2.10. ENGINES

The airplane is powered by two counter-rotating Pratt & Whitney PT6A-66 turboprop engines, each flat rated to 850 SHP. The rated power can be maintained during cruise to approximately 25,000 feet on a standard day.

Inlet air enters the engine through an annular plenum chamber, formed by the compressor inlet case. The four-stage axial and single-stage centrifugal compressor is driven by a single-stage turbine. Downstream the compressor the air is routed through diffuser tubes to the combustion chamber liner. The flow of air changes direction of 180 degrees as it enters and mixes with fuel. The fuel/air mixture is ignited by two spark igniters, which protrude into the combustion chamber, and the resultant expanding gases are directed to the compressor turbine and then to the power turbine. The compressor and power turbines are located in the approximate center of the engine with their respective shafts extending in opposite directions.
The exhaust gas from the power turbine is collected and ducted in the bifurcated exhaust duct and directed to atmosphere via twin opposed exhaust stubs.

The fuel supplied to the engine from the airplane fuel system is routed through an oil-to-fuel heater to an engine-driven fuel pump where it is further pressurized. The fuel pump delivers the fuel to a fuel control unit, which determines the correct fuel schedule for engine steady state operation, both with and without power augmentation and acceleration. A flow divider supplies the metered fuel flow to the primary or to both primary and secondary fuel manifolds as required. Fuel is sprayed into the annular combustion chamber through fourteen simplex fuel nozzles arranged in two sets of seven and mounted around the gas generator case.

All engine-driven accessories, with the exception of the propeller governor, overspeed governor and propeller tachometer-generator, are mounted on the accessory gearbox at the rear of the engine. These components are driven by the compressor by means of a coupling shaft which extends to drive through a tube at the center of the oil tank.
The engine oil supply is contained in an integral oil tank which forms the rear section of the compressor inlet case.

The dual-stage power turbine, counter-rotating with the compressor turbine, drives the propeller through a two-stage reduction gearbox located at the front of the engine. The gearbox is counterclockwise rotation propeller drive for the right mounted engine, and clockwise drive for the left mouted engine. An integral torquemeter device is embodied in the gearbox. A chip detector is installed at the bottom of the gearbox.
The propeller control system comprises the single-acting hydraulic propeller governor, which combines the functions of constant speed unit, blade pitch control and fuel reset valve (beta), and the coordinating system which includes the beta lever, the beta cam and the related cables and rods.

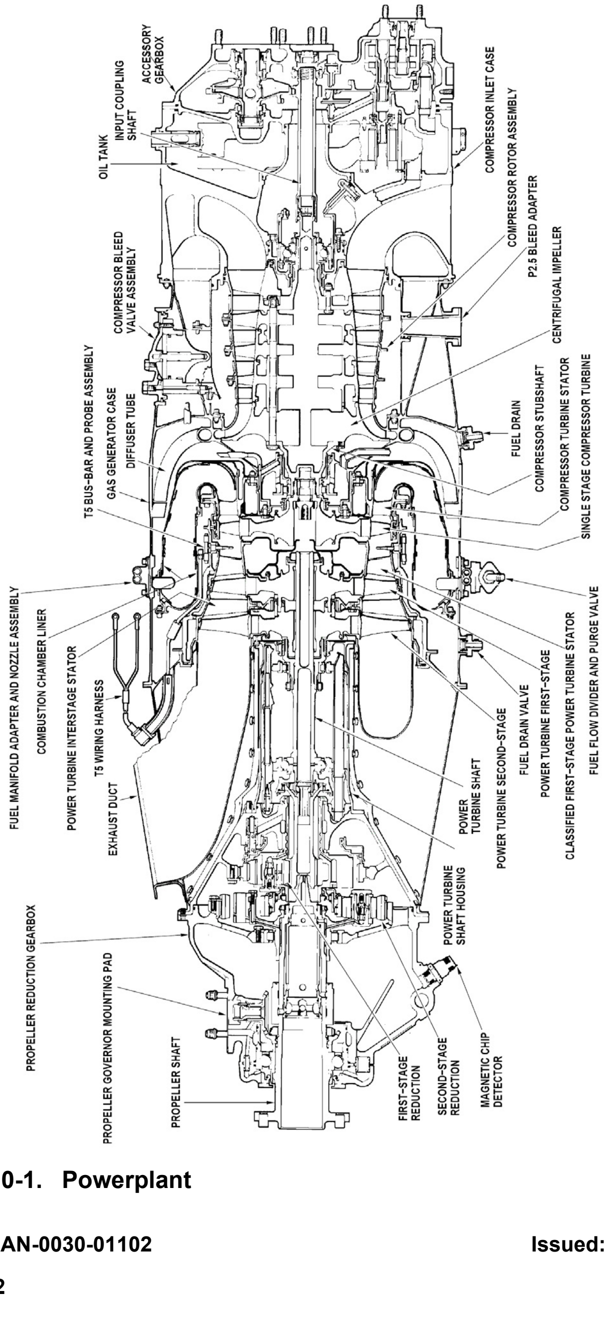

Figure 2.10-1. Powerplant

2.10.1 ENGINE FUEL SYSTEM

The engine fuel system consists of an oil-to-fuel heater, an engine driven fuel pump, a fuel control unit, a flow divider and purge valve, a dual fuel manifold with 14 nozzles, and two fuel drain valves.

Fuel from the oil-to-fuel heater enters the gear-type pump through an inlet screen. The pump gears increase the fuel pressure and deliver it to the fuel control unit through a pump outlet filter. A by-pass valve in the pump body enables unfiltered high pressure fuel to flow to the fuel control unit in the event of the outlet filter becoming blocked.

The fuel control unit schedules the fuel flow to the engine according to the operating conditions and position of the cockpit engine controls. The fuel control unit comprises a fuel condition lever that selects the start, low idle and high idle functions, a power lever that selects the gas generator speed between high idle and maximum, a flyweight governor that controls fuel flow to maintain the selected speed, and pneumatic bellows that control the acceleration schedule and act to reduce the gas generator speed in the event of propeller overspeed.

A fuel flow transmitter is installed downstream the fuel control unit. The metered fuel flow is then delivered to the flow divider and purge valve. The flow divider schedules the fuel flow between the primary and secondary fuel manifolds. During engine start-up, metered fuel is delivered initially by primary nozzles, with the secondary nozzles cutting in above a preset value. All nozzles are operative at idle and above.

On engine shutdown the purge valve allows compressed air to flush the residual fuel from the manifolds into the combustion chamber, where it is ignited and burned off.

The combustor drain valve ensure that all residual fuel accumulated in the bottom of the combustor case drains overboard in the event of an engine aborted start.

2.10.2 IGNITION SYSTEM

The spark-type ignition system consists of one exciter, two ignition leads, and two spark igniters for each engine. Ignition is by both igniters simultaneously. When the ignition switches, labeled L or R IGN-NORM, on the pedestal ENGINE/ PROPELLER control panel, are set to NORM position, the igniters will operate automatically to start the combustion.

Ignition to the engines may also be actuated manually by moving the switches to the IGN position.

D.C. power is delivered to the exciter of each engine from the essential bus through the 7.5-ampere IGN SYS circuit breaker on the pilot circuit breaker panel.

2.10.3 LUBRICATION SYSTEM

The engine oil system provides a constant supply of oil for lubricating the engine bearings, the reduction gears, the accessory drives, and for operating the torquemeter system and the propeller pitch control.

Pressure oil is circulated from the integral oil tank through the lubricating system by a gear-type main pressure pump mounted at the bottom of the tank. An engine-mounted oil filter downstream of the pressure pump ensures that the engine oil remains free of contaminants. The oil filter incorporates an internal by-pass feature. Two double-element scavenge pumps, one mounted within the accessory gearbox and the other one externally mounted on the gearbox, are provided: oil that collects into the reduction gearbox sump is forced back to the oil tank via an oil cooler, oil that collects into the accessory gearbox sump is directed to the oil-to-fuel heater and then, through a thermostatic by-pass and check valve, either to the oil cooler if hot or directly to the oil tank if cold.The oil cooler, mounted in the lower part of the engine nacelle, utilizes ram air through a flush scoop located on the outside of the engine nacelle to cool the engine oil before returning it to the oil tank. A by-pass/pressure relief valve is provided to control the oil flow through the oil cooler. A thermal operated flapper valve into the cooling air duct downstream of the oil cooler controls the air flow through the cooler.
An airflow may be activated, while on the ground, through the oil cooler by means of a venturi during prolonged ground operations, if an oil overheating is observed. The motive flow (bleed air) is routed, through a shut off valve, into the cooling airflow duct, downstream of the oil cooler, to activate the flow.

The electrically operated shut off valves, one for each engine are controlled through the OIL COOL L/R-OFF switches in the ENGINE/PROPELLER control panel below the central sectionof the instrument panel. D.C. power is delivered to the shut off valves from the right single feed bus through the corresponding 3-ampere OIL COOLER circuit breakers on the copilot circuit breaker panel. The OIL COOLING amber caution light on the annunciator display will come on while either one or both the forced oil cooling systems are operating.

The air inlet to the engine oil cooler is protected against icing: a compressor bleed air flow is routed to heat the inlet lip when the corresponding OIL COOLER INTK switch is set to L and R positions. On the MFD System Page, Anti-ice System status, two green ON indications will be displayed on the left and right side of the "OIL" annunciation while the corresponding side air intake of the oil cooler is heated and reaches a preset temperature.

A chip detector is mounted in the reduction gearbox. The chip detection condition can be checked by either removing the two rear nacelle panels to access to the chip detector or moving and holding the GROUND TEST switch to the SYST position: in the event of a L or R ENG OIL light flashing, with a rate of 3 Hz. (40% on and 60% off), a real chip detection condition is shown in the corresponding engine oil.

The oil tank is provided with a filler cap and dipstick, which includes a remote indicator transmitter, located at the top of the accessory gearbox housing. Markings on the indicator dipstick correspond to U.S. quarts and indicate the amount of oil required to fill the tank to the full mark under hot and cold oil conditions.
The L and R ENG OIL red warning lights, located in the ground test/refuel panel, are provided for indicating an oil low level condition: each warning light will come on when the oil level is two quarts low in the corresponding engine.

NOTE

For a correct indication the oil level must be checked within 10 minutes after the shutdown.

The following red warning lights on the annunciator panel are provided to alert the pilot:

– L and R OIL PRESS if the oil pressure falls below the minimum required in the corresponding engine;

– L and R OIL TEMP to alert the pilot if the oil temperature, in the corresponding engine, exceeds the limit (110° C or 104°C for more than 10 minutes).

2.10.4 ENGINE INDICATING SYSTEM

The Engine Indicating System (EIS) display is normally shown on the MFD (display upper section). The EIS provides for the following left and right engine indications: ITT (Interstage Turbine Temperature) and Torque on a shared analog gauge, N_G and Propeller (PROP) speed on individual smaller analog gauges, digital displays for Fuel Flow, Fuel Quantity, Oil Pressure, and Oil Temperature.
If the MFD fails, the engine indications can be displayed on the PFDs.

N_G and ITT indications monitor the gas generator operation, while the power turbine is monitored by the torquemeter and propeller RPM.
Engine torque is read in percent of foot pounds (where 100% value corresponds to 2230 ft.lbs). The ITT indications present the interstage turbine temperature in degrees centigrade. Interturbine temperature is monitored by means of a thermocouple probe assembly installed between the compressor and the power turbines with the sensing elements projecting into the gas path. The N_G or gas generator indications are read in percent of RPM, based on a figure of 37,468 RPM as 100%. The propeller indications are read directly in RPM. The fuel flow indications are read in pounds per hour. The oil pressure and temperature indications provide digital readings of oil pressure in PSI and digital readings of oil temperature in degrees centigrade.

Warning and caution indications are provided for each engine when operation is outside of the normal limits. Refer to Section 2 of the Airplane Flight Manual for color codes and operating limits explanation.

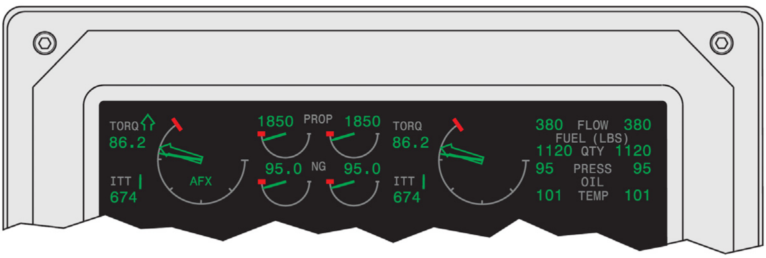

Figure 2.10-2. Engine Indicating System display

2.10.5 ENGINE FIRE WARNING

Fire warning is provided by a continuous type thermal detector running through each engine compartment around and along the engine. The pneumatic sensing element is capable of detecting a localized actual flame fire as well as a diffused overheating condition. The temperature threshold is of 545 °C on a discrete section of the detector and of 250 °C for diffused average temperature. The sensor is a sealed stainless steel capillary tube containing a core material which releases a large volume of gas when heated: the gas pressure operates a pressure switch that closes the warning circuit.

Fire indication is provided by the L and R FIRE red warning lights on top of the annunciator display and, if the optional Engine Fire Extinguishing System is installed, by the two red lighted pushbuttons L and R ENG FIRE EXT located each side of the Flight Guidance Panel. When the overheat or fire source is removed the inner core reabsorbs the active gas, the pressure switch opens again and the warning light goes off.

The system operation check can be performed by rotating to the FIRE DET position the SYS TEST selector on the pilot's instrument subpanel then pressing the selector inner pushbutton. The test circuit checks both the condition of the annunciator lights and the complete wire circuits to the detectors.

2.10.6 ENGINE FIRE EXTINGUISHING SYSTEM (IF INSTALLED)

In case of an engine fire a cockpit controlled engine fire extinguishing system is available. The fire warning detection is provided by a continuous type thermal sensor running through each engine compartment. Fire warning is provided by the red L and R FIRE warning lights, located at the top of the annunciator display panel: when the fire extinguishing system is installed, additional fire warning is provided by the L and R ENG FIRE EXT lighted control pushbuttons, located each side of the Flight Guidance Panel, which illuminates together with the L and R FIRE on the annunciator panel. The fire detection system can be checked for proper operation through the system test selector (Refer to the System Test paragraph of this POH).

Each engine nacelle contains a cylinder full of fire extinguishing agent, supercharged with gaseous nitrogen. The fire extinguisher in the engine nacelle may be manually activated by pressing the corresponding L or R ENG FIRE EXT lighted pushbuttons. An electrically operated cartridge (firing squib), screwed into the cylinder housing assembly, provides the means of releasing the extinguishing agent. An explosive charge shatters the seal on the cylinder pod,releasing the extinguishing agent through tubes into the hot section of the engine and engine accessory section.

NOTE

The engine fire extinguisher is a single shot system with one cylinder for each engine.

CAUTION

Fire extinguisher capability has not been evaluated by Airworthiness Authority.

To prevent the cylinder from bursting from the heat, a fitting and integral valve releases the contents when the internal temperature of the charged cylinder exceeds 101°C (215°F). A gauge mounted on each cylinder, visible from the outside through a window in the outboard side of each nacelle, indicates the internal pressure, which depends on ambient temperature as illustrated in Section 4 of the AFM.

The engine fire extinguishers are powered directly from the hot battery bus through the LH and RH FIRE EXT 5 Amp circuit breakers located on the main junction box circuit breaker panel in the baggage compartment.

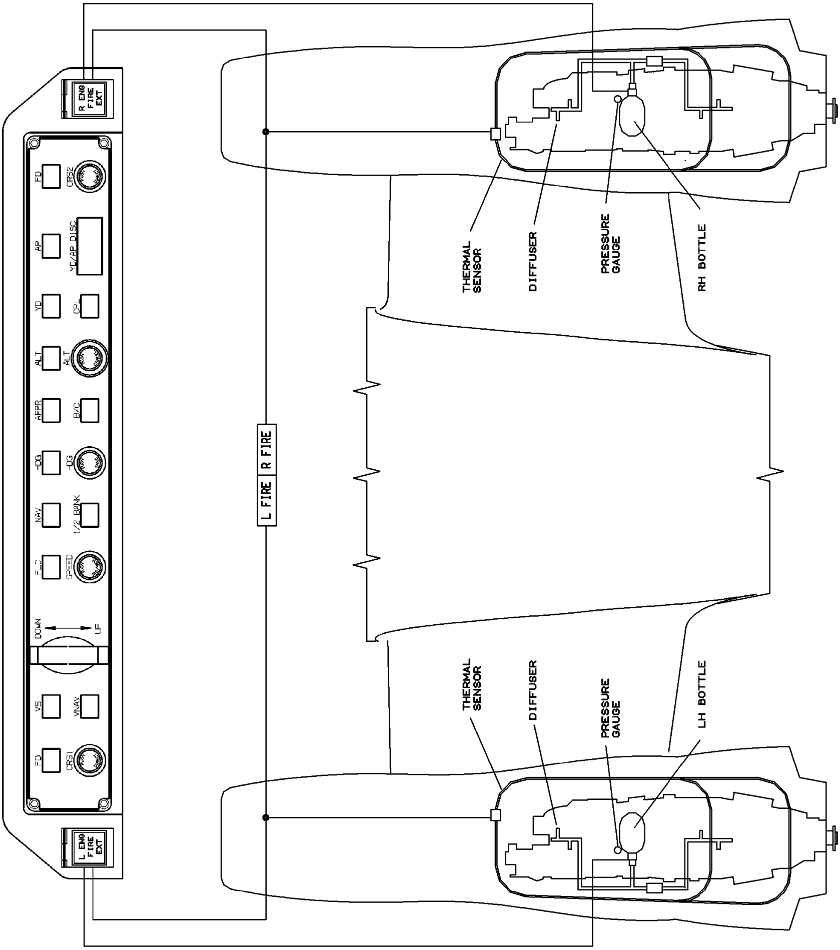

Figure 2.10-3. Engine Fire Extinguishing System

2.12. PROPELLERS

The pusher propellers are Hartzell counter-rotating, five blade, 85 inch diameter, single acting, constant speed, reversing and full feathering type. The all metal construction propellers are flange mounted on the engine shaft. Propeller speed is kept constant by a governor which controls the pressure of engine oil to the propeller pitch change mechanism.

The propeller governor, provided with an integral Beta valve, is installed on the front case of the reduction gearbox and is driven by the propeller shaft through an accessory drive shaft. When the oil pressure generated and controlled by the governor is increased, the blades are moved toward the low pitch (increase RPM) down to the hydraulic stop and through the Beta system to the reverse position. When the oil pressure is decreased, feathering springs and centrifugal counterweights allow the blades to move toward the high pitch (decreased RPM) position and into the feathered position.
The low pitch stop prevents the governor from moving the blades beyond the prescribed low pitch position separating the forward pitch range and the Beta and reverse ranges. The Beta and reverse blade angles are attained by manually overriding the low pitch stop position. This is accomplished by moving the power levers into the Beta and reverse ranges. Just after the low pitch stop position has been overriden, the L and R PROP PITCH amber caution lights of the annunciator display will come on and remain while the blade angles are in the Beta and reverse ranges.

The governor is also equipped with an airbleed orifice which serves to protect the engine against a possible propeller overspeed in the event of a primary governor failure. The orifice bleeds from the compressor discharge pressure sensor of the engine fuel control. Opening of the orifice results in a lower compressor discharge pressure signal being received in the sensor. The airbleed orifice will be opened at approximately 4% above the governor speed setting.

In the reverse thrust operation, the propeller speed adjusting linkage resets the airbleed link to a setting below the propeller governor control lever setting. Propeller speed is then controlled by the airbleed orifice and the blade pitch angle. Power supplied by the gas generator is reduced to allow a propeller speed approximately 5% under the speed set by the propeller governor.

An overspeed governor is installed on the front case of the reduction gearbox and is driven by the propeller shaft through an accessory drive shaft. The overspeed governor takes authority control the propeller speed in the event of malfunction of the primary governor or of any engine overspeed that can occur. The speed setting of the overspeed governor is approximately 2120 RPM (6% above the constant speed governor setting). The overspeed governor is provided with a solenoid operated reset valve which, when actuated, will reduce the speed setting of the overspeed governor to enable it to be checked during the runup. The solenoid reset valve is controlled through the PROP OVSP TEST LEFT-RIGHT- OFF switch located in the ENGINE/PROPELLER panel on the control pedestal. The test speed to which the overspeed governor is reset by the solenoid reset valve is approximately 1800 to 1840 RPM (above 90% of the maximum speed setting of the constant speed governor).

2.12.1 PROPELLER AUTOFEATHER

The automatic feathering system provides a means of immediately dumping oil from the propeller servo to enable the feathering spring and counterweights to start the feathering action of the blades in the event of an engine failure. Although the system is armed by a switch in the ENGINE/PROPELLER panel on the control pedestal, placarded AUTOFEATHER ARM-OFF-TEST, the completion of the arming phase occurs about two seconds after both power levers are advanced above the setting point (about 90% N_G), at that time both green AFX advisory annunciations are displayed on the MFD EIS section to indicate a fully armed system. The AUTOFEATHER amber caution light, on the center display panel, comes on, when the landing gear is in "down" position, if the autofeather system is either not armed (autofeather control switches in OFF position) or fails arming due to a malfunction or lack of electric power (pulled breaker).

The system will remain inoperative as long as either power lever is retarded below the setting position. The system is designed for use only during takeoff and landing and should be turned off when establishing climb. During takeoff or landing, if torquemeter oil pressure on either engine drops below a prescribed setting, the oil is dumped from the propeller, the feathering spring moves the blades toward feather, while the autofeather system of the other engine is disarmed. Disarming of the autofeather portion of the operative engine is further indicated when the advisory AFX annunciation for that engine extinguishes.

The microswitch which enables the operation of the autofeather, has a fixed position relative to the power lever, and, for the same lever setting, the power delivered by the engine is much more at low temperature than at high temperature.
For this reason, during takeoff at low temperature (below –25°C), it will be necessary to operate the main wing anti-ice and the engine ice vane systems to be sure that the autofeather is armed.

The proper operation of the system can be checked when on ground by moving momentarily the AUTOFEATHER switch to TEST; in this case the power lever may be maitained below 90% NG. The electrical power for operating the system is supplied from the right dual feed bus through the AUTOFEATHER 5-ampere circuit breaker on the copilot circuit breaker panel.

2.12.2 PROPELLER SYNCROPHASER

The Synchrophaser System allows the synchronization of the propeller, operating continuously on the propeller pitch to maintain a pre-defined propeller-phase relationship: the result is the reduction of the noise level in the cabin.

The Synchrophaser System consists of a control box, magnetic pick-ups and rotating propeller targets to send an electrical control signal to propeller governors having electrical speed trim capability.
The electrical power to the system is supplied by the right dual feed bus through the 3 Amp PROP SYNCPH circuit breaker, located on the right CB panel.

The system operates on electronic impulses generated by a rotating target passing each magnetic pick-up, and sensed by the control box.
The control box compares the LH and RH signals and then sends voltage signals to the magnetic coils in the propeller governors to maintain a fixed phase relationship between them: the faster propeller increases slightly the blades pitch to slow down the rotational speed while the slower propeller decreases slightly the blades pitch to increase the speed.
In operation, the system slightly increases both propellers speed setting and from that point adjusts speed up or down, as required, to maintain the pre-defined propeller phase relationship.

Before engaging the synchrophaser, it is necessary to match the propeller RPM within 10 RPM or less: this must be done by ear, since attempting to match the propeller levers or tachometers may not be sufficient.
Setting the SYNCPH switch, on the ENGINE/PROPELLER panel, to SYNCPH position, will engage the system when the relative position of the blades has drifted to within ± 30 rotational degrees of the preset internal phase setting.
The time required by the two propellers to drift within the phasing range before the system senses and corrects the phase relationship electronically, could be as long as 30 seconds.
If the RPM difference between the two propellers should exceed the holding range of the synchrophaser system (approximately 25 RPM), the system will disable its outputs and both propeller RPM will return to the original manual setting.

To reset the system, the SYNCPH switch must be turned to OFF, the propeller RPM must be re-adjusted to within 10 RPM or less, then the switch must be turned to SYNCPH position. Yet the re-engagement may occur without resetting the switch, provided the phase error is small.

If the synchrophaser system is engaged during an in-flight engine shutdown or a propeller feathering, the system will quickly detect an out of range condition and disengage automatically.

Whenever an in-flight engine shutdown occurs, or during approach and landing the synchrophaser must be turned OFF.

2.13. ENGINE AND PROPELLER CONTROLS

POWER AND CONDITION LEVERS

The engines and propellers are operated by two sets of controls mounted in the control pedestal below the center instrument panel.

The power levers (left side of pedestal) control engine power through the full range from maximum takeoff power down to full reverse. They also select the propeller pitch (beta control) when they are moved back from the detent. A gate provides unrestricted power lever movement from idle to maximum forward but requires the power lever handle to be pulled up before movement can be made from idle to reverse. Each power lever operates the N_G speed governor in the fuel control unit in conjunction with the propeller cam linkages. Increasing N_G results in an increased engine power.

The condition levers (right side of pedestal) provide the propeller speed commands as well as the fuel cutoff and propeller feathering functions. In flight, the condition levers provide the speed commands to the propeller governor for setting the desired propeller speed. The normal operating range is from 1800 to 2000 RPM. The condition levers are utilized to select high (about 70%) or low (about 54%) idle. Ground idle (low) is the normal condition for ground operations. Flight idle (high) is needed on ground for maintaining low ITTs during periods of high generator loads at high ambient temperatures or when increased bleed air flow is necessary. Moving the condition lever aft from the G.I. position, over the gate, and aft to the FTR and CUT OFF results in propeller feathering and fuel cutoff.

CONTROL PANEL

The ENGINE/PROPELLER Control Panel is located under the central section of the Instruments Panel and provides control of Starter/Generators, Engine Oil and Ignition Systems, Propellers Overspeed Governor, Autofeather and Syncrophaser Sytems operating mode.

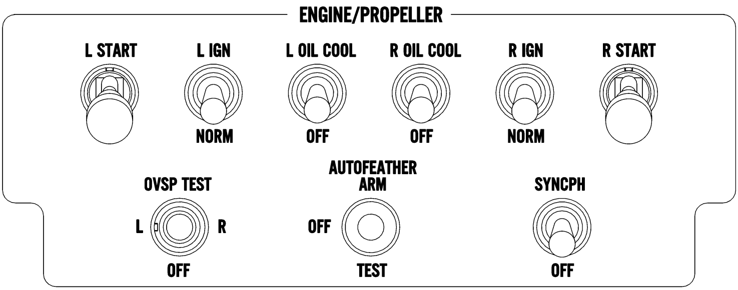

Figure 2.13-1. Engine/Propeller Control Panel