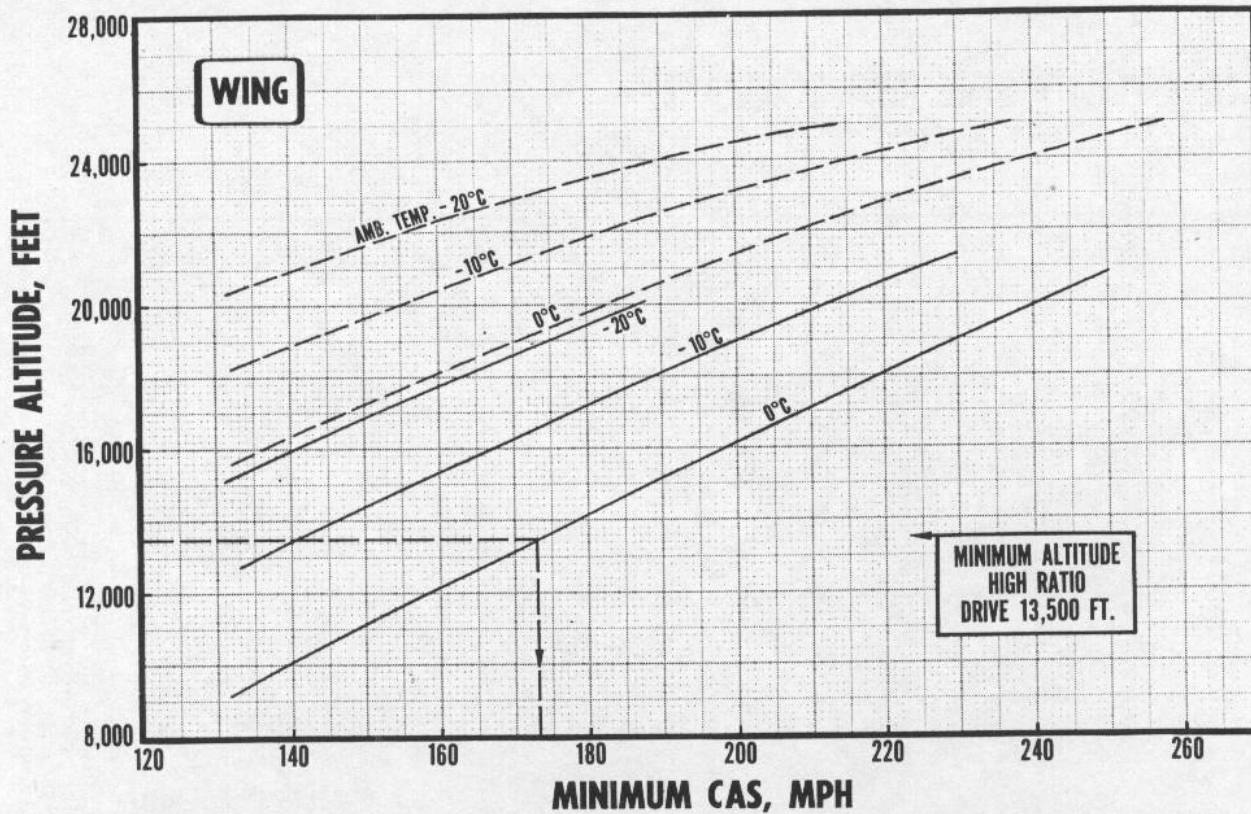
GROSS WEIGHT 230,000 LBS.



SHEET 2
12-171-A

Figure 5-4. (Sheet 2) Flight Strength Diagram

HEAT AND ANTI-ICING LIMITATIONS AT NORMAL RATED POWER



SHEET 1
C1-232-C

Figure 5-5. (Sheet 1) Heat and Anti-Icing Limitations

HEAT AND ANTI-ICING LIMITATIONS AT 1500 HORSEPOWER

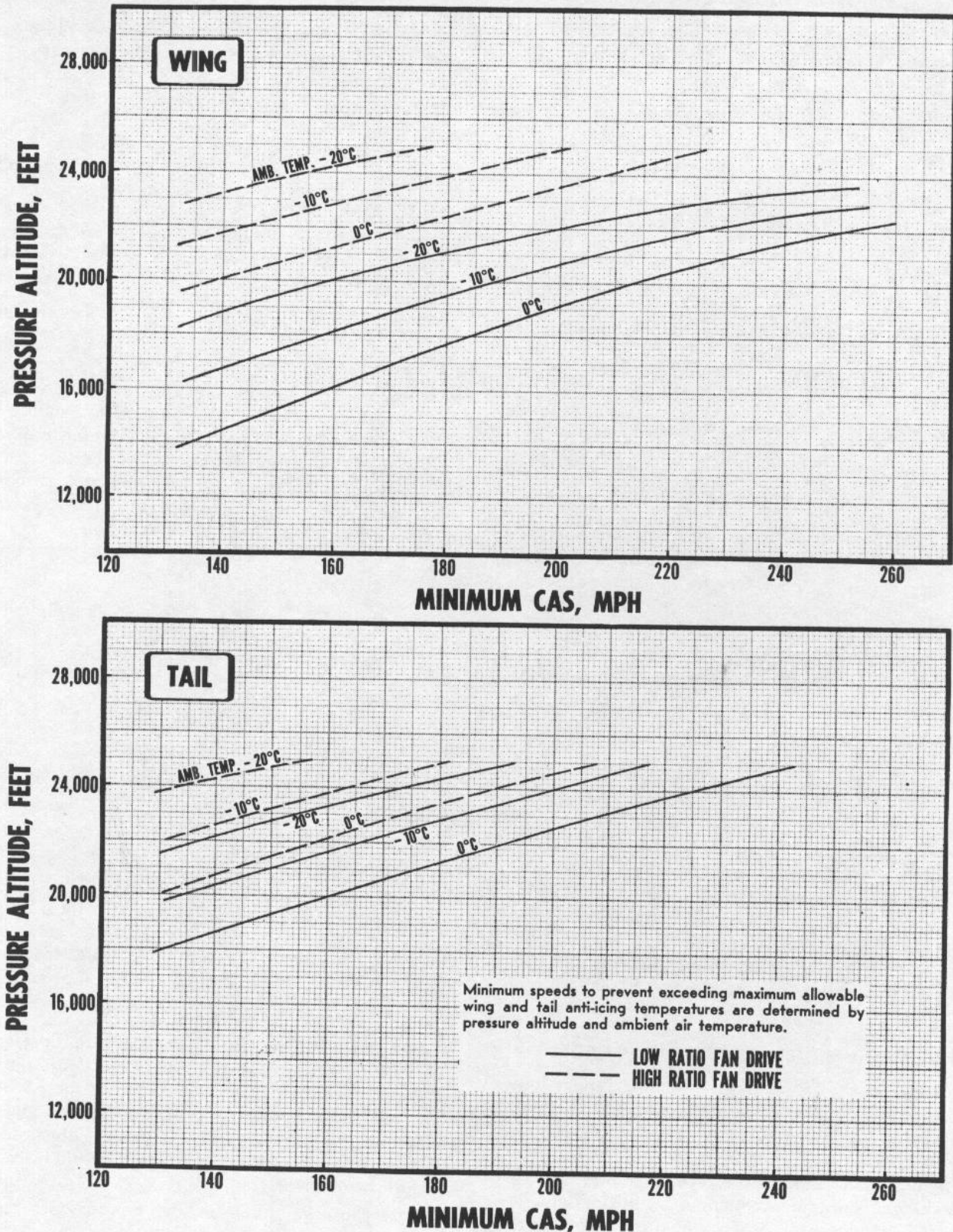


Figure 5-5. (Sheet 2) Heat and Anti-Icing Limitations

SHEET 2
CI-232-C

HEAT AND ANTI-ICING AIR TEMPERATURE LIMITATIONS.

The maximum allowable heat and anti-icing air temperatures are as follows:

1. Cabin Heat and Tail Anti-Icing Air—215°C.
2. Forward Cabin Duct Air—105°C.
3. Wing Anti-Icing Air—180°C.

The minimum speeds necessary to prevent exceeding these temperatures are given in figure 5-5.

WEIGHT LIMITATIONS.

The airplane is designed to provide optimum performance at high altitudes, an excess of power being available at take-offs and low altitudes. Maximum gross weight for operation is therefore established primarily by structural considerations. These considerations are explained in the following paragraphs.

LOAD FACTORS.

It is readily understandable that as a structure is loaded to higher weights, its ability to withstand gust shocks or additional maneuver loads becomes increasingly less. The minimum flight factor generally considered acceptable is 2.0. Should a mission involve excessive maneuvering or flight under very turbulent conditions early in the flight, higher factors might be advisable. It should be noted, however, that with the high percentage of expendable load carried by the airplane, the allowable load factor continually increases as the flight progresses.

DISTRIBUTION OF LOAD.

The maximum load that the airplane can carry is dependent on the way that load is distributed. The weight of an airplane in flight is carried by the wings, and therefore the more load that is carried in the fuselage, the greater will be the bending moment on the wings. This means that the airplane might safely carry 175,000 pounds if 55,000 pounds were carried in the fuselage and 120,000 pounds in the wings. But the same 175,000 pounds would be an unsafe load if 120,000 pounds were carried in the fuselage and 55,000 pounds in the wings.

OPERATIONAL WEIGHT LIMITATIONS CHART.

The purpose of the "Operational Weight Limitations Chart" (figure 5-6) is to illustrate the weight carrying capabilities of the airplane in relation to the various criteria that limit safe operation. In this fashion, the flight planner can visualize the type of limitation that is restricting maximum permissible weight and judge for himself, based on the urgency of the mission, as to how near any limitation shall be approached. In other words, the chart serves as a warning of the specific dangers involved in loading the airplane, but leaves

the matter of selecting maximum weight in the hands of the flight planner.

Operating Weight.

As shown in the upper right corner of the chart, the data is for B-36D's which weigh 177,600 pounds before any fuel or alternate load is added. The alternate load shown includes only bombs carried in the bomb bay. Alternate load could also include any additional load, such as extra fuel tanks, carried in the fuselage. The weight of the standard crew, oil, ammunition, standard equipment, etc., is included in the 177,600 pounds.

Gross Weight.

The gross weights of the loaded airplane are shown by the lines which slope at a 45-degree angle to the axes of the chart. Note that the zero point of the chart (intersection of the vertical and horizontal axes) represents a gross weight of 177,600 pounds.

Fuel Versus Alternate Load Capacity.

The various wing fuel tank capacities are shown on the chart. In order to provide maximum wing bending relief in flight, fuel should be maintained as far outboard as possible. To accomplish this, when the airplane is fueled the outer tanks should be filled first, then the center, then the inboard, and last the auxiliary wing tanks. In flight the fuel should be used in the reverse order. The load factors shown on this chart are based on this fuel sequencing.

The maximum bomb load of two 43,000-pound bombs is shown on the chart. The maximum bomb load for the various size bombs are tabulated below:

Size	Quantity	Bomb Wt.-Lbs.	Rack & Equip. Wt.-Lbs.	Total Wt.-Lbs.
500 lbs. (AN-M64A1)	132	68,904	2732	71,636
1000 lbs. (AN-M65A1)	72	71,784	1937	73,721
2000 lbs. (AN-M66-A2)	28	57,736	1552	59,288
4000 lbs. (AN-M56A1)	12	50,412	900	51,312
12,000 lbs. (M-109)	4	50,488	2004	52,492
22,000 lbs. (M-110)	3	69,411	1839	71,250
43,000 lbs. (T-12)	2	87,200	1894	89,094

The design limit factor for the supporting structure of any of the above bomb loads is 2.67.

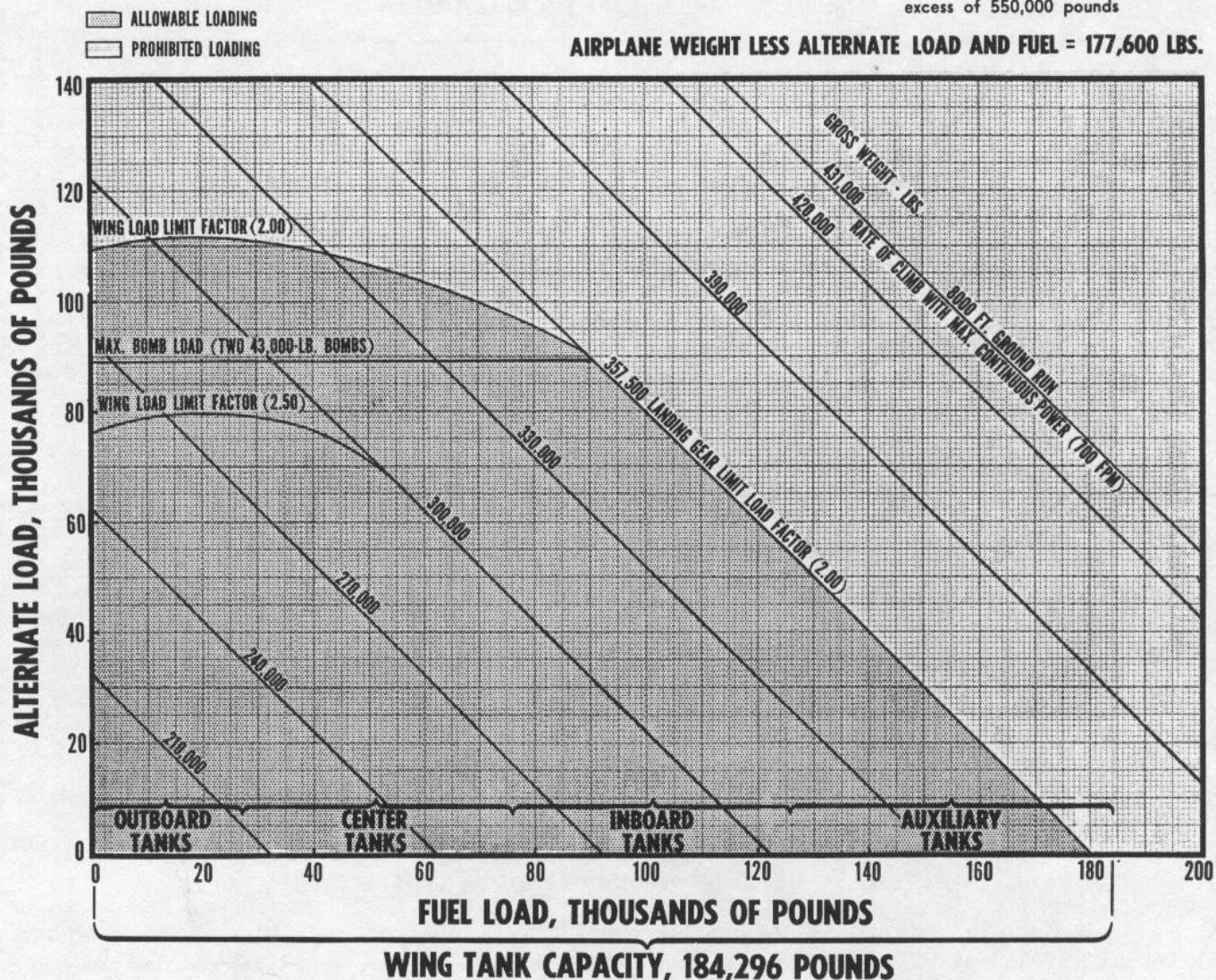
Wing Flight Load Factors.

Wing flight load factors of 2.0 and 2.5 are represented. The load factor 2.0 line represents the minimum normally considered acceptable; the load factor 2.5 line is included for comparative purposes. Notice that the effect of weight distribution is clearly illustrated by these lines. A load factor of 2.0 will result in each of the following instances:

1. At a gross weight of 287,000 pounds with no fuel in the wings.
2. At a gross weight of 334,000 pounds with 50,000 pounds of fuel in the wings.

OPERATIONAL WEIGHT LIMITATIONS WITH PODS ATTACHED

NOTE:
With one jet pod inoperative or with any two reciprocating engines inoperative, the maximum weight at which the service ceiling will be sea level is in excess of 550,000 pounds



CI-268-C

Figure 5-6. Operational Weight Limitations (With Pods)

3. At a gross weight of 357,500 pounds with 90,000 pounds of fuel in the wings.

Landing Gear Load Factor.

The gross weight at which the landing gear factor is 2.0 is shown by the gross weight line representing 357,500 pounds. The landing gear is satisfactory for this factor and gross weight for landing as well as take-off and taxiing.

Using the Chart.

The chart in figure 5-6 can be used for any B-36D airplane regardless of operating weight provided that

the pods are installed and that no external loads are supported by the wing. Any wing loading other than internal fuel, as shown on the chart, would invalidate the wing flight load factor curves. Two examples are given to illustrate the use of the chart.

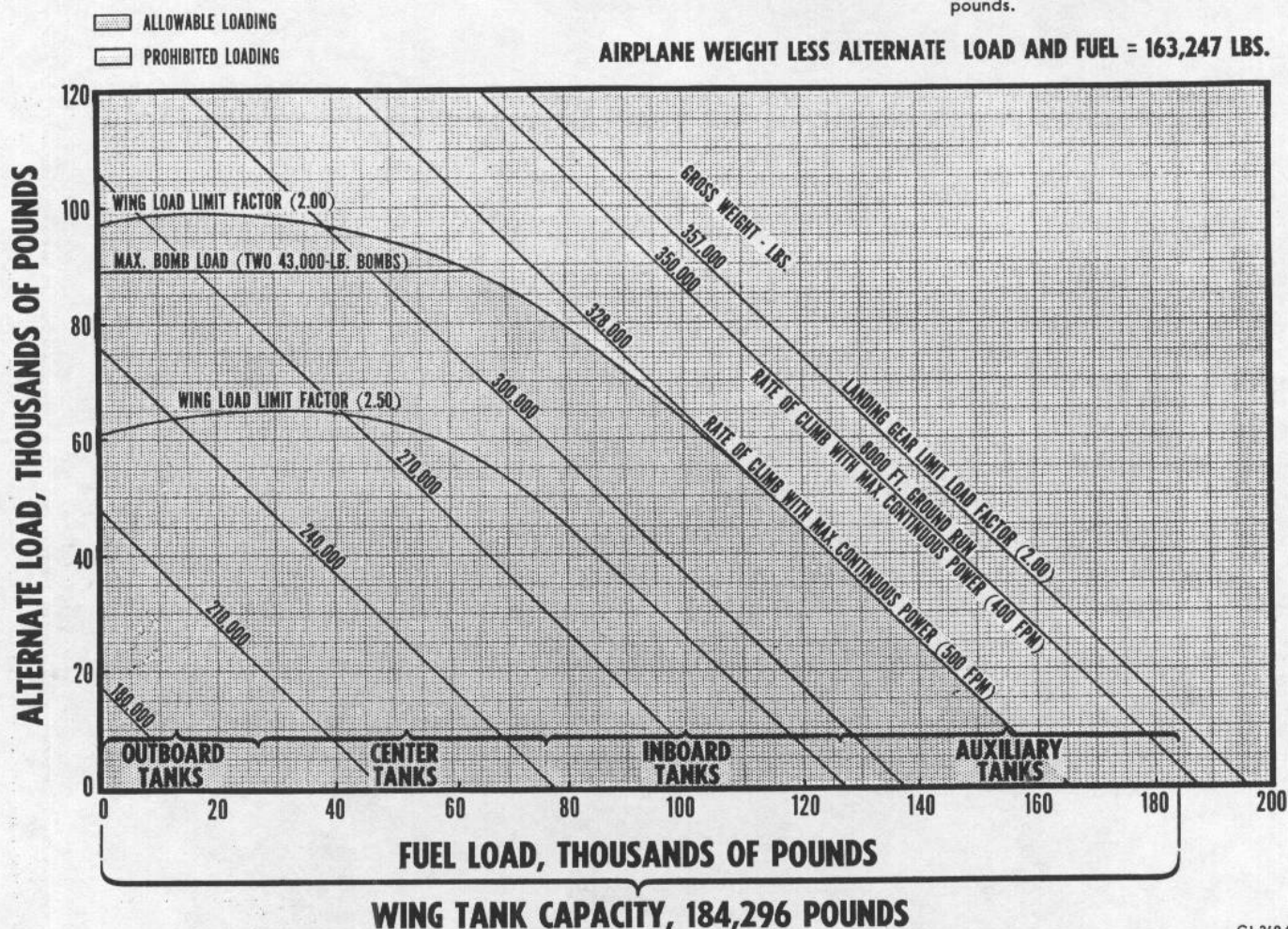
PROBLEM 1.—Twenty thousand gallons of fuel are required to attack a given target, what is the maximum bomb load that can be carried?

SOLUTION.—Having established from Form F that the airplane weighs 177,600 pounds before the fuel and bombs have been added, enter the chart at a fuel weight of 120,000 pounds (20,000 x 6 pounds per gal-

OPERATIONAL WEIGHT LIMITATIONS WITH PODS REMOVED

NOTE:
With any two engines inoperative, the maximum weight at which the service ceiling will be sea level is 375,000 pounds.

AIRPLANE WEIGHT LESS ALTERNATE LOAD AND FUEL = 163,247 LBS.



CI-269-C

Figure 5-7. Operational Weight Limitations (Without Pods)

ion). Moving vertically to the line representing a wing limit factor of 2.0, it is determined that a maximum bomb load of 60,000 pounds can be carried. Should it be established from Form F that the airplane weighs say for example, 185,000 pounds before the fuel and bombs have been added, subtract the difference between 185,000 and 177,600 from the allowable alternate load. That is, a maximum bomb load of 60,000 minus (185,000 minus 177,600) or 52,600 pounds can be carried.

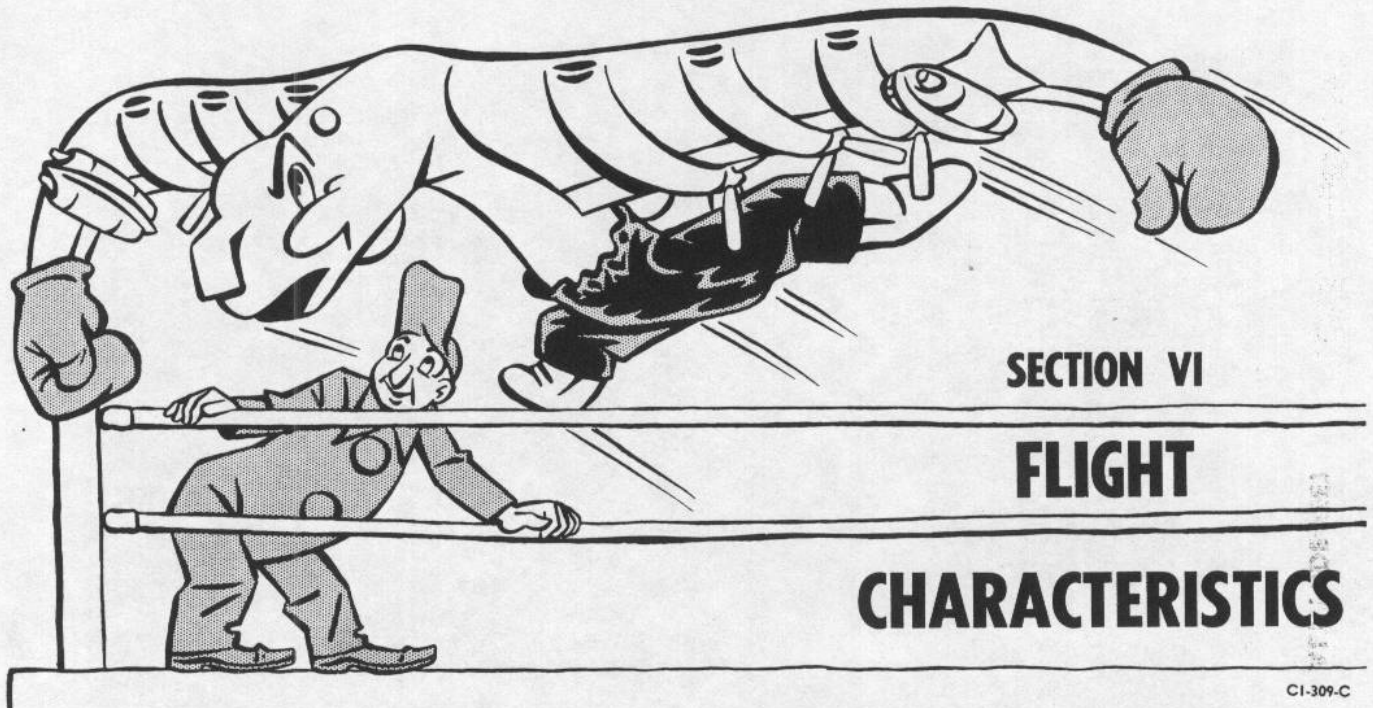
PROBLEM 2.—Determine if two 43,000-pound bombs can be dropped on a target requiring 15,000 gallons of fuel to accomplish the mission.

SOLUTION—Enter the chart at a fuel weight of 90,000 pounds (15,000 x 6 pounds per gallon). Move vertically up the line representing this weight until the line representing the maximum bomb load for two 43,000-pound bombs is reached. The chart indicates

that this loading condition is possible since the lines intersect in the green area representing allowable loads.

OPERATIONAL WEIGHT LIMITATIONS (WITHOUT JET PODS INSTALLED).

Occasionally, it may be desirable to operate the airplane without the pods installed to obtain maximum range (with a sacrifice in possible top speed). Figure 5-7 illustrates the weight limitations with this configuration. It will be noted that the maximum allowable gross weight is reduced because of structural and performance limitations as compared with those having pods installed. The structural decrease is due to the loss of the bending moment furnished by the weight of pods which tends to counteract the total bending moment of the wing. The performance decrease is, of course, due to the reduced total thrust available.



CI-309-C

Even though this airplane is the largest tactical type, its pusher design offers some advantages over comparable tractor designs. This is particularly true of flight characteristics and performance.

Uniform weight distribution and servo-tab controls account for the conventional response with normal stick forces. However, more weight is located at correspondingly greater distances from any given control axis.

This increased inertia effect reduces the rate of control response. Maneuvers must therefore be planned further ahead.

Along with this maneuver anticipation, you will need increased clearance perception or dimensional awareness. Roll and pitch limits on take-offs and landings are narrowed by the physical dimensions of the airplane.

PROPELLER INDUCED AIRFLOW EFFECT

SHADED WING TIP AREAS OUTSIDE THE PROPELLER ARCS WILL STALL WHEN CRITICAL ANGLE OF ATTACK IS REACHED.

WHEN POWER IS ON, PROPELLER SUCTION DELAYS STALL IN CENTER SECTION BY MAINTAINING SMOOTH AIRFLOW.

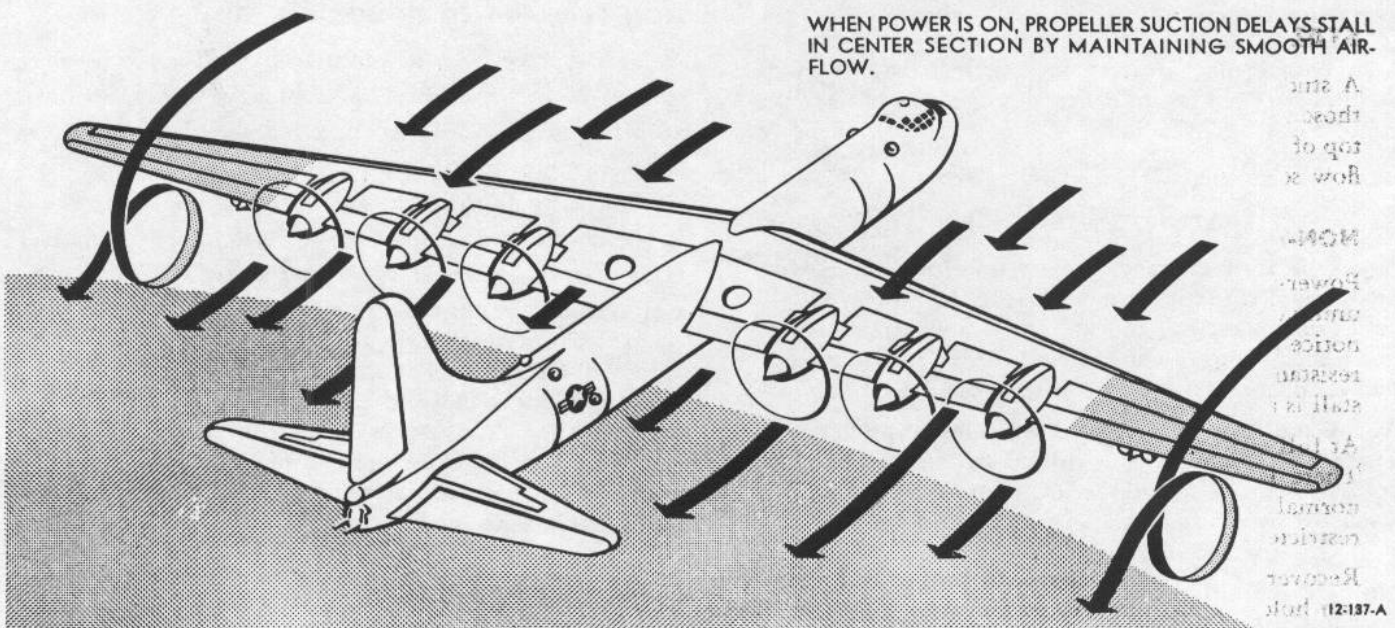


Figure 6-1. Propeller Induced Air-Flow Effect

RESTRICTED

* AIRFRAME STRUCTURE LIMIT SPEEDS

Based on Gross Weight of 357,500 Pounds

*SEE "OPERATING LIMITATIONS"
SECTION V FOR PROPELLER
LIMITATIONS

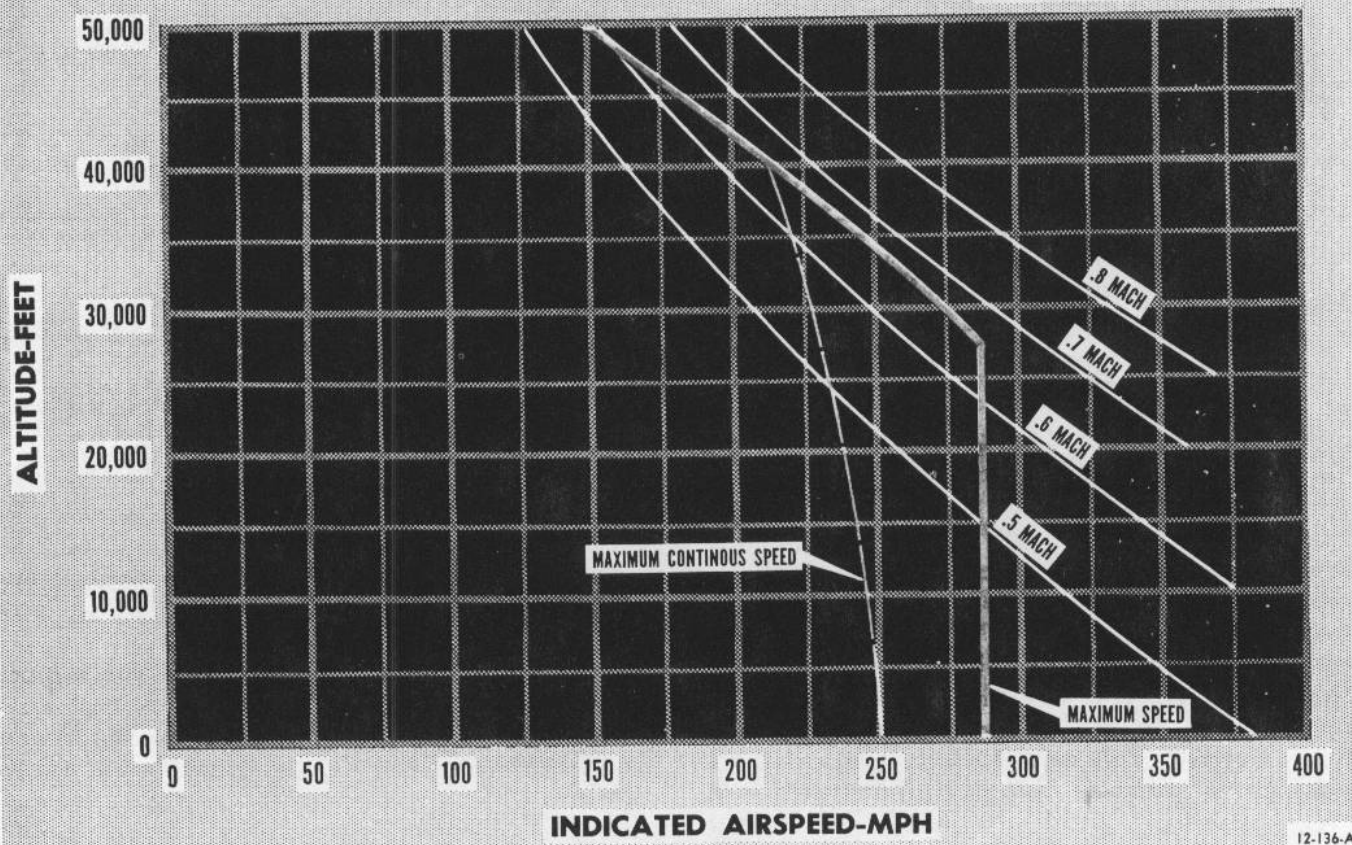


Figure 6-2. Airframe Structure Limit Speeds

STALLS.

A study of stall characteristics is primarily a study of those factors which influence the flow of air over the top of the wing. When flow is smooth, lift exists; when flow separates or burbles, lift is largely destroyed.

NON-ACCELERATED POWER-OFF STALLS.

Power-off stall characteristics are conventional with unusually distinct warnings. During the entry you will notice tail buffeting, aileron shake, and increased stick resistance. There is a slight tendency to roll as the full stall is approached, but this is controllable.

At full stall, you will notice both roll and pitch down. There is no predominant direction of roll, and with normal recovery technique the amount of roll will be restricted by the inertia effect of the wing.

Recovery is orthodox, and with proper technique you can hold the altitude loss to less than 1500 feet. Flaps may intensify tail buffeting and pitch down, but the position of the landing gear exerts no noticeable effect.

NON-ACCELERATED POWER-ON STALLS.

Full stalls have been accomplished with a power setting of 20 inches M.P. The usual power-off warnings are still present. Tail buffeting is reduced, but aileron shake is more noticeable. In addition, you will notice an unusually high deck angle during the approach. Propeller induced air flow, as shown in figure 6-1, maintains smooth flow over the center section of the wing well beyond the angle at which a stall would normally occur. This extreme nose-high attitude combined with very low air speed is another stall warning. Since the wing tips extend beyond the propeller air flow effect, separation of flow occurs when the critical angle is reached. This increases the rolling tendency, but roll is controllable up to complete stall. Conventional recovery technique is effective.

ACCELERATED STALLS.

No accelerated stalls have been accomplished, but entry, stall, and recovery should be normal.

PRACTICE STALLS.

Practice stalls are not permitted because propeller vibratory stresses during the approach to stall sharply reduce blade life.

SPINS.

Since spins are absolutely prohibited, no experimental recovery data is available.

ACROBATICS.

All acrobatics are prohibited.

FLIGHT CONTROLS.

TRIM TABS.

Control forces should be trimmed out to maintain nor-

mal control response. You should reset the elevator tab just before take-off using 30 per cent MAC as a cg reference point. Allow 1 degree nose-up trim for each 1 per cent cg forward of 30 per cent MAC, or 1 degree nose-down trim for each 1 per cent cg aft of 30 per cent MAC. Actuating either flaps or landing gear will change longitudinal trim. You can minimize the effect of flaps on trim by operating them in increments of 5 degrees, and retrimming the airplane between each operation.

ELEVATORS.

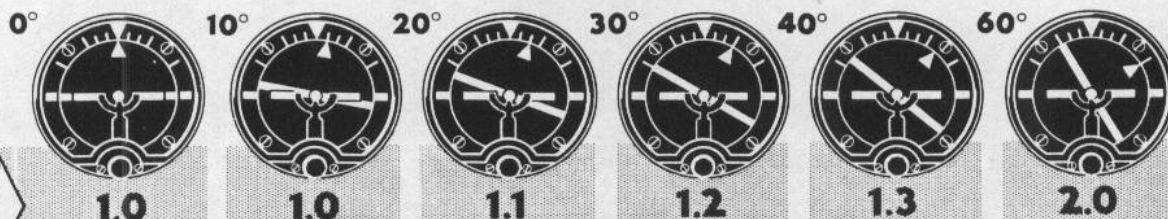
Elevator control is excellent within allowable cg limits (17 per cent to 45 per cent MAC). At minimum speed during the take-off run, you will have to apply 50 to 75 pounds of back pressure to establish the proper nose-high take-off attitude. After the "getaway," this pres-

CALCULATED STALLING SPEEDS

POWER OFF
GEAR DOWN
SEA LEVEL



ANGLE OF BANK



MANEUVER
FACTOR

GROSS
WEIGHT
LBS.

FLAP ANGLES

	0°			10°			20°			30°			40°			60°		
	0°	20°	30°	0°	20°	30°	0°	20°	30°	0°	20°	30°	0°	20°	30°	0°	20°	30°
200,000	106	95	90	108	96	91	110	98	93	114	102	97	120	108	103	150	134	128
240,000	116	103	99	118	104	100	120	106	102	126	111	106	134	118	113	165	146	140
280,000	126	112	107	128	113	108	130	116	111	136	120	115	144	127	122	180	158	152
320,000	135	119	114	137	120	115	140	124	118	145	128	123	154	137	131	190	170	162
360,000	143	126	121	144	128	123	147	132	126	154	137	130	163	144	138	204	180	172

NOTE: FIGURES ENCLOSED WITHIN HEAVY BORDERS ARE INDICATED AIRSPEEDS-MPH

12-138-A

Figure 6-3. Calculated Stalling Speeds

RESTRICTED

sure can be relaxed, and nose-down trim will be required as the airplane leaves "ground effect."

AILERONS.

Aileron control response equals or exceeds that of the nearest comparable bombardment type. More wheel movement is required at high altitude to obtain the same low altitude effect, but control is still positive.

At low air speed, the control force that ailerons can exert on the airplane is reduced. The resistance or inertia of the wing, however, remains constant. This means that you must allow more time to start and stop lateral movements.

RUDDER.

Rudder control is effective at very low air speeds with gear and flaps down. Under asymmetrical power conditions, air speed must be held above a critical value to maintain rudder effectiveness. These critical control speeds for various power combinations are shown in figure 3-1.

ASYMMETRICAL POWER CONDITIONS.

Operation with one or more engines inoperative is usually no problem since excess power is available at low altitude. If you are above the control air speed minimum for your power condition, normal turns can be made into the inoperative engines.

AFTER TAKE-OFF.

If you are below critical control air speed after take-off power failure, drop the nose and permit air speed to build up to the required minimum. Consider reducing gross weight if you cannot climb or maintain minimum terrain clearance.

CRUISE.

Power failure during cruising flight should not cause undue concern. Use jet engines to supplement your remaining reciprocating engines if required. Proper flying technique and pilot-engineer coordination will greatly increase the potential range under asymmetrical power conditions.

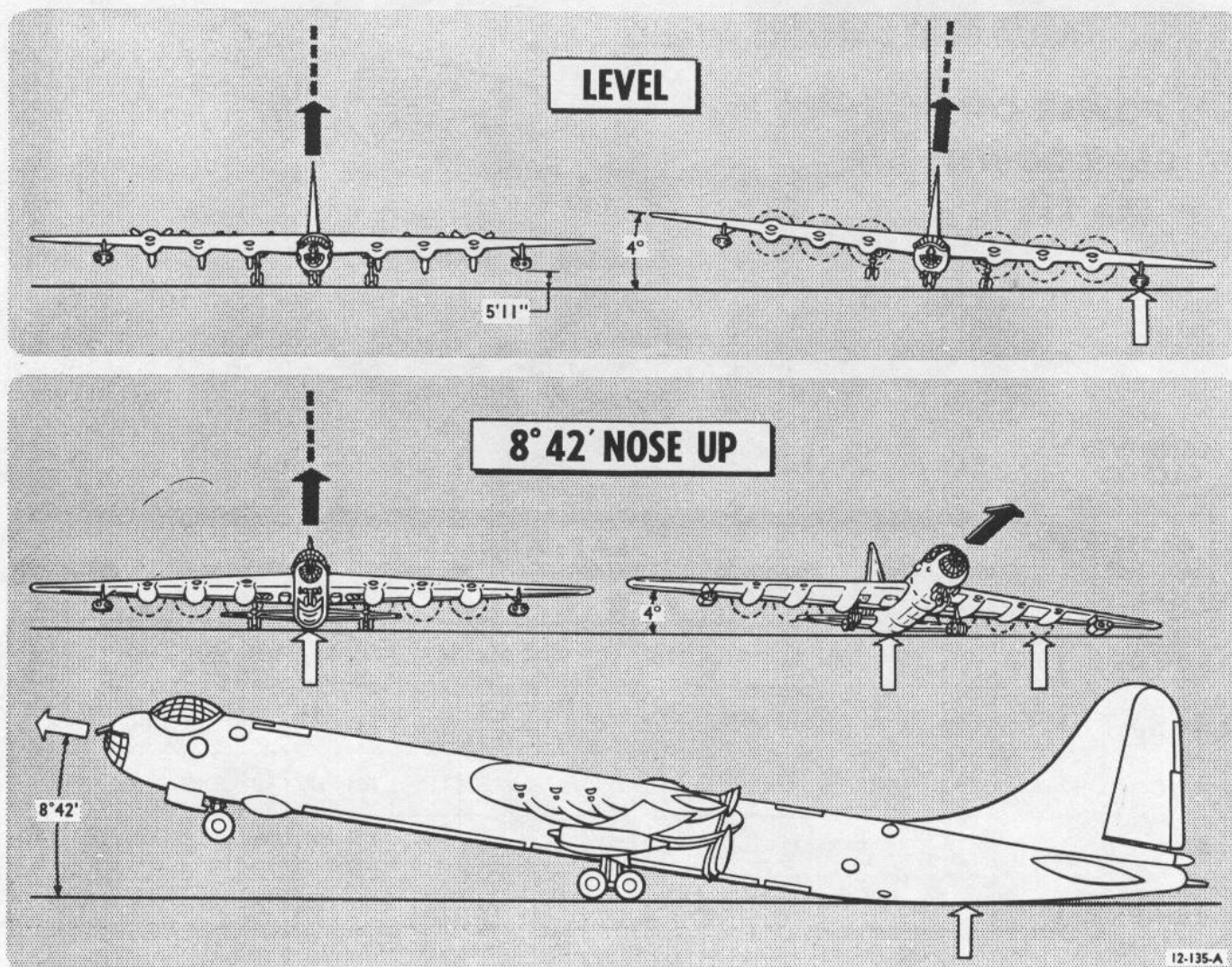


Figure 6-4. Angular Displacement Clearance Points

FLAP RETRACTION SPEEDS AT SEA LEVEL

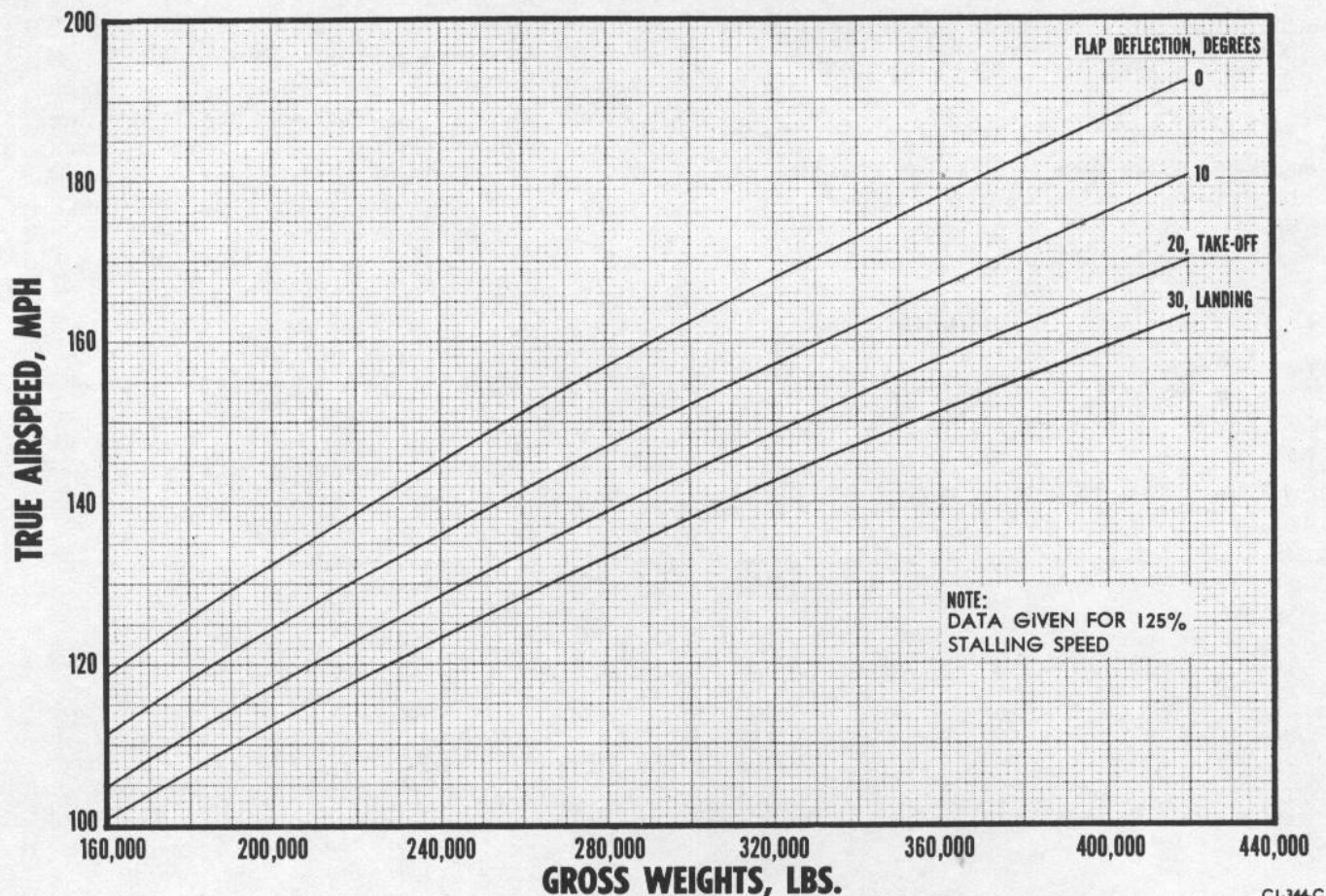


Figure 6-5. Flap Retraction Speeds

LANDING.

Partial power landings procedure is discussed in Section III. The power required to maintain level flight for your landing gross weight with gear and flaps down is shown by tables in the appendix.

LEVEL FLIGHT CHARACTERISTICS.

The range between slow and high speed flight is unusually large, but the upper air-speed limit is below the Mach number region where compressibility effect begins. Control and stability will be normal for any trimmed condition during slow, cruising, and high speed flight.

Air-speed limits for high speed level flight and high speed descent are shown in figure 6-2. Propeller vibratory stress limits are given in "Operating Limitations," Section V.

MANEUVERING FLIGHT.

A structural maneuver factor of 2 has been imposed as

a limit for full gross weight. This limit restricts banks to 60° or less, and pull-ups to 2 g's or less. As weight decreases, the maneuver factor increases slightly. Refer to figure 6-3 for calculated stalling speeds and induced maneuver factors at various angles of bank.

Stick forces will increase in steep turns and dives, and trim may be required. Response for any trimmed condition, however, will be normal within allowable load, cg, and maneuver limits.

DIVES.

Dives are permissible within the air-speed and propeller limits discussed under high speed level flight. Propeller restrictions can be ignored under stress of military necessity, but limit dive speeds should be observed under all conditions. Undetected flutter could cause structural failure.

Stick forces in dives should be continually trimmed out particularly when inadvertent relaxation would sharply increase the g load.

FLIGHT WITHOUT JET PODS.

Maximum range missions may require removal of jet pods. However, this does not noticeably change flight characteristics. Take-off and climb performance will be corresponding reduced by the loss of jet power.

DIMENSIONAL AWARENESS.

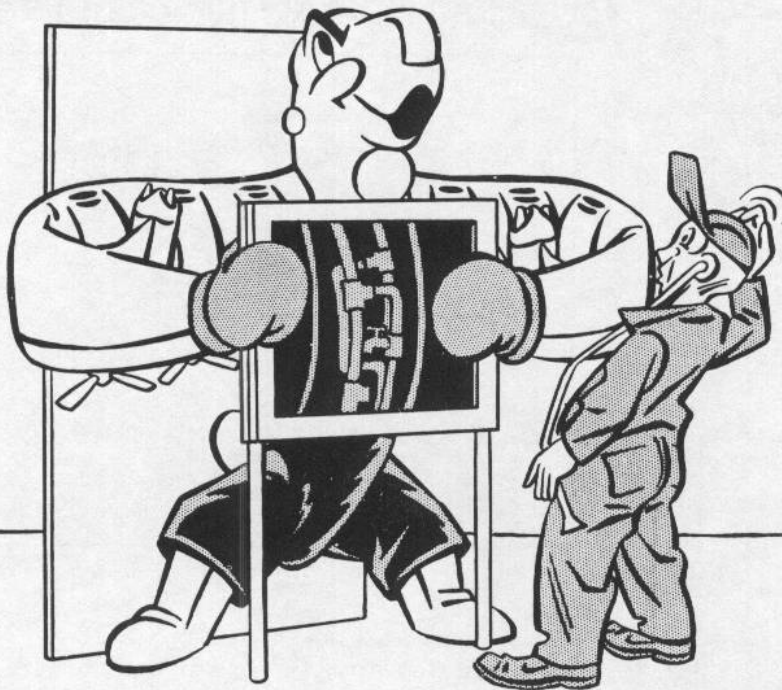
As mentioned in the general discussion, this airplane requires that you be more careful of clearances. A picture of clearance danger points with pitch and roll limits is shown in figure 6-4.

FLAP RETRACTION TECHNIQUE.

When take-off gross weight exceeds 300,000 pounds, you must use proper flap retraction technique to maintain the necessary lift with a safe margin above wing-tip stall.

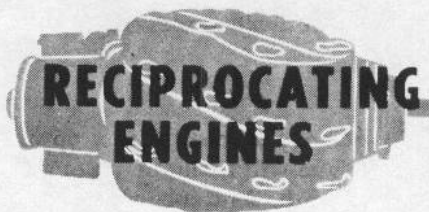
You will recall from the stall discussion that the wing

tips extend beyond the influence of propeller induced air flow as shown in figure 6-1. They will stall when their critical angle is reached regardless of power setting. The recommended air speeds for flap retraction are shown graphically in figure 6-5. You should select the ordinate corresponding to your take-off gross weight and record air speeds for each flap setting during the retraction from 20 degrees to 5 degrees. Interpolation will be required for 5-degree increments. After take-off, allow the airplane to accelerate to the air speed recorded for the 20-degree setting; repeat this procedure for each succeeding flap increment until flaps are fully retracted. This technique will carry you through the transition zone with a margin of 25 per cent above stall. If chart air speed exceeds the placard air speed limit for any flap extension, the chart should be given preference. Placard limits on flap extension were imposed by propeller restrictions—not flap structure. Maintaining lift at a safe margin above stall is considered to be more important than briefly extending operation in a propeller vibration zone.



SECTION VII SYSTEMS OPERATION

CI-310-C



CI-210-C

THE ENGINEER AND HIS ENGINES.

The engineer of the B-36 is provided with a formidable array of levers and switches to control the output and condition of his engines. Instruments enable him to interpret the results of these manipulations. Because the engines cannot be seen from his station, engine abnormalities are often difficult to diagnose either rapidly or accurately, while in flight. However, with proper interpretation of the instruments coupled with correct and clear information from the aft cabin scanners, fairly effective action can be taken in a minimum of time. Even though the levers and their corresponding instruments are very close together there is a long path between them. The levers and switches by themselves do not produce the instrument reaction. The engine is the necessary link that joins the control to the affected instrument.

The main concern of the engineer is not the portion of the engine to which the control or instrument is attached but rather the power section. It is in the power section that the impact of the power producing temperatures, pressures, and forces is applied and it is there

that the results of improper control adjustment or the imposition of unsuitable conditions are felt. Excessive manifold pressure will not blow up the supercharger manifold, but it may blow off a cylinder head. Improper use of the mixture or spark advance controls does not directly harm the carburetor or magnetos, but may cause combustion chamber difficulties.

In spite of this consideration for the power section it appears to be treated with indifference. None of the controls and only one instrument, the cylinder head temperature gage, are connected to this portion of the engine. The control of power section conditions is effected indirectly through other sections. The interpretation of the results of this control is through instruments which indicate the conditions of other sections. *Engine operation is not a matter of memorizing arbitrarily selected numbers. It is knowing what each control ultimately does to the power section and the meaning of the corresponding instrument indications in terms of power section temperatures, pressures, and forces.*

ENGINE RPM.

The adjustment of engine rpm is used to establish engine power output according to the operating requirements such as take-off, climb, or level flight. The engineer must consult operating charts in the appendix to determine the correct rpm for use under the various flight conditions. However, he should be acquainted with the basis for specifying the different rpm settings. Cruise defines the operating limits which apply in sustained level flight when less than normal rated power is used. On the B-36 this must be described in three steps as follows:

Step One—This step (figure 7-1)) considers only powers slightly less than normal rated, such as are used in the early stages of a mission. The maximum permissible bmepp for this step is that for normal rated power. As power requirements decrease, the rpm is lowered but the normal rated bmepp is maintained. If a propeller restriction is imposed, however, it will be necessary to adjust the power-rpm relationship to avoid the restricted range. In the example shown, when power is reduced to reach the restricted rpm range at point A, further power reduction is accomplished by

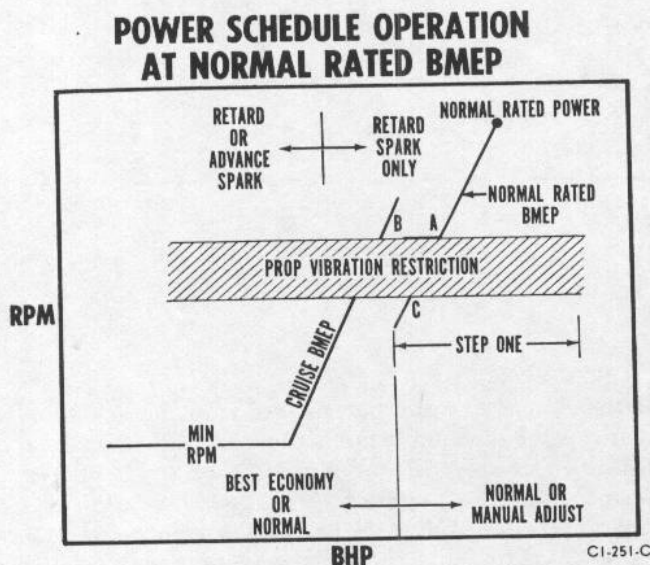


Figure 7-1.

reduction of torque alone. This continues until point B is reached at which time the rpm can be reduced to that shown at point C, which permits continued operation at normal rated bmepp. Usually, the power schedules do not allow operation at normal rated bmepp below the propeller vibration restricted range. In this power range manual leaning and advanced spark are not permitted. The only mixture manipulation from normal allowed is the manual adjustment necessary to obtain the specified fuel flows.

Step Two—This step (figure 7-2) is reached when level flight power is lowered to the maximum permitted for manual leaning, but is still above the maximum for using advanced spark. The limits under these conditions can be described as in step one except that maximum bmepp and rpm, hence maximum power, are lower.

Step Three—This step (figure 7-2) applies when power is reduced to the point where the spark can be advanced. In this condition the same bmepp limit applying to the higher power manual lean range continues but the maximum rpm and power are reduced.

In the above cases, the maximum rpm limit is imposed to control the temperature rise through the internal

POWER SCHEDULE—OPERATION CRUISE BMEP

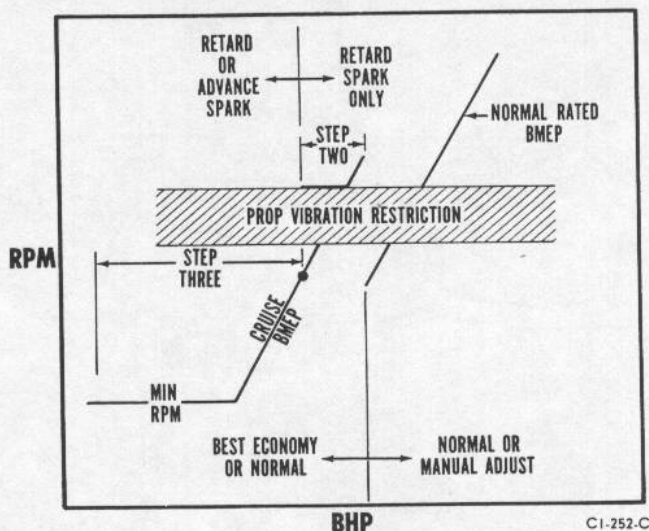


Figure 7-2.

supercharger. However, for time-limited powers the maximum permitted rpm is usually selected because maximum power is the goal. Then it becomes essential to maintain maximum air pumping action of the cylinders in order to keep bmepp within limits. A minimum rpm is specified to avoid undesirable structural vibration in flight.

Descent.

During a long range descent, thrust power is reduced so that the airplane will maintain an optimum attitude along the flight path. As the engine output is reduced the rpm is reduced to lower the true air speed of the propeller blades proportionally. Significant gains in range are realized during long descents by utilizing the minimum practical rpm, provided that bmepp limits are not exceeded and cabin pressure can be maintained. A propeller in low rpm produces much less drag than one in higher rpm because it is approaching high blade angle.

PERMISSIBLE RPM VARIATION

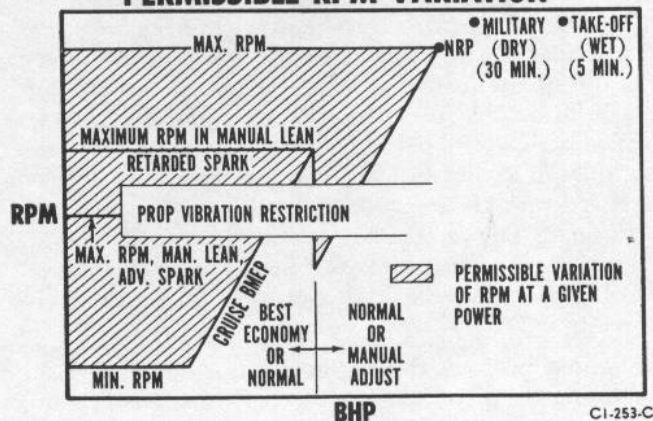


Figure 7-3.

Overspeed.

There are two main forces exerted on the master rod bearings, the resultant of which makes the act of overspeeding critical. The main factor (figure 7-4) is the centrifugal force caused by the inertia of the connecting rod and piston assembly. This force is partially opposed by the cylinder gas pressures, leaving a mean resultant of about 80 per cent of the centrifugal force.

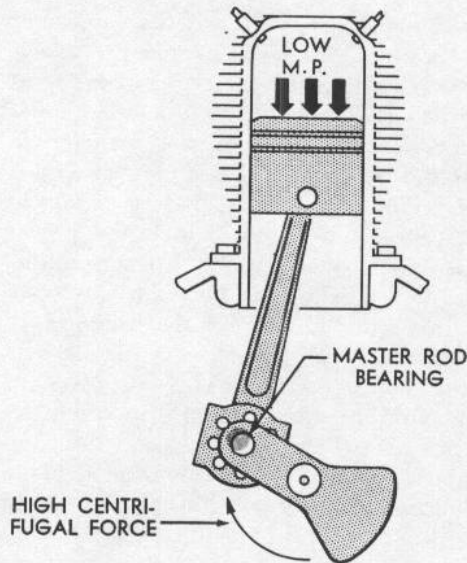
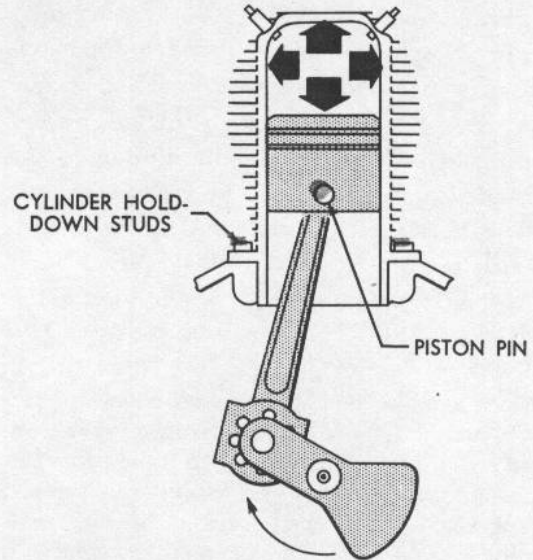


Figure 7-4.

Therefore, the resultant must be absorbed by the master rod bearing. The master rod bearing, crankpin, and their lubrication are designed for a 50 per cent overload factor. The centrifugal forces vary as the square of the rpm; therefore, at 120 per cent of normal rated rpm (100 per cent) the centrifugal load is 144 per cent, approaching the critical overload factor of 150 per cent. Under these conditions M.P. must be used to furnish gas pressures which reduces the resultant force on the master rod bearing.



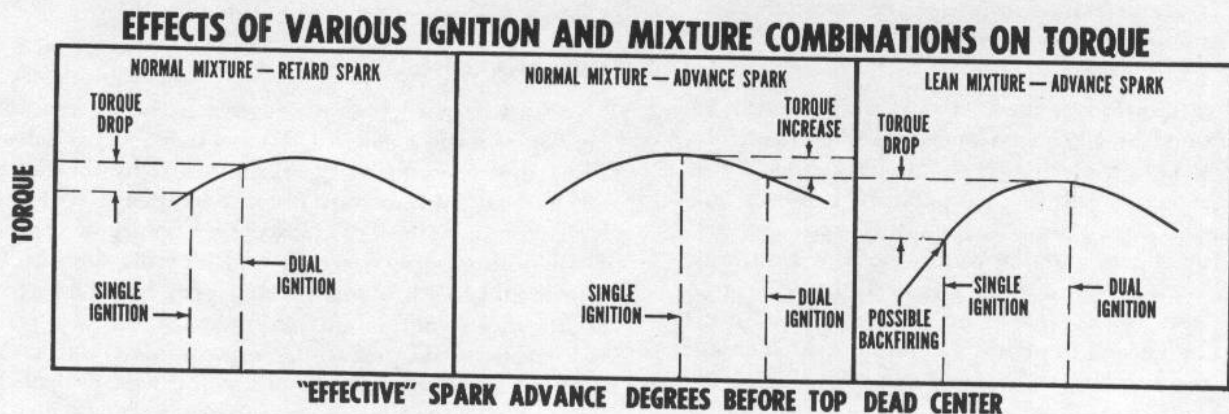
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Figure 7-5.

It should be noted that gas forces (figure 7-5) at high M.P. and bmep, and not centrifugal force, determine the strength of materials used in cylinder hold-down studs and piston pin.

Ground Operation.

The magnetos are usually checked at field barometric pressure with the propeller in complete low pitch. Combustion flame speed characteristics are used to provide a standard for comparison. The use of this engine speed results in an airflow that causes the carburetor, in NORMAL, to meter approximately "best power" mixture. This minimizes the influence of fuel-air ratio variables. Using one spark plug results in a single flame front requiring a longer time for the completion of the burning process. With the spark in RETARD, this is equivalent to retarding the spark timing about 10 degrees more. The resulting loss of power is indicated by a reduction of rpm and torque pressure (figure 7-6) and is normal reaction. Failure to register such a drop is evidence of improper timing in the advance direction, improper switch action, or other malfunctions.



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Figure 7-6.

RESTRICTED

Shifting to ADVANCE spark at the same check rpm, with dual ignition and a NORMAL fast burning mixture, results in the spark occurring too early for maximum power. However, an increase of rpm and torque pressure (figure 7-6) will occur. With single ignition, slower burning gives a more favorable timing to the process and equal or slightly more power is obtained. The lean slow burning mixtures used in flight with advanced spark require earlier ignition by two plugs (figure 7-6) for best combustion. Only one plug firing in each cylinder with the lean cruise mixtures will cause rough operation or backfiring.

Rpm variations are also used for ground checks of fan operation. When the fan drive is changed from low to high ratio more power is diverted from the propeller and the engine rpm decreases accordingly. In the air, with constant speed propeller operation, this change is reflected only on the tachometer reading. The fan check is made at the same rpm as the power and magneto check since higher rpm imposes excessive loads on the fan drive with high ratio.

The tachometer is the basic instrument for checking proper position selection and functioning of various electrical circuits which control the propellers, master motor speed, the propeller circuit breakers, and the selector and feathering switches. Propeller and control system response is judged by rpm indication. The engine tachometer is also consulted with regard to alternator operation, oil pressure, fuel pressure, oil spewing, and other functions.

MANIFOLD PRESSURE.

For practical purposes manifold pressure is a good tool for engine power setting, and when used with rpm in an unmodified form, a degree of accuracy sufficient for many types of operation is realized. B-36 missions cannot be accomplished with such "rule of thumb" methods, however, and the engineer must have a complete concept of the nature of manifold pressure and the steps that must be taken after rpm and boost adjustment before he can be sure that the engine power output is as specified. Manifold pressure required for take-off power is the best illustration of the necessary correction of manifold pressure for B-36 operating accuracy.

Test stand calibration of the R4360-41 shows that 3500 bhp is obtained at 2700 rpm and 63 inches manifold pressure when 31 inches Hg exhaust back pressure is imposed, the carburetor air temperature is 38°C, and all other factors are standard, including bone dry air. However, the engine installation on the B-36 results in an exhaust back pressure greater than 31 inches Hg at take-off power, and 66 inches or more manifold pressure would be needed to obtain 3500 bhp. This increase is required to overcome the additional exhaust pressure.

Bone dry air is included in the list of "all other factors" but isn't always present for maximum gross

weight take-off. The engine produces power in proportion to the amount of dry air consumed and as water vapor displaces dry air its presence constitutes a loss of power producing potential in the charge being pumped into the cylinders. The total pressure of the charge air is the total of the pressures of its component parts (nitrogen, oxygen, water vapor, etc.). Sensing total pressure only, the manifold pressure gage is unable to reject vapor pressure and concentrate only on pressure supplied by air.

Starting outside the induction system, if the barometer reads 29.5 inches Hg and .5 inches Hg vapor pressure is present, the dry air is responsible for 29.0 inches Hg of the barometer reading. By the time the charge has passed through the induction system, the .5 inches of vapor pressure is multiplied by the superchargers to about 1.25 in. Hg. Therefore, 66 inches of manifold pressure represents $66 \div 1.25$ or 64.75 inches of power producing charge—a loss of about 75 bhp per engine. The carburetor cannot distinguish between water vapor and dry air, so it sends in fuel for the water vapor thus furnishing too much fuel for the dry air actually taken in. This results in an additional loss of power for the observed manifold pressure. Humidity often accompanies high outside air temperatures and the combination of the above factors detract from the airplane take-off performance. Humidity corrections outlined in the appendix are for correcting the take-off manifold pressure setting so the air portion of the charge pressure is equal to the maximum allowable charge pressure if bone dry air were used. This correction assures maximum safe power delivery.

The humidity correction factor is used only during take-off since moisture at operating levels is negligible. This correction should not be neglected by the engineer when he calculates, beforehand, the take-off manifold pressure he will use.

The large variations in exhaust back pressure, resulting from the turbosupercharging system, cause discrepancies between the engine manufacturer's calibration and the power obtained in the airplane. The manifold pressure settings specified in the appendix are results of flight testing and with proper corrections of carburetor air temperature variations and humidity to take-off the required accuracy will be obtained.

SUPERCHARGING.

Two conditions of operation govern the procedure of manifold pressure control. If the turbo boost selector (TBS) is at zero, primary regulation is by the throttle and the manifold pressure obtained varies as with more elementary installations. However, because of the drag of the idling superchargers and ducting loss at full throttle and full low pitch, the pressure at the carburetor entrance is only about 26 inches at sea level resulting in a manifold pressure of approximately 46 inches. RPM lower than that for take-off causes reduced internal supercharger compression and accounts for further lowering of the available manifold pressure on the

ground. In flight with TBS at zero, variations of indicated air speed influence manifold pressure as the ram pressure changes. TBS at zero is used on the ground and for low level cruise requiring manifold pressure of less than 34 inches. As long as performance needs are satisfied, the TBS should be kept at zero due to better fuel economy without the back pressure and increased induction air temperature resulting from turbo use.

With full throttle and constant rpm, the manifold pressure varies directly with carburetor entrance pressure. The job of the turbosupercharger is to keep this pressure constant at a value that permits the internal supercharger to deliver the required manifold pressure for a selected rpm. Setting the TBS directs the pressure-retrol to maintain necessary entrance pressure. The pressure-retrol proceeds to do this by regulating the waste gate position.

During a climb with normal rated power, with the TBS set and individual turbo-calibration knobs trimmed for the required manifold pressure, the pressure-retrol actually works to maintain approximately 27 inches Hg carburetor entrance pressure. If the rpm is reduced with the TBS fixed, the manifold pressure lowers. This occurs because the internal supercharger compression ratio falls with the drop in crankshaft speed, and the pressure-retrol is unconcerned with this variation. However, if the indicated air speed were to be lowered, the manifold pressure would be unaffected as the pressure-retrol would act on the waste gates and compensate for the reduction of ram pressure.

As the climb progresses at normal rated rpm and the turbosupercharger entrance pressure falls off, the pressure-retrol continues to maintain the carburetor entrance pressure demanded by the TBS. The limit is reached when the turbo overspeed control takes over to prevent excessive turbine speed. At this point each supercharger is operating at maximum rpm and engine charge air flow falls off with altitude (figure 7-7) similar to a sim-

EFFECTS OF ALTITUDE ON ENGINE OPERATION

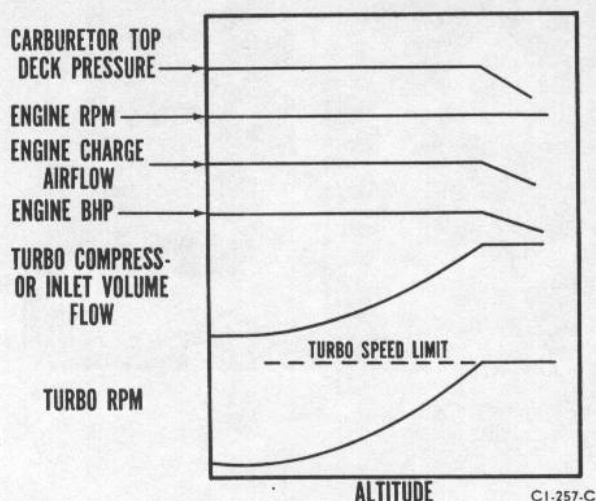
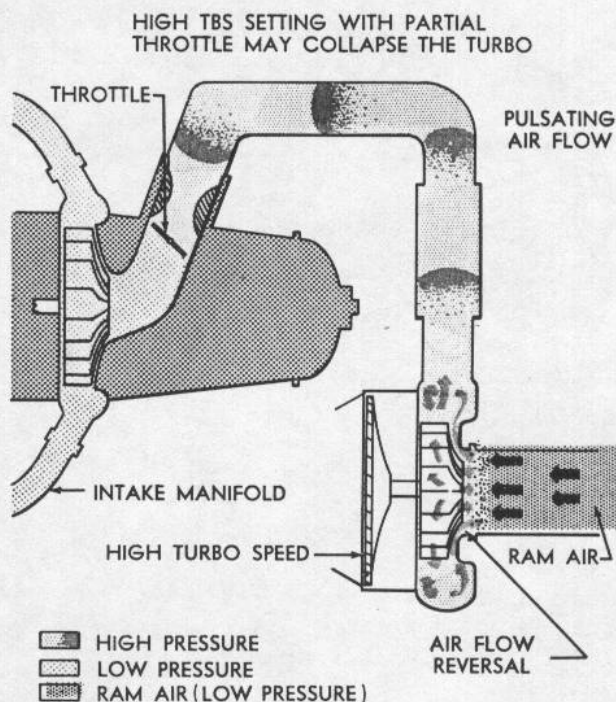


Figure 7-7.



CI-195-C

Figure 7-8. Power Collapse with Closed Throttle

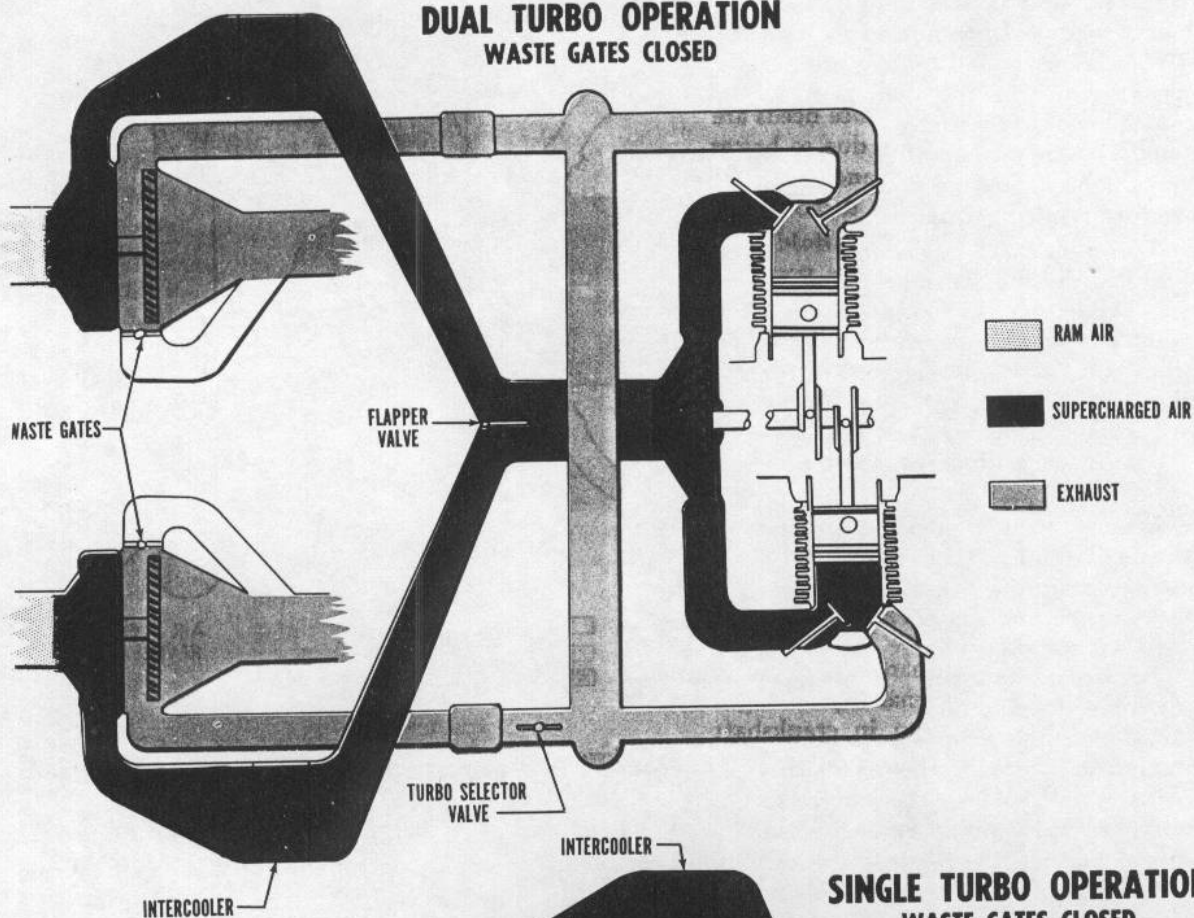
ple fixed speed supercharger. There is a mild hunting of the turbo overspeed control and the waste-gate. This hunting results in a wavering of 2 or 3 inches in manifold pressure. Air speed again exerts a direct influence on the manifold pressure indication.

The control sequence is as follows: First, with zero TBS, advance the throttle. Second, when full throttle will not give the needed manifold pressure, advance the TBS as required. Do not obtain manifold pressure with the TBS when the throttle is only partially open except for unusual situations. Damming the induction system (figure 7-8) after the turbos, can result in stalling of the turbo-compressors and cause severe cyclic pulsations accompanied by backfiring. Also, using turbos in this manner is inefficient since exhaust back pressure and carburetor air temperature are higher than necessary.

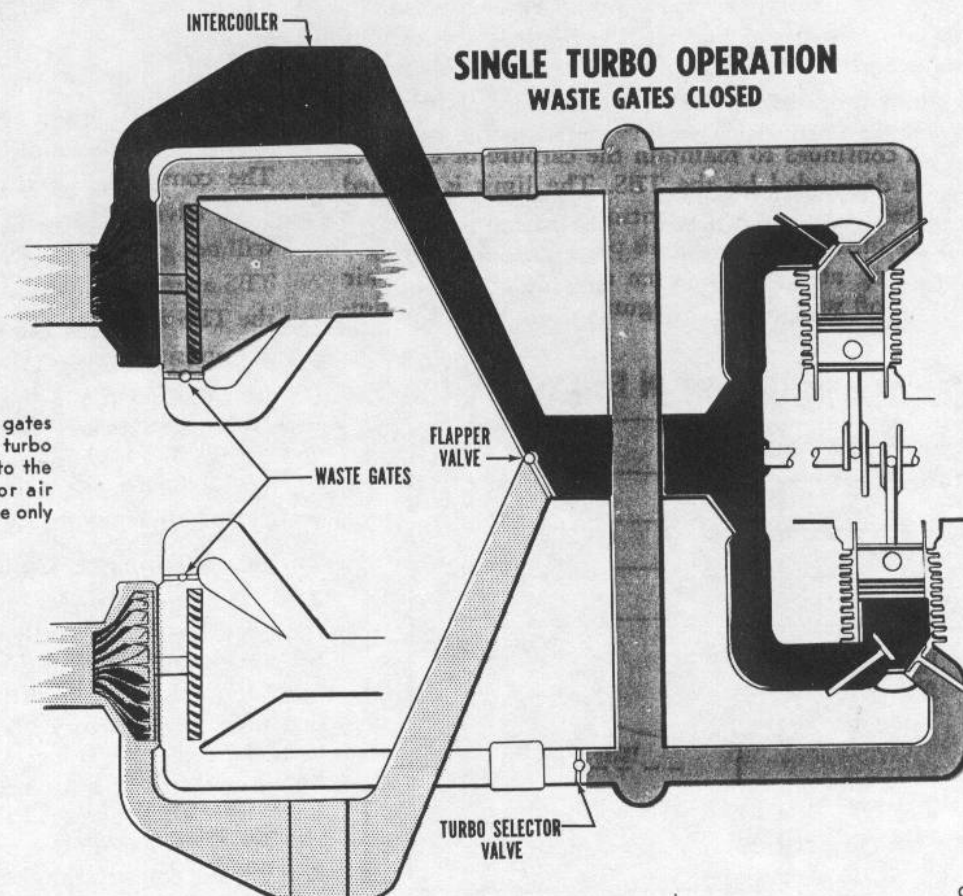
Turbosupercharger Operation

The use of single turbo in place of dual is necessary if the waste gates close fully. Its use may also be dictated by power collapse or pulsation possibilities at low air flow, low rpm, and high manifold pressure. By using one unit, the quantity of the charge air through the turbosupercharger is increased and stable operation can be maintained. It must be realized that during single turbo operation, there is a difference in the temperature rise from dual operation. Only one intercooler is removing the compression heat; therefore, the carburetor air temperature rises accordingly unless the intercooler shutters are opened. When shifting from dual to single turbo, and when returning from single turbo to dual,

DUAL TURBO OPERATION WASTE GATES CLOSED



SINGLE TURBO OPERATION WASTE GATES CLOSED



Above altitudes where the waste gates are fully closed the use of single turbo gives an increased air velocity to the engine; however the carburetor air temperature will tend to rise since only one intercooler is effective.

Figure 7-9. Single and Dual Turbo Operation

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the engineer can help the power plant make the change smoothly by following steps favorable to conditions present during the transition.

When shifting from dual to single, one turbo slows down and the other, influenced by the pressuretrol, speeds up to take over the entire pumping load. At first, the unit that is cut out loses speed faster than the active unit speeds up and a momentary drop of 2 to 5 inches manifold pressure results.

If shift does not occur within a reasonable length of time, pull the throttle back sufficiently to allow the turbo to shift. Pulling back the throttle reduces the exhaust gas loading on the selector valve to the left turbo and permits the actuator to break loose the valve gate in the exhaust duct and move it. If the shift is not completed in about one minute, the actuator motor is likely to overheat and burn out. Close observation of the alternator instruments just as switches are thrown often will give clues as to whether circuits and motors are acting properly.

When the shift is from single to dual turbo the selector valve quickly divides the exhaust flow, suddenly denying the active turbo a portion of its energy source, slowing it down. The previously inactive units speeds up, however, and for a moment the combined output of both is low and a drop in manifold pressure is noticed.

In either case the pressuretrol acts to increase the carburetor deck pressure to that of the TBS setting. There will be a small amount of overshooting, however, before it stabilizes. These momentary changes in air flow should not be allowed to occur with the carburetor mixture leaned to cruising because backfiring can occur. Therefore, the mixture control lever must be in NORMAL before making the shift. Also, the spark advance switch must be in RETARD because early ignition with the faster burning mixture can cause heat to build up in the combustion chamber materials faster than it can be transferred away.

This explains that the spark must be retarded before placing the mixture in NORMAL. However, the spark should not be retarded while operating with a fully leaned cruise mixture because retarded spark with the slow burning fuel-air ratio will cause backfiring. Therefore, the mixture must be partially richened before retarding the spark. This can not be done if the CHT is at its limit, for the increased mixture strength causes an increase of CHT that must be anticipated before starting the shift. Also, when shifting from BOTH to R.H. ONLY a carburetor air temperature rise occurs due to the greater heat rise through the use of single turbo.

Again, this temperature rise should be anticipated and the intercooler shutters must be adjusted accordingly preparatory to shifting to single turbo.

Shifting Turbos—Dual to Single. It is very desirable to remain in dual turbo as long as power can be main-

tained. At such time when power can no longer be maintained in dual turbo, proceed as follows:

1. Air plugs and intercooler shutters—Full open.

WARNING

It is very important to open the intercooler shutters because the CAT. increases very rapidly in single turbo operation.

2. Work on two symmetrical engines at a time.
3. Spark advance switches—RETARD.
4. Mixture control levers—NORMAL.
5. Reduce M.P. with turbo calibration knobs to approximately 25 inches.
6. Shift from dual to single turbo by placing the engine supercharger switches in R.H. ONLY.

Note

Manifold pressure will drop to approximately 22 inches and then will tend to surge upward.

7. After the shift has been completed, increase M.P. to approximately 35 inches while the other turbos are being shifted.

Note

If a shift does not occur within a reasonable length of time, pull throttle back sufficiently to allow the turbo to shift.

8. After all turbos are shifted to single, set desired power.
9. Readjust air plugs and intercooler shutters.

CAUTION

The alertness of the flight engineer is the only safety factor for maintaining CHT and CAT. below maximum limits.

Shifting Turbos—Single to Dual. The following procedure is for shifting to dual turbo at a constant altitude when additional power is required.

1. Air plugs and intercooler shutters—Full open.
2. Spark advance switches—RETARD.
3. Mixture control levers—NORMAL.
4. Decrease torque pressure (on all six engines) to approximately 150 psi, using the turbo boost selector lever.
5. Increase engine speed to at least 2000 rpm.

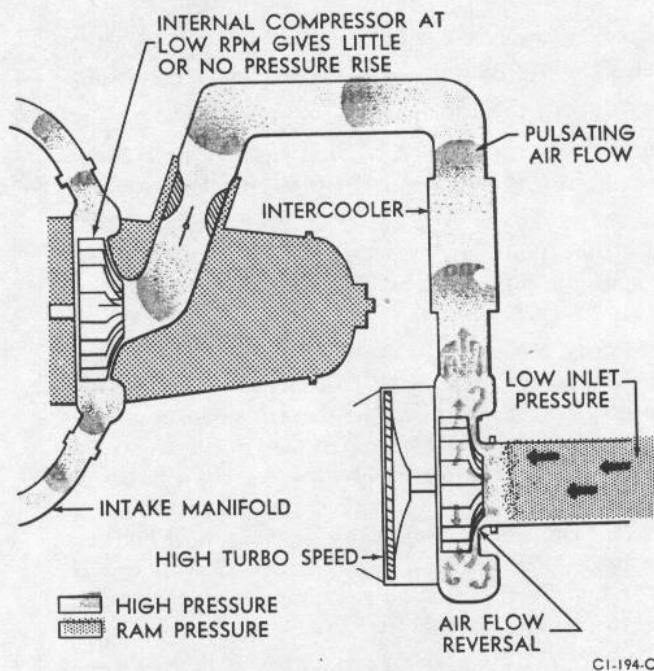
Note

This is a step toward keeping the power up without exceeding temperature limits during the shifting procedure.

6. Reduce M.P. on engines 1 and 6 with turbo calibration knobs to approximately 30 inches.
7. Shift to dual turbo by placing the engine supercharger switches in BOTH and trim engines to 200 psi torque pressure.
8. Repeat steps on engines 2 and 5, and 3 and 4, respectively.
9. Retrim engines to power required and readjust air plugs and intercoolers.

Power Collapse.

Satisfactory operation of the supercharging system requires that a balanced loading of all units be maintained. The pressure rise load of each compressor can be compared to the wing loading of an airplane. Similarly, the charge air velocity through the compressor closely follows the engine rpm and is comparable to the air velocity over a wing. If the load (pressure) is too high for the charge air velocity (rpm), the diffuser and compressor blades stall and power collapse, possibly accompanied by backfiring, takes place. This condition can occur at moderate to high altitudes (figure) by attempting to maintain a high manifold pressure at a low engine rpm. When this is done, the low internal supercharger pressure rise must be made up by driving the turbos faster and the system approaches instability. The turbo pulsation limits are defined in the appendix.



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Figure 7-11. Power Collapse

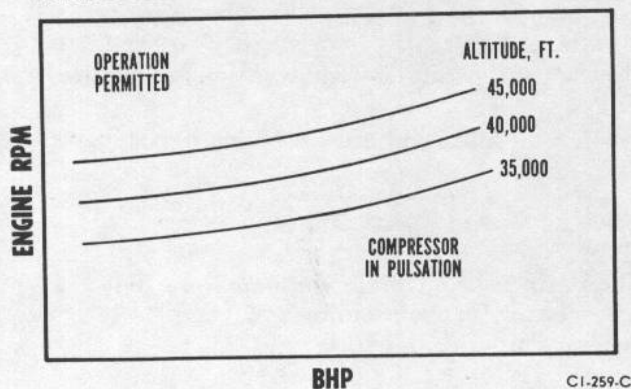
sudden and complete loss of power. It is so abrupt that the propeller automatic pitch control cannot compensate rapidly enough to maintain engine speed, with the result that rpm drops momentarily and then overshoots the initial setting slightly. When this happens, DON'T CLOSE THAT THROTTLE. This would be comparable to pulling back the stick of a stalled airplane. Placing a dam in the induction system only accentuates the difficulty and will bring on pulsations with attendant backfire.

The solution of this problem is to increase airspeed over the stalled surfaces of the turbosuperchargers, which is comparable to increasing the airspeed of a stalled airplane. The most effective means is to immediately increase the engine rpm which results in an increased velocity through the turbo compressors for the same carburetor deck pressure. In case of a marginally unstable power setting, increasing speed by 10 to 20 rpm and lowering the TBS setting slightly to retain the bhp are sufficient to restore harmony by developing balanced loads among the various pumping elements.

Other factors may be adjusted to alleviate the situation and permit maintenance of the established power and bmeP. A reduction of charge air temperature permits obtaining the required brake horsepower with less manifold pressure and reduces the pressure loading on the turbos. To accomplish this, lower the carburetor air temperature by opening the intercooler shutters. Even a small reduction in cylinder head temperature may remove the operation from the marginal condition and permit satisfactory power plant functioning.

Other corrective actions that can be taken from the engineer's station are: reduction of turbo boost, mixture

TURBO COMPRESSOR PULSATION LIMITS



CI-259-C

Figure 7-10.

These turbo characteristics cause difficulties during that portion of the flight when the airplane is very light and low power is being established with high bmeP. The low engine rpm shifts the manifold pressure load to the turbos and as the rate of air flow diminishes, the velocity through the turbo-compressors is critically slow and blade stalling is approached. When the critical point is reached, stalling occurs and power collapse takes place. There is seldom any instrument warning of this event from the manifold pressure gage, the torque-meter, the tachometer or other instruments, but there is plenty of unmistakable evidence afterward. There is a

enrichment, use of advanced spark (if within the permissible range), and increase of cabin air flow. Using any one of these steps aids the turbo function, either by increase of air flow and air velocity through the internal supercharger, or by reducing the pressure load on the turbo system.

It is apparent from the above considerations that increasing engine speed is the most effective means of recovering from power collapse. If the initial rpm is just marginally unstable, the slight overshooting of rpm after the momentary drop will frequently be enough to unload the turbo and permit self-recovery with no adjustment of controls. An increase of 10 to 20 rpm is then sufficient to prevent recurrence of the trouble.

Seasonal changes in outside air temperature affect the stable rpm-manifold pressure combination by a range of 75 rpm even with the same carburetor air temperature. This is due to the effect on efficiencies of the turbo-compressor and intercooler.

Leakage or restriction in the induction or exhaust systems may contribute to instability. Nicked or damaged turbo or engine compressors are inefficient and cause too high a temperature rise. These conditions reduce the weight of charge air that passes through the system.

Power Collapse Recovery. This procedure is designed to get the power plant into the stable operating range quickly and safely.

CAUTION

Do NOT retard the throttles because this results in an even worse condition of power collapse.

1. Master motor speed control lever—Increase until engine speed increases 25 to 50 rpm.

Note

This step will remove all engines from a marginal surge condition.

2. Turbo calibration knob of affected engine—Fully counterclockwise.
3. Spark advance switch—RETARD.
4. Mixture control lever—NORMAL.
5. Turbo calibration knob—Turn clockwise *slowly* to regain power and observe engine rpm.

CAUTION

Don't regain power too rapidly as rpm surges may result.

6. Re-establish proper setting of mixture and spark on affected engine.

CARBURETION.

Carburetor Air Temperature.

Carburetor air temperature is regarded by many as the indication of the possibility of induction system ice formation. It still serves this purpose on the B-36 but also provides other important items of information. As previously shown CAT. must be combined with manifold pressure and rpm to measure air flow. It is also a major factor affecting maintenance of satisfactory operating conditions.

The maximum CAT. is specified to prevent detonation. At engine speeds greater than 1900 rpm with advanced spark, this limit is not ideal but marginal. Occasionally, outside air temperature is 38 degrees plus, and since there is no refrigeration in the induction system, the heat rise through the turbosuperchargers results in a CAT. above the limit. A reduction of 1 inch manifold pressure for each 5.8°C above 38°C CAT. is then mandatory to insure safety during take-off. As engine speed is reduced from 2700 rpm and the heat rise through the internal superchargers is lowered, the margin increases. When this exists it is possible to consider CAT. with relation to engine efficiency rather than safety.

The power plant is a heat machine and the temperature of component parts or fluids flowing through it affects the combustion process, either directly or indirectly. The temperature level of induction air upon leaving the carburetor not only affects the charge density but also fuel vaporization. When considering rate of air flow at constant manifold pressure, the colder the CAT. the greater the weight packed into the charge air volume. By this measure alone, power should continue to increase as colder air enters.

However, this trend may reverse so that power may not increase in proportion to air flow and the brake specific fuel consumption may start to increase. This reverse trend (figure 7-12) is below a certain CAT. and is de-

LOSS OF POWER & EFFICIENCY AT LOW CAT

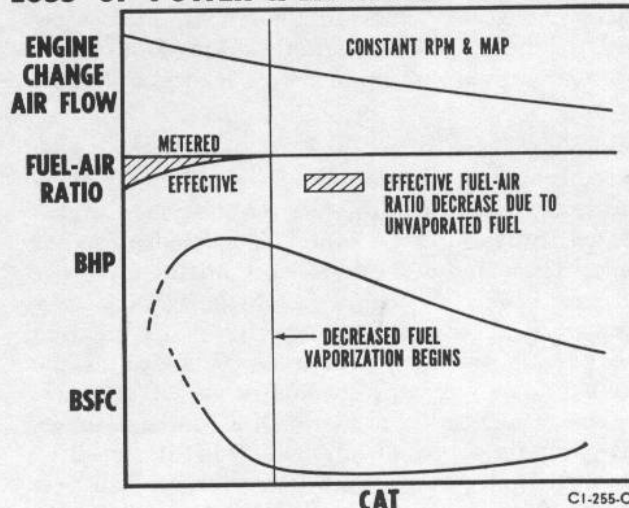


Figure 7-12.

pendent on variables such as rpm, mixture strength, fuel temperature, and the temperature of engine parts which the fuel contacts. Thus, at extremely low temperatures, it is possible for a critical condition to occur which results in power loss and consequently irregular operation.

These phenomena are brought about by failure of the fuel to vaporize in the cold induction air. Obtaining the maximum potential power from a given rate of charge air flow requires complete vaporization of all fuel supplied by the carburetor. Unevaporated fuel, even though finely divided into a spray or mist, does not burn and does not contribute to power. The carburetor does its job by providing fuel according to air flow requirements as previously discussed. It meters, or measures, liquid fuel and is unaware of occurrences downstream. The "measured" fuel-air ratio is based on the proportion of this liquid fuel to air. The "effective" fuel-air ratio is the proportion of vaporized fuel to air and if all the fuel is not vaporized the "effective" fuel-air ratio, which does the work, is lowered.

At high power with a high charge air flow and a rich mixture, this effect can be favorable for a range of temperature reduction as the "effective mixture" is approaching "best power." However, if continued to a frigid extreme, "effective" mixtures leaner than "best power" may result even though the "measured" fuel-air ratio is adequately rich. The unburned fuel often causes "torching" at the exhaust pipe. With cruise powers and lean "measured" mixtures, lack of vaporization results in overly lean "effective" fuel-air ratios and power loss. Because of charge distribution irregularities, some cylinders receive leaner mixture than others and they cease to fire since the mixture supplied to them will not support combustion. The lead in the fuel tends to stay with the unevaporated liquid which hastens its deposit on the combustion chamber surfaces and spark plugs.

Under the conditions described, more power for a given rpm, manifold pressure, and fuel flow is obtained by increasing the CAT. Even though air flow is decreased, the improved combustion resulting from better vaporization gives optimum performance and fuel economy.

Gasoline is a chemical mixture. Some of its components are highly volatile and evaporate easily under any operating condition. But the heavier components must be heated to over 100°C before rapid vaporization is possible. These heavier components finally leave the liquid state from 130° to 150°C. Obviously, air at carburetor air temperature cannot perform this function and large quantities of heat must be added as the charge air flows from the carburetor to the cylinder. The greatest amount comes from the internal supercharger, but its contribution varies with its speed of rotation. At high powers, with high rpm, its heat producing capacity is adequate and excess fuel can be absorbed by the engine without hesitation. As rpm is re-

duced, the heat rise through the impeller is less and its vaporizing capacity is lowered. At low cruise rpm the small heat rise, combined with low entering air temperature and lean mixture, can cause operating difficulties.

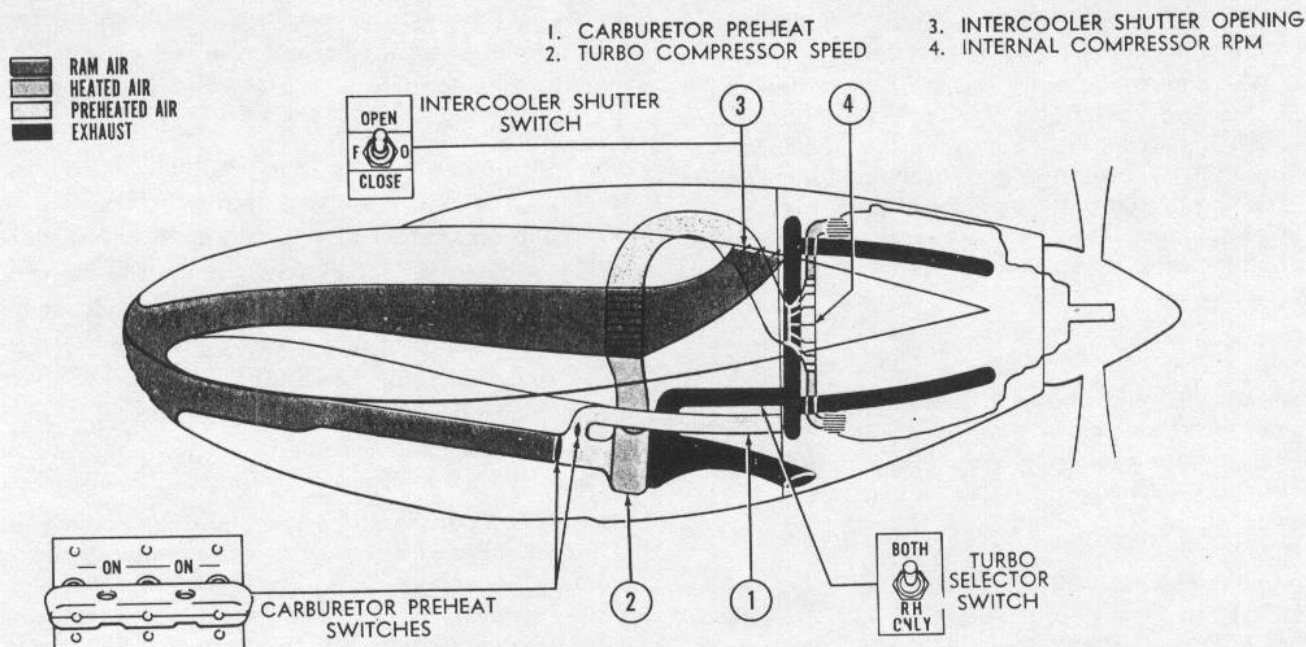
Besides heat from the internal supercharger, further heat exchange occurs through contact with the supercharger housing, intake pipes, and combustion chamber surfaces. The last increment of temperature before combustion is supplied by compression in the cylinder.

Elevated charge temperatures also retard the rate of spark plug fouling. If the heat rise through the internal supercharger is insufficient, control of CAT. effectively assists. A reduction in CAT. is necessary at the highest rpm permitted with advanced spark, since the engine can not tolerate the extra carburetor heat added to the supercharger temperature rise. When the rpm is reduced so that the supercharger rise is sufficiently low, it is permissible to return to the maximum limit.

The simplest application is to use 20°C as the maximum CAT. with manual leaning above 1900 rpm. The low fuel-air ratio lacks the ability to absorb the heat rise of the impeller at the higher rpm. Compensation for this is made by reducing the CAT. In controlling the CAT. by means of the intercooler shutters, set them at minimum opening to obtain maximum limiting temperatures. This reduces the drag of forcing air through the intercoolers and the disturbance of air flow over the wing. However, under maximum range conditions, with high bmep, this may lead to marginal operation, producing power instability. The high CAT. calls for more manifold pressure which, in turn increases the turbine load. A greater turbine load increases the exhaust back pressure, which in turn augments the original manifold pressure demand. At the same time, the elevated CAT. and additional back pressure start the CHT in the upward direction. There have been many instances in which backfiring at high altitude has been suppressed or eliminated by operating CAT. as cold as possible. Carburetor air temperatures from — 10 to — 25°C have stopped backfiring abruptly when shifted from higher temperatures. Continued use of low CAT. has permitted flights of five hours or more at 40,000 feet or higher.

Besides the primary carburetor air temperature control and the intercooler shutters, three other means of regulation are provided. The preheat system heats induction air by bleeding heated engine cooling air from the engine bay into the intake of the turbo-compressors. This system is used when power and altitude are insufficient to require a heat producing output of the turbosuperchargers. The use of single turbo is accompanied by an increase of CAT. since removal of induction air heat is through one intercooler instead of the usual two.

During icing conditions with low cruise power at low altitude there may not be sufficient heat available from the above means to maintain ice free operation. Under



C1-190-C

Figure 7-13. Controlling Carburetor Air Temperature

these conditions, another means of quickly raising the CAT. is to advance the TBS to a fairly high setting while controlling manifold pressure with the throttle. This action forces the turbo to higher speed with an increased temperature rise; however, caution should be observed to avoid stalling the turbo compressor and possibly causing backfiring.

In addition to its normal uses, CAT. is useful in checking the induction system condition. Excessive duct leaks on one power plant will cause its turbosuperchargers to increase their speed to maintain the carburetor entrance pressure called for by the TBS. This elevates the CAT. on that engine above the other five, thus giving a positive indication of the trouble.

Backfiring is indicated, momentarily, on the carburetor air temperature gage provided the heat is sufficient to be measured upstream at the carburetor air temperature measuring point. A sustained induction system fire during starting will show a continuous elevation of CAT.

During flight, power adjustments approaching instability or power collapse may cause a rise of CAT. As the turbo-compressor becomes less efficient, more of its energy is dissipated in heat, increasing the induction air temperature.

Carburetor air temperature should be noted on the ground before starting and just after shutdown. It is the best indication of fuel temperature in the carburetor body and indicates whether vaporization will be sufficient for the initial firing. Otherwise the mixture must be augmented by prime. If an engine is shut down for a short period of time, the residual heat in the carburetor makes it possible to rely on the vaporizing heat

in the fuel and power plant. Then priming is unnecessary. After shutdown, a high CAT. means that fuel trapped in the carburetor will expand producing high internal pressures. This force, if great enough, ruptures diaphragms and damages vent valve seats. The fuel lines and manifold valves should be open when the above conditions exist to allow fuel passage back to the tanks.

Carburetor Impact Icing.

Carburetor icing occurs on the airplane, but is not generally the screen type or throttle body type usually experienced on other aircraft. Some fuel is injected into the induction air at the face of the impeller, the remainder midway between the face and the tips. the charge is immediately subjected to compression heat; therefore, no ice forms due to fuel evaporation. Impact ice can form, however, on the carburetor screens and, in special instances, on the throttles. This is possible when the CAT. is near 0°C and there is high moisture content in the atmosphere. As this ice builds up, it restricts the air flow just as if the throttle were being closed. Any attempt to increase rpm merely aggravates this condition, resulting in an additional loss of power. The expected drop of manifold pressure is accompanied by reduction of torque and fuel flow readings.

This type of icing is prevented by maintaining the CAT. above 5°C. While greater than 0°C is sufficient to keep ice off the screen, there is a slight temperature drop through the throttle body and the extra 5°C takes this into account.

When anticipating icing conditions, the CAT. should be maintained as close to 38°C as possible. This is ac-

complished by closing the intercooler shutters. If this is not adequate, additional carburetor heat is obtained by turning on the carburetor preheat and varying the temperature with intercooler adjustments. If more heat is required, increase the speed of the external superchargers. This is accomplished by retarding the throttle to reduce M.P. approximately 6 inches, and increase the TBS setting to restore the original M.P. If this does not provide sufficient heat, switch to single turbo and repeat the preceding step, providing power conditions permit.

Note

It should be remembered that switching to single turbo reduces the efficiency of the heating and anti-icing systems since one primary heat exchanger is cut out in each nacelle.

If carburetor heat is still insufficient, continue to decrease M.P. in 5-inch decrements and increase TBS to restore M.P. until the desired CAT. is obtained.

It is also possible for ice to form on the throttle and mixture control linkage. This is detected only by attempting to move the controls. In event this type of icing occurs, an altitude should be found where icing conditions do not prevail. Icing conditions are seldom encountered above 25,000 feet; at lower altitudes a change in altitude, either up or down, often removes the airplane from the icing zone.

Carburetor Internal Icing.

The foregoing describes carburetor icing that affects the induction air passages by choking the engine. Another type of icing forms within the carburetor and restricts the air flow through A and B chambers. Manifold pressure does not diminish since the main air ducts are unaffected, but the fuel metering is upset causing a fuel flow change. In this case, power as measured on the torque meter will rise or fall, depending on the initial fuel-air ratio and the effect of changing fuel-air ratio on power.

This type of icing comes in two packages, rich and lean. If fuel flow increases under normal operation, it is probable that atmospheric moisture found its way to the bleed between the A and B chambers and froze. The tendency to freeze is influenced by the temperature reduction that accompanies the drop in pressure of air flowing from A to B chamber. However, the principal cause is from the cold fuel which flows through nearby D chamber taking heat from B chamber faster than it is brought in by the small air flow through the bleeds. The unrelieved A chamber pressure builds up, while that in B chamber decreases, increasing the metering differential to discharge more fuel. In this condition the carburetor can go as much as 100 per cent rich and, if nature takes its course, large power losses result. Depending on the

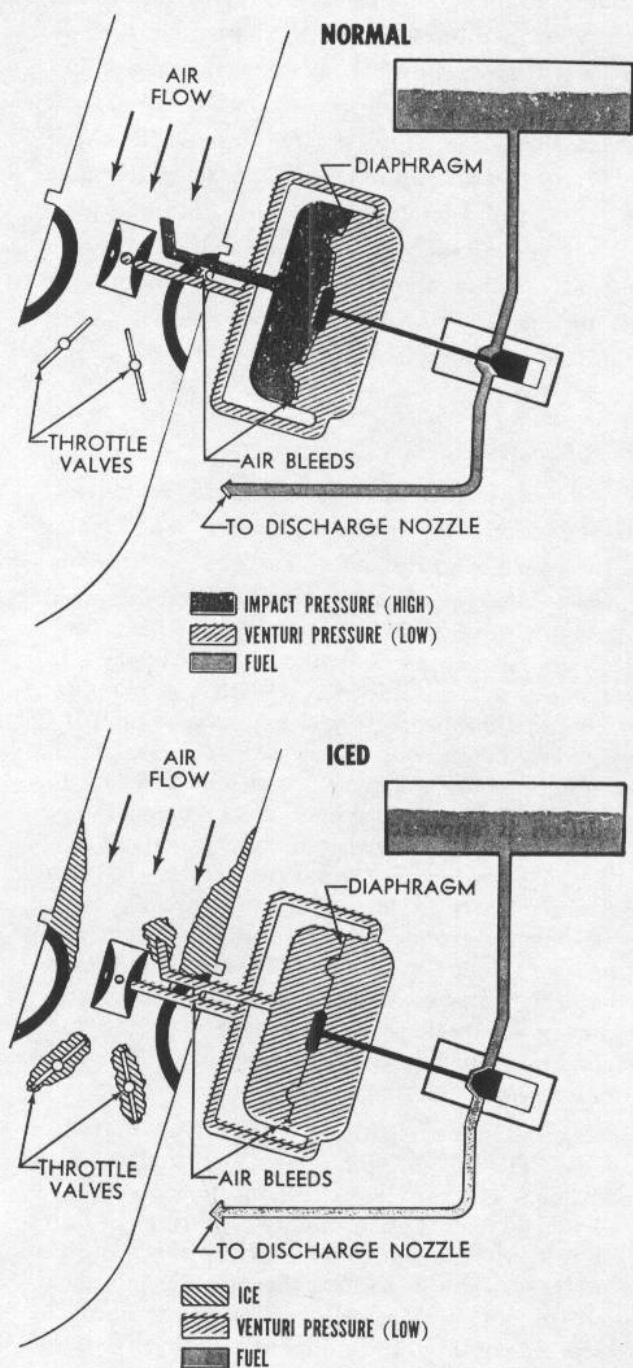
mixture setting and fuel-air ratio, the torque pressure may first increase or decrease. In severe cases, a large loss of torque pressure results, accompanied by torching at the exhaust pipe and where small leaks occur in the exhaust system.

Control of fuel flow is regained by manual leaning even though it is necessary to approach IDLE CUT-OFF. When restoration of normal conditions is indicated by a decrease in fuel flow, return the mixture lever to its proper position. The fuel flow must be watched if icing continues during the landing approach, since changing conditions will quickly thaw the bleeds, resulting in extremely lean mixture. High CAT., even to excessive values, benefits temperatures only slightly at the bleed between A and B chambers.

A leaning process results when moisture collects in the impact tubes and freezes in the passage to the A chamber. (See figure 7-14.) The pressure and temperature drop at the automatic mixture control unit can cause condensation and freezing, thereby, blocking air flow to A chamber. This permits its pressure to approach the B chamber pressure. The reduction of pressure difference between A and B chambers is not representative of air flow and causes the carburetor to lessen the fuel supply and "starve" the engine. Again the torque and fuel flow tell the story. In this situation, carburetor preheat is necessary. Enriching the mixture, by using prime together with mixture control adjustment, maintains fuel flow until the heat becomes effective.

Heat application to eliminate icing of the impact tube should be performed in the same order and to the same degree. However, the cure is more difficult. It is necessary for the metal supporting the carburetor, the automatic mixture control unit, and impact tubes to be warmed sufficiently to melt ice formed internally. Experience shows that manual mixture adjustment gives adequate control until a change of external conditions brings permanent relief. The basic causes for this condition is the affect on the carburetor body temperature of the induction air temperature, the engine cooling air flow temperature, the power plant operating temperature, and the fuel temperature. The rich or bleed type icing is encountered with cold fuel only; in fact, fuel temperatures above 7°C (45°F) thawed out frozen bleeds in laboratory tests.

Other icing effects in the induction system are indicated by unusual turbosupercharger control, peculiar readings of instruments vented to carburetor deck pressure, and undue surging or collapse after shifting to single turbo. Apparently, the carburetor flange and fittings for carburetor deck pressure sampling run cold enough in pusher type installations to cause ice formation over the openings under certain icing conditions even though the CAT. is just above freezing. When the pressuretrol fitting is affected, it is unable



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Figure 7-14. Icing of Impact Tube in Carburetor

to sense changes in carburetor deck pressure and relays signals for small changes in the waste gate setting to increase or decrease M.P. The TBS trim may be approximately set to balance the pressure locked in the sensing line by ice and thus maintain approximate power for several minutes. Eventually, a large loss or gain in M.P. may occur, control of which is regained by playing the trim against the locked pressure. Higher CAT. or warmer atmosphere clears the trouble.

If the fitting that senses carburetor deck pressure for the fuel pump, its pressure gage, the water pump and its pressure gage, becomes iced there are various indications. The degree of indication depends upon the effect of locked pressure on pressure regulating valves, gages, fuel flow, water flow, and whether or not the pressuretrol is iced. Since the fuel pump and gage are balanced to the same ice-locked pressure, the fuel pressure will read the proper value even though the true pressure relative to actual carburetor deck pressure is off. The fuel flow and fuel-air ratio varies under this situation. The water pressure gage will give readings of discharge nozzle pressure (which is vented to and regulated by the carburetor deck pressure) against the ice-locked balance pressure. The water gage reads high when the carburetor deck pressure is higher than the ice-locked pressure. In this instance water pressure can be controlled by turbo trim.

The intercoolers may partially ice internally when CAT. is below freezing, when air flow is low, and weather is conducive to external icing. When shifting to single turbo there will be an undue surge and power collapse, accompanied by a high CAT. rise before collapse. Returning to a warmer or ice free atmosphere clears the difficulty after a reasonable length of time and single turbo operation becomes normal. It is not known whether operation with high CAT. and a surge-free power will slowly thaw out the partially iced R.H. intercooler and eventually permit full single turbo operation or not. Also, it might be troublesome to resume climb power if the intercoolers were partially iced internally during extended cruise operation with CAT. below freezing.

Another type of internal icing which may occur is the freezing of water trapped in the fuel side of the regulator. This condition can be prevented by draining the fuel sumps during preflight inspection.

TORQUEMETER.

There are two methods frequently used to estimate reciprocating engine power in airplanes. One utilizes measurement of manifold pressure and engine speed. The other depends on measurement of torque pressure and engine speed. The primary difference between the two is that the manifold pressure method measures, in effect, power put into the engine, while the torque pressure method measures power output of the engine.

Manifold pressure and rpm, at best, are a crude indication of engine power, because they are only a rough measure of charge air flow into the engine. The charge air flow for a particular M.P. and rpm combination varies with CAT., exhaust back pressure, and CHT. Furthermore, power which is developed for a particular charge air flow varies with mixture conditions. Be-

sides the variables within the individual engine, additional variables result from slight differences among engines in valve timing, ignition timing, etc.

Since there is no simple equation relating bhp, M. P., and rpm, this type of schedule must be presented in chart form, such as the M-1 tables or curves found in the appendix. An attempt is made to achieve better accuracy by providing an approximate correction for CAT., and by providing M.P. values for a series of altitudes so the effects of varying back pressure can be approximated. Spark advance and mixture strength are considered with the assumption that definite values of the two factors will be used for each combination of bhp and rpm. However, it is either impossible or impractical to include in charts the other variables mentioned above. Therefore, M-1 charts leave much to be desired when accurate cruise control is the objective.

The torquemeter provides a direct measurement of the torque transmitted by the crankshaft to the propeller. In most airplanes, practically all torque developed is applied to the propeller, so that engine power may be determined from the following simple equation:

$$\text{Bhp} = \text{constant} \times \text{torque pressure} \times \text{rpm.}$$

This equation is independent of the many variables that affect the M.P. method of estimating power.

In this airplane an engine cooling fan is driven by a power take-off in the accessory section of the engine. Under some conditions, the fan absorbs a large amount of power. Fan power is not sensed by the torquemeter, which measures only the part of engine bhp transmitted through the propeller reduction gear. Therefore, the equation for bhp is as follows:

$$\begin{aligned} \text{Bhp} &= \text{propeller shaft hp} + \text{fan hp} \\ &= \text{constant} \times \text{torque pressure} \times \text{rpm} \\ &\quad + \text{fan hp} \\ &= \text{constant} \times (\text{torque pressure} + \\ &\quad \text{equivalent fan torque pressure}) \\ &\quad \times \text{rpm. (Constant for R4360-41} = \\ &\quad 0.0043) \end{aligned}$$

Fan power is easily obtained from the M-4 curves, so that only torque pressure, rpm, and altitude need be known for the rapid and accurate determination of bhp developed by the engine. To simplify the engineer's work, the above equation was solved for a large number of points along the recommended power schedules, and resultant values of torque pressure were summarized in the M-3 tables. Although torque-meter use is recommended in setting power for accurate cruise control, it must be remembered that the torquemeter senses only the total power output to the propeller shaft, regardless of how the individual cylinders are operating. Thus, if any cylinders are not operating properly due to faulty ignition or

other malfunction, the remaining cylinders would have to develop more than their share of power to produce the desired torque. To avoid damage under such conditions, M.P. should be used as a check against torque pressure. The simplest and most useful check is to ascertain that all engines which are set at the same torque, rpm, and fuel flow have manifold pressures within 2 inches of each other. If any engine requires a manifold pressure above this band to produce the desired torque, its torque should be reduced until the manifold pressure is within the allowable 2-inch spread.

SPARK SELECTION.

Spark selection is provided on the R4360 engines to obtain the maximum range advantage when using manually leaned mixtures. With retarded spark, cruise power fuel economy improves with decreasing mixture strength to approximately .062 fuel-air ratio. Further manual leaning will not increase fuel economy unless the spark is advanced. With a leaner ratio, flame propagation becomes so slow that combustion energy from the charge is released too late in the power cycle, making the cycle less efficient. When this condition is approached, use of advanced spark improves fuel economy in two ways. First, earlier ignition of the slow-burning mixture results in better timing of the energy release and, consequently, better cycle efficiency. Second, it permits use of leaner mixtures to approximately .057 fuel-air ratio before flame speeds again become too low for efficient operation. Thus, advanced spark provides a 4 to 6 per cent decrease in brake specific fuel consumption for manual lean cruise power operation.

Advancing the spark results in a rise in CHT and increases the cylinder cooling requirements. Because of the additional cooling requirement, it is essential to lean all the way to "best economy" mixture, in order to take full advantage of the cooling effect of lean mixtures. It is desirable to lean through the intermediate mixture range as rapidly as possible, since the most severe cooling requirements generally occur somewhere between normal and "best economy" mixture strengths. Advanced spark benefits fuel economy most at lean mixtures. Because of the effects on cooling requirements and detonation margin, advanced spark should not be used for operation with normal or rich mixtures.

The engineer must check the spark advance control for proper operation each time it is used. Failure of the actuator to change the spark timing calls for corrective action. Correct operation may be checked by noting the effect on engine power. Advancing the spark normally causes an increase of torque pressure. However, mixture strength may obscure this check on the ground. At 2000 rpm with the mixture in NORMAL, the fuel-air

ratio can be near "best power" if the carburetor is set on the rich side. In this case, advancing the spark will show very little torque increase and the operator might conclude that the spark mechanism is stuck in retard. This can be confirmed by switching the ignition to the right or left position which is equivalent to retarding the spark 10 degrees. If the timing is advanced and the mixture is near "best power" little or no change of power will occur. The torque pressure and rpm will remain practically constant because the mixture burns too fast to require advanced spark. If the timing is stuck in retard, the use of single ignition will cause a definite and recognizable power loss. In this event a recheck with the mixture lever in the manual lean range will give a more positive indication whether or not the spark has advanced properly. Lean mixtures on single ignition give large drops in rpm and torque, and sometimes backfire if very lean.

In flight the spark is not advanced until the mixture has its first dose of leaning from normal. In this condition single ignition can cause backfiring. The interpretation of the torque pressure reading is evidence that the timing has changed from retard to advance, or vice versa. With lean mixtures this is quite positive.

The cylinder head temperature rise is a further check that operation is satisfactory, but it is somewhat slow in response. Higher temperatures occur with the use of advanced timing than with retarded, if the mixture strength and other cooling factors are unchanged. While the direction of temperature change shows up in a short time, it takes about 5 minutes for the reading to stabilize after the shift of spark advance.

High spark advance is similar in detonation effect to high carburetor air and cylinder temperatures, high M.P. and high rpm (impeller speed). The combinations of these factors balance against each other when arriving at the limits for the use of advanced spark.

The use of advanced timing may be beneficial if ignition irregularities are present—magneto or plug malfunctioning. If an individual cylinder is operating on one plug, even with the switch in BOTH the effect in that cylinder is the same as though the timing had been retarded 10 degrees. This explains why backfiring can sometimes be eliminated by shifting from RETARD to ADVANCE. With one plug out, the combustion process lasts too long and burning is still going on when the fresh charge is admitted. By advancing the spark, timing in the offending cylinder is brought more nearly into line. This procedure is used only with powers permitting advanced spark with both plugs firing in the good cylinders. Richer or leaner mixtures may help the situation, depending upon how close the basic carburetor setting is to "best power" at the air flow being used. The use of prime helps the carburetor through a lean range when one or more cylinders are firing on one plug.

If the spark advancing equipment malfunctions, leaving the timing at advance, the engine should not be operated at higher powers than those permitted with advanced spark. In an emergency, when higher power is needed, alleviate the situation by operating that power plant on single magneto rather than dual. This will, in effect, retard the spark. The plugs not firing have a tendency to foul. Alternating between right and left magneto every few minutes may help in this situation, although it may be better to keep one set of plugs running and let the other set foul completely rather than partially foul both sets.

Procedure For Advancing Spark.

The procedure for advancing spark is included in "Manual Leaning" of this section.

Procedure For Retarding Spark.

The following procedure is used to retard the spark from advanced spark operation.

1. Reduce M.P. approximately 2 inches with the turbo calibration knob.
2. Restore torque pressure by enriching the mixture.
3. Spark advance switch—RETARD and note torque pressure drop.
4. Mixture control lever—NORMAL.

MIXTURE CONTROL.

It was shown, previously, that mixture strength of the charge can be varied and this variation produces changes in the engine operating condition affecting power, temperature, and spark timing requirements. "Best-power" fuel-air ratio (.074-.080 F/A) is desirable when the greatest power from a given charge air flow is required. "Best economy" mixture results in obtaining the given power output with the least fuel flow and is close to .062 with RETARD spark advance and about .057 with ADVANCE. The need for automatic enrichment above "best power" for detonation control was discussed.

The carburetor controls fuel flow by varying two basic factors. First, the fuel control unit, acting as a pressure reducing valve, determines the metering pressure in response to the metering forces. Then the metering unit, in effect, varies the size of the orifice through which the metering pressure forces the fluid. It is a law of hydraulics that the amount of fluid passing through an orifice varies with the pressure drop across the orifice and with the size of the orifice. The internal automatic devices and the mixture control act to determine the effective size of the fuel metering passage. The internal devices—fixed jets and variable power enrichment valve—are not subject to direct external control and by themselves determine the basic shape of the metering curve as the power changes from low cruise to take-off. The mix-

ture control, adjustable from the cockpit, permits a modification of this basic curve by directly changing the size of the effective orifice. The RICH position provides the maximum orifice opening possible for any given air flow. The fuel flow characteristics with this mixture determines the basic shape of the metering curve. If the control lever is fixed in intermediate position a new metering curve is established at leaner fuel-air ratios but with essentially the same shape as with RICH.

Fuel flow variations as a result of mixture control lever movement at fixed rpm and manifold pressure is shown in figure 7-15.

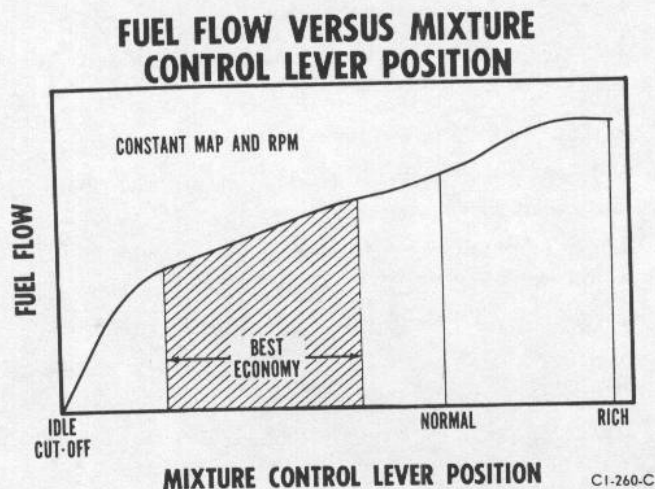


Figure 7-15.

A movement of the mixture control lever from IDLE CUT-OFF to approximately 20 on the mixture control quadrant produces a rapid increase of fuel flow to a value which is the minimum for ordinary use. Settings below 20 are used only in the event of internal carburetor icing or other malfunctioning resulting in excessive fuel discharge. Between 20 and NORMAL a gradual fuel flow increase provides the useful range for manual leaning. A more rapid rise above NORMAL furnishes a comparatively coarse range for manual adjustment. RICH gives the maximum fuel flow for a given air flow and is used most often to assist in cooling the engine under unusually hot conditions. The detented position marked NORMAL is one of an infinite number of fixed positions between IDLE CUT-OFF and RICH. It was selected because metering characteristics accompanying its use provide desirable operation throughout the power range. When operating in NORMAL, the carburetor meters approximately lean "best power" mixture (.074) in the cruising range and provides suitable enrichment for climb and take-off powers. This mixture setting is used for take-off, starting, and all ground operation except specific mixture checks. It is the initial position for climb and for starting manual adjustment. These lean "best power" mixtures are bene-

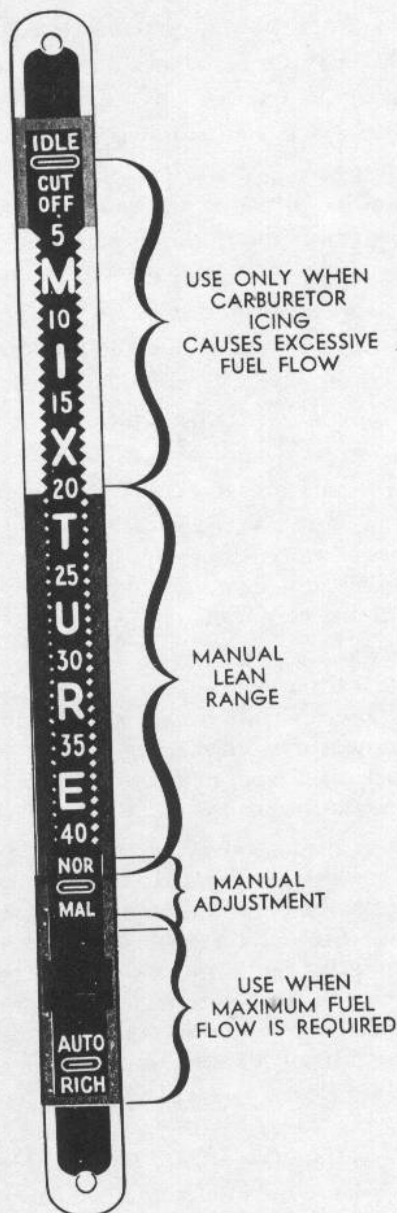


Figure 7-16. Use of Mixture Control

ficial for maintaining stable operation and preventing combustion chamber deposits. The NORMAL setting meets engine requirements, with respect to usual operating temperatures and powers; and, its lowest fuel-air ratio (in the cruise power range) accommodates accelerations over a moderate range of cool operating temperatures. The mixture strengths at the high power end are limited by detonation with a suitable safety factor. The basic metering curve with RICH added is shown in figure 7-17. The shape and position of the enriched portion of the curve at the high power end is determined by detonation. The limiting point of detonation at any power is not a fixed value but a variable, determined primarily by the final temperature of the charge as it is compressed and ignited. Adding the detonation limit line to this basic curve reflects the influence of other factors on operating

TYPICAL CARBURETOR METERING CURVES AND DETONATION LIMIT

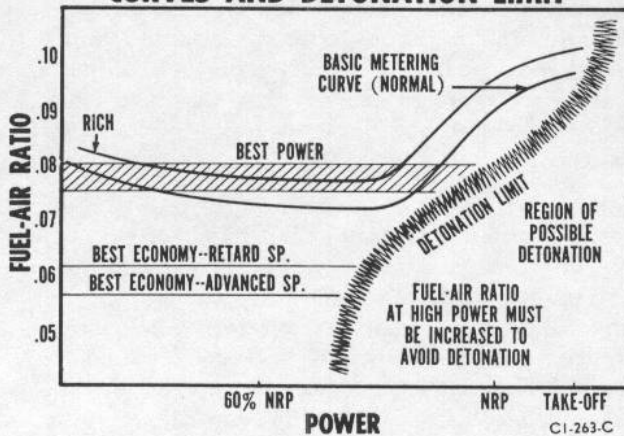


Figure 7-17.

safety. The detonation limits are not sharply defined, but will bounce back and forth even when an engine is tested under controlled conditions in the laboratory. A 10 to 15 per cent margin seems necessary to be safe.

Anything tending to keep the temperature down pushes the detonation limit away from the point of operation and permits higher powers for a given fuel-air ratio. Anything that elevates the charge temperature lowers the detonation limited power. Below about 60 per cent of normal rated power (including fan horsepower) the engine is virtually free of these detonation limits and with reasonable operating temperatures, engine conditioning, and the use of specified fuel, manual leaning can be used.

In the range of power between approximately 60 and 70 per cent normal rated power (including fan hp) manual leaning can be very marginal and the combination of unfavorable factors present must be considered. If the engine is in good condition manual leaning in this range is accomplished satisfactorily and safely, provided the temperature and spark advance limits are observed. If the combustion chambers are allowed to load up with lead and other deposits, the stage is set for detonation and probable preignition unless compensating reductions of carburetor air and cylinder temperature are used.

Mixture strength affects the power available from a given charge air flow, the temperature of that cylinder, and other temperatures. These effects are shown by curves in figure 7-18. The maximum values of torque pressure occur at "best power" fuel-air ratios and fall off as the mixture is enriched or leaned. The fact that loss of power is greater on the lean side explains the need for seemingly large increases of manifold pressure to maintain constant bhp while leaning. For example, during take-off or rated power climb it would be physically possible to lean manually to "best power" mixture. However, the temperature increase shown in the above curve would show its effects on

CHT. This would encourage detonation or preignition, backfiring, and burned pistons.

In this situation there would be noticeable loss of power output which could be measured by torque pressure, indicated air speed, rate of climb, and possibly failure to clear obstacles at the end of the runway.

Manual leaning is not only possible and permissible below approximately 75 per cent normal rated power (including fan hp) but is necessary when maximum range is desired. As the fuel-air ratio is reduced below .067, temperatures are reduced (figure 7-18) and cumulative gains are possible by adding the lowered cooling drag to the fuel saving. It is also possible that mixtures leaner than "best economy" are efficient. However, they would be impractical when the mixture distribution to the individual cylinders is such that power becomes unstable. While the bhp per

EFFECT OF FUEL-AIR RATIO UPON BHP & CHT

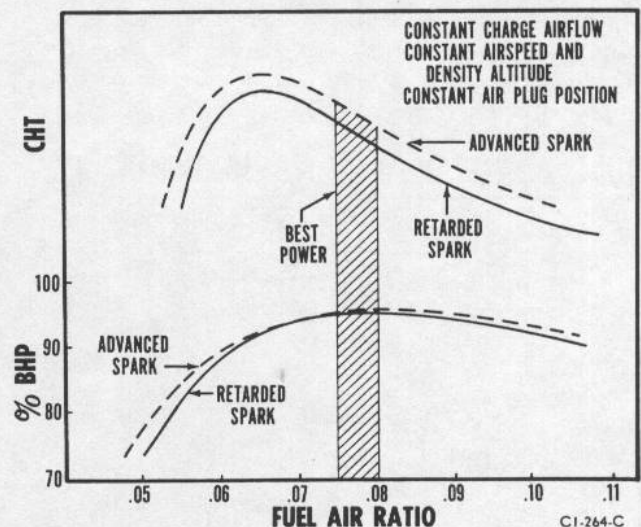


Figure 7-18.

pound cannot be increased, and may even decrease, the miles per pound may be favored by further permissible reduction of the cooling air flow. It is possible, and often desirable, to lean to such an extent with advanced spark that if the timing were retarded the engine would be rough due to poor combustion.

When establishing these super-lean mixtures consider the temperature factors. Usually the cruise power setting is made following a rated power climb with all operating temperatures near the maximum. The passage from normal to cruising lean mixtures is safely accomplished if the power plant is well cooled. Do not set up limiting cylinder head and carburetor air temperatures and then lean. First, for a minute or so, hold the temperatures well below the limits to allow piston heads, exhaust valves, spark plugs, and the superchargers to cool. Then adjust the mixture and, finally, establish the operating temperatures.

The idle mixture strength is of great importance. A mixture too lean results in poor acceleration, misfiring with possible plug fouling, and poor flight operation with nearly closed throttle. If the mixture is too rich, extended ground operation causes plug fouling due to carbon.

Manual Adjustment.

Because of manufacturing tolerances of the carburetors, it is possible for fuel flow variations to exist between the six engines, even when they are operating at the same rpm and M.P. (air flow) in NORMAL mixture. (See figure 7-19.) The M-2 (fuel flow) curves call for a definite fuel flow to each engine when set for climb power or in the high power range. The manipulation of the mixture control lever out of the NORMAL position on either side to attain the proper fuel flow is called manual adjustment.

Manual adjustment is authorized under all flight conditions, except take-off, provided the airplane is equipped with calibrated engine instruments and the engines are operating properly. Other than insuring that minimum specified fuel flow is provided to each engine, this procedure calls for no unusual attention on the part of the engineer.

MANUAL ADJUSTMENT OF NORMAL MIXTURE

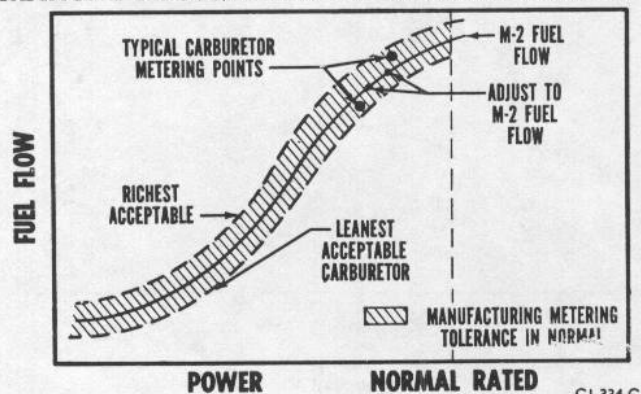


Figure 7-19.

Manual Leaning.

The B-36 engine handling practices are conceived primarily to attain long range and to promote engine life compatible with the tactical mission of the airplane. The conventional engine setting practices used on other aircraft will not accomplish these ends. Former limits of bmep, cruise power, and fuel-air ratio arbitrarily set higher than "best economy" result in an operating range considerably below that required. On the B-36, every limit that hinders obtaining maximum miles per pound of fuel is being raised as high as possible as experience progresses. The change from previous practices to B-36 operation has not been without difficulty and, in too many instances, all the apparent differences in engine handling are blamed. It would be more sound to examine each factor

separately and see which particular one contributes most to the reduction of engine service life.

The same basic engine, without external supercharging, using lower continuous cruise power and with atmospheric exhaust back pressure, achieves a normal service life with no more difficulty than that involving the maintenance of sufficient overall warmth to insure stable running.

The B-36, with its turbosuperchargers, can sustain high power to higher altitudes than have been flown regularly on service aircraft. This type of operation, requiring the higher sustained powers, results in higher cylinder and carburetor temperatures and more exhaust back pressure than would be encountered at lower levels. These general factors alone are unfavorable to long service life. When the long range cruise techniques are added, a real operating problem is given to the engineer.

Not every factor of combat cruise is unfavorable. The increase of bmep from 150 to 160 for a given power is accompanied by a reduction of the internal supercharger rpm and attendant lower charge-air heat rise which permits a higher bmep detonation limit at the lower rpm. The maximum limit of cruise bmep is often a structural fatigue limit concerned with the loads and deflections on the power transmitting system—rods, crankshaft, reduction gear, and propeller. Low rpm means a less frequent rate of power impulses to these parts and, consequently, is a favorable condition with respect to fatigue failure. The absolute limit is reached when distress results from a further increase of bmep, even with these favorable low rpms. All previous experience has been at a maximum of 150 bmep but there is no reason to expect that 160 bmep has exceeded a critical value in view of the experience accumulated so far.

The other operating factors are largely unfavorable. The increase of maximum power for use of lean mixture with both retard and advance spark bring the operation much nearer to the detonation limit line and fatigue limits.

With conventional operation, cruising at 1750 maximum bhp and normal mixture still left a good margin of safety commonly called a cushion. This came in handy when substandard ignition, valve operation, or combustion chamber conditions appeared. But with higher power operation and the manual leaning practiced on the B-36, the margin is greatly reduced. When substandard conditions show up, detonation and pre-ignition are more likely.

Other attendant problems can show up with long range cruise. The higher bmep requires that the turbosupercharger assume a greater share of the charge compression load and power collapse can result. Oil spewing,

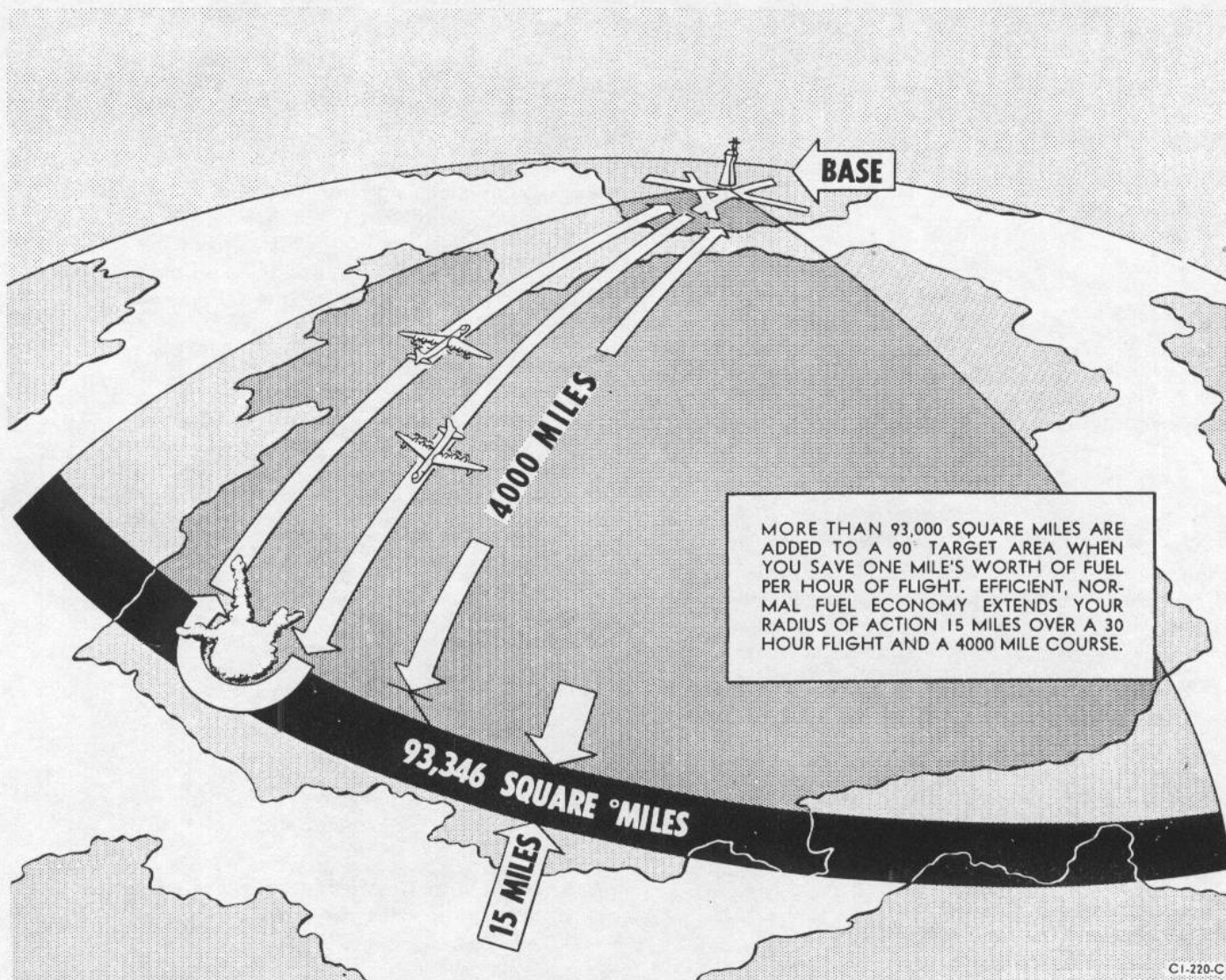


Figure 7-20. Range Extension

power instability, and ignition difficulties are accentuated by the extreme high altitude of operation. The correction for these malfunctions can be described with fair accuracy and are covered in other portions of this section.

However, exact steps to avoid detonation and pre-ignition cannot be as accurately described and no "pat" answer can be given for eliminating their occurrence if long range cruise procedures are followed. When the decision is made to leave the comparative safety of the conventional power settings and apply relatively high cruise power with manually leaned mixture, the operation is getting closer to the area where trouble has been known to exist. If detonation and pre-ignition can be avoided, the mission will probably be successful because this practice is used.

The consecutive steps in manual leaning and in returning to a rich mixture must follow a prescribed procedure which results in approaching the final set-

ting without going into the known danger area at any time. This requires considering the effect of each change on the conditions inside the combustion chamber after the change is made.

The first manual lean power setting may follow an extended climb during which the cylinder heads may have gone to the maximum limit. Immediate leaning with this temperature present is a bad procedure and possible engine damage may result. Some engineers have been pleased to find that the head temperature was reduced by leaning and have used it as the primary means of temperature control at this time. While the indicated temperature came down, there could be no assurance that the other 27 cylinders behaved as well and it can be certain that the temperature of the piston did not lower to the same degree. Do not start the manual leaning until the engine is well cooled and do not use mixture for cooling at this time. Cylinder head temperature is the only direct means of judging

the engine temperature and the most successful engineers leave the mixture control alone until the heads are down to 210 to 220°C. The time taken to bring about this cooling also allows the turbosupercharger to drop in temperature even though it has no direct means of advising the engineer.

The detonation limit line is further pushed to the right and out of the way if carburetor air temperature is brought down to 10 degrees or more below the final value.

Manual Leaning—Sea Level to 35,000 Feet. The following procedure is for manual leaning between sea level and 35,000 feet. Manual leaning can be performed at these altitudes with less concern for the immediate effect on CHT and engine condition due to the cooling ability of the more dense air.

CAUTION

Manual leaning in advanced spark is not permitted above 44.8 inches M.P. at 2200 rpm and above 1940 bhp because serious engine damage would probably result. Also, during all manual lean operation the maximum permissible CHT is 220°C. The maximum permissible CAT. in the 1900 to 2200 rpm range is 20°C.

Experience has shown that operation below these limits is essential to avoid detonation and preignition. With advanced spark, the maximum CAT. must be held below 20°C until reduced rpm gives a smaller temperature rise through the internal supercharger. This prevents the final temperature of the charge air from becoming excessive.

Note

It is very important to have the engine instruments calibrated to effect the procedures contained herein. The use of uncalibrated instruments could easily result in establishing dangerous conditions without the engineer being aware of the situation.

After reaching cruise altitude proceed as follows:

1. Spark advance switches—RETARD. The shift from retarded to advanced spark must be delayed until the mixture strength is sufficiently low to permit firing the charge further in advance of top center. Shifting to advanced spark while the mixture is still in the rich, hot burning area can result in immediate detonation possibly followed by preignition and cylinder damage.

2. Air plugs and intercooler shutters—Full open.

3. Insure that CHT and CAT. are below limiting cruise values. By reducing these temperatures to the lowest practicable value the engineer is insuring that

the engine is in a condition to receive the lean mixtures with advanced spark.

4. Find "best power" at the desired torque pressure and record readings. These readings determine relative engine condition and are used as a reference during the manual leaning procedure. Proceed with the following steps on one engine at a time. "Best power" is found by holding torque pressure constant with the turbo calibration knob while at the same time moving the mixture control from NORMAL, either richer or leaner, and noting manifold pressure. "Best power" is the range in fuel flow in which the desired torque pressure is obtained with the least manifold pressure (or for a given M.P. the power is greatest). Those engines requiring the greatest manifold pressure (more than an inch above average or two inches above the lowest) should be watched carefully during the ensuing steps as deficiencies may be present in these units.

5. Move the mixture control lever toward lean until a 25 psi torque drop is obtained. This reduces the mixture strength to a value that is safe to take advanced spark and about as lean as will remain stable in retarded spark.

6. Place the spark advance switch in ADVANCE and note that the torque pressure rises. It is important that the engineer be certain that the spark has advanced. Torque pressure rise is evidence that the change has taken place. Monitoring of each engine by means of the engine analyzer during this operation will provide a further indication that the spark has been advanced.

7. Re-establish desired torque pressure by increasing manifold pressure with the turbo calibration knob.

Note

Normally an increase of approximately $4\frac{1}{2} \pm 1\frac{1}{2}$ inches manifold pressure above best power manifold pressure will produce best economy mixture ratio for constant CAT., torque pressure, and rpm conditions.

8. If the manifold pressure is below the values given in the M-1 table of the appendix, continue leaning and re-establish torque with manifold pressure until desired M-1 manifold pressure values are obtained (corrected for CAT.). Manifold pressures below the M-1 table values are evidence that the mixture has not been leaned sufficiently. If the mixture is still in the range above .061 it is not suitable for advanced spark and further leaning must be accomplished for safe operation.

9. As a further check on the final fuel flow in the event fuel flow meter instrumentation is in doubt, the observed fuel flow at best economy will be slightly above the fuel flow which occurred after reducing torque pressure 25 psi before advancing spark. Every

possible check and cross check should be made throughout this operation to insure that suitable conditions are present. This is also an example of the greater desirability of following relative values rather than absolute values.

10. Once the desired manifold pressure is obtained, check the fuel flow and the fuel-air ratio. If the fuel flow is considerably higher than charted, the engine is in all probability malfunctioning and the fuel-air ratio may be in a dangerous and hot area (over .061). If this is the case reduce fuel flow with the mixture control, thus reducing fuel-air ratio within the desired limits (.055 to .061) and accepting the lower torque obtained.

WARNING

If fuel-air ratio over .061 is required for stable operation, return to 20 degrees spark and adjust mixture to obtain minimum stable operation.

Again the available cross checks are utilized to insure that too much reliance is not placed on any one instrument. The dangers of operating with advanced spark and mixture strengths greater than .061 require this care. If malfunctioning cylinders are encountered it should still be satisfactory to impose the specified manifold pressure on the remaining good cylinders as each of these cylinders is capable of putting out its portion of the indicated horsepower. The torque horsepower should not be maintained at the specified value as this would involve increasing the indicated horsepower in the good cylinders to make up for the deficiency of those that are malfunctioning.

If enrichment to .061 is necessary to obtain stable operation, the manifold pressure must be reduced about 5 per cent from the value used with .056; otherwise the imep of the good cylinders will become excessive and may initiate detonation or preignition.

Note

Any descent other than long range cruise descent must be made in retarded spark, since there is insufficient time to check fuel-air ratio.

12. It must be remembered that the values set forth in the M-1 table are most desirable with an engine in proper condition. However, satisfactory operation may be obtained between .055 and .061 fuel-air ratio at slightly lower M.P. values when engine instability is encountered at recommended M-1 values.

13. Subsequent cruise power changes in advanced spark manual lean operation will cause slight changes in fuel-air ratio and a check must be made to insure that the desired values are maintained.

Note

When "best economy" has been obtained, note the position of the mixture control lever with respect to the index markings on the quadrant. This will serve as a reference when manual leaning at higher altitudes.

This note is of particular importance when the power used for reference of the index markings is the same as the anticipated power for operation at higher altitude which will be seen in the procedure for manual leaning above 35,000 feet.

Manual leaning—35,000 Feet And Above. The problem of manual leaning above 35,000 feet is more critical than the procedure at lower altitudes due to the poor cooling ability of the low density air. As the mixture passes from comparatively rich fuel-air ratios through the chemically best mixture (.067) it becomes very difficult to maintain cylinder head temperatures at a satisfactorily low level. Therefore, the procedure is set up so that this passage is accomplished as rapidly as possible.

Note

Leaning will be accomplished on one engine at a time.

1. Air plugs and intercooler shutters—Full open. A cool engine is even more important at these altitudes than at lower levels.

2. Fan speed switch—HIGH RPM. This further aids cooling.

3. Master motor—2200 rpm. Manual leaning cruise at these altitudes will usually begin at the highest permissible manual lean cruise powers.

4. Spark advance switch—RETARD. The retard position must always be used for any mixtures richer than .061.

5. Mixture control lever—RICH. The advance from NORMAL to RICH further helps in alleviating the tendency for the engine to overheat.

6. Turn turbo calibration knob its full travel counterclockwise, allowing the CHT and CAT. to drop below limiting cruise values. This still further assists the cooling problem, especially the piston and valves.

7. Fan speed switch—LOW RPM. As the engine is now well cooled, the fan can be operated in the low speed. The engine will shortly receive internal cooling from lean mixtures.

8. Move the mixture control lever toward lean to a predetermined position on the quadrant.

Note

The approximate mixture control lever position should have been noted by the engineer for "best economy" at some lower altitude

where manual leaning techniques could be employed under less critical conditions. This procedure has been found necessary to prevent cylinder overheating.

The evaluation of the engine by noting "best power" mixture has already been performed at lower altitudes. Therefore, time, at the comparatively hot mixture at and near "best power," is saved by dispensing with this part of the procedure. The direct movement of the mixture control to the approximate final position, quickly transfers the operation from reliance on external cooling to reliance on internal lean mixture cooling.

9. Spark advance switch—ADVANCE. By now the mixture should be sufficiently lean and the engine still sufficiently cool to accept advanced spark.

10. Increase manifold pressure with turbo calibration knob until desired M-1 value is obtained (corrected for CAT.).

11. Adjust turbo calibration knob until the torque pressure is 5 psi below the desired value.

Note

This value is specified in order to prevent exceeding the bmep on that engine while the other engines are being set.

This procedure permits each engine to stabilize towards its final power and temperature values while settings are being made on the other engines, thus insuring that no engine will exceed its limits during the interval. Reducing the fuel flow quickly across the board to some reasonable value is preferable to letting some engines remain a long time at high flow while a small final gain is being squeezed out of the first ones.

12. Continue the above procedures until all engines have been manually leaned.

13. Make fine adjustments on each engine to obtain the desired setting. If the torque pressure is slightly low or CHT is climbing, adjustment of the manifold pressure plus or minus 1 inch from the M-1 table is permissible. If the torque pressure remains low, increase the fuel flow 5 to 15 pounds per hour. If the torque pressure is still low after the above adjustment, accept the torque obtained. If CHT increases beyond limits, reduce M.P. with the turbo calibration knob, enrich the mixture so that the engine will not backfire, and immediately return to retarded spark. Use rich mixture to cool the engines. When the engines are within limits, repeat the above procedure to return to manual leaning.

14. Adjust air plugs and intercooler shutters to desired settings.

Note

Engine stability is improved by operating with lower CAT.

Good engine handling procedures at this time can go far toward gaining the ultimate economy possible. It is generally recognized that it is better to decelerate to cruising air speed rather than allowing the airplane to fall below this air speed in the transition from climb to level flight and then requiring it to accelerate to this stabilized velocity. Many engineers have found it desirable to hold the climb power after leveling off so that the airplane accelerates rapidly to a figure well above the final anticipated value. Some cooling benefits are derived during this period with increasing air speeds. Then power is reduced on all engines to a point which is slightly above the final amount so that while the manual leaning procedure is followed, the necessary power reductions on individual engines do not result in allowing the airplane to decelerate below the recommended air speed.

ENGINE COOLING.

It should be remembered that the R4360 engine is an air-cooled engine and its requirements for cooling air should be met if long life is to be attained. When the cylinder head temperature has stabilized, it is known that equilibrium is being maintained between the heat absorbed by the cylinder head material from combustion and the extraction of this heat by the cooling air flow that is passing through the fin and deflector passages. The rate at which heat is forced into the head from the inside depends upon the amount of heat generated in the combustion chamber to produce indicated horsepower which in turn varies with rpm, manifold pressure, carburetor air temperature, mixture strength, spark advance, and other items affected by the general condition of the engine. The rate at which the heat is removed from the head is dependent upon the weight of the cooling air flow and the temperature difference between the head material and the cooling air. The quantity factor governs the number of air particles participating in the activity. The temperature difference factor is a measure of the heat absorbing capacity of each particle.

These two factors work in opposing directions as the altitude of operation is increased. The decreasing temperature is favorable as it widens the temperature difference of the heat exchange. Unfortunately the decreasing air density, which is unfavorable, reduces the weight of cooling air flow at a rate that overcomes the beneficial temperature factor. If constant power is maintained at high altitude, the cylinder cooling problem becomes increasingly difficult.

The principal factors that control engine cooling are those which regulate the rate of cooling air flow.

Air Speed Versus Cooling.

The air speed indicator reading is a measure of the effects of density and altitude, plus the forward speed of the airplane. Air speed variation generally is only

to be used as direct means of cooling control during climbs. At this time a small increase in indicated air speed above that for best rate of climb may materially assist in maintaining satisfactory temperature without appreciable loss of performance. At very low indicated air speeds requiring a high angle of attack, a peculiarity of the aircraft causes a change in the relationship between plug opening and cylinder cooling. In this attitude there is a tendency for the air under the wing to flow around the trailing edge to the upper side. This results in a forward flow through the bottom of the air plug opening which interferes with cooling air flow through a portion of the engine. This may be a limiting factor in attaining a minimum indicated air speed in climb and cruise at high altitude. If cylinder head temperature cannot be controlled by direct means, increased air speed may bring the required relief even though additional power is required.

Engine Fan Operation.

The engine fan is installed to aid in engine cooling. At low air speeds or during ground operation, the fan contributes its greatest share of the cooling load. As air speed increases, the fan becomes increasingly less essen-

tial, until at high air speeds, the naturally induced air flow provides most of the cooling air. The fan is driven by the crankshaft through hydraulic couplings. The low speed drive should be used as long as adequate cooling is possible because of the high power requirements of the high speed drive. High speed fan drive should be used only at very high altitudes with normal rated power.

WARNING

The use of high ratio fan operation is restricted because of structural limitations of the fan. (Refer to "Operating Limitations," Section V.)

When engine overheating is experienced, shifting to high fan drive should be accomplished if within structural limitations of the fan. It should be noted that the net loss in thrust caused by shifting from low to high fan is less than indicated by the torque drop because the higher fan power is partially compensated by added jet thrust of the cooling air.

In using the fan speed selection for cylinder head

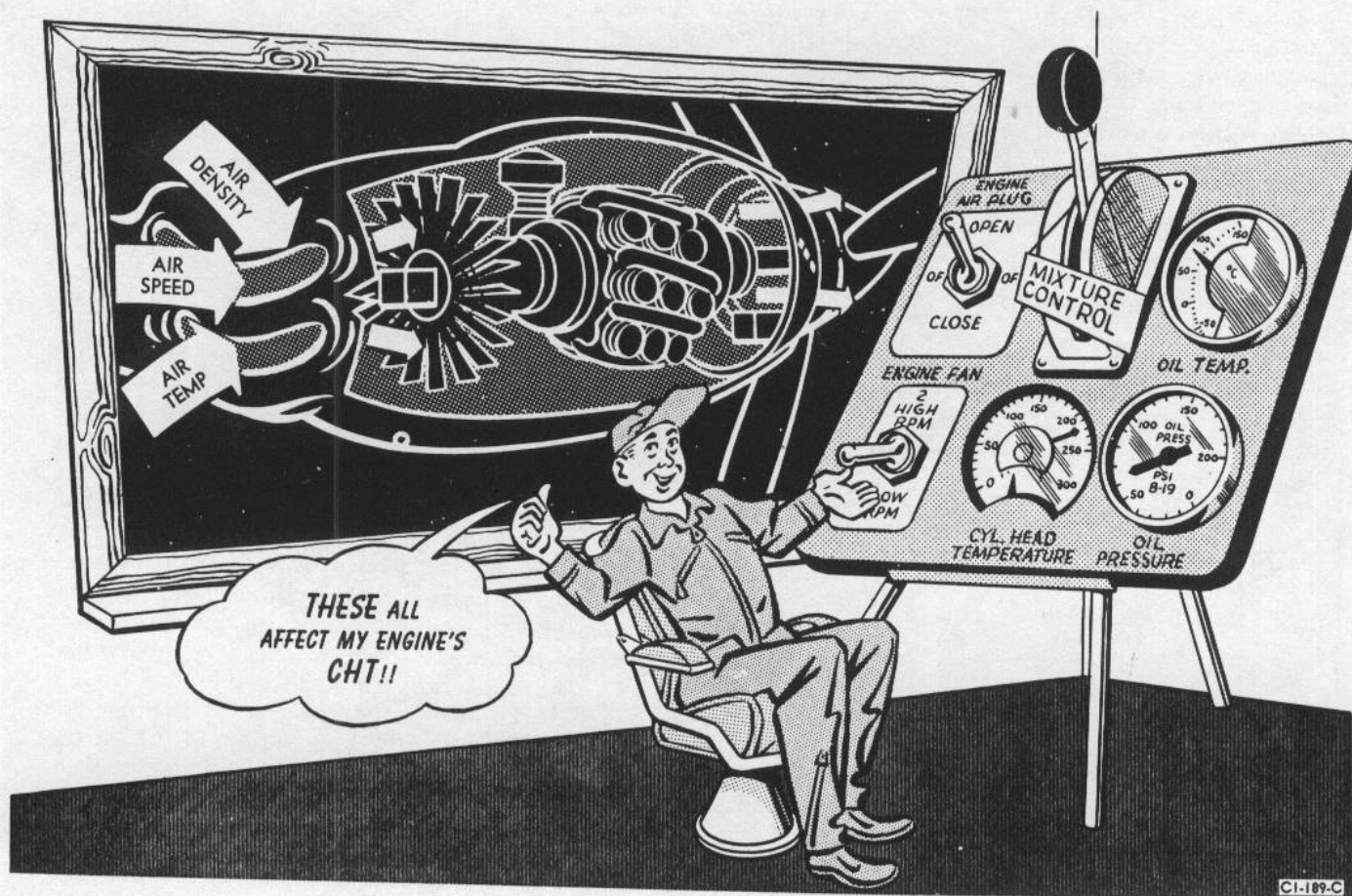


Figure 7-21. Principle Factors Affecting Engine Cooling

temperature control, the engineer must observe the torque pressure reactions as a check that the fan drive couplings are in satisfactory condition. The shift is performed by changing the flow of oil from the low speed coupling to the high speed coupling. As the low speed coupling drains, the high speed unit is filling and when the process is complete the fan is turning at the higher ratio. For a short interval, during which a quantity of oil still remains in the low speed coupling and the high speed coupling has received a sufficient amount to start transmitting power, the two couplings are bucking each other and more power is being absorbed from the crankshaft than when either coupling is functioning independently. This shows up in a momentary reduction of torque pressure, followed by an increase to a new reading that is below that when the fan was driven at low speed.

This torque oil pressure reaction furnishes a check as to the amount of sludge in the couplings. The usual momentary drop is 15 to 20 psi, and the maximum is 25 psi with a return to 12 to 15 psi below the original torque oil pressure.

Air Plug Operation.

The air plug is the remaining direct control over cooling air flow and can be considered as a throttle for the cooling air passage. When the combination of air speed and fan speed results in an excess of air being pumped, over that required to maintain satisfactory temperatures, considerable drag is eliminated by restricting the passage and the weight of air being pumped.

Cooling by Mixture Control.

If, after shifting to high fan drive, additional cooling is required during climb up to 40,000 feet, it can be obtained by increasing air speed or shifting to RICH mixture.

If the cylinder head temperatures exceed the limit with

NORMAL mixture and high fan drive in level flight at powers above the limit for manual leaning, shifting to RICH will improve cooling. For powers below this range, the use of RICH mixture provides little improvement, but manual leaning to "best economy" is very effective in reducing temperatures. Over 20°C CHT reductions can be realized by leaning out from NORMAL to "best economy." At the highest manual lean cruise powers, cylinder temperatures will be close to or above the limit in NORMAL mixture. Since normal mixture operation results in cylinder head temperatures higher than the temperature at "best economy," it is advisable to get into the air cooling range of mixtures in one step, rather than several small steps. This is accomplished by leaning out in the first step until the torque drops an amount which requires 4 inches M.P. increase to re-establish torque. A torque drop of 15 psi is generally about right.

To obtain the full benefit of the leaning effect on cylinder head temperature, it is important to lean out all the way to "best economy," because most of the temperature reduction results from the last portion of the mixture control adjustment. Following the initial leaning of 4 inches M.P., a range of 1 or 2 inches M.P. in either direction should be investigated (maintaining constant torque) to establish the minimum fuel flow accurately.

Cylinder Head Temperature.

The thermocouple for measuring cylinder head temperature is attached to only one of the twenty-eight cylinders. This single temperature connection between the gage and the engine provides a relatively restricted means for "seeing" the over-all heat condition and the resulting effect on combustion and critical parts. The particular cylinder was selected, as the result of ground and flight testing, to be the hottest under most operating conditions.

At low fuel-air ratios and low powers, however, the "hot" cylinder location shifts from the cylinder on which the cylinder head thermocouple is located, to one or more of several other cylinders which may run as much as 20 to 30°C hotter under these conditions than the cylinder with the thermocouple. These results were obtained on engines with ignition and carburetion in good condition. At the same time all limits of temperature, power, and other items were being observed. Therefore, the cylinder head temperature reading is representative of the general engine heat condition rather than evidence of individual cylinder malfunctioning. The chance of finding trouble on any one cylinder is the one out of twenty-eight chances that the difficulty is in the one to which the thermocouple is attached.

Also, the thermocouple is located in the cylinder head at an arbitrarily selected spot which is neither the hottest nor the coldest part of the head. The temperature measured at this point is merely a reference to

ENGINE COOLING THROUGH USE OF MIXTURE CONTROL

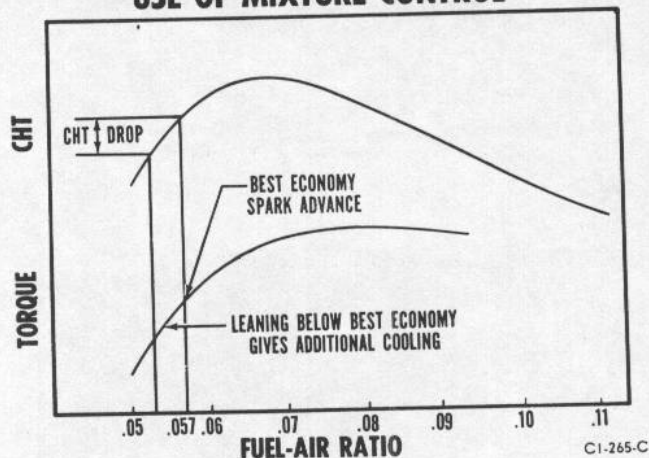


Figure 7-22.

temperatures at other critical points, especially the piston head, exhaust valve and seat, exhaust valve guide, and spark plug. The relationship between the temperatures at the critical points and the cylinder head temperature demands that limits be established. Experience shows that these limits are necessary, not only to prevent detonation and its destructive results, but also to prevent the formation of sludge and carbon. Failure to observe the CHT limits may also result in lead fouling and spark plug malfunctioning.

In deciding on the cylinder head temperature for operation, a compromise between performance and durability must be made. If the demands for maximum range are foremost, head temperature will be held at the upper limit to reduce the drag of excess cooling air flow. Tactical necessity will dictate this "all-out" operation on occasions. It must be realized that exceeding the limit can lead to difficulty. Since the carburetor air temperature is also at its limit during maximum cruise, the combination can bring about detonation or preignition if any engine item is in substandard condition.

When tactical demands are not pressing, it is sound judgment to hold more conservative temperatures. Engine operation and life through the years have been best with cylinder head temperatures 25 to 40°C lower than the maximum limits and there has been no recent change of material which would give the same durability with higher operating temperatures. Operation in this manner serves to keep the engine in a condition permitting sustained "all-out" performance when needed. Habitual use of limiting temperatures reduces the margin of safety and keeps the engine vulnerable to the unknown little things that go wrong or accumulate between inspections, little things that would not be destructive at lower temperatures and powers.

Most of the temperature concern of design, development, and testing has been of the troubles caused by high temperature. Cold temperatures can be equally troublesome with almost the same list of difficulties. Good operation should point to a middle range, where the greatest amount of satisfactory experience has been accumulated.

On the ground, experience has indicated that temperatures lower than 185°C are apt to cause lead fouling troubles. With temperatures above about 220°C, the tendency is toward sludging, rocker box coking, and a hardening of rubber seals and insulation resulting in oil leaks and ignition troubles. For these reasons the cylinder head temperatures on the ground are recommended to be about the middle of this range. For idling conditions the air plug is partially closed; for high power operation the plug is open in order to anticipate the need that will accompany the high power operation. At idling speeds the direction of the wind may offset the ability of the fan to circulate air through

the engine and cause some of the cylinders to run excessively hot, even though the one cylinder under observation is within limits.

For take-off it is realized that the power is going to be at the highest value of any time during the operation of the engine. The air speed will be the lowest, at the start, and gradually build up to the speed of the climb after take-off. The usual procedure is to set the air plugs approximately one-half open so that the maximum temperature limit will not be exceeded at any time during the take-off and initial climb. The air plug setting can vary some with the weight of the airplane as the gross weight affects the acceleration and length of time to attain final speed. The plug setting is also affected by the outside air temperature and can be partially closed for cold weather take-off; however, wide open plugs will usually be required during hot weather.

When the power is reduced from the take-off values to the normal rated power used in climb, there will be a reduction in the fuel-air ratio as delivered by the carburetor. This reduction tends to keep the cylinder head temperatures up and thus requires a fairly wide open setting of the air plug, particularly at low indicated air speed. If the mixture is manually adjusted to something less than the carburetor normal mixture strength, the air plug may have to be opened somewhat to accommodate the CHT rise.

EFFECT OF FUEL-AIR RATIO ON CHT

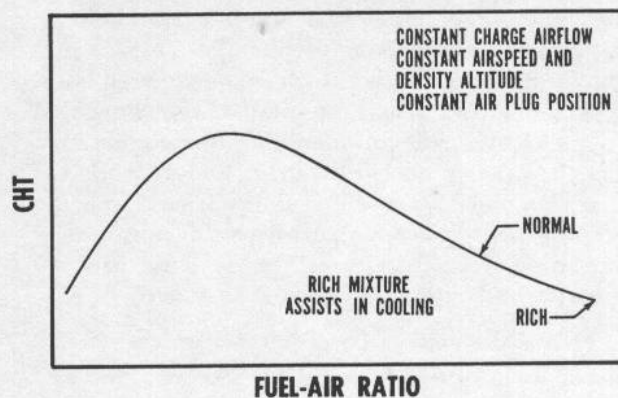


Figure 7-23.

CI-262-C

If anything is done during level cruising flight to change the drag of the airplane, such as opening the bomb bay doors, camera doors, or extending the gun turrets, the effect upon the indicated air speed and cooling air should be anticipated and the air plug reset to suit the new condition. If the indicated air speed of the airplane is maintained to carry on the cruise flight control at the weight of the airplane, there will be required an increase in power to offset the drag of the new condition.

It is obvious that increased horsepower will require a readjustment of the air plug. Temperature readings will start to rise very shortly after the increase in horsepower, but it will take three to five minutes for the temperatures to stabilize. This stabilization period is the time in which the air plug must be adjusted to prevent the cylinders from exceeding the limits.

During letdown, with reduced power and the air flow maintained as shown by the indicated air speed, it may not be possible to maintain the cylinder head temperature up to the desired minimum even with the air plugs in a closed position. This should not cause any undue concern unless the engine begins to run rough or backfire. In this case the mixture may be enriched somewhat, if the powers are quite low, in order to approach the .067 fuel-air ratio which is the hottest mixture strength.

While preparing for a landing, each time that the drag of the airplane is increased the power requirement are increased, and the cooling must be adjusted to keep the cylinder temperatures within limits. Again, power versus indicated air speed tell of the heat being forced into the cylinder heads and the ability of the air to remove it. The air plug must be opened to enable the engine to use the available air flow provided by the indicated air speed.

During all ground operation, including taxiing, the tendency will be to have the air plug open fairly well. However, it is necessary to adjust the plug opening to keep the cylinder head at a temperature that will not encourage plug fouling. Just prior to shutting down the engine, the cylinder head temperatures should be lowered as much as conveniently possible. Tests of rubber items around the engines, such as the pushrod housing seals and ignition harness installations, show that their temperatures rise considerably after engine shut down as they absorb heat from the cylinders while the cylinders cool. On days when there is no wind to bring cool air into the engine compartment the rubber temperatures can exceed their limiting values five to seven minutes after the engine has been shut down.

The effect on the rubber parts is cumulative. After a number of times of overheating they become hard and brittle. The oil seals lose their resiliency so that they are not able to seal the oil, and leaks ensue. The ignition harness will break down and more than likely cause trouble at altitude. Prolonged running of the engine at cylinder head temperatures below 180°C brings on lead fouling troubles and it does not pay to try to get the cylinder temperatures below 180°C. If the airplane is headed into a stiff breeze, there is less need of getting the cylinder head temperatures down to a low value. Carburetor air temperature after shut down is indicative of the flow of heat from the cylinders to other parts of the engine.

OIL SPEWING.

Oil spewing is a phenomenon connected with high altitude operation of some B-36 aircraft. Such factors as rpm, blowby, scavenge pump efficiency, oil pressure, temperature, viscosity, oil contamination, and crankcase pressure are believed to effect spewing severity, but the exact share each factor contributes to the whole is not agreed upon. Spewing is a limiting factor in that the oil supply may be depleted requiring that the propeller be feathered; also, the oil spewed from the crankcase breather congeals and blows into the props where it is sometimes thrown into the fuselage, causing structural damage.

One of the present "fixes" is a crankcase aneroid valve, which retains crankcase pressure at altitude, and thereby retains scavenge pump efficiency. The aneroids are not completely effective in all cases and are somewhat fail-prone. When they do fail in the closed position, excessive crankcase pressures can result and an excessive number of oil leaks may be encountered. A similar aneroid valve in the oil tank helps retain the oil "head" to the engine. If it fails in the closed position, excessive oil consumption, oil spewing, or oil tank rupture may result.

There is very little the engineer can do about oil spewing except reduce rpm, which is not always feasible. A reduction in altitude, which would constitute a compromise of the mission, may be the last resort.

One type of oil contamination, referred to above, is the presence of "pickling" fluids in the oil. Another type results from the presence of water in the oil.

Water, a product of combustion, condenses out in the cold portions of the oil tank and settles in the sump. When the sump becomes full or sloshes over, the water enters the oil-in line, and is at the temperature of the oil. When the pressure is reduced, by change in altitude or speed of the engine oil pump, there will result a combination of pressure and temperature that causes the water to evaporate and increase its volume. When the water vapor reaches the oil pump, a momentary or extensive drop in oil pressure will result, depending on how long it takes to pump out the vapor and get good oil again. As the oil and water vapors enter the engine oil passages, pressure causes the water vapors to recondense. As the oil and water are released within the engine, the water evaporates again. The resulting expansion increases the pressures in the crankcase and causes or increases oil pressure, breathing, and spewing troubles.

PREVENTION AND ELIMINATION OF SPARK PLUG FOULING.

Spark plug fouling is considered to be undesirable deposits that accumulate on or near the spark plug electrodes and cause misfiring. Fouling may result from carbon, lead, ice, thread lubricant, metal particles, or preservative compounds. The regular ignition system checks will give indications of malfunctions some-

where in the ignition system. Fouling, however, is concerned only with the combustion end of the spark plug and standard checks will not always point directly to the source of trouble. Regular monitoring with the engine analyzer provides a valuable means for determining the operating efficiency of individual spark plugs.

Ground Run-Up.

The tetra-ethyl lead used in the fuel contains certain scavenging agents. These agents unite with the lead and at low cylinder temperatures condense out on the inside of the cylinder. At idling speeds, low cylinder temperatures are especially conducive to lead fouling. However, during ground operation there must be a compromise between high temperatures to prevent fouling, and cold temperatures to prevent overheating of rubber seals, ignition harnesses, and magnetos. Therefore, the CHT must be kept within the established limits by means of air plug adjustment. For the procedures on prevention and elimination of spark plug fouling during ground operation, refer to "Reciprocating Engine Ground Operation," Section II.

In-Flight Prevention.

In-flight symptoms and procedures are basically the same as those on the ground except that governing propeller is used rather than fixed pitch; powers are at cruising or climb rather than idling, and very lean mixtures and advance spark may be in use while cruising. The M.P., rpm, and CHT are higher than at idling. The carburetor air temperature varies with weather conditions. These factors are practically all favorable to lead fouling prevention except the very lean mixtures. Periodic changes from rich to lean mixtures aid in-flight prevention. Other mild or severe thermal shocks help. Cylinder heads should not operate in flight for long periods at temperatures lower than 185°C. Cruising optimum is from 200 to 210°C and from 220 to 230°C for higher powers when considering fouling. Carburetor air temperature must be considered in relation to the existing heat rise in charge air through the internal supercharger and to the amount of fuel absorbing heat from air. Carburetor air temperature near 0°C is needed with high rpm and rich mixtures; medium carburetor air temperature with medium rpm (maximum cruising rpm); high carburetor air temperature is required with low rpm, even with lean mixtures, to compensate for low supercharger heat rise.

Primer Purging. The addition of prime to the metered lean mixtures produces a sudden temperature rise or fall (figure 7-24) which can remove combustion chamber deposits by thermal shock. The procedure that follows is beneficial in preventing lead fouling and in clearing incipient stages of leading before backfiring occurs. It should be accomplished once every two hours during cruising; whenever early stages of lead fouling are indicated by ignition analysis; and fifteen minutes before climbing. One engine or symmetrical pairs of

THERMAL SHOCK BY ADDITION OF PRIME

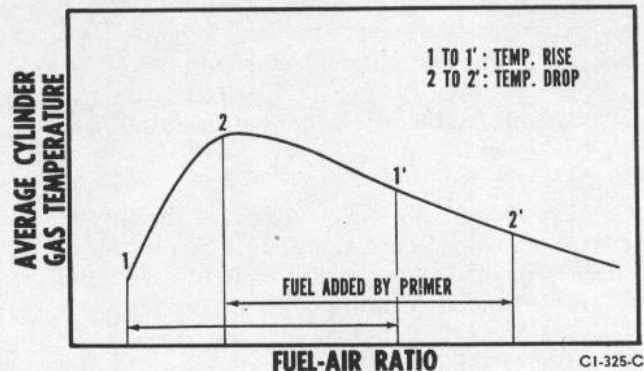


Figure 7-24.

engines are purged at a time.

1. Maintain manual lean setting.
2. Place the spark advance switch in RETARD and check that it shifts.
3. Hold the primer switch ON from sixty to ninety seconds.
4. Do not disturb the position of the mixture control levers.

Start to prime about the time the spark reaches the retard position since the lean mixture may be near unstable operation in retard spark. Satisfactory spark advance operation is indicated by a drop in torque pressure; instability with a lean mixture and retarded spark is indicated by torque pressure fluctuations. Addition of prime is indicated by increase in torque pressure (figure 7-25) as well as in fuel flow. Resulting fuel-air ratios are near those used during take-off and climb.

At the end of sixty to ninety seconds, release the primer and return the spark to the ADVANCE position. Fuel flow should return to that previously used. If the flow is higher, the primer solenoid valve may not have closed; a flick or two of the switch should shake it loose, otherwise the mixture will have to be reset.

TORQUE RISE WHEN PRIMING AT A LEAN MIXTURE SETTING

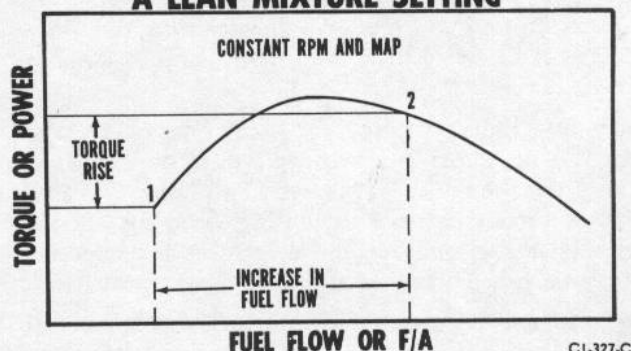


Figure 7-25.

CAUTION

Detonation may be experienced if advanced spark is used when thermal shocking with increased fuel flow (primer and/or rich mixture). Therefore, during all thermal shocking, the spark must be retarded.

If lead fouling causes backfiring in flight or the engine analyzer shows a fouled condition, the same procedure is used except to place the mixture in RICH after the spark is retarded. After priming 60 to 90 seconds place the mixture in NORMAL and manual lean, noting the purging effect. If the purging was effective, set the desired power and survey the engine with the ignition analyzer, determining if the condition was cleared completely. If the purging was not effective, repeat it once. If the repeated step was ineffective and water injection fluid remains, make one attempt to clear the condition by using water injection.

Water Injection. Before using water injection for purging, it is essential to make sure that the spark is actually retarded. Place the mixture control in NORMAL and use prime if necessary to get through the backfiring range. Then establish power near normal rated and turn on water injection for 30 to 90 seconds (fluid quantity permitting). Normal water pressure rise, rise in torque pressure, and drop in fuel flow indicate the water system is functioning. When indications show the fluid running out, shut off the water injection. Reduce to desired power *slowly* to determine effectiveness of the clearing procedure.

There is an apparent purging process in the return to cruising power which is due to temperatures and dimensions readjusting. Engines sometimes smooth out from 10 to 15 minutes after resuming cruise as evidenced by gradual reduction of fluctuations in the torque pressure.

Should backfiring continue after the water injection treatment, the underlying cause is probably not lead fouling or the plugs are fouled beyond recovery. A power setting should be chosen that does not produce backfiring. Usually, a setting in the power enrichment range or extremely low powers allows this. During any cruise condition determine whether shutting down the engine will be more profitable than using it with inefficient power.

Water injection purging, the principle of thermal shock, is similar to prime purging. Water injection purging has the added advantage of the power change action as a deterrent to lead fouling. Scan the affected engine with the analyzer and determine the effectiveness of the procedure.

Spark Advance. Tests made under laboratory conditions shows that the temperature of the spark plug core nose increases about 100°C (180°F) when shifting from

retarded to advanced spark (figure 7-26). These tests were made at power settings between cruise and normal rated. It can be seen that use of advanced spark may have considerable effect upon the accumulation of deposits or upon purging of the deposits after they have accumulated. The above example shows only one method of increasing the core nose temperature to prevent fouled spark plugs. The core nose temperature is also affected by many other factors such as: imep, exhaust back pressure, fuel-air ratio, CHT, rpm, and CAT.

Fuel-Air Ratio. The study of the effects of fuel-air ratio on spark plug core nose temperatures shows about the

EFFECT OF SPARK ADVANCE AND F/A ON SPARK PLUG CORE NOSE TEMP.

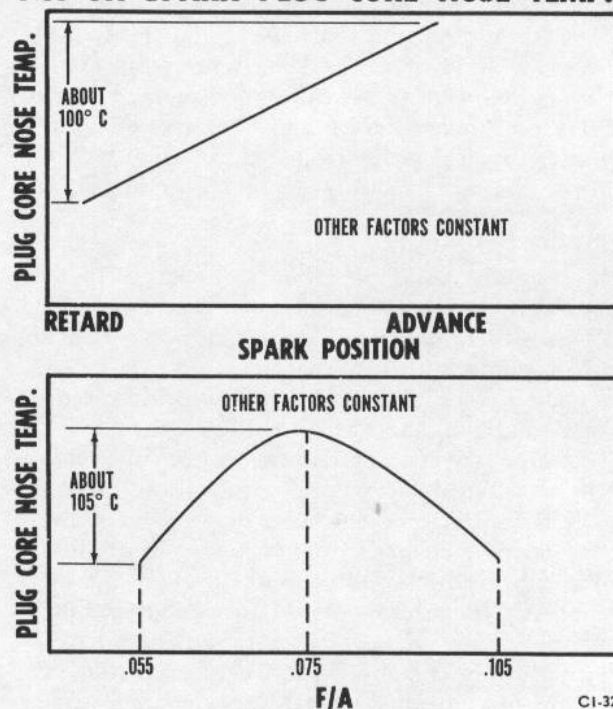


Figure 7-26.

same range of temperature change as for spark advance. The hottest temperature of the core nose did not come with the mixture strength for hottest gas temperature (.067) but at .075. This apparent discrepancy is associated with the compression effects on the first gases to burn after the flame is farther along and pressures are still increasing. The result is that the first gases to burn, near the spark plug under low pressure, rise to a certain temperature at the time of burning and the temperature increases greatly with further compression. Since the highest power at a given air flow or manifold pressure is found with "best power" mixtures, it may be surmised that the hottest temperature would come with lean "best power" mixtures. The temperatures, found in the test, lowered with fuel-air ratios leaner or richer than .075 (figure 7-26). At .055

and at a .105 fuel-air ratios, the temperature of the spark plug core nose was about 105°C (190°F) lower than at .075.

Rpm. An occasional increase of rpm may be used beneficially in clearing the combustion chambers. To do this, increase rpm to about 2300 for one or two minutes using cruise M.P., hot mixture strength (.067 to .075), and retarded spark. This purging procedure must be used carefully as operation will be approaching the detonation and preignition limits. The combustion chamber is being subjected to high temperatures, made even higher by the internal supercharger (at moderately high rpm), without the benefit of the rich mixtures ordinarily used with these engine speeds. The high temperatures tend to loosen lead deposits and allow them to be carried out the exhaust.

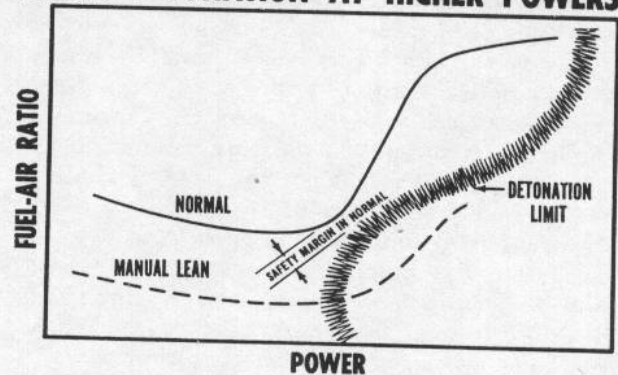
After this purging, the spark plugs, exhaust valves, and piston heads may have approached dangerous temperatures. It will be beneficial to operate for a minute or so at low rpm and power to allow the heat to dissipate and the temperatures to become lower than cruise power temperatures. When cruise power is resumed the engine temperatures will rise but will take a long time to stabilize completely. If the cruise power is established with internal parts hotter than stabilized values, the temperatures will fall rapidly at first. The remaining degrees take longer, never lowering fully, during which time engine distress may occur. To prevent such trouble, approach limiting temperatures from below rather than above.

Manifold Pressure Or Bmep And Exhaust Back Pressure. These items are discussed together in that they are difficult to separate when an engine is equipped with turbosuperchargers. Laboratory tests show that an imep increase of approximately 60 psi causes the spark plug core nose temperature to rise about 80°C (142°F). This imep change increases the bmep about the same amount because, at a fixed rpm, the change in friction horsepower is small. The same series of tests showed a core nose temperature rise of about 65°C (118°F) when exhaust back pressure is increased from 31 inches Hg. to 41 inches Hg. On the aircraft these two effects would be added together in suitable proportions for dual or single turbo operation and other actual operating conditions.

Cylinder Head Temperature. A cylinder head temperature rise can sometimes be used to aid in clearing fouled plugs. As might be expected, a change in cylinder head temperature produces a change in spark plug core nose temperature practically a degree for a degree. The spark plug core nose in the test for this effect runs about 300°C (710°F) hotter than the cylinder head bayonet thermocouple.

Carburetor Air Temperature. In the single cylinder tests being quoted there was no change in the temperature of the spark plug core nose when inlet air temperature was changed 28°C (50°F). The effect of inlet

CARBURETOR METERING IN MANUAL LEAN CAUSES DETONATION AT HIGHER POWERS



CI-331-C

Figure 7-27.

air temperature on imep and cylinder head temperature was compensated for by changes in manifold pressure and cooling air flow. This was necessary to hold other readings constant. In fact the whole series of tests was run in this manner. These tests show only the effects on the spark plug core nose temperature.

High Power Before Landing. Some operators have derived benefit from use of normal rated power for a minute or two, five or ten minutes before entering the landing pattern. This gives a purging effect after descent and, if ineffectual, a chance to size up the engines so that discrepancies can be reported and cleared up. To determine engine condition at high power it is recommended that a survey of all engines through ignition analysis be made after descent and prior to landing. In-flight checks of this nature are useful in reducing the running time on the ground after flight.

CONTROL OF DETONATION AND PREIGNITION.

Detonation limits almost all phases of B-36 engine operation. Its sustained occurrence in moderate form causes inefficient combustion and deterioration of combustion chamber parts. Short intervals of severe detonation cause in-flight failure necessitating shutdown.

When the mixture control is in NORMAL, detonation protection (figure 7-27) is provided by the "built-in" carburetor settings if other limits are observed. When mixture is leaned from NORMAL, the "built-in" margin is eliminated and the maintenance of detonation-free operation requires the greatest judgment of the engineer. He must rely on experience, either his own or someone else's. Remember, it is not the engine that detonates, but the charge air mixture and this is basically a condition brought about by temperature.

At high power all the temperature factors are unfavorable. The high rpm means the fast turning internal supercharger is giving its highest heat rise. The large amount of charge air being burned produces high combustion chamber temperatures. Therefore the greatest mixture enrichment is required with maximum engine

output. As power and rpm are reduced, the temperature factors become more favorable and it is possible to reduce mixture strength with safety. Eventually, power and rpm reduction reach a point below which it is possible to use "best power" fuel-air ratio without detonation. Finally, at still lower power and rpm, "best economy" fuel-air ratio is entirely safe. The carburetor was originally set for normal mixture use during all operation above 70 per cent normal rated (including fan) horsepower. The fan power is included to relate mixture strength to indicated horsepower, which describes the actual situation inside the cylinder. However, the B-36 range requirements are important enough to use manual adjustment up to normal rated power to compensate for differences in carburetor.

During manual leaning, engine operation is approaching the area of possible detonation. However, the lower fuel-air ratio is only one of the factors that make this procedure so marginal. To determine the effect of the many variables on the detonation limit, it is necessary to run the engine on a test stand. This must be done so that one factor can be checked while all others are held constant.

For instance, the test engine may be run with all

EFFECTS OF DETONATION ON CHT AND BHP

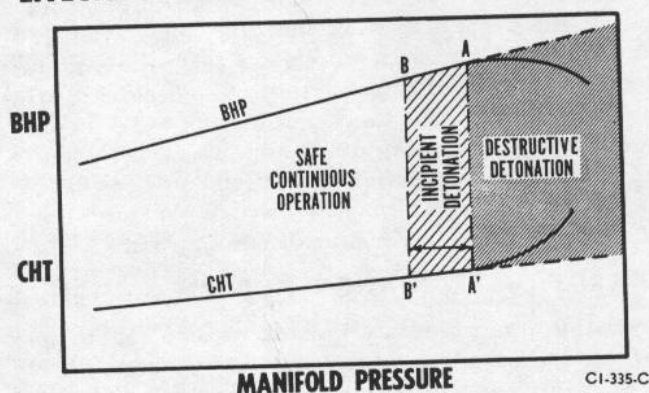


Figure 7-28.

known variables, except M.P., held constant. Readings taken at various increments of M.P. show that for most of the way horsepower and CHT increase in a straight line relationship with increasing M.P. (See figure 7-28).

The situation changes, however, if the M.P. is pushed far enough, the power line sags and the cylinder temperature line begins an upward swing. In a change from straight lines to curves, points A and A' are definite indications that detonation is present. By the time it progresses to a degree of evidence, it is mildly destructive. The operational interest is to the left of A and A' where detonation is present but not noticeable. To find these incipient stage limits, special analyzers are necessary that detect the slightest traces by the vibration effect on cylinder structure. This instrumentation indicates the immediate limit of safe operation to

be left of B-B.

Additional information is obtained in the same manner with different fuel-air ratios. Another series is run at different rpm using the previous series of constant fuel-air ratios. This is continued until every conceivable combination of rpm, fuel-air ratio, cylinder head temperature, carburetor air temperature, spark advance, and fuel grade has been tested. In addition to operating variables, design factors such as compression ratio, valve timing, cam profile, combustion chamber configuration, and spark plug type can be "cranked in." Also, conditions not within operation control such as humidity and exhaust back pressure are held constant or accounted for by accepted corrections.

The result of the study is data plotted in an orderly manner. Distinguishing the variations of rpm from the rest of the data shows the effect of engine speed on the detonation limit to power (figure 7-29). Rpm exerts influence principally through its relation to the internal supercharger temperature rise. With high rpm, the charge entering the cylinder is hottest and most likely to detonate. As engine speed reduces, the charge cools and is less likely to kindle ahead of the normal flame front. Do not confuse this with data based on unsupercharged engines, where heat does not rise ahead of the cylinder and the main detonation influence of rpm has a favorable turbulence effect as rpm increases. This occurs in supercharged engines but is outweighed by the heat rise factor.

Carburetor air temperature influence (figure 7-29) is similar to that of rpm because of its effect on the temperature of the unburned charge before and during combustion.

The cylinder head temperature (figure 7-29) also influences the heat condition of the charge.

Spark advance, another variable subject to the engineer's control, also has a definite effect on the detonation limit as shown in figure 7-29.

Humidity or water vapor in the atmosphere has a strong effect upon detonation, possibly because the water molecules disassociate into hydrogen and oxygen atoms as the temperature rises during compression and flame propagation. Tests show that there is a greater tendency toward detonation with dry air than with humid air. Lubricating oil has a very low octane or performance number and severely lowers the rating of a fuel when mixed with it, as it might if an oil tank leaks into the fuel tank. Leaking impeller shaft oil seal rings are not likely to give this type of trouble because of the reversal of flow past the seals between low manifold pressure, when oil is drawn into the induction system, and high manifold pressure, when charge air or air and fuel leak into the crankcase.

Backfiring.

The most frequent causes of backfiring are the use of excessively lean mixtures, which burn too slowly, and failure of the ignition system to provide a satisfactory

EFFECTS OF OPERATING VARIABLES ON DETONATION LIMITS

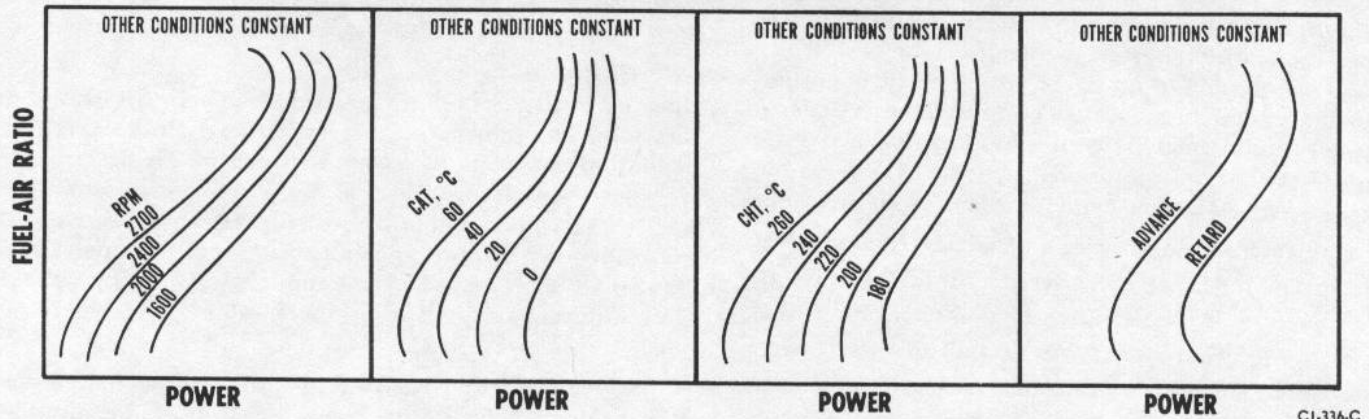


Figure 7-29.

spark. The two main classes of ignition malfunctions are energy losses in the system external to the cylinder and plug fouling from lead or other materials. The former results in insufficient voltage across plug electrodes and the latter in a short circuit instead of a spark. The external system performance depends on magneto pressurization and ventilation, clean connection throughout the system, and good insulation.

Mild backfiring due to lead fouling may be encountered during sustained flight at lean mixture settings. If it occurs, increase power *slowly*, keeping just within the range of mild backfiring until the backfiring ceases.

CAUTION

Sudden acceleration of power must be avoided as it may produce severe backfiring.

If operating with retarded spark and backfiring persists, it is sometimes stopped by shifting to spark advance, reducing power if necessary.

TRIM OF ENGINES VERSUS TRIM OF AIRCRAFT CONTROL.

When, for any reason, the power of one or more engines is low, or the propeller is feathered, some consideration must be given to the effects on the aircraft trim and miles per pound of fuel. Except for wing or fuselage warpage, the rudder and aileron trims will be in neutral positions when the engines are all evenly balanced on power, and the aircraft loads and drag items are balanced. If an outboard engine is low on power or its cooling drag is high compared to the other engines there is a yawing effect (a torque), the opposite good engine tending to turn the airplane toward the side with low power. An equal and opposing torque must be generated by the rudder which is offset at first by the pilot pushing on the rudder pedal, then

he transfers this load to the trim tab by an appropriate setting of the trim tab control. The offset rudder generates some drag that slows the aircraft or requires a little more power from all the engines to maintain speed. The offset rudder causes the aircraft to crab very slightly to follow the desired track, causing the air to flow over the wing with a cross component. The cross component works on the dihedral of the wing, setting up a slight rolling tendency that the pilot holds off for a little while with the wheel and soon transfers to the aileron trim tabs. The asymmetrical ailerons cause additional drag, slowing the airplane further and requiring additional rudder trim at the slower speed to trim the airplane, or additional power to maintain speed.

Under circumstances of this nature, it may be well to consider balancing up the engines by reducing power on the opposite outboard good engine, approximately equal to an outboard engine, about two-thirds of the loss in power of a center engine, and about one-third of the loss of an inboard engine. The proportionate reductions are due to the distances of the respective engines from the airplane center line. The total power required is attained by increasing the rpm of all engines to divide the loss of power of one engine among the others. Variations of this scheme can be applied by dividing the unequal power among two or three engines. It does not pay to shut down one good engine to balance another that is shut down. Here engine trim must be compromised with control trim. If the control trims get cockeyed, it is well to check engine trim.

The engineer and the pilot must cooperate closely at all times to obtain best range results. Precision piloting can be nullified by inaccurate power plant handling and it is equally true that top quality engineering can be cancelled by indifferent airplane handling. Five to ten miles an hour indicated air speed can be lost by sloppy airwork which can use up all the fuel that a good engineer can save.

ENGINE ANALYZER.

The engine analyzer, when installed as an airborne unit, provides a means of accurately and quickly evaluating the ignition system while in flight or during ground operation. On group 15 airplanes, through use of a vibration pickup mounted on individual cylinders, complete engine analysis is possible through interpretation of the various vibrations (figure 7-30) caused by valve closings and other cylinder vibrations.

Through regular use of ignition analysis, it is possible to determine the firing characteristics of all spark plugs and detect the various degrees of malfunctions in the rest of the ignition system. Weak and mistimed magnetos, open, shorted, or disconnected ignition leads, arcing or out of synchronization breaker points, as well as various distributor malfunctions can all be detected (figure 7-31). As combustion within the cylinder has a definite effect on the characteristics of the ignition pattern, intake manifold failures and valve malfunctions may often be detected. Individual defective spark plugs or other defective ignition units can, in this manner, be detected and replaced prior to severe malfunctioning of the engine. Considerable time and replacement part saving is thereby accomplished by replacing only those components of the ignition system known to be caus-

ing trouble. Also, in the case of malfunctioning engines due to causes other than ignition, it is possible to establish the serviceability of the ignition system and look further for possible carburetion or valve system malfunction.

Ignition analysis is particularly valuable in determining those components of the ignition system breaking down only at altitude. Very often engine malfunction is experienced at altitude operation, but returns to normal when trouble shooting procedures are applied on the ground. Through application of ignition analysis at altitude such items as weak condensers, ignition harness failures, and misfiring spark plugs may be detected.

When regularly applied in flight, the engine analyzer has been particularly valuable in detecting lead fouling of spark plugs in their early stages. The application of prime in purging procedures is far more effective when applied prior to complete shorting of the spark plug. In addition it is possible to determine the effect the application of prime has had, and whether additional applications are required to complete the desired procedure.

The engine analyzer should be employed whenever a magneto check is made in judging ignition system performance. It must be remembered that "no excessive drop-off" on either the left or right circuits is not necessarily an indication of "no trouble," since the system being checked might have equal dead components in both halves of the system and selecting either half of the dual ignition system will make no difference in output. In performing ground checks of suspected engines, magneto checks at higher power settings are not advisable. The engine analyzer can be safely utilized in detecting those spark plugs whose operation is satisfactory at normal magneto check engine powers but cut out at higher power.

It should be realized that the engine analyzer does not replace the present methods of trouble shooting or malfunction correction, but rather is a valuable aid or tool in supplementing these checks. The secret of successful analyzer utilization is that of a competent operator who can accurately interpret the patterns and who will use good, sound, logical reasoning in arriving at his decision for corrective action.

Cylinder Vibration Analysis (Group 15 Airplanes).

Vibration analysis on all cylinders should be made not only during the ground check, but also following each power change and before descent from altitude. Use a slow sweep to ascertain that all valves are functioning properly and that combustion is within the normal limits (not exceeding the exhaust valve closing event in amplitude) and that no mechanical malfunction is evident. Use vibration analysis at all other times as considered necessary, based on engine instrument indications and other engine checks.

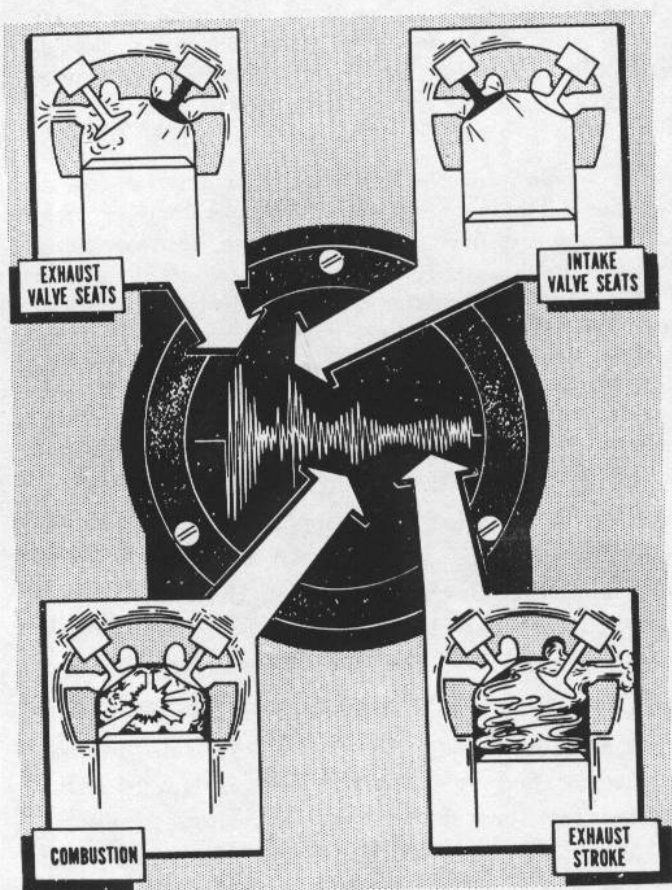


Figure 7-30. Normal Cylinder Vibration Pattern (Group 15 Airplanes)

3-1024-R3

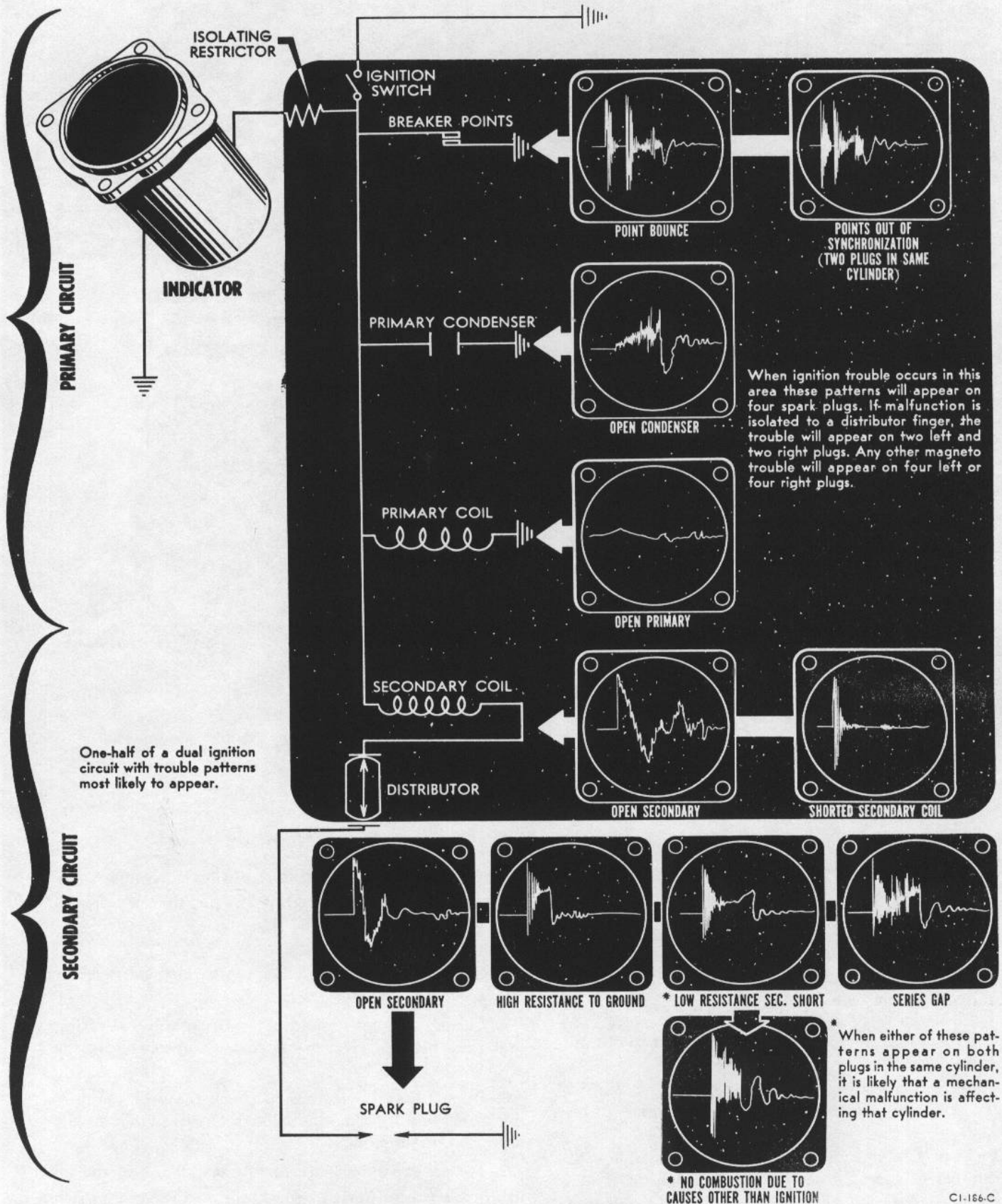
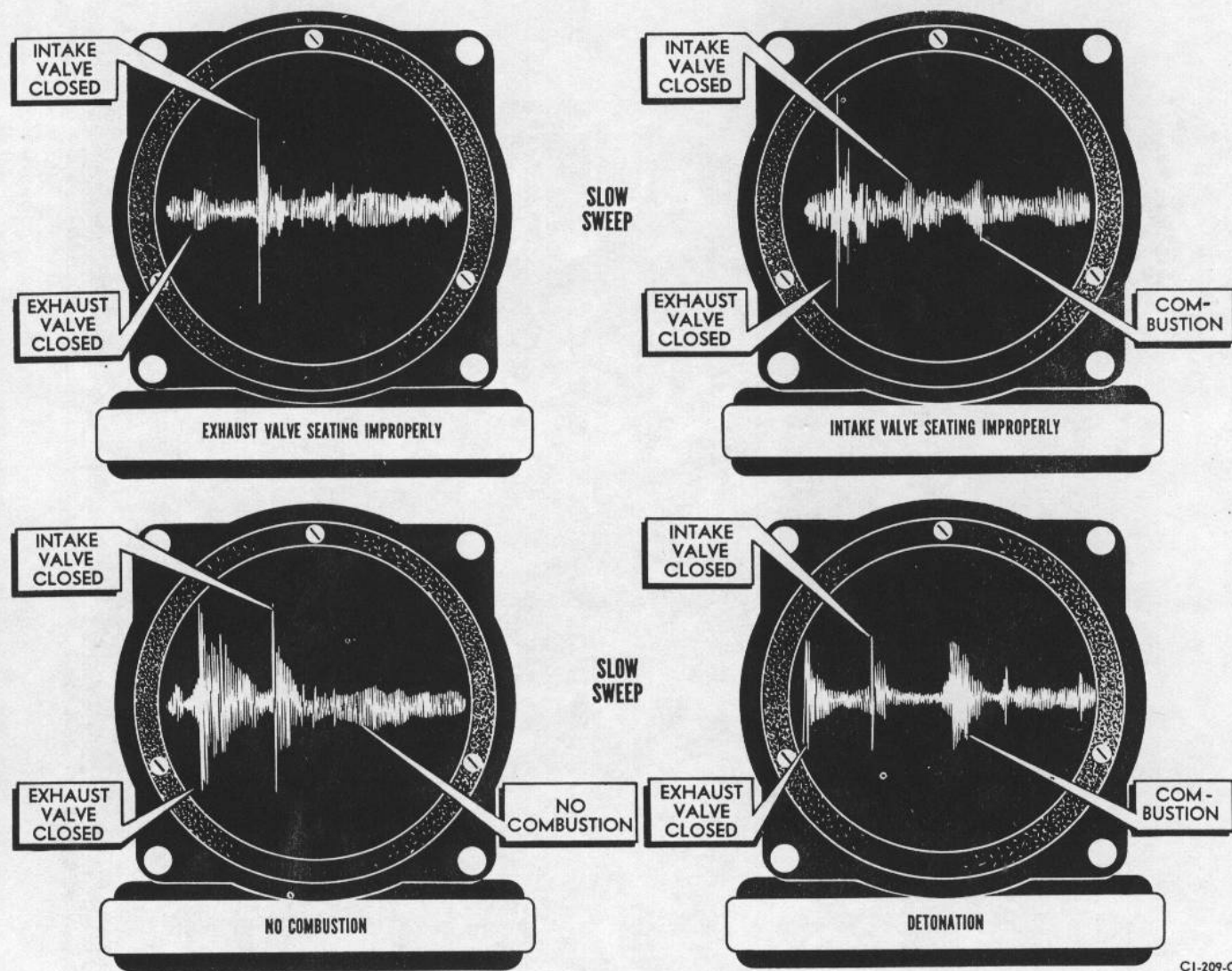


Figure 7-31. Typical Patterns of Ignition Malfunctions



CI-209-C

Figure 7-32. Abnormal Cylinder Vibration Patterns (Group 15 Airplanes)

To operate the engine analyzer for vibration analysis, proceed as follows:

1. Engine analyzer power switch ON.

Note

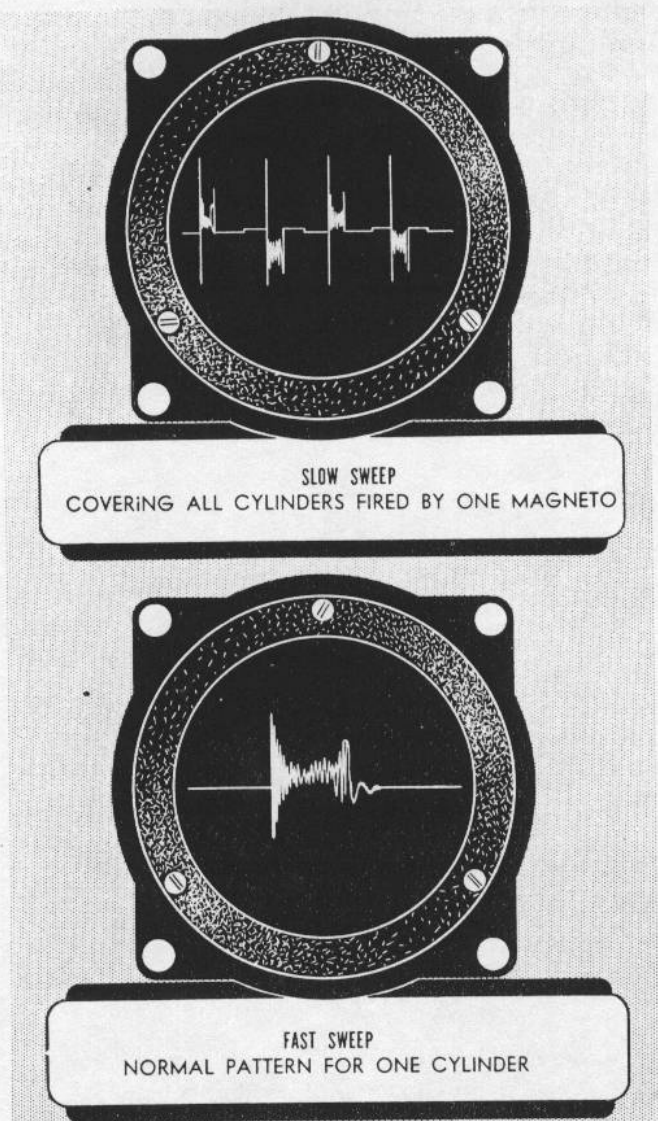
Allow approximately one minute for the power supply-amplifier and the indicator tube to warm up.

2. Condition selector switch knob—Pull out to obtain vibration patterns.
3. Condition selector switch—Set index line within the sector containing the number of the engine to be checked.
4. Pickup selector switch—Align the index line with the number of the cylinder to be checked.
5. Cycle switch—Place cycle switch dial with the designation E.C. (exhaust closing) approximately aligned for cylinder D1.

Note

Cycle switch setting must always correspond to the cylinder selected by the pickup selector or the reading will be inaccurate.

6. Indicator—Complete vibration pattern for cylinder D1.
7. Check all the remaining cylinders by selecting with the pickup selector switch and repositioning the cycle switch.
8. Repeat the above steps to check the other engines by repositioning the condition selector switch to the other engine sectors.
9. For an expanded pattern of any portion of the vibration pattern, push in the knob on the cycle switch for fast sweep, and index the cycle switch dial to the desired portion of the engine cycle to be inspected.



3-1025-R3

Figure 7-33. Normal Ignition Pattern

Ignition System Analysis.

For ignition analysis the engine analyzer is operated as follows:

1. Engine analyzer power switch—ON.

Note

Allow approximately one minute for the power supply-amplifier and the indicator tube to warm up.

2. Condition selector switch knob—Push in to obtain ignition patterns.
3. Condition selector switch—Place index line on L, R, or B within the sector for the engine to be checked. Indexing the dial to L, R, or B determines whether the pattern will be for the left, right, or for both magnetos of the particular row of cylinders to be checked.
4. Cycle switch—Align the IGN index line with the number of the cylinder to be shown first in the series of patterns for one magneto.

5. Cycle switch knob—Pull out to obtain a slow sweep covering the ignition patterns for all of the cylinders fired by the magneto. The cylinder selected by the cycle switch will appear to the left on the indicator followed by the other three in the order of firing of that magneto.

6. If all four patterns are abnormal during the slow sweep, the malfunction is associated with that portion of the magneto circuit that is common to all four ignition circuits. This would indicate magneto or distributor difficulty.

7. If a partial quantity of the series are abnormal, position the cycle switch to bring one of the abnormal patterns to the left side of the screen.

8. Cycle switch knob—Push in for a more thorough examination of the expanded pattern of any abnormal cylinder.

9. Repeat the above steps for left and right sides of all magnetos. It is suggested that at slack work periods all ignition patterns be investigated on the fast sweep for malfunctions that may not be observed on the slow sweep.

Magneto Synchronization Check.

The magneto synchronization check is made to determine that both magnetos simultaneously fire the two plugs in the cylinder. The magneto points are timed to row D, therefore, should be checked on row D. For this check proceed as follows:

1. Engine analyzer power switch—ON.

Note

Allow approximately one minute for the power supply-amplifier and the indicator tube to warm up.

2. Condition selector switch knob—Push in to obtain ignition patterns.
3. Condition selector switch—Index line on B under the engine number to be checked.
4. Cycle switch knob—Push in for fast sweep.
5. Cycle switch—Align the IGN index line with D1. This superimposes the ignition patterns of the left and right magnetos. If the magnetos are synchronized the patterns coincide and appear as one; otherwise, they overlap and the one appearing to the left is advanced with regard to the other. By measuring the distance on the scope between the points of breaker point opening and allowing 1/32-inch to equal 1 degree of crankshaft travel, the amount of synchronization error may be determined.
6. Repeat the above procedure for all magnetos on each engine.

Two methods are available for determining which magneto, right or left, is out of synchronization. The first is as follows:

1. Engine analyzer power switch—ON.

Note

Allow approximately one minute for the power supply-amplifier and the indicator tube to warm up.

2. Condition selector switch knob—Push in.
3. Condition selector switch—Set to R under the engine number to be checked.
4. Measure the exact distance between the start of the horizontal trace at the left edge of the indicator screen and the point at which the breaker points open.
5. Condition selector switch—Set to L.
6. Repeat the measurement.
7. The pattern with the shorter horizontal trace is advanced with respect to the other.
8. Compare the length of the traces to that obtained when the synchronizing generator was installed to determine which magneto is advanced or retarded with respect to the crankshaft position.

The second method is as follows:

1. Engine analyzer power switch—ON.

Note

Allow approximately one minute for the power supply-amplifier and the indicator tube to warm up.

2. Push in the knob on condition selector switch to obtain ignition patterns.
3. Set the condition selector switch to L. If activity of small magnitude is observed ahead of the breaker point opening, that activity is caused by the right magneto because of inductive pickup, indicating that the right magneto is opening early.
4. Switch the condition selector switch to R and this should eliminate the activity.

Perform the synchronization check for each magneto on the engine and repeat on the remaining engines.

Rpm Synchronization Analysis.

In comparing engine rpm of the different engines, engine number one is used as a reference and the other engine speeds are compared to its speed. This check should be made at any time that engine rpm synchronization system malfunction is suspected. To make this check proceed as follows:

1. Engine analyzer power switch—ON.

Note

Allow approximately one minute for the power supply-amplifier and the indicator tube to warm up.

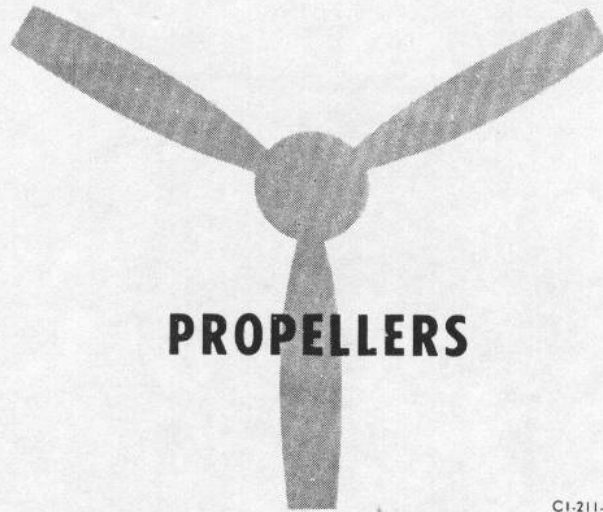
2. Cycle switch—Any position with knob in for fast sweep.

3. Condition selector switch knob—In to obtain ignition patterns.

4. Condition selector switch—Align the index line in the SYN sector with the number of the engine to be compared to engine number one.

5. Indicator—The ignition pattern will be stationary on the screen if the engines are synchronized, and moving if they are not synchronized. A progressive horizontal shift to the right indicates that the selected engine is under speed with respect to engine number one; a shift to the left indicates that the selected engine is over speed with respect to number one.

6. Condition selector switch—Index to each of the remaining SYN positions.



CI-211-C

If an engine is operating at less than master motor rpm and the propeller pitch changing system is actuated to move the blades from positive to reverse pitch or from reverse to positive pitch, the blades will stop before entering the normal operating range of either positive or reverse pitch. This stoppage is due to the necessary tolerance within the propeller limit switch system which prevents energizing two pitch changing systems simultaneously. If at this time the throttle is advanced past the point at which it is necessary to bring the engine up to master motor rpm and the master motor is set below 2700 rpm, the engine speed will exceed the rpm set on the master motor because of the low propeller blade angle. This excessive rpm condition will last for only a short time until the constant speed feature of the propeller system increases the propeller blade angles to give the desired rpm; however, this excess rpm condition reduces propeller efficiency and should be avoided. To eliminate overspeeding above master motor rpm (below 2700 rpm), a decrease rpm signal must be sent to the propeller pitch changing mechanism before the throttle is advanced. The decrease rpm signal is sent by reducing master motor rpm two or three hundred rpm below the rpm indicated on the engine tachometer.

This signal causes the pitch changing mechanism to increase the propeller blade angles, moving them into the normal operating range. The master motor can then be set to the desired rpm and the throttle can be advanced without engine overspeeding.

The manual pitch change system can also be utilized to transmit the increase blade angle signal to the pitch changes mechanism. Transmission of the signals can be accomplished by moving the propeller selector switch to the DEC RPM position and holding it there until a two or three hundred engine rpm drop occurs. The selector switch can then be moved to the AUTOMATIC OPERATION position and the throttle advanced without an overspeed condition occurring.

The propeller limitation charts in Section V should be followed closely. These limitations are primarily based on propeller vibration limits but the vibrations may be of such nature that they can also weaken the propeller shaft. The vibratory forces are caused by power impulses imposed as each cylinder fires; by the aerodynamic disturbances created as a blade or blades pass through a region of turbulent air behind the wing or adjacent to the fuselage; and by other causes such as misfiring cylinders, malfunctioning vibration dampeners, and extended flaps.

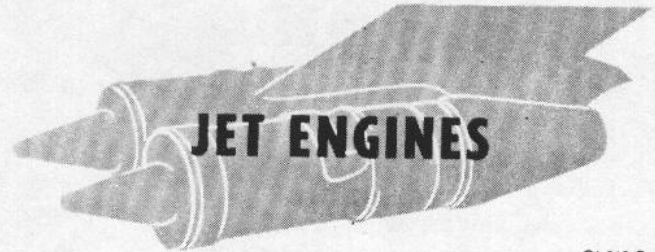
It must be understood that operation of the propeller in a restricted range will shorten its life and that the vibration stresses mentioned are present in the blades, hub, and shaft, even though no vibration of the aircraft is noticeable to the crew. However, if emergencies dictate that the propeller be operated in a restricted range for a limited period of time, there should be no hesitancy and no cause for alarm. Occasional limited operation in a restricted region is not dangerous; emergency as well as normal operation has been considered in specifying restrictions. For example, passing through a restricted rpm range to reach a higher or lower rpm is obviously necessary and is not harmful if the change is made as quickly as convenient. However, an accurate log should be kept of all such conditions, complete with the length of time that any propeller limitation has been exceeded.

FEATHERING.

On this airplane the engine nacelles are not parallel with the fuselage center line in the horizontal plane. The nacelles are "toed in" at the propeller end, resulting in the propellers on one wing having a slightly different relative wind than those on the other wing. This condition may lead to propellers on engines No. 1, 2, and 3 windmilling in a direction opposite to normal operation when they are feathered. This rotation can be stopped by utilizing the manual pitch changing system to make a slight blade angle change. Refer to "Reciprocating Engine Shutdown," in Section III.

REVERSE PITCH.

The jet engines should be inoperative during reverse pitch operation to avoid the necessity of counteracting their forward thrust and to prevent debris lifted from the ground by the propellers being drawn into the jet intakes.



CI-212-C

The primary purpose of the jet engines on the airplane is to provide additional power for take-off, climb, and operation in the target vicinity. High altitude cruise at high gross weights also requires operation of the jets. When performing high gross weight landings, the jets should be operating to at least idle rpm to provide additional power in the event a go-around is necessary. Operational requirements of the jets at various configurations and powers may be determined from the charts in Appendix I.

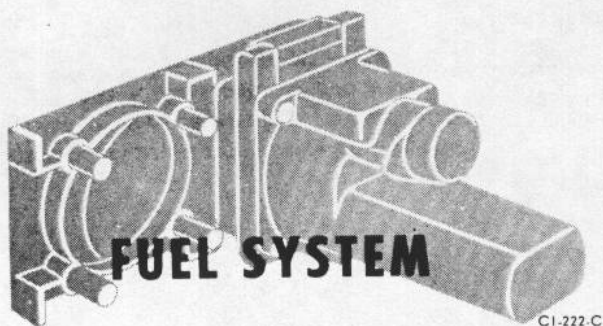
The jets are operated on the ground by the flight crew for only a short time, normally being started after the airplane is aligned with the runway just prior to take-off.

WINDMILLING.

Windmilling of the jets in flight with the air plug doors open causes an increased drag; consequently, the doors should be closed when the engines are not operating. Some air leakage through the doors is provided intentionally so that the engine will rotate to circulate oil and to prevent freezing of the rotors at low temperatures. If the jets will not windmill at sufficient rpm to circulate oil and to prevent freezing of the rotors with the doors closed, the air plug doors should be opened enough to maintain sufficient windmilling rpm.

JET ENGINE ICING.

If known icing conditions are to be encountered, the operator should be prepared to shut down the jets at the first indication of icing. It will be preferable to stop the engines prior to formation of large amounts of ice, since excessive accumulation of ice would prevent further use of engines during the flight unless the airplane was flown through non-icing conditions to allow the ice to melt and the water to pass out of the compressor.



FUEL DENSITY VARIATION.

Because of the wide range of climatic conditions under which this airplane operates, it is not feasible to assume that the fuel weight per gallon is always the same. With full wing tanks, it is possible to have an error of 4500 pounds if the actual density is 15/100 of a pound per gallon different from an assumed weight. To prevent such errors, the weight of the fuel can be more closely computed by use of a fuel hydrometer.

Fuel Weighing Procedure.

To determine fuel weight per gallon, proceed as follows:

Note

This procedure is based on the use of an aircraft fuel hydrometer (Stock No. 7800-414200) which is calibrated to read correctly at 15.6°C (60°F).

1. Insert fuel hydrometer tube into tank and hold the instrument in a vertical position with the bulb at the top as close to the tank as possible.

2. The float will show a reading in pounds per gallon and the thermometer will show the temperature of the fuel being sampled.

3. To use the chart (figure 7-34), enter chart at indicated weight (density) and move up vertically to base line of 15.6°C. Then move parallel to guide lines (either up or down) to actual temperature of the fuel, then move vertically downward to obtain actual weight.

4. The example on the chart shows an indicated density of 6.8 at a temperature of minus 10°C which gives a resultant density of 6.255 pounds per gallon.

5. The fuel weight should be obtained and recorded by the engineer before each flight.

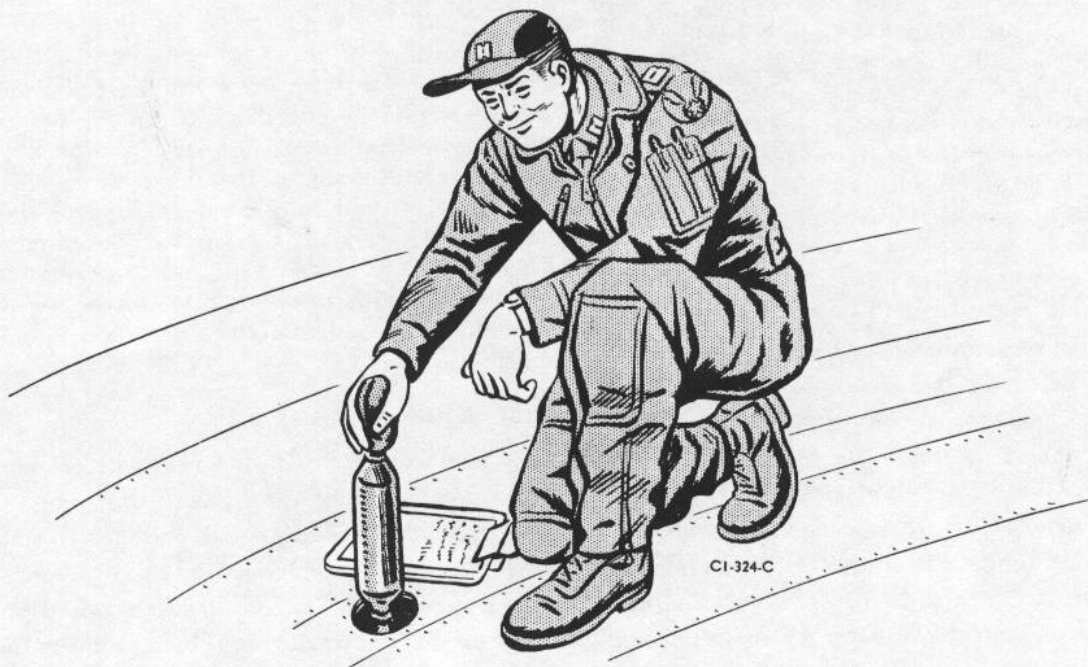
NORMAL CRUISE.

During normal cruise, use all fuel in the bomb bay tank first, auxiliary wing tanks second, inboard tanks third, center tanks fourth, and outboard tanks last. This is necessary to maintain the wing bending moments at a minimum. (Refer to "Distribution of Load," in Section V.)

Note

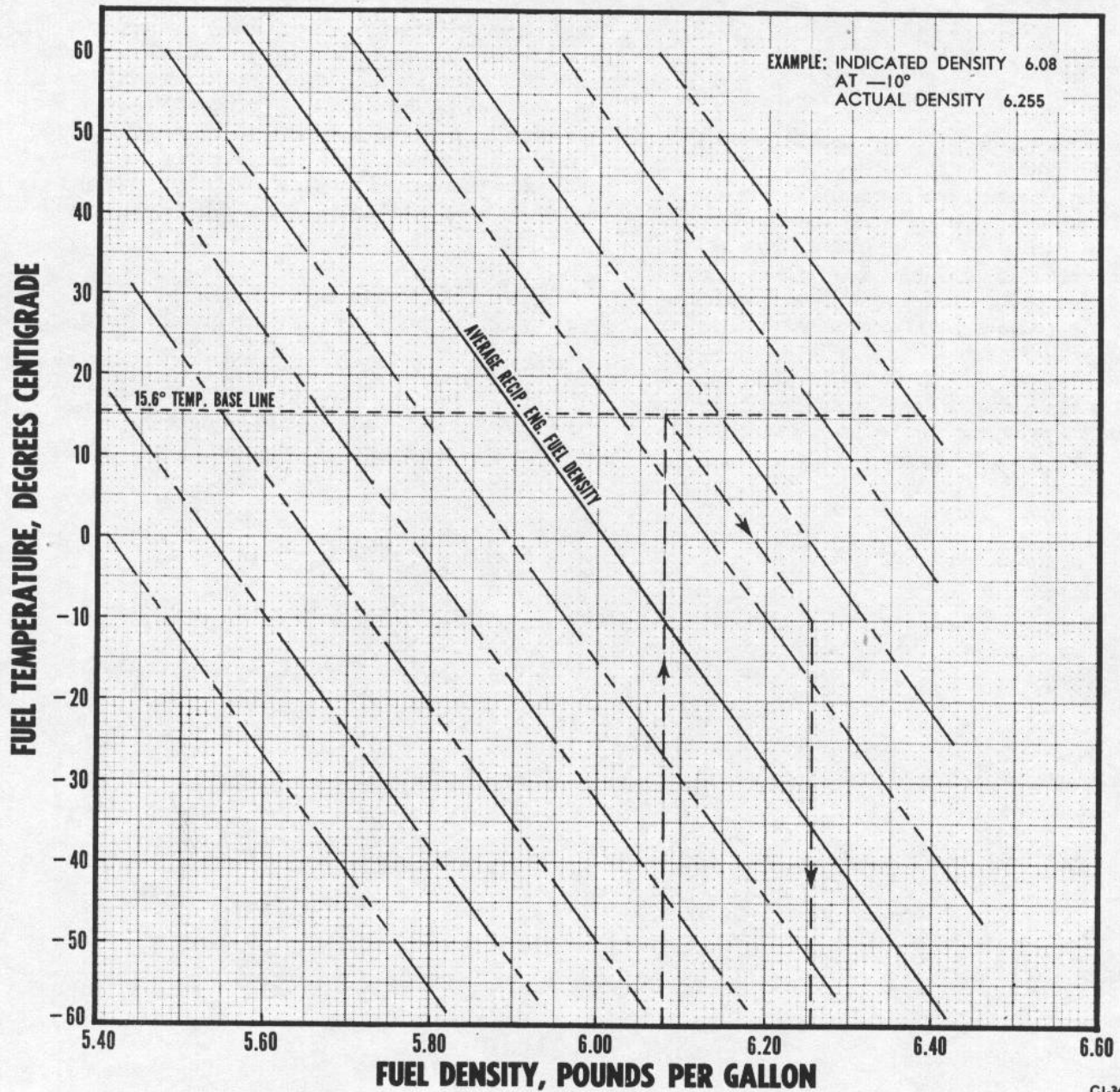
Whenever both the jet and the reciprocating engines are being used, it is essential that fuel be supplied from two tanks in each wing.

Because residual fuel of the empty tank will collect at the booster pump, it is usually advantageous to open the tank valve and turn on the booster pump approximately one hour after the tank was originally turned off. The booster pump should be allowed to operate five minutes to assure complete drainage of the tank.



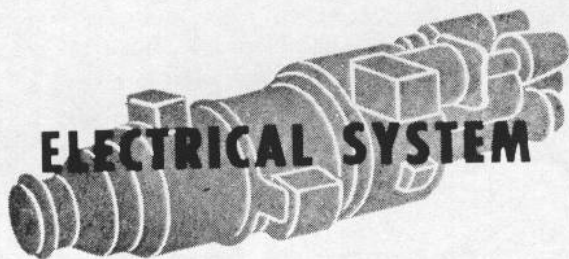
FUEL DENSITY CORRECTION CHART

NOTE: This chart is based on Aircraft Fuel Hydrometer (Stock No. 7800-414200) which is calibrated to read correctly at 15.6°C (60°F).



C1-345X-C

Figure 7-34. Fuel Density Correction Table



CI-214-C

TRANSFORMER-RECTIFIER UNIT.

The transformer-rectifier unit is used to convert a-c power to d-c power. Each unit consists of a transformer, a rectifier, and a cooling fan. The transformer reduces the normal a-c voltage and the rectifier converts the alternating current into direct current. The rectifier is a stack of selenium-coated plates through which the alternating current must pass. Metallic selenium on the rectifier plates permits the alternating current to pass through the plates in one direction only; hence, the alternating current becomes "direct" current. The fan is used to cool the rectifier stack. The d-c output of a t-r unit is automatically maintained by an adequate a-c input to the unit.

THE ALTERNATOR.

The alternator converts mechanical energy into electrical energy. The alternator consists of a stator assembly within which a rotor assembly is driven by the constant speed drive unit. Windings around the four sets of field poles on the rotor are energized by an exciter generator when the engine is operating and the exciter control relay is closed. When the alternator field poles are energized, magnetic fields are created and the alternating current is produced in the stator coils. The stator assembly consists of three sets of coils, one for each of the alternating current phases. When the rotating field poles are energized, the coils in the stator will supply three-phase alternating current at a frequency determined by the speed of rotation and at a voltage fixed by the strength of the alternator magnetic field.

Exciter Generator.

The exciter generator which supplies voltage to the alternator field poles is integral with the alternator. The exciter is a self-excited, shunt-wound, direct-current generator. A carbon stack voltage regulator is connected in series with the shunt circuit. Because the

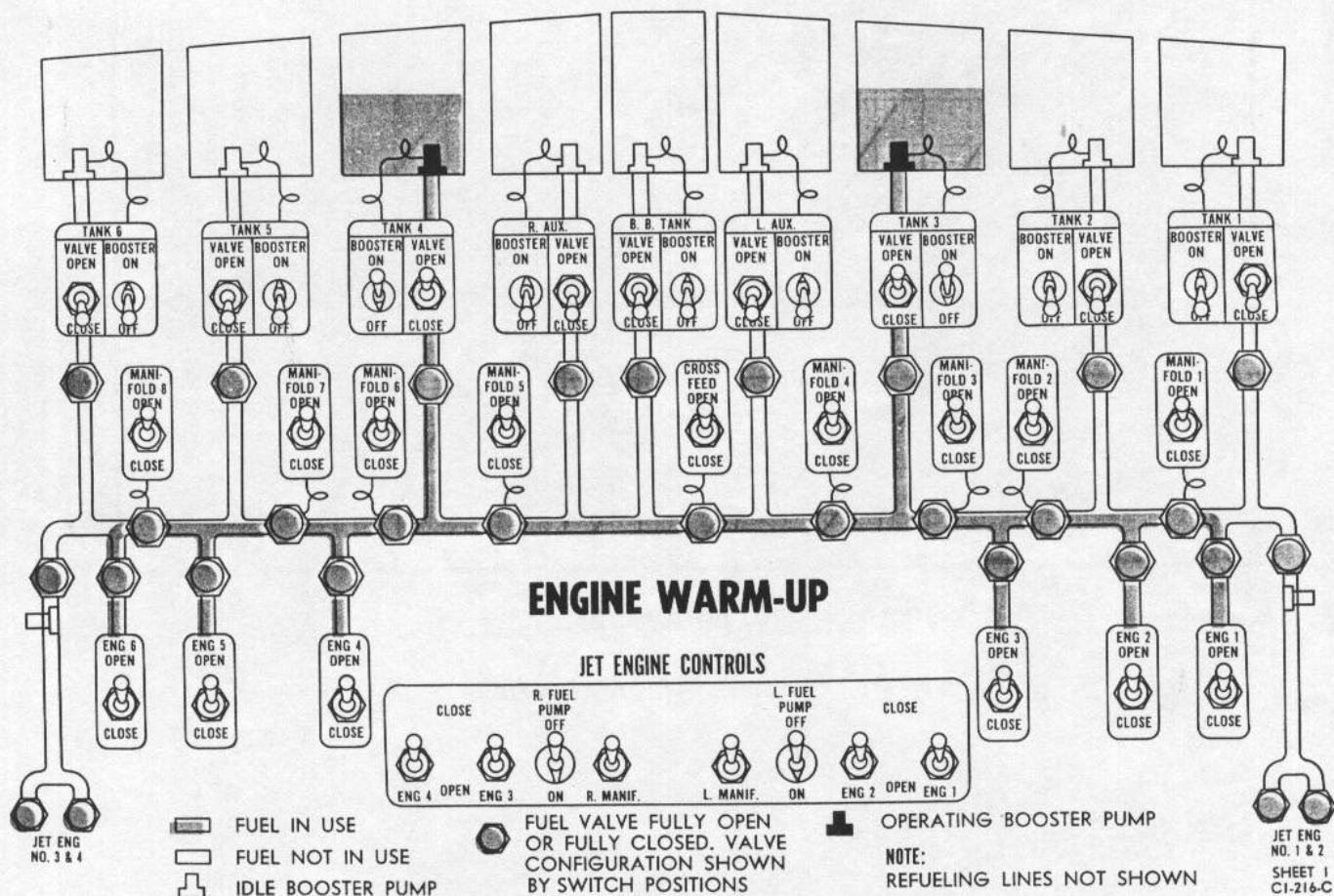


Figure 7-35. (Sheet 1) Fuel Management

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generator is self-excited and shunt-wound, it energizes its own magnetic field through the shunt circuit. The exciter armature is on the same shaft as the alternator rotor and current is directed from one to the other by means of slip rings.

When the exciter armature rotates at a constant speed, its electrical output depends on the amount of resistance in the shunt field circuit. This resistance is controlled directly by the voltage regulator and indirectly by means of the voltage control knob. The amount of exciter output to the alternator controls the alternator output voltage. Since the carbon stack controls the exciter shunt field strength and the exciter output, it regulates the voltage of the alternator.

Constant-Speed Drive Unit.

The constant-speed drive unit drives the alternator at a constant speed with the mechanical input it receives from the reciprocating engine. The unit consists of a variable angle wobble plate, a fixed angle wobble plate, and a cylinder block assembly which contains motor pistons at one end and pump pistons at the other. The cylinder block assembly is rotated between the wobble plates by gears on an input shaft which is

attached to the universal connection from the engine. The pump pistons rotate against the variable angle wobble plate and pump hydraulic fluid to the motor pistons, which turn the fixed angle wobble plate. When rotated, the fixed angle wobble plate turns the output shaft, which is connected to the alternator.

The speed of the output shaft is equal to the input shaft speed plus the speed change caused by the action of the motor pistons on the fixed angle wobble plate. The cylinder block assembly is connected to the fixed angle wobble plate so that the motor pistons can either increase or decrease the speed of the output shaft with respect to the input shaft. The increase or decrease in output shaft speed depends on the direction of oil flow from the pump pistons to the motor pistons, and the amount of speed change depends on the rate of oil flow. The displacement of the pump pistons and the direction of oil flow are controlled by the position of the variable angle wobble plate. The position of the variable angle wobble plate thus controls the increase or decrease in the output shaft speed of the constant-speed drive unit. A constant output speed is maintained by controlling the position of the variable angle wobble plate.

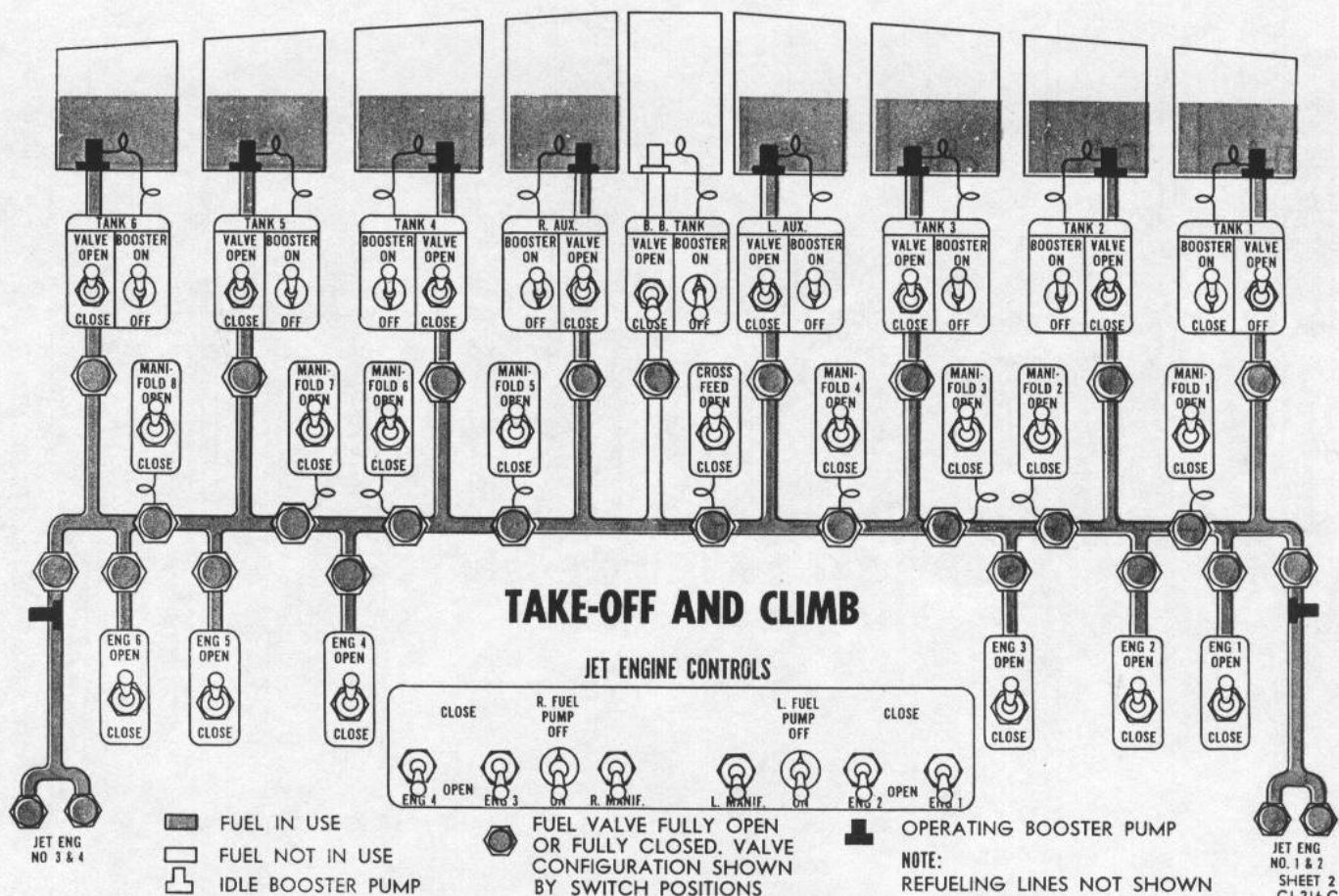


Figure 7-35. (Sheet 2) Fuel Management

CONTROLLING THE A-C SYSTEM.

The a-c system is controlled by regulating the output of the alternators. There are three types of alternator controls: frequency controls, voltage controls, and load division controls. In addition, protective devices are provided to protect the alternator from overloads, short circuits, and overspeeding. The frequency controls regulate the action of the constant-speed drive unit, and the voltage controls regulate the strength of the alternator magnetic field. The load division controls affect these other controls to assure equal real and reactive load division among the alternators. Both real and reactive loads must be equally shared by the paralleled alternators to prevent either mechanical overload or excessive current drain through the windings of any one alternator. The reactive load does not impose a mechanical load, but is a part of the current drain through the alternator windings.

Frequency Controls.

The alternator frequency controls consist of a tachometer generator on the output shaft of the constant-speed drive unit, a rectifier in the governor junction box, the engineer's frequency control knob, a spring-biased governor pilot valve and solenoid assembly,

and a servo unit which positions the variable angle wobble plate on the constant-speed drive unit. A frequency adjustment rheostat in the governor junction box adjusts the frequency control limits.

The tachometer generator produces 3-phase alternating current which is directly proportional to the speed of the drive unit output shaft. This current is rectified and applied to the control coil in the governor solenoid assembly. The engineer's frequency control knob regulates the amount of resistance in the circuit between the rectifier and the control coil. The magnetic pull of the control coil acts against the spring bias and positions the pilot valve in the assembly. When the output speed of the drive unit is correct, the tachometer generator current is sufficient to center the pilot valve, preventing a flow of oil to the control piston in the servo unit. However, any change in the output speed affects the tachometer voltage, causing the control coil to reposition the pilot valve. Depending on the position of the pilot valve, oil will flow to either side of the control piston in the servo unit, which is attached to the variable angle wobble plate on the constant-speed drive unit. The flow of oil will change the position of the control piston and cause the wobble plate to move in the direction which will restore

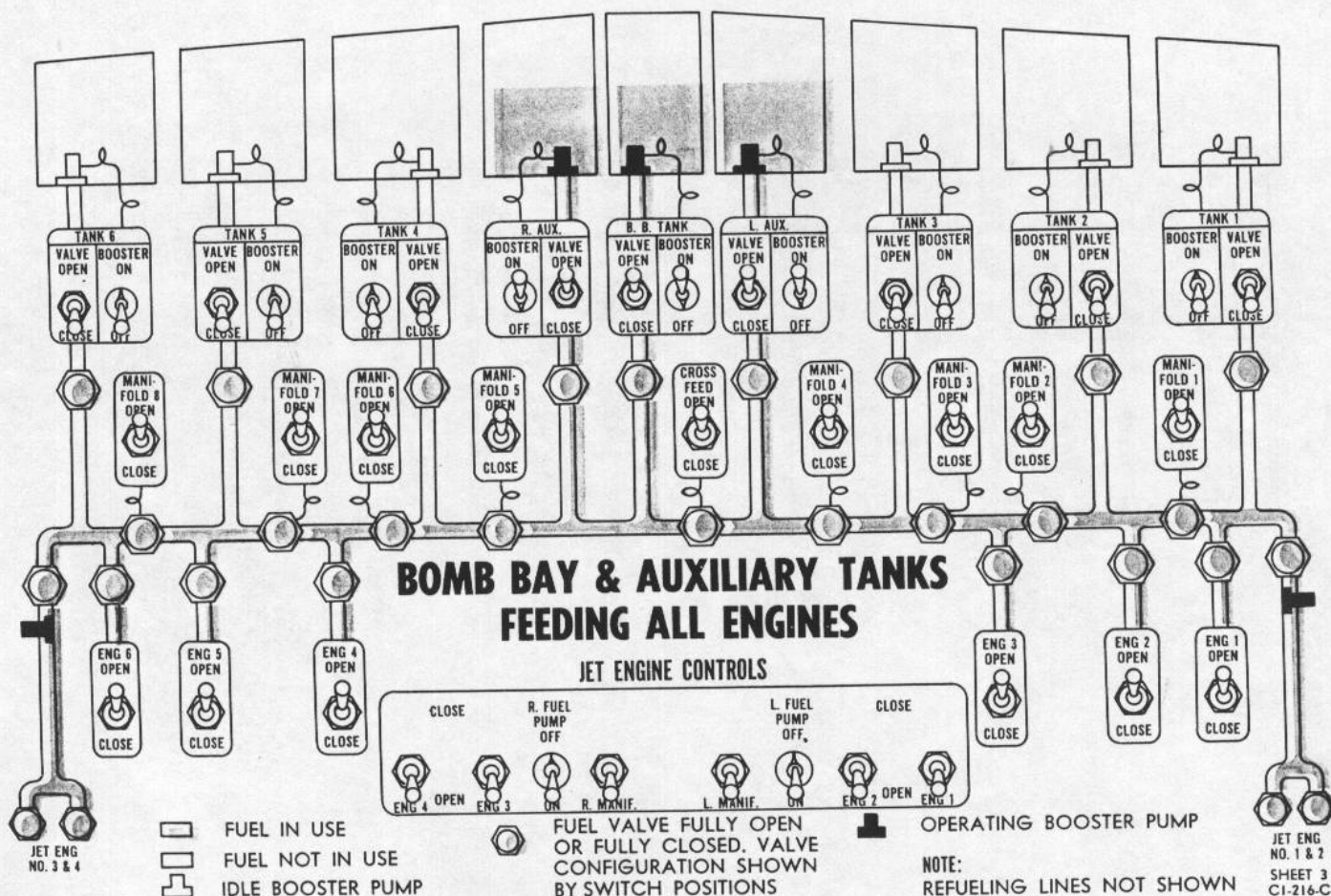


Figure 7-35. (Sheet 3) Fuel Management

the original speed required for the drive unit. The flow of oil ceases when the output speed is corrected and the tachometer current in the control coil repositions the pilot valve. The frequency controls are automatic and should not require manual adjustment except for temperature changes which affect the frequency.

Note

The frequency will drop with a decrease in ambient temperature.

Voltage Controls.

The alternator voltage is adjusted by the engineer's voltage control knob and automatically controlled by the voltage regulator unit. The voltage regulator unit consists of two line transformers, a rectifier, a regulator coil, and a carbon stack resistor. A voltage adjusting rheostat adjusts the voltage control limits. Compensating resistors are also provided for temperature changes and a damping transformer is provided to reduce hunting or prolonged oscillation of voltage changes. A mutual reactor located in the voltage regulator senses unbalanced reactive loads between alternators.

Three-phase voltage from the alternator is rectified, and the d-c current flows through the regulator coil in direct proportion to the alternator voltage except as modified by the mutual reactors. The carbon stack is composed of a number of carbon discs kept under compression by a spring. Current in the regulator coil creates a magnetic force which opposes the spring force and tends to decrease the compression on the stack when the current flow is increased. When the stack compression decreases, its electrical resistance increases. The carbon stack is in series with the exciter shunt field circuit and when the stack resistance increases, the strength of the exciter shunt field decreases, causing reduced alternator voltage output. Since the current in the regulator coil directly influences the alternator voltage, any change in alternator voltage affects the carbon stack resistance which acts to restore the voltage to its previous level.

Real Load Division.

The ability of an alternator to assume real load in kilowatts depends on the mechanical torque applied to it by the constant-speed drive unit. After the alternators have been paralleled, they normally will not change their frequency output. However, the torque applied to each alternator may be changed by its

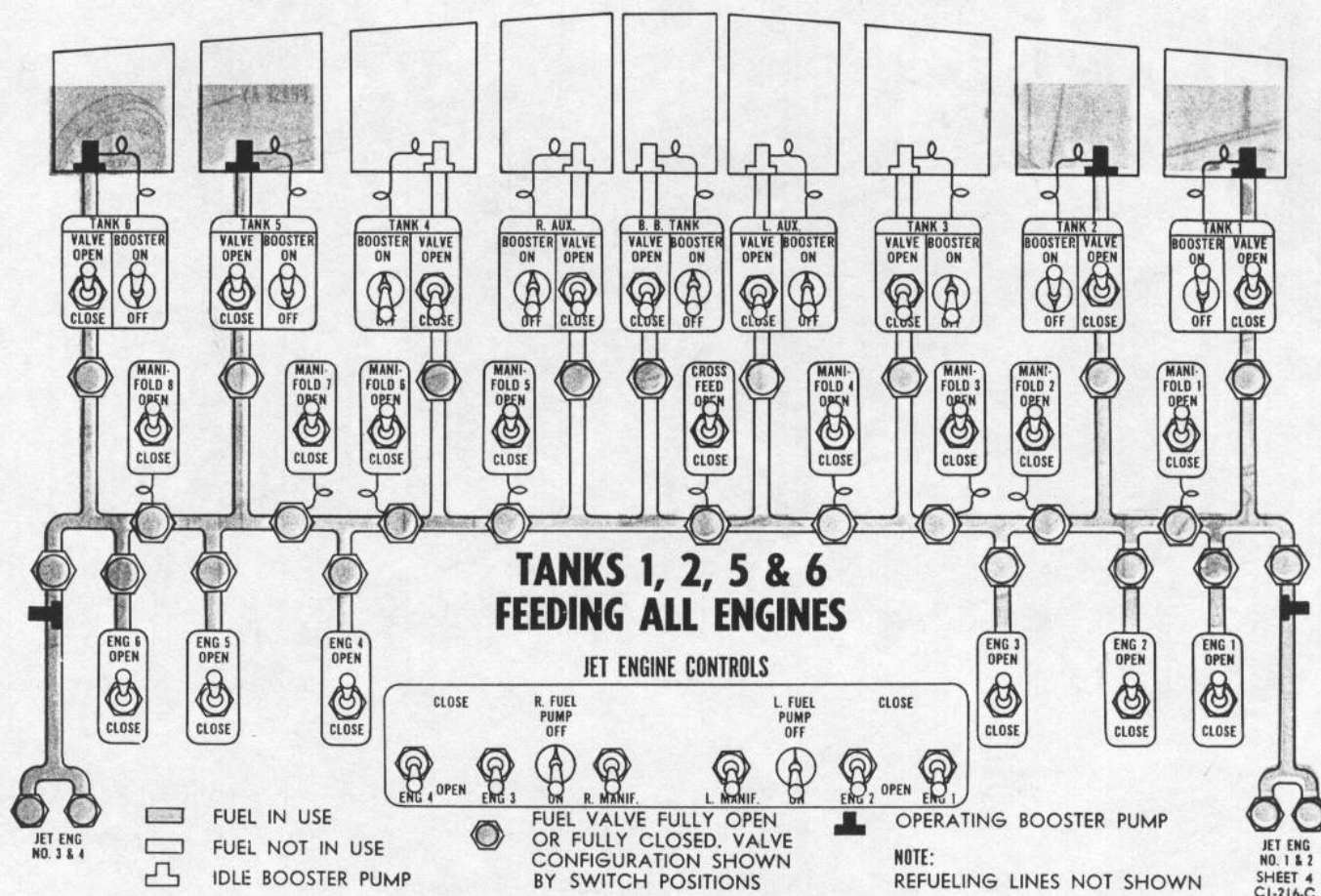


Figure 7-35. (Sheet 4) Fuel Management



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drive unit. The torque may be increased by causing the drive unit to attempt to speed up the alternator. This can be done with the engineer's frequency control knob or by the load equalization circuit. When the drive unit attempts to speed up, the alternator rotor will not revolve faster, because it is electrically locked in parallel; but the added torque from the drive will permit it to assume more real load.

Automatic division of the real load is accomplished by a load equalization circuit after the engineer's controls have been set. Basically the circuit consists of four droop coils, one in each governor solenoid assembly. Each droop coil has the same effect as the control coil on the pilot valve and the action of the constant-speed drive unit. When the alternators are unequally sharing real load, each droop coil receives rectified current from load measuring transformers in each governor junction box. A droop control rheostat in each governor junction box adjusts the sensitivity of each droop coil.

The four droop coils are parallel-connected in a circuit so that when the alternators are equally sharing real load, no current flows through the droop coils. When an alternator assumes unequal load, current flows through the droop coils in proportion to the unbalance in load division. This unbalance in current results in the pilot valves being repositioned to cause the overloaded alternators to reduce torque and the others to increase torque until the load is equally divided again. The action of the droop circuit ceases when the load is equally divided.

Reactive Load Division.

The ability of an alternator to assume reactive load in kilovars depends on its magnetic field strength. After the alternators have been paralleled, they normally will not change their voltage output. However, the output of the exciter to the alternator field may be changed with the engineer's voltage control knob or by the reactive load division circuit. When the exciter output is increased to a paralleled alternator, it increases the ability of that alternator to assume more reactive load.

The reactive load division circuit consists of the mutual reactor in each voltage regulator and a current transformer for each mutual reactor. The transformers supply the reactors with current when the alternators are unequally sharing reactive load. The four mutual reactors are in series. Therefore, when the alternators are sharing equal reactive load, only an insignificant amount of current passes through the mutual reactors and the regulator coils in the voltage regulators are not affected. However, when the alternators assume unequal reactive loads, current proportional to the unequal load on each alternator flows through its mutual reactor. The effect on the regulator coils is the same as if the alternators were producing

different voltages. The regulator coils change the resistances in the carbon stacks so that the overloaded alternators will receive less excitation and the others more excitation until the loads are equally divided again. The action of the reactive load division circuit ceases when the reactive loads are equally shared.

ALTERNATOR PROTECTIVE DEVICES.

Exciter Ceiling Relay.

An exciter ceiling relay protects the alternator from overloads. It consists of a thermal switch connected to the alternator breaker and the exciter control relay. When the alternator is overloaded, the thermal switch closes and completes a 28-volt d-c circuit to open the alternator breaker and de-excite the alternator.

Differential Protection Relay.

A differential protection relay protects the alternator from short circuits in the alternator windings. It consists of a transformer installed around the power and ground return leads for each phase and a switch connected to the alternator breaker and the exciter control relay. When the power and ground return leads have unequal current passing through them, the transformers are energized by the difference in current and close the switch, completing a 28-volt circuit to open the alternator breaker and de-excite the alternator.

Alternator Overspeed Control.

A constant-speed drive overspeed control protects the alternator from excessive speeding. It consists of a centrifugal switch in the tachometer generator and a coil in the governor pilot valve and solenoid assembly. When the output shaft speed is excessive, the centrifugal switch closes and completes a 28-volt d-c circuit to the coil in the governor solenoid. The energized coil pulls the pilot valve to an extreme position which causes the drive unit to go into full underdrive and reduce the output speed to a minimum. The pilot valve is latched into position, and the drive unit maintains lowered speeds to the alternator until the latch is manually released. (See figure 3-11).

When the drive unit is locked in underdrive, the alternator frequency closely follows engine rpm.

CHART FOR ELECTRICAL SYSTEM TROUBLE SHOOTING.

Directions for using the trouble shooting chart: The "Parallel Condition" column indicates the initial abnormal condition which would be noted while a malfunctioning alternator is operating in parallel with other alternators. After the breaker of the affected alternator is opened, the no-load operation should be observed and compared with the conditions shown in the "Isolated Condition" column. Directly opposite

the isolated condition is shown the trouble-shooting procedure which should be followed.

Note

The malfunctioning alternator may be determined by splitting the bus four ways. Isolate the affected alternator by opening its

alternator breaker. If necessary, the bus tie breakers may be closed after the affected alternator is isolated.

Note

When operating under reduced electrical power, the cabin heaters should be turned off to conserve power.

PARALLEL CONDITION	ISOLATED CONDITION	PROCEDURE
Frequency oscillations (Isolate alternator with largest variation in KVAR or KWATT load.)	Voltage oscillation (± 10 volts) Frequency oscillations.	1. Polarity of exciter field may be reversed—Flash the field. If the field is not flashed, leave unexcited. 1. Rotate frequency control knob rapidly back and forth to free sticky governor. Isolate alternator if fault cannot be corrected.
No KWATT or KVAR indications.	No frequency — No voltage — one or both synchronization lights out.	1. Alternator failure is indicated. 2. Be sure alternator breaker is opened. 3. Check AC INST fuses at engine power panel.
Alternator will not stay on line.	All readings normal when alternator breaker is opened and alternator re-excited.	1. De-excite alternator. 2. May be caused by the protective devices. In emergency, disconnect cannon plugs from exciter ceiling relay and differential protection relay at engine power panel.
Negative KVAR and KWATT load. (Alternator motoring)	Erratic or no frequency or voltage. Low frequency—Low voltage—Alternator frequency varies with engine speed.	1. Slipping clutch or broken drive shaft—Open alternator breaker. 2. In emergency, replace carbon stack with stack from non-operative unit. 1. Unit is in underdrive—Isolate alternator and manually reset. 2. If underdrive condition persists, use alternator at 2700 rpm engine speed.
No d-c power to alternator control panel.		1. Reset bus tie control circuit breaker on engineer's table.
No KVAR or KWATT indication on one alternator, but power is apparently being supplied by the alternator.	No frequency, voltage low or zero, synchronization lights dim or out.	1. Check AC INST fuses at engine power panel. 2. Remove alternator from line and use only in emergency on isolated bus.
Low or negative KVAR load.	Low voltage with little or no control.	1. Check AC INST fuses at engine power panel. 2. Check adjustment of voltage regulator rheostat at the engine power panel. 3. Remove either wire from terminal D-9 at the engine distribution panel and adjust voltage regulator rheostat at engine power panel. 4. In emergency only, replace carbon stack with stack from a non-operative unit (excitation must be off to remove stack).

PARALLEL CONDITION	ISOLATED CONDITION	PROCEDURE
Low KWATT load—Some control. KVAR's normal.	Frequency low—Some control. No frequency, low voltage.	1. Readjust frequency control rheostat on governor control junction box at the alternator control panel. 1. Check A C I N S T fuses at engine power panel.
High KVAR load—No control.	High voltage—No control.	1. Check AC PWR EQUIP. fuse at engine power panel. 2. Replace carbon stack when excitation is OFF. 3. De-excite alternator.
High KVAR load — or KVAR division wandering over wide range.	Frequency and voltage readings normal.	1. Isolate alternator and split bus.
High KWATT load—or KW division wanders over wide range.	Abnormal frequency control. Normal control.	1. Readjust frequency rheostat in the governor control junction box at engine power panel. 2. May be sticky governor—Rotate frequency control knob rapidly back and forth to free. 1. Isolate alternator and split bus if trouble persists.
Complete loss of power.		See "Emergency Electrical Operation" of Section III.

EMERGENCY OPERATION OF ELECTRICAL EQUIPMENT.

When it is necessary to jump three phases of a relay to perform emergency operations, extreme caution must be taken to insure that all jumpers are connected simultaneously. Failure to do so may result in damage to the unit's motors. In cases where limit switches are inoperative, a second crew member should observe movement of the unit being operated in order to prevent overtravel or other possible damage.

In fabricating jumpers for use in such emergencies, it is suggested that a minimum of two be prepared: one made of heavy wire, capable of carrying the largest power load which may be encountered; the other made of relatively thin wire for use on low current circuits. Each jumper should incorporate a switch. The jumper that is used with three-phase power should incorporate a three-pole switch. Use of these switches is important because:

a. When the jumper is connected from the unit to the power line, the circuit will remain open until the switch is closed. This eliminates the possibility of dangerous sparking.

b. If the limit switch of a unit is inoperative, the circuit will be kept open until the second crew member is prepared to observe movement of the unit.

c. If the circuit carries three-phase power, the three gang switch will permit all phases to be connected simultaneously.

Connect the jumper to the unit first, and then to the power line with insulated metal clips having a maximum of contact surface and a minimum of exposed outer surface.

WARNING

Because dangerous voltages will be encountered in various parts of the airplane, always open the circuit breakers or remove the fuses which will de-energize the circuit before attaching a jumper.

The procedures given in the following table are to be used when a unit fails to operate because of a faulty electrical circuit.

UNIT	TERMINAL LOCATION	OPERATION	
		TO CLOSE VALVE	TO OPEN VALVE
Aft Cabin Pressure Shutoff Valve	Just forward of aft cabin	1. Apply 115-volt AC to pigtail B.	1. Apply 115-volt AC to pigtail A.
Alternator Breaker	On aft side of Alternator Control Panel 2, 3, 4, or 5.	TO CLOSE BREAKER	TO OPEN BREAKER
		1. Open bus tie breakers to isolate alternator: Then momentarily apply 28-volt DC to terminal A6. (28-volt DC power available at terminals B2 and B3).	1. Momentarily apply 28-volt DC to terminal A8 (28-volt DC available at terminals B2 and B3).
Alternator Exciter Control Relay	On aft side of Alternator Control Panel 2, 3, 4, or 5.	TO CLOSE RELAY	TO OPEN RELAY
		1. Apply 28-volt DC to terminal B11 (28-volt DC available at terminals B2 and B3).	2. Apply 28-volt DC to terminal B10 (28-volt DC available at terminals B2 and B3).
Bomb Bay Doors	Landing Gear Control Relay Panel	TO CLOSE DOORS	TO OPEN DOORS
		1. Apply 28-volt DC to terminal B2 of hydraulic fluid temperature control relay. Also apply 28-volt DC to terminal X1 and ground terminal X2 of the No. 1 hydraulic pump relay. 2. If the main selector valve fails to operate, depress the CLOSE plunger on the valve. If pump No. 1 fails to operate, No. 2 may still be operative; however, if No. 2 pump is also inoperative, apply 28-volt DC to terminal X1 and ground X2 of No. 2 pump relay.	1. Apply 28-volt DC to terminal C1 on the bomb bay door open relay. Also apply 28-volt DC to terminal X1 and X2 of the No. 1 hydraulic pump relay. 2. If the main selector valve fails to operate, depress the OPEN plunger on the valve. If pump No. 1 fails to operate, No. 2 may still be operative; however, if No. 2 pump is also inoperative, apply 28-volt DC to terminal X1 and ground X2 of No. 2 pump relay.
Bus Tie Breaker 2-3 3-4 4-5 5-2	Bhd. 7.2 terminal strips	TO CLOSE BREAKER	TO OPEN BREAKER
		Apply 28-volt DC to terminal: C-18 on L.H. Strip C-15 on L.H. Strip C-18 on R.H. Strip C-15 on R.H. Strip (28-volt DC available at Bhd. 8.0 DC Power Panel.)	Apply 28-volt DC to terminal: C-19 on L.H. Strip C-16 on L.H. Strip C-19 on R.H. Strip C-16 on R.H. Strip (28-volt DC available at Bhd. 8.0 DC Power Panel.)
Cabin Pressure Wing Shutoff Valve	Overhead in bomb bay No. 3	TO CLOSE VALVE	TO OPEN VALVE
		1. Apply 115-volt AC to pigtail B.	1. Apply 115-volt AC to pigtail A.

UNIT	TERMINAL LOCATION	OPERATION	
		TO CLOSE AIR PLUG	TO OPEN AIR PLUG
Engine Air Plug	At Engine Distribution Panels	1. Apply 28-volt DC to terminal A9 of engine distribution panel. 2. If motor fails to operate, connect jumpers between the following air plug motor relay terminals: T1 to L1; T2 to L3; T3 to L2.	1. Apply 28-volt DC to terminal A10 of engine distribution panel. 2. If motor fails to operate, connect jumpers between the following air plug motor relay terminals: T1 to L1; T2 to L2; T3 to L3.
Engine Fan	At Engine Distribution Panels	FOR LOW RPM	FOR HIGH RPM
		1. Apply 115-volt AC to terminal A1. NOTE: Circuit breaker on engineer's panel must be open.	1. Apply 115-volt AC to terminal A2. NOTE: Circuit breaker on engineer's panel must be open.
Engine Oil Flight Cooling Door	At Engine Distribution Panels	TO CLOSE DOOR	TO OPEN DOOR
		1. Apply 115-volt AC to terminal N5. NOTE: Fuse must be removed from engine power panel.	1. Apply 115-volt AC to terminal N4. NOTE: Fuse must be removed from engine power panel.
Flaps (Inboard)	At L.H. Wing-Fuselage Splice (L.H. Flap) or R.H. Wing-Fuselage Splice (R.H. Flap.)	TO RETRACT	TO EXTEND
		1. Apply 28-volt DC to terminals A1 and A4.	1. Apply 28-volt DC to terminals A2 and A4.
Flaps (Center)	At L.H. Wing-Fuselage Splice (L.H. Flap) or R.H. Wing-Fuselage Splice (R.H. Flap.) At Speed Control and Motor Reversing Relays.	TO RETRACT	TO EXTEND
		1. Apply 28-volt DC on terminals A5 and A8. 2. If motor still fails to operate, check fuses, and if blown, replace. Apply 28-volt DC to motor reversing relay terminal X1 and speed control relay terminal X1. 3. If fuses not blown, or fuses continue to blow and motor fails to operate, connect jumpers between the following terminals: T1 on reversing relay to L11 on speed relay, T2 to L13, T3 to L12. 4. If the motor does not run, remove the jumpers and connect them as follows: T1 on reversing relay to L1 on speed relay, T2 to L3, T3 to L2.	1. Apply 28-volt DC on terminals A6 and A8. 2. If motor still fails to operate, check fuses and if blown, replace. Apply 28-volt DC to motor reversing relay terminal Y2 and speed relay terminal X1. 3. If fuses not blown, or continue to blow and motor does not operate, connect jumpers between the following terminals: T1 on reversing relay to L11 on speed relay, T2 to L12, T3 to L13. 4. If the motor does not run, remove the jumpers and connect them as follows: T1 on reversing relay to L1 on speed relay, T2 to L2, T3 to L3.

UNIT	TERMINAL LOCATION	OPERATION	
		TO RETRACT	TO EXTEND
Flaps (Outboard)	At L.H. Wing-Fuselage Splice (L.H. Flap)	1. Apply 28-volt DC to terminals A10 and A12.	1. Apply 28-volt DC to terminals A9 and A12.
	At R.H. Wing-Fuselage Splice (R.H. Flap)	Apply 28-volt DC to terminals A9 and A12.	Apply 28-volt DC to terminals A10 and A12.
	At Speed Control and Motor Reversing Relay	2. If motor still fails to operate check fuses, and if blown, replace. Apply 28-volt DC to motor reversing relay terminal X1 and speed control relay terminal X1. 3. If fuses not blown, or fuses continue to blow and motor fails to operate, connect jumpers between the following terminals: T1 on reversing relay to L11 on speed relay, T2 to L13, T3 to L12. 4. If the motor does not run, remove jumpers and connect them as follows: T1 on reversing relay, to L1 on speed relay, T2 to L3, T3 to L2.	2. If motor still fails to operate, check fuses, and if blown, replace. Apply 28-volt DC to motor reversing relay terminal Y2 and speed control relay terminal X1. 3. If fuses not blown, or continue to blow and motor does not operate, connect jumpers between the following terminals: T1 on reversing relay to L11 on speed relay, T2 to L12, T3 to L13. 4. If the motor does not run, remove jumpers and connect as follows: T1 on reversing relay to L1 on speed relay, T2 to L2, T3 to L3.
Fuel Booster Pump	At Engine Distribution Panels	TO OPERATE	
		1. Apply 28-volt DC to pump relay terminal X1. Ground terminal X2. 2. If pump fails to operate, add jumpers between the following relay terminals: L1 to T1; L2 to T2; L3 to T3.	
Hydraulic Pump	At Landing Gear Control Panel	TO OPERATE	
		1. Apply 28-volt DC to pump motor relay terminal X1. Ground terminal X2. 2. If pump fails to operate, apply 28-volt DC to No. 2 pump relay terminal X1 and ground terminal X2.	
Intercooler Controls	At Engine Distribution Panels	TO OPEN SHUTTERS	TO CLOSE SHUTTERS
		1. Apply 115-volt AC to terminal B12 for LH shutter and C12 for RH shutter.	1. Apply 115-volt AC to terminal B13 for LH shutter and C9 for RH shutter.

UNIT	TERMINAL LOCATION	OPERATION		
		TO RETRACT	TO EXTEND	
Landing Gear	At Landing Gear Control Panel	1. Apply 28-volt DC to terminal X2 of retract relay and ground terminal X1. Also, apply 28-volt DC to terminal X1 and ground terminal X2 of the No. 1 hydraulic pump relay. 2. If the main selector valve fails to operate, depress the UP plunger on the valve. If No. 1 pump fails to operate, No. 2 may still be operative; however, if No. 2 is also inoperative, apply 28-volt DC to terminal X1 and ground X2 of No. 2 pump relay.	1. Apply 28-volt DC to terminal X2 of the extend relay and ground terminal XI. Also apply 28-volt DC to terminal X2 of the No. 1 hydraulic pump relay. 2. If the main selector valve fails to operate, depress the DOWN plunger on the valve. If No. 1 pump fails to operate, No. 2 may still be operative; however, if No. 2 is inoperative also, apply 28-volt DC to terminal X1 and ground X2 of No. 2 pump relay.	
Nacelle Dump Valves	At RH Fuselage Wing Splice	TO CLOSE DUMP VALVE	TO OPEN DUMP VALVE	
	At Engine Distribution Panels 3 and 4	1. Apply 115-volt AC to terminals A16 and A18. 2. If motor fails to operate, apply 115-volt AC to terminal M16. NOTE: Circuit breakers on engineer's table must be open.	1. Apply 115-volt AC to terminals C12 and C9. 2. If motor fails to operate, apply 115-volt AC to terminal M15. NOTE: Circuit breakers on engineer's table must be open.	
Propeller	At Engine Distribution Panels	TO INCREASE RPM	TO DECREASE RPM	TO FEATHER
		Apply 28-volt DC to terminal A3.	Apply 28-volt DC to terminal A4.	Apply 28-volt DC to terminal B7.
Spark Advance	At Engine Distribution Panels	TO ADVANCE	TO RETARD	
		1. Apply 115-volt AC to terminal A13. NOTE: Circuit breakers on engineer's panel must be open.	1. Apply 115-volt AC to terminal A14. NOTE: Circuit breakers on engineer's panel must be open.	
Turbo Selector Valve	At Engine Distribution Panels	FOR SINGLE TURBO	FOR DUAL TURBO	
		Apply 115-volt AC to terminal B5. NOTE: Circuit breaker on engineer's panel must be open.	Apply 115-volt AC to terminal B6. NOTE: Circuit breaker on engineer's panel must be open.	
Wing Anti-Icing Controls	At Engine Distribution Panels 1, 2, 5, and 6	TO CLOSE VALVE	TO OPEN VALVE	
		1. Apply 28-volt DC to terminal X1 of anti-icing dump valve relay. Ground terminal X2. 2. If motor fails to operate, apply 115-volt AC to terminal M16. NOTE: Fuses must be removed from power panel.	1. Apply 28-volt DC to terminal X1 of anti-icing dump valve relay. Ground terminal X2. 2. If motor fails to operate, apply 115-volt AC to terminal M15. NOTE: Fuses must be removed from power panel.	

LANDING GEAR SYSTEM.

Listed below are troubles which may be encountered and remedied in flight.

TROUBLE	PROBABLE CAUSE	REMEDY
All gears fail to retract.	Hydraulic system malfunction.	Refer to "Emergency Landing Gear Operation," Section III.
	Failure of d-c control power.	Check all d-c fuses. Check output to pilot's circuit breaker panel.
	Selector valve not operating.	Check fuses in d-c control system; operate selector valve manually.
	Low fluid supply.	Fill main reservoir to proper level.
No pressure indication.	Pumps not operating.	Check fuses in d-c control system and a-c power to pump.
	Low fluid supply.	Fill main reservoir to proper fluid level.
Main gear retracts; nose gear does not.	Emergency release pin pulled.	Replace pin. Refer to "Emergency Retraction of Nose Landing Gear," Section III.
Pumps do not stop at end of cycle.	One or more limit switches not actuating.	Pull circuit breakers.
	Faulty relay.	Remove pump fuses to prevent overheating.
All gears fail to extend.	Hydraulic system malfunction.	Refer to "Emergency Landing Gear Operation," Section III.
	Failure of d-c control power.	Check fuses in d-c control system and a-c power to pump.
Retraction exceeds time limits.	One pump inoperative.	Check a-c fuses in pump power circuit. Check fuses in a-c power to pumps.
Hydraulic fluid lost during gear operation.	Leaky connections.	Tighten connections, disconnect reservoir pressure line and refill reservoir.
Main gear door fails to retract and lock.	Air speed too high.	Reduce air speed.

NOSE WHEEL STEERING SYSTEM.

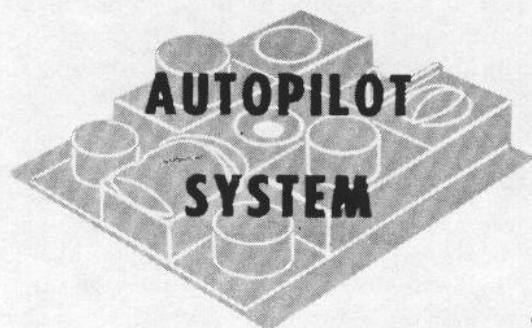
Listed below are troubles that may be encountered and remedied in flight.

TROUBLE	PROBABLE CAUSE	REMEDY
No pressure indication.	Blown fuse.	Check all nose steering fuses. Check circuit breaker on pilot's panel.
	Broken gage line.	Check gage line connections.
No pump action.	Blown fuse.	Check all nose steering fuses. Check circuit breaker on pilot's panel.
No actuation.	Selector valve malfunction.	Manually position selector valve.
	Relief valve stuck in open position.	Lightly tap relief valve.
	Nose gear extension too high.	Bleed nose strut.

BOMB BAY DOOR SYSTEM.

In the event of improper bomb bay door operation the emergency system should be employed as directed in "Bomb Bay Door Emergency Hydraulic System," Section IV. However, listed below are troubles that may be encountered and remedied in flight.

TROUBLE	PROBABLE CAUSE	REMEDY
Doors do not open, pumps operating.	Hydraulic malfunction. Solenoid on selector valve not operating.	Refer to "Bomb Bay Door Emergency Hydraulic System," Section IV. Depress plunger on selector valve.
Doors do not open, no pump operation.	Control circuit malfunction. Pump power failure.	Check circuit breakers and 28-volt d-c fuses. Check a-c fuses to pump.
Doors open, then close part way.	Door open pump limit switches out of adjustment.	Hold bomb bay door switch in OPEN position until doors lock open.
Lamp does not light, bomb bay doors open.	Rack selector circuit breaker open.	Close circuit breaker at d-c power panel.
Door operation exceeds time limits.	One pump inoperative.	Check fuses in a-c power to pumps.
Door opens part way and pumps continue to operate.	Bomb bay door switch actuated when bomb bay door safety switch is ON.	Place bomb bay door safety switch OFF.
Doors open part way and fluid pressure ruptures emergency reservoir in aft cabin.	Emergency selector valve at reservoir is not in OFF position.	Place valve in OFF position. Check fluid level in reservoir.



CI-215-C

A fundamental autopilot design assumption is that the airplane to be controlled is rigid. This assumption applies to small airplanes with negligible error. Large airplanes, however, must either be more flexible or must sacrifice useful load for additional weight of structure. Flight tests with the unmodified E-6 autopilot show that the control frequency and the natural rudder vibration frequency interact to produce a pronounced tail shake or divergent rudder oscillation. Several changes are indicated to improve autopilot adaptation to the airplane and reduce tail shake.

E-6 MODIFICATIONS.

The following modifications are being made on the E-6:

1. Relocation of the yaw rate gyro from the amplifier-calibrator rack to a position near the airplane's center of gravity.
2. Addition of a roll rate gyro, also at a position near the center of gravity of the airplane.
3. Addition of the auxiliary calibrator unit mounted on the amplifier-calibrator rack in place of the yaw rate gyro.
4. Addition of noise filters in each of the control circuits.
5. Modification of the autopilot control panel so that a smaller displacement of the pilots' turn control knob is required to establish a turn of a given bank angle.
6. Replacement of the A-8 directional coupler amplifier with the A-11 directional coupler amplifier. (The A-11 amplifier is capable of introducing 8 degrees of bank angle per degree of heading correction required, as compared to three degrees of bank angle for the same heading correction with the A-8. Also, the A-11 amplifier has maximum output signal from the computer output potentiometer 1 1/2 seconds after the initia-

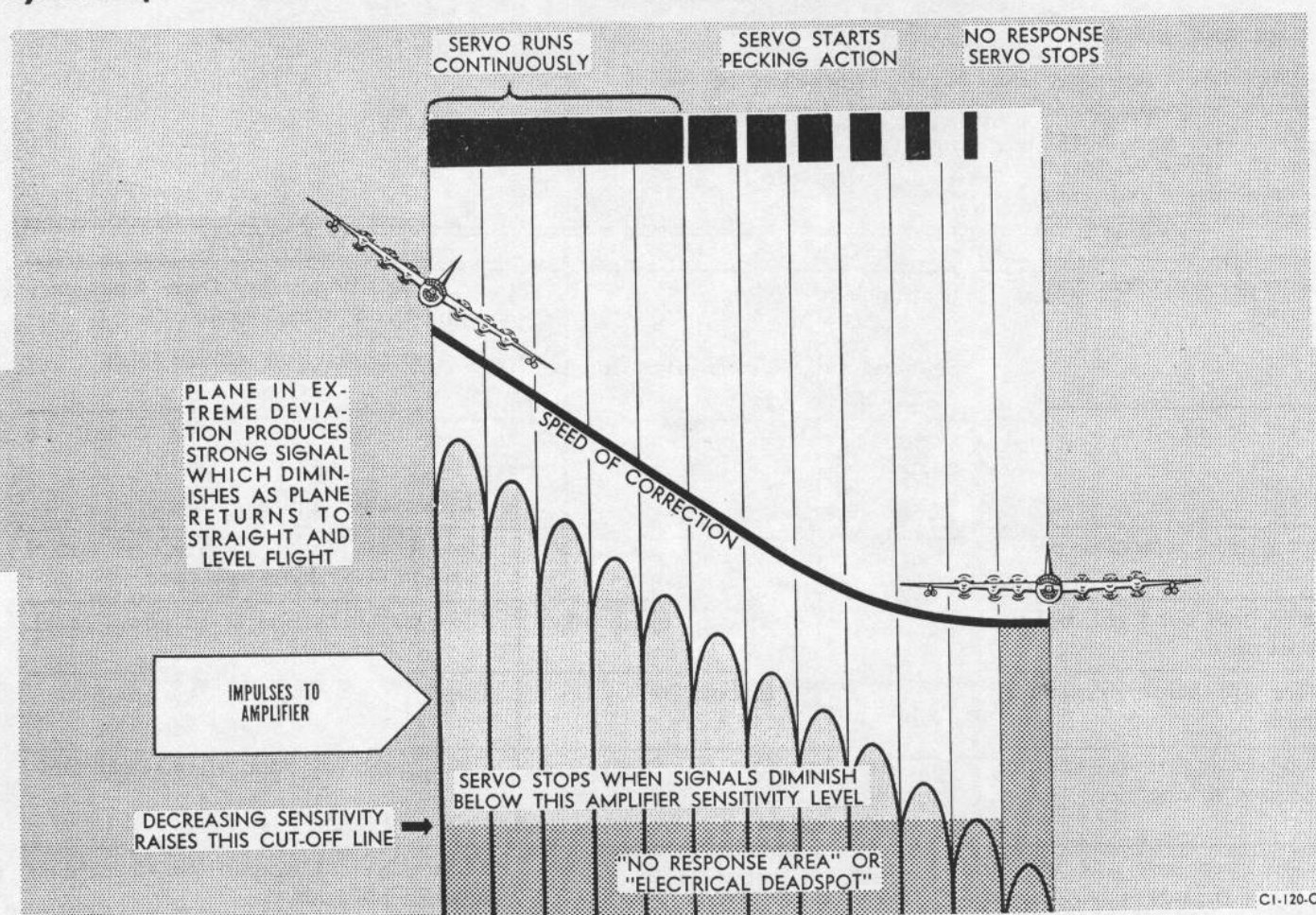


Figure 7-37. Autopilot Response Curve

tion of automatic control as compared to 6 seconds for the A-8.)

If the autopilot calibrator chassis doesn't have a decal pointing out that it is "modified," look at the top of the chassis. The modified chassis will have a big black box in the middle which is labeled "Auxiliary Calibrator." Three calibration controls are located under the cover plate of this unit—rudder gain, aileron roll rate, and rudder roll rate. Another check point is the directional coupler amplifier located under the radar-bombardier's table. The unmodified amplifier is the A-8; the improved amplifier is the A-11.

CHARACTERISTIC RESPONSE CURVE.

The characteristic E-6 response curve is shown in figure 7-37. Note that servo correction signals at any given time are proportional to the remaining error. Normal corrections should be smooth with no overshoot or damped oscillation. The shaded electrical deadspot area is a graphical representation of the effect of the sensitivity controls.

FAMILIARIZATION WITH CALIBRATION CONTROLS.

Before you attempt to set the autopilot calibration controls for optimum performance, study the effect of each

control by operating it through its range of adjustment while all other settings are constant. Use the basic settings tabulated in "Autopilot," Section IV for the initial calibration control configuration. Turn on the autopilot, trim the airplane, and engage autopilot. Go down to the chassis and manipulate each of the following controls:

Sensitivity.

Turn all three sensitivity knobs down near zero and notice that the aircraft becomes sluggish but still flies a good heading straight and level. Turn them all up to 10 and notice that the controls become a little jittery but the aircraft itself is not affected and still flies straight and level. Turn them back to zero again and notice that you can still make a normal maximum bank turn with the turn control knob. Carry sensitivity as high as possible—further adjustment here is somewhat futile.

Ratio.

Turn all three ratio knobs to zero and notice that the aircraft gets "sloppy" in all three axes. Notice the altimeter and compass. The aircraft will hold neither altitude nor heading. Try a maximum bank turn with the turn control knob. Notice how long it takes to get into

the bank and establish any degree of coordination. Set the knobs back to the basic setting and increase them (one axis at a time) toward 10. In aileron, notice that a wing tip "hunt" occurs near a knob setting of 7.5 to 8. In rudder (use caution) notice that the tail begins to "hunt" and shake near a knob setting of 8. In elevator, notice that the aircraft begins to "porpoise" near 8.5 to 9. At these increased settings the aircraft is over-correcting for small gyro displacements, therefore overshooting gyro null points. The aircraft reacts this way because too much control movement is being used to correct for these small displacements. Once this overshoot is started, it easily becomes divergent. Ratio settings are the most important ones on the autopilot. They should be your first adjustment in correcting for an abnormal flight condition.

Throttling.

Turn aileron ratio up just to the point where a wing tip "hunt" appears. Then turn aileron throttling to zero and notice that the "hunt" increases in frequency and amplitude. Now turn aileron throttling up to 10 and notice that the "hunt" has practically disappeared or at least has been reduced to a very low frequency and amplitude. Try the same procedure with the elevator axis. Be very careful if you try it with the rudder—this is one of the best ways to develop a divergent tail shake. Throttling is second only to ratio in importance. These knobs are particularly handy in getting rid of bumps, shakes, and shudders during high speed turns.

Automatic Recovery.

The automatic recovery switch is obstructed on most aircraft, but the knobs on the calibrator are still active. They will change the attitude of the aircraft—leave them alone.

E-FS and FS.

These knobs were used to coordinate formation stick turns. They are still in the circuit but they should not be changed. Moving E-FS will change the pitch attitude of the aircraft.

TC Coordination (Unmodified System).

Put the aircraft into a 20-degree bank with the turn control knob and reduce the TC coordination knob to zero. Notice the needle and ball—the aircraft is skidding. Raise the TC coordination setting to 10. Check needle and ball again; the aircraft is slipping. Adjust the knob for a coordinated turn and leave it there.

TC Coordination (Modified System).

Leave this knob at zero. Turns are coordinated with the rudder gain knob on the auxiliary calibrator.

Bomb Coordination.

This knob has little or no dynamic effect on any axis. Set it at 8 on the unmodified system and at 2 on the modified system.

Rate Coordination.

Turn this knob to zero and notice that the tail begins to "hunt." Make a small turn and notice that the aircraft "fish-tails" around the turn. Place this knob at 10 and leave it there. This circuit still does not provide enough damping for this aircraft.

Up-Elevator Coordination.

Go into a 20-degree bank turn and turn this knob up to 6. Notice that the aircraft is climbing in the turn. Reduce the setting to zero. Notice that the aircraft is diving in the turn. Adjust this knob so that altitude is held constant during turns in both directions. This knob may require frequent adjustment on long flights. It should be readjusted every time a large change in manual elevator trim is required. A compromise setting may be required to equalize performance in right and left turns. This is caused by the exceedingly long length of elevator rigging in the aircraft.

Rudder Gain (Modified System Only).

Set this knob at 10, and notice that the aircraft makes a skidding turn. Set it at zero and notice that the aircraft makes a slipping turn. Adjust for a coordinated turn and leave it alone. This knob is more sensitive than the TC coordination knob, but it rarely needs readjusting.

Aileron Roll Rate (Modified System Only).

Turn this knob to zero and go into a turn. Notice that the aircraft is on the verge of a wing tip "hunt." It will probably overshoot the roll-in and roll-out of the turn and wind up with a wing tip "hunt." Turn the knob up to 10 and notice how sluggish the response is during the roll-in and roll-out of a turn. This knob is very sensitive—adjust it to the point just below which the aircraft begins to "hunt" and overshoot in turns.

Rudder Roll Rate (Modified System Only).

First try the zero setting and then go into a 20-degree bank turn. Notice that the aircraft tends to have a rudder "bump" when rolling in and out of the turn. Now turn the knob up to 10 and notice that the aircraft actually "skids" when rolling in and out of the turn. This circuit puts in bottom rudder for any roll. The amount depends on the knob setting. Adjust for the type roll-in and roll-out turns that you prefer. Once set, this knob rarely needs readjustment.

Compass Maximum Bank.

Note

Of the four knobs on the directional coupler amplifier (type A-8 or A-11), this is the only one of interest to the pilot. The other three knobs concern the operation of the autopilot in "second station."

Turn this knob (figure 4-22) to zero and displace the slaved gyro magnetic compass (with the caging knob) 10 degrees and hold it there. Notice that the aircraft takes up a 12.5 degree bank (1.25 degrees per degree of heading displacement). Recover, turn the knob to 10, and repeat the procedure. Notice that the aircraft takes up a 26.5 degree bank (2.65 degrees bank per degree of heading displacement). In turbulence or at low air speeds (150 IAS), reduction to zero is recommended. Normally, however, 2.5 is the optimum setting.

IN-FLIGHT ADJUSTMENT OF AUTOPILOT.

Now that you are familiar with the individual calibration controls, you must learn to refine the basic settings for top performance under all conditions. The following procedure is recommended for in-flight adjustment.

1. Upon reaching a safe altitude, turn the autopilot ON.
2. Trim the aircraft very delicately for "hands off" straight and level flight.

Note

Do this very meticulously because you are setting up the attitude the autopilot will interpret from the reference gyros and maintain electronically.

3. When the green lights begin to flicker, engage the autopilot. In the event that one of the electrical trim knobs is oscillating when the engage switch is pressed, the autopilot will be out of "electrical trim" and the knob will have to be adjusted. If one knob is moving rapidly, hold it at its point of least resistance while you press the engage switch. Another method involves the use of the calibration unit. Turn throttling on the oscillating axis up to 10. If the knob still oscillates, reduce sensitivity on the same axis until oscillation stops. Engage autopilot and set calibration knobs back to their normal settings.

4. Crack the turn control knob out of its detent—first one direction, then the other. If the aircraft banks momentarily in the wrong direction then goes into the correct turn, the autopilot needs trimming. Find out which surface is the biggest offender. Use only the autopilot trim knobs.

a. Lift up the wing that is dropping in the wrong direction.

b. Try the turn control again. If the bank in the wrong direction persists, the ailerons are not out of trim. Trim the wing tip back where it was.

c. Trim in a reasonable amount of bottom rudder for a turn in the desired direction. Try the turn control knob again. Most of the maladjusted trim should be gone. Both surfaces could have been out of adjustment.

d. If the condition persists, disengage the autopilot, retrim manually, and repeat this procedure.

You should now be set up for a good straight and level flight.

5. Try a few 20-degree bank turns and see if the aircraft holds altitude in both directions. If not, adjust the Up-E coordination knob toward 10 for "nose up" and toward zero for "nose down."

6. Check the needle and ball for coordination and adjust the TC coordination knob (or rudder gain in the modified system) for slip or skid.

7. Check the roll-in and roll-out. If it "bumps" or "hunts," turn rudder throttling up and rudder ratio down.

CAUTION

Do not use ratio unless it is absolutely necessary. On modified systems turn rudder throttling up and rudder roll rate up. Turn rudder ratio down only if necessary.

CAUTION

Use these knobs in the above order on the modified system and use only as many as needed.

Note

Establish optimum performance with the autopilot control panel before attempting to adjust "second station" automatic flight controls.

MALFUNCTION AND CORRECTIONS.

If the autopilot appears to be maladjusted and abnormal flight response appears, there are two questions you should ask yourself.

- a. What has changed?
- b. What would I be doing to the controls to make the aircraft fly like this?

Divergent Rudder Shake.

If the aircraft shakes violently in the yaw axis with increasing amplitude either in turns or straight and level, use the following procedure:

1. Disengage autopilot and go into a sharp bank turn. Level out when shake disappears.
2. Set rudder ratio at 4 or below.
3. Set rudder throttling at 10.
4. Set compass maximum bank at 0.
5. If rudder shake is only in "second station" operation, request radar-bombardier to reduce directional stiffness (proportional range).
6. Re-engage autopilot and try it again.

Rudder Hunt.

If the aircraft oscillates constantly at a regular frequency in the yaw axis either in turns or in straight and level flight, use the following procedure:

1. Reduce rudder ratio.
2. Set rate coordination up to 10.

Rudder Wallow.

If the aircraft "fish-tails" and will not maintain heading, use the following procedure:

1. Increase rudder ratio.
2. Set rate coordination to 10.

Nose Hunt in Turns.

If the aircraft oscillates in the yaw axis in turns, use the following corrective measures:

1. Increase rudder throttling.
2. Set rate coordination to 10.
3. Decrease rudder ratio.
4. For modified autopilot, decrease rudder roll rate.

Wing Tip Hunt.

If the aircraft oscillates constantly at a regular frequency in the roll axis, use the following procedure:

1. Reduce aileron ratio.
2. Increase aileron throttling.
3. Increase aileron roll rate (modified system).

Loose rigging is very capable of causing a wing tip "hunt," but it is usually accompanied by a yaw "hunt."

The combination produces a "dutch roll" (wing tip describing an ellipse). Loose rigging should be spotted by the general feel of the controls at the higher altitudes. If loose rigging is suspected the following procedure will confirm your suspicion and alleviate the problem to some extent.

1. Rudder ratio at 1 or 2.
2. Rudder throttling at 10.
3. Increase aileron ratio until the "hunt" stops.
4. Write up "Loose Rigging" in the Form 1.
5. If just one wing or the cross rigging is loose, adjustment will not help.

Wing Wallow.

(Don't confuse "wing wallow" with wing tip "hunt"). If the aircraft is "sloppy" in heading, occasionally drops a wing, and "wallows" erratically in straight and level flight, the following steps should be taken:

1. Increase aileron ratio.
2. Increase directional stiffness (compass maximum bank toward 10).

Aircraft Dips Wing in Opposite Direction when Starting Turn.

If the aircraft dodges in the wrong direction before

going into a turn, the following corrective action should be used:

1. Go through electrical trim procedure discussed under "In-Flight Adjustment of Autopilot," of this section.
2. If this does not help, the equipment is faulty or the rigging is bad.

Note

If this condition occurs in both directions, the equipment is faulty or the rigging is exceptionally bad.

Aircraft "Shudders" When Turn Control Is Moved Out of Detent.

The following procedure should be used when aircraft "shudders" as the turn control is moved out of detent:

1. Decrease directional stiffness (compass maximum bank knob towards zero).
2. Increase aileron throttling.
3. Decrease aileron ratio.
4. Retrim aircraft.
5. If this does not help, the autopilot needs a "zero signal" suppressor. Write this up for maintenance.

Aircraft Overshoots Roll Out Of Turn Made With Turn Control Knob.

If this conditions occurs, try the following remedy:

1. Move the turn control back in to detent very slowly.
2. Turn aileron ratio down.
3. Turn aileron throttling up.
4. Turn aileron roll rate toward zero (for modified systems).

Green Lights Will Not Come On.

If the green lights fail to come on, try the following procedures:

1. Check that all circuit breakers are in. There are two on the autopilot calibrator chassis, and one on the copilot panel.
2. See if the trim knobs are effective. Turn the knobs both ways and see if they drive back. If one is inoperative, turn it by hand until the green lights come on; then engage the autopilot. If it seems too erratic in one axis, pull out the tubes located in the amplifier on the main autopilot chassis for that axis, and drive the trim knobs by hand until the lights come on.
3. If one of the tubes is burned out, there are some spares in the spare turbo amplifier. The TE-5 is interchangeable with the 1274.

Elevator Trim Knob Malfunction.

If the first few trim knob adjustments do nothing and

the last one produces a violent change, the following procedures will apply:

1. Increase elevator ratio until a "hunt" appears.
2. Remove the "hunt" with elevator throttling.
3. Shake the control column when you put in a correction.

Autopilot Becomes Sluggish.

If the aircraft "wallows" after 10 to 15 hours, the following corrective procedure should be used. The air-

craft is much lighter now and is probably overcorrecting rather than "wallowing."

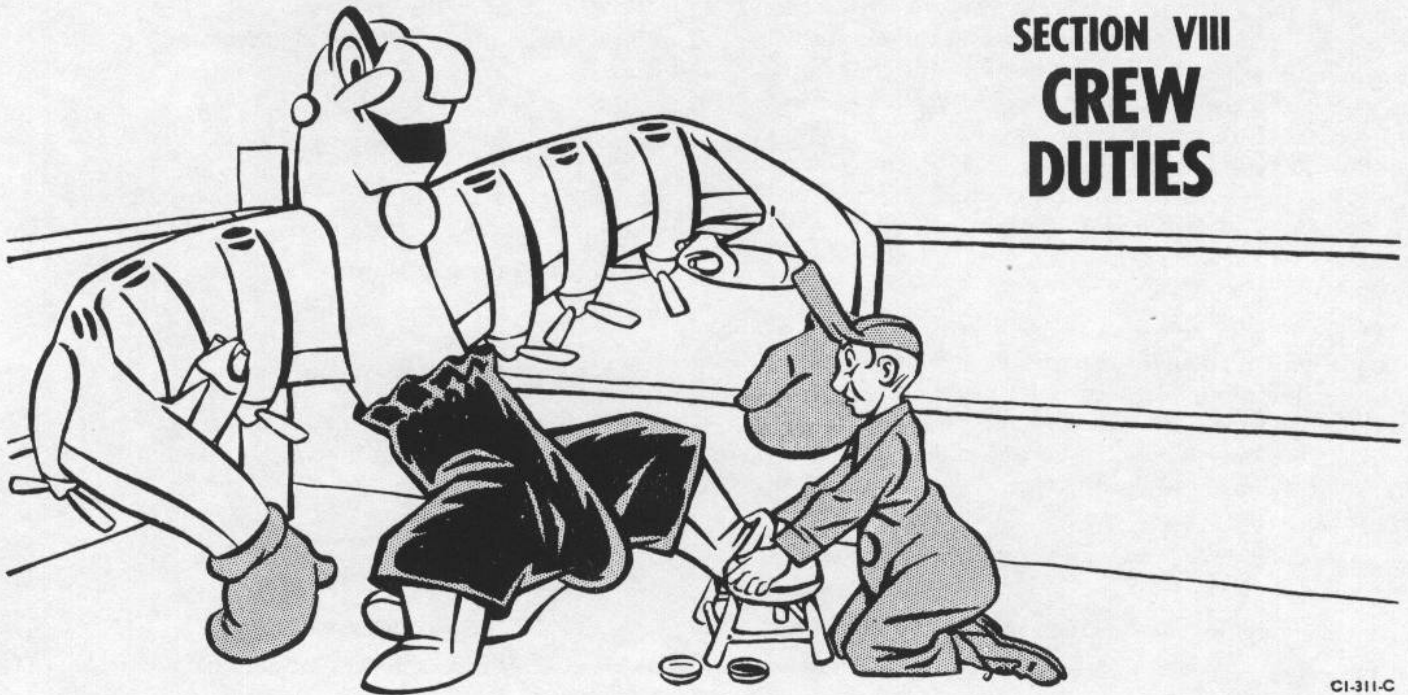
1. Reduce ratio in the oscillating axis.
2. Reduce directional stiffness.

Aircraft Precesses.

If the aircraft precesses, it is probably caused by the slaved gyro magnetic compass.

1. Make sure navigator has slave switch IN.
2. Have the slaved gyro magnetic compass checked.

SECTION VIII CREW DUTIES



CI-311-C

Each crew member of the airplane has primary and alternate duties. Generally, the primary duties of the crew member are explained by his station title. Each crew member has additional duties which must be performed to insure proper flight of the airplane and to support crew safety and comfort during ground operation and flight.

The aircraft commander's, the pilots' and the first and second flight engineers' preflight inspection and duties are covered in "Normal Procedures," Section II. Additional duties and responsibilities of other crew members, including the aircraft commander, are assigned in the following text. It is your individual responsibility to be familiar with each item of equipment and to be able to inspect it thoroughly for any irregularities. Don't let this inspection become so routine that you check it off as completed without doing a thorough job of it. Remember, it is not just your life at stake but also the lives of your fellow crew members.

AIRCRAFT COMMANDER

The aircraft commander is responsible for the issuance of instructions governing all phases of flight operation. His duties and preflight inspection are given in "Normal Procedures," Section II. His responsibilities with regard to formal crew briefing are discussed in the following paragraphs.

AIRCRAFT COMMANDER'S RESPONSIBILITIES.

A formal crew briefing should be conducted by the aircraft commander as soon as possible after detailed mission planning. The first item that the aircraft com-

mander should cover in his crew briefing is a recapitulation of the mission plan to insure that all crew members are completely familiar with the requirements to be accomplished. In case there is any doubt in any crew member's mind, the aircraft commander should completely review that phase of the mission. He should discuss personal equipment that will be carried and assign additional duties such as oxygen officer, and the drawing of extra parachutes, water jugs, and lunches to the various crew members. Before dismissing the crew, he should once again check to make certain that each member is aware of the schedule for reporting to the aircraft, of station time, and of take-off time. If the aircraft commander has paid close attention to the premission planning and has conducted his briefing well, one of the most difficult phases of flying a mission will have been accomplished successfully.

Personal Equipment Requirements.

Personal equipment plays such an important part in the safety and comfort of the crew during a flight that the aircraft commander must never assume that all crew members are adequately equipped. It is his responsibility to make certain prior to flight that all crew members know what equipment they must carry, and he will perform a formal crew inspection before boarding the aircraft. Personal equipment as used on the B-36 is similar to that used on several other aircraft. In the briefing that you will attend prior to flight, either the operations officer or the aircraft commander will specify the equipment needed on the specific flight for which you have been briefed.

Common sense will tell you that if you are scheduled for any altitude work you will need heavy clothing, oxygen equipment, and bail-out bottles plus your normal gear. Keep the cabin heat down when flying over cold regions so that your crew may wear their heavy clothing with comfort. In this manner, if an emergency occurs, the crew will be properly clothed for survival. The following minimum clothing and equipment will be carried by each crew member on all flights above 25,000 feet:

1. Oxygen mask, pressure demand (type A-13, A-13A, or A-15) with adapter for use with H-2 emergency cylinder (bail-out bottle). Demand oxygen mask, type A-14, may be substituted when foregoing types are not available, but only for flights up to 34,000 feet. No attempt will be made to use the type A-14 as a pressure breathing mask.

2. Emergency oxygen cylinder, type H-2, attached to parachute.

3. Helmet, flying, intermediate, type A-11, standard.

4. Goggles, type B-8, for eye and face protection in case of a high altitude bail-out.

5. Jacket, flying, winter, type B-11, standard, or M-1.

6. Trousers, flying, winter, type A-10, standard.

7. Gloves, flying, winter type A-9A, or gloves, flying, intermediate, type A-11A, and insert glove, rayon.

8. Shoes, flying, intermediate, type A-6A.

9. Flashlight.

For overwater flights the following minimum personal equipment will be carried in addition to the above.

1. Mae West for each crew member.

2. Gibson Girl radio.

3. One-man life raft for each crew member.

4. Six-man life rafts sufficient for crew.

5. Anti-exposure suit for each crew member.

6. Applicable survival kits.

Time Schedule.

It is very important that all crew members know station time, when to complete their preflights, crew inspection time, etc. The aircraft commander, assisted by the pilot and copilot, should see to it that all crew members meet these schedules; nothing makes a crew more slovenly than stragglers. Insist on promptness!

COPILOT (RIGHT UPPER FORWARD GUNNER).

In addition to serving as an assistant to the pilot and the aircraft commander, the copilot operates the right forward gun turret. His primary duties and preflight inspections are given in "Normal Procedures," Section II. His additional duties are preflighting the right forward turret as follows:

1. Night-flying curtain.
2. Visual check of right forward turret for stowage and security.
3. Check turret bay for proper condition.
4. Both forward turret safety switches ON.
5. Forward sight and blister checked for proper installation and cracks.
6. Gunsight—Properly stowed.
7. Be ready for final crew briefing.

RADAR-BOMBARDIER.

The radar-bombardier operates the radar set and the K-() bombing system. Following is an abbreviated check list for this position:

WARNING

This aircraft has snap action bomb bay doors.

1. PREFLIGHT

a. MISSION PLANNING

(1) STATION TIME AND PREFLIGHT TIME	RADAR SHOP NOTIFIED
(2) MISSION ORDERS	CHECKED
(3) TARGET DATA	CHECKED
(4) BLANK FORMS	CHECKED
(5) TARGET STUDY	COMPLETED
(6) ULTRASONIC TRAINER RUNS	COMPLETED
(7) FLIGHT PLAN & WEATHER	CHECKED WITH NAVIGATOR

b. PREFLIGHT (ARRIVAL AT AIRCRAFT)

(1) PERISCOPE SIGHT COVER	REMOVED
(2) BOMB BAY DOOR GROUND LOCKS	INSTALLED
(3) BOMB BAY DOOR SWITCHES ACTUATED	INSPECTED
(4) CIRCUIT BREAKERS (9.0 BULKHEAD)	IN
(5) CIRCUIT BREAKERS (8.0 BULKHEAD)	IN
(6) BOMB BAY LIGHT CIRCUIT BREAKERS (7.0 BULKHEAD)	IN
(7) CIRCUIT BREAKERS (6.0 BULKHEAD)	IN
(8) CONSTANT SPEED MOTOR SWITCH	ON
(9) ALL EQUIPMENT IN RADOME	CHECKED AND SECURE
(10) CAMERA DOOR LINKAGE AND ACTUATOR	CHECKED

c. PREFLIGHT (STATION)

- | | |
|---|--------------------|
| (1) BOMB BAY SAFETY SWITCH
(ON PEDESTAL) | OFF |
| (2) BOMB BAY SELECTOR SWITCHES | OFF |
| (3) INTERVALOMETER | SELECT AND
ZERO |
| (4) INTERVALOMETER
HEATER BREAKER | OFF |
| (5) RADAR OPERATOR'S PANEL
CIRCUIT BREAKERS | ON |
| (6) AUXILIARY PANEL
CIRCUIT BREAKERS | ON |
| (7) BOMB MASTER SWITCH | ON |
| (8) BOMB STATION INDICATOR
LIGHT SWITCH | ON |
| (9) SELECTOR SWITCH (AUXILI-
ARY-BOMB RACK REL) | AS DESIRED |
| (10) BOMB ARMING SWITCH | OFF |
| (11) SALVO SWITCHES (2) | OFF |
| (12) D-2 RELEASE SWITCH
(HOLLYWOOD TYPE) | CHECKED |
| (13) PRESSURE SWITCH | ON |
| (14) TONE SWITCH | OFF |
| (15) EQUIPMENT STATUS (FORM
1 AND MAINT LOG) | CHECKED |
| (16) PREFLIGHT RADAR IN
ACCORDANCE
WITH SOP | ACCOMPLISHED |
| (17) TABLE LIGHTS | CHECKED |
| (18) ALL FUSE PANELS
IN NOSE | CHECKED |
| (19) TURN RADAR OFF
IN ACCORDANCE
WITH SOP | ACCOMPLISHED |
| (20) RADAR ACCEPTANCE
FORM | SIGNED |
| (21) INFORM PILOT OF
DISCREPANCIES WHICH
MAY CAUSE RADAR
FAILURE ON
MISSION | ACCOMPLISHED |

d. DUTIES AT STATION TIME

- | | |
|---|-----------------------|
| (1) PERSONAL EQUIPMENT | STOWED |
| (2) SURVIVAL AND
COMBAT EQUIPMENT | STOWED |
| (3) OXYGEN PRESSURE | CHECKED |
| (4) NORMAL AND PRIVATE
INTERPHONE | CHECKED |
| (5) BOMB BAY DOORS
(4 LOCKS REMOVED) | CLEARED AND
CLOSED |
| (6) FORWARD ENTRANCE
LADDER | STOWED |

- | | |
|--|---------|
| (7) FORWARD ENTRANCE
HATCH | CLOSED |
| (8) ALL CIRCUIT BREAKERS
POSITIONED IN ACCORD-
ANCE WITH SOP FOR
TYPE MISSION | CHECKED |

2. IN-FLIGHT CHECK LIST

**a. TURN ON—TUNE—OPERATE RADAR IN
ACCORDANCE WITH CURRENT SOP**

b. PREBOMBING CHECK (ACTUAL DROP)

- | | |
|--|--|
| (1) RADAR OPERATOR'S PANEL
CIRCUIT BREAKERS | IN |
| (2) AUXILIARY PANEL
CIRCUIT BREAKERS | IN |
| (3) BOMB MASTER SWITCH | ON |
| (4) BOMB STATION INDICATOR
LIGHT SWITCH | ON |
| (5) BOMB ARMING SWITCH | ON |
| (6) INTERVALOMETER | AS DESIRED |
| (7) INTERVALOMETER
HEATER BREAKER | ON |
| (8) AUXILIARY—BOMB RACK
RELEASE SWITCH | AS DESIRED |
| (9) BOMB BAY DOOR SAFETY
SWITCH (PEDESTAL) | ON |
| (10) BOMB BAY
SELECTOR SWITCH | (ON JUST PRIOR
TO RELEASE
AND OFF IM-
MEDIATELY
AFTER RELEASE) |

c. PREBOMBING CHECK (RBS)

- | | |
|---|--------------------|
| (1) INTERVALOMETER | SELECT AND
ZERO |
| (2) BOMB BAY SELECTOR SWITCH | OFF |
| (3) BOMB BAY DOOR GROUND
SAFETY SWITCH—K()
PRIMARY CONTROL MOUNT | OFF |

**d. TURN OFF RADAR IN ACCORDANCE WITH
CURRENT SOP**

3. POSTFLIGHT

a. COMPLETE THE FOLLOWING:

- | | |
|---|-----------|
| (1) ENTER RADAR STATUS
IN FORM 1A | COMPLETED |
| (2) COMPLETE AND TURN IN
8AF FORM ODA 13 | COMPLETED |
| (3) PROPER DISPOSITION OF
RADAR CAMERA
MAGAZINE AND LOG | COMPLETED |
| (4) POLICE STATION | COMPLETED |
| (5) TURN IN ALL
LOGS AND FORMS | COMPLETED |

NAVIGATOR.

Following is an abbreviated check list for this position:

1. PREFLIGHT

a. MISSION PLANNING

- | | |
|--------------------------|------------|
| (1) MISSION REQUIREMENTS | UNDERSTOOD |
| (2) WEATHER | CHECKED |
| (3) FLIGHT PLAN | COMPLETED |
| (4) MAPS AND CHARTS | COMPLETE |
| (5) TIME HACK | OBTAINED |
| (6) TARGET STUDY | COMPLETED |

b. PREFLIGHT (ARRIVAL AT AIRCRAFT)

- | | |
|---|---------------------|
| (1) NAVIGATION KIT | COMPLETE |
| (2) HIGH ALTITUDE EQUIPMENT | AS REQUIRED |
| (3) HIGH LATITUDE MAP KIT | CHECKED |
| (4) SPARE ASTRO COMPASS | CHECKED |
| (5) SPARE SEXTANT | CHECKED |
| (6) RATED CHRONOMETER | CHECKED |
| (7) PERSONAL, COMBAT, AND EMERGENCY EQUIPMENT (AS APPLICABLE) | CHECKED AND STOWED |
| (8) FORM 1 | CHECKED |
| (9) ASTRODOME AND BLISTERS | CLEANED AND CHECKED |
| (10) LORAN ANTENNA | CHECKED |
| (11) LORAN AND DIRECTIONAL GYRO SWITCHES | OFF |
| (12) OXYGEN EQUIPMENT ON NORMAL, AND PRESSURE | CHECKED |
| (13) ASTRO COMPASS AND MOUNT | CHECKED AND ALIGNED |
| (14) COMPASS, AIR SPEED, TEMP, AND ALT CARDS | CHECKED |
| (15) FUSES-CIRCUIT BREAKERS FOR NAV EQUIP | CHECKED |
| (16) SAFETY BELT | CHECKED |
| (17) ALTIMETER SETTING AT 29.92 INCHES | SET |
| (18) B-16 COMPASS | CHECKED |
| (19) AIRCRAFT CLOCK | SET |

c. PREFLIGHT (STATION)

- | | |
|-----------------------------------|-------------------|
| (1) CIRCUIT BREAKERS | IN |
| (2) GYROSYN COMPASS | SLAVE IN |
| (3) N-1 COMPASS | PWR SW ON LAT OFF |
| (4) INTERPHONE NORMAL AND PRIVATE | CHECKED |

- | | |
|--------------------------------------|--------------------|
| (5) LORAN | CHECKED |
| (6) TABLE, HAND, AND DOME LIGHTS | CHECKED |
| (7) RADIO COMPASS | CHECKED |
| (8) RADIO ALTIMETER (IF INSTALLED) | CHECKED AND ZEROED |
| (9) GYROSYN OR N-1 COMPASS OPERATION | CHECKED |

2. CREW INSPECTION HACKED AND BRIEFED

3. IN-FLIGHT

a. INITIAL HEADING TO AIRCRAFT COMMANDER

b. NAVIGATIONAL METHODS AS DESCRIBED IN DUTIES OF NAVIGATOR

4. POSTFLIGHT

- | | |
|-------------------------------------|-----------------------------------|
| a. LOG AND FLIGHT PLAN | CLOSED |
| b. SWITCHES | OFF |
| c. NAVIGATIONAL EQUIPMENT | REMOVED |
| d. OXYGEN REGULATOR | ON NORMAL AND OFF |
| e. FORM 1 | COMPLETED |
| f. POSTFLIGHT CREW INSPECTION | COMPLETED |
| g. LOGS, MAPS, FOLDERS, AND REPORTS | COMPLETED, TURNED IN, AS REQUIRED |

OBSERVER (NOSE GUNNER).

The observer operates the nose gun and assists the radar operator and navigator when required. Following is an abbreviated check list for this position:

1. PREFLIGHT

a. MISSION PLANNING

- | | |
|-------------------------------|-------------|
| (1) MISSION ORDERS | CHECKED |
| (2) MISSION FOLDER | COMPLETE |
| (3) TARGET STUDY | COMPLETED |
| (4) FLIGHT PLAN AND WEATHER | CHECKED |
| (5) ASSIST NAVIGATOR AND V.O. | AS REQUIRED |

b. PREFLIGHT (ARRIVAL AT AIRCRAFT)

- | | |
|---|--------------------|
| (1) OBSERVER'S KIT | COMPLETE |
| (2) PERSONAL EQUIPMENT | CHECKED AND STOWED |
| (3) COMBAT AND EMERGENCY EQUIPMENT | CHECKED AND STOWED |
| (4) HEMISPHERE SIGHT COVER | REMOVED |
| (5) FORWARD CABIN PARACHUTE STATIC LINE | CHECKED |

(6) CABIN FIRST AID KIT	CHECKED	b. AN/CRT-3 (DINGHY TRANSMITTER—WHEN APPLICABLE)	STOWED
(7) CABIN HEATER	OFF	c. AN/CRC-7 (VHF EMERGENCY TRANSCEIVER)	STOWED
(8) SPARE BULB BOX	FILLED	d. AN/ARC-3 (VISUAL AND OPERATIONAL)	CHECKED
(9) CABIN WINDOWS	CHECKED	e. AN/ART-6 DESTRUCT CIRCUIT	CHECKED
(10) OXYGEN WALK-AROUND BOTTLE	FILLED	f. BC-453 (VISUAL AND OPERATIONAL)	CHECKED
(11) OPERATION OF NOSE SIGHT	CHECKED	g. INSTRUMENT LANDING EQUIPMENT (VISUAL AND OPERATIONAL)	CHECKED
(12) OXYGEN PRESSURE	CHECKED	h. RADIO COMPASS (VISUAL AND OPERATIONAL PILOT'S AND NAVIGATOR'S CONTROL BOXES)	CHECKED
(13) NORMAL AND PRIVATE INTERPHONE	CHECKED	i. T.O. 08-15-1 (-2) AND FLIGHT HANDBOOKS	CHECKED
(14) NOSE TURRET ACCESS DOOR	SECURED	j. INTERPHONE (VISUAL AND OPERATION, ALL SYSTEMS)	CHECKED
(15) ASSIST NAVIGATOR AND V.O.	AS REQUIRED	k. ALDIS LAMP AND FILTERS	CHECKED
2. IN-FLIGHT		l. FIRE AXES AND FIRST AID KITS (FORWARD COMPARTMENT)	STOWED
a. OPERATE NOSE SIGHT AND TURRET	AS REQUIRED	m. ESCAPE HATCHES (FORWARD COMPARTMENT—RELEASE AND REMOVE TO CHECK OPERATION THEN REINSTALL)	CHECKED
b. RCT HANDSET INFORMATION TO CREW	AS REQUIRED	n. RELIEF CONTAINER (EMPTY AND VALVE CLOSED)	CHECKED
c. ASSIST NAVIGATOR	AS REQUIRED	o. CATWALK ENTRANCE HATCH (OPERATION)	CHECKED
d. ASSIST RADAR-BOMBARDIER	AS REQUIRED	p. BOMB BAY LIGHT	CHECKED
3. POSTFLIGHT		q. COMMUNICATION TUBE (OPERATION OF CART AND BRAKE)	CHECKED
a. NOSE TURRET SIGHTING STATION		r. OXYGEN PRESSURE (400 PSI)	CHECKED
(1) DESICCATOR	OFF	s. ALL PERSONAL EQUIPMENT	CHECKED AND STOWED
(2) CIRCUIT BREAKER (HEATER POWER)	OUT		
(3) ALL TURRET SAFETY SWITCHES	OFF		
(4) CHARGER AND BOOSTER LEADS	DISCONNECT		
(5) WARNING SIGN ON CONTROL PANEL	INSTALL		
(6) SIGHT AND DOME COVERS	REPLACE		
b. OXYGEN REGULATOR	NORMAL AND OFF		
c. PERSONAL EQUIPMENT	REMOVED		
d. COMBAT AND EMERGENCY EQUIPMENT	REMOVED		
e. CREW INSPECTION	COMPLETE		
f. REPORTS AND FORMS	COMPLETE		

FIRST RADIO OPERATOR (ECM OPERATOR).

The first radio operator operates the high frequency liaison communications equipment, the ECM equipment, the IFF equipment, and the left forward gun turret. Following is an abbreviated check list of additional duties for the first radio operator:

1. PREFLIGHT
 - a. FORM 1 CHECKED

SECOND RADIO OPERATOR (ECM OPERATOR).

The second radio operator assists the first radio operator in the preflight. Following is a list of additional duties for which the second radio operator is responsible:

1. PREFLIGHT
 - a. EXTRA PARACHUTE (FORWARD COMPARTMENT) CHECKED
 - b. TWO HOT CUPS (FORWARD COMPARTMENT) CHECKED

- | | |
|---|---------|
| c. ONE INSULATED LIQUID CONTAINER (FORWARD COMPARTMENT) | CHECKED |
| d. ALL PERSONAL EQUIPMENT ABOARD | CHECKED |

LEFT FORWARD GUNNER.

The second flight engineer is responsible for the left forward turret although the radio operator's have been assigned this responsibility previously.

1. Visual check of left forward turret for stowage and security.
2. Check turret bay shear panel for cracks and security.
3. All combat equipment stowed aboard aircraft.
4. Combat station report to radio operator over private interphone.
5. Night-flying curtain.
6. Hand axe and knife.
7. Overwater and survival equipment—Checked and stowed.
8. Sight and blister checked for proper installation and cracks.
9. Gunsight—Caged and mount locked.
10. Crew briefing.

UPPER AFT GUNNER (RIGHT)

In addition to his duties as gunner and scanner this crew member will also check the following:

1. Rudder locks and covers removed.
2. Visual check of upper right aft turret and blister.
3. Check turret bay shear panels for cracks and security.
4. All combat equipment stowed aboard aircraft.
5. Combat station report to radio operator over private interphone.
6. Check and stow overwater and survival equipment.
7. Check first aid kits, crash axe, and fire extinguishers.
8. One insulated liquid container aboard and in place.
9. Battle splints and blood plasma kits.
10. Visual inspection and preflight in accordance with SOP.
11. Turret safety switch—ON.
12. Crew briefing.

UPPER AFT GUNNER (LEFT).

In addition to his duties as gunner and scanner this crew member will check the following:

1. Check all safety locks removed.

2. Visual check of upper left aft turret for stowage and security and shear panels for cracks.
3. Rudder locks and covers removed.
4. All combat equipment stowed aboard aircraft.
5. Combat station report to radio operator over private interphone.
6. Aft entrance ladder aboard and stowed.
7. Aft cabin heating and anti-icing valves as required.
8. Check aft cabin entrance door for tightness of fit.
9. Check and stow overwater and survival equipment.
10. Check trouble light.
11. Aft cabin oxygen supply.
12. Check sight and blister for proper installation and cracks.
13. One insulated container aboard and in place.
14. Check relief container empty and valve closed.
15. Turret safety switch—ON.
16. Visual inspection and preflight accomplished with SOP.
17. Check other gunners on completion of preflight.
18. Crew briefing.

LOWER AFT GUNNER (RIGHT).

In addition to his duties as a gunner and scanner this crew member will check the following:

1. Remove the right gear safety lock.
2. Visual check of lower right aft turret for stowage and security.
3. Check turret bay shear panel for cracks and security.
4. All combat equipment stowed aboard aircraft.
5. Combat station report to radio operator over private interphone.
6. Two Aldis lamps aboard, plugged in and checked.
7. One spare chute aboard aircraft.
8. Check and stow overwater and survival equipment.
9. Trouble light checked.
10. Catwalk entrance door checked for tightness of fit.
11. Aft cabin power panel checked.
12. Aft cabin lights checked.
13. Sight and blister checked for installation and cracks.
14. Aft turret bay and No. 3 and 4 bomb bay. Light checked.
15. Turret safety switch—ON.
16. Visual inspection and preflight in accordance with SOP.
17. Crew briefing.

LOWER AFT GUNNER (LEFT).

In addition to his duties as a gunner and scanner, this crew member will also check the following:

1. Remove left gear safety lock.
2. Visual check of lower aft left turret for stowage and security.
3. Check turret bay shear panel for cracks and security.
4. All combat equipment stowed aboard aircraft.
5. Combat station report to radio operator over private interphone.
6. Check and stow overwater and survival equipment.
7. Two insulated liquid containers aboard and in place.
8. Parachute static line.
9. Portable fire extinguishers.
10. Communication tube and flange valve in door checked for proper fit.
11. Trouble light checked for operation.
12. Sight and blister checked for proper installation and cracks.
13. Visual inspection and preflight in accordance with SOP.
14. Turret safety switch—ON.
15. Crew briefing.

TAIL GUNNER.

In addition to operating the radar equipment which controls the tail turret this crew member will check the following:

1. Inspection of empennage.
 - a. Condition of control surfaces.
 - b. Condition of horizontal and vertical stabilizer.
 - c. Installation of inspection panels.
2. Complete visual check of turret.
3. All combat equipment stowed aboard aircraft.
4. Combat station report to radio operator over private interphone.
5. Two walk-around bottles filled and in place.
6. Check paper cup dispenser cleaned and filled.
7. Two hot cups cleaned and in place.
8. Check and stow overwater and survival equipment.
9. Toilet paper in place.
10. Complete visual check of AN/APG-32 set.
 - a. Check radar pressurization and pressurized units.
 - b. Check all cannon plugs in tail cone.
11. Inspect cables in rear section for frays and breaks.
12. Dome lights in rear section inspected for operation.
13. Rear pressurized door checked for proper fit.
14. Aft cabin entrance hatch—Checked and closed before take-off.
15. Tail cone lights—As required.
16. Turret safety switch—ON.
17. Set aft cabin altimeter to 29.92.
18. Crew briefing.



CI-346R-C



CI-312-C

This section contains discussions and specific procedures pertaining to operation of the airplane at night, under instrument conditions, in thunder storms, in cold weather, in hot weather, and in the desert. The normal

operating instruction of Section II are repeated only when the unity of this section requires this duplication. Operation of the various systems and equipment is discussed in Section VII.



CI-267-C

Night flying and instrument flying are identical in many points of technique. Take-off, climb, and landing will require instrument reference when visual orientation becomes uncertain. Since most missions involve night flight, the following items should be checked prior to each flight:

1. Landing lights.
2. Position lights.
3. Formation lights.
4. Wing crawlway lights.
5. Instrument panel lights.
6. Flight deck flood lights.
7. Aldis lamps (1 in forward compartment—2 for aft scanners).
8. Spare bulbs.
9. Flashlights.
10. Night-Flying curtains.

NIGHT TAKE-OFF.

1. Keep cockpit lights dim to protect your night vision.

2. Use night-flying curtain to permit engineer to illuminate his panel.
3. Check flight instruments during taxi turns.
4. Be particularly alert for taxi strip obstructions. Use Aldis lamp or dispatch wing walkers to check clearances with flashlights.
5. Line up with runway; have nose wheel straight.

Note

A constant 2-degree difference in runway heading and airplane heading will cause airplane to run off runway prior to take-off.

6. Set gyro to zero or to 5-degree mark nearest runway heading.
7. Perform usual checks.
8. During the ground run, the aircraft commander should maintain visual contact, and the pilot should watch instruments.
9. After the "getaway," aircraft commander should go on instruments, and pilot should maintain visual con-

tact to prevent airplane from settling back onto the runway.

NIGHT CLIMB.

1. Use nose down trim after leaving ground effect if climb becomes too steep.
2. Retract flaps in the usual five-degree increments, retrimming between retractions.

Note

Flap retraction technique for take-off gross weight in excess of 300,000 pounds is discussed in Section VI, "Flight Characteristics."

3. Maintain take-off power until airplane is "clean" and altitude is between 500 and 1000 feet above the terrain.

4. Maintain climb speed somewhat higher than optimum climb speed.

NIGHT LANDING.

1. Make normal checks. Scanners should use Aldis lamps for visual inspections.
2. Use landing lights for last part of final approach.
3. Use caution in judging height over the end of the runway.



INSTRUMENT FLIGHT PROCEDURES

CI-233-C

The instrument flight characteristics of this airplane are conventional. Operation of flaps and landing gear do not cause pitch changes that would be dangerous at any stage of instrument flight.

Duplicate flight instrumentation is provided along with all standard electronic aids to instrument navigation and approach. The limiting factor will usually be availability of ground facilities. You will have to consult applicable radio and navigational charts for specific local equipment and procedures.

BEFORE STARTING ENGINES.

Prior to starting the engines and with the portable power cart operating, check the following:

1. Windshield wiper operation and blade contact.
2. Pitot heater operation.
3. Navigation lights.
4. Flight instrument switches—ON.
5. Flight indicators operating and instruments erecting.
6. Cockpit lights and flashlights.
7. VHF, low frequency, ILAS, radio compass, and VOR.
8. Gyrosyn compass uncaged and operating. (Check against magnetic compass.)
9. Position cockpit heat and anti-icing valves for maximum windshield defrost.
10. Position pilots' ventilating fans to aid windshield defrost.

AFTER STARTING ENGINES.

Check the anti-icing equipment for proper operation and then turn OFF after starting the engines.

DURING TAXI.

During taxi, check:

1. Landing lights.
2. Turn needles.
3. Gyros and compass (for proper swing and operation).

BEFORE TAKE-OFF.

Check the following items before take-off.

1. Radio receivers turned to proper stations.
2. Altimeter and gyros set.
3. Pitot heater ON (if icing conditions exist).

TAKE-OFF.

The aircraft should be flown off the ground as during a visual take-off; however, instrument take-off should not be attempted unless there is sufficient visibility to aid in steering the aircraft during the initial take-off roll.

CAUTION

A constant 2-degree error in heading will cause aircraft to go off runway before take-off.

In aircraft equipped with A-1 and J-8 attitude indicators, because of the high angle of pitch on take-off, the horizon bar will ride near the bottom of the indicators, and only limited pitch and roll information will be displayed. Therefore, during the instrument take-off, the air-speed indicator will have to be used to provide additional pitch information. Since the aircraft accelerates rapidly after becoming air-borne, use caution to prevent exceeding the maximum flap speed.

The following instrument take-off procedure is recommended:

1. Visually align the aircraft on the center line of the runway with nose wheel straight.
2. Use normal elevator tab and flap settings.
3. Set miniature aircraft reference on attitude indicator as desired.
4. Position cockpit heat and anti-icing valves for maximum flow to pilots' enclosure in the event icing conditions are encountered on take-off.
5. Advance power and make normal VFR take-off.

CAUTION

A constant 2-degree error in heading will cause airplane to go off runway before take-off.

6. Retract landing gear after becoming definitely airborne.
7. Retract flaps in accordance with the procedure in Section VI, if your take-off gross weight exceeds 300,000 pounds.
8. Apply nose down trim as required between flap retractions.
9. Establish climb configuration.

CAUTION

Limit turns to a maximum bank angle of 15 degrees.

10. Anti-icing equipment ON (if required).

INSTRUMENT CLIMB.

1. Maintain air speed somewhat higher than optimum climb speed.
2. Keep turns under one-needle width.

INSTRUMENT CRUISING FLIGHT.

CAUTION

At no time should the aircraft be permitted to enter an unusual attitude which might result in exceeding the critical Mach number and entering the buffet or compressibility range.

Extended operation on instruments can usually be avoided by cruising at high altitude. As you increase your flight level, the number of cloud types that can exist is substantially reduced. While you are cruising on instruments, the following points are significant:

1. Trim airplane "hands off" before engaging autopilot.

2. Repeat hands off trimming operation every one and one-half to two hours to compensate for cg changes.

3. Avoid extreme turbulence if possible.

4. If you cannot avoid turbulence, disengage autopilot and fly "attitude" rather than "altitude."

5. Cross check all instruments and electronic aids.

SPEED RANGE.

The rapidity with which you must scan all flight instruments varies with the speed of flight. While this airplane has a very wide speed range for a bomber, normal operating speeds are not high enough to make instrument flight more difficult. Ordinarily, the speeds established by cruise control requirements will be the desirable instrument speeds.

RADIO AND NAVIGATION EQUIPMENT.

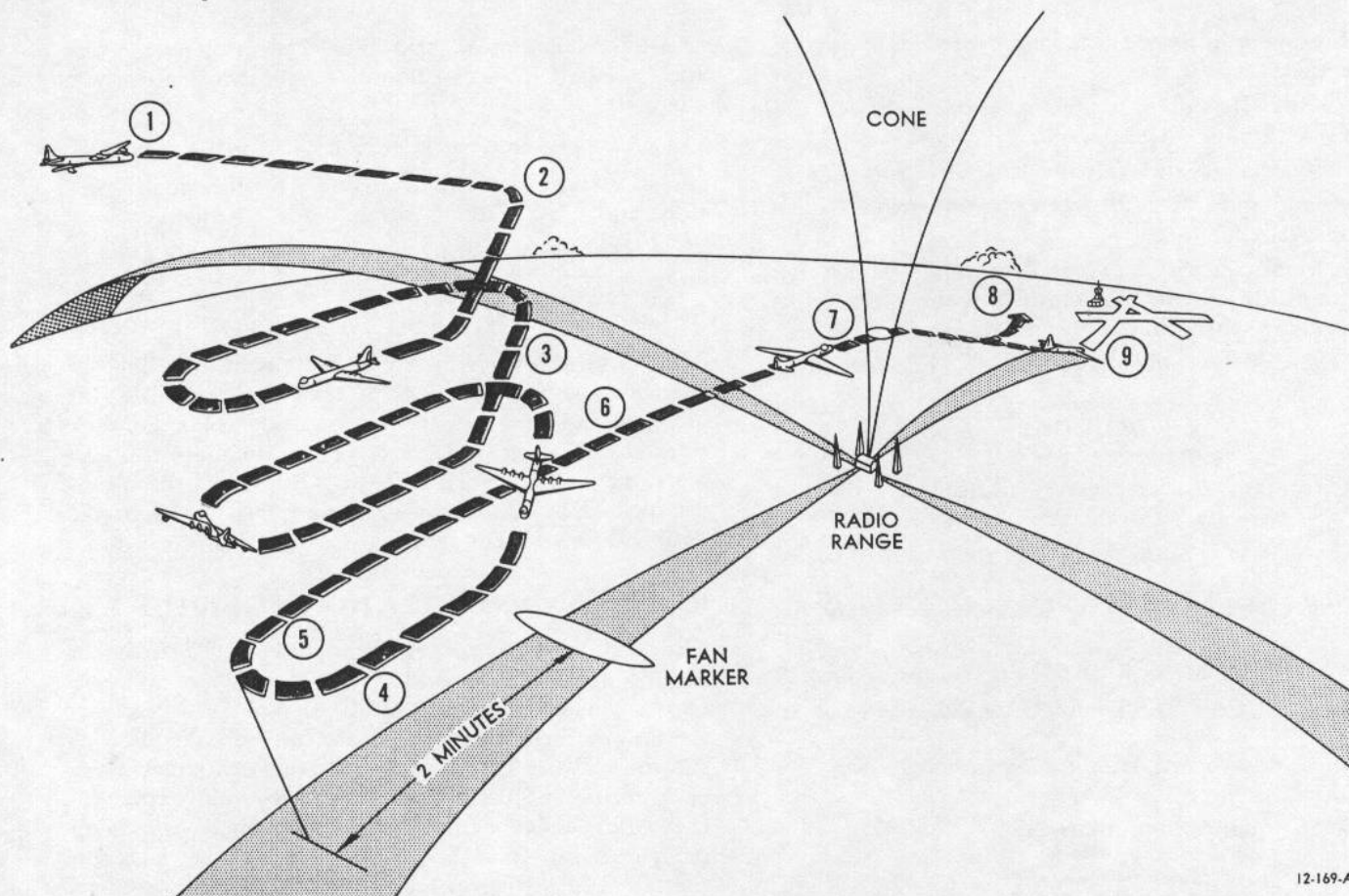
The dependability of electronic aids to instrument flight and navigation is closely related to the influence of the various types of static. Man-made static, precipitation static, and dust static can be controlled or suppressed. Crash static from active storm areas, however, cannot be controlled. This accounts for the increased dependence on very high frequencies which are comparatively immune to this type of interference. Electrical disturbances will affect equipment with frequencies below 75 mc within a radius of several thousand miles. Therefore, under severe instrument conditions, VHF equipment will offer greater dependability. A classification of electronic aids according to frequency range is listed as follows:

<i>Low to High Frequency</i>	<i>Very High Frequency or Above</i>
Liaison Radio	Instrument Approach Indicator
Radio Range Receiver	Command Set
Radio Compass	Marker Beacon Receiver
Loran Set	Radar Equipment

AIR-BORNE RADAR.

This equipment permits visual or contact flight precision under instrument conditions. The amount and accuracy of information obtained through radar scope interpretation depend largely on the skill of the operator. Distinctive terrain features can be used for navigation regardless of prevailing visibility. Relative bearings and distances can be read directly from the scopes; relative altitudes can be determined by comparing flight altitude with map elevation lines or color codes.

When the radar system is used for navigation, radar-observed drift corrections can be coupled directly from the radar ground position computer to the autopilot. Grid navigation in latitudes above the 70th parallel can also be accomplished with certain parts of the radar system. A great circle path between the high



1. Obtain approach clearance upon entering control area.
2. Hold as directed—monitor all conversations.
3. Report leaving each altitude promptly.
4. Time your holding pattern to put you over the fan marked inbound when anticipated landing clearance comes through.
5. Complete check list prior to this point except:
 - a. Flaps—extend 10°

- b. IAS—160 or 130% stall—whichever is greater.
6. Extend flaps 20°—stabilize IAS at final approach speed.
7. Establish proper rate of let down by reducing MP (on 6 engines) 1" for each 100 ft./min. rate of descent desired.
8. If you are not contact at specified minimum, use "missed approach" procedure.
9. Report "below all clouds" as soon as possible.

Figure 9-1. Typical Radio Range Procedure

latitude entry and exit points can be followed by reference to a free gyro rather than magnetic field of the earth in the polar regions.

At low altitude, the strong ground echo and the greater apparent speed of the airplane relative to the ground make accurate scope interpretation almost impossible. For this reason, instrument low approaches accomplished exclusively by air-borne radar are not recommended.

Turbulence does not provide a discontinuity that would show up on the radar scope. Thunderstorm research, however, shows that rain and turbulence are related. Consequently, you can pick the smoothest path through a thunderstorm area by avoiding strong rain echoes. This path should be selected before entering the storm area. Heavy local rain will temporarily block the radar scope with strong echoes.

Absolute altitude can be read from the radar scope with a degree of accuracy that depends on the terrain. When

the ground is smooth, accuracy is best; when the ground is rough or hilly, the scope shows altitude above an "average" ground level. The radial distance on the scope to the first ground echo is the altitude index.

DESCENT.

Descent under instrument conditions will be in accordance with normal procedures discussed in Section II unless atmospheric conditions dictate changes in power settings. Rapid drops in CHT should be avoided, and prolonged operation with CHT below 180°C can cause lead fouling. If icing conditions exist, it will be necessary to change power settings to provide sufficient heat for carburetor, wing, and tail de-icing.

HOLDING.

Endurance ordinarily is not critical. If you are required to hold while waiting for airways or approach clearance, use maximum endurance power settings for your

gross weight and altitude. A typical holding procedure is shown in figure 9-1 in conjunction with the radio range procedure.

INSTRUMENT APPROACHES.

Equipment is provided for the reception of Radio Range, ILAS, and GCA signals. ILAS and Omnidirectional Range signals are interpreted by visual indicators. Approaches based on any combination of equipment are recommended for additional safety.

The following points of technique will apply to all instrument approaches:

1. Consult applicable radio and navigational charts for specific local procedure.
2. Limit flaps to 20 degrees until landing is assured.
3. Pilot should double check aircraft commander's procedure.
4. Pilot should check for runway or high intensity approach light as aircraft commander reaches final stage of approach.

CAUTION

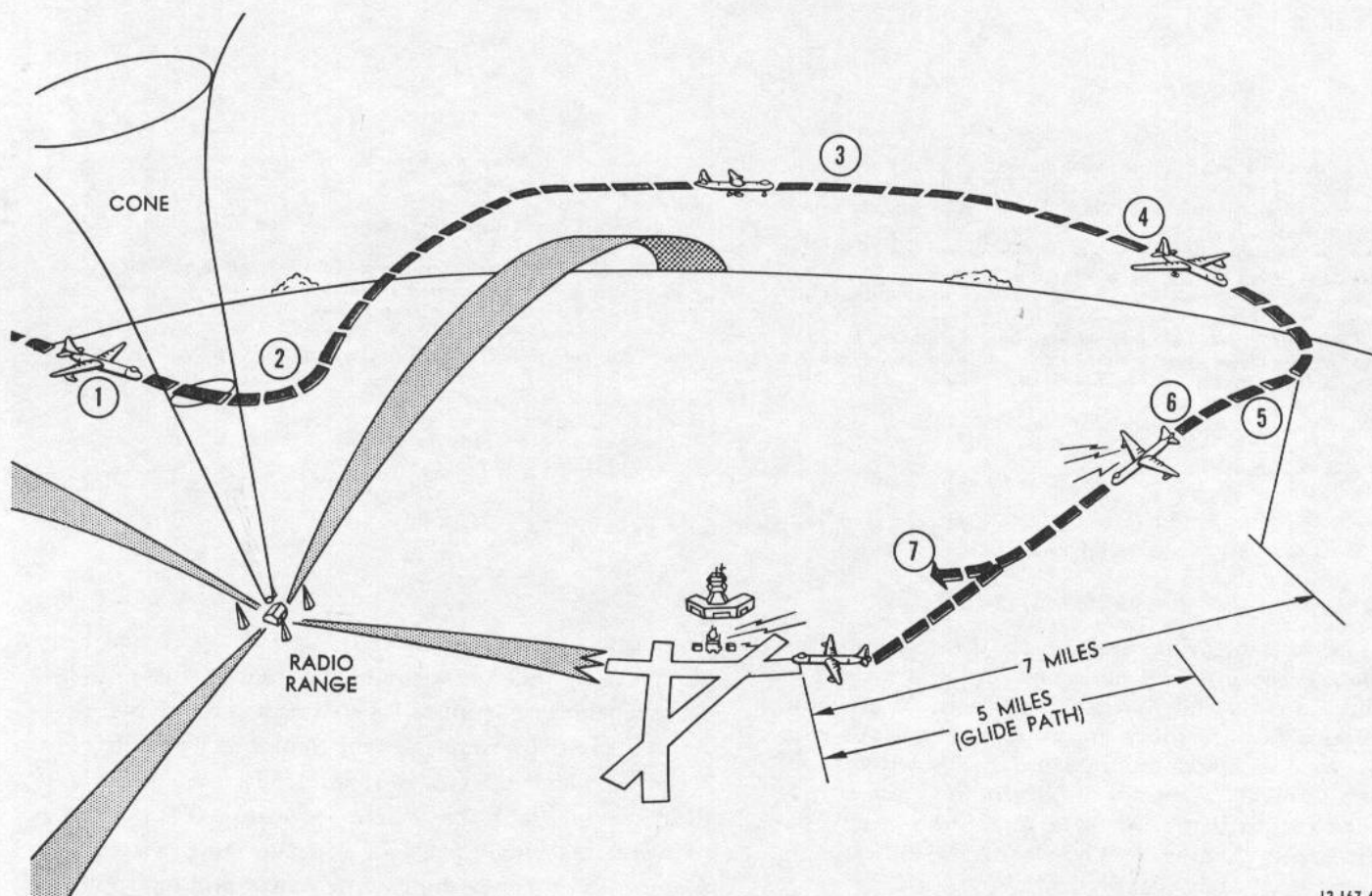
Do not change from your approach system until you are in the clear. Partial visibility can introduce serious errors in depth perception.

RADIO RANGE LETDOWN.

Range procedures will remain fundamental until new techniques are developed. More precision is offered by GCA and ILAS for low approaches, but preliminary orientation and holding on the radio range are usually required. A typical range procedure is shown in figure 9-1, along with specific procedure for this airplane.

GROUND CONTROLLED APPROACH.

This system is usually referred to as GCA, and the instrument publications should also be consulted for procedure in obtaining a GCA channel. Low frequencies are usually available if vhf equipment is inoperative. Procedural check points are shown in figure 9-2.

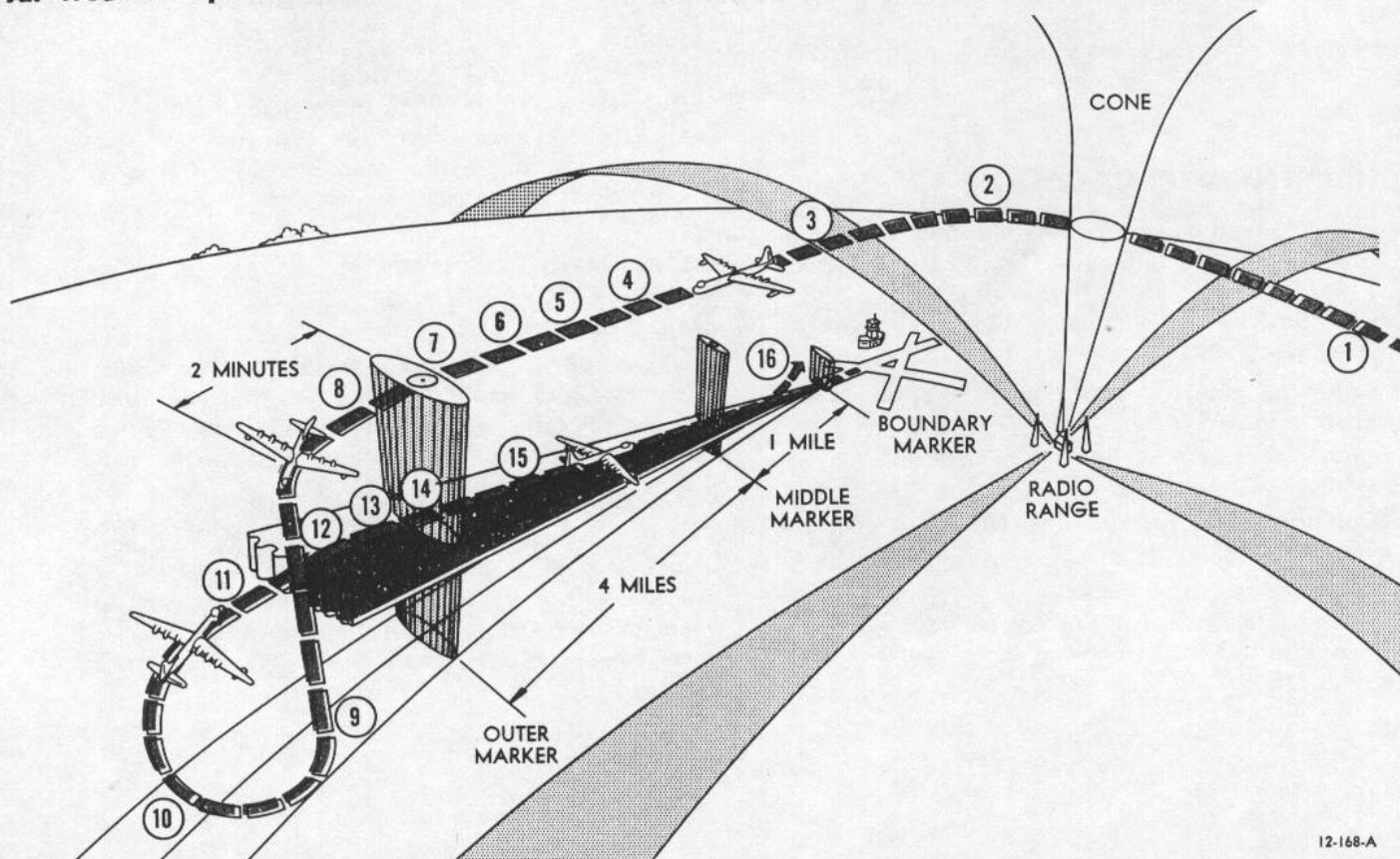


12-167-A

1. Turn as directed by GCA—report leaving cone.
2. Descend as directed to GCA traffic altitude.
3. Complete check list prior to this point except:
 - a. Flaps—extend 10°
 - b. IAS—160 or 135% whichever is greater.
4. Hold 150 IAS—descend approximately 500 feet to final approach altitude, flaps 20°.
5. Level off at final approach IAS, stabilize IAS at final approach speed.
6. When you intercept glide path, reduce power on 6 engines approximately 1" MP for each 100 ft./min. rate of descent required. After air-speed and descent rate stabilize, adjust power as required.
7. Minimum conditions will depend on pilot proficiency, urgency of mission, local regulations, and local obstructions.

Figure 9-2. Typical GCA Procedure

RESTRICTED



12-168-A

1. After clearance has been received, descend to initial approach altitude.
2. Perform final landing check but do not set propellers, or extend gear, and flaps.
3. Use low frequency homing facility to aid interception of localizer beam out bound at an angle of less than 30 degrees.
4. Bring ILAS cross pointer into normal sequence of cross-check (out bound deflections are reversed.)
5. If interception is made close to localizer, turn to corrected published heading (use metro winds or drift calculated during holding procedure) until localizer needle settles to steady indication.
6. Center the localizer needle (out bound).
7. Course should be established within 1 or 2 degrees. (Degrees of bank should not exceed degrees of correction indicated.)
8. Note out bound drift correction.
9. Standard procedure turn.
10. Cross check needle frequently during last 90° of turn toward in bound heading—adjust turn to give "on course" indication when turn is complete.
11. Set propellers, lower flaps 20°, lower gear, and descend to final approach altitude.
12. Stabilize IAS at final approach speed—straight and level flight.
13. When glide path is intercepted establish proper rate of descent (approximately 1" MP off 6 engines for each 100 ft./min).
14. Compare altimeter and published intersection altitude—allowable error is 50 feet. If error is excessive and ground is not visible, go around.
15. Increase speed of cross check and make smooth coordinated corrections as soon as pointers deviate—avoid overcontrolling.
16. Minimum ceiling will depend on local regulations, local obstructions, urgency of mission, and pilot's proficiency.

Figure 9-3. Typical ILAS Procedure

INSTRUMENT LOW APPROACH SYSTEM.

ILAS is the standard designation for this low approach system. Procedures and minimums are also defined in applicable radio and navigational charts. When both ILAS and GCA facilities are available, an ILAS with GCA monitor is desirable from the standpoint of safety. General procedure is shown in figure 9-3. If signal strength is too low to give accurate needle deflections, red warning flags appear in the indicator.

ICE, SNOW, AND RAIN.

Proper technique is essential when flying in ice, snow, or rain. The various types of icing are probably the greatest hazard, but rain and snow can impair forward visibility to the extent that instrument technique will be required.

ICE

The "catch" or rate of ice build-up is proportional to air speed. Consider a section of the leading edge of the wing where the curvature is based on a one-foot radius. At 200 mph the water "catch" will be .5 pounds of water each hour per foot of span. Under the same conditions at 400 mph the "catch" increases to 6.5 pounds of water each hour per foot of span. Heat available for anti-ice goes up along with power and air speed, but not fast enough to compensate for the more rapid increase in ice build-up. It is desirable to establish optimum anti-ice configuration prior to operation in an icing zone. Maximum heat will then be available for propeller, wing, windshield, and tail de-icing. Optimum anti-ice configuration is listed as follows:

1. Dual turbo.
2. High rpm.
3. High fan.
4. Low speed.
5. High temperature.

A low speed climb at normal rated power is recommended for climb through an icing zone.

The anti-icing system should be turned on before entering icing conditions. In severe icing conditions, flow-back freezing may be encountered, and this will result in a loss of air speed. Under these conditions, ice may also form along the bomb bay doors. Periodic opening and closing of the doors will break up this accretion. If windshield is icing or frosting accomplish the following:

1. Position valves for maximum heat in forward compartment. (Refer to "Heat and Anti-Ice System," Section IV.)
2. Direct air flow to pilots' enclosure, and position pilots' air circulating fans for windshield defrosting.
3. Turn on booster fan to increase flow of air in pressure duct.

During flight in heavy icing conditions, especially in freezing precipitation and thunderstorms, icing of the induction system may be encountered. Refer to "Carburetion," Section VII.

Emergency Use of Carburetor Preheat.

The temperature range that is most critical for induction system icing is from -50°C to $+15^{\circ}\text{C}$. In event it becomes necessary to maintain the CAT. above the icing range throughout a descent to touch down, the following procedure will apply. Use single turbo and a high turbo setting with part throttle down to the traffic pattern altitude with carburetor preheat off. At traffic pattern altitude, with the carburetor preheat circuit breakers pulled, place the carburetor preheat switch to the ON position. Advance the throttle on one engine at a time to 37 inches M.P. and shift to dual turbo. As the shift occurs, push the carburetor preheat circuit breaker in for that engine. This procedure will maintain the CAT. at approximately 30°C during and after shifting from single to dual turbo.

CAUTION

In icing conditions it is imperative to maintain the CAT. well above the icing range during the transition of the turbo shift. Repeat these steps for the other five engines.

CAUTION

If the landing is rejected, turn the carburetor preheat switch OFF as go-around power is applied.

Ice Formation in Jet Engines.

To prevent the formation of ice in the jet engines at temperatures above -40°C (-40°F), use the following procedure when icing conditions are present.

Note

The wing anti-icing system must be in operation before jet pod preheating can be accomplished.

1. Pod preheat control switch—ON.

CAUTION

If there is evidence that insufficient heat is available for wing anti-icing, turn the pod preheat switch OFF to obtain adequate heat for anti-icing the wing.

2. Nose de-ice control switch—ON.
3. Jet air plug control switches—CLOSE.

Note

Closing the air plug doors will minimize the amount of moisture entering the engine and at the same time will allow adequate windmilling (approximately 3-5 per cent rpm).

Note

If the windmilling rpm of the jet engines shows a tendency to decrease, ice is probably forming on the compressor blades. Increase wing anti-icing air temperature to maximum to provide additional heat to the jet pods.

4. After icing conditions are past, open the air plug doors for a few minutes to blow out any water or loose ice.

At temperatures below -40°C (-40°F) use the following procedure to prevent the jet engine oil from congealing.

Note

The wing anti-icing system must be in operation before jet pod preheating can be accomplished.

1. Pod preheat control switch—ON.
2. Nose de-ice control switch—OFF.

Note

At temperatures below -40°C (-40°F) impact icing does not occur.

3. Jet air plug control switches—CLOSE.

Note

If sufficient windmilling (3-5 per cent rpm) cannot be obtained with the air plug doors fully closed, open them slightly.

SNOW.

Impaired forward visibility is the main problem when flying in a snowstorm. Windshield wipers and maximum windshield defrost will improve forward visibility under these conditions. Side visibility will not be greatly reduced. Optimum anti-ice configuration should be maintained.

RAIN.

Forward visibility in rain is also a serious problem. Side visibility will not be seriously impaired, but final approaches in heavy rain will be rather difficult. Proper windshield wiper blade contact will reduce the hazard considerably.

TURBULENT AIR AND THUNDERSTORM FLYING.

Note

Flight through a thunderstorm should be avoided. However, since circumstances may force you to fly into a zone of severe turbulence, you should be familiar with the piloting techniques recommended for these conditions. Power setting and pitch attitude are the keys to proper piloting technique when flying in turbulent air. The power setting and pitch attitude required for the proper penetration air speed are established before entering the storm. This speed, if maintained throughout the storm, will result in a constant air speed, regardless of any false readings of the air-speed indicator. Specific instructions for preparing to enter a storm and flying in it are given in the following paragraphs.

Approaching the Storm.

It is imperative that you prepare the airplane prior to entering a zone of turbulent air. If the storm cannot be seen, its proximity can be detected by radio crash static. Prepare the airplane as follows:

1. Disengage the autopilot.
2. Propeller controls—2200 rpm for gyroscopic stability.
3. Mixture controls—NORMAL.
4. Pitot heater switches—ON.
5. Carburetor preheat—As required.
6. Throttle—Adjust as necessary to obtain recommended penetration speeds as listed below. These speeds provide the maximum margin under turbulent air conditions between stall possibilities at slower speeds and structural limits and compressibility buffeting at higher speeds.

<i>Altitude</i>	<i>Indicated Speeds With or Without Pods</i>
10,000	220
20,000	220
30,000	220
35,000	215
40,000	195

7. Check gyroscopic instruments for proper settings.
8. Safety belts—Tightened. (Check with crew members.)
9. Turn off radio equipment rendered useless by static.
10. At night, turn on the white flight deck flood lights to minimize the blinding effect of lightning.

WARNING

Do not lower the landing gear or the flaps as they merely decrease the aerodynamic efficiency of the airplane.

In the Storm.

1. Maintain power setting and pitch attitude (established before entering the storm) throughout the storm. Hold these constant and your air speed will be constant—regardless of what the air-speed indicator reads.
2. Devote all of your attention to flying the airplane.
3. Expect turbulence, precipitation, and lightning, but do not allow them to cause you undue concern.
4. Maintain attitude. Concentrate principally on holding a level attitude by reference to the artificial horizon.
5. Do not "chase" the air-speed indicator, since doing so will result in extreme airplane attitudes. If a sudden gust should be encountered while the airplane is in a nose-high attitude, a stall might easily result. A heavy rain may partially block the pitot tube pressure head, causing the reading on the air-speed indicator to decrease by as much as 70 mph.
6. Use as little elevator control as possible to maintain your attitude in order to minimize the stresses imposed on the airplane.
7. The altimeter is unreliable in thunderstorm flying because of differential barometric pressures within the turbulent area. A gain or loss of several thousand feet may be expected. Make allowances for this error in determining minimum safe altitude.

Note

Normally, the least turbulent area in a thunderstorm will be at an altitude of 6000 feet above the terrain. Altitudes between 10,000 feet and 20,000 feet are usually the most turbulent.



CI-234-C

The following operating instructions are written as a supplement to the instructions in Section II and should be complied with when cold weather conditions are encountered. The success of the next day's operation depends greatly on the preparations made during engine shutdown and postflight procedures. These procedures are outlined in "Stopping Engines" and "After Engine Shutdown" of this section.

BEFORE ENTERING AIRPLANE.

1. Check the Y-drains and oil tank sumps for oil flow. Drain enough oil to make sure that it is flowing from the tank and not merely draining the line. If oil does not flow, apply external heat to the Y-drain.
2. Oil screens should be checked before each flight during the early part of the cold weather period to remove engine sludge which has been washed down by oil dilution. After the first few weeks of low temperature operation, oil screens can be checked according to the latest available instructions.
3. Check the turbo oil system drains for free flow and the tank vents for freedom from frozen moisture. Apply heat if necessary.
4. Check all fuel, water, and oil tank vent lines and crankcase breathers for freedom from frozen condensate. Remove any ice or snow plugging the drainage and ventilation holes in the wing and fuselage. Apply heat if necessary.
5. Always preheat engines if temperatures are below -9°C (16°F) even though oil dilution was accomplished at shutdown. Preheat engines if temperatures have fallen below 2°C (35°F) and oil dilution was not accomplished at previous shutdown. Preheat should never be considered adequate until oil will flow from the Y-drain and the propellers can be pulled through by two men. Be sure to leave the air plug and inter-cooler shutters closed for all preheating.

Note

Normal starts can be made when the cylinder head temperature reaches 15°C (50°F). Marginal starts will result when cylinder head temperature is 5° to 10°C (41° to 50°F). No damage can result from prolonged heating, whereas considerable difficulties may result from insufficient heat.

6. Warm the oil supply by plugging in the external power source to the heating receptacle on the wing lower surface near each oil tank. The heaters heat the

oil tank hopper and oil tank out line. Use of heat is necessary when the OAT. is below the pour point of the oil which will vary from $+20^{\circ}$ to 0°F .

Heating Time Requirements

$+20^{\circ}\text{F}$ to -10°F	10 minutes
-10°F to -65°F	1 minute for each degree F below 0°F

The heaters must be fully covered by oil. Therefore the oil tanks must have at least 140 gallons when the heaters are used.

Note

To check for proper heater operation, see that the load output of the external power source is 5250 watts or 46 amperes for each heater installation; otherwise, because of their locations, it will be impossible to tell whether or not the heaters are functioning.

CAUTION

The hopper heaters heat only the oil in the hopper and oil out line. The warm return oil from the engine will melt oil in the tank at a rate of about 1/3-gallon per minute. Therefore, in case of a serious oil leak, the rate of loss of oil may exceed the melting rate. Watch oil pressures closely since the oil level liquidometer may be in congealed oil and may not show a change in oil level.

7. Preheat the forward and aft cabins to heat flight instruments, radios, dynamotors, rectifiers, radar, and other equipment within the airplane; and to retard the formation of frost on transparent areas when the crew enters the airplane.
8. Check the fuel system for leaks and check all fuel drains for free flow. Apply heat where necessary to obtain flow.
9. Install warm battery or heat cold battery if it has not been removed after preceding flight.
10. Check the tires and shock struts for proper inflation.

CAUTION

Checking and servicing of tires and shock struts may result in valve leakage. Usually this can be corrected by applying external heat.

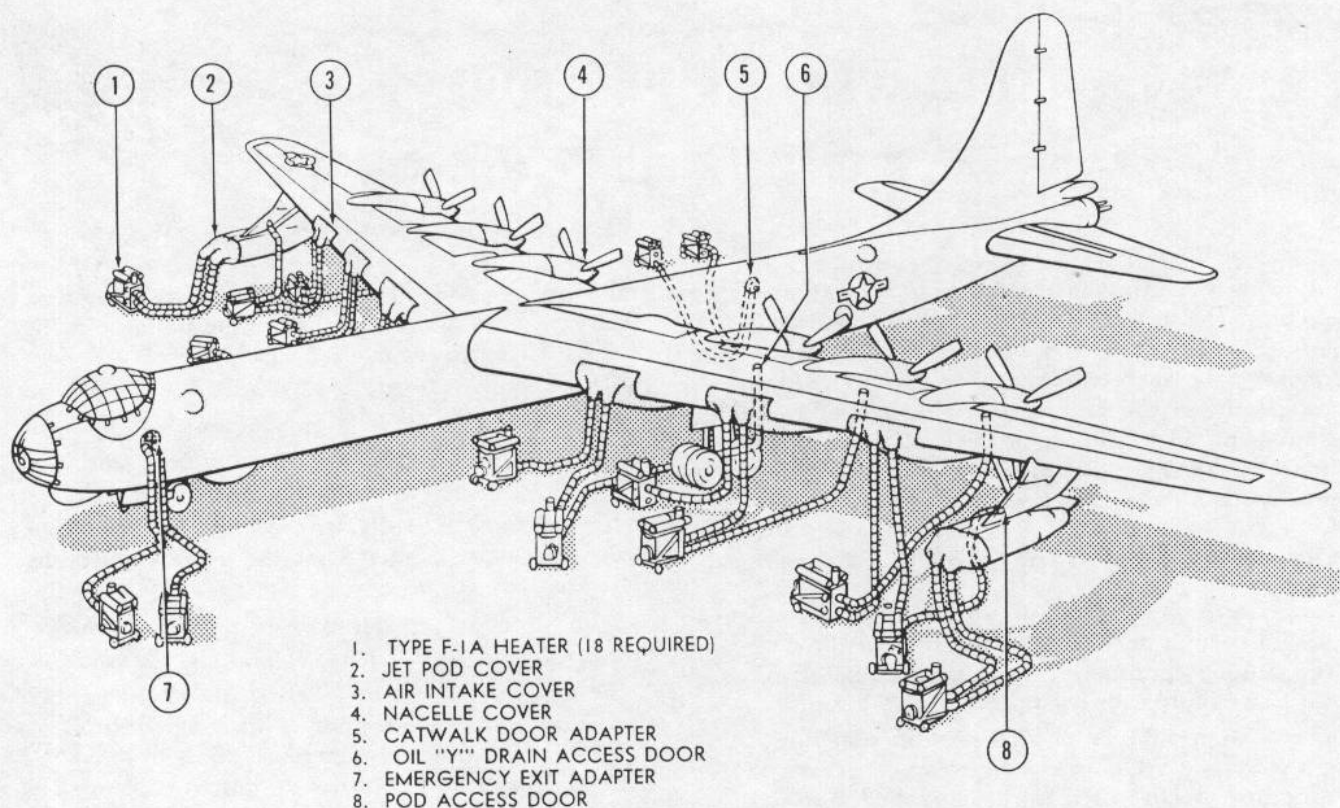


Figure 9-4. Ground Heating

B-104-B5

11. Remove the covers of the engines, wing and tail, guns, pilots enclosure, nose compartment, blisters and pitot masts. Also, remove tape from static ports.

12. Remove ice, snow, and frost from the fuselage, wings, and horizontal stabilizer. Inspect gun turret door tracks and remove ice and snow. Snow can be removed by brushing with brooms.

Note

Ice can be removed by use of portable heaters and alcohol, or by vibrating a rope across the wing surface. Ice must be removed carefully to prevent scratching or marring the wing surfaces.

13. Remove ice, frost, snow, and dirt from the landing gear shock struts, actuating cylinders, wheels, and brakes. After shock struts and actuating cylinders are clean, wipe with a hydraulic-fluid-soaked cloth.

14. Connect external power source to the airplane's electrical system.

ON ENTERING AIRPLANE.

1. Turn each engine over intermittently at least twelve blades with starters.

2. At ambient temperatures of 0°C (32°F) and below turn on the oil tank vent line heaters. After 20 min-

utes, check for heater operation by touching exposed end of vent line with hand to see if it is warm.

3. Check that cabin electric heaters are turned off.

4. Check gun turret bays for freedom from frost, snow, and ice, and check extension and retraction of turrets.

5. Operate all movable surfaces three or four times to check ease of operation.

6. Check functioning of instruments that can be checked without engine operation.

7. Check operation of the pitot heaters.

8. Operate windshield defrosting system to remove or prevent frosting.

9. Check operation of the fuel booster pumps.

10. Operate the flaps, bomb bay doors, and fuel system valves through two cycles. Also, check the operation of the armament system, cabin booster fan, hydraulic pumps and brakes. Do not use propeller controls until after the engine is running. If the brake assemblies leak hydraulic fluid, heat from an F-1A heater will usually alleviate this condition.

CAUTION

At extreme low temperatures, the initial operation of the above equipment may be sub-

ject to malfunctioning due to frosted limit switches, snow or ice accumulation, congealed oil, etc. Several carefully controlled attempts may be necessary to obtain correct operation. If after several cycles satisfactory operation of equipment does not result, apply external heat and thoroughly dry the switches.

11. Exert light pressure on the brake pedals several times before setting parking brakes.

STARTING RECIPROCATING ENGINES.

1. A normal start should be made by following the procedure outlined in Section II, "Normal Procedures," as soon as the propellers have been pulled through. Start with closed air plugs and intercoolers. Do not open the air plugs until the engine CHT is 205°C. In the event the air plugs were inadvertently left open, do not attempt to close them until the engines are started and sufficient heat from the engine has warmed the air plug actuator and screw jacks.

2. If the engine does not start readily in sub-zero temperatures because of frosted spark plugs, apply additional preheat.

3. For a normal start of the engine, do not use the oil dilution system.

4. If the oil pressure is too high after starting or if it fluctuates and drops back with an increase of engine rpm, do not exceed 1000 rpm until the oil temperature reaches 40°C. Erratic or high oil pressures may be caused by the high viscosity of the oil due either to applications of insufficient preheat or to insufficient dilution after the last flight.

CAUTION

If fuel pressure is lower than normal, check for a stuck oil dilution valve.

5. If there is less than 20 psi oil pressure after thirty seconds of engine operation, immediately shut the engine down and investigate. The primary and most common causes for lack of oil pressure are:

- a. Frozen condensate or congealed oil in Y-drain.

- b. Failure of oil pressure gage to indicate properly due to congealed oil or lack of fluid in the pressure lines.

6. Apply carburetor heat as soon as possible after engine is started to assist in fuel vaporization and reduce after-firing.

ENGINE WARM-UP.

1. If oil pressure drops after a few minutes of ground operation, shut down the engine and check the following:

- a. Y-drain for congealed oil or ice.
 - b. Blown lines or oil coolers.

- c. Failure of pressure gage.

- d. Oil strainers for foreign materials which might indicate that engine failure is the cause of low oil pressure.

Note

Oil dilution may be used to reduce viscosity of the oil if time does not permit normal engine warm-up or if the oil pressure is too high for a prolonged period.

CAUTION

Dilute oil with care because engine failure can result from over-dilution.

2. Check all instruments for proper operation.

3. To prevent the flight instruments from cooling and to aid in windshield defrosting, operate the cabin heating system as follows:

- a. Increase the manifold pressure on the inboard engines until a good cabin heat air flow is obtained. If the air thus supplied is insufficiently warm for defrosting, turn on the tail anti-icing system to raise the temperature of the cabin heating air at the secondary heat exchanger.

- b. To prevent overheating of the tail structure do not allow the temperature of the tail anti-icing air to exceed 100°C (212°F) during ground operations. Use the cabin heat and tail anti-icing control switches to reduce the temperatures of the tail anti-icing air.

- c. Increase cabin temperature and aid defrosting by utilizing the auxiliary cabin heaters.

CAUTION

To avoid overloading of the a-c system due to the high power requirements of the auxiliary cabin heaters, do not operate these heaters unless two or more alternators are on the line.

4. Operate the windshield wipers.

5. Operate the wing flaps and bomb bay doors through at least one cycle.

6. Check wing and empennage anti-icing.

CAUTION

Be careful not to exceed anti-icing air temperature of 100°C (212°F).

7. Attempt to maintain CHT of 185° to 205°C during all ground operation. This may require keeping the air plugs fully closed.

Note

It would require 3/4 to 1 hour of engine operation at normal temperatures to evaporate all the fuel in the diluted oil. Even though high oil inlet temperatures of 70°C (158°F)

and above would shorten the period, this procedure is not recommended. Normal warm-up procedure will evaporate sufficient fuel to assure normal scavenging.

8. After several days layover, during which time the engine has been started and diluted several times, it is advisable to ground run the engine for at least 1/2 hour at normal cylinder head and oil inlet temperatures prior to take-off. It is also recommended to check the oil level; it may have fallen considerably due to evaporation of gasoline. The ground run will tend to eliminate any excess dilution which might otherwise cause oil discharge through the breathers or loss in oil pressure during high power take-off or operation.

STARTING JET ENGINES.

Use the normal starting procedure.

TAXIING.

CAUTION

Under certain snow and ice conditions the use of differential power and braking may result in a skipping or lateral skidding action of the nose wheel. This skipping action can best be overcome by stopping the airplane, changing the nose wheel angle, and resuming taxiing. Light braking may be erratic and lack proper brake "feel"; therefore, control ground speed with one pair of propellers in reverse. Use propeller reversing with caution as the resulting snow cloud may blind the pilot. Reversing the outboard propellers will reduce this possibility.

BEFORE TAKE-OFF.

Keep CHT as high as possible within allowable limits using the air plugs to control temperatures.

CAUTION

Flight indicators are not very reliable at temperatures below -43°C (-45°F). For this reason cabin heating is very necessary during warm-up and take-off, and all flight instruments must be cross checked.

TAKE-OFF.

1. Turn on pitot heaters, and the wing, tail, and propeller anti-icing systems if precipitation is encountered or if icing conditions are anticipated at the beginning of the take-off roll. Icing conditions may exist where there is visible moisture in the air at outside air temperatures of $+70^{\circ}\text{C}$ (45°F) and below. Most severe icing conditions usually occur in the range from 0°C (32°F) down to -15°C ($+5^{\circ}\text{F}$).

2. If oil dilution was used on previous engine shutdown, take-off can be made as soon as oil pressure is normal, engine operation is smooth, and CHT is up to 150°C . Precaution must be taken to insure that the oil pressure is normal. Oil pressure below normal may be due to over-diluted oil. Cold oil properly diluted has the same viscosity as warm undiluted oil and therefore the same ability to circulate and properly lubricate the engines. The term "over-dilution" has been used to indicate any amount of dilution which causes the engine scavenging system to break down and discharge diluted oil through the engine breather. Inasmuch as the R4360 engine cannot handle highly diluted oil during extended periods of high power operation, it is possible to completely lose all engine oil in a short period of time if proper procedures are not followed.

Note

Higher take-off power is available in cold climates than in normal climates due to low OAT. Static rpm will be 100-200 rpm lower than usual at normal rated and take-off power because of the greater air density in cold weather.

CAUTION

Do not exceed limit torque pressure or M.P. on take-off.

3. Turn off all auxiliary cabin heaters until after the landing gear and flaps are up.

4. Instruct the scanners to watch for locked wheels during take-off. Don't be alarmed if the brakes should lock temporarily while on snow and ice, because you will be able to retain control of the airplane. Ordinarily, the brakes will not hold the airplane on ice and snow above normal rated power.

5. Carburetor preheat may be used on take-off to add vaporization of fuel and improve carburetor performance. However, special precaution should be taken to maintain carburetor air temperature either above $+7^{\circ}\text{C}$ (45°F) or below -5°C (23°F) and preferably in a range between $+7^{\circ}\text{C}$ (45°F) to 38°C (100°F) depending upon the capacity of the carburetor preheat system. Excessive carburetor preheat is as detrimental as insufficient preheat. Place carburetor preheat in operation if icing conditions prevail or if outside air temperature is -40°C (-40°F) or colder. Also, open intercooler shutters. Icing conditions can be encountered in clouds at very low temperatures and may be encountered unobserved at night.

Note

Although the CAT. may be within limits with carburetor preheat on at the beginning of the take-off run, the application of full power may cause the CAT. to increase rapidly and

exceed the safe range resulting in loss of manifold pressure and power. The flight engineer should watch the carburetor air temperature indicator and be ready to reduce CAT. by opening the intercooler shutters or by turning off the carburetor preheat system.

6. If discharge through the oil breather is noted at take-off, reduce rpm as quickly as practicable and operate engines at moderate powers for 10 to 15 minutes before increasing rpm. Oil discharge should cease soon after the reduction in rpm. When most of the diluted oil has been expelled as indicated by normal oil pressure and temperature, normal engine operation can be resumed. If the oil discharge does not cease after reducing rpm, land and investigate the cause. Should the persistent discharge of oil be caused by high dilution of oil throughout the tank, drain the oil from the tank and refill with undiluted oil.

DURING FLIGHT.

For *all* operation, maintain the recommended range of CAT. to (1) aid in fuel vaporization, (2) improve fuel-air distribution, (3) reduce tendency to lead-foul spark plugs, and (4) improve fuel economy to extend range.

APPROACH.

1. Follow the normal procedure except use carburetor preheat as required and employ a long, low approach to aid in keeping cylinder heads above critically low temperatures of 100°C (212°F).

2. Apply carburetor preheat as required during the entire landing operation. If a sudden acceleration is necessary, heat will be available for fuel vaporization regardless of how low cylinder head temperatures have dropped. However, should full power be required for a take-off or a go-around, keep carburetor air temperature below maximum allowable limit and be ready to reduce or shut off carburetor preheat. (See "Emergency Use of Carburetor Preheat," of this section.)

3. The air plugs should be closed during prolonged glides or approaches.

4. Temperature inversions are common in winter in arctic regions. Thus, the air may be 15° to 30°C (27° to 54°F) colder on the ground than at altitude. Therefore, care must be taken to avoid rapid cooling when letting down. Extend the landing gear and use partial flaps to reduce air speed. Also, regulate the intercooler shutters to eliminate excessive engine cooling. If possible, maintain cylinder head temperatures above 100°C (212°F).

LANDING.

When landing on slick or icy runways and traction is poor, nose wheel steering may have little effect on directional control of the airplane, even though it is operating properly. When landing on a dry runway

spotted with ice, it is possible to skid the nose gear on the ice and damage it by a full deflection. Directional control should be maintained with the throttles until the airplane is almost completely stopped. Practice this procedure on dry runways so as to become accustomed to the reverse action of the throttles when the propellers are in reverse thrust position. When landing in loose snow, exercise caution during reverse thrust application to prevent obscuring the runway with flying snow particles. Obscuring the runway with flying snow is especially possible below 50 mph forward speed.

The following precautions should also be observed:

1. Use the brakes with caution when landing on snow or ice.
2. When reversing propellers, apply only enough power to decelerate airplane without obstructing vision by blowing snow.
3. Toward the end of the landing roll turn off the wing, empennage, and propeller anti-icing.
4. Approach the end of the runway very slowly to prevent skidding when turn is started.

PARKING.

1. When parking, head the airplane into the wind and set the brakes. Release the brakes after chocking the wheels.

STOPPING RECIPROCATING ENGINES.

OIL DILUTION.

To accomplish satisfactory engine starts, it is imperative that each engine oil system be diluted in accordance with the following procedure:

1. Stop the engines, check the oil level, and service if necessary. Allow the engines to cool until oil temperatures reach 0° to 10°C. Then restart the engines.

Note

If possible, the oil tanks should be filled immediately after engine shutdown and dilution should be accomplished thereafter. If servicing cannot be accomplished immediately after shutdown, and the OAT. is below -18°C (0°F), it will be necessary to effect one half of the dilution before adding the oil and the other half after the oil has been added. If ambient temperatures are above -18°C (0°F), dilute only after servicing.

CAUTION

If oil is added after dilution has been accomplished, use diluted oil. It is dangerous to service the airplane with cold, undiluted oil without additional dilution, since this heavy oil will collect on the bottom of the tank where it may congeal and block oil flow.

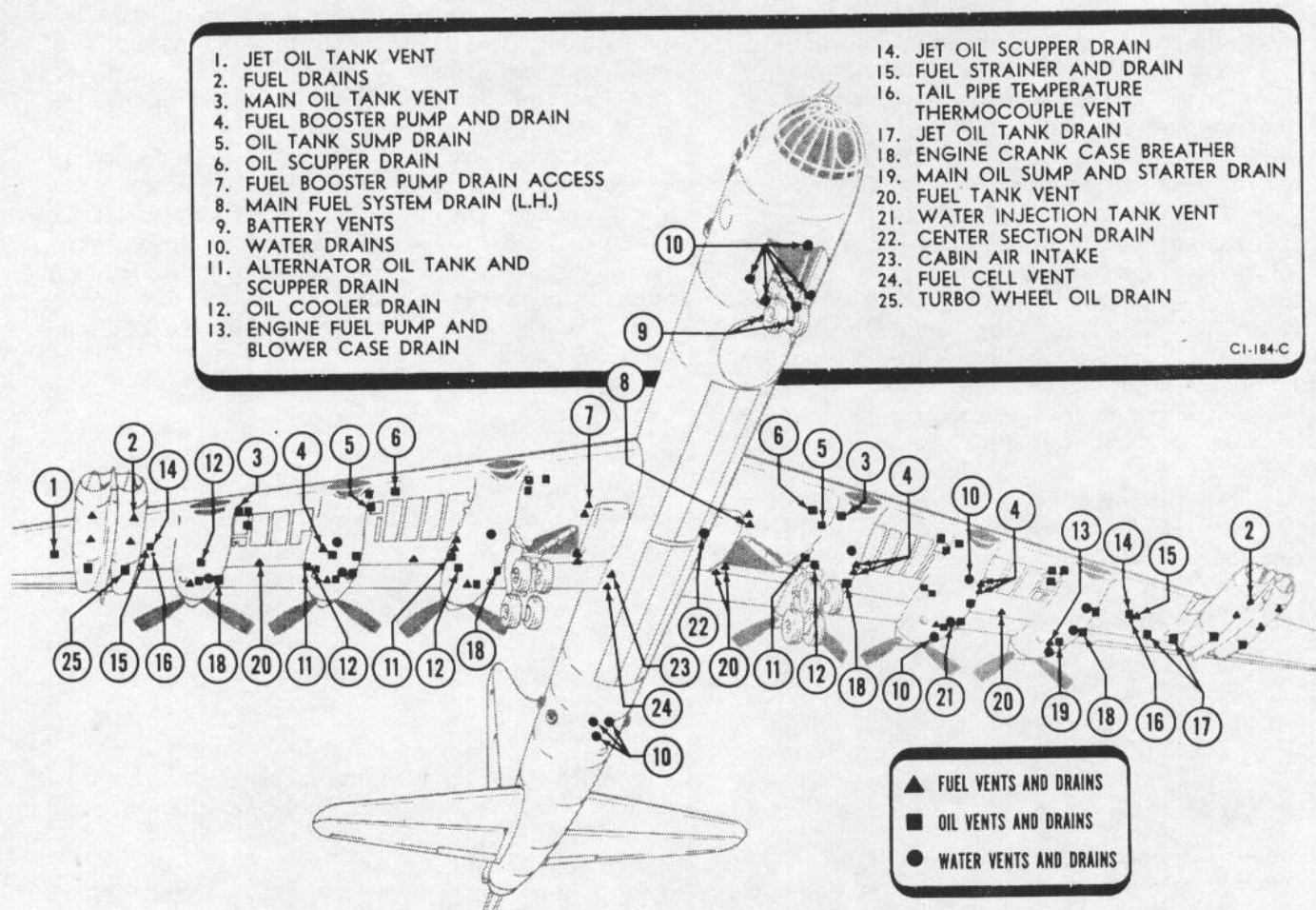


Figure 9-5. External Drain and Vent Locations

2. Idle engines at 1200 rpm and hold the oil dilution switches on as long as required for proper oil dilution. See the following chart:

Expected Outside Air Temperature	Per-centage Dilution	Dilution Time Required (Minutes)
4°C (40°F)	0	0
4° to — 4°C (40° to 25°F)	5	1
— 4° to — 12°C (25° to 10°F)	10	2
— 12° to — 21°C (10° to — 5°F)	15	3.5
— 21° to — 29°C (— 5° to — 20°F)	20	5
— 29° to — 37°C (— 20° to — 35°F)	25	7
— 37° to — 54°C (— 35° to — 65°F)	30	9

Note

a. The actual required dilution at — 65°F is excessive for this airplane. For operation below this temperature, it is necessary to heat the oil system after the maximum recommended dilution is accomplished. Higher dilutions could be obtained by increasing the time period, but excessive amount of diluent would therefore be required and this would reduce the oil capacity necessary for extended flight.

b. The operation of the dilution system is indicated by a fuel pressure drop to approximately 12 psi. If this pressure drop is not obtained, investigate the cause. Pay particular attention to dilution solenoids which may be stuck, dilution lines which may be plugged, and restrictor fittings which may be reversed.

CAUTION

If at any time during the dilution process the oil pressure drops below 15 psi, or the oil temperature reaches 50°C (122°F) the engine must be stopped. The dilution procedure may be continued when the temperature drops to 0° to 10°C.

3. Do not release the dilution switch until the engine has stopped turning. This is important because only diluted oil must be circulated through the engine oil system.

4. If oil dilution is to be accomplished and 50 hours engine time has elapsed since the last dilution, the oil screens must be inspected and cleaned after the dilution has been completed. This process must be repeated after each subsequent dilution until the screens are free of sludge.

5. Whenever engines have been previously diluted and have not been flown, the engine should not be given a full dilution until 45 minutes operating time with oil temperature above 50°C (122°F) have been obtained. If a short ground run-up is made, the engines should be rediluted by reducing the required time period to equal the ratio of operating time to a 1-hour period. For example, if the ground-run time is of 30 minutes duration, the additional time will be half the chart value. Since redilution percentages are difficult to control, every second redilution engine run must be of at least 90 minutes duration, followed by a full chart value dilution not to exceed 6 minutes. A dilution period should never be less than 30 seconds.

CAUTION

Dilution in excess of 30 per cent may greatly reduce engine life.

6. Normally, with proper oil dilution and ground heaters available, draining of the oil system should never be necessary. However, in an emergency when draining of the oil system is required, proceed as follows:

- Idle the engines until the oil temperatures stabilize at 40°C (104°F).
- Use the normal procedure for stopping the engines.
- Install the engine covers.
- Drain the oil into clean containers.
- If possible, store the oil in a warm place. If the oil cannot be kept warm, heat it to approximately 75°C (167°F) before it is returned to the tank.
- Use the normal starting procedure as soon as the heated oil is returned to the tanks.

AFTER ENGINE SHUTDOWN.

DRAINS AND VENTS.

- The fuel tanks should be kept filled to minimize condensation. The fuel tanks and booster pumps should be drained of moisture after each flight to prevent freezing of the condensation.
- The oil tank sump and Y-drain must be drained of condensate and a small amount of oil before moisture freezes or nondiluted oil in these areas congeals.

Drain the oil tank sumps 15 minutes after shutdown, and twice more at 30 minute intervals. This is very important since this area cannot be reached with external heat.

3. Drain condensation and remove ice from turbo oil system vents and drains.

4. Remove the ice from caps and vents of fuel tanks, oil tanks, and crankcase breathers.

5. Turn each propeller at least 9 blades approximately 30 minutes after stopping engines.

6. Close engine air plugs and intercooler shutters after engines have cooled.

TURBOSUPERCHARGER OIL.

Consult the following chart to determine the proper oil for use in the turbo oil system.

Ground Temperatures	Oil
Above —9.4°C (15°F)	Specification No. MIL-O-6082 (AN-O-8), Grade 1065
—9.4°C (15°F) and Below	MIL-O-6081 (AN-O-9A), Grade 1010

WARNING

Oil must be warm when drained.

BATTERY.

The battery should be kept warm at all times. At freezing temperatures and below, remove the battery and stow it in a heated room if possible. Batteries give best performance at 27°C (81°F) and the performance of a fully charged battery decreases as the temperature decreases.

PROTECTIVE COVERS.

Install air intake ducts, engine, turret, nose compartment, blister, pilots' enclosure, and pitot mast covers. Install tape over static ports.

1. Install the wing and tail covers if there is any possibility of ice or frost formation. Melted and refrozen snow is extremely difficult to remove. Loose snow may be removed with a long-handled broom.

HOT WEATHER PROCEDURES

BEFORE ENTERING AIRPLANE.

1. Cool the forward and aft cabins by the use of two type A-1 portable coolers. The 15-foot refrigerant lines can be routed into the aft cabin through the entrance hatch on the left side of the fuselage. Route the lines

through the nose wheel well entrance to cool the forward cabin and the line for the camera compartment through its entrance hatch. (See figure 9-6.)

2. Check all fabric surfaces and control surface hinge points for freedom from fungi. If fungi are evident, re-

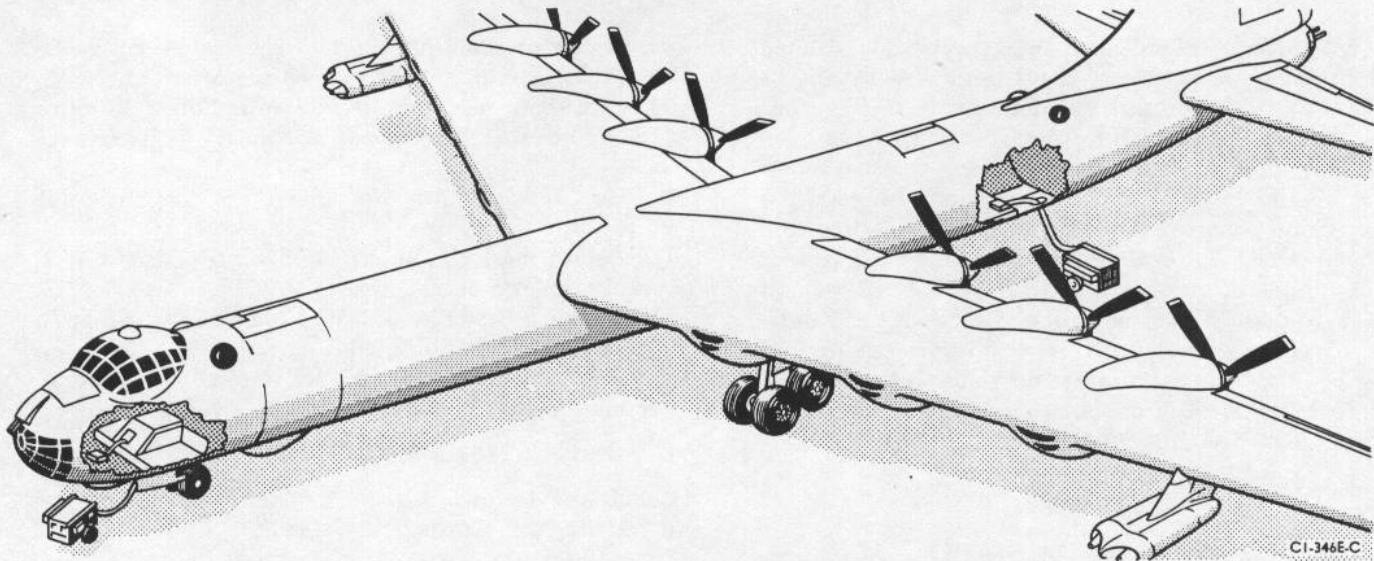


Figure 9-6. Ground Cooling

move it from all surfaces, except the fabric surfaces, with a stiff brush or compressed air. Use a clean soft cloth for the fabric surfaces.

3. Inspect the oleo struts and tires for cleanliness and proper inflation.
4. Inspect all limit switches for moisture.
5. Remove the engine and air duct covers and other protective covers.

ON ENTERING AIRPLANE.

1. Operate all movable surfaces.
2. If necessary, warm electrical instruments with an external source of heat until all moisture is eliminated.
3. Inspect gun turret bays for excess moisture and remove by the application of heat.
4. Start the cabin ventilating fans as soon as the external power supply is connected.
5. Check the wing and fuselage drainage and ventilating holes.

STARTING RECIPROCATING ENGINES.

Use the normal starting procedure.

1. Operate the engine-driven fans only in low ratio.
2. Do not overprime the engines.

Do not exceed cylinder head and carburetor air temperature limits during engine warm-up.

STARTING JET ENGINES.

Use the normal starting procedure.

STOPPING ENGINES.

Stop the engines as soon as possible.

BEFORE LEAVING AIRPLANE.

1. Install covers for the nose compartment, pilots' enclosure, gun turret, pitot mast, and blisters.
2. As soon as the engines have cooled, install the engine and the air duct covers. The covers will keep out moisture, thus preventing corrosion and growth of fungi.
3. If possible, keep delicate instruments such as communication equipment, warmer than ambient temperature by approximately 6°C (10°F). If heating cannot be accomplished, circulation of air over this equipment will be helpful.
4. Leave all windows and hatches slightly open to aid in air circulation. Close above openings during rains.



BEFORE ENTERING AIRPLANE.

1. Cool the forward and aft cabins by the use of two type A-1 portable coolers. (See figure 9-6.)
2. Make sure the carburetor air filters are installed

and connected.

3. Check the operation of the filter doors.
4. Operate all movable surfaces.
5. Use a cloth moistened with hydraulic fluid to wipe

the nose and both main gear shock struts and exposed portions of actuating cylinders free of dust and sand.

6. Check tires and shock struts for proper inflation.
7. Remove ground cooling ducts, engine, and airplane covers.

ON ENTERING AIRPLANE.

1. Start the cabin ventilating fans as soon as the external power supply is connected.
2. Clean the instrument panels with a lint-free cloth to remove any dust or sand.
3. Operate all instruments that can be checked without engine operation by using an external source of power.

STARTING RECIPROCATING ENGINES.

Use the normal starting procedure.

1. Operate engine-driven fans in low ratio only.
2. Do not overprime the engines.
3. Set the carburetor air filter switch in the ON position.

ENGINE WARM-UP.

1. Conduct ground operation in a minimum amount of time.

CAUTION

Do not operate the engine-driven fans in high ratio during ground operation or take-off.

2. Do not exceed cylinder head and carburetor air temperature limits.

STARTING JET ENGINES.

Use the normal starting procedure.

TAKE-OFF AND LANDING.

Extremely warm weather necessitates a longer take-off and landing run, and increases the sinking speed of the airplane. Maximum cylinder head and carburetor air temperatures for take-off must be kept within limits.

STOPPING ENGINES.

1. Park the airplane into the wind.
2. Stop the engines as soon as possible.

BEFORE LEAVING AIRPLANE.

1. Install the covers for the pitot mast, pilots' enclosure, nose compartment, blister, and gun turrets.
2. After the engines have cooled, close the air plugs and install the engine air intake covers.

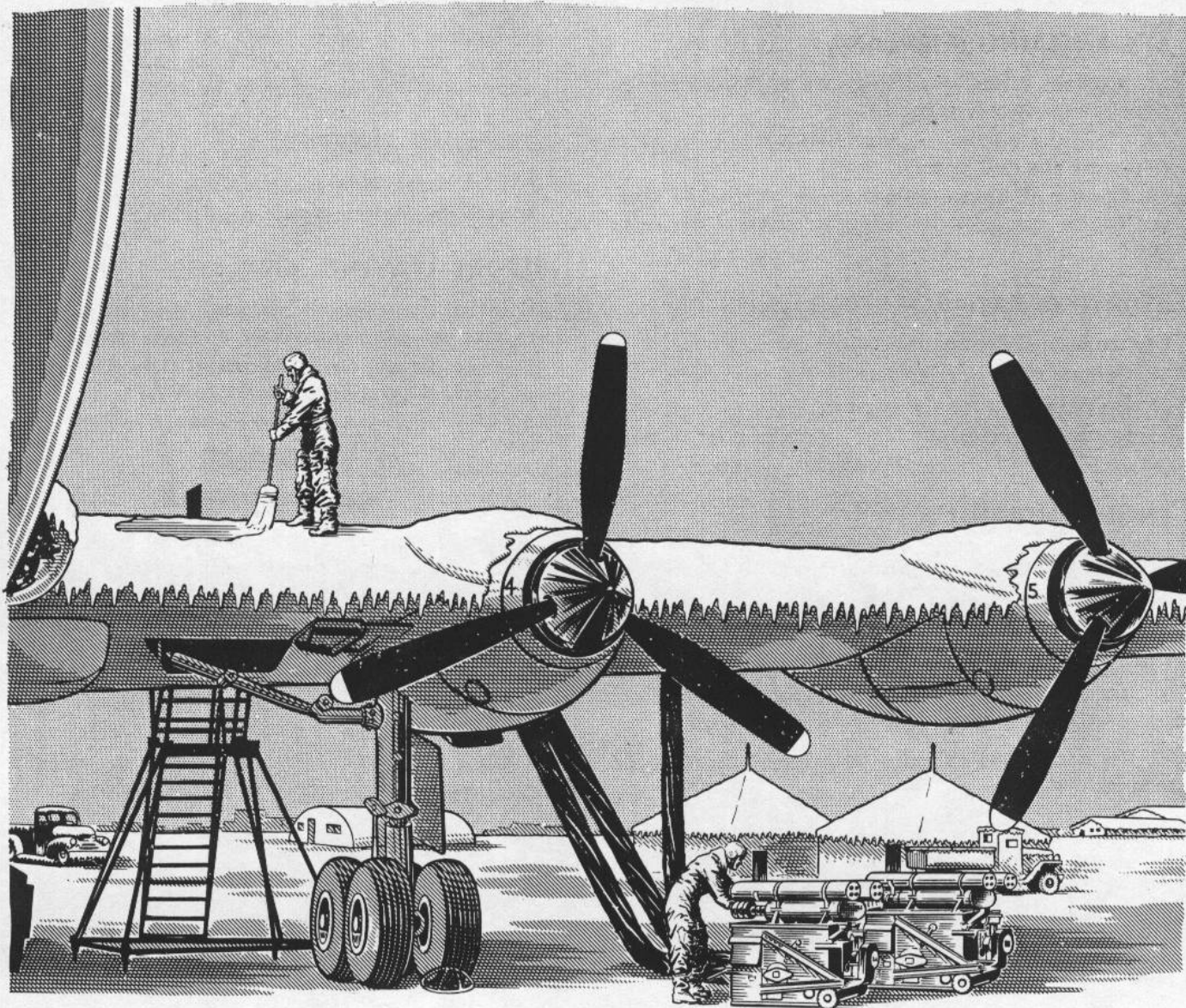
WARNING

Handle high octane fuels with care. Make sure all fueling equipment and airplane are well grounded.

3. Exercise care to avoid letting sand or dust enter the engine fuel and oil tanks, and turbo oil tanks while servicing.

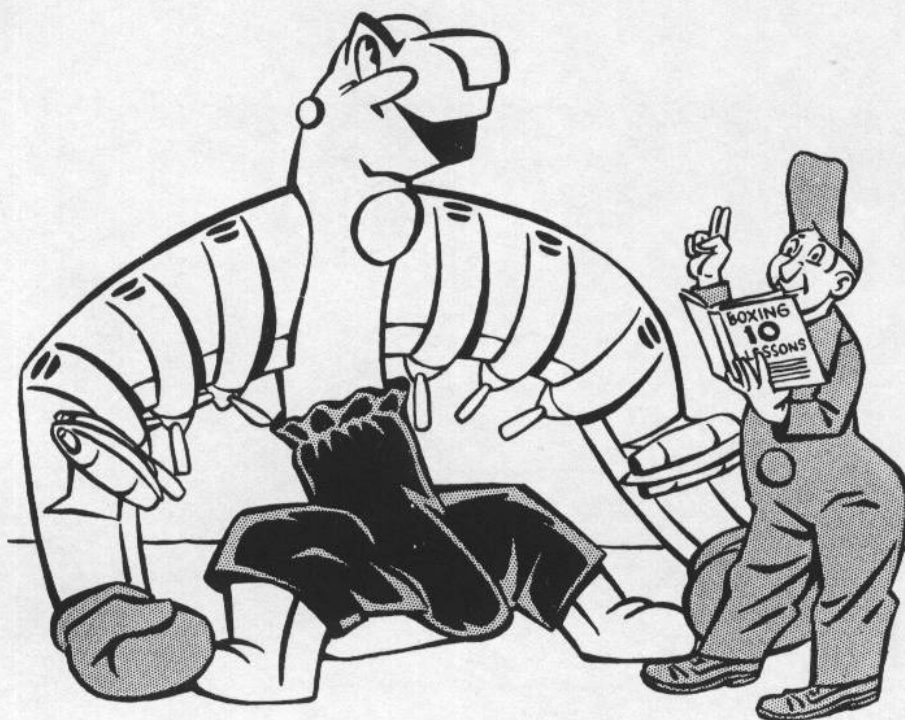
4. Clean the carburetor air and instrument filters. Replace any that are in questionable condition.

5. Leave windows and hatches slightly open to aid air circulation. Close during sand and dust storms.



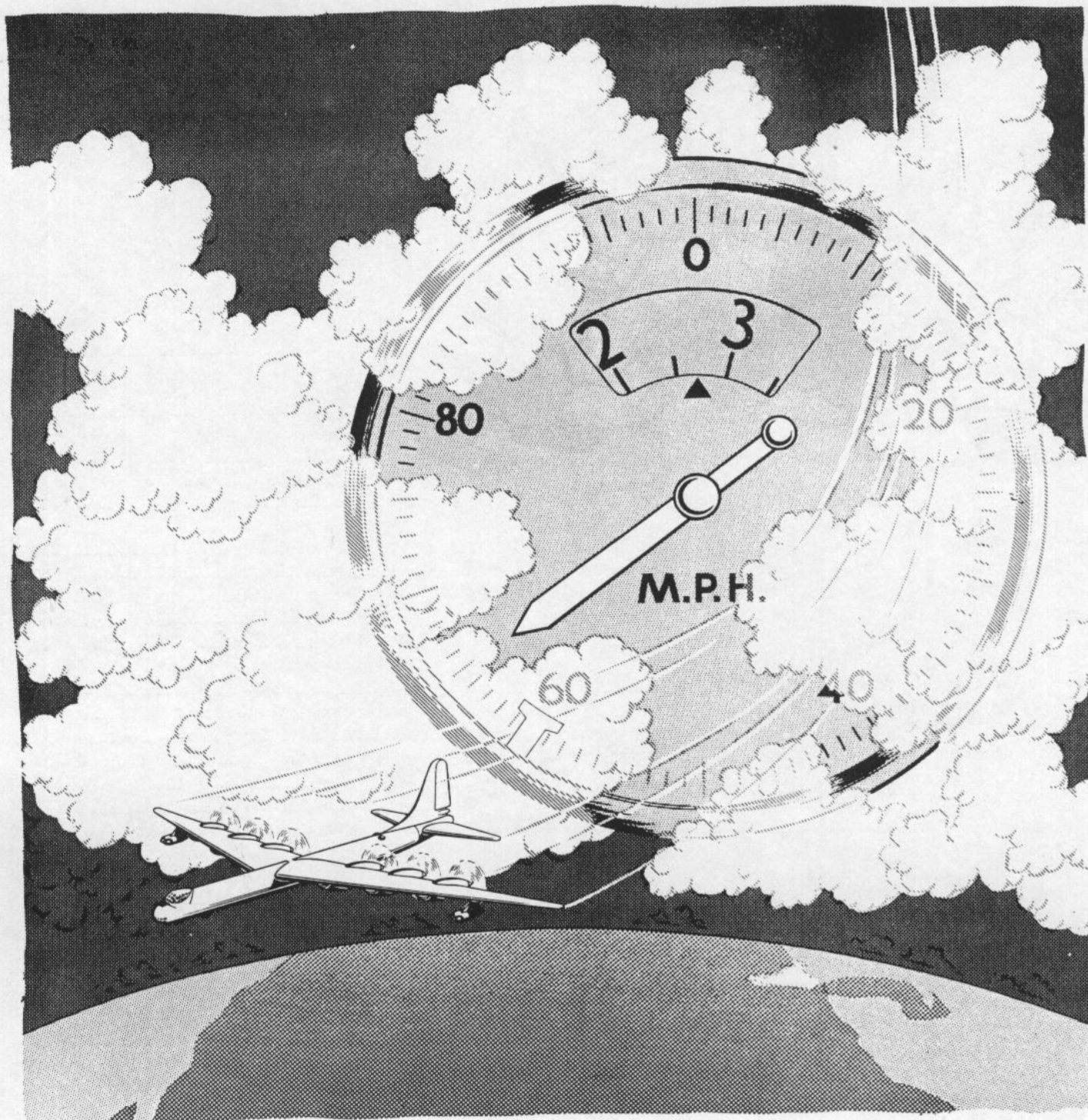
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APPENDIX I OPERATING DATA CHARTS



CI-313-C

This section will be
included when available



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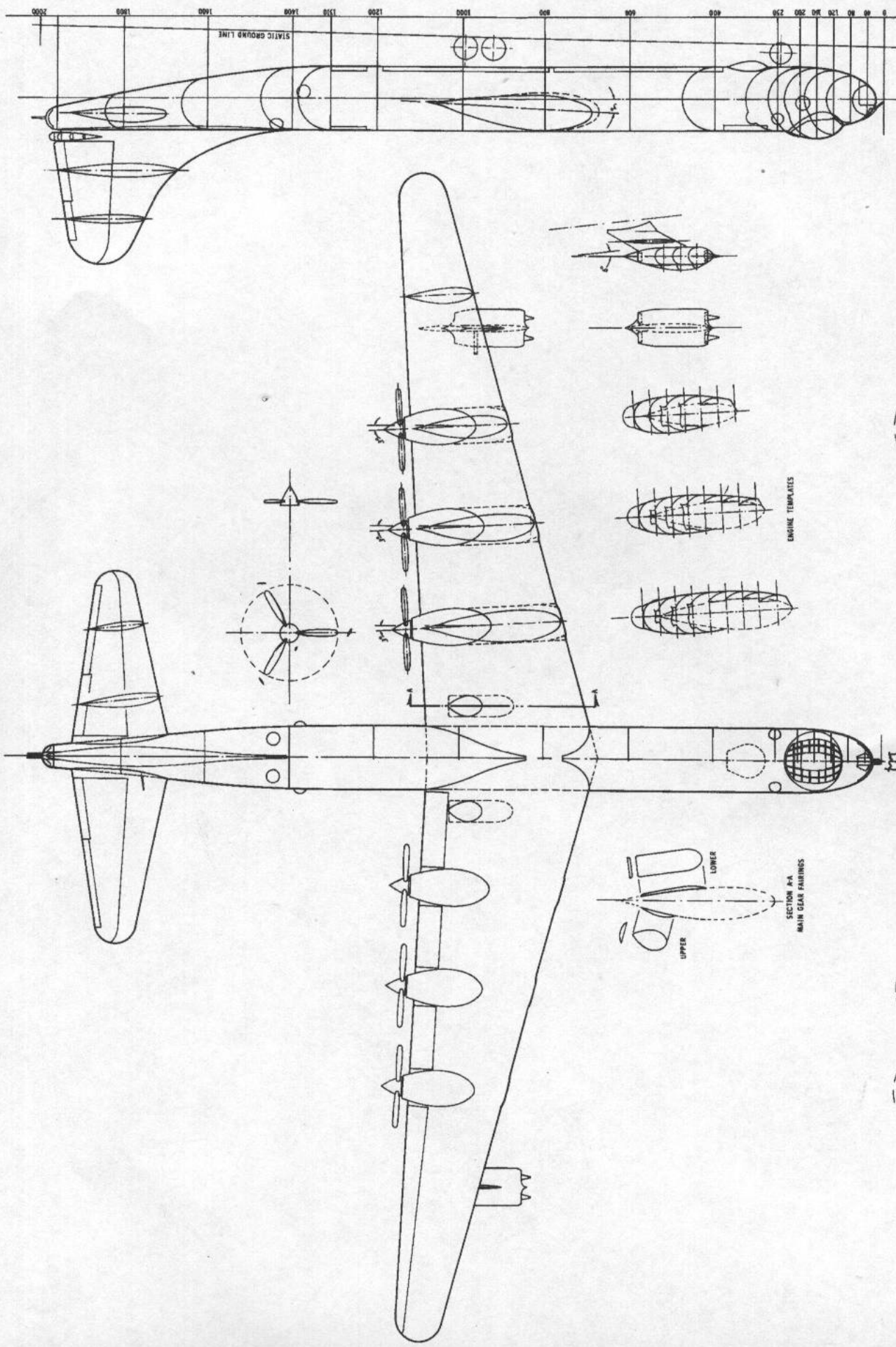
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