ENGINE

GENERAL

Jet engines produce thrust by accelerating air. It is the product of the mass of the air times the increase in velocity that determines thrust output. To generate a given amount of thrust, a small volume of air can be accelerated to a very high velocity, or a relatively large amount can be accelerated to a lower velocity.

In a turbofan engine, with which the Citation Sovereign is equipped, only a portion of incoming air is combusted. This combusted hot air drives the compressor and a fan, which is used to accelerate a large volume of uncombusted air at a lower velocity. This uncombusted air is bypassed around the engine and exhausted at the rear, being mixed with the combustion exhaust. The relation of the total mass of bypassed air to the amount of air going through the combustion section is known as the Bypass Ratio.

The PW306C Engine is a two-spool, turbofan engine, featuring a full-length annular bypass duct. A concentric shaft system supports the high- and low-pressure rotors. The inner shaft supports the low-pressure (LP) compressor (fan) and is driven by a three-stage turbine at the rear. The outer shaft is mechanically independent of the LP shaft and supports the four axial stages and one centrifugal stage of the high-pressure (HP) compressor, and is driven by a two-stage turbine supported at the rear.

Air enters the engine through the fan case, is accelerated rearward by the fan and is split into bypass and core flow streams through concentric dividing ducts. The bypass air passes through a single stage of stators and a faired bypass duct before exiting with the core flow through a common mixing nozzle.

The core airflow passes through variable inlet guide vanes and first-stage variable stator vanes, which allow optimum airflow into the HP compressor. Both sets of vanes are hydraulically actuated by fuel pressure from the hydro-mechanical unit, as commanded by the electronic engine control. From the HP compressor, core airflow is passed through 24 diffuser tubes, which convert velocity to static pressure. The diffused air then passes to the annulus surrounding the combustion chamber liner.

The combustion chamber liner consists of an annular straight-through assembly with multi-holed patterns for air mixing and dilution with the combustion gases located between the core and bypass flow passages.

The air enters the combustion chamber liner and mixes with fuel. Fuel is injected into the combustion chamber by 24 air blast nozzles supplied by a single tube manifold. Two of the nozzles are a hybrid type, having an additional fuel supply line of lower pressure, to provide a separate primary fuel flow for ease of starting. During starting, the mixture is ignited by two spark igniters that protrude into the combustion chamber liner.

The resultant gases expand from the combustion chamber liner and pass through the first stage HP turbine stator to the first-stage HP turbine. The first-stage HP vanes and rotor blades are cooled by air flowing through internally cast passages. The still expanding gases pass rearward to the cooled second-stage HP vanes and turbine, then to the three-stage LP turbine and associated stator vanes, to the atmosphere through the exhaust duct, subsequently mixing with the bypass flow.

All engine driven accessories, with the exception of the N_1 LP rotor speed sensor, are on the accessory gearbox secured to the bottom of the intermediate case. The accessories are driven by a tower drive shaft geared to the HP rotor shaft (N_2), passing downward through the intermediate casing to mesh with a bevel gear in the accessory gearbox. The N_2 speed sensors located on the right side of the accessory gearbox are of an electromagnetic pulse type. A spur gear on the alternator gear shaft passes over the probes, creating an impulse which is transmitted to the Electronic Engine Control (EEC). The two N_1 sensors are mounted in the front of the engine, forward of the No. 1 bearing and are connected by a wiring harness on the upper port side of the intermediate case. The operation of the N_1 probes is the same as the N_2 probes, and transmits signals to the EEC. The engine oil tank is integral with the intermediate case and is located between the core and bypass flow passages.

ENGINE CONTROL PANEL

A28832

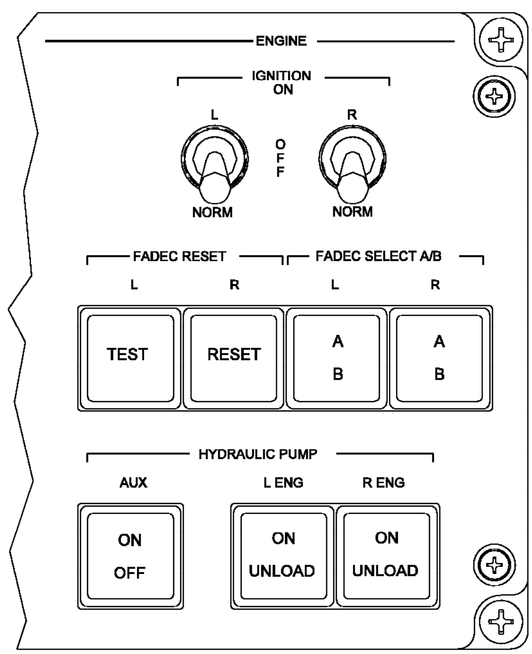

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Figure 2-1

ENGINE AIRFLOW AND CROSS SECTION

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FLANGES

A	NACELLE TO FAN CASE
B	FAN CASE TO INTERMEDIATE CASE
C	INTERMEDIATE CASE TO OUTER BYPASS DUCT
D	BYPASS DUCT TO AIRFRAME SUPPLIED BYPASS DUCT
E	COMB. CHMBR. OUTER CASE TO LP TURBINE MODULE
F	LP TURBINE CASE TO EXHAUST CASE

STATIONS

0	AMBIENT
1	FAN CASE INLET (ID)
12	FAN BYPASS INLET
13	FAN BYPASS OUTLET
16	BYPASS EXHAUST
2	FAN CORE INLET
2.1	FAN CORE OUTLET
2.2	HP COMPRESSOR AXIAL INLET
2.5	HP COMPRESSOR INTERSTAGE
2.8	HP COMPRESSOR IMPELLER INLET
3	COMBUSTION CHAMBER INLET
4	HP TURBINE INLET
4.5	INTERTURBINE
5	LP TURBINE OUTLET
6	CORE EXHAUST

CORE AIR FLOW

BYPASS AIR FLOW

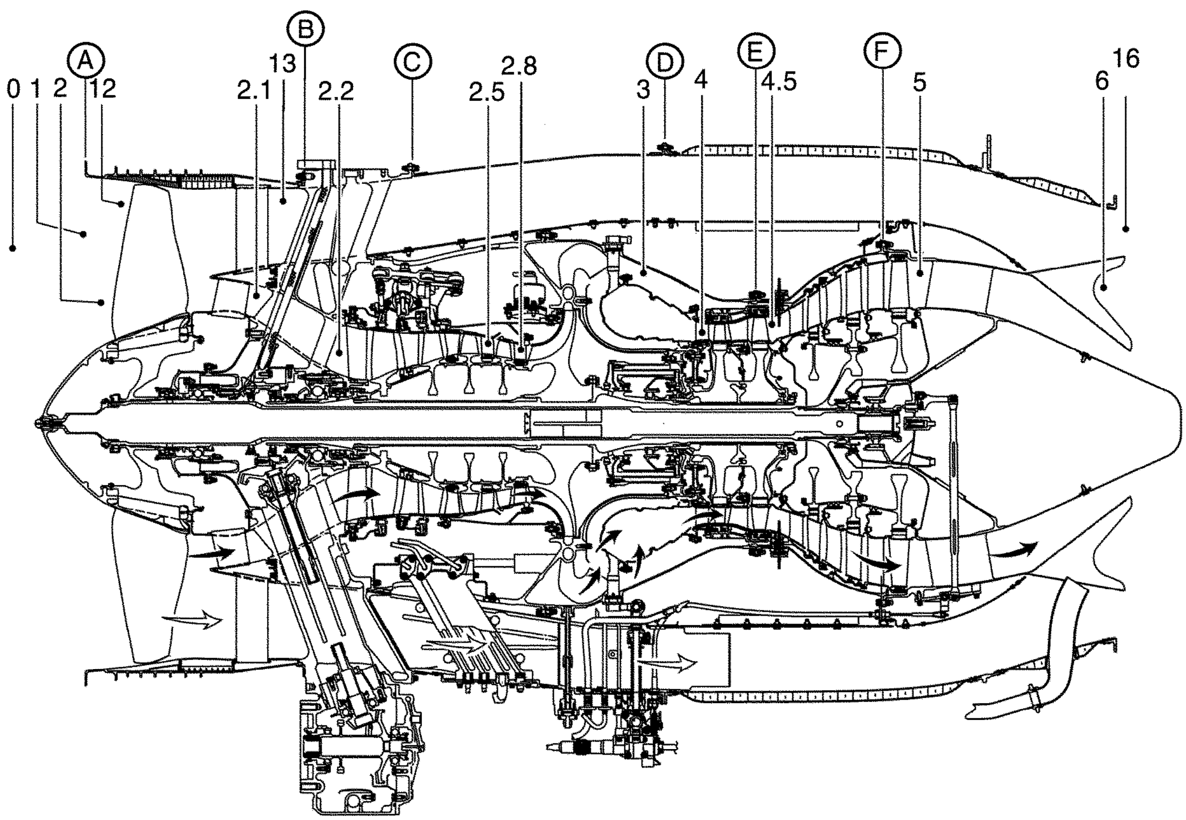

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Figure 2-2

FULL AUTHORITY DIGITAL ELECTRONIC CONTROL (FADEC)

A Full Authority Digital Electronic Control (FADEC) controls engine thrust. The FADEC operates all of the time; however, only one channel is in command of each engine at any one time. The FADEC channel not in command will automatically assume command of the engine in case of a FADEC channel failure. The FADECs must be functioning in normal mode for dispatch. Selection of the FADEC operating channel is by the FADEC SELECT A/B RESET NORM/SELECT switch-annunciator. These switches are spring loaded to NORM. Momentarily pressing the switch to SELECT will select the opposite FADEC, unless the opposite FADEC has failed. Momentarily pressing the switch to RESET resets the fault memory only; it does not clear the fault.

The FADEC channel is automatically alternated at each engine start to ensure equal use and reliability; therefore, do not arbitrarily select an alternate FADEC channel.

FADEC power is provided by 28-volt direct current (DC) power from the airplane batteries, APU generator, or by engine driven permanent magnet alternators (PMA). The PMAs provide power for the engine ignition system after the engine reaches approximately 10% N_2 RPM on start. If the engine is running, it will continue to supply FADEC power to allow continued engine operation. The PMAs are the primary power source; the batteries provide backup power and power for starting only.

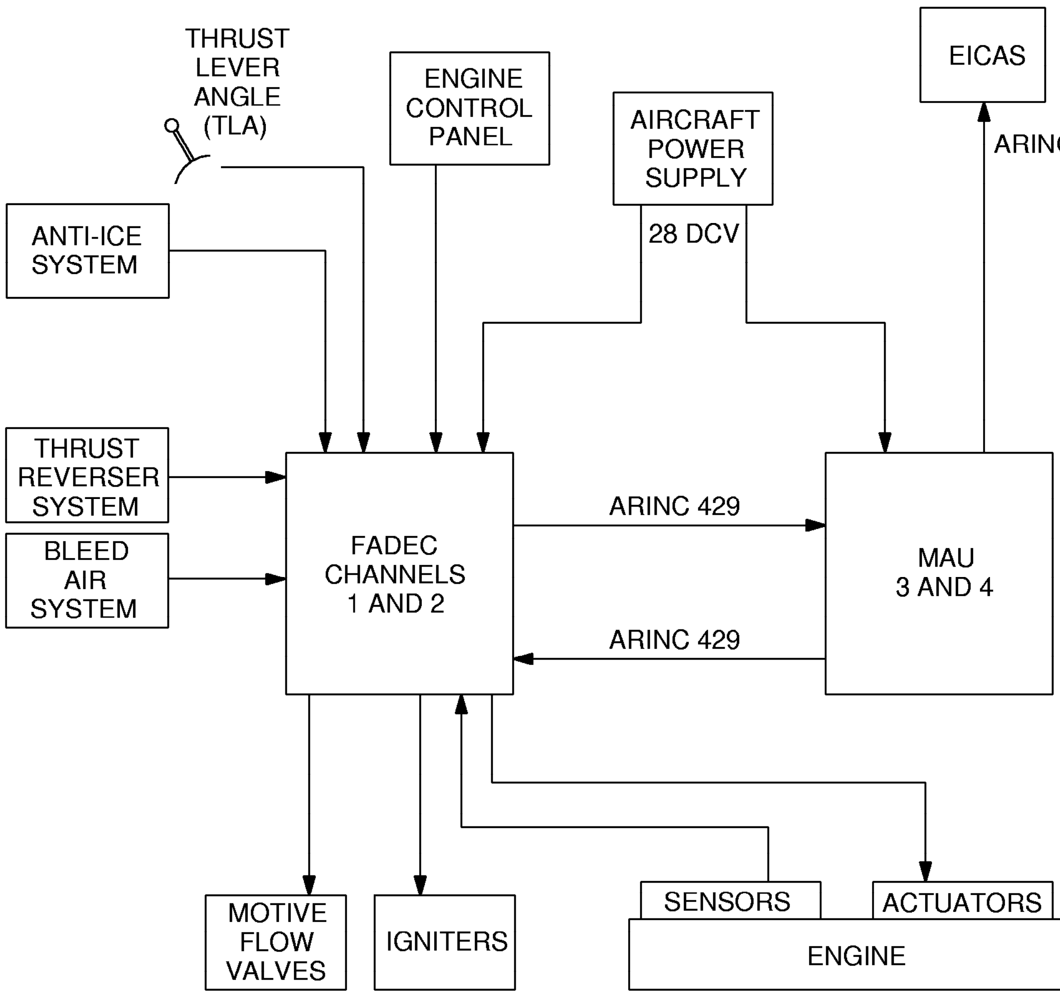
Information is provided to the FADEC by resolvers on each throttle lever in the throttle quadrant, from the dual air data computers, and from the various cockpit and aircraft switches. In order to schedule engine thrust, the FADEC compares data from the dual air data computers. If there is a discrepancy, the FADEC will select the air data that most closely agrees with the engine internal temperature and pressure. The FADECs compute thrust commanded by the throttle lever resolvers and transmit engine data to the EICAS cockpit displays.

The FADEC channel in command schedules actual engine thrust and displays it as tape and digital N_1 on the EICAS engine display. The FADEC not in command displays commanded thrust as a digital target (the lower value of that computed by both the left and right not in command FADECs) and the N_1 target bugs. All other EICAS displayed engine data is from the FADEC in command. In the case of failure, the remaining FADEC channel will assume command; however, the target bug information will then be coming from the FADEC in command as well as the actual N_1 data. To alert the crew to this fact the target symbol will change from cyan to amber.

When the throttle lever is placed in cutoff, a micro switch to the FADEC, which commands the engine to be shut down, transmits information. Above cutoff, and increasing from idle, the throttle resolvers signal the FADEC to vary the thrust until reaching a series of three detents. The first detent is labeled CRU and will, in normal FADEC mode, command the normal maximum cruise thrust. The second detent is labeled CLB and will command the normal maximum climb thrust. The third detent is labeled TO and will command the normal takeoff thrust. Pushing the throttle levers beyond the TO detent will still command the normal takeoff thrust. The commanded mode, CRU, CLB, or TO, will be annunciated by the FADEC mode indicator adjacent to the command N_1 box in the EICAS N_1 display.

CONTROL SYSTEM SCHEMATIC

A28813



ARINC 429 = AERONAUTICAL RADIO INCORPORATED 429 DIGITAL DATA BUS

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Figure 2-3

In flight, when a throttle is in detent, the command N_1 display from the FADEC channel not in command will show the command thrust for that detent. In flight, with landing gear up, and the throttle levers not in a detent, the command N_1 display will be the next higher detent. On the ground, or in flight with landing gear down, the command N_1 display will be takeoff.

CAUTION

IF ENGINE DAMAGE HAS OCCURRED, THE FLIGHT SHOULD NOT BE CONTINUED. LAND AS SOON AS PRACTICAL.

The FADEC also provides engine monitoring and will not allow engine ITT limits to be exceeded. They will provide automatic engine shutdown if N_1 or N_2 limits are significantly exceeded due to a failure, but will normally not allow N_1 to exceed the N_1 command.

ENGINE SYNCHRONIZATION

The Engine SYNC switch enables engine synchronization, if the following conditions exist:

- TLA is at or above idle and at or below the MCT detent.
- N_1 differential is less than 5%.
- The landing gear is up.

ENGINE SYNCHRONIZER

An engine synchronizer system provides automatic N_1 fan RPM matching of the right (slave) engine to the left (master) engine. The synchronizer will continuously monitor the engine speeds and adjust the slave engine speed setting as required. The actuator has a range capability of 4.75% of fan RPM.

A green "SYNC" is displayed on the EICAS when the engines are synchronized.

IGNITION SYSTEM

Each engine incorporates dual exciter units and two igniters. The exciter units convert battery or generator input to high voltage Direct Current (DC), store it momentarily until a given energy level is reached, and allow it to discharge in spark form through the igniters. System wiring is such that malfunction of one igniter or exciter will not affect normal operation of the other.

Cockpit control consists of two-position L and R ignition switches. In the NORM position, the igniters are automatically activated during engine start or when anti-ice is selected ON. Moving the throttle to IDLE after depressing the start button activates ignition until it is terminated automatically at approximately 38% turbine RPM (N_2). Continuous ignition occurs any time the respective engine anti-ice or ignition switch is ON.

A green "IGN" above the ITT graph on EICAS illuminates when both exciters are receiving electrical power. If one igniter should fail, ignition will still be available from the remaining igniter. If the ignition light does not illuminate when ignition is selected, or should be automatically provided, check the applicable ignition system circuit breaker on the left circuit breaker panel, or fuse in the aft power junction box.

ACCESSORY GEARBOX

The starter/generator, fuel pump, fuel control, hydraulic pump, oil pump, N_2 monopole speed sensor, and an AC generator for the windshield anti-ice are driven by the accessory gearbox mounted below the engine. Power to drive the gearbox is transmitted from the N_2 section through the tower shaft and a series of bevel gears. Lubrication is provided by the engine oil system.

OIL SYSTEM

The lubrication system is an unregulated system that provides the required oil-flow to the main shaft bearings, all accessory drive gears and accessory bearings throughout the entire engine speed range. Calibrated nozzles in the main engine-bearing compartment provide the bearings with the required oil flow in all operating conditions. The oil system consists of the following basic components: oil pressure system, scavenge system and an oil breather system.

Oil is drawn from the oil tank by a gear type fixed displacement pressure pump. An integrated oil pressure adjusting and cold start valve monitor oil pressure downstream from the gear driven pump. The Pressure Adjusting Valve (PAV) bleeds oil pressure that is in excess of a preset limit back to the pressure pump inlet.

Oil from the pressure pump is passed through the oil filter, which incorporates a bypass valve to safeguard against blockage. If there is an impending oil filter bypass, an indicator in the filter housing will provide an electrical cockpit warning prior to bypass valve activation.

The scavenge oil system incorporates three two-element scavenge pumps. These pumps are of the gear type and are driven by the fuel pump gear shaft. Oil from the No.1 and 2 engine main bearings is drained into the accessory gearbox oil sump. The oil pump along the bottom of the engine, pumps scavenge oil from the No. 3 and No. 4 bearings via external transfer tubes into the accessory gearbox. Scavenge oil collects in a sump at the bottom of the accessory gearbox housing and is pumped to the top of the oil tank by a separate scavenge pump. The main oil pressure pump will not be driven in the event of a failure of any one of the scavenge pumps. This prevents oil flooding the engine core.

Breather air from the accessory gearbox and engine bearing compartments is vented overboard by an impeller type centrifugal air/oil separator located on the alternator gear shaft.

The fuel/oil heat exchanger is mounted to the oil pressure manifold on the left hand side of the accessory gearbox. Engine oil enters the heat exchanger from the pressure manifold and is directed to flow around tubes, which use bypass fuel from the fuel-metering unit for oil cooling. The transferred oil raises the fuel temperature before it enters the fuel filter assembly. The heat exchanger also serves to cool engine oil prior to distribution to the engine and accessory gearbox.

ENGINE OIL SYSTEM SCHEMATIC

A28814

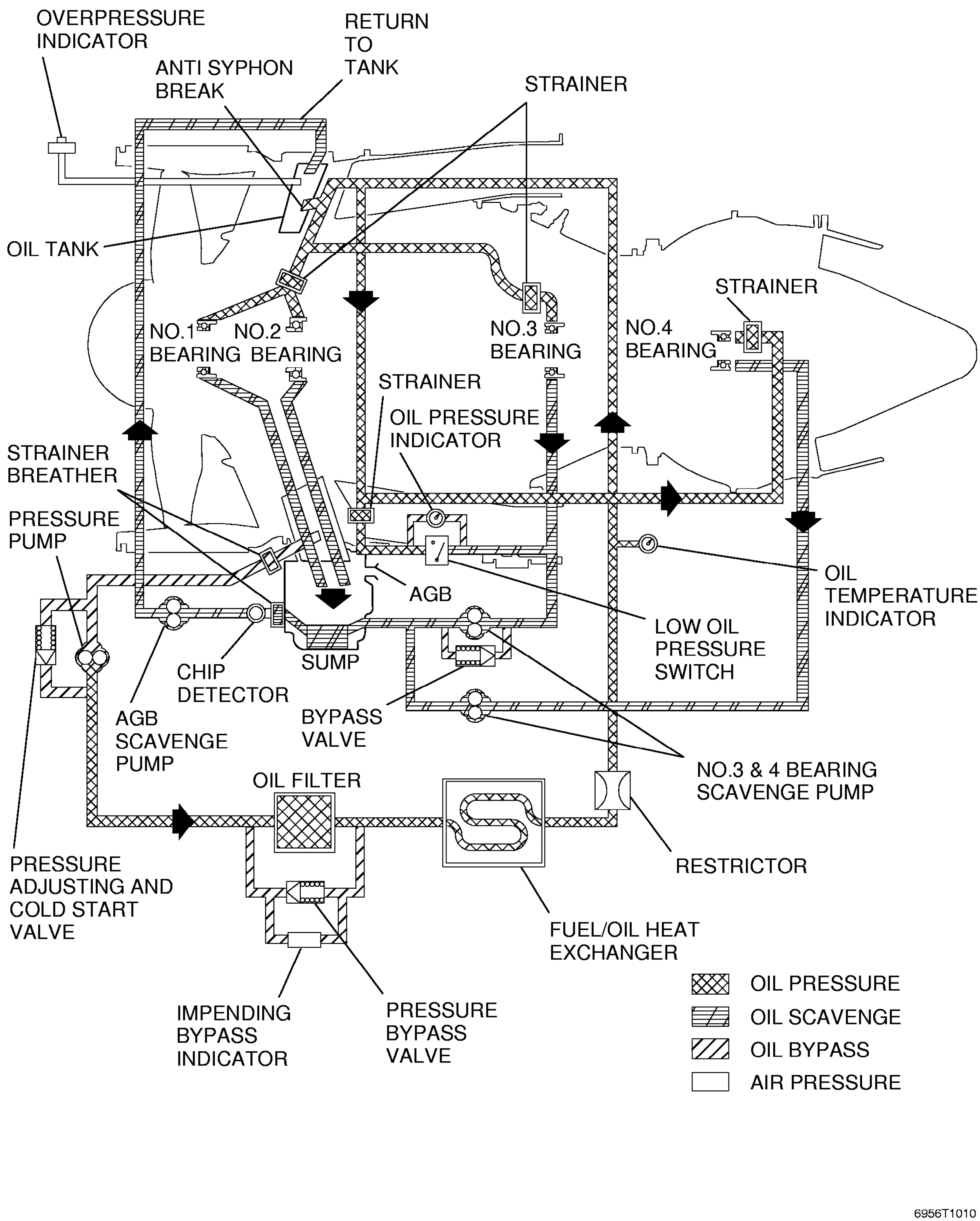

Figure 2-4

THRUST REVERSER SYSTEM

GENERAL

The thrust reversers (T/R's) are of the external target type employing two vertically oriented doors or buckets. When deployed, the buckets direct exhaust gases forward to provide a deceleration force for ground braking. When stowed, the reversers fair into external airplane contours to form the aft portion of the nacelle. The thrust reverser doors are attached to the thrust reverser body, which bolts to the aft end of the engine case. The faired reverser doors seal sufficiently to control and direct the escape of the high-pressure exhaust gasses. The reverser system is designed for two-position operation: stowed during takeoff and flight and deployed during landing ground roll. The position of the thrust reversers is indicated to the pilots on the Engine Indicating and Crew Alert System (EICAS) display unit immediately above the N_1 indication for the respective engine. The reversers are activated by pilot operation of the thrust reverser throttle levers and deployed using hydraulic pressure supplied by the engine-driven pump and directed to the drive actuators through the electrically operated thrust reverser control valves. Each reverser uses two hydraulic actuators connected by pushrods to the reverser door. The hydraulic actuators are located on the left and right sides of the thrust reverser. The aft end of the thrust reverser door is attached to a fixed hinge. As the hydraulic rams move aft, pushrods open the doors to the full-deployed position. As the hydraulic rams move forward, the pushrods pull the doors into the stowed position.

NORMAL OPERATION

Control of the individual thrust reverser is through a reverse thrust lever mounted on each of the engine throttles (thrust levers). The reverser thrust levers can only deploy the reversers when the primary throttle (thrust lever) is in the idle thrust position and the airplane is on the ground as sensed by the weight-on-wheels switches. The reverse thrust levers also control engine thrust during reverse thrust operation.

NOTE

- If at any time during the deploy sequence or stow sequence the T/R EICAS indications flash reverse video (black on amber background), an erroneous input to the thrust reverser control unit (TRCU) has occurred. This condition requires maintenance.
- To ensure of actuation of the squat switches and to eliminate any delay in the deployment of the thrust reversers, it is recommended that the speed brakes be extended immediately following touchdown.
- The deploy sequence should be complete within 1.5 seconds from unlock to deploy.
- When stowing the thrust reversers, the main throttles should not be advanced from idle until the thrust reversers are stowed as indicated by the "UNLK" message clearing.

The thrust reversers are not to be used during touch-and-go landings. A full stop landing must be made once reverse thrust has been selected. Even on a slick runway, less distance is required to stop once the reversers have been deployed, than is required to stow the reversers and takeoff.

Moving the reverse thrust lever from the STOWED to the DEPLOY position actuates the deploy cycle. This supplies power through the TRCU logic modules to open the thrust reverser isolation valve, which allows hydraulic pressure to reach the T/R hydraulic control valve (HCV). A pressure switch is located immediately downstream of the isolation valve. When this pressure switch senses hydraulic pressure, it causes the amber T/R "ARM" message on the EICAS to display. Signals from the thrust reverser logic modules will cause the T/R HCV to direct hydraulic pressure to the latch actuator causing the latches to begin to retract. The initial retraction of each latch will activate its respective T/R lock switch (S1, S2, S6, and S7). When any two of the four lock switches indicate unlock, the T/R "ARM" message will be replaced by the T/R "UNLK" message on the EICAS display. Signals from the thrust reverser logic modules also causes the T/R HCV to direct hydraulic pressure to the stow side of the actuators causing the actuator ram to retract slightly. This draws the thrust reverser doors into the overstow position and allows the door latches to unlatch and release the doors. Once the latches have retracted and both latch switches (S3 and S5) are activated, the thrust reverser logic module will cause the T/R control valve to pressurize the deploy side of the actuator and the T/R doors will move to the fully deployed position. With the thrust reversers in the fully deployed position, a barb on the actuator ram will activate the deploy switch (S4) and will cause the green T/R "DPLY" message to replace the T/R "UNLK" message and energize the pedestal-mounted T/R throttle lockout solenoid allowing the T/R throttle levers to control the thrust of the engine. The purpose of the lockout solenoid is to prevent the pilot from increasing engine thrust until the reversers have fully deployed. Do not attempt to advance the throttles before the T/R "DPLY" message appears.

After deployment, moving the thrust reverser throttle levers aft increases power for maximum reverse thrust. The FADEC system will govern the maximum reverse thrust according to the amount of thrust called for by the reverser lever angle, up to a percentage of takeoff power, which is determined by preset stops in the throttle quadrant. This allows the pilot to keep attention on the landing rollout instead of diverting attention to the reverser power settings. Single-engine reversing has been demonstrated during normal landings and is controllable. Reverse thrust should be brought to idle at 65 KIAS. For increased aerodynamic drag during landing rollout, it is suggested that the thrust reversers remain in the deployed position after reverse thrust power has been terminated at 65 KIAS. Use of reverse thrust power below 65 KIAS is not recommended due to the possibility of foreign object damage caused by ingestion of debris from the runway.

To stow the thrust reversers, move the reverse thrust lever through the idle reverse detent to the stow position. This will remove the deploy signal to the TRCU and cause the TRCU to start the stow sequence. The TRCU will signal the T/R HCV to remove hydraulic pressure from the latch actuators and internal springs in the latches will cause the latch to rotate against the T/R door leaf springs. The logic module will also signal the T/R control valve to apply hydraulic pressure to the stow side of the actuators. The T/R doors reach the overstow position and the green "DPLY" message will be replaced by the amber "UNLK" message. After the T/R doors reach the overstow position, the latches will rotate to the fully latched position deactivating the latch and lock switches. The amber "UNLK" message will be replaced by the amber "ARM" message. The TRCU will then close the T/R HCV and isolation valve allowing the doors to move to the fully closed position and the amber "ARM" message to extinguish. The throttle levers can then be advanced to control forward thrust as needed.

EMERGENCY STOW OPERATION

In the event of an inadvertent thrust reverser deployment, there is an automatic electronic power reduction circuit, activated by the thrust reverser deploy switch. It will send a signal to the FADEC, which will bring the engine power to idle, but the throttle lever position will remain the same. In the event of a system failure that causes the FADEC to bring the engine back to idle power with no other indications of the T/R deployment, thrust control can be restored by bringing the throttle back to IDLE. This will override the FADEC logic to bring the thrust to idle during a T/R deployment and the thrust can be controlled with throttle movement.

An emergency stow switch for each thrust reverser, located on the cockpit pedestal immediately behind the throttle levers labeled "EMER STOW", will apply power to open the T/R isolation valve and cause the T/R HCV to apply hydraulic pressure to the stow side actuator. This will hold the T/R in the overstow position in the event of a T/R system malfunction. The emergency stow function can be checked on the ground by deploying the reversers normally and then actuating each emergency stow switch. The "ARM" messages remain illuminated. Return the thrust reverser lever to the stow position, then turn each emergency stow switch off. The "ARM" messages will extinguish.

During in-flight operation, the amber MASTER CAUTION light and amber T/R ARM L-R CAS message will alert the crew to the presence of pressure downstream of the T/R HCV's isolation valve. The respective "ARM" message above the N_1 indicator will also appear as black letters on an amber background.

If any two lock switches are showing unlock during in-flight operations, the red T/R emergency stow switches will start flashing, the MASTER WARNING will flash and the amber T/R UNLOCK L-R CAS message will display. The "UNLK" message above the respective N_1 indicator will also appear as black letters on an amber background. Pressing the T/R emergency stow switch will activate the emergency stow system and power the T/R into overstow position. The T/R EMER STOW switch will change to a steady red light and the amber T/R ARM L-R CAS message will appear.

NOTE

Pressing the T/R EMER STOW switch while it is a steady red light will deactivate the emergency stow system.

FIRE PROTECTION

The Fire Detection/Warning/Extinguishing systems provide identification of fire in the engine or APU or smoke in the tailcone baggage compartment of the airplane. It also provides extinguishing capabilities for the engines, APU, and tailcone baggage compartment. There are two fire detection sensors on each engine, one sensor for the APU, and two smoke detectors in the tailcone baggage compartment. The engine fire sensors provide a signal that will produce a warning in the form of an aural announcement, a LH or RH ENG FIRE annunciation top center of the cockpit instrument panel, and warning displays on the EICAS. Two engine fire bottles provide extinguishing materials that can be used on either engine and two baggage compartment fire bottles are installed for use in the event of a tailcone baggage fire.

ENGINE FIRE SYSTEM

In the event of an engine fire, the EICAS will display the ENGINE FIRE L and/or ENGINE FIRE R warning message. The red MASTER WARNING lights will illuminate and an aural "LEFT ENGINE FIRE" and/or "RIGHT ENGINE\FIRE" announcement will also be heard. The fire detection module, located in the L or R Aft J-Box, will illuminate the L ENGINE FIRE PUSH and/or R ENGINE FIRE PUSH annunciator switch located at the top center instrument panel. Pushing the L or R ENGINE FIRE PUSH annunciator switch will illuminate the BOTT 1 and BOTT 2 ARMED PUSH annunciator switches. The engine fire bottles will then be armed for use in engine fire extinguishing. Either bottle may be discharged to the selected engine by pushing the BOTT 1 or BOTT2 ARMED PUSH annunciator switch. In the event an engine fire indication still exists, the remaining engine fire bottle may be utilized.

TAILCONE BAGGAGE COMPARTMENT FIRE SYSTEM

The baggage compartment smoke detection system indicates a presence of smoke in the tailcone baggage compartment. Multiple warnings and provisions are provided to extinguish a tailcone baggage compartment fire. Two smoke detectors located forward and aft, are installed in the tailcone baggage compartment. Once a baggage compartment fire condition is detected, a red BAGGAGE FIRE annunciation is displayed on the EICAS, the aural "BAGGAGE FIRE" warning is heard, the red BAG FIRE PUSH annunciator switch (located on the right instrument panel) and the red MASTER WARNING light will illuminate. The baggage heat shutoff valve will close. If the baggage heat shutoff valve fails to close the EICAS will display the amber BAGGAGE HEAT SHUTOFF FAIL annunciation.

When the BAG FIRE PUSH annunciator switch is pressed, both baggage compartment fire bottles will discharge. The pressure of both baggage compartment fire bottles is monitored. Upon a low bottle pressure condition, the EICAS will display the BAG/APU FIRE BOTTLE LOW message.

FIRE DETECTION INDICATING LIGHTS

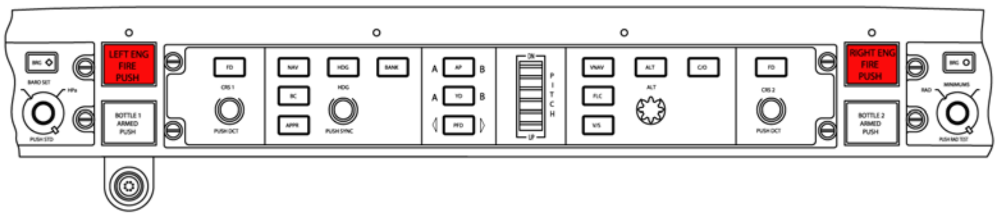

Figure 2-5

ENGINE FIRE EXTINGUISHING SYSTEM

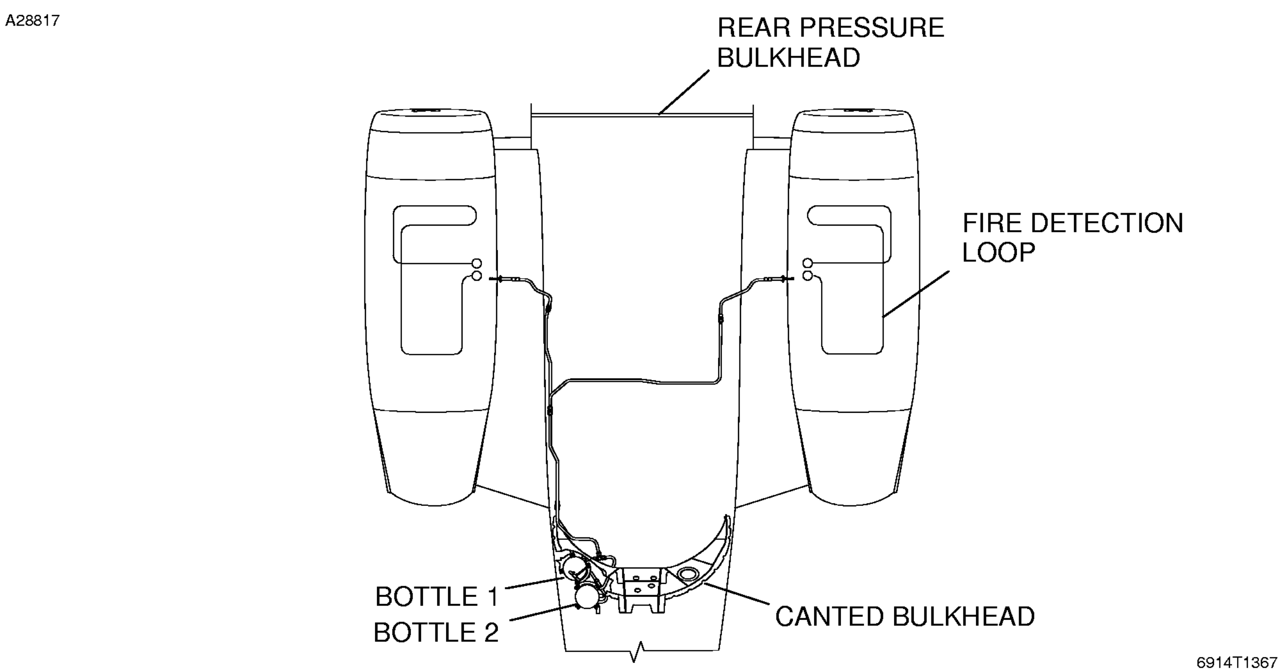

Figure 2-6