ENGINE

GENERAL

The Honeywell model TFE731-40AR turbofan engine is a lightweight, two-spool, geared-stage, front-fan, jet engine.

The cross section of the engine is shown in Figure 7-71-1, page VII-71-3. The spinner and high-efficiency axial-flow fan are located at the forward end. The fan is gear driven by a low-pressure (LP) rotor with a fan gearbox output-to-input speed ratio of 0.5556. The LP rotor consists of a four-stage LP axial compressor and a three-stage LP axial turbine, both mounted on a common shaft. The accessory gearbox is driven through a transfer gearbox by the high-pressure (HP) rotor. This rotor consists of an HP single-stage, centrifugal compressor and an HP single-stage, axial turbine, both mounted on a common shaft. The LP and HP rotor shafts are concentric, so that the LP shaft passes through the HP shaft.

An annular inlet duct, also called the splitter, bypasses fan air for direct thrust and diverts a portion of the fan air to the LP compressor. Air from the LP compressor flows through the HP compressor and is discharged to the annular combustor. Combustion gases flow through the HP and LP turbines and are discharged axially through the engine exhaust duct to provide additional thrust. Compressor bleed air is available for aircraft uses such as cabin air conditioning / pressurization and anti-ice system. The engine incorporates an LP venturi extraction design for both LP and HP bleed air.

Oil for engine lubrication is supplied by an oil pump mounted on the engine accessory gearbox. The pump provides positive oil displacement for the bearings and gears, and scavenges the sump areas. A cartridge-type oil filter and a magnetic (electrically sensed) chip detector are installed.

(Continued)

Fuel for engine operation is supplied by a fuel pump mounted on the engine accessory gearbox. An auxiliary motive flow fuel pump is mounted on the accessory gearbox, opposite the main fuel pump. The auxiliary motive flow fuel pump provides flow for the aircraft jet pumps.

Primary automatic control of engine fuel is accomplished by the digital electronic engine control (DEEC) and the hydro-mechanical fuel control unit (FCU). The FCU is mounted on and driven by the fuel pump. The DEEC provides smooth, surge-free operation of the engine through monitoring and commanding of the interfaces between the engine and the control system. Additional integrated features of the DEEC include the following:

- Engine condition trend monitoring (ECTM) system records engine parameters to provide useful information to the operator regarding engine health.
- Automatic performance reserve (APR) provides an automatic increase in thrust in one engine if the other engine loses thrust during takeoff.
- Manual performance reserve may be activated by pressing APR ON pushbutton, allowing increased thrust as for single-engine APR operation but with both engines operating.
- Engine synchronization to trim fan/LP or HP rotor speed (N_1 and N_2, respectively) eliminates the acoustic beat-generated noise from unsynchronized engines.

If the primary DEEC/FCU control system fails, backup engine fuel control is done by the FCU only. In this mode, the FCU meters fuel flow in response to inputs from the power lever.
Engine sensors provide real-time indications of engine conditions and status on EICAS.

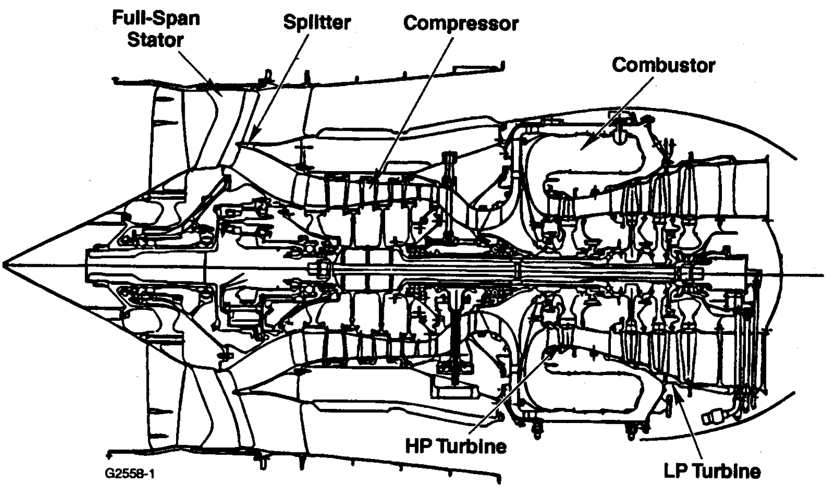

Figure 7-71-1. TFE731-40 Engine Cross-Section

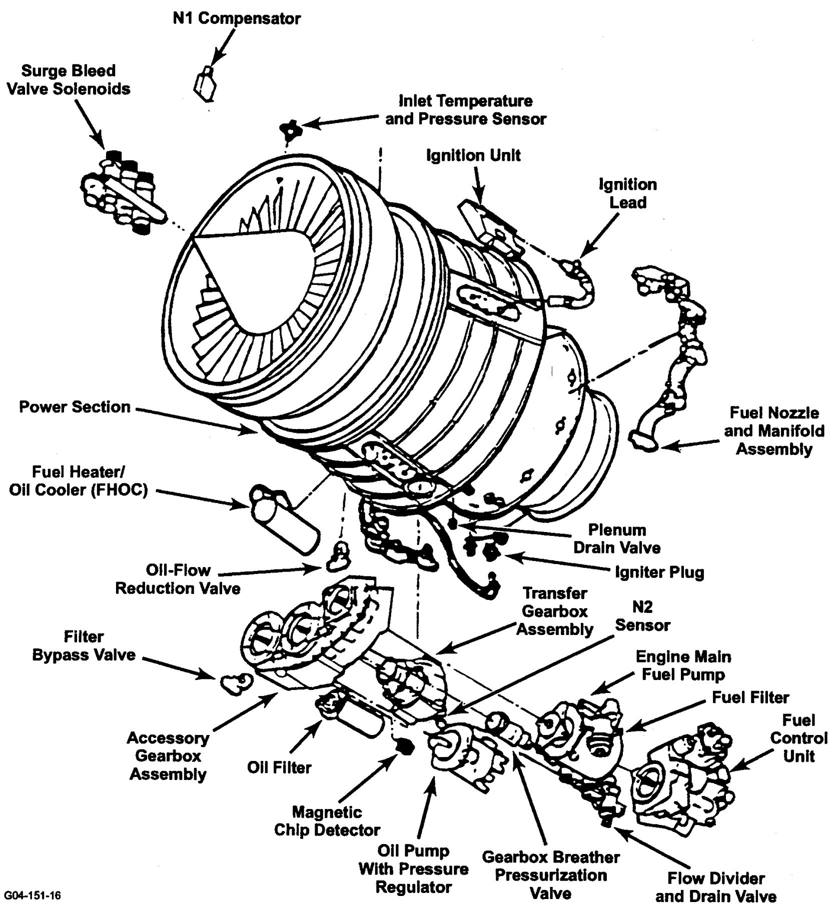

Figure 7-71-2. TFE731-40 Engine Modules and Components

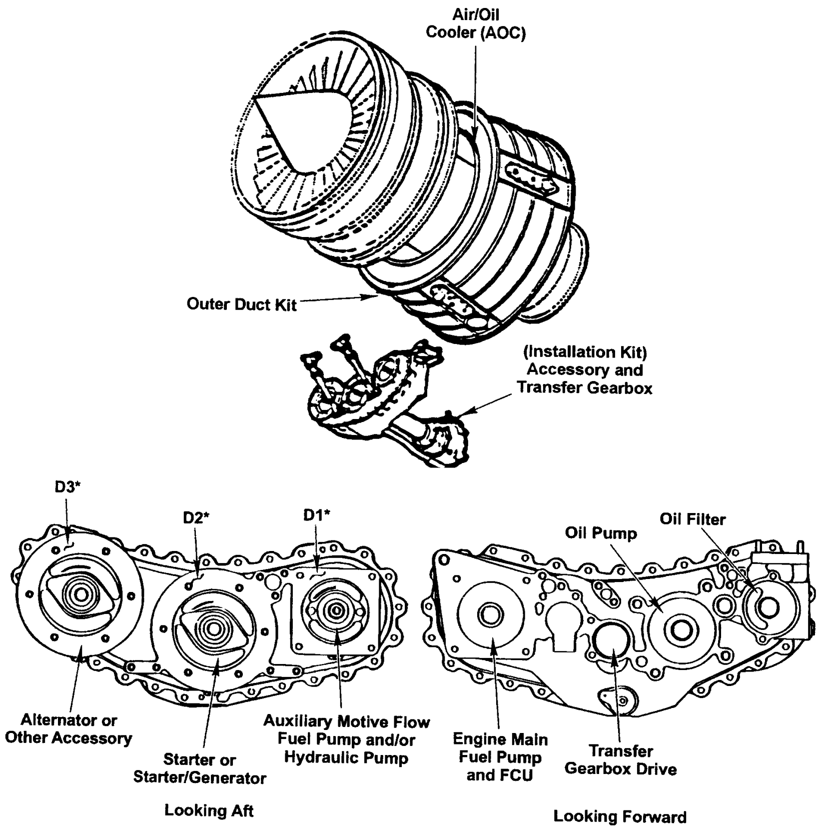

Figure 7-71-3. TFE731-40 Engine Accessory Gearbox

ENGINE FUEL DELIVERY AND CONTROL

The aircraft fuel system provides strained fuel at the correct pressure to the engine fuel system inlet. The engine fuel delivery system filters the fuel, heats it as necessary to prevent filter icing, raises it to high pressure, and delivers it to the engine fuel control system. The engine fuel delivery system also provides fuel to the aircraft fuel system jet pumps through a separate motive flow pump powered by the accessory gearbox.

Upon receipt of fuel, the engine fuel control system meters the required amount to the engine combustor. The required amount is that which corresponds to the power lever position and to the atmospheric and engine operating conditions. Protection against LP compressor surge is provided by the surge bleed valve (SBV), which is operated by the engine control system.

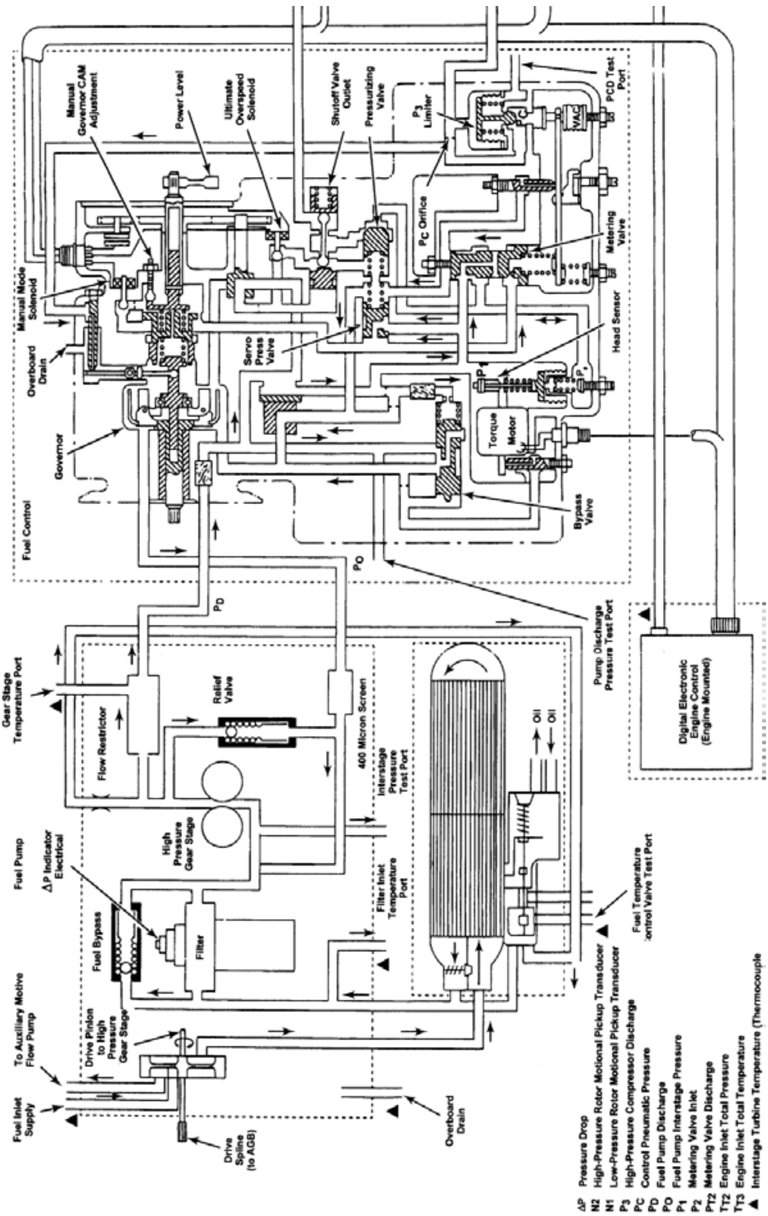

Figure 7-71-4. Engine Fuel System - Schematic

Engine Fuel Control

Engine operation is controlled by the DEEC and the hydro-mechanical fuel control unit (FCU). The FCU has two sections, one for fuel shutoff and the other for fuel metering. The FCU is mounted on the engine main fuel pump, and provides power lever connection point, fuel shutoff function, and mechanical overspeed protection for the HP rotor during all engine operations.

During normal engine operation, the DEEC performs the functions of thrust setting, speed governing and acceleration and deceleration limiting through electrical control inputs to the hydro-mechanical FCU. If electrical or DEEC failure occurs, the hydro-mechanical FCU functions independently in manual mode to provide for engine operation at reduced performance. The DEEC also controls the SBV setting in normal operation. When the DEEC is deactivated, the SBV is set to a conservative position.

Control System Components

The fuel control system comprises the following components that provide the required functions:

- Hydro-mechanical FCU - The FCU contains the fuel metering section, the fuel shutoff section (i.e., shutoff valve), the power lever input, the outlet pressurizing valve, and the mechanical governor. The mechanical governor has two functions, one being to act as the overspeed governor for the HP rotor, and the second is to provide manual control when the DEEC is deactivated. The FCU is controlled by an electrical input to the fuel metering section when the DEEC is scheduling engine fuel flow. The FCU incorporates a combined vent and drain fitting. During manual mode operation, this vent discharges P3 air, which is used as a controlling function by the hydro-mechanical FCU. Interruption of this discharge flow results in loss of engine speed control.

(Continued)

- DEEC - The DEEC is basically an LP rotor speed governor, with provisions for limiting fuel during acceleration and deceleration. Inputs to the DEEC are engine inlet pressure and temperature (Pt_2/Tt_2), interstage turbine temperature (ITT), LP and HP rotor speeds (N_1 and N_2), and power lever position (power lever angle - PLA). From these, the DEEC computes the necessary engine control parameters.
- Surge bleed valve - Surge control is provided via a system comprising two externally-mounted SBV control solenoids and one internally-mounted SBV, which is opened to prevent compressor surge. SBV position is controlled to maintain an adequate margin from engine surge under all operating conditions.
- Flow Divider - The flow divider controls the routing of fuel to the fuel manifold and nozzle assembly to ensure proper atomization of the fuel.
- Fuel manifold and nozzle assembly - The fuel manifold and nozzle assembly routes and atomizes the fuel to ensure proper combustion-

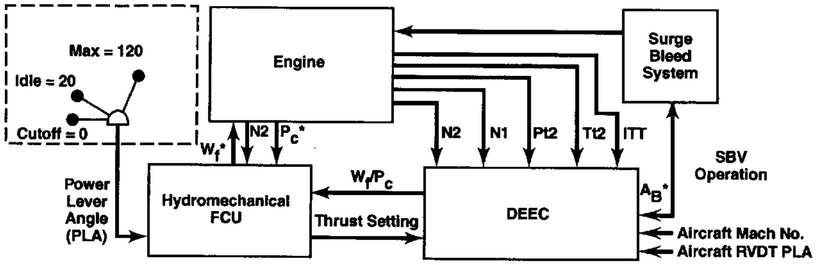

Figure 7-71-5. Engine Fuel Control Logic

LUBRICATION SYSTEM

The system provides proper oil cooling and component lubrication under all operational altitude conditions up to a 125°F (52°C) day.

The system includes the following components:

- Combined lubrication and scavenge pump
- Modular pressure regulator
- Oil filter, oil pressure indicator and filter bypass valve
- Air-oil cooler and its bypass valve
- Fuel heater/oil cooler (FHOC) and its bypass valve
- Oil-flow reduction valve (ORV)
- Scavenge screens
- Gearbox breather pressurization valve (BPV) and vent
- Electrical magnetic chip detector and check valve
- Oil tank and sight gage
- Associated plumbing.

The lubrication system operates in the following manner: engine lubricant is drawn from the oil tank by the oil supply section of the pump, and is passed through the filter and the pressure regulating valve on its way to the air/oil cooler (AOC). This heat exchanger is a three-segment, finned cooler that forms the inner surface of the engine fan duct. The AOC is equipped with a temperature valve to maintain the oil at the desired temperature regardless of flight envelope ambient temperature conditions. It also provides rapid warming of the oil on cold days.

From the AOC, the oil flow is divided, with part of the flow directed to the accessory and transfer gearboxes and the No. 6 bearing, and the remaining flow passing through the FHOC on its way to the No. 4 and 5 and fan gearbox bearings, seals, hydraulic mounts, and gears. The FHOC is equipped with an oil bypass valve that is activated by the FCU to preclude excessive heating of the fuel when the FCU senses that the fuel temperature is above limit. Both the FHOC and AOC control valves have integral oil pressure relief bypass valves to assure oil flow for cold starting. The FHOC also heats the fuel on cold days to prevent fuel icing.

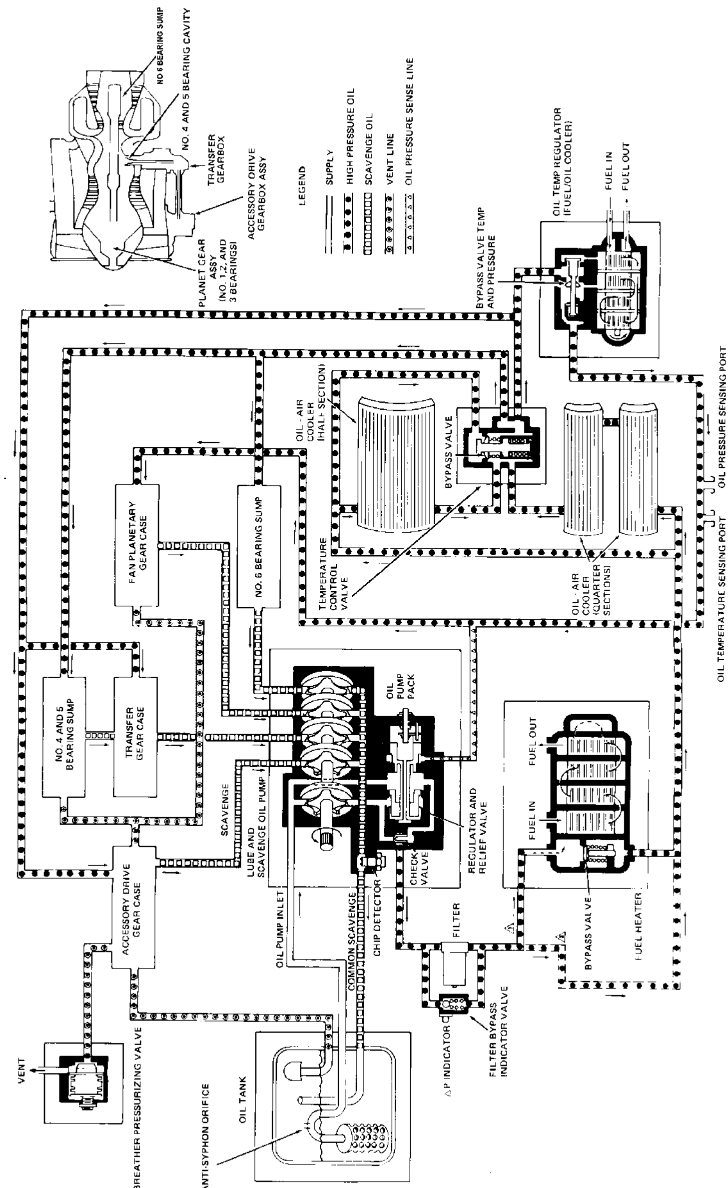

Figure 7-71-6. Engine Oil System - Schematic

ENGINE CONTROL

Engine thrust is controlled from the throttle quadrant with two main power levers. Motion is transmitted from the throttle quadrant by a control cable to the engine fuel control unit.

The throttle quadrant in the pedestal comprises main power levers, thrust-reverser levers and main power lever latches. The main power levers control forward and reverse engine thrust from IDLE to MAX thrust. During forward thrust, the thrust-reverser levers are retained in stowed position, and engine power is controlled by moving main power levers forward or aft. For reverse thrust, the main power levers must be in the IDLE position, and the thrust-reverser levers in DEPLOY detent, to deploy the thrust reverse buckets. When the thrust reverse buckets are fully deployed, a lock solenoid in the throttle quadrant is energized, enabling the thrust-reverser levers to function in reverse thrust mode from IDLE to MAX reverse.

Each main power lever has three positive stops: CUT OFF, IDLE and MAX thrust. The IDLE stop is non-adjustable and is used as a rigging point for the main power lever IDLE position. The CUT OFF and MAX power stops are adjustable to enable full travel of the main power lever. Additional two intermediate positions determined by power lever position are CRZ (MAX Cruise) and CLB (Max Climb).

Moving the main power lever forward from the IDLE and MAX thrust position and back through to the IDLE position is a non-obstructed movement. To move the thrust power lever aft from the IDLE position to the CUT OFF position and back through to IDLE position, the power lever latch must be raised, preventing inadvertent engine shutdown. A power lever retarder automatically retards the main power lever to IDLE position during an inadvertent deployment of thrust reverse buckets.
The APR mod enables maximum thrust at higher ITT, expanding engine thrust envelope for single engine operations. APR comes on automatically if engine fails during take-off if APR ARM pushbuttons pressed, or manually by pressing the APR ON pushbutton.

ENGINE CONTROL SYSTEM CONTROLS

DEEC switch - LEFT ENGINE and RIGHT ENGINE - Located on overhead panel; it has three positions:

AUTO - Energizes the DEEC. engine operates in normal mode. Fuel control and scheduling is automatic.

MAN - Deactivates the DEEC. Engine operates in manual control mode, with electronic overspeed protection only. DEEC MAN MODE (L/R) message comes on. Abnormal condition.

OFF - Disconnects power to the DEEC. DEEC MAN MODE (L/R) message comes on.

Start switch - Located on overhead panel; it has three positions:

START - Momentary position to engage starter.

OFF - Switch rest position

STOP - Stops starter operation.

STBY PUMP switch - Located on overhead panel; it has three positions:

AUTO - Standby pump comes on automatically, when required.

OFF - Standby pump is off.

ON - Standby pump is on continuously.

IGNITION switch - Located on overhead panel; it has two positions:

AUTO - Ignition comes on when required during engine start or by DEEC command.

ON - Ignition is continuous.

APR ARM pushbutton, on center panel - Arms the APR system.

APR ON pushbutton on, center panel - Manually activates the APR or indicating (L or R) APR activated after being armed.

ENG. SYNC toggle switch, on pedestal: it has three positions:

OFF - No synchronization

N1 - Synchronization using N_1

N2 - Synchronization using N_2

ENG EVENT pushbutton - Pressed to download ECTM data.

Warning Messages

ENG EXCEEDANCE (L/R) - Engine limits exceeded: N_1, N_2, ITT
ENG FIRE - Overheating or fire in zone 1 (accessories section)
ENG OVERHEAT - Overheating or fire in zone 2 (combustor section)
OIL PRESS HI (L/R) - Engine oil pressure above limit
OIL PRESS LOW (L/R) - Engine oil pressure is low
OIL TEMP HI (L/R) - Engine oil temperature is high

Caution Messages

DEEC MAJOR (L/R) - Engine fuel controller malfunction
DEEC MAN MODE (L/R) - Engine fuel controller switched to manual mode either manually or automatically
DEEC MAN XFER INOP (L/R) - Engine fuel controller cannot automatically switch to manual mode
ENG FUEL TEMP HI (L/R) - Engine fuel temperature is high
ENG FUEL TEMP LOW (L/R) - Engine fuel temperature is low
ENG MISCOMPARE (L/R) - Engine data channels difference
OIL PRESS HI (L/R) - Engine oil pressure above limit
OIL PRESS LOW (L/R) - Engine oil pressure is low
OIL TEMP HI (L/R) - Engine oil temperature is high
OIL TEMP LOW (L/R) - Engine oil temperature is low. Minimum oil temperature for start is -40°C; minimum oil temperature for take-off is +30°C

Advisory Messages

IGNITION ON (L/R) - Engine ignition is on

Status Messages

DEEC COMM FAIL (L/R) - DEEC Arinc 429 communication failure
ECTM DOWNLOAD (L/R) - Engine condition trend monitoring download is required within next three flights
ENG CHIP DETECT (L/R) - Metal particles found in engine oil
ENG COMPARE INOP (L/R) - Engine data comparator inoperative between DCU and DEEC
FUEL FILTER BYPASS (L/R) - Respective fuel filter is clogged
OIL FILTER BYPASS (L/R) - Engine oil filter is clogged

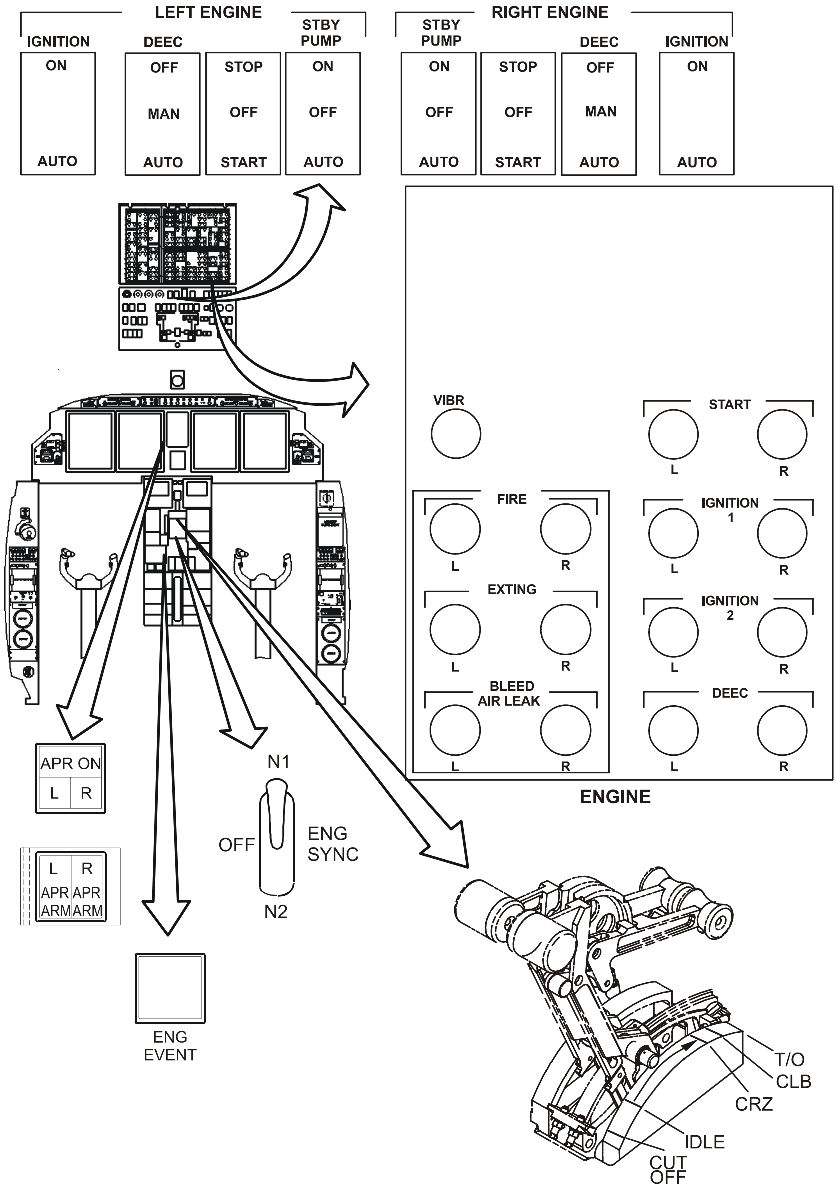

Figure 7-71-7. Engine Controls

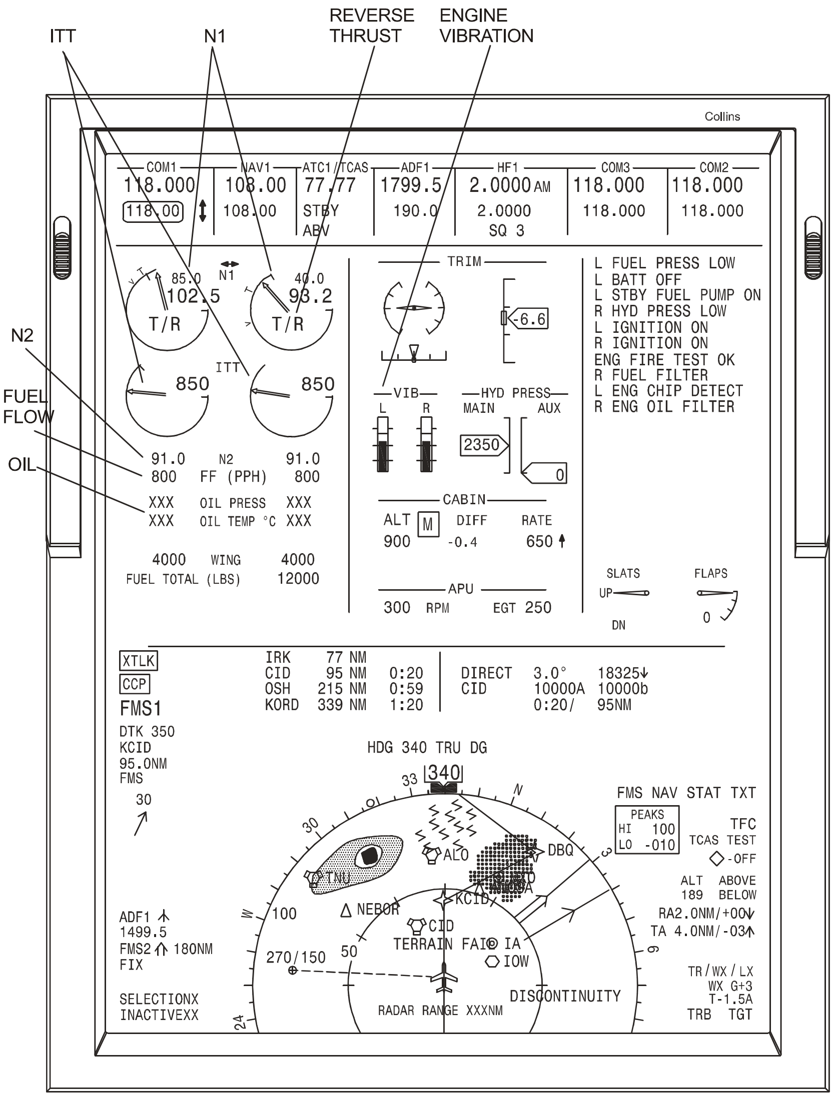

Figure 7-71-8. Engine Indications on EICAS