STUDY GUIDE
C118

Prepared By:

SIMULATOR TRAINING BRANCH

2750th AIR BASE WING

This Study Guide is a supplemental reference which you may retain permanently. It will provide you with study material which will help you understand and assimilate our classroom instruction. Illustrations to supplement this publication are contained in the classroom daily handouts.

We have endeavored to omit all superfluous data and present you with a simple condensed text of the aircraft systems, component units, and their operation. It will provide a valuable source of interesting and readable information, complied expressly for you as a flight crew member.

NOTE: It must be understood that Technical Orders and other official directives supersede this Study Guide when the information contained herein conflicts.

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SECTION 1 AIRPLANE GENERAL

INTRODUCTION

The aircraft is a 4-engine, 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 79 troops when used as a personnel transport, or approximately 60 litter patients with provisions for 7 medical attendants when used as an ambulance transport, or diversified cargo when used as a cargo transport.

Accomodations are provided for 4 crew members: pilot, copilot, flight mechanic, and navigator. Some aircraft have provisions for a radio operator.

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.

AIRCRAFT 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 section 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 fiberglass batting is added. A final lining of laminated fiberglass 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 fiberglass 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 fiberglass 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 control 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 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 event of primary latch failure. Hatches are installed in the main cabin floor to provide internal access to the lower compartments.

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.

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.

ALCOHOL DE-ICING

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 carburetor de-icing switches on the heater control panel. The alcohol de-icing system pump is energized and the corresponding shutoff valve is opened when a carburetor de-icer switch is closed. A total of 17 minutes continuous flow to the four carburetors 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 windshield solenoid shutoff valve. A metering valve is located to the right of the copilot to control the flow. When the metering valve is in the full open position and the windshield de-icing switch is placed in the "ON" position a supply of 16 gallons will last approximately 48 minutes, provided no alcohol is used for the carburetor de-icing system.

MAIN 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 compartments 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 connected 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 Gal Each	Usable Gal Each
Nos 1 and 4 Main		700.3	695
Nos 2 and 3 Main		722.6	719
Nos 1 and 4 Alternate		531.0	526
Nos 2 and 3 Alternate		773.7	762
	Total	5455.2	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 tank 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 forward of the pilot's throttles and are marked with the following positions: "Main On" (forward position, green band), "Alternate On" (center positions, 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

MAIN ON	(Main tank supplying respective engine)
ALT ON	(Alternate tank supplying respective engine)
OFF	(Both main and alternate tanks off)

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 valves) are located on the control pedestal to the right of the tank selector levers. Their positions are:

LEFT CROSS-FEED LEVER

OFF	(Left Wing Cross-feed system closed)
ENG 1-2	(Engines No. 1 and No. 2 being supplied from same left wing fuel tank)
ALL ENG. TO CROSS-FEED	(Makes fuel from right side of aircraft available to left engines when right cross-feed lever is in same position)

RIGHT CROSS-FEED LEVER

OFF	(Right wing cross-feed system closed)
ENG 3-4	(Engines No. 3 and No. 4 being supplied from same right wing fuel tank)
ALL ENG. TO CROSS-FEED	(Makes fuel from left side of aircraft available to right engines when left cross-feed lever is in same position)

BOOSTER PUMPS

Electrically driven fuel booster pumps are used to supplement the engine driven pumps by keeping the engine-driven pump inlet fuel pressure above the cavitation, range.

One booster pump is submerged in the bottom of each MAIN tank. The four ALTERNATE fuel booster pumps are external type. Each is an integral unit composed of a centrifugal pump and an electrical motor.

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 should be operated in LOW speed boost whenever possible; HIGH boost is provided primarily for use in the event of engine-driven pump failure.

It is recommended that engines be started with booster-pump switches in LOW boost position except in extremely cold weather.

Recommended uses of LOW boost pressure are:

1. For engine start.
2. For take-off/landing.
3. When climbing.
4. When selecting a new fuel supply source.
5. For fuel conditioning.
6. When fuel pressure drops below 22 psi or fluctuates.
7. For oil dilution.
8. For flight in turbulence.

Fuel booster pump operating pressures are:

LOW BOOST:	12 - 18 PSI.
HIGH BOOST:	21 - 33 PSI.

A warning light will come "ON" any time the fuel pressure drops below 18 PSI.

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 strainers 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 shut-off 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 shut-off 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.

Engine driven fuel pump pressures are:

Minimum allowable, idling	14 psi
Normal operating range	22 to 24 psi
Maximum allowable	25.5 psi

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, because 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 over-board 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 to 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

Fuel dumping facilities 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 dump valve. A stand-pipe is installed in each main tank so that when all possible fuel is dumped in level flight, sufficient fuel will remain in the main tanks for approximately 40 minutes of flight on three engines at METO power or 30 minutes on four engines. Fuel is dumped overboard from an extended chute at the rear of each nacelle. Dump valves and chutes are controlled by four cable rigged control levers located beneath the floor plate, aft of the control pedestal. Each handle controls one dump chute and two dump valves and has three positions, CLOSED-DRAIN- and OPEN. The open position extends the dump chute and opens the two dump valves in one operation. After the dumping operation is completed, move the handle to the DRAIN position and allow five minutes for residual fuel to drain. Then, after visually checking the chute to make certain no fuel is running out, return handle to CLOSED position.

The maximum speed at which fuel may be dumped is 185 knots. Both landing gear and flaps must be UP during dumping operations. Normal dumping rate is 456 gallons per minute or 2736 pounds per minute.

FUEL SYSTEM MANAGEMENT

Various tank-to- engine combinations of fuel feeding may be obtained by proper positioning of the selector and cross-feed valve controls. Prior to take-off, check for unobstructed fuel flow by operating each engine on both its main and alternate tanks. For normal operation, take-off is made with fuel flow from the main tanks to the respective engines. When a transfer is made from one tank to another, first turn the booster pump for the new source to LOW. This insures proper fuel flow to the engine. Then open the selector valve for the new tank before shutting OFF the original source.

Cross-feed valves are used to direct the flow of fuel to its destination, if other than direct tank-to-engine feed is necessary. Select the fuel tank to be used by opening that tank's selector valve and direct fuel flow to the engines desired by positioning the cross-feed valves for these engines.

FIRE DETECTION AND EXTINGUISHING SYSTEMS

The C-118 aircraft has both a mechanically controlled fire extinguisher system and an electrically controlled fire extinguisher system.

Both systems are controlled from the flight compartment, although, controls for each system are located on separate control panels.

The main fire control panel is just below the pilot's glare-shield and contains controls for the mechanically controlled system. The heater fire control panel is located in the ceiling above the pilot's seat and contains controls for the electrically controlled system.

Six large cylinders in the nose-wheel well provide the CO_2. In addition, there are individual CO_2 cylinders for the cabin heater, tail anti-icing heater and the GTPU. The mechanically controlled system delivers CO_2 to the nacelle sections, lower cargo compartments, heater compartment and the hydraulic accessories compartment. The electrically controlled system delivers CO_2 to the wing anti-icing heaters, and also actuates the individual CO_2 cylinders at the cabin heater, tail anti-icing heater and the auxiliary power plant.

Two flush type CO_2 discharge indicators (discs) are mounted near each bank inside the nose-wheel well, representing their respective bank of cylinders. The forward indicators are yellow and indicate normal cylinder discharge (manual or electrical). The aft indicators are red and indicate thermal discharge. Each cylinder flood valve is equipped with a safety disc set to rupture between 2650 and 3350 psi. Thermal discharge of one cylinder in a bank will not discharge the remaining cylinders as will a normal discharge.

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 CO_2 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 CO_2 discharge but does not discharge CO_2. The engine selector valve handles also operate the emergency shutoff valves at the firewall.

MAIN FIRE EXTINGUISHER CO_2 DISCHARGE CONTROLS

Two CO_2 discharge handles, one for each bank of CO_2, 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 CO_2 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 CO_2, the light on the appropriate selector valve handle and the lights on both CO_2 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 CO_2 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 Zone II and III have both fire detectors and CO_2 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. Three red warning lights, one on the heater fire control panel, one on the auxiliary power unit panel, and the master Fire Warning Light will all 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.

THERMAL 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 controls 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.

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 their respective airscoops. During ground operations 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 ground operation. Wired through the left landing gear strut switch, the ground blowers are automatically in operation whenever the airfoil deicer switch is ON and the weight of the airplane is on the landing gear.

A group of cycling and overheat thermoswitches in the heater air ducts regulates the temperature of the air leaving the heaters to a maximum temperature of 210°C. These temperatures are indicated on the heater control panel temperature gauges.

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 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 may be used 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.

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 automatic operation. Two 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 guage showing the position of the mixing valve is adjacent ot the manual control door.

The cockpit temperature is normally consistent with main 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 clock-wise rotation of the rheostat is required to turn the heater ON which will CYCLE at 115° 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 turbine, cool air from an aftercooler, and/or hot air from a cabin heater, mixes any two of them in the proper proportions to give a desired 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 counter-clockwise position. This opens the 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 after cooler, 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 cabin heater and/or ventiliation 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 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.

CABIN PRESSURIZATION

The cabin pressurization system is designed to keep cabin air as near sea-level pressure as possible throughout flight 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 feet, the pressure in the cabin decreases from the time of take-off, but at 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 4,515 feet 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.

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 predetermine 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 enables 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 instruments 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 pressure 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 firewall.

The supercharger drive shaft clutch is contained in a housing which is bolted 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.

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".

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 airflow 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 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 conected to the butterfly.

The anticipator bulb system is in effect a minature 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 represnets 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.

For ratio operation 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" at the lower left corner of the instrument, controls an arc or metal sector shich 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 pressure 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.

CABIN PRESSURE CHANGE LIMIT CONTROL

This unit has two pointers each controlled by its respective adjustment knob marked "UP" and "DOWN". For RATIO operation, which is the method used on most flights, the pointers are set 600 feet per minute "UP" and 300 feet per minute "DOWN". This does not limit the rate of cabin change while the airplane is ascending or descending. If necessary to maintain the selected schedule of the Cabin Pressure Regulator, cabin altitude changes can, and will, exceed the "UP" or "DOWN" settings of the Cabin Pressure Change Limit Control. This is a desirable design feature of the system.

However, during RATIO operation, the Cabin Pressure Change Limit Control will limit the cabin rate of change to its up and down settings when a change is made in Cabin Pressure Regulator setting in level flight, or if the airplane lands with pressure in the cabin.

The cabin altitude rate of change can be controlled independent of aircraft altitude changes by using RATE control. This is accomplished by setting both the "UP" and "DOWN" hands of the cabin pressure change limit control to the desired rate of ascent (above zero) or descent (below zero) and setting both the Cabin Hand and Start Marker of the Pressure Regulator to the desired cabin altitude.

CABIN EMERGENCY RELIEF VALVES

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. When 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.

Two emergency relief valves located at the six o'clock position in the aft pressure dome will automatically open when cabin pressure control valve operation is inadequate. The # 1 valve will begin to open at 4.20 psi. The #2 valve will begin to open at 4.34 psi. Both valves will be fully open at 4.67 psi. These valves may be opened manually by rotating the emergency altitude control handle located to the right of the copilot's seat. The pressure relief valves may also be opened by pulling UP the cabin emergency control lever.

VACUUM RELIEF VALVE

A vacuum emergency relief valve is located just below the floor level, on the right side of the pressure dome 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 1/4 psi.

DUMP VALVE

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 exists between this valve and the rear valves however. 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 EMERGENCY DEPRESSURIZATION CONTROL LEVER

A cabin emergency depressurization control lever located on the floor outboard of the copilot's seat has down and up positions. Normally the control lever remains in the down position. Pulling the lever rapidly to the up position declutches both cabin superchargers, opens both cabin pressure relief valves, opens the emergency dump valve, and closes the cabin pressure control valve. This action locks the pressure control valve in the closed position, the pressure relief valves in the open position, and the superchargers are locked in the DECLUTCH position. These positions should be maintained until reset by the ground crew.

SECTION 2 ELECTRICAL

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 above the battery compartment. The master battery switch has two positions, "OFF" and "BATT & GND PWR". A 500 ampere current limiter protects the batteries from an overload.

The batteries must be removed for a capacity check every 120 days. The water level must be maintained 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. Flush thoroughly.

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 springloaded 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 BAT" 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.

BATTERY CIRCUIT AND CONTROL

One battery relay connects and disconnects the batteries from the bus. This relay is located above the batteries and is controlled by the battery switch.

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

DC power is available to:

1. Emergency Inverter.
2. Pilot's and Copilot's Turn and Slip Indicators.
3. Instrument panel white lights.
4. Magnetic compass light.
5. Sextant light.
6. Pilot's overhead white light.
7. Inverter warning lights.

At the same time AC power is available for:

1. Pilot's and Copilot's Gyro Horizons.
2. Pilot's S-2 Compass.

DC POWER SUPPLY AND DISTRIBUTION

DC power is supplied by four engine driven generators rated 350 amperes at 30 volts, two gas turbine driven auxiliary power generators rated at 350 amperes at 30 volts, and the 24 volt 88 ampere hour battery system.

All DC power is fed to a master bus in the Main Junction Box, just aft of the navigator's station. The main circuit breaker panel is located on the forward panel of the Main Junction Box and contains the major circuit breakers for the DC electrical circuits.

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.

REVERSED CURRENT RELAY

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

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 and control panel is mounted in the crew compartment adjacent 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 FOR STARTING

The GTPU generator switch located on the forward overhead switch panel must be in the OFF position.

STARTING

1. Check that the APU generator switches located on the forward overhead panel are OFF. Then check that the airfoil de-icer switch located on the heater control panel is OFF. Position the battery switch to PLANE BATTERY, or to GROUND POWER if external power source is plugged in.

NOTE

If using PLANE BATTERY, all loads except emergency loads are to be OFF.

CAUTION

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 that the following circuit breakers are ON:

APU control
APU fire warning
Heater and APU fire extinguisher
Main heater fuel pump
Airfoil heater and APU fuel pump
APU scoop heater

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

4. The APU scoop heater should be ON, if it is below freezing.

5. Turn ON the APU master switch.

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

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

8. The engine should run and show a constant increase in RPM. The duty cycle of the generator acting as a starter is 1 minute out of any 5-minute period.

CAUTION

If RPM does not exceed 95 percent in 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.

WARNING

Stop APU if combustion chanber temperature difference exceeds 300°C.

9. 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.

NOTE

To facilitate cooling after shut-down, wait until the speed of the unit reaches ZERO, as indicated on the percent RPM indicator and, if practical, wait 5 minutes before turning the APU MASTER switch OFF, which closes the air intake door. This is not necessary in case of a fire. When the auxiliary power unit is selected for fire extinguishing on the heater control panel, the intake door closes simultaneously with shutdown of the unit.

4. If the auxiliary power unit circuit breakers are to be opened, wait approximately 10 seconds in order to insure that the air intake door has had time to close.

ALTERNATING CURRENT

INVERTERS

Three rotary inverters are installed in a compartment behind the radio rack. These inverters supply alternating current for the instruments and electronic equipment. Each inverter supplies 115 volt, 400 cycle three phase AC power. DC power for inverter operation is supplied through 125 ampere circuit breakers from the master bus in the main junction box. The circuit breakers are located on the master circuit breaker panel. The AC output is protected by six AC circuit breakers located on the bulkhead behind the pilot.

CONTROLS

Two control switches for the inverters are located on the forward overhead panel and are decaled "ELECT-RADIO and RADAR". Each switch has three positions; NORMAL, OFF and STANDBY.

The "ELECT-RADIO" switch, when in the NORMAL position, causes the normal inverter to supply power to the aircraft electrical and radio equipment. The "RADAR" switch, when in the normal position, causes the other normal inverter to supply power to the Radar and Radio equipment. When either switch is placed in the STANDBY position, the standby inverter supplies power to its normal circuits. The switches are mechanically interlocked so that either "ELECT-RADIO", or "RADAR" switches may be positioned to STANDBY, but not both simultaneously.

An engine instrument switch adjacent to the inverter switches controls 26 volt, single-phase AC current, either from the Normal or Standby step-down transformer to the engine instrument bus.

Two inverter warning lights, installed on the main instrument panel, provide indication of power failure to the gyro flight instruments. If the lights illuminate, the standby inverter or the emergency inverter should be energized to supply AC power for the flight gyro instruments.

NOTE

If the gyro flight instruments are not already running, the instrument power warning light may not go out until approximately 1 minute after the inverter is turned on.

EMERGENCY INVERTER

An emergency inverter is installed in a case to the left of the pilot's position at floor level. It supplies 115 volt, 400 cycle AC power to the pilot's S-2 Compass and the two Gyro Horizon instruments in the event of complete failure of the main inverters.

A gangbar OFF-ON emergency instrument power and instrument lighting switch is mounted on the forward overhead panel. Moving the switch to the "ON" position automatically disconnects the normal inverter from the flight instruments and connects the emergency inverter. At the same time, a battery relay circuit is completed to supply 24 volt DC battery power to the emergency inverter, the instrument panel white lights, and the two Turn and Slip indicators.

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

Six 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 case.

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.

WARNING AND SAFETY SYSTEMS

LANDING AND SAFETY SYSTEMS

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

The three position indicators are located on the main instrument panel. When the landing gear is actuated, a marker appears on the instrument, indicating the position of the respective gear. When the landing gear is up, the word "UP" will appear. When the gear is down and locked, a picture of an extended gear will appear. During the time the gear is in an intermediate position, a striped area called the "Barber Pole" position is visible.

Whenever any of the three gears 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 pilot's seat, automatically sounds when any throttle is retarded and the gear is in any position other than full down and locked. In the event operation must 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

One of the red indicator lights installed on the cabin pressure control panel indicates belly compartment door position. These doors are: (1) Lower Rear Baggage, (2) Fuselage Accessory Compartment, (3) Heater Compartment and (4) Lower 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.

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 de-icing is necessary. The maximum airspeed at which landing lights may be extended is 152 knots.

NAVIGATION LIGHTS

The navigation lights 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 controlled 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 6-8 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

Two rotating red anti-collision lights are located on top of the vertical stabilizer and the bottom of the fuselage for better night recognition. These lights operate on 28 volts DC power and are operating whenever the navigation lights switch is in the "STEADY" position.

START, PRIME AND BOOST CIRCUITS

Spring loaded starter and starter safety 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 de-icer 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.

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 AUTOMATIC position.

SECTION 3 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. Above the AC-DC voltmeter panel is the cabin temperature control panel on which is mounted the cabin temperature indicator and the cabin temperature mixing valve position indicators. Just aft of the AC-DC voltmeter panel is a small bracket containing the super-charger duct pressure gauge 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 GTPU control and instrument panel.

PITOT-STATIC SYSTEMS

The pitot-static system supplies impact air pressure and atmospheric air pressure to the pneumatically operated instruments in the pilot's, copilot's, and navigator's instrument panels. The pitot-static system contains two electrically heated pitot-static tubes mounted on each side of the aircraft.

Impact air from the left side pitot-static tube is applied to the pilot's airspeed indicator. Pressure from the right side pitot-static tube is applied to the copilot's and navigator's airspeed indicators. The existing pilot's static vents are located forward of the flight compartment, one on each side of the aircraft. These vents and the static ports of the pitot-static tubes admit static air to the equalizer manifolds which equalize the static air in the system. The static air then goes through the static selector valves to static manifolds where the static air is equally distributed to indicators using static air.

Two static source selector switches, one outboard of the pilot's seat and one outboard of the copilot's seat permit selection of either the NORMAL static source or the ALTERNATE ice-free source, for either set of instruments.

The pitot-static tubes contain 28-volt DC heater elements to prevent icing. Pitot-static tube 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 "ON" 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 to sea level. When the correct "altimeter setting" has been 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 GAUGE

On the cabin pressure control panel is a differential pressure gauge, 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 GAUGES

Two direct reading dual manifold pressure indicators are mounted on the center section of the main instrument panel. The gauges 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 a low RPM and the manifold pressure less than field barometric pressure.

An abnormal manifold pressure indication for any given RPM may indicate engine trouble, gauge 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 GAUGES

The hydraulic pressure gauge 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 gauge 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 gauge is also mounted on the hydraulic and oxygen instrument panel. This gauge shows the pressure in the system used by the copilot, navigator and flight mechanic. The pilot's oxygen pressure gauge 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 gauge 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 produce 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 temperature indicators which require 28-volt 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 No. 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.

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

These indicators require 28 -volt 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 gauge is connected to the GTPU fire warning circuit breaker.

28-VOLT DC LIQUID QUANTITY GAUGES

These are often called "Liquid-ometers" 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 gauge 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 water-alcohol tanks mounted in the engine nacelles. Each outboard tank has a usable capacity of 9.4 gallons, and each inboard tank has a usable capacity of 10.24 gallons.

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 lown-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 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 the 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. 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 carburator. The system indicates the amount of fuel going to the engine.

The torquemeters (BMEP gauges) 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 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 the 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 No. 1 and No. 4 engines. The pressure indicated is that within the low pressure bridle.

The cabin temperature mixing valve position indicator is on the cabin temperature control 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 in the right hand annex of the Main Junction Box.

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.

No. 1 and 4 main tanks each have six tank units. The remainder of the fuel tanks have three tank units apiece. In each of the oil tanks is one tank unit. 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 condensor.

As the dielectric constant of fuel or oil is greater than that of air, the capacitance value of the condensor 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 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 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 AC or DCpower 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 emergency instrument power and instrument lighting switch will operate for approximately two and one-half hours, on fully charged batteries.

S-2 COMPASS SYSTEMS

The C-118 has two 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 AC power. In addition both system require 28-volt DC power.

The pilot's S-2 Compass System is supplied 115-volt power by either the RADIO-ELECTRIC or the STANDBY inverter. If there is a failure of the normal AC or 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 power by either the RADAR-ELECTRIC or STANDBY inverter. It cannot be connected to the EMERGENCY inverter.

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

Both systems have two 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 two circuit breakers on the main circuit breaker panel, one for each system.

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 two 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 two Directional Gyro Controls are in the hydraulic accessory compartment. Each Directional Gyro Control contains an 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 position, 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 two 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 cannot 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 presentand must be compensated for by the pilot. The random drift of the gyro varies with 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.

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 AUTO-PILOT 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.

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.

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 positions.

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. 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 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 heading pointer 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.

NOTE: 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 reingage.

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.

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.

AUTOMATIC APPROACH PROCEDURES

The basic ILS procedures are shown in Section IX of T.O. 1C-118A-1. The same procedures plus 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 receivers - ON
5. The APPROACH READY light on the automatic approach selector panel - ON

WARNING

DO NOT attempt to execute an automatic approach if the light is out.

When over the outer marker outbound, reduce airspeed to 140 knots. One minute after crossing the outer marker outbound 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, the gear is up and the flaps are at 20 degrees.

After a standard ILS procedure turn, the inbound heading is normally 45 degrees from the localizer heading. However the automatic approach equipment allows the aircraft to approach the localizer beam at any angle up to 90 degrees from the landing heading. During the inbound heading the pilot turns the automatic approach selector switch 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

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 on to 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.

SECTION 4 PROPELLERS

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.

A constant engine RPM can be selected 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 positioning the throttle(s) in the reverse range (aft) which actuates 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 +96° for feather. The maximum indicated airspeed at which the unfeather operation should be accomplished is 135 knots.

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 deenergized 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 to the 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 or 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 is then 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.

ON-SPEED (RPM REMAINS STEADY)

This condition exists when the airspeed, attitude 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 neutral or constant speed position.

OVERSPEED (RPM INCREASES)

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 the blades to higher pitch. The engine speed slows down to its former RPM setting.

UNDERSPEED (RPM DECREASES)

This condition results if the aircraft should start to climb from level flight and the propeller pitch becomes too high due to a reduction in airspeed while the power remains unchanged. In order to keep the propeller turning at the same RPM, while its pitch has been effectively increased, more power is required from the engine. However, as the engine power remains the same, the higher pitch in the climb will cause the engine to slow down, thus causing underspeeding. This makes the flyweights droop, moving the pilot valve. Oil then flows to the inboard side of the piston. The resulting action twists the blades to a lower pitch, automatically increasing the speed of the engine to the former RPM setting.

FEATHERING AND REVERSING

PROPELLER FEATHERING PUMP

A propeller feathering pump assembly is installed in the lower right side of each engine accessory section just forward of the firewall. The assembly consists of an electrical motor, an adapter assembly, and a gear-type pump. An aluminum shroud over the motor switch area of the pump prevents the accumulation of water and oil from entering the pump motor and switch assembly.

PROPELLER FEATHERING OIL SYSTEM

Engine oil is transferred from the engine oil supply tank to the propeller feathering pump and from the pump forward to the governor. The engine oil supply tank has a standpipe which insures a reserve supply of oil, 2.5 U.S. gallons, which is sufficient for feathering 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 bases of the standpipes and is trapped there, preventing its entrance into either the engine lubricating systems or the propeller feathering system.

FEATHERING SWITCHES

Four feathering switches are mounted on the forward overhead instrument panel. The switches are the push-pull type having three positions. Fully depressed is the feathering position. Pulled full out is the unfeathering position. The switch is spring loaded to the neutral or normal inoperative 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 $+96^{\circ}$ 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 curcuit to ground, deenergizing 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 curcuits to energize the feathering pump and the governor reverse unfeather solenoid valve (open). Feathering pump oil pressure is then exerted against the decrease-pitch of aft side of the propeller piston to unfeather or change propeller blades to a lower angle. At 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 deenergize 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 positioned 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 and also starts the propeller feathering pump. The pilot valve is moved to the underspeed 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 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.

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 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 No. 2 MASTER or No. 3 MASTER position. When the master lever is put in the full forward position, it actuates a switch which cuts out the synchronizing curcuit 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 No. 2 or No. 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 each time the resynchronizer switch is depressed and released. 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 3% increase or decrease is available.

PROPELLER AUTO CONTROL SWITCH

The automatic propeller synchronizing system is controlled by a three-position switch, marked No. 2 MASTER, MANUAL, No. 3 MASTER, on the propeller control panel. When the switch is in the No. 2 or No. 3 MASTER position 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 deenergized.

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. The system is protected by an "ON" "OFF" switch type circuit breaker marked "Sync. Prop" 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 tachometer generators 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 the master lever is in FULL increase RPM position, at which time synchronization is inoperative.

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

DE-ICING SYSTEM

The propellers are protected from ice formation by an electric de-icing 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 hydraulic 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 de-icing circuit individually in sequence.

The propeller de-icing 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 MANUAL operation in the event of timer failure, or if it is desired not to de-ice one propeller. The switches are normally guarded to the TIMER position. 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 de-iced). Unlimited ground operation of the propeller de-icing system is permissible when the engines are running at generator cut-in speed. Takeoffs and landings can be made with the system in operation.

When manually de-icing all four propellers, it is recommended that the de-icing time period for each propeller does not exceed 60 seconds ON and 180 seconds OFF. Partial timer and manual de-icing 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 de-icing).

When the engines are not running, the propeller de-icing 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 de-icing system circuits are opened and the system is inoperative during propeller feathering, unfeathering, reversing and unreversing operation.

SECTION 5 ENGINES

ENGINE GENERAL

Specifications R-2800-52W

Number of Cylinders	18
Type	Radial, Two-Row, Aircooled
Displacement	2804 Cubic Inches
Bore	5.75 Inches
Stroke	6.00 Inches
Compression Ratio	5.75 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 63" MP	2300 BHP 232 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).

For descriptive purpose, 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 torquemeter 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 torquemeter booster pump. There are mounting pads on the case for the magneto, 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. 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 mehtods 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.

LUBRICATION SYSTEM

GENERAL

The R-2800-52W engine has a full pressure, dry sump oil system which used 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 scavenge 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 is in each tank and 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 control the flow of oil through it. The cooling system controls the temperature of the oil for proper lubrication and cooling of the internal work ing parts of the engine.

OIL QUANTITY INDICATORS

The oil quantity is measured by a Simmonds Pacitron Gauge 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 gauge 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 ($\pm$ 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 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 for-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 auxiliaryoil 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% oil, grade 1100 and 50% 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.

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 valves 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.

[redacted]?

[redacted], 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 readily be determined.

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

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

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 corrections 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 gauge. 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 gauge to determine power input and the torquemeter to determine power output. The operator should be aware of the proper relation ship between the two and recognize the meaning of failure by the engine to demonstrate this relationship.

Then 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 inability 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 detent 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 gauge. In fact, proper interpretation of torquemeter readings may be a more accurate indication of ignition difficulties than the conventional magneto check procedure.

Observation of the oscillating period of the BMEP gauge hand will permit an operator to detect engine roughness or irregular operation at an early stage. This is only true, however, where the torquemeter gauge 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 torquemeter requires consideration. Its accuracy can be no better than that of the gauge 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.

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 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 timperature 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 1200 BHP)	Max CAT 15°C
High Blower (Below 1200 BHP)	Max CAT 30°C

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.

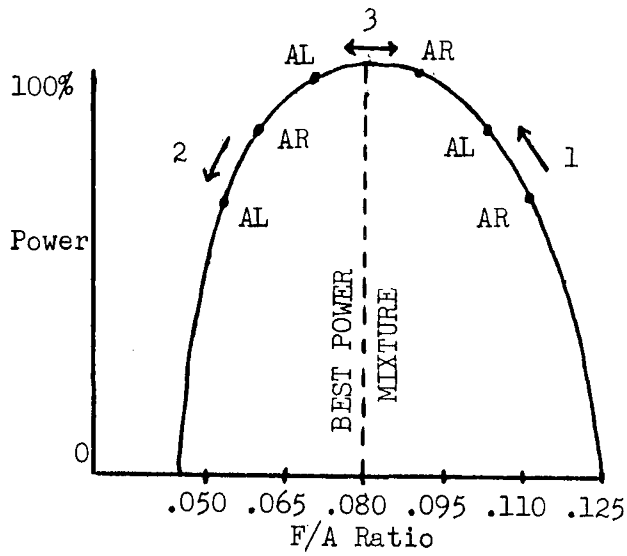


Figure 1

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.

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 output is decreased. At position #3, Figure 1, moving the mixture control does not materially change output, as the setting is at best power.

TEMPERATURE

The relation of cylinder head temperature to mixture strength is much the same as that of power. However, the picture is complicated somewhat by distribution inequalities. All cylinders do not receive the same fuel/air ratio at any one operating condition. The two fuel/air ratios which must be considered are as follows:

1. The measured ratio which is the overall average and is obtained by dividing the total fuel consumption by the total air consumption.

2. The virtual ratio which is the ratio being supplied to any one cylinder and which may vary be a significant amount from the measured ratio.

The temperature of any one cylinder is affected by the virtual ratio of the charge delivered to that cylinder, rather than the measured ratio of the entire engine. On the R-2800 engine the cylinder head temperature is measured on one cylinder only.

Theoretically, the fuel/air ratio giving the hottest temperature is .067. Mixtures leaner than .067 fuel/air ratio lower the cylinder head temperature as the result of the cooling effect of the excess air which is surplus to combustion requirements. Mixtures richer than .067 lower the cylinder head temperature because of the excess fuel over complete combustion requirements. Enrichment beyond .080 is for the purpose of suppressing detonation.

If the mixture were distributed uniformly to all cylinders the reaction of temperature to fuel/air change with other factors held constant would be as shown in Figure 2.

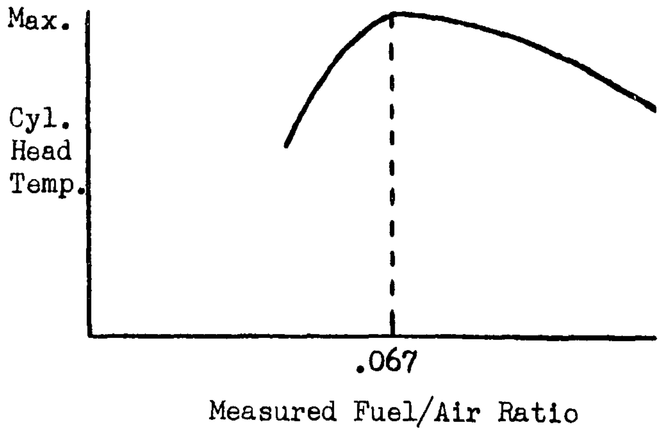


Figure 2

Fuel/Air Ratio Curves

FUEL/AIR RATIO CURVES

In general, if an engine is provided with a carburetor setting giving a rich mixture, in the cruise power range, shifting from the auto rich to the auto lean mixture position will result in higher power and higher cylinder head temperature. Further leaning * below the auto lean position will decrease the power and the cylinder head temperature.

*This describes the result of leaning to mixtures leaner than auto lean. This procedure may be followed only if permitted by specific instructions.

CARBURETOR

The carburetor controls the amount of fuel and air delivered to the engine and maintains the correct fuel/air mixture through the entire engine operating range.

The injection carburetor employs a simple, proven method of metering fuel through fixed jets according to the mass of airflow, combined with the function of atomizing the fuel spray under positive pump pressure. This method of carburetion eliminates ice formation in the carburetor, assures positive fuel metering during all maneuvers, and provides accurate fuel metering at all conditions of engine operation.

THE FIVE MAIN UNITS OF THE CARBURETOR

1. The Throttle Body Unit which controls and measures the flow of air to the engine.

2. The Regulator Unit which adjusts and regulates the fuel pressure across the metering jets.

3. The Fuel Control Unit, containing metering jets that meter fuel to the engine, the power enrichment valve, the idle metering valve, and the manual mixture control valve.

4. The Automatic Mixture Control Unit maintaining a constant fuel/air ratio under varying air density and temperature conditions.

5. The Acceleration Pump is linked to the throttle and supplies additional fuel to the engine during a sudden throttle advancement.

COMPONENT UNITS OF THE CARBURETOR

Throttle Body

The throttle body is the principal part of the carburetor. It contains boost venturis and impact tubes, which transmit the pressure of entering air to the air chamber. The throttle valve is located at the bottom of the throttle body. Since the throttle valves are directly in the path of the incoming air, they control the amount of air passing through the carburetor.

AUTOMATIC MIXTURE CONTROL UNIT

Air passing through the carburetor varies in density due to altitude and temperature changes. The correct mixing of air and fuel is based on weight of the mass air flow. A means of measuring this weight is provided by the automatic mixture control. This prevents a natural enrichment at higher altitudes.

REGULATOR UNIT

A diaphragm type pressure regulator is used in the carburetor. The two main diaphragms are the air and fuel diaphragms. The fuel and air diaphragms control the fuel inlet poppet valve at the entrance of the regulator unit. If the regulated fuel pressure tends to drop below the air pressure, the diaphragms deflect, open the poppet valve and allow an increase in fuel pressure and fuel flow to balance out the higher air pressure.

Fuel is delivered to the regulator unit at 23 psi by the engine-driven fuel pump. Float type vapor separators are installed in the regulator unit, allowing air bubbles to be piped back to the inboard main tanks. Normal flow-back of the fuel with these air bubbles is less than 2 gallons per hour.

FUEL CONTROL UNIT

The fuel, after passing through the regulator unit, is forced through the metering jets of the fuel control unit. At idle speed, fuel flow to the idle valve is insured by the constant head idle spring which holds the poppet slightly off its seat. This permits fuel to flow through the regulator when the air metering pressure is low. At low RPM the amount of fuel flow to the engine is governed by the position of the idle valve. At small throttle openings a considerable restriction exists but as the throttle is advanced out of the idle range, the valve opening increases. At cruise power the valve is completely open, and metering is accomplished either by jets or predetermined size or by the manual mixture adjustment.

To enrich the mixture in the high power range, a power enrichment jet is placed parallel to the normal jet. Flow from this jet is controlled by a spring loaded valve and a diaphragm. The diaphragm begins to lift the valve off its seat when the differential pressure between the unmetered and metered fuel becomes great enough at higher powers. This is called the power enrichment valve.

A derichment valve located in the fuel control unit reduces the fuel flow when water is injected into the engine. As water pressure is applied to the derichment valve diaphragm, the needle valve closes and shuts "off" the fuel flow through the derichment jet. This reduces the fuel/air ratio towards the best power mixture; while sufficient water and alcohol is injected into the engine to provide the cooling necessary to prevent detonation. If the water injection system is not in operation, the derichment valve remains open and normal fuel/air ratios are maintained.

A manual mixture control valve is incorporated into the fuel control unit to provide for operating conditions during which the normal settings are inadequate. This is a clover leaf valve, which is mechanically linked to a control lever at the control pedestal.

FUEL FEED VALVE

The metered fuel from the fuel control unit is discharged directly into the engine blower by means of the fuel feed valve.

The fuel feed valves open at 9 to 11 psi.

FUNCTIONS OF THE FUEL FEED VALVE

The fuel feed valve spring maintains a constant metered fuel pressure, which prevents foaming in the engine fuel system, the carburetor jets and aids in distribution of fuel.

THE ACCELERATION PUMP AND PRIMER

The acceleration pump is located on the right rear corner of the carburetor and is operated mechanically by the throttle. Rapid advancement of the throttles forces fuel under pressure into the balance chamber at the end of the poppet valve shaft. This pressure momentarily opens the poppet valve and allows more fuel to go out to the fuel control unit to enrichen the mixture to the engines.

The priming solenoid located on the rear of the carburetor discharges fuel on both sides of the blower throat just below the carburetor.

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 $-10^{\circ}C$ to $+15^{\circ}C$. A carburetor alcohol de-icing system provides a 17 minute supply of fluid to the four (4) carburetors, providing alcohol is not also used for windshield de-icing.

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 <u>increase</u> in fuel flow and <u>decrease</u> 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 gallons in the inboard tanks. The supply is adequate for approximately five (5) minutes operation at take-off 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) duel 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 psi.

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 flash-over.

DLN - 10 MAGNETO

The dual magneto for each engine is mounted on the front accessory case. The magneto is driven by the engine, in a counter-clock-wise direction, at one and one-eighth crankshaft speed. Each magneto contains two 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 two 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 condensors prevent arcing and burning of the breaker points.

In the base of each distributor are two 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 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, whichis 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".
2. Return the Ignition switch to "BOTH".
3. Next, move the Ignition switch to "L".
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.

SECTION 6 HYDRAULICS

HYDRAULIC SYSTEM GENERAL

Hydraulic units which operate on main system 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 with the auxiliary pump.

Hydraulic Reservoir

The hydraulic reservoir, located in the hydraulic accessories compartment, has a fluid 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 liquid-ometer float-type transmitter in the reservoir. It is calibrated REFILL, NORMAL FLIGHT, and FULL-ZERO PRESSURE. A relief valve on the hydraulic reservoir maintains an air pressure of 8 psi to supply fluid to the engine-driven pumps.

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 forewall. The valves are operated by their respective inboard engine fire selector handles.

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 engine 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 for each pump similar in construction to a pressure accumulator is mounted on the firewall to dampen the impact of the hydraulic pump pulsations.

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, 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 hydraulic 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 the pump output will again charge the system to 3100 psi. This process of the regulator opening and closing is called "cycling". The "cycling" can be checked by watching the pressure rise and fall between 2650 and 3100 psi on the system pressure gauge.

Main Hydraulic Pressure Accumulators

The main pressure accumulators, connected in parallel, are used to store fluid under pressure, prevent sudden surges in the system and to aid the pumps under peak loads. These accumulators are located in the hydraulic accessories compartment. The two pressure gauges near the accumulator indicate the air charge when the main system pressure gauge in the cockpit reads zero. The accumulator air charge is 1000 (+200, -0) psi.

System Relief Valve

The hydraulic system relief valve is mounted on the hydraulic power manifold in the hydraulic accessories compartment. It prevents excessive system pressure if the pressure regulator fails to bypass fluid when the pressure exceeds 3100 psi. One important point to understand is that the system relief valve does not assure that the pressure will be 3300 (+100, -0) psi, if the pressure regulator fails. The pressure indicated on the gauge will depend on the volume of fluid passing through the valve. At take-off RPM, the pumps are putting out approximately 12 gpm. Under this flow the pressure in the system would be above 3400 psi.

Emergency Hydraulic Pump

An electrically-driven auxiliary hydraulic pump, mounted in the hydraulic accessories compartment, provides an emergency source of pressure. The momentary-contact controlling switch is marked, "EMER. HYD. PUMP" ON-OFF, and is located aft of the hydraulic and oxygen instrument panel. The auxiliary pump can be used if the engine-driven pumps fail or if pressure is desired while the aircraft is on the ground and the engine inoperative.

Emergency Pump Relief Valve

There is an auxiliary pump relief valve mounted in the hydraulic accessory compartment. The purpose of this valve is to prevent the auxiliary pump from building up excessive pressure. This valve is set to open at 3000^{+50}_{-0} psi.

Emergency Pump Selector Handle

The selector valve lever for the auxiliary pump operation is located on the floor left of the co-pilot's seat. The lever has three positions; brake system, general system and pressure accumulator. The control lever will normally be left in the brake system position.

BRAKE SYSTEM - (forward position) Fluid directed to brakes and cargo doors only.

GENERAL SYSTEM - (center position) Fluid directed to general system, brakes, and cargo doors.

PRESS. ACCUM. (aft position) Fluid directed to brakes, general system, accumulators, and cargo doors.

LANDING GEAR SYSTEM

The landing gear hydraulic system uses full system pressure to both retract and extend the gear. The system consists of a control valve, landing gear actuating struts, nose gear down-latch bungee strut, nose gear bungee gland, nose gear up line orifice and the necessary lines and fittings. A control lever, located on the aft face of the control pedestal in the flight compartment, actuates the landing gear control valve through a two-way cable system. A spring-loaded over-center asssist cable reduces the effort required to shift the control lever to either the UP or DOWN position and aids in insuring that the lever will be fully positioned at either end of the quadrant.

In the event of hydraulic failure, movement of the control lever to the DOWN position will release the uplatches and permit emergency extension by gravity. In the event of control cable failure, a spring on the control valve piston automatically places the valve in NEUTRAL allowing emergency extension by free fall. During emergency extension by free fall, any vacuum created in the down line is relieved by the down-line vacuum relief line connected to the reservoir. A check valve in this line prevents any loss of pressure during normal gear operation.

Landing Gear Safety Solenoid Pin

A solenoid operated pin which projects across the control lever prevents moving the gear control handle to the UP position when the aircraft is on the ground. The circuit energizing this safety solenoid is wired through a switch on the right main gear. When the right gear strut is extended, the switch is closed. This energizes the safety solenoid which pulls the pin out of the way allowing the gear handle to be placed into the UP position.

Main Gear Bungee Springs

The bungee is formed of two independent springs held under tension to pull the down-latch into the locking position when the landing gear is lowered without hydraulic pressure. The bungee also aids in down locking the gear during normal extension.

Nose Gear Bungee Strut and Downlatch

The nose gear downlatch, which locks the nose gear in the extended position, is formed by two short links between the knee joint of the drag linkage and the center of the shock strut supporting yoke. The downlatch is controlled by a hydraulically operated spring-loaded bungee strut mounted on the yoke and connected to the downlatch at the piston end.

When the nose gear is extending, the spring in the bungee strut extends the bungee piston, forcing the down latch knee 1/16 inch past center and locking the nose gear in the DOWN position. During retraction, hydraulic pressure is directed to the bungee strut to overcome spring tension and force the bungee piston to retract. This breaks the down latch knee joint and allows the gear to retract.

Ground Safety Pins

Landing gear ground safety pins should be installed in the landing gear retracting links to prevent inadvertent collapsing of the gear while on the ground. The ground safety pins are stowed in the aircraft when not in use.

Landing Gear Limitations

The miximum airspeed for landing gear extension is 170 knots. The landing gear should retract in 7 to 10 seconds and free fall in the maximum of 1 minute.

BRAKE SYSTEM

An expander tube type brake on each main gear is operated by hydraulic pressure. The major units of the system are the brake control valve, four debooster cylinders, four shuttle valves and two main gear glands. System pressure 2650 to 3100 psi is directed to the brake control valves from the landing gear down line permitting operation of the brakes only when the landing gear control lever is in the DOWN position. The brakes operate under a maximum pressure of 630 ± 15 psi, the reduction from main system pressure is accomplished by the brake control valve and the debooster cylinders. The debooster cylinders also prevent hydraulic failure in one brake from affecting the operation of the other brake.

Brake Control Valve

A dual power brake control valve is located in the top of the nose wheel well. This valve meters pressure to the deboosters at approximately 1800 psi. This valve is controlled by both the pilot and co-pilot brake pedals through a mechanical linkage.

Brake Deboosters

There are four brake deboosters. They are mounted two on the rear of each main strut. The purpose of the deboosters is to give quick application and quick release of the brakes. The ratio of the brake deboosters is 2.87 to 1. They reduce approximately 1800 psi from the power brake control valve to 630 $\pm$ 15 psi to the brakes.

Brake Line Shuttle Valves

The shuttle valves are located at the junction of the hydraulic and emergency air pressure lines at the brake assemblies on the main gear. A small spring, assisted by hydraulic pressure, keeps the cone seated on the air pressure port during normal hydraulic brake operation. When the air brake valve is opened, air pressure pushes the cone off the seat on the air port and over a seat on the hydraulic line. This blocks off hydraulic pressure and directs the air pressure to the brakes.

Parking Brakes

The parking brake control handle is installed on the left side of the control pedestal. To set the parking brakes, make certain that full hydraulic pressure is available, depress the pilot's brake pedals, then turn the parking brake handle to the "ON" position, releasing the brake pedals while holding the parking brake handle in the "ON" position. Brake engagement can be checked by moving the parking brake lever forward. Freedom of movement indicates that the parking brake is engaged. To release the parking brakes, fully depress the brake pedals.

Emergency Air Brake System

The emergency air brake system consists of a pressure cylinder, pressure gauge, pressure control valve and shuttle valves which admit the air pressure to the brakes. The cylinder is located in the right nose wheel well tunnel and is charged to 1000 ± 50 psi. The pressure gauge is on the hydraulic and oxygen instrument panel, and the control valve is on the main fire extinguisher panel, convenient to the pilot only. The control valve handle meters the air into the brake system and has three positions: OFF, HOLD, and ON. Sufficient air pressure is available for three full brake applications. The brake hydraulic system must be bled after operation of the air brake system.

Air Brake Operation

If no hydraulic pressure is available to the brakes, stop the airplane with the air brake system. Do not use the air brakes before the nose wheel has touched the ground. Apply the brakes slowly and intermittently after ground speed has been reduced by an extended roll, gradually increasing the braking power rather than applying it suddenly.

Brake Antiskid System

The brake antiskid system is an auxiliary to the regular braking system. The system assists the pilot by automatically preventing wheel skidding during landing. As a result, the greatest possible braking efficiency is obtained and tire blowouts are prevented.

The antiskid system consists essentially of skid detectors, a pressure modulator, antiskid control valves, and control boxes. The skid detectors are mounted in the axle of each main landing gear wheel. The detector is a fly-wheel-inertia mechanism which is used to detect a rapid rate of change in wheel rotation. The pressure modulator is, primarily, an accumulator installed in the pressure line ahead of the brake control valves on the right-hand side of the nose wheel well. The modulator reduces pressure to the brakes simultaneously with each skid control cycle. After cycling stops, brake pressure gradually increases and maximum braking is produced as the aircraft weight increases on the runway.

The antiskid control valves are located between the brake control valve and the shuttle valves. They are mounted in pairs on each landing gear shock strut. The antiskid control valves are three-way, solenoid operated and each valve operates a wheel brake. The control valves are normally open spring loaded solenoids and are energized by signals from the control box to shut off metered brake pressure when a skid signal is received from the skid detectors. The antiskid control valves are energized in flight and remain energized until the main landing gear wheels have touched the ground during the landing roll and have gained sufficient rotational speed to allow braking operation to start.

Operation of the emergency airbrake system is not affected by the antiskid system. The antiskid control valves are operated by two control boxes installed in the fuselage accessories compartment. The forward control box provides right hand wheel brake control and the aft control box provides left hand wheel brake control.

Each skid detector controls only the wheel to which it is attached. If continuous brake release occurs on one wheel, a fail-safe circuit returns the wheel to normal control and turns on the flight compartment warning light to indicate the loss of antiskid protection on at least one wheel.

WING FLAPS AND WINDSHIELD WIPERS

Wing Flaps

The wing flaps are controlled by a lever located on the aft face of the control pedestal. Control cables are routed from the wing flap selector handle to the hydraulic selector control valve in the fuselage accessories compartment. This causes hydraulic pressure to be directed to the ports of the four flap actuating struts when the control lever is operated.

As the flaps move in response to the applied hydraulic force, the flap synchronizing (mechanical bus system) cables in the wing rotate a double drum at the rear spar in the wing center section. Follow-up cables, locked to the smaller of these drums travel forward to a linkage that actuates the selector control valve.

The follow-up cables return the hydraulic selector control valve to neutral when the flaps reach the preset angle fixed by the position of the control lever on the control pedestal. Any tendency of one flap to travel ahead of the other is instantly checked by the bus cables, thus insuring uniform travel.

A two-speed flap control valve is connected to the control valve linkage for the purpose of restricting the flaps retraction speed between 20 degrees DOWN and the full UP position. There is no neutral or OFF position for the control handle. The handle is marked in degrees of flap travel from 0 degrees (full UP) to 50 degrees (full DOWN). At an airspeed of 105 knots, the flaps will extend from 0 degrees to 50 degrees in 10 to 15 seconds, then retract from 50 degrees to 20 degrees in 9 seconds, and retract from 20 degrees to the full UP position in 13 seconds. Maximum speed for flap extension is 170 knots to 30 degrees DOWN and 150 knots over 30 degrees DOWN.

A pressure relief valve, and two pressure-operated check valves are installed in the wing flap control valve. The relief valve will relieve any excessive pressure caused by the wing flaps being forced up by airloads during flight. The two pressure operated check valves are installed to prevent wing flap droop.

Windshield Wipers

The two synchronized windshield wipers are operated by system pressure. The speed control valve, located on the nose wheel steering panel acts as an ON-OFF control and regulates wiper speed by varying the size of the opening through which the fluid must pass. The blades are locked in place when the speed control is turned OFF. Full or partial stoppage of one blade will not interfere with complete operation of the other blade.

NOSE WHEEL STEERING SYSTEM

The nose wheel is steerable to a maximum of 67 degrees in either direction from the flight compartment through a combined hydraulic and mechanical system. A separate pressure accumulator serves to dampen any tendency of the nose wheel to shimmy during taxiing. The steering wheel in the cockpit is located to the left of the pilot's seat. Two matching white lines indicate when the nose wheel is centered.

Steering Selector Valve

The steering selector valve is located on the left side of the nose wheel well. An access door is located on the left side of the fuselage just above the nose wheel doors. This valve is controlled by a differential mechanism which is connected by cables to the steering wheel in the cockpit. The purpose of the steering selector valve is to select pressure as desired for left and right turning actions.

Steering Relief Valve

The steering relief valve maintains a snubbing pressure of 150 psi in the steering accumulator and on the steering struts. The relief valve is mounted on the selector valve. It stops the flow of fluid in the return line until pressure from the accumulator builds up to 150 psi.

Steering Pressure Accumulator

The steering accumulator is located in a compartment on the left side of the fuselage aft of the nose wheel well. The purpose of the accumulator is to hold 150 psi snubbing pressure to the steering struts to help dampen shimmy of the nose wheel. Initial air charge is 50 +5 -0 psi. Snubbing pressure must be relieved by opening the bleeder valve when charging the accumulator with air. The gauge for the air pre-load of the accumulator is located at the bottom of the accumulator.

CARGO DOORS

Forward Cargo Door

The forward cargo door on the left side of the aircraft opens outward and upward to approximately 172 degrees.

Before the door can be operated hydraulically it must be unlatched. The door can be unlatched from the inside by removing the safety pin from the latch and engaging the plunger in the handle. The lock lever is then released by pushing upward and turning the latch handle clockwise. The door is unlatched from the outside by actuating the lock lever, located directly above the latch handle, and moving the latch handle upward.

After unlatching, the door may be operated hydraulically and controlled from either of two switches. One switch is on the exterior of the fuselage under an access door, just forward of the cargo door. The other switch is inside the fuselage just forward of the door.

Holding the switch in the OPEN position turns on the emergency hydraulic pump and opens the door. The door may be stopped at any desired opening by releasing the switch.

The door is closed by holding the switch in the closed position until the door is completely closed.

The door is latched from inside the aircraft by turning the latch handle counterclockwise until the lock lever engages, then install the safety pin in the forward latch.

CAUTION

All latches must be overcenter and against link stops when the door is in latched position. Do not attempt to open door without first removing safety pin.

Aft Cargo Door

The aft cargo door assembly, on the left side of the aircraft, consists of two doors. The main entrance door portion permits entry without operating the aft cargo door. The main entrance door opens outward and forward. The door controls consist of a set of eight latch bolts which are operated simultaneously by the door handle. A hold-open mechanism in the door will hold the door against the fuselage in full open position.

The aft cargo door opens outward and upward. A removable latch handle is stowed adjacent to the fire extinguisher just forward of the door. A safety pin, attached to the door structure with a length of red webbing, is installed through the forward latch.

CAUTION

Do not attempt to open aft cargo door without first removing safety pin.

After unlatching the door by operating the latch handle, the door may be operated hydraulically and controlled by a switch just forward of the main entrance door. A hold-open catch is actuated by a limit switch in the circuit. To operate the door, hold the control switch in the OPEN position until the desired degree of opening is obtained. The main entrance door must be full open and latched before the aft section will operate.

NOTE: The portion of the circuit normally completed by the aft cargo door hold-open catch is automatically actuated by an emergency switch if the main entrance door is jettisoned in flight.

Close the door by holding the switch in the CLOSED position. When fully closed, latch the door with the latching handle and reinstall the safety pin.

The auxiliary hydraulic pump selector valve handle should be in the Brake System (normal) position for cargo door operation.

SECTION 7 COMMUNICATIONS

INTERPHONE SYSTEM

The AN/AIC-10 interphone system provides:

1. Voice communication between all crew members.

2. Communication outside the aircraft by integration with radio equipment.

3. Ability to monitor one or more radio receivers simultaneously.

4. Ability to attenuate low frequency range or voice signals.

The AN/AIC-10 interphone system has:

3 - Interphone control panels.

8 - Interphone controls.

2 - Dynamotors

2 - Low frequency range filters

Interphone Control Panels

There is an interphone control panel at the pilot's, copilot's and navigator's position. The system is so designed that a malfunction of one control panel will not normally affect the other control panels. On each control there are 10 audio selectors, a microphone selector, volume control and a normal/aux listen switch.

Audio Selectors

The 10 audio selectors are two-way toggle switches, which are electrically connected to the various receivers. Positioning the selector to the "UP" (on) position allows that crew position to monitor the selected receiver. It is possible to monitor all 10 audio selectors simultaneously.

Microphone Selector

The microphone selector connects the operator's microphone to the various transmitters. The spring loaded CALL position furnishes the operator with a "hot" microphone and permits that crew member to transmit and be received at all crew stations, regardless of the position of the audio selectors at the various stations. All other reception is interrupted at all stations and only the call transmission is heard.

The microphone selector will automatically supply the user with both a talk and listen facility regardless of the position of the associated audio selector.

Volume Control

The volume control allows the operator to vary the volume of received signals in the NORMAL position only.

Normal/Aux Listen Switch

The Normal/Aux Listen switch is a two-way toggle switch which is safety wired to the NORMAL position. The AUX LISTEN position is used only when the system is not operating normally. The purpose of this switch is to bypass the mixer amplifier.

Mixer Amplifier

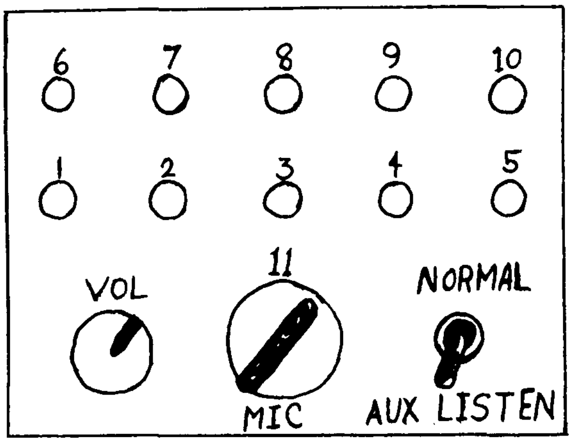
The mixer amplifier is the common terminology for a subassembly of the AN/AIC-10 interphone system. There is a mixer amplifier located in each interphone control panel and each interphone control. This subassembly performs three functions:

1. Audio amplifier, which amplifies weak audio signals received.

2. Interphone amplifier, making interphone transmission possible.

3. Preamplifier for the microphone making voice transmission possible.

Since the mixer amplifier is in the headset and microphone circuit, a malfunction will cause loss of all reception and voice transmission at the associated crew position. Reception can be maintained by using the Aux Listen Circuit. In the AUX LISTEN position, the mixer amplifier is bypassed, thereby limiting the operator to single reception and CW transmission. To preclude the possibility of two systems being selected, a priority system has been incorporated so that only one audio circuit will be received, regardless of the control settings. Refer to the following diagram for the priority system.



Interphone Controls

The interphone control furnishes the operator with communications between crew members only. Located on the control is a Call Button, Volume Control and Normal/Aux Listen switch. There are eight interphone controls in the C-118 A/C as follows:

1- Nose wheel well

1 - Forward Cargo loading door.

6 - Main cabin.

MI-36 Address System

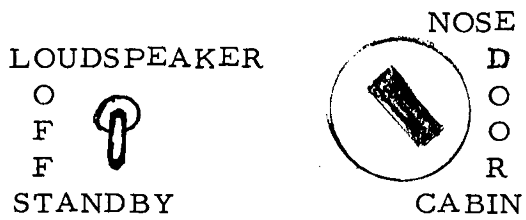
The public address system has 7 speakers, 2 amplifiers, a volume control, and a remote control. Complete operation is possible from the cockpit. The function selector located on the remote control has three positions - Standby, Off, and Loudspeaker.

The three-position speaker selector provides the operator with a choice of speakers. (Doors, Cabin, Nose)

A volume control on the forward cargo loading door controls the volume of that speaker only.

To operate, select Loudspeaker on the function selector and the desired speakers. Next position the microphone selector to Interphone, now any transmission on interphone will be broadcast over the public address system.

PUBLIC ADDRESS CONTROL



Collins VHF - 101

The Collins VHF - 101 provides the operator with the ability to communicate on 680 operating frequencies in the frequency band of 116 to 151.95 MHZ. The equipment consists of a transmitter, receiver, and remote control. The operating controls, and a brief description of their functions are listed below.

1. Power Switch - turns equipment ON or OFF.

2. SCS-DCS/DCD Switch -

SCS - Single Channel Simplex

DCS - Dual Channel Simplex

DCD - Dual Channel Duplex

This switch enables the operator to select the same operating frequency for transmitting and receiving (SCS) or a transmitting frequency six megahertz above the receiving frequency (DCS/DCD).

3. Frequency Dial - Indicates the selected operating frequency.

4. MHZ Dial - Used to select the whole megahertz of the desired frequency such as 126.00 MHZ.

5. 50 KHZ Dial - Used to select the 50 kilohertz step of the desired frequency such as 126.20 MHZ.

6. Volume Control - Increase or decrease the signal level in the headset.

7. Squelch Control - Used to reduce background noise in the headset.

Operation

1. DC Power - ON

2. Power Switch - ON

3. SCS-DCS/DCD Switch - SCS

4. MHZ Dial - Desired whole megahertz

5. 50 KHZ Dial - Desired 50 KHZ step of frequency

6. Volume Control - As desired

7. Squelch Control - Comfortable listening level of background noise.

Note: The SCS-DCS/DCD switch is normally safety wired to the SCS position.

UHF Command AN/ARC-27A

This UHF Radio is a complete airborne transmitting and receiving station, providing two-way communication on any one of 1750 frequencies (225.0 to 400 MHZ). Any twenty of these frequencies may be preset on the twenty channels for remote control operation from the cockpit. The set also has a guard channel in which the frequency could be changed, but for standardization should always be on the emergency frequency of 243.0 MHZ. Continuous monitoring of the emergency frequency is possible by using the guard receiver. A manual channel is also provided so the operator can use a frequency that has not been preset.

Operation

1. DC Power - ON

2. Function Selector - T/R

3. Channel Selector - Desired Channel

4. Volume Control - As Desired

Note: The above procedure will enable the operator to transmit and receive on the selected channel only. To monitor the guard frequency simultaneously, select the T/R + G position.

Installing a Frequency on the Manual Channel

1. Function selector to T/R

2. Channel selector to manual

3. Dial desired frequency on frequency selector.

Sensitivity Adjustment

There are two sensitivity adjustments on the ARC-27A located on the transreceiver. To adjust the sensitivity controls on the transreceiver:

1. Select the T/R position.

2. Vary the main receiver sensitivity control so that a comfortable noise level is obtained.

3. Select the T/R + G position.

4. Repeat Step No. 2 using the guard receiver sensitivity adjustment.

UHF Homing Adapter AN/ARA-25

The UHF Homing Adapter is used in conjunction with AN/ARC-27A UHF Command Equipment to provide the pilot with relative and magnetic bearings to any UHF transmitter, that is transmitting in the frequency range (225 to 400 MHZ).

The homing adapter is put into operation by selecting the ADF position on the UHF remote control. No warmup time is necessary if the function selector was in the T/R or T/R+ G position.

This equipment may be utilized for homing or direction finding depending on the pilot's need. Information displayed on the radio magnetic indicator (RMI) will be accurate within + or - 4 degrees.

Operation

1. DC and AC Power - ON

2. Function Selector - ADF

3. Select frequency and insure station is transmitting.

4. Read RMI.

HF Command Radio Set 618S-1

The 618S-1 is a complete airborne station providing the pilot with communications of short and long range in the HF Band (2.0 - 25.0 MHZ or 2,000 - 25,000 KHZ).

The main components and their purposes are:

1. Transceiver - Voice of CW transmission and reception.

2. Power Supply - Converts aircraft power supplies to higher power for operation of the transceiver and antenna tuner.

3. Antenna Tuner - Electronically shortens antenna wire to match operating frequency.

4. Remote Control - Allows operation to turn set on or off, select desired frequency, and adjust volume of received signals.

The controls are located on the control pedestal. Operation requires AC and DC voltage. The equipment is protected by fuses and circuit breakers on the power supplies in addition to the main circuit breaker panel.

Operation - Reception

1. DC and AC (inverter power) - ON

2. Function Selector - Phone (for voice reception)

3. Channel Selector - Desired Channel

4. Volume Control - As Desired

Operation - Transmission

1. DC and AC (inverter power) - ON

2. Function Selector - Phone (for voice transmission)

3. Channel Selector - Desired Channel

4. Volume Control - As Desired

5. Depress microphone button momentarily and observe red light on the remote control. When the light goes out, the set is ready for operation.

Note: 618S-1 Antenna Tuners are equipped with a thermal time delay switch. Should a malfunction of the equipment occur, the thermal switch will be energized to prevent overheating of the system. After attempting to tune for 45 seconds, the equipment will become inoperative. Do not attempt to tune any frequency for a period of one minute, in order to allow the antenna tuning unit to cool. After the antenna tuning unit has cooled, the operator should channel away from the present frequency and immediately back to the desired frequency and again engage the microphone to return the antenna.

Radio Magnetic Indicators

The ID-250 is commonly referred to as the RMI because it displays both radio and magnetic information. Radio information is fed to the pointers and magnetic information is fed to the card.

The five RMI's are located:

2 - on pilot's instrument panel,

2 - on copilot's instrument panel

1 - on navigator's instrument panel

Visual information from the ADF #1 and ADF #2 will usually be displayed on the #1 RMI. Information from the UHF/ADF and OMNI/TACAN will usually be displayed on the #2 RMI. The RMI's should be placarded to indicate the navigational aid associated with each pointer.

The RMI's require 26 volts, 400 cycle, AC for operation. The power is supplied by the radio electrical inverter, through the C-1 compass amplifier.

Operation

Radio magnetic indicators normally display the following information: Top Index - magnetic heading of the aircraft, Pointers - magnetic bearings, aircraft to station.

The ADF pointers will always point to the station, displaying relative information, when power and radio information is being fed to them.

Note: Relative bearings must be computed from the top index to the desired pointer. The OMNI/TACAN equipment operates on a different principle and should continue to display magnetic bearings to the station if the RMI card fails.

OMNI (AN/ARN-14)

Omni provides the pilot with radio aids to navigation in the Very High Frequency (VHF) range of 108.0 to 135.9 MHZ. It also can receive the majority of the communications (VHF) now available for airborne communications. This reception range includes both military and commercial communication channels, Omni Directional range channels, and 90/150 cycle tone modulated Omni Localizers.

The control is located on the pilot's control pedestal. It provides the pilot with 280 crystal controlled channels which are selected by setting in the desired frequency. However, any frequency in the range of 108.0 and 135.9 MHZ can be received by setting the selector switch to the nearest tenth of a megahertz. For example, the frequency of 126.18 cannot be selected because the frequencies are graduated every tenth megahertz, but it can be received by setting the control to 126.2, which is the nearest tenth megahertz.

The range of this equipment is determined primarily by the line of sight distance between the antennas.

DC power is required for minimum instrumentation. For complete operation 26 volts, 400 cycles, AC (from the C-1 amplifier) is required for certain indicators.

The indicators requiring AC power are the RMI, Heading Pointer, and the Glide Slope Indicator. It can be seen that the primary indicators are DC operated and that it is possible to use the Omni equipment for radio navigation with only DC power.

All presentations from this equipment are visual and are available to the pilots from two indicators. These are the Radio Magnetic Indicator (RMI) and the Course Indicator.

Operation

1. ON-OFF Switch - ON

2. Dial desired frequency

3. Volume Control - As Desired

Course Indicator

The course indicator is a multipurpose indicator consisting of:

1. Course Selector

2. TO-FROM Indicators

3. Course Deviation Indicator

4. Glide Slope Indicator

5. Heading Indicator

6. Flag Alarms

7. Marker Beacon Light

The following is a brief description of the functions performed by these various indicators.

Course Selector

The course selector consists of a course indicating window and course set knob. The pilot may select any one of 360 Radials of an "OMNI" or "TACAN" station, or the approach bearing to a localizer equipped runway.

TO-FROM Indicator

The TO-FROM Indicator solves ambiguity for the Pilot when using "OMNI" or "TACAN". It indicates whether the course selected, if intercepted and flown, will lead the aircraft to or from the station.

Course Deviation Indicator (CDI)

The Course Deviation Indicator displays lateral positional deviation from the selected "OMNI" or "TACAN" course. It also indicates the lateral positional deviation from the center line of the runway localizer.

Glide Scope Indicator (GSI)

The Glide Slope Indicator displays the aircraft's position above or below the Glide Path.

Heading Indicator

The heading indicator displays the magnetic heading of the aircraft-relative to the course selected.

Flag Alarms

The Flag Alarms associated with the "CDI" and "GSI" are visible when the signal level falls below a value sufficient to provide reliable operation.

Marker Beacon Light

Illumination of this light indicates passage over a Marker Beacon transmitting a 75 MHZ signal.

Reception of 90/150 Cycle Tone Localizer Signals in the 108.0 to 111.9 Megahertz Band

When the radio receiver is tuned to the operating frequency of a TONE type runway localizer and the aircraft is flying within receiving distance of the station, the facilities of the localizer will be available to the pilot to aid him in making a safe landing under adverse weather conditions. Actually, the localizer provides an imaginary vertical plane extending along the centerline of the runway in the direction of the final approach course. The Course Indicator is used to provide the pilot with a visual indication of his positional deviation from this imaginary centerline when making the final approach to the runway.

Glide Slope Receiver AN/ARN-18

The Glide Slope Receiver operates in conjunction with the Omni receiver. Operation is UHF (329.3 - 335.0 MHZ) and is automatically selected by selecting a localized frequency (108 - 112 MHZ) on the Omni remote control. The glide path receiver information is presented visually by the glide slope indicator of the course indicator. The glide path receiver requires AC power for operation.

Marker Beacon AN/ARN-12

The function of the Marker Beacon Receiver is to receive modulated 75 MHZ signals transmitted by a ground beacon transmitter and delivery of an aural and visual indication of the received signal. When the marker signal is of sufficient strength, a light on the course indicator will be actuated giving a visual indication of position. The marker beacon audio signal may be monitored by use of the associated audio selector. The marker beacon receiver is automatically turned on anytime power is applied to the DC bus.

TACAN/AN/ARN-21

TACAN is a radio navigation aid operating in the UHF frequency band, designed to operate in conjunction with a surface navigation beacon. The airborne and surface equipment form a radio navigation system which enables an aircraft to obtain continuous indications of its distance and bearing from any selected surface beacon located within a line-of-sight distance from the aircraft up to 195 nautical miles. The bearing information is displayed on the RMI and Course Indicator.

Operation

Positioning the function selector to REC turns the equipment on. The equipment should be warmed up in this position for three minutes. By positioning the function selector to T/R, Course Indicator, RMI and Range Indicator information will be displayed.

Frequency selection is made automatically be selecting the appropriate channel number (01-126).

Radio Compass ARN-6

The ARN-6 functions as a general radio receiver over a frequency range of 100 KHZ to 1750 KHZ in four bands. The radio compass provides the following navigational aids:

1. Automatic visual indication of bearings between the aircraft and the transmitting station by means of a RMI.

2. Aural Null Homing, using a loop antenna.

3. Radio reception, using a non-directional sense antenna.

Tuning is accomplished through four remote control heads, two on the control pedestal and two at the navigator's station. Voltage requirements are 24-28 Volts DC for the receiver, 115 Volts AC (100 cycles) for the loop motor and 26 Volts AC (400 cycles) for the indicator system. A circuit breaker is located on the radio rack.

Operation

1. DC Power and Inverter - ON

2. Turn Function Selector to either compass, antenna or loop position (normally warm up in compass position).

3. Turn tuning crank until desired frequency is indicated.

4. Tune the frequency for maximum audio.

5. CW/Voice switch in appropriate position.

6. Adjust volume control for the desired level.

Loop operation is governed by a loop left/right switch on each control. The speed of rotation (fast or slow) is dependent upon the degree of turn (left or right) that the switch is moved. Transfer of control is accomplished with the function switch.

Trouble Shooting

The power for the loop motor is supplied by a vibrator located in the receiver. Should the vibrator become inoperative, the loop cannot be rotated. To determine if the vibrator is operative, place the function selector to the loop position and actuate the left/right switch. If signal intensity does not change in the headset, the loop is not turning. A spare vibrator is located under the receiver cover. Replacing the inoperative vibrator with the spare will correct the malfunction.

Pilot's Radio Altimeter AN/APN-22

The APN-22 is a low range absolute radar altimeter. The operating range is 0 to 10,000 feet over water. The receiver transmitter and antenna are one component, flush mounted on the underside of the fuselage aft of the rear cargo loading door. All operating controls are positioned on the indicator.

Operation

1. AC and DC power - ON

2. Turn the ON-LIMIT knob clockwise to position the Limit Bug at the lowest desired flight altitude.

Note: When the ON-LIMIT knob is turned on, the red light will come on.

3. During aircraft ground movement, the altitude needle will fluctuate but will settle down after takeoff.

4. After passing the preset altitude the red light will go out and remain out until the aircraft is again flying at or below the preset altitude.

5. The black area painted on the face of the indicator is referred to, as the drop-out mask. The altitude needle will position itself under the drop-out mask anytime the information received is unreliable.

Nav. Radar Altimeter SCR-718

The SCR-718 altimeter is a high range absolute altimeter. It sends out pulses and times their return. The altimeter is accurate within plus or minus one tenth of one percent, with a maximum error of 50 feet at 50,000 fet.

A toggle switch on the indicator is marked "Times Ten" and "Times One". When set on "Times One", the indications are from 0 to 5,000 feet. When set on "Times Ten", they are from 0 to 50,000 feet.

Operation

1. Turn receiver gain switch ON before takeoff and allow 3 minutes for warmup.

2. After warmup, turn receiver gain control until the green circle appears on the indicator tube.

3. Set to "Times One" and adjust circle size control so that the circle is barely visible as a luminous ring at the outer edge of the black calibrated scale.

4. Adjust "Receiver Gain" so that a pulse approximately 1/4 inch high appears on the circle near 0 on the scale. This is the reference, pulse or lobe.

5. Set to "Times Ten". The circle will be smaller, about 1/4 inch inside of the black scale.

6. Adjust "Times Ten Zero Adj" until the reference pulse is at 0. Use the counterclockwise edges of the pulses.

7. Set on "Times One" and adjust "Times One Zero Adj" so that the reference pulse is at 0. This should be done in level flight.

As the airplane gains altitude, the reflected pulse moves away from the reference pulse. The counterclockwise edge indicates the altitude.

On "Times One" the pulse goes all the way around and joins the reference pulse at 5,000 feet and will indicate 1,000 feet when the aircraft is at 6,000 feet. For each 5,000 feet an encirclement takes place. With the scale switch on "Times Out" there is no indication of the number of revolutions the pulse has made. For each revolution of the pulse 5,000 feet must be added to the reading. Calibrations are spaced so that readings can be estimated to the nearest 25 feet.

On "Times Ten", it is possible to read to within 500 feet. The switch should be left in this position especially at high altitudes. When greater accuracy is required, read the reflected pulse position on the small circle "Times Ten" position to the next lower 5,000 foot mark and then switch to "Times One" and add the readings.

Radar altimeter SCR-718 is not designed for use as an extremely low altitude altimeter. As the height of the aircraft above the ground decreases to less than 1,000 feet, the gain must be reduced to prevent the reflected pulse from becoming too broad and more than 1/4 inch high.

The indicator and control are located at the navigator's station. The altimeter operates on 115 Volts 400 cycles AC from the main inverter.

When operating over mountainous terrain, several altitude lobes appear because of numerous reflections. Over water the reflections should be steady. At altitudes of 5,000 feet and multiples thereof, with the scale switch at "Times One" position, the reflected pulse coincides with the reference pulse and causes a blind spot. (Improper operation will make the indicator circle become oval in shape.)

AN/APX-25 Radar Identification Equipment (IFF, SIF)

The purpose of this equipment is to provide positive control and surface tracking of the aircraft by a radar station.

The APX-25 is a transponder. A transponder must receive and interrogate the proper signal before it will trigger the transmitter to make a reply.

Note: The only means to determine that the equipment is operating properly is to check with the ground radar control by radio.

Operation

1. Before takeoff set the master control to the "stand by" position. There is an automatic time delay of approximately one minute when the master control is moved from the "off" position. In the "stand by" position the equipment is ready, but not transmitting.

2. After takeoff turn the master control until "normal" appears under the index. This is MODE 1 operation.

3. The "emergency" position should be utilized when the aircraft is experiencing an emergency. The emergency stop release button must be depressed to position "emergency" under the index.

4. MODE 2 and MODE 3 operations are controlled by the respective two-way toggle switches. "Low" or "Normal" must be selected on the master control position. These toggle switches should be in the OUT position unless directed to reply using that MODE.

5. "Low" should be selected only when directed. To select "low", turn the master control until "low" is positioned under

the index. This is MODE 1 low. MODE 2 low and MODE 3 low are other possible selections.

6. The I/P-OUT-MIC toggle switch is used to identify the aircraft from other aircraft on the radar scope. When the switch is held in the I/P position for a few seconds, the equipment will automatically send a double reply for thirty seconds. The I/P position is spring loaded to the OUT position.

The MIC position is not normally used in C-118 installations.

NOTE: To select the proper "code number", the proper MODE must first be selected.

7. MODE 1 codes and MODE 3 codes are selected by the large dials. The left dial is used to selct MODE 1 codes, the right dial for MODE 3 codes. MODE 1 has thirty-two possible codes and MODE 3 has sixty-four possible codes. The codes are selected by turning the inner and outer knobs until the desired code is read under the index. The codes must be read from the outer scale to the inner scale.

RADAR SET AN/APS-42

HAIL

Ever wonder what would happen if a plane flew into a sky full of baseballs?

How long would it take for these ice baseballs to severely batter your plane? .... just a few seconds.

How long would it take to fix this airplane so that it would fly again? Perhaps thousands of man hours.

What is it like to hit two and one-half inch hail? Here is a description given by an aircraft commander. "The first indication was a ticking noise similar to a metal object being tapped against the wall. This was probably caused by isolated hail stones hitting the aircraft. This was followed by a loud explosion similar to the discharge of a gun, or someone dropping a heavy box two or three feet. At this time, I realized the right hand center panel of the windshield was completely shattered and had holes in it, all windshields broken and the leading edge of the wings were almost flat and had holes in them".

Is hail avoidance possible? One of the Major Airlines reports it has never had a radar equipped airplane damaged by hail.

How is hail avoidance accomplished?

1. By knowing the limitations and capabilities of the radar equipment.

2. By proper operation of the radar set.

3. By knowledge of echo interpretations on the scope.

4. By always following avoidance techniques.

Limitations and Capabilities

Proper operation of the APS-42 radar set and proper interpretation of the scope make these functions possible.

Drift Angle

Regardless of weather conditions, you can compute your drift angle from radar intelligence without leaving your course.

Ground Painting

By showing coastline and recognizable ground features, the APS-42 can help you make a landfall at the desired point when visibility is poor. Get used to operating in contact weather. Then you will be ready.

Ground Speed

The APS-42 makes it possible to follow your track through darkness or undercast and compute your ground speed.

Wind Data

From the ground speed and drift information you can check the wind velocity and direction. It is not necessary to leave your course to do it.

Beacon Homing

The APS-42 is equipped to give you range and bearing to a beacon. You can home or navigate by coded beacon signals anywhere within reception range.

Distance from Ground

The very nature of radar makes it possible to interpolate the distance to the ground (the distance to the nearest echo).

Weather Interpretation and Avoidance

The APS-42 is an excellent device for determining turbulence, hail, and other adverse weather conditions which might effect the safe operation of the aircraft.

Spotting a Fix

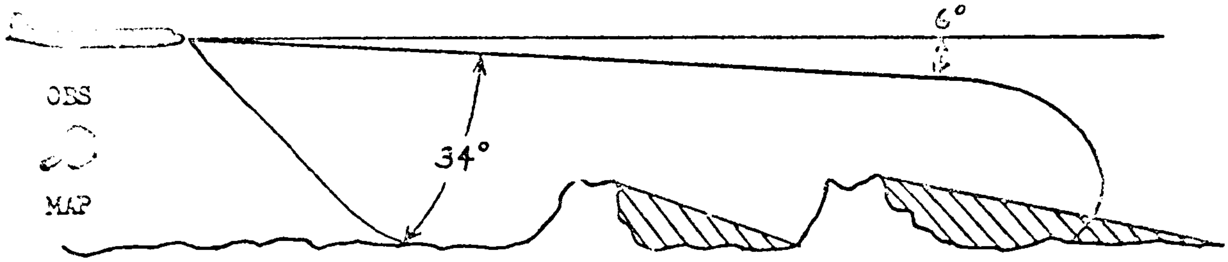
Many of the navigation functions that are possible with visible fixes may now be accomplished through use of the radar even through 10/10 clouds and at night.

Operation

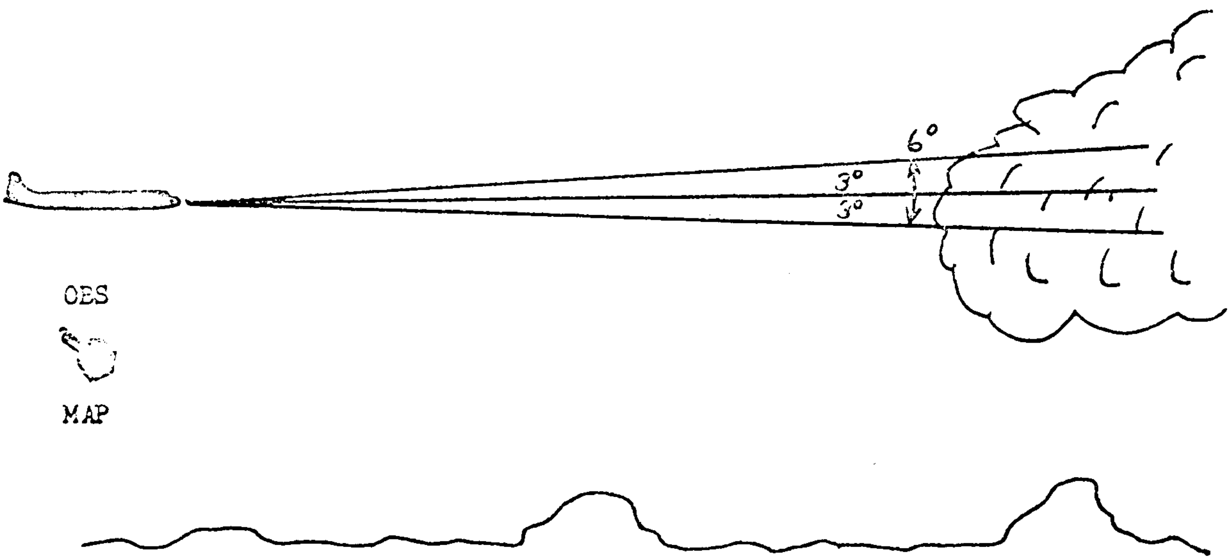
The key to successful radar operation and interpretation comes from correct use of the antenna tilt and the proper setting of the gain control. While there is no normal setting for either of these controls, there is a best setting for any specific target or type interpretation. This section will stress the settings of these controls as used for weather avoidance, but the operator must realize that they are not a magic formula for all radar targets and will vary for terrain, beacon displays, etc.

BEAM PATTERNS

0° Antenna Tilt



MAP BEAM, SHOWING SHADOWS BEHIND PROMINENT TERRAIN FEATURES



OBS BEAM, AS USED FOR AVOIDANCE OF THUNDERSTORMS AND TERRAIN COLLISIONS

Operation for Weather Avoidance

1. Turn all controls counterclockwise or DOWN.

2. Place Function switch to STANDBY and wait three minutes.

Note: The antenna tilt meter will respond when the set is sufficiently warmed up for operation.

3. Rotate the INTENSITY control on the scope clockwise until the sweep trace line is just barely visible.

4. Adjust the FOCUS control on the scope for a sharp and clear sweep Trace Line.

5. Set the FUNCTION switch to either SEARCH, BEACON, or WEATHER, as desired.

Note: When using the 5, 10, or 30-mile ranges, a better weather return is usually obtained on the SEARCH position. For weather displays on the 100 and 200 mile ranges, the WEATHER position should be used.

6. Place Beam Selector switch to the OBS position for weather, MAP for terrain.

Note: Use SECTOR SCAN any time it is desired. The scan will be 120 degrees on Sector and 240 degrees on Full. For this reason observation of specific targets in the direction of the aircraft heading are slightly improved by using SECTOR SCAN.

7. Place the SCAN switch to either SECTOR or FULL.

8. Rotate the GAIN control clockwise until the scope is covered with heavy yellow salt-like noise returns. Knob should then be turned counterclockwise until a very faint trace of salty flecks still remain.

9. Range Selector - As desired, usually no greater than 30.

10. Set the Antenna Tilt.

Note: Setting the antenna tilt correctly is very important for weather interpretation. A good rule of thumb is to run the tilt up until ground clutter is just visible at the outer edge of the scope. This will allow readable pickup of all storm echoes. Occasionally, when flying through storm areas, it will be desireable to run the tilt up momentarily to estimate the height of the storm.

11. Set the Stab control as desired. When placed to the STB position, a gyro in the antenna unit will compensate the antenna for both pitch and roll.

The above controls are all that are generally used for weather interpretation. However, in many cases, the other controls will prove helpful and may be used. For that reason, a brief explanation of each is given below.

HTR (Heater)

This switch is on all APS-42 controls, however, it is important only to the older model antennas. In the later models, the antennas have no need for heaters and therefore are not installed. The switch is left on the newer models to satisfy interchangeability requirements. In the older models there are two heaters, one of 75 watts and the other 375 Watts. The 75 Watt heater is thermostatically controlled and is usually sufficient. In extreme temperatures the 75 Watt heater is insufficient and, in this event, the 375 Watt heater may be turned on to preheat the antenna by placing the HTR switch to the HTR position (Use it only as a PREHEATER).

A-J Control

The Anti-Jam control is normally left in the OUT position. Turn it to the Fast Time Constant or Instantaneous Automatic Gain Control (FTC or IAGC) position enables the operator to reduce the clutter on the scope for the entire range of the set. Use the setting that gives the best results and readjust the gain, if necessary.

Note: The A-J switch should not be used unless definite improvements are noted as the overall sensitivity of the set is reduced.

STC Switch

This switch control is similar to the A-J control in many respects as it also reduces clutter. In addition, it will reduce the return from targets up to a maximum of ten miles. Occasionally, a nearby city or rough sea will appear too bright on the scope and can be diminished by using this control.

Tune Control

This control has two positions - AFC (Automatic Frequency Control) and MANUAL. Use the AFC position in all normal operation. Manual tuning is used only when the automatic is inoperative. This will be indicated by severe spoking on the scope or loss of all returns.

Delay Control and TD (Target Discrimination feature of the Range Selector

On the TD feature of the Range switch the display on the scope is delayed from 5 - 175 miles as indicated by the delay control; and only a 30-mile area is amplified.

Example of TD Operation

Assume a target that you want to scrutinize is 150 miles out. First, place the range switch to 200 and observe the target on the sixth range mark. (25 miles range marks at this setting). Rotate the delay control until the delay (variable) marker is just below the target in question. Switch to TD and the area from where the delay marker appeared plus 30 miles will be displayed.

Echo Interpretation

A radar scope does not picture turbulence, hail, or tornadoes. Insofar as weather displays are concerned, it pictures only moisture. There is no differentiation between moisture in the form of rain or hail, but from the moisture return we attempt to identify degrees of turbulence and probable hail areas.

Turbulence

Turbulence is caused by sheer. Sheer occurs when wind flow in adjacent areas varies in direction or speed, or both.

The degree of turbulence is in proportion to the difference in wind flow speed, angular change of flow direction, or both. Turbulence is extreme in thunderstorms because vertical currents of air are flowing in opposite directions at high rates of speed.

The degree of turbulence encountered during flight through any such area is dependent upon how fast the aircraft passes through the sheer zone. To a degree, the pilot has some control over this by slowing down when storms are penetrated, but this slight control is not nearly as effective as picking an area of more gradual sheer gradient.

Radar enables a pilot to "see" and avoid areas of maximum sheer (turbulence). If his set is equipped with contouring circuitry (iso-echo), he can choose a flight path through areas of most gradual sheer gradient since the contouring circuitry blanks out returns above a fixed degree of brightness.

Frequently two storms that appear approximately equal in size and intensity without iso-echo are found to be of considerably different intensity when viewed with iso-echo.

Is there any way comparative severity of storms can be determined without iso-echo? Yes, to some degree. By decreasing gain on the set, the target will grow smaller. Those which decrease the most are the least intense. This gives an approximation of iso-echo. Use of low gain as a means of determining storm intensity cannot be considered as accurate as iso-echo, but may help on occasions when all storms cannot be circumnavigated.

If the "low gain" technique is practiced, the following procedure is suggested: Mark the normal gain setting in order to return to this exact setting. Decrease gain to obtain some target fade and mark this setting. Any time a check is made for storm intensity, ALWAYS decrease the gain control to the exact low setting mark; then ALWAYS return it to the normal gain setting mark. In this way, the comparative pictures will always be in the same relative proportion. Any other setting will give the operator an erroneous impression of storm intensity.

Hail

A good procedure for radar identification of probable hail is to watch for, identify, and avoid the following echo patterns:

Pointed Fingers

Hooked Fingers

Scalloped Edges

Hail shafts appear to form quickly in active thunderstorms and constant scope monitoring is mandatory during flight near such storms. Any time a storm is changing shape fairly rapidly, chances of hail shafts are excellent.

Radar Turbulence and Hail Avoidance Tips - When You MUST Fly Through Storm Areas

*Set the gain correctly, then never change it.

*If your set is iso-echo equipped, use it.

*If your set has no iso-echo feature and a low gain setting is being used in an attempt to simulate iso-echo information, always use the same low gain settings.

*Tilt setting should be adjusted until ground return is visible toward the outer range.

*Sharp rainfall gradients are indicative of sharp sheer areas (turbulence).

*Watch for and avoid hail echoes:

Hooked Fingers

Pointed Fingers

Scalloped Edges

*Fly at least five miles from storms below the freezing level, and at least ten miles from storms above the freezing level.

*Monitor the scope constantly, if possible, when in storm areas.

*Fly well clear of rapidly developing storm echoes.

*Never fly under an overhanging thunderstorm cloud - you are asking to be hit by hail.

*Watch for trouble from above, visually and by running tilt up occasionally. A protuberance can form and hail can fall rapidly. It is not necessary to fly into a shaft of hail - equal damage can result when hail suddenly drops on your aircraft as you fly through a clear corridor.

*A thirty-mile range setting is ideal for close up detail and hail detection, but switch to the one hundred-mile setting occasionally to keep from flying into a "blind alley".

*Do not use radar to find out why it is rough - use it to avoid areas where it may be rough.