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C118 FLIGHT CREWS



This handout is a supplemental reference which you may retain permanently. It will provide you with study material which will help you understand and accomplish your classroom instruction.

NOTE

Technical orders and other official directives supersede this handout when the information conflicts

AIRPLANE GENERAL

Section 1



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Chapter 1

INTRODUCTION

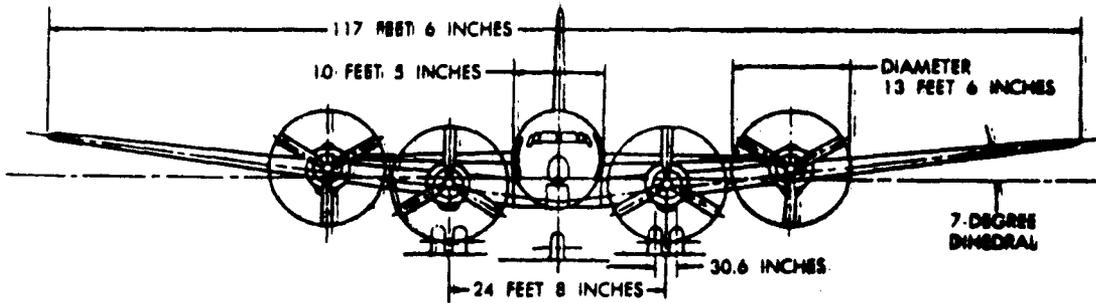
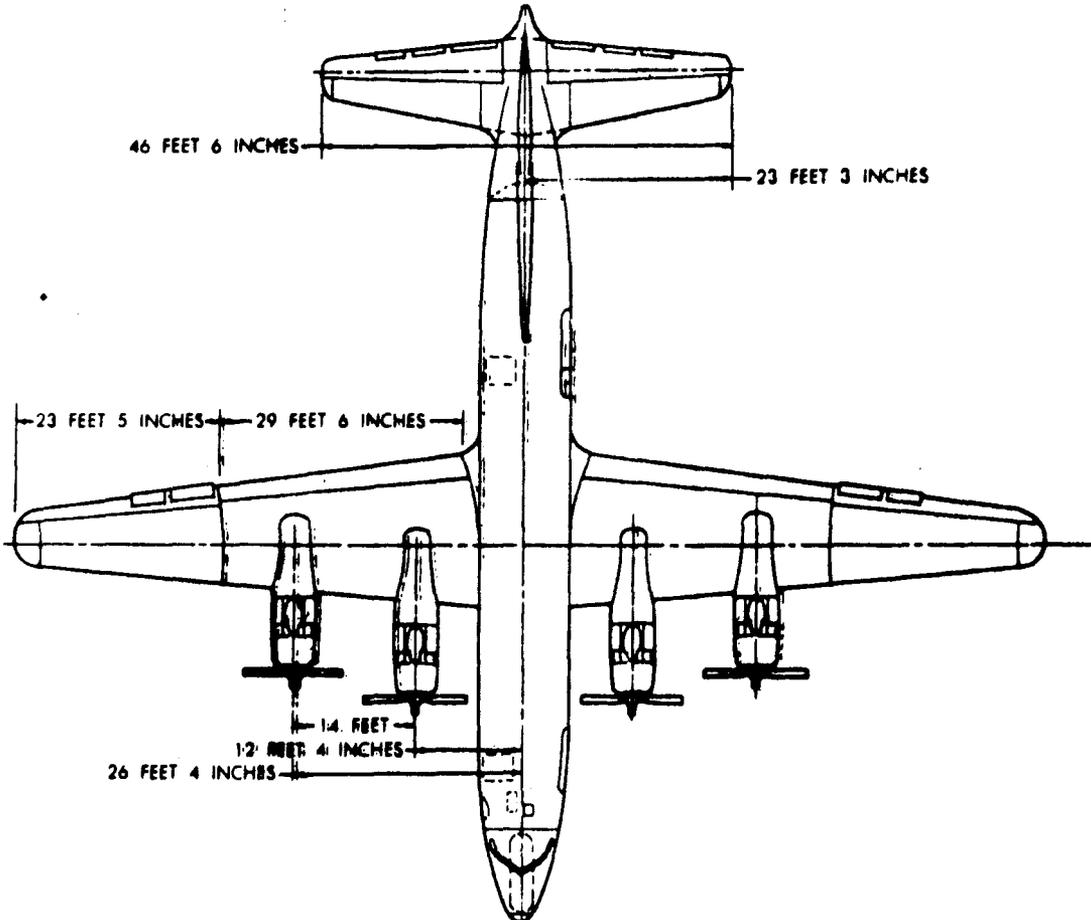
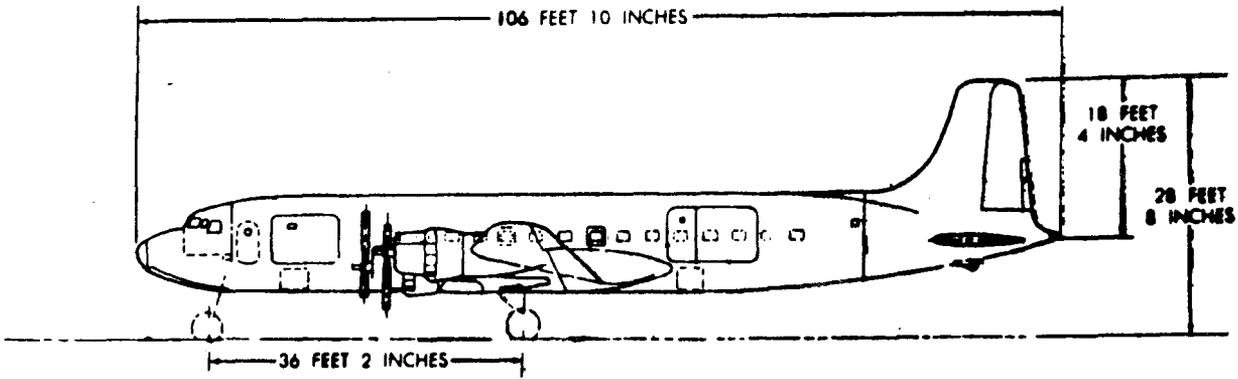
The aircraft is a long range, low wing monoplane, equipped with a retractable tricycle landing gear. The cabin is pressurized and air conditioned.

The aircraft was designed for carrying approximately 76 passengers when used as a personnel transport, and ap-

proximately 60 litter patients with provisions for 6 medical attendants when used as an ambulance transport, or diversified cargo when used as a cargo transport.

Accommodations are provided for 4 crew members: pilot, copilot, flight mechanic, and navigator.

Section 1



Three-Dimensional View of Aircraft

4

1-2

The designed gross weight is 107,000 pounds with a landing gross weight of 88,200 pounds. Fuel dumping provisions are for the express purpose of reducing the landing gross weight.

Airframe Construction

The fuselage structure is all metal. It is semi-monocoque construction having transverse frames and longitudinal stiffeners covered with aluminum alloy. The nose and tail sections are removable. The fuselage is permanently attached to the center wing with pressure sealed connections.

The outer wing panels and tips are detachable. The center wing has attached engine nacelles.

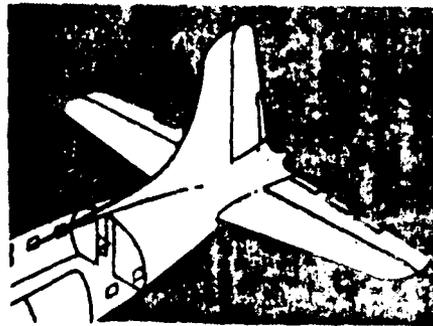
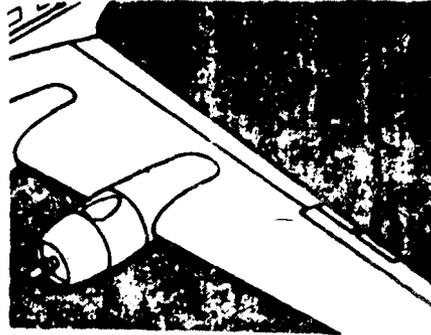
Leading edges of the wings are of double skin construction to permit thermal anti-icing. Access doors are provided for wing interior inspection, except in the integral fuel tank areas. The leading edge of the center section between the fuselage and the outboard nacelles are provided with access panels.

The airplane is soundproofed to attain a minimum interior noise level. A flexible mica sheet is cemented to the inside skin of the fuselage, over which a layer of fiberglas batting is added. A final lining of laminated fiberglas completes the installation. These materials also afford a maximum degree of fire resistance.

Control Surfaces

The ailerons and elevators are of all metal construction, except for the plastic impregnated fiberglas trailing edges. They are sealed to reduce the entry of water and have drain holes and vents in the lower surface. The rudder and its tab are of fabric covered metal frame construction.

The aileron and rudder tabs are spring-loaded and serve the dual purpose of trimming the airplane and providing aerodynamic boost for the respective control surfaces. In each



case, control is accomplished by varying the spring load. The elevators are controlled similarly, except that separate tabs are provided for control and trim. Inflight, movement of any of the controls actuates the spring tabs for that system in an opposite direction to the intended movement of the surfaces.

With no airload on the surface, movement of the controls from the flight compartment will move the main surfaces only until that surface meets its stop. Further movement of the controls will then deflect the tab in an opposite direction to the main surface against the spring load in the tab.

Doors and Exits

The main cargo door is on the left side of the fuselage aft of the wing and provides an opening 124 inches wide by 78 inches high. The door is divided into two sections. The forward section opens outward (passenger entrance) and swings forward. This section may be used independently of the aft section. The aft section is hydraulically operated from the emergency hydraulic system and opens upward. This aft door opens to a maximum of 172 degrees. A hold-open rod is provided for support when the door is opened to its normal position of 105 degrees. The passenger entrance door may be jettisoned by unlocking and pulling the hinge pins. The aft section cannot be raised until the forward section is latched in the open position or is jettisoned.

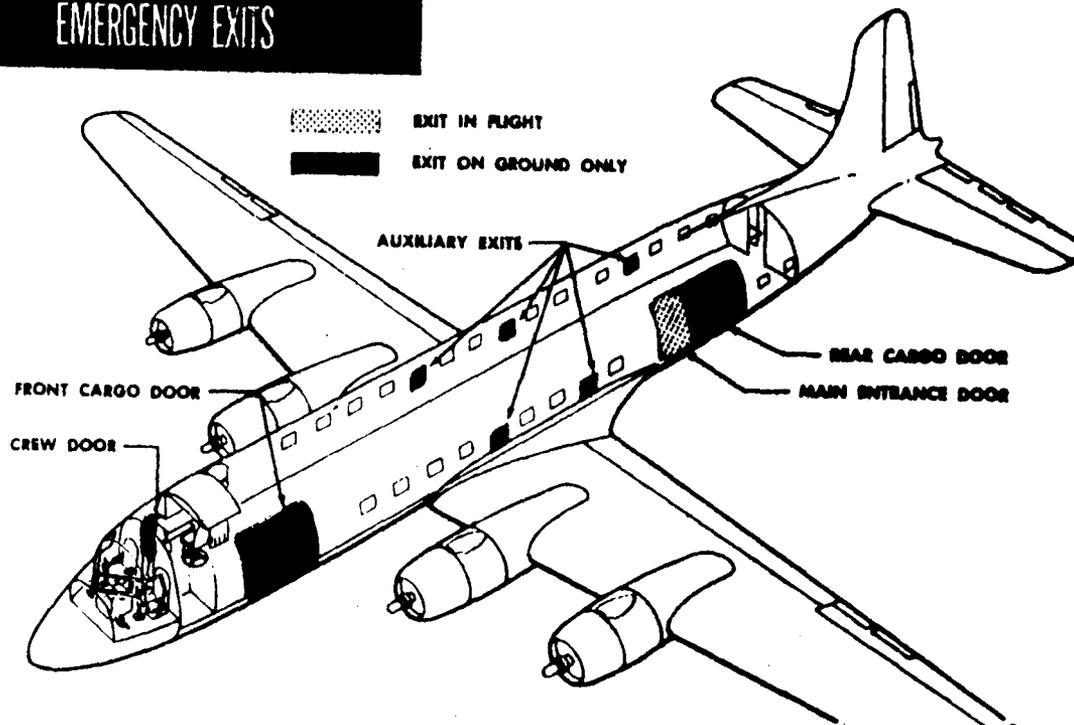
The forward cargo door is also on the left side of the fuselage but forward of the propellers. It is opened

upward by the emergency hydraulic system. This opening is 91 inches wide by 67 inches high.

The crew entrance door, which is 30 inches wide by 61 inches high, opens outward and forward. It is on the right side of the fuselage forward of the propellers.

The lower cargo doors open outward and down, providing an opening of 37 x 51 inches. These doors are located on the right side, one forward of the leading edge of the wing and the other aft near the trailing edge. Rubber bungees are used to assist in opening and closing the doors. Safety latches are installed to permit restricted opening of the doors for gradual depressurization in the vent of primary latch failure. Hatches are installed in the main cabin floor to provide internal access to the lower compartments.

EMERGENCY EXITS



Five emergency exits, all opening outward, are provided. Two hatches are located on the left side and three on the right side of the main cabin. Each hatch has a standard cabin window. The lower part of each exit contains the release handle and is operable from both the inside and outside of the airplane. Ditching ropes are installed over the five emergency exits and over the crew and passenger entrance doors.

Ground Locks

Main and nose gear ground locks should be installed after landing and should remain installed while the airplane is on the ground.

Gust Locks

The surface controls are locked from the cockpit in a neutral position, as follows:

1. Place all flight controls in the neutral position.
2. Lift the gust lock lever, on the floor inboard of the pilot's seat, to a vertical position.

Equipment

A 20 man life raft for the crew

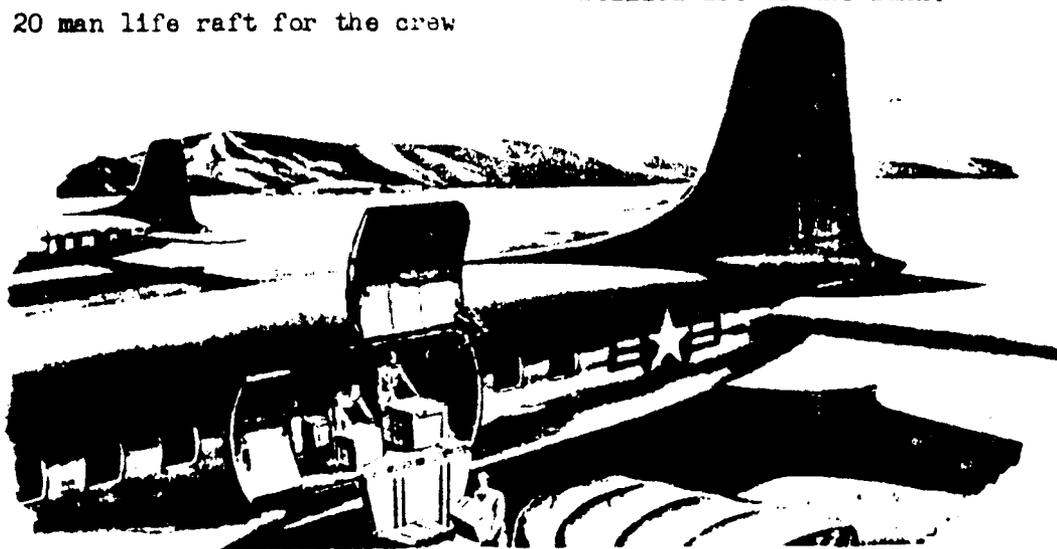
(standard cargo aircraft) is stowed inside the cabin on the left side just forward of the forward cargo door. On passenger, troop or litter aircraft, in addition to the life raft for the crew, four 20 man life rafts are stowed on the left side just forward of the rear cabin door.

Five hand fire extinguishers are located as follows: one by the navigator's station; one on the left side of the crew compartment aft of the radio rack, one forward of the rear cargo door, one in the rear of the cabin on the right side, and one on the forward bulkhead above the crew bunks.

Standard AF tie-down fittings, arranged in a 20 inch grid pattern, are installed in the cabin floor.

The crew's toilet is located in the forward cabin on the right side, aft of the navigator's station. Additional toilet facilities are provided for other configurations in the extreme rear of the main cabin.

There are two folding bunks forward, on the right side, for crew members and a portable bulkhead is installed aft of the bunk.



Chapter 2

OXYGEN SYSTEM

Description

A low pressure, diluter demand oxygen system; filled to 400 + 25 -0 PSI, is provided for the flight crew. The system is serviced through a filler neck inside of the main cabin just forward of the passenger entrance door. Three portable oxygen cylinders are installed in the cabin of the aircraft, to supplement the fixed system or to provide oxygen at locations other than the established crew positions. Three recharger fittings are installed in the flight compartment for recharging the portable cylinders.

Fixed Oxygen System

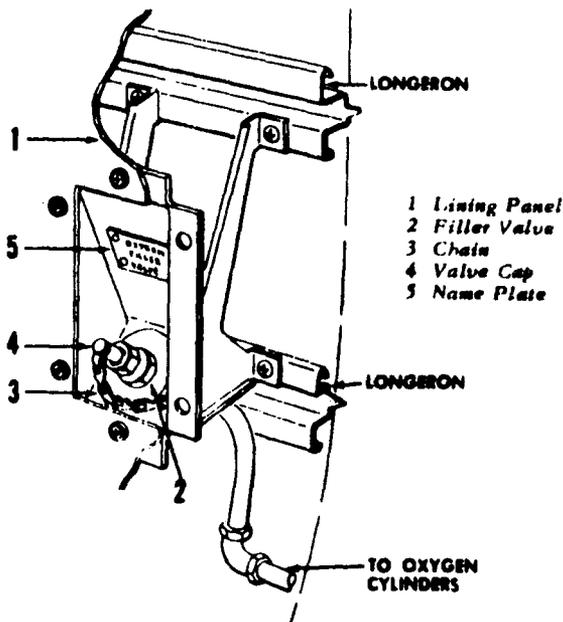
Two supply cylinders are installed in the wing center section between the front and center spars. The D-2 cylinder on the left side is for the exclusive use of the pilot. The G-1

cylinder on the right side is for the use of the copilot, navigator and flight mechanic.

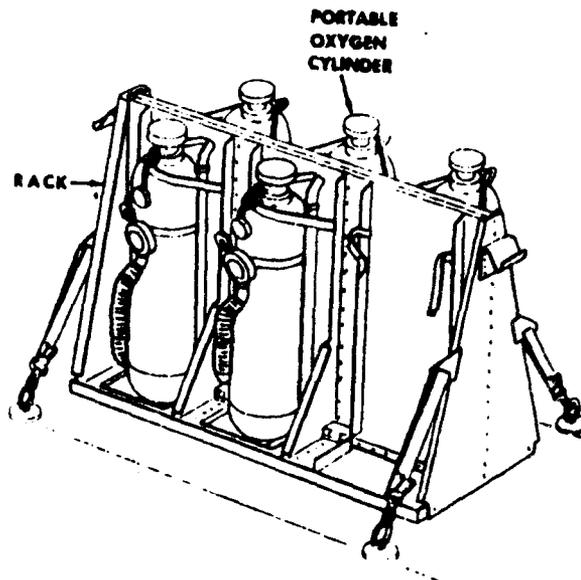
A diluter demand regulator and flow meter assembly is installed at the pilot, copilot and flight mechanic positions. One additional assembly is installed above the crew entrance door for the navigator.

Litter Patient Portable Oxygen Cylinders

When the aircraft is used to transport litter patients, a rack containing six portable high pressure oxygen cylinders is installed on the right side in the rear of the main cabin. Each of these cylinders is secured in the rack with a quick detachable strap assembly. The rack is secured to the fuselage floor by using four cargo tie-down fittings and adjustable strap assemblies.



Oxygen System Filler Valve



Litter Patient Oxygen

OXYGEN DURATION, HOURS (UNPRESSURIZED)
CREW MEMBER (PILOT)
ONE TYPE D-2 CYLINDER

ALTITUDE (FEET)	GAGE PRESSURE (PSI)							Below 100
	400	350	300	250	200	150	100	
25,000	1.0 .7	.8 .6	.7 .5	.5 .4	.3 .3	.28 .2	.14 .1	EMERGENCY Descend to Altitude not requiring Oxygen
	20,000	1.1 .6	.9 .5	.8 .4	.6 .34	.47 .25	.3 .17	
15,000		1.4 .5	1.2 .4	1.0 .35	.8 .28	.6 .21	.4 .14	
	10,000	1.8 .4	1.5 .3	1.3 .3	1.0 .22	.77 .17	.5 .11	

PLAIN FIGURES-INDICATE DILUTER DEMAND USAGE
SHADED FIGURES-INDICATE 100% OXYGEN USAGE

OXYGEN DURATION, HOURS (UNPRESSURIZED)
CREW MEMBER (OTHER THAN PILOT)
BASED ON FOUR CREW MEMBERS, ONE TYPE G-1

ALTITUDE (FEET)	GAGE PRESSURE (PSI)							Below 100
	400	350	300	250	200	150	100	
25,000	1.0 .8	.8 .68	.7 .57	.5 .45	.4 .34	.28 .22	.14 .11	EMERGENCY Descend to Altitude not requiring Oxygen
	20,000	1.1 .6	.93 .5	.79 .43	.62 .34	.47 .25	.31 .17	
15,000		1.4 .5	1.2 .4	1.0 .35	.8 .28	.6 .21	.4 .14	
	10,000	1.9 .4	1.6 .34	1.3 .28	1.1 .22	.8 .17	.54 .11	

PLAIN FIGURES-INDICATE DILUTER DEMAND USAGE
SHADED FIGURES-INDICATE 100% OXYGEN USAGE

ALCOHOL SYSTEM

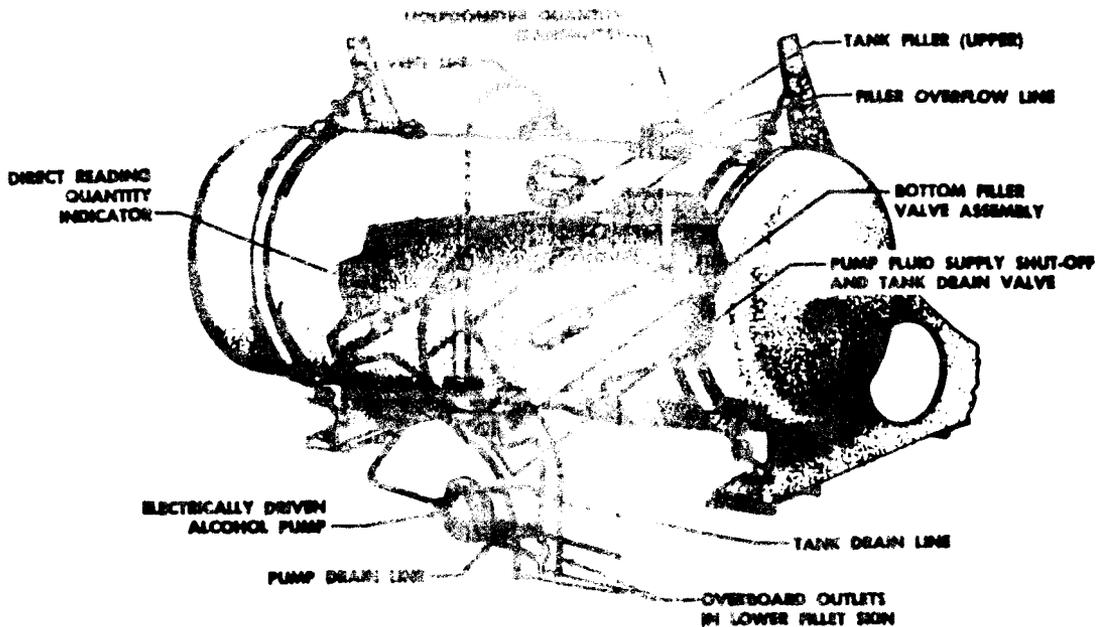
Carburetor Alcohol De-Icing

Isopropyl alcohol is delivered under pressure to a spray manifold in each carburetor for the elimination of ice in the carburetor intake throat. It is supplied from the 16 gallon tank located in the right wing fillet and is routed through a pump, filter, and solenoid shutoff valve to each carburetor. The system is controlled by four spring-loaded switches on the heater control panel. The alcohol de-icing system pump is energized and the corresponding shutoff valve is opened when any one of the carburetor de-icing switches are closed. A 16 gallon tank provides approximately 48 minutes continuous flow to the carburetors.

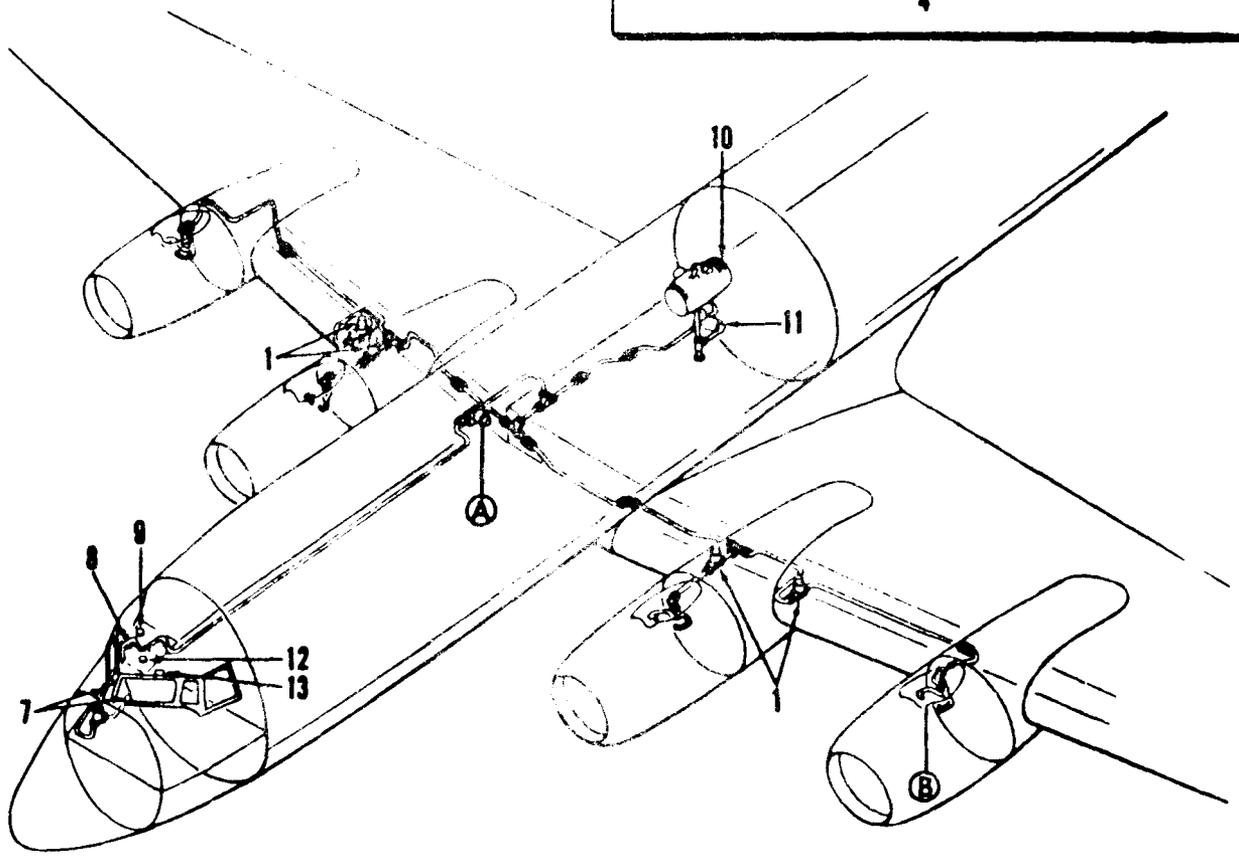
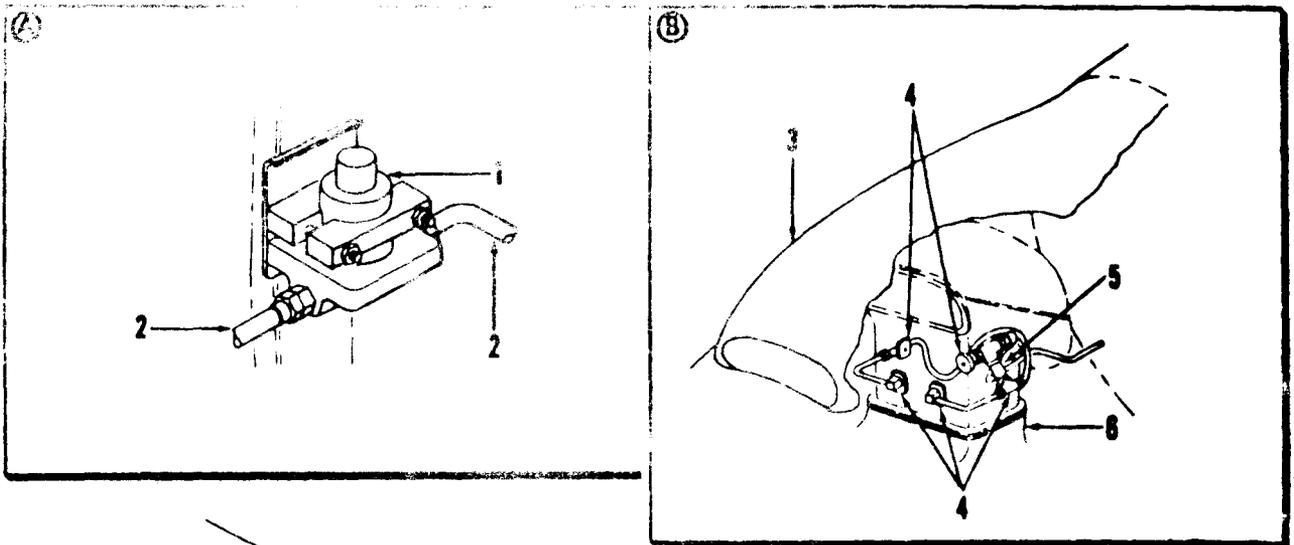
Carburetor alcohol de-icing system is available from 16 gallons, provided alcohol is not used for the windshield de-icing system.

Windshield Alcohol De-Icing

The exterior of the windshield is de-iced from the same system as the carburetors. It has its own ON - OFF switch which operates the pump and a solenoid shutoff valve. A metering valve is located to the right of the cockpit to control the flow. When the metering valve is in the full open position, a supply of 16 gallons will last approximately 48 minutes, provided alcohol is used for the carburetor de-icing system.



Alcohol Tank



- 1 Solenoid Shutoff Valve
- 2 Fluid Line
- 3 Carburetor Airscup
- 4 Jets
- 5 Filter
- 6 Carburetor
- 7 Windshield Spray Tubes

- 8 Windshield Alcohol Control Knob
- 9 Windshield Alcohol De-Icer Switch
- 10 Supply Tank
- 11 Pump
- 12 De-Icing Fluid Quantity Indicator
- 13 Carburetor Alcohol De-Icer Switches

Alcohol De-Icing System Component Locations

FUEL SYSTEM

The fuel tank installation extends throughout the length of the wings. It consists of both integral compartments and bladder type fuel cells. The integral tanks are built into the wings between the center and front spars. The cells are arranged between the main and rear spars and also aft of the rear spar. There are six integral compartments and twenty-two cells arranged and interconnected so as to form a total of eight tanks. These are identified as four main and four alternate tanks, or a main and alternate tank for each engine. The following table shows the fuel capacities of the various tanks.

Tanks	Serviceable Total	
	Gal. Base	Useable Gallons
Nos. 1 and 4 Main	704.3	1300
Nos. 2 and 3 Main	722.6	1438
Nos. 1 and 4 Alternate	431.0	1052
Nos. 2 and 3 Alternate	773.7	1524
Total	3455.2	5404

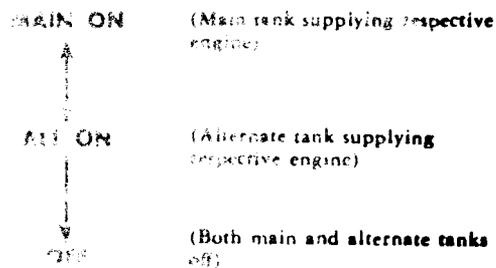
The Nos. 1 and 4 main tanks are large integral compartments. The Nos. 2 and 3 main tanks consist of one integral compartment and three cells. The Nos. 1 and 4 alternate tanks consist of one integral compartment and two cells. The Nos. 2 and 3 alternate tanks are made up entirely of cells, six to each tank.

Tank Selector Valves

There are four main selector valves which control the flow of fuel to the individual engines and which select either the main or alternate tanks of the respective engines. These valves are of the three-position type and are controlled by levers, one

for each valve. They are located on the left forward face of the control pedestal and are marked with the following positions; "Main On" (forward position, green band), "Alternate On" (center position, red band), "OFF" (aft position, white band). Selector valve controls should be in the "OFF" position whenever the engines are inoperative.

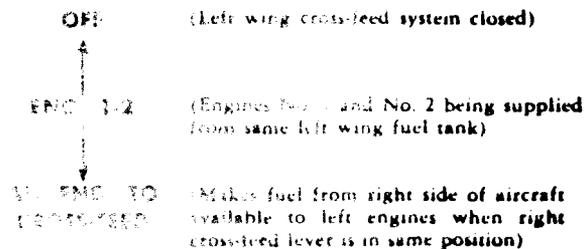
MAIN AND ALTERNATE FUEL TANK SELECTOR VALVE LEVERS

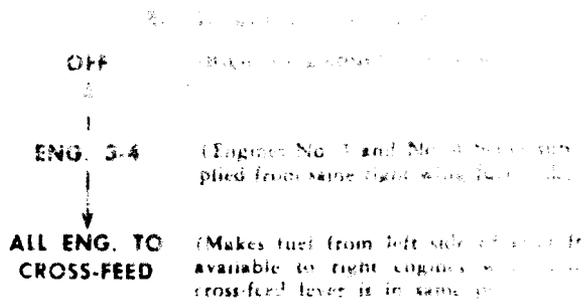


Cross-Feed Valves

Cross-feed valves are placed at two points in the cross-feed system. They are installed in the fuel supply system on the engine side of the fuel tank selector valve, providing a link between all tanks and engines. Two cross-feed valve control levers (which control the three-position cross-feed system) are located on the control pedestal to the right of the tank selector levers. Their positions are:

LEFT CROSS-FEED LEVER





Booster Pumps

Electrically driven fuel booster pumps are used to supplement the engine driven pumps by providing the engine driven pump with fuel pressure above the cavitation rate.

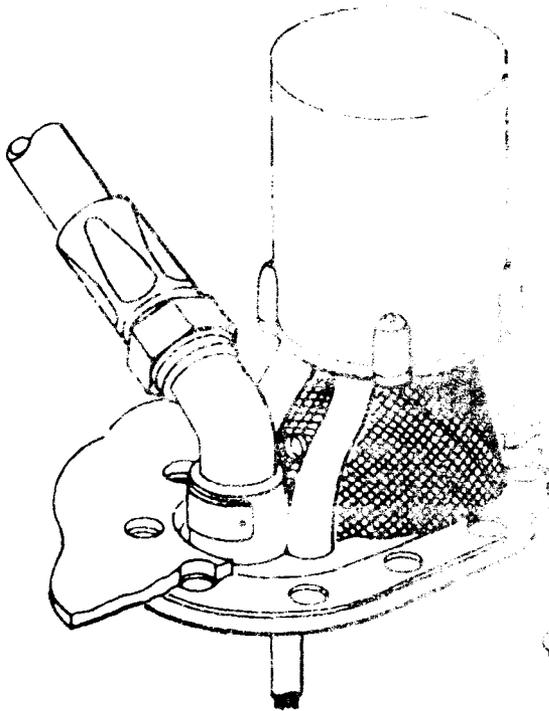
One booster pump is installed on the bottom of each main tank. Each is an integral unit composed of a ceramic

electrical motor. The motor is mounted inside the tank and is completely submerged. All other fuel booster pumps are of the external type with the pump motor located outside the tank.

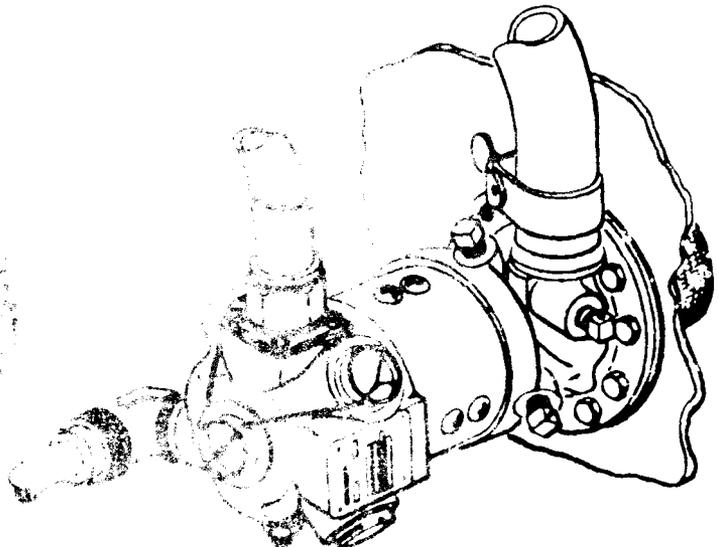
The electrically driven fuel booster pumps are controlled by individual three-position switches, grouped on the forward overhead panel in the cockpit, and marked LOW-OFF-HIGH. The pump can be operated in LOW speed boost during normal conditions; HIGH boost is provided primarily for use in the event of engine-driven pump failure. It is recommended that engines be started with the booster pumps in LOW boost except in extremely cold weather.

Fuel pressures with booster pumps are:

Min Allowable Below 1200 RPM-----	17 PSI
Normal Operating-----	22
Maximum Allowable-----	25.5



SUBMERGED PUMP



EXTERNAL PUMP

A warning light will come "ON" any time the fuel pressure drops below $18 \pm 1/2$ PSI.

A recommended use of fuel booster pumps in low boost are:

- 1. For engine start.
- 2. For take-off.
3. During climb after reaching 10,000 feet to cruising altitude.
- 4. When selecting a new fuel supply.
5. For 1-1/2 hours on the selected fuel tanks after reaching cruise altitude.
6. Any time the fuel pressure drops below 22 psi or fluctuates.
7. For oil dilution.
- 8. Landing

Tank Shut-Off and Drain Valves

Each tank system has a manually operated tank shut-off and drain valve. Each valve is accessible through an access door in the under side of the wing. When the valve handle is in any position other than "TANK TO SYSTEM", a curved rod, which is linked to the handle, protrudes through the access door opening to prevent closing of the door. This safety device is designed to prevent take-off with a shut-off valve in the "TANK OFF" position.

Thermal Relief Valve

A thermal expansion relief valve, preset to open at 65 to 85 psi, is installed in the left cross-feed valve junction to relieve the thermal expansion of fuel in the cross-feed system.

Fuel Strainers

Four fuel strainers, one mounted in the lower aft section of each nacelle, trap sediment and water in the fuel coming from the tanks. The

strainer must be drained daily to remove any accumulated water. Periodically, the strainers are removed and cleaned of sediment accumulation.

Firewall Shut-Off Valves (Emergency)

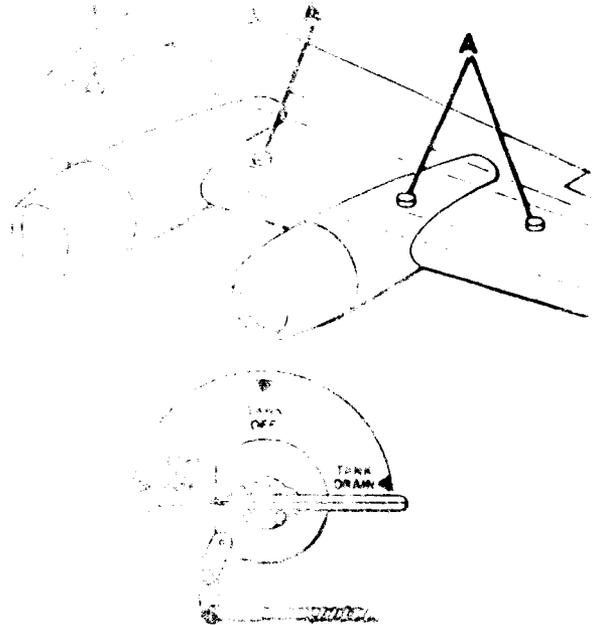
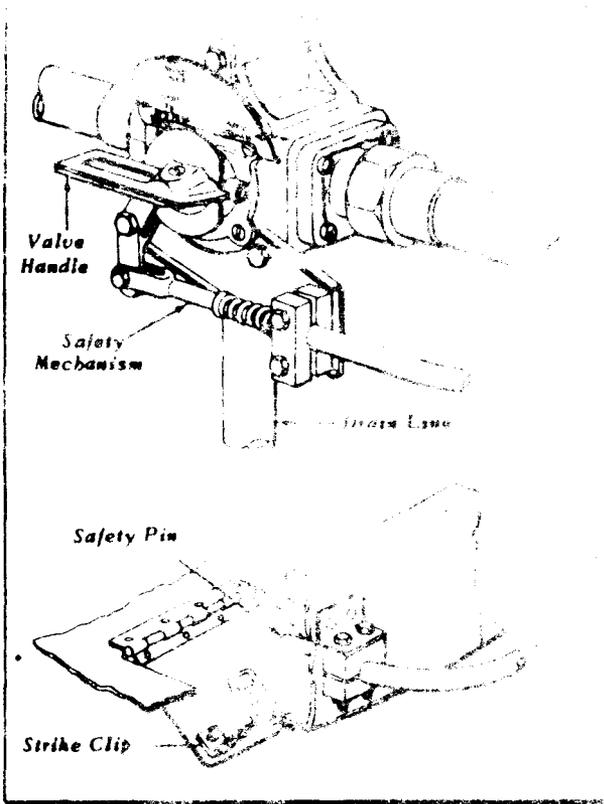
A fuel emergency shutoff valve is located in the fuel supply line and on the aft side of the firewall in each nacelle. Its purpose is to shut off the supply of fuel to the engine in an emergency. The emergency shutoff valves are cable operated by four fire extinguisher selector valve handles. These handles are located at the top of the main instrument panel, below the glare shield. The valves are closed by pulling the respective handles.

Engine Driven Fuel Pumps

A positive displacement vane type fuel pump driven by each engine is used to pump fuel from the tanks to the engines. Each pump has an adjustable relief valve to regulate fuel pressure and a bypass valve to permit fuel, under pressure from the electric booster pump, to flow through the pump. Since cavitation is possible under certain conditions, such as decreased pump inlet pressure (increased altitude) or high fuel temperatures, it may become necessary to assist the engine pumps by use of the electrically driven booster pumps.

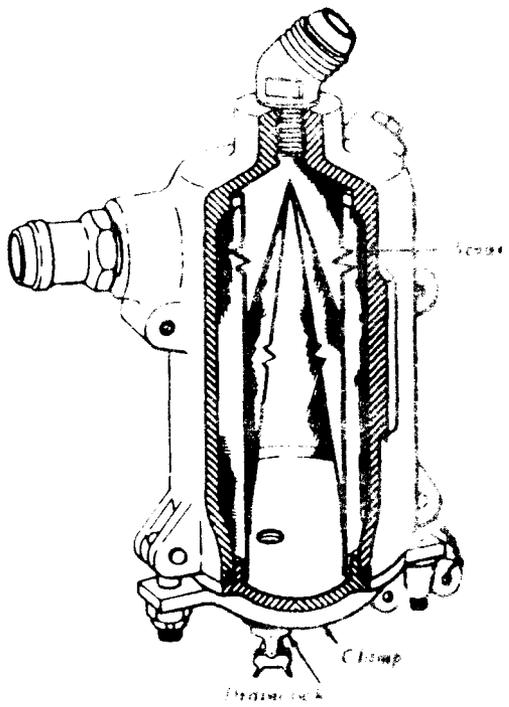
Carburetor Vent Lines

Vapor vent return lines are connected to each engine carburetor. The vapor vent lines from the No. 1 and No. 2 carburetors are routed back to No. 2 main fuel tank; the vapor vent lines from No. 3 and No. 4 carburetors are routed back to No. 3 main tank. The return flow will normally be less than 2 gallons per engine per hour. It is possible to obtain a maximum flow of 20 to 30 gallons per engine per hour, be-

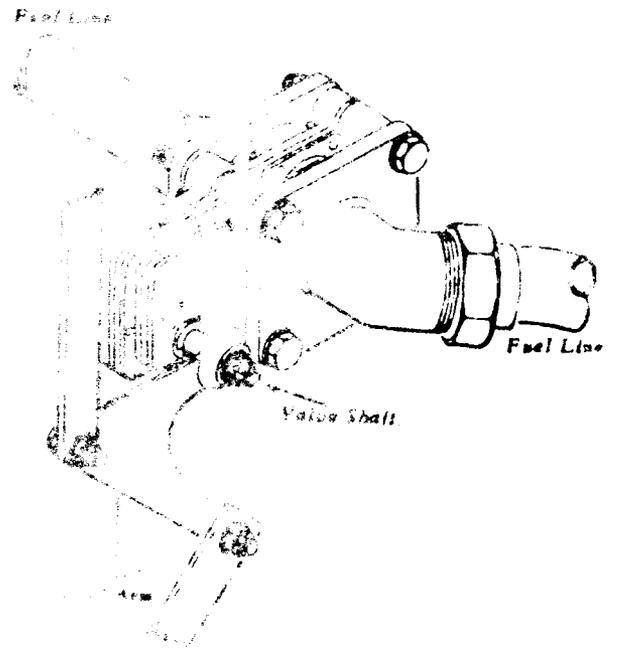


NOTE
 ALL HAND WING SHUT-OFF VALVE SHOWN
 LEFT-HAND WING SHUT-OFF VALVE SIMILAR

Fuel Tank Drain and Shut-off Valve



Fuel Strainer



Fuel Tank Shut-off Valve

cause of carburetor malfunctions or vent float sticking. For this reason, the fuel level of the No. 2 and No. 3 main fuel tanks should be checked periodically to avoid overfilling.

Thermal Expansion

Aside from the previously mentioned thermal relief valve in the cross-feed system, all fuel check valves installed in the fuel tank system have a thermal expansion bleed incorporated in the valve.

Tank Vents

All fuel tanks are vented to the atmosphere through a vent compartment which prevents fuel from spilling overboard as a result of excessive surge. Some of these vent compartments are contained inside the tank proper, while others are outside the tank. The vent compartments are partitioned horizontally with a vent line leading into the lower portion from the tank area and another vent line extending from the upper portion of the outside atmosphere. A hinged flapper valve in the vent compartment partition swings open under normal conditions for venting and closes automatically to prevent leakage from surge conditions.

If the internal pressure of a fuel tank should increase abnormally, such pressure will be limited to 2.5 psi, which is the opening static pressure of a weight loaded relief valve. When the relief valve opens, it allows excess pressure to enter the upper portion of the vent tank and exhaust overboard. However, in a sharp turn, the same centrifugal action that forces the fuel in an outboard direction, increases the downward force of the weights on the relief valve, thereby making it unlikely that the relief valve will ever open under such circumstances.

Fuel dumping chutes are provided for the emergency jettisoning of fuel in flight to decrease the airplane gross weight. Each main and alternate tank is fitted with a sump valve. A standpipe is installed in each main tank so that when all possible fuel is dumped in level flight, sufficient fuel will remain in the tank to run for approximately 45 minutes of flight at 75% rated power, or 30 minutes of flight at rated power. Fuel is dumped overboard from an extended chute at the rear of each main tank. Dump valves and chutes are controlled by four handle rigged control levers located beneath the floor plate,



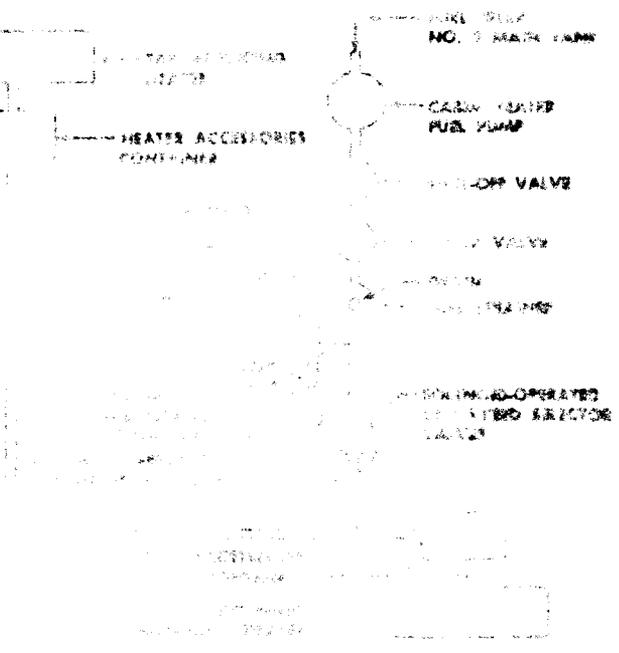
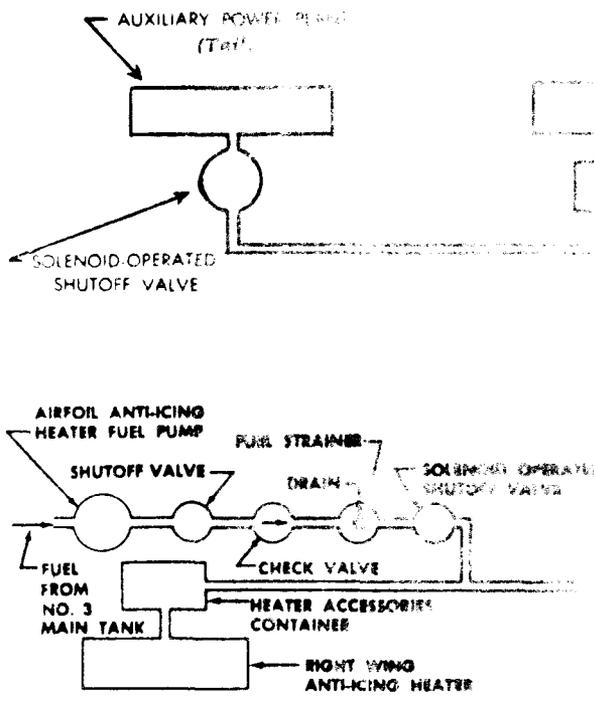
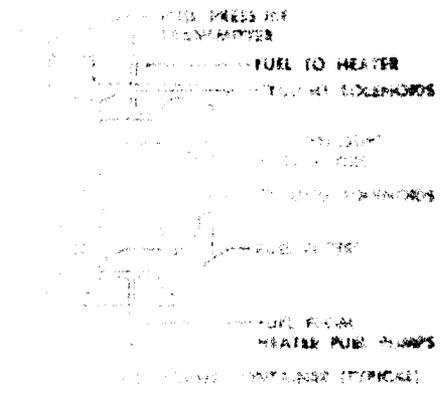
FUEL DUMP SYSTEM CONTROLS

Heater and Auxiliary Pumps

The 3 anti-icing heaters are supplied from No. 3 main tank. The cabin heater is supplied from No. 2 main tank. A cross-feed arrangement makes it possible to operate all heaters from either tank. Operation of the cross-feed system is controlled electrically by a toggle switch on the heater control panel.

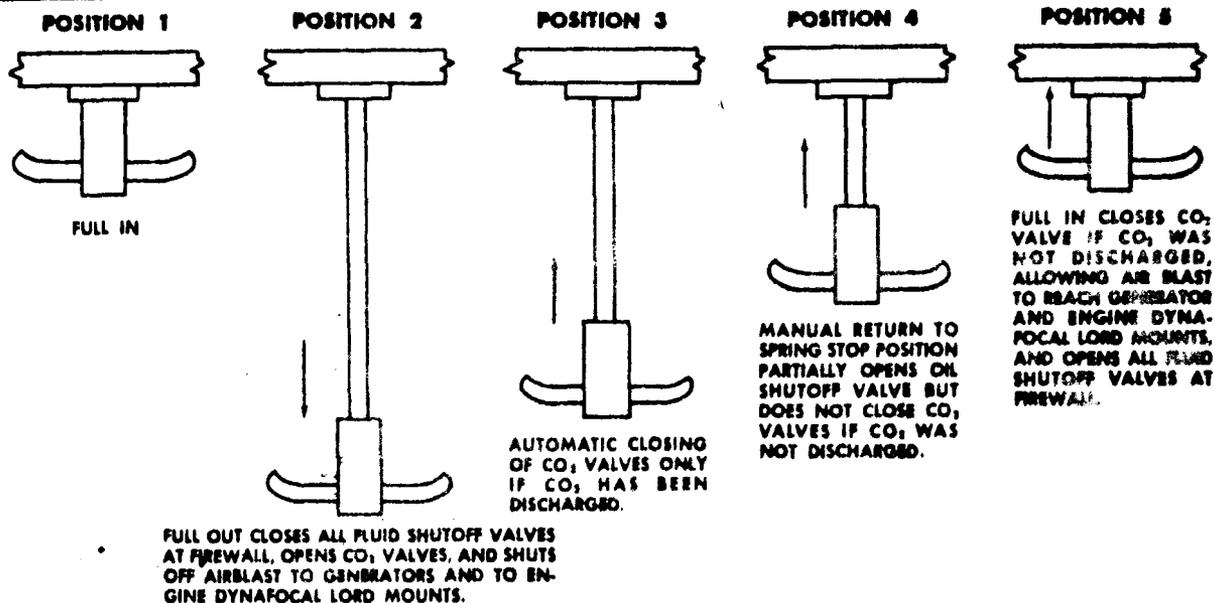
The heater fuel drain and shutoff valves are manually operated. The solenoid-operated fuel shutoff valves operate simultaneously with the heater fuel pump.

Control
The
the APP solenoid
fuel shutoff valve.



Heater and Auxiliary Pumps

FIRE EXTINGUISHER SELECTOR VALVE HANDLE POSITIONS—Typical



Main Fire Extinguisher Selector Valve Handles

Eight fire extinguisher selector valve handles are mounted in a row on the main fire control panel immediately below the glareshield. The handles are identified from left to right, starting inboard of the left CO₂ discharge handle, as follows: FWD BAG, HYD ACC COMPT, engines 1, 2, 3, 4, HEATER COMPT, and AFT BAG. Each handle selects the area for CO₂ discharge but does not discharge CO₂. The engine selector valve handles also operate the emergency shutoff valves at the firewall.

Main Fire Extinguisher CO₂ Discharge Controls

Two CO₂ discharge handles, one for each bank of CO₂, are mounted on the outboard ends of the main fire control panel and are identified as

follows: LH CYL and RH CYL.

Main Fire Extinguishing System Indicators

Dual warning lights, mounted in each fire extinguishing selector valve handle and CO₂ discharge handle are illuminated by action of thermal fire detectors installed in the critical areas or by actuation of the respective fire detection test switches. Dual lights are installed to insure indication in the event of failure of either bulb. Thermocouple-type fire detectors are mounted in each nacelle area, forward and aft of the firewall, and thermal switch fire detectors are located in the lower fuselage compartments. If a fire is detected in an area protected by CO₂, the light on the appropriate selector valve handle and the lights on both CO₂ discharge handles will illuminate. In the event of a fire warning in Zone I

of a nacelle, the light on the respective selector valve control handle will illuminate, but the lights on the discharge handles will not illuminate, since no CO₂ discharge is provided for Zone I.

NOTE

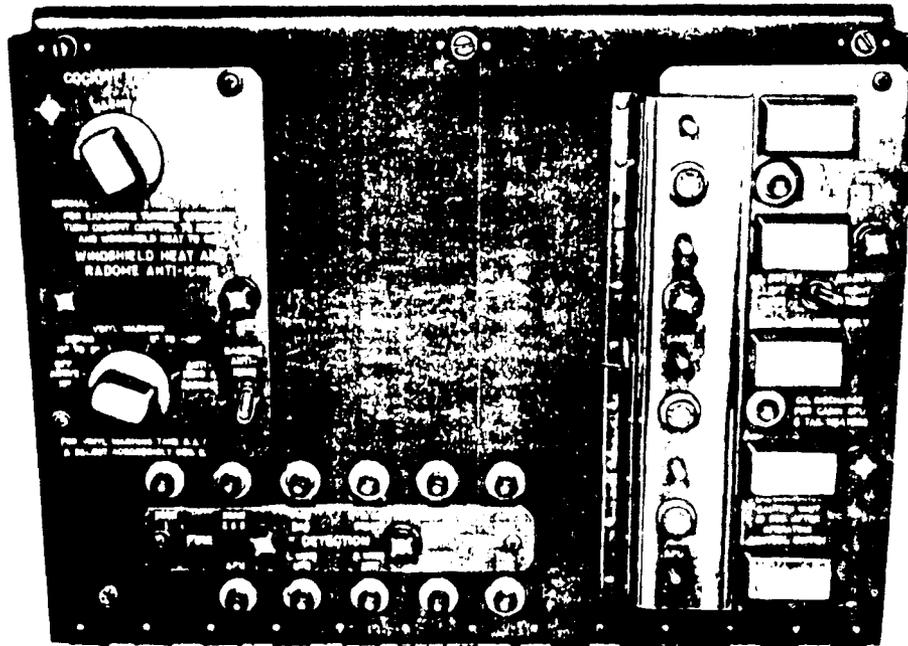
Each nacelle is divided into three zones: Zone I, the power zone; Zone II, the engine accessories sections; and Zone III, the area aft of the firewall. Zone I has fire detectors only, while Zones II and III have both fire detectors and CO₂ protection.

In addition to the main fire extinguisher panel warning lights, strategically located fire detectors will actuate fire warning lights on the heater control panel. A dual red warning light, on the heater fire control panel and on the auxiliary power unit panel, will both illuminate to indicate a fire warning from the GTPU.

Fire Detector Test Switches

Fire detector test switches, mounted on the heater fire control panel, provide a means of testing the detector circuits.

HEATER FIRE CONTROL PANEL



THEMAL ANTI-ICING AND CABIN HEATER

Windshield and Radome Anti-Icing

Hot air supplied to the windshield from the cabin heater is routed up the center post of the windshield and forced between the inner and outer windshield panes. The air is exhausted to the curved corner windows through the corner posts of the windshield. It is then exhausted either into the flight compartment or beneath the floor by the windshield exhaust valves on each side of the cockpit.

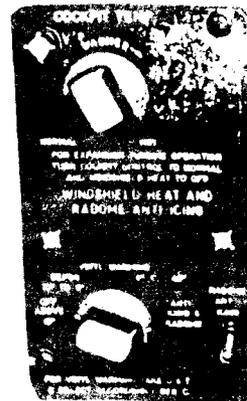
In addition to supplying heat for anti-icing, this system also supplies the necessary heat to maintain the vinyl layer of the windshield in a sufficiently plastic state to retain its impact-resistance. Vinyl becomes soft when too warm and brittle when too cold. The desired temperature range is 80° F to 120° F.

Controls. The control switch on the heater fire control panel is marked OFF ABOVE 10°, DEFOG 10° to 0°, 0° to -40° and ANTI-ICING & RADOME. The temperature selections are in degrees centigrade and the switch should be positioned to correspond to the outside air temperature.

In the 10° to 0° position, heated air is supplied from the cabin superchargers only. In the 0° to -40° position, heated air from the cabin heater is supplied providing the cabin heater master switch is ON. In the anti-icing position, the anti-icing control valve opens fully and the mixed air duct damper in the cabin mixing valve creates a back pressure to increase the cabin heater air flow to the windshield.

Radome anti-icing is controlled by the Radome anti-icing switch on the heater control panel. This switch con-

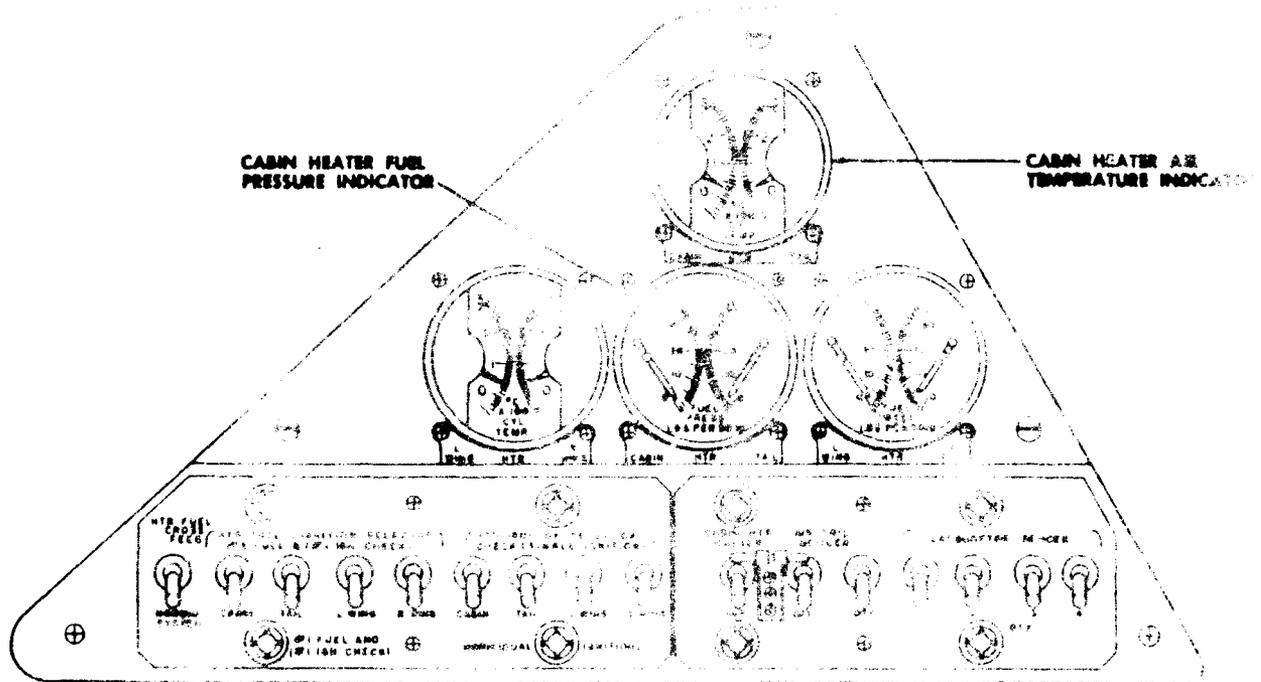
trols a solenoid shut-off valve in the windshield anti-icing duct which can direct heated air through ducts to the fiberglass nose. This shutoff valve is located in the nose wheel well. Placing the control switch to RADOME ANTI-ICING opens the valve and allows heated air to be distributed through the fiberglass nose.



Windshield Heat Selector Switch

Surface Anti-Icing System

The leading edge of the wing and stabilizers are kept ice free by three combustion heaters. These heaters receive their normal fuel supply from No. 3 main fuel tank or their emergency fuel supply from No. 2 main fuel tank. The normal fuel consumption of each heater is approximately 3 to 5 gallons per hour. The system is controlled by a group of switches on the heater control panel. In flight the heaters receive ventilating and combustion air from the airscoops. During ground operations the wing heaters are supplied with ram air for ventilation from No. 2 and No. 4 propeller blasts and combustion air from the ground blowers. In the tail anti-icing systems both ventilating and combustion air are supplied by a blower for



Heater Control Panel

ground operation. Wired through the left landing gear strut switch, the ground blowers are automatically in operation whenever the airfoil de-icer switch is ON and the weight of the airplane is on the landing gear.

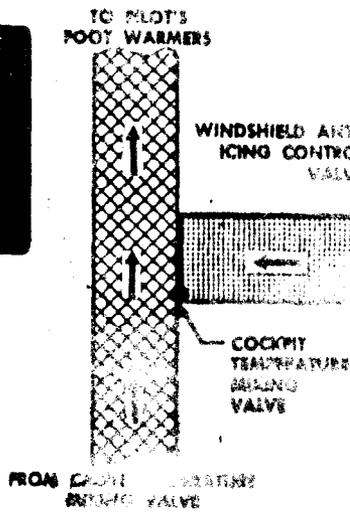
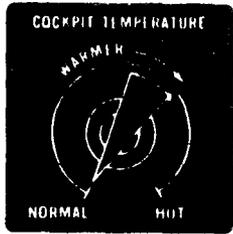
A group of cycling and overheat thermostats in the heater air ducts regulates the temperature of the air leaving the heaters to a maximum temperature of 219°C. These temperatures are indicated on the heater control panel temperature gages.

Controls A single ON - OFF switch controls the anti-icing heaters and is mounted adjacent to the cabin heat switch on the heater control panel. A gang bar is mounted above both switches for simultaneously shutting OFF both systems. Adjacent to these

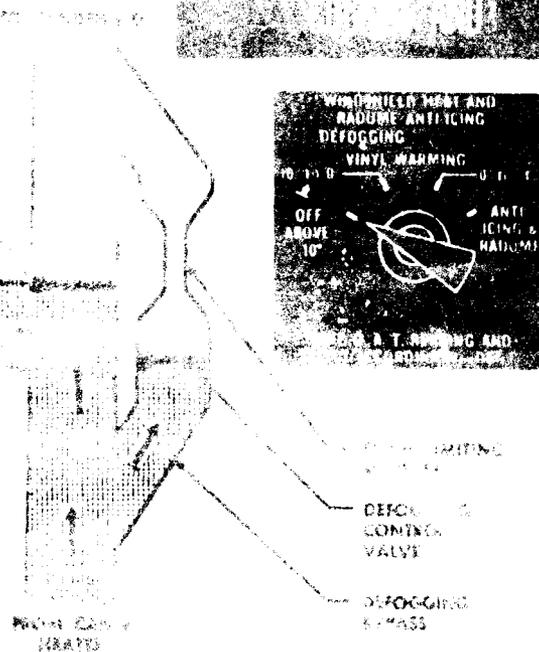
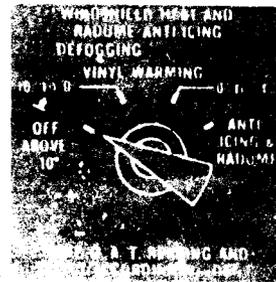
switches are toggle switches for selecting either dual or single ignition and No. 1 or No. 2 fuel systems. Each ignition and fuel system is independent and will operate the heaters in the event of faulty operation or failure of one set of controls. A heater fuel system switch located at the extreme left of the heater control panel operates the heater fuel cross-feed valve.

Cabin Heater

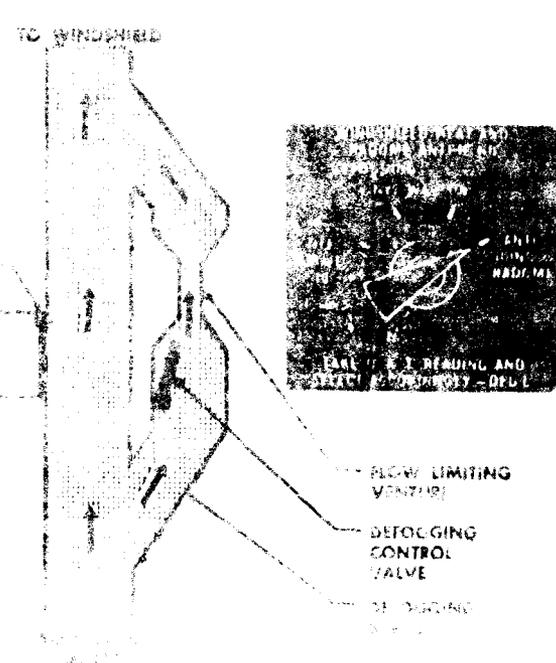
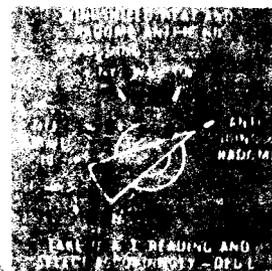
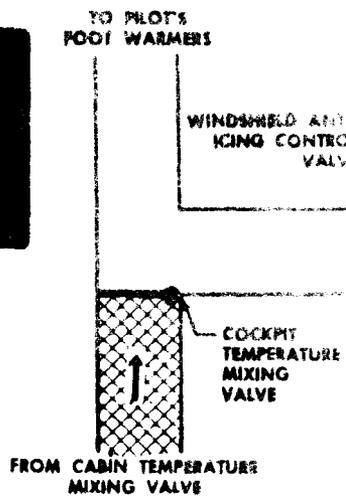
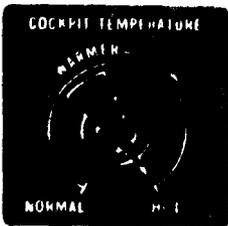
The cabin heater is located in the heater accessories compartment. Heat is produced by spraying fuel into the combustion air and igniting the fuel air mixture. The combustion air may come from either the wing combustion air intake, located on the leading edge of the fuselage, or from the ground blower. The combustion flame extends along the entire length of the



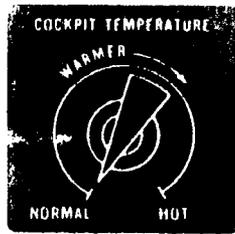
SCHEMATIC A



SCHEMATIC C



WINDSHIELD AIRFLOW SCHEMATIC



TO PILOT'S FOOT WARMERS



WINDSHIELD ANTI-ICING CONTROL VALVE

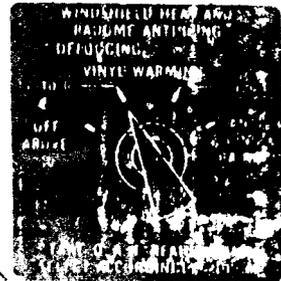
COCKPIT TEMPERATURE MIXING VALVE

FROM CABIN TEMPERATURE MIXING VALVE

TO WINDSHIELD



TO PILOT'S FOOT WARMERS THROUGH PRESS-HEADS



FLOW LIMITING VENTURI

DEFROGGING CONTROL VALVE

DEFROGGING BYPASS

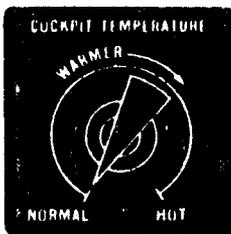
FROM CABIN SUPERCHARGERS

SCHEMATIC B



SCHEMATIC D

TO WINDSHIELD



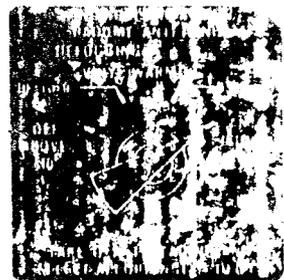
TO PILOT'S FOOT WARMERS



WINDSHIELD ANTI-ICING CONTROL VALVE

COCKPIT TEMPERATURE MIXING VALVE

FROM CABIN TEMPERATURE MIXING VALVE



FLOW LIMITING VENTURI

DEFROGGING CONTROL VALVE

DEFROGGING BYPASS

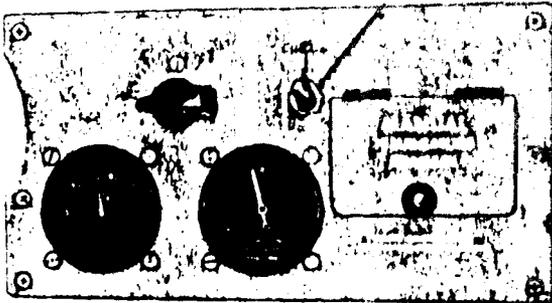
FROM CABIN SUPERCHARGERS

chamber heating the ventilating air as it passes through the outer chamber of the heater.

The ON - OFF cabin heater master control switch is mounted adjacent to the heater ignition selector switches. The OFF position shuts off the heater ignition, fuel supply and the cabin heater fuel pump, regardless of heater fuel and ignition selector switch positions. This switch should be operated ONLY when the heater must be turned OFF as a result of erratic heater operation or to maintain a consistent temperature during manual control of the heaters.

A cabin heater drop-out safety switch is provided in the heater system to prevent the heater combustion chamber from exceeding a safe temperature.

Temperature Controls Operation of the temperature control system is automatic after the temperature has been manually selected by the cabin temperature rheostat located on the temperature control panel. The rheostat control is marked with a range from 60 to 85 degrees Fahrenheit.



Cabin Temperature Control Panel

A manual temperature control door on the cabin temperature control panel de-energizes the automatic control circuit when it is opened. Closing the door returns the system to auto-

matic operation. The pushbuttons under the door control the position of the cabin temperature mixing valve. One pushbutton will close Port A (Cold) and open Port C (Hot). To prevent cabin temperature overshoot, move the cabin temperature mixing valve in small increments and wait for temperature changes. A gage showing the position of the mixing valve is adjacent to the manual control door.

The cockpit temperature is normally consistent with seat cabin temperature. However a rheostat on the heater fire control panel permits manual temperature variation within the cockpit. Heat is delivered through the distributing duct when the cockpit temperature control is placed in the "WARMER" position and when the windshield heat switch is in the anti-icing position, although the hot air exhaust from the windshield may be diverted into the cockpit or beneath the floor as desired.

With the windshield anti-icing heat ON the cockpit temperature control should be in the NORMAL position. The cockpit mixing valve movement is controlled by the cockpit temperature control rheostat. A 40-degree clockwise rotation of the rheostat is required to turn the heater ON which will cycle at 115°C to 135°C. To receive cool air in the cockpit from the cooling turbine, the cockpit temperature control should be in the NORMAL position and the windshield heat control should be turned "OFF".

The thermister is a special temperature sensitive resistor used in the cabin temperature electrical control bridge circuit. A thermister blower draws the air over the thermister while the airplane is on the ground. A small venturi accomplishes this in flight. The thermister senses any change in temperature and causes the cabin mixing valve to be adjusted accordingly.

VENTILATION, AIR CONDITIONING, AND PRESSURIZATION

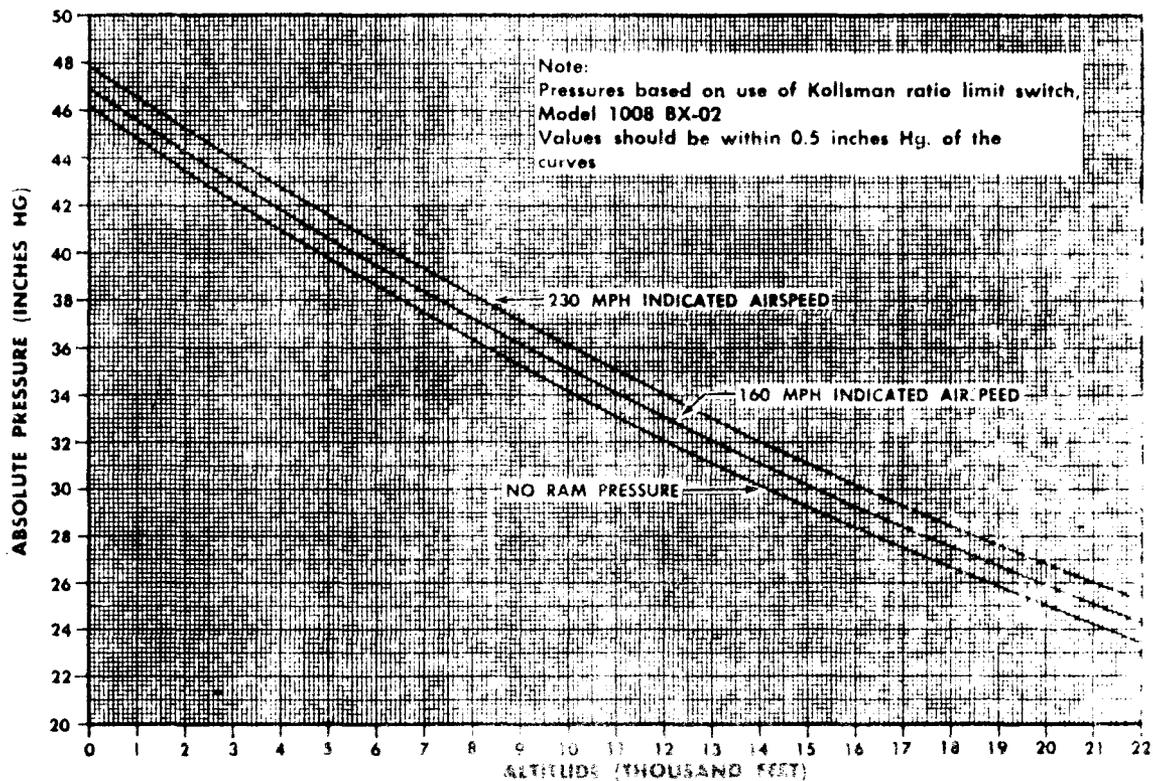
General

The aircraft is equipped with a heating and ventilating system designed to keep cabin air temperatures within comfortable limits for passengers and crew. The equipment consists of two engine-driven superchargers, installed in the outboard nacelles, which supply pressurized air to the temperature conditioning equipment in the fuselage. An automatic temperature control system regulates the flow of pressurized air by means of a cabin temperature control mixing valve. The valve takes cold air from a cooling coil, cool air from an aftercooler, or hot air from a cabin heater, mixes any two of them in the proper proportions to give a de-

sired cabin temperature. From the temperature conditioning equipment, the air is distributed and circulated throughout the aircraft by a system of under-floor and wall ducts and is eventually discharged overboard through a cabin pressure control valve in the side of the fuselage.

By an automatic and/or manual system of control, air pressure can be maintained so that the aircraft can travel at varying altitudes up to approximately 25,000 feet without discomfort in the cabin. The fuselage can be rapidly depressurized, in case of emergency, by moving the emergency cabin altitude control to the extreme counterclockwise position. This opens the

SUPERCHARGER DUCT MAXIMUM PRESSURE CHART



emergency relief valves and the dump valve.

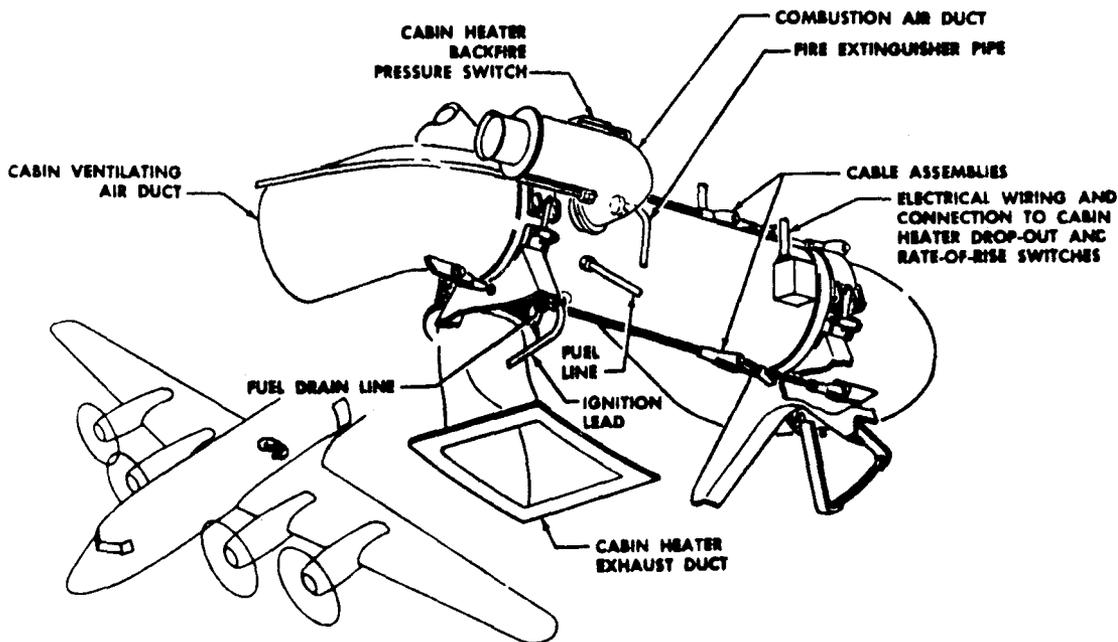
Heating and Air Conditioning

During a large percentage of flight operations, the 300,000 BTU cabin heater may not be required since the air from the cabin superchargers will be heated sufficiently as it is compressed to maintain the cabin temperature within comfortable limits. When both superchargers are inoperative, a bypass check valve in each outboard nacelle will allow ram air to enter the cabin for ventilating purposes.

Adjustable cold air orifices are located at each crew station and in the toilets for individual requirements of air that is cooler than that supplied by the conditioning system. All of the temperature controls are located on the heater control panel in the cockpit.

The basic unit of the cabin temperature conditioning system is the three-port mixing valve, which receives cold air from the cooling turbine, cool air from the aftercooler, warm air from the engine-driven cabin superchargers, and/or hot air from the cabin heater. Depending on the outside air temperature and cabin temperature requirements, the mixing valve mixes the air from any two adjacent ports in the proper proportions to maintain cabin temperatures within the limits of 65° to 85° F. The cooling turbine has a limited capacity, but is capable of holding cabin temperature approximately 15° F below outside air temperature, provided excessive humidity is not encountered.

The ventilating system also operates on the ground with engines shut down. An automatic ground ventilating blower is operated electrically from external power or the auxiliary power plant, supplying air for the cab-



Cabin Heater

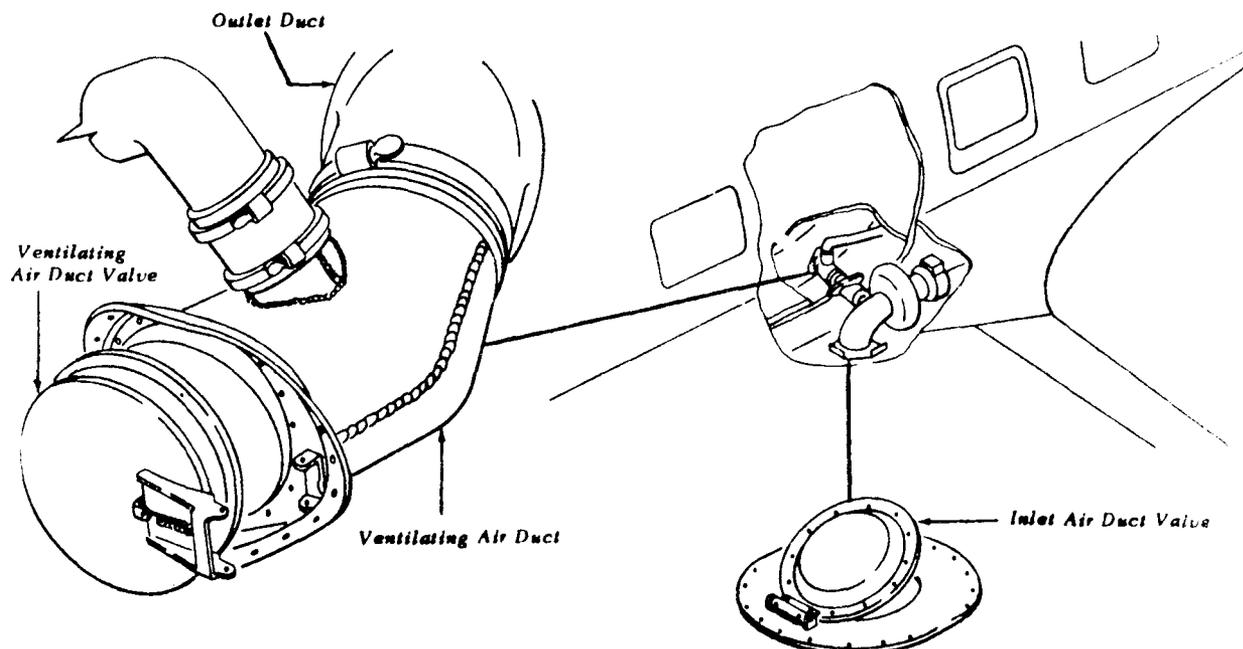
in heater and/or ventilation when on the ground. The ground blower is located in the left wing fillet area, adjacent to the air conditioning accessories compartment. The air supply for this blower is received through a flapper valve located directly beneath the blower in the lower surface of the wing. Another flapper valve is contained in the blower duct at a point where it enters the fuselage to prevent air from escaping in flight when the blower is inoperative.

During flight, the ventilating system will normally receive air from the superchargers, but should both superchargers be inoperative, ram air from the supercharger inlets would continue to supply air sufficient for ventilating purposes. However, the manual control switch located behind the manual control door on the supercharger instrument panel, must be operated to

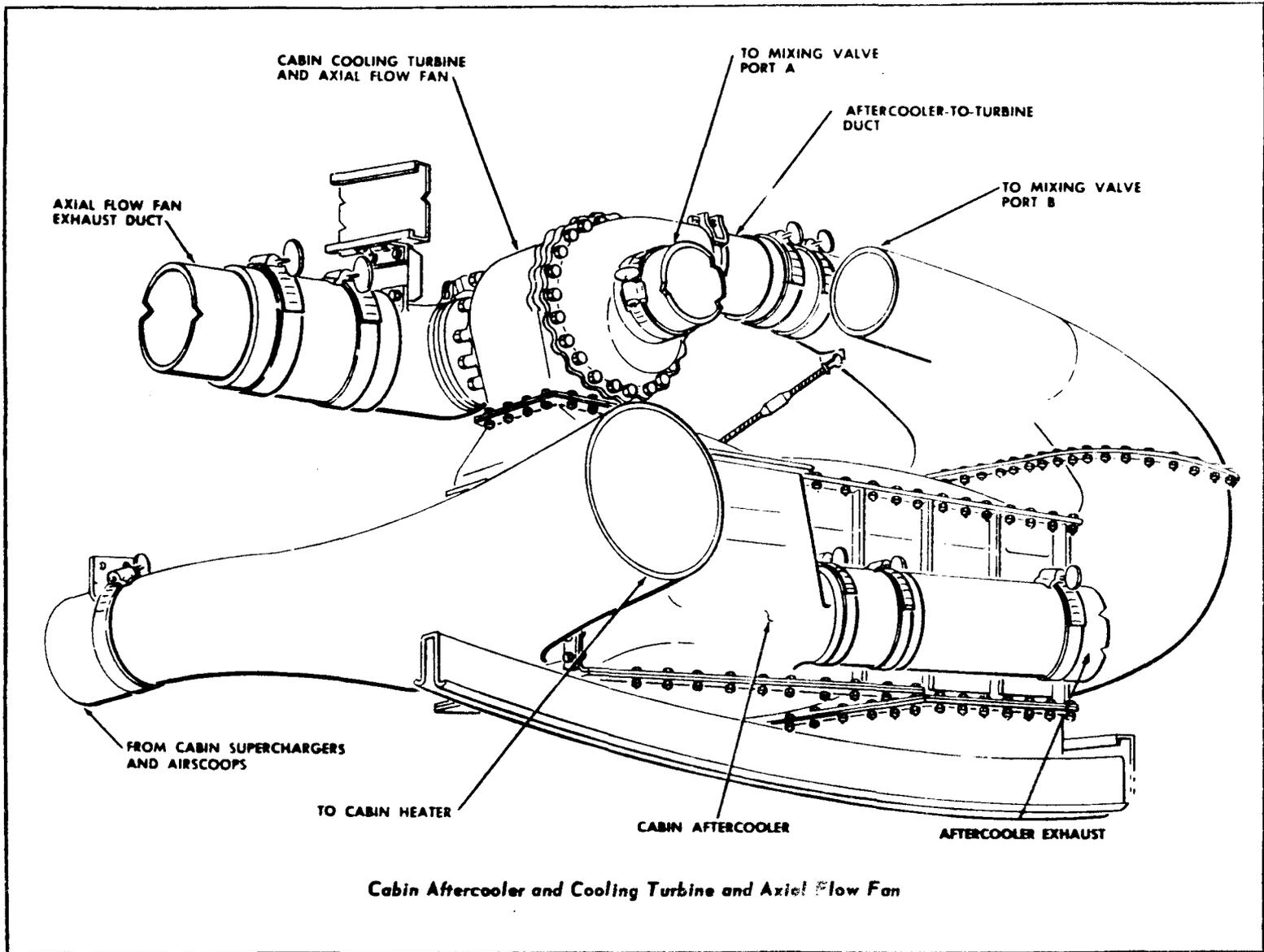
open the pressure control valve to enable the air to circulate. Should circulation be inadequate through the pressure control valve, it may be necessary to open the emergency relief valves by operating the control crank beside the copilot. The control door must be left open, otherwise the automatic controls will attempt to pressurize the cabin.

The air conditioning and distribution system mainly consists of (1) an air cooling radiator, known as the aftercooler, (2) the turbine which is also a cooling unit, (3) the mixing valve, (4) the combustion heater and (5) inter-connecting ducts necessary to conduct the air through the conditioning system. These units are grouped in the heater accessories compartment.

The aftercooler consists of a number of tubes through which air from the engine-driven cabin superchargers passes



Cabin Heater Ground Blower Inlet and Ventilating Air Ducts

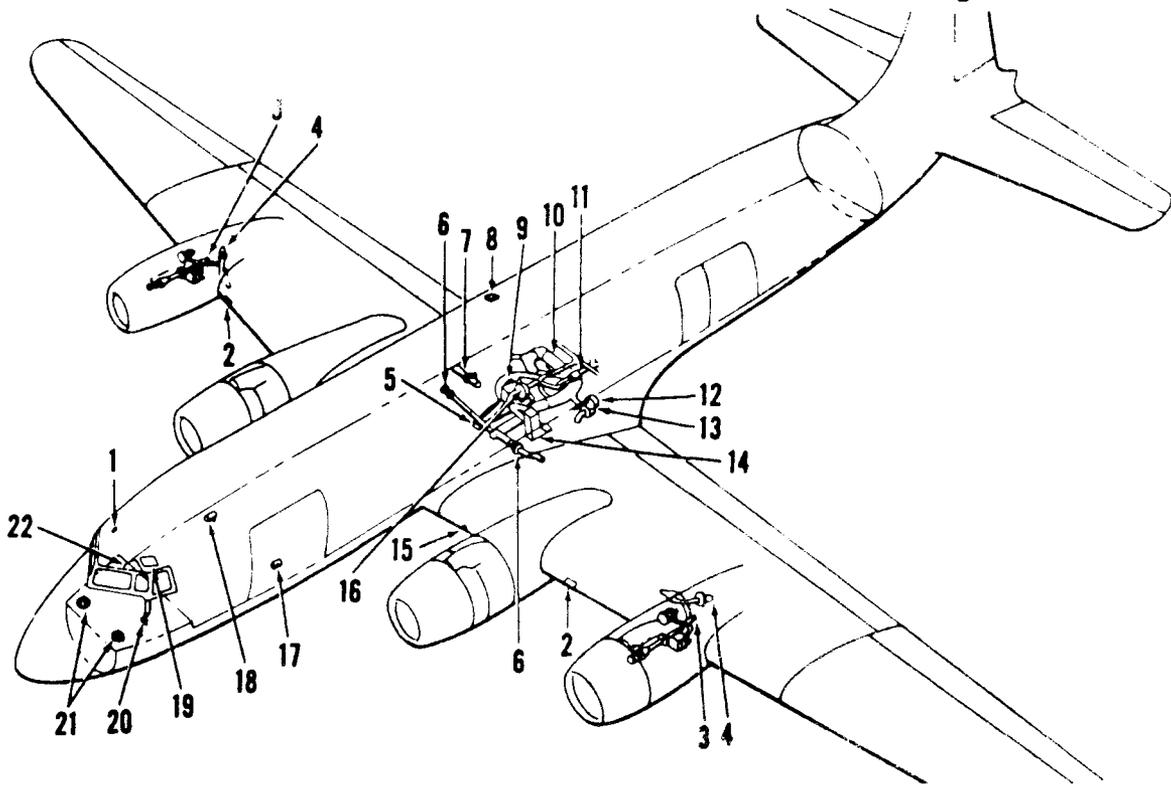


to the cabin temperature control mixing valve. Outside air enters through a scoop on the lower surface of the fuselage and flows over the tubes, cooling the heated air from the cabin superchargers. At full coolant airflow, the supercharger air is cooled to approximately outside air temperature. After flowing over the tubes the cooling air is routed through an axial flow fan and exhausted overboard through an electrically-actuated exhaust flap in the under surface of the left wing fillet.

The degree of cooling accomplished

by the aftercooler is varied by opening or closing the exhaust flap. This is automatically controlled by a circuit operated by the mixing valve. During ground operation cooling air is drawn through the scoop by the axial flow fan which is mechanically driven by the cooling turbine. The work required to drive the fan relieves the heat energy from the warm compressed supercharger air.

A ground heating and cooling access opening through the skin to the floor ducting is used for supplying heated or cooled air from a ground source.



- | | |
|--|--|
| 1 Cabin Temperature Control Panel | 12 Cabin Heater Accessories Container |
| 2 Airscoop | 13 Cabin Heater Ground Blower |
| 3 Cabin Supercharger | 14 Coolant Air Exhaust Duct |
| 4 Cabin Supercharger Bypass Air Duct Check Valve | 15 Cabin Heater Combustion Airscoop |
| 5 Coolant Airscoop | 16 Cabin Cooling Turbine and Axial Flow Fan |
| 6 Cabin Supercharger Delivery Air Duct Check Valve | 17 Flight Compartment Temperature Control Mixing Valve |
| 7 Cabin Pressure Control Valve | 18 Windshield Anti-icing Control Valve |
| 8 Cabin Thermister | 19 Heater Fire Control Panel |
| 9 Cabin Aftercooler | 20 Windshield Anti-icing Air Exhaust Duct |
| 10 Cabin Heater | 21 Footwarmer |
| 11 Cabin Temperature Control Mixing Valve | 22 Heater Control Panel |

Heating and Ventilating System, Component Locations

Cabin Pressurization

The cabin pressurization system is designed to keep cabin air as near sea-level pressure as possible throughout flights at various altitudes.

On flights up to 9,000 feet, the system can maintain the cabin air at sea-level pressure. When flights are planned for altitudes above 9,000 Ft., the pressure in the cabin decreases from the time of take-off, but at a much slower rate than atmospheric pressure outside the airplane.

The differential between outside pressure and cabin pressure increases to a maximum of 4.16 psi as altitude is gained and then is automatically held there. Hence, as the airplane climbs to 15,000 feet, pressure will decrease slowly to the equivalent of a 4,515 ft. altitude. When the airplane is flying at 20,000 feet, the altitude of the cabin is maintained at 8,000 feet.

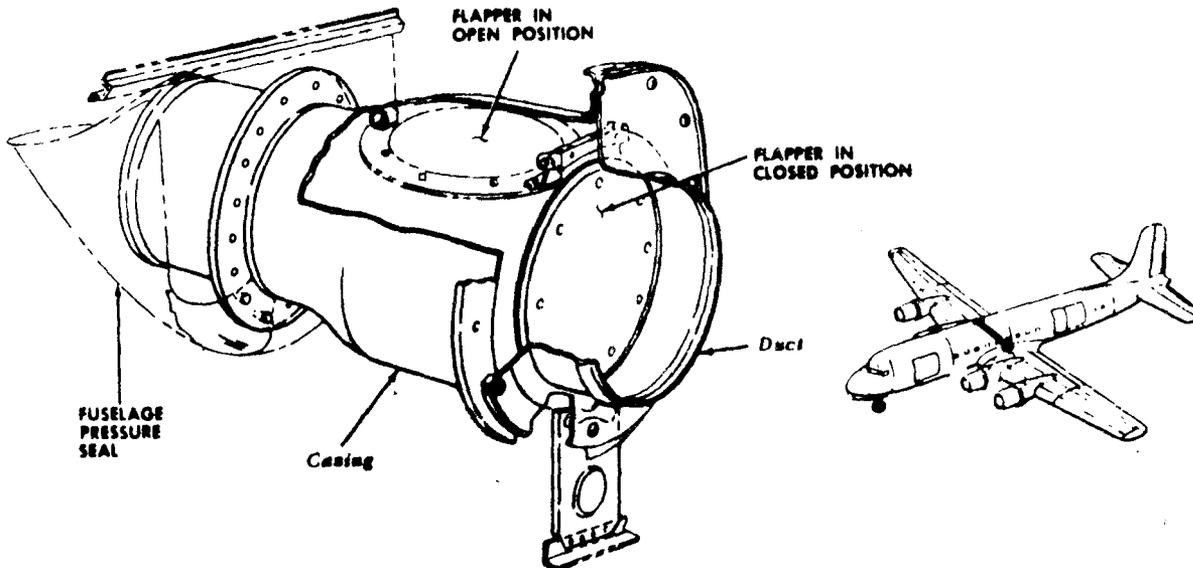
Above 25,000 feet, where the cabin pressure altitude reaches 11,300 feet,

the limiting pressure differential of 4.16 psi is decreased to prevent overloading of the cabin superchargers.

Ram air for cabin ventilation enters air scoops in the leading edges of the wings between the nacelles and is ducted to the cabin supercharger. The impeller increases the ram air pressure forcing it through ducts to the air conditioning units located beneath the main cabin floor. The air conditioning devices cool or add more heat to this air as needed before it enters the cabin.

An air flow valve or regulator on each supercharger detects the rate of air mass flow coming from the impeller. It is connected to a hydraulic system which regulates the speed of the impeller, thereby maintaining a constant output of air regardless of engine RPM or airspeed.

Each supercharger is rated at 710 cubic feet of air flow per minute. This provides a complete change of air in the cabin every three minutes, with both superchargers operating.



Cabin Supercharger Delivery Air Duct Check Valve

The air is continuously taken into the airplane, pressurized, conditioned and circulated through the fuselage section. It is then exhausted overboard. It is the control of this air exhaust, rather than any control of the supercharger which determines the degree of pressurization.

Such control is completely automatic, although there are standby devices which permit manual control. There are five fuselage valves for regulating cabin pressure. Four of them provide for release of air pressure from the cabin. The fifth valve provides an air inlet to prevent outside pressure from exceeding inside pressure.

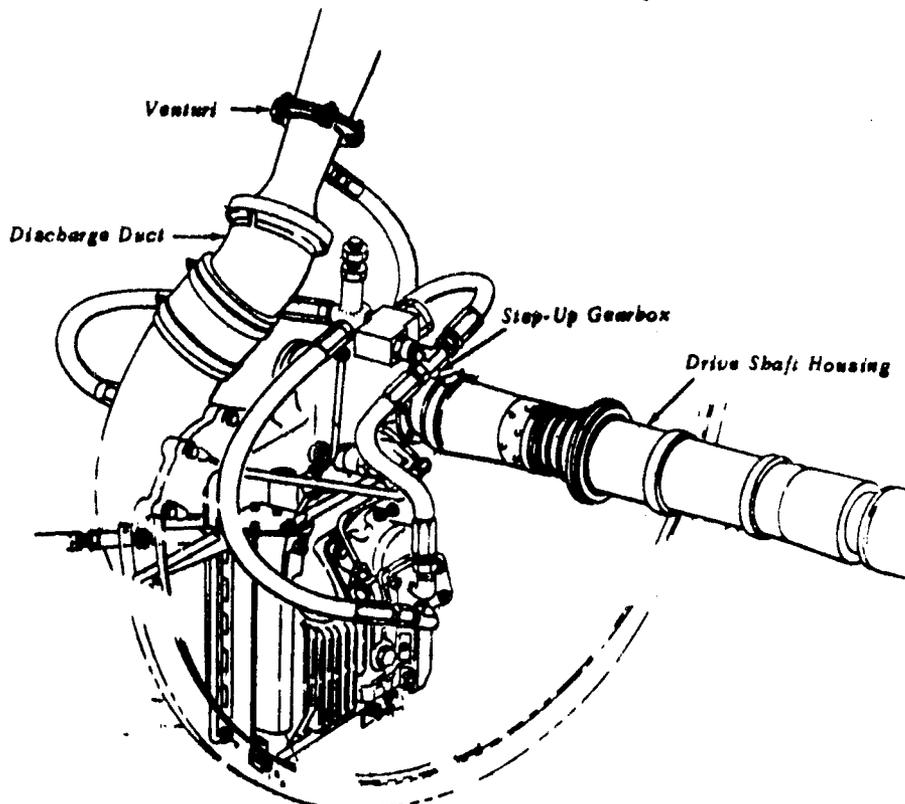
There are several cabin pressure controlling and indicating instruments. The controlling units enable the flight crew to set up in the system the expected altitude conditions at which the

airplane will be flown and to pre-determine the rate of cabin "climb" and "descent", the cabin-to-outside air pressure differential, and the altitude at which the cabin will be maintained throughout the flight.

These controlling units make or break electrical circuits which energize an electrical actuator on the pressure control valve.

The indicating instrument enable the flight crew to visually check the operation of the system.

The two supercharger systems are practically identical. Each consists of an air intake scoop and ducting, a cabin supercharger with allied speed controls, and ducting to the fuselage. Both are normally operated at the same time, although each may be operated independently of the other. The pressure control system of valves and instru-



Cabin Supercharger Transmission Assembly

ments is common to the complete pressurization system.

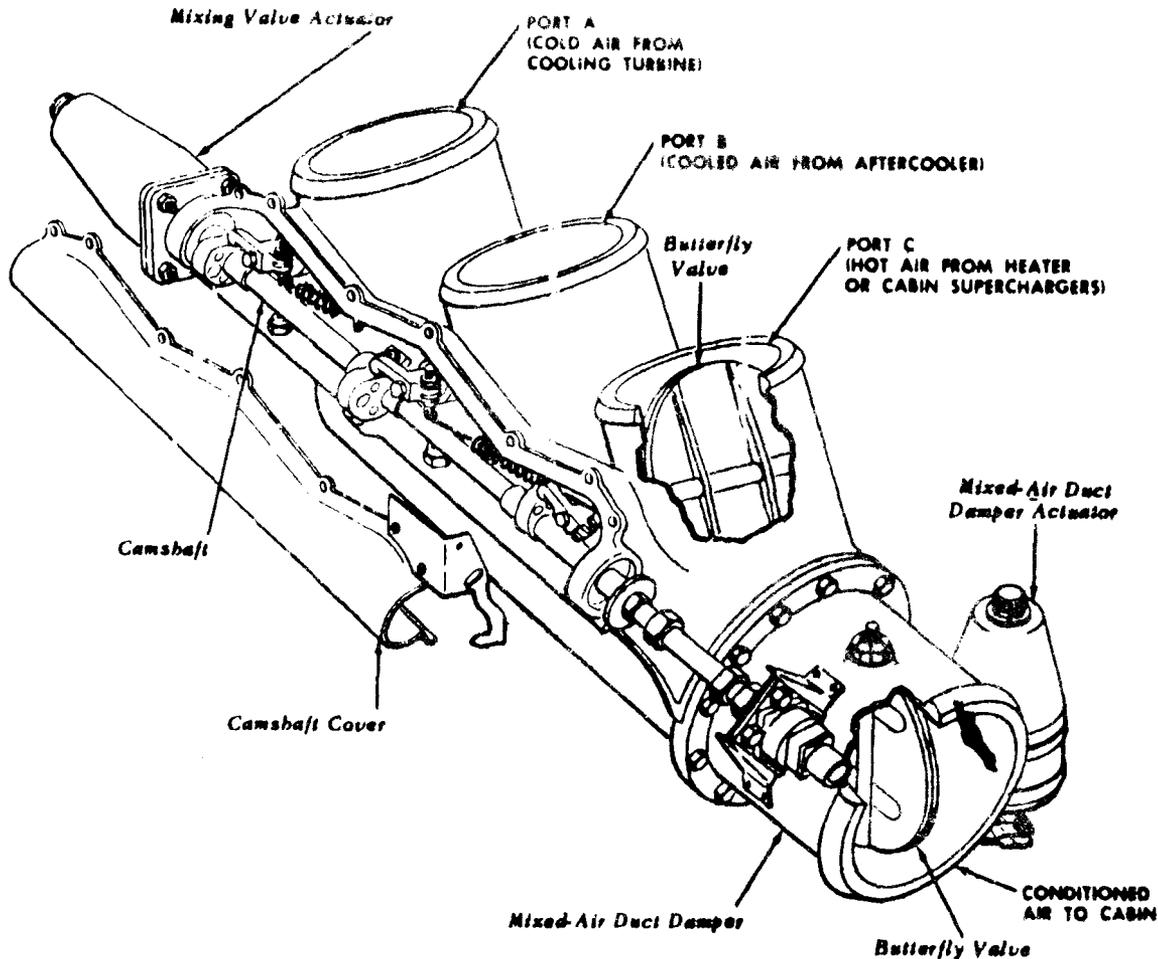
If one supercharger fails, the other can provide adequate pressurization under most conditions. If neither supercharger is operative, ram air enters the air scoops and flows through ducting to the air conditioning equipment and cabin for heating and ventilation.

Power Take-Off and Supercharger Drive Assemblies

Each supercharger absorbs from 10 to 25 engine horsepower, depending on atmospheric conditions and back pres-

sure in the air ducts. The power for driving the supercharger is derived from the right hand accessory pad on the rear engine case, then continues through a quick disconnect clutch and a drive shaft to a gear box on the supercharger assembly behind the fire-wall.

The supercharger drive shaft clutch is contained in a housing which is belted to the right hand drive pad on the rear engine case. The coupling between the engine drive pad and the clutch is splined at both ends. A shear section is provided to protect the engine accessory gear train in the event of clutch shaft bearing failure.



Cabin Temperature Control Mixing Valve

WARNING

The clutch may be disengaged instantly while the engine is running, but must not be reengaged until the engine is stopped.

The supercharger must maintain a selected cabin pressure. Since air density, ram air pressure and engine speed are variables, it is necessary for the supercharger to compensate for these variables. The planetary gear system, acting as a transmission, increases and decreases supercharger speed to make this possible.

Supercharger Airflow Control System

The airflow control system detects variations in supercharger air mass output and changes the position of the variable displacement pump to control impeller speed accordingly.

It is possible to build up back pressure in the delivery air duct downstream from the impeller to the extent that the impeller will "stall out". In such cases, the load under which the impeller is working is so great that it fans air without being able to move the air along. This is indicated in the cockpit by the airflow rate indicator. It fluctuates rapidly, indicating that a decrease in airflow through the diffuser has occurred.

There are two units in the air conditioning system which, when operating, increase the back load on the impeller. One is the expansion turbine and the other is a butterfly valve located in the mixing air duct outlet, which imposes a restriction on airflow from the superchargers for windshield anti-icing.

To relieve a condition of this nature, a Compression ratio limit switch located in the lower right hand side of No. 4 nacelle, is incorporated in the electrical circuit. This switch is designed to reduce the restriction involved by either closing the turbine mixing valve port, or by opening the butterfly damper, whichever the case may be. This condition is sensed through a line from the supercharger diffuser.

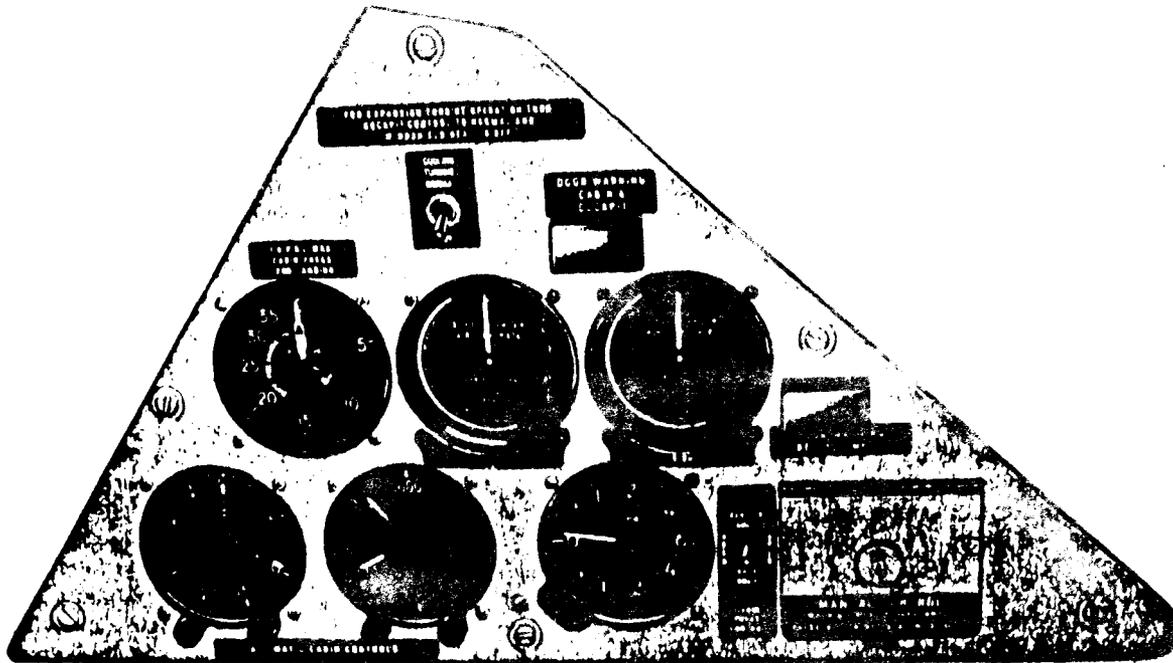
Cabin Supercharger Oil System

The cabin supercharger assembly contains its own oil supply. The main supply is contained in a sump at the bottom of the planetary gear box. An auxiliary supply tank is mounted on the firewall forward of the supercharger transmission and is connected to the sump by a hose. The supply is replenished through a filler neck on the auxiliary tank. Not only does the tank augment the reserve of fluid available to the system, but it provides additional volume for expansion. A drain hole has been drilled at the base of the filler neck. Fill the system until oil runs out this drain hole. A spring-loaded valve attached to the filler cap seals off this hole when the cap is installed. The oil capacity of each supercharger is **16 quarts, 5 ounces.**

Cabin Pressure Instruments and Controls

All cabin pressure instruments and controls are located on or behind the cabin pressure control panel in the flight compartment with the exception of the supercharger oil pressure and temperature indicators.

Two of the three pressure controlling units are mounted on the panel and look like instruments. They are the "Cabin Pressure Regulator", and the "Cabin Pressure Change Limit Control".



CABIN PRESSURE CONTROL PANEL

The other controlling unit, the "Cabin Pressure Limit Control", is located in the ceiling above and slightly aft of the copilot's window.

Four instruments on the cabin pressure control panel are pressure indicating instruments for checking operation of the pressurization system.

Two of the instruments are the air-flow rate indicators, one for each supercharger. They measure the pressure differential across the supercharger diffuser and indicate this differential in terms of air mass flow.

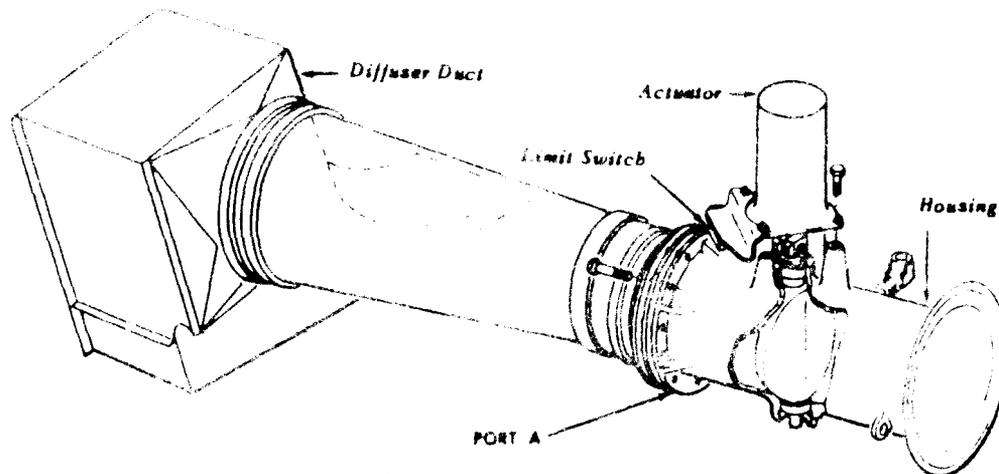
A dual instrument, which indicates the cabin altitude, the altitude of the aircraft, and the differential pressure between the two is also installed on this panel.

The cabin rate-of-climb indicator

is used as another general check over the pressure controlling system. It will indicate the rate of cabin pressure change in terms of feet per minute.

The automatic pressure control system operates only when the Manual Control Door is closed. This door is located on the cabin pressure control panel in the flight compartment. Opening the door actuates a switch which breaks the automatic circuit and completes a manual control circuit. This latter circuit energizes Open and Close push buttons, (located behind the door) which control the Pressure Control Valve directly. If the automatic control malfunctions, the flight crew may use the manual buttons to adjust the control valve.

The Cabin Pressure Control Valve consists of a cast aluminum cylinder



Cabin Pressure Control Valve

and a butterfly mounted on a vertical shaft. The cylinder is mounted laterally at the forward right hand corner of the heater compartment. Air on its way out of the airplane enters the flared inboard end of the valve. The outboard end is flanged and bolted to a stainless steel diffuser.

An electric actuator (reversible DC motor) is mounted on top of the control valve cylinder and connected to the butterfly.

The anticipator bulb system is in effect a miniature cabin designed to reflect cabin pressure changes immediately for the benefit of controlling instruments. Without it there would be a lag between cabin pressure changes and detection of them. The bulb is in a small T-shaped chamber located above the flight compartment entrance door.

The piping system introduces two pressures to the anticipator bulb, high pressure from the mixed air duct and a lower pressure (with some venturi effect) from the pressure control valve. The two tend to balance each other in the bulb. A sudden change, such as a surge or drop in either line, will immediately show up in the bulb,

while effects of these changes will become evident in the cabin sometime later. Thus, pressure conditions in the cabin are anticipated in the bulb before they become evident in the cabin. The two controlling instruments connected to the bulb pick up these anticipated changes promptly and react to them with minimum lag.

Cabin Pressure Regulator

The two pointers of the cabin pressure regulator are fixed at an angle of 107 degrees to each other. This angle represents the 4.16 psi operating pressure differential, as well as the difference in feet between flight altitude of the cabin and aircraft. One of the pointers is labeled "Flight" and the other "Cabin". They are rotated by a knob marked "Hands" at the lower right corner of the instrument.

The pointer marked "Flight" is adjusted before take-off for the maximum planned flight altitude. The cabin pointer will then indicate the cabin pressure altitude which is maintained by the pressure regulator at that flight altitude.

The knob labeled "Start Marker"

the lower left corner of the instrument, controls an arc or metal sector which moves around the rim of the dial. The "Start Marker" setting is the altitude at which pressurization begins on ascent of the airplane, and at which depressurization is completed on descent. During automatic control, the cabin operates unpressurized at all altitudes below the setting of the "Start Marker".

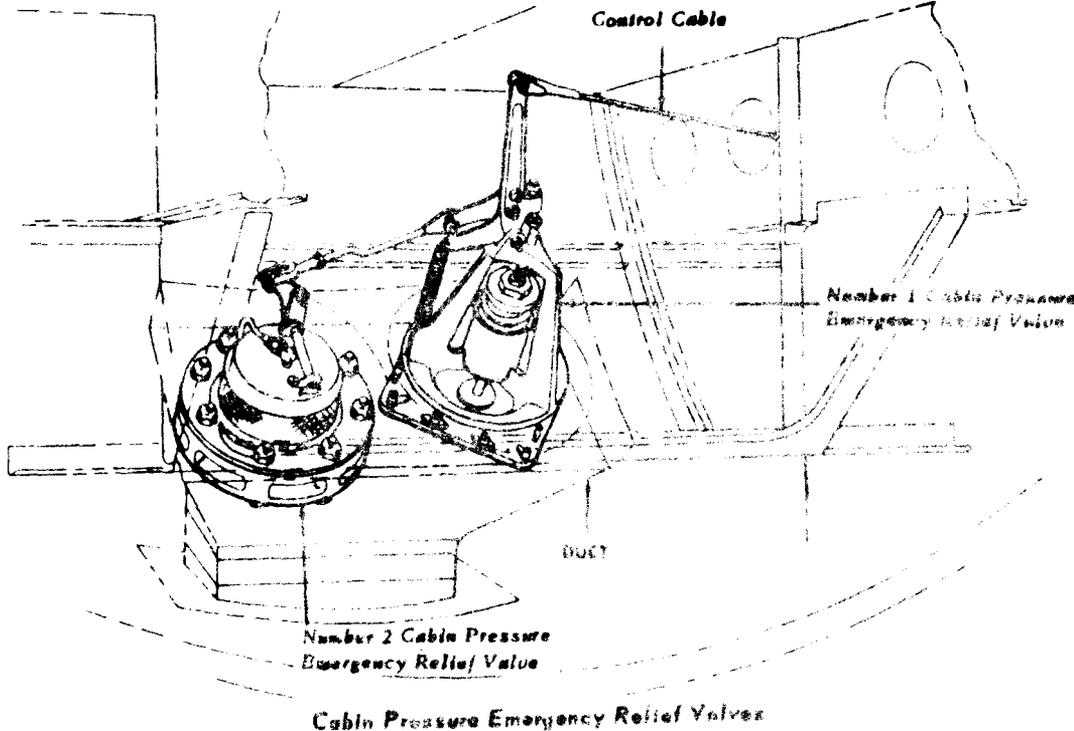
Before starting descent to a landing field of an elevation different from the take-off field, the "Start Marker" must be reset to the landing field altitude. Resetting is necessary to obtain the proper ratio between the rate-of-descent of the cabin and the airplane, so that the airplane will land fully depressurized.

The "Cabin Pressure Change Limit Control" controls the rate of change of cabin pressure under certain operating conditions. Stating it another way, it limits the cabin's rate-of-climb and rate-of-descent of simulated altitude.

Before starting descent, the pilot sets the position of the control desired rates of climb and descent - usually 600 feet per minute UP and 300 feet per minute DOWN.

There are four cabin pressure emergency relief valves on the airplane. Three of them release cabin air pressure, aiding the cabin pressure control valve in decreasing pressure differential when needed. The fourth emergency relief valve admits outside atmospheric pressure to the cabin. When it exceeds cabin air pressure, slow rapid depressurization of the airplane is required, the cabin pressure control valve may be inadequate. Furthermore, in case of electric actuator failure on the control valve, or in case the valve butterfly has been tripped and closed, a standby method of pressure control is needed.

The manual emergency relief valve # 1 is located at six o'clock position in the aft. pressure dome and consists of a cast aluminum housing, a circular cover plate, rod and spring.



Cabin Pressure Emergency Relief Valves

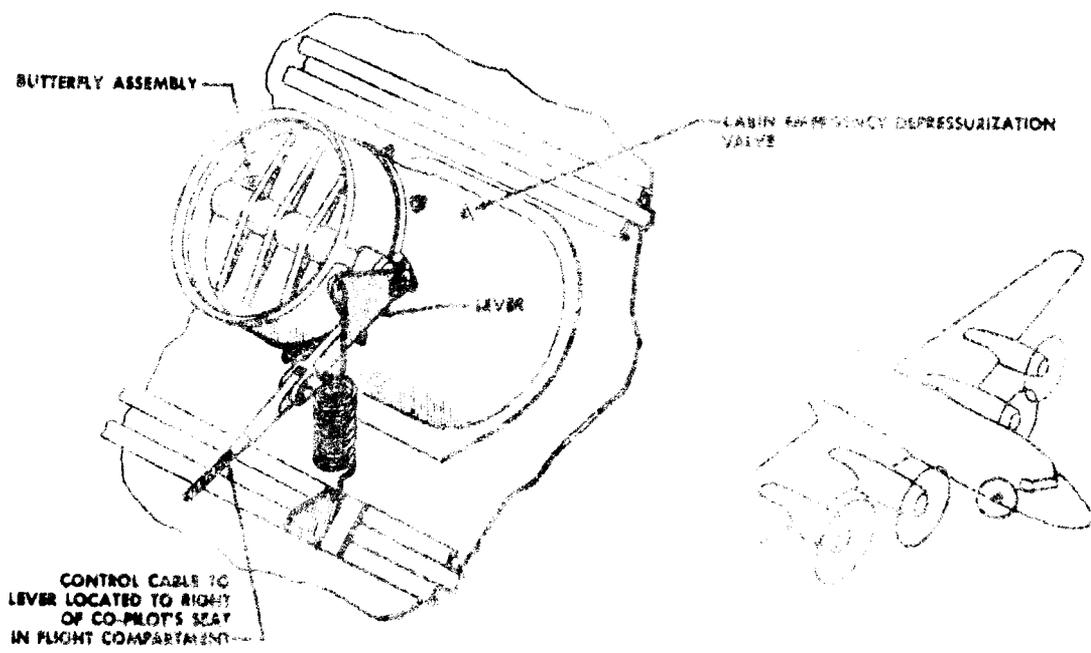
top of the housing, a rubber diaphragm which serves as a sealing member, a pressure actuated bellows assembly and a small pilot valve.

At approximately 4.2 psi, the bellows will contract enough to let the pilot valve disc move up to the open position, thus discharging air pressure overboard. This automatic emergency relief valve operates independently of any other valve action. However, a lever assembly on top of the valve housing assembly will open the valve manually. A rod connects the bellcrank on the manual relief valve to the automatic emergency relief valve.

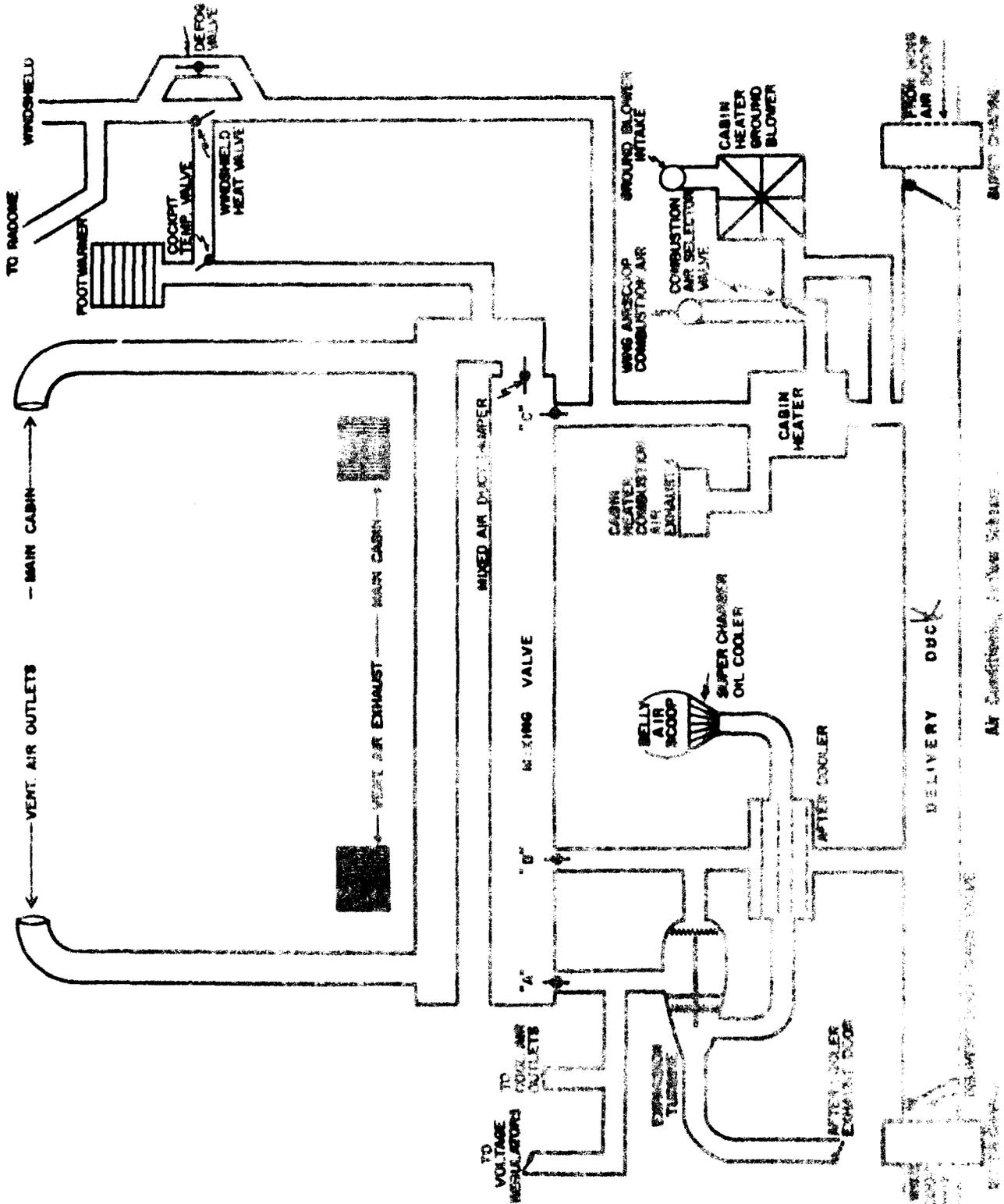
Both valves will be full open at 4.67 psi and may be opened manually in an emergency from the cockpit. The control crank is mounted at the right of the co-pilot's seat.

The automatic emergency relief valve is located just below the floor level on the right side of the pressure door at the aft end of the cabin. It is a simple flapper type valve held closed by its own weight and cabin pressure. It opens inwardly should outside pressure exceed the inside pressure by 1/2 psi.

An emergency cabin pressure dump valve is located below the flight compartment entrance door which performs a similar function to that of the rear valves, and is operated by the same rigging as the rear valves. One main difference, however, exists between this valve and the rear valves: It will not relieve under excessive pressure automatically. Its main purpose is for fast emergency dumping of air pressure. It helps to rapidly clear away any fumes which may find their way into the forward cabin and flight compartments.



Cabin Pressure Emergency Dump Valve



Air Conditioning System Schematic

1951 SERIES AIRCRAFT

VERSUS

1951 SERIES AIRCRAFT

1. AIRPLANE GENERAL

- a. Right main strut micro-switch.
 - 1. Landing gear safety lock solenoid.
 - 2. Cabin pressure warning lights.
 - 3. Automatic depressurization (landing).
 - 4. Reverse flag (if applicable).
- b. Left main strut micro-switch.
 - 1. Five ground blowers.
 - 2. Generator outcut circuit.
- c. Flare chute.
 - 1. One available for use.
 - 2. Located at the navigator station.
 - 3. Located externally.
- d. Green sun shades for pilot and co-pilot available in cockpit.
- e. Height 28' 8".
- f. Five oxygen regulator for crew.
- g. Oxygen system procedure which allows pilot to use oxygen from crew O-1 bottle. (Some aircraft).

1. AIRPLANE GENERAL

- a. Right main strut micro-switch.
 - 1. Landing gear safety lock solenoid.
 - 2. Cabin pressure warning lights.
 - 3. Automatic depressurization (landing).
 - 4. Anti-collision light.
- b. Left main strut micro-switch.
 - 1. Five ground blowers.
 - 2. Anti-skid brakes (if applicable).
 - 3. Airfoil heater switch must be off before the GTPU can be started on the ground.
 - 4. #1 or #4 engine must be above generator out-in speed for ground operation of "A" post.
 - 5. Generator outcut circuit.
- c. Flare chute.
 - 1. One available for use.
 - 2. Located in the right wing butt.
 - 3. Located externally.
- d. Turntable never used.
- e. Height 29'.
- f. Four oxygen regulators for crew.
- g. Oxygen system procedure which allows pilot to use oxygen from crew O-1 bottle. (Some aircraft).

1. PRESSURIZATION

- a. Univus 54 or Solvis 200 (cannot be mixed with Skydrol).
- b. Turbine switch on center overhead electrical panel.
- c. Separate instruments for cabin altitude and cabin pressure.

2. AIR CONDITIONING

No de-fog valve or de-fog selection on the windshield heat switch.

3. HEATERS

No difference.

4. FUEL SYSTEM

Ten tank system (seven aircraft).

5. OIL SYSTEM

No difference.

6. FIRE DETECTION AND CO₂

a. Four warning lights on fire detection panel, four selector pins, two discharge buttons and one selector switch.

b. Four repeater lights at bottom of co-pilot's instrument panel.

c. None

d. None

e. Discharge discs for the main banks of bottles installed externally on the nose of the aircraft.

1. PRESSURIZATION

- a. Skydrol (cannot be mixed with Univus 54 or Solvis 200).
- b. Turbine switch on pressurisation panel.
- c. Dual instrument used for cabin altitude and cabin pressure.

2. AIR CONDITIONING

Uses a de-fog valve and has the de-fog selection on the windshield heat switch.

3. HEATERS

No difference.

4. FUEL SYSTEM

Eight tank system (All aircraft).

5. OIL SYSTEM

No difference.

6. FIRE DETECTION AND CO₂

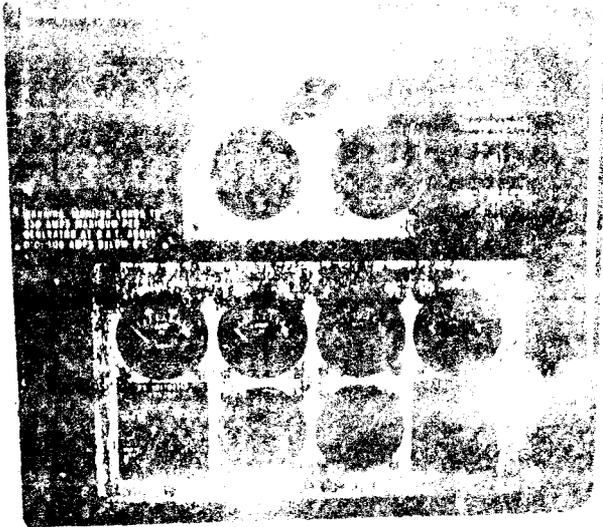
a. Five warning lights on fire detection panel, five selector pins, two discharge buttons and one selector switch.

b. None.

c. One master repeater light is utilized; located forward of the co-pilot on the main instrument panel.

d. Five isolation switches utilized with the master repeater light; they are located on the fire detection panel.

e. Discharge discs for the main banks of bottles installed inside the nose wheel well of the aircraft.



A circular graphic with the text "Section 2" written in a stylized, cursive font. The text is white against a dark background.

CONTENTS

Battery and Charging System	2-2
Generator System	2-8
Auxiliary Power	2-9
Alternating Current	2-12
Warning and Safety Systems	2-18
Miscellaneous Systems	2-19

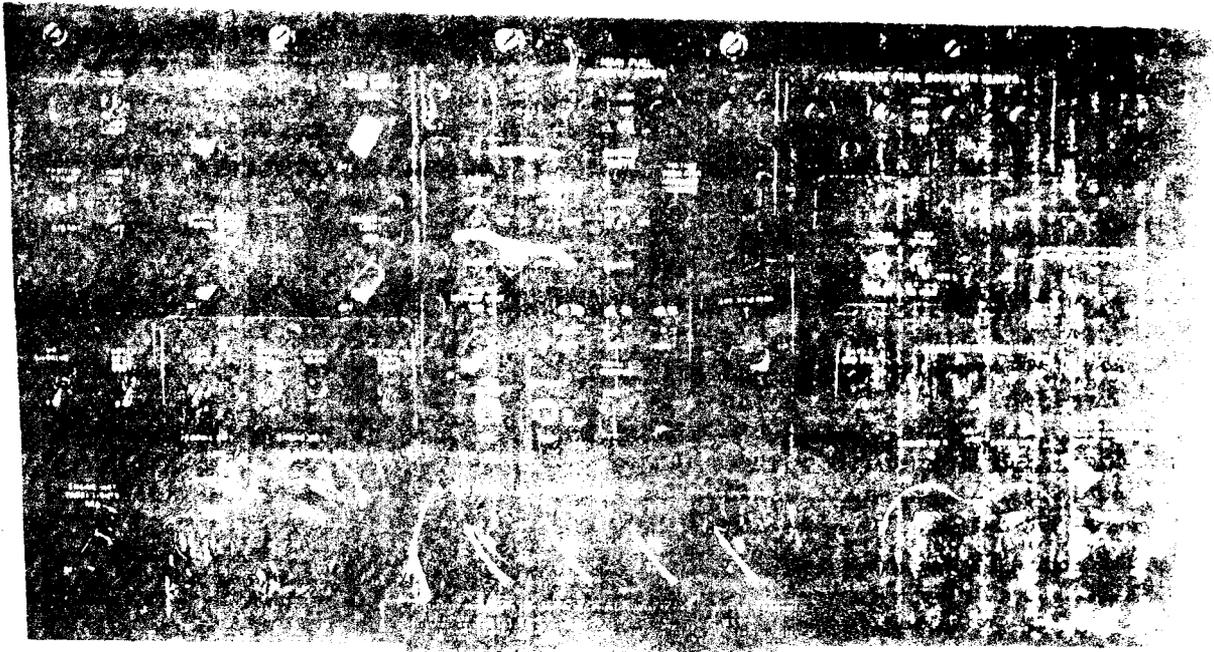


Figure 2-1. Control Room

BATTERY AND DC DISTRIBUTION

The two sources of DC electrical energy on the C-118A are the generators and the batteries.

The batteries provide a surge chamber for the generator system and are an emergency source of DC power. The 12 volt, 88 ampere hour batteries are attached to spring-loaded battery elevators which lower through access doors aft of the nose gear well. These batteries are connected in series to deliver 24 volts, 88 ampere hours to the DC Bus.

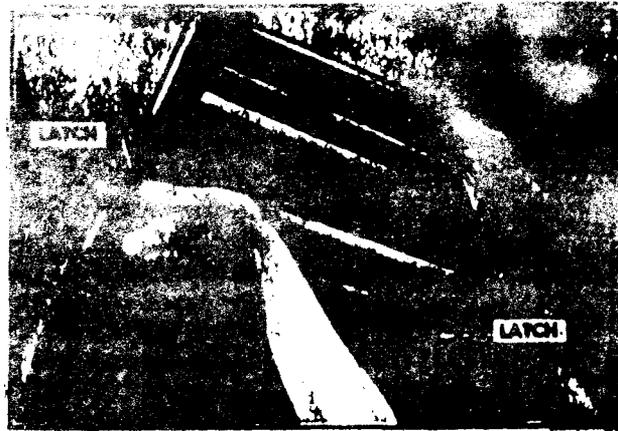
The batteries are connected to the DC bus by a relay located in the battery compartment. The master battery switch located on the forward overhead switch panel has two positions, "OFF" and "PLANE BATT PWR". A 500 ampere current limiter protects the batteries from an overload.

The batteries must be removed for a capacity check every 120 days per T.O. 1C-118-6. The water level must be maintained $\frac{3}{8}$ of an inch above the plates. A specific gravity reading of each cell and water level check is required every seven days and at each periodic inspection. If the specific gravity, after temperature correction, exceeds 1.310 or is below 1.240 on any cell, or a variation exists greater than .020 between the highest cell and the lowest cell, the battery must be replaced.

CAUTION

The sulphuric acid in the electrolyte is extremely injurious to the skin and to clothing. If acid is spilled,

neutralize it at once with sodium bicarbonate (baking soda) and wash with water. Wash aluminum or aluminum-alloy surfaces of the aircraft that have been contaminated with battery acid with soap and water or ammonia and water to neutralize acid. Wash thoroughly.

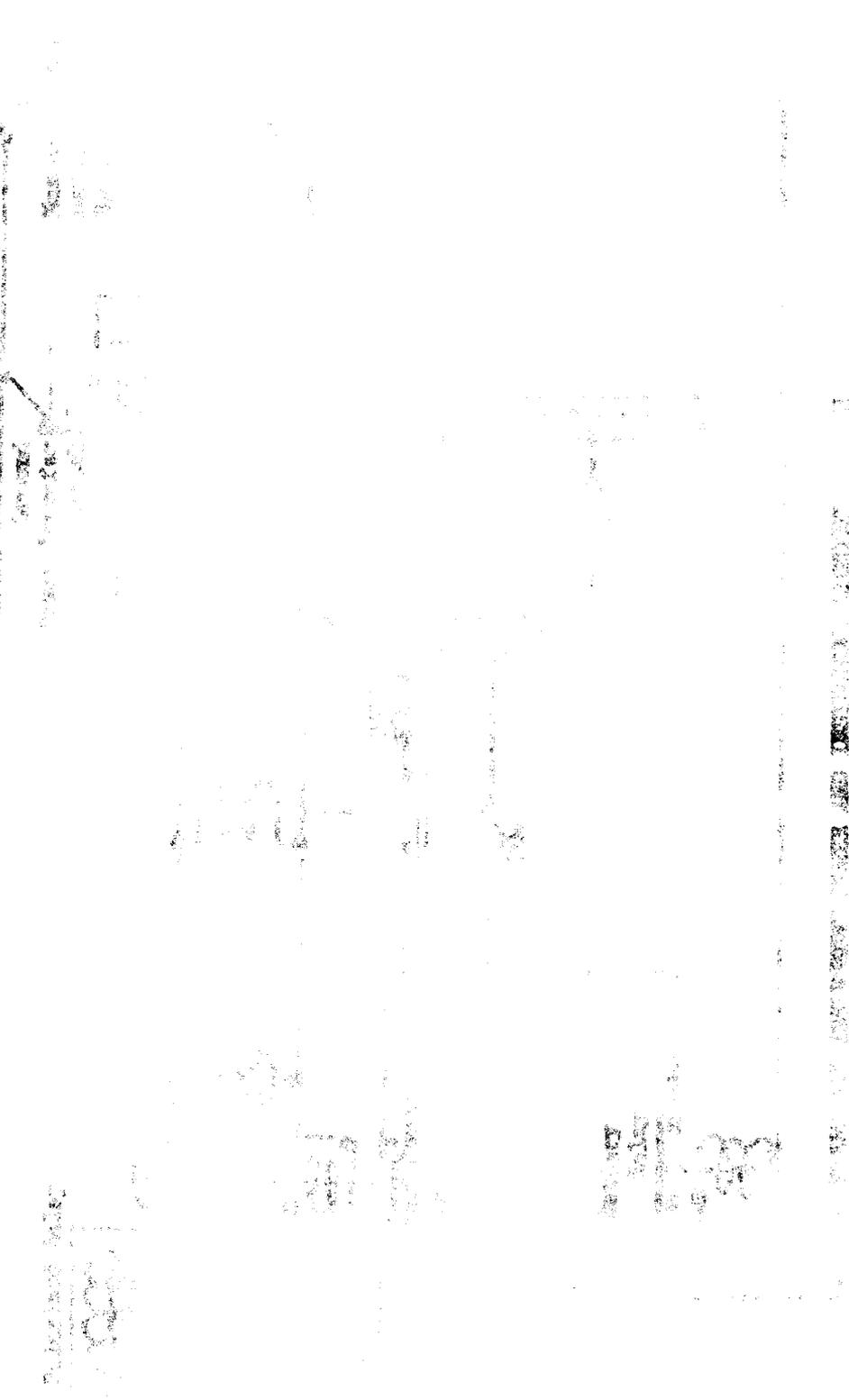


Battery Installation

External Power

24-28 volt DC external power can be connected to the aircraft electrical DC bus system through a three-prong receptacle aft of the nose wheel well. It is covered by a flush mounted spring-loaded door. External power is connected to the bus bar by means of a ground power relay, and controlled by a switch located on the forward overhead switch panel with "PLANE BATT" and "GROUND POWER" positions. This switch must be in the "GROUND POWER" position to connect the external power to the bus. A red light on the forward overhead switch panel illuminates when external power is connected to the Bus.

Plate
No. 10



U.S. GEOLOGICAL SURVEY

WATER RESOURCES DIVISION

Battery Control

One battery relay is provided which connects the battery to the main bus. This relay is located between the batteries and is controlled by the battery switch.

With the battery switch in the OFF position, but the engine instrument power and instrument lighting switch ON.

DC power is available for:

1. Emergency lights
2. Pilot's instruments when engine Slip indicated
3. Instruments when engine failure
4. Magnetic compass
5. Sextant
6. Pilot's flashlight
7. Inverter for cabin lighting

At the same time, power is available for:

1. Pilot's instruments when engine horizontal
2. Pilot's Sextant

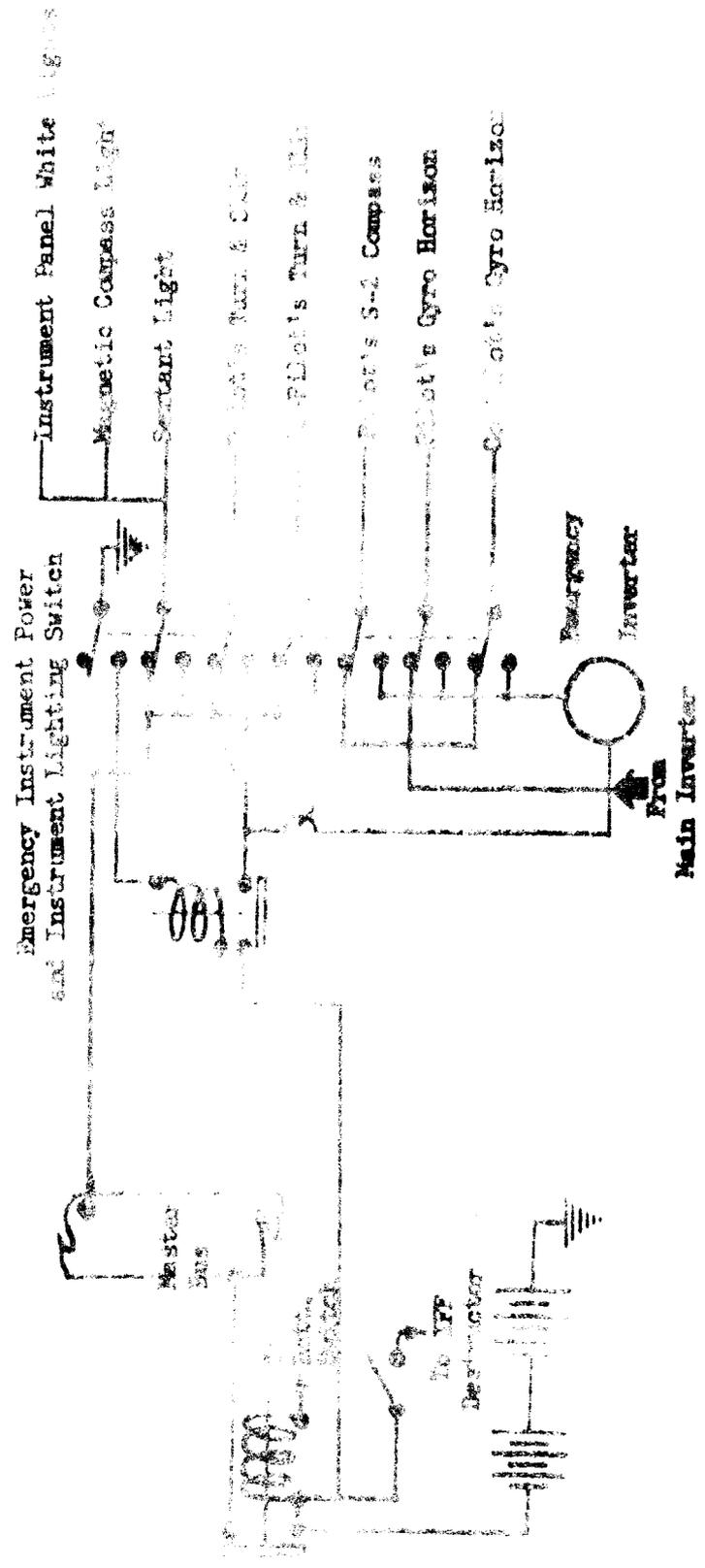
Emergency Power System

The emergency power system consists of two emergency generators, one rated at 150 ampere hours at 30 volts, the gas turbine driven auxiliary power generators rated at 100 ampere hours at 30 volts, and the 24 hour 24 ampere hour battery system.

The emergency power is fed to a master battery junction box. The emergency power is ready to maintain the emergency power system in operation. The emergency power is used to the master bus through a master battery junction box.

The primary and secondary buses are connected to a junction box just behind the main battery station. The emergency power panel is located behind the main panel of the Main Junction Box and is used to the master battery junction box through a master battery junction box.





C-118 EMERGENCY CIRCUIT

Chapter 2

GENERATOR SYSTEM

Primary power for the electrical system is supplied by the engine-driven generators. Each generator is connected to the main bus through a reverse current relay and reverse current circuit breaker. The aircraft total load demand is such that normal operation may be maintained with two generators.

Voltage Regulators

Voltage control is achieved by four carbon pile-type voltage regulators installed in the Main Junction Box Left Hand Annex. The regulators maintain a constant generator voltage of 28 volts at approximately 1000 engine RPM.

When two or more generators are operated in parallel the voltage regulators through the equalizer circuit, assist each generator in assuming its proportional share of the total load. This is accomplished by reducing the voltage of the generators carrying the highest current and increasing the voltage of the generators carrying the least current. The equalizer circuits are wired through the generator switches.

The voltage regulator cooling system consists of small air jets ducted from the airplane cold air system. If this cooling system fails to maintain the proper temperature in the voltage regulator compartment, a red warning light, adjacent to the inverter switches will illuminate. When this happens, the voltage regulator compartment panel must be opened for increased ventilation.

Reverse Current Relay

Each generator circuit incorporates a reverse current relay located in the Main Junction Box. The relay automatically connects and disconnects the gener-

ator from the bus. The reverse current relay will close when generator voltage is approximately 1/2 volt above bus voltage, provided the corresponding generator switch is in the ON position. A reverse current, created when bus voltage is higher than generator voltage, of approximately 20 to 35 amperes will cause the reverse current relay to open.

Generator Switches and Circuit Breakers

Generator switches are located on the forward overhead switch panel. These switches complete a circuit closing the reverse current relay when generator voltage is higher than bus voltage. A master shutoff bar is provided to turn off all generator switches in the event of an emergency.

The generator field circuit breakers are located on the main circuit breaker panel. Each circuit breaker is rated at 15 amperes and will trip under a load of 18 or 19 amperes field current flow.

Four reverse-current circuit breakers are installed in the Main Junction Box to disconnect a generator system when a heavy surge of reverse current flows in the circuit. The generator field is also de-energized when this circuit breaker is tripped.

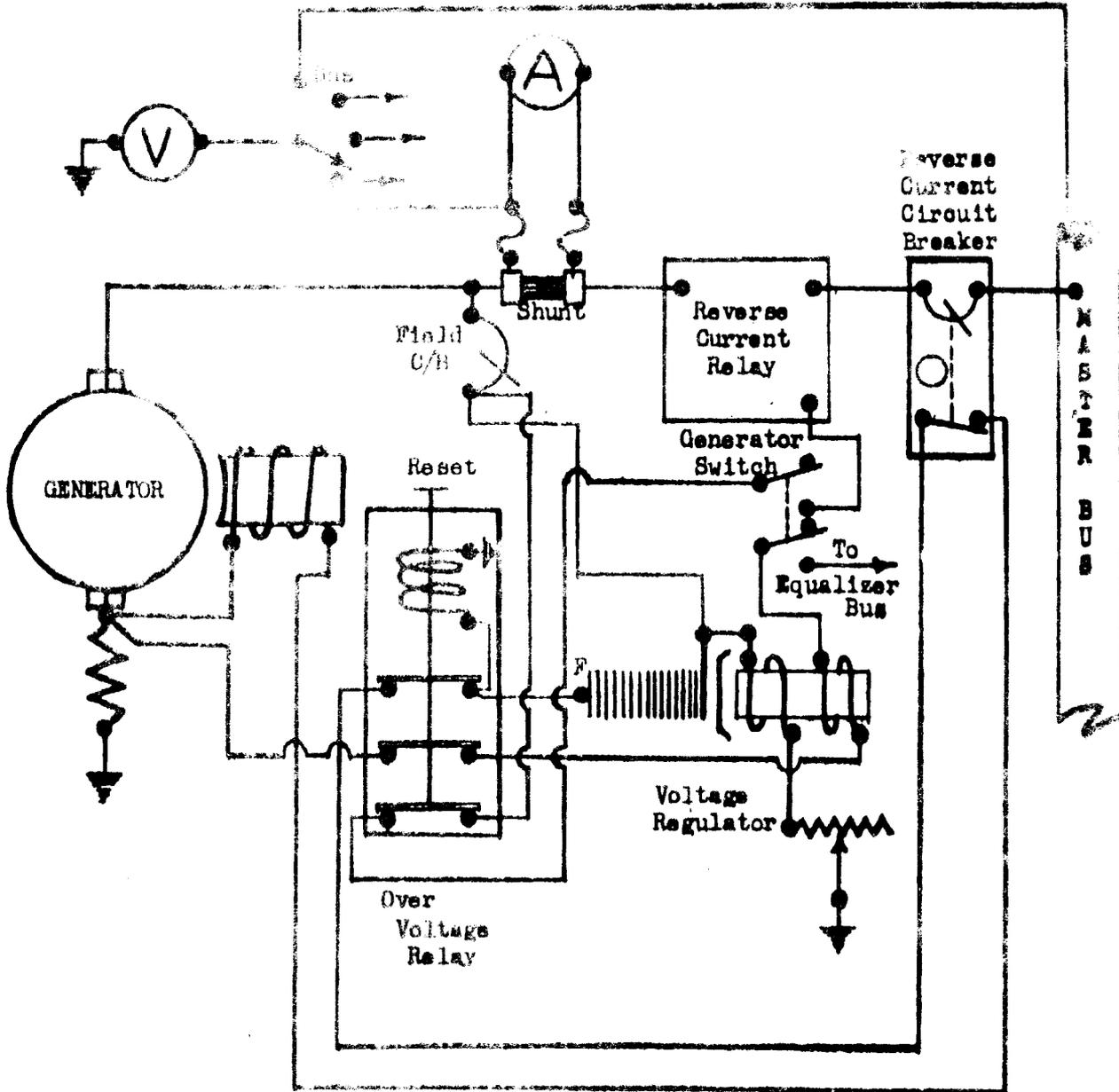
A tripped reverse current circuit breaker is identified by an orange dot appearing in a window adjacent to the name plate. This circuit breaker will not be reset in-flight.

The generator circuits are protected by four overvoltage relays, mounted in the bottom left side of the Main Junction Box. Each relay serves to disconnect its respective generator from

the bus when the output voltage of the generator becomes abnormally high.

The reset mechanisms are manually operated and can be reset if emergency conditions warrant, by actuating the push button on the top of the relay. This relay can be reset just once, if the relay trips again, leave the system "OFF" for the duration of the flight.

Four ammeters, one for each generator, are located on the ammeter voltmeter panel, and indicate the current output of the generators. A voltmeter mounted on this panel and controlled by a five-position switch connects the voltmeter to MAIN BUS (normal position) or to any one of the four generators.



TYPICAL GENERATOR CIRCUIT

Chapter 3

AUXILIARY POWER UNIT

General

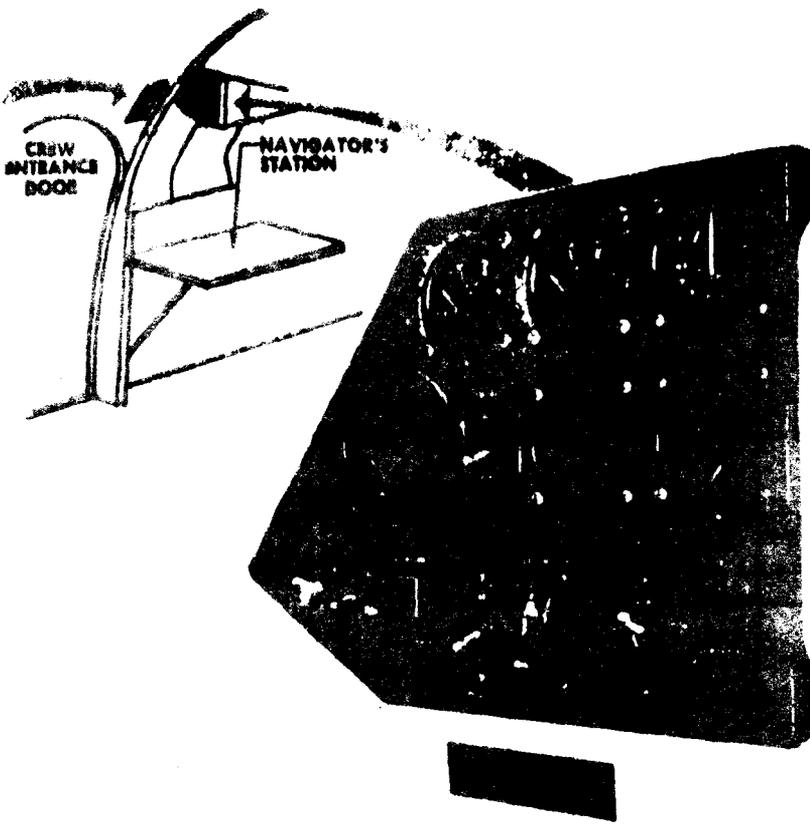
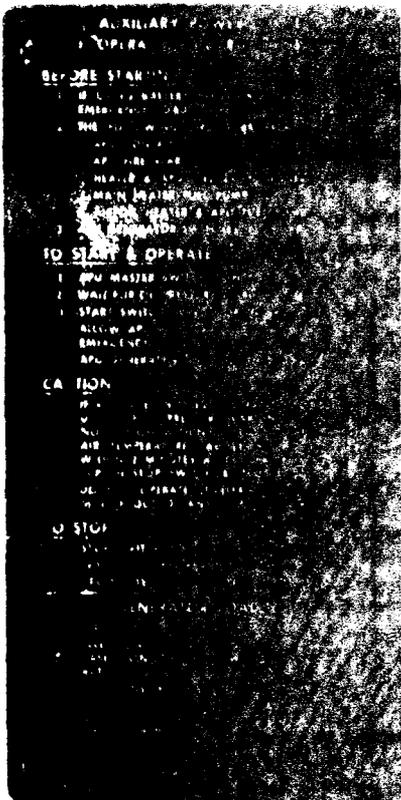
A gas turbine auxiliary power unit, complete with two 350-ampere generators and two voltage regulators, is installed in the tail compartment of the aircraft aft of the pressure bulkhead. This unit is fully enclosed and includes all necessary accessories and connections. Fuel and electrical power is supplied to the unit from the aircraft. The unit will deliver up to 84 horsepower at approximately 6000 RPM. Normal rated power is 70 horsepower with fuel consumption approximately 97.5 pounds per hour.

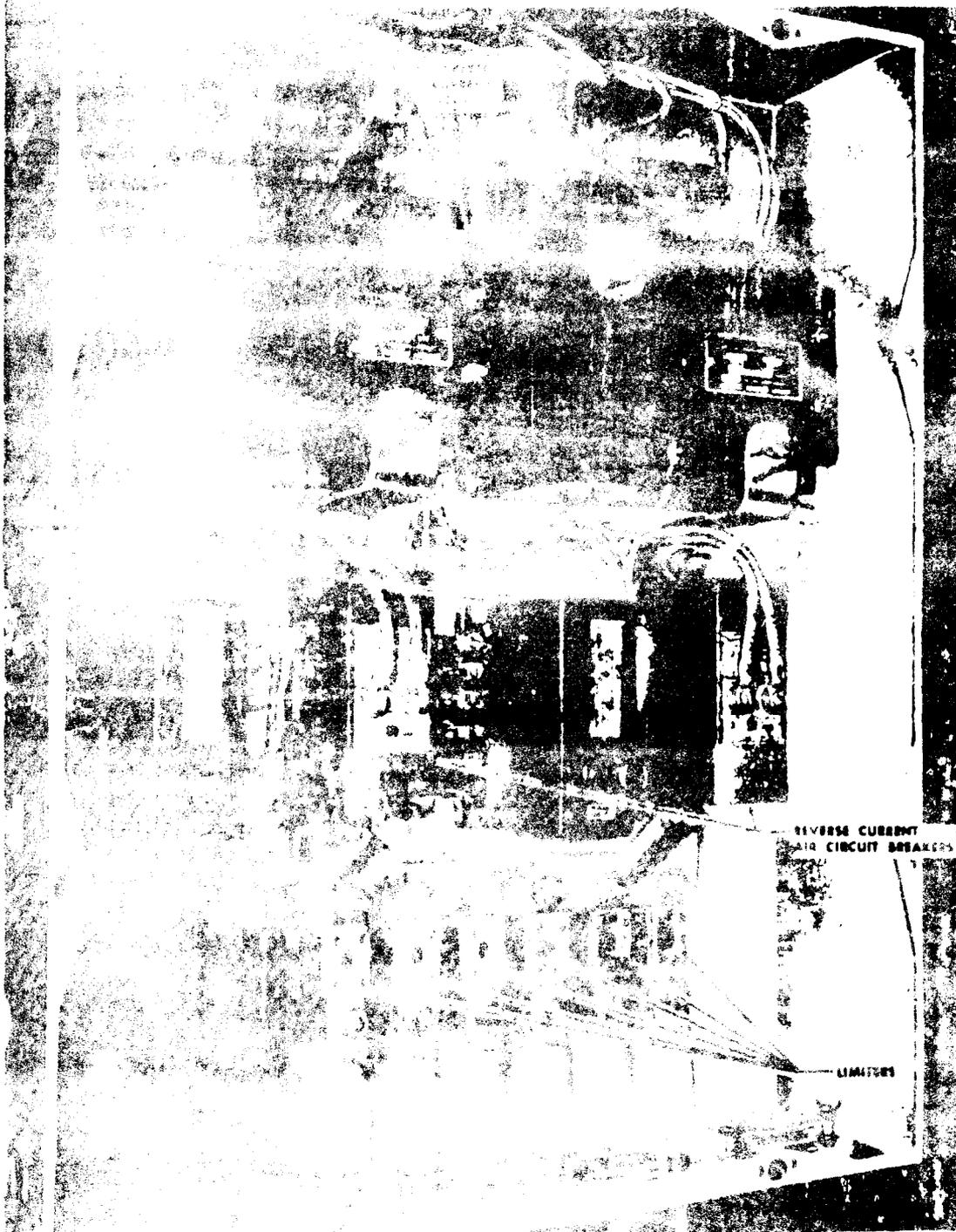
An instrument control panel is mounted in the crew compartment ad-

jacent to the navigator's station. Instruments indicate turbine engine RPM, oil temperature, and combustion chamber temperatures. A warning light illuminates whenever oil pressure drops below a safe operating range. Generator output is indicated by two ammeters and a voltmeter. Control switches are provided for starting and stopping the unit.

Operation

Control of the unit is automatic. Instrumentation is limited to a minimum and should be closely monitored while starting the unit and checked periodically during operation.





Preparation

The CTPU generator master switch on the forward overhead switch panel must be in the OFF position.

Starting

1. Check that the CTPU generator switches located on the forward overhead panel are OFF. Also check that the airfoil de-ice system is in the heater control panel. In this position the battery is connected to BATTERY, or to GROUND if an external power source is plugged in.

If using external power, disconnect except emergency, and set to OFF.

Do not attempt to start the auxiliary power unit if the airfoil de-icer switch is ON, unless the engines are operating above generator cut-in speed.

2. Check the following circuit breakers are closed:

- APU control
- APU fire warn
- Heater and de-ice system breaker
- Main heater and de-ice
- Airfoil heater and de-ice power
- APU scoop power

3. Test the fire warning signal on the heater fire control panel and the auxiliary power unit fire panel by pressing in the emergency stop test button located on the heater control panel.

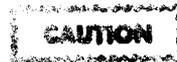
4. The APU scoop door is closed ON, if it is below 10°C.

5. Turn the master battery disconnect switch.

6. Wait 10 seconds, allowing sufficient time for air scoop door to open.

7. Hold start switch ON until oil pressure warning light goes OUT.

8. The engine should run and show a significant increase in RPM. The duty cycle of the generator acting as a starter is limited out of any 5 minute period.



If RPM does not exceed 9 percent for 1 minute, or if oil pressure warning light does not go off within 20 seconds at outside air temperatures above -35°C (-31°F) or within 2 minutes at colder temperatures, push stop switch and investigate. Do not operate starter more than 1 minute out of any 5 minute period.



Stop APU if combustion chamber temperature difference exceeds 100°C.

8. After 3 to 5 minutes of warmup time, turn the generator switch on the forward overhead switch panel to ON.

Stopping

1. Momentarily place the stop switch in the STOP position.

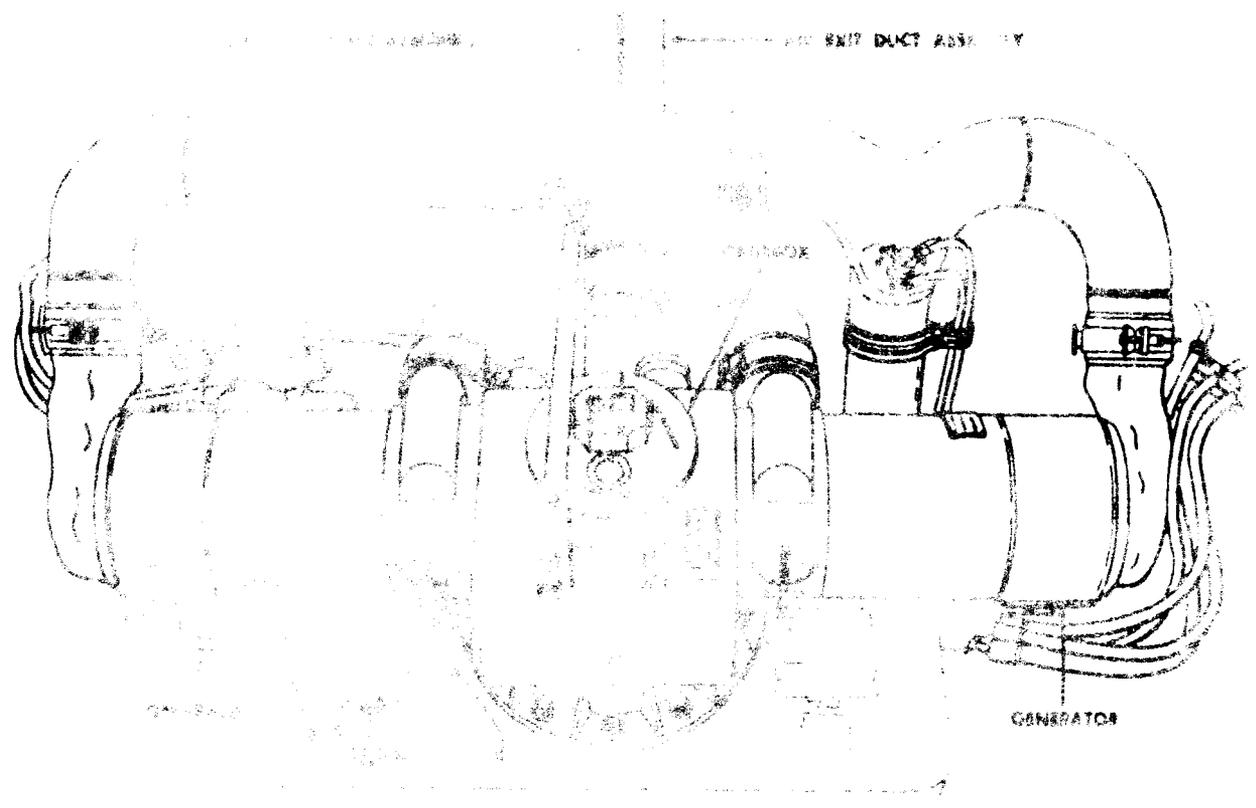
2. Wait until the percent RPM indicator reads ZERO.

3. Place the APU master switch in the OFF position.

down, wait until the pressure of the air has reached the normal level of 100 percent rpm. If the pressure is low, wait 5 minutes before starting the MASTER action. The door should be closed and the air intake door should be closed in case of a fire. When the auxiliary

selected unit is started, the heater control unit should be closed simultaneously with shutdown of the unit.

If the auxiliary power unit electrical breakers are to be opened, wait approximately 10 seconds in order to insure that the air intake door is closed and the air close.



Generator installation

INVERTERS

Three rotary inverters are installed in a compartment in the main instrument rack. These inverters supply alternating current for the aircraft electronic equipment. They are supplied with 115 volt, 400 cycle AC power from the 2250 VA. DC power source. Protection is supplied by circuit breakers in the main junction. The circuit breakers are labeled "INVERTER" and "CIRCUIT BREAKER".

Controls

Two control switches are located in the overhead panel. They are labeled "RADIO" and "RADAR". Each switch has three positions, "OFF", "ON" and "STANDBY".

The "RADIO-RADAR" switch is used in the NORMAL position to supply power to the normal inverter. In the STANDBY position, the aircraft electronic equipment. The "RADAR" switch is used in the NORMAL position to supply power to the Radar and other normal inverter. When either switch is in the STANDBY position, the inverter supplies power to the aircraft. The switches are normally locked so that either "RADIO" or "RADAR" switches can be moved to STANDBY, but not simultaneously.

An engine instrument is located adjacent to the inverter controls. It is a 26 volt, 400 cycle AC.

...the Normal or Standby step-down inverter to the engine instrument.

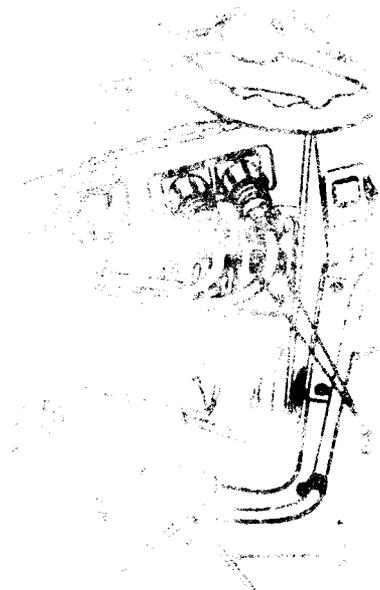
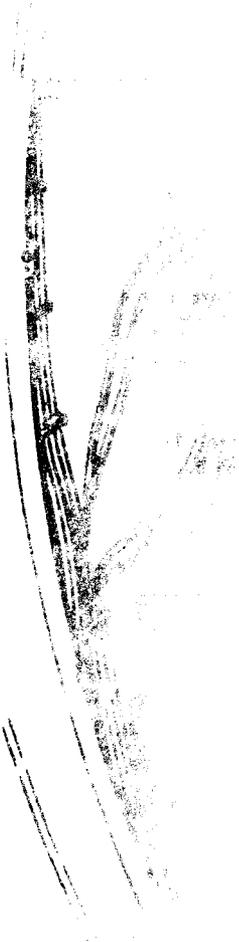
...warning lights, installed in the main instrument panel, provide warning of inverter failure to the pilot. These lights are labeled "INVERTER". The lights are normally on. They should be on sized in the flight instrument panel.

...light instruments are normally on. If the instrument lights go out, the pilot should check the inverter.

Emergency Inverter

An emergency inverter is installed in the main instrument panel to the left of the pilot's position at floor level. It supplies 115 volt, 400 cycle AC power to the aircraft electronic equipment and the two Gyro instruments in the event of failure of the main inverters.

The emergency inverter supplies power and instrument lighting when the aircraft is in the STANDBY position. The switch to the emergency inverter is located in the main instrument panel. When the flight instrument panel is in the emergency position, a battery is connected to supply 26 volt, 400 cycle AC power to the emergency inverter. The emergency inverter panel white and the inverter and Slip In-



Generator
Wiring

EMERGENCY INVERTER COMPARTMENT



CAUTION

The life of the battery, when operating the emergency inverter is approximately two and a half hours. All AC operated engine instruments are inoperative.

Circuit Breakers

Three 15 ampere circuit breakers are located on the bulkhead behind the pilot and protect the AC output of each main inverter. The two circuit breakers in the DC input circuit of the emergency inverter are located in the emergency inverter.

Fuses

A fuse panel is used in the AC

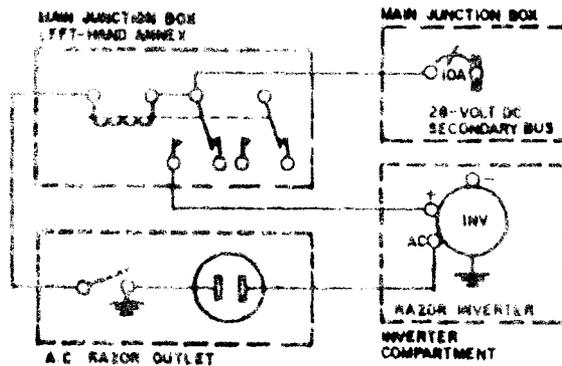
power system and is located in the right hand junction box annex.

Transformers

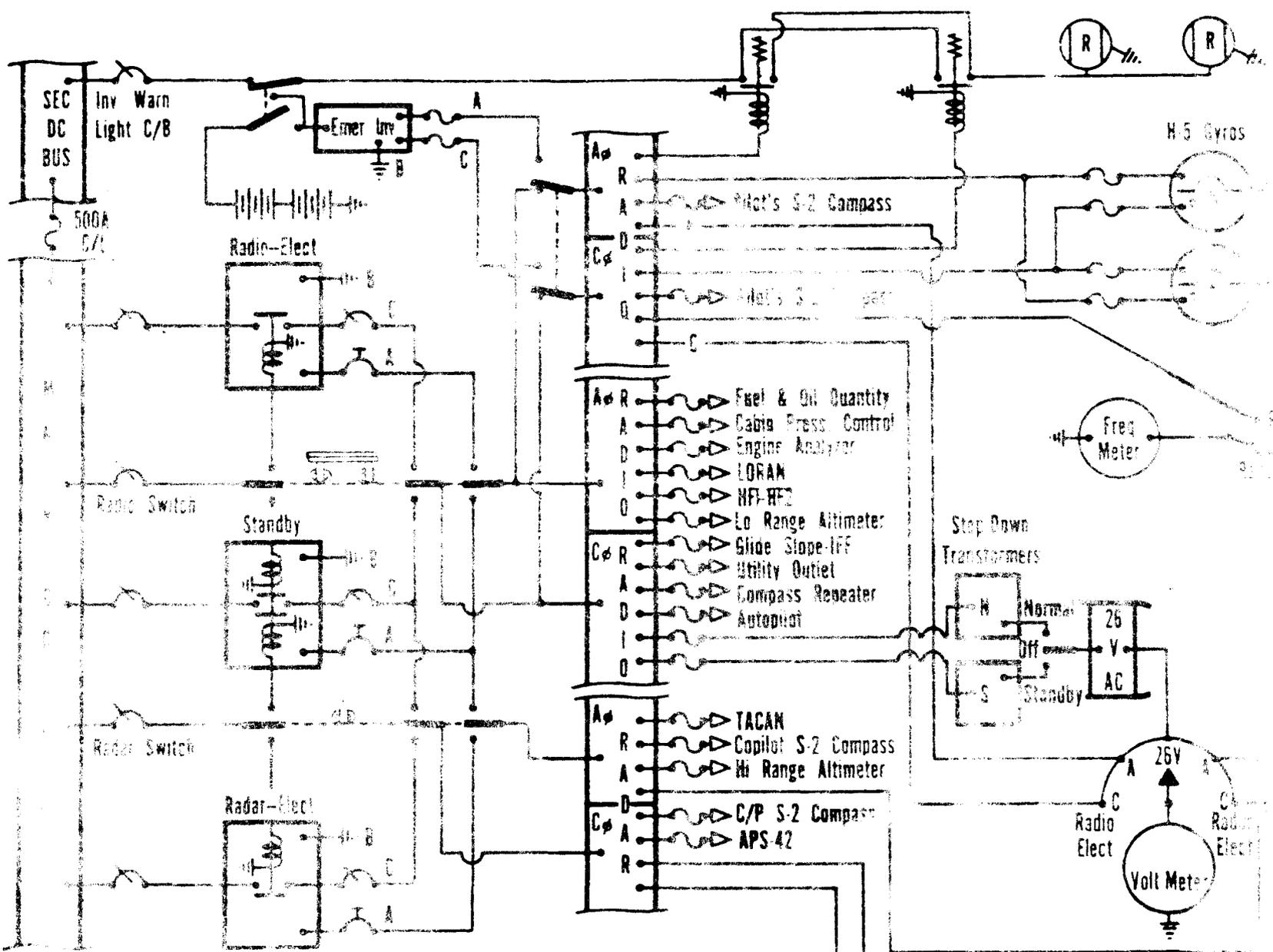
Two transformers located in the main junction box are used to reduce the 115 volts, 400-cycle AC power, to 26 volts, 400-cycle AC power for operation of the 26 volt instruments.

Aircraft Razor Outlet

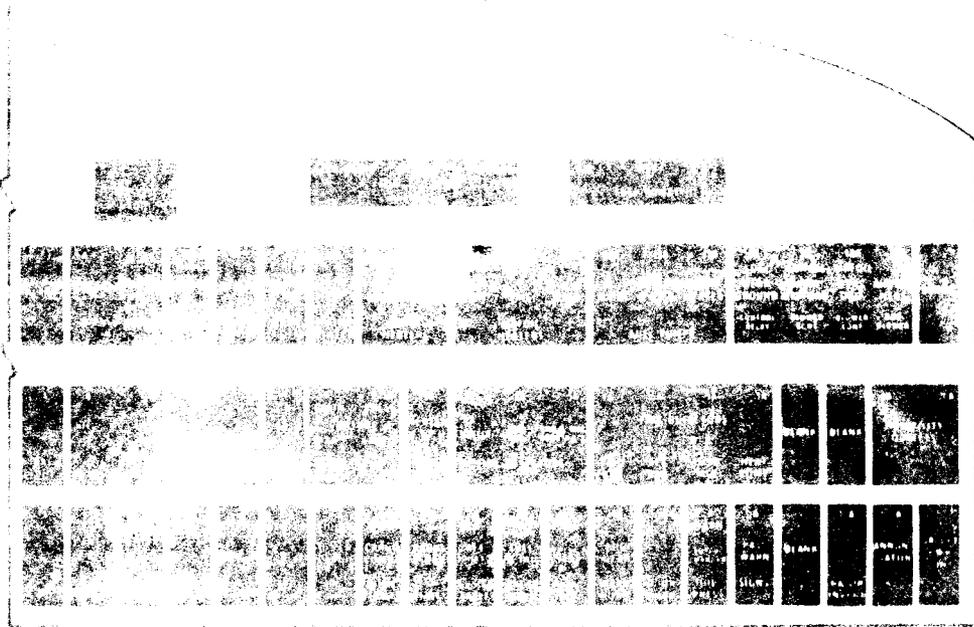
A household-type outlet is installed in the three latrines for electrical shavers. A vibrator-type power supply furnishes power to the razor outlets. The power supply circuit to the vibrator is controlled by a relay in the Main Junction Box left hand annex and is energized by plugging in the electric razor which completes the ground circuit



Razor Inverter, Simplified Circuit



THREE PHASE AC POWER SYSTEM



GROUND POWER
INDICATOR LIGHT
CIRCUIT BREAKER

MAIN
JUNCTION
BOX
RH ANNEA

MAIN
JUNCTION
BOX
LH ANNEA

MAIN JUNCTION
BOX

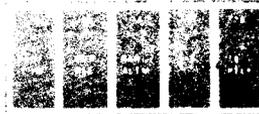
RADIO SPEAKER
CIRCUIT BREAKER
PANEL



GROUND POWER
INDICATOR LIGHT
CIRCUIT BREAKER

RADIO
CIRCUIT BREAKER
PANEL

RADIO CIRCUIT
BREAKER PANEL



RADIO CIRCUIT
BREAKER PANEL



Landing Gear Warning System

The landing gear warning system consists of a position indicator for each gear, a red "WASAP" indicator light and a warning horn.

The three position indicators are located on the main instrument panel. When the landing gear is retracted, a marker appears on the instrument, indicating the position of each respective gear. When the landing gear is down, the word "UP" will appear. When the gear is down and locked, a marker of an extended gear will appear. At the time the gear is in the full down position, a striped arrow, called the "Barber Pole" position, is visible.

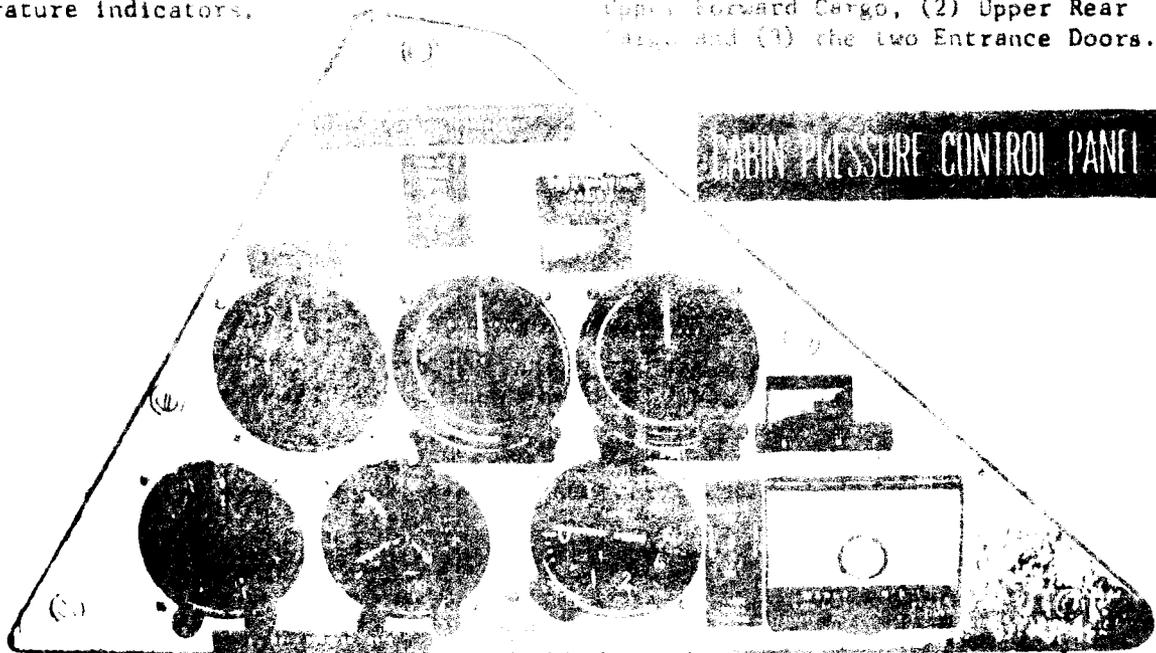
Whenever any of the landing gear is in an intermediate position, the red light will illuminate. The red light is located on the main instrument panel, below the cylinder head temperature indicators.

Landing Gear Warning Horn and Cut-Off Switch

A warning horn mounted back of the instrument panel, automatically sounds when any throttle is retarded and the gear is in any position other than full down and locked. In the event operation may be continued with a throttle retarded, the horn may be silenced and reset by using the landing gear warning horn cut-off switch on the control pedestal.

Door Warning Lights

Each of the red indicator lights in-
stalled on the cabin pressure control panel indicates belly compartment door position. These doors are: (1) Lower Rear Engine, (2) Fuselage Accessory compartment, (3) Heater Compartment and (4) Forward Baggage. The other red light indicates cabin and cockpit door position. These doors are: (1) Upper Forward Cargo, (2) Upper Rear Cargo and (3) the two Entrance Doors.



Chapter 1

MISCELLANEOUS SYSTEMS

Landing Lights

A retractable landing light is installed in the underside of each outer wing panel near the trailing edge. Each light has a switch controlling extension and retraction and an OFF-ON filament switch. The lights may be turned on in the fully retracted position if desired. The maximum airspeed at which landing lights may be extended is 152 knots.

Navigation Lights

The navigation light consist of:
 (1) a green light on the right wing tip, (2) a red light on the left wing tip, (3) an amber and white light on the tail cone tip and (4) a white light on the top and bottom of the fuselage. These lights are controlled by a three position switch on the forward overhead switch panel. The switch positions are STEADY, OFF and FLASH. When the switch is placed in the FLASH position, the wing tip lights and the white tail light flash ON and OFF together. The white fuselage lights and the amber tail light will flash ON and OFF together, but alternately from the other lights provided the white fuselage light switch is in the ON position.

NOTE

Regardless of which light sequence is flashing, a failure of the flasher mechanism motor will result in a steady illumination of the wing tip lights and the white light in the tail cone.

Taxi Lights

A sealed beam taxi light, installed on the nose gear shock strut, is con-

trolled by an OFF-ON switch located on the forward overhead switch panel.

Wing Illumination Lights

Wing illumination lights are located on the fuselage just forward of the leading edge of each wing. The illumination from these lights is used to detect wing ice and inspect nacelle areas. The lights are controlled by an OFF-ON switch on the overhead panel.

Emergency Cabin Dome Lights

Four 248 volt emergency dome lights are provided in the cabin ceiling. These are controlled by an impact switch on the aft right side of the flight compartment partition. A 7.5 volt dry cell power supply is located in the right main junction box annex. A test switch is located on the main cabin switch panel for checking the system.

Anti-Collision Light

One rotating red anti-collision light is located on the top of the vertical stabilizer for better night recognition. This light operates on 28 volts DC power and is controlled by the navigation light switch which should be in the STEADY position for inflight operations.

Start, Prime and Boost Circuits

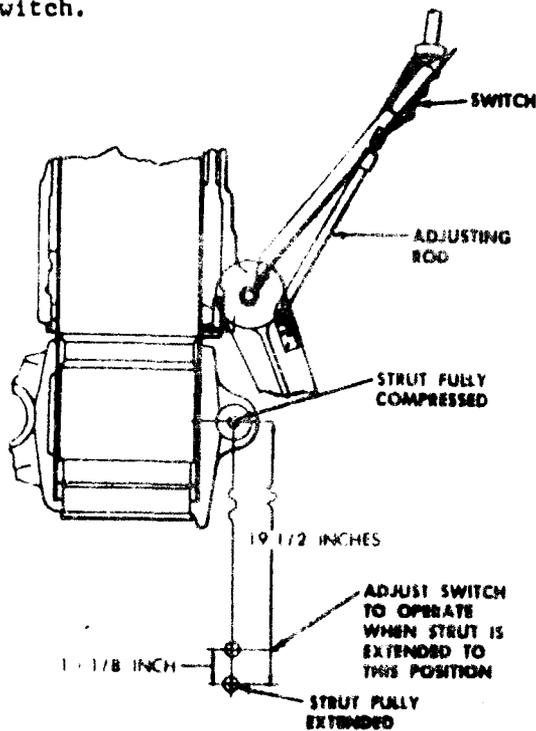
Spring loaded starter and starter selector switches are mounted on the forward overhead panel. The engine selector switch must be set to the engine being started. The starter safety switch and the starter switch must be depressed simultaneously before

the starter will function.

The starter, prime and ignition boost control circuits are protected by one control circuit breaker on the main circuit breaker panel. In the power circuit located within each engine nacelle "J" box, a 200 ampere current limiter protects the starter motor and propeller deicer circuits for each engine. The entire power portion of the circuit, including the propeller auxiliary pump circuit is protected by a 500 ampere current limiter.

In the ignition boost circuit, one induction vibrator for all four engines is located behind the boost switch on the overhead switch panel.

The engine prime circuit consists of one prime switch to all four engine primer solenoids through the selector switch.



Adjustment of Main Landing Gear Safety Switch

Landing Gear Control Lock

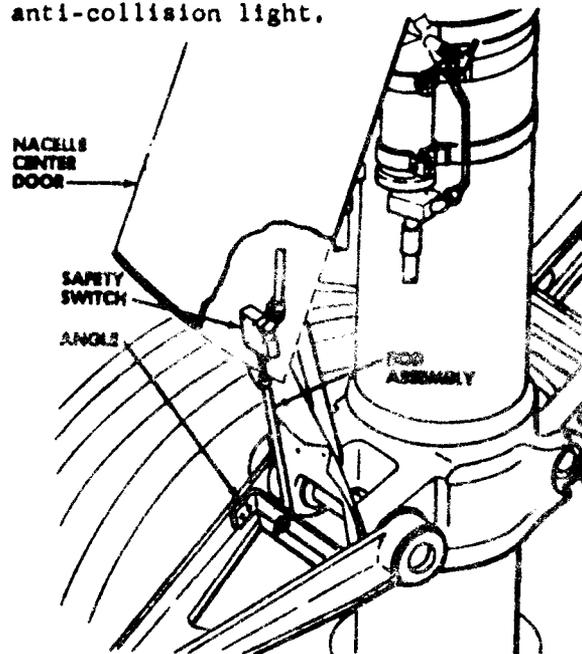
A safety solenoid prevents the landing gear control lever from being moved out of the DOWN position while any load remains on the right landing gear. When the aircraft leaves the ground, the safety solenoid is energized allowing free movement of the landing gear control lever. A finger hole in the control pedestal cover permits manual release of the solenoid.

Landing Gear Strut Safety Switches

These switches provide an automatic means of controlling circuits.

The left gear strut switch controls: (a) ground blowers, (b) anti-skid brakes and (c) allows uninterrupted airfoil heater operation in flight.

The right gear strut switch controls: (a) the landing gear locking solenoid, (b) door pressure warning, (c) cabin pressure control valve whenever the cabin pressurization system control is in the AUTOMATIC position and (d) the anti-collision light.



Main Landing Gear Safety Switch

STUDY OF THE DIFFERENCES

1951 SERIES AIRCRAFT

VERSUS

1953 SERIES AIRCRAFT

1. AIRCRAFT APU

a. Located in forward luggage compartment. Utilizes one generator of 175 amps. Generator control switch on the APU control panel. Not designed to operate ~~in flight.~~ Receives fuel from #2 tank.

2. ENGINE DC GENERATORS

a. Rated at 400 amps.
 b. May be interchanged with 53 series.
 c. Reverse current relay set to trip at 15-20 amps.

3. INVERTERS

a. ~~Three~~ main and one emergency three phase inverters.
 b. A and C phases are conductive with B phase grounded.
 c. Five DC power input circuit breakers (3 power and 2 control) located on the main circuit breaker panel.
 d. Six AC power output circuit breakers, on inverter circuit breaker panel.
 e. Voltage check; 115 ± 3 volts on C phase.
 f. Two ganged together inverter switches. The switches have three positions.

1. AIRCRAFT GTPU

a. Located in the tail of aircraft. Utilizes two generators rated at 350 amps. Generator control switches in cockpit adjacent to engine generator control switches. Designed to operate at all altitudes. Receives fuel from #3 main tank.

2. ENGINE DC GENERATORS

a. Rated at 350-400 amps.
 b. May be interchanged with 51 series.
 c. Reverse current relay set to trip at 20-35 amps.

3. INVERTERS

a. Three main and one emergency three phase inverters.
 b. A and C phases are conductive with B phase grounded.
 c. Five DC power input circuit breakers (3 power and 2 control) located on the main circuit breaker panel.
 d. Six AC power output circuit breakers (3 switch type and 3 push button type) located on bulkhead behind pilot's seat.
 e. Voltage check; 115 ± 3 volts on A and C phases.
 f. Frequency check; 400 ± 20 cycles, all main inverters. Emergency inverter frequency check with selector switch in RADIO position.
 g. Two main inverter switches. The RADIO switch is the gangbar type. The RADAR switch is the single toggle type. Both switches have three positions.

4. PHASE ADAPTERS

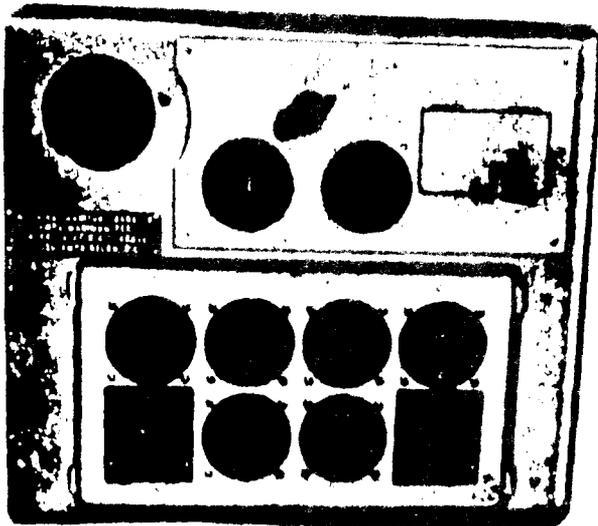
- a. One used for the autopilot.
- b. Located in the right hand annex.
- c. Can be interchanged with the 53 series.

5. LIGHT SWITCHES

- a. Anti collision light switch located forward of #3 and #4 propeller feathering button.
- b. Taxi light switch located forward of #3 and #4 propeller feathering button.
- c. Wing lumination and wheel well light switches located forward of #1 and #2 propeller feathering buttons.

6. COCKPIT LIGHTING

Flood type used for all instruments and panels.



AF51-3818 THROUGH AF51-3835,
AF51-17626 THROUGH AF51-17661,
AF51-17667, AND AF51-17668

4. PHASE ADAPTERS

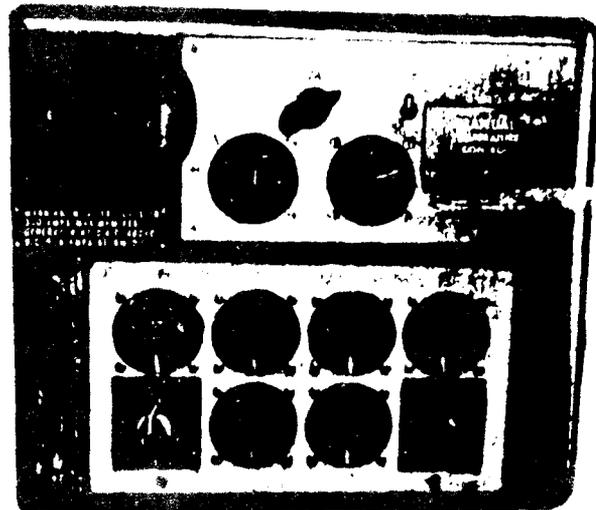
- a. One used for the autopilot.
- b. Located in the right hand annex.
- c. Can be interchanged with the 51 series.

5. LIGHT SWITCHES

- a. Anti collision light automatic with navigation lights in steady position.
- b. Taxi light switch located adjacent to seat belt and no-smoking light switches.
- c. Wing lumination and wheel well light switches located adjacent to seat belt and no-smoking light switches.

6. COCKPIT LIGHTING

Console type used for all instruments and panels.



AF53-3223 THROUGH AF53-3228,
AF53-3230 THROUGH AF53-3239, AND
AF53-3241 THROUGH AF53-3305

AMMETER VOLTMETER PANEL

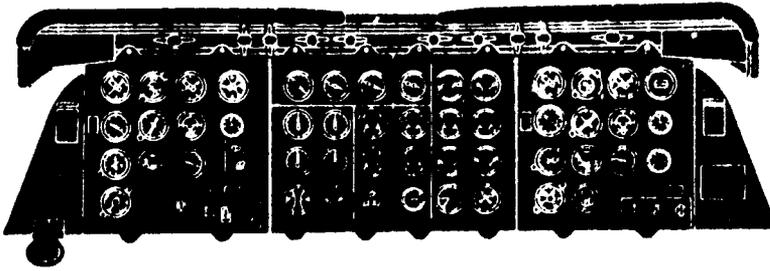


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Chapter 1

INSTRUMENTS

Panels

The main instrument panel extends the full width of the flight compartment and is divided into three sections. The left section has the pilot's flight instruments, while the right section has the copilot's flight instruments. The center section contains the engine instruments.

In the ceiling is the upper instrument panel. The upper instrument panel is primarily a liquid quantity indicator panel. To the left of the upper instrument panel is the heater control panel, which contains the heater temperature and fuel pressure indicators. To the right of the upper instrument panel is the cabin pressure control panel, which has the instruments used during cabin pressurization.

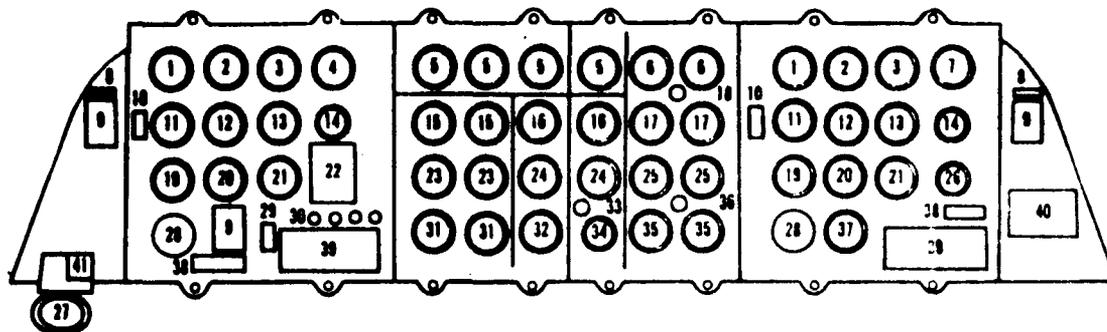
Still in the ceiling but above the copilot is the AC-DC voltmeter panel,

which allows checks to be made of the AC and DC power systems. On the upper portion of the AC-DC voltmeter panel are the two indicators which are used during cabin temperature control. Just aft of the AC-DC voltmeter panel is a small bracket containing the supercharger duct pressure gage and a frequency meter.

A small instrument panel is located on the right wall just forward of the copilot's seat. This panel contains the hydraulic pressure, emergency air brake pressure and oxygen pressure indicators.

Aft of the crew entrance door is the navigator's station. Above the navigator's table is the navigator's instrument panel with an airspeed indicator, altimeter, compass and outside air temperature gage. Also located at the navigator's station is the GPU control and instrument panel.

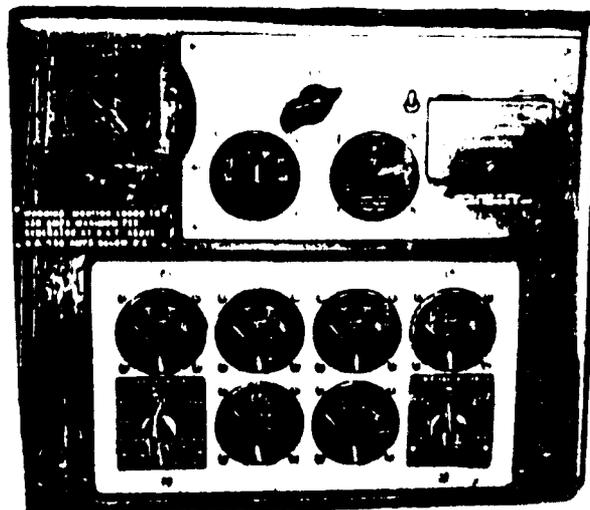
MAIN INSTRUMENT PANEL



- | | |
|--|---|
| 1. ADF RADIO MAGNETIC INDICATOR (2) | 22. AUTOPILOT FUNCTION SELECTOR |
| 2. COURSE INDICATOR (2) | 23. TACHOMETER INDICATOR |
| 3. VOR RADIO MAGNETIC INDICATOR (2) | 24. CYLINDER HEAD TEMPERATURE INDICATOR |
| 4. A-12 COMPASS HEADING SELECTOR | 25. FUEL PRESSURE INDICATOR |
| 5. TORQUEMETER | 26. ELAPSED TIME CLOCK |
| 6. OIL PRESSURE INDICATOR | 27. RADAR SCOPE |
| 7. RANGE INDICATOR | 28. RADIO ALTIMETER (2) |
| 8. RADIO CALL PLACARD (2) | 29. MARKER BEACON SELECTOR SWITCH |
| 9. COMPASS CORRECTION CARD (2) | 30. ADI SYSTEM WARNING LIGHTS (RED) |
| 10. INVERTER WARNING LIGHT (2 RED) | 31. ADI SYSTEM PRESSURE INDICATOR |
| 11. AIRSPEED INDICATOR (2) | 32. GEAR AND FLAP POSITION INDICATOR |
| 12. DIRECTIONAL INDICATOR (2) | 33. LANDING GEAR WARNING LIGHT (RED) |
| 13. ATTITUDE INDICATOR - H-S (2) | 34. OUTSIDE AIR TEMPERATURE INDICATOR |
| 14. CLOCK (2) | 35. FUEL FLOWMETER |
| 15. MANIFOLD PRESSURE GAGE | 36. FUEL PRESSURE WARNING LIGHT (RED) |
| 16. CARBURETOR AIR TEMPERATURE INDICATOR | 37. WARNING LIGHT DIMMING SWITCH |
| 17. OIL TEMPERATURE INDICATOR | 38. AIRSPEED CORRECTION CARD |
| 18. OIL PRESSURE WARNING LIGHT (RED) | 39. COMPASS CONTROLLER PANEL |
| 19. ALTIMETER (2) | 40. TRUE INDICATED AIRSPEED PLACARD |
| 20. TURN-AND-SLIP INDICATOR (2) | 41. ANTISKID SWITCH AND INOPERATIVE LIGHT |
| 21. VERTICAL VELOCITY INDICATOR (2) | |

CABIN TEMPERATURE CONTROL PANEL

AMMETER VOLTMETER PANEL



Pitot-Static Systems

The two pitot systems supply ram air pressure to the airspeed indicators. The pitot tubes are mounted on the left and right sides of the fuselage forward of the windshield. The left pitot system is connected to the pilot's airspeed indicator. The right pitot system supplies the copilot's and navigator's airspeed indicators.

There are two static systems in the C-118 that provide the normal static pressure. Each static system has two static vents; one on each side of the fuselage, forward of the flight compartment. The two vents of a static system are interconnected by a "balance line" to minimize the "turn error." The normal static systems supply static or still air pressure for operation of the airspeed indicators, vertical velocity indicators and altimeters.

The lower static system is connected to the pilot's instruments. The upper static system supplies the copilot's instruments, navigator's instruments and pressurization units.

An alternate static source is located inside the fuselage aft of the rear pressure bulkhead. The alternate system can be used in the event of failure of either the normal pilot's or copilot's system by operating the proper static selector valve located to the left or to the right of the main instrument panel. The autopilot altitude control unit is always connected to the alternate static source.

Both the pitot tubes and the static vents contain 28 volt DC heater elements to prevent icing. All heaters are controlled by one switch mounted on the upper instrument panel. Maximum ground operating time is one minute.

If the pitot-static heaters are turned off in flight they should be left on for the remainder of the flight as this procedure prolongs the life of the heaters.

Airspeed Indicators

The airspeed indicators use both pitot and static pressure. The pilot, the copilot and the navigator each have an airspeed indicator.

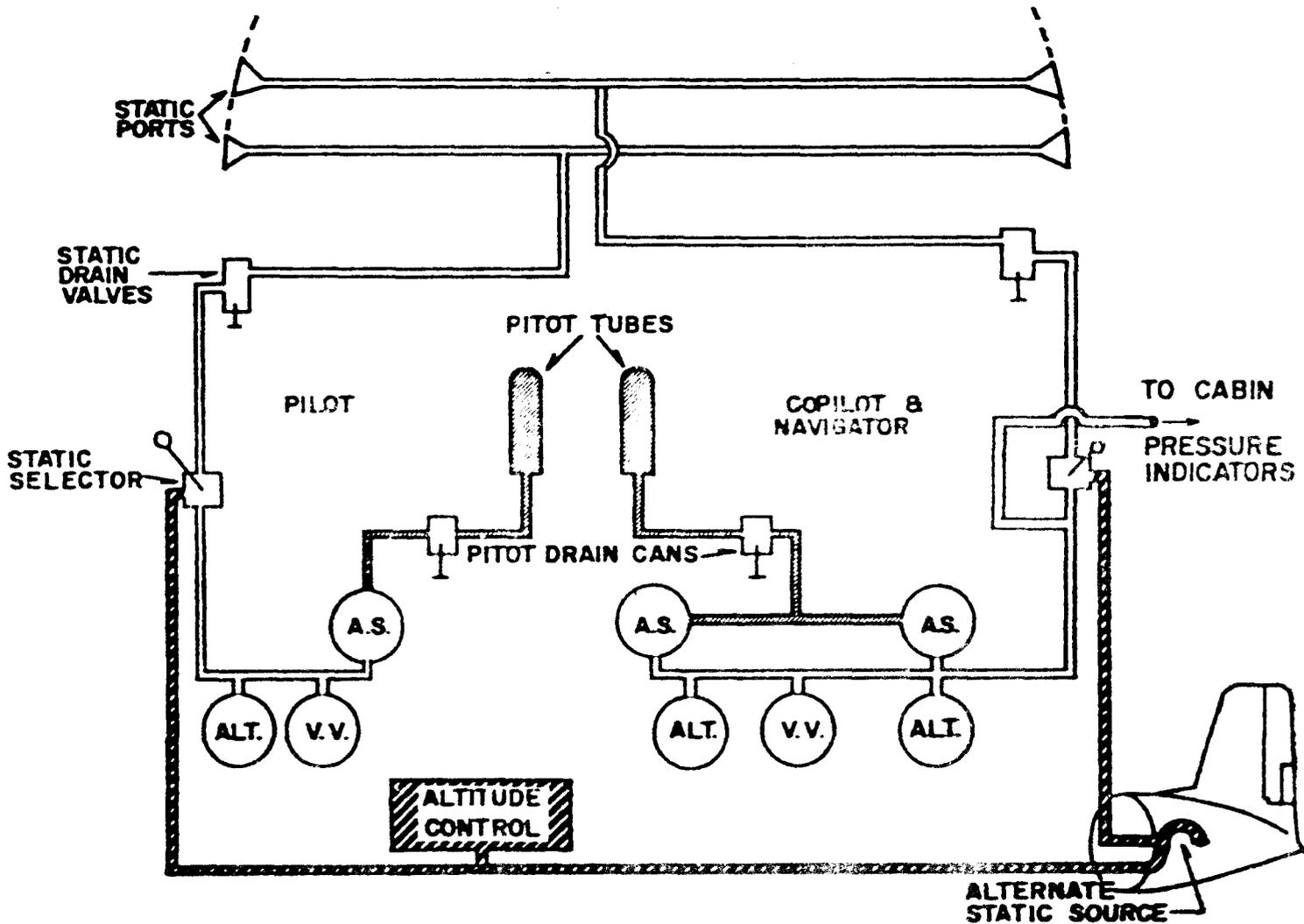
The three airspeed indicators are identical and are known as maximum allowable airspeed indicators. The red and white striped pointer indicates the maximum allowable airspeed at all altitudes. This striped pointer is restricted by an adjustable mechanical stop to a maximum of 330 knots and is automatically governed by an aneroid and linkage to lower the allowable airspeed limit with increased altitude. This feature is known as the MACH setting and is adjustable. On the C-118 the setting is .625 MACH.

To show indicated airspeed the indicator has a white pointer supplemented by a horizontally rotating sub-dial. The sub-dial is graduated in two knot increments for a finer reading of the airspeed. The sub-dial makes one complete revolution for each 100 knot change of airspeed.

Altimeters

The altimeters use static pressure. Three are installed on the C-118, one each for the pilot, copilot and navigator. After the correct pressure setting has been selected on the barometric scale or Kollsman window the pointers will indicate the altitude of the aircraft.

One setting used is called the "altimeter setting" and is local barometric pressure reduced or corrected



PITOT AND STATIC SYSTEMS SCHEMATIC

to sea level. The "indicated altitude" altimeter setting" is set into the barometric scale. The pointers will indicate height above sea level or "indicated altitude." Normally the pilot will use "indicated altitude."

The second setting is 29.92" Hg. When 29.92" Hg has been set into the barometric scale, the pointers will indicate "pressure altitude." "Pressure altitude" is the height of the aircraft above the standard reference datum plane. "Pressure altitude" is used for cruise control work, over-water navigation and pressure pattern flying.

Note: The maximum allowable altimeter error is plus or minus 75 feet indicated.

Differential Pressure Gage

On the cabin pressure control panel is a differential pressure gage, which is two altimeters in one case. The "A" pointer indicates the altitude of the aircraft, and the "C" pointer shows cabin altitude. A scale fastened to the "C" pointer and calibrated in PSI is uncovered by the movement of the "A" pointer to indicate the differential pressure existing between the outside and inside of the aircraft.

Vertical Velocity Indicators

The pilot and copilot have vertical velocity indicators. The indicators use static pressure, and indicate vertical movement of the aircraft in feet per minute. An adjustment screw for zeroing the pointer is located in the lower left corner of the indicator.

A third vertical velocity indicator is located on the cabin pressure control panel. Vented to the cabin, this indicator shows the rate of change of cabin pressure in feet per minute.

Manifold Pressure Gages

Two direct reading dual manifold pressure indicators are mounted on the center section of the main instrument panel. The gages indicate the absolute pressure in inches of mercury within the engine intake manifold.

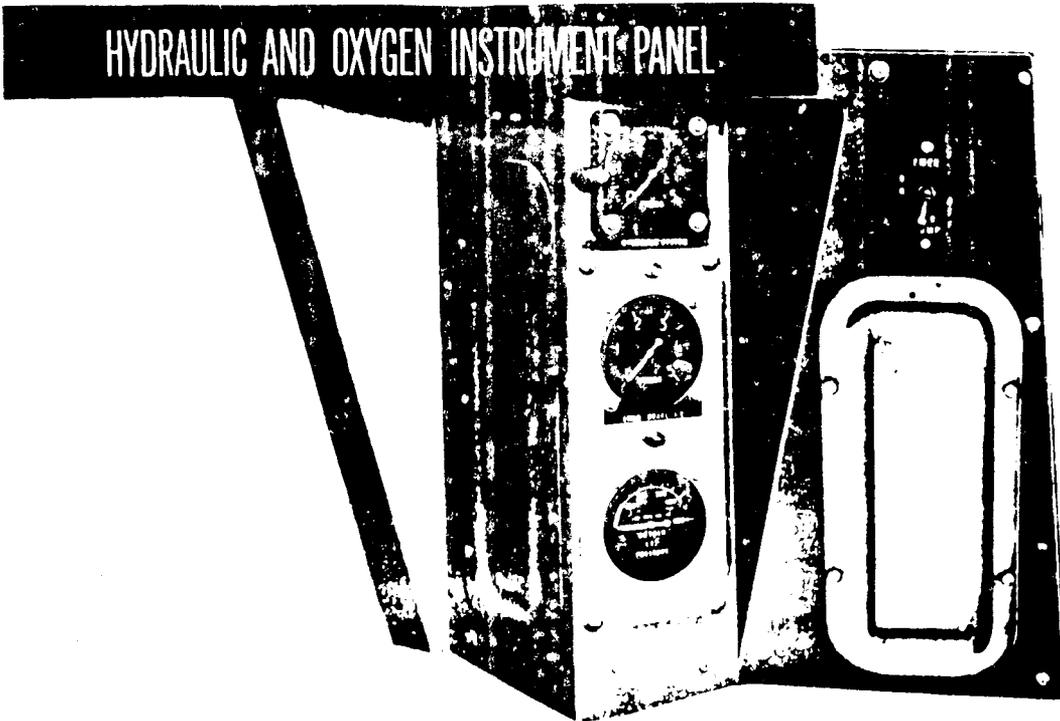
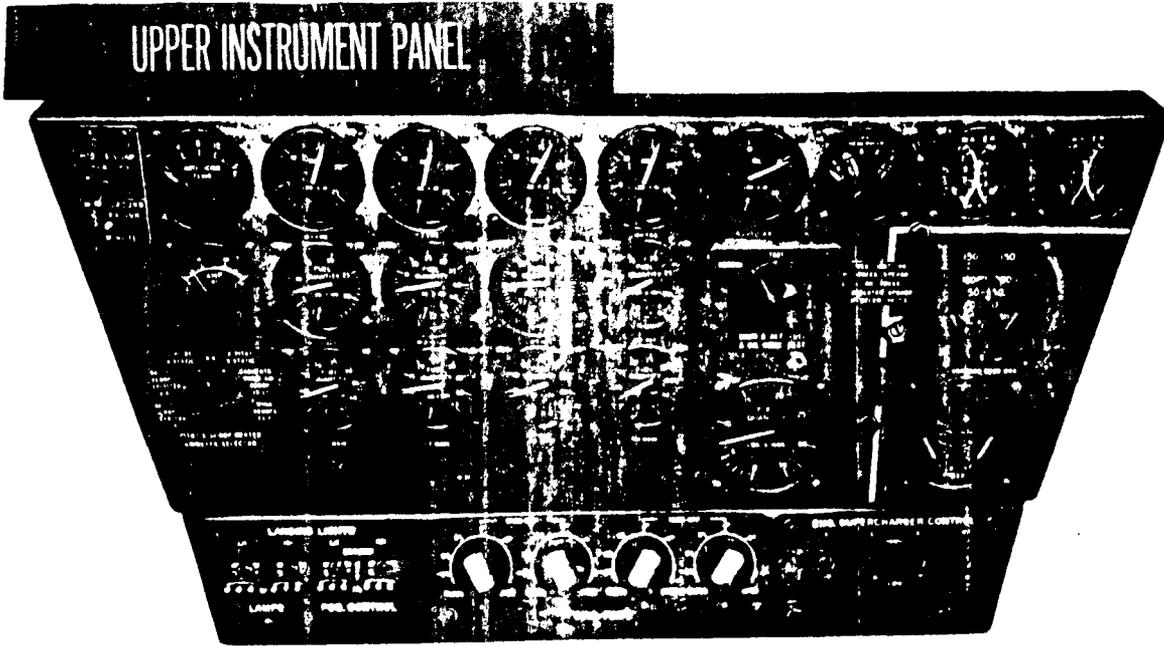
Four purge valves, located below the main instrument panel, provide a means of clearing the manifold pressure lines of foreign matter. Purging should be accomplished at preflight for at least 30 seconds. The engine should be at low RPM and the manifold pressure less than the static pressure in the cockpit.

An abnormal manifold pressure indication for any given RPM may indicate engine trouble, gage trouble or a leak in the instrument line. A cross check with the torque pressure, fuel flow and cylinder head temperature indicators will assist in determining which is defective. If the other indicators are indicating correctly, a malfunction of the manifold pressure indicator or a leak in the line is probable.

Tachometers

The two dual tachometers are mounted on the center section of the main instrument panel. The tachometers are operated by four heavy duty tachometer generators, one on each engine. The tachometer generator output varies with engine speed thus controlling the indicator motor speed and the indication.

Each tachometer generator supplies power to its respective tachometer indicator and to the propeller synchronizer. Two guarded ON-OFF isolation switches are mounted in the bulkhead aft of the pilot's seat. The isolation switches are used to disconnect the tachometer generator output from the propeller synchronizer in the event of tachometer system trouble.



The GTPU tachometer operates on the same principles as the engine tachometer. This indicator is mounted on the GTPU instrument panel. It is calibrated in percent of RPM. The two dials and pointers allow the indicator to read up to 110% RPM.

Springed Instruments

The springed instruments are four clocks. There are three eight-day clocks and one elapsed time clock. The eight-day clocks are mounted on the pilot's panel, the copilot's panel and the navigator's panel. The elapsed time clock is on the copilot's panel.

Direct Reading Gages

The hydraulic pressure gage is mounted on the hydraulic and oxygen instrument panel. It is connected to the hydraulic system downstream from the relief valve. Normal reading is 2650-3100 PSI.

The emergency air brake pressure gage is mounted on the hydraulic and oxygen instrument panel. The indicator is connected to the system between the air pressure cylinder and the air metering control valve. Normal reading is 1000 PSI plus or minus 50 PSI.

The copilot's oxygen pressure gage is also mounted on the hydraulic and oxygen instrument panel. This gage shows the pressure in the system used by the copilot, navigator and flight mechanic. The pilot's oxygen pressure gage is mounted by itself on a small bracket next to the pilot's interphone control panel. The charged system pressure is 400 PSI plus 25 minus 0 PSI.

The two supercharger airflow rate indicators are on the cabin pressure control panel. These indicate the pressures at the flow control valve of each cabin supercharger. A cabin supercharger

duct pressure indicator shows the pressure existing in the pressure air ducts. This gage is mounted on a small bracket aft of the AC-DC voltmeter panel.

Thermocouple Type Thermometers

These indicators use thermocouples to produce the electrical current necessary for operation. A thermocouple is a junction of two dissimilar materials which when heated produces an electrical current. The current produced is very small, and no current protection is necessary.

Thermocouples as sensing elements supply an indication to the left and right wing heater temperature indicator and to the cabin and tail heater temperature indicator.

Another thermocouple temperature indicator is the dual GTPU combustion chambers temperature indicator mounted on the GTPU instrument panel.

28 Volt DC Thermometers

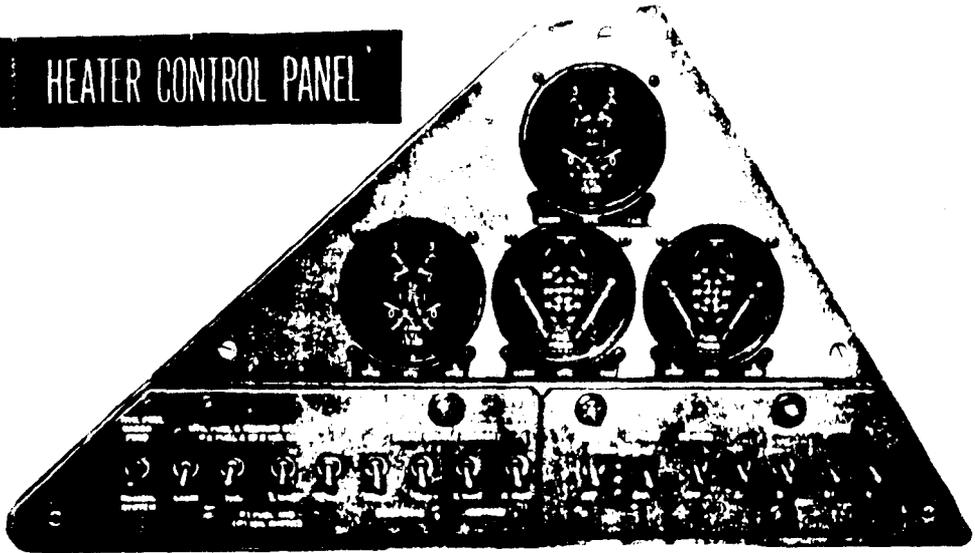
The thermometers which require 28 volts DC power for operation are:

- 4 cylinder head temperature
- 4 carburetor air temperature
- 4 engine oil temperature
- 2 outside air temperature
- 1 cabin air temperature
- 2 cabin supercharger gear box oil temperature
- 1 GTPU oil temperature

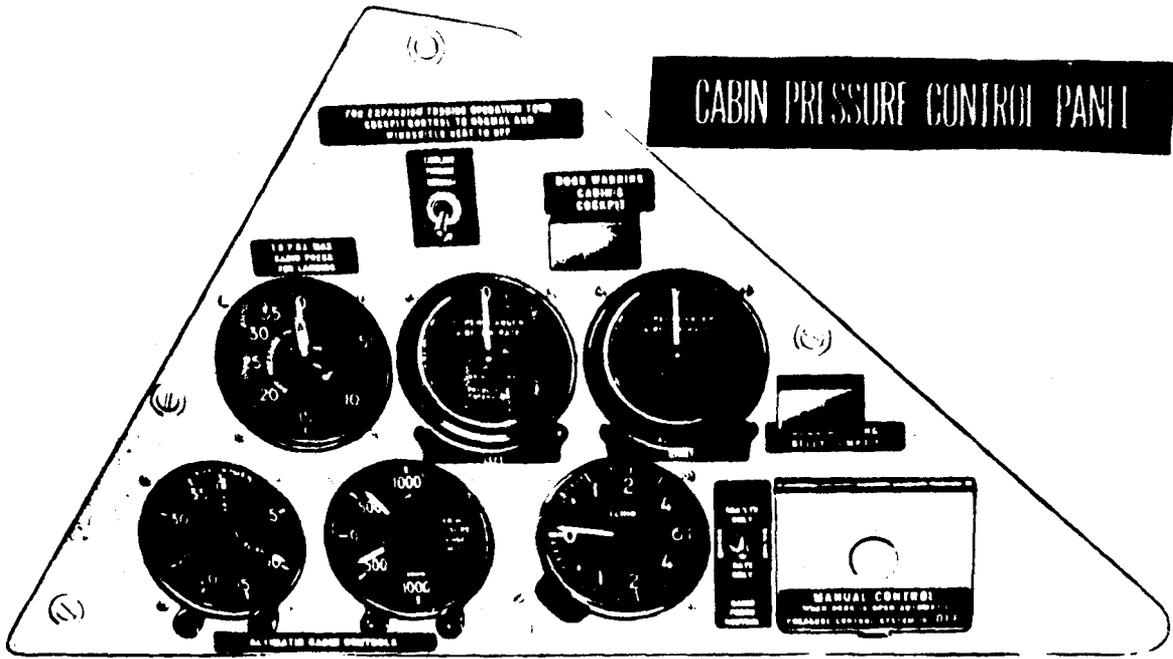
The cylinder head temperature indicators are on the center section of the main instrument panel. The temperature bulb is mounted in Nr 2 cylinder.

The carburetor air temperature indicators are on the center section of the main instrument panel. The temperature bulb is mounted in the carburetor air inlet.

HEATER CONTROL PANEL



CABIN PRESSURE CONTROL PANEL



The engine oil temperature indicators are on the center section of the main instrument panel. The temperature bulb is mounted in the "Tee" fitting below the oil tank and measures the temperature of the oil going into the engine.

One outside air temperature indicator is mounted on the center section of the main instrument panel. The second outside air temperature indicator is on the navigator's panel. The two temperature bulbs are mounted outboard of the battery compartment on both sides of the aircraft. The left bulb is connected to the main instrument panel indicator and the right bulb to the navigator's indicator.

The cabin air temperature indicator is mounted on the cabin temperature control portion of the AC-DC voltmeter panel. The cabin air temperature bulb is mounted next to the thermister.

The cabin supercharger gear box oil temperature indicator is on the upper instrument panel. The bulbs are in the low pressure bridle of the superchargers.

The GTPU oil temperature gage is on the GTPU instrument panel. The bulb is in the oil system of the GTPU.

These indicators require 28 volts DC power for operation. Whenever power is lost they will automatically move to an "off scale cold" position. Voltage higher or lower than normal does not affect the accuracy of the indication.

These instruments are protected by circuit breakers on the main circuit breaker panel. The 4 cylinder head temperature indicators have 2 circuit breakers, with 1 and 2 engines on one circuit breaker and 3 and 4 engines on the other circuit breaker.

Connected to the adjoining circuit breaker are 3 and 4 engine oil temperature indicators, 3 and 4 carburetor air temperature indicators and both supercharger gear box oil temperature indicators.

Connected to the next circuit breaker are 1 and 2 engine oil temperature indicators, 1 and 2 carburetor air temperature indicators and both outside air temperature indicators.

The cabin air temperature indicator is connected to the cabin heater control circuit heater.

The GTPU oil temperature gage is connected to the GTPU fire warning circuit breaker.

28 Volt DC Liquid Quantity Gages

These are often called "Liquidometers" and have float type transmitters mounted in the various tanks. The operational power is 28 volt DC and the entire group is protected by 1 circuit breaker on the main circuit breaker panel.

The anti-icing fluid quantity indicator is on the upper instrument panel. The transmitter is located in the 16 gallon alcohol tank which is mounted in the right wing fillet at the trailing edge of the wing.

The hydraulic quantity gage is on the upper instrument panel. The transmitter is located in the 5.4 gallon hydraulic fluid tank mounted in the hydraulic compartment.

There are 2 dual water-alcohol (ADI) quantity indicators on the upper instrument panel. The transmitters are located in the four 10 gallon water-alcohol tanks mounted in the engine nacelles.

Landing Gear and Wing Flap Position Indicator

This indicator requires 28 volt DC power. It has its own circuit breaker on the main circuit breaker panel. The indicator is on the center section of the main instrument panel.

The landing gear portion of this indicator consists of three drum type indicators. These are actuated by the landing gear up-lock and down-lock switches as the gear is moved. When the gear is up the word UP is visible. If the gear is in the down position a WHEEL is displayed. Anytime the gear is not up or down or instrument power is not applied a striped area called the "barber pole" is shown.

The wing flap portion of this indicator is a single flap-like device. The flap indicating device is actuated by a transmitter located in the left flap well. The transmitter is connected mechanically to the flap. When DC power is lost the flap device disappears and the word OFF appears.

26 Volt AC Instruments

These are often called the Magnesyn instruments. The AC power for operation is supplied by either the RADIO-ELECTRIC or the STANDBY inverter. As the inverters produce 115 volts AC power, transformers are required to step the voltage down to 26 volts. The two transformers, a NORMAL and a STANDBY, are located in the MAIN Junction Box. A switch on the forward overhead panel must be used to select the desired transformer. There are two fuses on the right hand annex of the Main Junction Box which protect the 115 Volt AC power input circuits to the transformers.

The 26 volt AC instruments of the C-118 are:

- 4 engine fuel pressure indicators
- 4 engine oil pressure indicators
- 4 water-alcohol (ADI) pressure indicators.
- 4 torque (BMEP) pressure indicators
- 4 fuel flow indicators
- 2 cabin supercharger oil pressure indicators
- 4 heater fuel pressure indicators
- 1 mixing valve position indicator

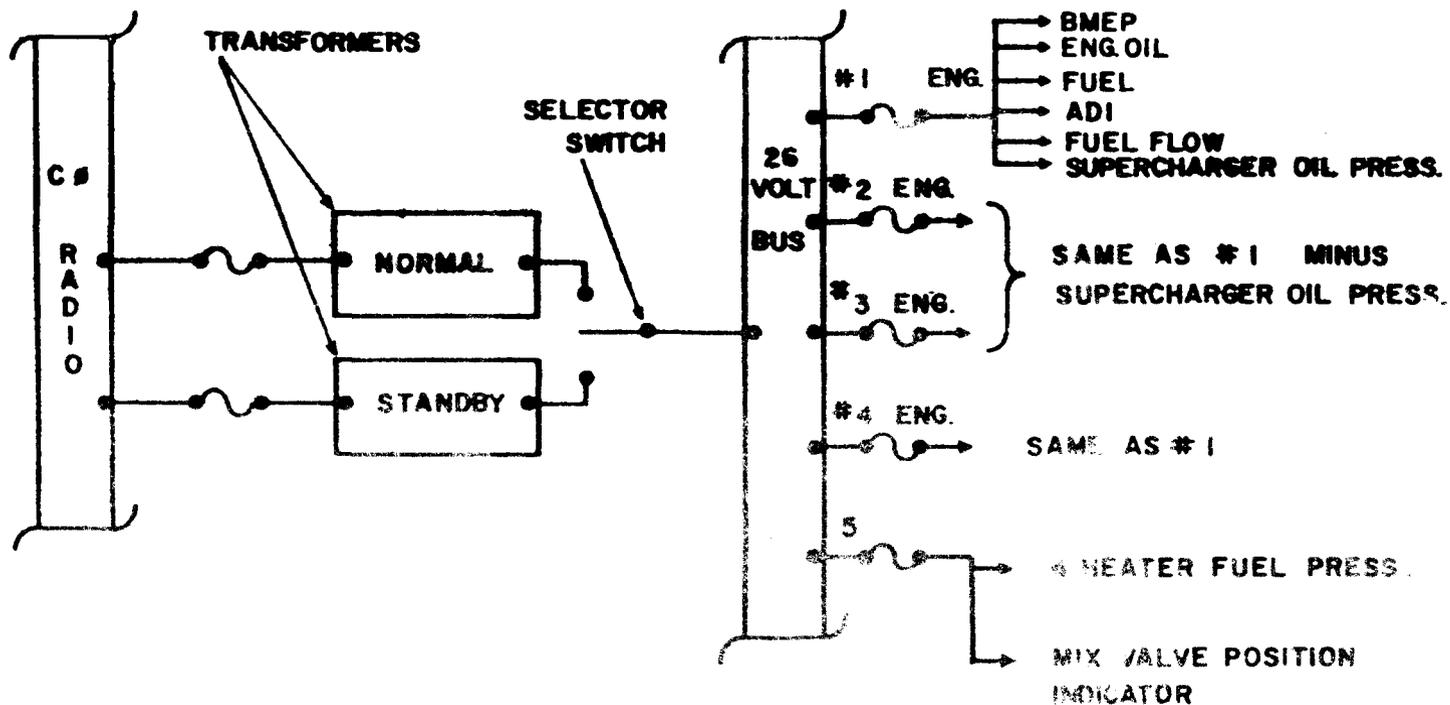
The engine fuel pressure indicators are on the center section of the main instrument panel. The transmitters are on the right side of engine accessory section on the engine mount. They are connected to "E" chamber of the carburetor.

The engine oil pressure indicators are on the center section of the main instrument panel. The transmitter is on the engine mount on the right side of the engine. It is connected to the outlet side of the main oil pump.

The water-alcohol (ADI) indicators are also on the center section of the main instrument panel. They are in the engine accessory section on the right hand engine mount. These are connected to the ADI regulator. With ADI switches OFF a pressure reading of 8-12 PSI is normal. A rapid drop to ZERO pressure indicates a leak in the system.

The fuel flow indicators are on the center section of the main instrument panel. The transmitters are on a bracket above the generator. The transmitter is in the fuel line between the fuel feed valve and the fuel control unit. The system indicates the amount of fuel going to the engine.

The torquemeters (BMEP gages) are on the center section of the main instrument panel. The transmitters are on the left side of the engine nose section. The transmitters are connected



26 VOLT AC INSTRUMENTS POWER SCHEMATIC

to the torque oil pressure pump. The indicators are calibrated in PSI. By multiplying the PSI reading by the RPM and dividing by "K" (283), the brake horsepower can be determined.

The heater fuel pressure indicators are on the heater control panel. The transmitters are in heater accessories container. They indicate the pressure to the heaters as controlled by the heater fuel regulator.

The cabin supercharger gear box oil pressure indicators are on the upper instrument panel. The transmitters are located on the rear firewall of Nr 1 and Nr 4 engines. The pressure indicated is that within the low pressure bridge.

The cabin temperature mixing valve position indicator is on the cabin temperature control panel of the AC-DC voltmeter panel. The transmitter is mounted on the mixing valve. The system shows the position of the mixing valve in relation to ports A, B, or C.

The 26 volt AC instruments are protected by fuses, which are found on the right hand annex of the Main Junction Box. There are 5 fuses.

Each of the fuses protects a group of instruments as shown by the chart on page 3-11.

These indicators and transmitters are essentially synchronous motors. The indicator rotor to which the pointer is attached maintains a position relative to the rotor of its transmitter. The rotor of the transmitter is moved by a mechanical device reacting to pressure, flow, or position movement.

The pointer of these indicators will tend to remain fixed, when electrical power fails or is turned OFF. Suspected electrical power failure to an engine instrument group can be quickly checked

by flicking the booster pump for the affected engine ON and OFF while observing the fuel pressure indicator. Other methods of checking for power failure are changing a power setting and observing fuel flow indication, or changing the mixture control and observing fuel flow indication.

Electronic Quantity Indicating Systems

The Simmonds electronic quantity indicating systems are used to indicate fuel and oil quantity. A fuel totalizer shows the total fuel load.

The systems use 115 volt, single phase AC power from either the RADIO-ELECTRIC or the STANDBY inverter. The systems are protected by fuses on the main fuse panel in the right hand annex of the Main Junction Box. Four of the fuses protect the MAIN and ALT fuel quantity indicators and the OIL quantity indicator for each of the engines. The FUEL TOTALIZER has an individual fuse and the AUX OIL quantity indicator has an individual fuse.

The advantages of using this type of indicator are:

1. The indication is in pounds
2. There is very little error in the indication due to temperature changes.
3. There are no moving parts in the tank units to stick or jam.
4. There is a minimum of pointer movement due to the liquid sloshing or changes of aircraft attitude.

The indicators are mounted on the upper instrument panel. There are 9 fuel quantity indicators including the fuel totalizer. There are 5 oil quantity indicators. The indicators are calibrated in pounds. Inside is an electric motor, turning in response to signals from the tank units. The motor

drives both the indicating pointer and a wiper on a potentiometer. Thus, as the motor rotates the indicating pointer to indicate the new liquid quantity, the wiper movement is also balancing a bridge circuit.

On the upper instrument panel is a test switch. When the switch is placed to TEST, the bridge circuit is changed to correspond to an empty tank. The pointers then move counterclockwise toward empty. If the switch is returned to NORMAL the pointers will return to the normal reading. This is an operational check and not an accuracy check.

There is a bridge calibrator for each indicator. The bridge calibrators are located overhead in the forward part of the forward baggage compartment. These bridge calibrators are used by instrument personnel to adjust the accuracy of the system.

One amplifier is used for each indicator. All are located on the fourth shelf of the radio rack. They take the weak signal from the bridge circuit and amplify the signal until it is strong enough to operate the indicator motor. The amplifiers are interchangeable.

Nr 1 and 4 main tanks each have 6 tank units. The remainder of the fuel

tanks have 3 tank units apiece. In each of the oil tanks is 2 tank units. The tank units are variable condensers and are sometimes called probes. Two concentric cylinders profiled to that particular tank extend from the top to the bottom of the tank and form the plates of the condenser.

As the dielectric constant of fuel or oil is greater than that of air, the capacitance value of the condenser varies with the amount of fuel or oil in the tank. This unbalances the bridge circuit and causes a current flow to the amplifier. The current is now amplified and applied to the indicator motor. The unbalance continues and the current flows until the indicator motor moves to give the correct indication. As the indicator motor moves the indicating pointer a wiper is also moved, balancing the bridge circuit until the next change in fuel or oil level, when the above process is again repeated and the bridge circuit balanced.

The TOTALIZER system consists of a totalizer bridge, an amplifier and the indicator. The system reads the total fuel aboard in pounds. The signals from the individual indicators are fed to the totalizer system to obtain this result. The operating principle is the same as the individual indicating systems.



Flight Gyros

The pilot and the copilot have a turn and slip indicator. These indicators require 28 volt DC power. Each indicator has a circuit breaker on the main circuit breaker panel.

Both the pilot and the copilot have an H-5 attitude gyro indicator. These indicators use 115 volt, 400 cycle, three phase AC power. The power is normally obtained from the RADIO-ELECTRIC or the STANDBY inverter. In an emergency the power can be obtained from the EMERGENCY inverter.

The three phase output of the inverter reaches the indicators through two fuses for each indicator. These fuses are on the main fuse panel in the right hand annex of the Main Junction Box.

The H-5 attitude gyro indicator is self erecting. The erection time is 7 to 13 minutes. When up to operating speed a "winking" flag that "winks" 69 times per minute is visible on the indicator face. The H-5 attitude gyro has a heated bezel or cover glass, which is hot to the touch. The purpose of the heated bezel is to prevent fogging of the cover glass.

In the event that the normal DC power system fails, flight gyro operation can be obtained by the use of the EMERGENCY INSTRUMENT POWER AND INSTRUMENT LIGHTING SWITCH. This switch is on the forward overhead panel. Placing the switch to ON sends DC power directly to the turn and slip indicators from the battery. At the same time DC power is sent to the EMERGENCY inverter from the battery. Operation of this switch has also set up the AC output circuits so that the H-5 gyros will receive the output of the EMERGENCY inverter. The gyros will operate for

approximately two and one-half hours, on fully charged batteries.

S-2 Compass Systems

The C-118 has 2 separate S-2 Compass Systems. One system supplies the pilot and the navigator with a directional heading, while the second system supplies the copilot with a directional heading.

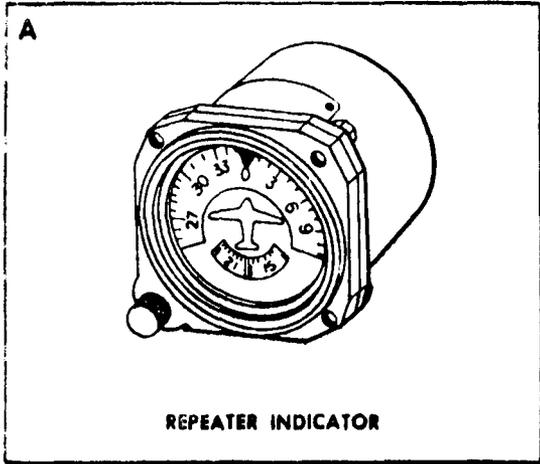
Both of the compass systems require 115 volt, 400 cycle, single phase AC power and 115 volt, 400 cycle, three phase AC power. In addition both systems require 28 volt DC power.

The pilot's S-2 Compass System is supplied 115 volt, single phase and three phase power by either the RADIO-ELECTRIC or the STANDBY inverter. If there is a failure of the normal DC power system, the pilot's system can be connected to the EMERGENCY inverter by using the switch on the forward overhead panel.

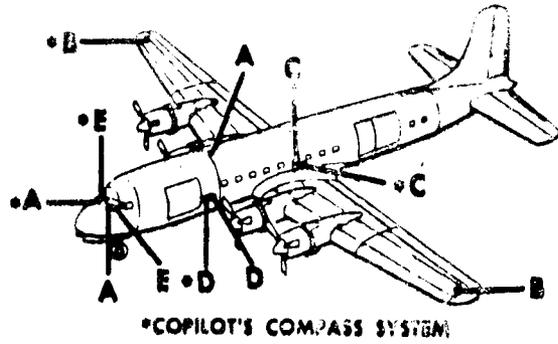
The copilot's S-2 Compass System is supplied 115 volt, single phase and three phase power by either the RADAR-ELECTRIC or STANDBY inverter. It cannot be connected to the EMERGENCY inverter.

In both systems the three phase AC power is used by the Directional Gyro Controls for gyro stability. The single phase AC power is used in the sensing circuit. The DC power heats the filaments of the amplifier tubes.

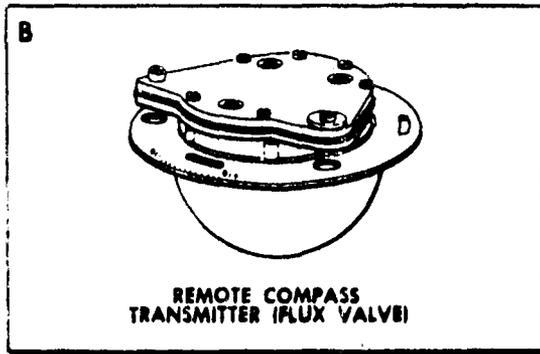
Both systems have 2 fuses apiece in the three phase power supply. These fuses are on the main fuse panel in the right hand annex of the Main Junction Box. The DC input circuits are protected by 2 circuit breakers on the main circuit breaker panel, one for each system.



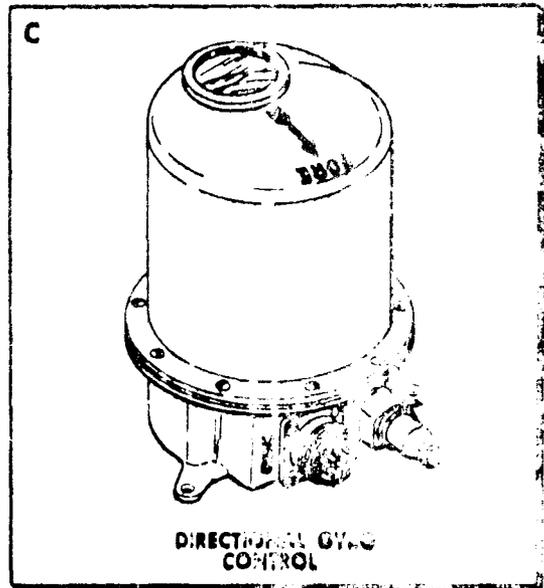
REPEATER INDICATOR



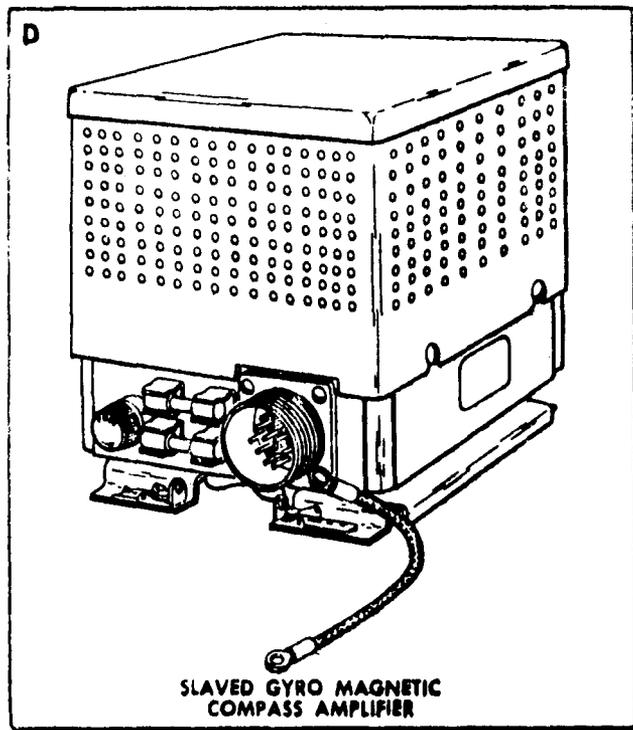
COPILOT'S COMPASS SYSTEM



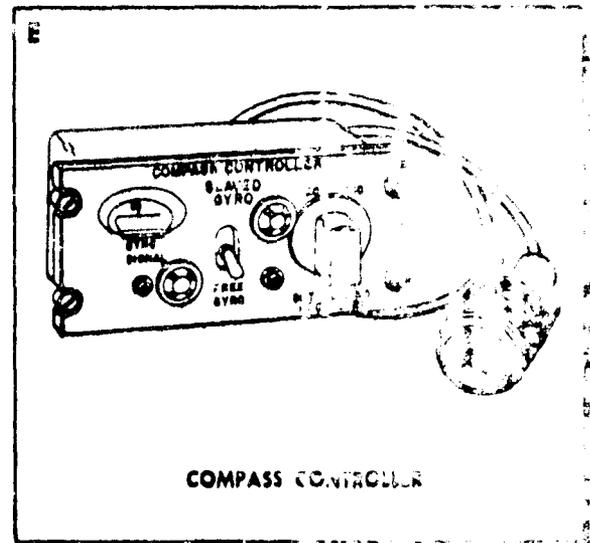
REMOTE COMPASS TRANSMITTER (FLUX VALVE)



DIRECTIONAL GYRO CONTROL



SLAVED GYRO MAGNETIC COMPASS AMPLIFIER



COMPASS CONTROLLER

8-2 SLAVED GYRO MAGNETIC COMPASS SYSTEMS

The S-2 Compass Systems start with the Flux Valves. The Flux Valve for the pilot's system is in the left wing tip. The Flux Valve for the copilot's system is in the right wing tip. As the earth's lines of magnetic flux pass through the Flux Valve, the magnetic flux creates a signal. The Flux Valves are fastened to and turn with the aircraft, so these magnetic flux lines pass through at different angles. Thus, for each position of the aircraft relative to the north magnetic pole, a definite and different signal is created. This magnetically induced signal is sent to the Amplifiers.

The 2 Amplifiers are on the main radio rack. Each Amplifier receives the magnetically induced signal from its Flux Valve. The Amplifier strengthens the signal until it is strong enough to operate a motor, and passes the signal to the Directional Gyro Controls.

The 2 Directional Gyro Controls are in the hydraulic accessory compartment. Each Directional Gyro Control contains a 3 phase electrically powered gyro, which will remain rigid in space unless a force is applied. The Directional Gyro Control stabilizes the magnetic indication to free the indication from northerly turning, acceleration, and deceleration errors. In FREE GYRO operation the Directional Gyro Control serves as the sole heading reference. When the amplified signal from the Flux Valve reaches the Directional Gyro Control, it is applied to a torque motor. The torque motor is used to "slave" the gyro to a position corresponding to the magnetic heading of the aircraft by applying a force against the gyro.

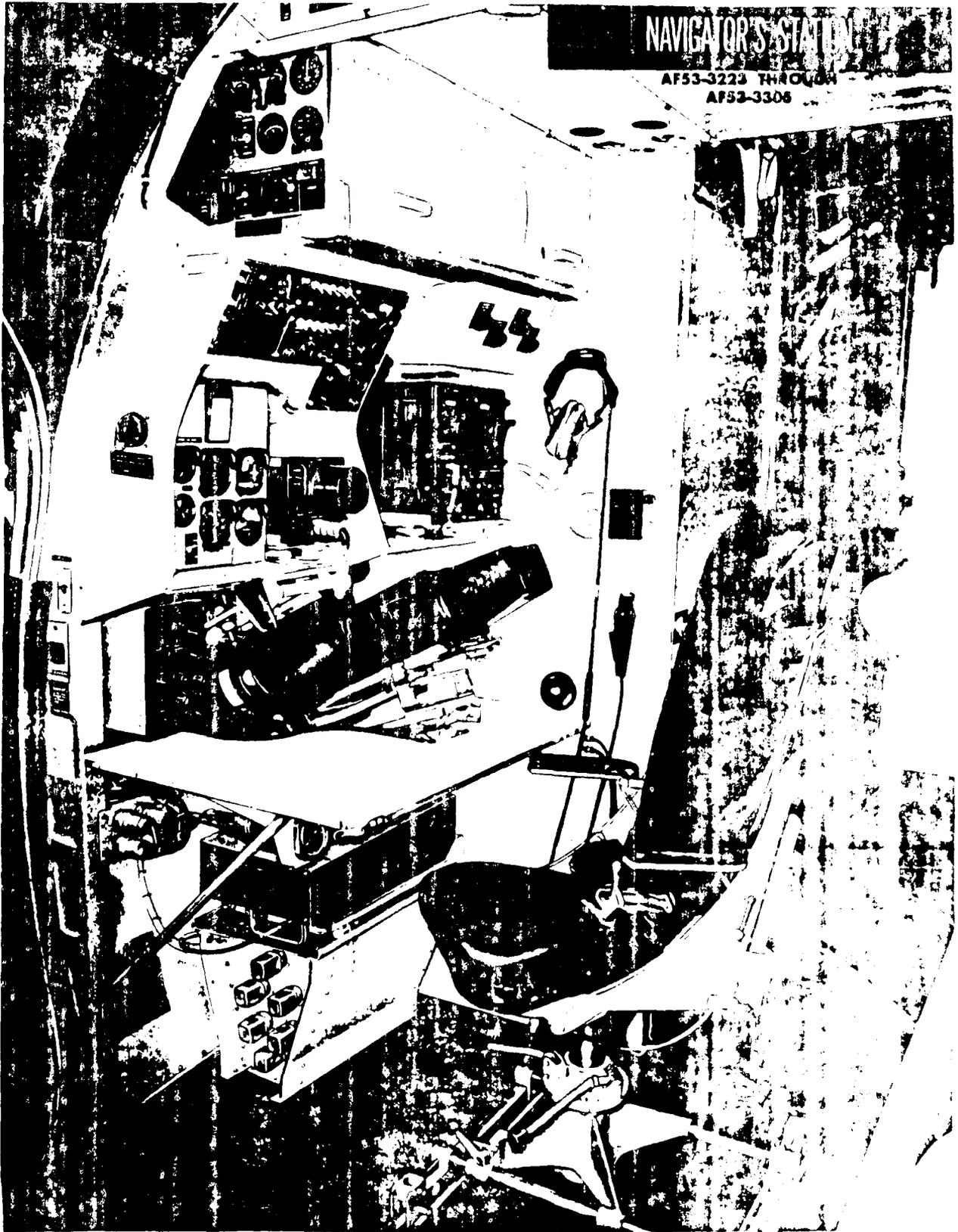
At the time the system is first turned ON, the "slaving" rate is approximately 90 degrees per minute, if the misalignment is 7 degrees or more. As the gyro swings to the proper po-

sition, a gyro signal device sends back to the amplifier a cancelling signal, which slows down the "slaving" rate as the gyro nears the proper position. This "fast slaving" rate will also take place when aircraft power is restored after an interruption. After the initial "slaving", the "slaving" rate is 3 to 6 degrees per minute if a large misalignment occurs. For small misalignments the rate is smaller to give a smooth compass indication. Mounted below the gyro is a second signal device connected to the Repeater Indicator. This device sends out a signal corresponding to the position of the gyro.

The pilot's S-2 Compass System has 2 Repeater Indicators, one on the pilot's section of the main instrument panel and one on the navigator's instrument panel. The Repeater Indicator for the copilot's S-2 Compass System is on the copilot's side of the main instrument panel. When a signal reaches the Repeater from the Directional Gyro Control, the indicator motor moves the indicating pointer to a position corresponding to the gyro position.

Both compass systems have a Compass Controller Panel, which are mounted on the lower edge of the left and right sections of the main instrument panel. If a magnetic heading is desired, the toggle switch on that panel should be placed in the SLAVED GYRO position. In this position the system will continue to show the correct magnetic heading no matter how much the aircraft turns.

In areas where the magnetic indication can not be relied on, the switch should be placed in the FREE GYRO position. As long as this position is used, the magnetic signals are disconnected from the gyro. This means that the compass should now be used the same way as a conventional directional gyro. To set the gyro on the

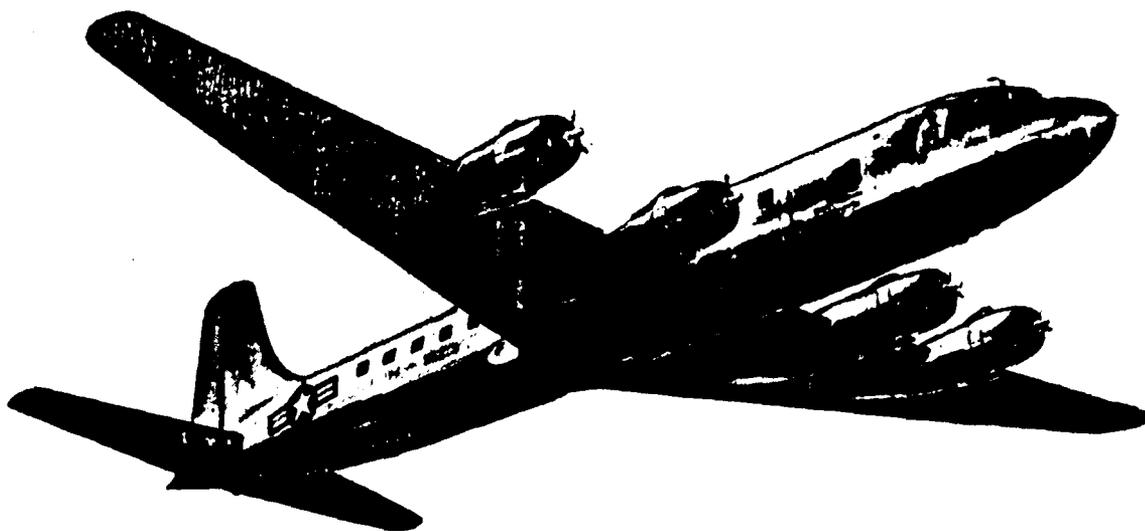


desired heading while the switch is in FREE GYRO position, use the SET HEADING-FREE GYRO knob on the Controller Panel. To go up-scale place the knob to INC and to go down-scale place the knob to DEC. When the pointer has reached the desired heading, release the knob which is spring loaded to return to neutral. While FREE GYRO is being used, the random drift of a conventional gyro is present and must be compensated for by the pilot. The random drift of the gyro varies with a maximum of 8 degrees per hour.

The Controller Panel can also be used to preflight the S-2 Compass System. After the system has synchronized to the correct magnetic heading, place the toggle switch to FREE

GYRO. Next use the SET HEADING-FREE GYRO knob to move the Repeater off the magnetic heading a few degrees. Then set the toggle switch back to SLAVE GYRO. The Repeater should "slave" back to the magnetic heading. Repeat the above process except for moving the Repeater off the magnetic heading in the opposite direction.

On the Controller Panel is a SYNC SIGNAL meter. The meter indicates whenever the gyro is being "slaved" and so acts as a "quick" operational check of the system. When in FREE GYRO, if the SET HEADING-FREE GYRO knob is moved to INC the meter hand moves to the right and if set to DEC the meter hand moves to the left.



Chapter 2

THE E-4 AUTOMATIC PILOT

General

The Air Force E-4 (Sperry A-12) Autopilot will automatically maintain a desired flight attitude. The Autopilot Gyrosyn Compass System through the E-4 Autopilot will keep the aircraft on any selected heading. The E-4 has a barometric pressure altitude control which will maintain, within 20 feet, any selected altitude.

By using an elevator trim tab servo, in addition to an elevator servo, the E-4 offers automatic compensation for changes in weight distribution. Because of this feature, any time the autopilot is disengaged, the aircraft will be in perfect elevator trim.

Smooth coordinated turns using the autopilot flight controller are easily and consistently accomplished, as the ratio of turn in degrees per minute to the bank angle is automatically coordinated for all airspeeds.

Automatic approach equipment is connected to the E-4 Autopilot. When this equipment is used, the autopilot responds to radio signals and maintains an on-course flight path controlled by the localizer and glide slope radio beams.

Power Requirements

The E-4 Autopilot uses both 115 volt single phase and 115 volt three phase AC power. The single phase power can be obtained from either the RADIO-ELECTRIC or the STANDBY inverter. While these inverters produce three phase power, in this case, only "C" phase (single phase) power is used by the autopilot. The AUTOPILOT fuse is located on the AC fuse panel in the right hand annex of the Main Junction Box.

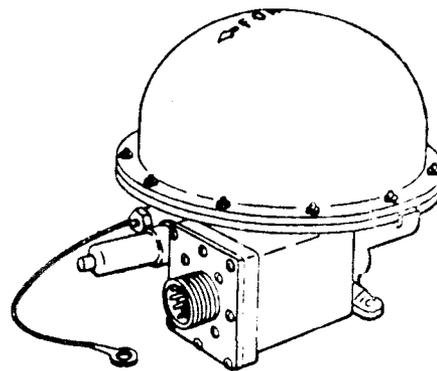
The E-4 Autopilot uses three phase AC power in the Autopilot Compass Directional Gyro Control and in the Autopilot Vertical Gyro Control for gyro stability. Therefore the single phase AC power is converted to three phase AC power by the autopilot phase adapter. The autopilot phase adapter is located in the right hand annex of the Main Junction Box.

The E-4 Autopilot also uses 28 volt DC power. The three autopilot circuit breakers are on the main circuit breaker panel. These three circuit breakers protect the TUBE FILAMENT, INTERLOCK and SERVO GENERATOR CONTROL circuits.

The interlock system will prevent the turning ON of the autopilot unless the proper power is available.

Location

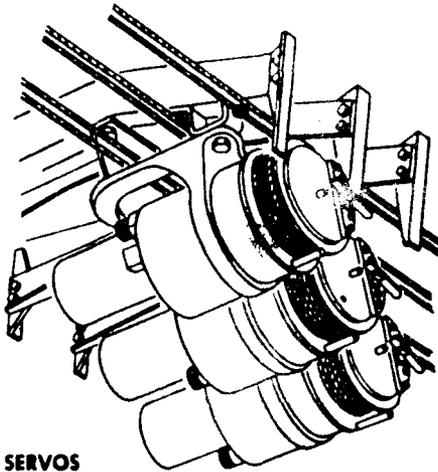
The Vertical Gyro Control is in the hydraulic accessory compartment. This electrical gyro controls the ailerons and elevators when the autopilot is engaged.



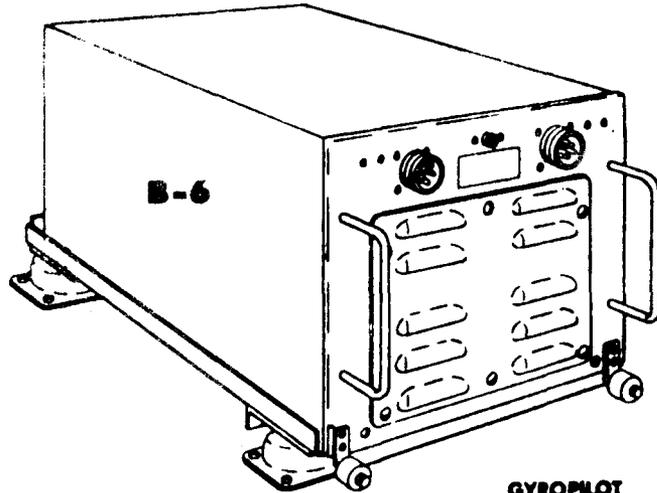
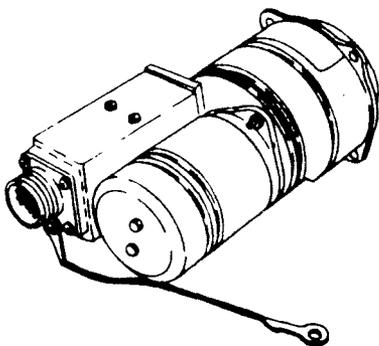
VERTICAL GYRO
CONTROL

The aileron, rudder, elevator and elevator trim tab servos are in the hydraulic accessory compartment. All servos, except the elevator trim tab servo move the control surfaces.

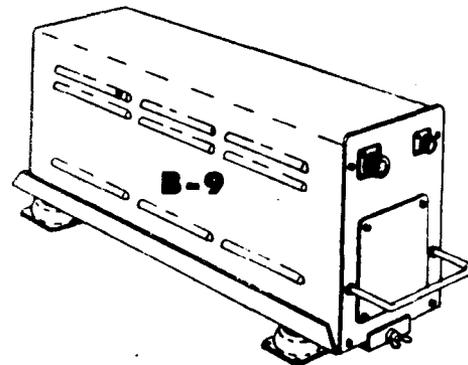
The B-6 Amplifier, on the main radio rack is the autopilot amplifier. The B-6 is also used to connect the Autopilot Compass System to the autopilot. The B-9 Amplifier (Approach Amplifier) on the main radio rack connects the automatic approach radio equipment to the autopilot.



SERVOS

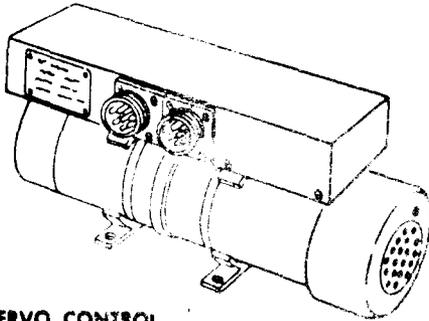
GYROPILOT
AMPLIFIER

ELEVATOR TRIM TAB SERVO

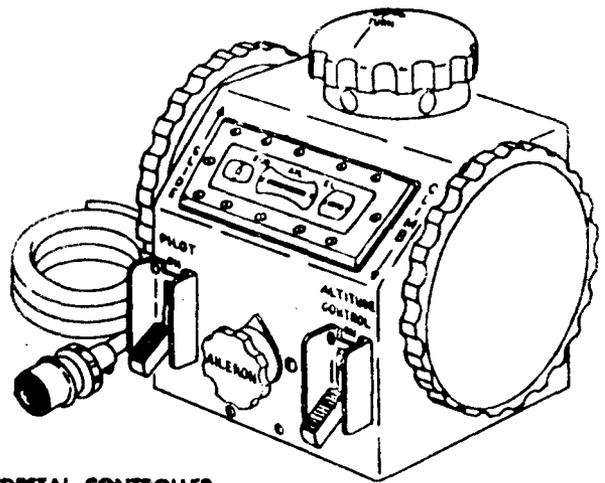
AUTOMATIC APPROACH
AMPLIFIER

The Servo Control Motor Generator is in the inverter compartment. The signals from the B-6 Autopilot Amplifier do not have sufficient power to operate the servos. The Servo Control Generator acting as a power generator delivers the required power to the Servos.

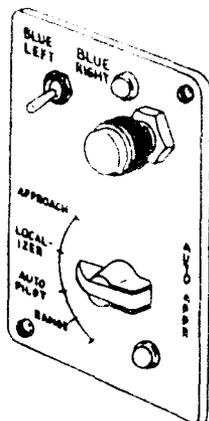
All of the E-4 autopilot control units are in the flight compartment on the pedestal. An Autopilot Controller turns ON and controls the autopilot. An Automatic Approach Selector switch is used to connect the automatic approach radio equipment to the autopilot. The C-118 aircraft have mechanical engage-disengage levers. The levers are spring loaded to both the engaged and disengaged position.



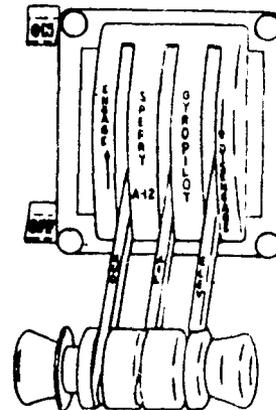
SERVO CONTROL MOTOR GENERATOR



PEDestal CONTROLLER



AUTOMATIC APPROACH SELECTOR



MECHANICAL ENGAGING CONTROL LEVERS

Autopilot Compass System

For directional control, the E-4 autopilot uses a compass system. The Autopilot Compass System operating principles are similar to the S-2 Compass Systems discussed earlier in Chapter 1. The Autopilot Compass Flux Valve is in the right wing tip. The Directional Gyro Control is in the hydraulic accessory compartment. The Autopilot B-6 Amplifier is used to amplify compass signals, rather than a separate amplifier as in the standard S-2 Compass System. The Autopilot Compass System signals are used to control the rudder servo.

The Autopilot Compass System uses both single phase and three phase 115 volt AC power, plus 28 volt DC power. The three phase power is used for gyro stability and the single phase power is used in the sensing circuit. As related under autopilot power, the AC power comes from either the RADIO-ELECTRIC or STANDBY inverter. The AC power comes through the AUTOPILOT fuse and the DC power from the AUTOPILOT FILAMENT circuit breaker.

Anytime the DC power is ON and the inverter is ON, the Autopilot Compass System will operate. The Autopilot Compass System operates regardless if the autopilot is engaged or not.

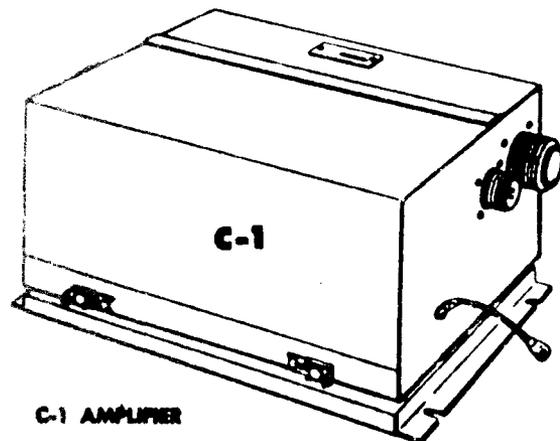
Besides furnishing the E-4 Autopilot directional control, the Autopilot Pilot Compass System is also used as a reference source for the Radio-Magnetic Indicators. There are five Radio Magnetic Indicators; two for the pilot, two for the copilot and one for the navigator.

The compass heading from the Autopilot Compass System is sent to a C-1 Compass Signal Amplifier located on the main radio rack. The compass signal is amplified within the C-1 Amplifier and sent to operate the "cards" or magnetic

dials of the RMI's. At the same time, magnetic data is fed from the Autopilot Compass System to the "do-nut" needle of the Course Indicator (ID-249) on the pilot's panel via the C-1 Amplifier.

The C-1 Compass Signal Amplifier uses 115 volt, single phase power ("C" phase only) from either the RADIO-ELECTRIC or the STANDBY inverter. The power is fed to the C-1 Amplifier through the COMPASS REPEATER fuse located on the AC fuse panel in the right hand annex of the Main Junction Box. This COMPASS REPEATER fuse and the AUTOPILOT fuse comprise the two autopilot system fuses.

Notes: In the event that the COMPASS REPEATER fuse should fail, the entire Radio Magnetic Indicator will be inoperative as the C-1 Amplifier furnishes the power to both the "cards" and the "hands" of the Radio-Magnetic Indicators.



Interlock System

One feature of the E-4 Autopilot is the interlock system. This system prevents the turning ON of the autopilot unless the correct procedures have been followed. The system will also turn the autopilot OFF, if improper procedures are attempted during autopilot operation.

To turn ON the autopilot, the following conditions must exist:

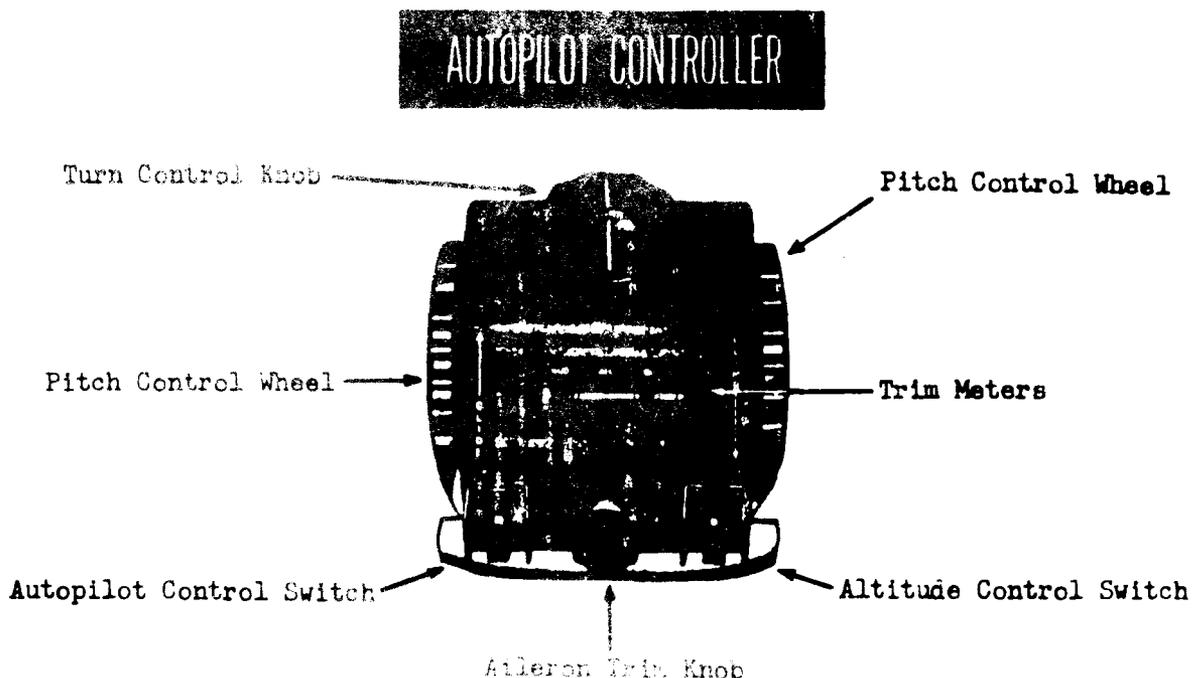
1. Proper power must be available to the autopilot.
2. The power must have been on for at least 2 minutes.
3. The engaging levers should be in the DISENGAGE position.
4. The turn control knob must be centered.
5. The automatic approach switch must be in the AUTOPILOT position.

Autopilot Operational Procedures

For autopilot operation, first check that the conditions listed under Interlock System have been met. Second, trim the aircraft to fly "hands off". Next move the autopilot control switch to "ON". Then check the autopilot signal meters for less than one (1) needle width deflection. Finally place the mechanical engaging levers into the ENGAGE position.

When on autopilot, the aircraft pitch angle can be changed by rotating either of the pitch control wheels on the sides of the autopilot controller. Rotate towards the nose for nose down and rotate away from the nose for nose up. These pitch control wheels are inoperative when the altitude control switch is "ON" or the automatic approach switch is on "APPROACH".

To turn the aircraft with the autopilot, use the turn control knob on the top of the autopilot controller. A coordinated turn is produced at all airspeeds.



The aileron trim control knob between the two switches of the autopilot controller is used to trim the aircraft when on autopilot.

With the autopilot engaged, move the altitude control switch on the right side of the controller to "ON". The autopilot will then maintain a constant barometric pressure altitude. If the autopilot is disengaged, the altitude control switch will snap to "OFF" at the same time.

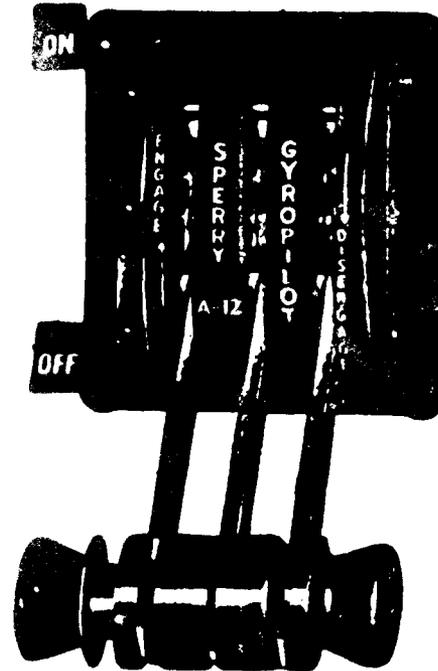
CAUTION

The altitude control switch must be turned "OFF" prior to changing the static source selector valve switch to the alternate position. Failure to do so will result in an abrupt change in the attitude to the limit of 6 degrees.

The three autopilot signal meters on the autopilot controller indicate by the deflection of the pointer that the autopilot is correcting. A constant deflection of more than one pointer width indicates an out-of-trim condition. The proper procedure is to disengage, retrim manually, and re-engage.

The autopilot servos are mechanically engaged by manual engaging levers on the control pedestal. The three levers have two positions, "ENGAGE" and "DISENGAGE" and are normally operated as a single control. An interlock system prevents turning the autopilot control switch "ON" when any servo is engaged. Disengaging the elevator engaging lever while the altitude control switch is "ON" will automatically return the altitude control switch to the "OFF" position.

AUTOPILOT MECHANICAL ENGAGING LEVERS



The first disengaging procedure is to move the mechanical levers to "DISENGAGE". The servos are disconnected, but the electronic units continue to operate.

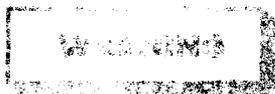
Another way to disengage is to press either the pilot's or the copilot's autopilot release button on the aircraft control wheel. The autopilot control switch will snap "OFF", but the engaging levers will remain ENGAGED. Manually move the levers to "DISENGAGE".

The last disengaging method is to turn off the autopilot control switch on the autopilot controller. The autopilot engaging levers will remain in "ENGAGE" and must be manually disengaged.

The following procedure is used for automatic approach in Section 1A of the FAA, TERRESTRIAL. The same procedure and the following steps are used for automatic approach.

Prior to attempting automatic approach, the pilot should check for:

1. Autopilot - ENGAGED
2. Altitude control switch - ON
3. Automatic approach selector switch - AUTOPILOT
4. The Instrument Landing Receiver - ON
5. The APPROACH READY light on the automatic approach selector panel - ON



Do not attempt to execute an automatic approach if the light is out.



AUTOMATIC
APPROACH
SELECTOR

When over the outer marker outbound, reduce airspeed to 140 knots. One minute after crossing the outer marker inbound make a standard ILS procedure turn, using the autopilot turn control knob. The altitude should be approximately 1500 feet above the runway. The speed is held at 140 knots, engine RPM is 2100,

and the flaps are at 20 degrees.

After a standard ILS procedure turn, the inbound heading is normally 90 degrees from the localizer heading. Engage the automatic approach equipment. This allows the aircraft to approach the localizer beam at any angle up to 90 degrees from the landing heading, bringing the inbound heading the pilot sets on the automatic approach selector knob to LOCALIZER when the vertical needle of the Course Indicator leaves the stops. As the aircraft approaches the center of the localizer beam, the needle will continue to the center, overshoot, and then return to center.

CAUTION

When attempting to correct for this overshoot by using the turn control knob will electrically disengage the autopilot.

When the aircraft is steady on the localizer, watch for the glide slope by means of the cross pointer indicator. When the horizontal bar shows one to two dots above center, turn the altitude control switch "OFF". Next use the pitch control wheel to bring the aircraft onto the glide slope. The flaps are dropped to 30 degrees, the gear is left up, the engine RPM set at 2100, and the aircraft retrimmed. The airspeed should be maintained between 120 to 140 knots IAS.

An alternate method used is to wait until the aircraft is centered in the localizer beam. Then set up the approach configuration. Next turn the altitude control switch "OFF". Use the pitch control wheel to set a nose down attitude equal to the glide slope angle. This is usually 2.5 degrees down from the level flight attitude. Finally return

the altitude control switch to the "ON" position.

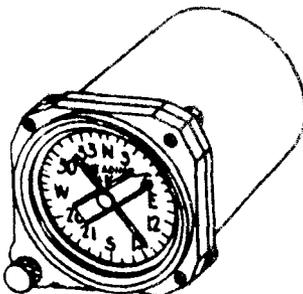
As the glide slope is intercepted, lower the gear. Retrim the aircraft and check the indicator to make sure the glide slope is being held. When steady on the glide slope, turn the automatic approach selector switch to APPROACH. If the altitude control switch is "ON" at this time, it will automatically snap to "OFF". Continue flying on in, maintaining the 120 knot airspeed with small power changes.

If visual contact of the runway, is made before the descent minimum altitude is reached, the autopilot is DISENGAGED and the approach is completed manually. When visual contact is NOT made before the descent minimum altitude is reached, the autopilot is DISENGAGED and the pilot flies a standard missed-approach procedure manually.

In any case the autopilot is DISENGAGED within 5 seconds of the time the aircraft passes over the middle marker to avoid passing over the glide path transmitter with the autopilot engaged.

Automatic Range Operation

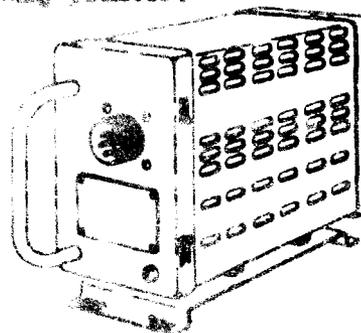
This equipment causes the autopilot to respond to VOR, VAR, and TACAN radio range beam signals. For this operation the pilot uses the Automatic Approach Switch, and the Heading Selector. The Heading Selector is located on the pilot's section of the main instrument panel.



HEADING SELECTOR



AUTOMATIC
APPROACH
SELECTOR



REPEATER
AMPLIFIER

A Repeater Amplifier serves as a power distributor and amplifier for this system. The power source for the amplifier is the autopilot power system. The Repeater Amplifier is mounted on the main radio rack.

For automatic range operation the pilot first moves the Automatic Approach Switch to the RANGE position. Next the BLUE LEFT/BLUE RIGHT switch is set. The BLUE RIGHT position is used for OMMI operation. Either the BLUE LEFT or BLUE RIGHT is selected for VAR operation depending on the direction of flight. Then the Heading Selector must be set to the desired heading. In setting the Heading Selector the knob in the lower left corner is rotated until the double needle is on the desired course. The single needle on the Heading Selector shows the magnetic heading of the aircraft as it is connected to the autopilot Gyrosyn Compass System. If VAR range operation is desired the pilot must also set the Course Selector on the pilot's Course Indicator to the desired OMMI heading.

Once the above procedures have been completed the aircraft will turn to and stay on the desired heading. The maximum turn during the turn to the heading is 45 degrees.

Under crosswind conditions the autopilot may "hunt" from side to side of the course to the OMMI station. To eliminate the "hunting" align the double needle of the heading selector with the average heading shown by the compass heading pointer.

SERIES AIRCRAFT

1. INSTRUMENTS

- a. H-5 or H-5 gyro heading utilized.
- b. Warning light will come on with loss of any phase.
- c. Green landing gear indicator lights, one for each gear.
- d. The selector switch for H-5 or Omni range. (See heading)

2. AUTOPILOT

- a. Flux valve located in the vertical stabilizer.
- b. Selector switch located on pedestal for autopilot controller.

3. REMOTE COMPASS

- a. Flux valve located in vertical stabilizer.
- b. Two master indicators.
- c. Two controller panels.
- d. Two indicator panels.
- e. Selector switch located on pilot's instrument panel.
- f. Master indicator cards:
 1. Stabilized magnetic heading, or gyro heading if selected.
 2. Reciprocal heading.
 3. Gyro heading indicator. (Non-stabilized magnetic heading).

INSTRUMENTS

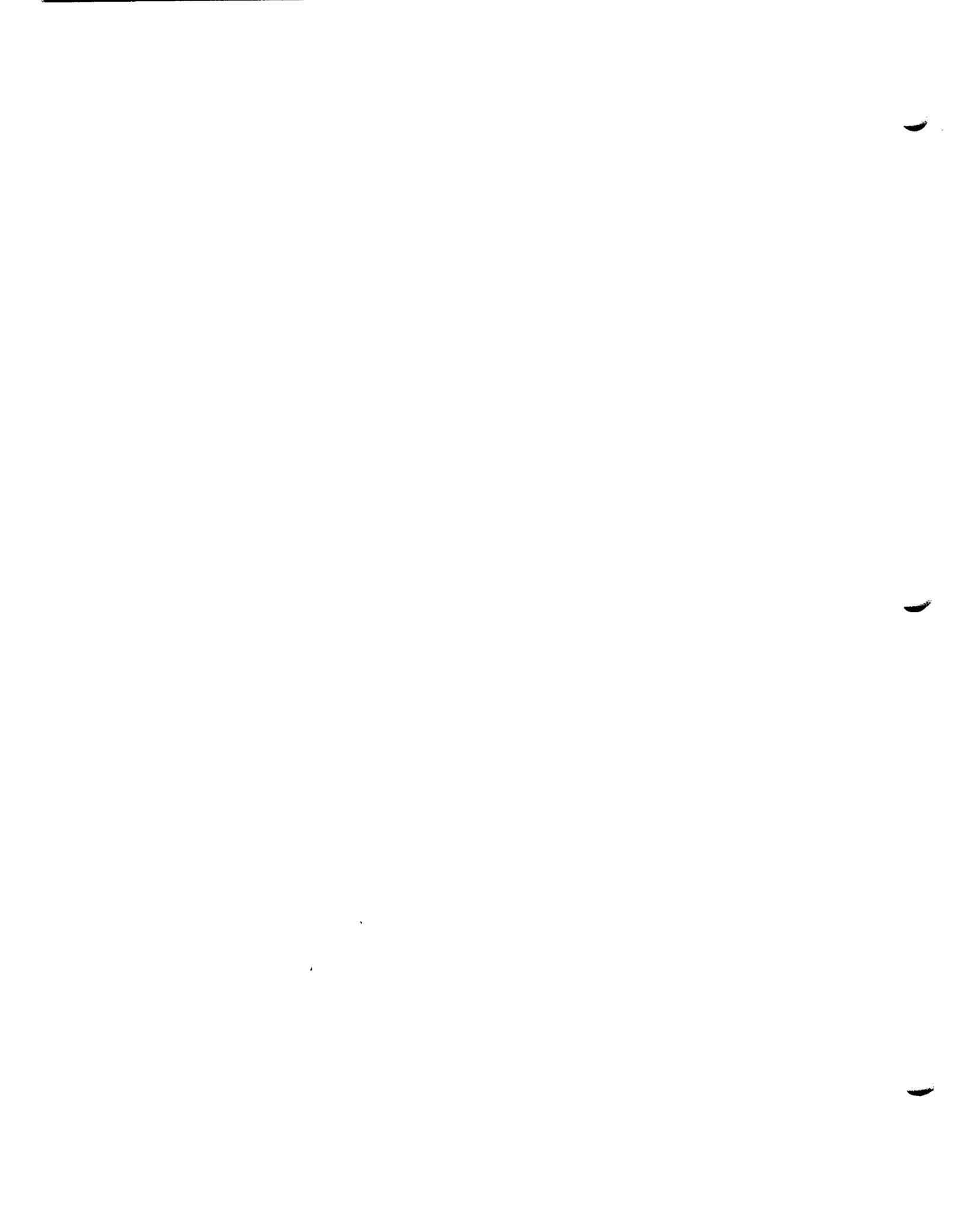
- a. H-5 utilized.
- b. Warning light will come on with loss of any phase.
- c. Selsyn gear indicators.
- d. Blown H-5 Gyro fuses will not cause inverter warning lights to come on.

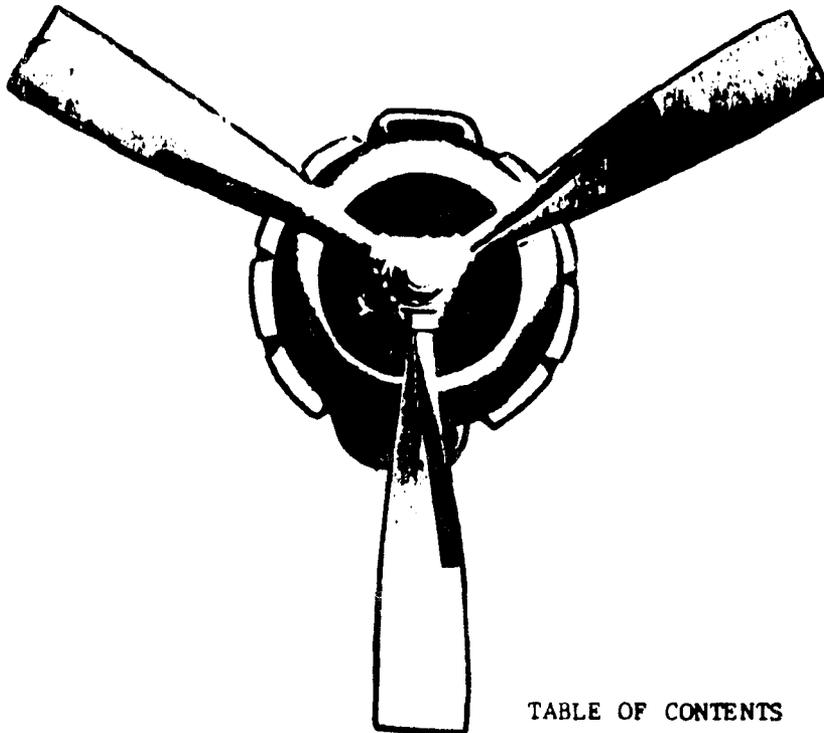
AUTOPILOT

- a. Flux valve located in the wing tip.
- b. Selector switch located on pilot's instrument panel.

REMOTE COMPASS

- a. Flux valve location:
 1. Pilot's in left wing tip.
 2. Co-pilot's in right wing tip, approximately 18 inches from autopilot flux valve.
- b. Two master indicators.
- c. Two controller panels, located on pilot's and co-pilot's instrument panels.
- d. No pre-set knob on indicator.
- e. Switch located on pilot's and co-pilot's controller panel.
- f. All indicators have two cards:
 1. Stabilized magnetic heading, or gyro heading if selected.
 2. Reciprocal heading.
 3. None.



**TABLE OF CONTENTS**

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Chapter 1**PROPELLER DESCRIPTION**

Each of the four engines is equipped with a Hamilton Standard, three blade, full feathering, reversible pitch, constant speed propeller, which is 13 feet 6 inches in diameter. During constant speed operation, the required blade angle is maintained hydraulically. RPM settings are selected electrically through the propeller governor head (stepmotor). The propeller assembly consists of the Hub and Blade Assembly, Dome Assembly, Low Pitch Stop Lever Assembly and the Oil Transfer Housing.

Constant engine RPM can be maintained automatically or manually through changes in propeller blade angles. All four propellers are maintained in automatic synchronization by an electric synchronizer system. The pilot is provided with four individual selector switches, a master engine selector switch, a master RPM control lever, a resynchronizing switch and four feathering buttons. Reversing is initiated by actuating the throttle micro-switches, after the reverse arming bar is moved to the

aft position.

A propeller feathering system transfers oil from the engine oil tank to the propeller feathering pump and then to the propeller governor.

An electrical master RPM control system controls and synchronizes the RPM of the four engines.

The propeller has an electric de-icing system. Electrically heated elements are attached to the leading edge of each propeller blade. Power is supplied from the starter bus to the de-ice brush assembly attached to the engine nose section and is then transmitted to the rotating propeller.

The two forces that control the propeller are the centrifugal twisting moments on the propeller blades and the oil, delivered under pressure by the pump, in the governor assembly (constant-speed control). The centrifugal twisting moment is a component force which acts on the blades of the rotating propeller tending to move the blade toward low pitch. The

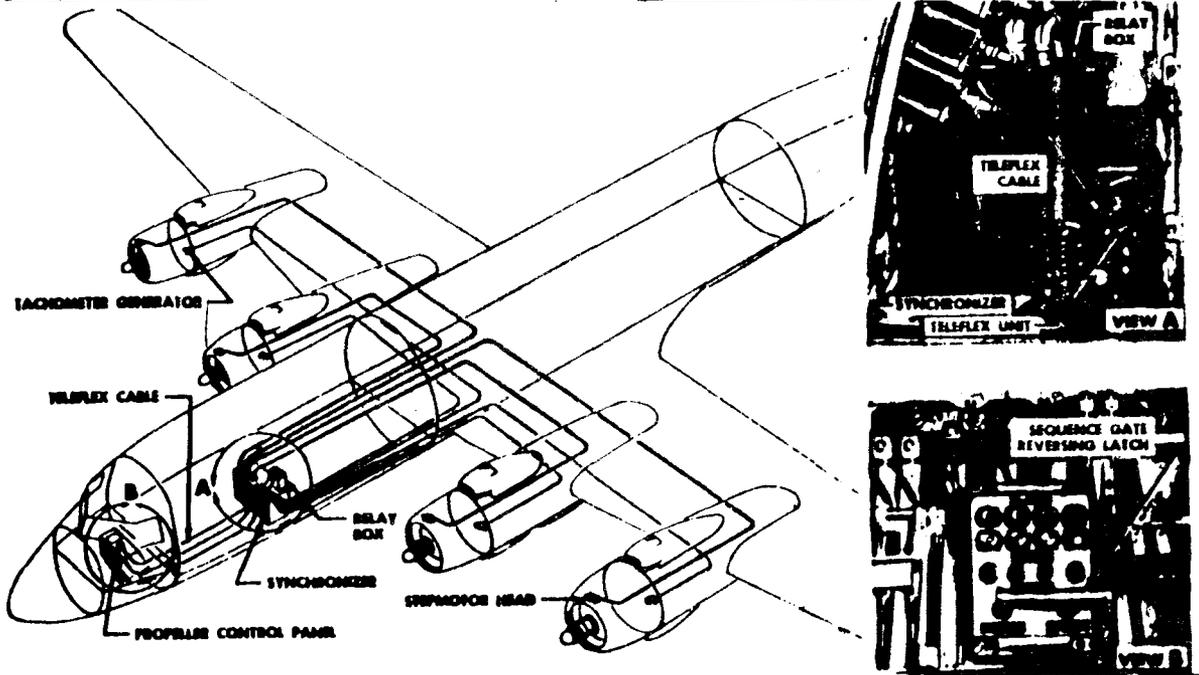
oil pressure is directed as required by the governor assembly (constant speed control) to either the increase or decrease side of the propeller piston.

Blade angles specified for this propeller installation are:

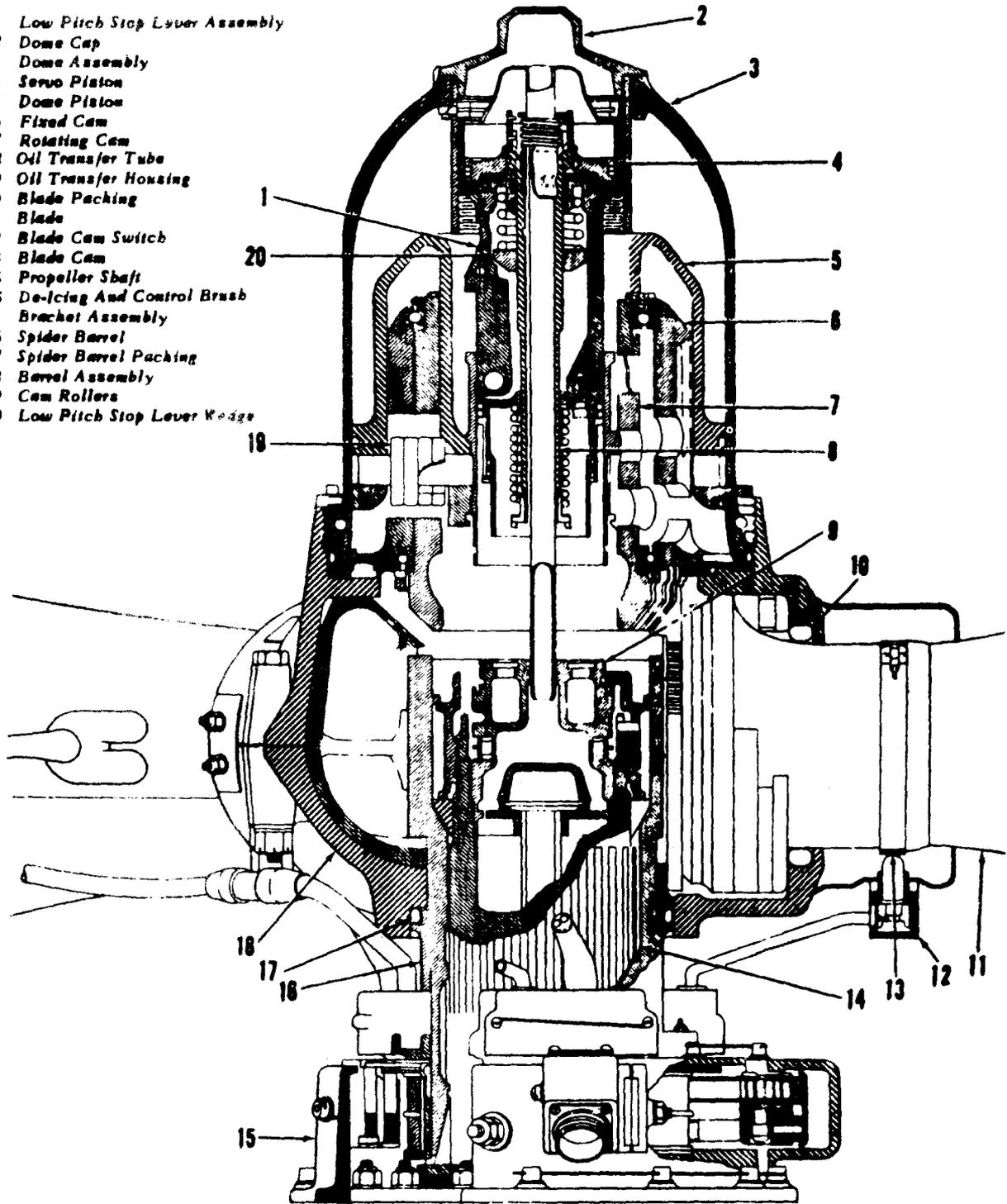
Low Pitch	+30 Degrees
Feather Pitch	+96 Degrees
Reverse Pitch	- 8 Degrees

The governor RPM Control limits are set to control the engine RPM between a range of 1200 ± 50 RPM and 2800 ± 25 . Normal continuous range of operation is 1400 to 2600 RPM. The range between 2600 and 2800 RPM is termed the limited range of operation.

Feathering the propeller in flight is accomplished by depressing the feathering switch. A normal feathering cycle should be completed in approximately 12 to 15 seconds. The mechanical stop rings limit the blade angle to a $+96^\circ$ for feather. The maximum indicated air-speed at which the unfeather operation should be accomplished is 135 knots.



- 1 Low Pitch Stop Lever Assembly
- 2 Dome Cap
- 3 Dome Assembly
- 4 Servo Piston
- 5 Dome Piston
- 6 Fixed Cam
- 7 Rotating Cam
- 8 Oil Transfer Tube
- 9 Oil Transfer Housing
- 10 Blade Packing
- 11 Blade
- 12 Blade Cam Switch
- 13 Blade Cam
- 14 Propeller Shaft
- 15 De-icing And Control Brush Bracket Assembly
- 16 Spider Barrel
- 17 Spider Barrel Packing
- 18 Barrel Assembly
- 19 Cam Rollers
- 20 Low Pitch Stop Lever Wedge



Cutaway View of Propeller Assembly

Chapter 2

PROPELLER GOVERNOR

Normal Governor Operation

Each propeller is directly controlled by a double acting hydraulic governor. The propeller governor includes the electric stepmotor head, speeder rack and spring, flyweights, and pilot valve. Operating inside the governor is the governor oil pump, high and low pressure relief valves, and the solenoid selector valve. This selector valve is electrically energized. Open for reverse and unfeather. When the valve is de-energized it is spring loaded closed for feather and unreverse.

The governor flyweights are driven by a shaft coupled to the reduction gears in the engine. The pilot valve in the body of the governor directs oil pressure to the forward or aft side of the dome piston as required to effect necessary blade angle changes. The speeder spring holds the pilot valve down and the flyweights tend to pull it up. By increasing and decreasing compression on the speeder spring, the engine RPM can be varied.

During normal flight, the desired RPM is selected by imposing the required amount of compression on the speeder spring. Whenever the RPM surges over the desired setting, the RPM of the flyweights increases and the additional centrifugal force, forces them to fly up. This movement of the pilot valve allows oil to flow to the forward side of the piston increasing blade angle and decreasing RPM until the compression of the speeder spring and the centrifugal force acting on the flyweights are again in balance.

If the RPM should fall below the desired setting, the flyweights having less centrifugal force will be overcome by speeder spring compression and move inward. The speeder spring then is holding the pilot valve down and oil

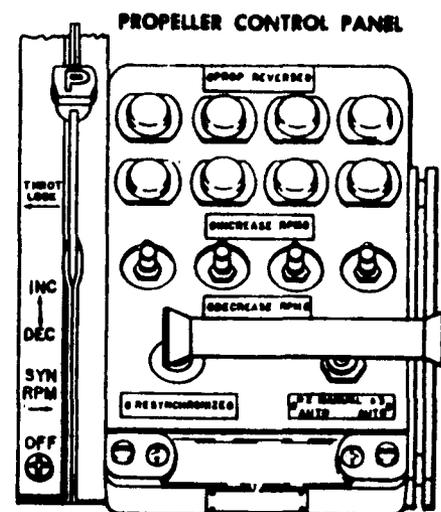
will flow to the inboard side of the piston, decreasing blade angle and increasing RPM until once more the centrifugal force acting on the flyweights and speeder spring compression are in balance.

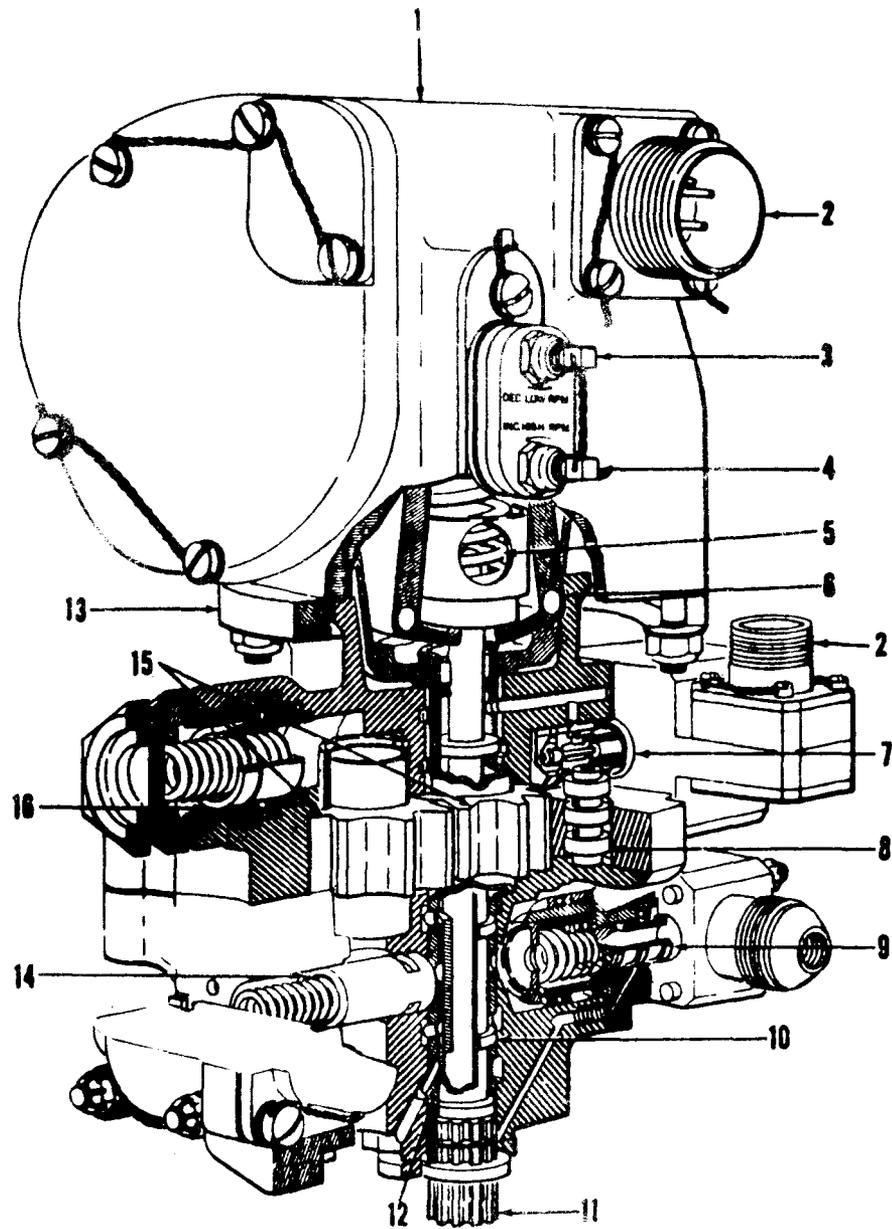
The oil for the governor oil pump comes under pressure from the engine nose section. The pressure is boosted by the governor oil pump to the required operating pressure of the propeller. Normal operating pressure is limited to 90 PSI by the low pressure relief valve.

During feathering, unfeathering, reversing, and unreversing, the pilot valve is held down or up, as required, by auxiliary oil pump pressure directed to the top or bottom of the pilot valve through an electrically operated solenoid valve. When any one of these operations is used, the governor head is completely bypassed.

Propeller RPM Limit Lights

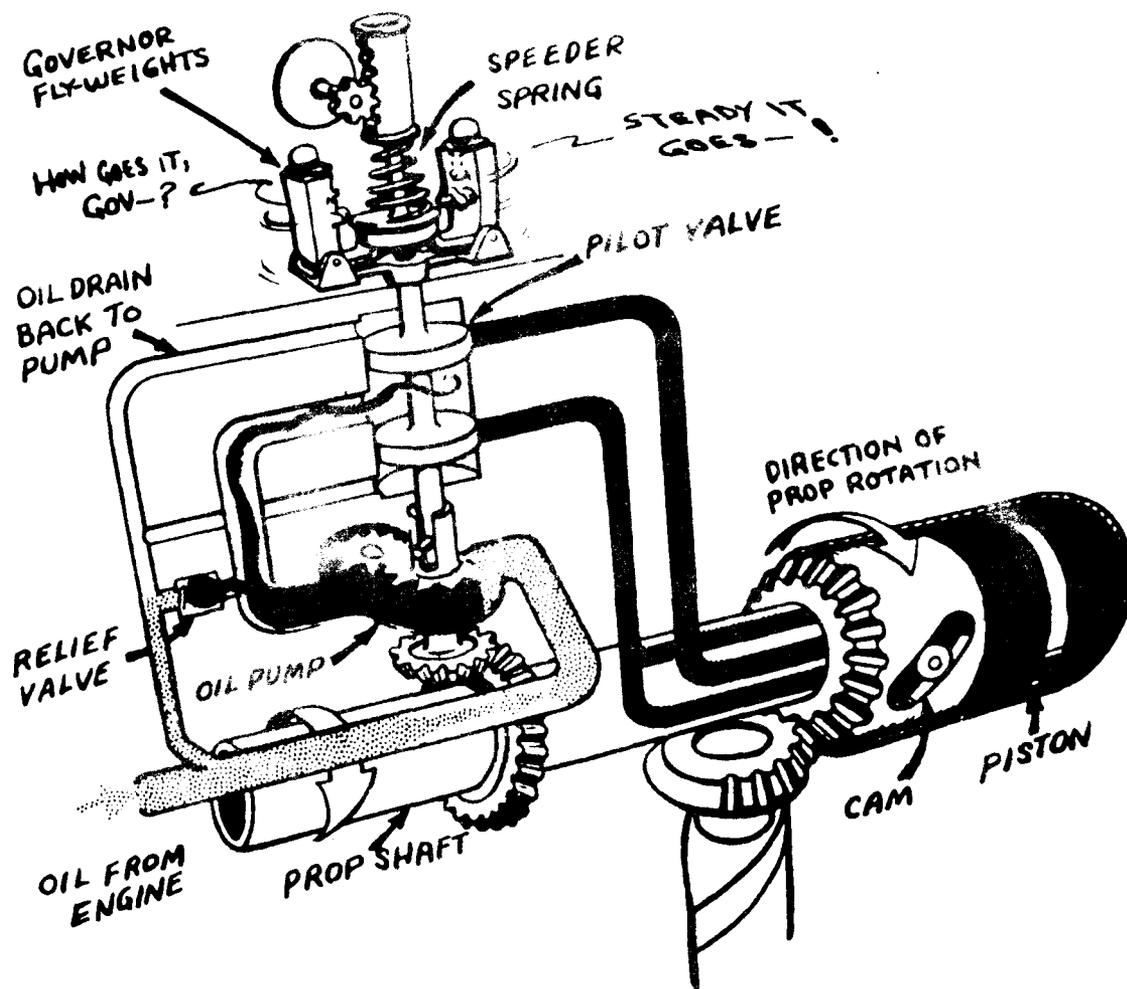
Four blue lights on the propeller control unit of the pilot's control pedestal illuminate to indicate when the maximum or minimum governor RPM limit setting is reached.





- | | |
|-----------------------------|--------------------------------------|
| 1 Stepmotor Control Head | 9 Check Valve |
| 2 Electrical Receptacle | 10 Pilot Valve |
| 3 Low RPM Adjustment Screw | 11 Drive Shaft Coupling |
| 4 High RPM Adjustment Screw | 12 Drive Shaft |
| 5 Speeder Spring | 13 Stepmotor Control Head Clamp Ring |
| 6 Flyweight | 14 Low-Pressure Relief Valve |
| 7 Solenoid Valve | 15 Governor Pump Gear |
| 8 Selector Valve | 16 High-Pressure Relief Valve |

Propeller Governor

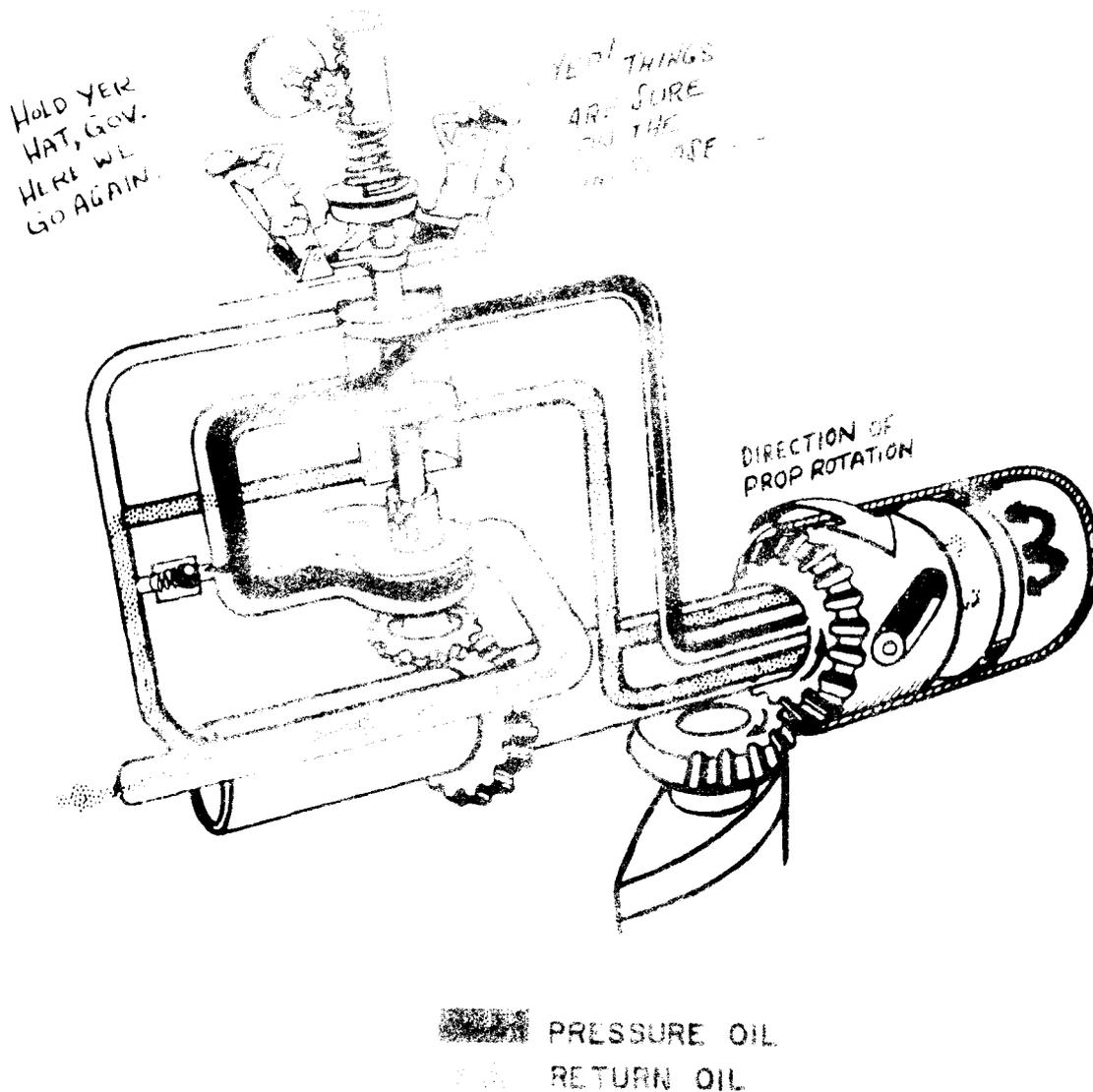


On-Speed (RPM Remains Steady)

This condition exists when the air-speed, altitude and engine power of the aircraft are constant. The speeder spring has been set by the pilot for the RPM desired. The flyweights moved the pilot valve which directed oil to the piston in the hub. This, in turn,

moved the propeller blades until they found a pitch that absorbed the engine power at RPM selected by the pilot.

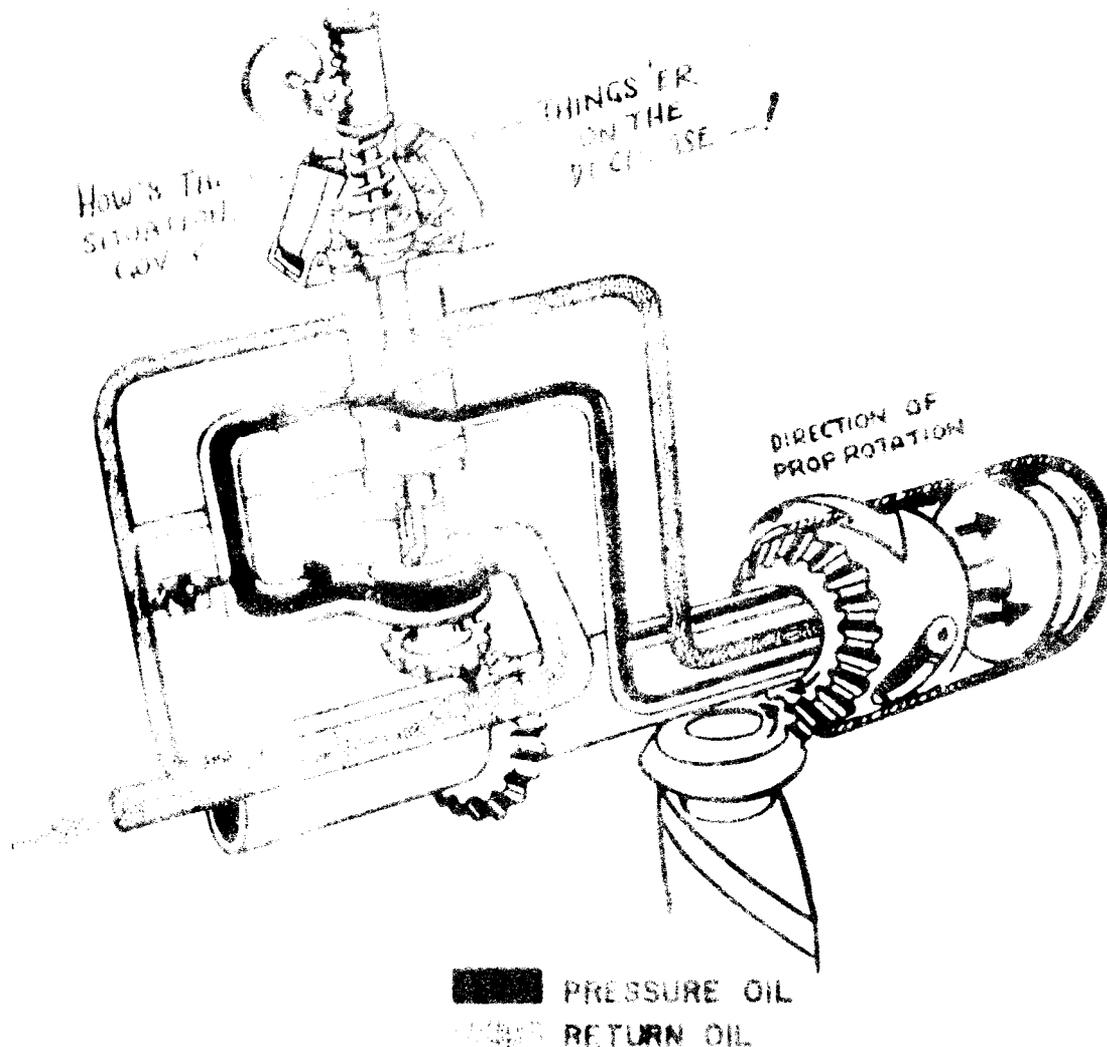
When that moment of speed balance occurred, the forces of the flyweights balanced the speeder spring load and positioned the pilot valve in the neutral or constant speed position.



Overspeed (RPM Increase)

This condition results, for example, when a let-down is started causing an increase in airspeed while still using the same power output from the engine. When the airspeed increases, the pitch setting, in effect, becomes too low. Therefore, it requires less power to turn the propeller. The engine

is still developing the same power, so it starts to overspeed. This will cause the flyweights to spread out, thus lifting the pilot valve, so that oil flow is routed to the front side of the piston in the dome. The piston pushes the cam, which, in turn, twists one blades to higher pitch. The engine speed slows down to its former RPM setting.



Underspeed (LPM) Condition

This condition occurs when the engine will start to slow down in flight and the propeller speed becomes too high due to a reduction in air speed while the power remains constant. In order to keep the propeller speed at the same RPM, while the air speed is effectively increased, an increase in power is required from the engine to increase the

engine power. When the speed of the propeller in the climb will cause the engine to slow down, thus causing underspeeding. This makes the elevator droop, moving the pilot valve to the position shown above. Oil then flows to the inboard side of the piston. The resulting action twists the piston to a lower pitch, automatically increasing the speed of the engine to the former RPM setting.

Chapter 3

PROPELLERS AND REVERSING

Propeller Feathering

A propeller feathering oil assembly is installed on the aft side of each of the propeller pistons just forward of the firewalls. The assembly consists of an electrical motor, and adapter assembly and feather pump. An aluminum threaded motor motor switch assembly connects the accumulator to the motor entering the pump of the feathering assembly.

Propeller Feathering Oil

Engine oil from the engine to the engine oil separator feeds the propeller feathering pump. The pump feeds forward to the engine oil supply tank. The separator insures a reserve supply of oil which is sufficient to operate the propeller two times. The propeller-feathering oil outlet in the bottom of the tank sump also has a small standpipe. Any sludge that may enter the tank accumulates around the base of the standpipes and is drawn there, preventing its entrance into the engine lubricating system or the propeller feathering system.

Feathering Switch

Four feathering switches are mounted on the forward instrument panel. The switches are push-pull type having three positions. Fully depressed is the feathering position. Pulled full out is the unfeathered position. The switch is spring loaded to the neutral, or normal, unfeathering position which is half-way between the feather and unfeather positions.

When the switch is depressed, a circuit is established from the electrical bus through the switch holding coil and the propeller timer, located in a relay box aft of the pilot's station.

The timer operates to terminate feathering. As long as the circuit remains closed the holding coil keeps the switch in the depressed position. Closing the feathering switch completes a circuit from the electrical bus to the feathering pump motor. The feathering pump picks up oil from the engine oil tank and supplies it under pressure to the propeller governor where it combines with the oil output from the governor pump. The oil is then directed into the forward, or increase pitch side of the propeller dome piston. Movement of the dome piston stops as the blades reach +96° or the feathered position. The feathering timer will continue to operate 12 to 15 seconds, after the switch is depressed, then the timer will break the circuit to ground, de-energizing the switch holding coil and allowing the switch to pop out to neutral, thus stopping the feathering pump.

To unfeather, the feathering switch is manually pulled out and held momentarily (A maximum of two seconds). This completes the circuits to energize the feathering pump and the governor reverse unfeather solenoid valve (open). Feathering pump oil pressure is then exerted against the decrease-pitch or aft side of the propeller piston to unfeather or change propeller blades to a lower angle. At the first indication of propeller windmilling, the feathering switch is released, unfeathering stops,

and normal constant-speed governor controlled operation is resumed. In case the feathering switch is inadvertently held out too long, the propeller blade control switch on #1 blade will break the circuit and de-energize the governor solenoid valve (close it) well above the low pitch angle.

A sequence gate reversing latch mechanism, (called-The Reverse Throttle Lock) is incorporated into the control pedestal at the rear of the copilot's throttle quadrant. The mechanism consists of a ball bearing detent roller attached to each throttle lever on the throttle quadrant; a gate assembly, pivoted from the pedestal structure, which blocks the throttles from the reverse range during normal throttle operation; and a reverse-unlock handle (Reverse Throttle Lock), between the pilot's and copilot's throttles, which must be operated to unlock the gate assembly for reverse operation. The mechanism is sequence-interlocked so that the throttles must be full open or closed before the reverse-unlock handle can be depressed and the reversing operation initiated. The mechanism also provides an automatic reset upon the return of one or more throttles to the forward power range.

Reversing Operation

Reversing is initiated by movement of the throttle into the reverse portion of the quadrant after the Reverse Throttle Lock has been positioned. This action energizes the governor solenoid, opening its valve to direct governor pump oil to the upper positioning chamber in the pilot valve sleeve, and also starts the propeller feathering pump. The pilot valve is moved to the under-speed position, where it directs governor pump and feathering pump oil to the aft side of the piston, forcing it forward. At the same time, pressure is exerted against the servo piston valve.

When the pressure is sufficient the valve opens and the pressure is exerted against the servo piston, moving the piston and the servo piston shaft forward. As soon as the stop lever wedge is pulled beyond the stop levers, they close in rapidly, out of the way of the piston sleeve. The piston continues forward turning the rotating cam, which moves the blades toward reverse blade angle.

When the propeller reaches the reverse position, the piston sleeve has moved far enough to allow the high-pressure oil to dump through the slots in the aft end of the piston sleeve to the forward side of the piston. Four amber lights on the pilot's control pedestal illuminate when the propeller is in reverse thrust.

Unreversing Operation

During the unreversing operation, which is initiated by moving the throttle into the forward portion of the quadrant, feathering pump oil is directed to the lower positioning chamber thus positioning the governor pilot valve for overspeed operation. Feathering pump oil is delivered to the forward side of the propeller piston to move the propeller blades toward positive pitch in the constant-speed range.

As soon as the blades reach an angle of five to seven degrees above the low-pitch setting, the control switch on blade No. 1 closes to energize the unreversing termination circuit. The governor (constant-speed control) now assumes control of the propeller in the constant-speed range.



Chapter 4

PROPELLER SYSTEM CONTROLS

The components of the propeller control system are a propeller synchronizer, master RPM control lever, master engine selector switch, individual selector switches and resynchronizing switch. Other controls are the throttle actuated reversing switches, tachometer isolation switches and feathering switches.

The Individual Selector Switches

The selector switches are toggle type, one for each engine. They are mounted on the propeller control panel and have three positions. The center position is spring loaded OFF, forward is INCREASE RPM and aft is DECREASE RPM.

These switches provide RPM variation for any engine independent of other engines and can be used with the Master Engine Selector Switch in either the AUTOMATIC or MANUAL position.

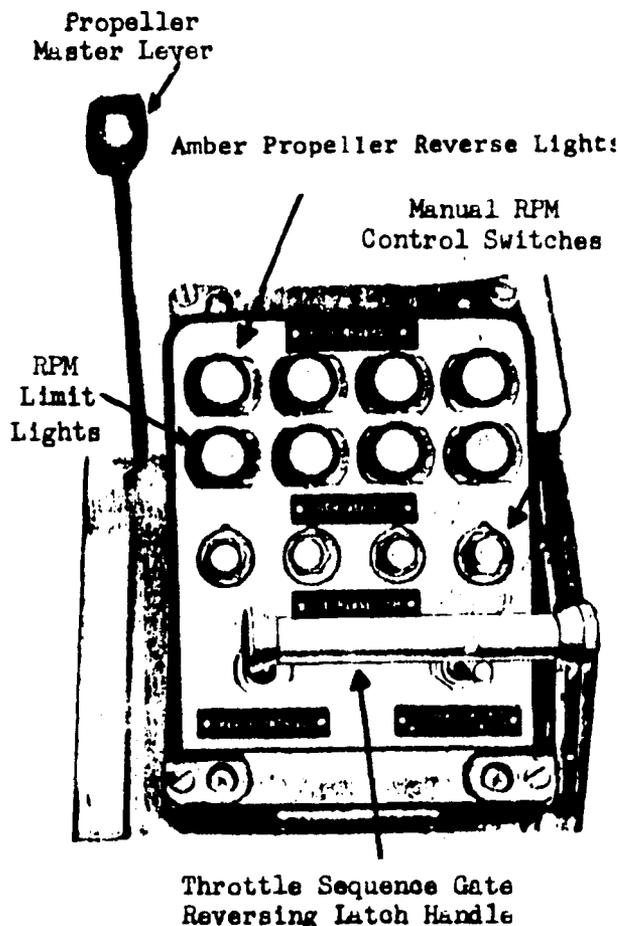
While the individual selector switches can be used to vary the RPM of one or more engines, the engine being used as the MASTER should be controlled by the MASTER RPM CONTROL LEVER, during automatic operation. If an individual selector switch is used to change a slave engine RPM more than 3% away from master engine RPM, the master cannot pull the slave back into synchronization because synchronization is limited to 3% of the operating engine RPM. For more than 3% corrections, the limited range mechanisms must be reset by depressing and releasing the synchronizer switch.

A blue light is mounted adjacent to each individual selector switch and illuminates when the corresponding

governor reaches the high or low RPM limit setting.

Propeller Master RPM Control Lever

This lever adjacent to the propeller control unit operates all four propeller governors simultaneously. Forward movement of the synchronizer lever causes an increase in RPM. Aft movement causes a decrease in RPM. The lever is used in conjunction with the automatic propeller synchronizing



system and is operative only when the propeller automatic control switch is in the Nr 2 MASTER or Nr 3 MASTER position. When the master lever is put in the full forward position, it actuates a switch which cuts out the synchronizing circuit as long as the master lever is in that position. Thus, failure of the master engine on takeoff will not affect the speed of the slave engines.

The Electrical Synchronizing System

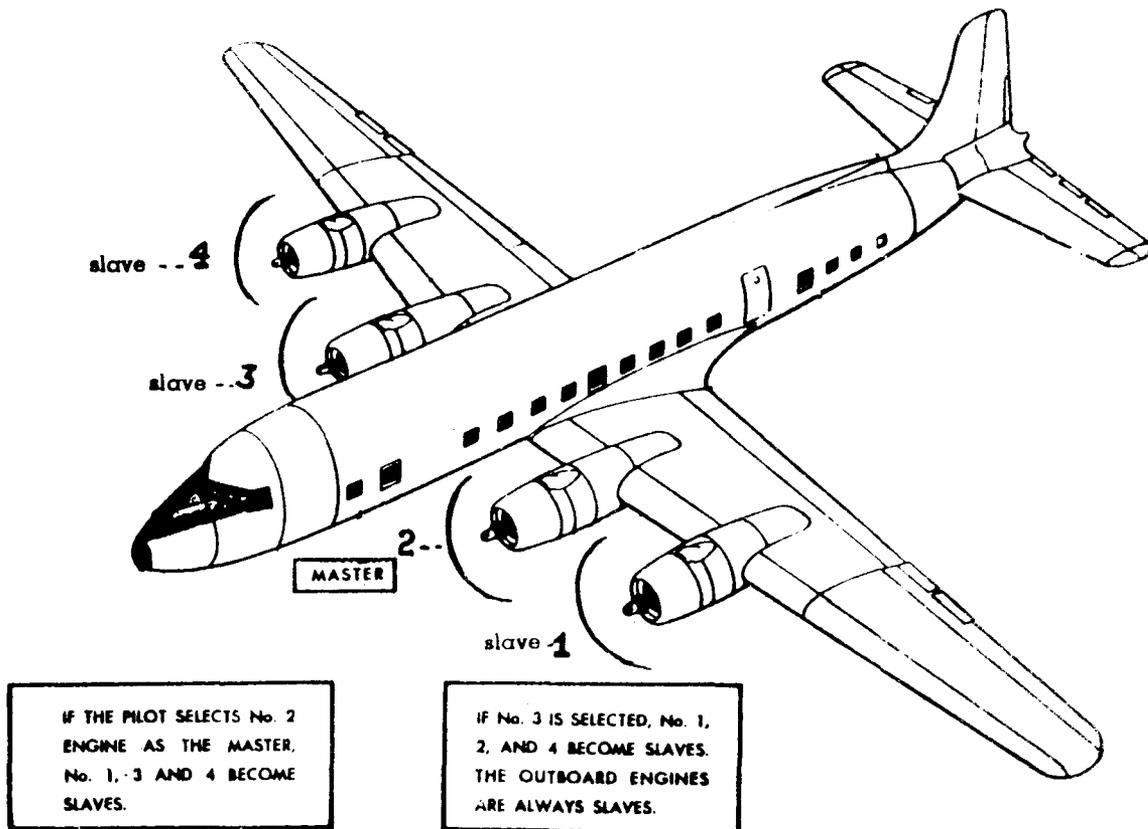
The propeller synchronizer is housed in a compact moisture proof case installed on the left side of the compartment just forward of the forward baggage compartment. It provides a means of controlling and synchronizing the RPM of the four engines. Either Nr 2 or Nr 3 engine may be selected for master RPM reference. Each propeller is under governor control at all times so that

constant speed operation is retained in event of failure of the synchronization system.

Synchronization of all engines is available throughout the entire operating range and is limited to 3% INC or DEC of slaves toward master engine RPM at a time. For more than 3% correction of the slave engine RPM the resynchronizer switch must be depressed and released. As soon as it is released another three percent increase or decrease is available.

Propeller Auto Control Switch

The automatic propeller synchronizing system is controlled by a three position switch, marked Nr 2 MASTER, MANUAL, Nr 3 MASTER, on the propeller control panel. When the switch is in the Nr 2 or Nr 3 MASTER posi-



tion the selected engine becomes the master which the other engines follow. When the switch is in the **MANUAL** position, the automatic synchronizing and master lever system are de-energized.

The range of control is 3% increase or decrease of the operating engine RPM. This feature prevents slave engines from going either above or below the controlled range in event of master engine malfunction. An ON - OFF switch type circuit breaker for the auto control switch is located on the MAIN circuit breaker panel.

Synchronizer

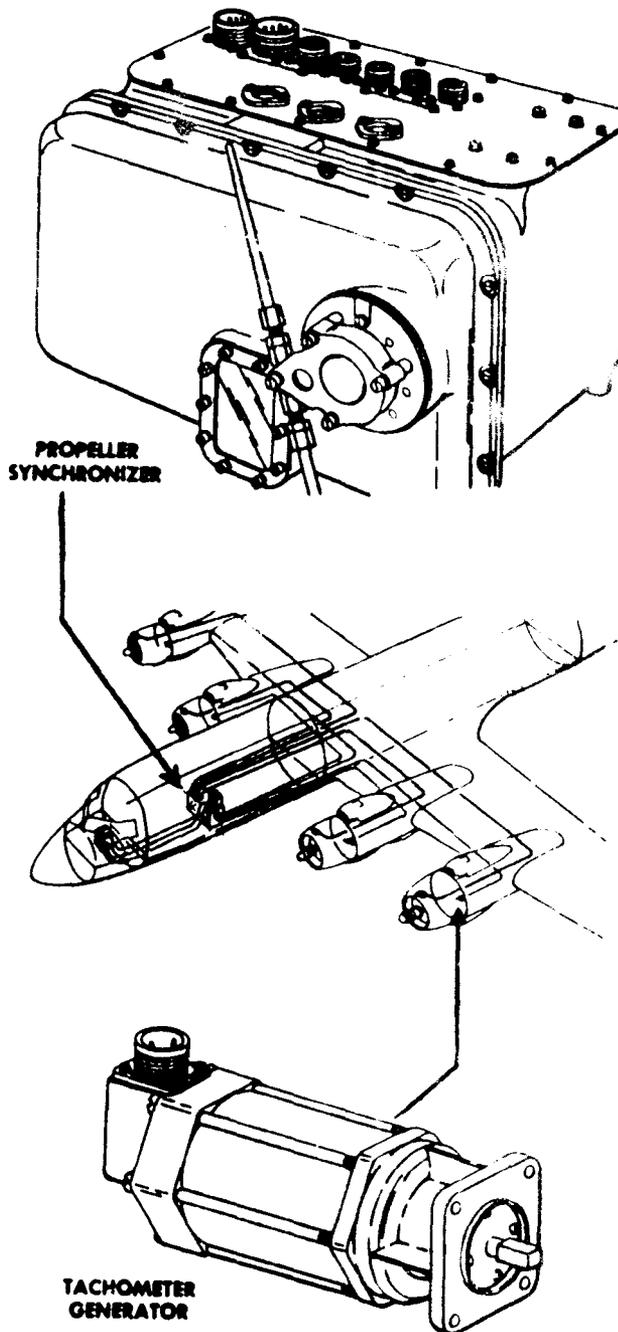
A tachometer generator, mounted on the accessory section of each engine, supplies the electrical power for the synchronizer to compare the RPM of the four engines. The same tachometers also provide voltages for the engine RPM indicators in the cockpit. Two tachometer isolation switches are located on the panel aft of pilot's position. They may be used to disconnect the tachometer generators from the synchronizer system without interfering with operation of the master lever or RPM indicators in the cockpit.

The Resynchronizing Switch

This switch is a push-button type, spring loaded to the OFF position, mounted on the propeller control panel adjacent to the master engine selector switch. During flight the resynchronizer switch should be used after each time the RPM is changed with the master lever **EXCEPT** when master lever is in **FULL** increase RPM position, at which time synchronization is inoperative.

With master engine selected, synchronization is automatic after RPM change by master lever, but is limited to 3% by the limited range mechanism.

Each time the resynchronizing switch is depressed and released, it permits slave engines to progress another 3% toward the master engine RPM, until all engines are in synchronization.



DEICING SYSTEM

The propellers are protected from ice formation by an electric deicing system, which consists of heating elements mounted on the leading edges of the blades. The elements create sufficient intermittent heat to raise the blade surface temperature above the freezing point so that existing ice is loosened and is thrown off periodically by centrifugal force.

The system is equipped with a timing device, mounted in the fuselage accessories compartment, that controls the flow of current to the heating elements. To prevent an excessive power drain from the aircraft's electrical system, the timer energizes each propeller deicing circuit in sequence.

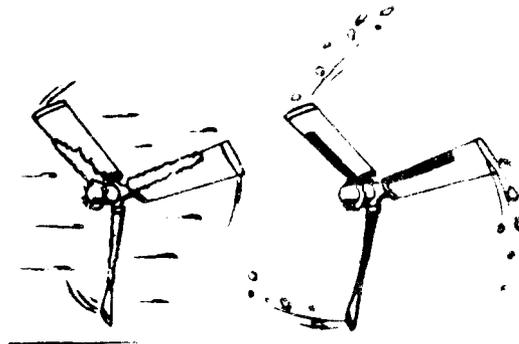
The propeller deicing system is controlled by a single ON-OFF master switch on the heater control panel. Four 2-position selector switches mounted on the aft overhead panel are provided to select automatic TIMER operation or MANUAL operation in the event of timer failure, or if it is desired not to deice one propeller. The switches are normally guarded to the TIMER position. An ammeter with a selector switch is mounted on the aft overhead panel. Positioning the ammeter selector switch to the desired propeller will indicate the current load for the propeller when the timer cycles the selected propeller ON.

For manual operation, position the individual selector switches to MANUAL and rotate the ammeter selector switch in sequence to the four positions (the ammeter reading will be indicated and the propeller selected will be deiced). Unlimited ground operation of the propeller deicing system is permissible when the engines are running at genera-

tor cut-in speed. Takeoffs and landings can be made with the system in operation.

When manually deicing all four propellers, it is recommended that the deicing time period for each propeller does not exceed 60 seconds ON and 180 seconds OFF. Partial timer and manual deicing operation is not recommended as it is possible to have a manually selected propeller and a timer selected propeller on at the same time with a possibility of overloading the generators. (Approximately 200-ampere load per propeller is required for propeller deicing.)

When the engines are not running, the propeller deicing system must not be left ON for longer than one cycle, because the propeller blades do not have a cooling airflow. Allow a minimum of 30 minutes between operations so that the heating elements can cool sufficiently. The propeller deicing system circuits are opened and the system is inoperative during propeller feathering, unfeathering, reversing and unreversing operation.



Ice is allowed to accumulate.

Heat is turned on. Centrifugal force throws ice off.

Chapter 6

INSPECTIONS AND CHECKS

Exterior InspectionsPropeller Deicer Brush Block

Check general condition, security and that the brush block is bolted in place.

Propeller Blades and Dome

Check for blade looseness, pitting, nicks and cracks. Dome for excessive oil leaks, dome retainer nut safetied and for burned or charred area where the electrical lead enters the deicer boot. Check blade switch leads for security.

Interior Check

Propeller deicer switches - OFF
Tachometer isolation switches - NORMAL
Emergency propeller deicer switches - TIMER
Propeller master lever - FORWARD
Master engine selector switch - Nr 3 MASTER
Governor limit lights - ON

Runup ChecksDeicer Check

Set throttles to 1500 RPM. The propeller deicer switch should be turned ON and the propeller deice ammeter checked for a twenty second cycle on each propeller. The switch should then be placed in the OFF position. The minimum amperage during this check should be 150 amperes and the desired amperage is 180 to 225 amperes.

Propeller Check

1. Place master engine selector switch in the MANUAL position, propeller

selector toggle switches to DECREASE RPM and hold until 1200 \pm 50 RPM is reached and the limit lights illuminate.

2. Move propeller selector switches to INCREASE RPM until 1500 RPM is reached and the limit lights illuminate.

Note: The limit lights should go out and come on again after approximately 12 to 14 seconds.

3. Place master engine selector switch on Nr 2 MASTER position, pull master control lever to the full DECREASE RPM position and wait until 1200 \pm 50 RPM is reached and the limit lights illuminate.
4. Change master engine selector switch to Nr 3 MASTER position and push master control lever to the full INCREASE RPM position. When 1500 RPM is reached, the limit lights should illuminate.

Feathering Check

Copilot checks Nr 4 and Nr 3 propellers. Pilot checks Nr 2 and Nr 1 propellers. Push in on feathering button, pull out after noting a 200 to 300 RPM drop.

Reversing Check

If the propeller reversing system is checked during the preflight by maintenance personnel, as is the normal procedure, it is not considered necessary for the pilot to repeat this procedure prior to flying. At enroute stops, or when there is a crew change, it is not considered necessary to again check this system if reversing was used

during landing or was checked by home station maintenance prior to departure. During the propeller reversing check, the aircraft should be on a clean hard surface.

1. Close the throttles to the forward thrust idle stops.
2. Set the reverse-unlock handle (Reverse Throttle Lock) to unlock the gate assembly for reverse operation.
3. Move one or more throttles aft through the detent to the reverse idle position.
4. Upon reversal of the propeller, the amber light on the propeller control box will come ON and power may be applied.

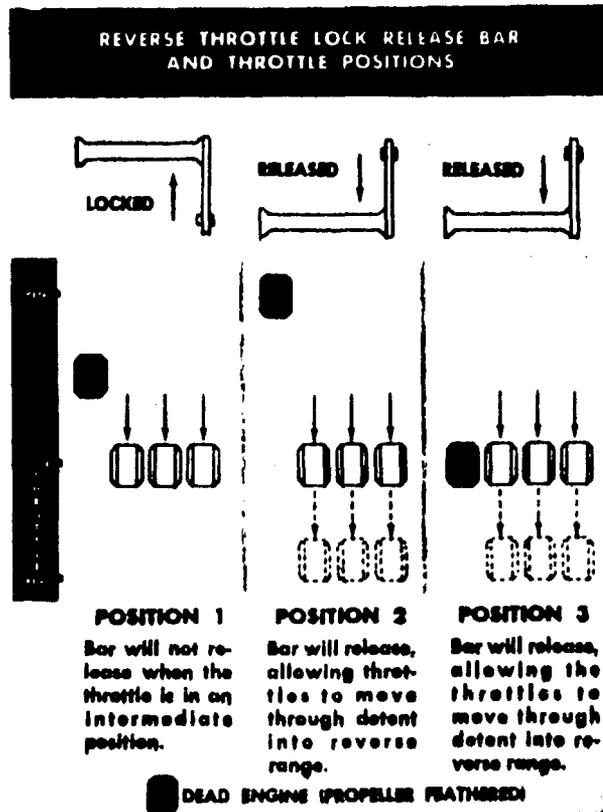
IT IS NOT NECESSARY TO APPLY POWER IN REVERSE DURING THIS CHECK.

5. Move throttle to forward position, amber light should go out.

The reverse-unlock handle must be reset each time a throttle is repositioned to the forward range, if other propeller reverse checks are to be made.

Any malfunction of the reverse-unlock mechanism will not prevent returning the throttles to the Forward position.

Note: If an engine is inoperative or feathered on landing, the throttle for that engine must be in either the OPEN (full forward) or CLOSED (normal idling) position before reversing can be accomplished on the remaining engines.



Chapter 7

EMERGENCY OPERATING PROCEDURES

Propeller Manual RPM Control Malfunction

On early aircraft, if a short circuit occurs in the propeller automatic RPM control circuit, an automatic control circuit breaker will trip, causing the automatic system to become inoperative.

Propeller manual RPM control is normally accomplished by simultaneous actuation of the four propeller selector switches located on the control pedestal; however, in case a short circuit exists in any one of the four individual manual control circuits and the propeller selector switches are toggled simultaneously, a 10 ampere propeller manual control circuit breaker, located on the main circuit breaker panel, will trip and further RPM control will be impossible until the manual control circuit breaker is reset.

To change propeller RPM manually when a short circuit exists in an undetermined individual manual control circuit, proceed as follows:

1. Reset the propeller manual control circuit breaker.
2. Toggle each propeller selector switch separately until the malfunctioning circuit is found (circuit breaker tripped).
3. Reset the propeller manual control circuit breaker.
4. Toggle only the remaining propeller selector switches for RPM change. (Full RPM control is available for the remaining propellers.)
5. Land as soon as possible.

WARNING

Do not actuate the propeller selector switch for the propeller in which a short circuit exists, as the manual control circuit breaker will trip.

On later aircraft, the 10 ampere magnetic type manual control circuit breaker is replaced with a 5 ampere thermal type circuit breaker. A 5 ampere fuse in each of the individual manual RPM control circuits is replaced with a 2 ampere slow-blow fuse.

These changes permit simultaneous actuation of the propeller selector switches, as the 2 ampere slow-blow fuse will open and isolate the shorted circuit without tripping the manual control circuit breaker.

All Engines Hunting Or Surging

If all engines are hunting or surging, attempt to establish synchronized operation as follows:

1. Position the master engine selector switch to the opposite engine.
2. If this does not correct the trouble, place the master engine selector switch in the MANUAL position.
3. If the engines continue to hunt or surge, place the tachometer isolation switches in the EMERGENCY position.

Individual Propeller Out Of Synchronization

If an individual propeller is out of synchronization in AUTOMATIC and the remaining propellers are functioning properly, perform the following:

1. Push the resynchronizing button repeatedly until the propeller is in synchronization.
2. If this does not correct the condition, actuate the respective propeller back into synchronization.
3. If the propeller does not stay in synchronization, place the master engine selector switch in the opposite inboard engine position and push the resynchronizing button.
4. If the propeller will not stay in synchronization, place the master engine selector switch in the MANUAL position and operate the individual propeller selector switches for synchronizing and change of RPM.
5. If the engine tachometers continue to fluctuate, place the tachometer isolation switches in the EMERGENCY position, which deletes automatic operation.

Propeller Overspeeding

If an engine tends to seriously overspeed, indicating that the propeller is not functioning to reduce RPM, proceed as follows:

1. Throttle - CLOSE
2. Airspeed - Decrease to 135 Knots IAS
3. Feathering button - As required
4. Propeller selector switch - Toggle to DECREASE RPM

5. Engine feathering procedure - As required

Note: The two most important factors to be considered in the event of propeller overspeeding are the true airspeed of the aircraft and the power to the engine. If overspeeding occurs during cruise, feather the propeller, reduce all throttles and increase the angle of attack (if conditions permit) in order to slow the aircraft to the recommended 135 Knots IAS as soon as possible. If engine feathering is impossible, reduce the throttle and maintain RPM within limits by regulating the TAS of the aircraft.

Airspeed may be resumed after the propeller becomes stationary. In a high RPM windmilling condition, passengers should be moved out of the plane of propeller rotation. A high RPM windmilling condition may be partially restored to normal by descending to a lower altitude, inasmuch as the propeller windmilling characteristics are a function of true airspeed.

When engine overspeeding occurs, land at the nearest base. The following information should be noted on Form 781 and reported to maintenance personnel: The maximum RPM and manifold pressure that were obtained during flight, duration in minutes of the overspeed condition and overpower condition and the reason for overspeed if known. Allowable RPM is 2800 to 2950, while an inspection is required at 2950 to 3400 RPM. An engine change is required when RPM exceeds 3400 RPM.

Note: Engine overspeeding usually occurs after a momentary power loss that is followed by a return to full engine power.

Unreversing In Flight

If a propeller is inadvertently reversed during flight, proceed as follows:

1. Reduce the airspeed to 135 Knots IAS or less.
2. Move the throttle forward of detent to the CLOSE position.
3. Depress the feathering button.

Note: In case a propeller is reversed immediately after takeoff, make certain the throttle is forward of the detent and feather the propeller. The same pump accomplishes feathering and reversing; therefore, the throttle must be forward of the reverse detent before power is available to the pump for the feathering operation.

Failure of Propeller to Unreverse During Ground Operation

1. If one or more reverse indicator lights remain on after the throttles are returned to forward thrust position (or if failure to unreverse is suspected on aircraft not equipped with reverse indicator lights), check the propeller deicing ammeter for load. If load is indicated, trip affected reverse control circuit breaker(s) and momentarily depress feathering button to position blades to forward thrust position.
2. If propellers are believed to be in reverse pitch after unreversing and no load is indicated on propeller deicing ammeter, toggle propeller to high pitch (low RPM) and advance throttle to approximately 25 inches Hg manifold pressure. If propeller is in forward thrust it will be governed at 1150 to 1250 RPM; if in re-

verse pitch RPM will be approximately 1600 to 1800 RPM.

3. If any of the above procedures fail to accomplish unreversing, secure the engine as follows:
 - a. Throttle - REVERSE range
 - b. Propeller reverse and feathering control circuit breaker - Tripped
 - c. Mixture control lever - IDLE CUTOFF
 - d. Engine - Secure
4. If propeller feathering pump continues to operate beyond usual point of automatic cutoff after unreversing (malfunctioning blade cutout switch), immediately trip feathering pump circuit breaker to prevent full feathering of propeller. Propeller blades should automatically return to the low pitch, high RPM setting. If propeller has reached full feather position, secure the engine as outlined in step 3.

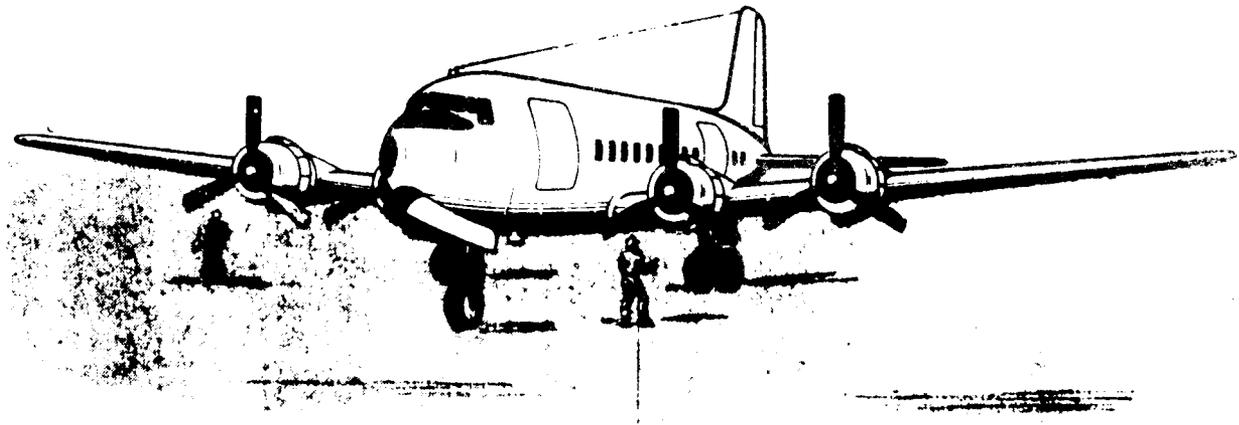
Note: If an engine has been stopped while in reverse, or in the feathered position when coming out of reverse, the engine should be restarted prior to servicing the oil tank. This will preclude overfilling the oil tank when excess oil (pumped into engine nose section by the feathering pump) is returned to the oil tank.

Failure of Propeller to Go Into Governor Control After Unreversing

If the propeller feathering pump continues to operate beyond the usual point of automatic cutoff after unreversing, immediately trip the pro-

propeller reverse control circuit breaker for the affected engine to prevent full feathering of the propeller. The propeller blades will automatically return

to the low-pitch, high RPM setting. If the propeller already has reached the feathered position, secure the engine.



STUDY GUIDE SUPPLEMENT

1951 SERIES AIRCRAFT

VERSUS

1953 SERIES AIRCRAFT

1. PROPELLERS

- a. Aux. pump starts and stops in reverse.
- b. Pressure cutout switch used for feathering.
- c. The #2 blade switch used for reverse and feathering.
- d. Four dual purpose circuit breakers for reverse and feather.
- e. Test switch and lights in spare bulb locker.
- f. No reverse indicator lights.

1. PROPELLERS

- a. Aux. pump runs continuously while in reverse.
- b. Time delay relay used for feathering. Set for 15 seconds.
- c. The #2 blade switch used for the amber lights on .
- d. Four single circuit breakers for feather, two dual circuit breakers for reverse indicators and two dual circuit breakers for reverse control.
- e. None available.
- f. Amber reverse indicator lights.



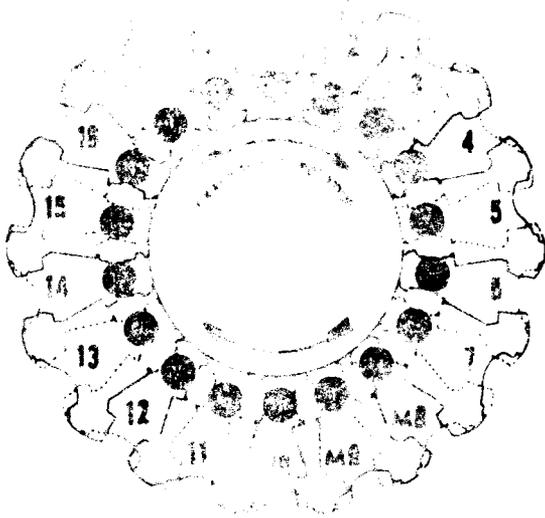


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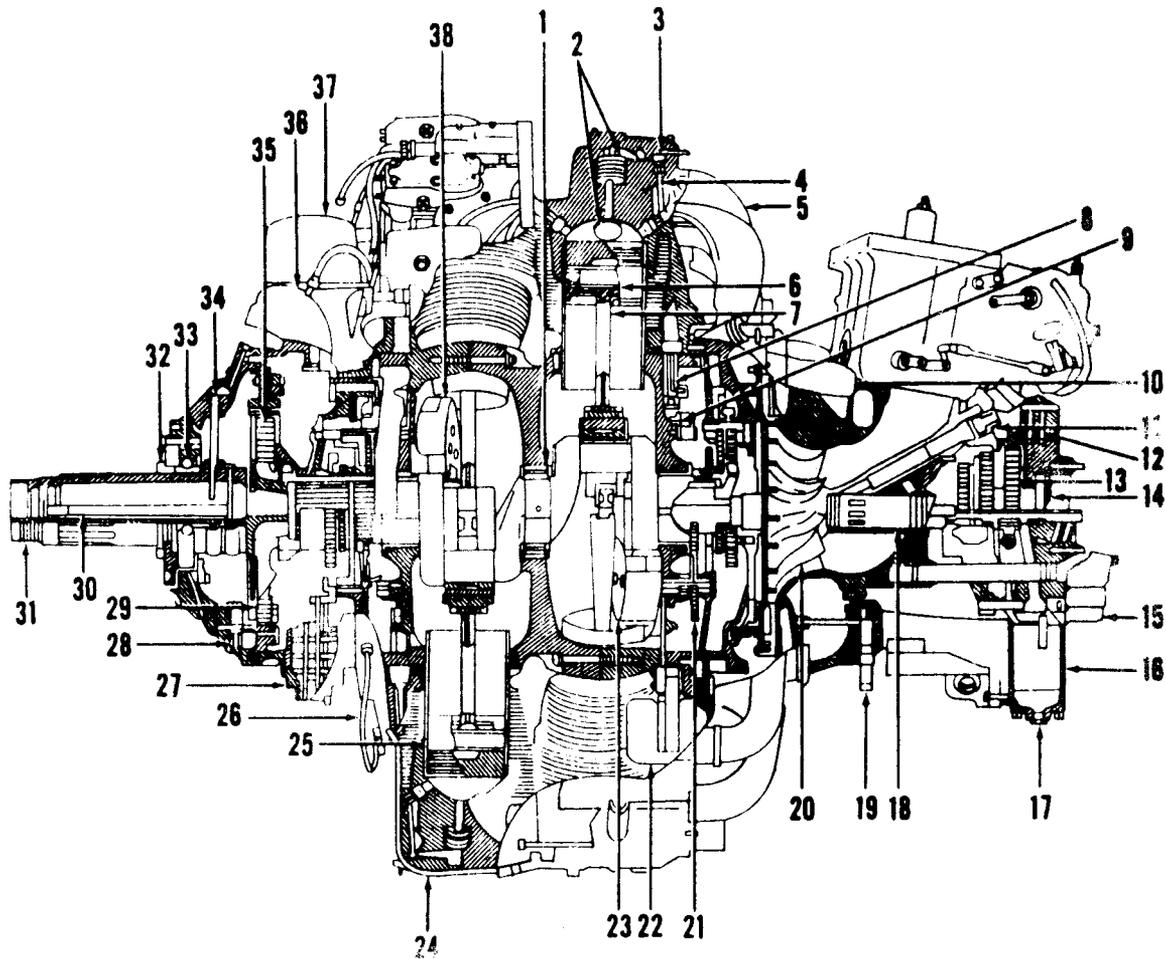
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Chapter 1
ENGINE GENERAL

<u>Specifications R-2800-52W</u>	
Number of Cylinders	18
Type	Radial, Two-Row, Aircooled
Displacement	2804 Cubic Inches
Bore	5.75 Inches
Stroke	6.00 Inches
Compression Ratio	6.75 to 1
Impeller Ratio	Low: 7.29 to 1 High: 8.58 to 1
Propeller Reduction	.450 to 1
Take Off Rating, Dry 2800 RPM 60" MP	2200 BHP 222 BMEP
Take Off Rating, Wet 2800 RPM 62" MP	2500 BHP 253 BMEP

All directional references for this engine are established looking forward

from the accessory section (rear) to the propeller end (front).



- | | |
|---------------------------------------|---|
| 1 Crankshaft Center Main Bearing | 20 Impeller |
| 2 Intake Valve and Spring | 21 Lower Cam Reduction Gear |
| 3 Rocker Arm | 22 Main Oil Sump |
| 4 Pushrod | 23 Rear Counterweight |
| 5 Intake Pipe | 24 Rocker Drain Oil Manifold Suction Line |
| 6 Piston Pin | 25 Piston |
| 7 Linkrod | 26 Ignition Harness |
| 8 Tappet | 27 Front Oil Scavenge and Torque Booster Pump |
| 9 Cam | 28 Torquemeter Piston |
| 10 Supercharger Case | 29 Reduction Drive Pinion |
| 11 Fuel Feed Valve | 30 Propeller Oil Transfer Tube |
| 12 Supercharger Clutch Selector Valve | 31 Propeller Shaft |
| 13 Accessory Drive Gear | 32 Thrust Bearing Nut |
| 14 Starter Jaw | 33 Thrust Bearing |
| 15 Main Oil Pressure Pump | 34 Propeller Governor Oil Transfer Tube |
| 16 Main Oil Screen | 35 Reduction Drive Gear |
| 17 Main Oil Screen Cover Plug | 36 Distributor |
| 18 Impeller Shaft | 37 Magneto |
| 19 Supercharger Drain Valve | 38 Front Counterweight |

CUTAWAY VIEW OF ENGINE

For assembly purposes, the engine is divided into six major assembly groups:

1. Front (Nose) Section
2. Front Accessory Section
3. Power Section
4. Supercharger Collector Section
5. Intermediate Rear Section
6. Rear (Accessory) Section

The Front (Nose) Section is a magnesium casting and houses the propeller reduction gears and the torque meter system. A mounting pad for the torque transmitter is installed on the left side of the nose section.

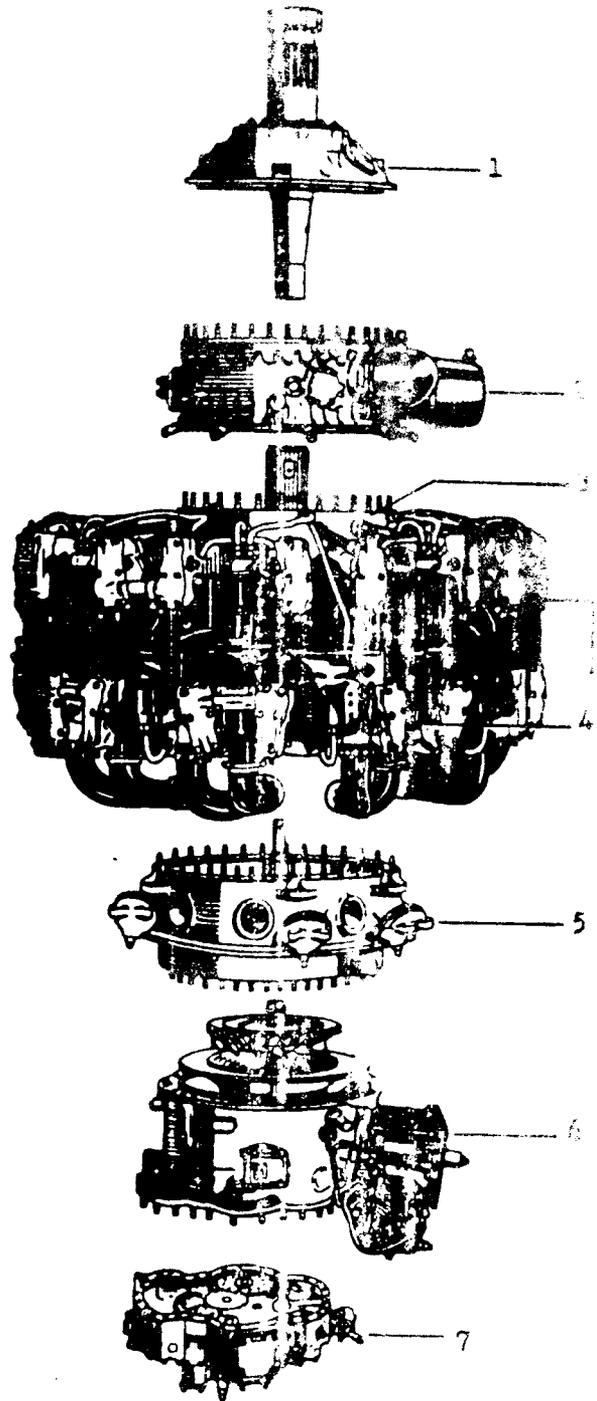
The Front Accessory Section is a magnesium casting and houses the front accessory drives, the front oil scavenging pump and the torque meter booster pump. There are mounting pads on the case for the magnets, distributors and the propeller governor.

The Power Section is made of three forged aluminum alloy sections. Two rows of cylinders are mounted around the circumference of the crankcase assembly.

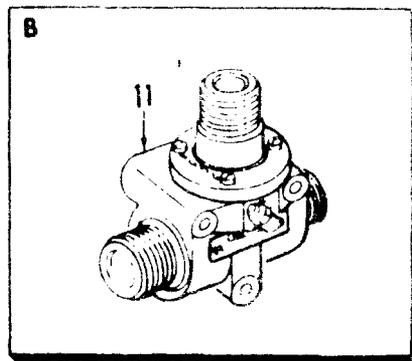
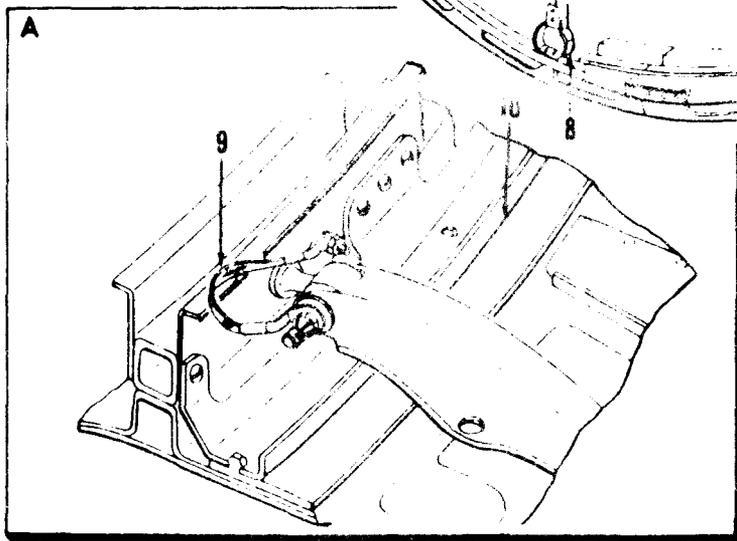
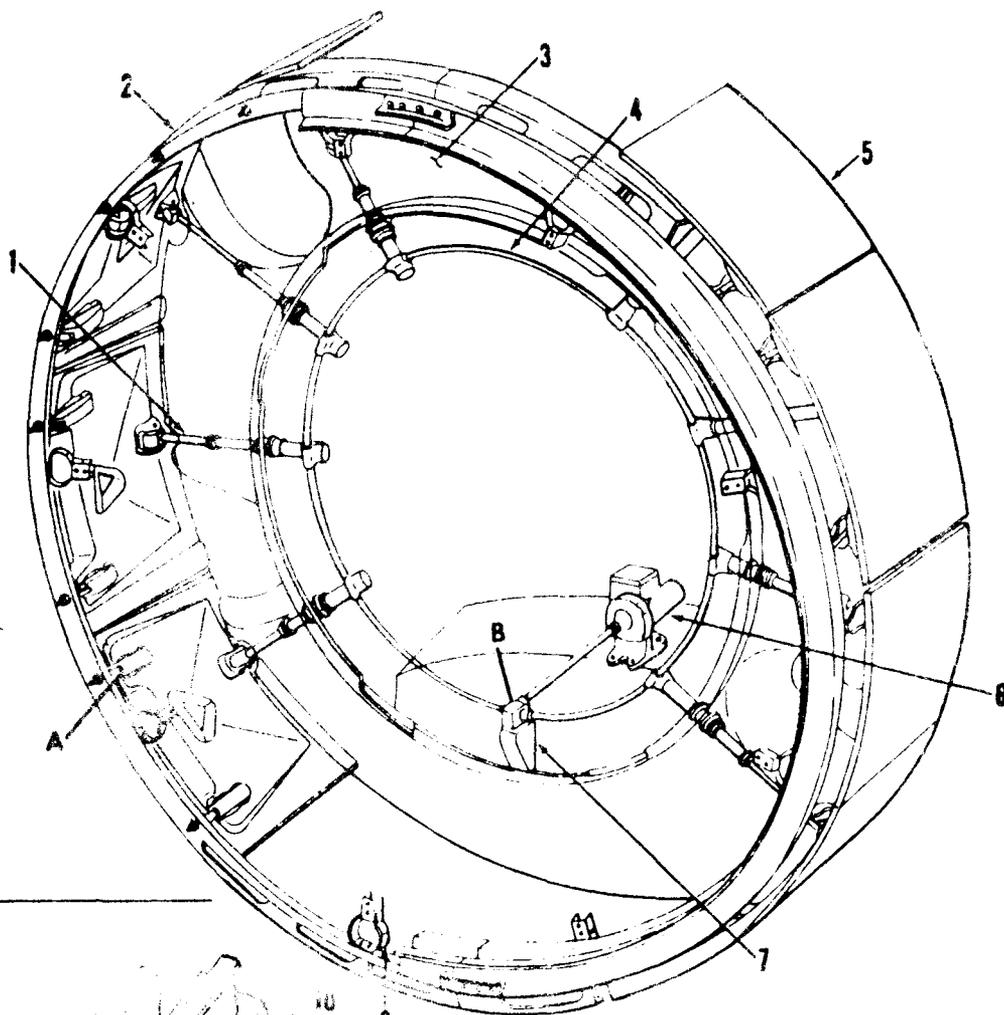
The Supercharger Collector Section is a magnesium casting and houses the diffuser, impeller wheel and collector. There are nine intake pipe ports and six engine mount brackets around the case.

The Intermediate Rear Case is a magnesium alloy casting and houses the blower clutches and accessory drive gears. The carburetor is mounted on top of the case.

The Rear Section is a magnesium alloy casting and, together with the Intermediate Rear Case, supports the accessory gear trains. The pressure and main scavenge oil pumps are installed on the rear face of the case.



- | | |
|---------------------------|-----------------------------|
| 1 Front Section | 5 Collector Section |
| 2 Front Accessory Section | 6 Intermediate Rear Section |
| 3 Crankcase Section | 7 Rear Section |
| 4 Cylinders | |



- 1 Jackscrew
- 2 Cowl Flap Support Ring
- 3 Inner Cowl Ring
- 4 Flexible Drive Shaft

- 5 Cowl Flap
- 6 Electric Power Unit
- 7 T-Drive Support Bracket
- 8 Spring Bracket

- 9 Bonding Jumper
- 10 Rubber Seal
- 11 T-Drive

The main oil screen and a check valve are located in the bottom of the case. The blower clutch selector valve is mounted on the top of the case. Other accessories mounted on the rear case are the fuel pump, generator, oil pump, auxiliary drives, vacuum pump, starter and tachometer generator.

Cowl Flaps

The adjustable aluminum-alloy cowl flaps for each engine are operated by an electric motor mounted on the top of the oil cooler fairing. The flaps are adjustable through a range of -4 to $+22$ degrees.

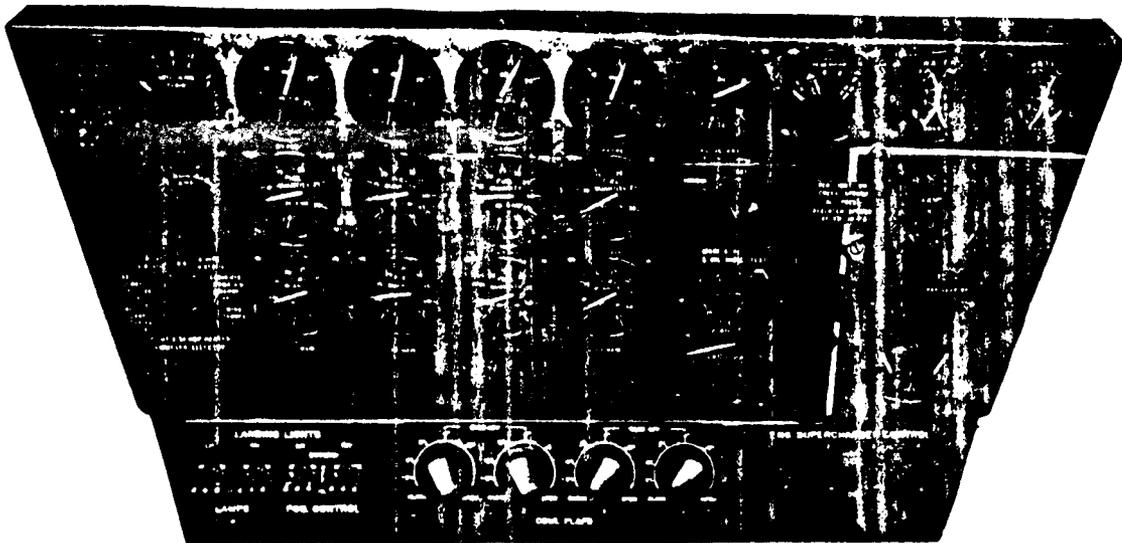
There are two ways of controlling the position of the electrically operated cowl flaps. The two methods are; manual operation and remote positioning. Both methods use the same switches, which are located on the aft overhead panel. These four position toggle switches

have the following positions: OFF, OPEN, CLOSE and POSITIONING.

In the manual operation the switch is placed either in the OPEN or the CLOSE position. The flaps move in the direction selected until the maximum travel point is reached.

In remote positioning the switch is moved to POSITIONING. As long as the switch remains in POSITIONING, the movement of the desired cowl flaps is controlled by a rheostat control. These 4 rheostat controls are on the upper instrument panel. The rheostats have a CLOSE and an OPEN position. They also are calibrated in increments of 2 degrees from -2 to $+6$ degrees to obtain intermediate cowl flap settings.

For ground operation, it is imperative that the cowl flaps be open, regardless of outside air temperature.



UPPER INSTRUMENT PANEL

Chapter 2

LUBRICATION SYSTEM

General

The R-2800-52W engine has a full pressure, dry sump oil system which uses grade 1100 oil.

An independent oil system supplies lubricating oil to each engine. Oil is supplied under pressure to the engine by the engine-driven oil pump. The oil is returned by the engine-driven scavenger pump through an oil cooling system to the supply tank. The oil from the tank passes through an emergency shut-off valve as it flows by gravity to the engine. Temperature, quantity, and pressure indicating systems, as well as an oil dilution system, are provided. An auxiliary engine oil tank transfer system provides additional oil for extended operation.

Oil Tanks

Each engine tank has a capacity of 38 gallons. A standpipe reserves 2.5 gallons for propeller feathering. A hopper in each tank aids in rapid engine warm-up and in reducing oil foaming. The filler cap is accessible through an access door on the left side of each carburetor airscoop fairing. Two oil tank vent lines connect from the fittings on top of each oil tank to the rear case vent connections of the engine.

Oil Cooling System

The oil cooling system consists of: (1) an airscoop (2) an oil cooler (3) an air exit door, which controls the flow of air through the cooler (4) an actuator, which opens and closes the air exit door (5) a thermostat assembly that controls operation of the air exit door actuator and (6) an inlet bypass valve, which is mounted on the cooler to con-

trol the flow of oil through it. The cooling system controls the temperature of the oil for proper lubrication and cooling of the internal working parts of the engine.

Oil Quantity Indicators

The oil quantity is measured by a Simmonds Pacitron gage tank unit located in each oil tank and in the auxiliary oil tank. The oil quantity indicators are located on the upper instrument panel. A stick gage is installed near the filler neck of each oil tank.

Oil Pressure Indicators

The oil pressure is measured by a transmitter connected to a restricted fitting on the top of the rear accessory section case. The pressure is shown by two dual indicators on the center section of the main instrument panel. A separate pressure warning switch for each engine is set to close at 50 (± 5) PSI, and operates a single oil pressure warning light located below the dual oil pressure indicators on the main instrument panel.

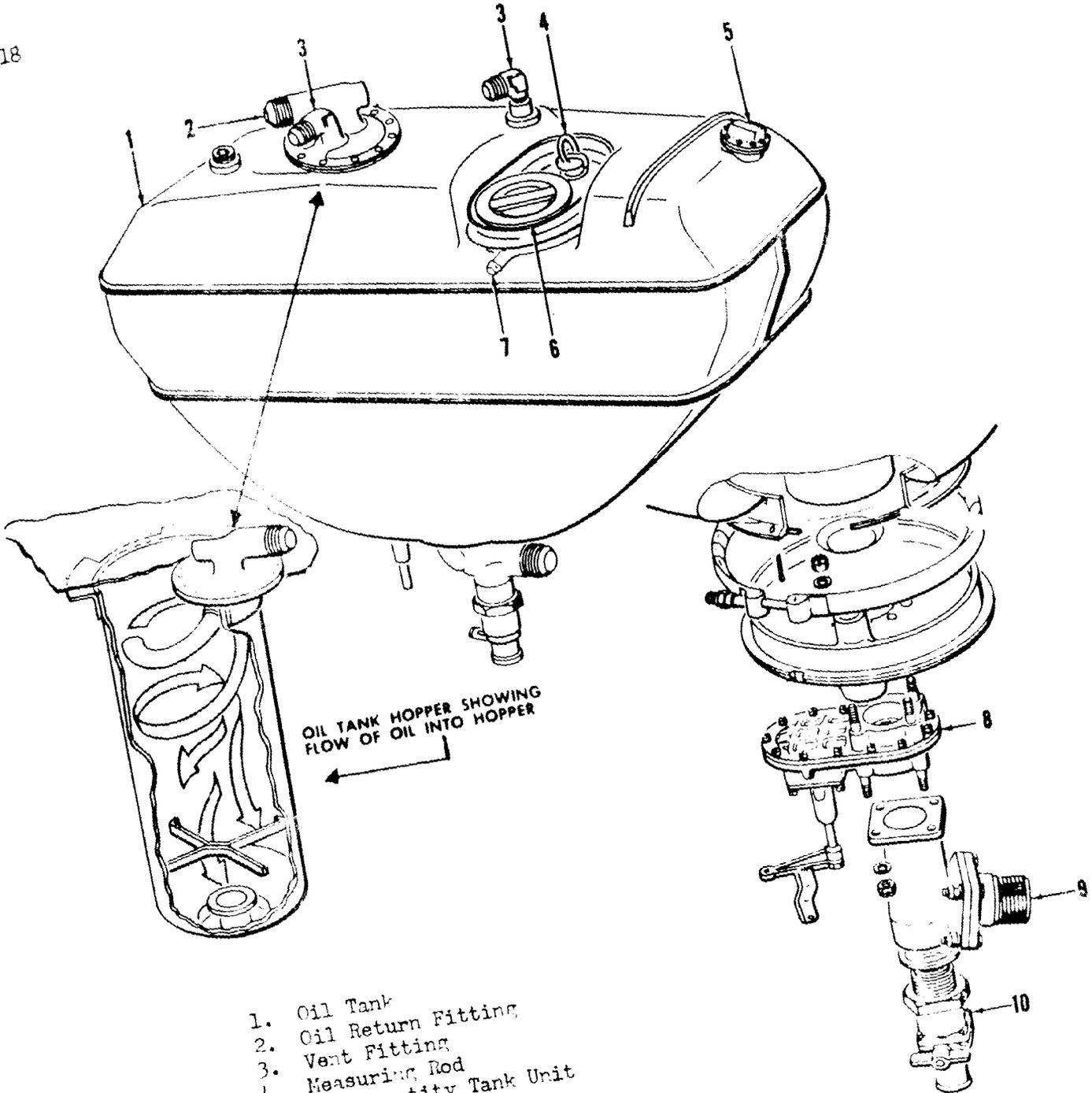
Oil Temperature Indicators

The temperature of the oil as it flows to the engine is measured electrically by a resistance bulb, which extends into each engine oil tank outlet. Two dual oil temperature indicators, calibrated in degrees centigrade, are mounted on the main instrument panel.

Oil Dilution System

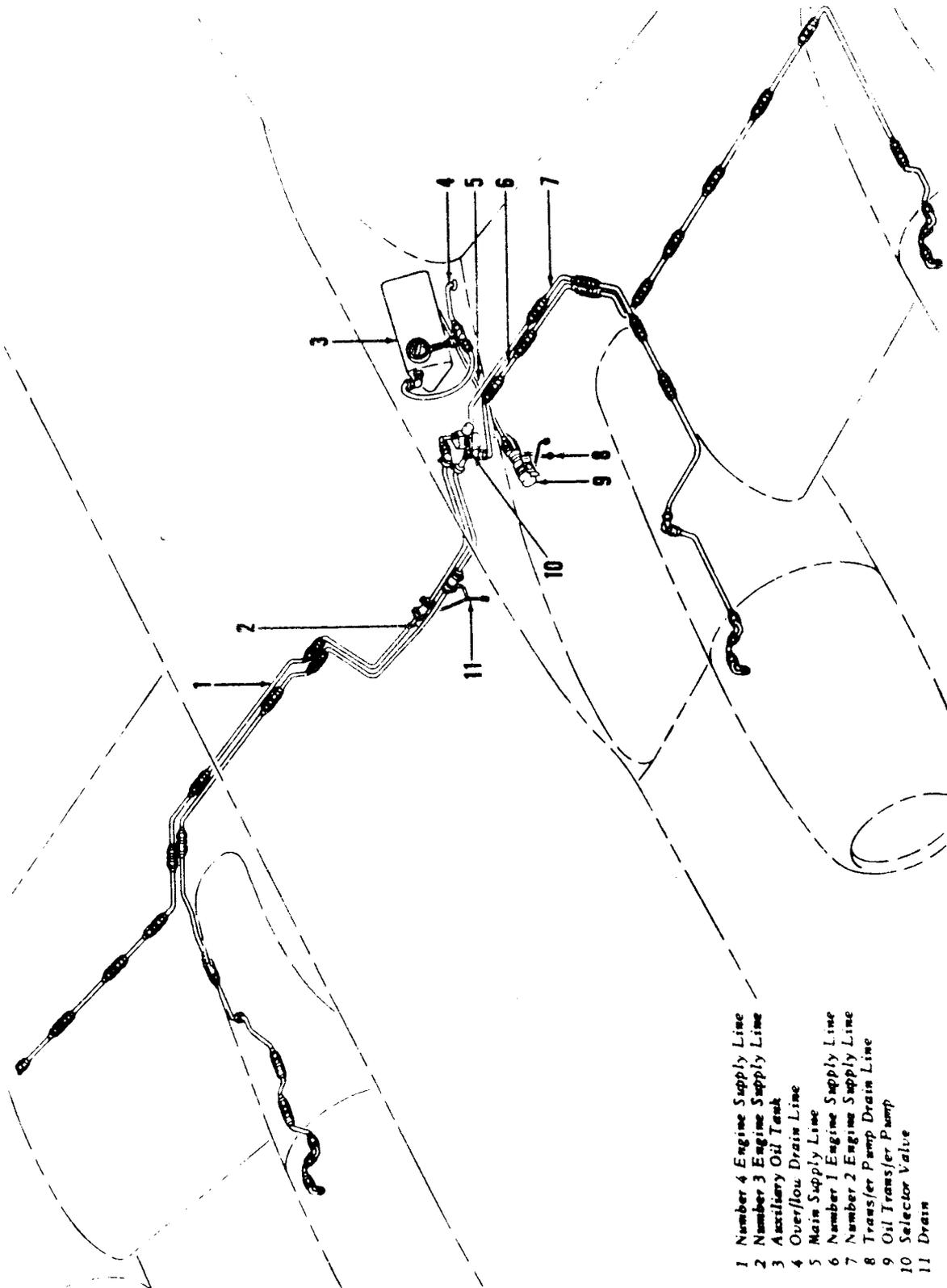
An oil dilution system is provided to dilute the engine oil during engine shut-down when a cold-weather

C-118



- 1. Oil Tank
- 2. Oil Return Fitting
- 3. Vent Fitting
- 4. Measuring Rod
- 5. Oil Quantity Tank Unit
- 6. Oil Tank Filler Cap
- 7. Scupper Drain
- 8. Emergency Oil Shutoff Valve
- 9. Oil Outlet Fitting
- 10. Drain Valve

ENGINE OIL TANK AND EMERGENCY OIL SHUTOFF VALVE



AUXILIARY OIL SYSTEM

- 1 Number 4 Engine Supply Line
- 2 Number 3 Engine Supply Line
- 3 Auxiliary Oil Tank
- 4 Over/low Drain Line
- 5 Main Supply Line
- 6 Number 1 Engine Supply Line
- 7 Number 2 Engine Supply Line
- 8 Transfer Pump Drain Line
- 9 Oil Transfer Pump
- 10 Selector Valve
- 11 Drain

start is anticipated. An oil dilution solenoid valve allows the fuel to flow from the main fuel supply line in each nacelle to the main oil supply line at the bottom of the oil tank. Each solenoid is controlled by an OFF-ON spring-loaded switch on the aft overhead panel. The fuel tank booster pump must be on LOW BOOST during the oil dilution operation to furnish fuel pressure as the oil dilution fuel line is connected to the inlet side of the engine-driven fuel pump. For this reason, the fuel pressure indication will not drop during dilution. The propeller oil system may be diluted by operating the propellers from low to high pitch three times, and into and out of reverse at least once during the dilution period.

Oil Emergency Shutoff Valve

An emergency shutoff valve is installed between the oil tank sump and the oil outlet elbow fitting to which the main oil supply pipe is connected. It is operated by the corresponding fire extinguisher selector handle located below the glareshield in the flight compartment.

Auxiliary Oil System

The regular oil system is supplemented by an auxiliary oil and transfer system. The auxiliary oil tank is located in the left wing fillet and has a capacity of 26 gallons. The oil transfer system consists of a combination oil pump and motor, a tank selector switch, an electrically operated four-way selector valve, and a spring-loaded pump actuating switch.

Oil can be transferred from the auxiliary tank to any one of the engine oil tanks by positioning the auxiliary oil tank selector switch to the desired engine tank and then operating the pump switch. Release the pump switch when the desired amount of oil has been transferred. After the oil has been transferred, the auxiliary system oil lines should be evacuated by reversing the pump switch approximately one minute, to avoid the possibility of oil congealing in the transfer lines.

The auxiliary oil tank selector switch and the auxiliary oil pump switch are located on the aft overhead panel. The oil quantity indicator for the auxiliary oil transfer system is located on the upper instrument panel.

Engine oil tanks must not be filled above the 150 pound oil level by use of the oil transfer system. It is desirable that oil be transferred into the engine oil tank when the level falls to 110 pounds.

The auxiliary oil tank is located in the left wing fillet which is an unheated portion of the aircraft. In order to minimize the possibility of oil congealing in the tank and transfer lines, the auxiliary tank is filled with a mixture of 50 percent oil, grade 1100 and 50 percent 100 octane gasoline. The oil and fuel should be thoroughly mixed before pouring them into the tank. The tank level should be checked periodically in order to make certain that excessive amounts of fuel have not evaporated.



Chapter 3

TORQUEMETER

What is the Torquemeter?

The torquemeter is an instrument which indicates propeller shaft torque. This is accomplished by hydraulically balancing the force transmitted from the propeller shaft to the fixed members of the engine gear train. Since the force on the fixed members is always equal to propeller torque, torquemeter oil pressure values are also equal to propeller torque. On the C-118 aircraft the dial of the torque indicating instrument has been calibrated and converted to indicate BMEP.

What is BMEP?

Brake Mean Effective Pressure is the actual amount of pressure in pounds per square inch within the cylinder, available for work obtained from the ignition of a specific fuel air charge after friction and heat loss are considered. It is used as an index of measure to rate or limit an engine's performance. Since a rise in BMEP will normally mean an increase in actual

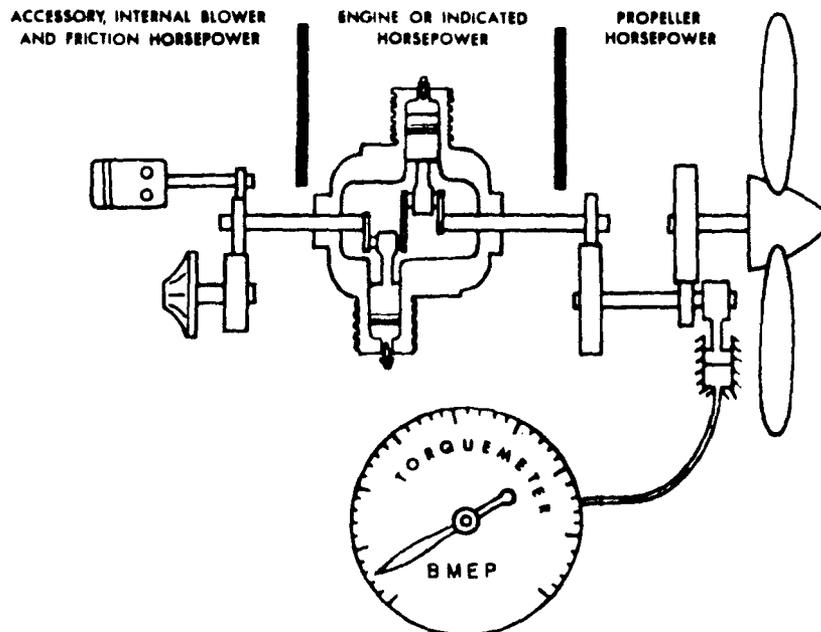
cylinder pressures, structural considerations will dictate that operation be confined below certain BMEP values, or the stresses imposed may result in engine failure. Since high cylinder pressures will normally be accompanied by high cylinder head temperatures, it follows that BMEP values also set a series of operational limits for preventing detonation and eventual engine failure. Thus, the torquemeter and engine tachometer are used to determine propeller shaft power output.

Why Measure Propeller Shaft Torque?

If the propeller shaft torque and the engine speed are known, the horsepower being supplied to the propeller shaft can be readily determined.

Propeller shaft brake horsepower (BHP) can be calculated from the basis formula:

$$\text{BHP} = \frac{\text{RPM} \times \text{BMEP}}{K}$$



The formula components are:

RPM = Engine speed in revolutions per minute.

K = A BMEP constant (283) which applies to this specific engine installation and includes the various factors and ratios needed to complete the formula.

BMEP = Brake Mean Effective Pressure read on the airplane instrument

Then What does Manifold Pressure Measure?

Engine or indicated horsepower (IHP) is used to drive the propeller, internal blower, and various accessories and to overcome all friction within the engine and gear cases.

IHP is essentially engine input power and depends on the engine air flow. Manifold pressure, carburetor air temperature, RPM, and carburetor mixture setting are required to define IHP, once exhaust back pressure (altitude) effects have been determined from flight test. Thus, manifold pressure is an accurate measure of one thing only: the pressure in the intake manifold; however, when manifold pressure is used in conjunction with other readings, it is an indication of engine input. This, in turn, is related to useful engine output.

If Manifold Pressure is an Indication of Engine Input and Output, Why Install Torquemeters?

The torquemeter is used to measure output power because it is a direct means of measurement.

Manifold pressure, on the other hand, does not detect changes in engine output power. Manifold pressure is a valid indication of engine output only when cor-

rections are made for operating variables, such as humidity, mixture, etc., and when the engine is in proper mechanical condition. For example, suppose fouling of the spark plugs causes one engine cylinder to malfunction. Engine output power will drop even though the manifold pressure is maintained by the pilot.

Then all Power Settings should be made with the Torquemeter?

Yes, but not with the torquemeter alone. The torquemeter supplements rather than replaces the manifold pressure gage. The proper interpretation of the relative readings of both instruments increases the accuracy of power adjustments and dependability of engine operation.

Aircraft performance is the result of propeller shaft output which, in turn, depends upon BMEP. Engine dependability and durability depend upon the power input conditions of which manifold pressure is a primary measure. An operator who relies entirely on propeller shaft output, as measured by the torquemeter, is ignoring the conditions under which the engine is producing this power. Consider again the previous example of fouled spark plugs.

If manifold pressure is increased, at a constant RPM to compensate for the loss in power, then every operating cylinder works harder to supply its share of the power normally produced by the dead one. The established input to output power relationship should never be exceeded.

Proper operation with the torquemeter can thus be described as using the manifold pressure gage to determine power input and the torquemeter to determine power output. The operator should be aware of the proper relationship between the two and recognize the meaning of failure by the engine to

demonstrate this relationship.

What the Main Advantage of having a Torquemeter is to be able to Monitor Engine Condition by Comparing the BMEP and MP Values shown by the Proper Chart?

Right, but the torquemeter also has several other important advantages. It is very desirable to measure take-off power just before take-off. The stability of a power plant to develop expected take-off power and BMEP should always be corrected before the take-off is attempted. The torquemeter also pays dividends when used for long range cruise control.

For maximum cruise economy, mixture settings more precise than those provided by the auto lean quadrant device are required. Manual leaning procedures have been established and are outlined in the appropriate aircraft flight handbooks. These procedures all depend on relative torquemeter readings and other allied instruments to determine the amount of mixture leaning required to provide best economy operation.

In addition to these flight applications, the assistance of the torquemeter in early detection of malfunctions is of great value. As previously stated, the flight crew members should constantly be aware of the proper relationship between input and output power as a general measure of power plant condition.

Several malfunctions, such as burned valves, fouled plugs, shorted ignition harness, bearing failures, and power section mechanical failure will be detected by a drop in BMEP at constant manifold pressure and RPM settings. The operators should be constantly alert for indications of spark plug fouling during long range cruise as indicated by a gradual drop in pressure on the BMEP gage. In fact, proper interpretation of torque-

meter readings may be a more accurate indication of ignition difficulties than the conventional magneto check procedure. Detailed information is available in Chapter 7, under Engine Analyzer pattern interpretation.

Observation of the oscillating period of the BMEP gage hand will permit an operator to detect engine roughness or irregular operation at an early stage. This is only true, however, where the torquemeter gage system is relatively undamped and is free to respond to small pressure surges.

The Torquemeter seems to be a very useful Instrument

It is. However, complete reliance on the torquemeter for the control of engine power can also lead to abuse of the engine. It is important that crews do not form the habit of ignoring manifold pressure readings. The following are the most critical abuses resulting from sole reliance on the torquemeter.

1. Attempting to maintain a constant BMEP value in spite of engine deficiencies.
2. Attempting to maintain the same BMEP value while using carburetor heat and MP values above recommended charted limits.

As in every useful device, the torquemeter has some limitations, which cannot be overlooked. Occasionally, due to wear, friction, or accumulated tolerances, the torquemeter mechanism located in the engine nose section does not accurately measure engine power, particularly in the higher power output ranges. In such a case, however, the torquemeter in question is generally useful as an aid to cruise control and as an indicator which will detect a change in engine condition.

One other aspect of the torque-meter requires consideration. Its accuracy can be no better than that of the gage system. Proper calibration and maintenance of that system, as dictated by experience, is necessary.

Then Proper Aircraft Maintenance and Operation should include the Torquemeter?

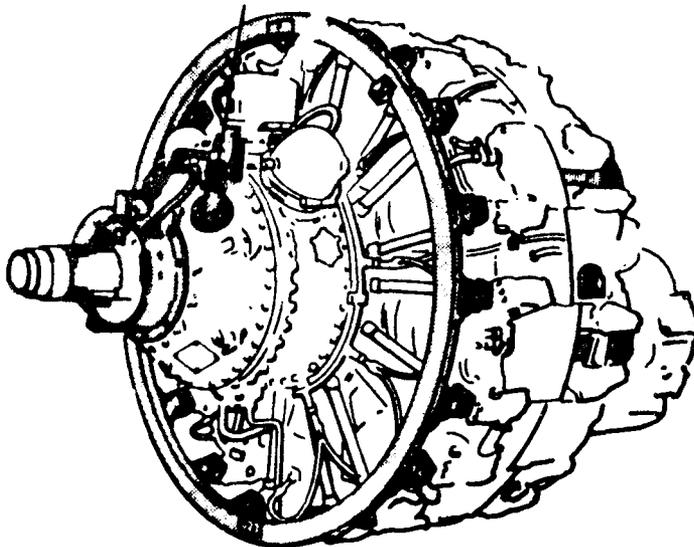
Maintaining all aircraft engine instrument reliability and accuracy is very important. A reliable torquemeter provides the ability to:

1. Read propeller shaft output power

directly.

2. Ascertain take-off brake horsepower output on all engines.
3. Check for equal brake horsepower output on all engines.
4. Improve range by using manual leaning procedures.
5. Judge engine performance and conditions.
6. Detect or identify many operational malfunctions of the engine.

TORQUEMETER (BMEP) TRANSMITTER



Chapter 4

ENGINE SUPERCHARGER

Each engine incorporates a single stage, two-speed supercharger. Four two-position switches are mounted on the upper instrument panel for shifting the superchargers from Low Blower to High Blower. Movement of the switch energizes the 28 volt DC solenoid operated supercharger clutch selector valve which results in operation of the clutch. It must be remembered that this valve does not meter oil but is simply a directional mechanism. The supercharger clutch selector valve routes engine oil under pressure to the low or high blower clutch.

The driving of the single impeller at either low or high speed makes possible high performance both at sea level and at higher altitudes. At or near sea level, the engine is operated in the low blower clutch ratio, thus keeping to a minimum the temperature rise through the supercharger. At an altitude determined by the conditions under which the engine is operating, the supercharger clutch shift is made from the low to the high clutch ratio. The increased airflow and higher manifold pressure available in high ratio makes possible high performance at high altitudes.

Engine Ground Operation

All ground operation of the engine such as starting, warm-up, idling, taxiing, and ground test checks, except the supercharger clutch selector valve and blower clutch operational checks, should be performed with the supercharger in the low blower ratio.

Supercharger Selector Valve and Blower Clutch Check

The supercharger selector valve

and blower clutch check are part of the pre-flight ground test, to make certain that the selector valve is supplying oil to both clutches and the clutches are engaging properly. These checks are performed as follows:

1. Warm up the engine until the oil temperature is 40°C or higher.
2. With the propeller governor set in the high rpm position, open the throttle until the engine manifold pressure is equivalent to field barometric pressure, the tachometer should now indicate from 2070 to 2170 RPM. With the oil temperature at 40°C and the RPM as indicated, sufficient oil pressure to operate the blower clutches is insured.
3. Move the supercharger control switch from "LOW" to "HIGH" position.
4. Observe for changes in engine oil pressure, manifold pressure, engine RPM and BMEP. Proper selector valve and clutch operation when shifting from "LOW" to "HIGH" position is indicated by:
 - (a) A momentary drop in BMEP.
 - (b) A rise in manifold pressure of approximately 2 inches as the centrifugal pumping capacity of the impeller is increased.
5. Move the supercharger control switch from "HIGH" back to "LOW".
6. Observe for changes in engine oil pressure, manifold pressure, and BMEP. Proper selector valve and clutch operation when shifting

from "HIGH" to "LOW" position is indicated by:

- (a) A momentary increase in BMEP.
- (b) A slight drop in manifold pressure, (2 inches) as the centrifugal pumping capacity of the impeller is decreased.

Take-Off

Take-offs, should be made in the low blower ratio, whether operating with or without water injection. The use of the high blower ratio at or near sea level will reduce the horsepower available to the propeller shaft, because of the power absorbed by the impeller. It will increase the tendency of detonation, because of the temperature rise through the supercharger.

Climb

Technical Order 1C-118A-1 lists the following instructions for shifting from Low to High Blower.

When the critical altitude for Low Blower has been reached, reduce manifold pressure to approximately 25 inches.

Cruising

The blower ratio for cruising is selected with reference to altitude and to the type of operation (i.e. percentage of power) desired. For maximum fuel economy it is generally desirable to operate in the low blower ratio wherever possible. In general, a half-closed throttle in the high ratio indicates the desirability of shifting to the low ratio.

Descent

During descent from high altitudes, the supercharger should be shifted to "LOW" position when convenient. If the need for maximum performance is anticipated before descending to the range of low ratio operation, the shift from "HIGH" to "LOW" should not be made until the shift altitude for maximum permissible BHP in the low ratio has been reached.

Carburetor Air Temperature Limits

Because the heat rise imparted to the fuel air charge by the supercharger is greater in the high blower ratio, the carburetor air temperature (CAT) limits are lower for the high blower operation. The operator must be careful to observe CAT limits to prevent detonation.

Low Blower	Max CAT 38°C
High Blower(Above 1200BHP)	Max CAT 15°C
High Blower(Below 1200BHP)	Max CAT 30°C



Chapter 5

CARBURETION

Theory of Carburetion

Cylinder head temperatures and engine power sometimes decrease rather than increase when the mixture is leaned. A clear understanding of the nature of this effect and the direction of power change to be expected should be thoroughly understood.

Cylinder temperature and power are sensitive to mixture strength. If at one extreme, we use a mixture composed of too much air and too little fuel the resulting temperature and power will be at a minimum. At the other extreme of too much fuel and not enough air the same results will occur. A specific fuel/air ratio somewhere between these extremes will produce peak power.

If the mixture strength is leaner or richer than at the peak, the power and cylinder head temperature will be less than maximum. The question of whether temperature and power increases or decreases with change of mixture strength depends upon whether or not operation is moved toward or away from this peak.

It is well to examine the power and temperature variation separately as their peaks occur at somewhat different mixture strengths.

Power

If mixture strength is varied and all other factors affecting airflow are held constant (RPM, manifold pressure, carburetor air temperature, supercharging) the resulting effect upon power can be plotted as shown in Figure 1.

Somewhere above .040 the first flicker of power begins to show and increases steadily until at .080 the peak is reached. As enriching is continued beyond .080, the power starts to decrease until at .125 combustion is too weak to furnish a useful output. Above .180 the mixture will not burn.

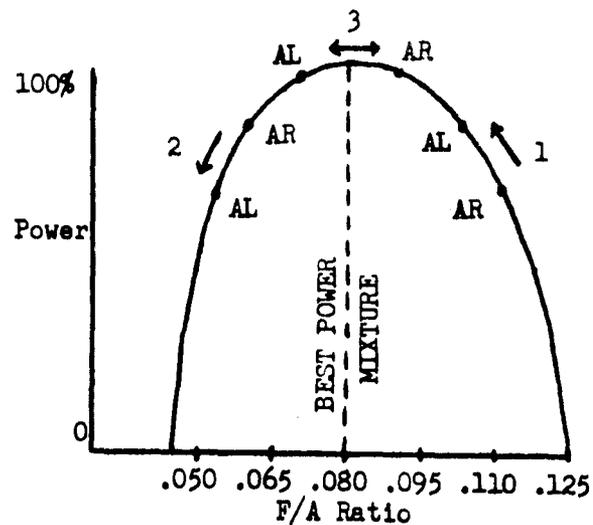


Figure 1

Transferring attention to a typical carburetor setting, it can be seen how variations in the mixture affect performance. If the engine is operated at an airflow corresponding to position #1, Figure 1, and the mixture is changed from auto rich to auto lean; the operation is now brought closer to best power and the output is increased. However, if the airflow is at position #2, Figure 1, and the mixture is changed from auto rich to auto lean; we find that the operation is moved away from best power and the

Carburetor Icing

Throttle Body Icing

There are three types of carburetor throttle body icing: impact icing, fuel vaporization icing, and throttle icing. Impact icing can be eliminated or prevented by the timely use of carburetor heat. Fuel vaporization icing is eliminated on this aircraft by injecting the fuel at the impeller. Throttle ice is generally formed during part throttle operation when moisture freezes as a result of the temperature drop caused by the expansion of air around the throttle valve. The best way to prevent throttle icing is to avoid a carburetor air temperature of -10°C to $+15^{\circ}\text{C}$. A carburetor alcohol deicing system provides a 17 minute supply of fluid to the four (4) carburetors, providing alcohol is not also used for windshield deicing.

Mixture Control Bleed Icing

In addition to the three types of throttle body icing, there is also the possibility of mixture control bleed icing. This form of icing may occur when moisture is present in the internal carburetor air bleeds and the fuel temperature is below freezing. The moisture may have entered the system either through the impact tubes from an accumulation of snow or water in the induction system, or by condensation inside the carburetor.

The freezing of the moisture in the mixture control bleeds is caused by the cooling effect of the cold fuel flowing through the regulator body of the carburetor. This cooling increases with an increase in fuel flow; consequently, bleed icing conditions are indicated by increase in fuel and decrease in torque pressure.

The following procedures should be

used when mixture control bleed icing is experienced:

- A. Restore normal fuel flow by manual leaning. This may require moving the mixture control almost into idle cutoff position.
- B. Apply carburetor heat.
- C. Observe fuel flowmeter and BMEP to detect return to normal operation as severe leaning will result if mixture control is not returned to auto lean as recovery is made.

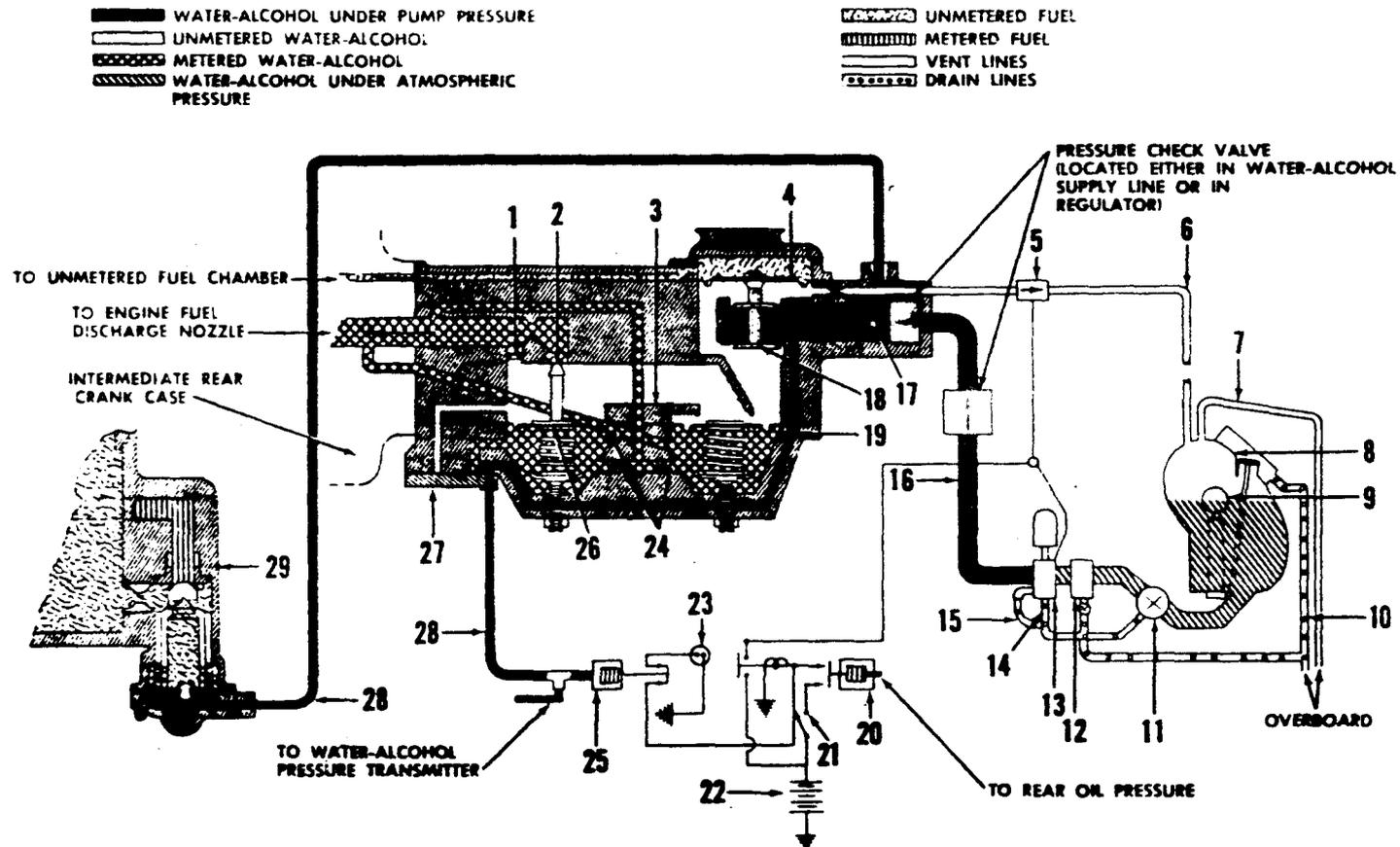
Antidetonation Injection (ADI)

A water/alcohol system is installed to permit an increase in engine take-off power. The injection of water acts as a detonation suppressor, allowing engine operation with best power mixture when operating in excess of dry limits. The fluid supply is carried in four tanks having a capacity of 9.4 gallons in the outboard tanks and 10.24 useable gallons in the inboard tanks. The supply is adequate for approximately five (5) minutes operation at takeoff power.

The ADI control switches are located on the aft overhead electrical panel. Two (2) dual water/alcohol quantity indicators are located on the upper instrument panel. These quantity indicators show the available water/alcohol supply in gallons.

The two (2) dual water pressure indicators are on the engine instrument panel. They indicate the pressure at the water/alcohol regulator.

There are four (4) red water pressure indicating lights on the pilot's flight instrument panel. The lights come ON when the water/alcohol pressure at the inlet side of the regulator drops below $18\frac{1}{2}$.5 PSI.

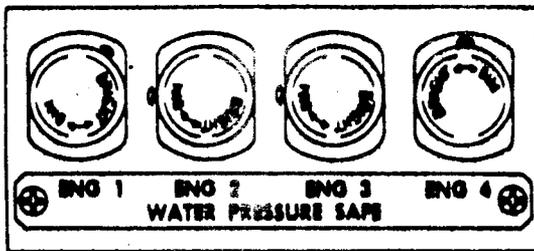


- 1 Main Water-Alcohol Jet
- 2 Water-Alcohol Enrichment Valve
- 3 Chamber
- 4 Control Valve Diaphragm
- 5 Solenoid Check Valve
- 6 Vapor Vent Return Line
- 7 Tank Vent (Overboard)
- 8 Water-Alcohol Tank
- 9 Quantity Transmitter
- 10 Drain Line (Overboard)
- 11 Water-Alcohol Drain and Shutoff Valve

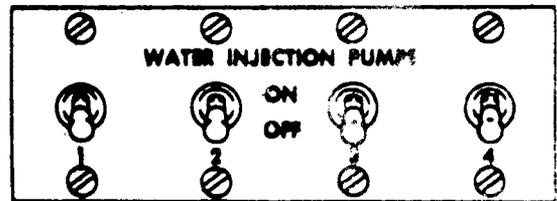
- 12 Water-Alcohol Strainer
- 13 Water-Alcohol Pump
- 14 Seal Drain Line
- 15 Pressure Relief Valve
- 16 Water-Alcohol Supply Line
- 17 Strainer
- 18 Metering Pressure Control Valve
- 19 Spring-Loaded Check Valve
- 20 Oil Pressure Switch
- 21 Manual Control Switch

- 22 Battery
- 23 Water-Alcohol Pressure Warning Indicator Light
- 24 Delay Bleeds
- 25 Water-Alcohol Pressure Warning Indicator Light Switch
- 26 Water-Alcohol Enrichment Valve Diaphragm
- 27 Regulator
- 28 Pressure Transfer Line
- 29 Derichment Valve

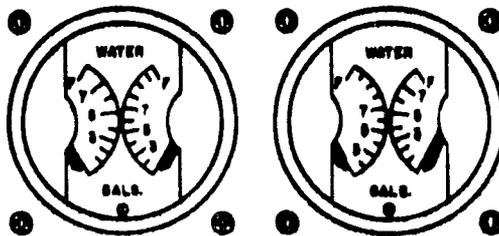
WATER/ALCOHOL INJECTION SYSTEM SCHEMATIC



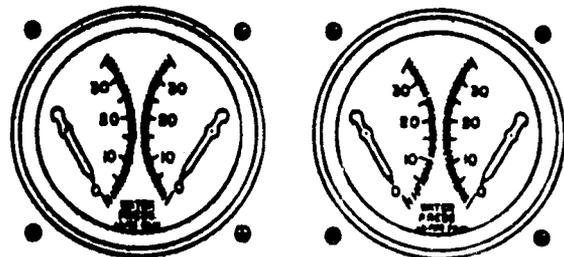
Water Alcohol Pressure Warning Indicator Lights



Water Alcohol Manual Control Switches



Water Alcohol Quantity Indicators



Water Alcohol Pressure Indicators

Chapter 6

ENGINE IGNITION SYSTEM

Each engine has a Low Tension ignition system. The system magneto is driven by the engine to create an electrical current, which is used to fire the spark plugs. Each ignition system consists of a magneto, two distributors an ignition harness, eighteen dual transformers and an ignition switch. The one induction vibrator is used by all of the ignition systems during starting.

The magneto creates a low voltage, which causes a current flow through the distributors to the transformer units. The transformers step up the voltage to provide the high voltage needed by the spark plugs. The low voltage throughout most of the system reduces the possibility of flashover.

DIN-10 Magneto

The dual magneto for each engine is mounted on the front accessory case. The magneto is driven by the engine, in a counterclockwise direction, at one and one-eighth crankshaft speed. Each magneto contains 2 four-pole rotating magnets, four primary coils and two sets of double pole shoes. The magnets are rotated by the engine to induce a current within the coils.

Distributors

The two distributors are mounted on the front accessory case of each engine. Each distributor contains an engine-driven shaft incorporating 2 nine-lobe cams, plus two sets of breaker points and two condensers. The number 1 cam (upper) operates the number 1 breaker points, which control the firing of the rear (odd) row cylinder spark plugs. Cam number 2 (lower) operates the number

2 breaker points, firing the front (even) row cylinder spark plugs. The condensers prevent arcing and burning of the breaker points.

In the base of each distributor are 2 rings of contact blocks. Carbon brushes pass over these blocks in making the proper distribution of current to the cylinders.

The designations R-1, R-2, L-1 and L-2 make it possible to identify the spark plugs each circuit will fire. For example: R-1 will fire the FRONT spark plugs in the ODD row, while L-1 will fire the REAR spark plugs in the ODD row.

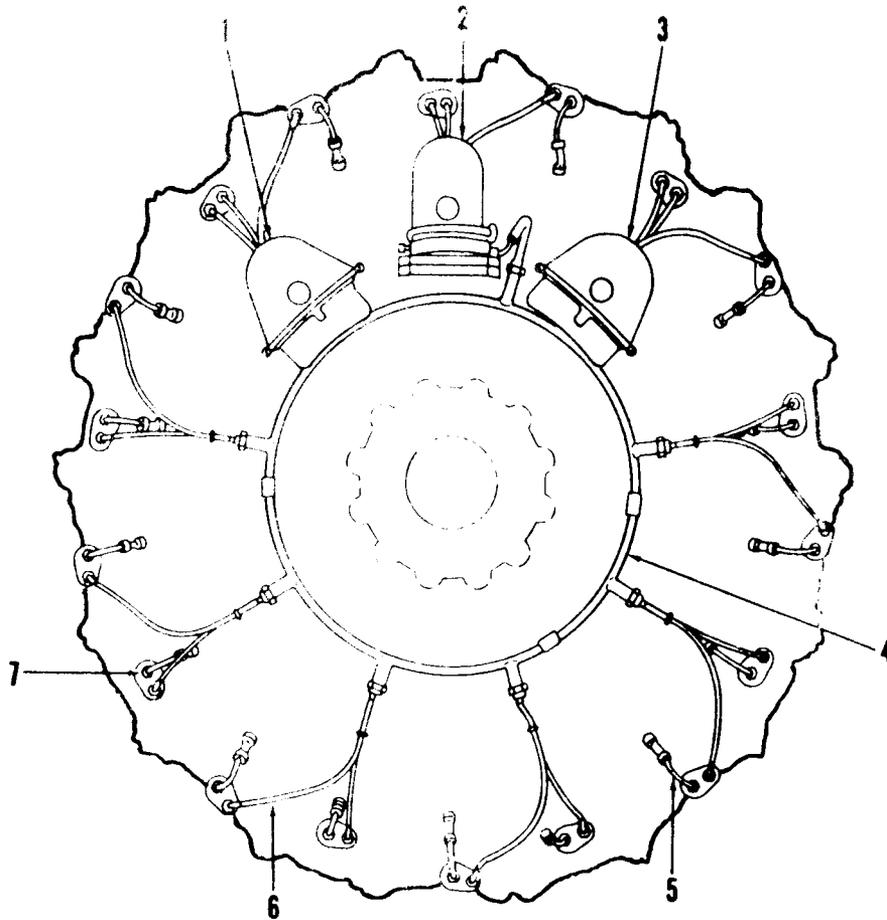
Dual Transformer Units

The 18 dual transformer units are mounted on the top baffle of each cylinder. At the forward end of the unit are two connections. One connection receives the current from the primary coils while the second connection delivers the high tension current to the front spark plug of that cylinder. The rear end of the transformer unit has one connection, which carries high tension current to the rear spark plug of that cylinder.

The two transformers of a unit receive the current from the primary coils. By having more windings in the secondary than in the primary of the transformer, the voltage is stepped up until it is strong enough to fire the spark plugs.

Ignition-Switches

The four ignition switches, one for each engine, are mounted on the forward

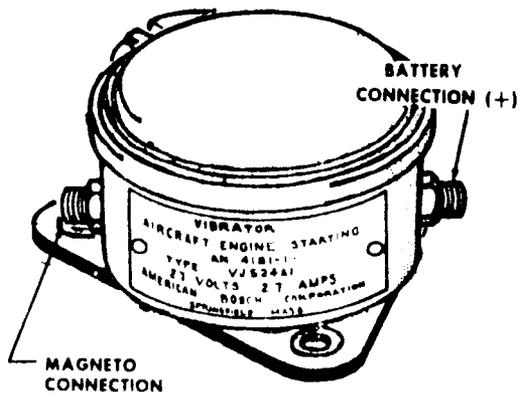


- 1 Right-Hand Distributor
- 2 Magneto
- 3 Left-Hand Distributor

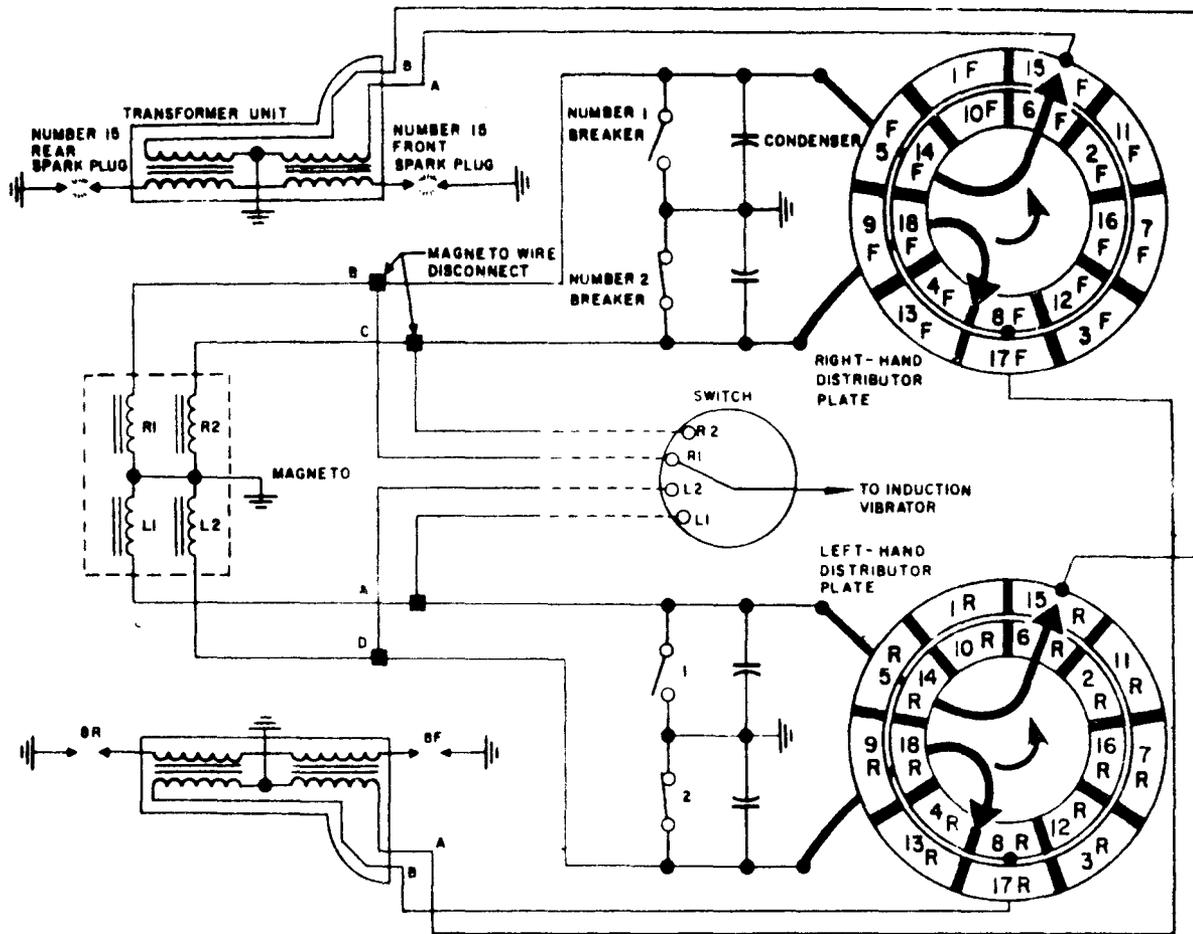
- 4 Ignition Harness
- 5 High-Tension Lead

- 6 Low-Tension Lead
- 7 Transformer Unit

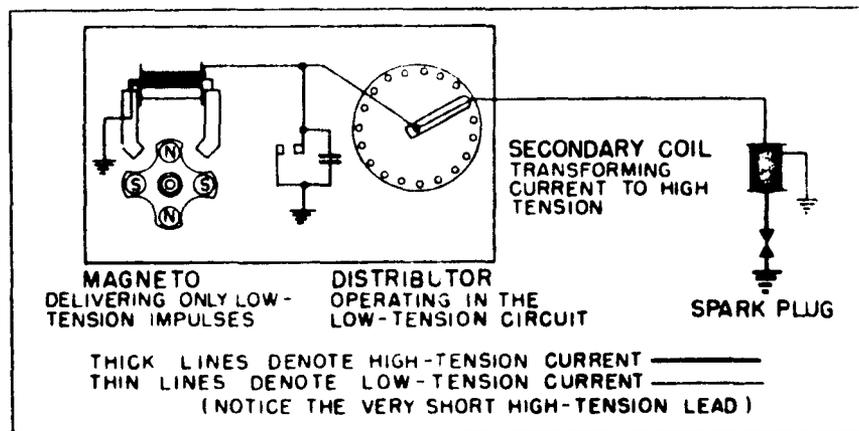
IGNITION SYSTEM LOCATIONS



INDUCTION VIBRATOR



IGNITION SYSTEM SCHEMATIC



OPERATING PRINCIPLE
LOW TENSION IGNITION SYSTEM

overhead panel. These switches have the following positions: OFF, R, L, and BOTH. If the switch is placed to "OFF" both magneto primary circuits are grounded and neither the front nor the rear spark plugs will fire. Moving the switch to "R" will ground the left hand magneto circuits, but the right hand magneto will fire the FRONT spark plugs in the cylinders.

Shifting to the "L" position will ground the right hand magneto circuits, allowing the left hand magneto circuits to fire the REAR spark plugs in the cylinders. Movement to "BOTH" allows both magnetos to become operative, and the FRONT and REAR spark plugs in all cylinders will fire.

Induction Vibrator

The induction vibrator is installed behind the forward overhead electrical panel, which is in the flight compartment. The purpose of the vibrator is to supply ignition voltage during the starting. The unit is necessary as the engine rpm is too low to produce a strong enough spark from the magnetos.

The induction vibrator switch is marked BOOST and is located on the forward overhead electrical panel. The Boost switch is used in conjunction with the Engine Selector switch, which must be moved from the OFF position, before the Boost circuit will operate. The Boost switch will return to "OFF" whenever it is released.

Operational Check-Engine Ignition System

This check is made during engine runup, when the engine manifold pressure is equal to field barometric pressure.

The procedure is as follows:

1. Move the Ignition switch from "BOTH" to "R".
Observe the RPM and BMEP drop.
2. Return the Ignition switch to "BOTH".
3. Next move the Ignition switch to "L".
Observe the RPM and BMEP drop.
4. Return the Ignition switch to "BOTH".

As step 1 through 4 are being performed leave the Ignition switch on the single positions long enough for the rpm to stabilize. Single ignition operation as long as one minute is not considered excessive. Tap the tachometer indicator rim to eliminate possible indicator pointer sticking.

The normal RPM drop is 50 to 75 RPM. The maximum RPM difference allowed between the left and right magnetos is 40 RPM. The maximum RPM drop is 100 RPM. The normal BMEP drop is 6 PSI., while the maximum BMEP drop is 12 PSI.



Chapter 7

ENGINE ANALYZER

Introduction

The analyzer is a versatile unit, which can be used on the ground or in flight. It is limited in its usefulness only by the operator's ability to analyze patterns. One does not have to be an electronics expert to operate the analyzer. Anyone following a simple checking procedure can pinpoint the trouble to a specific spark plug, ignition lead etc.

Sample analyzer patterns are provided for comparison against actual scope patterns. These sample patterns define the actual mechanical defect.

In flight, this provides a means of evaluating the extent of the engine malfunction. Using the analyzer, the flight crew can report the trouble more effectively. For example, without the analyzer, the write-up would be: "Number one engine ran rough at 10,000 feet". In this case the maintenance man must trouble shoot, system by system and unit by unit, until the cause is found. However, if the pilot uses the analyzer, the write-up would be specific as: "Number one engine has the following shorted spark plugs, front #3, rear #7 and front #2. Now the ground crew have a known trouble, and can clear it up in a short period. Furthermore the flight crew can report troubles detected by the analyzer at high altitude, which may not occur during ground operation.

Engine Analyzer Power Switch

The engine analyzer is controlled by an OFF-ON toggle switch on the engine analyzer panel. The engine analyzer panel is located to the right of the flight mechanic's jump seat.

Turning "ON" the power switch sends 115 volt, single phase AC power to the engine analyzer amplifier. The power comes from the RADIO-ELEC inverter through a fuse in the right hand annex of the Main Junction Box.

Engine Analyzer Amplifier

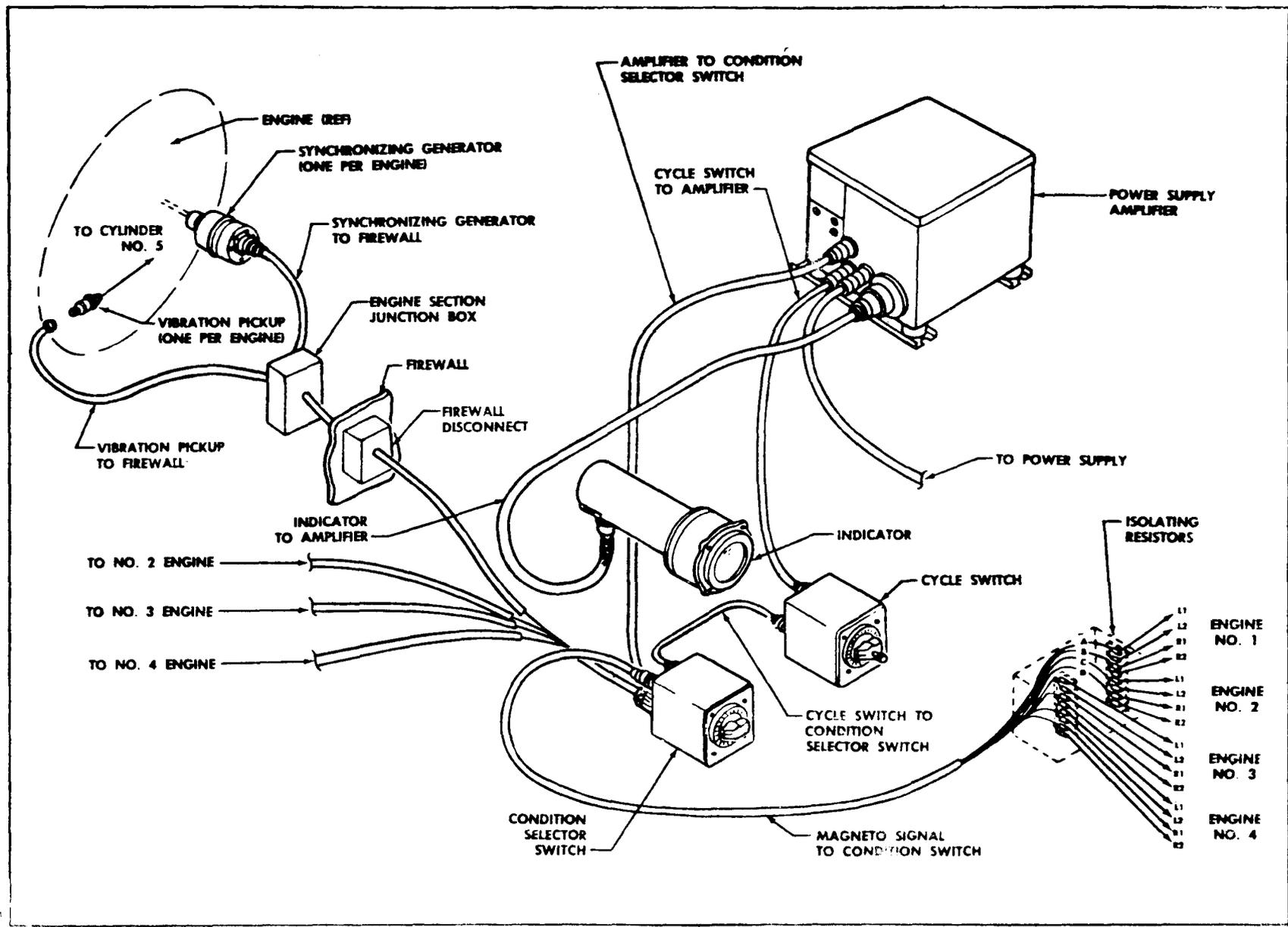
The engine analyzer amplifier is located at station 69 next to the analyzer panel. It contains the circuits for triggering, amplifying and controlling the indication. The amplifier also acts as a power source for the indicator.

The amplifier has several controls to be used in obtaining better patterns. Turning the INTENSITY screw controls the brilliance of the pattern. The FOCUS is used to obtain a "sharp" pattern. The HOR POS adjustment is used to start the leading edge of the trace line at from the left hand side of the indicator. To set the horizontal sweep length to the desired length, use the control marked LENGTH.

When using the vibration pattern, the VIB GAIN control can be used to obtain the size of pattern desired.

Engine Analyzer Resistors

The box containing the resistors is in the ceiling at station 69. These 3000 ohm resistors are used to isolate the engine analyzer from the engines. Thus an electrical malfunction in the analyzer will not cause a malfunction of the engine ignition system.



ENGINE ANALYZER SYSTEM

Engine Analyzer Generators

Each engine has an engine analyzer synchronizer generator mounted on the right side of engine accessory section. The generator is driven by an engine tachometer drive, and provides the reference voltage for the system.

Engine Analyzer Vibration Pickup

Each engine has a vibration pickup mounted on number 5 cylinder. The vibration pickup converts the mechanical vibrations into electrical signals.

Condition Selector Switch

The Condition Selector Switch is mounted on the engine analyzer panel. This switch is used to select the engine and magneto to be checked. This switch is also used to select the type of pattern to be analyzed such as ignition, synchronization, or vibration.

Cycle Switch

The Cycle Switch is mounted on the engine analyzer panel. This switch is used to select the individual spark plug and the desired portion of the engine cycle.

The push button at the center of the Cycle Switch selector knob may be pulled OUT or left IN. If the button is pulled OUT, the analyzer will show simultaneously all the patterns for all of the spark plugs in a row. The patterns will start with the cylinder selected by the rotary selector knob of the Cycle Switch. Pushed IN the button will cause the analyzer to show two patterns only, for a more thorough examination of the patterns. The numbers on the Cycle Switch dial identify the particular spark plug and thus show the location of the trouble.

The Cycle Switch is also used to select vibration analysis. Only # 5 cylinder can be selected for this operation.

Engine Analyzer Indicator

The indicator is mounted on the engine analyzer panel. It presents its data in the form of patterns or voltage waveforms on the screen of a 3 inch cathode ray tube.

Ignition Analysis

The correct procedure is as follows:

1. Turn the engine analyzer power switch "ON".
2. Wait 1 minute for the analyzer amplifier and the indicator tube to warm up.
3. Place the Condition Selector Switch index line at "B" in the ignition sector of the engine to be checked. This indexing determines that the patterns displayed will be for both distributors.
4. Move the Cycle Switch until the IGN index line is aligned with the number of the cylinder desired. This cylinder will be shown first in the pattern series.
5. Next pull the button on the Cycle Switch knob "OUT". This obtains a "slow sweep" indication showing 720 degrees of crankshaft rotation. The cylinder selected by the Cycle Switch position (see step 4) will appear first on the left side of the engine analyzer indicator, followed by the other 17 cylinders in the magneto firing order.
6. Check the patterns, if all 18 patterns are abnormal, the trouble is in the circuit common to all 18 cylinders. This indicates either magneto or distributor trouble.
7. If only part of the patterns are abnormal, use the Cycle Switch (see step 4) to bring the abnormal pattern to the left side of the indicator.
8. Then push "IN" the button on the cycle

Switch for "fast sweep" operation. In this position a careful check of the pattern can be made to pin-point the trouble.

9. The above steps should be repeated with the Condition Selector Switch being moved to the "L" and "R" positions for individual checks. If possible all patterns should be checked in "fast sweep" for possible malfunctions missed on the "slow sweep" check.

When the check at "B", "L" and "R" have been completed, move to the next engine and repeat the above process.

Distributor Synchronization Check

This check is made to determine that both distributors simultaneously fire the two spark plugs in a cylinder. The distributors are timed to #1 cylinder, therefore this check should always be made on #1 cylinder.

The check is made as follows:

1. Engine analyzer power switch "ON".
2. Wait 1 minute for the amplifier and indicator tube to warm-up.
3. On the Condition Selector Switch set the index line under "B" in the ignition sector of the engine to be checked.
4. The Cycle Switch button should be pushed "IN" for "fast sweep".
5. Next the Cycle Switch knob should be moved to align the IGN index line with #1 cylinder.
6. The ignition patterns of the left and right distributors are now superimposed. If the distributors are synchronized, the patterns will coincide and appear as one. On the other hand, if the

distributors are out of synchronization, the patterns overlap. The pattern appearing to the left is advanced in relation to the other pattern.

7. By measuring from the point where the trace line begins and where the breaker point opening "pip" appears, the amount of synchronization error can be determined. This is accomplished by figuring $1/32$ of an inch equals one degree of crankshaft travel. The normal distance between these points is $15/32$ of an inch.

8. Repeat the above procedure on each of the remaining engines.

Note

To determine which one of the distributors is out of synchronization, use the following method:

1. Leave the Cycle Switch with the IGN index line aligned with #1 cylinder. The button should be pushed "IN".
2. Set the Condition Selector Switch either to "L" or "R" for the engine being checked: (Example: L). If a small magnitude activity is observed on the pattern ahead of breaker point opening "pip", the opposite distributor (Example: R) is out of synchronization. The activity is caused by "inductive pickup" as the opposite (R) distributor opens early.
3. Now move the Condition Selector Switch to the opposite position. That is to "R" if "L" was used first or to "L" if "R" was used first. The activity should now disappear. This will confirm the fact that it is this distributor that is out of synchronization.
4. Repeat the process at any engine, where the analyzer shows that the distributors are out of synchronization.

RPM Synchronization Analysis

In comparing the engine rpm of different engines, number 1 engine is always used as the reference. Make this check whenever the engine rpm synchronization system is suspected of malfunctioning. The check proceeds as follows:

1. Cycle Switch at any position. The button is "IN" for "fast sweep".
2. The Condition Selector Switch is set to align the index line in the SYN sector at the number of the engine to be checked.
3. Check the pattern on the indicator. It should be stationary, indicating that the engines are synchronized. If the patterns shift to the right, the selected engine is in an underspeed condition in respect to number 1 engine. On the other hand, a shift to the left, shows that the engine being checked is overspeeding as compared to number 1 engine.
4. Continue the process of moving the Condition Selector Switch to each of the remaining SYN positions and checking the pattern as described above.

Synchronization Timing Check

Synchronization generator timing should be checked once during each flight. The procedure is as follows:

1. Set the Condition Selector Switch to VIB for the desired engine.

2. Pull "OUT" the button on the Cycle Switch to obtain "slow sweep".
3. Turn the Cycle Switch until E.C. is aligned with number 5 cylinder.
4. Check the pattern. The E.C. event should be approximately 1/8 inch from the start of the trace line. This indicates the synchronizing generator is properly timed to the crankshaft, and that during ignition analysis the correct cylinder pattern order will occur.

Vibration Analysis

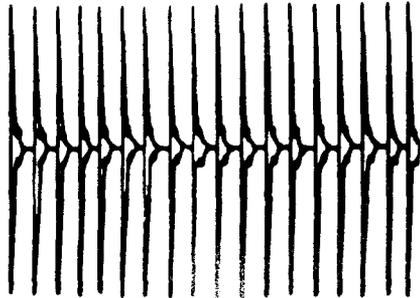
For engine vibration analysis, the engine analyzer is operated as follows:

1. On the Condition Selector Switch align the index line within the VIB sector to the number of the engine to be checked.
2. The Cycle Switch button should be pulled "OUT".
3. Next move the Cycle Switch to align the E.C. position at the number 5 cylinder.
4. Check the indicator for a complete vibration pattern.
5. For an expanded vibration pattern, push "IN" the button on the Cycle Switch for "fast sweep". Then index the Cycle Switch dial to the desired portion of the engine cycle to be inspected.



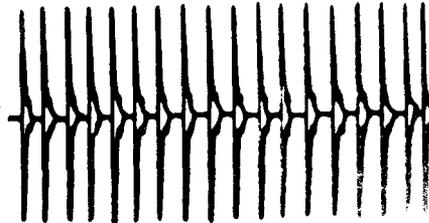
ENGINE ANALYZER PATTERNS

NORMAL PATTERNS



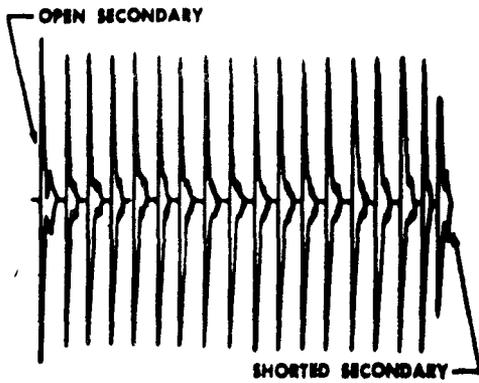
SLOW SWEEP

LOW AMPLITUDE OF PATTERNS INDICATES LOW MAGNETO VOLTAGE OUTPUT



SLOW SWEEP

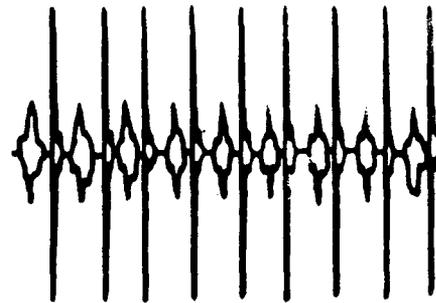
NORMAL PATTERN



SLOW SWEEP

SHORTED SECONDARY

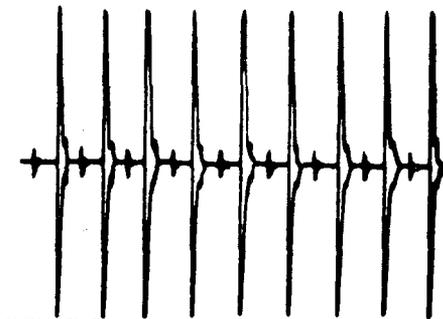
LOW MAGNETO VOLTAGE OUTPUT



SLOW SWEEP

RESULT OF OPEN SECONDARY OF ONE CYLINDER AND SHORTED SECONDARY ON ANOTHER

INDUCTIVE PICKUP FROM OTHER MAGNETO

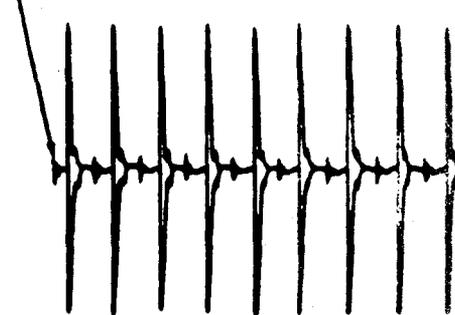


SLOW SWEEP

SHORTED PRIMARY IN ONE MAGNETO CIRCUIT

OPEN PRIMARY IN ONE MAGNETO CIRCUIT

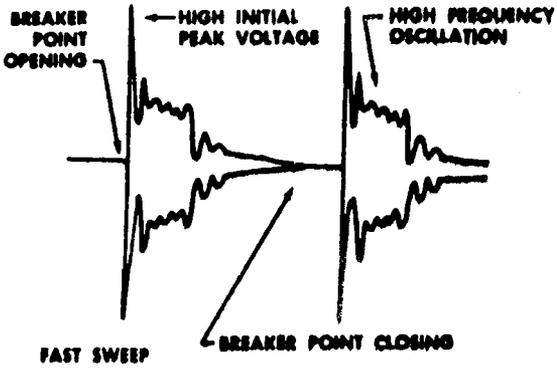
INDUCTIVE PICKUP FROM OTHER MAGNETO



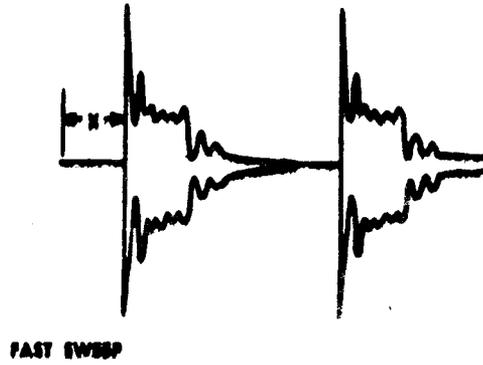
SLOW SWEEP

OPEN "P" LEAD, ONE PRIMARY, ONE MAGNETO (L¹ OR L² OR R¹ OR R²)

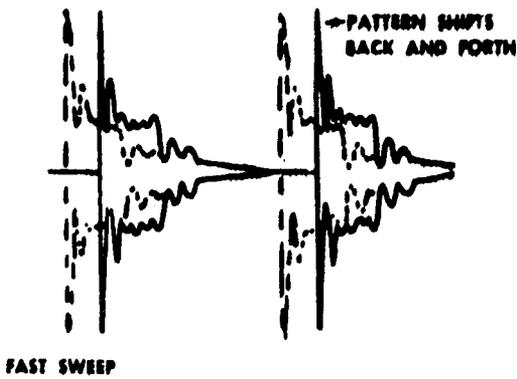
TRIPINT ANALYZER PATTERNS



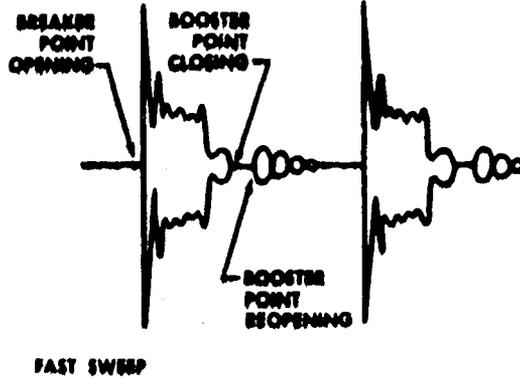
NORMAL PATTERN (SHOWING REFERENCE POINTS ON WAVE)



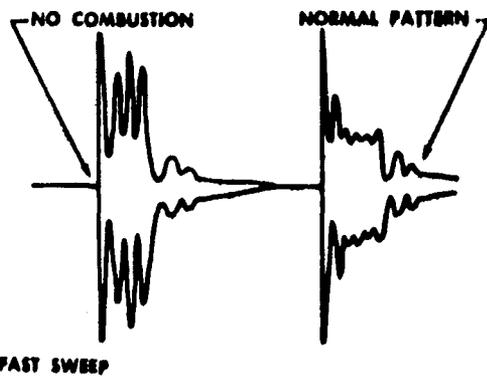
NORMAL PATTERN (SHOWING MAG TIMING X)



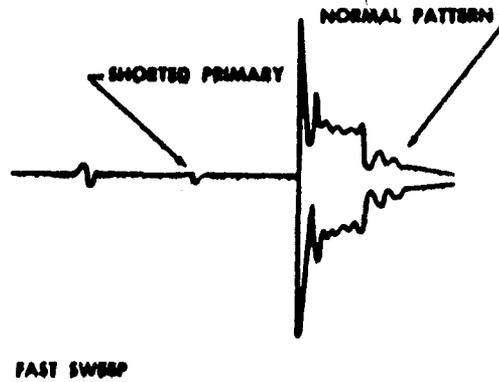
ROUGH ENGINE



NORMAL PATTERN (SHOWING BOOSTER POINT CLOSING)

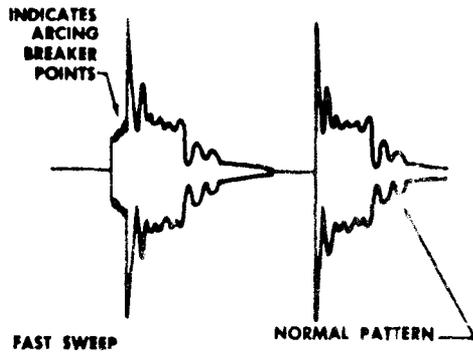


NO COMBUSTION

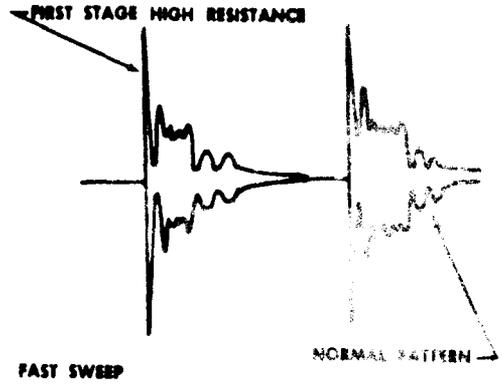


SHORTED PRIMARY ON ONE CYLINDER COIL

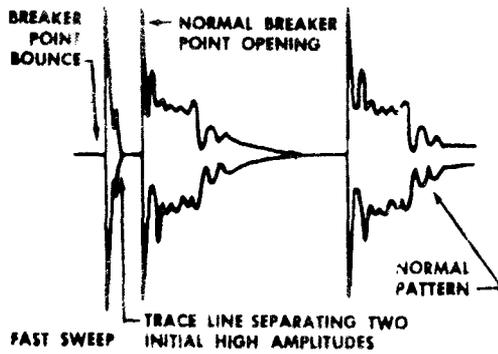
ENGINE ANALYZER PATTERNS



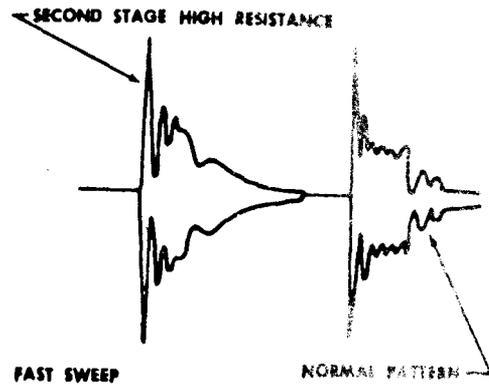
ARCING BREAKER POINTS



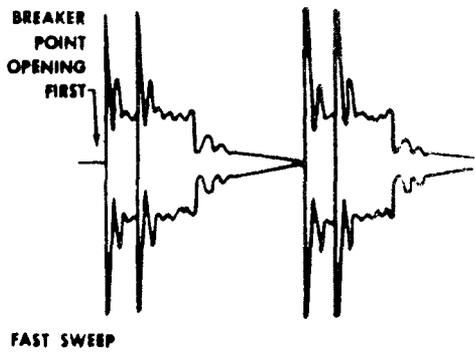
FIRST STAGE HIGH RESISTANCE



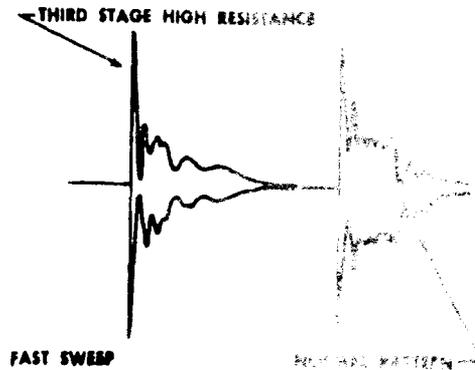
BOUNCING BREAKER POINTS



SECOND STAGE HIGH RESISTANCE

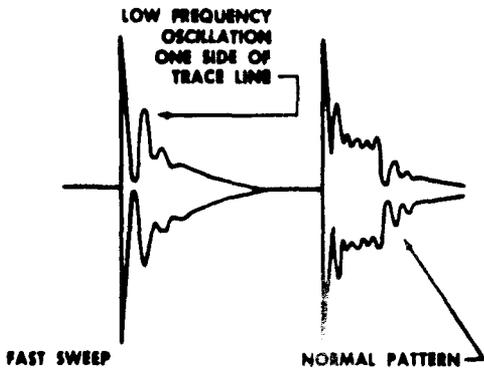


INCORRECT BREAKER POINT SYNCHRONIZATION

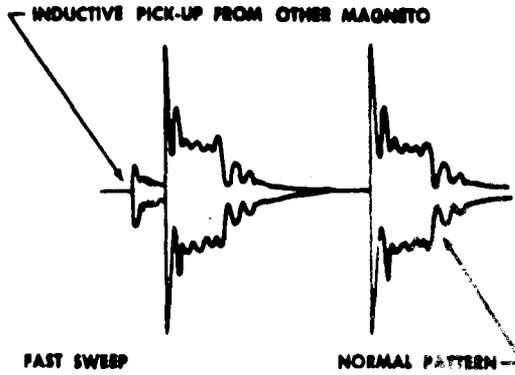


THIRD STAGE HIGH RESISTANCE

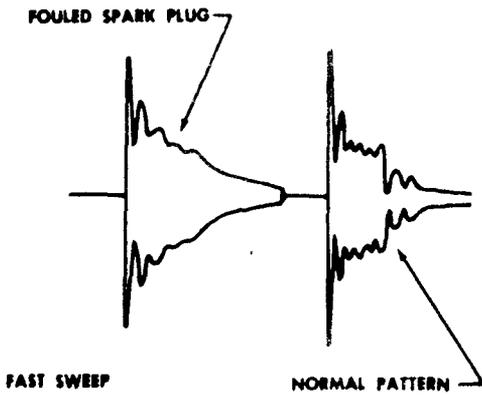
ENGINE ANALYZER PATTERNS



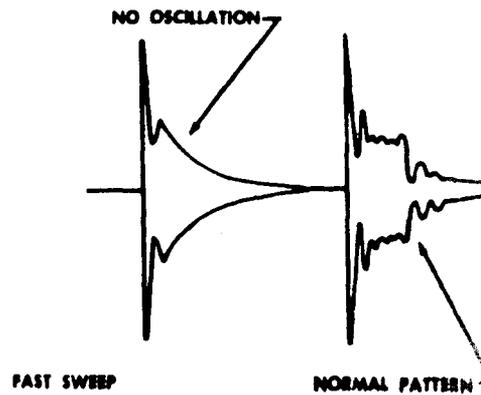
OPEN SECONDARY



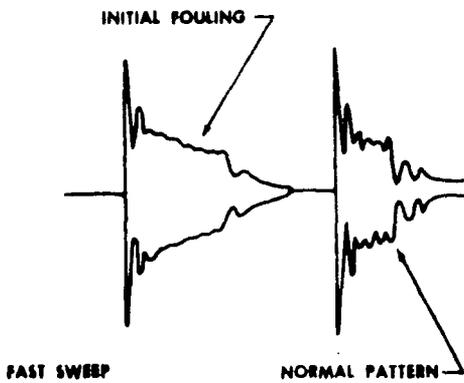
**BREAKER POINT SYNC.
(CONDITION ON L OR R)**



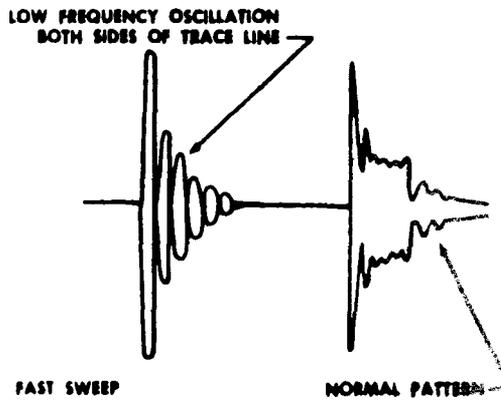
FOULED SPARK PLUG



SHORTED SECONDARY



INITIAL SPARK PLUG FOULING



OPEN PRIMARY ONE CYLINDER CON

STUDY GUIDE SUPPLEMENT

1951 SERIES AIRCRAFT

VERSUS

1953 SERIES AIRCRAFT

1. ENGINE AND ACCESSORIES

No difference.

2. ENGINE ANALYZER

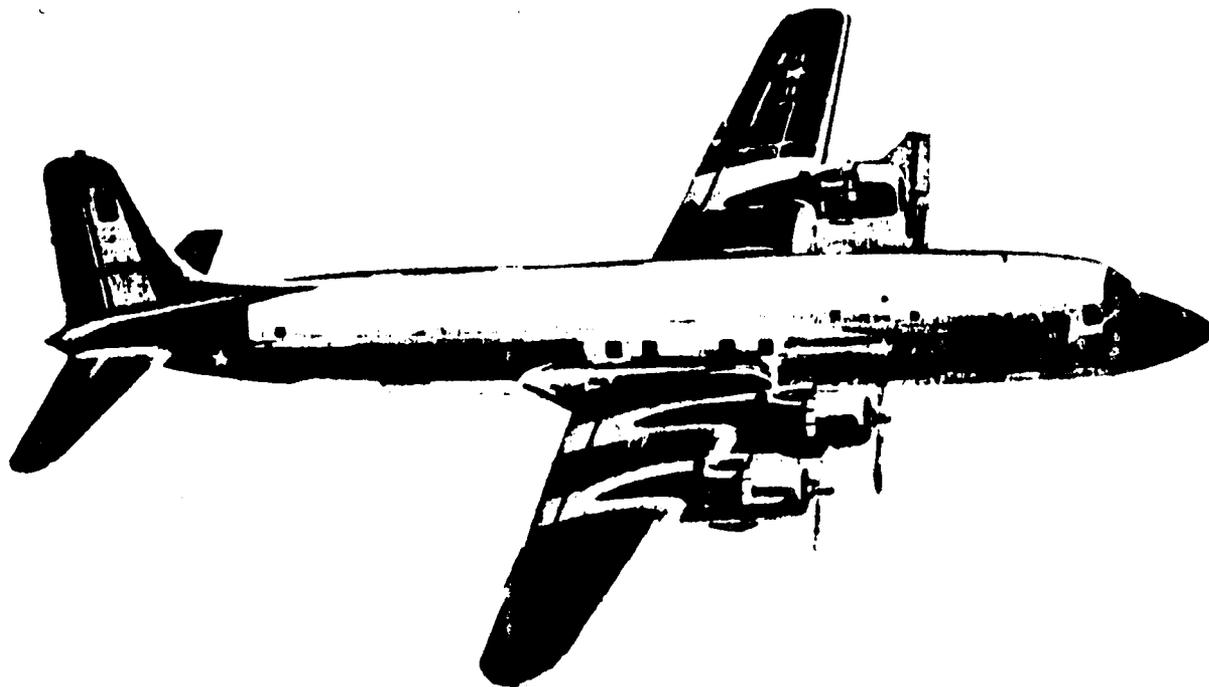
Analyzer equipment located on the left side of the aircraft on the radio rack.

1. ENGINE AND ACCESSORIES

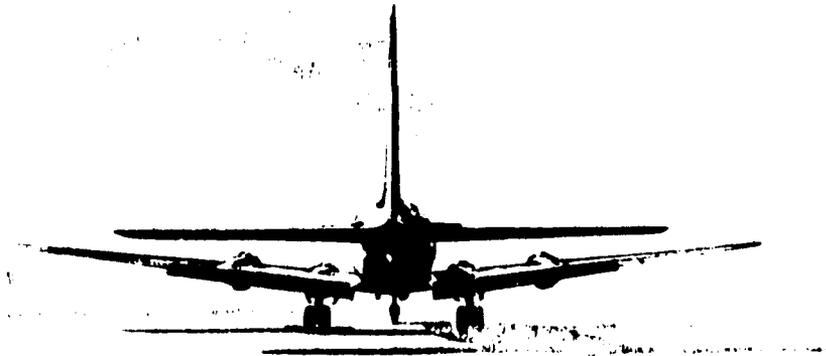
No difference.

2. ENGINE ANALYZER

Analyzer equipment located on the right side of aircraft at the navigator's station.





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Chapter 1**HYDRAULIC SYSTEM GENERAL**

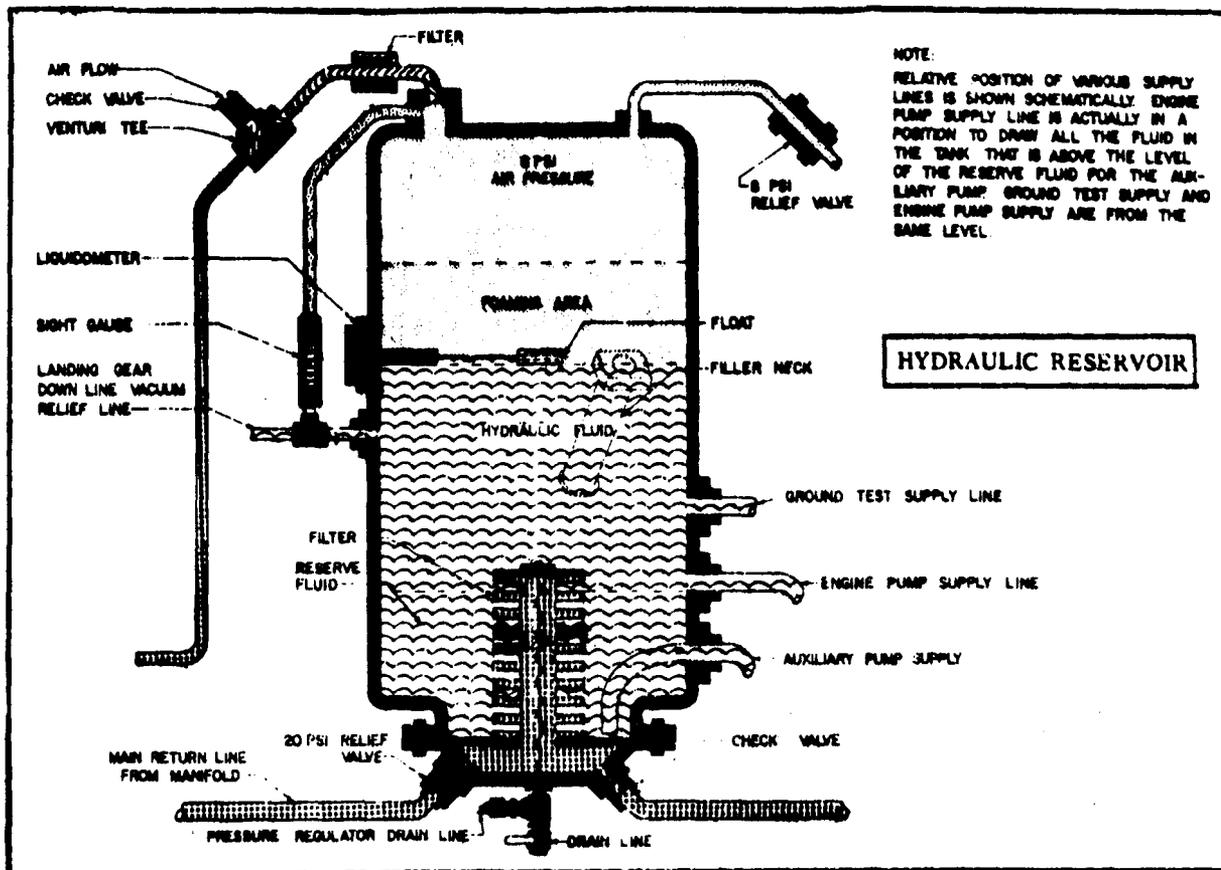
Hydraulic units which operate on main system pressure are; the landing gear, wing flaps, nose wheel steering, brakes and windshield wipers. All of the above units plus the forward and rear cargo doors may be operated on auxiliary pump pressure.

Hydraulic Reservoir

The hydraulic reservoir, located in the hydraulic accessories compartment, has a capacity of 5.4 U.S. gallons. Of the total fluid capacity, 2.9 gallons are available to the two engine-driven hydraulic pumps. A supply of 2.5 gallons is reserved in the reservoir for the auxiliary (emergency) pump. A foaming space is provided above the filler neck. A paper disc-type filter is located in the

bottom of the reservoir. It filters the hydraulic fluid as it returns from the system. The filter is retained by a spring, which allows the returning fluid to by-pass the filter (at 3 psi), if it becomes clogged.

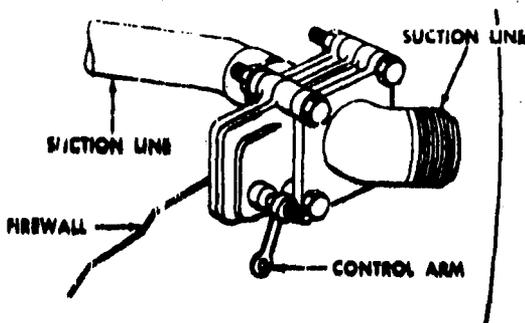
Fluid level in the reservoir is indicated by a sight gauge on the side of the reservoir and a remote quantity indicator on the upper instrument panel. This indicator is actuated by a liquidometer float-type transmitter in the reservoir. It is calibrated REFILL, NORMAL FLIGHT, and FULL-ZERO PRESSURE. With the engines operating, the fluid level should indicate NORMAL FLIGHT. A relief valve on the hydraulic reservoir maintains an air pressure of 8 psi to supply fluid to the engine-driven pumps.



NOTE:
RELATIVE POSITION OF VARIOUS SUPPLY LINES IS SHOWN SCHEMATICALLY. ENGINE PUMP SUPPLY LINE IS ACTUALLY IN A POSITION TO DRAW ALL THE FLUID IN THE TANK THAT IS ABOVE THE LEVEL OF THE RESERVE FLUID FOR THE AUXILIARY PUMP. GROUND TEST SUPPLY AND ENGINE PUMP SUPPLY ARE FROM THE SAME LEVEL.

Firewall Shutoff Valves

An emergency shutoff valve is installed in the supply line of each of the engine-driven hydraulic pumps. These shutoff valves are located in each inboard nacelle aft of the firewall. The valves are operated by their respective inboard engine fire selector handle.



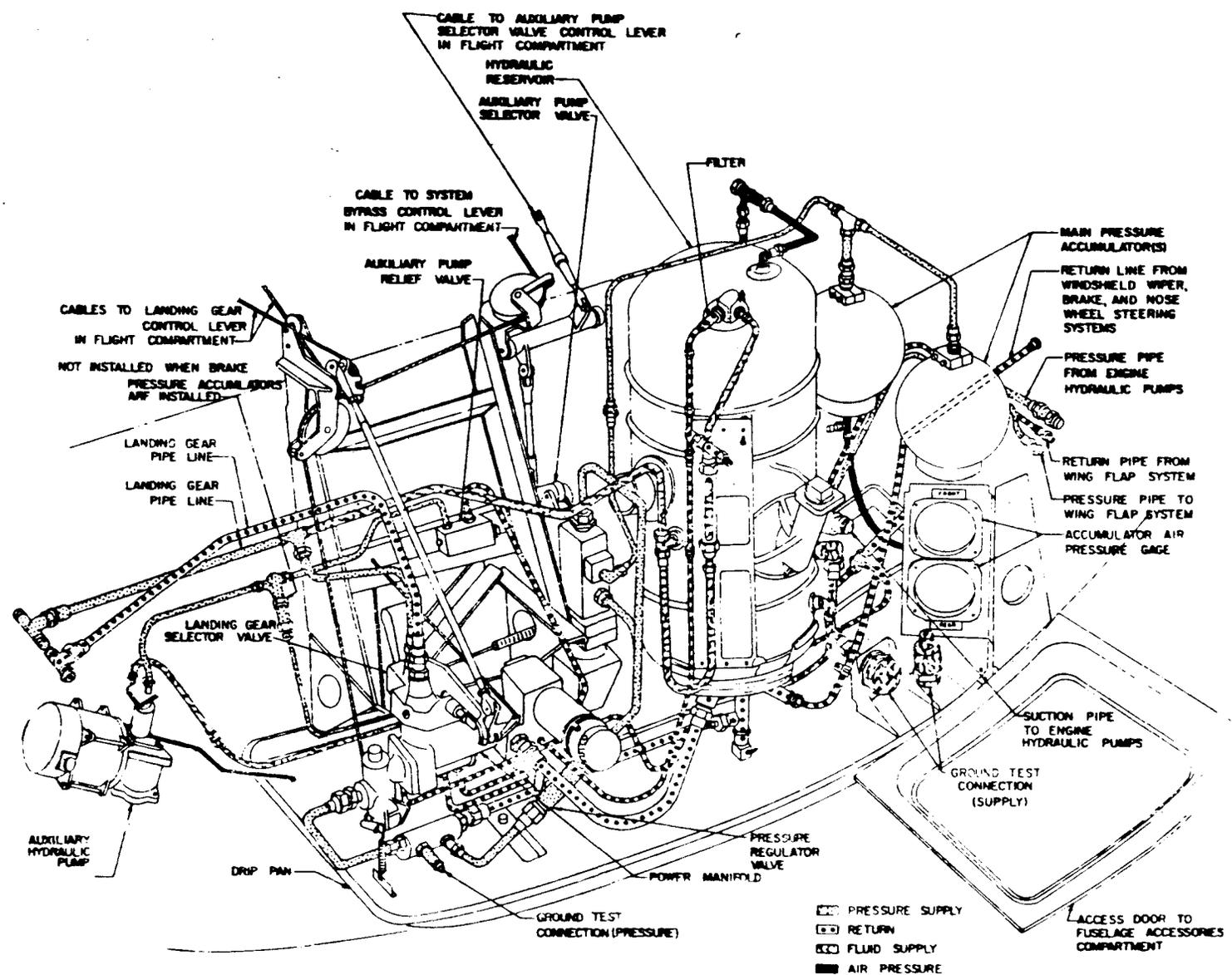
Hydraulic Fluid Emergency Shutoff Valve

Engine-Driven Hydraulic Pumps

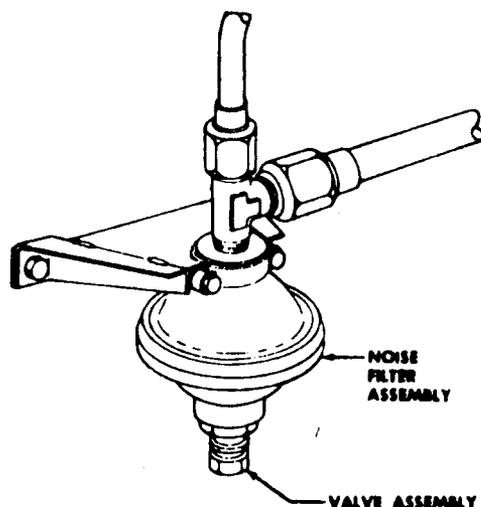
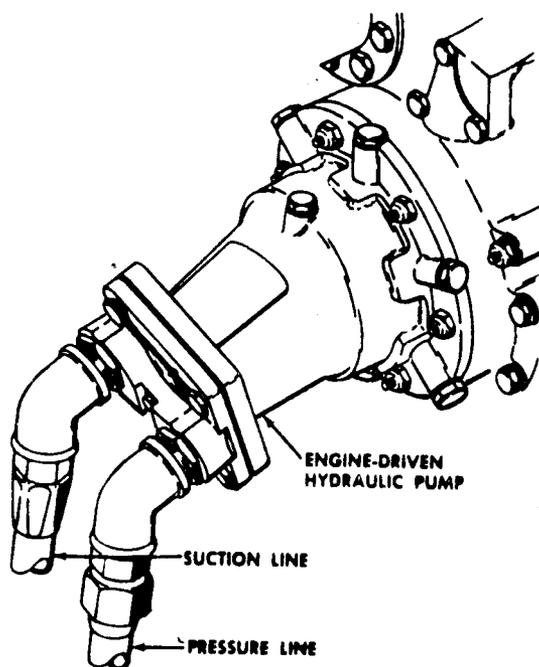
Pressure is supplied to the hydraulic system by two engine-driven pumps, one mounted on the accessory case of each inboard engine. Each pump has a normal output of six gallons per minute at 2800 rpm. Failure of an engine-driven hydraulic pump will be indicated by a reduced rate of system pressure buildup during hydraulic system operation. The pumps are internally lubricated by hydraulic fluid. Both pumps supply fluid to the system manifold and there is no means of selecting one pump or the other.

Noise Dampener

A noise dampener similar in construction to a pressure accumulator is mounted on the firewall to dampen the impact of the hydraulic pump pulsations.



FUSELAGE ACCESSORIES COMPARTMENT HYDRAULIC UNITS



Check Valves

One way check valves are installed in the pressure lines between the engine pumps and the manifold to prevent reverse flow of fluid into the pumps.

Hydraulic System Bypass Valve

A slide-type, manually operated bypass valve permits the hydraulic fluid to be bypassed directly from the

engine-driven pumps to the reservoir. This reduces wear on both the pressure regulator and the engine-driven pumps when pressure to the various units is not required. Placing the hydraulic system bypass control lever in the OFF (system inoperative) position opens the bypass valve. The bypass handle is located on the lower right corner of the pedestal.

The bypass valve may also be used in the event of pressure regulator failure, since continuous flow through the system relief valve will result in excessive heating of the fluid (indicated by excessive pressure on the gauge) endangering the operation of the engine-driven pumps and other units of the hydraulic system. Place the hydraulic system bypass control in the OFF position whenever operation of hydraulically operated units is not desired. However, during take-offs, landings, or ground operation, the bypass control must be in the ON position. The bypass valve does not require positioning for operation of the auxiliary pump. The valve is installed on the hydraulic power manifold in the fuselage accessories compartment.

Pressure Regulator

A pressure regulator maintains pressure in the system between 2650 PSI and 3100 PSI, bypassing hydraulic fluid from the pumps to the reservoir when the system pressure exceeds 3100 PSI. The pressure regulator is installed on the hydraulic power manifold in the fuselage accessories compartment. Whenever the pressure builds up in the system, the regulator is said to be "closed." After the pressure reaches 3100 PSI, the regulator "opens." This causes pump output to go directly to the reservoir rather than to charge the system. The pressure will now either remain at 3100 PSI or drop slowly due to internal leakage. When the pressure drops to 2650 PSI, the regulator will close and