

A330-200
TECHNICAL TRAINING MANUAL
MECHANICS / ELECTRICS & AVIONICS COURSE
70 CF680-E1 ENGINE
GE Metric

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FULL AUTHORITY DIGITAL ENG CTL (FADEC)

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GENERAL

Engine Characteristics
Pylon
Nacelle
Engine Control

ENGINE CHARACTERISTICS

The Airbus A330 is powered by two General Electric CF6-80E1 engines developing a take-off thrust of up to 70,000 Lbs (31500 kgs).

The engines are flat rated up to ISA + 15°C.

PYLON

The engines are attached to the lower surface of the wings by pylons.

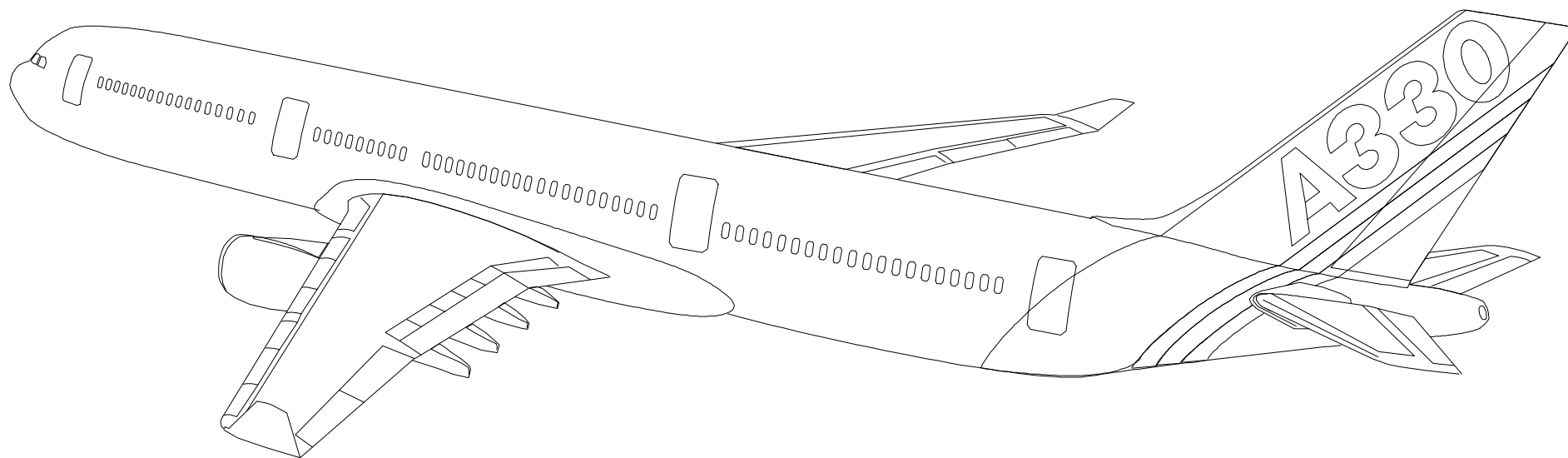
The pylons provide an interface between the engine and the aircraft for electrics and fluids.

NACELLE

The engine is enclosed in a nacelle which provides aerodynamic airflow around the engine and ensures protection for the accessories.

ENGINE CONTROL

The engine includes a Full Authority Digital Engine Control (FADEC) which provides engine control, engine monitoring and provides help for maintenance and trouble shooting on the engine.



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STUDENT NOTES:

POWER PLANT PRESENTATION

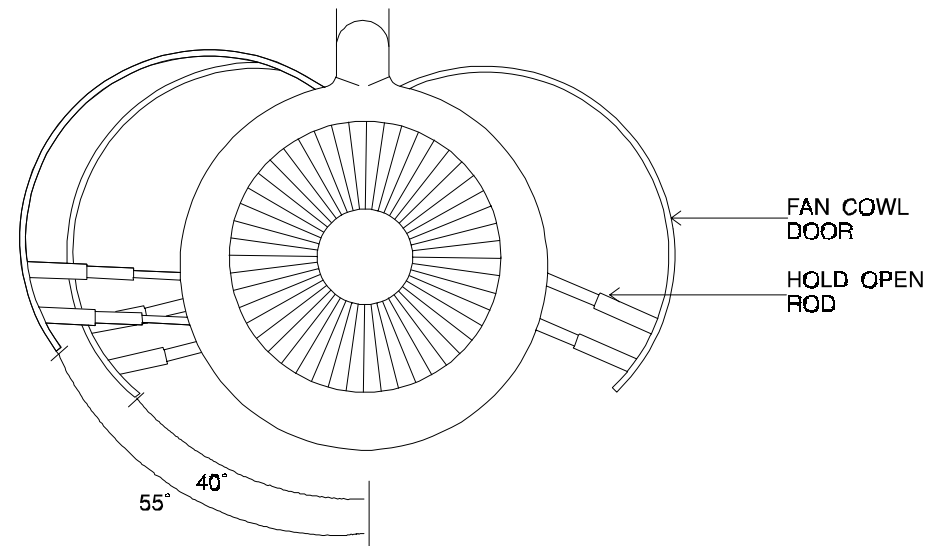
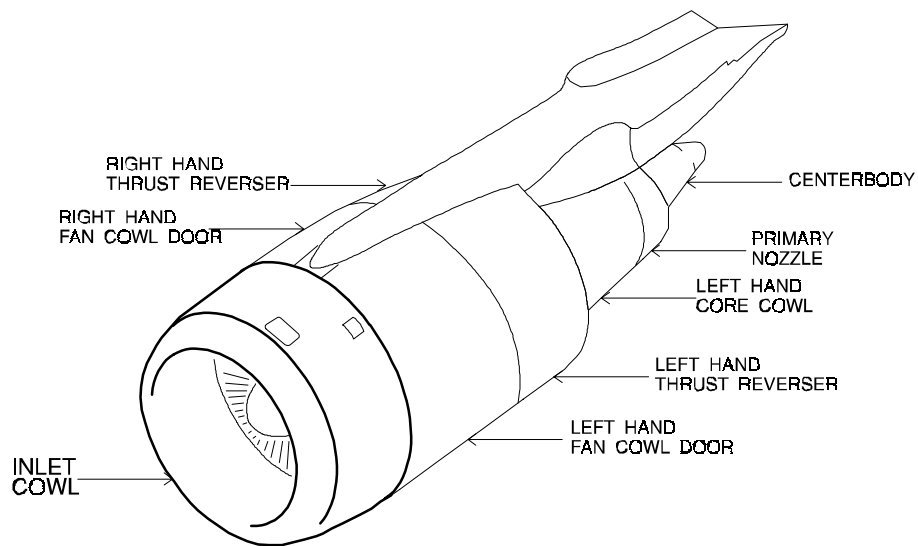
Inlet Cowl
Fan Cowl Doors
Thrust Reverser Doors
Core Cowl Doors
Exhaust
Access Panels
Engine Mounts

INLET COWL

The inlet cowl is a fixed structure which ensures proper engine inlet airflow for the whole envelope.
The air inlet is anti-iced.

FAN COWL DOORS

The fan cowl doors allow access to the fan case mounted accessories.
They are latched at their bottom center line and when opened maintained by two hold open rods.
The fan cowl doors may not be opened when the wind speed is above TBD knots.



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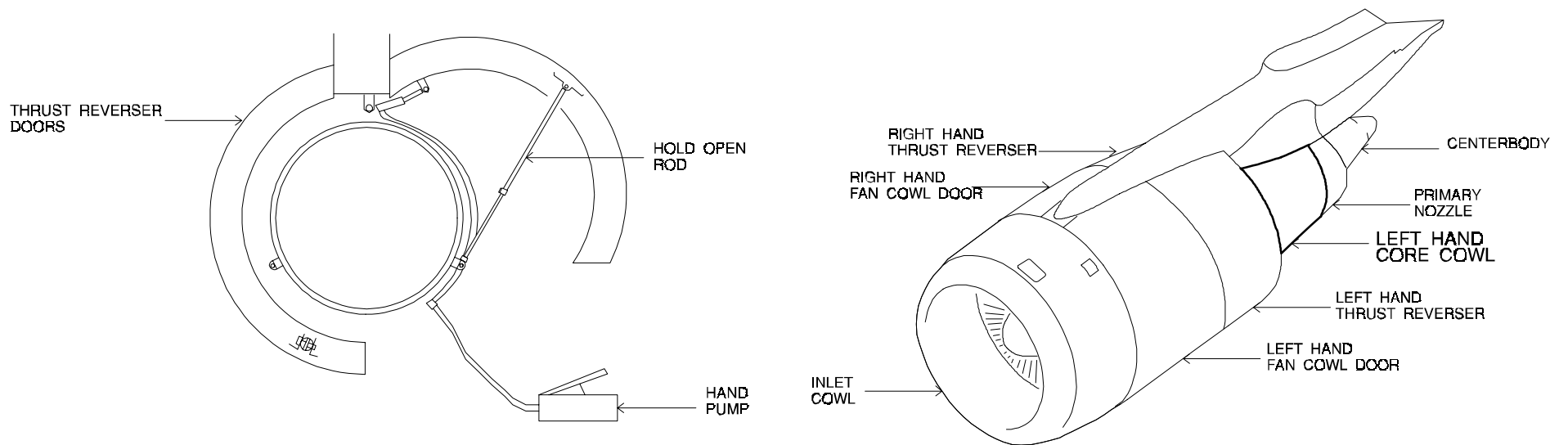
THRUST REVERSER DOORS

The thrust reversers provide ducting for fan air exhaust.
The thrust reverser doors may be opened to get access to the core engine mounted accessories.

The thrust reverser doors are maintained open by a hold open rod.
Due to their weight, the thrust reverser doors are operated by an hydraulic actuator using a manual hand pump.

CORE COWL DOORS

When opened the core cowl doors allow access to the turbine section area.
The core cowl doors are maintained open by two hold open rods.



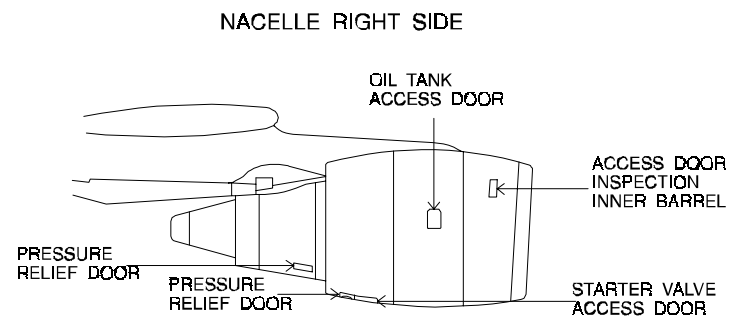
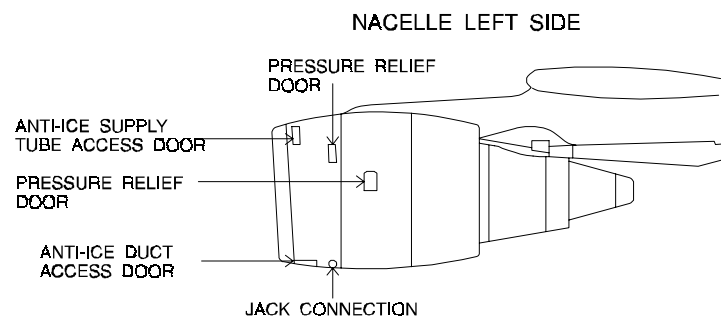
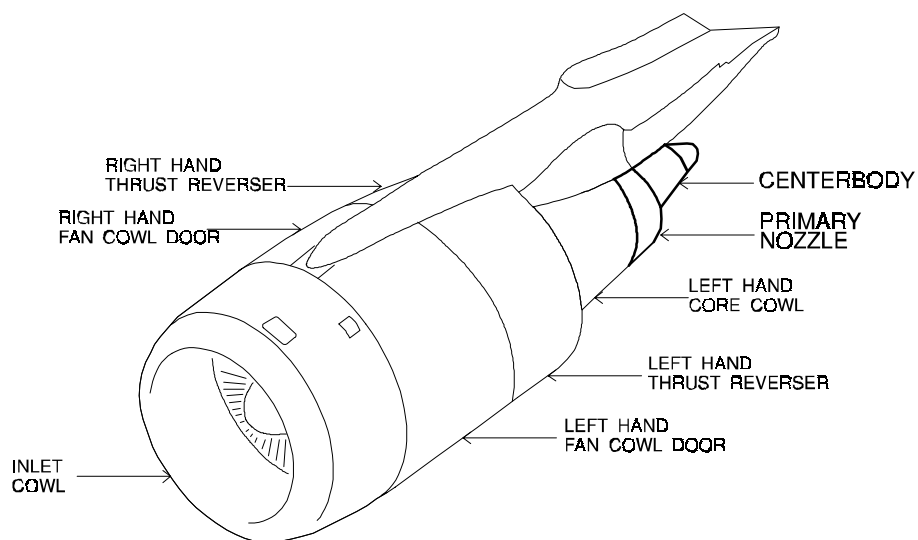
EXHAUST

The fixed exhaust directs rearward engine core exhaust and provides noise reduction.

The exhaust is composed of the primary nozzle and the centerbody.

ACCESS PANELS

For quick servicing the nacelle is equipped with access panels and inspection doors.



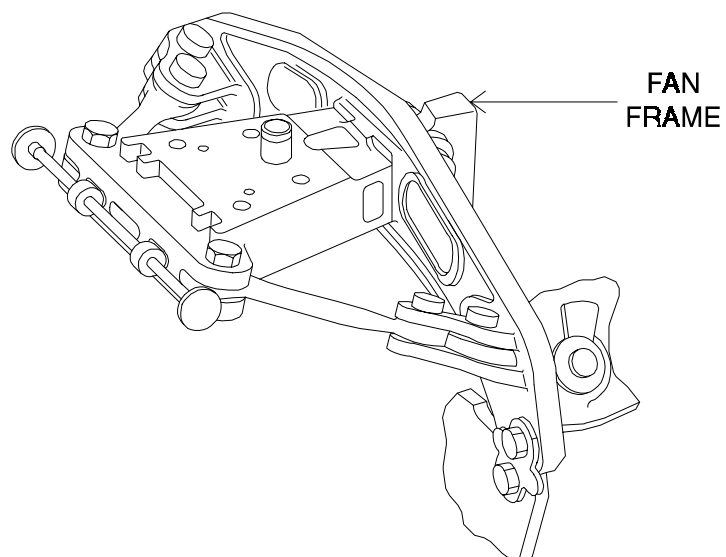
ENGINE MOUNTS

The engine is attached to the pylon by two mounts.

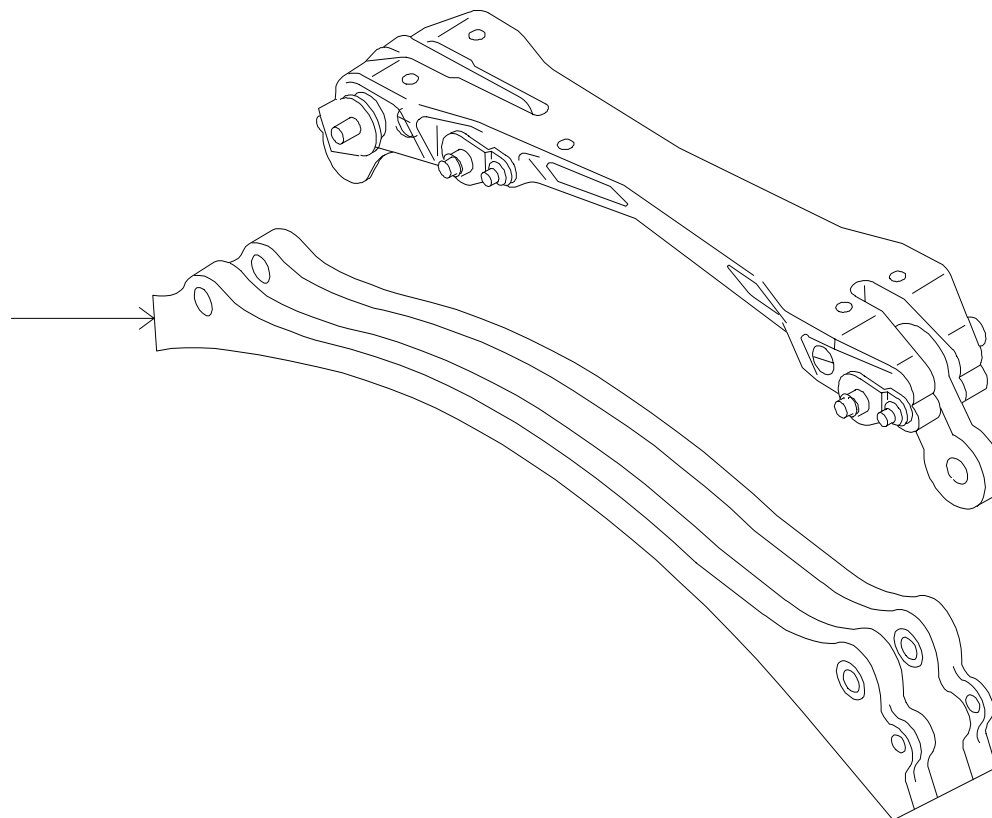
The forward mount or thrust mount transmits the efforts in all directions, the aft mount transmits the efforts in all directions except forward and aft to allow engine thermal expansion.

FORWARD MOUNT

AFT MOUNT



ENGINE
FLANGES



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STUDENT NOTES:

DRAIN SYSTEM PRESENTATION

General
Pylon Drains
Mountings Pads
Engine Drains
Drain Mast

GENERAL

The engine drain system is of dynamic design. The drain system drains directly overboard any fluid coming from double walled connectors or drive pads.

PYLON DRAINS

A drain line removes any leak in the pylon, another line drains the fluid junction box.

A specific line drains the oil tank scupper below the oil tank in the cowl.

MOUNTINGS PADS

The following gearbox mounted accessory pads are connected to the drain mast :

Starter,
Hydromechanical Unit (HMU),
fuel pump,
hydraulic pumps and Integrated Drive Generator (IDG).

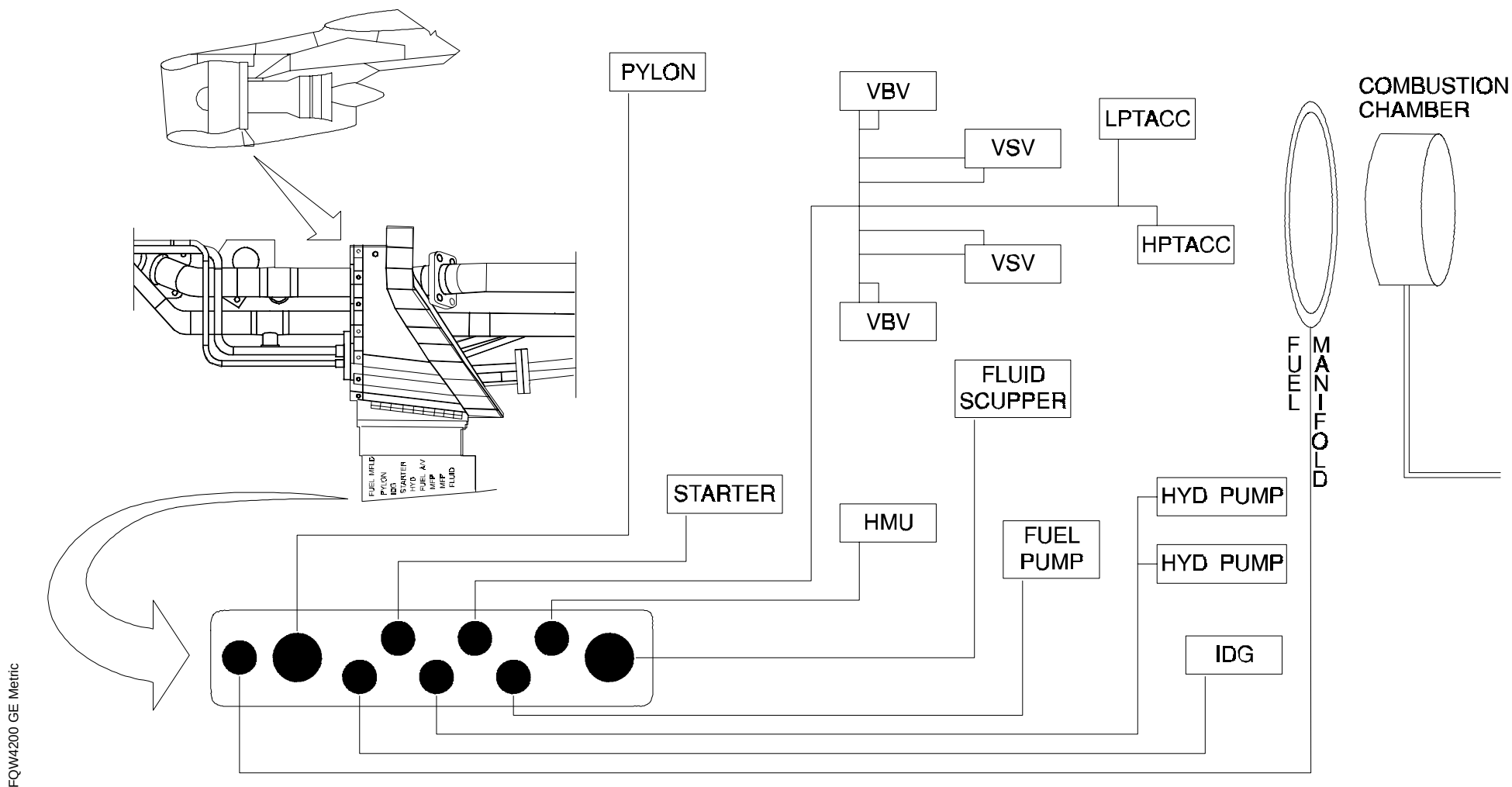
ENGINE DRAINS

All the fuel connections are double walled and drained overboard.

A specific line drains the combustion chamber aft of the core cowl.

DRAIN MAST

To help trouble shooting, the drain incoming lines are labelled.



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STUDENT NOTES:

INSTALLATION COMPONENTS

Inlet Cowl
Fan Cowl doors
Thrust Reverser Cowl doors
Core Cowl doors
Primary Nozzle
Centerbody
Forward Mount
Aft Mount
Drain Mast

SAFETY PRECAUTIONS

- Do not start the engine.
- Make sure that the engine has been shut down for at least 5 min.
- Make sure that the ENG FADEC GND PWR pushbutton is OFF.
- Make sure that the ENG MASTER switch is in the OFF position.

STUDENT NOTES

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INLET COWL

FIN : 5000 EA.

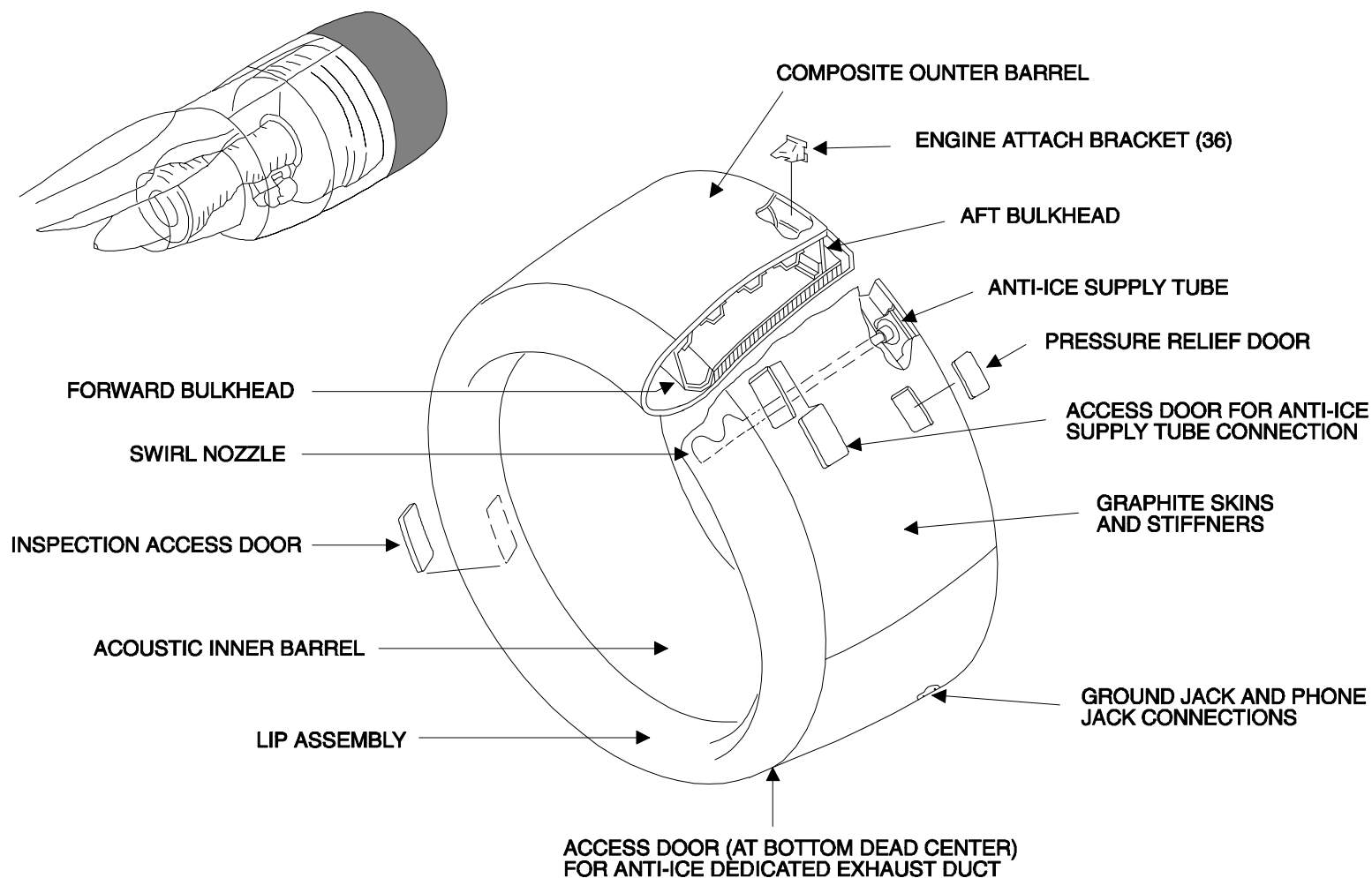
ZONE : 411 - 421.

COMPONENT DESCRIPTION :

The outer barrel of the air intake cowl is a composite sandwich-frame construction. The lip assembly consists of an outer skin and bulkhead. It is made of aluminum alloy. The inlet lip aft bulkhead is made of titanium sheet metal.

REMOVAL INSTALLATION :

Four hoist pins, for ground support equipment (GSE), are provided on the top portion of the air intake cowl. The air intake cowl can be removed with the engine installed on the aircraft or with the engine during engine removal.



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FAN COWL DOORS

FIN : 5110 EA COWL DOOR - FAN,R

5120 EA COWL DOOR - FAN,L

ZONE : 415 - 425

416 - 426.

COMPONENT DESCRIPTION :

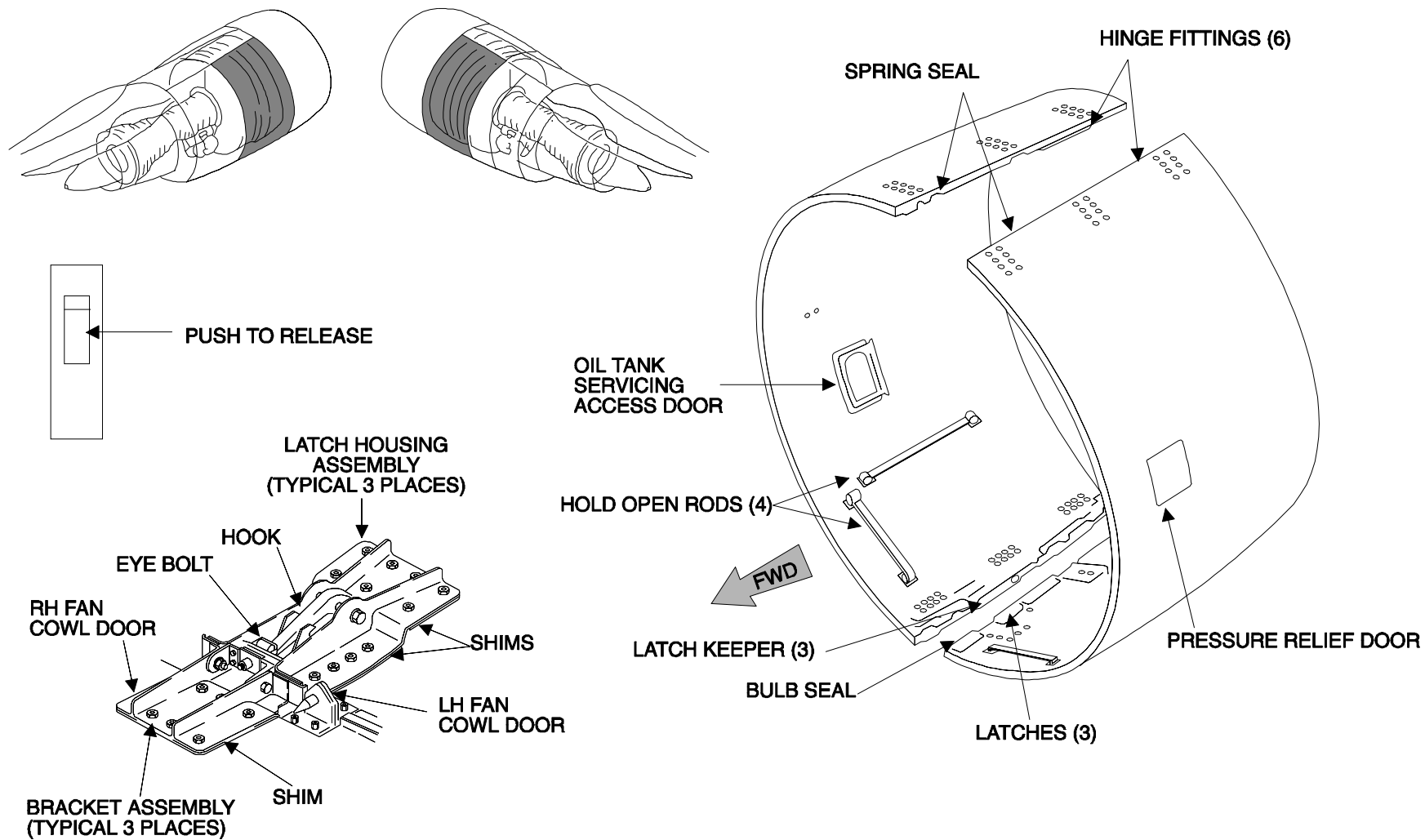
The fan cowl door assemblies are engine to engine interchangeable units enclosing the engine fan case between the air intake cowl and thrust reverser cowl doors. Each assembly is supported by three hinges at the pylon and latched along the bottom split line with three tension hook latches.

LATCHES :

Three hook latches are provided on the left hand fan cowl, and mate with three latch keepers the right hand door.

REMOVAL INSTALLATION :

Three hoisting points are provided on the top portion of the fan cowl door for ground support equipment (GSE) installation.



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THRUST REVERSER COWL DOORS

FIN : 4120KS Thrust Reverser Cowl door right,

4130KS Thrust Reverser Cowl door left.

ZONE : 417 - 427

418 - 428.

COMPONENT DESCRIPTION :

The thrust reverser cowl doors are composed of various metallic and non metallic materials. Opening of the thrust reverser cowl doors will provide access to the accessory gearbox.

Each cowl door assembly includes a fixed structure and a translating cowl.

ACCESS DOOR :

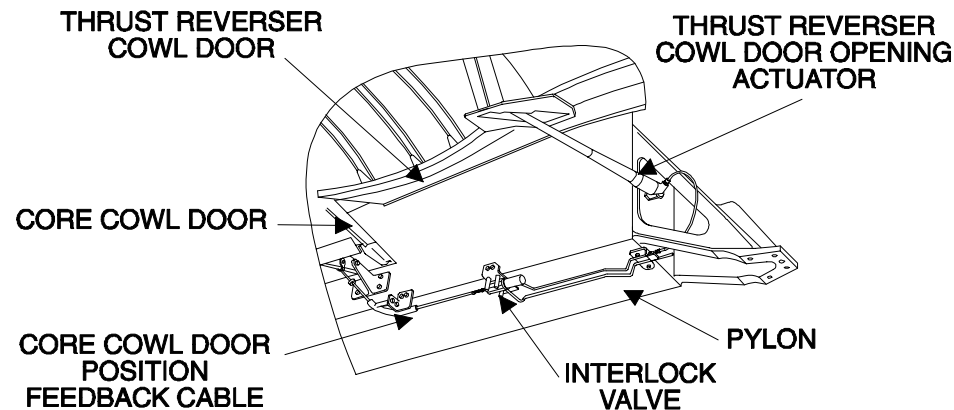
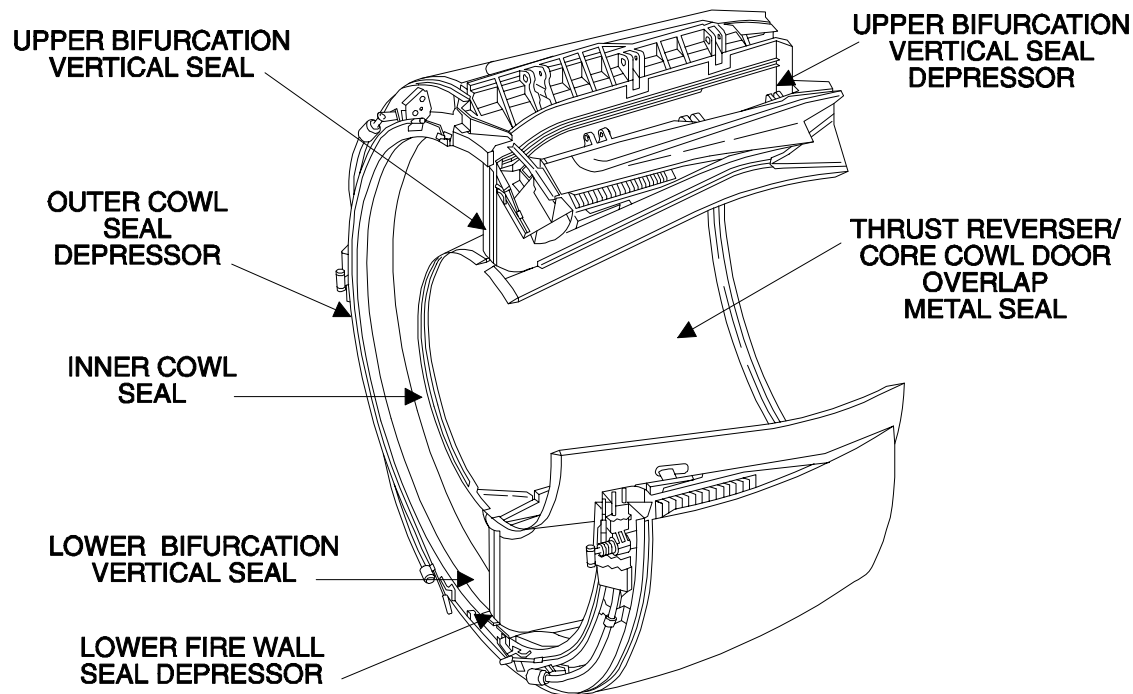
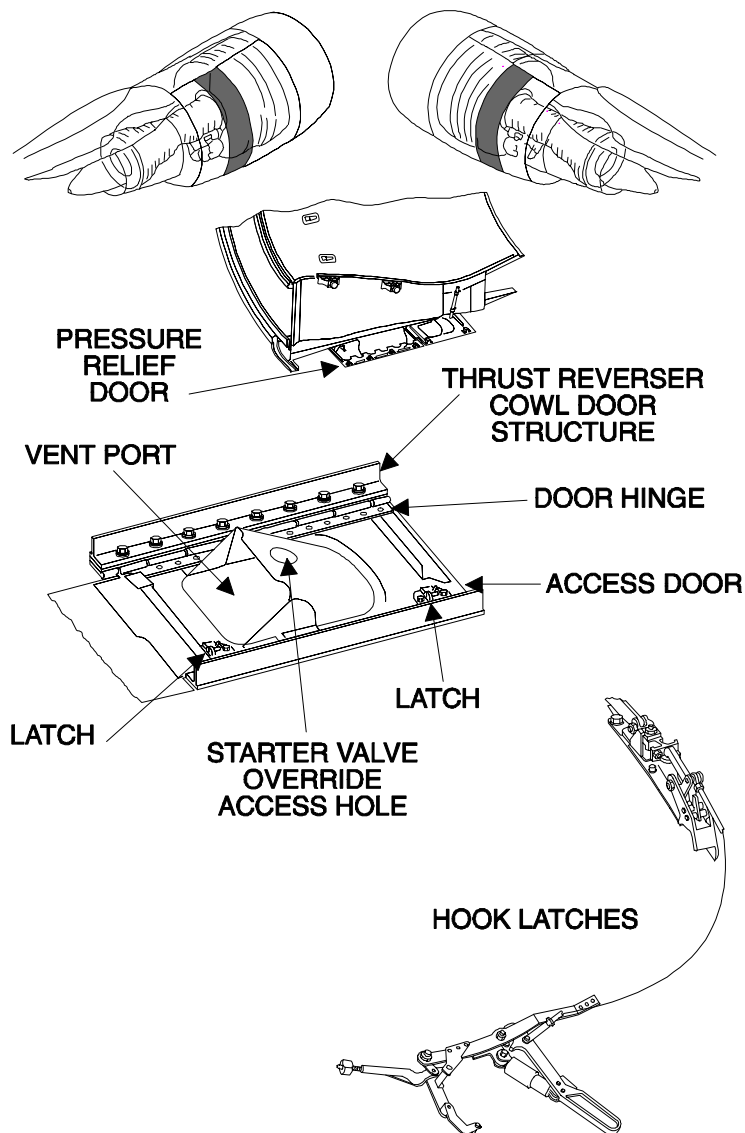
The access and pressure relief door assembly provides access to the starter valve and the thrust reverser cowl door lower Splitline latches. Access through the thrust reverser left hand side inner wall provides access to the IDG reset handle, the IDG oil reservoir (pressure fill and quantity check) and the hydraulic filter bypass indicator.

HOOK LATCHES :

Each thrust reverser cowl door is attached to the engine by the inner and outer engine rings ; the outer engine ring being latched to the aft fan case by upper and lower tension hook latches.

INTERLOCK VALVE :

An interlock system is provided to prevent the thrust reverser cowl doors from closing when the core cowl doors are open.



CORE COWL DOORS

FIN : 5410 EA Core cowl door right,

5420 EA Core cowl door left.

ZONE : 410 - 420.

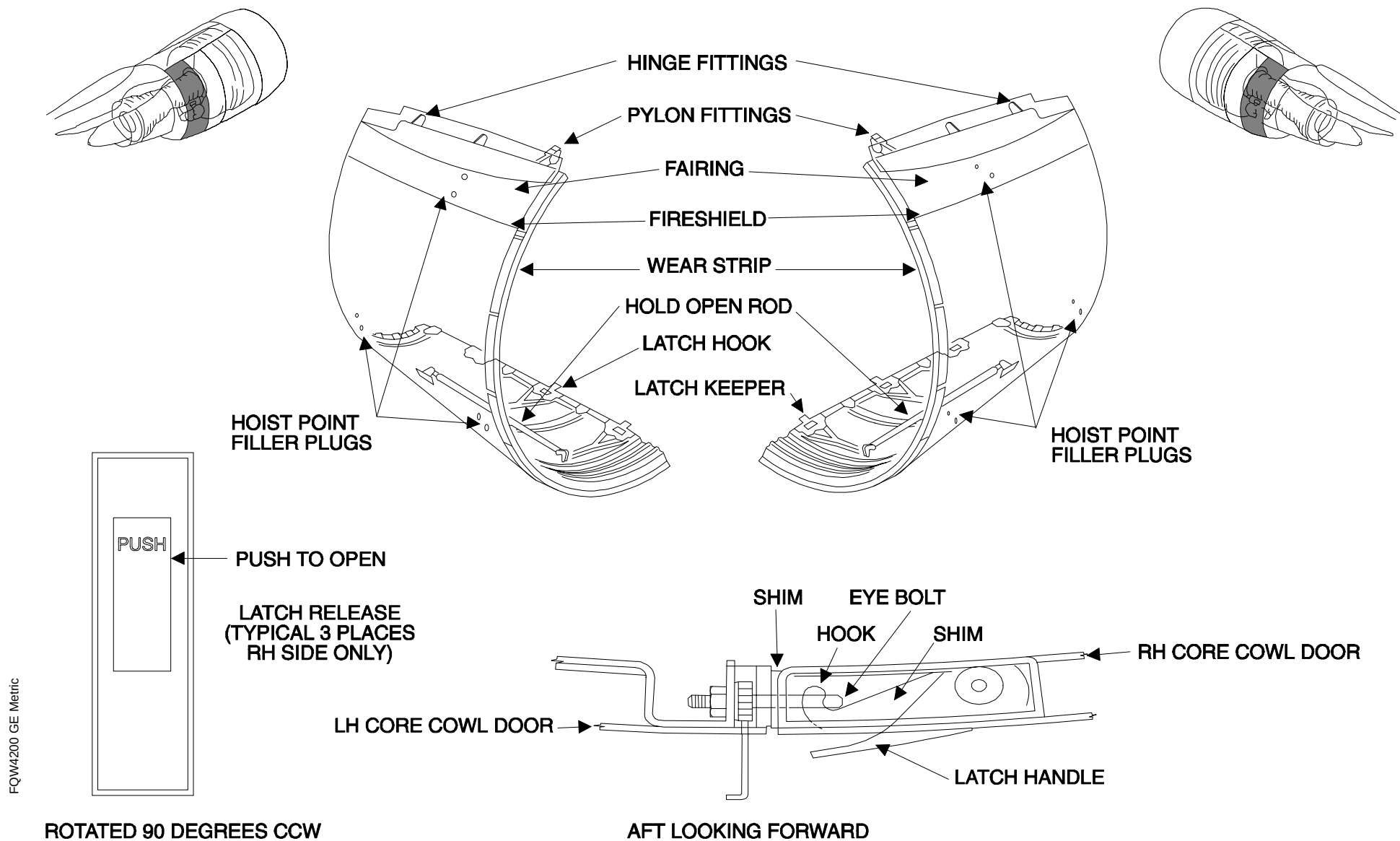
COMPONENT DESCRIPTION :

The core cowl doors are a conventional metal structure.

A hold open rod supports each core cowl door in the open position.

CORE COWL LATCHES :

Three hook type latches are provided on the right hand core cowl door and mate with three latches keepers on the left hand core cowl door.



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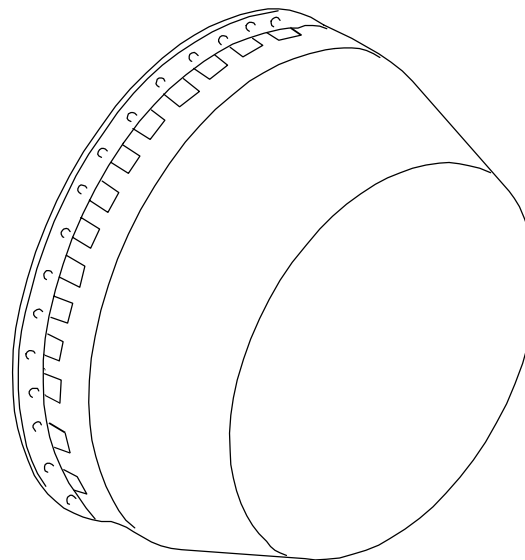
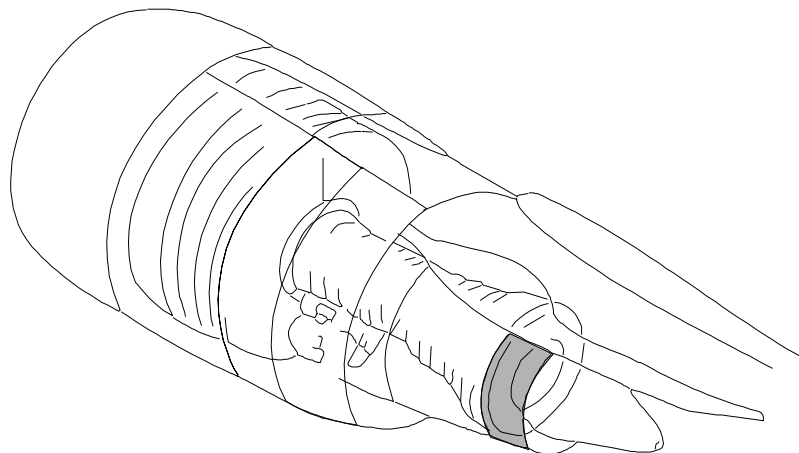
PRIMARY NOZZLE

FIN : 5120 EG.

ZONE : 414 - 424.

COMPONENT DESCRIPTION :

The primary nozzle provides a fixed area annular for exhausting the core engine gas stream flow and provides a continuation of the aerodynamic cowl from the core cowl interface.



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CENTERBODY

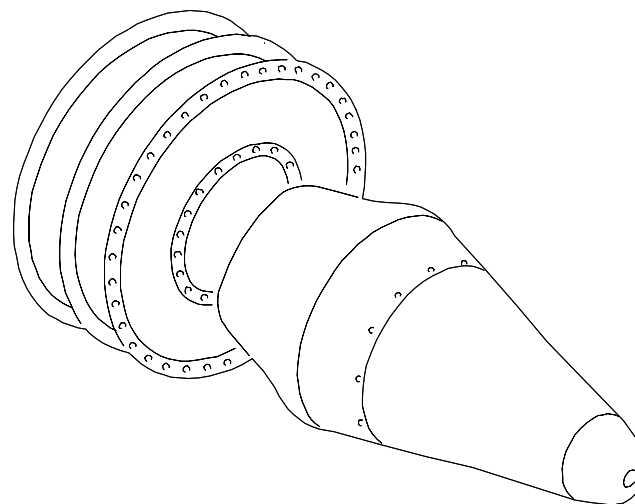
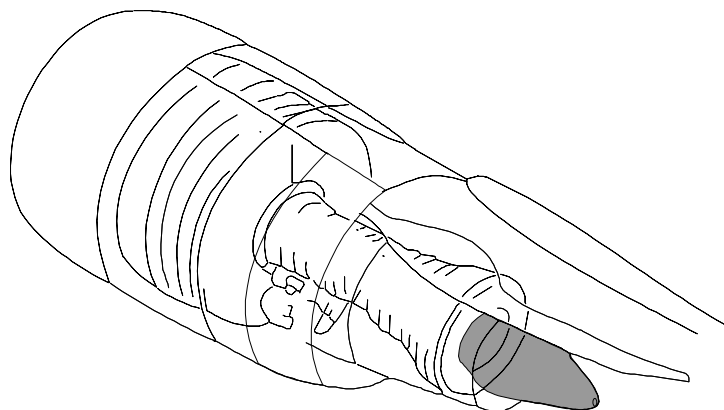
FIN : 5110 EG1 Forward Centerbody,

5110 EG2 Aft Centerbody

ZONE : 414 - 424.

COMPONENT DESCRIPTION :

The two piece centerbody plug is composed of a forward flange for attachment to the engine turbine rear frame hub flange, the forward sheet metal formed section is attached to an aft sheet metal formed section. The aft centerbody section has a truncated open aft end for the engine center vent system.



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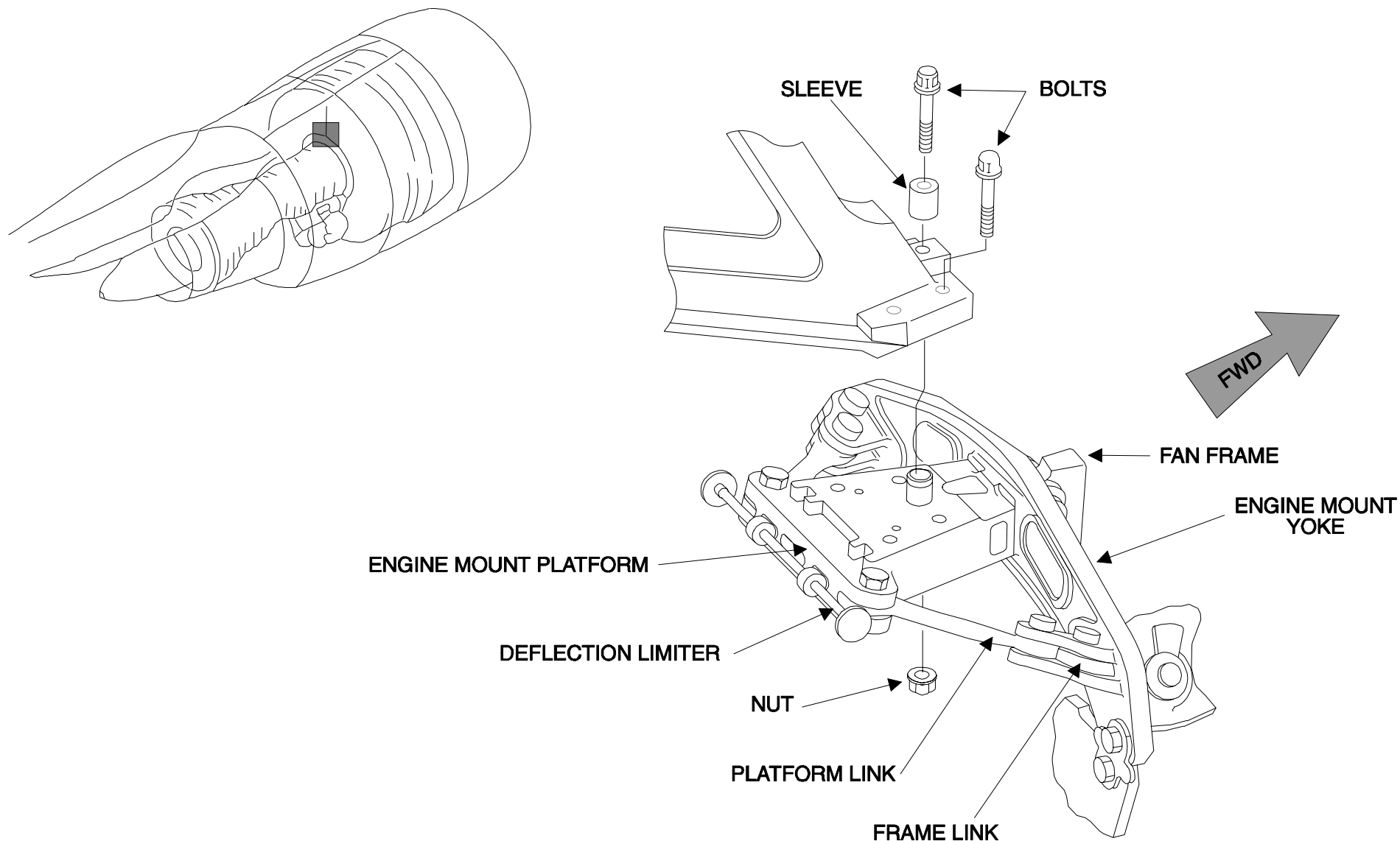
FORWARD MOUNT

FIN : 5300 EA.

ZONE : 451 - 461.

COMPONENT DESCRIPTION :

The forward mount is composed of a major yoke which is joined by thrust links to the fan frame on the forward side and by thrust links to the mount platform on the aft side, and to the compressor forward flange by two vertical links.



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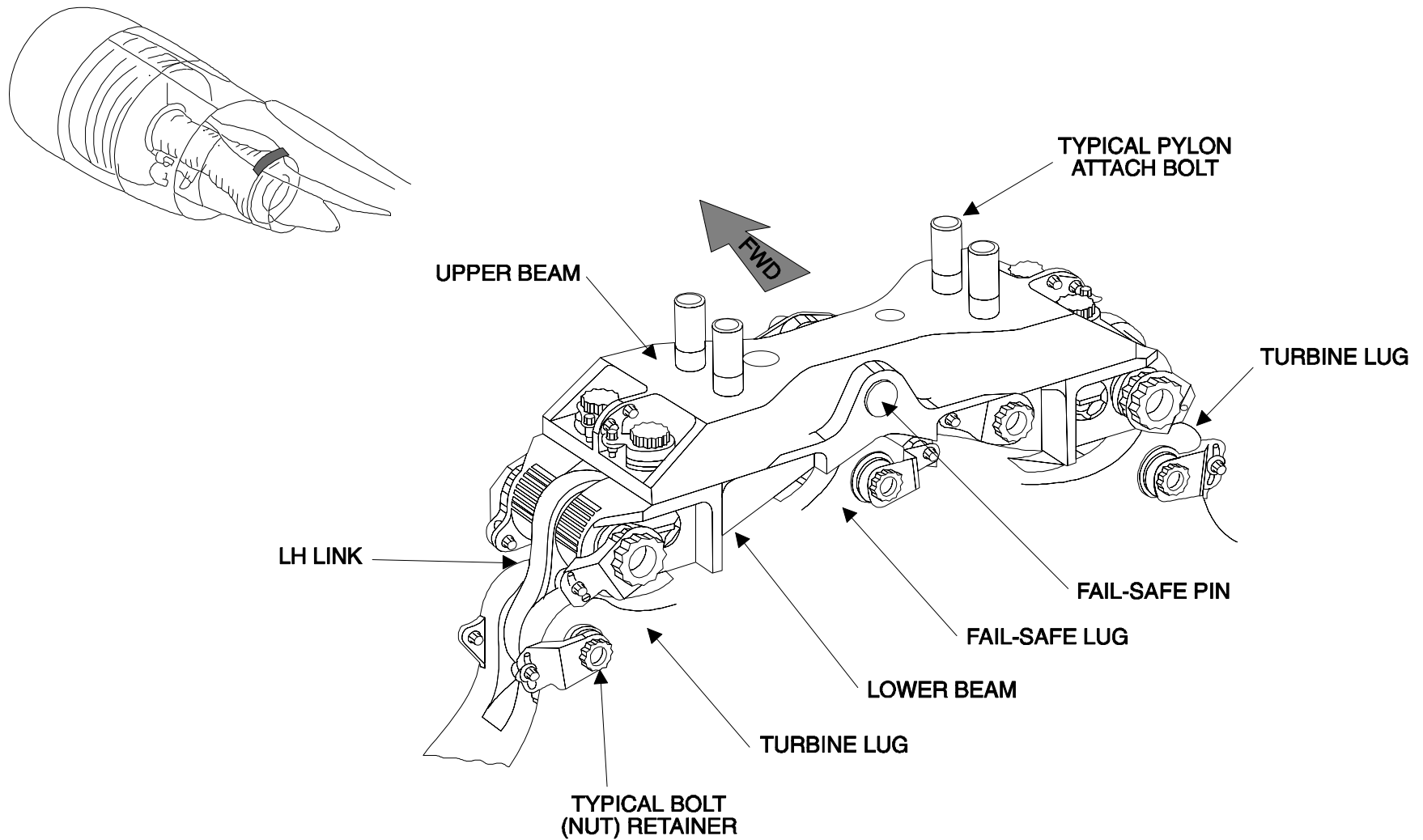
AFT MOUNT

FIN : 5350 EA.

ZONE : 450 - 460.

COMPONENT DESCRIPTION :

The Aft mount assembly consists of beams and links with swaged in spherical bearings on the ends. The lower mount beam is connected to the flange of the turbine rear frame by two links secured by bolts, washers and nuts, and a center fail-safe lug.



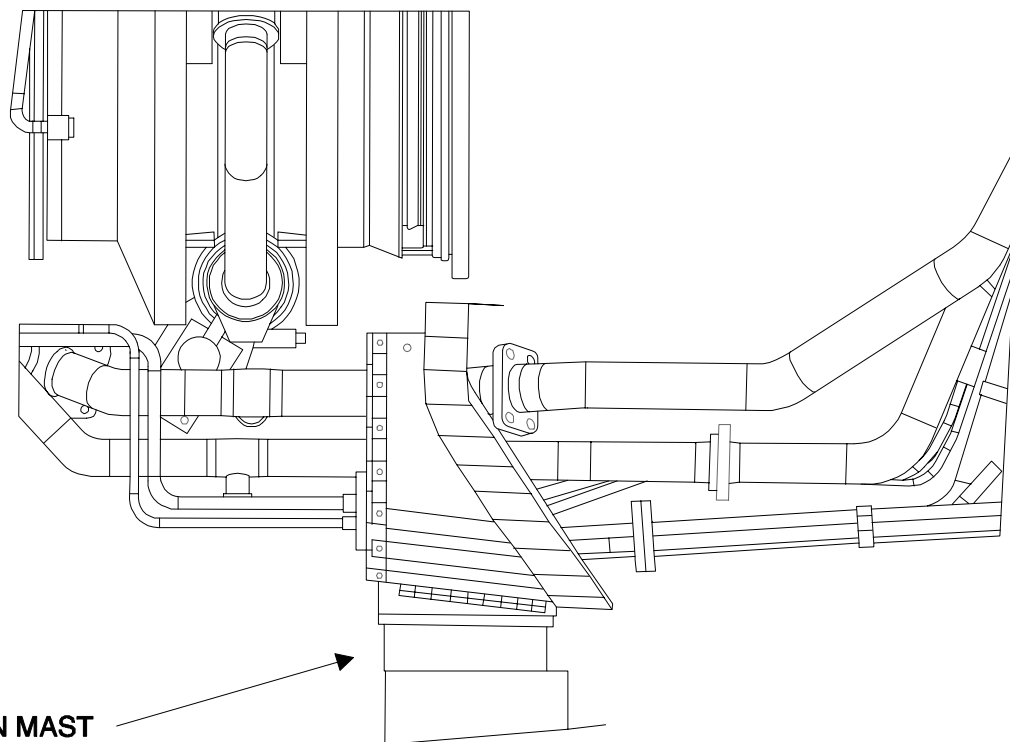
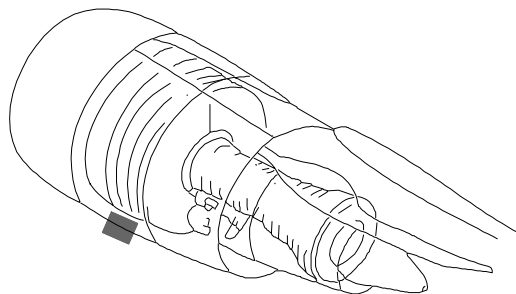
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DRAIN MAST

ZONE : 412 - 422.

COMPONENT DESCRIPTION :

The fuel drain system discharges through a drain mast. The drain mast has nine passages for routing the drained fluids overboard. Each passage is labelled with the identity of the drain source to which it is connected to aid in isolating the leak source.



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STUDENT NOTES

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ENGINE PRESENTATION

Dimension and Weight
Modular Design
Low Pressure Rotor
High Pressure Rotor
Combustion Chamber
Bearings Design
Accessory Drive
Accessory GearBox
Aerodynamic Stations

DIMENSION AND WEIGHT

The airbus A330 is powered by two General Electric CF6-80E1 engines.

Lenght : 288.89 inches

Diameter : 119.38 inches

Weight :

engine 10,850 lbs

nacelle 3,603 lbs

dry propulsion system 14,453 lbs.

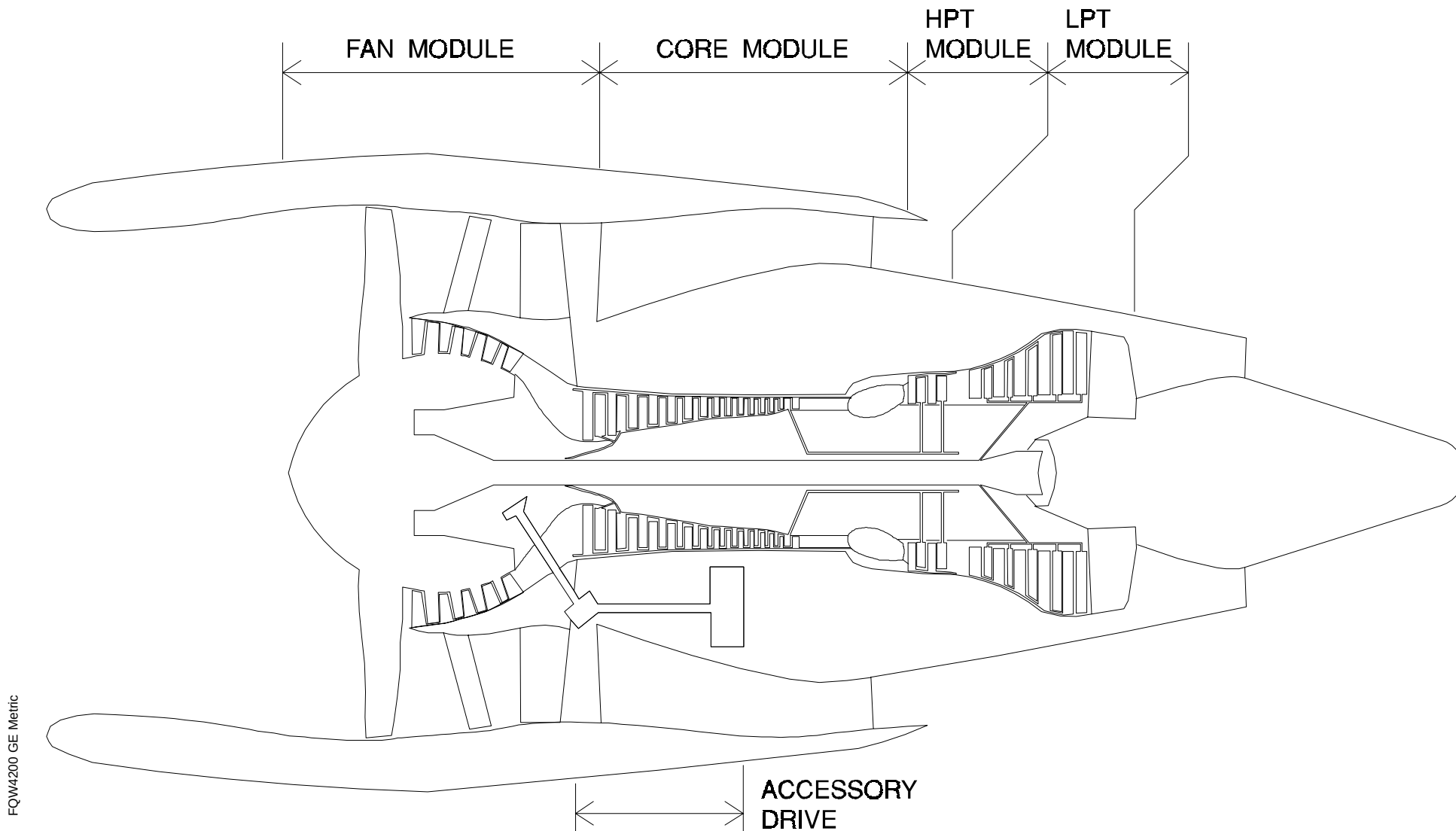
MODULAR DESIGN

The engine made of five primary modules, permits the changing of a module without completely disassembling the engine.

The modules are :

- High Pressure Turbine module
- Low Pressure Turbine module
- Accessory drive module

Modular design also allows engine split for transportation.



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LOW PRESSURE ROTOR

The low pressure rotor (N1), supported by three bearings, consists of a front fan and a four stage compressor driven by a five stage turbine.

Bearings :

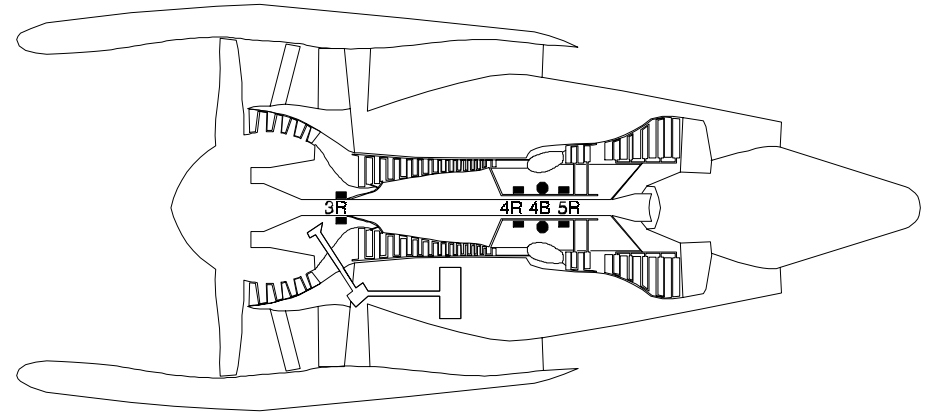
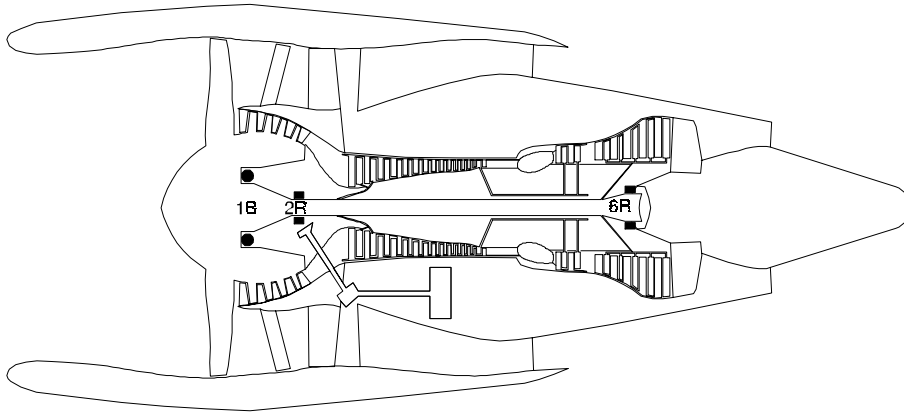
- 1B thrust ball bearing
- 2R roller bearing
- 6R roller bearing.

HIGH PRESSURE ROTOR

The high pressure rotor (N2), supported by four bearings, consists of a fourteen stage compressor driven by a dual stage turbine.

Bearings :

- 3R roller bearing
- 4R roller bearing
- 5R roller bearing
- 4B thrust ball bearing.



COMBUSTION CHAMBER

The combustion chamber is annular and fitted with thirty fuel nozzles and two igniters plugs.

BEARINGS DESIGN

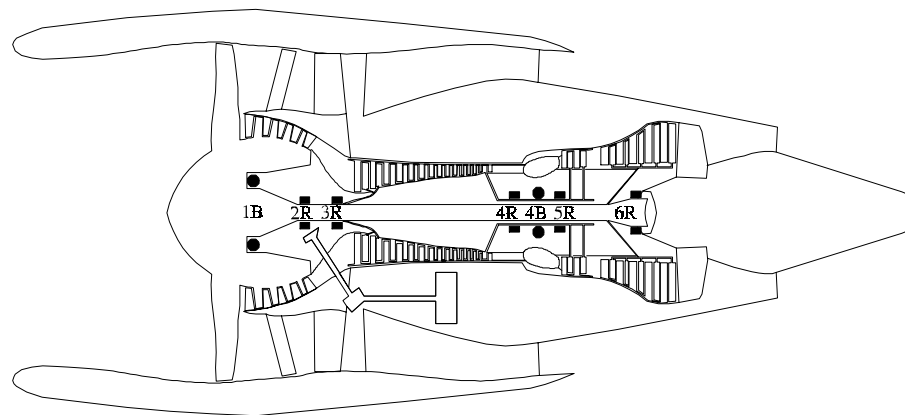
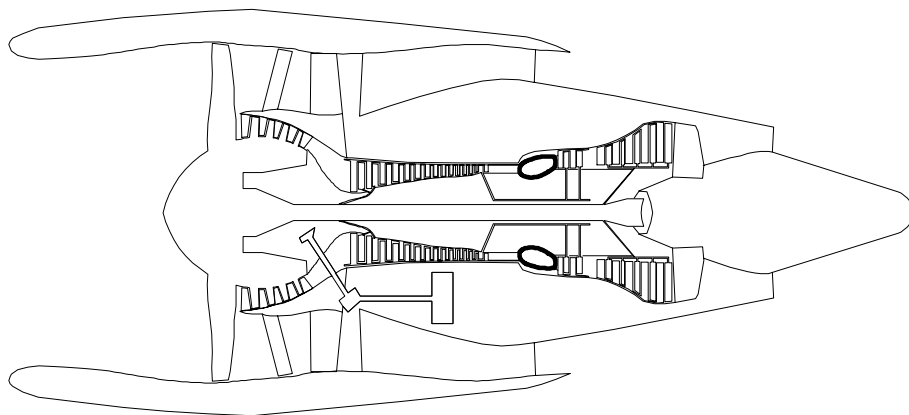
Each bearing is lubricated by pressurized oil which is scavenged in different areas called sumps.

Sump "A" includes bearings n° 1B, 2R and 3R bearings.

Sump "B" includes bearings n° 4R and 4B bearings.

Sump "C" includes bearing n° 5R bearing.

Sump "D" includes bearing n° 6R bearing.



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ACCESSORY DRIVE

The accessory gearbox, located at the bottom of the high pressure compressor case, receives torque from the HP rotor through a gear train.

The gear train consists of the inlet gearbox, radial drive shaft, transfer gearbox, horizontal drive shaft and accessory gearbox.

ACCESSORY GEAR BOX

The accessory gearbox is equipped with mounting pads to drive the accessories.

The accessory gearbox is equipped with mounting pads to drive the following accessories :

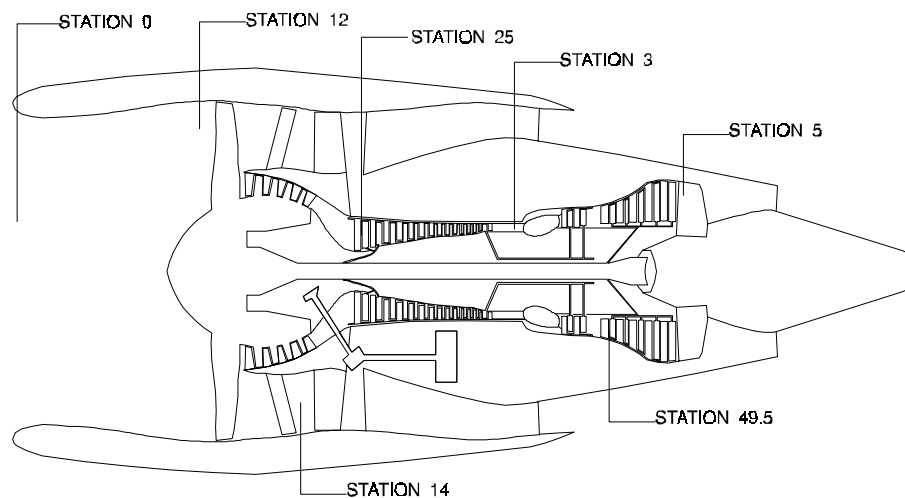
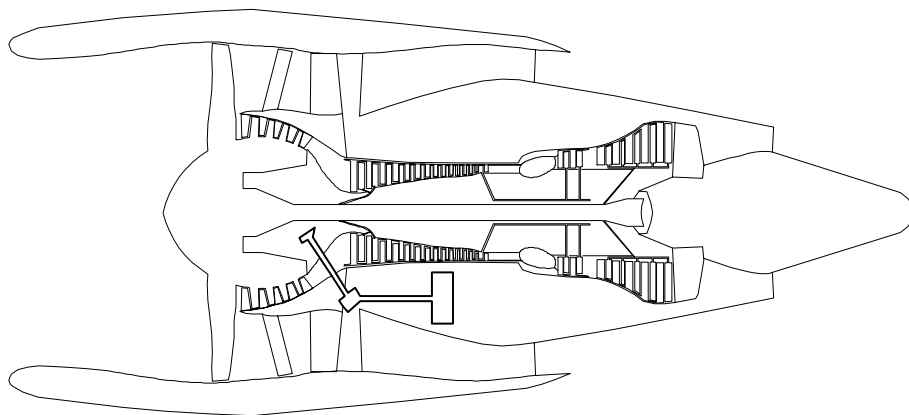
- Main fuel pump
- Hydromechanical Unit (HMU)
- Lube and scavenge pump
- Integrated Drive Unit (IDG)
- Two hydraulic pumps
- A permanent magnetic generator
- An N2 speed sensor
- An N2 manual drive pad.

AERODYNAMIC STATIONS

Here are the main aerodynamic stations.

Engine station identification :

- STA 0 : nose cowl inlet
- STA 12 : fan inlet, blade tip section
- STA 14 : fan discharge
- STA 25 : HP compressor inlet
- STA 3 : HP compressor discharge
- STA 49.5 : exhaust gas temperature
- STA 5 : LP turbine discharge.



STUDENT NOTES:

FAN MODULE DESCRIPTION

Fan Rotor And Booster Assembly
Forward Fan Case
Fan Frame And Case Assembly
Fan Booster Stator Assembly

FAN ROTOR AND BOOSTER ASSEMBLY

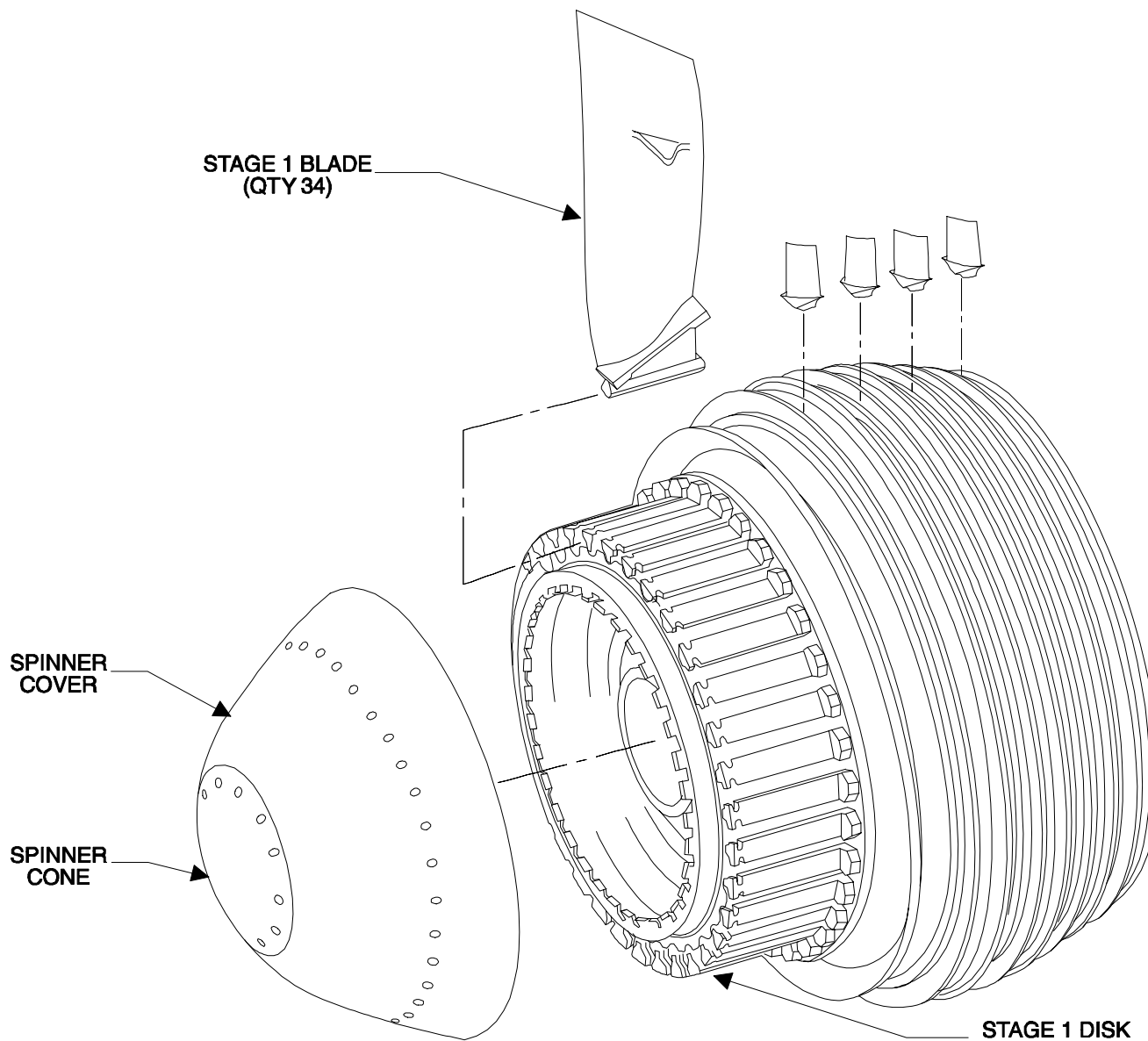
The fan and booster assembly consists of the following major parts:

- stage one disk
- booster spool
- fan and booster blades
- spinner
- fan forward shaft.

The fan rotor and booster assembly is a major subassembly of the fan module.

The major components of the fan rotor assembly include a two piece spinner, stage 1 disk, stages 2 to 5 booster spools, five stages of rotor blades, and the fan shaft.

The major function of the fan rotor assembly, by means of the stage 1 blades, is to develop thrust by accelerating the speed of the air being ingested into the engine inlet. Secondly, the stage 2 to 5 booster blades working with the stages 1-5 fan stator vanes act as a low pressure compressor and an inlet to the high pressure compressor.

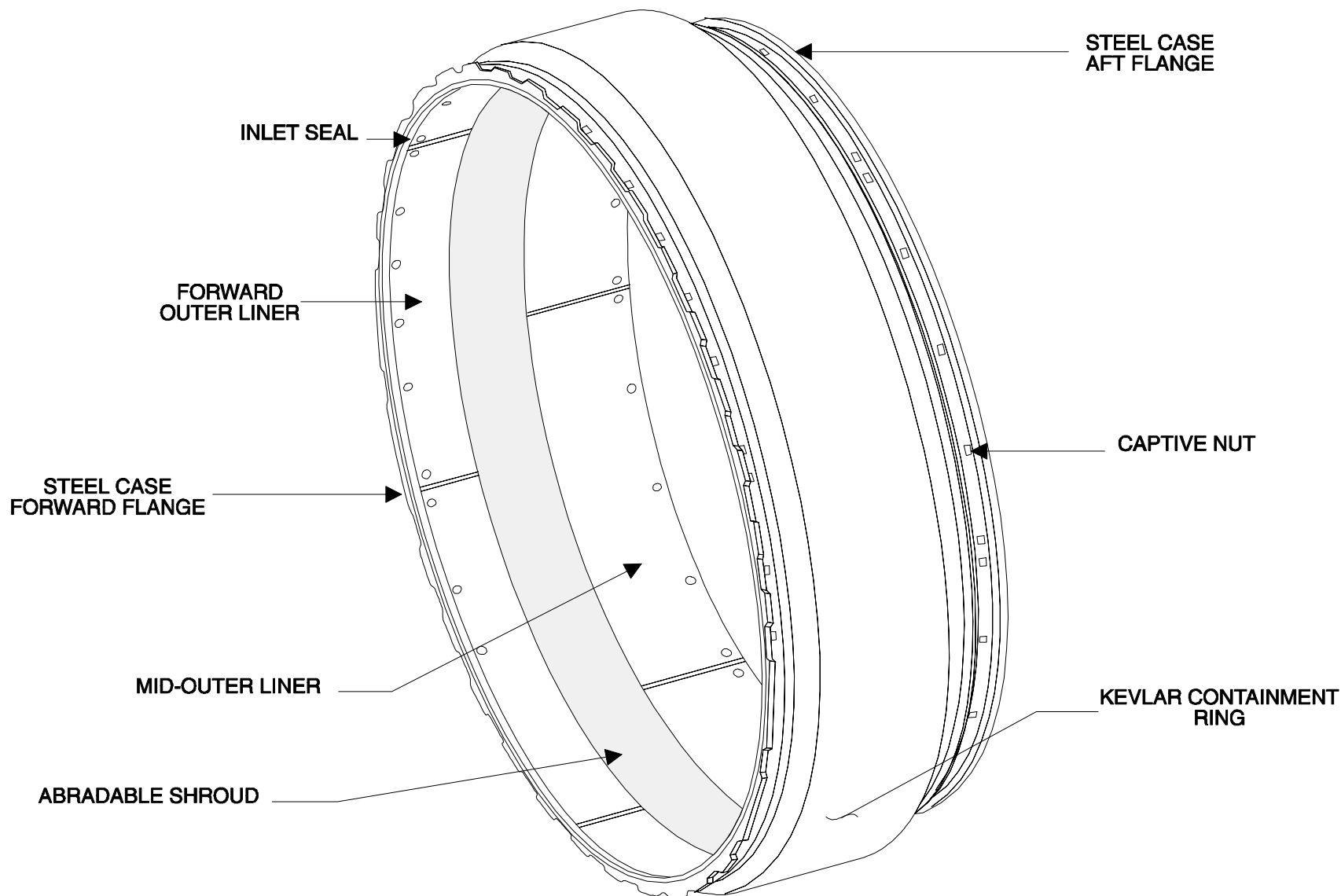


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FORWARD FAN CASE

The forward fan case performs the following primary functions:

- provides for attachment of the engine inlet structure
- provides support and transmission of attachment loads
- provides the fan blade containment
- provides attachment points for the acoustic panels
- provides an abradable microballoon shroud for the stage 1 blade tips.



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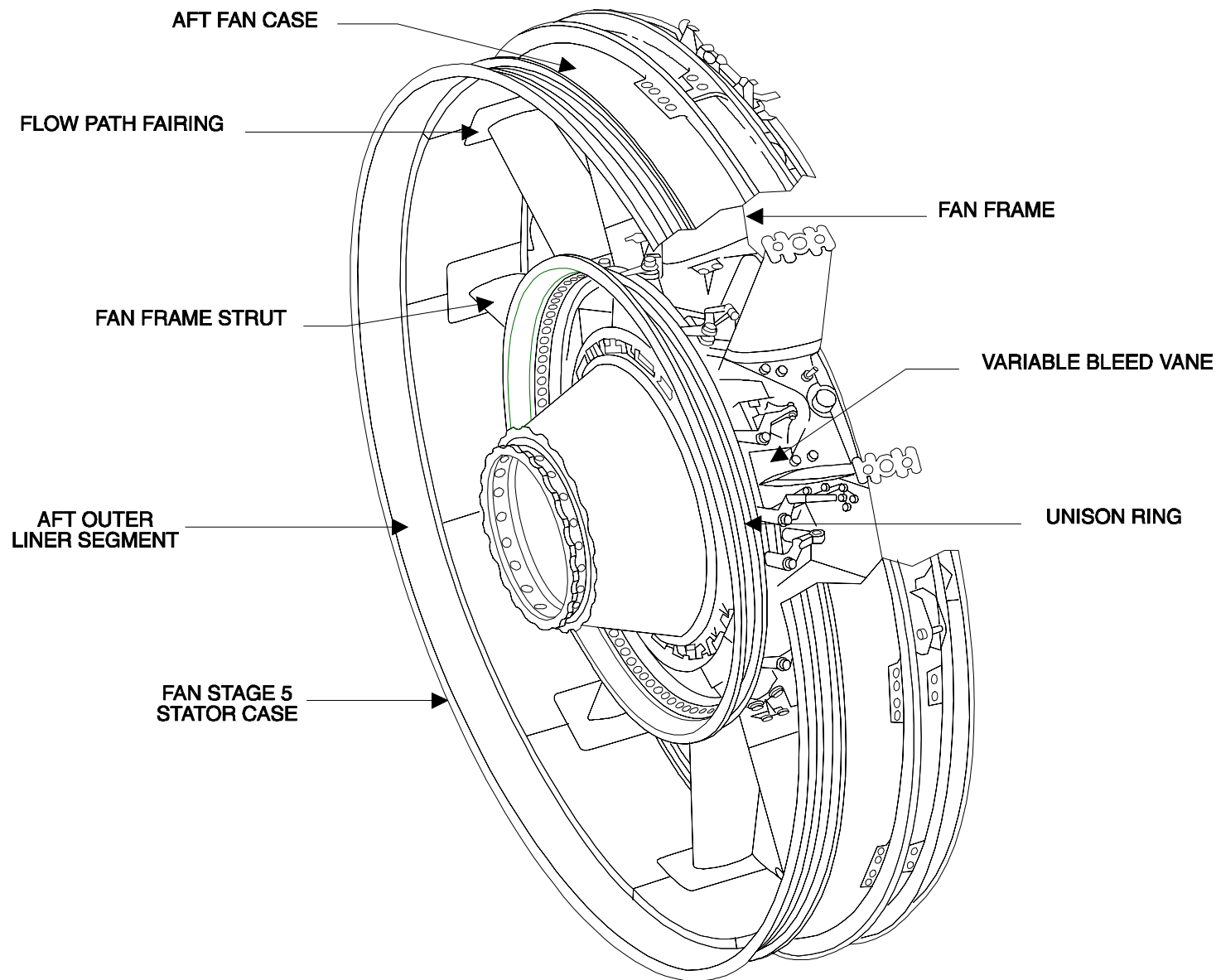
FAN FRAME AND CASE ASSEMBLY

The fan frame and case assembly consists of the following major parts:

- fan frame
- aft fan stator case.

The fan frame and aft fan stator case perform the following primary functions:

- an inlet airflow path to the core engine
- a support for loads of the forward fan case, fan booster stator, fan rotor and the thrust reverser
- containment of accessory drive power take off gearing and shaft
- a Variable Bleed Valve (VBV) system
- housing for service lines for lubrication of bearings, inlet gearbox and scavenge of the "A" sump
- support for the fan Outlet Guide Vanes (OGVs) and fan inner flowpath acoustic panels
- structural support for the forward engine mount.

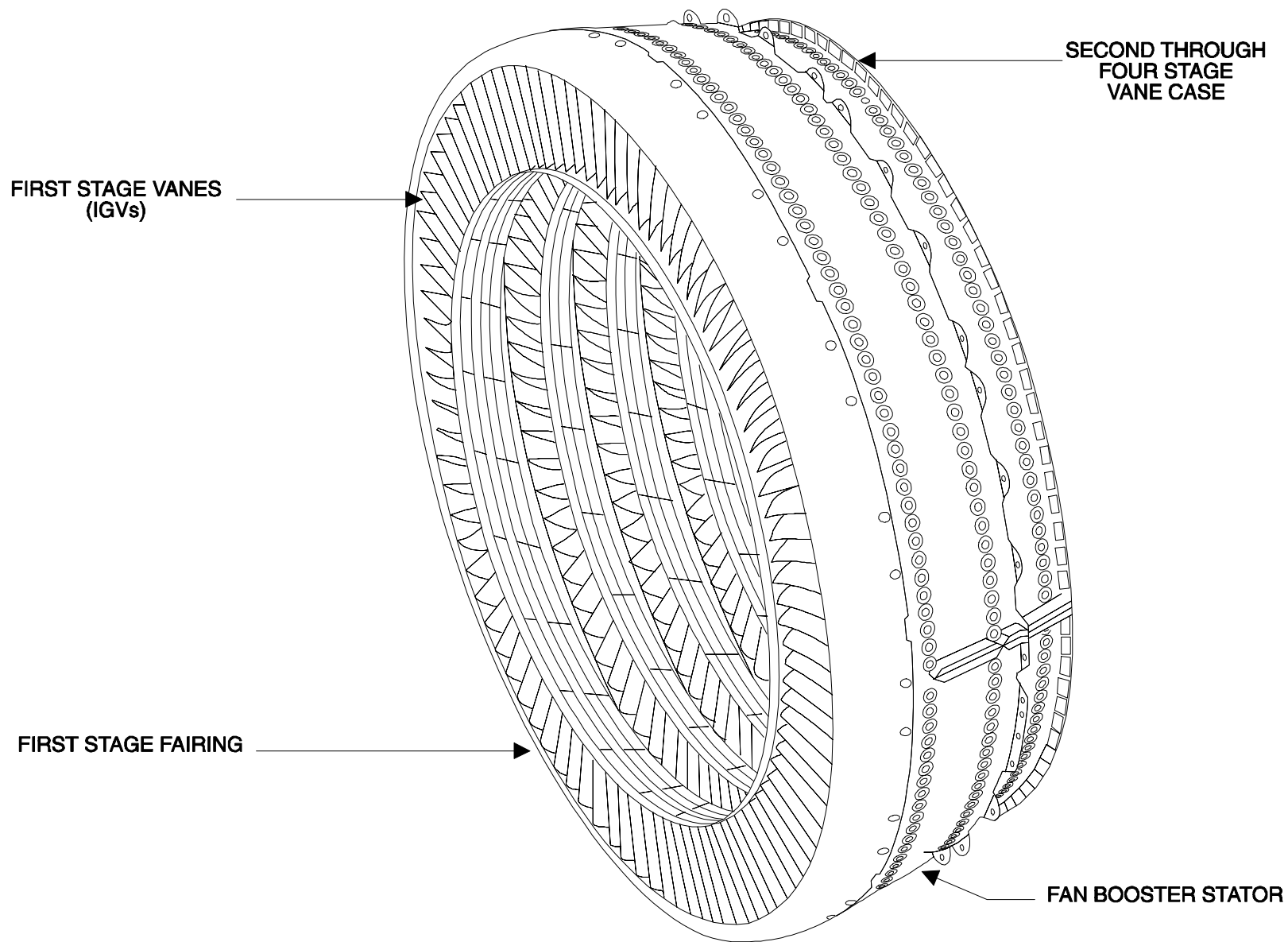


FAN BOOSTER STATOR ASSEMBLY

The fan booster stator assembly is a major sub-assembly of the fan module.
When the fan booster stator assembly is coupled with the fan rotor assembly
the low pressure compressor is formed.

The fan booster stator assembly consists of the following major parts:

- stator 2-4 and stage 5 stator casings
- stage 1 fairing
- stage 1-5 vanes
- stage 1-5 shrouds.



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STUDENT NOTES

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CORE MODULE DESCRIPTION

HP Compressor
HP Compressor Rotor Assembly
HP Compressor Rear Frame
Combustion Chamber

HP COMPRESSOR

The major components of the compressor section are: the compressor stator, and the Compressor Rear Frame (CRF).

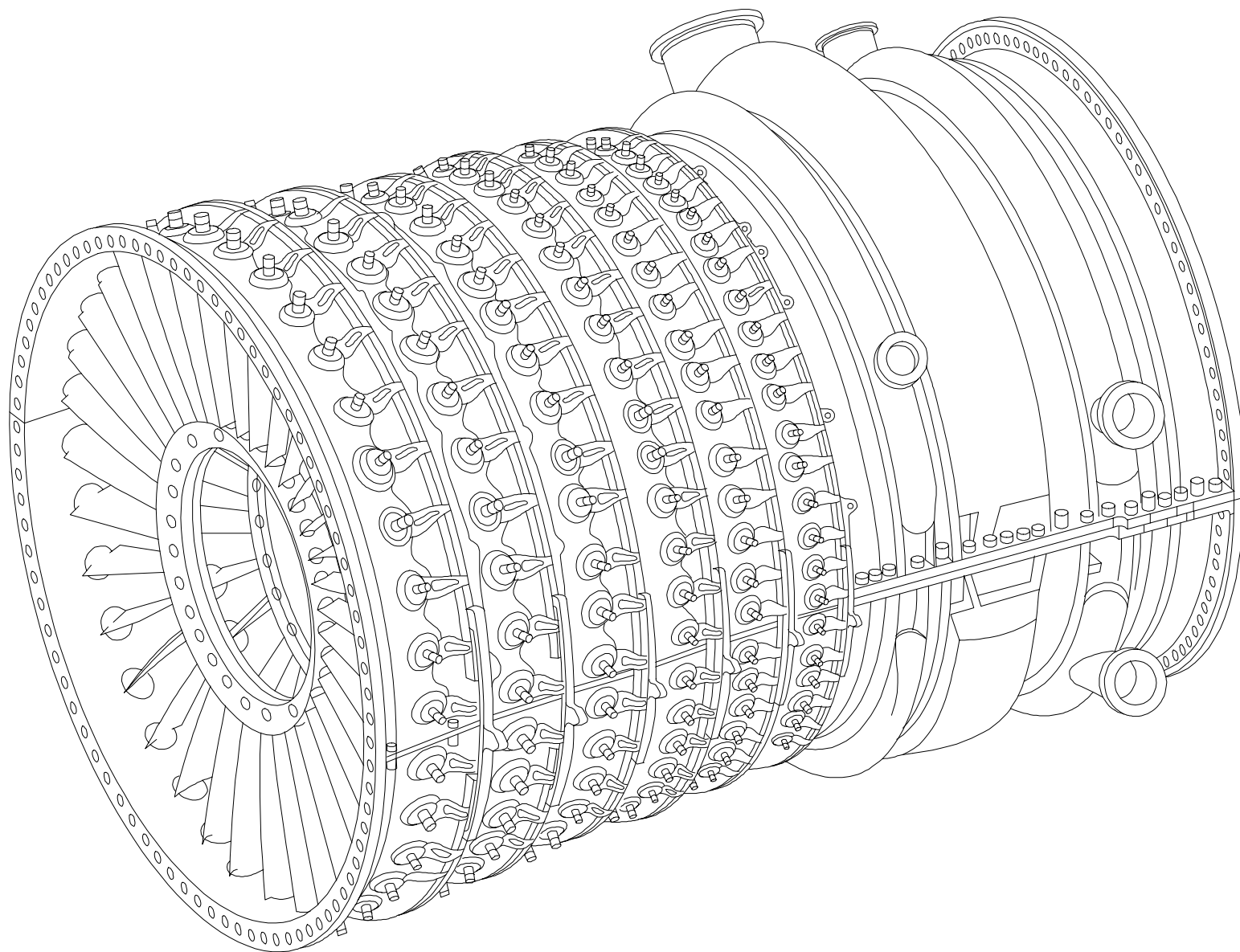
The front of the compressor stator is supported by the 3R bearing in the fan frame. The rear of the compressor stator is supported by the compressor rear frame, and the rear of the rotor is supported by the 4R and 4B bearings in the compressor rear frame.

The CRF assembly is the structural support in the middle of the engine. It also acts as a diffuser that connects the high pressure compressor with the combustion chamber assembly. It contains the No. 4B bearing (the thrust bearing), the No. 4R bearing, the No. 5 bearing, the B-sump, and High Pressure Turbine (HPT) stationary seal support. There are six borescope ports in the CRF assembly.

Air, taken in through the fan section, passes through successive stages of compressor rotor blades and compressor stator vanes, being compressed as it passes from stage to stage.

The inlet guide vanes and the first 5 stages of the stator are variable, and change their angular position as a function of compressor inlet temperature and corrected engine speed.

The purpose of this variability is to optimize efficiency and stall margin for engine speed and compressor inlet temperature and pressure conditions.



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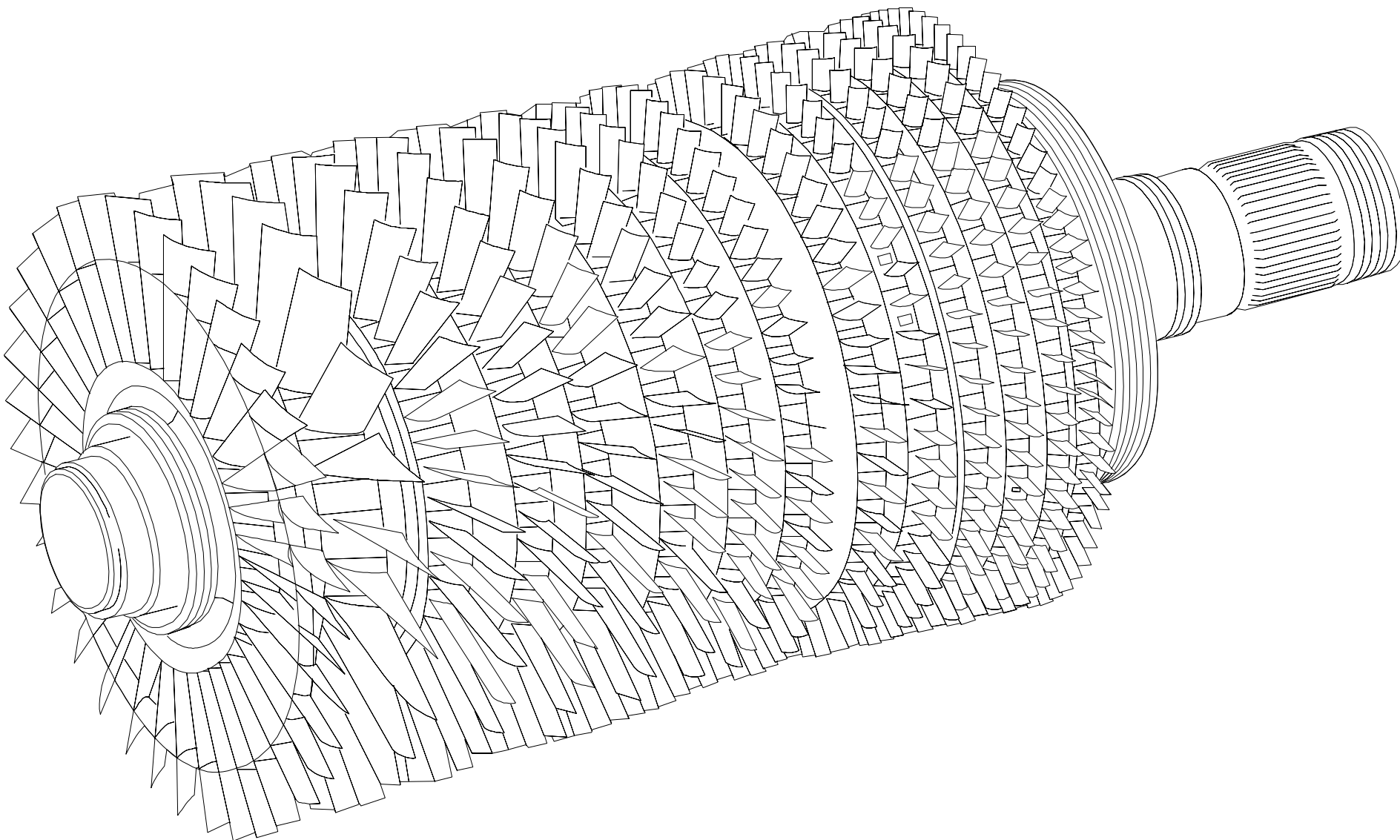
HP COMPRESSOR ROTOR ASSY

The compressor rotor features the unitized spool/disk structural concept. By use of circumferential dovetails and a smooth-spoolrotorstructure, several stages of blades can be carried on a single piece of rotor structure. A portion of fan discharge airflow flows through the compressor. Compression of the air is progressive as the airflow moves from stage to stage through the fourteen stage axial compressor.

There are 5 major structural elements and 2 main bolted joints. The first stage disk, the second stage disk (with integral front stub shaft) and the stage 3 to 9 spools are all joined at one bolted joint at stage 2. These are followed by the stage 10 disk and the stage 11 to 14 spool (with integral rear shaft) which are joined at the bolted joint at stage 10. Interference fit diameters are used in all flange joints for good positioning of the rotor components for stability. The rotor spool flowpath lands are coated with an abradable material to allow for close vane to spool clearances.

The first and second stage blades are installed in axial dovetail slots and retained by individual blade retainers. The blades in stages 3 through 14 are installed circumferentially and retained by 2 locking lugs. Stages 6 through 9 have an additional locking lug. The stage 1 blades feature a mid span shroud to provide blade stability and reduce vibratory stresses. The rotor provides accessory system drive by means of a splined adapter that is fitted into the internal splines of the front stub shaft. The compressor discharge air is sealed from the sump area by a 6 tooth rotating seal.

The seal support is integral with the stage 11-14 spool/shaft.



HP COMPRESSOR REAR FRAME

The CRF transmits axial and radial loads from the high pressure compressor rotor to the CRF case. It is also a flow path between the high pressure compressor and the high pressure turbine and provides a housing for the combustor.

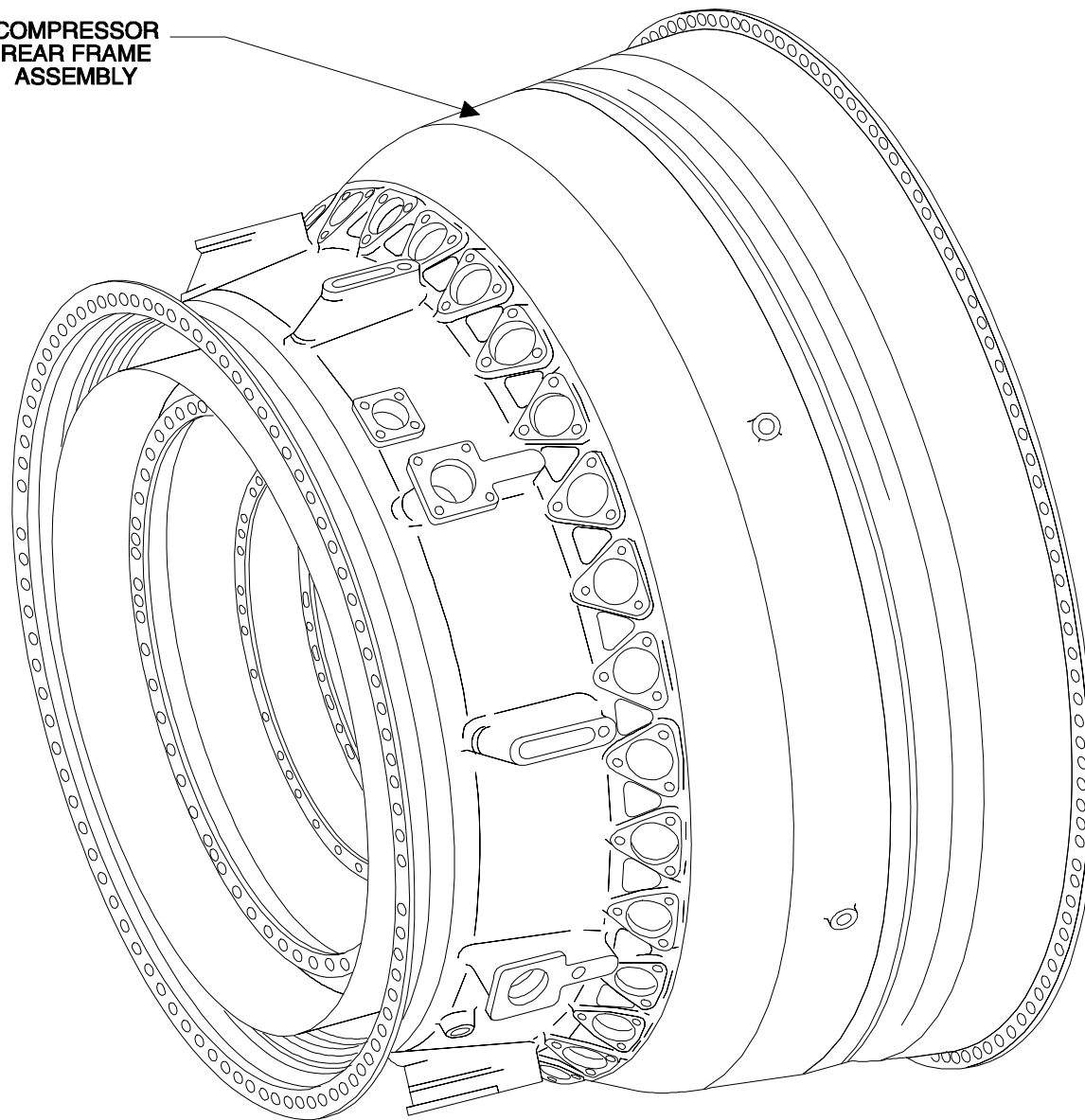
The CRF provides housing for the following:

- combustion liner assembly
- fuel nozzles, fuel manifold and igniter plugs
- No 4 roller and ball bearings and No 5 roller bearing.

The compressor rear frame assembly (CRF) is a main body Rene 220 casting located between the high pressure compressor and the high pressure turbine. The compressor rear frame provides a structural support for the "B-C" sump bearings and seals and is therefore a principal support for the core rotor.

It provides the diffuser for compressor air to dynamic pressure recovery (reduce velocity) needed for optimum combustor operation. It houses the combustor, the stage 1 high pressure turbine nozzles and mounting bosses for 30 fuel nozzles, 2 threaded ports for igniters, 5 borescope inspection plugs, PS3 port, T3 port, and a combustor drain port.

COMPRESSOR
REAR FRAME
ASSEMBLY



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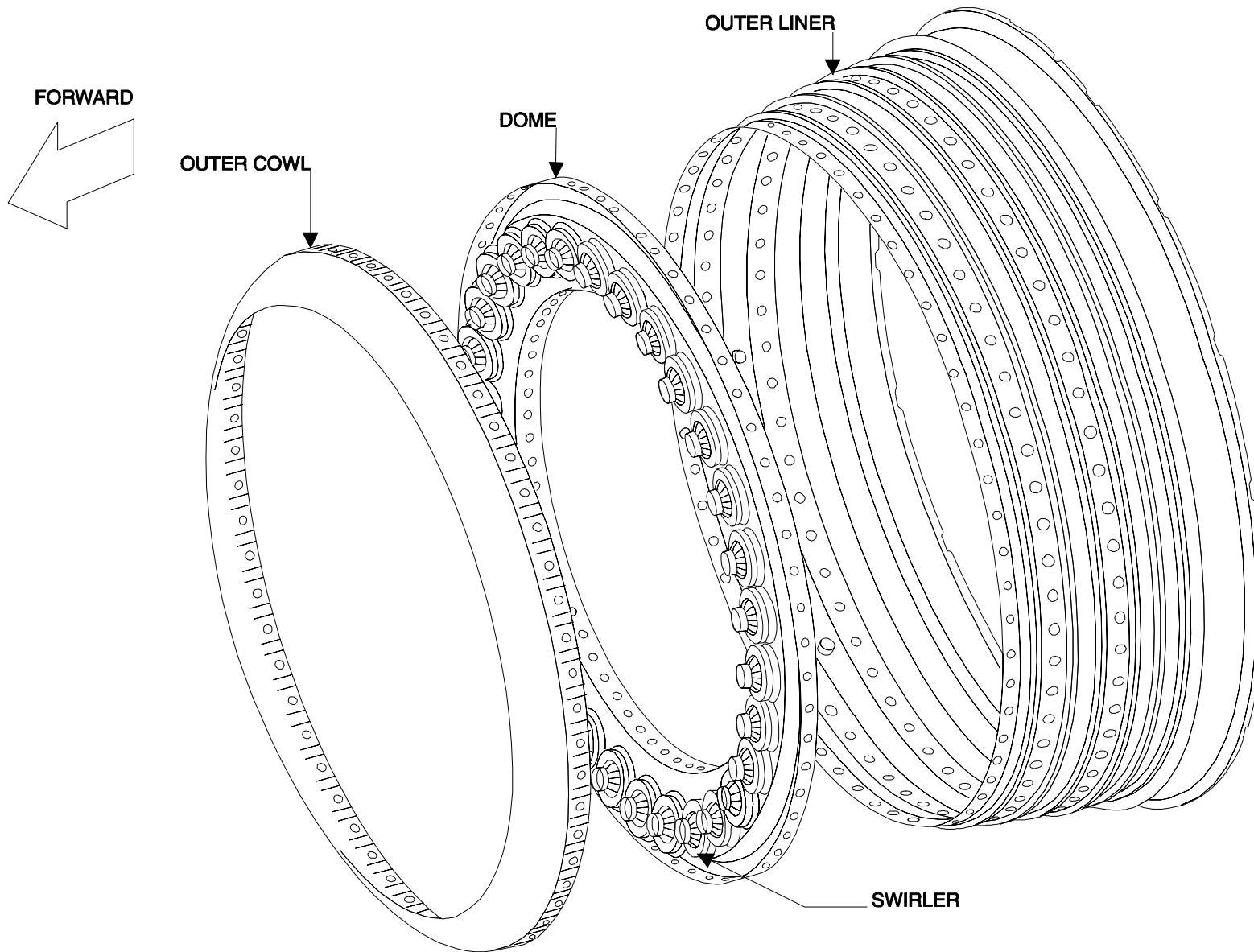
COMBUSTION CHAMBER

The combustion chamber assembly is located aft of the compressor rear frame. It provides a zone for the combustion and control of the fuel air mixture.

The combustor is built up of five major assemblies: inner and outer cowls, a dome, and inner and outer liners. The individual parts are bolted together for ease of disassembly and assembly.

The combustion chamber assembly consists of the following major components:

- cowl assembly
- liners
- dome.



STUDENT NOTES

FQW4200 GE Metric

HPT MODULE DESCRIPTION

HP Turbine
Stage 1 HPT Nozzle
Stage 2 HPT Nozzle
HP Turbine Rotor

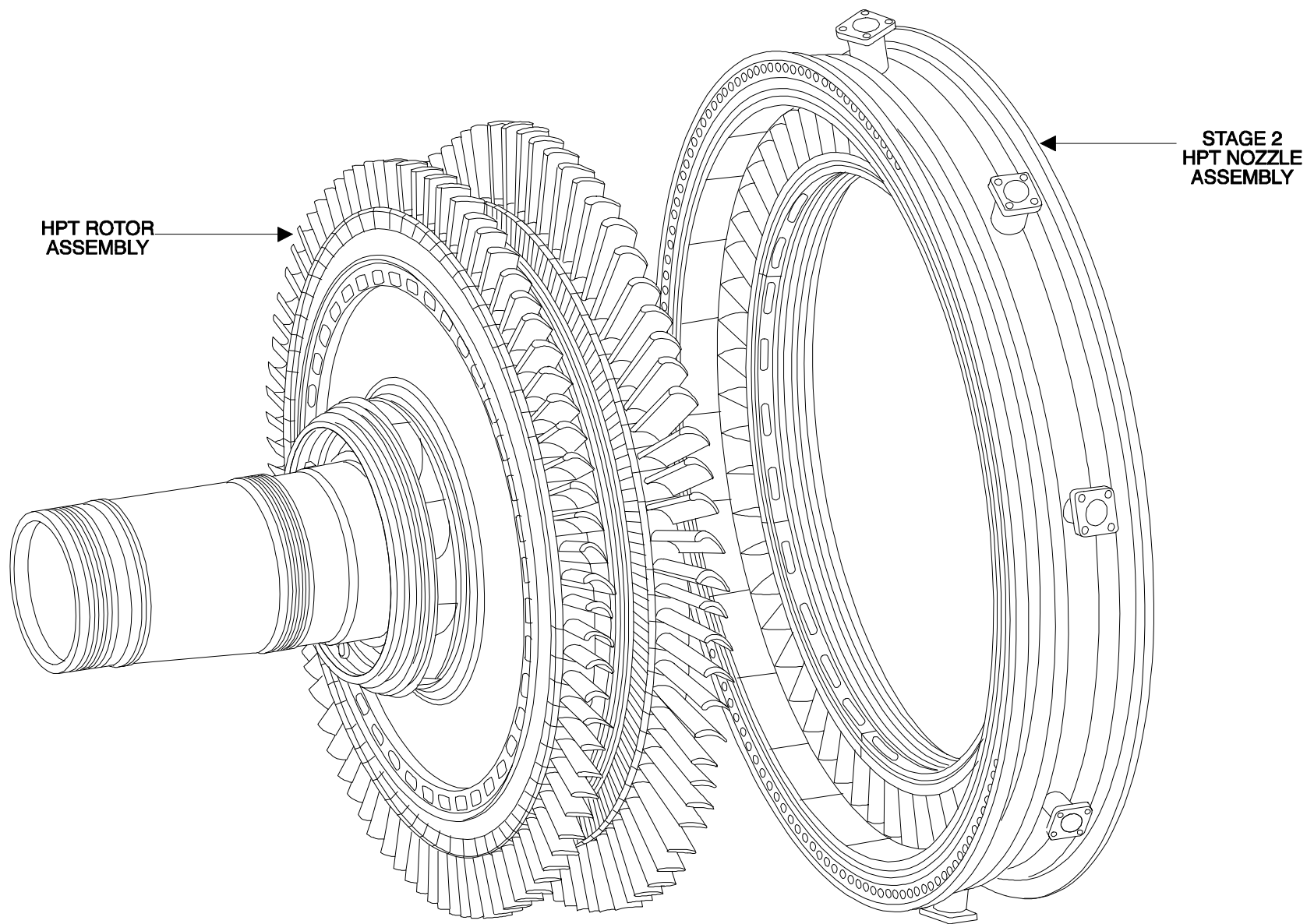
HP TURBINE

The function of the High Pressure Turbine (HPT) is to drive the High pressure compressor by converting the combustor exhaust gas flow into mechanical force.

The high pressure turbine is a two stage turbine, consisting of a two stage HP rotor assembly, stage 1 nozzle assembly, and stage 2 nozzle assembly.

The rotor is connected to the HP compressor rotor and supported by the 4R and 5R bearings.

The stage 1 nozzle assembly is bolted to the CRF inner structure and is supported at the aft outside diameter by the HPT stage 2 outer structure. The stage 2 nozzle assembly forms the engine outer structure and turbine flowpath.



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STAGE 1 HPT NOZZLE

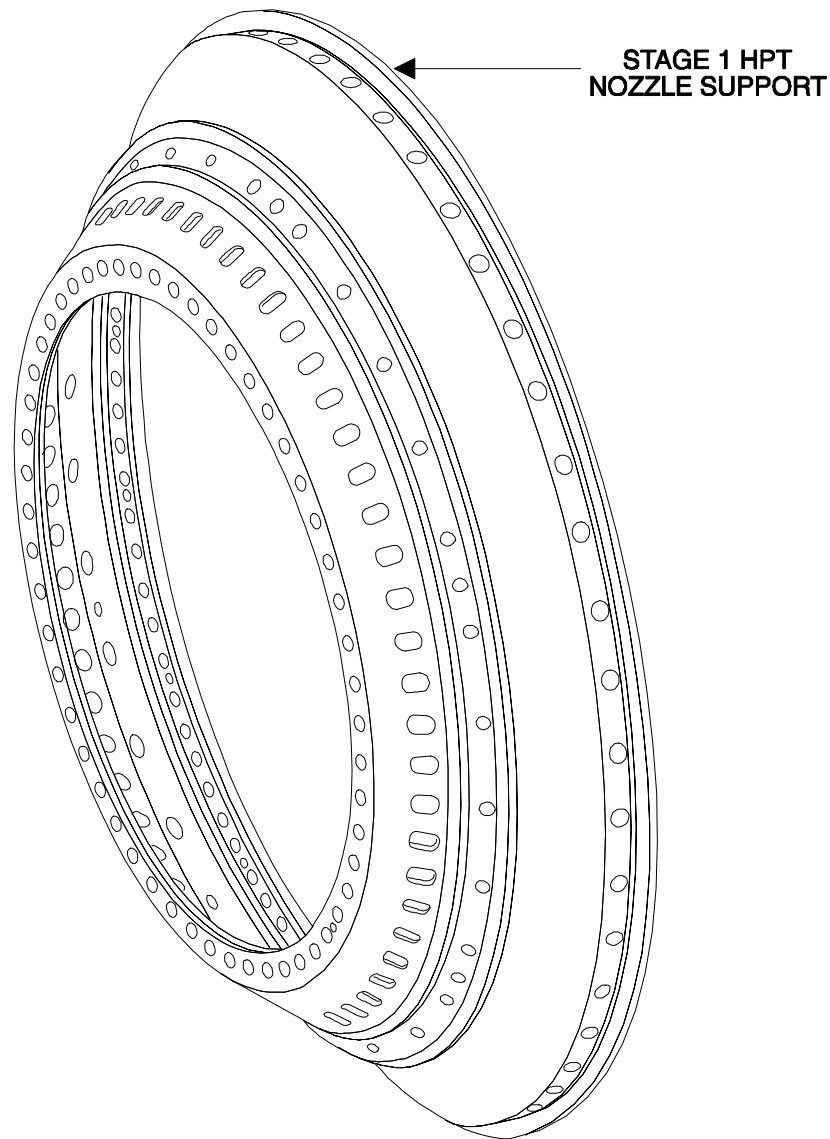
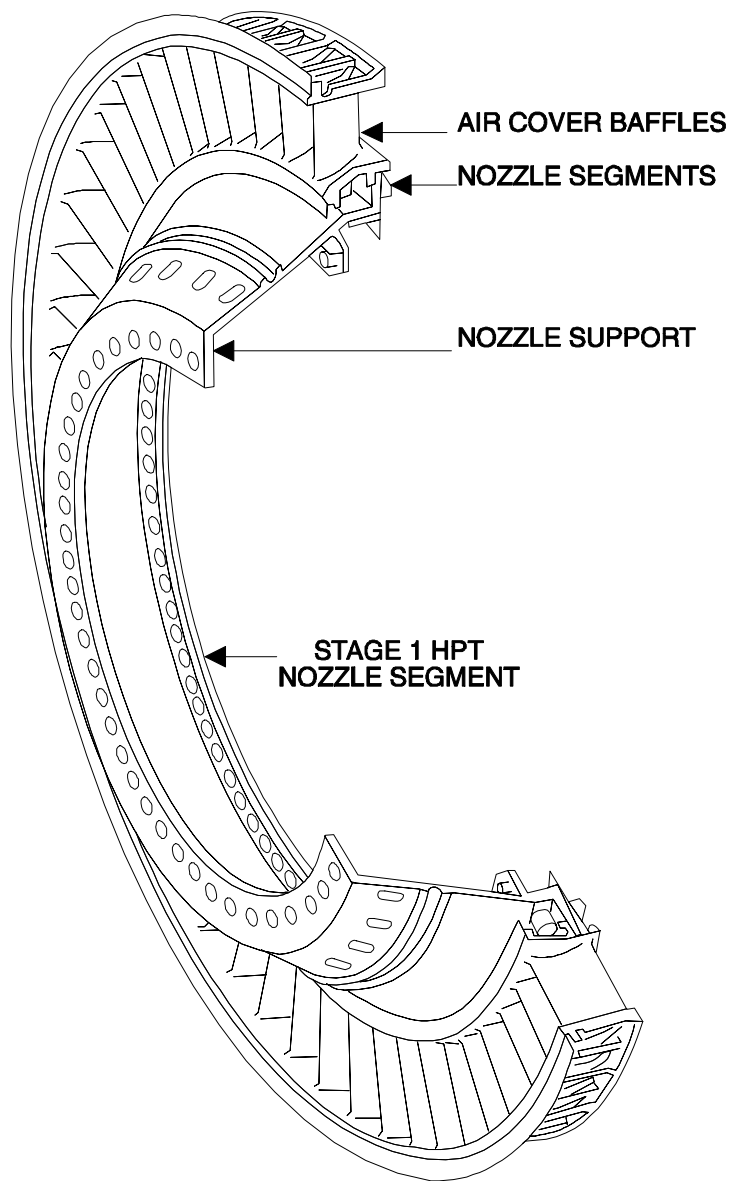
The major components of the stage 1 nozzle assembly include: the nozzle segments, nozzle support and air baffles.

The mini nozzle and torroid supports also form an integral part of the structural assembly.

The stage 1 HPT nozzles direct high pressure gas from the combustor onto the HPT rotor blades at the proper angle and velocity to cause rotation of the HP system. The nozzle segments are supported at the inner and outer flanges.

The nozzle, mini nozzle and torroid supports form the inner structural load path from the nozzles and are bolted to the CRF. They also provide the inner flowpath for the combustor chamber and channel the HPT rotor cooling air. The stage one HPT nozzle assembly consists of the following major components:

- stage 1 nozzle segments
- stage 1 nozzle support
- air cover baffles.



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STAGE 2 HPT NOZZLE

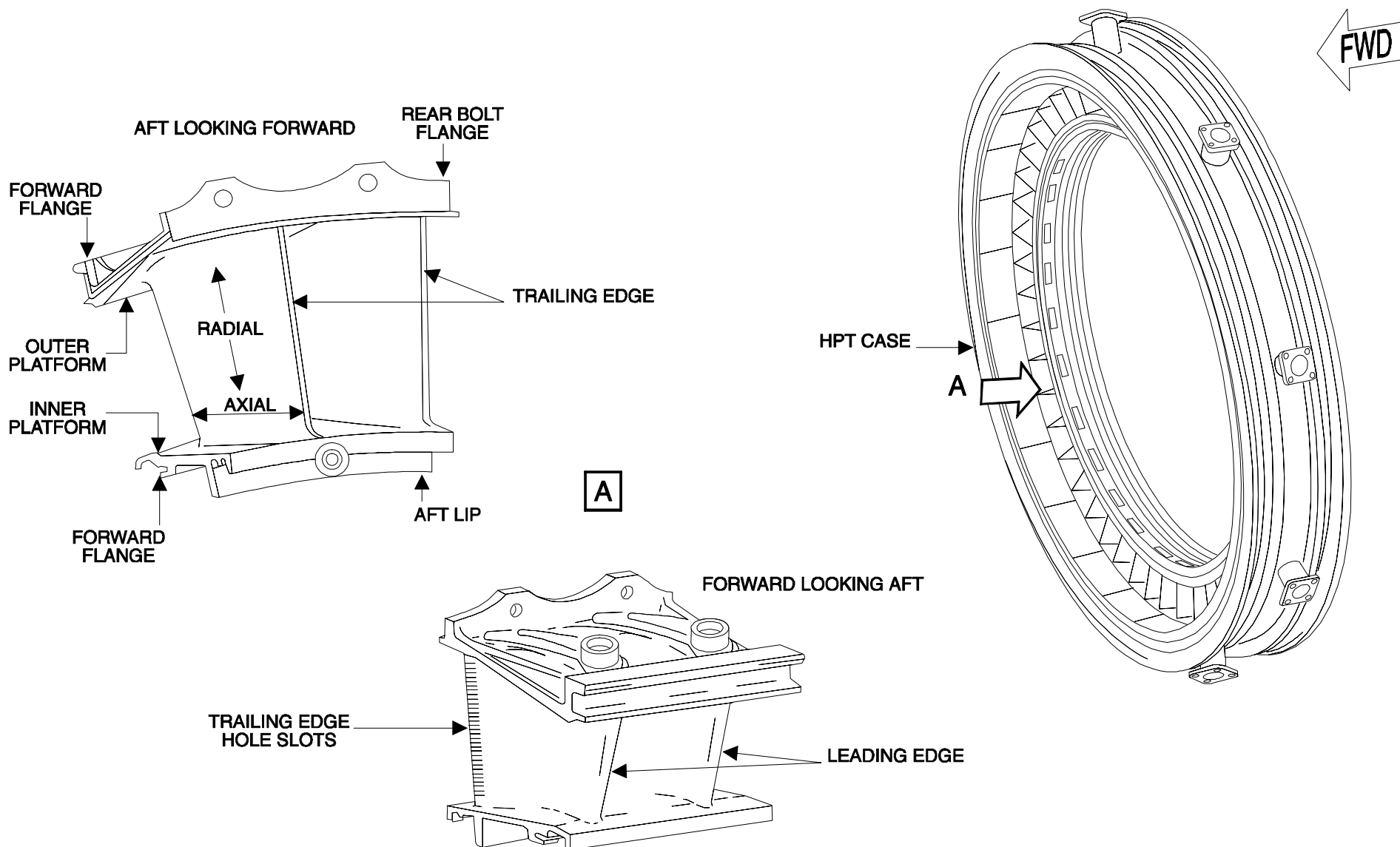
The stage 2 HPT nozzle assembly consists of stage 2 nozzle segments, stage 1 and stage 2 shrouds, HPT stator (case), stage 1 and stage 2 shroud supports, inter-stage seal, stage 2 impingement ring and active clearance control manifolds.

The HPT stage 2 nozzle assembly:

- provides support to the stage 1 nozzle system
- forms the turbine outer flowpath
- channels the shroud cooling air and provides the turbine clearance control system
- supports the stage 2 nozzle which direct the gas stream onto the stage 2 blades at the proper orientation.

The major components of the stage 2 nozzle assembly are:

- HPT stator support case
- stage 2 nozzle vane segments
- turbine shrouds and supports
- interstage seal
- clearance control and impingement ring.



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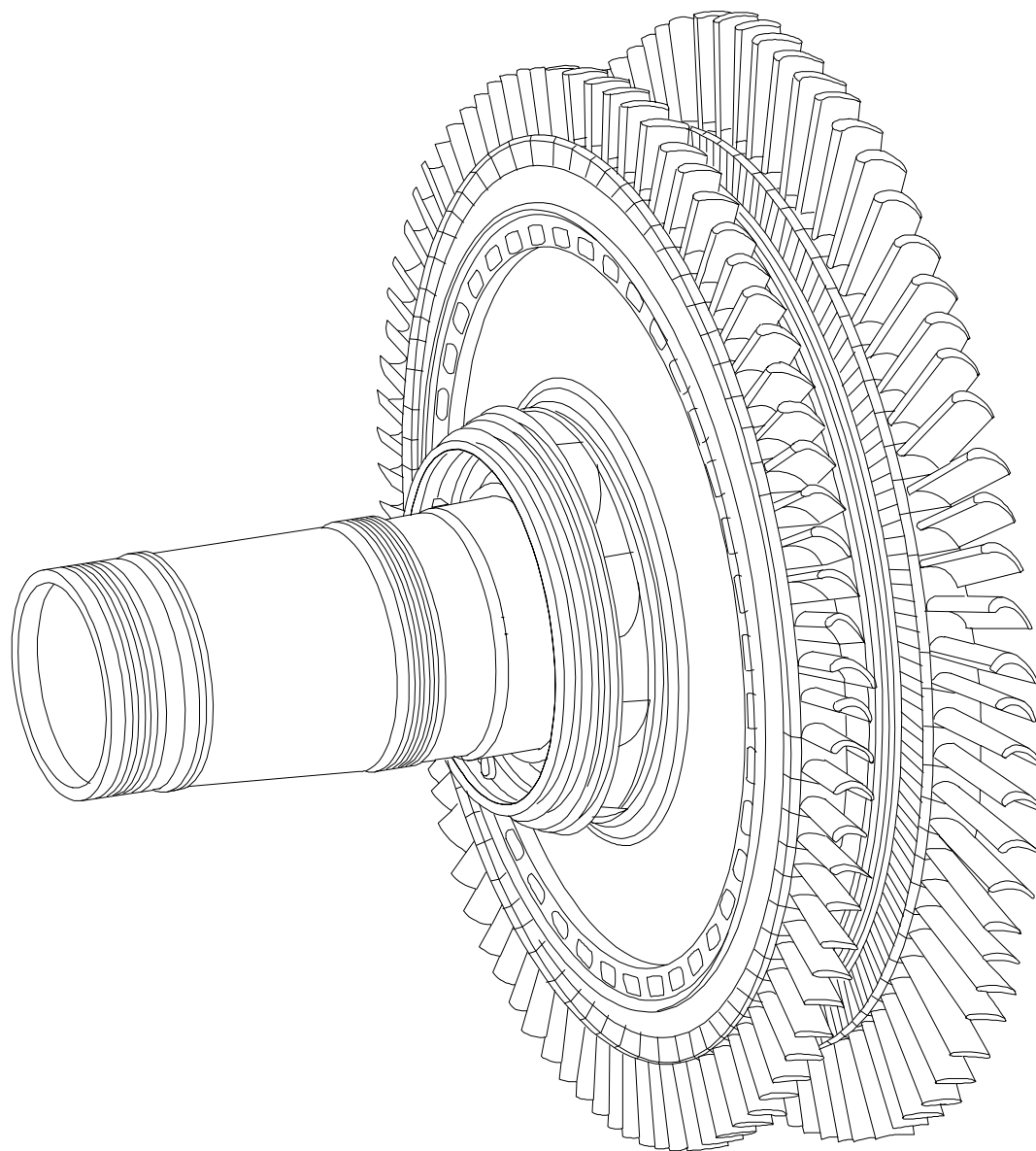
HP TURBINE ROTOR

The High Pressure Turbine (HPT) rotor is a 2 stage air-cooled turbine.

The HPT rotor assembly consists of an integral stage 1 turbine/disk shaft, a conical impeller (vaned) spacer with cover, thermal shield and stage 2 disk. Forward and aft rotating air seals are assembled onto the HPT rotor shaft and provide air cooled cavities about the rotor system. An integral coupling nut and pressure tube are used to seal and form the internal cavity.

The rotor disks and blades are cooled by a continuous flow of compressor discharge air directed to the internal cavity of the rotor through diffuser vanes which are part of the forward seal system.

The impeller/cover increases the pressure of the air discharged to the stage 1 blade dovetails which cools the blade airfoils. The remaining air is centrifuged through the stage 2 blade dovetails and cools the stage 2 blade airfoils.



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STUDENT NOTES

FQW4200 GE Metric

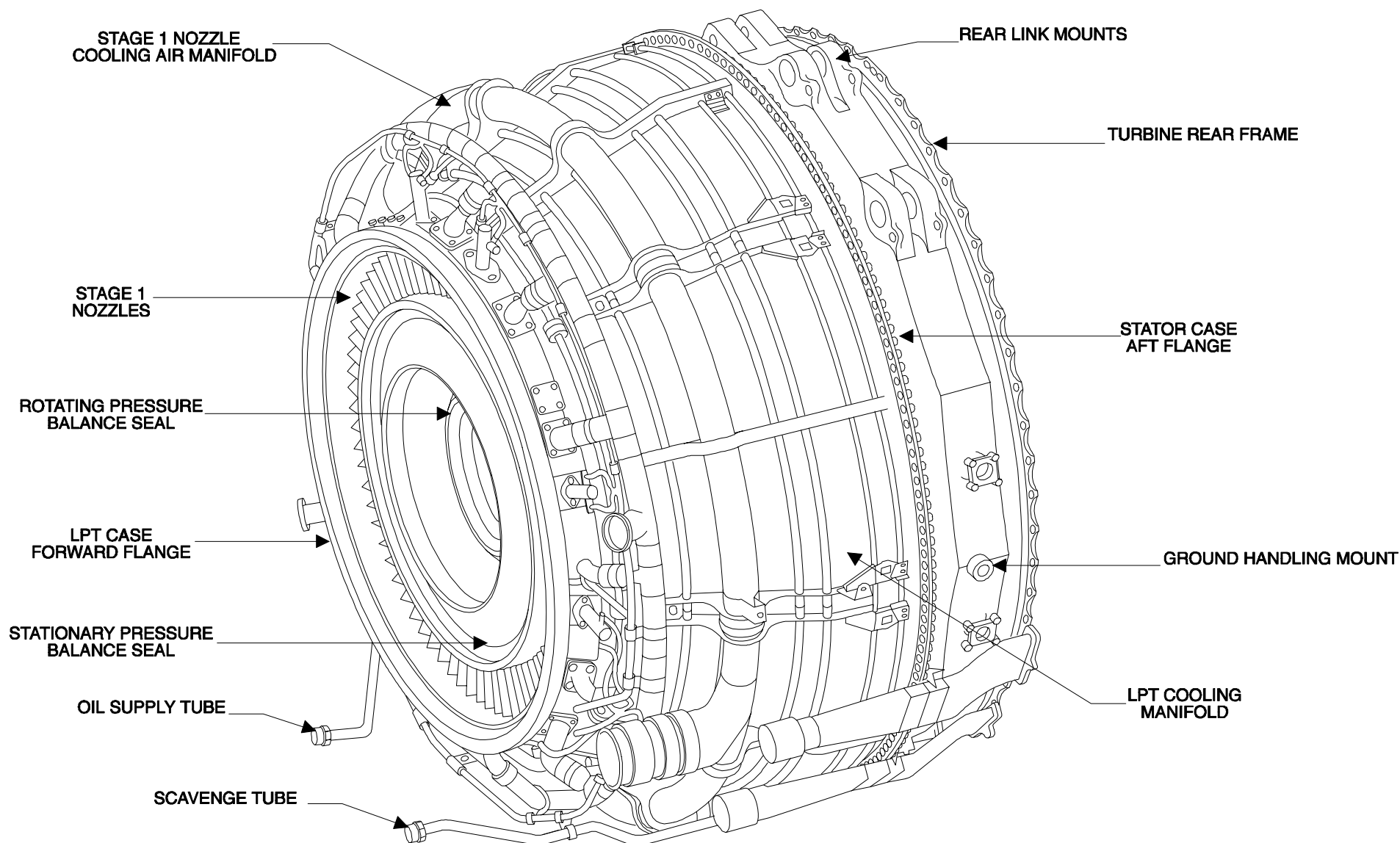
LPT MODULE DESCRIPTION

LPT Module
LPT Stator Assembly
LPT Rotor Assembly
Turbine Rear Frame

LPT MODULE

The Low Pressure Turbine (LPT) converts the combustor gas flow into force to drive the fan and booster assemblies.

The low pressure turbine is a 5 stage system consisting of a turbine rotor, stator case and nozzles, a turbine rear frame, and fan mid shaft.



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LPT STATOR ASSEMBLY

The low pressure turbine stator assembly consists of a one-piece casing, five stages of nozzle segments and turbine shrouds.

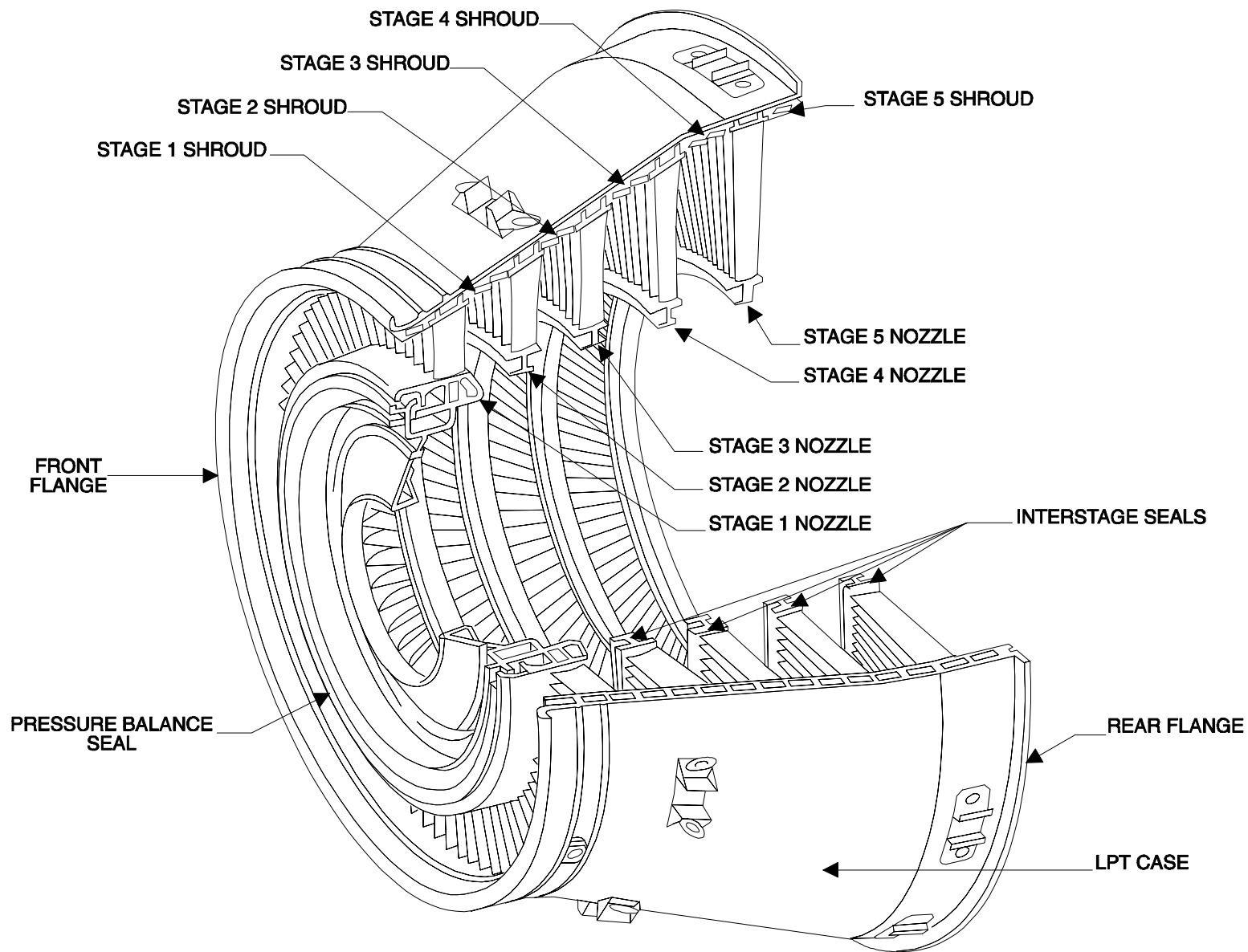
The casing serves as the load carrying structure between the High Pressure Turbine (HPT) stator support and the turbine rear frame. The casing retains the turbine shrouds and nozzle segments.

The first stage nozzles are segmented with multiple vanes in each segment. The stage 1 nozzle are hollow and use 7 th stage compressor air for leading edge cooling and HP recoup air for trailing edge cooling. The cooling air is transmitted to the pressure balance seal supported at the nozzle inside diameter which provides inner cavity temperature control and purge air.

The stage 2-5 nozzles are split and have integral honeycomb interstage seal segments.

Ports are provided in the case and stage 1 nozzles for attachment of thermocouple probes and borescope inspection of the turbine.

The segmented turbine shrouds are of conventional honeycomb design. The shrouds, which are located axially in line with the shrouded turbine rotor blades, provide spline seals close tolerance sealing and also act as heat shields to reduce casing wall temperature. A clearance control manifold discharges fan air onto the surface of the case through an array of small holes. The cooling air reduces the radial clearance of the LPT rotor improving the LP turbine efficiency.



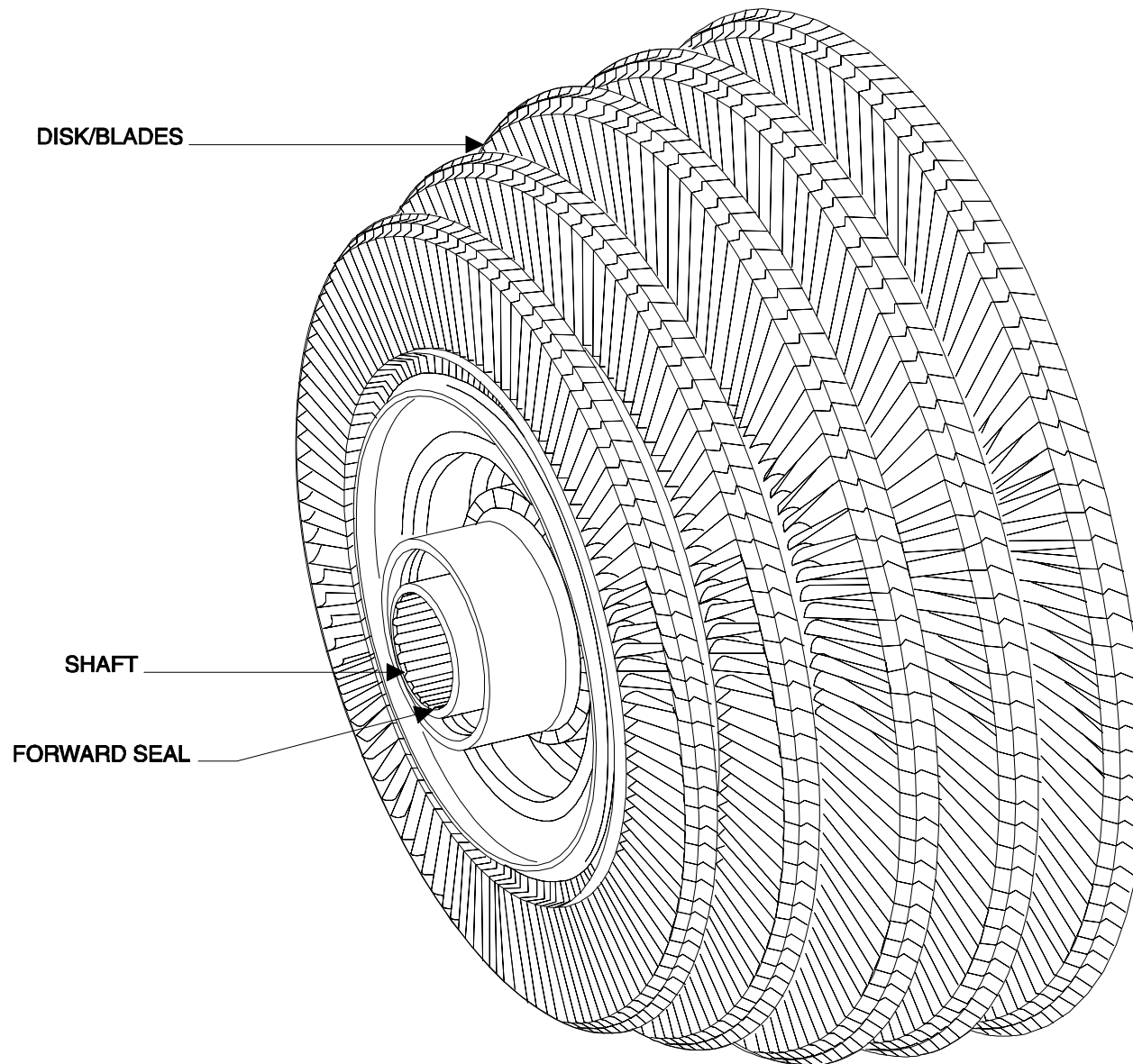
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LPT ROTOR ASSEMBLY

The low pressure turbine rotor drives the fan and booster rotors through the LPT rotor shaft by extracting energy from the combustion gases leaving the HPT.

The rotor is located between the HP turbine and the turbine rear frame and is supported by the 6 R bearing in the D sump. The low pressure turbine rotor consists of five turbine disks of similar construction bolted together at the spacer arm flanges. The torque cone outer flange and the interstage rotating seal are sandwiched between the spacer arms of stage 2 and 3 disks and bolted together.

The stage 1 disk has an air seal integral with the forward side of the disk. All 5 stages of blades contain individual interlocking tip shrouds the lower vibratory stresses and are secured in the disks dovetails by means of long oval bent tab retainers. The blade platforms provide extended angel wings to improve the inner flowpath.



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TURBINE REAR FRAME

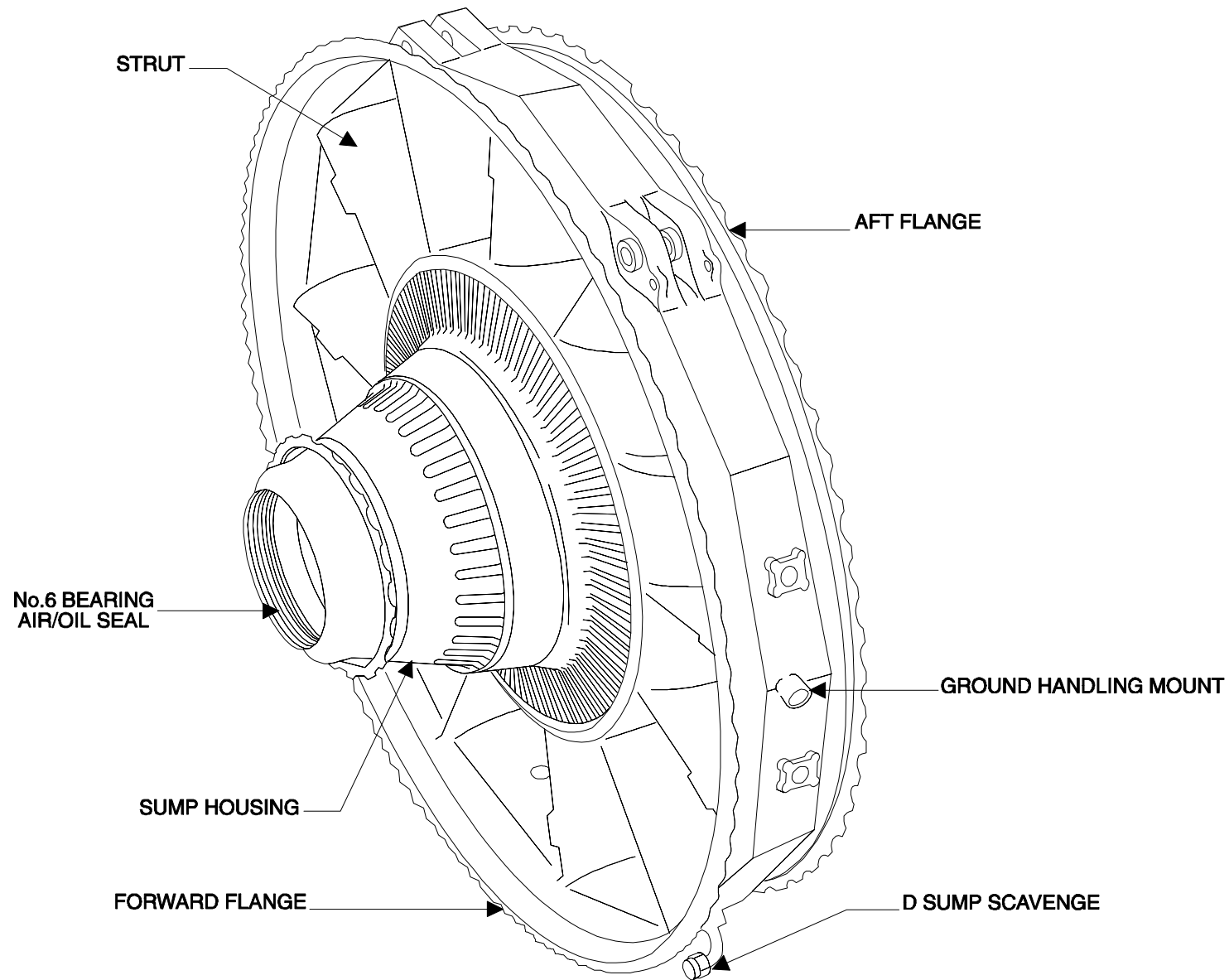
The turbine rear frame assembly consists of the one-piece cast frame structure, the 6R bearing housing, the stationary air seal and the sump service piping.

Two main components of the turbine rear frame assembly are the:

- frame structure
- bearing support.

The turbine rear frame assembly provides the following structural and aerodynamic functions:

- forms a smooth aerodynamic outlet guide vane transition from the low pressure turbine to the exhaust system
- supports the low pressure turbine rotor through the 6R bearing in the sump
- provides service piping for number six bearing lubrication
- supports the low pressure stator at their common flange attachment
- provides the attachment points for rear main engine mount
- houses the aft ground handling mounts
- supports the exhaust nozzle and centerbody.



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STUDENT NOTES

FQW4200 GE Metric

ACCESSORY DRIVE MODULE DESCRIPTION

Inlet Gearbox Assembly
Transfer Gearbox And Horizontal Drive Shaft
Accessory Gearbox

INLET GEARBOX ASSEMBLY

The inlet gearbox assembly is located in the "A" sump of the engine. It provides a drive train proportional to core speed (N2). This drive train is used to transmit engine torque to the radial drive shaft.

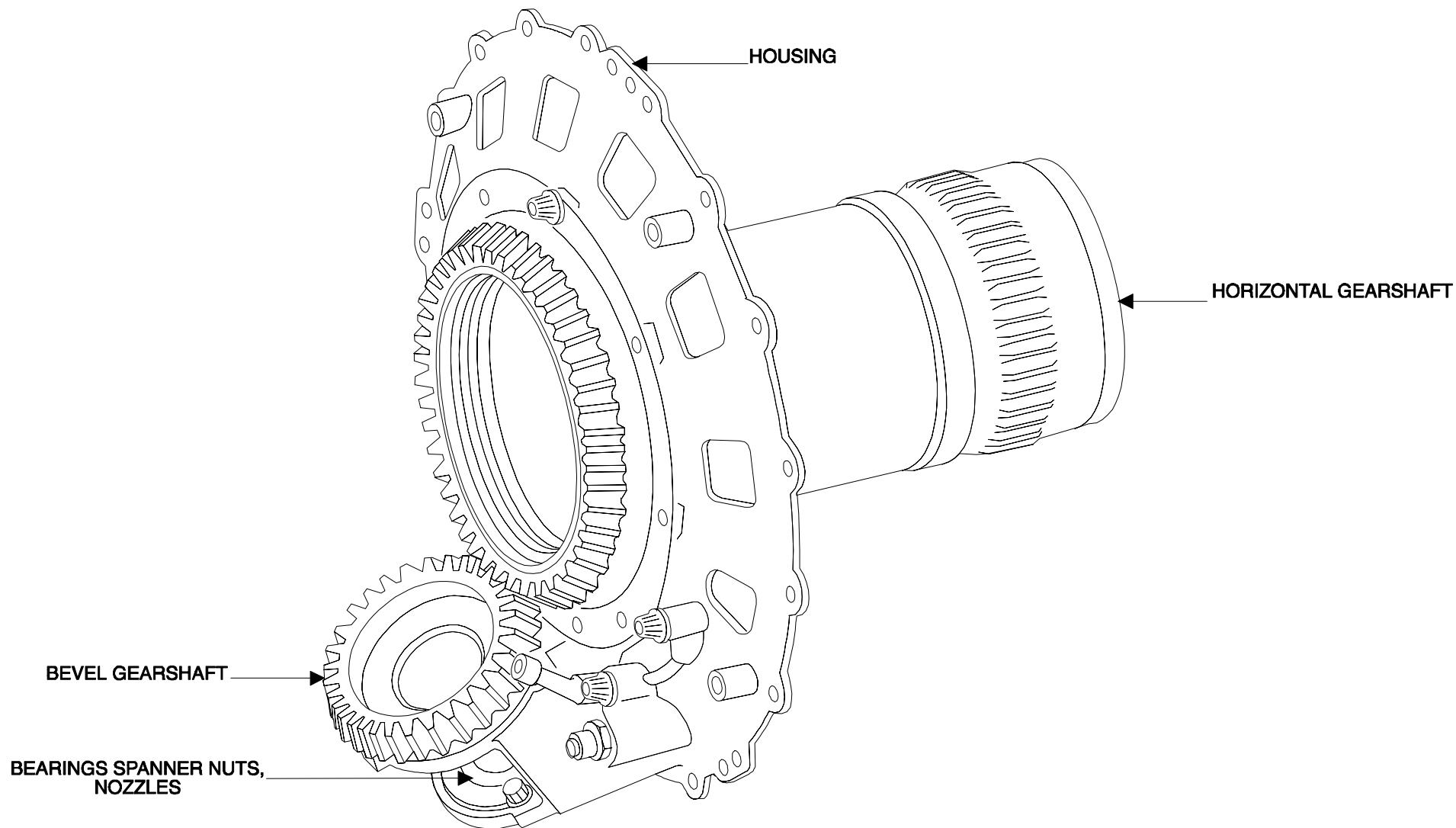
The gearbox assembly consists of a cast titanium housing, a pair of main power transmission bevel gears, bearing and oil jets.

The housing, which is bolted directly to the fan frame, mounts the bevel gears and their respective bearings.

The housing has internal oil passages and jets to provide lubrication for the gears and bearings.

The upper bevel gearshaft, which rotates on a horizontal axis, is splined at the aft end and mates with the second stage disk of the compressor rotor. The upper end of the radial gear shaft is supported by a roller bearing and its lower end by a ball bearing.

The lower end is also splined to mate with the radial drive shaft.



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TRANSFER GEARBOX AND HORIZONTAL DRIVE SHAFT

The transfer gearbox assembly is mounted below the core on the fan frame at the 6 o'clock position. The gearbox transmits torque from the radial drive shaft to the horizontal drive shaft.

The transfer gearbox assembly consists of a three piece cast aluminum casing, a set of bevel gears, associated bearings and oil jets. The gearbox casing consists of the main housing, the radial adapter and the horizontal adapter.

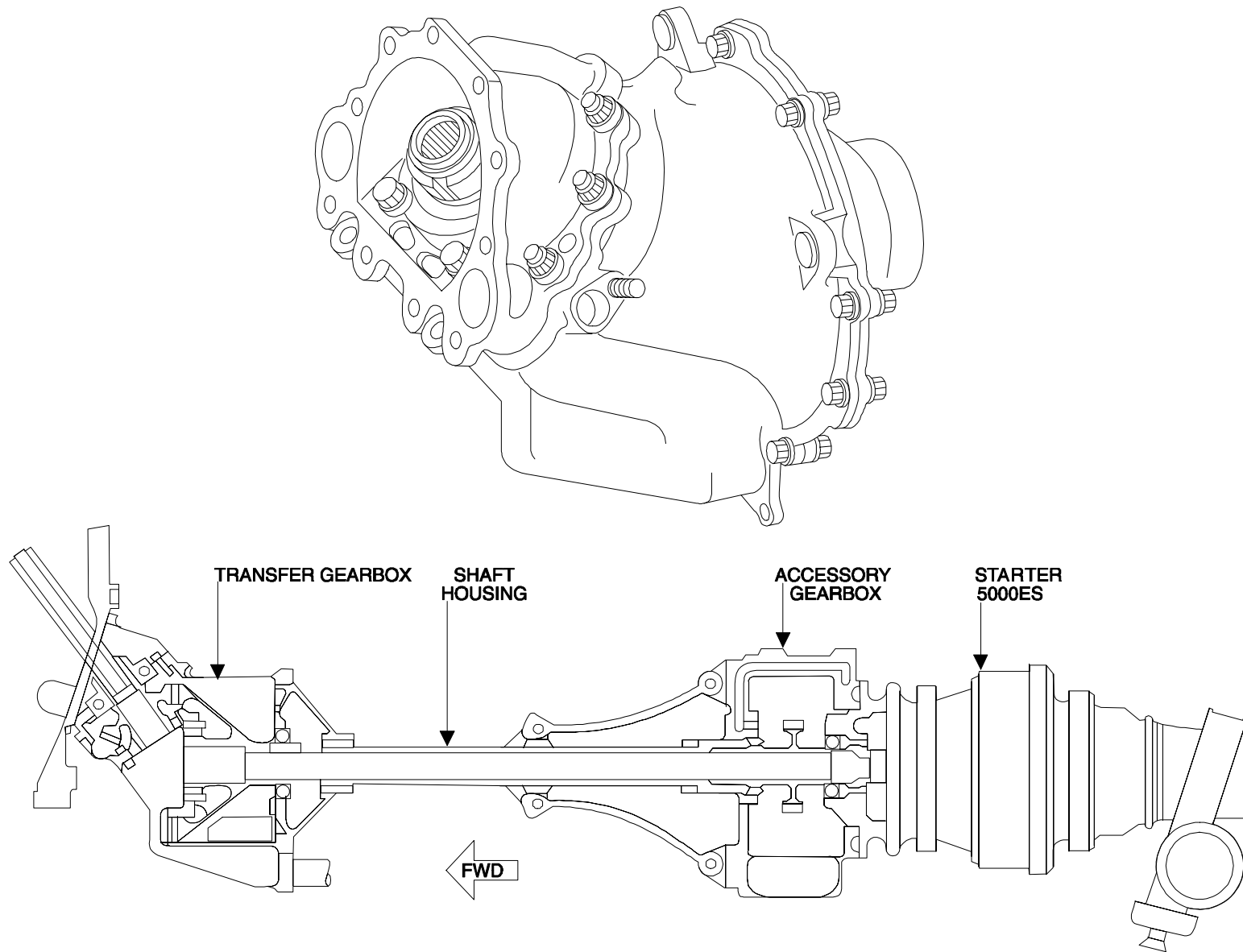
The casing has internal passages and oil jets to provide lubrication for the gears and bearings. Bolts at the top of radial adapter mount the gearbox to the fan frame. Each of the two bevel gears is supported by a ball bearing and a roller bearing. The bevel gear which rotates on the inclined axis is splined and mates with the radial driveshaft. The bevel gear which rotates on the horizontal axis is splined on the aft end and mates with the horizontal drive shaft.

The horizontal drive shaft assembly is mounted between the transfer and accessory gearboxes. The function of the drive shaft is to transmit torque from the transfer gearbox to the accessory gearbox.

Components of the horizontal drive shaft assembly include a one-piece machined tubular steel shaft and titanium alloy housing.

Features of this assembly include:

- a one piece tubular shaft with splines to mate with the gearshaft of the transfer and accessory gearboxes
- removable teflon wear sleeves and O-rings which are fitted into external surfaces of the drive shaft ends housing
- upper and lower tie rods (non-adjustable) which secure the drive shaft to the accessory gearbox.



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INLET GEARBOX ASSEMBLY

The accessory gearbox assembly is mounted to the compressor casing. The gearbox receives torque from the horizontal drive shaft and distributes the torque through spur gears to drive the gearbox mounted accessories.

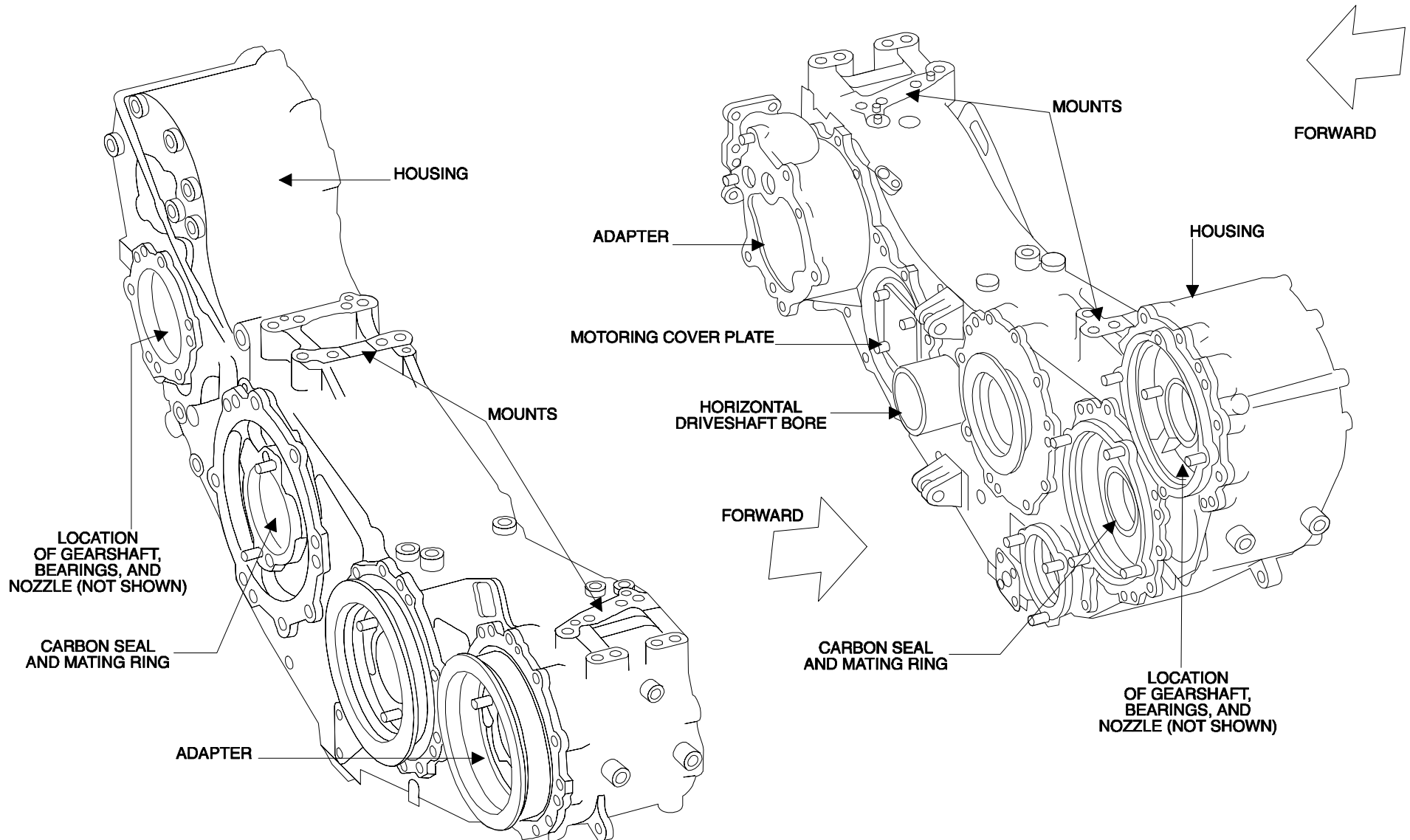
The accessory gearbox assembly consists of a one piece, cast aluminum, casing, aluminum adapters, spur gears and associated bearings, seals and oil jets.

The gearbox design features a "plug in" gear concept on all accessory pads and idler gears. With this concept, an entire gear, seal and pad assembly may be removed and replaced without otherwise disassembling the gearbox.

The accessory pads incorporate female splines to accept accessory quill shafts and Quick Attach/Detach (QAD) connections to facilitate accessory removal/installation.

Internal oil jets provide lubrication of the gears and bearings. All gearbox seals, which are carbon face seals, are retained from the outside of the gearbox and can be replaced without teardown of the gear box.

The accessory drives are mounted on the accessory pads. To facilitate borescope inspection of core rotor, it can be rotated manually or by a drive motor via the accessory gearbox. The drive adapter is accessed by removing a cover plate on the accessory gearbox.



FQW4200 GE Metric

STUDENT NOTES

FQW4200 GE Metric

WARNINGS (ENGINE)

CTL SYS FAULT
BLEED STATUS FAULT
ENG FAIL
ENG SHUT DOWN
T.O THRUST DISAGREE
REDUCED THR NOT SET
ALL ENG FLAME OUT

CTL SYS FAULT

An engine transient limitation is requested due to any of the following reasons :

- There is a torque motor wrap fault either on a Variable Bleed Valve (VBV), or Variable Stator Vane (VSV), or Fuel Metering Valve (FMV), or the VBV operates on a failsafe value, and the Electronic Control Unit (ECU) channel indicating one of the above faults is active. - Or there is a confirmed disagreement between the position and the demand for the VBV, VSV, or FMV loops. There is a risk of engine blow out or surge.

BLEED STATUS FAULT

The ENG 1 bleed status is faulty. The Electronic Control Unit (ECU) does not receive the bleed status ARINC label from the Engine Interface and Vibration Monitoring Unit (EIVMU).

ENG FAIL

ENG 1 is not running for more than 30 seconds with :

- ENG 1 master lever ON.
- ENG 1 fire pushbutton not released out.
- ENG 1 start sequence not active.

ENG SHUT DOWN

ENG 1 was shut down :

- In flight with the ENG 1 master lever set to OFF.
- Or on ground with the ENG 1 FIRE pushbutton released out.

T.O THRUST DISAGREE

This appears when the take-off power is set, if each engine Electronic Control Unit (ECU) has not selected the same take-off mode. (ex:(D01) derated take-off N.1)

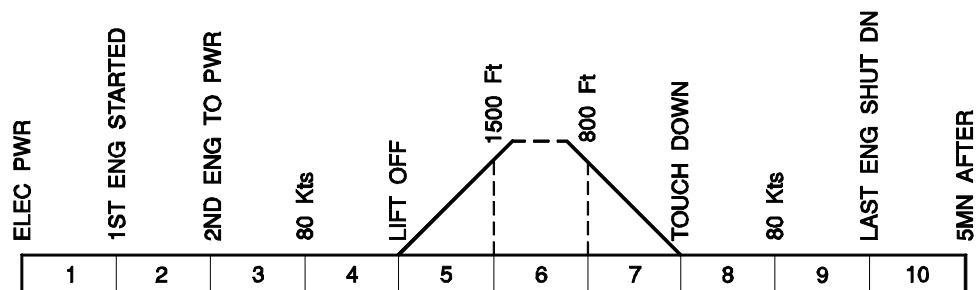
REDUCED THR NOT SET

This appears when the take-off power is set, if at least one engine Electronic Control Unit (ECU) has selected a limit mode which is not in accordance with the thrust lever position :

- Max TOGA limit mode selected with thrust lever in MCT position.
- Or Derated take-off limit mode selected with thrust lever in TOGA position.

AL ENG FLAME OUT

This appears in flight in case of four engines flame out.



E/WD : FAILURE TITLE	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLT PHASE INHIB
CTL SYS FAULT	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 5, 7, 8
BLEED STATUS FAULT	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 5, 7, 8
ENG FAIL	SINGLE CHIME	MASTER CAUT	NIL	NIL	NIL
ENG SHUT DOWN	SINGLE CHIME	MASTER CAUT	NIL	NIL	NIL
T.O THRUST DISAGREE	SINGLE CHIME	MASTER CAUT	NIL	NIL	1, 4, 5, 6, 7, 8, 9, 10
REDUCED THR NOT SET	SINGLE CHIME	MASTER CAUT	NIL	NIL	1, 4, 5, 6, 7, 8, 9, 10
ALL ENG FLAME OUT	CONTINUOUS REPETITIVE CHIME	MASTER WARN	NIL	NIL	1, 2, 3, 4, 8, 9, 10

STUDENT NOTES

FUEL SYSTEM PRESENTATION

Main fuel pump
Fuel/oil heat exchanger
Fuel filter
Hydromechanical Unit
Fuel nozzles
Servo fuel heater
IDG oil cooling
Fuel control
Fuel monitoring

MAIN FUEL PUMP

Fuel, from the aircraft tanks, passes through the two stage main fuel pump mounted on the accessory gearbox. It is then sent to the main fuel/oil heat exchanger.

FUEL/OIL HEAT EXCHANGER

The fuel/oil heat exchanger is attached to the bottom of the main fuel pump. It receives fuel from the high pressure stage of the main fuel pump. The fuel enters and flows through the main fuel/oil heat exchanger to prevent fuel icing and provide engine oil cooling. The fuel then re-enters the main fuel pump on route to the fuel filter.

FUEL FILTER

The fuel filter is attached to the outboard side of the main fuel pump. It receives fuel coming from the main fuel oil heat exchanger. The fuel flows through a disposable filter element and then re-enters the main fuel pump on route to the Hydromechanical Unit. In addition, a small amount of filtered fuel is sent from the fuel filter, directly to the servo fuel heater.

HYDROMECHANICAL UNIT

The HMU is provided with an HP shut off valve, controlled from the master lever in the cockpit, for positive control over engine shut down. The accessory gearbox mounted Hydromechanical Unit receives fuel from the main fuel filter. It meters and distributes the proper amount of fuel needed for combustion thanks to signals from the Electronic Control Unit. The Hydromechanical Unit also receives fuel from the servo heater. This fuel is used to position the Variable Stator vane actuators and Variable Bleed Valve actuators in response to Electronic Control Unit commands. This same servo fuel is also used to position the High Pressure Turbine and Low Pressure Turbine Clearance Control valves and the Fuel Metering Valve.

FUEL NOZZLES

The 30 nozzles are equally spaced around the circumference of the compressor rear frame. There are 28 standard and 2 relight nozzles.

SERVO FUEL HEATER

The servo fuel heater provides additional heating for the fuel that will be used in servo sections.

IDG OIL COOLING

Hydromechanical Unit bypass and servo return fuel flows through the Integrated Drive Generator fuel/oil heat exchanger to provide Integrated Drive Generator oil cooling. The fuel is then returned to the main fuel pump interstage.

FUEL CONTROL

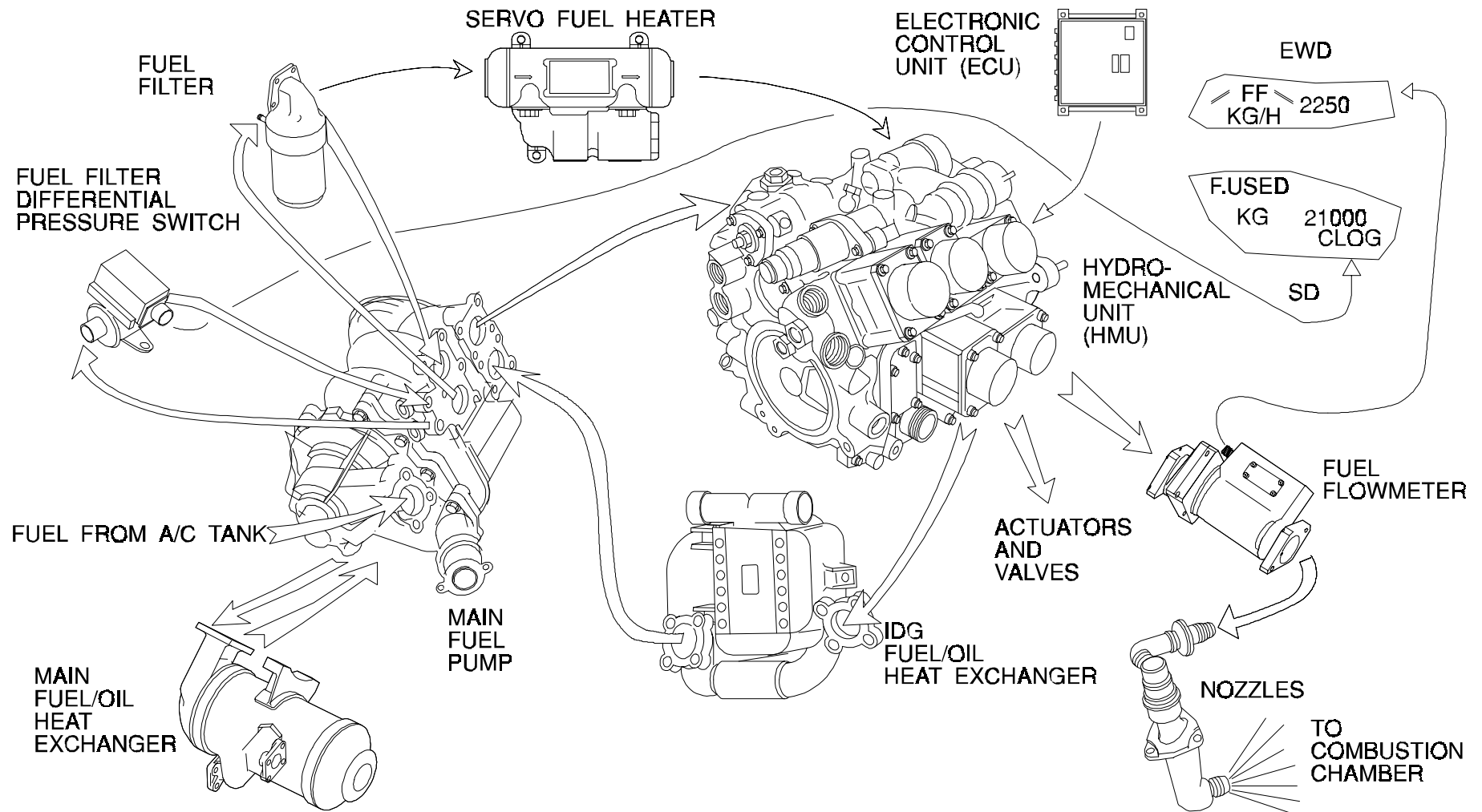
Based upon engine sensors and aircraft data, the Electronic Control Unit commands the dual torque motor controlled fuel metering valve which regulates the fuel needed for combustion.

As an additional protection, in case of excessive uncontrolled fuel flow, a mechanical overspeed governor causes additional fuel to be bypassed back to the main fuel pump.

FUEL MONITORING

The following fuel system parameters are shown on the ECAM :

- Fuel flow as indicated by the fuel flowmeter ;
- Fuel filter clogging as monitored by the fuel filter differential pressure switch.



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STUDENT NOTES:

FUEL SYSTEM D/O

FUEL FEED

- Tank and LP Valve
- Main Fuel Pump
- Fuel Filter

H.M.U.

- Servo Control Circuit
- Fuel Metering Circuit
- Bypass Circuit

FUEL SUPPLY

- Fuel Flow Meter
- Fuel Manifold
- Fuel Nozzles

OPERATION

- ECU Fuel Scheduling
- Control
- Operation
 - Starting Sequence
 - Engine Shut Down
- Monitoring

FUEL FEED

TANK AND LP VALVE

Fuel from the aircraft tanks is supplied to the engines via a fuel tank pump and a Low Pressure shut off valve.

MAIN FUEL PUMP

The Main Fuel Pump consists of a boost stage, an interstage strainer, a High Pressure relief valve and a High Pressure gear stage.

Pressurized fuel is ducted to the main fuel filter via the main fuel/oil heat exchanger.

FUEL FILTER

The High Pressure fuel filter consists of a disposable paper filter element, a wash screen and a bypass valve.

Filtered fuel is sent to the HMU to be used as servo fuel for operating VSV, VBV, LPTACC, HPTACC actuators and Fuel Metering Valve (FMV); it is also sent to be used as engine fuel for combustion.

H.M.U.

SERVO CONTROL CIRCUIT

The Hydromechanical Unit comprises 5 Electro-Hydraulic Servo Valves which convert electrical signals from the ECU into servo fuel signals for positioning VSV, VBV, LPTACC, HPTACC actuators and Fuel Metering Valve.

EHSV : Electro-Hydraulic Servo Valve.

FUEL METERING CIRCUIT

The fuel metering circuit is composed of a Fuel Metering Valve and a Pressurizing and Shut Off Valve.

Under ECU demand, the Fuel Metering Valve determines the section of the delivery orifice for supplying metered engine fuel to the Pressurizing and Shut Off Valve (PSOV).

The Pressurizing and Shut Off Valve ensures that servo pressure is sufficient before engine starting and during low flow conditions.

It also acts as fuel shut off valve at engine shut down.

The PSOV is controlled by the shut off solenoid and servo fuel operated.

BYPASS CIRCUIT

The bypass circuit consists of a servo fuel operated bypass valve controlled either by a Delta Pressure Regulator or by an Overspeed Governor.

It enables unmetered fuel, that exceeds the metered fuel supply requirement of the Fuel Metered Valve, to be bypassed between the stages of the Main Fuel Pump.

The Delta Pressure Regulator regulates a constant drop across the FMV by controlling bypass flow in order to ensure that metered fuel flow is proportional to the FMV position.

The Overspeed Governor is a hydromechanical device that limits core engine overspeeds to 113.4 % by overriding Delta Pressure Regulator function.

The Overspeed Governor (OSG) is active in case of ECU/HMU fuel metering circuit failure and is tested during the start sequence by the ECU.



FUEL SUPPLY

FUEL FLOW METER

The Fuel Flow Meter generates electrical pulses to the ECU which provides the ECAM with a signal proportional to the mass fuel flow.

The unit is electrically self energized when driven by the fuel flow.

FUEL MANIFOLD

The manifold provides protection from fire due to leaking fuel couplings by incorporating shrouded couplings and shrouded drains.

It is divided into two independent halves which supply 15 fuel nozzles each.

FUEL NOZZLES

Each nozzle is fitted with a check valve designed to block fuel flow at engine shut down according to fuel pressure and so to prevent the manifold from draining into the combustor.

Of the 30 nozzles, 28 are standard and 2 special altitude relight nozzles.

The latter are located at the 6 o'clock position of the compressor rear frame and provide a higher primary fuel flow.

STUDENT NOTES

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OPERATION

ECU FUEL SCHEDULING

Fuel flow is scheduled as a function of ambient conditions (TAT, PT, P0), engine operating conditions(PS3, T25, N2, N1) , power setting (TRA) and external system demands (Environmental Control System, Anti-Ice System).

According to these parameters, the ECU determines a FMV position and monitors the command (CMD) thanks to feedback signals (FB) from the FMV resolvers.

CONTROL

The Master Lever sends directly a 28 Volts DC signal to the shut off solenoid to close the PSOV for engine shut down.
This signal overrides any ECU demand.
When de-energized, the shut off solenoid is spring loaded to enable PSOV opening.

The FIRE pushbutton controls the LP shut off valve to the closed position in order to isolate the engines from aircraft tanks.

OPERATION

Starting Sequence

When the Master Lever is set to ON and core speed reaches 15 %, the ECU controls the Fuel Metering Valve to open which results in the loss of upstream pressure in the closing chamber of the PSOV.

As the start cycle continues and increased flow is scheduled by the FMV, the PSOV begins to open when metered fuel pressure overcomes combined forces of spring and servo pressure.
After start up, metered fuel pressure moves the PSOV completely out of the flow stream.

Engine Shut Down

The Master Lever, set to OFF, sends a 28 Volts DC signal to the shut off solenoid which routes servo pressure to the closing chamber of the PSOV and also to the bypass valve to increase bypass flow.

As fuel pressure decreases, spring tension and servo fuel pressure close the PSOV.

With N2 below idle, Master Lever off and PSOV closed, the ECU controls the FMV to the fully closed position, which enables upstream fuel pressure to latch the PSOV in closed position.

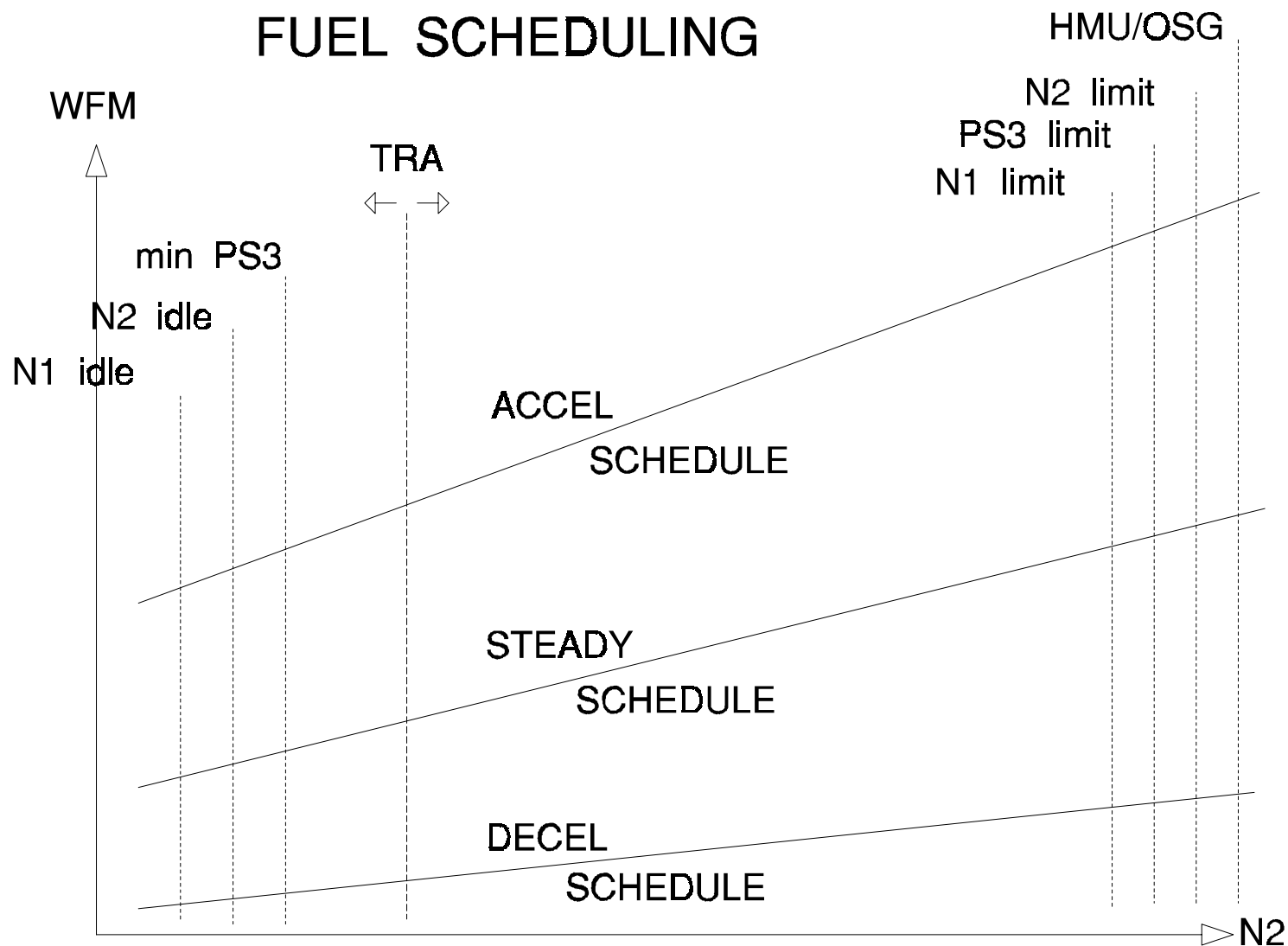
MONITORING

The Fuel Filter Delta Pressure Switch monitors the difference of fuel filter inlet and outlet pressure.

At approximately 23 PSI, the switch will close, sending a signal to the ECU for displaying the clogging information on the ECAM.

According to the fuel flow signal (WFM), the ECU calculates a fuel flow and a total fuel used value for displaying on the ECAM.

FUEL SCHEDULING



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STUDENT NOTES:

FQW4200 GE Metric

HEAT MANAGEMENT SYSTEM DESCRIPTION/OPERATION

General
Description
Operation

GENERAL

The Integrated Drive Generator (IDG) has a self contained independent lubrication system. The purpose of the IDG cooling system is to keep the IDG oil temperature within limits.

The IDG oil cooling system contains the following engine mounted items :

- IDG air/oil cooler and control valve
- IDG fuel/oil heat exchanger
- IDG oil inlet temperature sensor.

DESCRIPTION

The lubrication oil exits the IDG and flows through the IDG air/oil cooler. The oil then flows through the fuel/oil heat exchanger over the IDG inlet temperature sensor and back into the IDG.

The IDG cooling valve receives booster or fan discharge air from the fan frame area. The air flows through the valve and into the manifold which carries it to the air/oil cooler. The air then exhausts overboard into the airstream through the gearbox and core vents.

The IDG air/oil cooler is equipped with a bypass valve for cold weather operation or if the cooler becomes clogged. The valve is spring loaded to the open position.

OPERATION

The IDG cooling valve is controlled by the ECU based on IDG oil inlet temperature and fuel temperature. If oil or fuel temperature gets too high the ECU will de-energize the valve solenoid shutting off 11th stage bleed air which will open the valve.

Two inputs are provided to the valve :

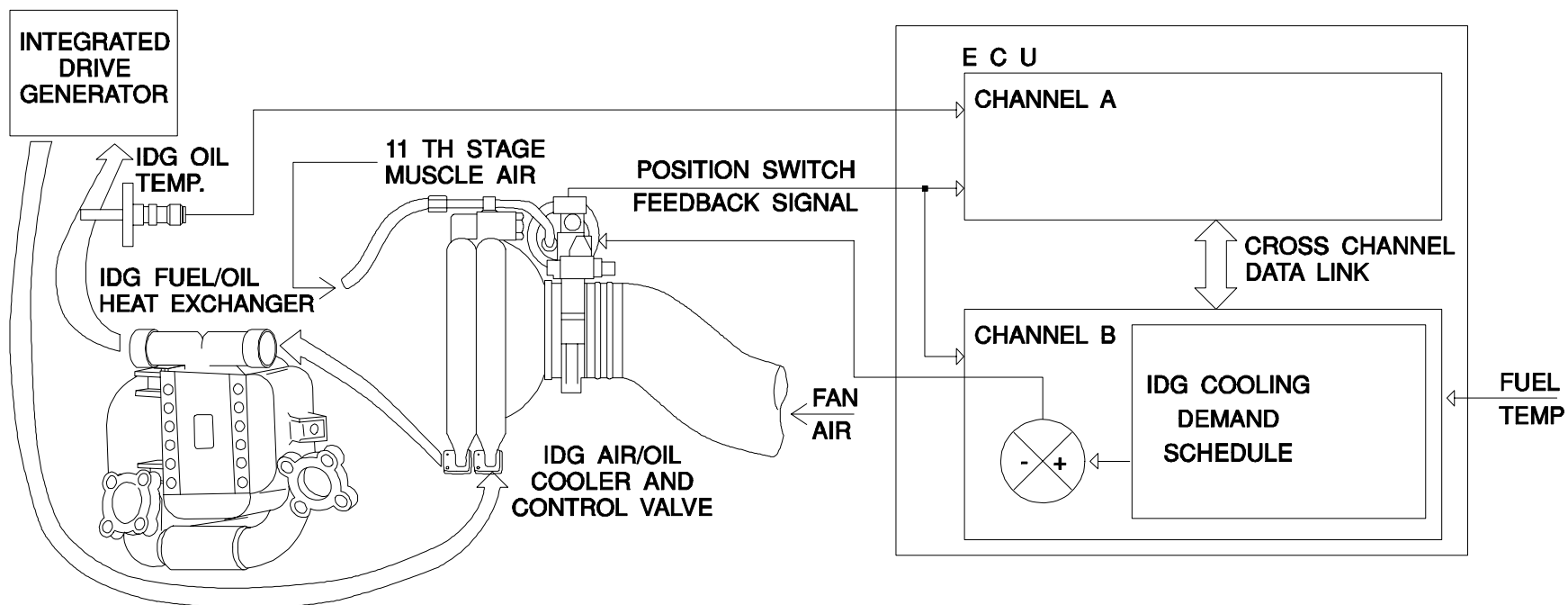
- a electrical signal from the ECU
- an eleventh stage air actuation pressure.

The valve position is feedback to the ECU by a switch that closes when the valve is closed.

The ECU senses IDG oil temperature and fuel temperature and will open the valve if : temperature fuel 177°C (350°F) or temperature IDG oil 127°C (260°F). The valve will remain open until sensed fuel temperature and IDG oil temperature falls below 149°C (300°F) and 104°C (219°F) respectively.

In normal operation, fuel and oil temperature within limits, the valve position depends of the pressure of eleventh stage bleed air.

When the solenoid valve is energized, oil and fuel temperature within limits, the valve will close by 50 psig increasing air pressure and will open by 35 psig decreasing air pressure. When the solenoid is de-energized, the valve remains open at all air pressures.



11TH STAGE PRESSURE	< 35 PSI	> 50 PSI	ALL
SOLENOID VALVE	ENERGIZED	ENERGIZED	DE-ENERGIZED
VALVE POSITION	OPEN	CLOSE	OPEN

STUDENT NOTES:

FUEL SYSTEM COMPONENTS

Safety Precautions
Fuel filter

SAFETY PRECAUTIONS

- Do not start the engine.
- Make sure that the engine has been shot down for at least 5 minutes.
- Make sure that the ENG FADEC GND PWR P/B is off.
- Make sure that the master lever is in the off position.

STUDENT NOTES

FUEL FILTER

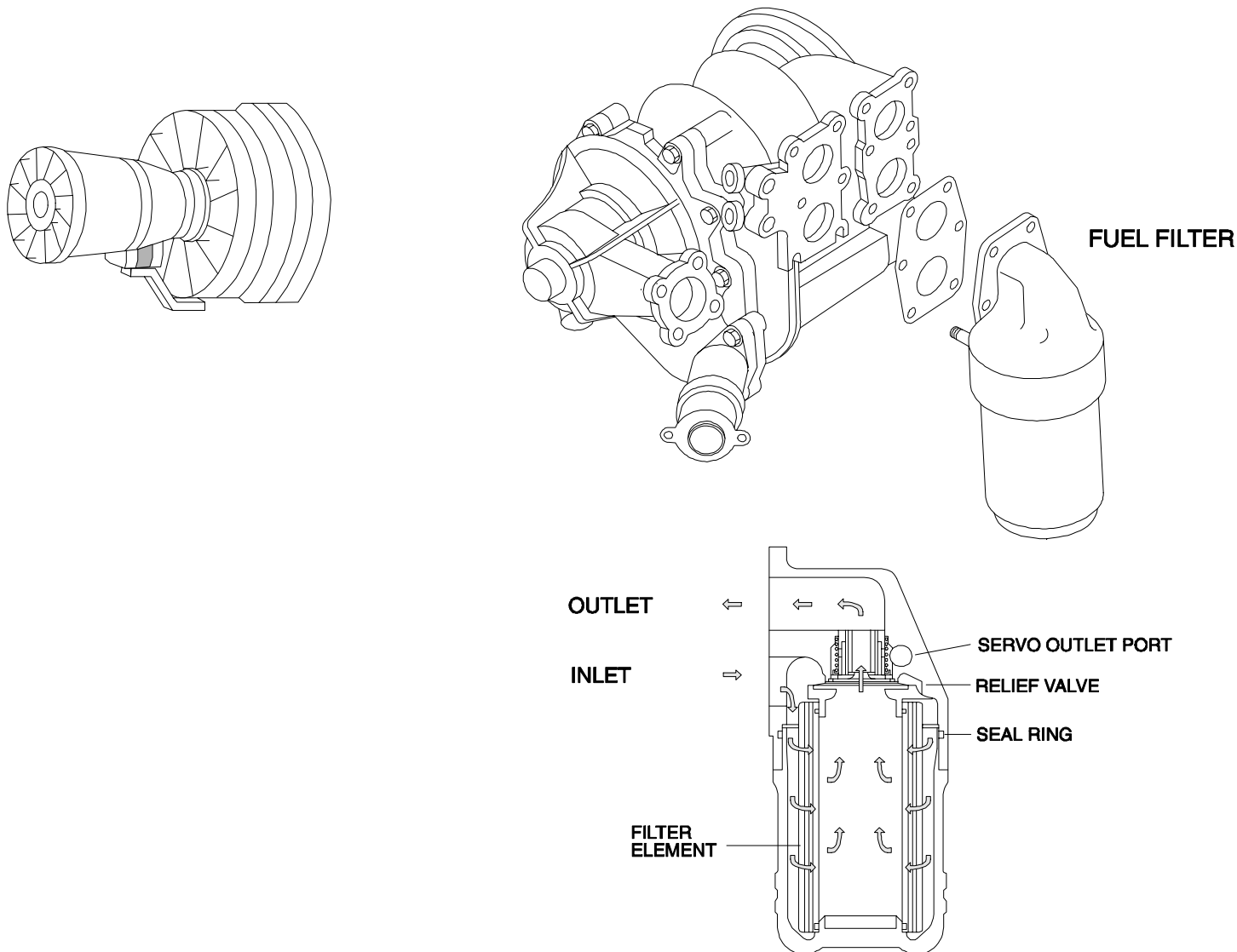
FIN / ZONE

FIN : 5051 EB.

Zone : 412 / 422.

COMPONENT DESCRIPTION

The fuel filter is used to remove contaminants from the engine fuel. It has a removable filter bowl and a disposable filter element. The fuel filter is equipped with a bypass valve should the filter element become clogged.



STUDENT NOTES

FUEL SYSTEM COMPONENTS

- Safety Precautions
- Fuel Pump
- Fuel Nozzles
- Fuel Temperature Sensor
- Servo Fuel Heater
- HMU
- Fuel Flowmeter
- Fuel Filter Differential Pressure Switch
- Shut Off Solenoid
- IDG Fuel Oil Heat Exchanger
- IDG Air/Oil Cooling Valve
- IDG Air/Oil Cooler
- IDG Oil In Temperature Sensor

SAFETY PRECAUTIONS

- Do not start the engine.
- Make sure that the engine has been shut down for at least 5 minutes.
- Make sure that the ENG FADEC GND PWR P/B is off.
- Make sure that the master level is in the off position.

STUDENT NOTES

FUEL PUMP

FIN / ZONE

FIN : 5050 EB

Zone : 412 - 422

COMPONENT DESCRIPTION

The main fuel pump is shaft driven by the accessory gearbox.

Fuel from the aircraft passes through the boost stage, inlet strainer and high pressure gear stage of the pump.

REMOVAL INSTALATION

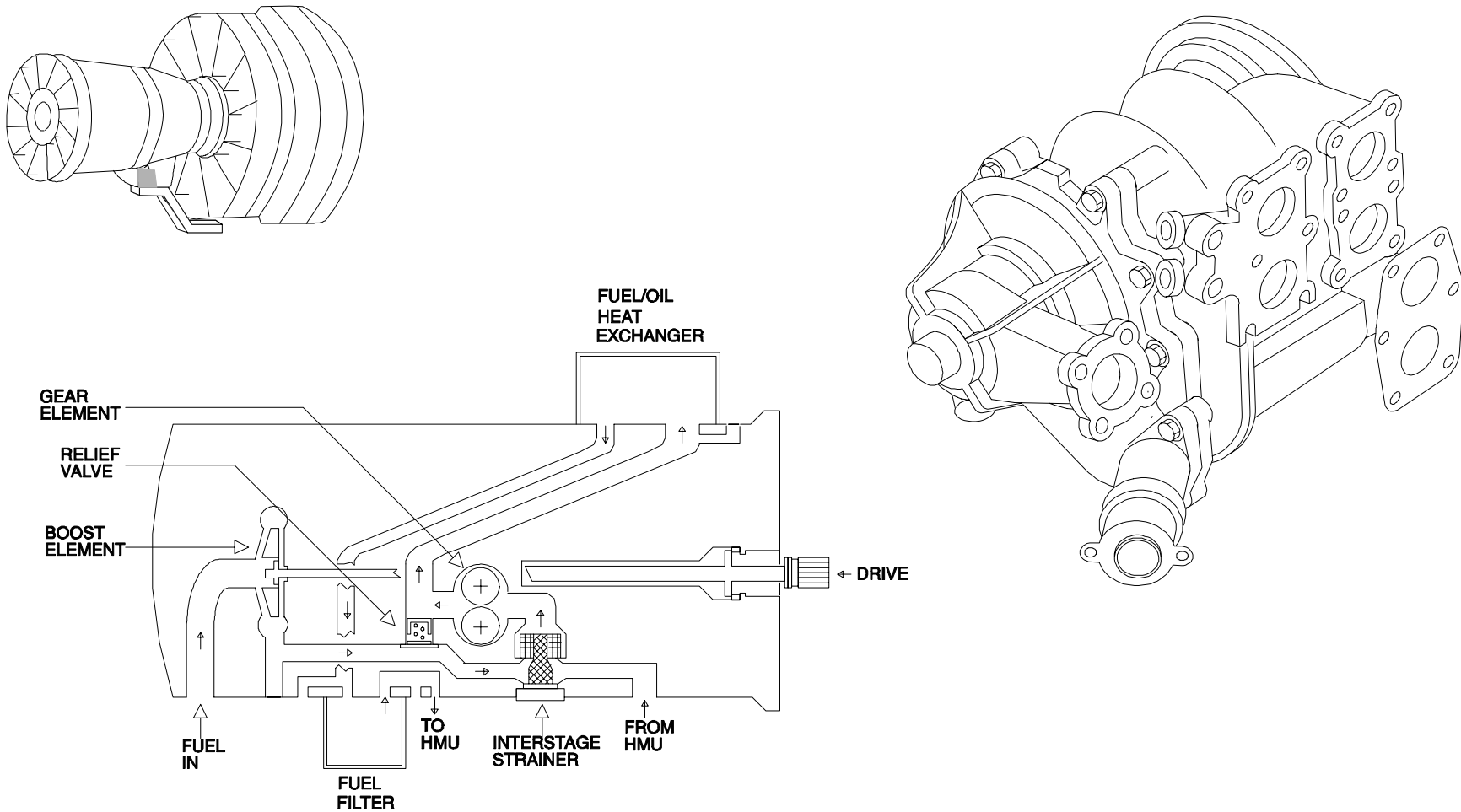
Before removal of the fuel pump, remove the fuel filter housing, the main fuel/oil heat exchanger.

SAFETY PRECAUTIONS

WARNING : BE CAREFUL when you remove the fuel pump.

The fuel pump weighs 43 LBS (19.5 kg) and can cause injury.

WARNING : do not let the weight of the fuel pump be on the splines of the drive shaft. Hold the fuel pump perpendicular to the accessory gearbox to prevent damage to the splines of the drive shaft.



FQW4200 GE Metric

FUEL NOZZLES

FIN / ZONE

FIN : 5020 EB

Zone : 413 - 423

COMPONENT DESCRIPTION

The 30 fuel nozzles are equally spaced around the circumference of the compressor rear frame.

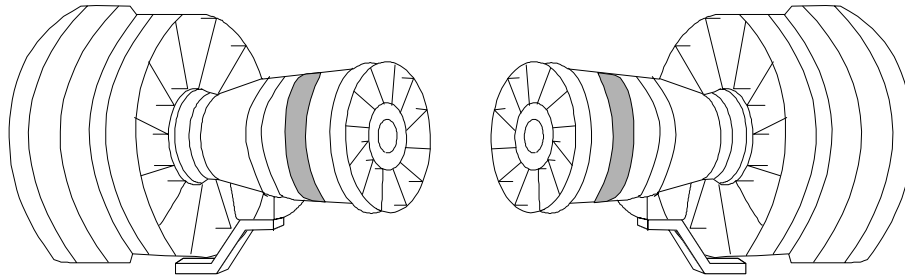
Each nozzle provides a primary and secondary flow spray pattern.

The primary circuit is used during start and low power. The secondary circuit provides additional flow at high power.

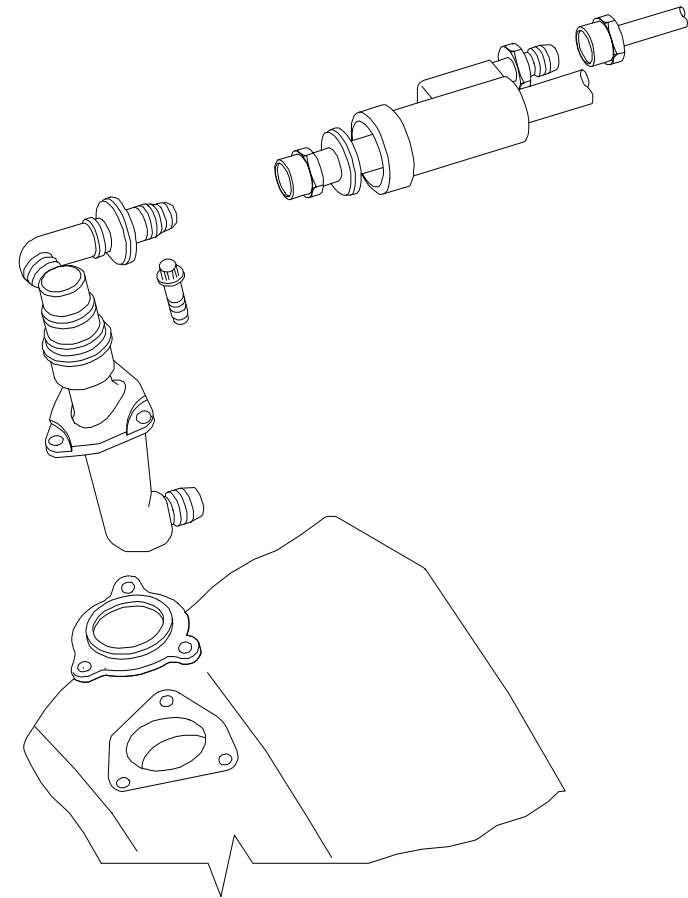
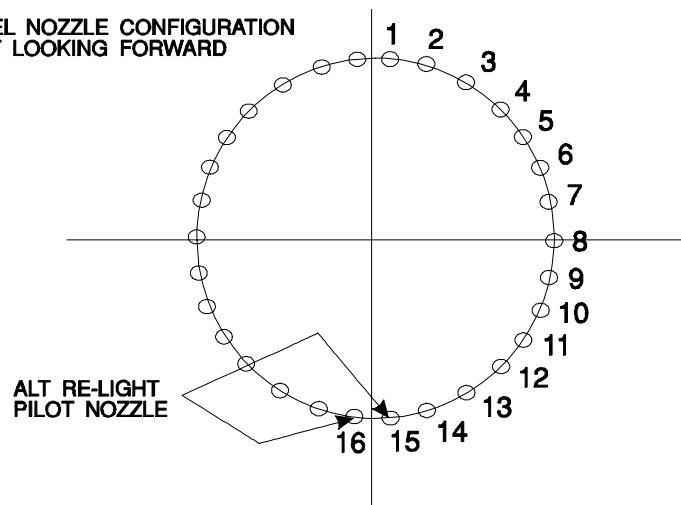
Each nozzle has a check valve that will close at engine shut down to prevent the manifolds from draining into the combustor.

There are 28 standard nozzles and 2 relight nozzles.

The relight nozzles have a higher fuel flow primary circuit and are installed at the 6:00 position of the compressor rear frame.



FUEL NOZZLE CONFIGURATION
AFT LOOKING FORWARD



FUEL TEMPERATURE SENSOR

FIN / ZONE

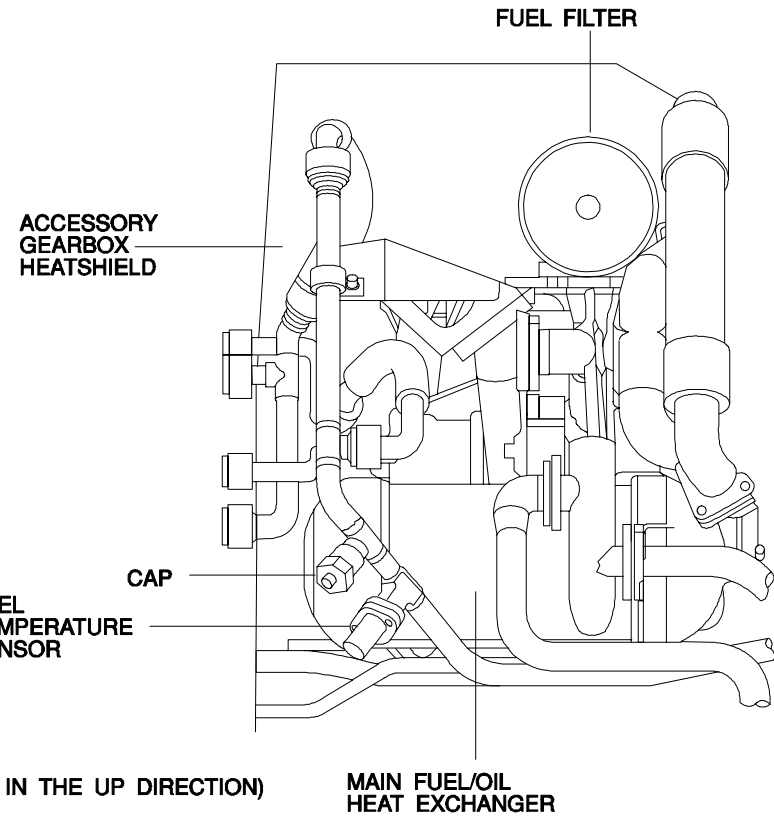
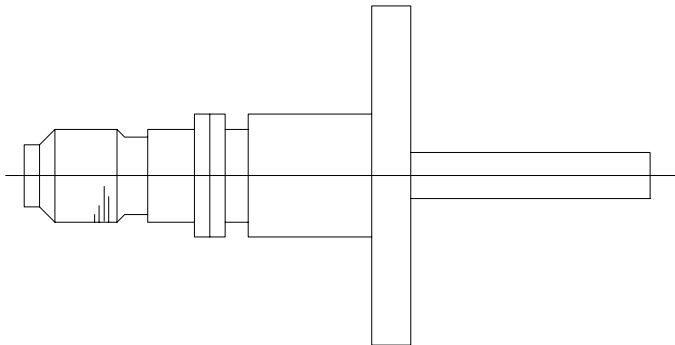
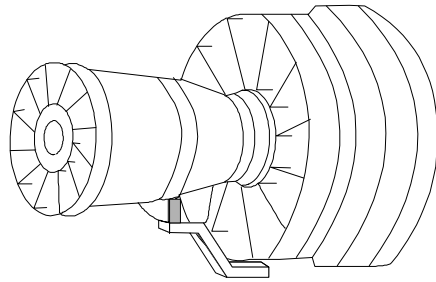
FIN : 4018 KS

Zone : 412 - 422

COMPONENT DESCRIPTION

The fuel temperature sensor is a thermocouple type device.

Its output varies as the temperature of the fuel passing over it changes.



(VIEW IN THE UP DIRECTION)

SERVO FUEL HEATER

FIN / ZONE

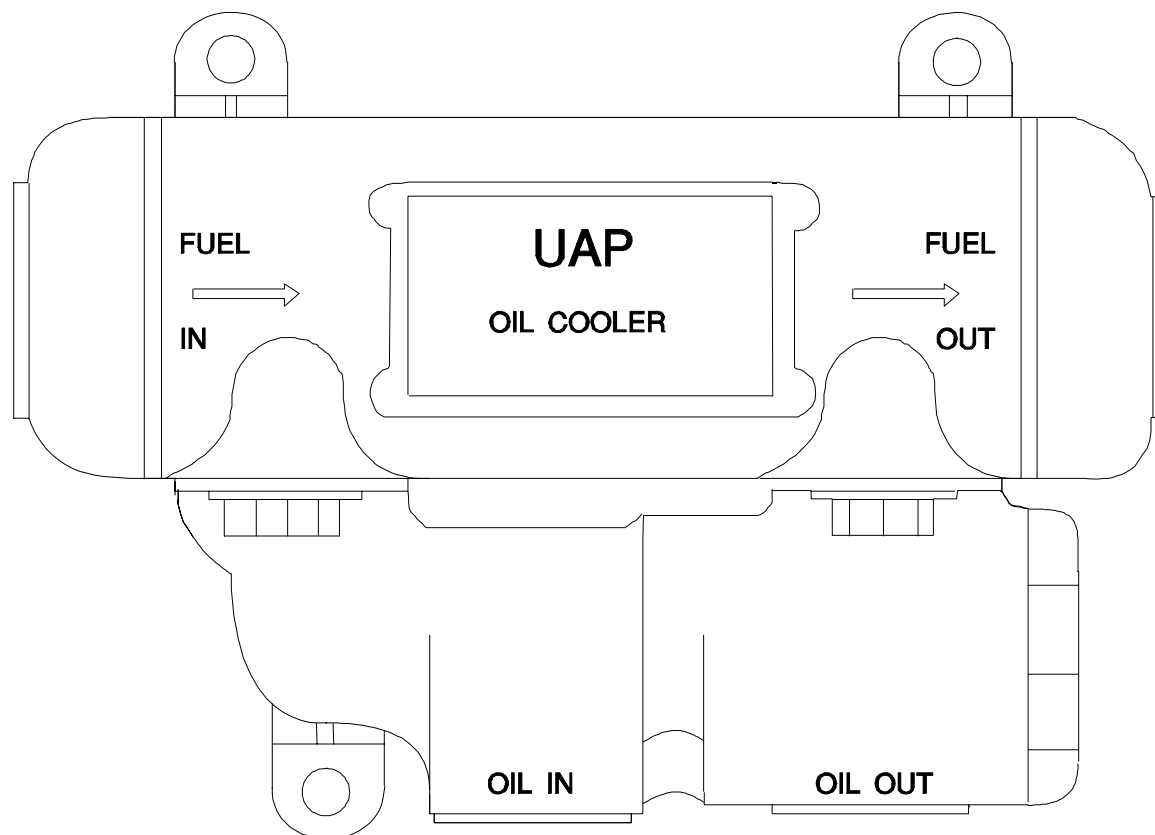
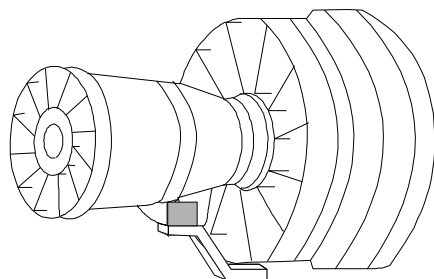
FIN : 5010 EB

Zone : 412 - 422

COMPONENT DESCRIPTION

The servo fuel heater is a tube type fuel/oil heat exchanger.

It is equipped with an oil bypass valve for cold weather or if the heater becomes clogged.



FQW4200 GE Metric

HMU

FIN / ZONE

FIN : 4000 KC

Zone : 412 - 422

COMPONENT DESCRIPTION

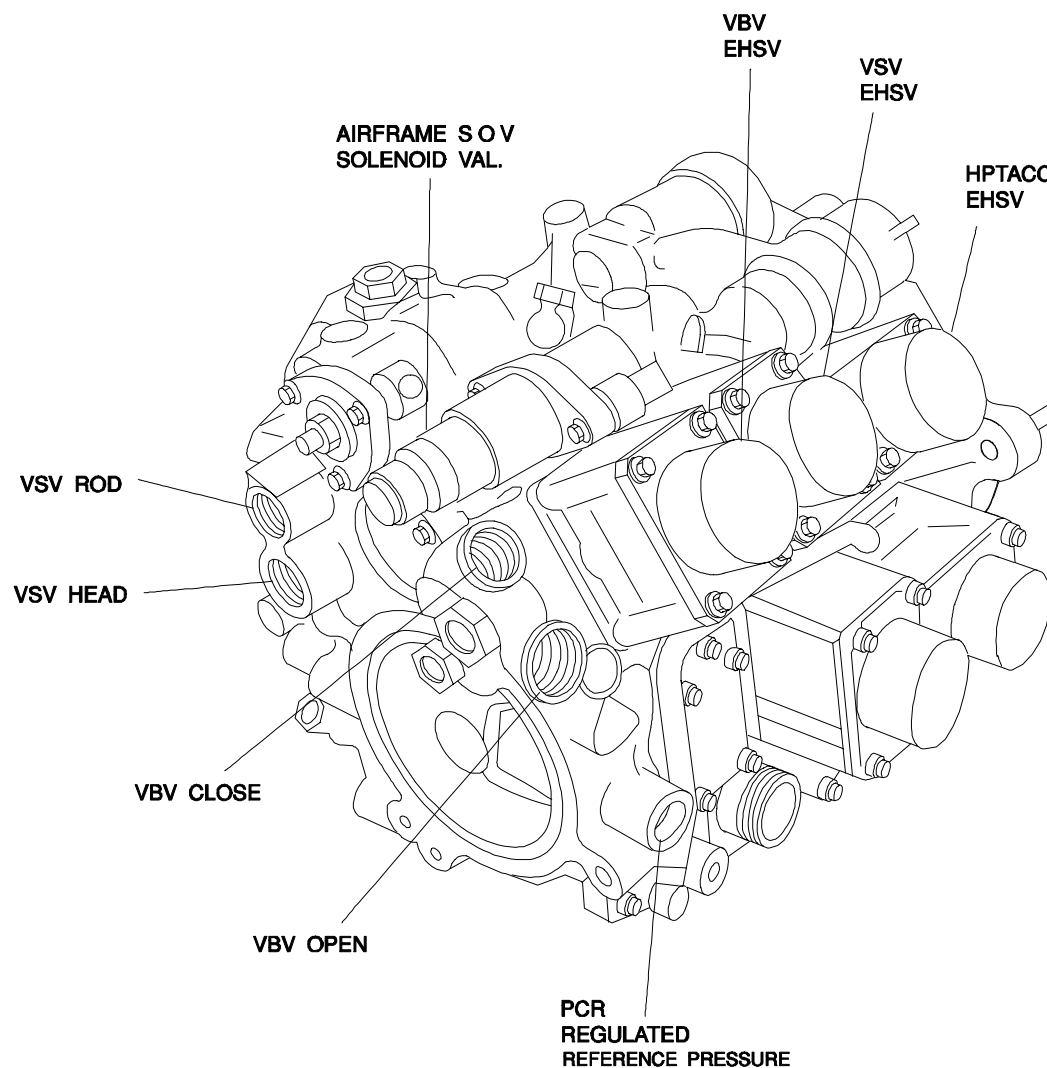
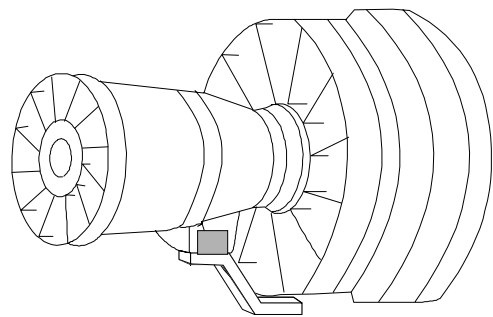
The HMU (Hydromechanical unit) meters and distributes the proper amount of fuel needed for combustion and provides the servo fuel to position the actuators and valves of other engine systems.

SAFETY PRECAUTIONS

WARNING : Be careful when you remove the HMU.

The HMU weighs 53 pounds (24 kg) and can cause injury to you if you hold its weight.

CAUTION : The HMU must be held correctly when you remove it : damage can occur to the drive splines of the HMU or to the drive gear of the accessory gearbox.



FQW4200 GE Metric

FUEL FLOWMETER

FIN / ZONE

FIN : 4010 KS

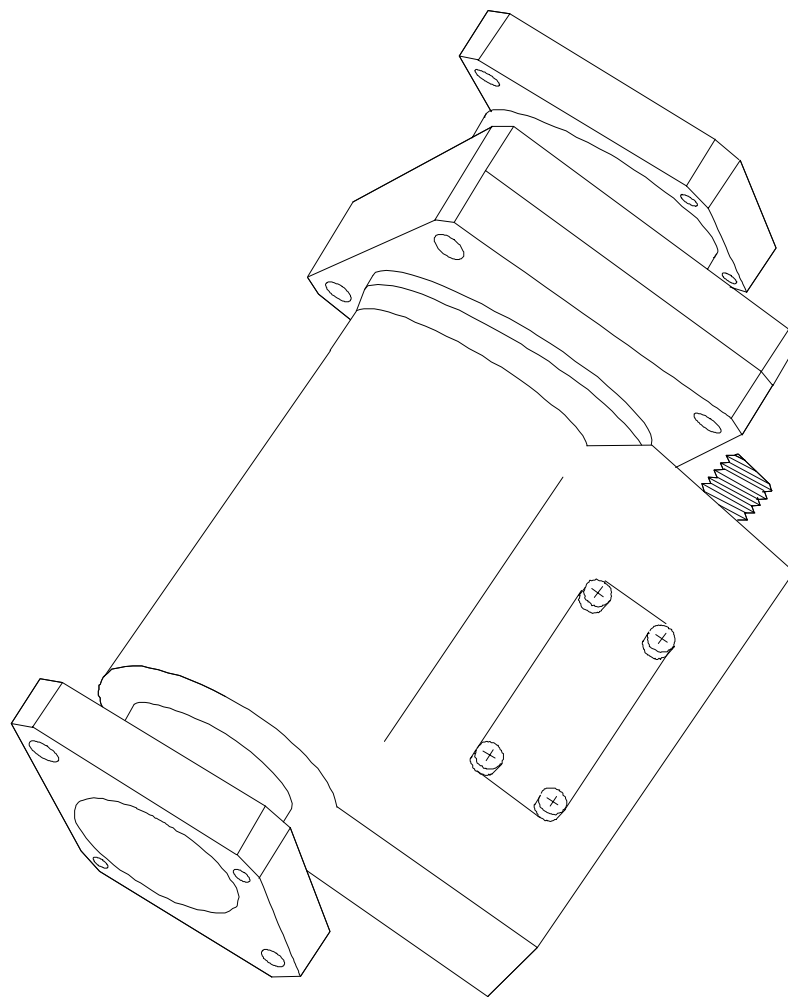
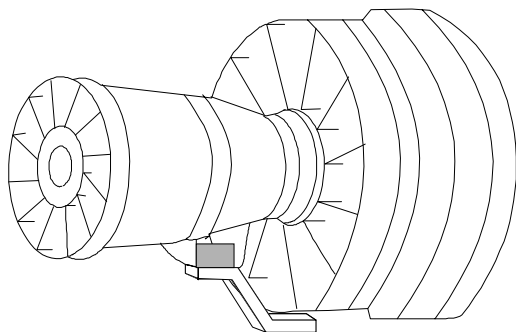
Zone : 412 - 422

COMPONENT DESCRIPTION

The mass flowmeter provides the correct amount of fuel to the combustor. It sends electrical pulses, produced by magnets on the rotor and sensing coils in its housing, to the ECU. The time difference of the pulses corresponds to the amount of fuel flow.

SAFETY PRECAUTIONS

WARNING : You must hold the fuel flowmeter during the removal of the attachment bolts. The fuel flowmeter will cause injury to you and damage to the fuel flowmeter, if it falls.



FQW4200 GE Metric

FUEL FILTER DIFFERENTIAL PRESSURE SWITCH

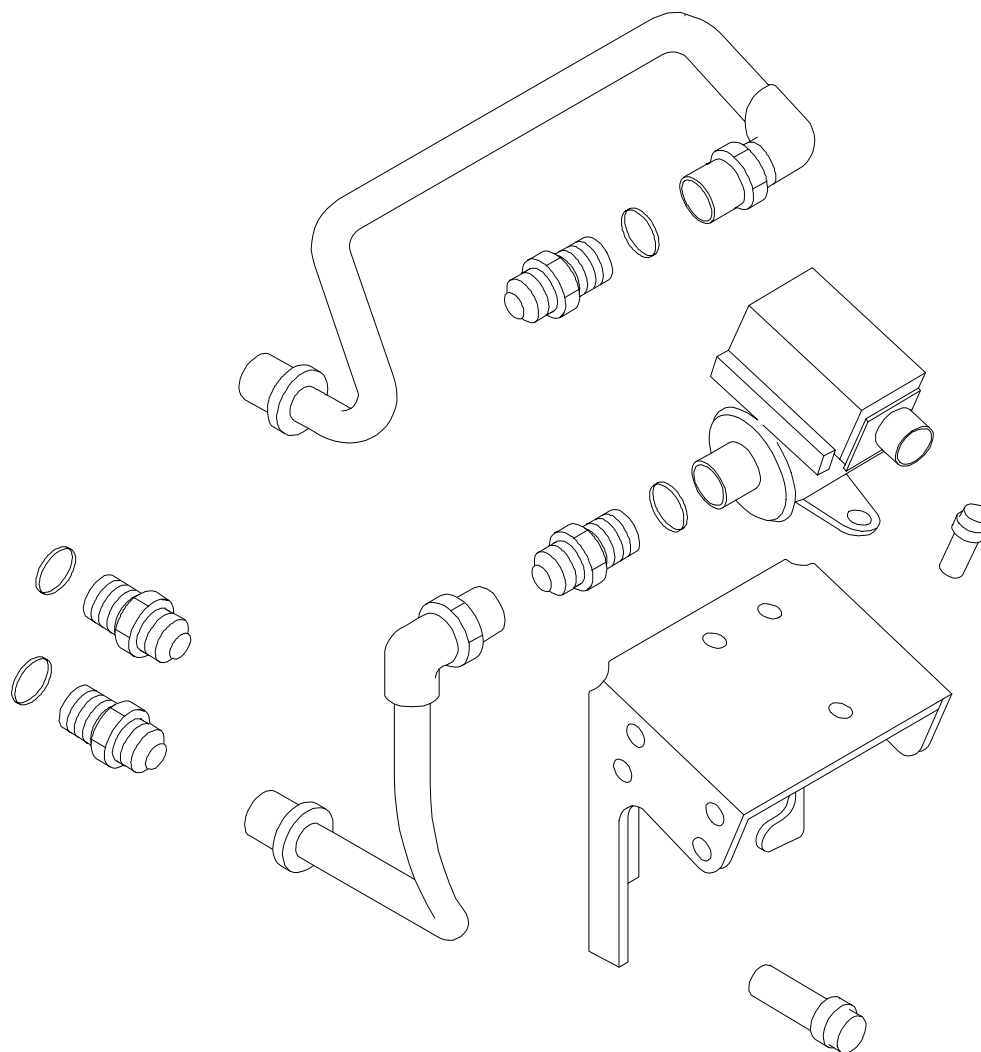
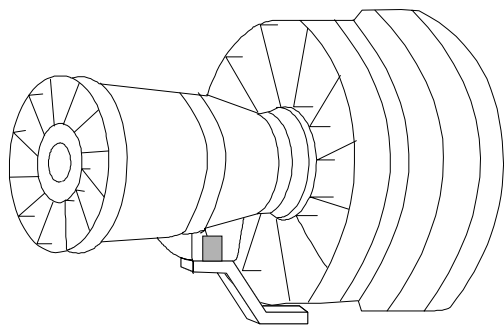
FIN / ZONE

FIN : 4034 KS

Zone : 412 - 422

COMPONENT DESCRIPTION

The fuel filter differential pressure switch monitors the differential of the fuel inlet and outlet pressure. At approximately 23 psid the switch contacts will close.



FQW4200 GE Metric

SHUT OFF SOLENOID

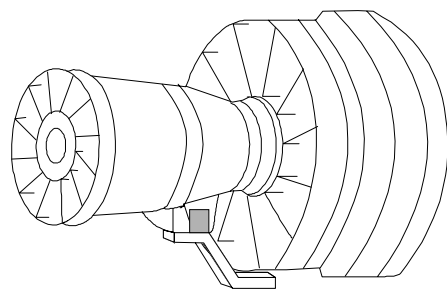
FIN / ZONE

Zone : 412 - 422

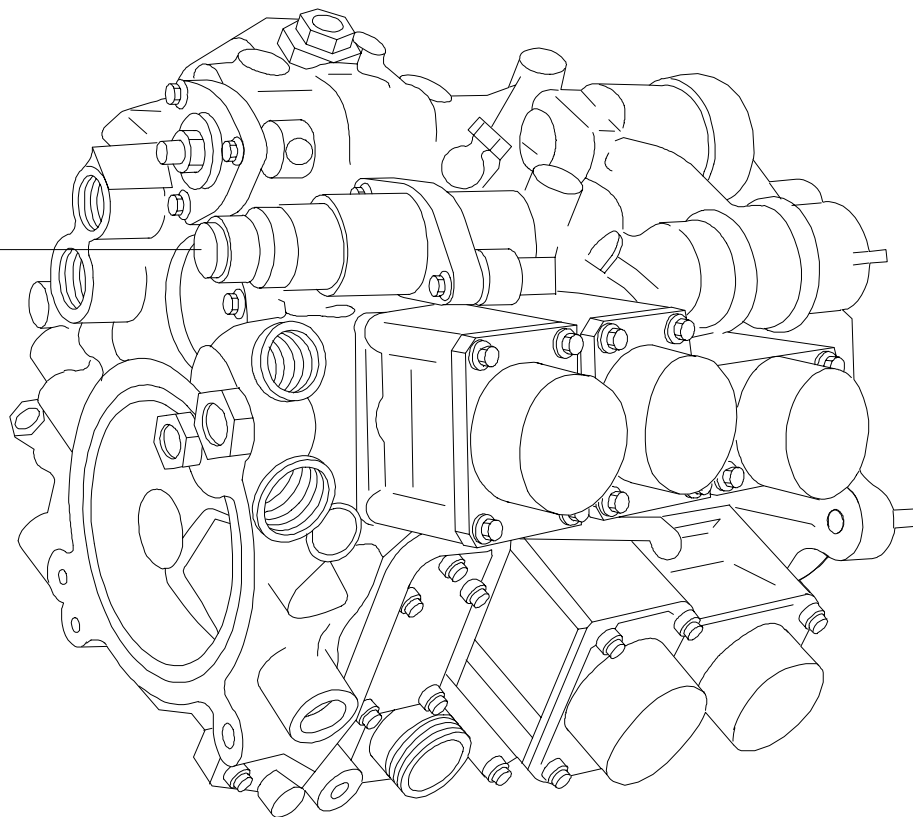
COMPONENT DESCRIPTION

The shut off solenoid is a spring loaded plunger that interfaces with the HMU.

When 28 VDC is applied to the solenoid it retracts its plunger and allows high pressure fuel to be sent to the high pressure shut off valve, forcing it to close. This blocks all fuel flow to the engine which results in shutdown.



SHUT OFF
SOLENOID



IDG FUEL OIL HEAT EXCHANGER

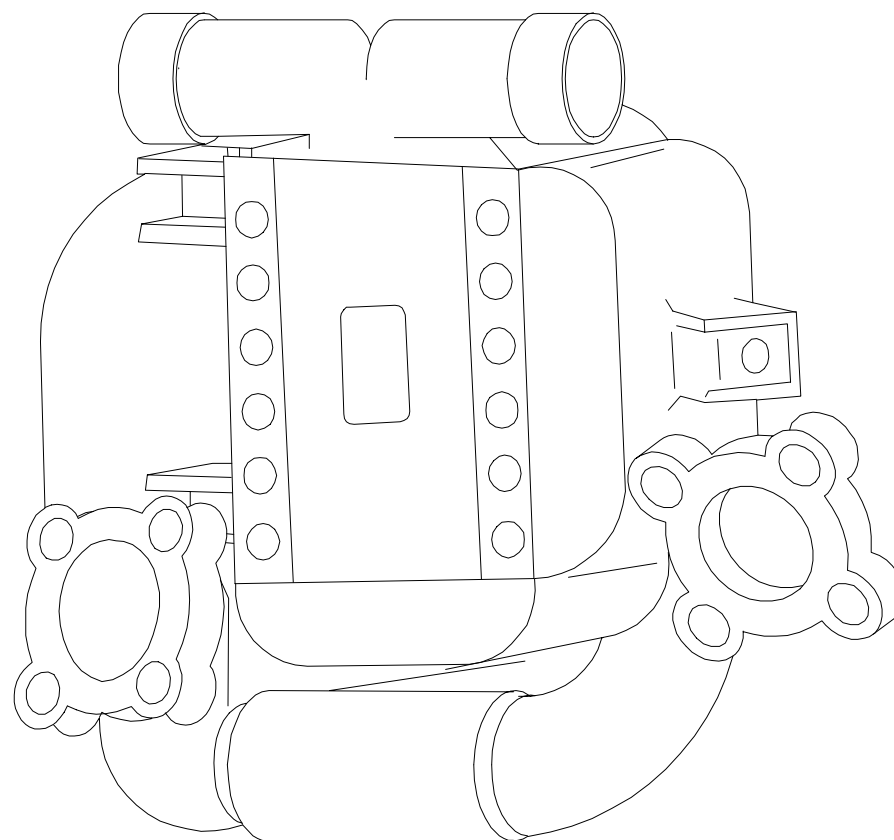
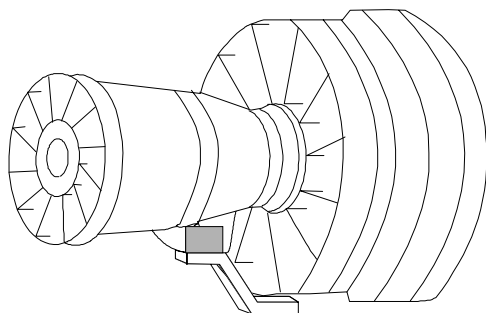
FIN / ZONE

FIN : 5030 EB

Zone : 412 - 422

COMPONENT DESCRIPTION

The IDG fuel/oil heat exchanger is a tube type exchanger that provides cooling of the IDG oil.



FQW4200 GE Metric

IDG AIR/OIL COOLING VALVE

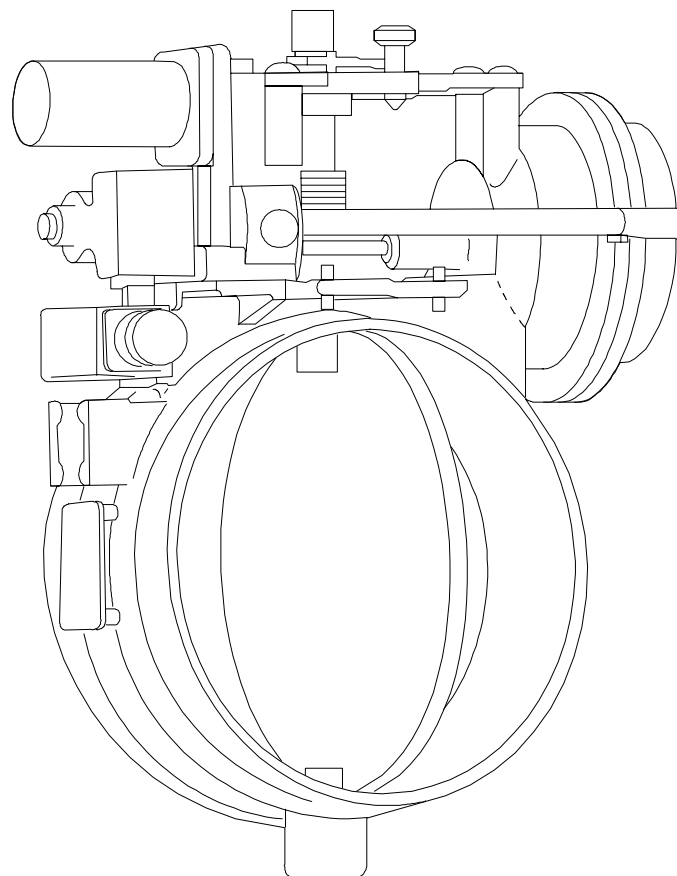
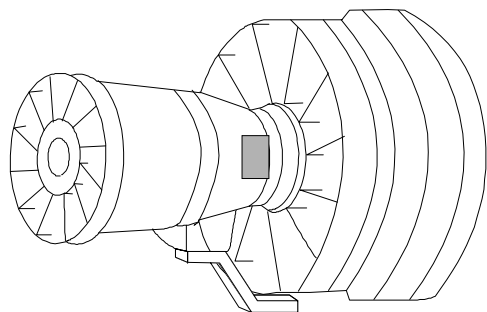
FIN / ZONE

FIN : 4019 KS

Zone : 413 - 423

COMPONENT DESCRIPTION

The IDG Air/oil cooling valve is a butterfly type valve which is spring loaded open. It is an electrically controlled, pneumatically operated. It has an 11th stage muscle air connection and 1 electrical connection.



FQW4200 GE Metric

IDG AIR/OIL COOLER

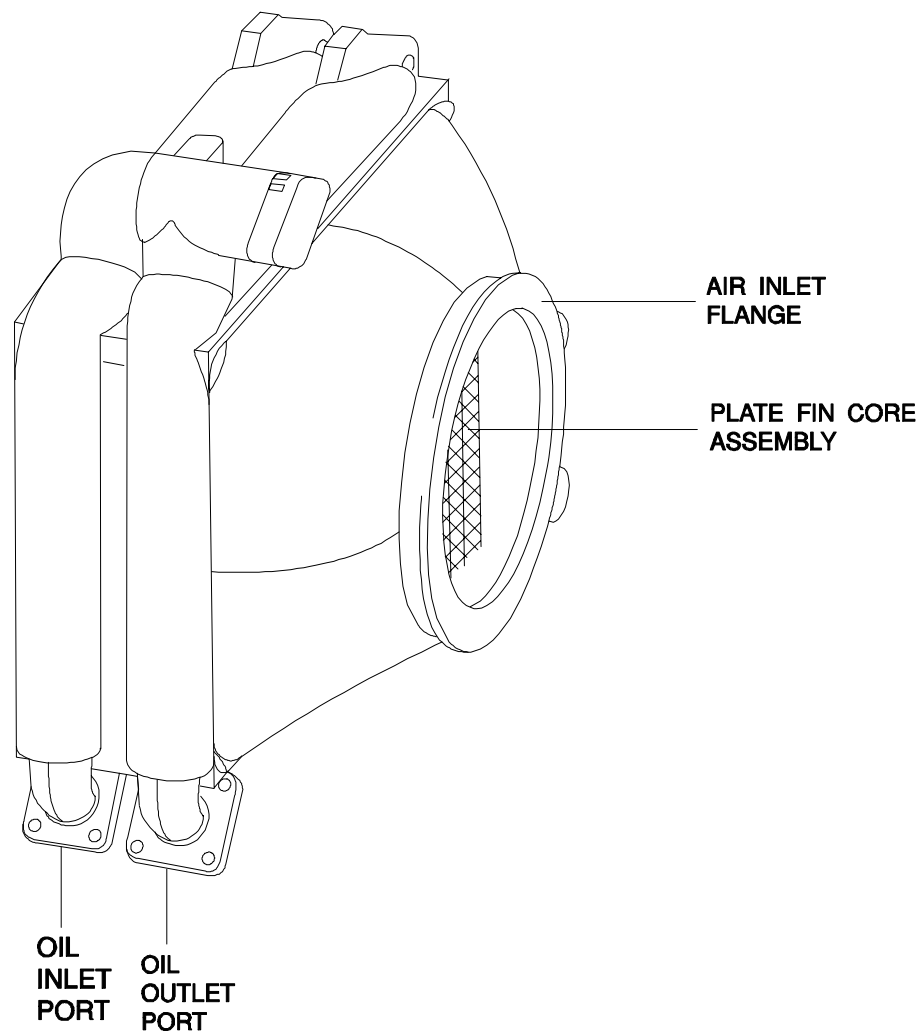
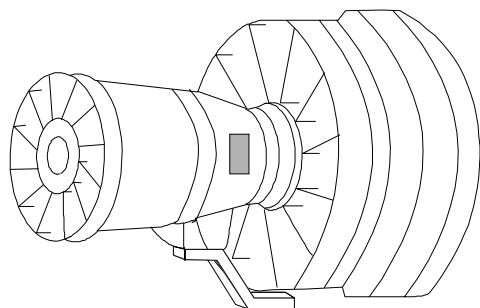
FIN / ZONE

FIN : 4015 KS

Zone : 413 - 423

COMPONENT DESCRIPTION

The IDG Air/oil cooler is a tube fin "radiator" type heat exchanger. The oil circulates through the tubes and the air passes over the fins to cool the tubes and liquid contents. It is equipped with a bypass valve for cold weather operation or if the exchanger becomes clogged.



IDG OIL IN TEMPERATURE SENSOR

FIN / ZONE

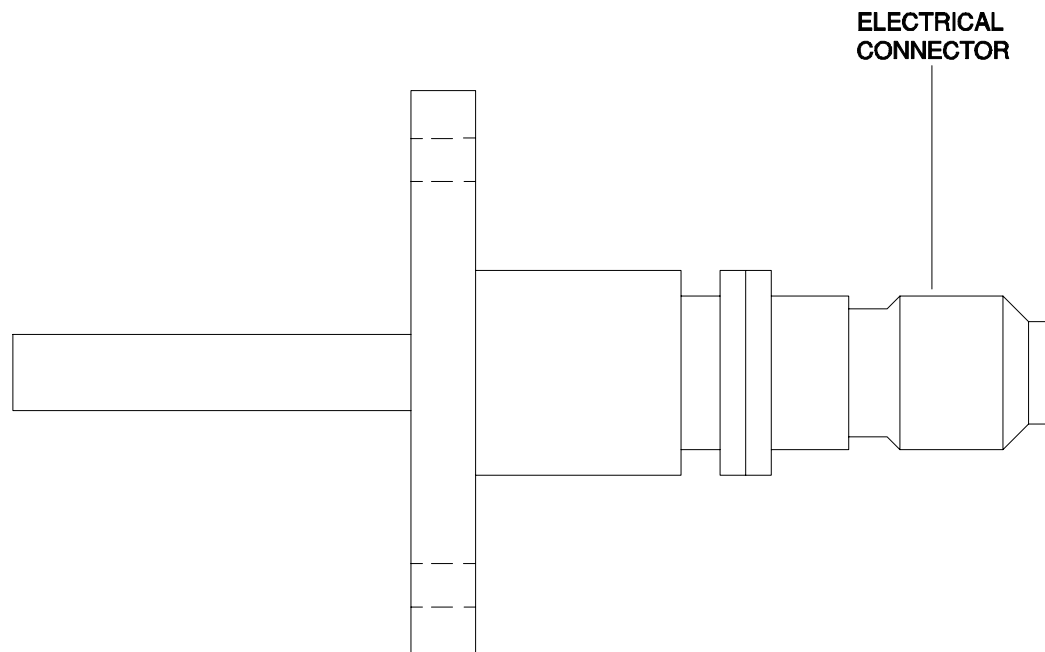
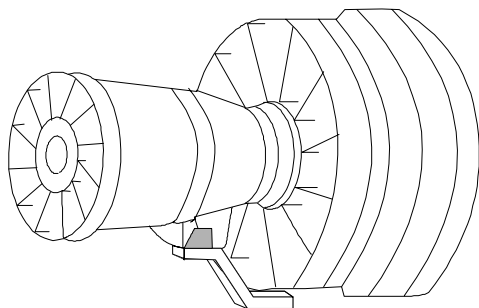
FIN : 4015 KS

Zone : 413 - 423

COMPONENT DESCRIPTION

The IDG oil temperature sensor is a thermocouple type device.

Its output varies as the temperature of the oil passing over it changes.



FQW4200 GE Metric

STUDENT NOTES

FQW4200 GE Metric

FADEC PRESENTATION

Fadec Philosophy
Fadec Principle
Fadec Functions
Aircraft Integration
Power Supply

FADEC PHILOSOPHY

The FADEC is built around an Electronic Control Unit (ECU) which has several functions : engine controls, fault isolation, maintenance tests and condition monitoring.

FADEC PRINCIPLE

Most of the FADEC operations are based on the same principle. As a response to a demand, and taking into account input parameters, the ECU elaborates a command signal. The ECU ensures that its commands have been followed by monitoring the feedback signals.

FADEC FUNCTIONS

The control functions performed by the FADEC are the following :

- fuel flow control,
- power management,
- air system valve and actuator control,
- IDG oil cooling,
- core compartment cooling,
- bore cooling,
- ignition and starting control,
- reverse system control.

IDG A/O : IDG Air/Oil Cooling

CCC : Core Compartment Cooling

BC : Bore Cooling

VSV : Variable Stator Vanes

VBV : Variable Bleed Valves

H(L)PTACC : High(Low) Pressure Turbine Active Clearance Control

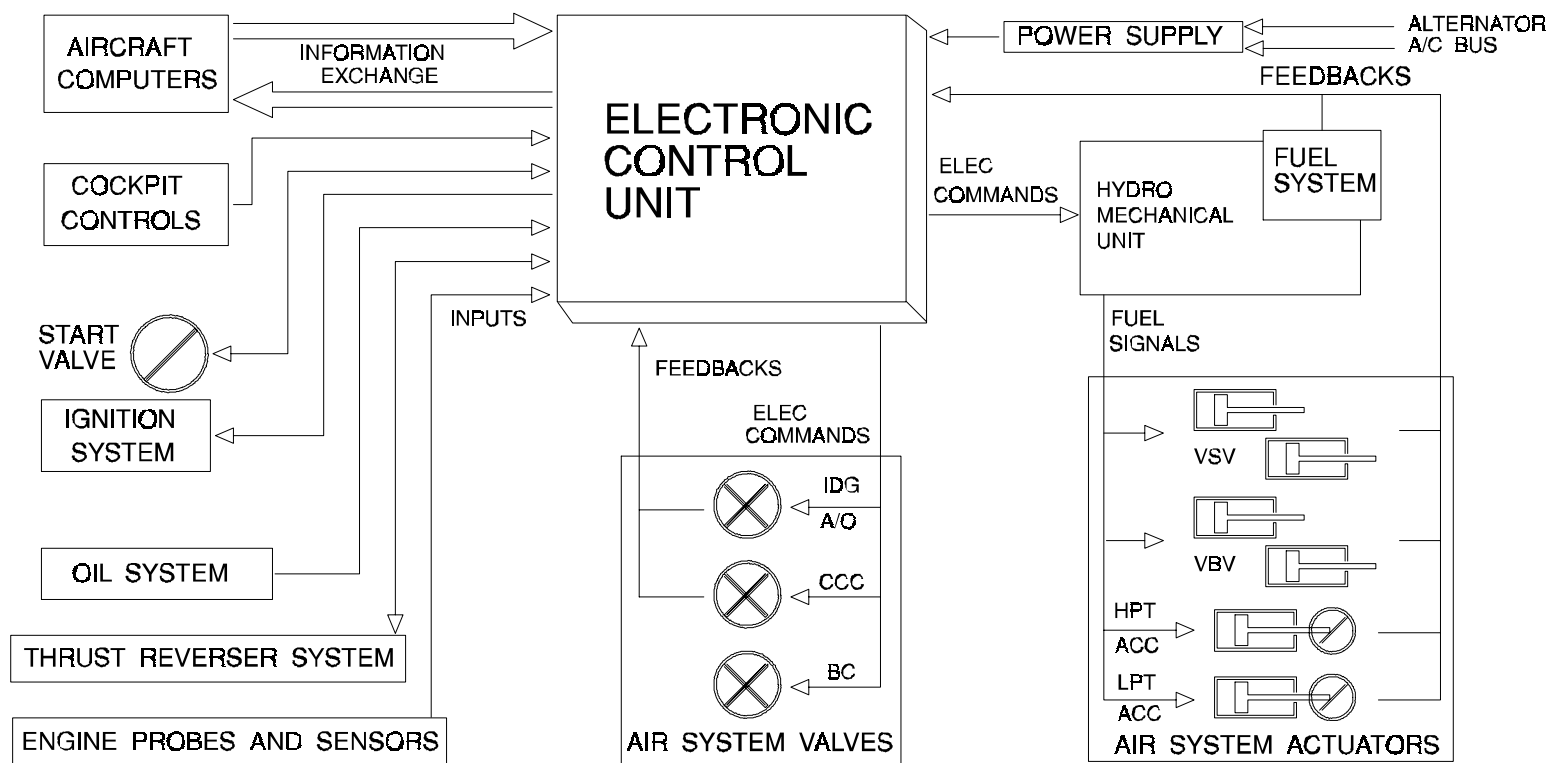
AIRCRAFT INTEGRATION

The FADEC concept allows a better aircraft integration through automatic functions such as automatic start sequences, engine monitoring and fault isolation.

POWER SUPPLY

The Electronic Control Unit has its own electrical power supply via an accessory gearbox mounted permanent magnet alternator.

With engine shut-down, low speed or alternator failure, the ECU is powered from the aircraft electrical network.



FQW4200 GE Metric

STUDENT NOTES:

FQW4200 GE Metric

FADEC ARCHITECTURE

Dual Channel
Dual Inputs
Hardwired Inputs
Dual Outputs
Bite Capability
Fault Strategy
Fail Safe Control
Main Interfaces

DUAL CHANNEL

The FADEC system is fully redundant built around two independent control channels.

Dual input, dual outputs and automatic switch over from one channel to the other eliminate any dormant failure.

Only one channel is in control of the engine at any time.

The other channel is in stand by, ready to take over in case of failure.

DUAL INPUTS

All control inputs to the FADEC system are doubled.

Only some secondary parameters used for monitoring and indicating are single.

To increase the fault tolerant design, the parameters are exchanged between the two control channels (inside the ECU) via the cross channel data link.

HARDWIRED INPUTS

Most of the information exchanged between the aircraft and the ECU is transmitted over digital data buses, many signals over a single line.

In addition some signals are hard-wired directly from the aircraft to the ECU. These signals are used as backup, or to confirm the signals being sent over the data buses.

A few inputs only have single entry to the ECU, then internally are hard-wired to both channels.

DUAL OUTPUTS

All the ECU outputs are double, but only the channel in control supplies the engine control signals to the various receptors such as torque motors, solenoids.

BITE CAPABILITY

The ECU is equipped with BITE which provides maintenance information and test capabilities via the MCDU.

FAULT STRATEGY

Using the BITE system, the ECU can detect and isolate failures.

It also allows the ECU to switch engine control from the faulty channel to the healthy one.

FAIL SAFE CONTROL

If a channel is faulty and the channel in control is unable to ensure one engine function, this control is moved to a fail-safe position.

Example :

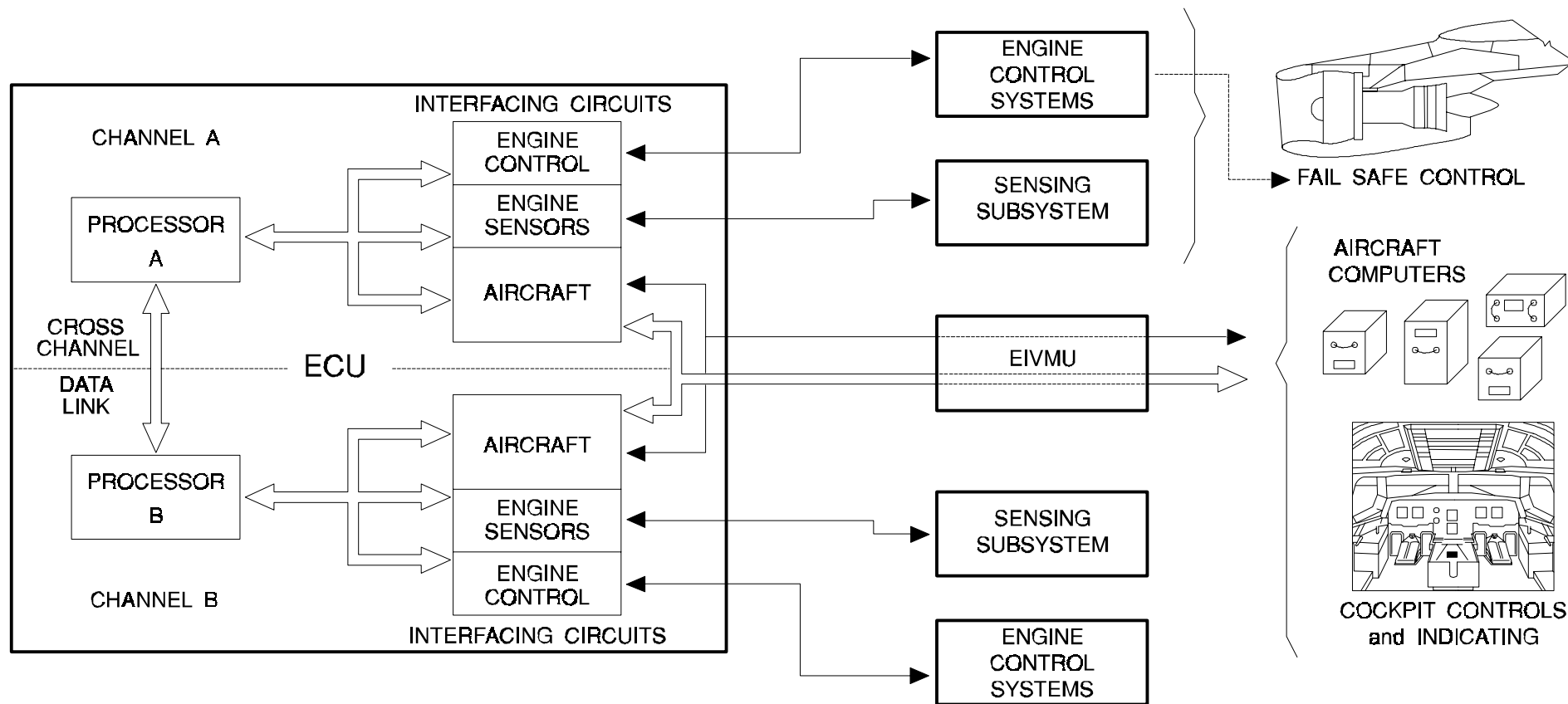
if the channel is faulty and the channel in control is unable to control VBV position, the valves are operated to the open position.

MAIN INTERFACES

To perform all its tasks the ECU interfaces with aircraft computers, either directly or via the Engine Interface and Vibration Monitoring Unit.

It receives inputs from : Flight Control Primary Computer(FCPC), Landing Gear Control and Interface Unit(LGCIU), Slat Flap Control Computer(SFCC), Zone Controller, Centralized Maintenance Computer(CMC), Air Data Inertial Reference Unit(ADIRU), Flight Control Unit(FCU), cockpit engine controls, fire and anti-ice systems.

It sends outputs to : Bleed air Monitoring Computer(BMC), Electronic Control Box(ECB), Flight Warning Computer(FWC), Display Management Computer(DMC), Flight Management Guidance and Envelope Computer(FMGEC), System Data Acquisition Concentrator(SDAC), Data Management Unit(DMU), Centralized Maintenance Computer(CMC).



FQW4200 GE Metric

STUDENT NOTES:

ECU INTERFACES

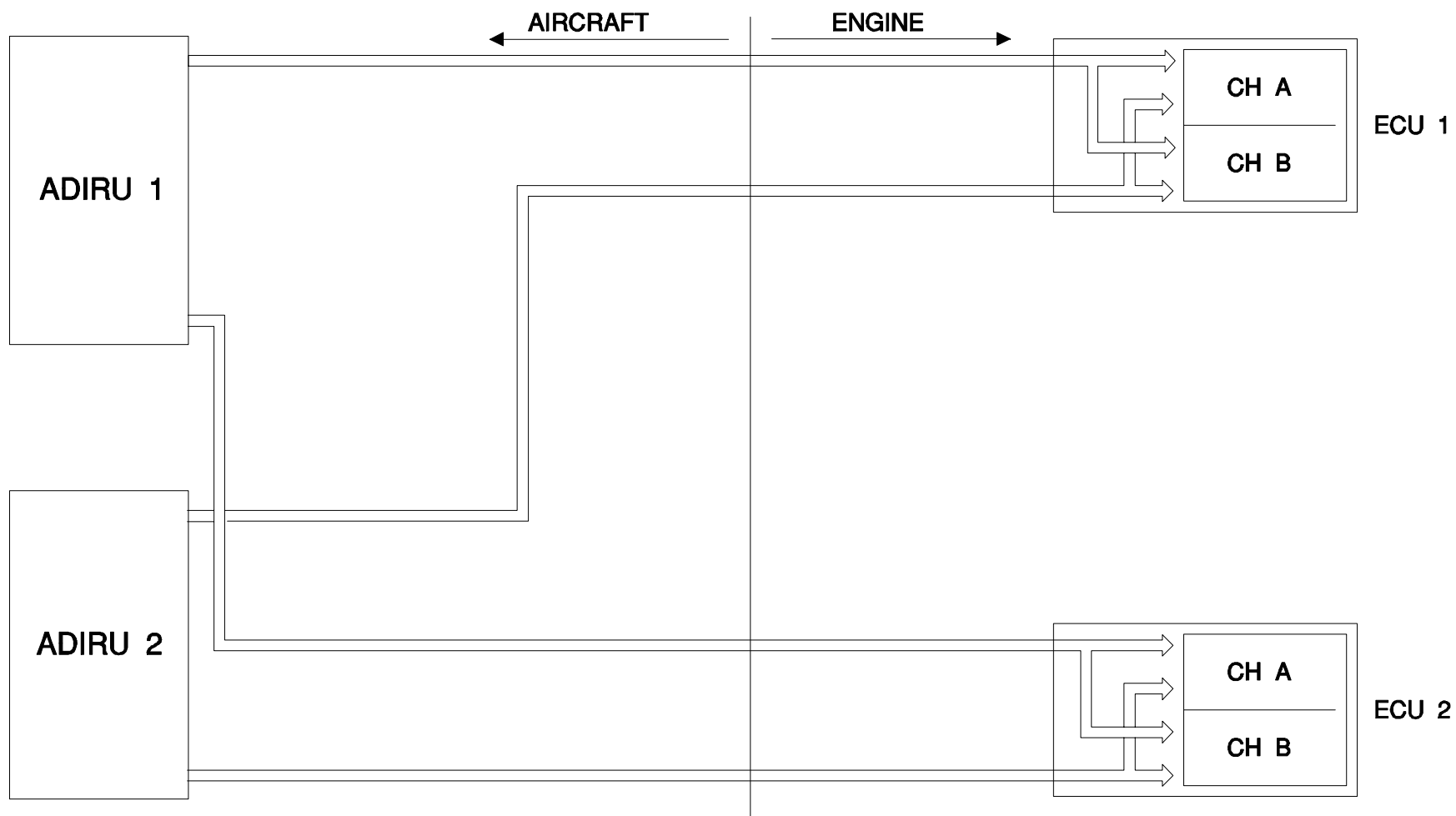
ADIRU Input
EIVMU Inputs
Digital Output
Discrete/analog Signals
FWC/DMC
ATHR LOOP

ADIRU INPUT

The ECU receives data from the ADIRUs thru ARINC 429 buses. Each ADIRU output bus is dedicated to one ECU where it is internally cross connected to both channels.

The ECU receives :

- the corrected static pressure ;
- the total air temperature ;
- the total pressure ;
- discrete status word.



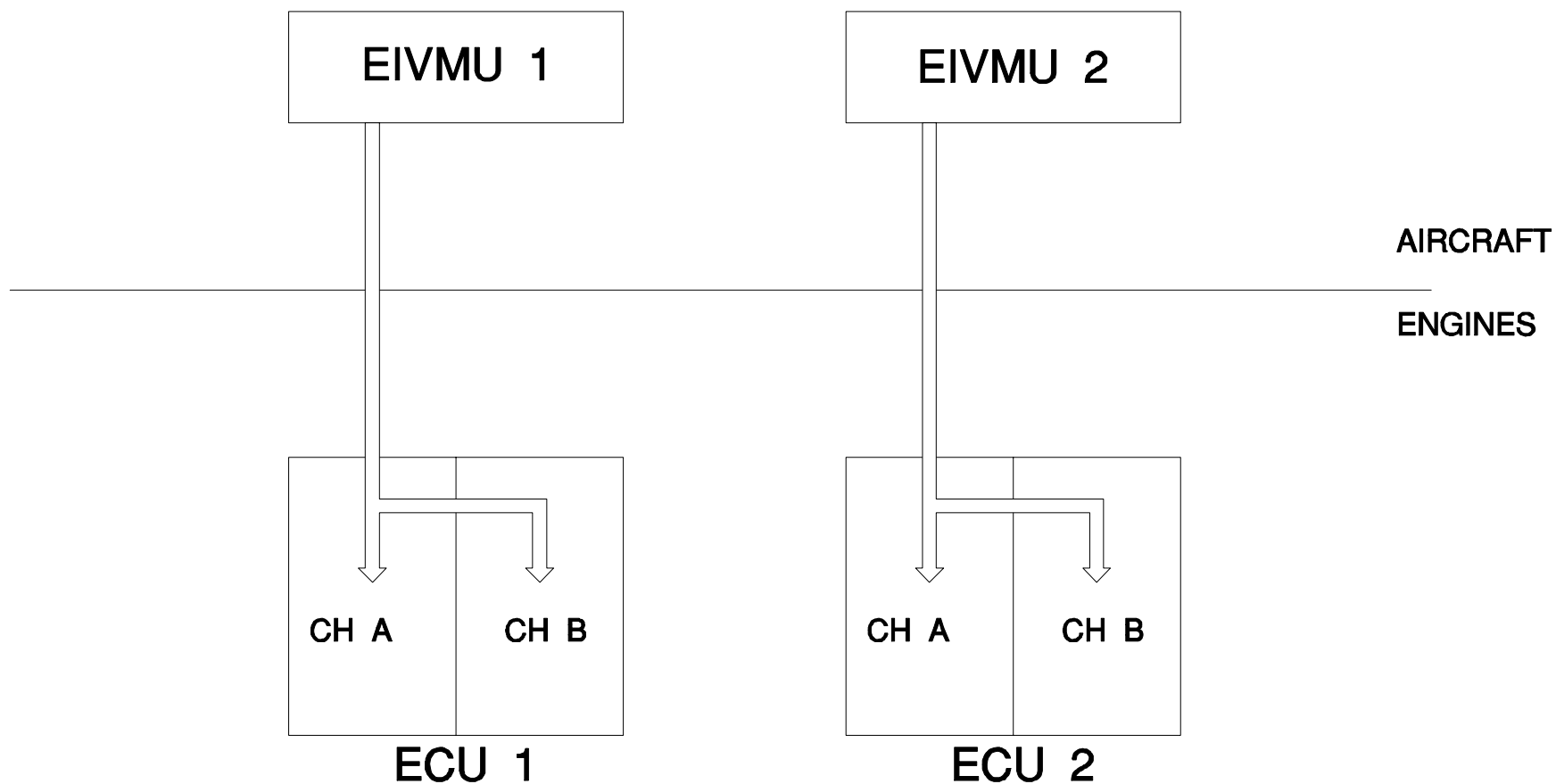
FQW4200 GE Metric

EIVMU INPUTS

Each EIVMU communicates with its associated ECU through ARINC digital data bus. Each EIVMU output bus is internally cross connected inside the ECU to both channels.

The following categories of aircraft data are transmitted by the EIVMU to the ECU :

- General aircraft data (Pin programming).
- Idle setting data (Bleed configuration, Air conditioning pack flow, Landing gear and Flap/Slats position).
- Engine starting data (Engine Controls, Panel switches).
- Autothrust function data (Autothrust, Derate, Alpha Floor).
- Maintenance function data.



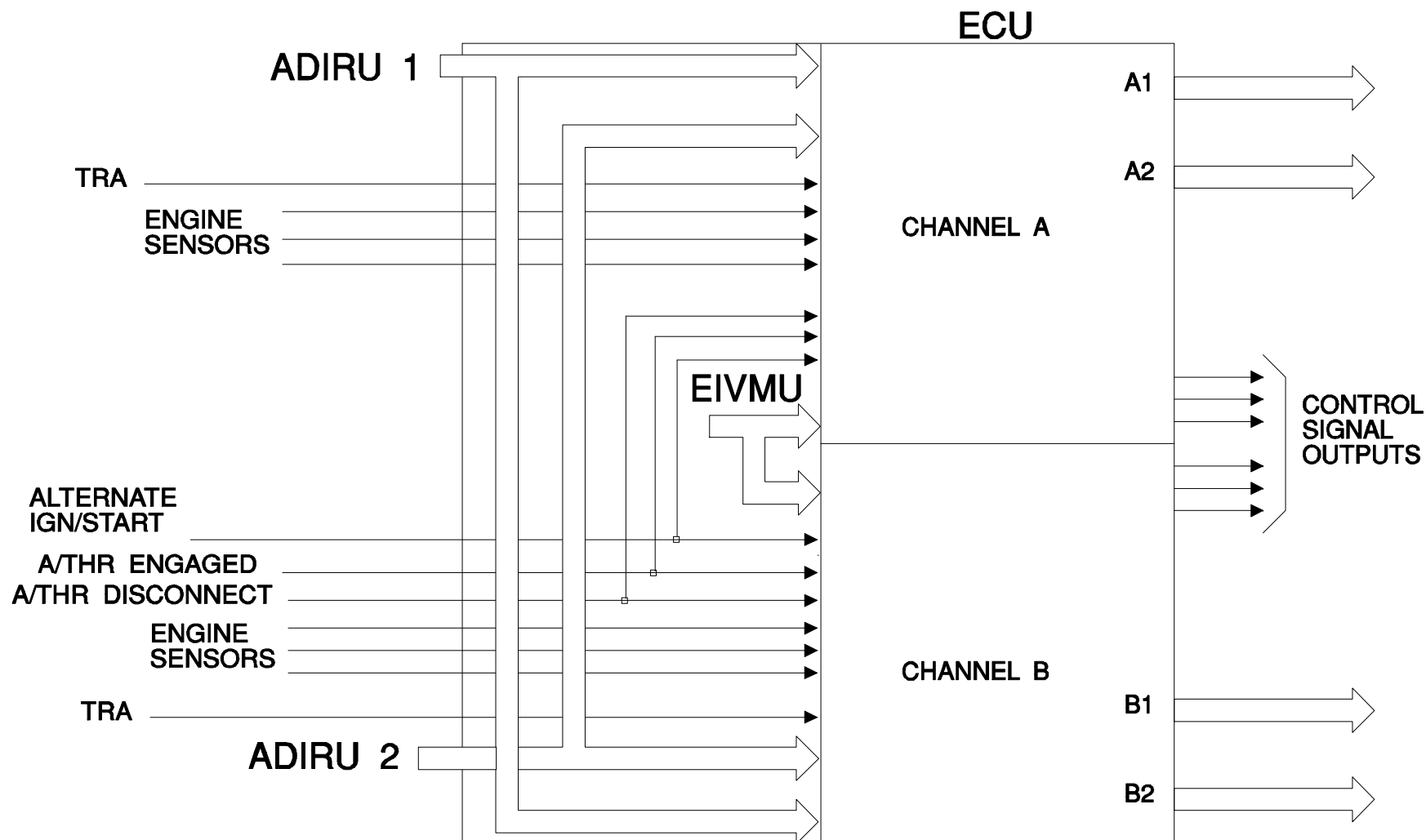
FQW4200 GE Metric

DIGITAL OUTPUT

The ECU transmits the propulsion system status information to the aircraft systems on four ARINC 429 busses (two per channel).

Information contained on FADEC output buses includes the following general items :

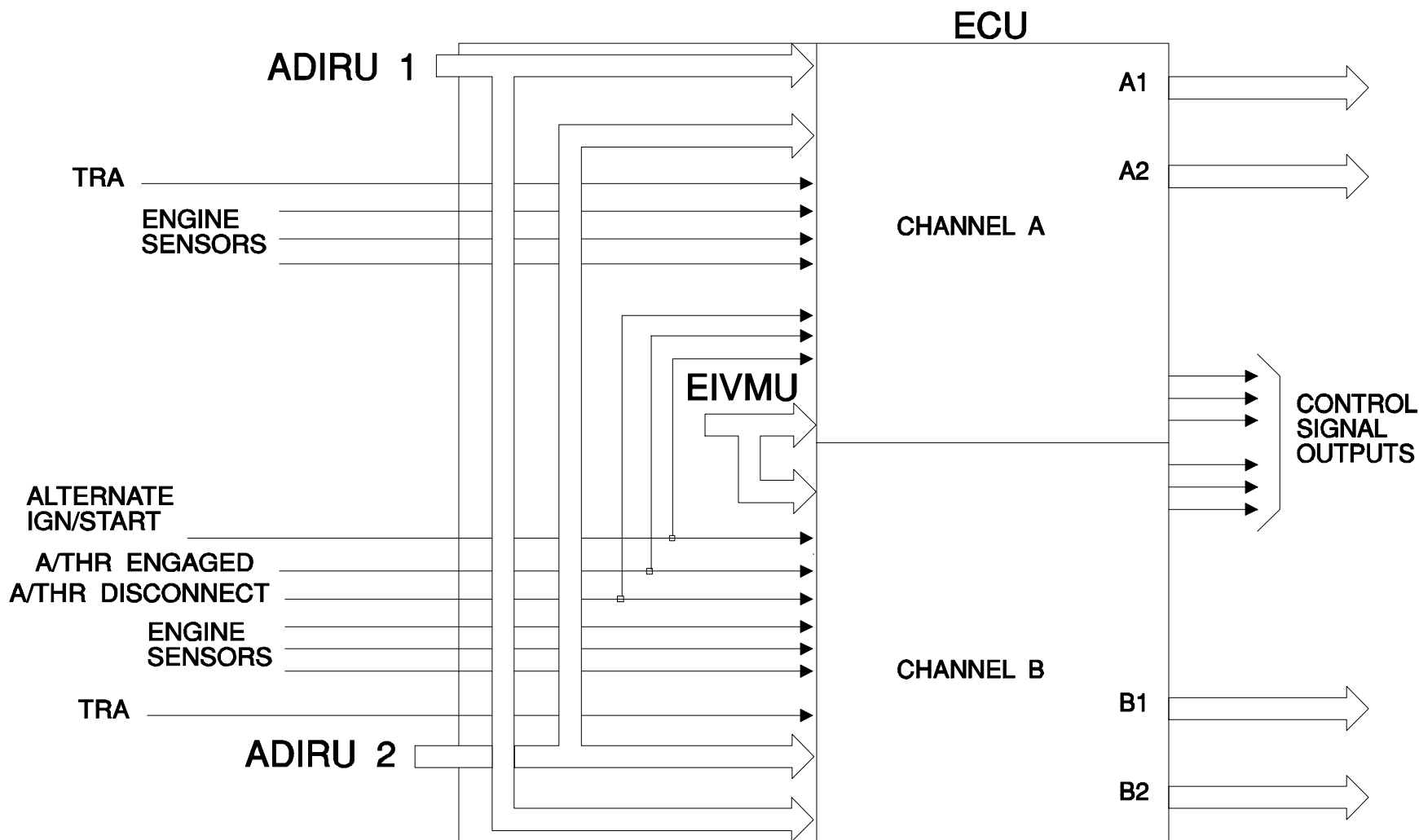
- Engine rating parameter information.
- Parameter used for engine control.
- FADEC system maintenance data.
- Engine condition monitoring parameters.
- ECU status and fault information.
- Propulsion system status and fault information.



FQW4200 GE Metric

DISCRETE/ANALOG SIGNALS

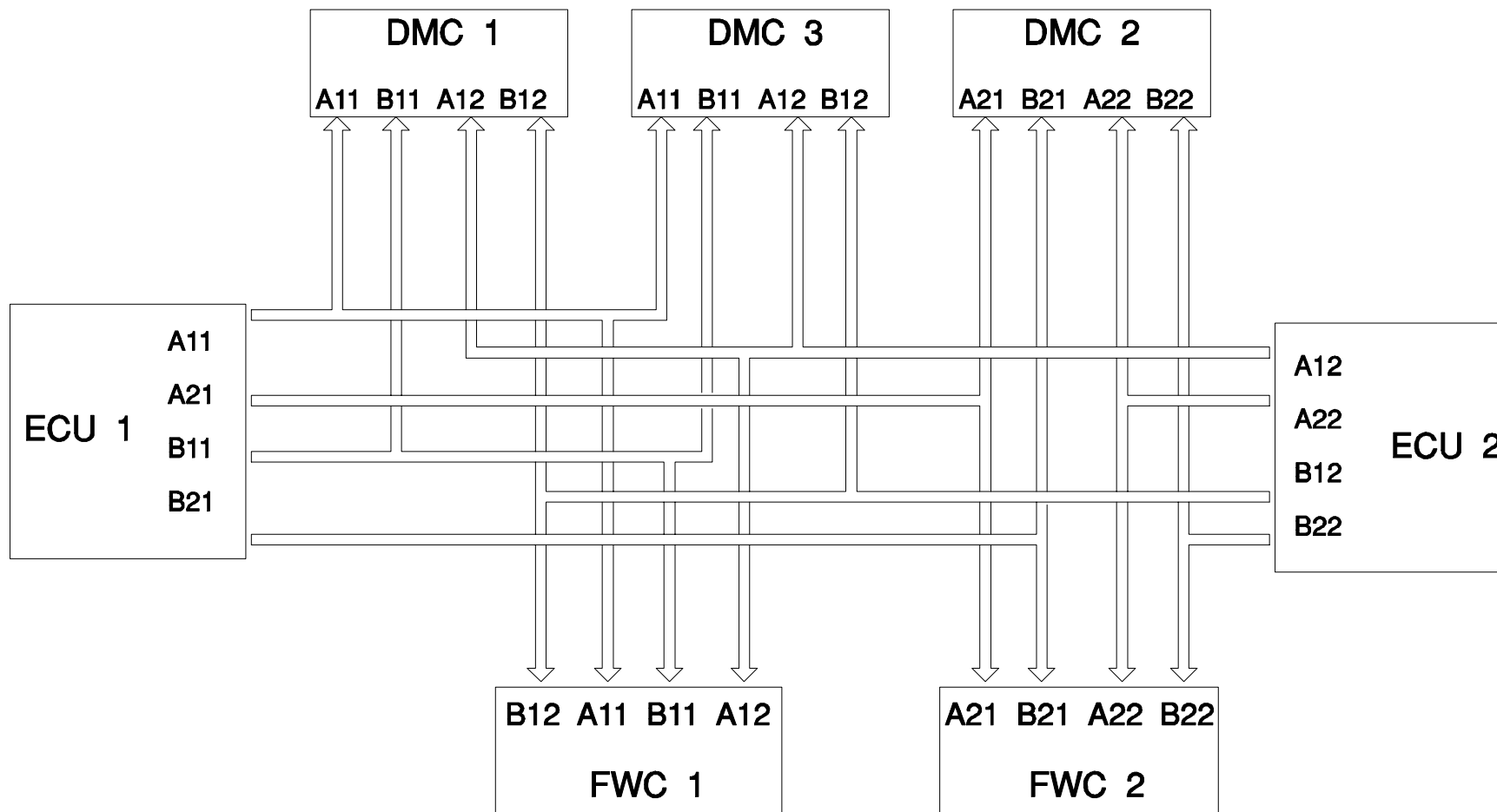
The ECU receives the Thrust Resolver Angle, Alternate Start/Ignition signals, autothrust engagement and disconnect discretes from the aircraft. It also receives all engine sensor signals.



FQW4200 GE Metric

FWC/DMC

The DMCs and FWCs use FADEC system data for indication and warning respectively.



FQW4200 GE Metric

ATHR LOOP

The autothrust function is assumed by the Auto Flight System (AFS). The data needed by the ECU for the autothrust function is provided from the FMGECs via the FCU and through the EIVMU.

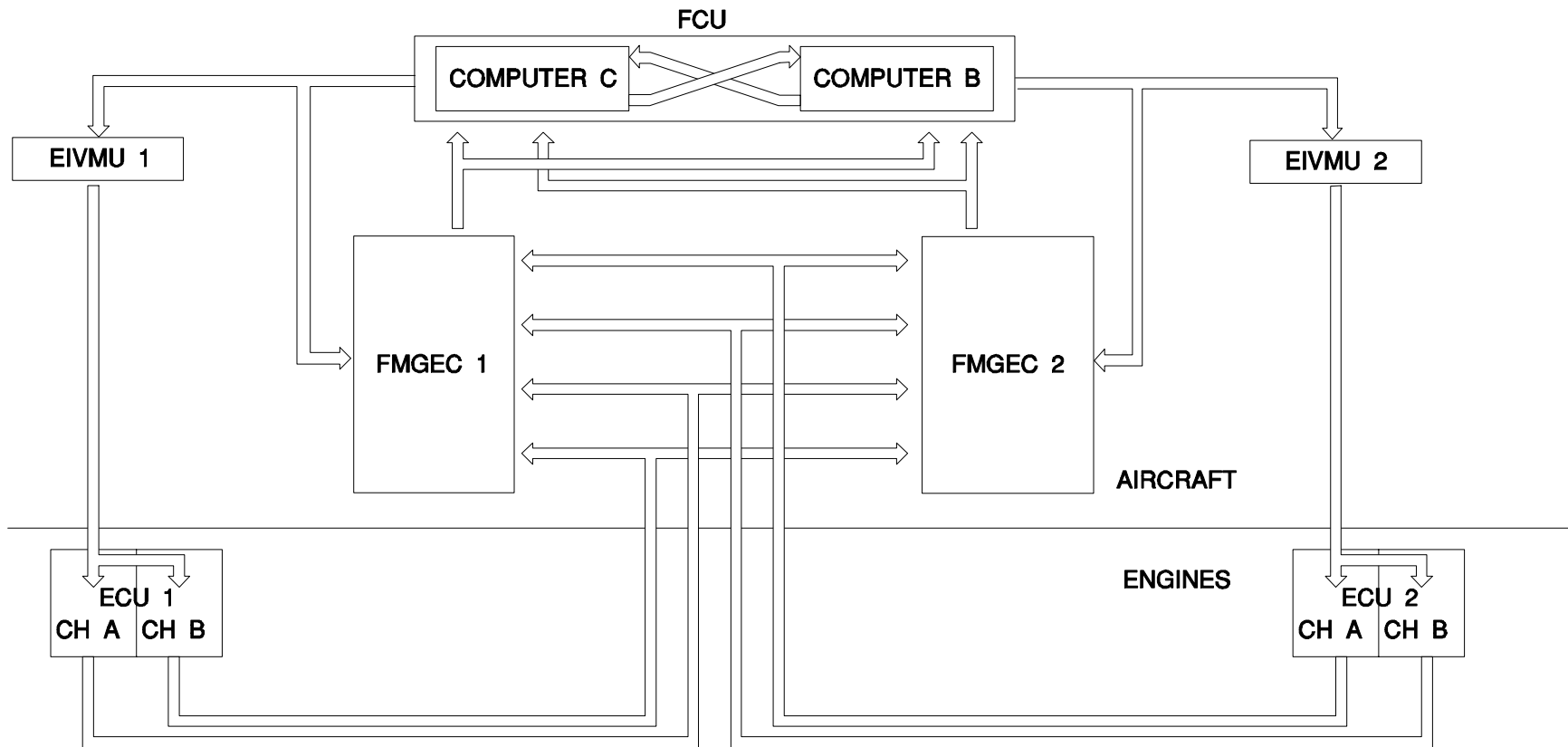
The transmitted data includes :

- Autothrust N1 Target
- Autothrust engaged signal
- Autothrust active signal
- Autothrust voluntary disengagement
- Alpha Floor protection selection
- Flexible temperature
- Derated Climb requested
- Derated Take-Off requested level.

The ECU directly sends specific feedback outputs to the FMGECs without going through the EIVMU.

The ECU also receives two hardwired discretes :

- FMGEC autothrust engagement
- Cockpit thrust lever push button A/THR disconnect



FQW4200 GE Metric

STUDENT NOTES

EIVMU INTERFACES

- ECU Interface
- ECS Interface
- Engine Start Control
- CMS Interface
- Other Interfaces

ECU INTERFACE

The EIVMU is linked to the ECU by one output bus and two identical input buses which carry exactly the same information. The EIVMU takes its information automatically from the "better" bus in case of transmission problems.

The EIVMU controls the power shut-down for ECU, the ignitors and the thrust reverser deployment. The EIVMU interfaces signals and data between aircraft computers, cockpit panels and ECU (Display data, monitoring data for maintenance use).

ECS INTERFACE

The EIVMU receives one input bus from the Environmental Control System (ECS). This bus provides information from the active lane of the Zone Controller (lane 1 or lane 2).

The ECS determines the various airbleed configurations according to logics of air conditioning, wing anti-ice and nacelle anti-ice. This information is transmitted by the EIVMU to the ECU to compute the bleed air demand required at the engine customer bleed ports.

ENGINE START CONTROL

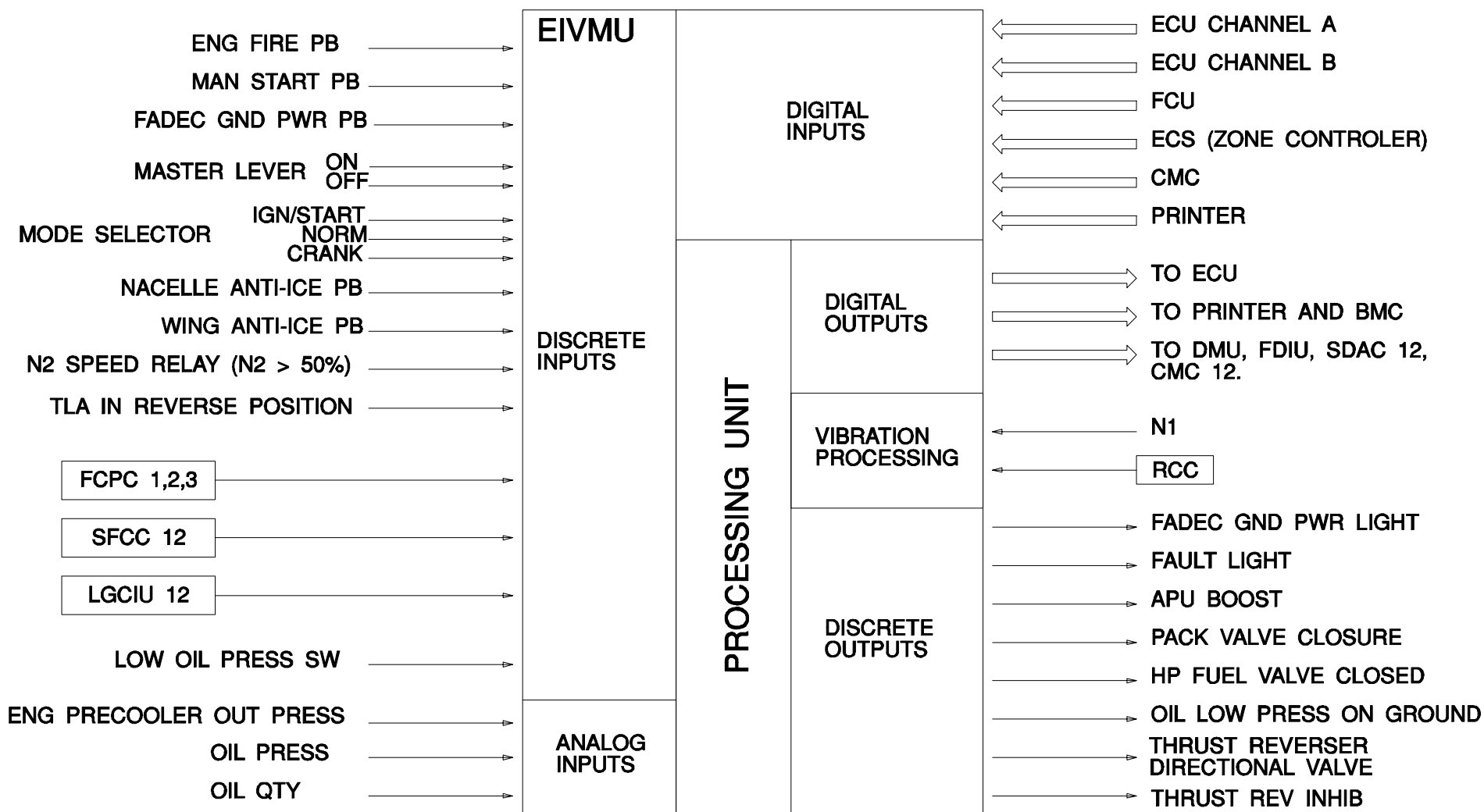
The EIVMU receives all starting ignition and cranking signals from the cockpit engine control panels and sends them to the ECU in digital format through its ARINC Buses.

The control panels provide the following signals to the EIVMU :

- Engine Start mode selector position.
- Master Lever position.
- Manual start pushbutton state.

OTHER INTERFACES

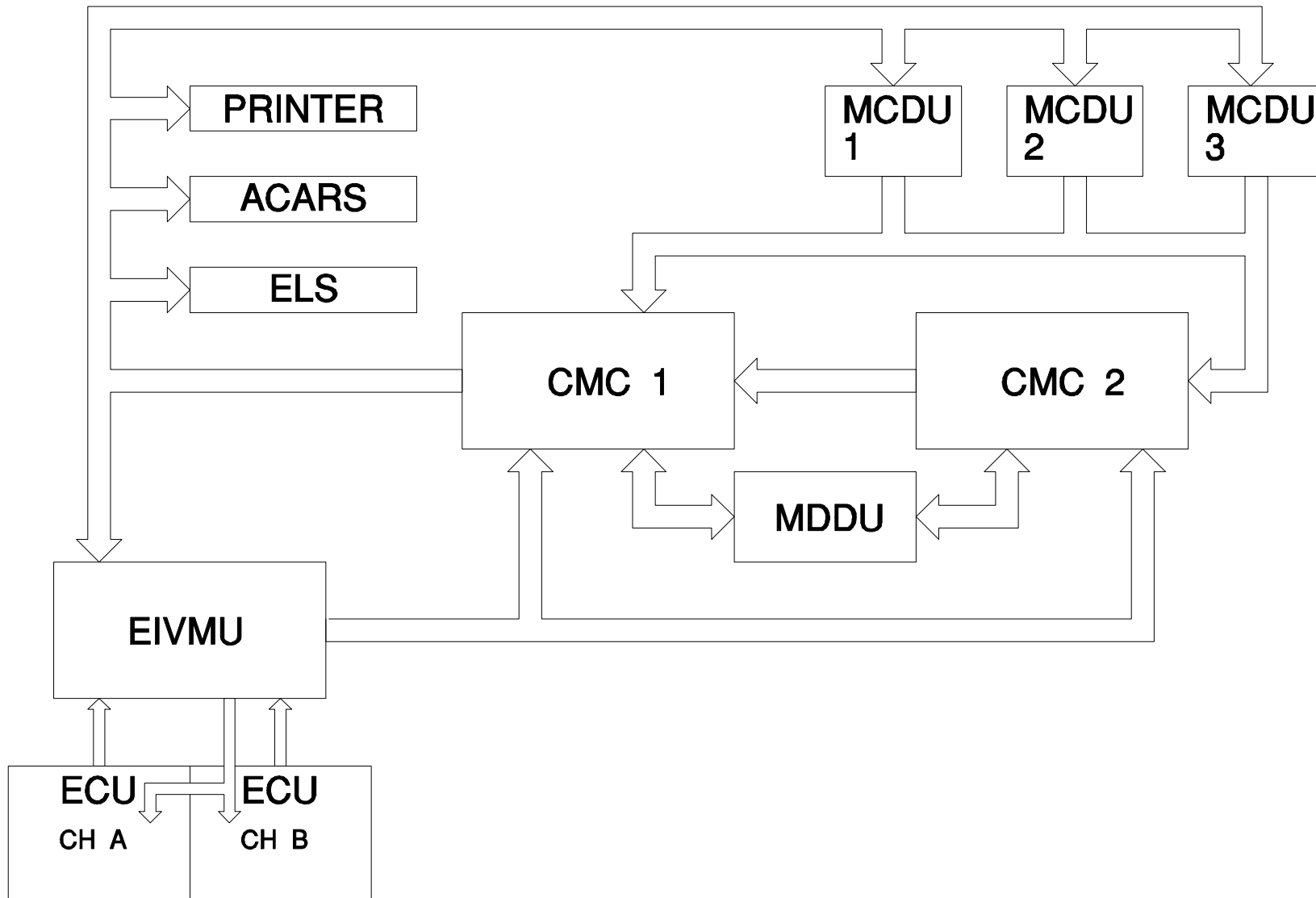
The EIVMU also receives and generates signals for control and monitoring purposes from and to various aircraft systems.



FQW4200 GE Metric

CMS INTERFACE

The ECU interface with the Central Maintenance Computers (CMCs) through the EIVMU for all fault reporting and maintenance operations.



FQW4200 GE Metric

STUDENT NOTES

WARNINGS (FADEC/FUEL)

EIU FAULT
FADEC SYS FAULT
FADEC FAULT
FADEC OVHT
FUEL FILTER CLOG
MINOR FAULT

EIU FAULT

There is a failure detected in all data bus inputs to the N.1 Engine Interface and Vibration Monitoring Unit (EIVMU).

FADEC SYS FAULT

This happens when a class 1 "NO GO" fault is detected on the FADEC system by the ECU. This appears on ground only.

FADEC FAULT

This happens when there is a total loss of control of the ECU. No channel is in control and no class 1 "NO GO" fault is detected by any channel. This is not due to an auto shut down of the FADEC supply. Normal engine operation should be monitored on the engine system page, and if necessary shut down the engine.

FADEC OVHT

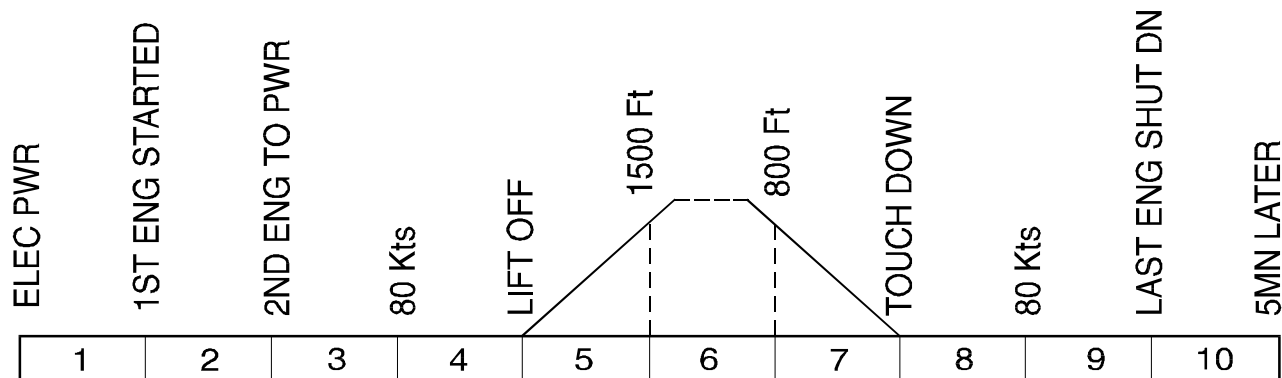
The ENG 1 Electronic Control Unit (ECU) internal temperature exceeds 105 deg. C. If the aircraft is on the ground, the engine should be shut down. If the aircraft is in flight, normal engine operation should be monitored on the engine system page, and if necessary shut down the engine.

FUEL FILTER CLOG

The engine is running and the fuel filter is clogged, ie : the pressure drop across the filter exceeds 43 psid.

MINOR FAULT

This appears on ground when there is a FADEC system 2 fault. The level 2 faults are "GO IF" conditions, and therefore, are dispatchable at the propulsion system level provided a specific maintenance or operational procedure is applied prior to departure, or for which a time limited dispatch exists (repairing before 150 hours).



E/WD : FAILURE TITLE	AURAL WANING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLT PHASE INHIB
EIU FAULT	SINGLE CHIMIE	MASTER CAUT	NIL	NIL	3, 4, 5, 8
FADEC SYS FAULT	NIL	NIL	NIL	NIL	4, 5, 6, 7, 8
FADEC FAULT	SINGLE CHIMIE	MASTER CAUT	ENG	NIL	4, 5, 7, 8
FADEC OVHT	SINGLE CHIMIE	MASTER CAUT	ENG	NIL	4, 5, 7, 8
FUEL FILTER CLOG	NIL	NIL	ENG	NIL	3, 4, 5, 7, 8
MINOR FAULT	SINGLE CHIMIE	MASTER CAUT	ENG	NIL	4, 5, 7, 8

FQW4200 GE Metric

STUDENT NOTES

FQW4200 GE Metric

FADEC COMPONENTS

Safety Precautions
P/T25
T12
PMA
ECU
Electrical Harnesses
Engine Rating / Identification Plug
Cable Tray

SAFETY PRECAUTIONS

- Do not start the engine.
- Make sure that the engine has been shut down for at least 5 minutes.
- Make sure that the ENG FADEC GND PWR pushbutton is off.
- Make sure that the ENG MASTER switch is off.

STUDENT NOTES

P/T25

FIN / ZONE

FIN : 4032 KS

Zone : 412-422

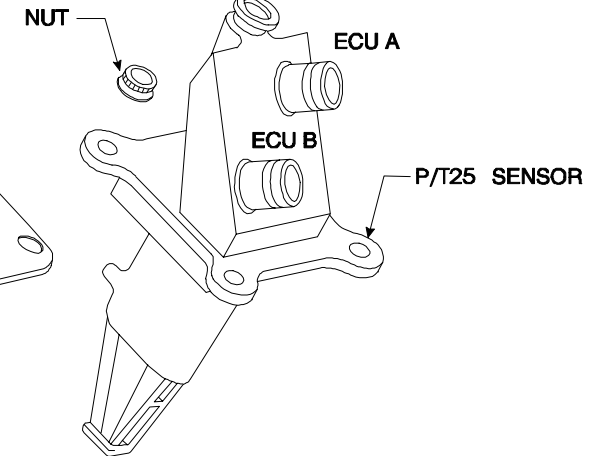
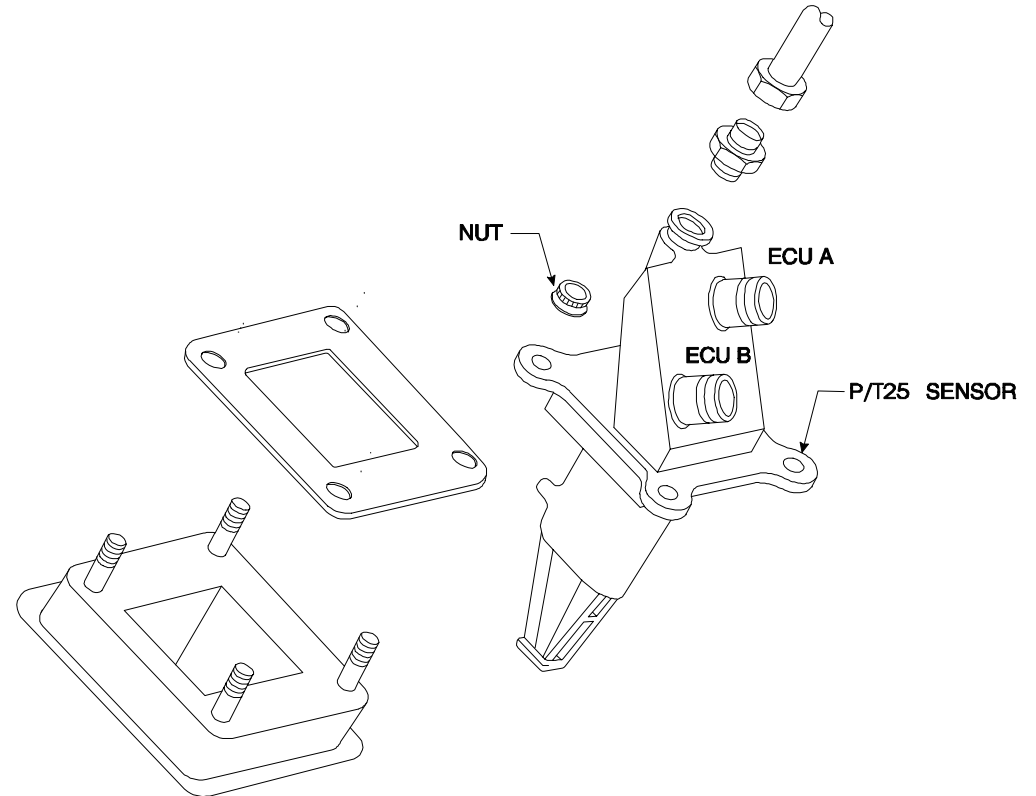
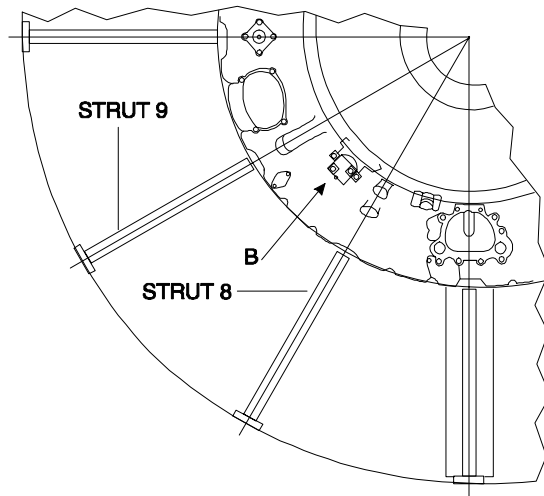
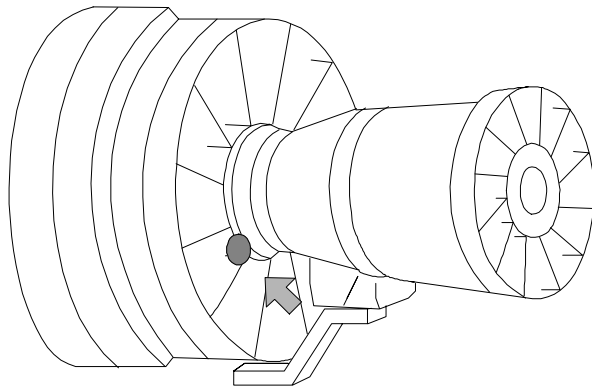
COMPONENT DESCRIPTION :

The P/T25 temperature sensor is a resistive thermal device. It protrudes into the high pressure compressor inlet air, where the resistance of the sensing elements changes with the temperature.

The sensor provides redundancy by having two separate temperature sensing elements. One dedicated to each channel of the ECU.

REMOVAL INSTALLATION :

The sensor is fitted by means of 4 nuts.



T12

FIN / ZONE

FIN : 4048 KS

Zone : 412-422

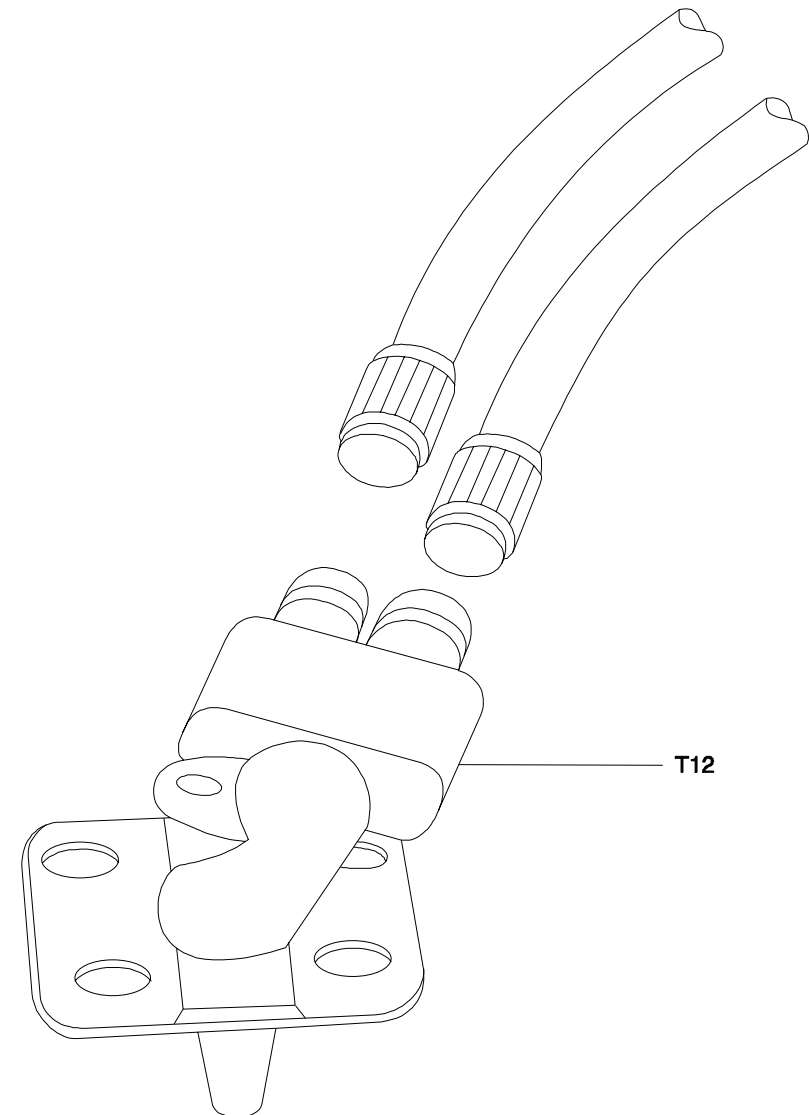
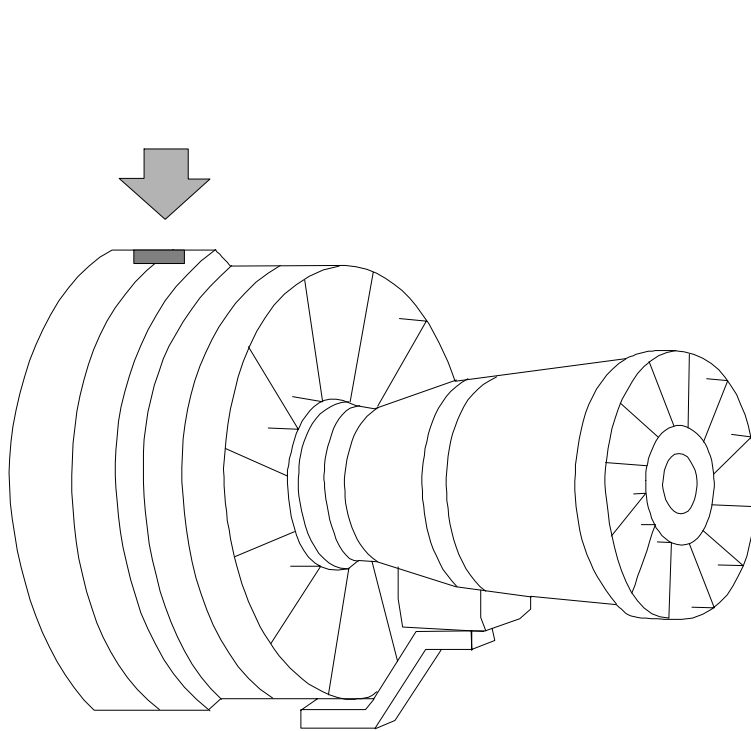
COMPONENT DESCRIPTION :

The T12 sensor is a resistive thermal device. The T12 sensor protrudes into the fan inlet air, where the resistance of the sensing elements changes with the air temperature.

The sensor provides redundancy by having two separate sensing elements. One dedicated to each channel of the ECU.

REMOVAL INSTALLATION :

The sensor is fitted by means of 4 bolts.



PMA

FIN / ZONE

FIN : 4044 KS

Zone : 413-423

COMPONENT DESCRIPTION :

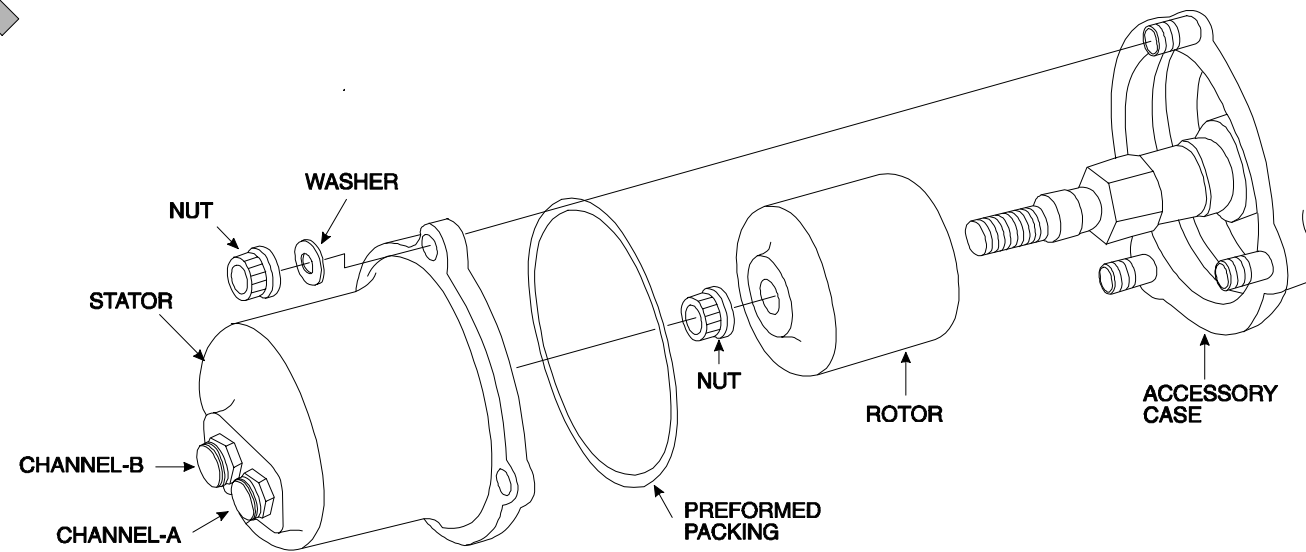
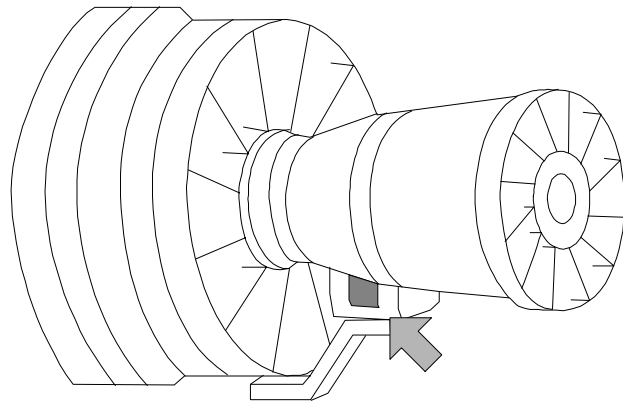
The PMA provides electrical power for the ECU during normal engine operation (115 VAC, 400 Hz).

The ECU will use aircraft electrical power until the core speed, which drives the PMA through the accessory gearbox, is high enough for the PMA to provide sufficient power. The PMA produces two separate electrical power sources, one for each channel of the ECU.

Two, three phase stator windings produce electrical power when a magnetic rotor spins inside the windings.

REMOVAL INSTALLATION :

The stator of the PMA is attached to the accessory gearbox drive pad by means of three nuts.



FQW4200 GE Metric

ECU

FIN / ZONE

FIN : 4000 KS

Zone : 412-422

COMPONENT DESCRIPTION :

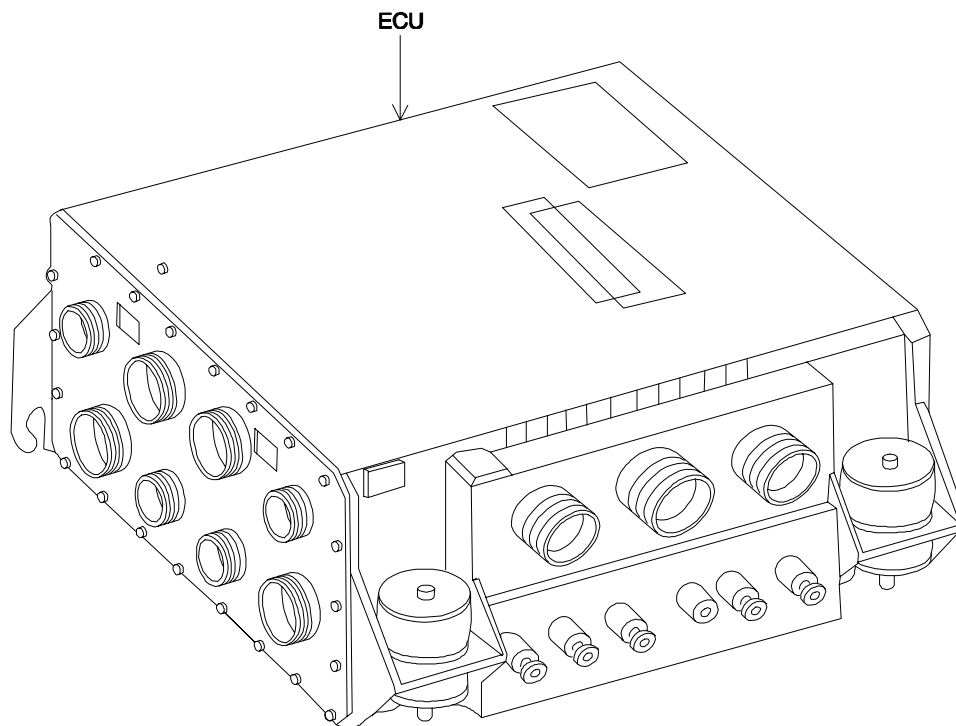
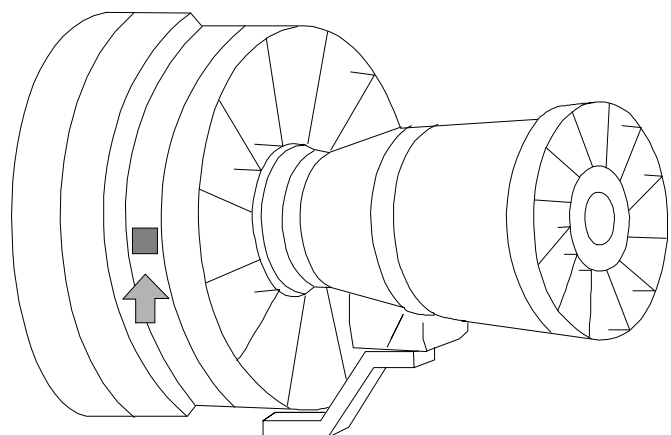
The ECU is a dual channel digital electronic control unit, each channel utilizing a microprocessor for main control functions, a microcontroller for pressure transducer interface functions and a microcontroller for ARINC communication functions.

The ECU is powered by a three phase dedicated alternator. Aircraft power is required up to 15% N2 above which the alternator is able to self power the unit.

The ECU is a vibration isolated single unit mounted on the fan case and is forced air cooled.

REMOVAL INSTALLATION :

The ECU is fitted to the fan case brackets by means of 4 mount bolts. To remove the ECU the mount bolts must be loosened but not fully removed. The vibration isolators must not be removed.



FQW4200 GE Metric

ELECTRICAL HARNESSSES

FIN / ZONE

FIN : 4274KS, 4255KS

4275KS, 4256KS

4254KS, 4257KS

4258KS, 4259KS

4260KS, 4261KS

4262KS, 4263KS

4264KS, 4265KS

4266KS, 4267KS

4268KS, 4269KS

Zone : 412-422 / 413-423

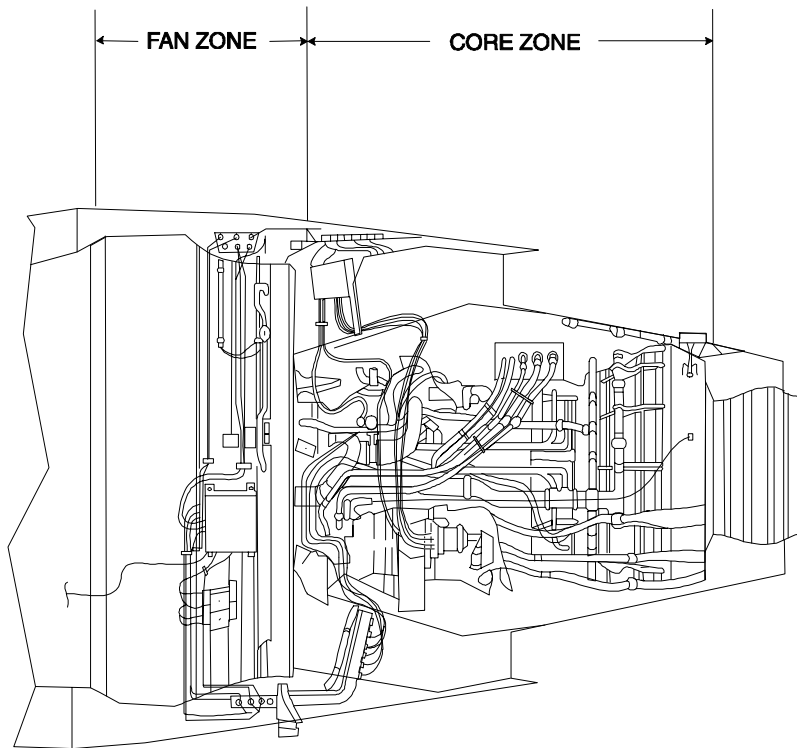
COMPONENT DESCRIPTION :

The cable harnesses run from the ECU to different subsystems or components.

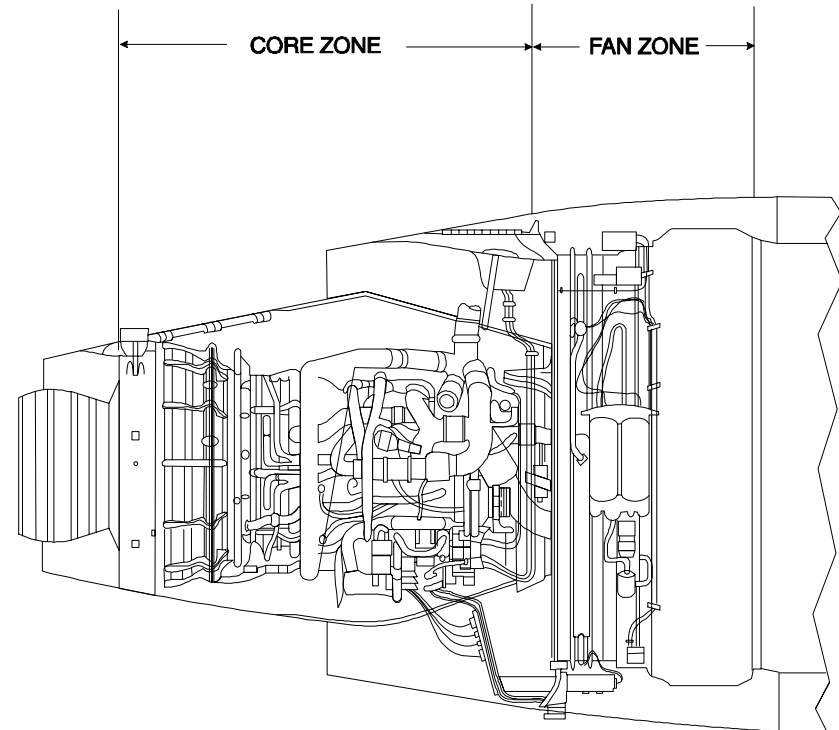
They are color coded and attached by means of clips or clamps.

REMOVAL INSTALLATION :

Do not bend or twist the harness cable when you remove it.



LEFT SIDE



RIGHT SIDE

FQW4200 GE Metric

ENGINE RATING / IDENTIFICATION PLUG

FIN / ZONE

FIN :4091 KS

Zone : 412-422

COMPONENT DESCRIPTION :

The engine rating / identification plug is a dual stacked plug, mounted to the J11 connector of the ECU.

The engine rating / identification plug provides thrust and engine configuration information to the ECU for proper engine valve and actuator control.

The ECU reads both plugs each time it is powered.

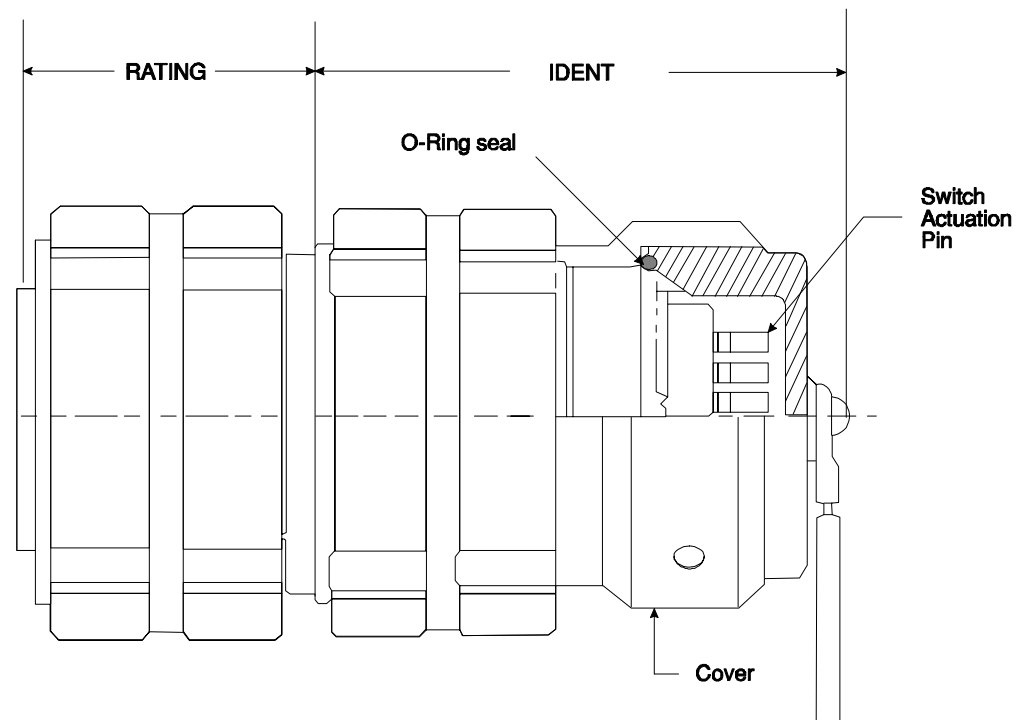
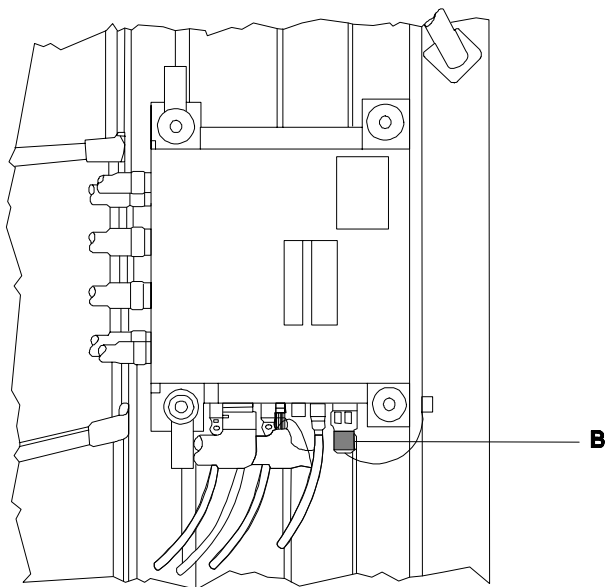
The engine rating plug provides engine thrust rating and bump rating information to the ECU.

The engine identification plug provides the engine hardware configuration, serial number information, as well as, whether the optional expanded condition monitoring probes are installed.

The engine rating / identification plug is attached to the fan case by a lanyard and remains with the engine, not the ECU.

REMOVAL INSTALLATION :

Once the plug has been removed from the ECU, the lanyard, attached by a bolt to the fan case, must be removed.



CABLE TRAY

FIN / ZONE

FIN : 4010 EM-1, 4010 EM-2

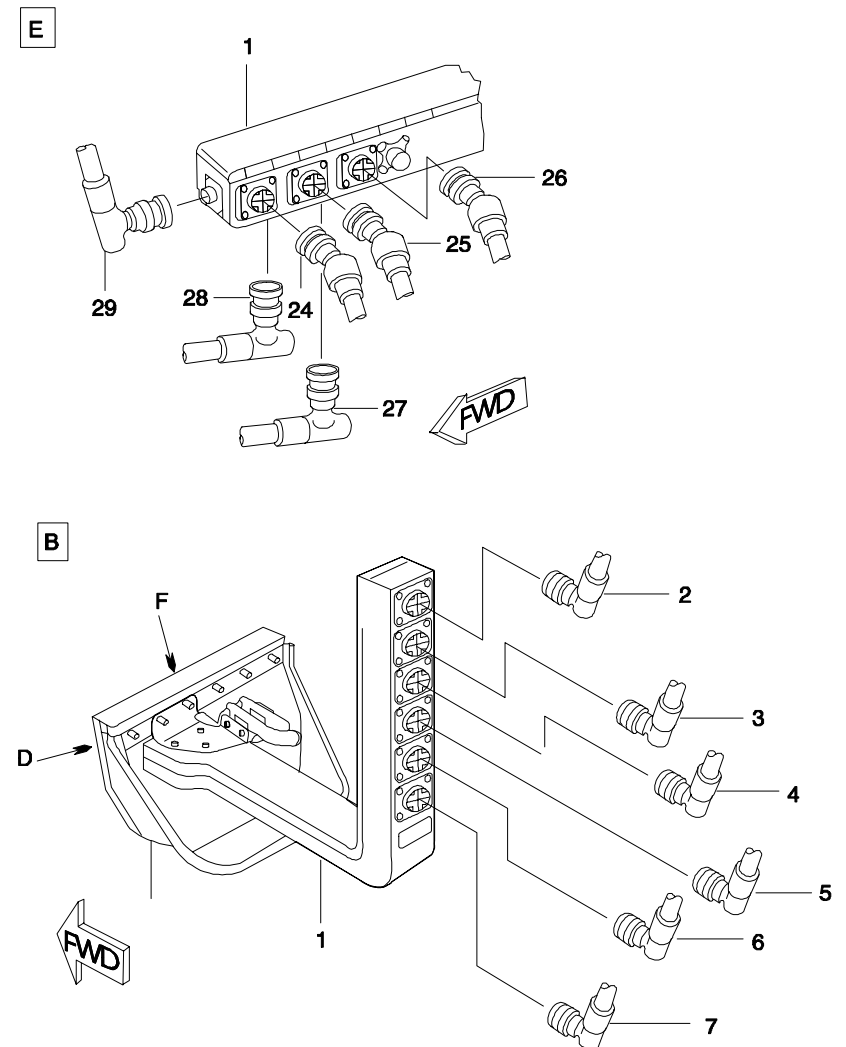
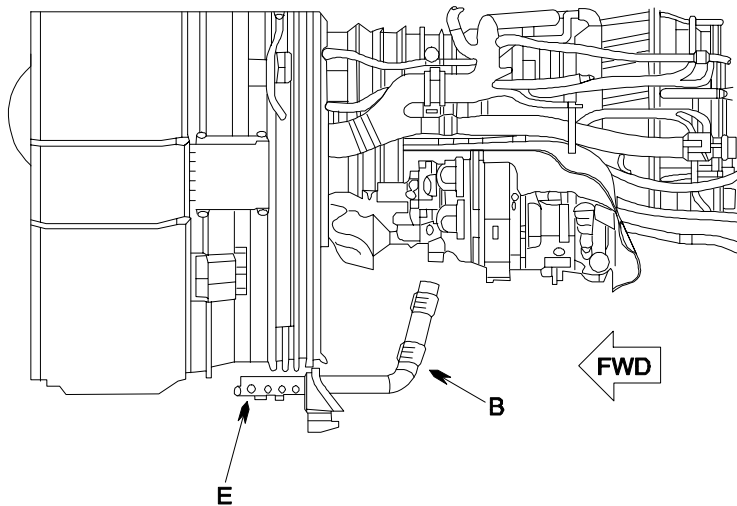
Zone : 413-423

COMPONENT DESCRIPTION :

The cable tray is made of reinforced materials.

REMOVAL INSTALLATION :

Once all the electrical connectors have been removed, the bolts that attach the cable tray to the pylon barrier and different brackets can be removed.



STUDENT NOTES

FQW4200 GE Metric

ECU ELECTRICAL SUPPLY

Powering N2 <12%
Powering N2 >12%
Auto De-Energization
FADEC Ground Power

POWERING N2 <12%

The ECU is supplied with power from the aircraft electrical power network when N2 is below 12%.

Each channel is independently supplied by the 115V AC through the EIVMU.

The aircraft 115V AC permits :

- Automatic ground check of the FADEC when the engine is not running (power up test).
- Engine starting (The ECU is powered when the Master lever is set to ON or the rotary selector set to IGN/START or CRANK position).
- ECU operation in case of dedicated alternator fault.

POWERING N2 >12%

As soon as the engine is running above 12% of N2, the dedicated permanent magnet alternator directly supplies the ECU.

The dedicated alternator supplies each channel with three phases Alternative Current. Switching between the aircraft 115V AC power supply and the dedicated generator power supply is done automatically by the ECU.

AUTO DE-ENERGIZATION

The FADEC is automatically de-energized on ground, through the EIVMU, after engine shut down.

The ECU automatic de-energization occurs on ground :

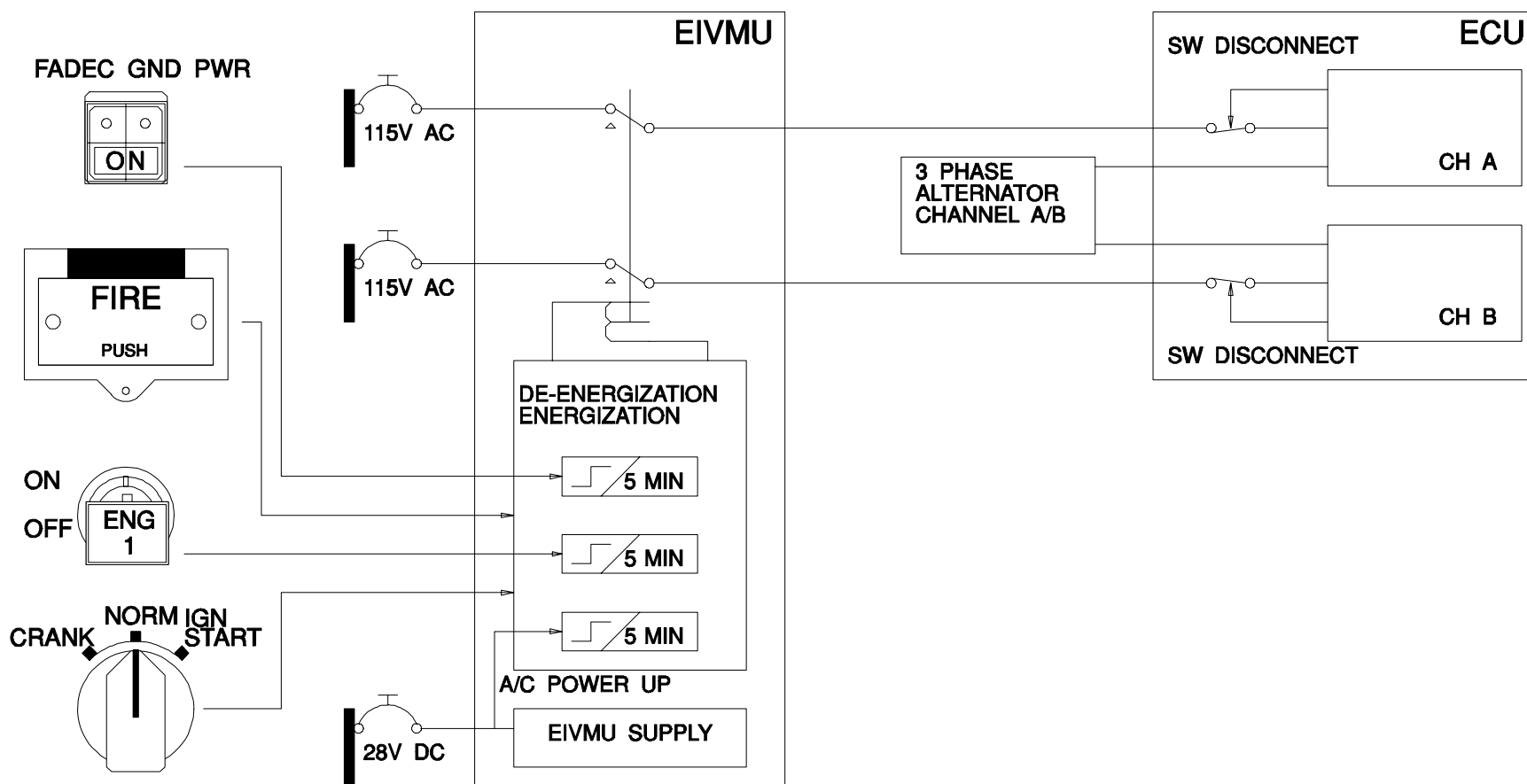
- 5 mn after aircraft power up.
- 5 mn after engine shut down.
- 5 mn after FADEC GND PWR if the CMS is not in menu mode.
- At any time when the ENG FIRE pushbutton is released out.

Note: The EIVMU's failsafe, it powers the ECU even when it is not powered itself.

FADEC GROUND POWER

For maintenance purposes and MCDU engine tests, the engine FADEC GROUND POWER panel allows FADEC power supply to be restored on ground, with engine shut down.

When the corresponding engine FADEC GND PWR pushbutton is pressed ON, the ECU recovers its power supply.



FQW4200 GE Metric

STUDENT NOTES:

FQW4200 GE Metric

IGNITION AND STARTING PRESENTATION

- General
- Control and Indicating
- Automatic Start
- Manual Start
- Cranking
- Continuous Ignition
- Safety Precautions
- Maintenance Practices

GENERAL

The ignition system provides the electrical spark needed to start or continue engine combustion. The ignition system is made up of the exciter and the ignitor.

The pneumatic starting system drives the engine core at a speed high enough for a ground or air start to occur. The start system is made up of the start valve and the starter.

CONTROL AND INDICATING

The Electronic Control Unit(E.C.U.) controls the ignition and starting systems but has no authority to abort auto or manual start in flight.

The operation of the start valve and of the exciter is displayed on the ENGINE ECAM page.

AUTOMATIC START

During an automatic start, the Electronic Control Unit opens the start valve, then the exciter is energized when core speed is nominal.

The ECU provides full protection during start sequence. When the automatic start is completed, the ECU closes the start valve and cuts off ignition

MANUAL START

During a manual start, the start valve opening and the ignition are manually initiated under the authority of the Electronic Control Unit.

The ECU can abort manual start operation if EGT limit is exceeded.

CRANKING

The dry cranking and the wet cranking are selected manually via the Electronic Control Unit.

CONTINUOUS IGNITION

With engine running, continuous ignition can be selected via the Electronic Control Unit either manually or automatically.

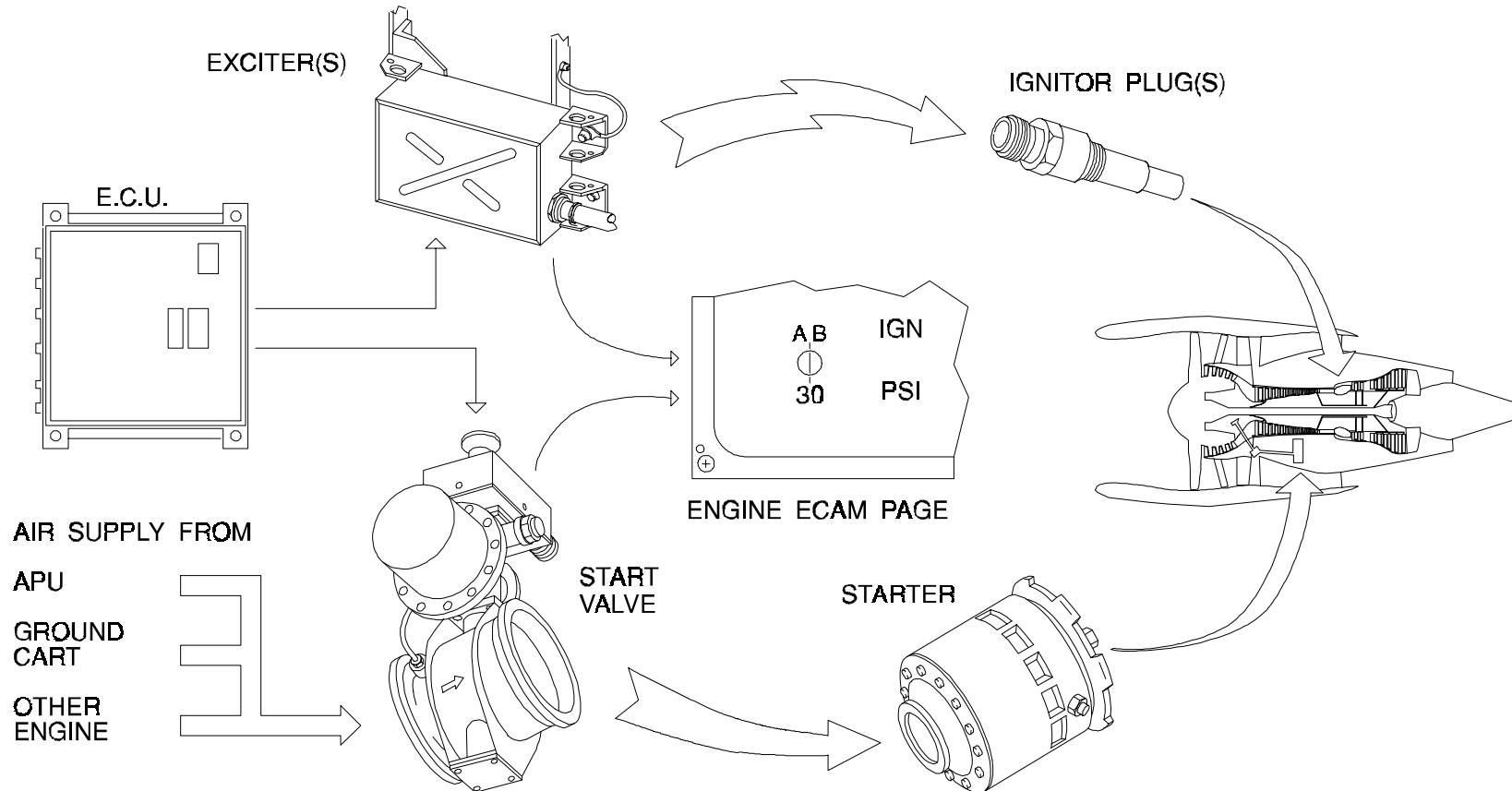
SAFETY PRECAUTIONS

Warning : the Electronic Control Unit sends the 115 volts to the ignition exciters, which convert it and send high energy pulses through the ignition leads to the ignitors.

Safety precautions have to be taken prior to working in this area.

MAINTENANCE PRACTICES

To increase aircraft dispatch, the start valve is equipped with a manual override. For this manual operation, the mechanic has to be aware of the engine safety zones.



FQW4200 GE Metric

STUDENT NOTES:

FQW4200 GE Metric

AUTOMATIC START SEQUENCE

- General
- A/C configuration
- Ground autostart
- Air autostart
- Autostart interruption
- No light off abortion sequence
- Stall/overtemperature abortion sequence
- Continuous ignition

GENERAL

During automatic start, control of the ignitors, fuel and starter air valve is under the full authority of the ECU.

The ECU ensures monitoring and provides protection up to idle for :

- engine limits (EGT and starter engagement time) ;
- engine abnormal start functioning ;
- starter re-engagement.

The ECU enters the automatic start mode when the engine is not running, and if either of the following conditions is met :

- 1) With valid EIVMU data :
Rotary selector is positionned to IGN/START followed by Master Lever set to ON.
- 2) With invalid EIVMU data :
Alternate start ignition discrete active and hardwired Master lever discrete ON.

A/C CONFIGURATION

- ENG START SEL : NORM ;
- ENG MASTER LEVER : OFF;
- Engines not running ;
- A/C ELEC PWR available ;
- Air is available at the SAV;
- EWD ECAM page data are amber crossed
- SD ECAM page: DOOR/OXY.

GROUND AUTOSTART

As soon as the ENG START selector is set to IGN/START the ECU is powered on. On the EWD the amber crosses are replaced by engine parameters. On SD the ENG PAGE shows on.

	IGNITION START SEL to IGN/START	If after 30s the Master Lever is not set to ON
APU (if used)	Bleed demand increases	Bleed demand decreases
PACK VALVES	CLOSE	OPEN

When the ENG MASTER LEVER is set to ON, the automatic starting sequence is initiated by the ECU. The High Pressure Shut Off Valve (HPSOV) is unlatched.

The start air valve opens and N2 increases.

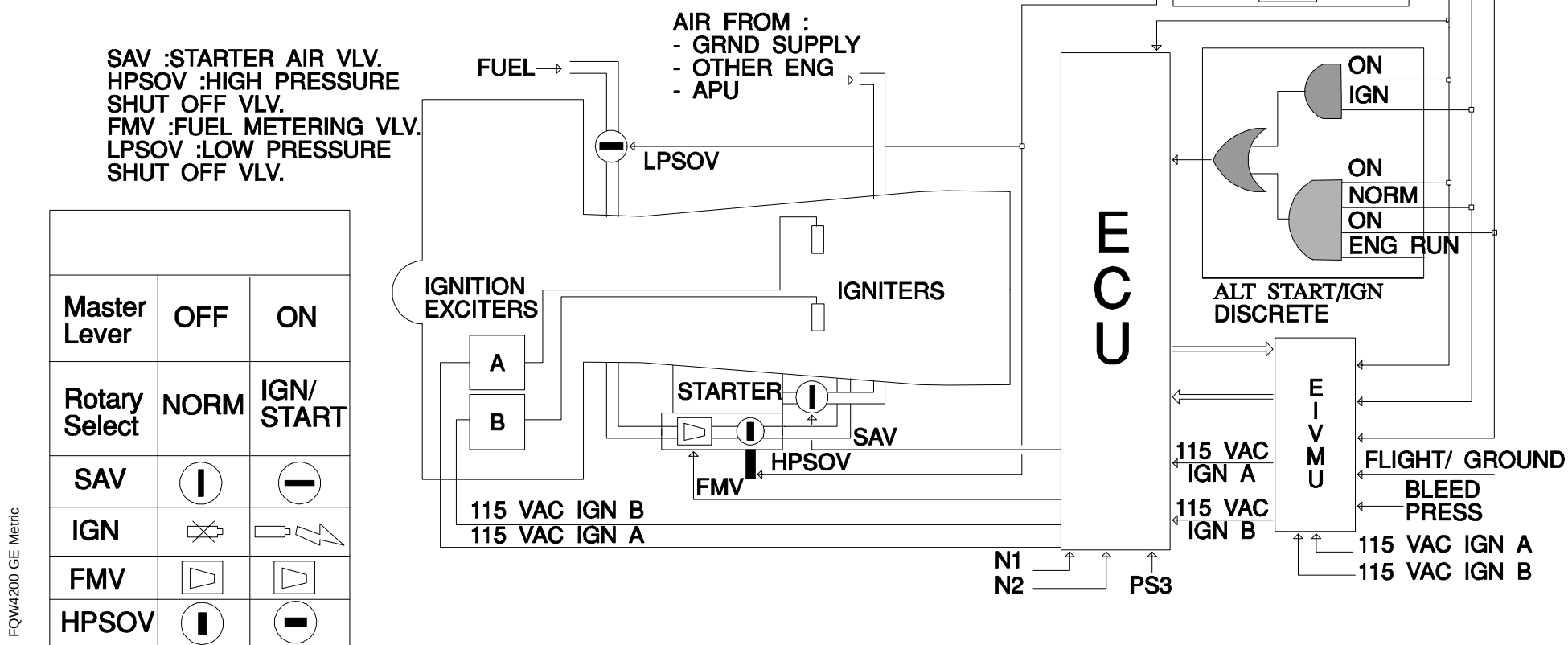
When N2 reaches 10% one ignition system is excited. At each start the ECU selects alternatively one ignition system A or B. The second ignitor may be turned on in case of delayed or no light operation.

At N2=15% the fuel metering valve open.

When N2 reaches 50% the starter air valve closes. If the Master Lever is not placed in the ON position 30s later, the pack valves will close and the APU demand will decrease.

N2=54% the ignition system is de-energized.

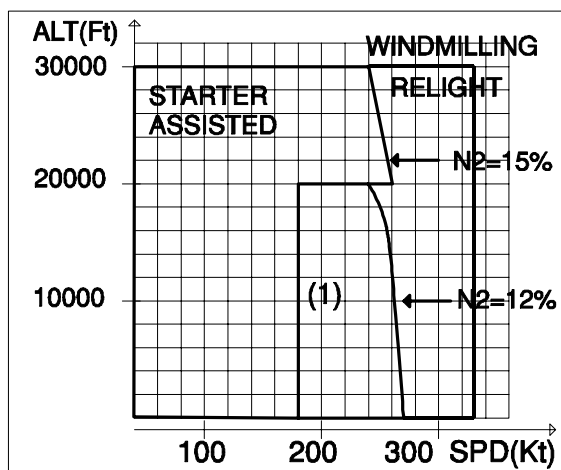
The ECU considers that the start sequence is completed when the engine reaches the minimum idle core speed. Then the rotary selector is turned back to the NORM position.



AIR AUTOSTART

When the autostart sequence logic is active in flight firstly the ECU identifies the windmilling or starter assisted air start conditions according to the flight parameters (Mach, Altitude) and the engine parameters.

The engine can be relight without using the starter provided N2 is greater than 12% when below 20000 ft, or N2 is greater than 15% when above 20000 ft.



(1) A windmilling relight can be attempted in this zone provided N2 has not dropped below 12%.

The starting sequence is similar to the ground start sequence except that the ECU has no authority to abort the sequence. Prior to initiate the starting sequence, the master lever has to be selected off.

Start Seq Initiation	>15%	>50%	>54%
MASTER LVR	ON	ON	ON
ROT SEL	IGN	IGN	IGN
SAV if used	OPEN	OPEN	CLOSED
IGNITERS ON	BOTH	BOTH	NONE
FMV	CLOSED	OPEN	OPEN

In order to guard against the effects of some failures which could jeopardize the in-flight restart, the ignition and fuel are selected ON by the ECU in the following conditions :

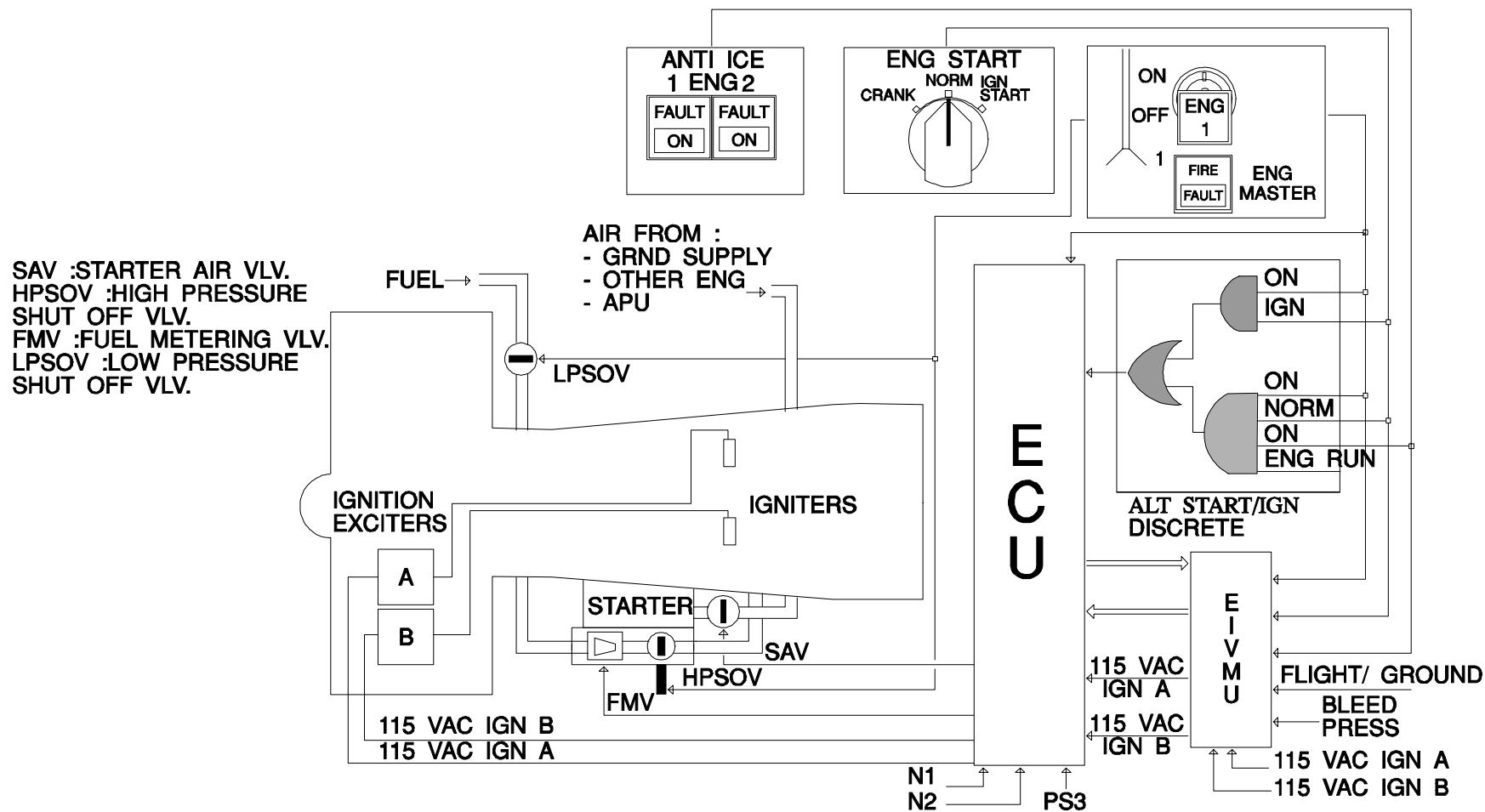
- Insufficient air pressure at the SAV inlet ;
- The SAV does not open ;
- N2=15% is not achieved within 10s of SAV opening.

AUTOSTART INTERRUPTION

The autostart can be interrupted only by placing the MASTER LEVER back to the OFF position. Note that Turning the ENG START selector to NORM or CRANK while in autostart has no effect.

The Master Lever placed back in the OFF position leads to the following :

- HPSOV, LPSOV closure (directly from the MASTER LEVER) ;
- FMV closure (through the ECU) ;
- Ignition cut-off (via the ECU) ;
- SAV closure (via the ECU).



FQW4200 GE Metric

NO LIGHT OFF ABORTION SEQUENCE

During ground start, engine light off should occur within 20s following the selection of the first ignitor by the ECU.

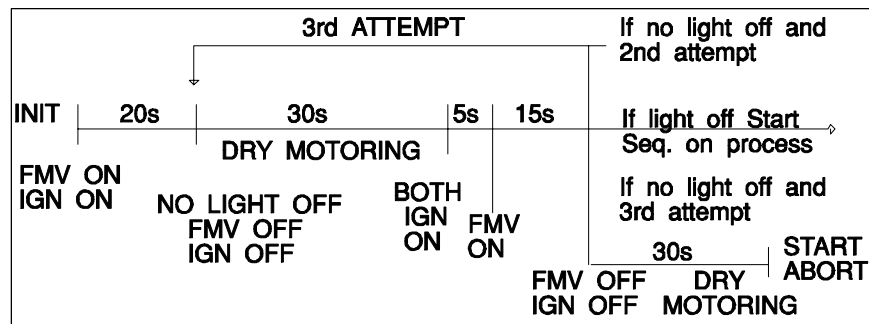
In case of no light off within 20s, the ECU will perform a second attempt by closing the FMV and dry motors the engine for 30s.

Then both ignitors are switched ON and 5s later the FMV opens.

15s later if there is still no light off the ECU will repeat the sequence.

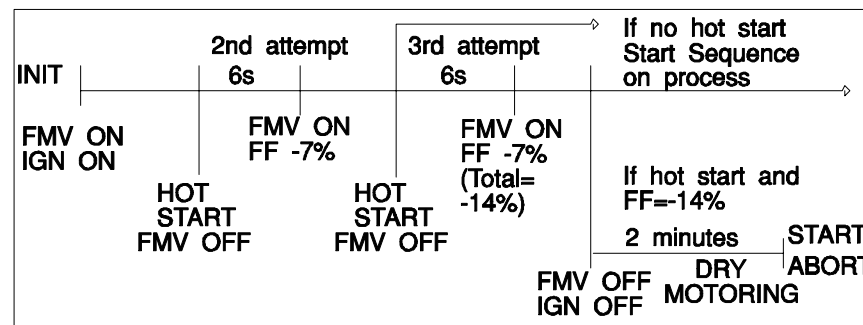
If after the third attempt there is still no light off, the start is aborted. The FMV closes and the ignition is turned off.

A fault message and a maintenance advisory are generated by the ECU. The ECU will automatically performs a dry motoring sequence for 30 s.



STALL/OVERTEMPERATURE ABORTION SEQUENCE

In case of stall or overtemperature the ECU will reduce the fuel flow schedule in step of 7% down to 14% until start is successful.



CONTINUOUS IGNITION

A manual selection of the continuous ignition by the ECU is accomplished when the engine is running and one of the condition below is met :

With valid EIVMU data:

- . on ground from the ENG SEL being turned from NORM to IGN /START position.
- . in flight, from the ENG SEL being in the IGN/START pos.

With invalid EIVMU data :

- . when the alternate start/ignition discrete is active.

The ECU automatically selects continuous ignition when with engine running if any of the conditions below exist :

- the anti-ice pushbutton is ON
- an engine flame out is detected.

In those cases both ignition systems are turned ON.

STUDENT NOTES:

STUDENT NOTES

MANUAL START SEQUENCE

General
A/c Configuration
Ground Start
Air Start
Start Interruption

GENERAL

In the manual start sequence, engine starting control is under limited authority of the ECU. The starter air valve, fuel metering valve and ignition are controlled by the ECU.

In the event of an abnormal start the ECU provides fault annunciation to the FWC which generates warning messages for manual action.

Note that the manual start sequence can only be selected with valid EIVMU data.

On ground the ECU will abort the manual start sequence if the starting EGT temperature limit is exceeded. But the ECU has no authority to abort a manual start sequence in flight.

A/C CONFIGURATION

ENG START SEL: NORM ;

ENG MASTER LEVER: OFF ;

Engines not running ;

A/C ELEC PWR available ;

Air is available at the SAV ;

EWD ECAM page data are amber crossed ;

SD ECAM page: DOOR/OXY.

GROUND START

As soon as the engine start selector is set to ignition/ start, the ECU's are powered on. On the EWD the amber crosses are replaced by engine parameters. On the SD the engine page shows on.

	IGNITION START SEL to IGN/START	If after 30s the ENG MAN START P/B is not ON
APU (if used)	Bleed demand increases	Bleed demand decreases
PACK VALVES	CLOSE	OPEN

When the engine manual start switch is set to on the manual start sequence is initiated by the ECU. The starter air valve opens and N2 increases.

Note that in case of starter air valve malfunction, the valve can be operated by use of a manual override wrenching socket. In that case the ground personnel is advised to close the valve when N2 reaches 45%.

When N2 reaches 15%, the master lever is moved to the ON position. Both ignition systems are switched on, the FMV and the HPSOV open under ECU control.

The ECU controls the starter air valve to the closed position when N2 equals 50%. If the other engine is not started within 30s, the pack valves will open and the APU bleed demand will decrease.

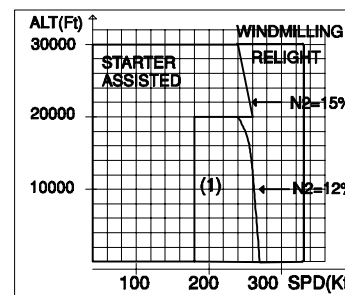
The ignition is de-energized when N2 reaches 54%.

When the engine is at idle, the engine manual start pushbutton is switched to OFF and the engine start rotary selector is turned to NORM.

AIR START

When the manual start sequence has been initiated, firstly the ECU identifies the windmilling or starter assisted air start conditions according to the flight parameters (Mach, Altitude) and the engine parameters.

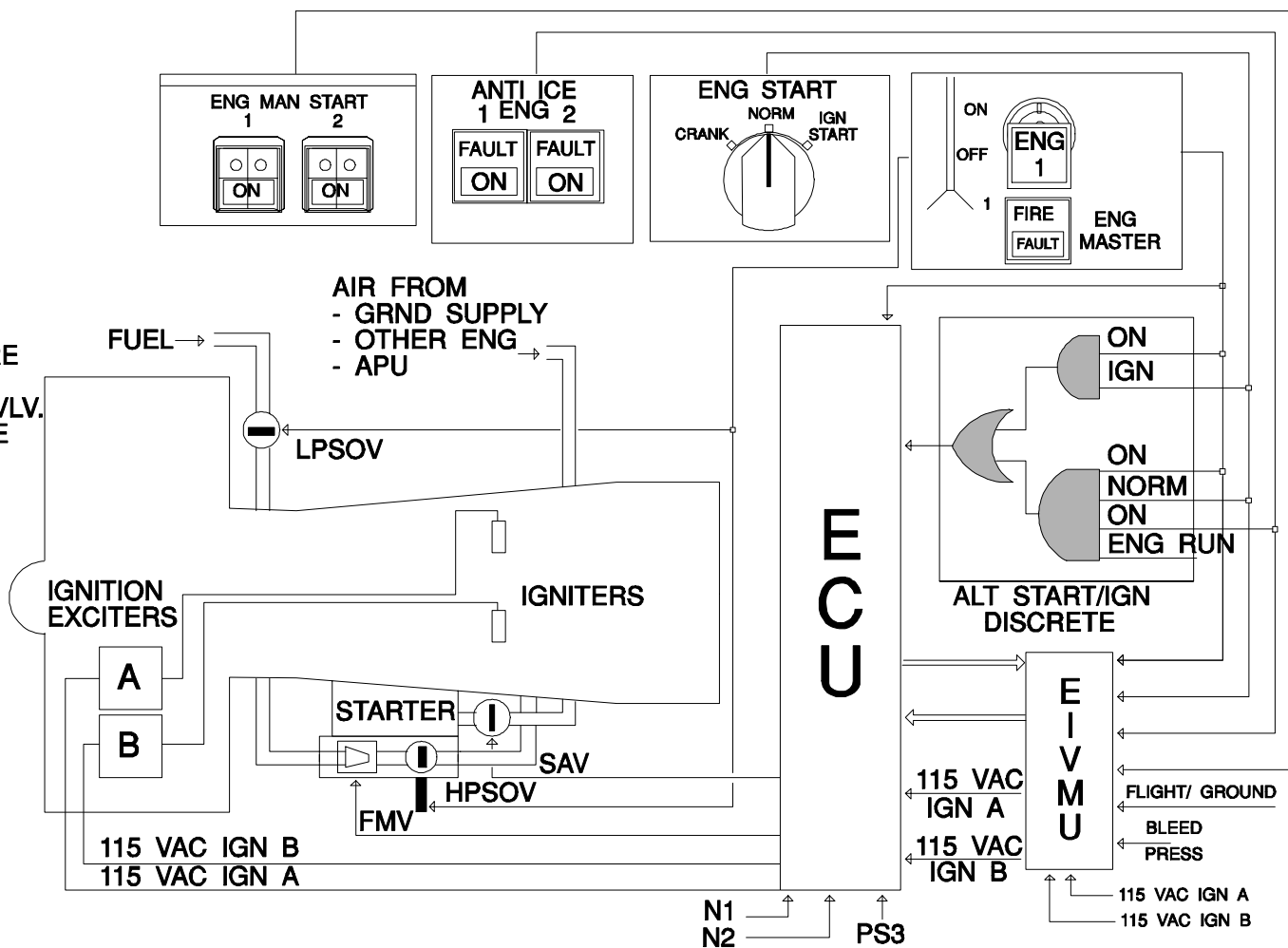
The engine can be relighted without using the starter provided N2 is greater than 12% when below 20000ft or N2 is greater than 15% when above 20000ft.



A windmilling relight can be attempted in this zone provided N2 has not dropped below 12%.

SAV :STARTER AIR VLV.
HPSOV :HIGH PRESSURE
SHUT OFF VLV.
FMV :FUEL METERING VLV.
LPSOV :LOW PRESSURE
SHUT OFF VLV.

Manual start	OFF	ON
Master Lever	OFF	ON
Rotary Select	NORM	IGN/START
SAV		
IGN		
FMV		
HPSOV		



START INTERRUPTION

The manual start sequence can be interrupted by placing the engine manual start switch to OFF providing that the master lever is still in the OFF position. This leads to the starter air valve closure

Once the engine master switch has been placed in the ON position, placing the engine manual start switch to OFF has no effect.

But the sequence can be interrupted at any moment by placing the master lever to the OFF position :

- HPSOV, LPSOV closure (directly from the MASTER LEVER),
- FMV closure, Ignition cut-off and SAV closure (via the ECU) .

STUDENT NOTES:

STUDENT NOTES

ENGINE MOTORING

General
Dry Motoring
Wet Motoring

GENERAL

The FADEC system provides capability of control for dry and wet motoring. Both are provided with valid EIVMU data.
Only dry motoring is possible without EIVMU valid data.

DRY MOTORING

When the engine start selector switch is placed in the crank position the amber crosses on the EWD are replaced by engine parameters. On the SD the engine page shows on.

Once the engine manual start pushbutton is placed in the ON position the starter air valve opens. The motoring continues as long as required for the check being performed, observing the starter limitations.

Normal dry motoring can be interrupted at any time by placing the engine manual start pushbutton in the OFF position.

Note that ignition is inhibited when the ENG START selector is in the CRANK position.

STARTER :

Maximum N2 re-engagement : N2=20%

Maximum continuous operation : 5 min Duty cycle.

If the 5 min time limit is exceeded :

- cool starter for 30s for each one minute of operation
- After two consecutive 5 min duty cycles cool starter for 10 min prior to each subsequent 5 min duty cycle.

Turning the ENG START SEL switch to NORM while the ENG MAN START pushbutton is still ON, does not abort the cranking sequence.

WET MOTORING

When the engine start selector switch is placed in the crank position the amber crosses on the EWD are replaced by engine parameters. On the SD the engine page shows on.

Once the engine manual start pushbutton is placed in the ON position the starter air valve opens. The motoring sequence is carried out observing the starter limitations.

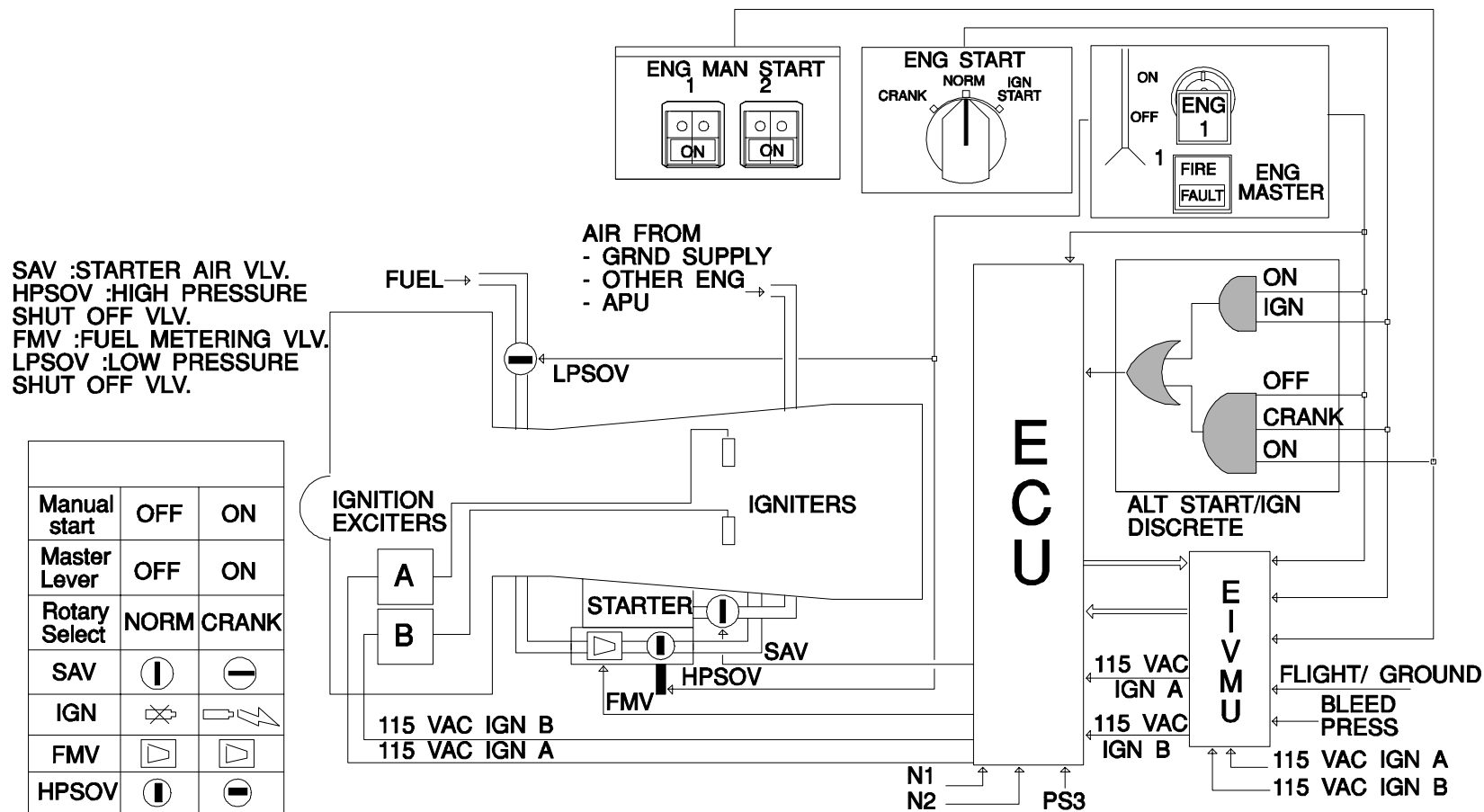
When the master lever is placed to the ON position at N2 equals 15%, the ECU controls the FMV to open.

Placing the master lever back in the OFF position leads to a dry motoring sequence. Consequently, the engine manual start pushbutton will be selected off at the end of the dry motoring sequence.

If necessary the wet motoring sequence can be aborted by placing the engine man start pushbutton in the OFF position or by placing the engine start selector in the NORM position.

Note that ignition is inhibited when the ENG START selector is in the CRANK position.

Reminder : A wet motoring sequence is always followed by a 60s dry motoring sequence to clear fuel from engine.



STUDENT NOTES:

FQW4200 GE Metric

WARNINGS (IGNITION/START)

IGN A+B FAULT
IGN A (B) FAULT
START VALVE FAULT
START FAULT
HP FUEL VALVE

IGN A+B FAULT

Both ENG 2 (1) ignition systems, A and B are faulty, or their corresponding 115V electrical power supply is not available.

IGN A (B) FAULT

The ENG 1(2) ignition system A is faulty, or the corresponding 115V electrical power supply is not available.

START VALVE FAULT

The valve is controlled to open but it remains in its closed position with a sufficient bleed pressure

The ENG 1(2) Starter Air Valve does not open due to insufficient bleed pressure which is below 25 psi.

The valve is controlled to close but remains in the open position. Note that the starter may be damaged if the operation is continued.

START FAULT

This appears when a sheared starter shaft is detected. In other words, when the starter air valve is commanded to open and a low starter air pressure is not detected with a N2 lower than 10% after 30 seconds.

It happens when the engine has not yet reached idle speed and the five minutes starter activation time limit has been exceeded.

An ENG 1(2) stall is detected during a start sequence. Stall detection is based on N2 and EGT monitoring.

An ENG 1(2) EGT overtemp is detected during a start sequence. This happens when the engine status is below idle and the EGT exceeds 750 °C and lightoff has been detected.

An ENG 1(2) no light up condition is detected. This happens when a ground autostart or manual start is in progress and no light up has been detected 20 seconds after ignition has been selected.

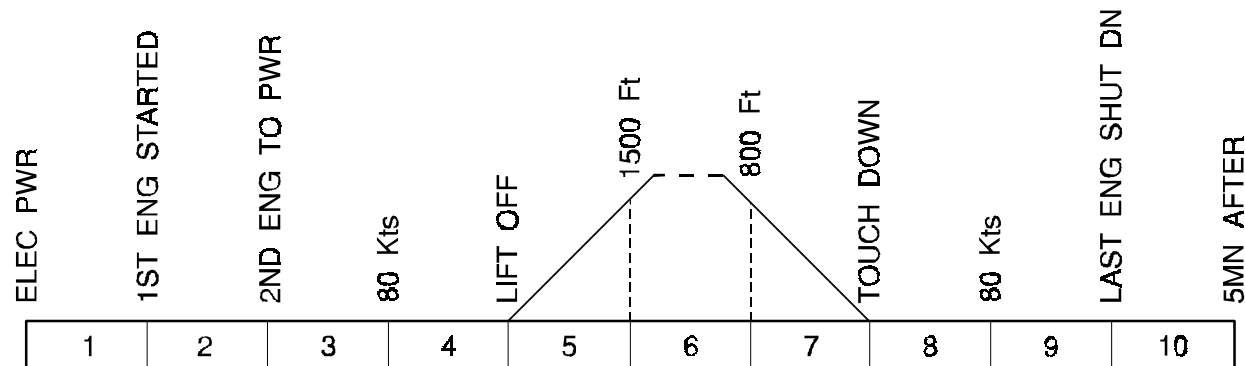
This happens when an N1 low pressure rotor speed is detected during a start when N2 is above 53%.

This appears when the thrust lever is not in idle position during a manual or automatic start sequence.

HP FUEL VALVE

This happens when the engine is not running, the ECU commands the FMV to the minimum flow position or above, the master lever is ON and the HPSOV is in the closed position.

The ENG 1(2) HP fuel shut off valve has failed in the opened position with the master lever in the OFF position.



E/WD : FAILURE TITLE	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLT PHASE INHIB
IGN A + B FAULT	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 5, 7, 8
IGN A (B) FAULT	NIL	NIL	NIL	NIL	3, 4, 5, 7, 8
START VALVE FAULT	SINGLE CHIME	MASTER CAUT	ENG		3, 4, 5, 7, 8
START FAULT	SINGLE CHIME	MASTER CAUT	ENG		3, 4, 5, 7, 8
HP FUEL VALVE	SINGLE CHIME	MASTER CAUT	ENG		3, 4, 5, 7, 8

STUDENT NOTES

FQW4200 GE Metric

IGNITION AND STARTING COMPONENTS

- Safety precautions
- Pneumatic starter
- Start air valve
- Starter air ducts

SAFETY PRECAUTIONS

WARNING : Before any action on the engine :

- Do not start the engine
- Make sure that the engine has been shut down for at least 5 minutes.
- Make sure that the ENG FADEC GND PWR pushbutton is OFF.
- Make sure that the master lever is in the OFF position.

STUDENT NOTES

FQW4200 GE Metric

PNEUMATIC STARTER

FIN / ZONE

FIN : 5000 ES
ZONE : 410/420

DESCRIPTION

The starter comprises a turbine wheel which drives, when pressurized, an internal gear train.
The rotating elements are lubricated by specific oil contained in the gear housing.

LOCATION

The starter is located on the aft side of the accessory gearbox at the 6 o'clock position.

SERVICING

For servicing purposes, the gear housing is fitted with two oil filler plugs, an oil overflow plug and a magnetic probe. The latter is mounted in a check valve plug which prevents oil draining when the probe is removed.

ACCESS

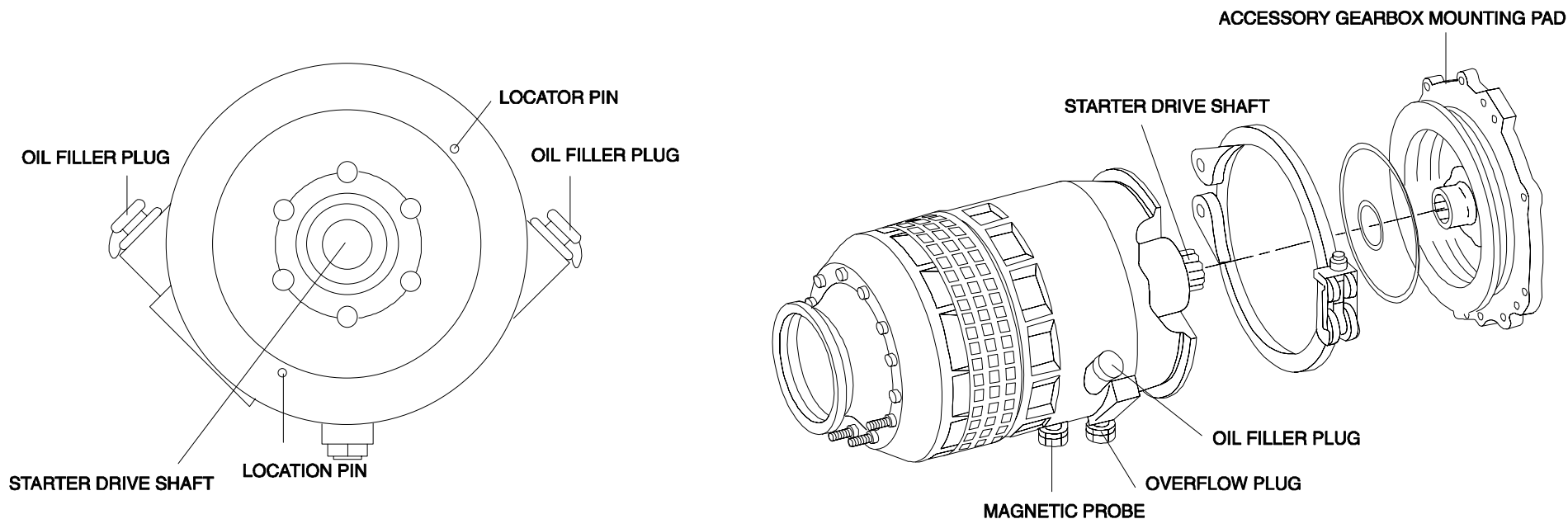
To gain access to the starter, the fan cowl doors and thrust reverser cowl doors must be opened.

VISUAL INSPECTION

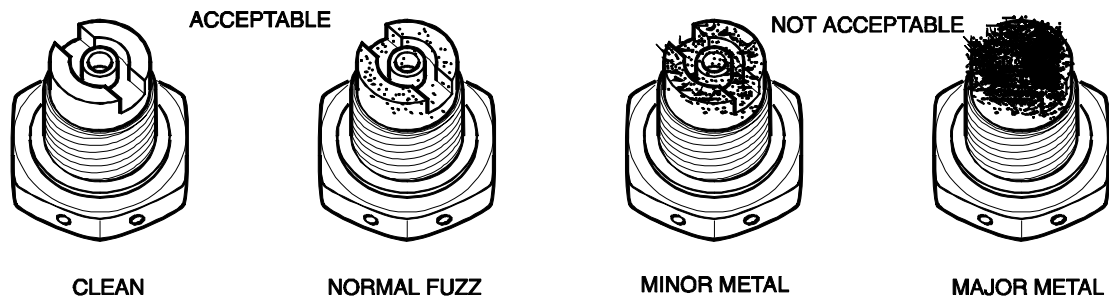
Examine the surface of the starter ; in case of oil leakage, replace it.

MAGNETIC PROBE INSPECTION

Remove and examine the magnetic probe for quantity and type of contamination. If the contamination is acceptable, the starter is serviceable, otherwise an oil analysis must be performed. Change the O'ring after inspection.



MAGNETIC PROBE INSPECTION



START AIR VALVE

FIN / ZONE

FIN : 4005 KS
ZONE : 410/420

DESCRIPTION

The start air valve (SAV) is electrically controlled and pneumatically operated. It is spring loaded closed and opens to pressurize the starter under ECU command.

LOCATION

The SAV is installed in the core compartment at the 6 o'clock position.

SERVICING

To enable engine start with a faulty control solenoid, the SAV is equipped with a manual override socket.

ACCESS

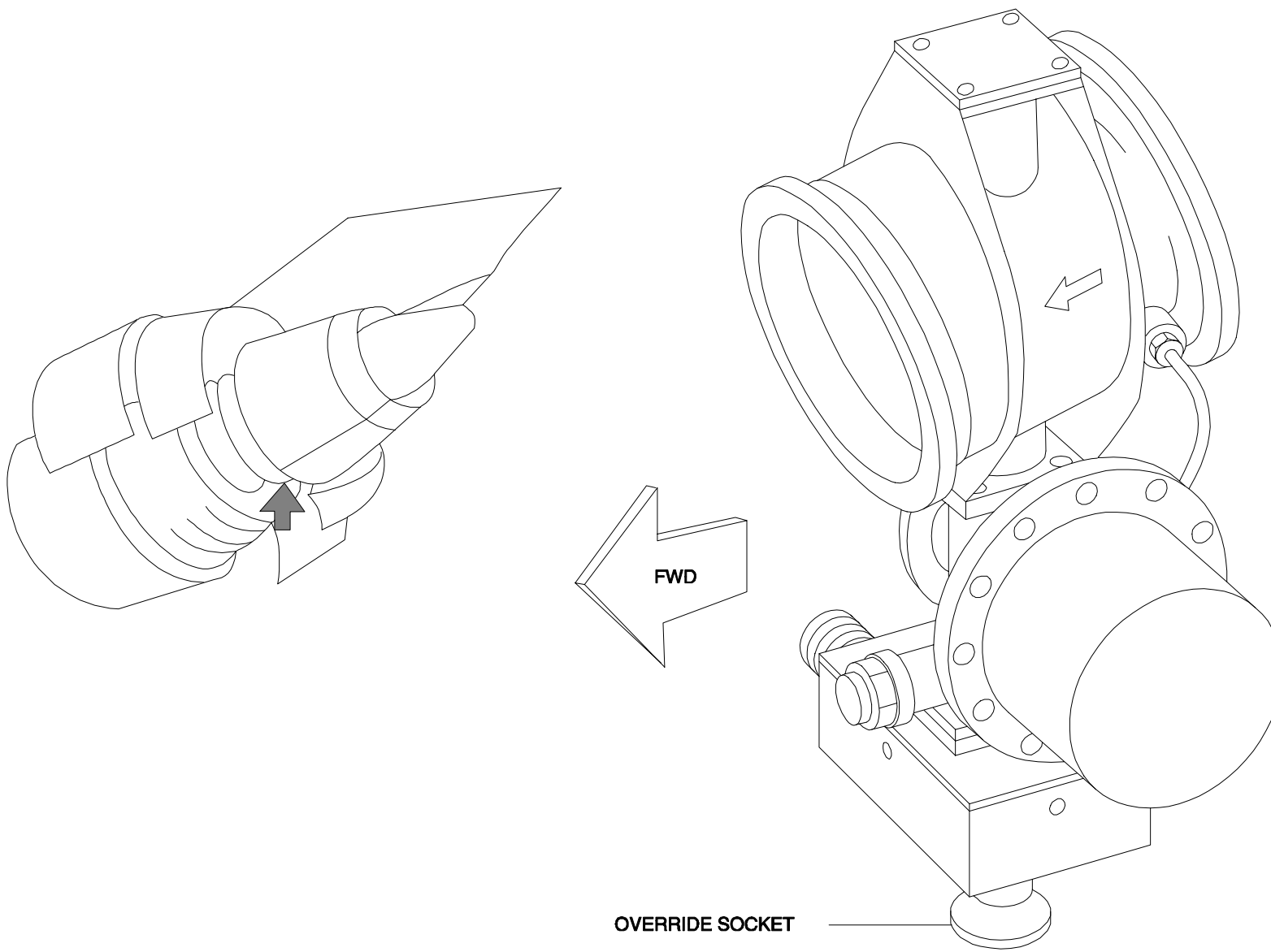
The latch access door is equipped with a hole to insert a tool into the guide tube to the socket.

MANUAL START

In communication with the cockpit, the mechanic inserts the wrench handle onto the override square socket and pushes and rotates it counterclockwise to open the SAV. The SAV will automatically return to the closed position when the handle is released.

VISUAL CHECK

The butterfly position is indicated by markings on the valve and on the socket, when the thrust reverser cowl doors are opened.



FQW4200 GE Metric

STARTER AIR DUCTS

FIN/ZONE

FIN : -
ZONE : 410/420

DESCRIPTION

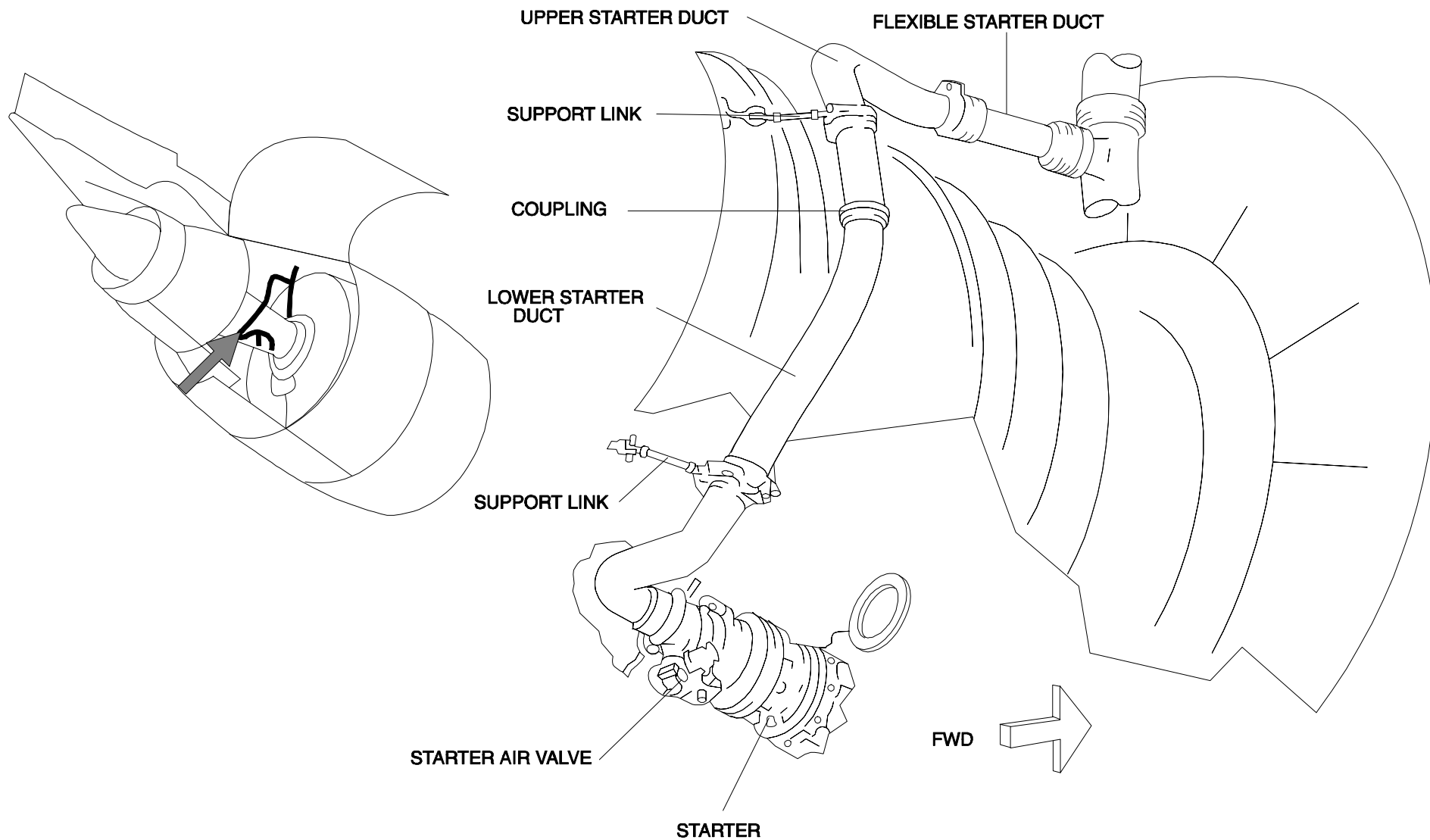
The starter duct assembly is a three piece duct comprising a flexible duct, an upper and lower rigid duct, support links and couplings.

LOCATION

The assembly runs from the pylon interface aft and around the right-hand side of the engine to the SAV.

PURPOSE

During a start sequence, bleed air is ducted from the air source through the precooler, the overpressure valve and the starter duct to the SAV. At this point, the ECU controls the air supply to the starter via the SAV.



FQW4200 GE Metric

STUDENT NOTES

FQW4200 GE Metric

IGNITION AND STARTING COMPONENTS

- Safety precautions
- Ignition exciters
- Ignition leads
- Igniter plugs
- Start Air Valve
- Pneumatic Starter

SAFETY PRECAUTIONS

The ignition voltage is dangerously high and can cause serious injury or death.

Do not operate the ignition system for 5 minutes before you remove the ignition components.

Make sure you ground the ignition exciters output terminal after you disconnect the ignition lead.

Make sure that the engine has been shut down for at least 5 minutes.

STUDENT NOTES

IGNITION EXCITERS

FIN/ZONE

FIN : 4000EH1/2
ZONE : 410/420

DESCRIPTION

Each exciter is enclosed in a sealed aluminium housing in order to protect the components from vibrations or environmental conditions.
Each ignition exciter has :

- one ignition lead connector
- one electrical input connector.

LOCATION

The two exciters are shock mounted, one above the other on the aft fan case at the 8 o'clock position.

OPERATION

The ignition exciter is of the capacitor type. It requires a 115 VAC, 400 Hz input current from the aircraft via the ECU. The output voltage is about 18000 volts at the end of the ignition leads at a nominal cyclic rate of 1 spark/sec.

ARCHITECTURE

The ignition exciter consists of :

- one input/power transformer circuit,
- one rectifier/storage circuit,
- one discharge circuit.

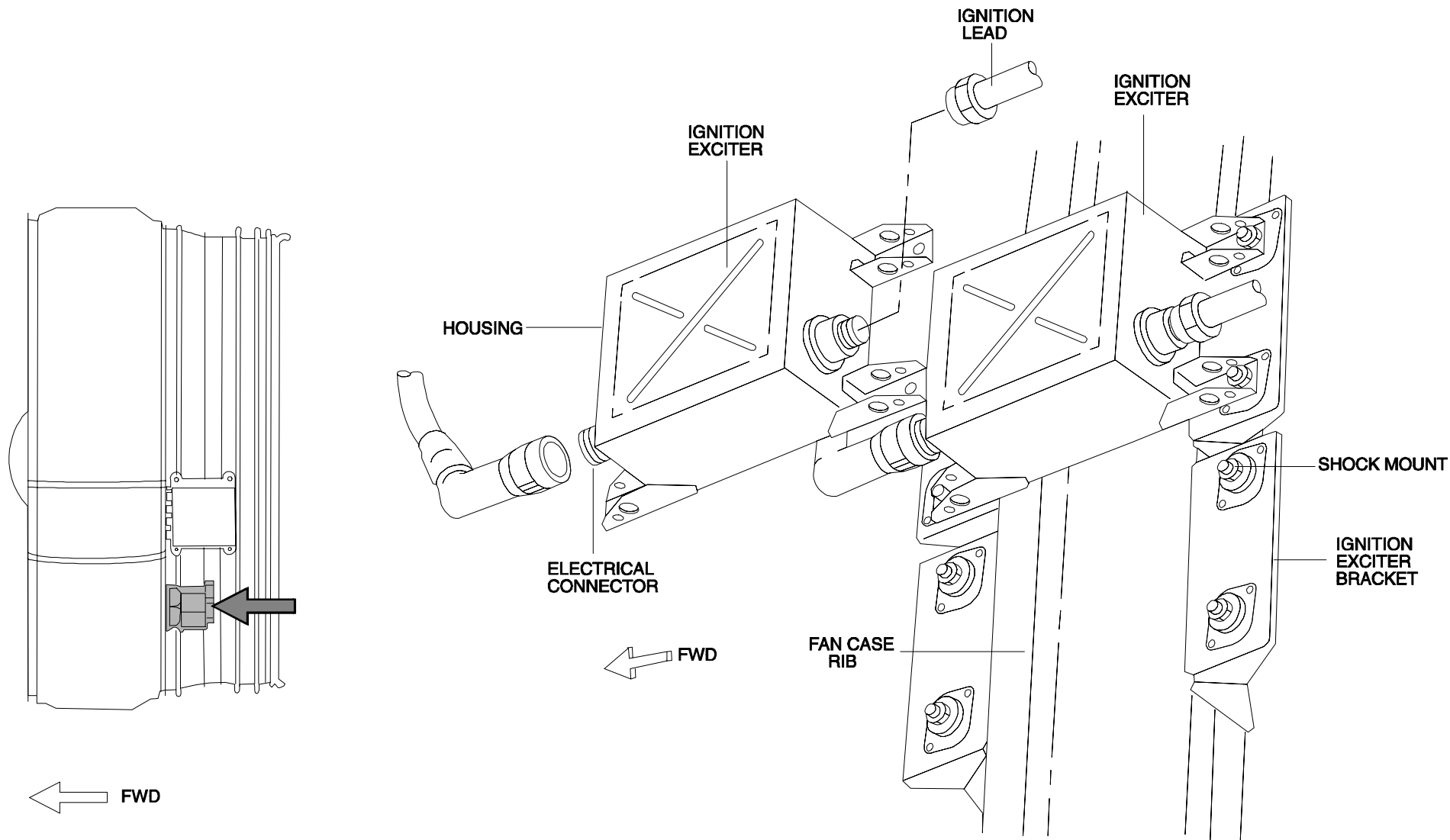
SUPPLIES

The ignition exciters A and B supply respectively the igniter plugs located at the 3:30 and 5 o'clock positions

REMOVAL/INSTALLATIONS

Each ignition exciter is installed on a bracket by means of four nuts and washers.

FQW4200 GE Metric



IGNITION LEADS

FIN/ZONE

FIN : 4001EH1/2

ZONE : 410/420

DESCRIPTION

The ignition lead consists of a silicone insulated cable containing nickel/copper conductors and housed within a flexible conduit.

LOCATION

The ignition leads run from the ignition exciters to the igniter plugs following the cable tray and brackets on the engine right side.

OPERATION

The ignition leads transmit electrical energy from the ignition exciters to the igniter plugs. Fan discharge air is introduced into an enlarged diameter portion of each ignition lead conduit for cooling of the silicone insulated cable and igniter plug connection.

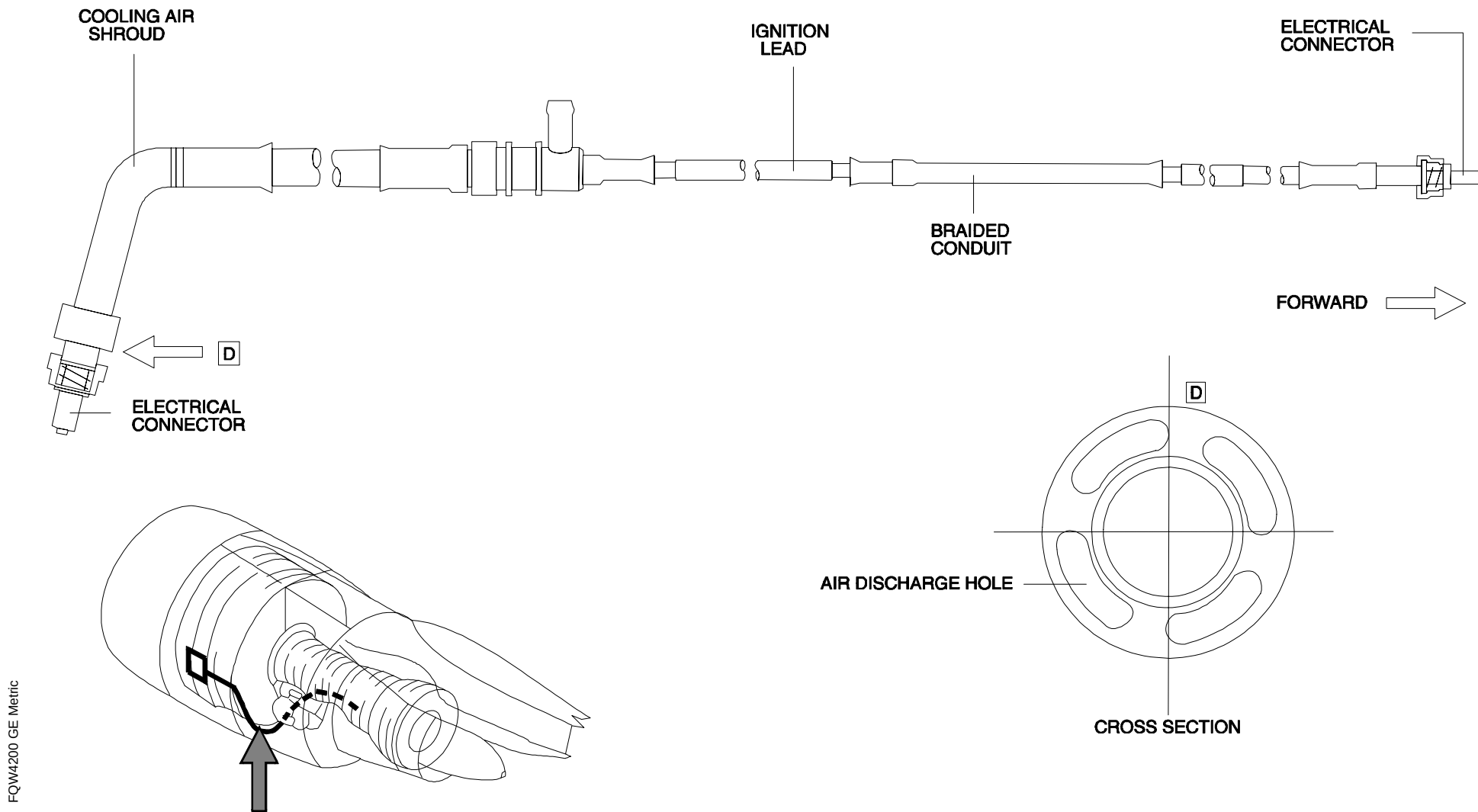
REMOVAL/INSTALLATION

CAUTION : DO NOT TWIST OR BEND THE IGNITION LEAD

The ignition leads are installed on brackets by means of clamps.

ACCESS

Fan cowl doors, thrust reverser cowl doors and right core cowl door must be opened.



IGNITER PLUGS

FIN/ZONE

FIN : 4002EH1/2
ZONE : 410/420

DESCRIPTION

The igniter plugs are of recessed surface gap type and fitted with ignition cooling shrouds.

LOCATION

The two igniter plugs are installed in bosses at the 3:30 and 5 o'clock positions on the combustion case assembly.

ACCESS

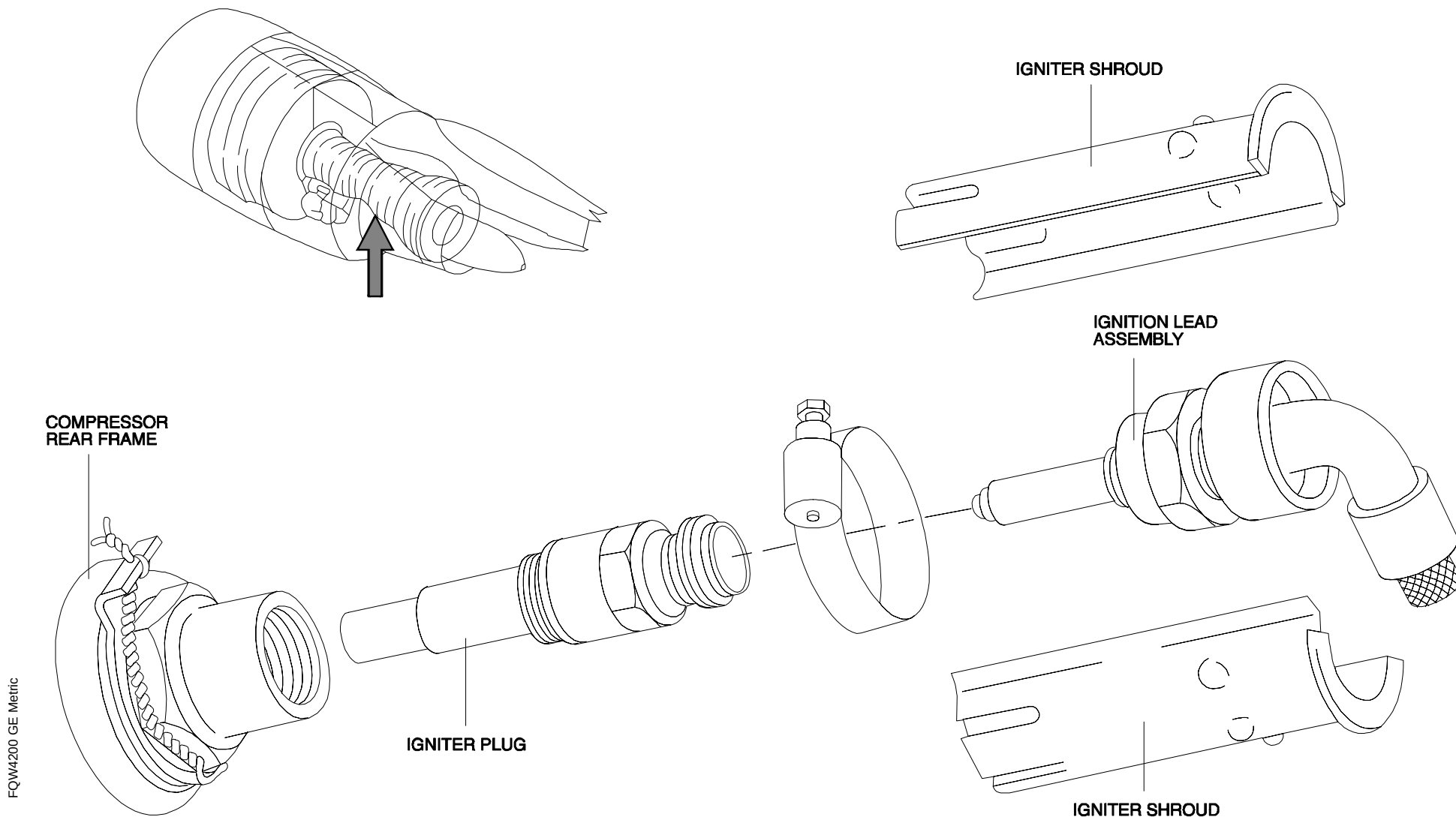
The fan cowl and the thrust reverser cowl doors must be opened. The removal of the fuel manifold attach bracket will ease the removal of the lower igniter plug.

REMOVAL/INSTALLATION

Disconnect the ignition lead from the ignition exciter and ground the output to the fan case.
Remove the igniter cooling shroud from the ignition leads (held by a hose clamp).
Remove the ignition leads from the igniter plug.
Remove the igniter plug.
Perform the operations in the opposite order to install the igniter plug.

TEST

An audible test of the system can be performed.



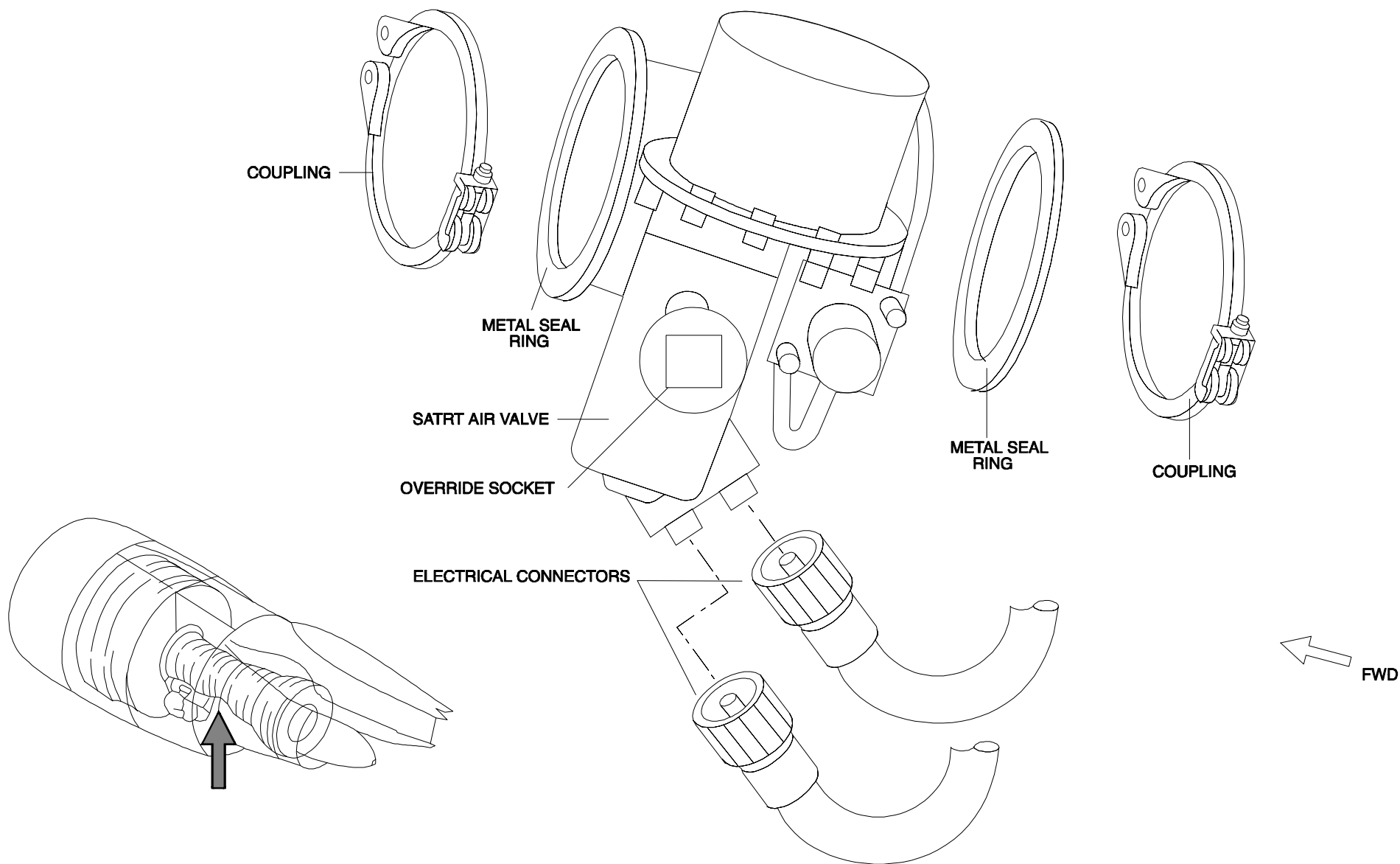
START AIR VALVE

FIN/ZONE

FIN : 4005 KS
ZONE : 410/420

REMOVAL/INSTALLATION

Disconnect the electrical connectors from the Start Air Valve (SAV).
Make an alignment stripe between the SAV and the starter.
Remove the couplings that attach the SAV to the starter air duct and the starter.
Remove and discard, if damaged, the two metal seal rings.
Remove the SAV.
Perform the operations in the opposite order to install the SAV.
Through the open IDG Oil Service door, make sure the override socket is aligned with the guide tube.



FQW4200 GE Metric

PNEUMATIC STARTER

FIN/ZONE

FIN : 5000 ES
ZONE : 410/420

REMOVAL/INSTALLATION

WARNING : MAKE SURE YOU HAVE SUFFICIENT SUPPORT FOR THE PNEUMATIC STARTER BEFORE YOU REMOVE IT FROM THE ACCESSORY GEARBOX (AGB).

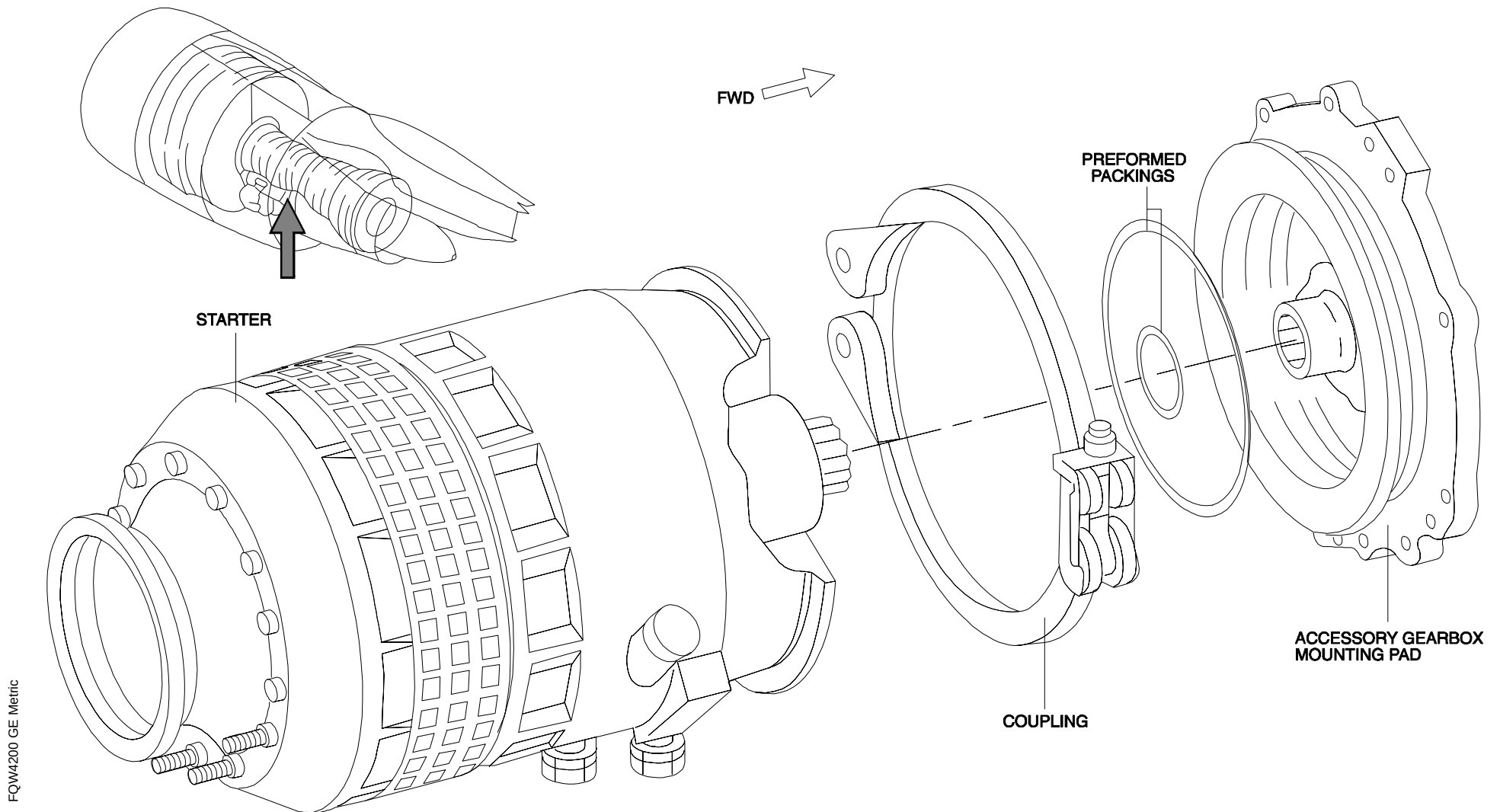
Remove the SAV.

Remove the coupling clamp that attaches the starter to the AGB.

Move the starter aft until the drive shaft splines are free from the gearbox splines.

Remove and discard the preformed packing from the starter drive shaft and starter pad.

Perform the operations in the opposite order to install the starter.



STUDENT NOTES

FQW4200 GE Metric

AIR SYSTEM PRESENTATION

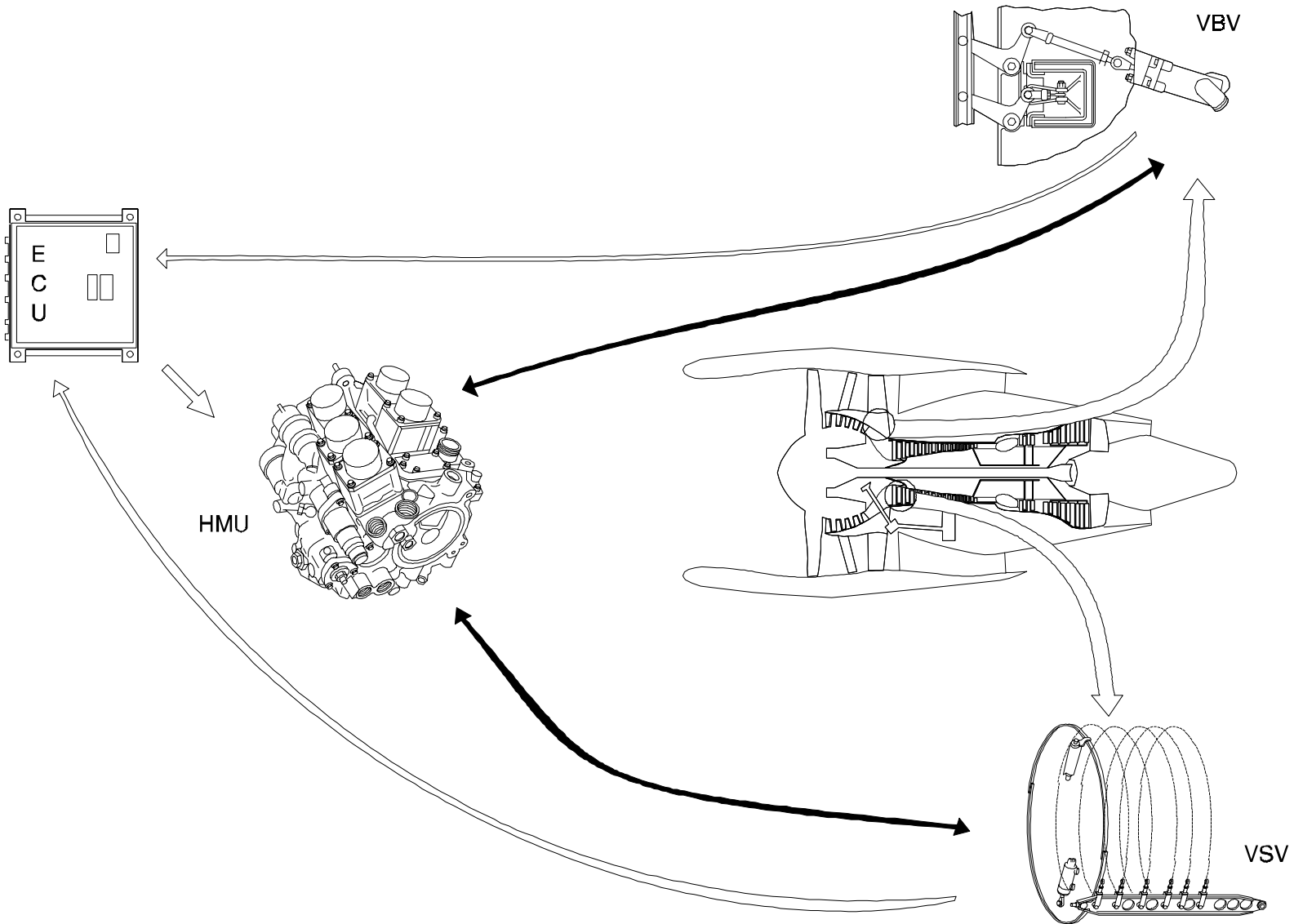
Airflow Control
Active Clearance Control
Bore and Core Compartment Cooling
Pneumatic Sources

AIRFLOW CONTROL

To limit compressor surge and to provide good acceleration, the CF6-80E1 is equipped with Variable Bleed Valve system and Variable Stator Vane system. Both systems are fuel operated by the Hydromechanical Unit (HMU) and controlled by the Electronic Control Unit (ECU).

The Variable Bleed Valve (VBV) system controls airflow from the LP compressor to the HP compressor by using 12 valves.

The Variable Stator Vane (VSV) system controls airflow through the HP compressor by using the first 6 rows of pivoting vanes.

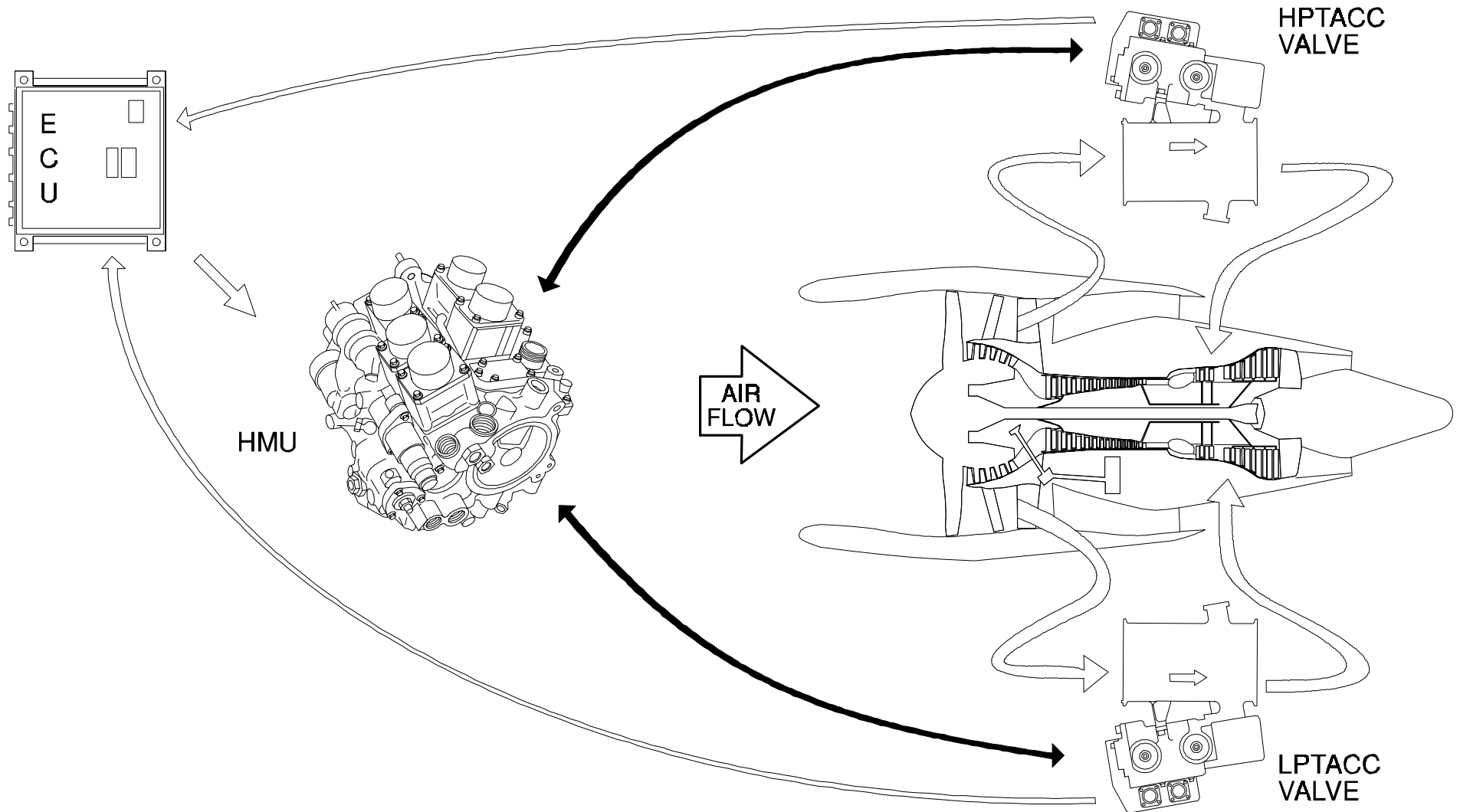


FQW4200 GE Metric

ACTIVE CLEARANCE CONTROL

To control the gap between the turbine and casing and thus improve turbine efficiency, the turbine casing is cooled by fan air during flight phases where maximum power is not required.

The HP(LP)Turbine Active Clearance Control system is made of manifolds and a fuel powered valve controlled by the Electronic Control Unit.



FQW4200 GE Metric

BORE AND CORE COMPARTMENT COOLING

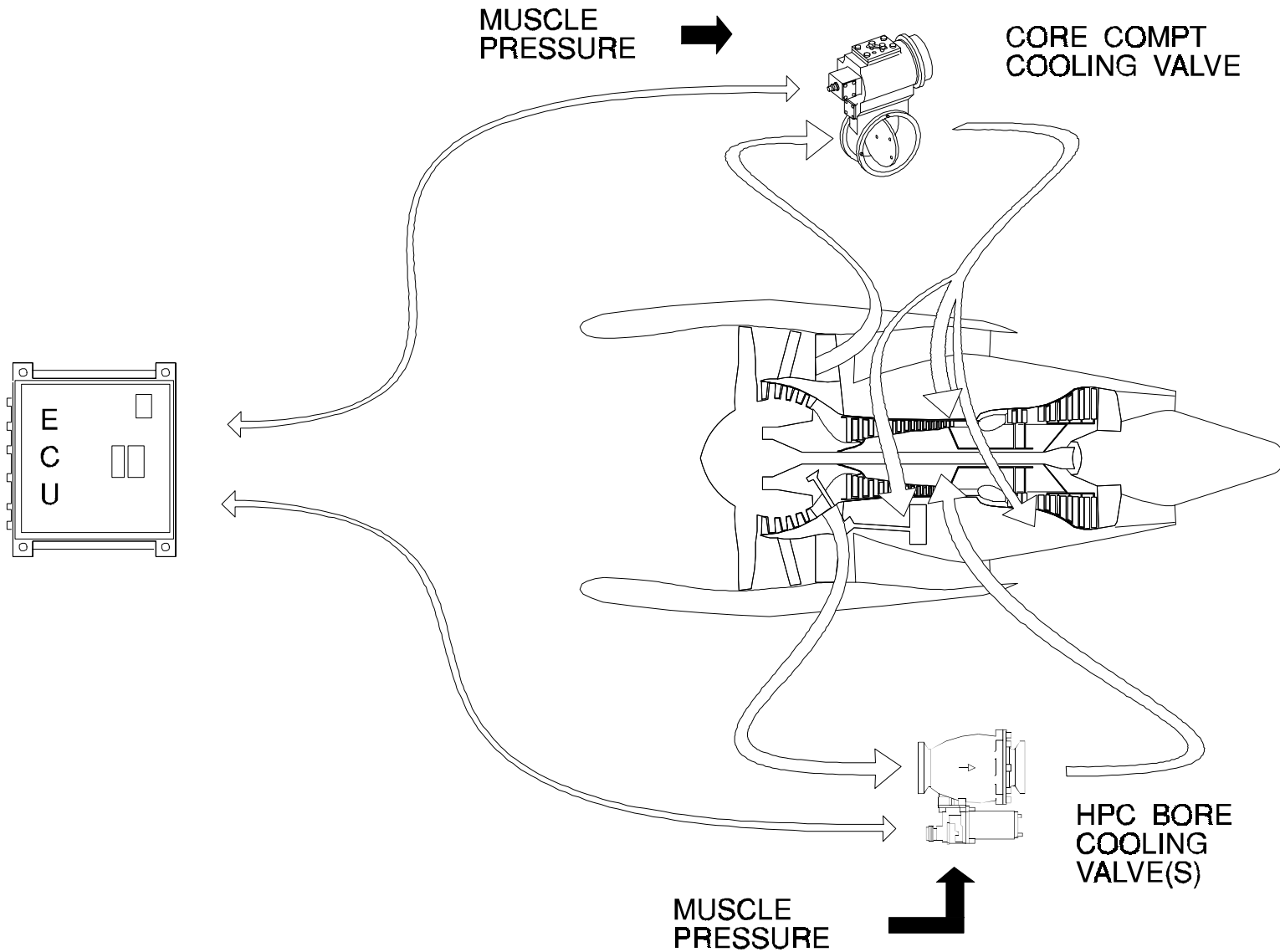
To keep air temperatures within structural and component limits, the Core Compartment Cooling system removes heat and vapors from the core compartment cavities and components.

The Core Compartment Cooling system consists of a valve and pneumatic ducts.

The valve is electrically controlled by the ECU and pneumatically operated.

To control the gap between the High Pressure Compressor and casing and thus preserve primary airflow, the HPC bore cooling airflow is reduced during cruise conditions.

The Bore Cooling system consists of 3 valves and pneumatic tubing. The valves are electrically controlled by the ECU and pneumatically operated.



FQW4200 GE Metric

PNEUMATIC SOURCES

The engine provides the following pneumatic sources :

- LPC discharge air used for B/C sump pressurization,
- 7th stage HPC air used to cool the LPT stage 1 vanes and for N1 rotor thrust balance chamber,
- 11th stage HPC air used to cool the HPT stage 2 nozzles and shrouds and for nacelle anti-ice,
- 8 & 14th stage HPC air used for customer bleed and thrust reverser operation.

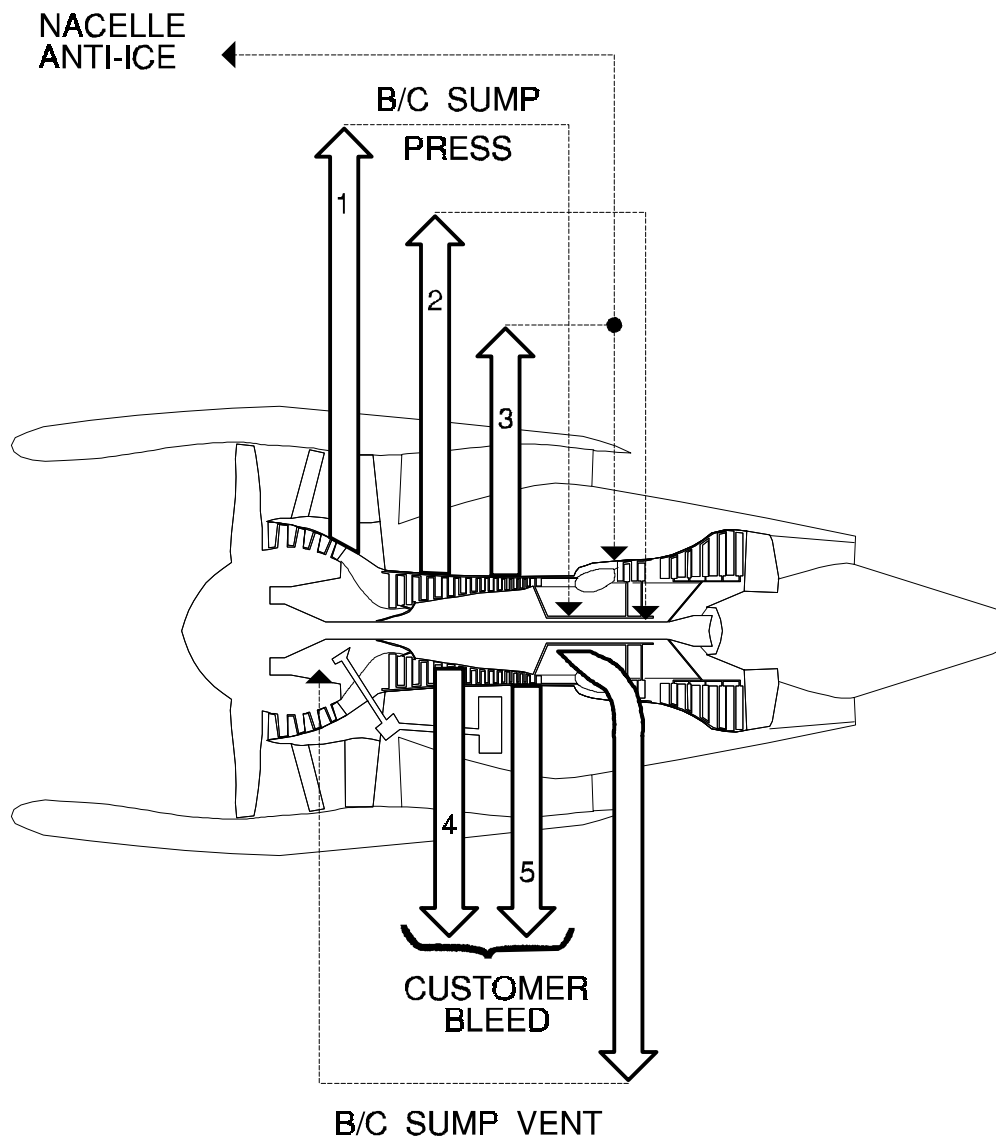
1 LOW PRESSURE
COMPRESSOR
DISCHARGE AIR

2 7th STAGE

3 11th STAGE

4 8th STAGE

5 14th STAGE



FQW4200 GE Metric

STUDENT NOTES:

FQW4200 GE Metric

COMPONENTS (AIR SYSTEM)

- Safety precautions
- Bore Cooling Valve
- Core cooling Valve
- Low Pressure Active Clearance Control Valve
- High Pressure Active Clearance Control Valve
- Variable Stator Vane Actuator
- Variable Bleed Valve Actuator
- Nacelle Temperature Sensor

SAFETY PRECAUTIONS

WARNING : Before any action on the engine :

- Do not start the engine ;
- Make sure that the engine has been shut down for at least 5 min ;
- Make sure that the ENG FADEC GND PWR pushbutton is off ;
- Make sure that the master lever is in the off position ;
- Put notices to tell persons not to power supply the ECU and not to start the engine.

STUDENT NOTES

FQW4200 GE Metric

BORE COOLING VALVE

FIN : 4053KS1 / 4053KS2 / 4053KS3

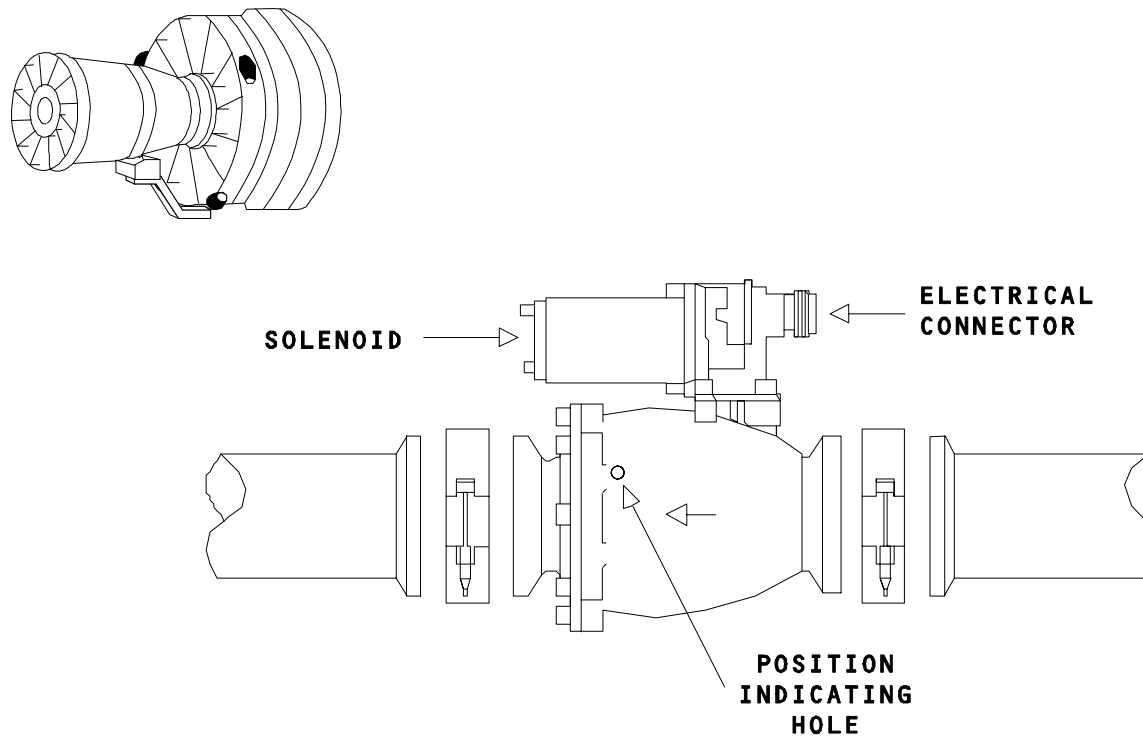
ZONE : 412-422

COMPONENT DESCRIPTION

The three Bore Cooling Valves (BCVs) are identical and interchangeable. Each consist of a sleeve type valve that is operated by a dual winding solenoid. The valve has two positions open or closed, and is spring loaded open.

REMOVAL / INSTALLATION

The valve is fitted to the cooling tube manifolds by means of two V-band clamps.



CORE COMPARTMENT COOLING VALVE

FIN : 4057KS

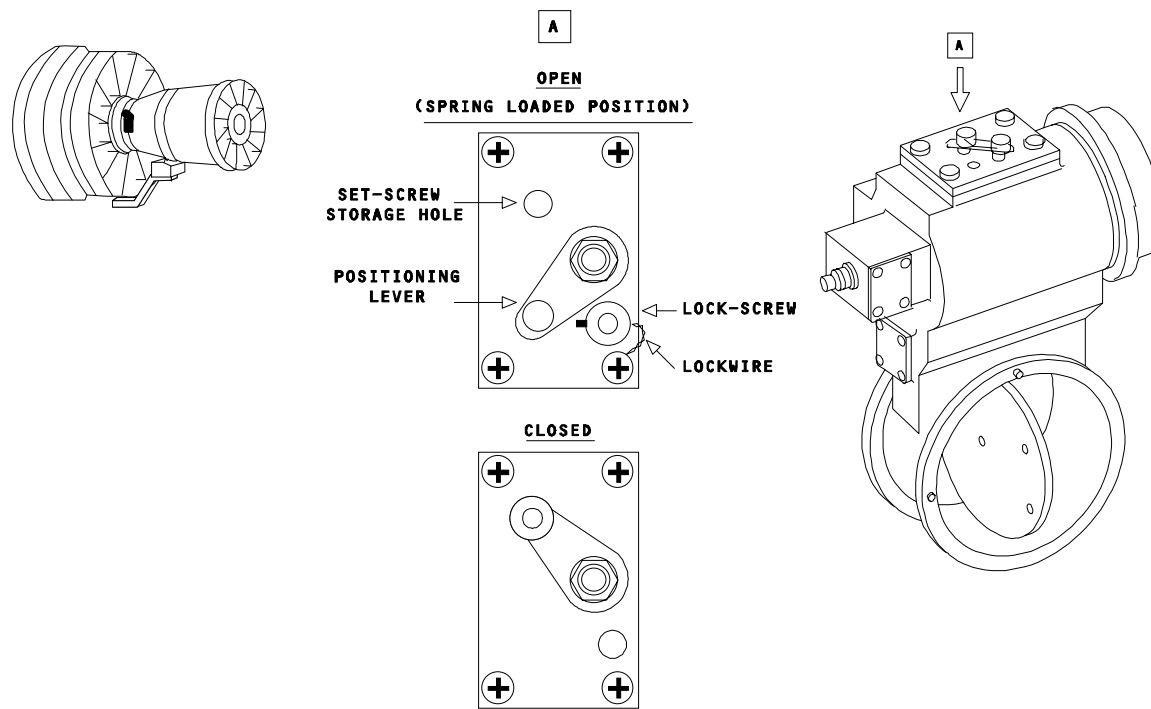
ZONE : 413-423

COMPONENT DESCRIPTION

The valve is an electrically controlled, pneumatically operated butterfly type valve. It has an 11th stage muscle air connection. A feedback switch is located inside the valve. The valve is spring loaded open and is controlled by channel A.

REMOVAL / INSTALLATION

Prior to removing the valve, the flap must be locked in the closed position otherwise the valve will be stuck by the flap. This is done by moving the positioning lever to the closed position and installing the lock screw through the positioning lever and into the set screw storage hole. The valve is fitted by means of two clamps.



LOW PRESSURE ACTIVE CLEARANCE CONTROL VALVE

FIN : 4037KS

ZONE : 413-423

COMPONENT DESCRIPTION

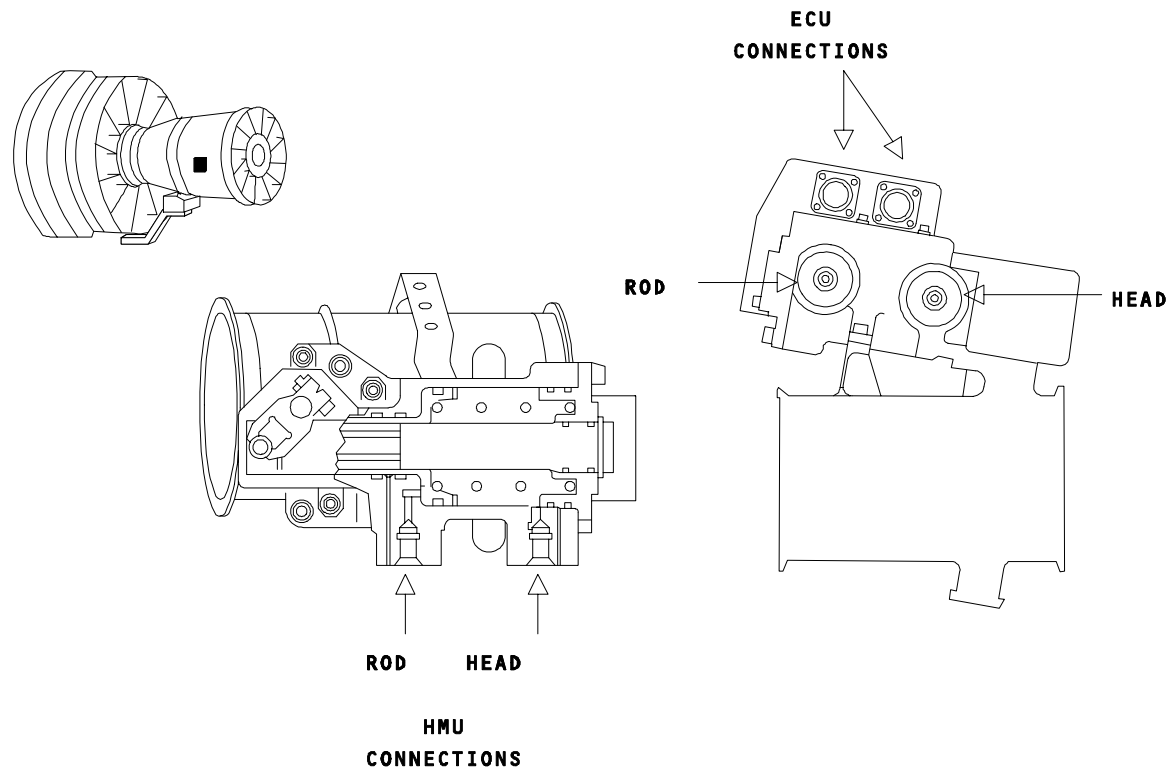
The LPTACC valve is fuel operated butterfly type valve. It has two fuel connections and two electrical connectors. There are two linear variable differential transducers located inside the valve. The valve is spring loaded to the closed position when no fuel pressure is present. Note that the LPTACC valve and HPTACC valve are interchangeable.

LPTACC : Low Pressure Turbine Active Clearance Control

HPTACC : High Pressure Turbine Active Clearance Control

REMOVAL / INSTALLATION

The valve is fitted to the manifolds by means of clamps.



HIGH PRESSURE ACTIVE CLEARANCE CONTROL VALVE

FIN : 4035KS

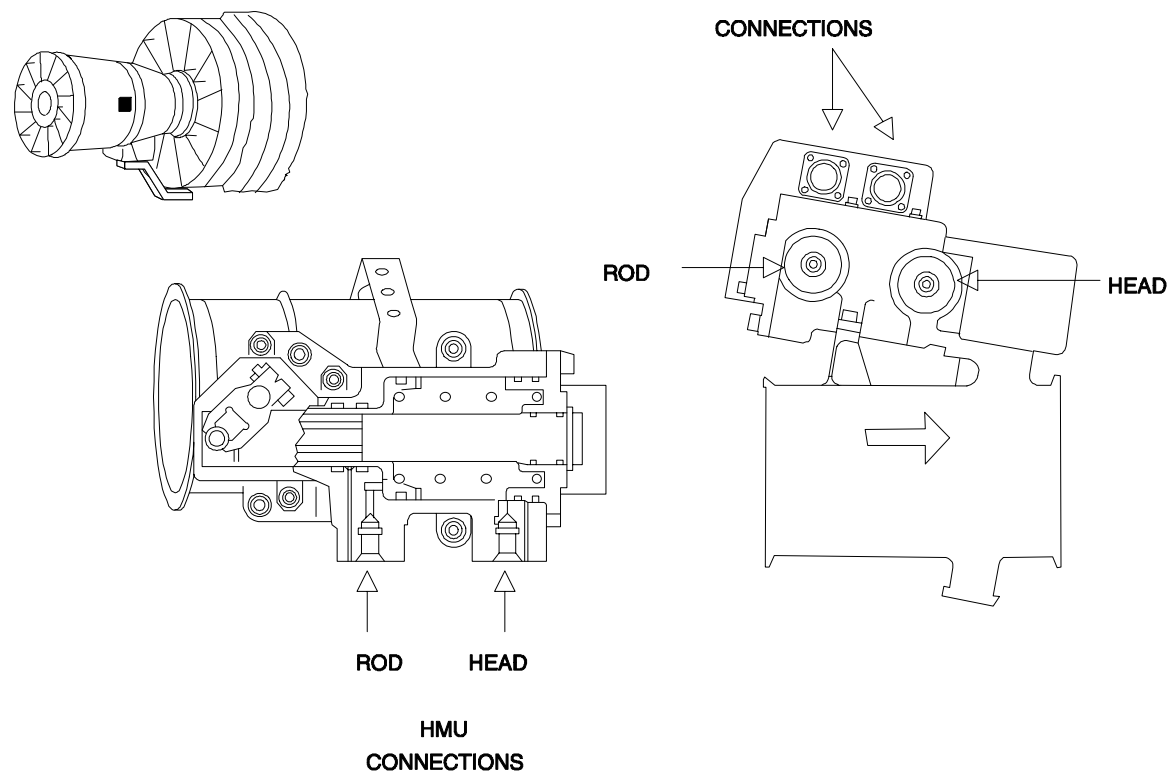
ZONE : 413-423

COMPONENT DESCRIPTION

The HPTACC valve is fuel operated butterfly type valve. It has two fuel connections and two electrical connectors. There are two linear variable differential transducers located inside the valve. The valve is spring loaded to the closed position when no fuel pressure is present. Note that the LPTACC valve and HPTACC valve are interchangeable.
LPTACC : Low Pressure Turbine Active Clearance Control
HPTACC : High Pressure Turbine Active Clearance Control

REMOVAL / INSTALLATION

The valve is fitted to the manifolds by means of clamps.



FQW4200 GE Metric

VARIABLE STATOR VANE ACTUATOR

FIN : 4040KS1 / 4040KS2

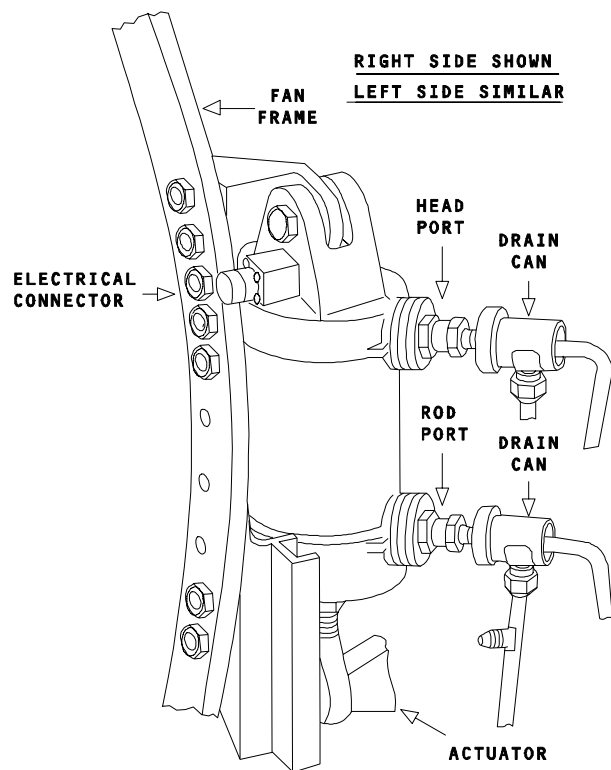
ZONE : 413-423

COMPONENT DESCRIPTION

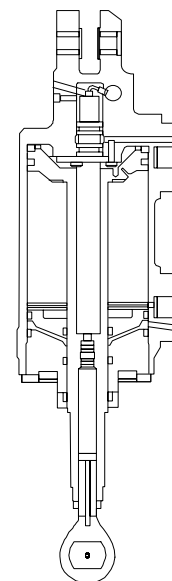
There are two VSV actuators which are identical and interchangeable.
Each actuator has two fuel connectors and one electrical connector.
There is a Linear Variable Differential Transducer (LVDT) located inside each VSV actuator.
VSV : Variable Stator Vane

REMOVAL / INSTALLATION

The VSV actuator is linked to the actuator lever and the fan frame flange by means of bolts and nuts. Note that the actuator rod end bearing should not be adjusted. It is set by the vendor in relationship to the LVDT inside.
LVDT : Linear Variable Differential Transducer



CROSS VIEW



VARIABLE BLEED VALVE ACTUATOR

FIN : 4080KS1 / 4080KS2

ZONE : 413-423

COMPONENT DESCRIPTION

The VBV actuators are identical and interchangeable. Each actuator has two fuel connections and one electrical connector. There is a Linear Variable Differential Transducer located inside each VBV actuator.

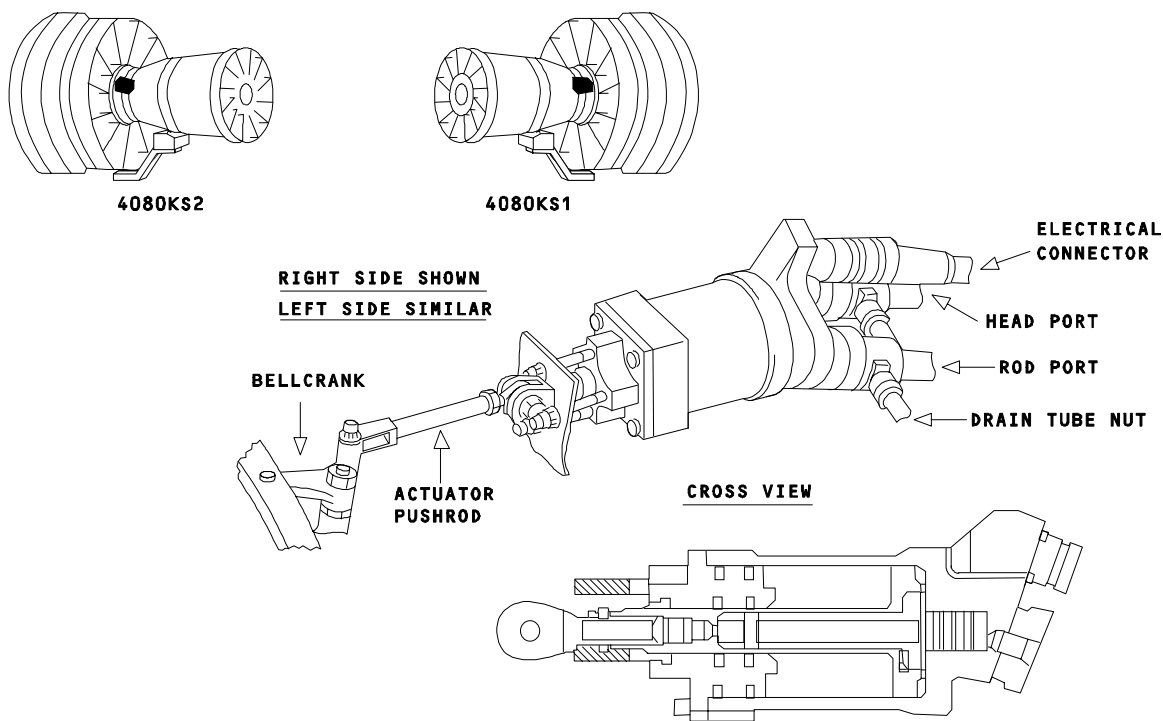
VBV : Variable Bleed Valve

REMOVAL / INSTALLATION

The VBV actuators are attached to the fan frame by means of nuts and the clevis is linked to the actuator pushrod by a bolt and a nut. The VBV actuator rod end bearing should not be adjusted. It is set by the vendor in relationship to the LVDT inside.

VBV : Variable Bleed Valve

LVDT : Linear Variable Differential Transducer



NACELLE TEMPERATURE SENSOR

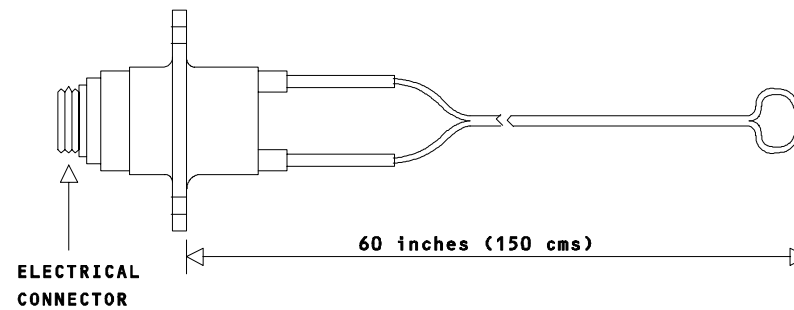
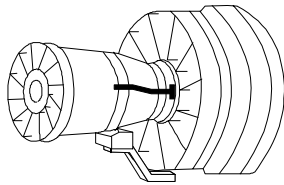
FIN : 4008KS

ZONE : 413-423

COMPONENT DESCRIPTION

The nacelle temperature sensor is a continuous platinum resistance sensing element. It runs along the HPTACC air duct where the resistance of the sensing element changes with air temperature.

HPTACC : High Pressure Turbine Active Clearance Control



STUDENT NOTES

ENGINE CONTROLS PRESENTATION

Thrust Levers
Engine Start Panel
Engine Master Panel
FADEC Ground Power Panel
Fire Pushbutton Panel
Engine Manual Start Panel

THRUST LEVERS

The two thrust levers are used as conventional throttles and as thrust rating limit selectors when they are in one of the detents. Each thrust lever is fitted with a thrust reverser control lever.

An autothrust instinctive disconnect pushbutton is provided outboard of each control lever.

ENGINE START PANEL

The rotary selector is used to initiate a start sequence or selecting continuous ignition and to initiate an engine crank sequence.

After engine start or crank sequence, the selector has to be set to the NORMAL position.

ENGINE MASTER PANEL

The two position Engine Master Switches control to open or close the high pressure fuel shut-off valves and the low pressure fuel shut-off valves. They command and reset the FADEC functions.

The red indicator light is activated in case of engine fire and the amber FAULT light is activated in case of start abort or HP fuel shut-off valve disagree.

FADEC GROUND POWER PANEL

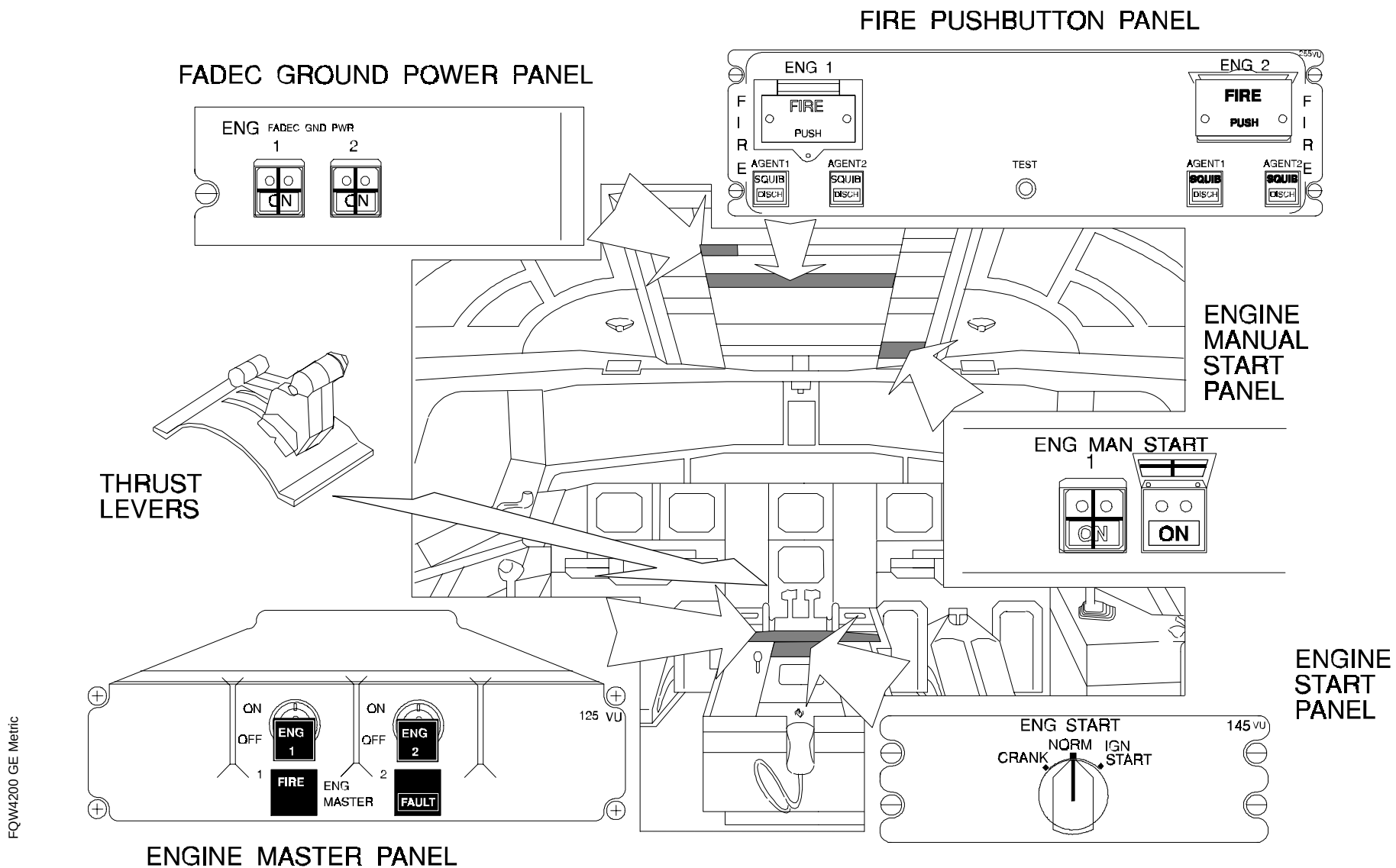
When the engine is not running, the FADEC can be electrically powered from the aircraft network by using the Engine FADEC Ground Power pushbutton. The supply is automatically limited to 5 minutes.

FIRE PUSHBUTTON PANEL

When the engine FIRE pushbutton is released out, the low pressure valve closes and at the same time, the Engine Interface and Vibration Monitoring Unit cuts off the aircraft electrical supply to the FADEC system.

ENGINE MANUAL START PANEL

The Engine Manual Start pushbuttons are used to open the start valve during an engine manual start or a crank sequence.



FQW4200 GE Metric

STUDENT NOTES:

THRUST CONTROL ARCHITECTURE

- System Philosophy
- Manual Thrust
- Thrust Limit Selection
- Thrust Limit Mode
- Autothrust Function
- Autothrust Active
- Alpha Floor

SYSTEM PHILOSOPHY

The thrust control includes the same functions as a conventional aircraft : manual thrust setting, thrust limits selection, autothrust function.

MANUAL THRUST

In manual mode, the Electronic Control Unit (ECU) computes a thrust corresponding to the thrust lever position.

The Electronic Control Unit controls the fuel metering in such a way that computed fuel flow leads to a desired thrust.

THRUST LIMIT SELECTION

A thrust limit is selected when the thrust lever is in a corresponding detent. The limit and its value are displayed on the Engine and Warning Display. When the thrust lever is between two detents, the limit displayed corresponds to the upper detent limit, but the engine thrust limit corresponds to the actual thrust lever position.

THRUST LIMIT MODE

The different thrust limits are as follows :

- IDLE,
- MAX CLIMB(CL)/ DERATED CLIMB,
- MAX CONTINUOUS(MCT)/ FLEXIBLE TAKE OFF(FLX),
- MAX TAKE OFF(TO)/ GO AROUND(GA).

AUTOTHRUST FUNCTION

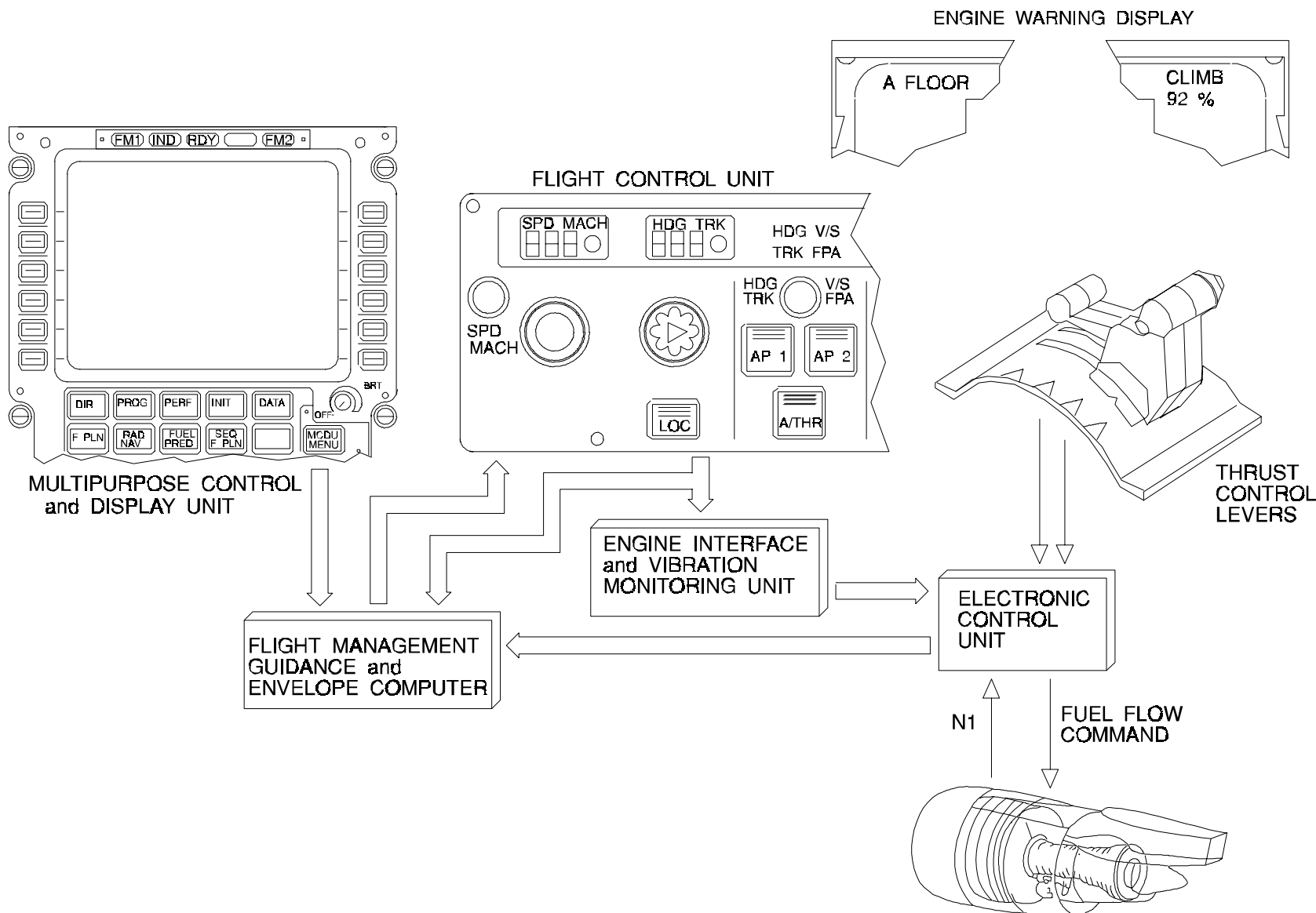
The Flight Management Guidance and Envelope Computer (FMGEC) computes the thrust according to the data inserted into the MCDU, the Flight Control Unit (FCU) and also the engine parameters from the Electronic Control Unit. The thrust computation is sent to the ECU via the FCU and the EIVMU.

AUTOTHRUST ACTIVE

In flight, the autothrust function is ensured when the autothrust is engaged and active. Normally in flight the thrust levers should be in the CLIMB detent.

ALPHA FLOOR

When an alpha floor condition is detected, the Flight Management Guidance and Envelope Computer sends a signal to the Electronic Control Units to drive the engines to TAKE OFF thrust regardless of thrust lever position, autothrust engaged or not.



STUDENT NOTES:

LP AND HP CONTROL D/O

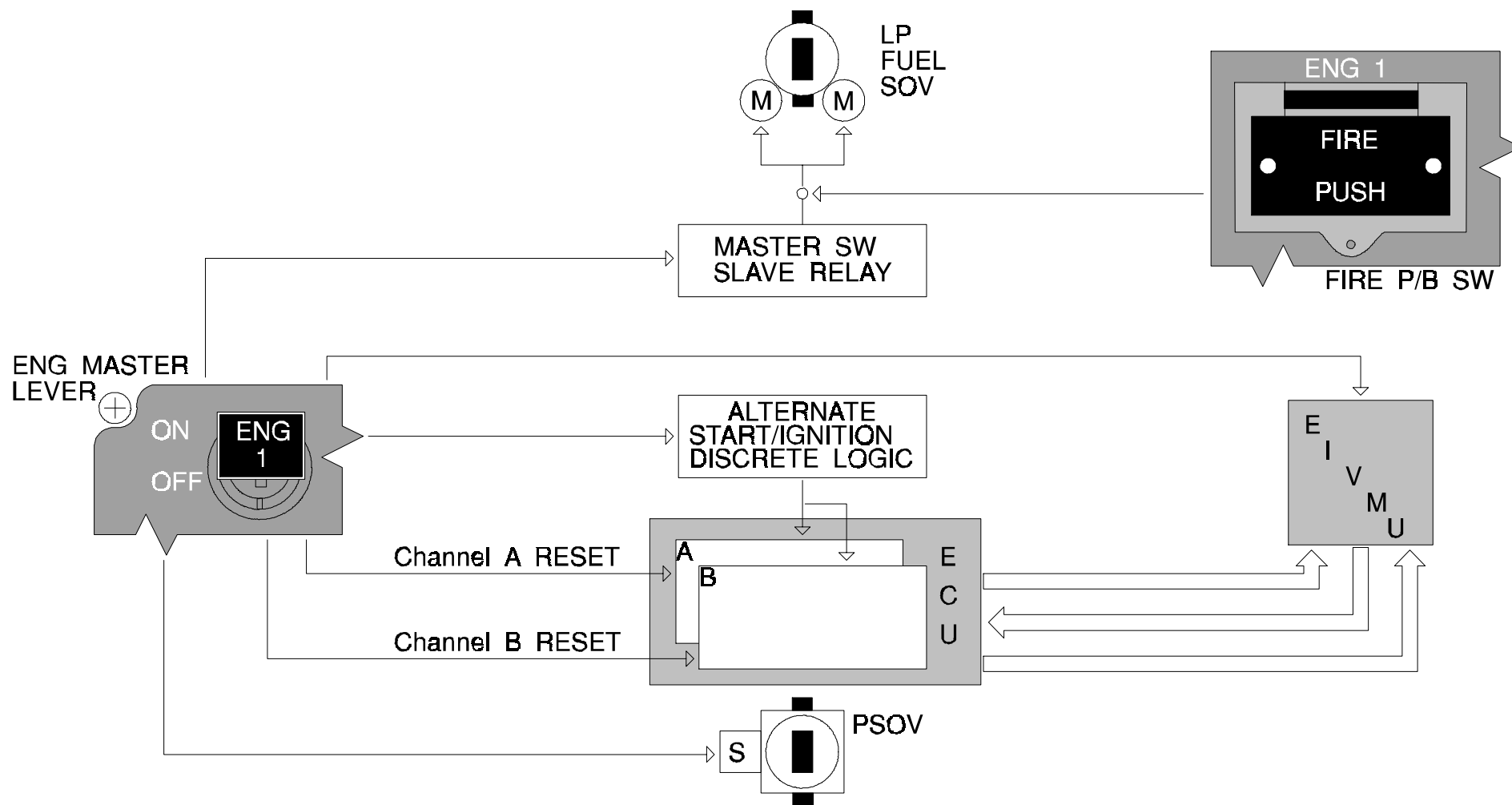
Engine Master Control
HP Fuel Control
LP Fuel Control

ENGINE MASTER CONTROL

The Engine Master Lever is a two position selector. It is equipped with a safety locking mechanism to avoid accidental selection.

They supply 6 different signals :

- 28Vdc to the master switch slave relay to control the LP fuel shut-off valve,
- the Eng Master Lever position discrete signal to the EIVMU (primary source),
- the hardwired alternate start/ignition discrete signal used in case of EIVMU data fault as an alternate control signal for ignition and automatic start,
- the channel A and B reset signals (hardwired discretes compared with EIVMU Master Lever position signal for fault detection and accommodation),
- 28 Vdc to the Pressurizing and Shut-Off Valve (PSOV) solenoid.



FQW4200 GE Metric

HP FUEL CONTROL

The Pressurizing and Shut-Off Valve (PSOV) is electrically controlled and fuel pressure operated.

It opens with fuel pressure coming from the Fuel Metering Valve provided the shut-off solenoid (S) is de-energized (Eng Master Lever set to ON).

The Pressurizing and Shut-Off Valve closes when the shut-off solenoid is energized (Engine Master Lever set to off) or when the Fuel Metering Valve is commanded to the closed position by the ECU (automatic start abort).

Note that the command from the Engine Master Lever takes priority over the command from the ECU.

HMU : Hydro Mechanical Unit
EHSV : Electro-Hydraulic Servo Valve

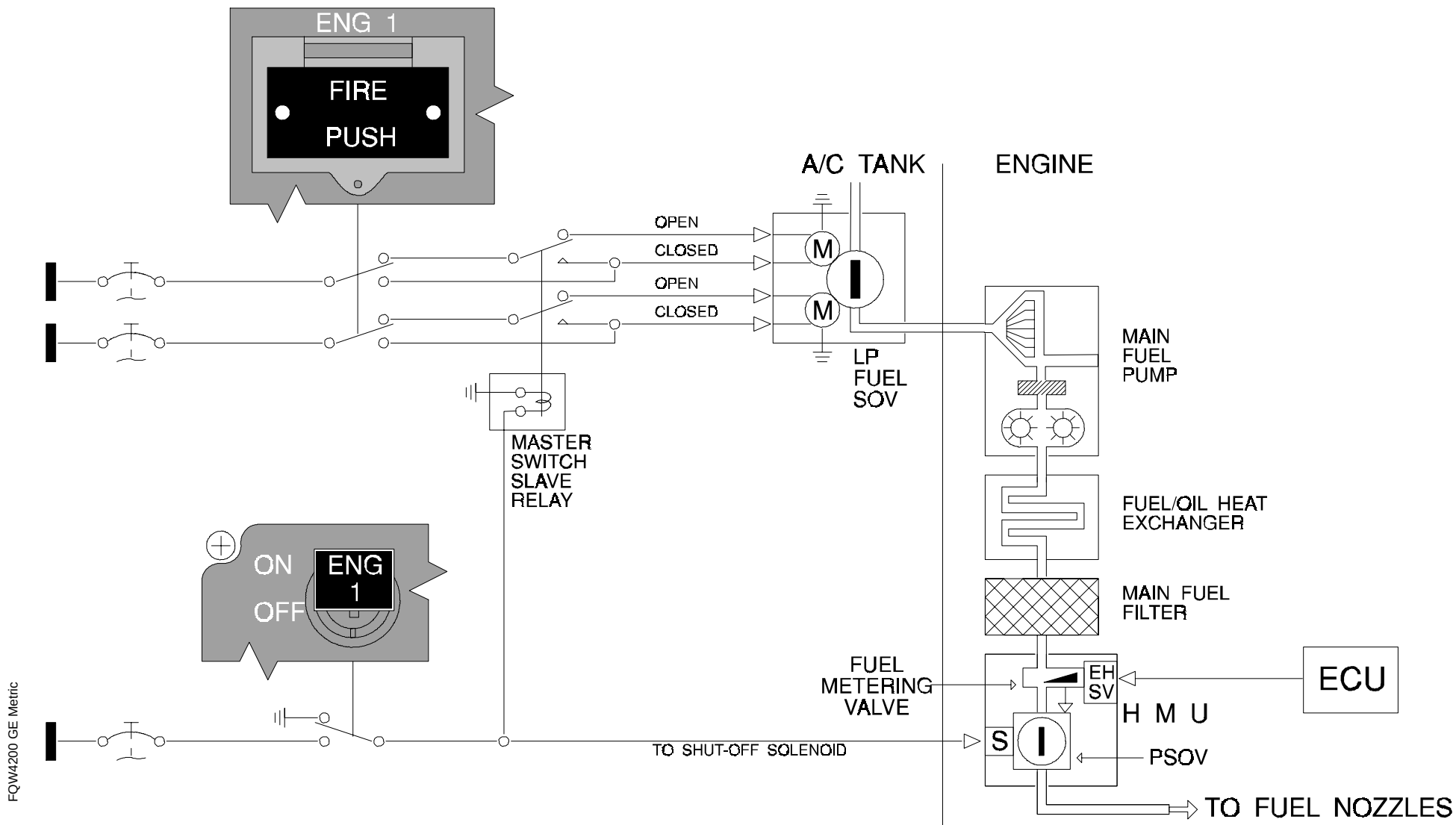
LP FUEL CONTROL

The Low Pressure Fuel Shut-Off Valve is normally controlled by the Engine Master Lever.

The Low Pressure Fuel Shut-Off Valve opens when the Master Switch Slave Relay is de-energized (Eng Master Lever set to ON) and provided the Engine Fire pushbutton is not released out.

The Low Pressure Fuel Shut-Off Valve closes when it receives a shut-off signal through the master switch slave relay by setting Engine Master Lever to off position.

The Low Pressure Fuel Shut-Off Valve also closes when it receives a shut-off signal from the Engine Fire pushbutton in the released out position.



FQW4200 GE Metric

STUDENT NOTES:

FQW4200 GE Metric

ENGINE CONTROLS COMPONENTS

Thrust Levers
Artificial Feel Unit
Throttle Control Unit

THRUST LEVERS

FIN/ZONE

Zone : 212

COMPONENT DESCRIPTION

The thrust levers unit consists of :

- two throttle control levers, each having an autothrust instinctive disconnect pushbutton
- two thrust reverser control levers
- one graduated fixed sector

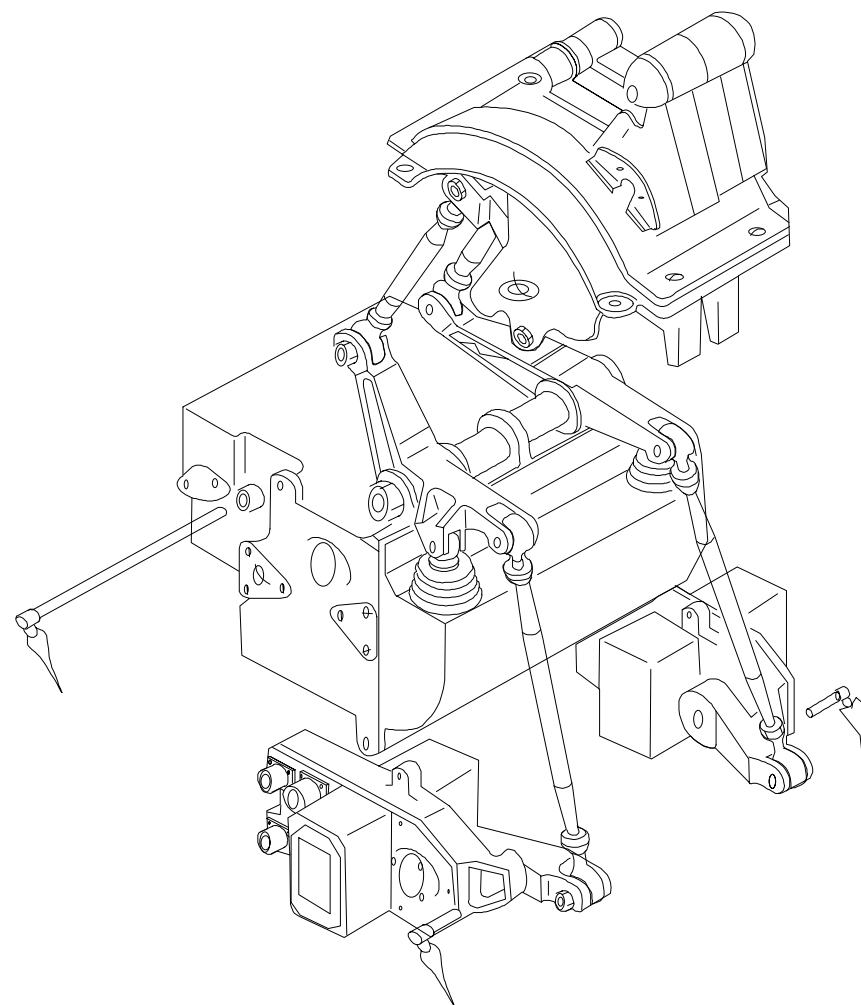
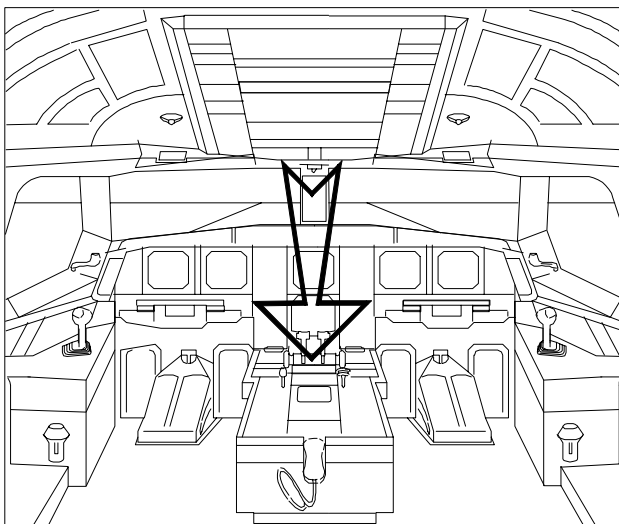
REMOVAL INSTALLATION

The throttle control lever assembly is fitted by means of screws. The index plate and the lighted plate must be removed.

Move the throttle control lever rearward to get access to the rods to disconnect them. Disconnect the electrical connectors.

For the installation, once the throttle control lever assembly has been correctly installed the throttle control artificial feel unit rigging task must be performed.

In addition, to complete the task, the throttle control unit operational test must be performed.



FQW4200 GE Metric

ARTIFICIAL FEEL UNIT

FIN / ZONE

FIN : 5000KC

Zone : 210

COMPONENT DESCRIPTION

The throttle control artificial unit is a friction system which provides a load feedback to the throttle control levers.

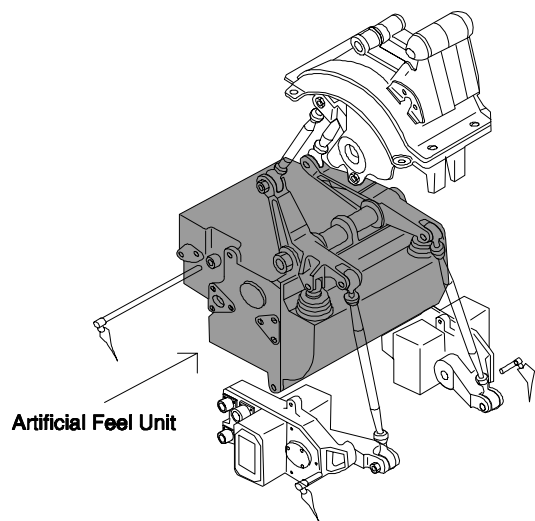
The artificial feel unit comprises :

- two adjustable friction assemblies
- two cam gears which determine the six positions of the control levers
- two adjustable rockers
- two rods

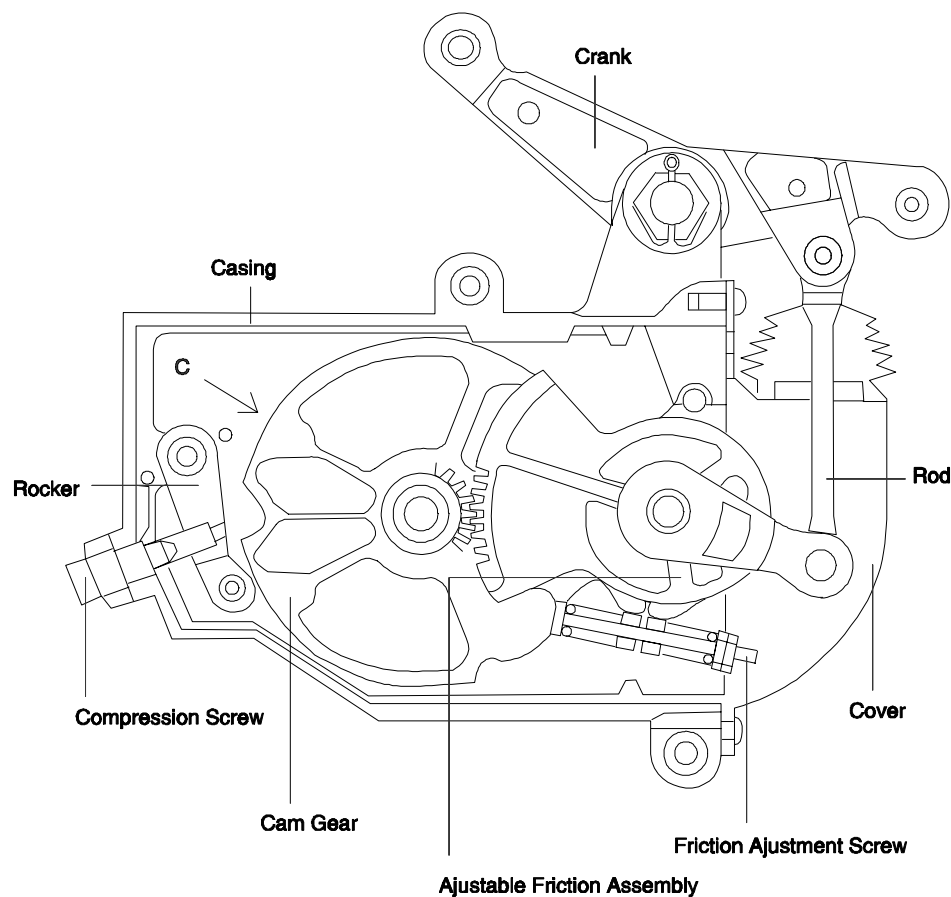
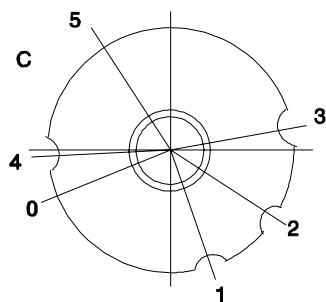
REMOVAL / INSTALLATION

Prior to removing the throttle control artificial feel unit, the throttle control lever assembly must be removed as well as the ECAM control panel.

For the installation, once the throttle control lever assembly has been installed, the throttle control artificial unit must be rigged.



POINTS	POSITIONS
0	IDLE STOP
1	MAX CLIMB
2	MAX CONTINUOUS
3	MAX TAKE OFF (STOP)
4	REVERSE IDLE
5	MAX REVERSE (STOP)



THROTTLE CONTROL UNIT

FIN / ZONE

FIN : 9KS1 - 9KS2

Zone : 210

COMPONENT DESCRIPTION

The throttle control unit transforms a mechanical movement into an electrical signal. There are two units (one per engine).

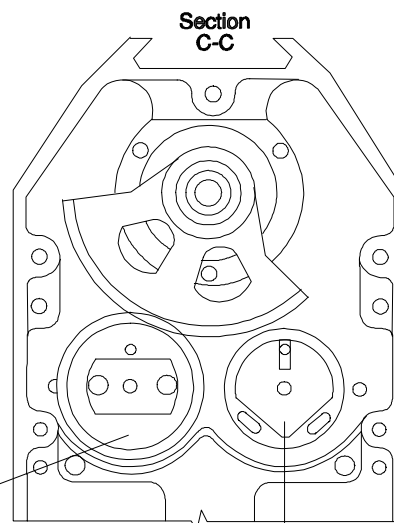
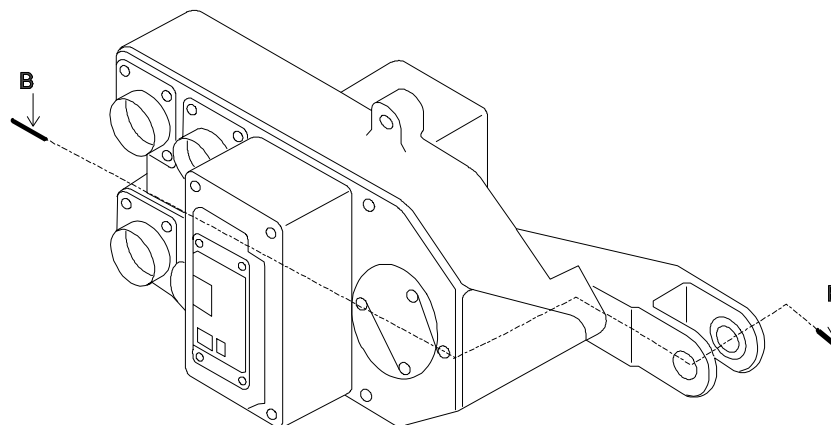
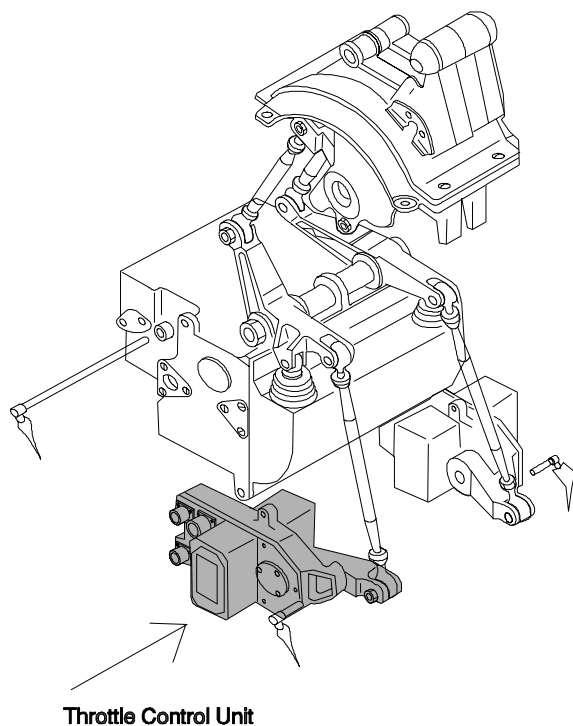
Each unit comprises :

- two resolvers (one per ECU channel)
- two units comprising three pairs of potentiometers

REMOVAL / INSTALLATION

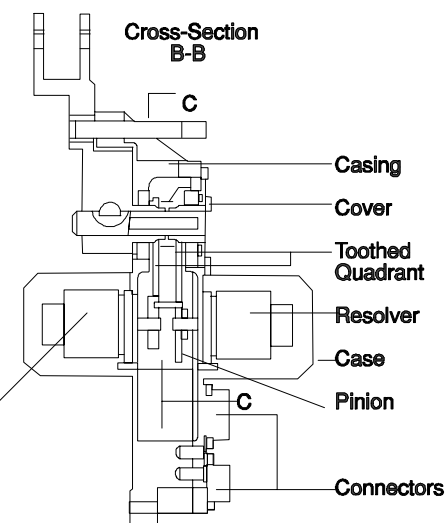
Put the throttle control in the Max Take off position and put a warning notice to tell persons not to operate the throttle control levers.

Disconnect the electrical connectors and the rods.



Unit comprising three pairs of potentiometers

Resolver



Unit comprising three pairs of potentiometers

- Casing
- Cover
- Toothed Quadrant
- Resolver
- Case
- Pinion
- Connectors

STUDENT NOTES

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ENGINE INDICATING PRESENTATION

Primary Parameters
Secondary Parameters
Cruise Page

PRIMARY PARAMETERS

The engine primary parameters are permanently display on the upper ECAM display.

They are from top to bottom :

- N1,
- EGT,
- N2,
- Fuel Flow.

Other indications are also displayed such as :

- limit thrust,
- flexible take-off temperature.

In particular phases, specific indications are displayed.

There are :

- alpha floor indication,
- idle message,
- reverse indications.

SECONDARY PARAMETERS

The secondary parameters are displayed on the lower ECAM display.

They are from top to bottom :

- fuel used,
- oil quantity,
- oil pressure,
- oil temperature,
- vibration (N1 and N2),
- nacelle temperature.

The latter is replaced by starting indications during engine start.

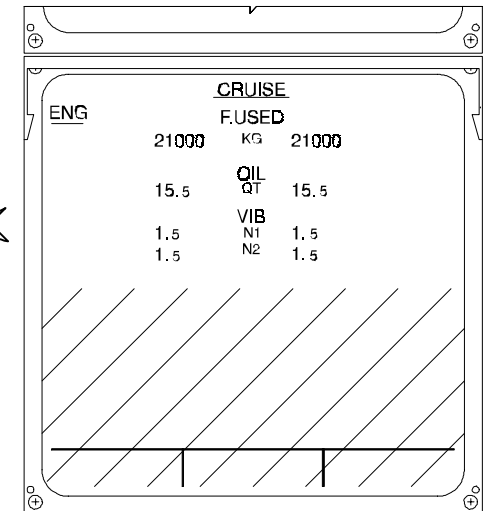
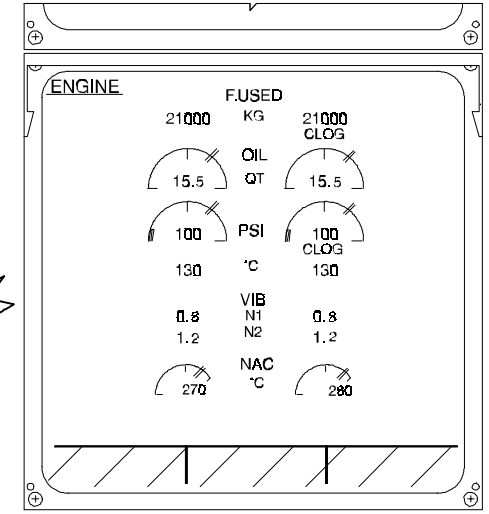
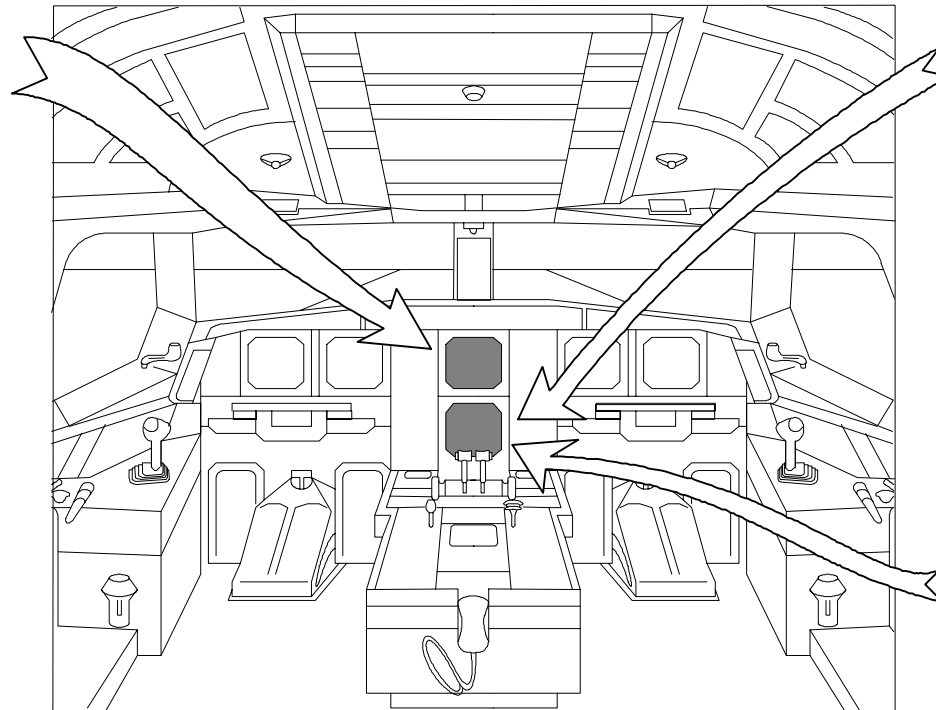
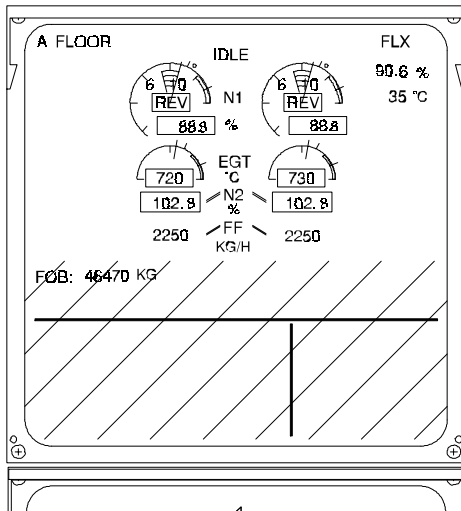
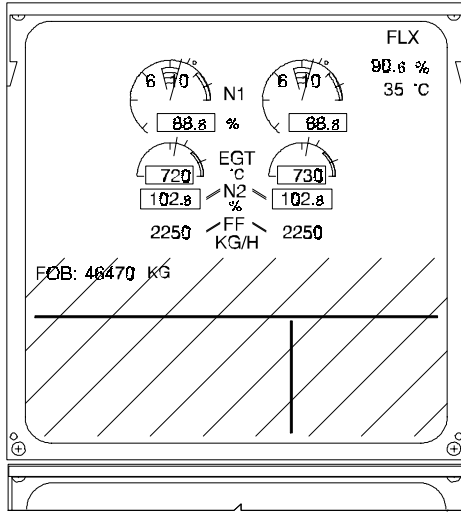
There are also attention getters such as :

- fuel filter clogging,
- oil filter clogging.

CRUISE PAGE

Some engine parameters are displayed on the ECAM cruise page. These parameters are :

- fuel used,
- oil quantity,
- vibration level (N1 and N2).



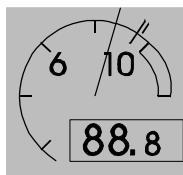
STUDENT NOTES:

PRIMARY PARAMETERS DESCRIPTION

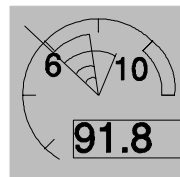
N1 Indicator
Thrust Limit Mode
Exhaust Gas Temperature (EGT) Indicator
N2 Indicator
Fuel Flow
Lack of Valid Data
Check EWD
Idle Speed

N1 INDICATOR

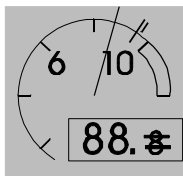
The actual N1 needle and N1 digital indication are :



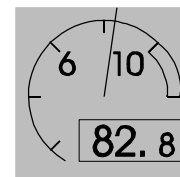
Normally Green



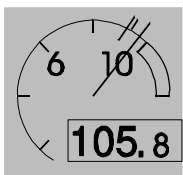
In autothrust mode, four green arcs symbolize the difference between the actual N1 and the N1 target. A green triangle accentuates the direction of the trend regulation.



If N1 is degraded (both N1 sensors failed), the last digit is amber and dashed.

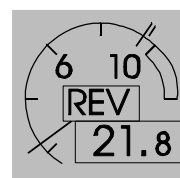


The N1 throttle (cyan circle) represents the predicted N1 (N1 value reached in manual control after engine stabilization).



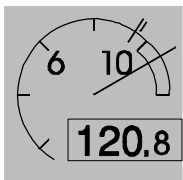
Amber when above N1 MAX.

N1 MAX (amber index) corresponds to the TOGA or REV mode N1 limit value.



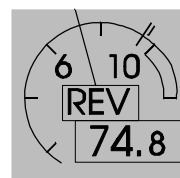
The reverse indication appears in amber when the reverser is unstowed or unlocked.

If it occurs in flight, the amber REV first flashes for 9 seconds and then remains steady.



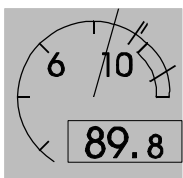
Red when above the N1 RED line (115.5%).

If 115.5% is exceeded, a red mark remains at the maximum value reached.

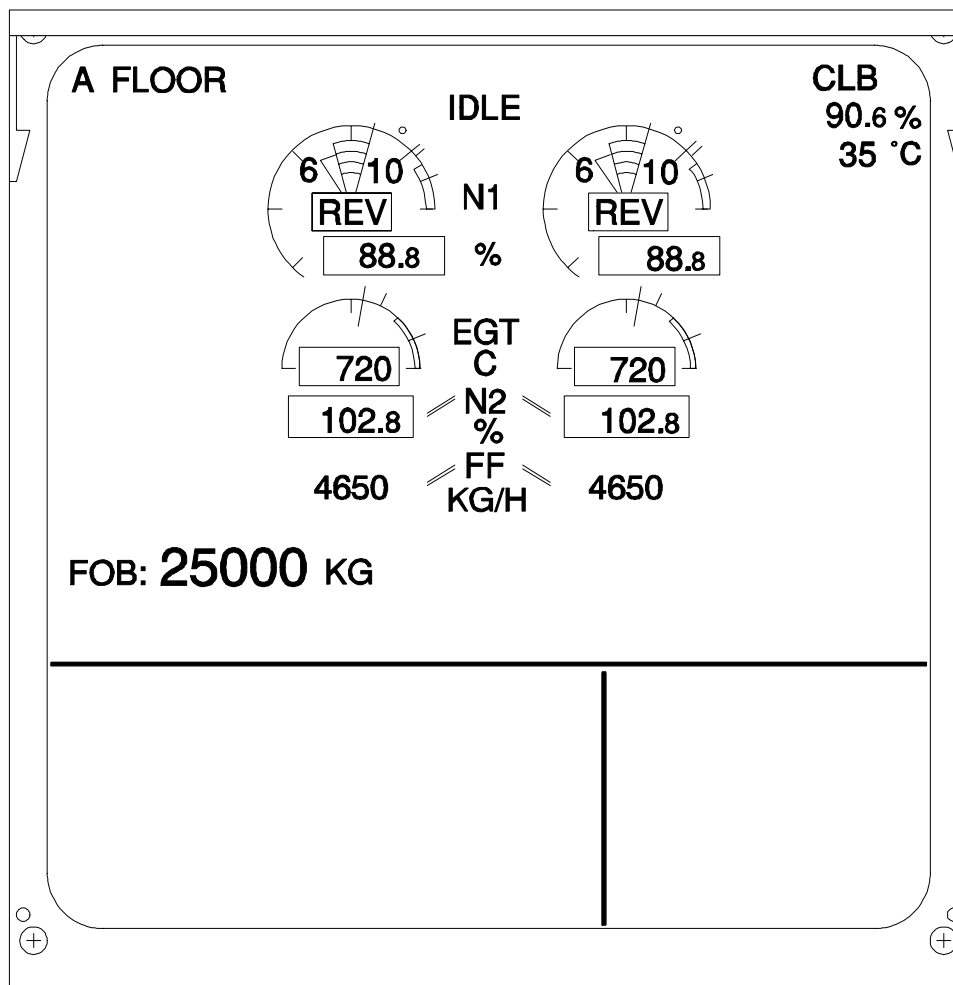


When the reverser is fully deployed, the REV indication changes to green.

Note : there is no indication when reversers are fully stowed and locked.



It disappears after a new start on ground or maintenance action through the MCDU.



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THRUST LIMIT MODE

Six possible modes can be selected through the throttle position :

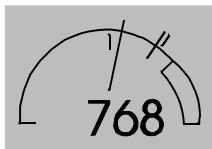
- Take-Off/Go Around.....:	TOGA XX.x %	
- Flexible take-off.....:	FLX XX.x % XX °C	← The Flexible take-off display comprises the fictious take-off temperature entered through the MCDU.
- Maximum Continous.....:	MCT XX.x %	
- Climb.....:	CLB XX.x %	
- Derated take-off.....:	DXX XX.x %	← Six levels selected through the MCDU.
- Derated climb.....:	DCLBX XX.x %	← Two levels selected through the MCDU.

↑

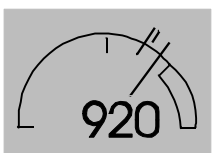
In all modes, the N1 LIMIT value is the highest N1 limit value of the two engines.

EXHAUST GAS TEMPERATURE (EGT) INDICATOR

The actual EGT needle and EGT digital indication are :



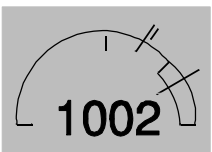
Normally Green



Amber when above EGT MAX (amber index).

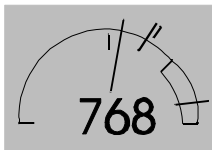
EGT MAX can take two positions :

- 750°C during engine start,
- 940°C after start.



Red when above the EGT RED line (975°C).

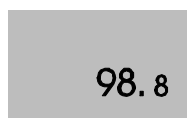
If 975°C is exceeded, a red mark remains at the maximum value reached.



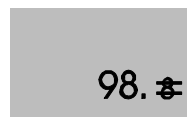
It disappears after a new start on ground or maintenance action through the MCDU.

N2 INDICATOR

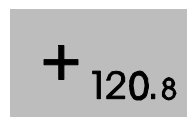
The actual N2 digital indication is :



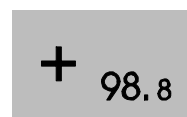
Normally Green



If N2 is degraded (both N2 sensors failed), the last digit is amber and dashed.



Red and a red cross appear when above the N2 RED limit (113.0%).



The red cross will disappear after a start on ground or after a maintenance action through the MCDU.



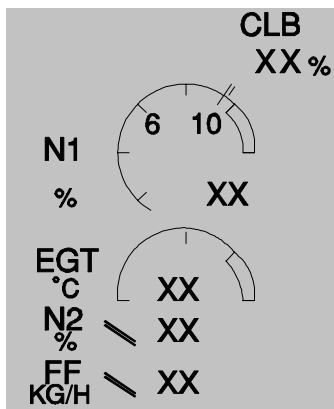
During engine starting, the digital N2 indication comes on brighter and is located in a specific grey background box.

FUEL FLOW

4250 $\frac{FF}{KG/H}$

Displayed in green.

LACK OF VALID DATA



In case of invalidity of any parameter, the associated digital indication is replaced by two amber crosses.

This lack of valid data happens when the ECU power is off (which is the case on the ground five minutes after engine shut down).

ECU : Electronic Control Unit.

CHECK EWD

The CHECK EWD message is displayed in amber in case of disagreement between N1, N2, EGT, FF values on the ECU-DMC bus and the corresponding displayed information.

ECU : Electronic Control Unit.

DMC : Display Management Computer.

EWD : Engine Warning Display.

IDLE SPEED

The IDLE message is displayed in green if both engines are at idle speed. The message first pulses for 10 sec and then remains steady.

SECONDARY PARAMATERS DESCRIPTION

SECONDARY PARAMETERS

Fuel Used
Oil Quantity Indicator
Oil Pressure Indicator
Oil Temperature
Vibration
Ignition/Start
Nacelle Temperature
Lack of Valid Data

CRUISE PAGE

Fuel Used
Oil Quantity Indicator
Vibration
Lack of Valid Data

SECONDARY PARAMETERS

FUEL USED

9500 F.USED
KG

Displayed in green, the fuel used is computed by the ECU from engine start to shut down. It is reset at engine start on ground.

9500 F.USED
KG

The fuel used is given in KG.

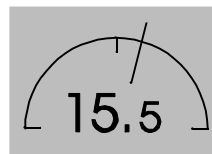
~~4575~~ F.USED
KG

The value is amber and dashed if it does not correspond to the actual value sent by the ECU.

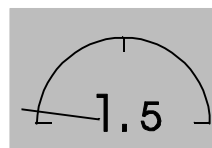
9500 F.USED
CLOG KG

The CLOG message appears in amber if the pressure loss across the fuel filter is excessive.

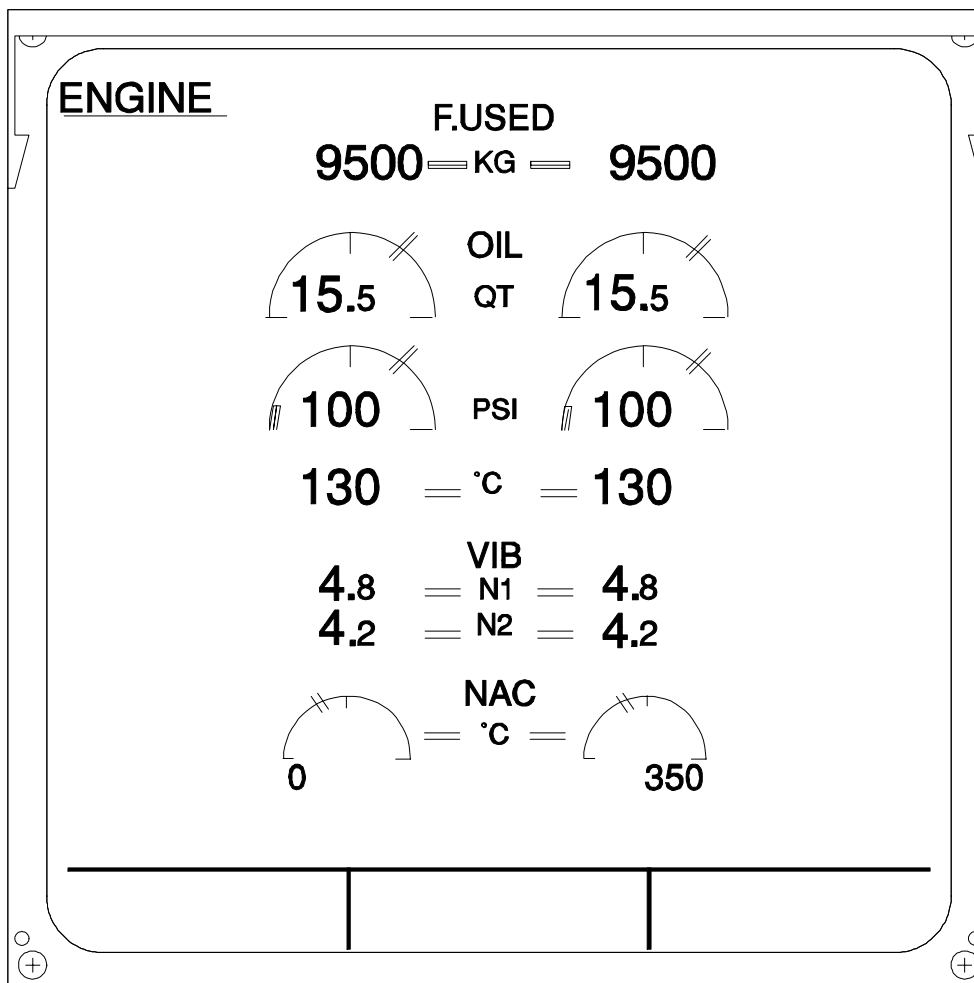
OIL QUANTITY INDICATOR



The oil quantity indication (needle and digital indicator) is normally displayed in green.

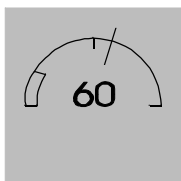


The oil quantity digital indication is in pulsing green, if the quantity drops below 2 quarts (low oil quantity advisory).

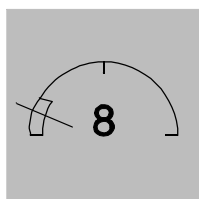


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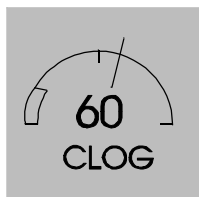
OIL PRESSURE INDICATOR



The oil pressure indication (needle and digital indicator) is normally green.



The oil pressure indication (needle and digital indicator) is in red if the pressure drops below 10 psi (Low press limit).



The CLOG message appears in amber if the pressure loss across the oil scavenge filter is excessive.

OIL TEMPERATURE

The oil temperature digital indication is :

130 °C

Normally in Green.

170 °C

In pulsing green if the temperature exceeds 160°C (High oil temperature advisory).

205 °C

In steady amber if the temperature is higher than 175°C or higher than 160°C for 15 minutes.

VIBRATION

The N1 and N2 vibration digital values are :

VIB
4.8 == **N1**
4.2 == **N2**

Normally in Green

VIB
7.8 == **N1**
9.2 == **N2**

In pulsing green if the vibration level exceeds :

- 5.6 units for N1.
- 5.7 units for N2.

IGNITION/START

Ignition display :

IGN

A **IGN**

For a dedicated engine, the selected ignitors "A" or "B" or "AB" are displayed in green.

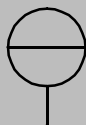
B **IGN**

AB **IGN**

Start valve display :



Fully open.



Fully Closed



No valid data at the DMC input.

Note : in case of position disagreement, the valve is shown in amber.

The bleed pressure is :

28 **PSI**

Normally in Green

In amber if :

- The pressure is below 20 psi with N2 over 10%
- The pressure exceeds 60 psi.

18 **PSI**

61 **PSI**

NACELLE TEMPERATURE

The nacelle temperature indications are :

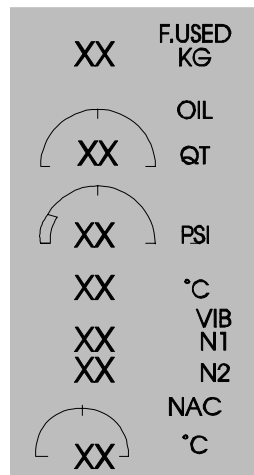


In green in normal operation.



In pulsing green if the temperature exceeds 260°C (High nacelle temperature advisory).

Note: The nacelle temperature is not displayed during the start sequence.



LACK OF VALID DATA

In case of invalidity of any parameter, the associated digital indication is replaced by two amber crosses.

STUDENT NOTES

FQW4200 GE Metric

CRUISE PAGE

FUEL USED

The total fuel used indication is :

9150

Normally in green.

~~9150~~

Amber and dashed as soon as any engine fuel used indication is crossed.

Note : Total fuel used remains displayed after an ECU power cut.

4575 F.USED
KG

Displayed in green, the fuel used is computed by the ECU from engine start to shut down.
It is reset at engine start on ground.

OIL QUANTITY INDICATOR

15.5

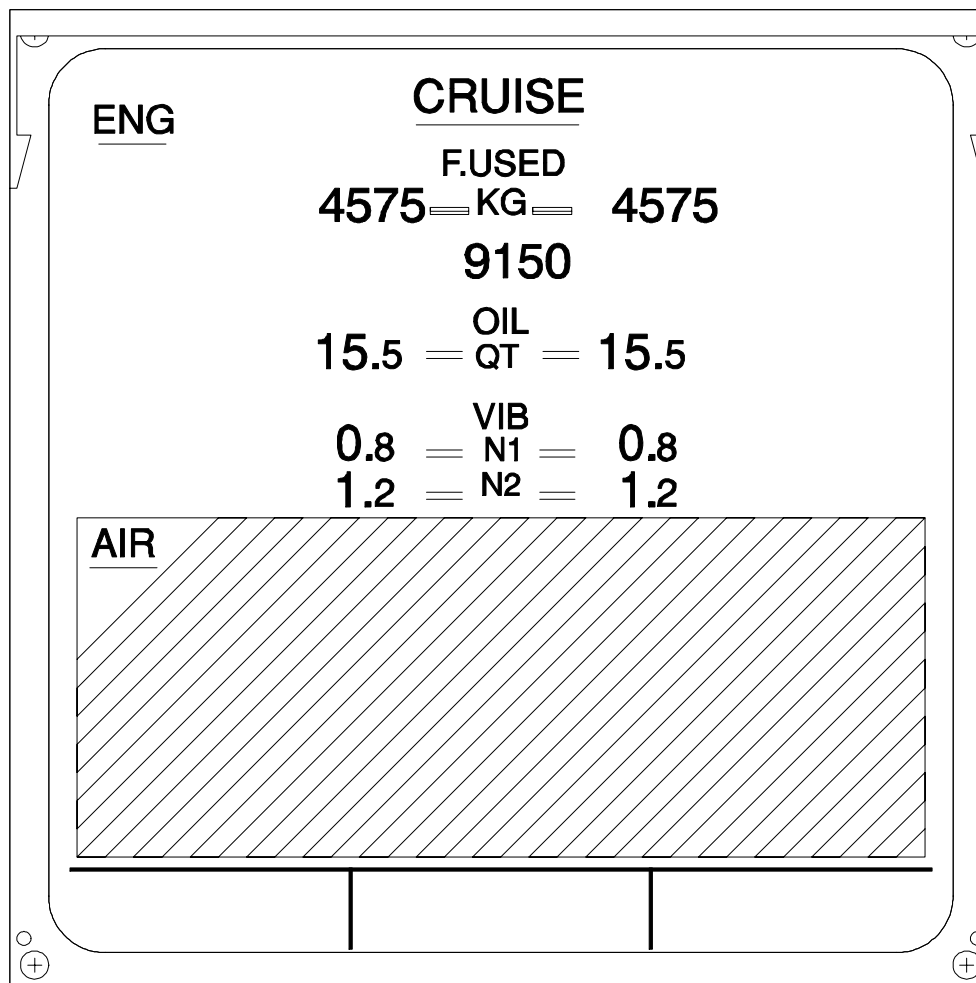
The oil quantity indication is normally displayed in green.

1.5

The oil quantity digital indication is in pulsing green, if the quantity drops below 2 quarts (low oil quantity advisory).

4575 F.USED
CLOG KG

The CLOG message appears in amber if the pressure loss across the fuel filter is excessive.



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VIBRATION

The N1 and N2 vibration digital values are :

VIB
4.8 = N1
4.2 = N2

Normally in green.

VIB
7.8 = N1
9.2 = N2

In pulsing green if the vibration level exceeds :
- 5.6 units for N1.
- 5.7 units for N2.

LACK OF VALID DATA

F. USED
XX = KG
XX = OIL
XX = QT
XX = VIB
XX = N1
XX = N2

In case of invalidity of any parameter, the associated digital indication is replaced by two amber crosses.

ENGINE PARAMETER PROCESSING

N1 Speed Sensor
N2 Speed Sensor
Exhaust Gas Temperature
Reverse
Fuel Flow
Fuel Used
Fuel Filter Clog
Oil Quantity
Oil Press
Oil Low Press
Oil Filter Clog
Oil Temperature
Vibration
Nacelle Temperature

N1 SPEED SENSOR

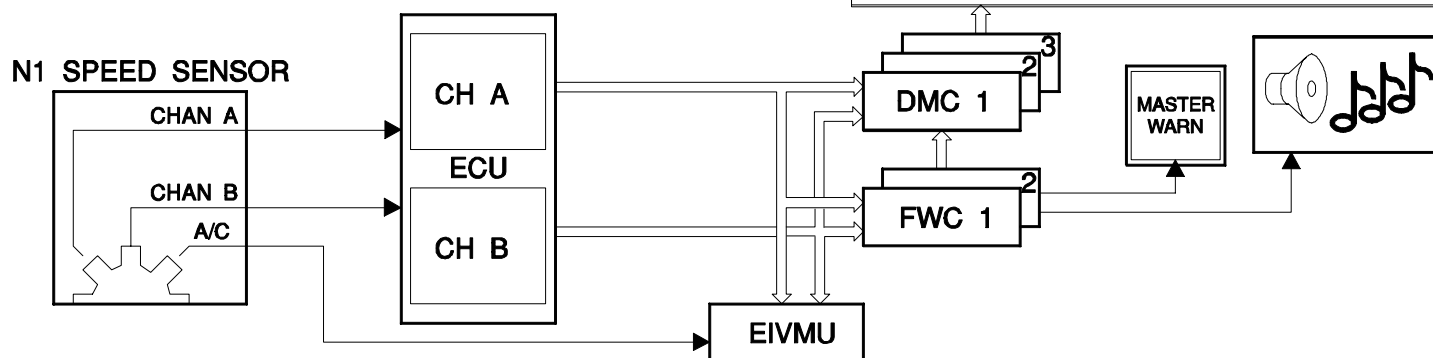
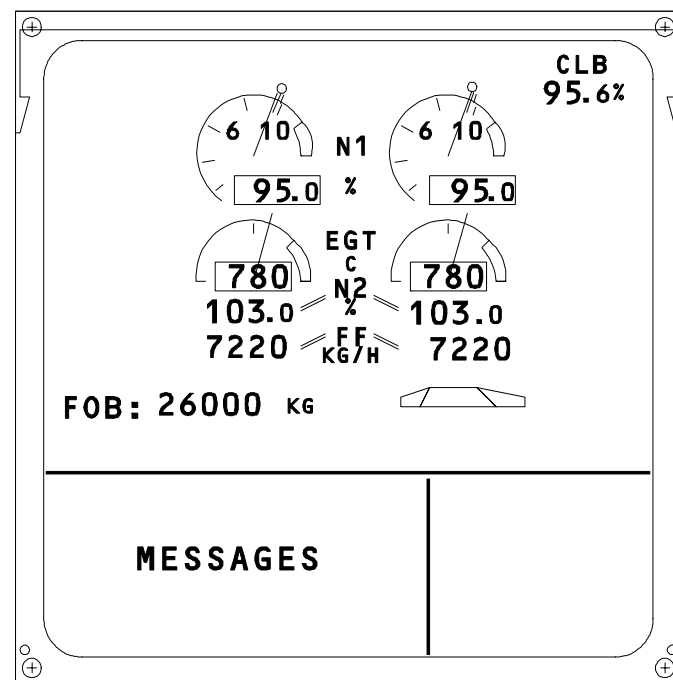
The N1 speed sensor consists of three independent sensing elements. Two of them are dedicated to the ECU (Electronic Control Unit) channels A and B.

The other one is dedicated to the EIVMU and is used for vibration monitoring.

The ECU processes the N1 probe signal and sends the value to DMC (Display Management Computer) 1, 2 and 3 for ECAM display.

It also sends the N1 value to FWC (Flight Warning Computer) 1 and 2 for warning activation and display on the STAND-BY page.

NOTE : the sensor ring has one tooth higher than the 37 others. This tooth generates a signal of greater amplitude used as phase reference for trim balance purposes by the EIVMU (Engine Interface Vibration Monitoring Unit).



N2 SPEED SENSOR

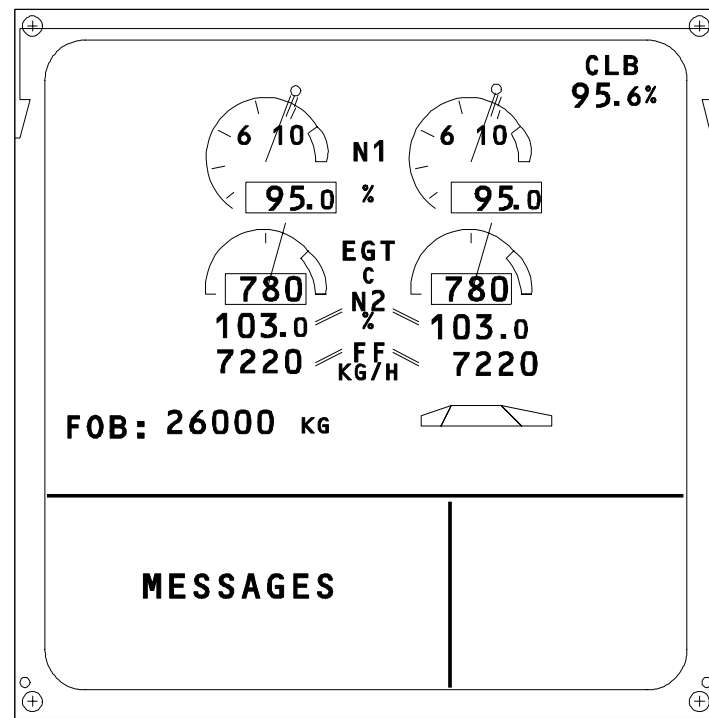
The N2 speed sensor consists of three independent sensing elements.

Two of them are dedicated to the ECU channels A and B.

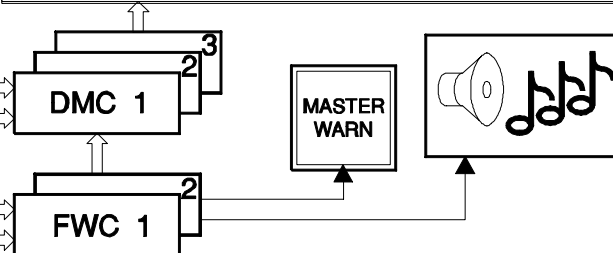
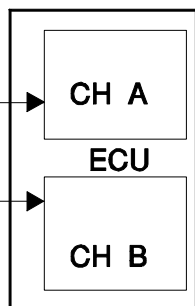
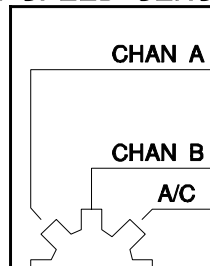
The other one is not used.

The ECU processes the N2 probe signal and sends the value to DMC 1, 2 and 3 for ECAM display.

It also sends the N2 value to FWC 1 and 2 for warning activation and display on the STAND-BY page.



N2 SPEED SENSOR

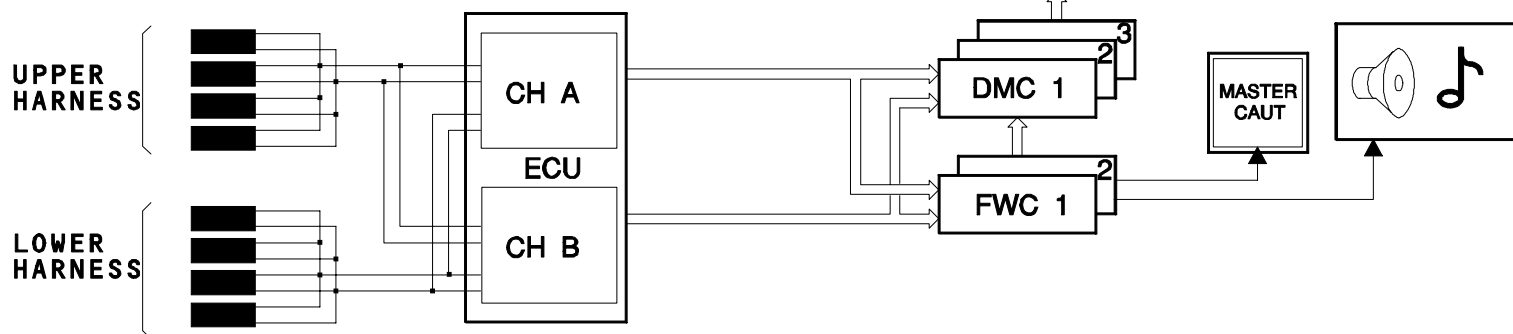
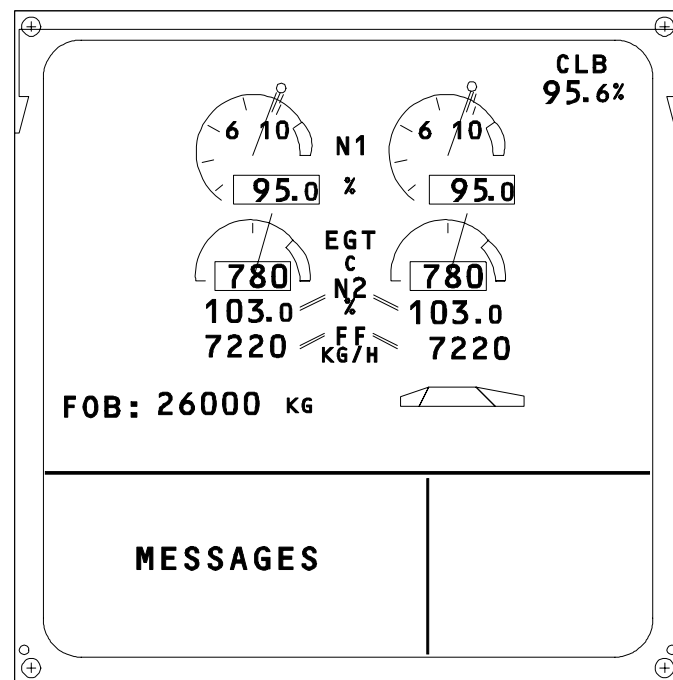


EXHAUST GAS TEMPERATURE

There are two T49.5 (EGT) wiring harnesses.

There are four EGT probes for each harness. The four EGT probes are in a parallel circuit to provide an averaged thermocouple signal to the ECU from each thermocouple harness. Each channel of the ECU receives both upper and lower EGT signal inputs.

The signal received from the thermocouples is digitized by the ECU and sent to DMC 1, 2 and 3 for ECAM display, and to FWC 1 and 2 for warning activation and display on the STAND-BY page.



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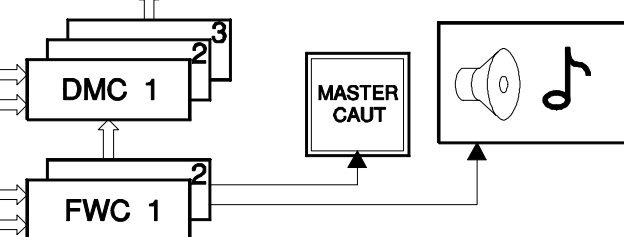
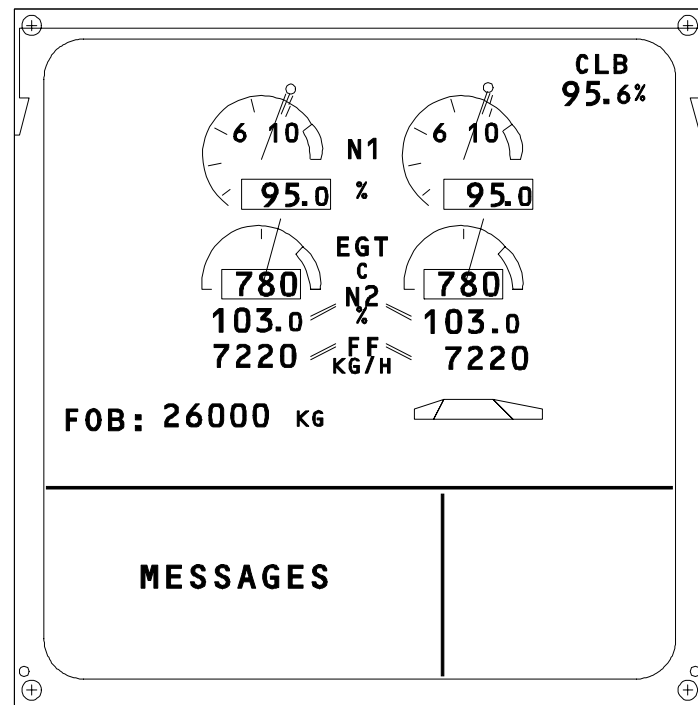
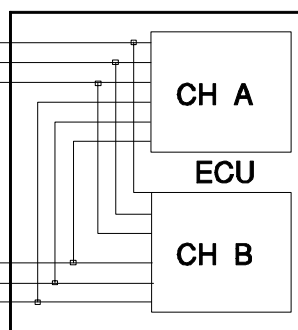
REVERSE

The Thrust Reverser status from the stow and deploy switches, from the pressure switch and inhibition switch is digitized by the ECU which sends it to DMC 1, 2 and 3 for ECAM display and to FWC 1 and 2 for warning activation and display on the STAND-BY page.

RIGHT STOW/
DEPLOY SW

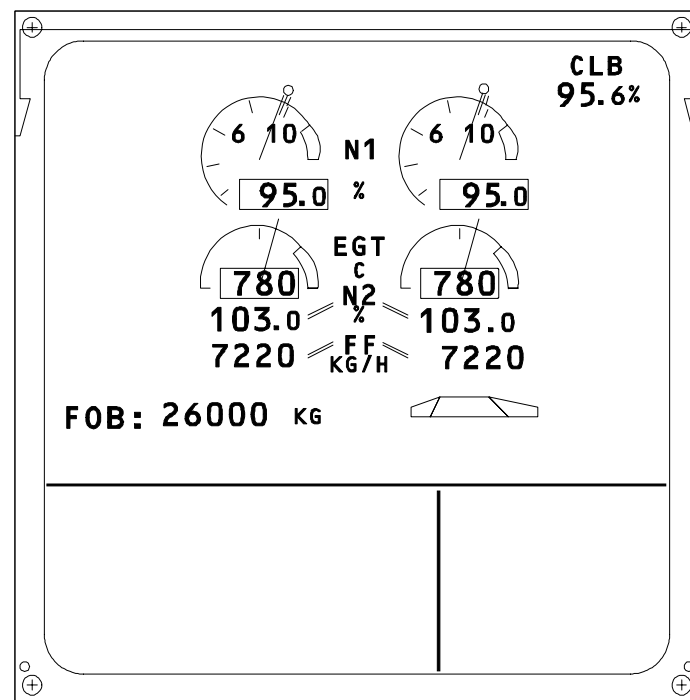


LEFT STOW/
DEPLOY SW

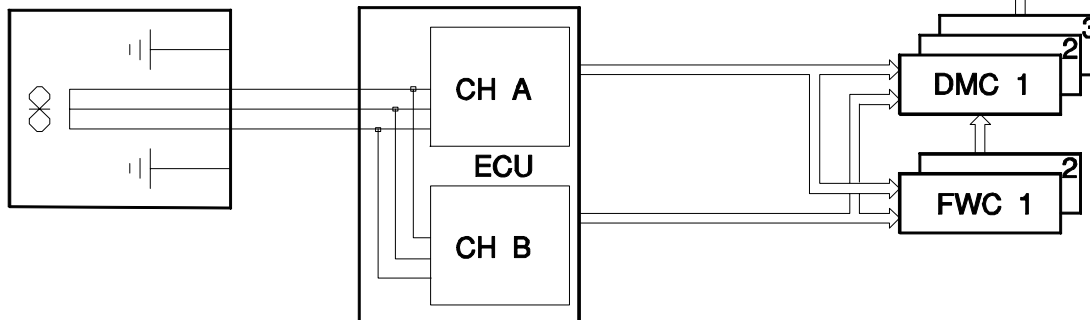


FUEL FLOW

The fuel flowmeter signal is digitized by the ECU which sends it to DMC 1, 2 and 3 for ECAM display, and to FWC 1 and 2 for display on the STAND-BY page.



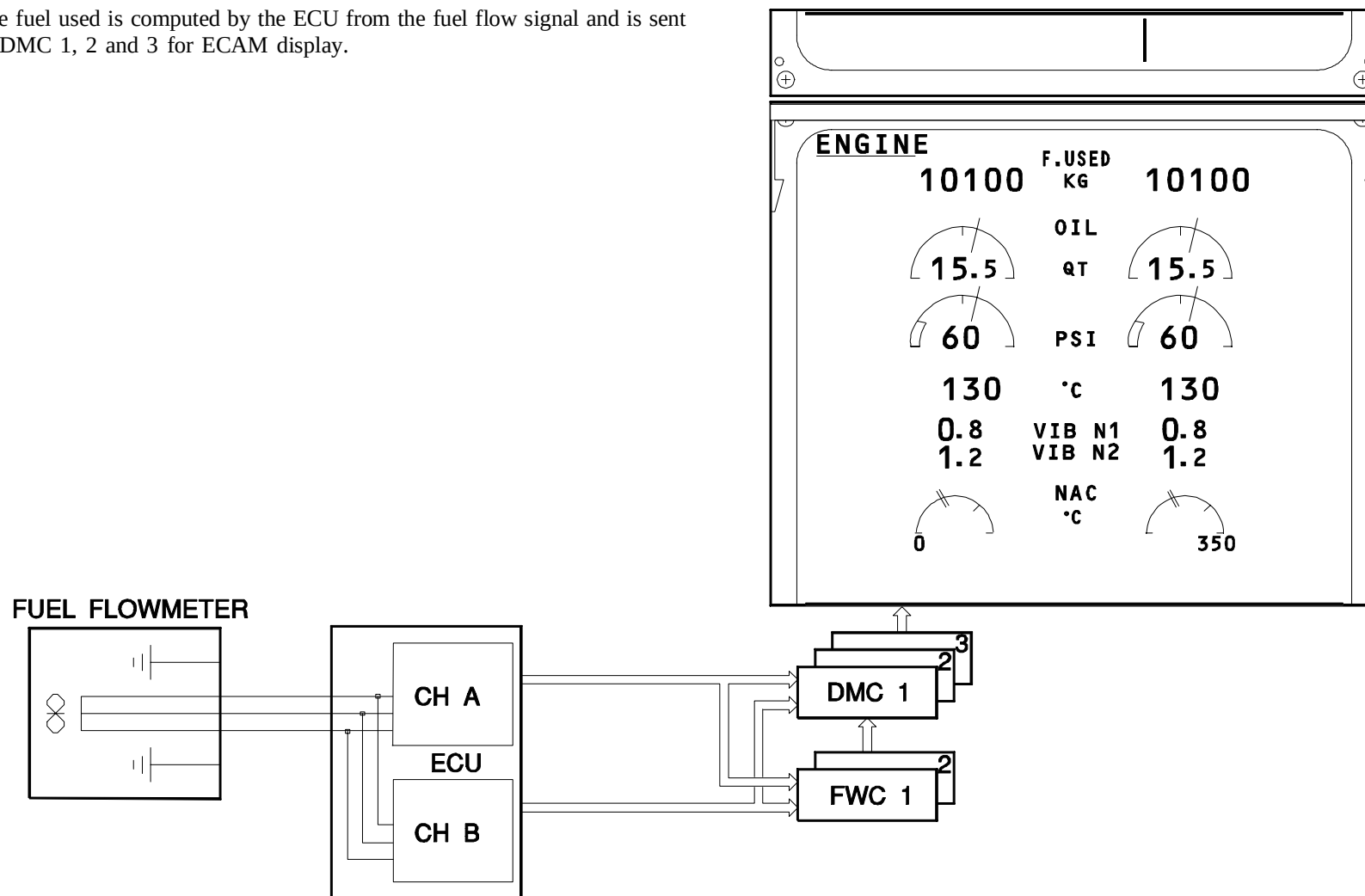
FUEL FLOWMETER



FQW4200 GE Metric

FUEL USED

The fuel used is computed by the ECU from the fuel flow signal and is sent to DMC 1, 2 and 3 for ECAM display.

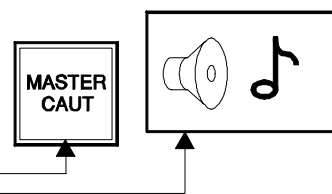
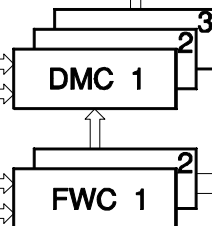
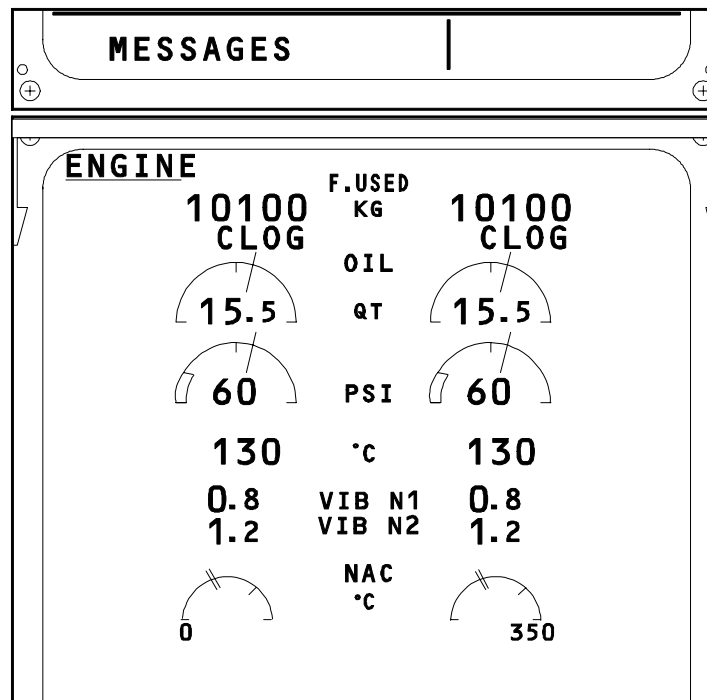
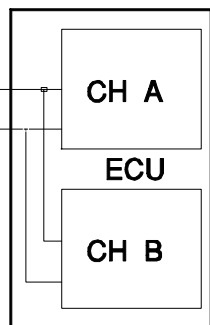
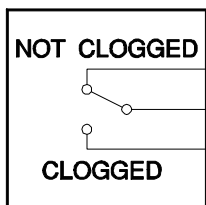


FQW4200 GE Metric

FUEL FILTER CLOG

The fuel filter clog signal is sent to the ECU which sends it to DMC 1, 2 and 3 for ECAM display, and to FWC 1 and 2 for warning activation.

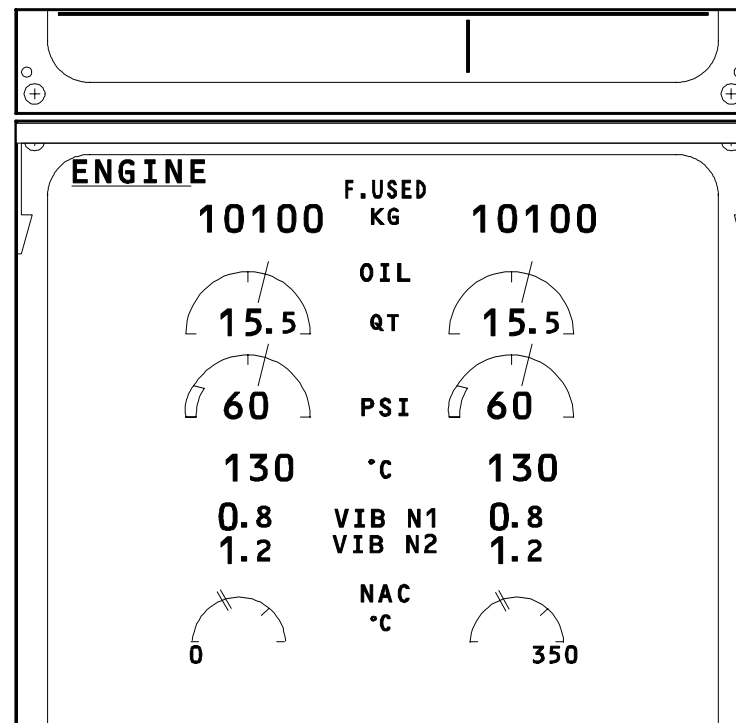
FUEL FILTER DIFF PRESS SW



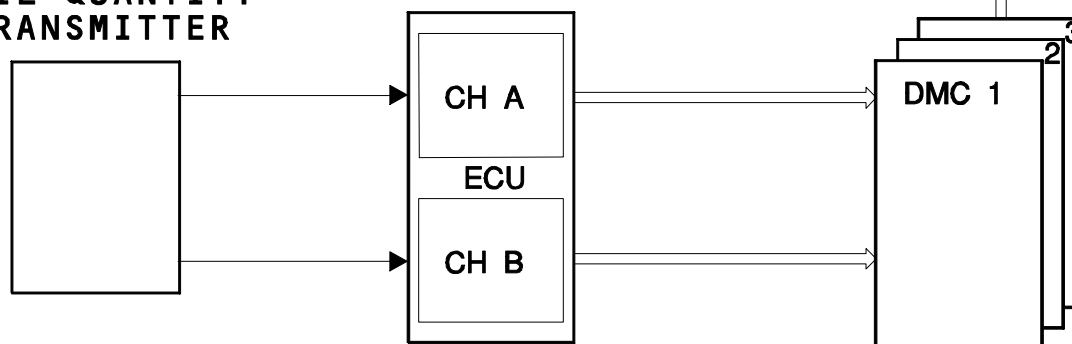
FQW4200 GE Metric

OIL QUANTITY

The oil quantity signal is sent to the ECU (Channel A and channel B). Once digitized, it is sent to DMC 1, 2 and 3 by each computer for ECAM display with a priority order managed by the DMCs.

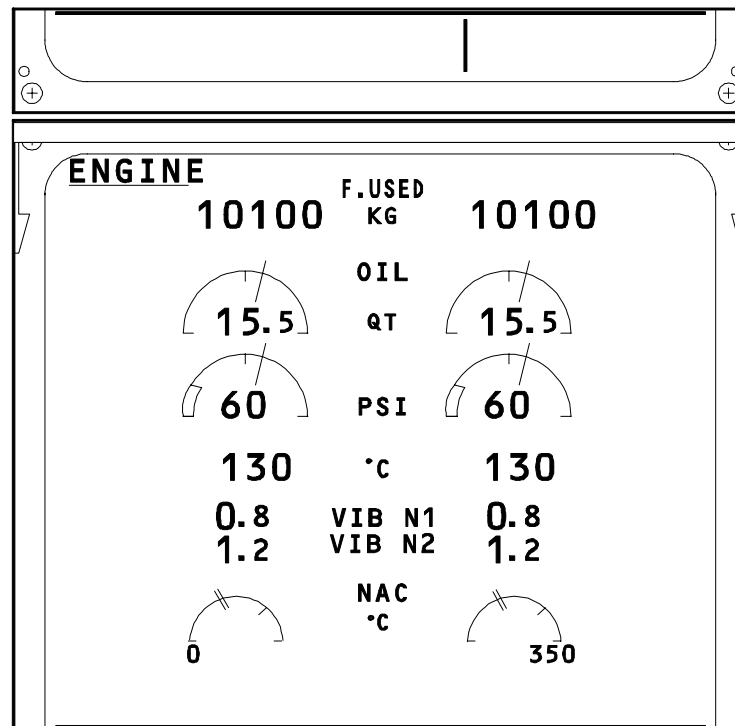


OIL QUANTITY TRANSMITTER

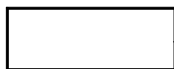


OIL PRESS

The oil pressure signal is sent to the ECU (Channel A and channel B). Once digitized, it is sent to DMC 1, 2 and 3 for ECAM display with a priority order managed by the DMCs.



OIL PRESSURE
TRANSMITTER



CH A

ECU

CH B

OIL PRESSURE
TRANSMITTER



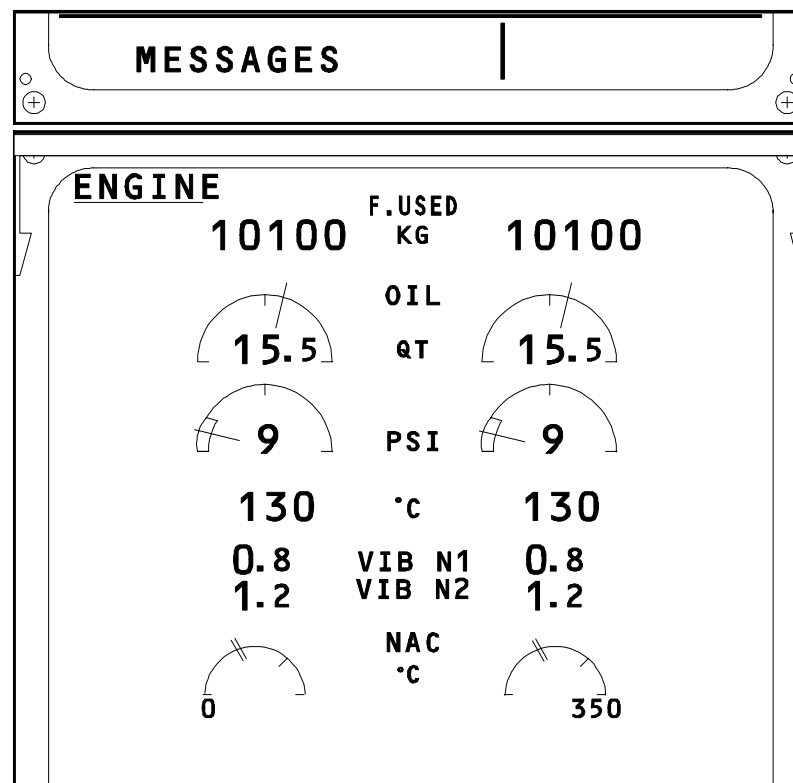
DMC 1

2

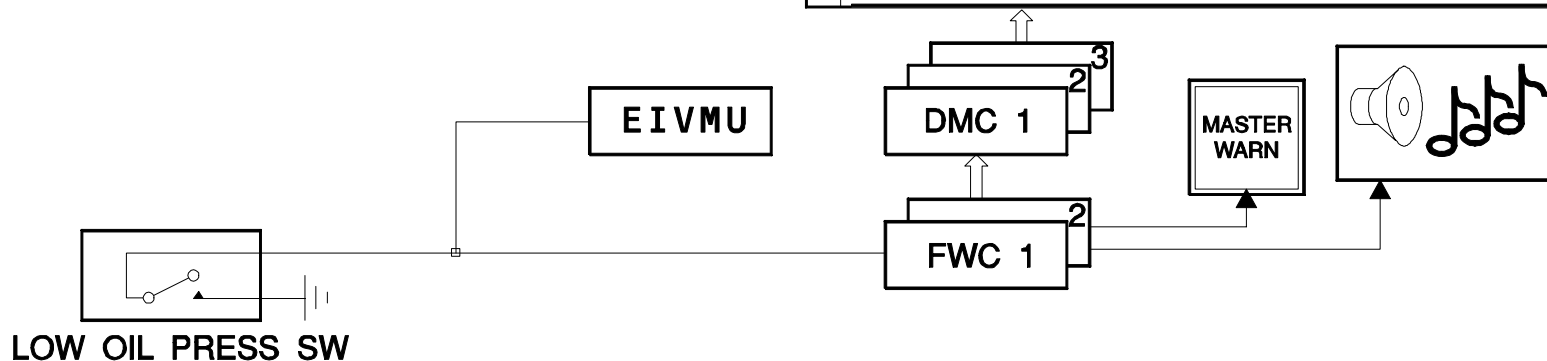
3

OIL LOW PRESS

The oil low pressure signal is sent to FWC 1 and 2 for warning activation. The appropriate message is then generated and displayed on the ECAM through DMC 1, 2 and 3.



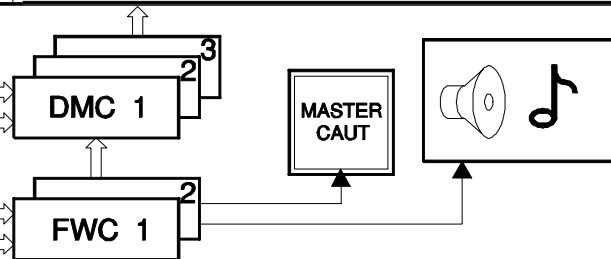
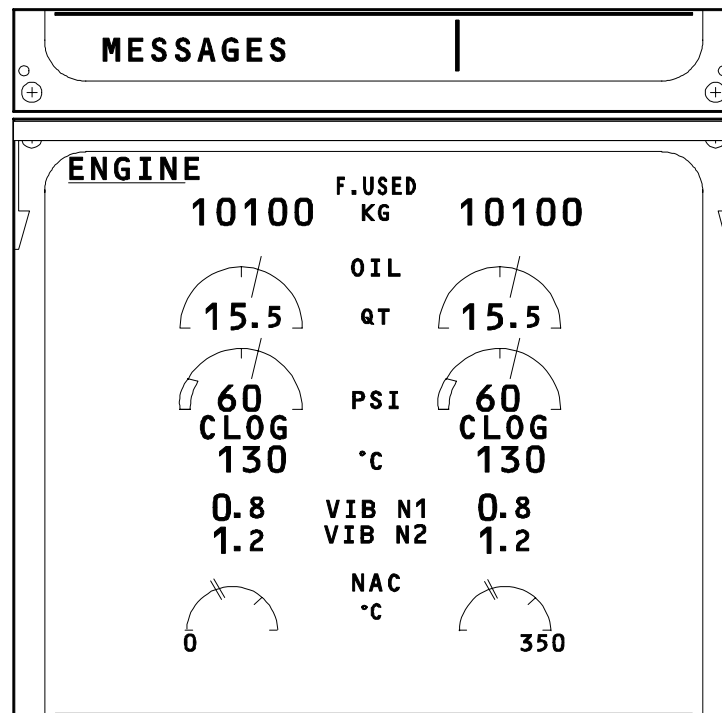
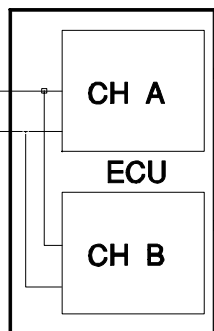
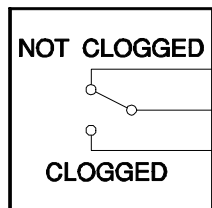
FQW4200 GE Metric



OIL FILTER CLOG

The oil filter clog signal is sent to the ECU which sends it to DMC 1, 2 and 3 for ECAM display and to FWC 1 and 2 for warning activation.

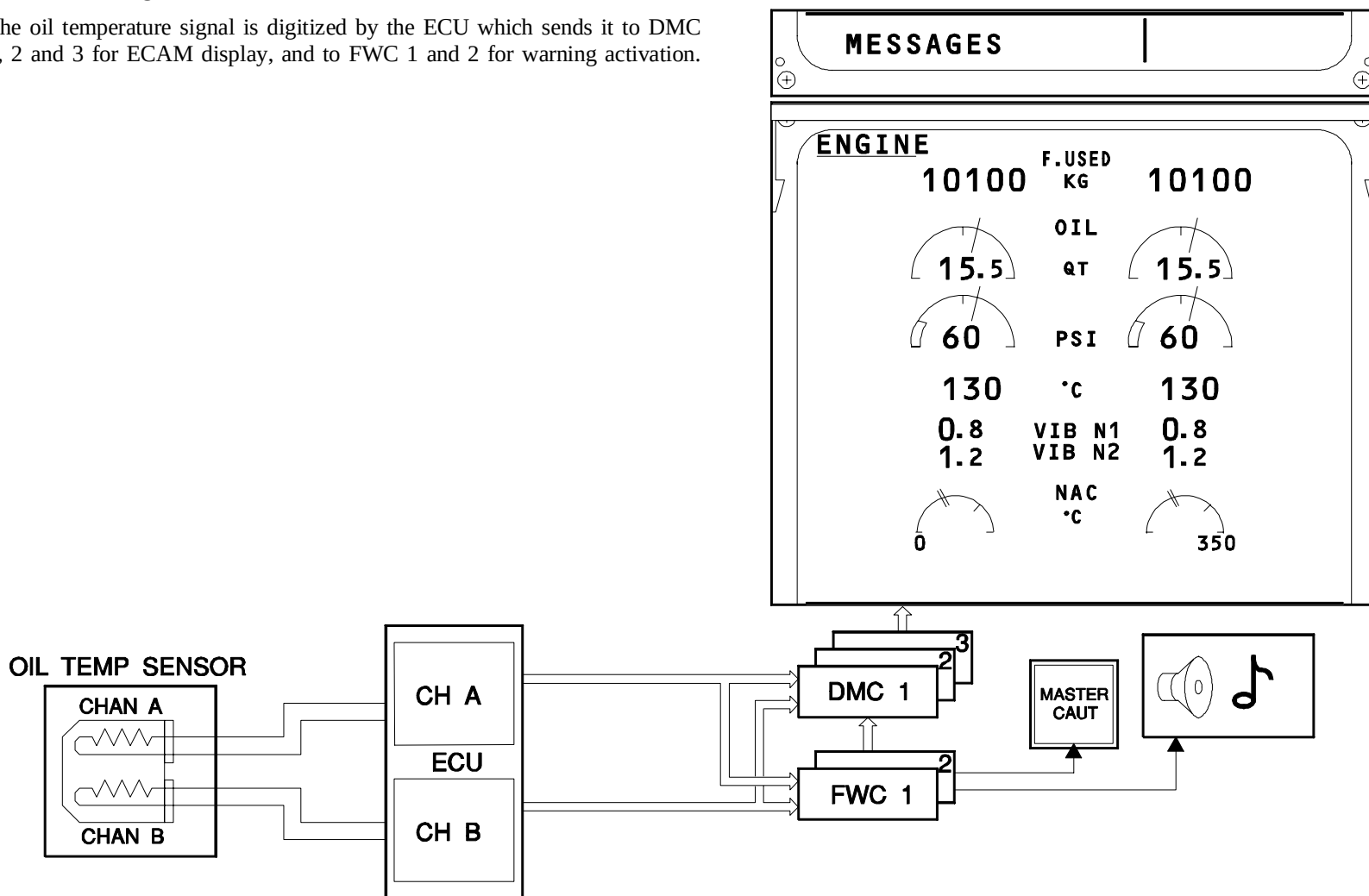
OIL FILTER DIFF PRESS SW



OIL TEMPERATURE

The oil temperature signal is digitized by the ECU which sends it to DMC 1, 2 and 3 for ECAM display, and to FWC 1 and 2 for warning activation.

FQW4200 GE Metric



VIBRATION

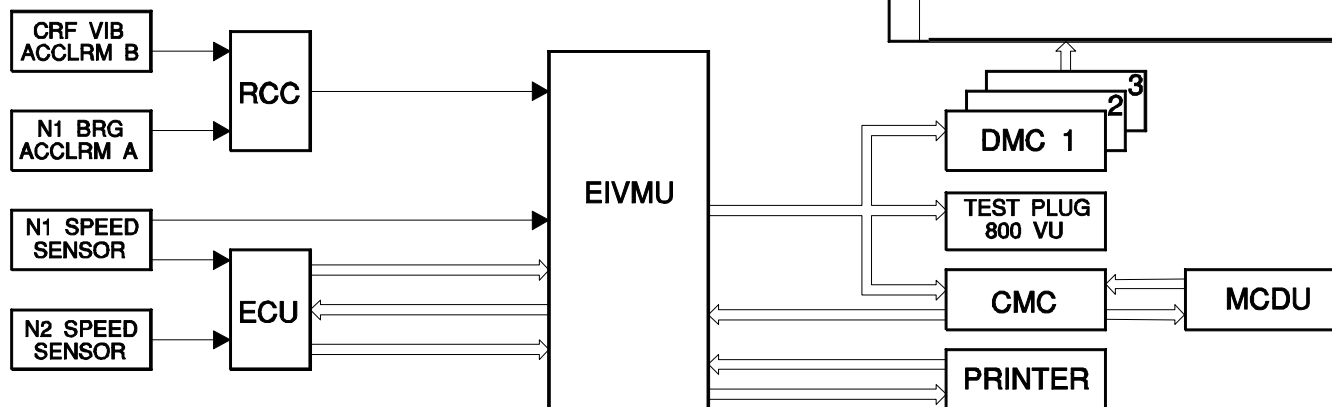
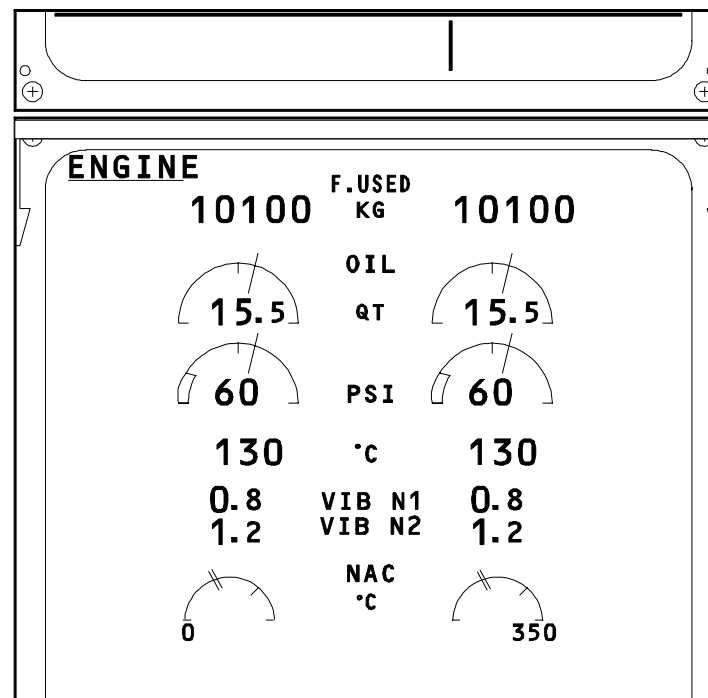
To process the vibration monitoring, the EIVMU receives :

- Two digital signals from the ECU :
N1 speed,
N2 speed.
- Three analog signals from :
N1 speed sensor,
No 1 bearing vibration sensor through the RCC Turbine
Compressor Rear Frame vibration sensor through the RCC.

Once processed, the EIVMU transmits digital signals to :

- DMC 1, 2 and 3 for ECAM display,
- CMC (Centralized Maintenance Computer), Test Plug and Printer for maintenance purposes.

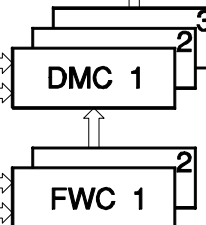
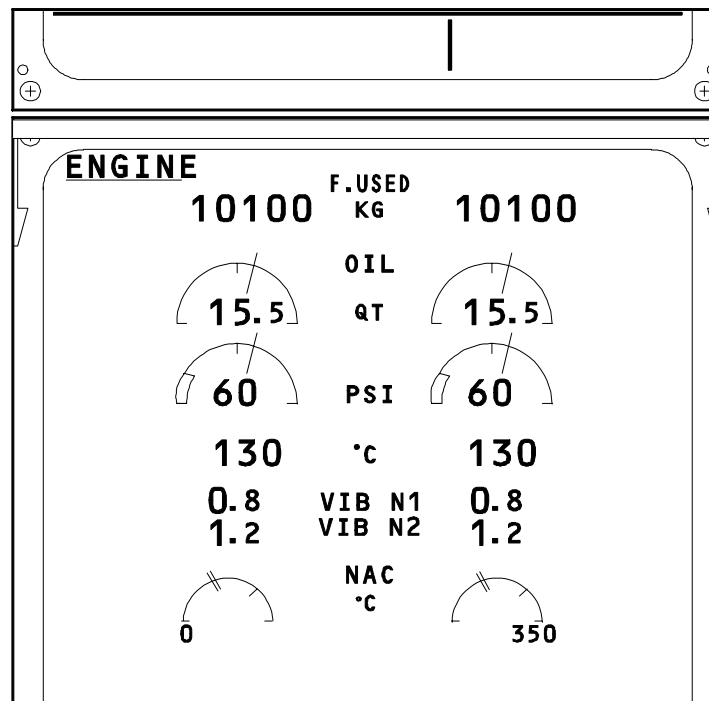
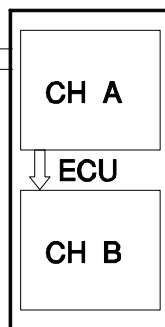
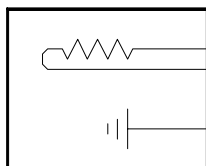
RCC : Remote Charge Converter.



NACELLE TEMPERATURE

The nacelle temperature probe signal is digitized by the ECU which sends it to DMC 1, 2 and 3 for ECAM display, and to FWC 1 and 2 for warning activation.

NACELLE TEMP SENSOR



STUDENT NOTES

FQW4200 GE Metric

WARNINGS (INDICATING)

TYPE DISAGREE
N1 OVERLIMIT
N2 OVERLIMIT
EGT OVERLIMIT

TYPE DISAGREE

There is an engine configuration disagreement. At least one of the engine configuration plugs is not in agreement with the engine coding identification of the Flight Warning Computer (FWC). This can appear on ground at FADEC power up.

N1 OVERLIMIT

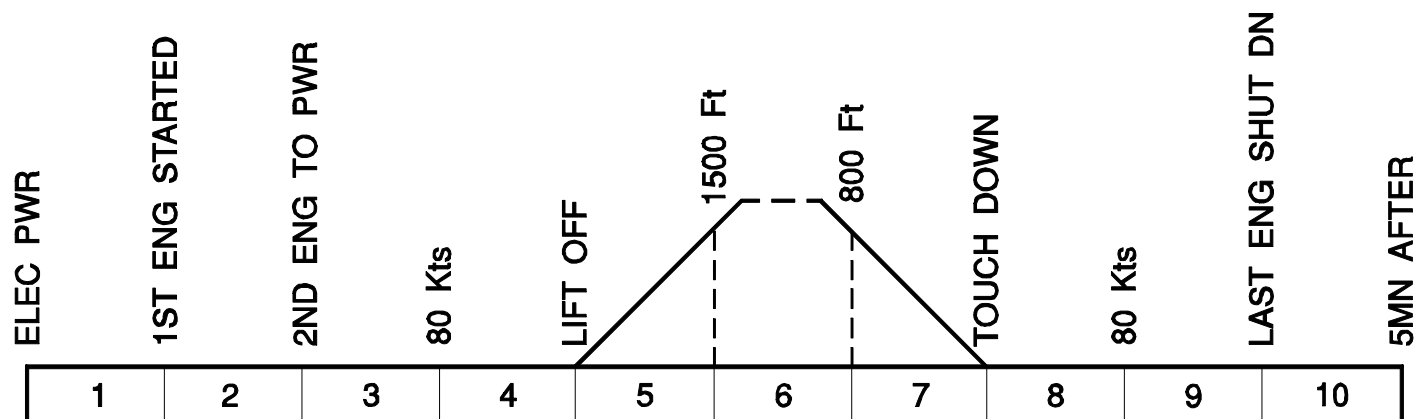
This happens if N1 exceeds the red line limit (115.5 %). If N1 remained below the red line limit (115.5 %), the engine thrust must be reduced to keep N1 below the red line limit. If the red line limit (115.5 %) was exceeded, the engine must be shut down.

N2 OVERLIMIT

This happens if N2 exceeds the red line limit (113 %). If N2 remained below the red line limit (113 %), the engine thrust must be reduced to keep N2 below the red line limit. If the red line limit (113 %) was exceeded, the engine must be shut down.

EGT OVERLIMIT

This happens if EGT exceeds the red line limit (975 Deg C) or when it is compared to amber line (940 Deg C). If EGT remained below the red line limit (975 Deg C), the engine thrust must be reduced to keep EGT below the red line limit. If the red line limit (975 Deg C) was exceeded, the engine must be shut down.



E/WD : FAILURE TITLE	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLT PHASE INHIB
TYPE DISAGREE	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 5, 6, 7, 8, 9, 10
N1 OVERLIMIT	CONTINUOUS REPETITIVE CHIME	MASTER WARN	NIL	NIL	4, 8
N2 OVERLIMIT	CONTINUOUS REPETITIVE CHIME	MASTER WARN	NIL	NIL	4, 8
EGT OVERLIMIT	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 8

STUDENT NOTES

FQW4200 GE Metric

COMPONENTS (ANALYSER SYSTEM)

Safety Precautions

PS3 Sensor

PS12 Sensor

PS14 Sensor

T3

P49

T5 Probe

T5 Harness

SAFETY PRECAUTIONS

WARNING : Before any action on the engine :

- Do not start the engine.
- Make sure that the engine has been shut down for at least 5 min.
- Make sure that the ENG FADEC GND PWR pushbutton is off.
- Make sure that the ENG MASTER switch is in the off position.

STUDENT NOTES

FQW4200 GE Metric

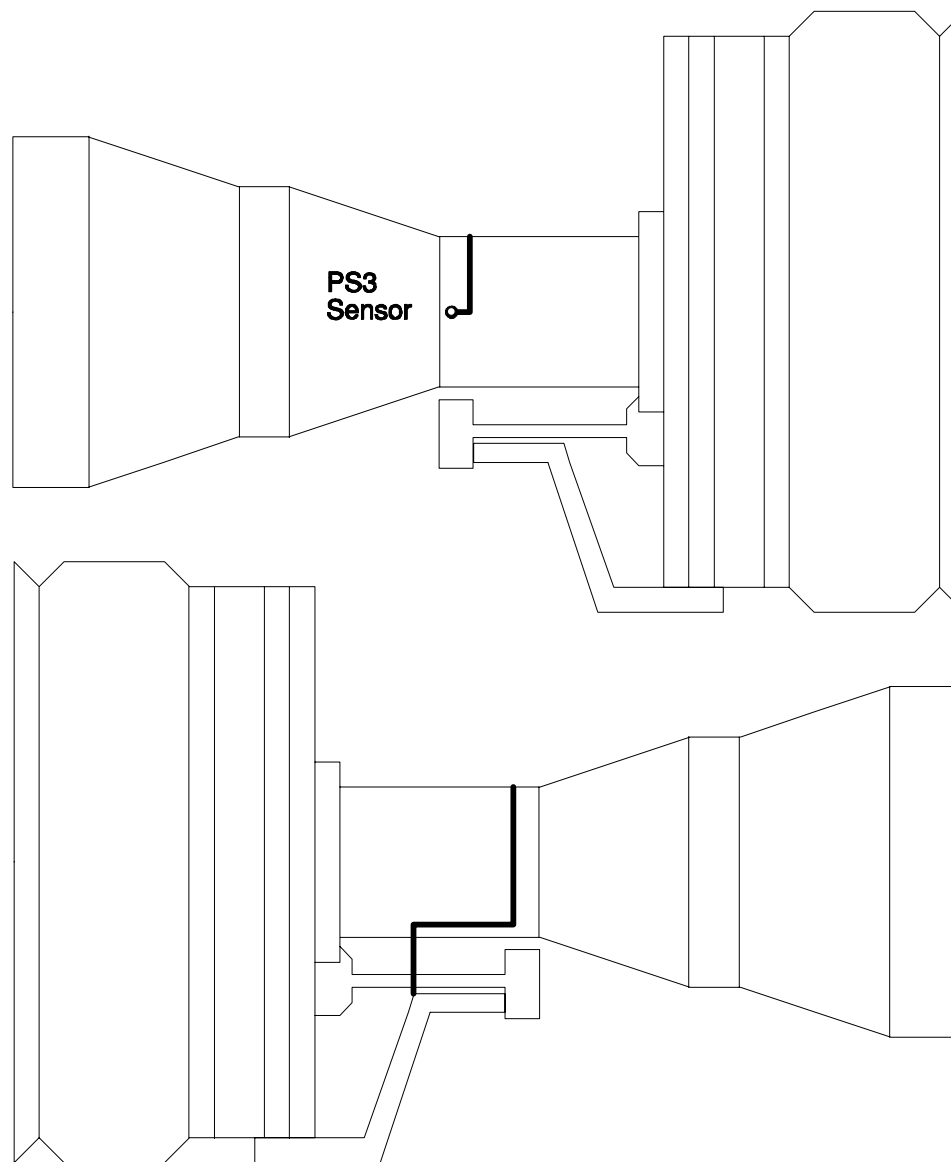
PS3 SENSOR

FIN / ZONE

Zone : 413-423

COMPONENT DESCRIPTION

Compressor Discharge Pressure is sensed through a fitting located at the 3:00 position of the compressor rear frame just aft of it's forward flange. From this fitting PS3, air is routed through tubing to the pressure manifold at the ECU. Within the manifold, the air is split and sent to two separate pressure transducers, one for channel A and one for channel B.



FQW4200 GE Metric

PS12 SENSOR

FIN / ZONE

FIN : 5101 EB

Zone : 412-422

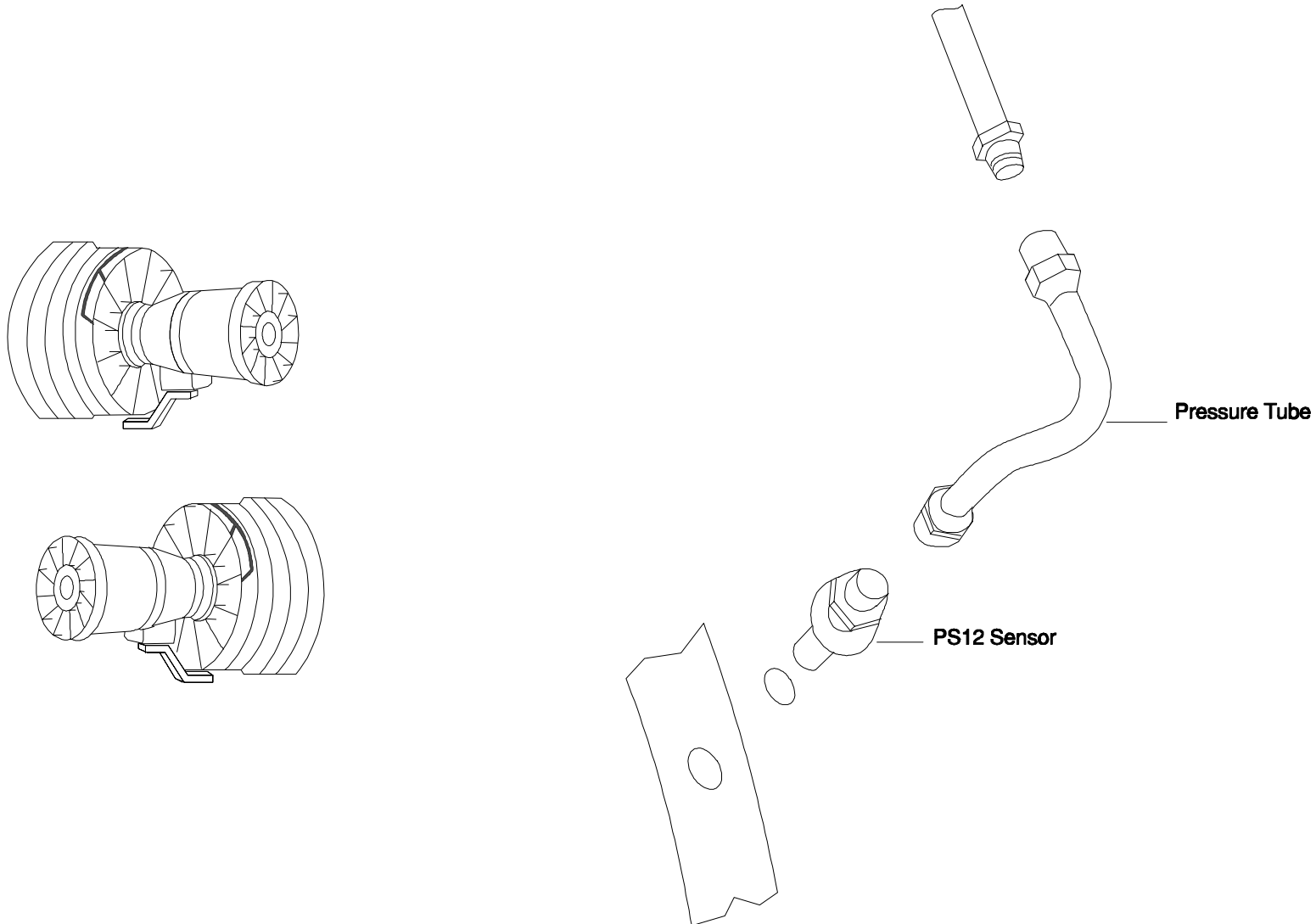
COMPONENT DESCRIPTION

There are four PS12 pressure sensors installed in the forward fan case at the 1, 3, 9 and 11 O'clock positions.

The PS12 pressure sensors are static ports located in the fan case ahead of the fan. The sensors are joined together by a manifold that routes this pressure to two pressure transducers in the ECU.

REMOVAL / INSTALLATION

To remove the sensor, use the flats on the base and turn the sensor in a counter clockwise direction.



FQW4200 GE Metric

PS14 SENSOR

FIN / ZONE

FIN : 5102 EB

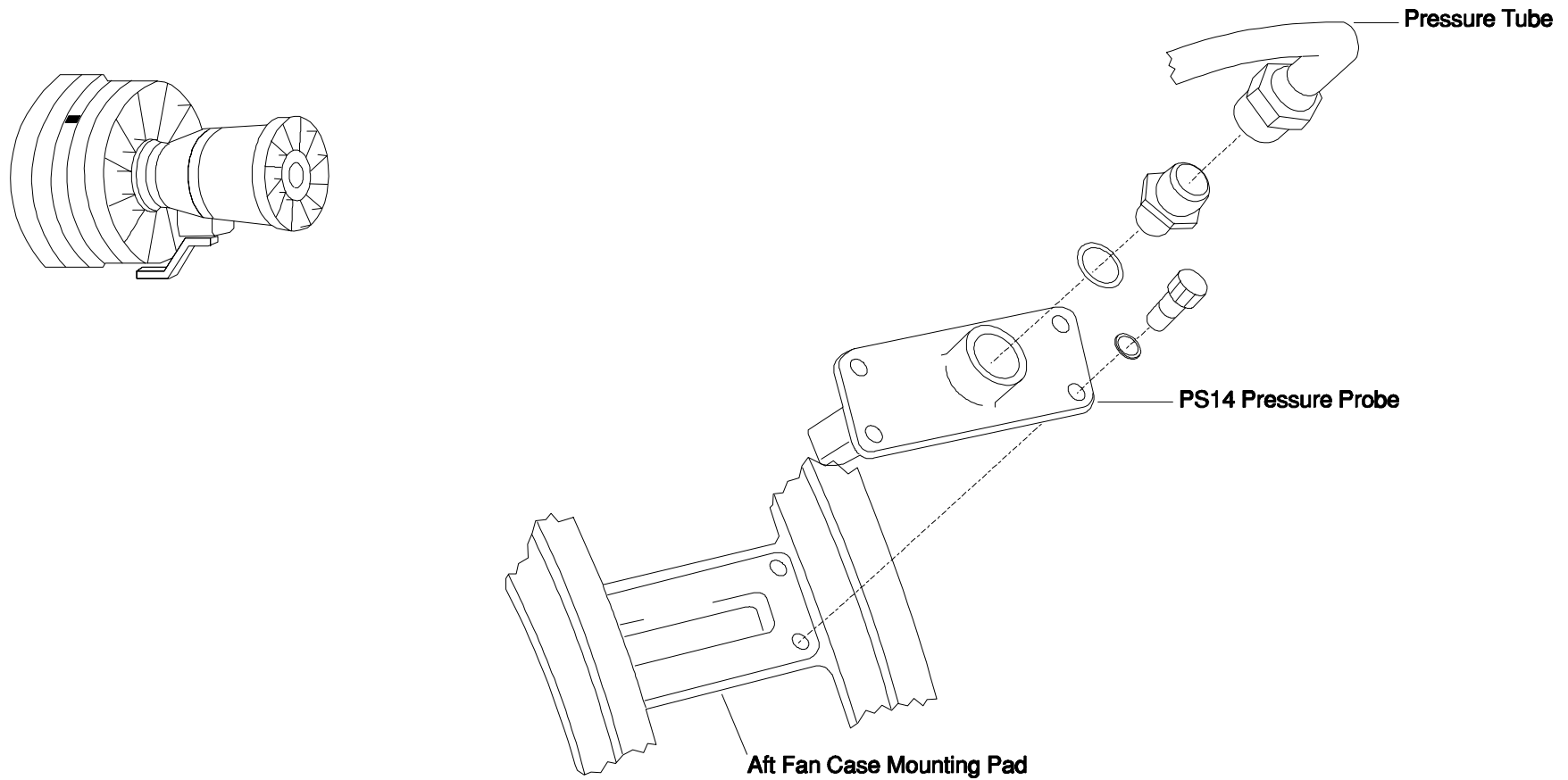
Zone : 412-422

COMPONENT DESCRIPTION

The probe is located at the 10:30 position on the aft fan case. It provides the static pressure of the fan discharge airflow to the ECU. Through a drilled passage way in the probe, the static pressure of the fan discharge air flow is directed through an external line from the probe to an ECU pressure transducer.

REMOVAL / INSTALLATION

The sensor is fitted by means of 4 bolts.



FQW4200 GE Metric

T3

FIN / ZONE

FIN : 4047 KS

Zone : 413-423

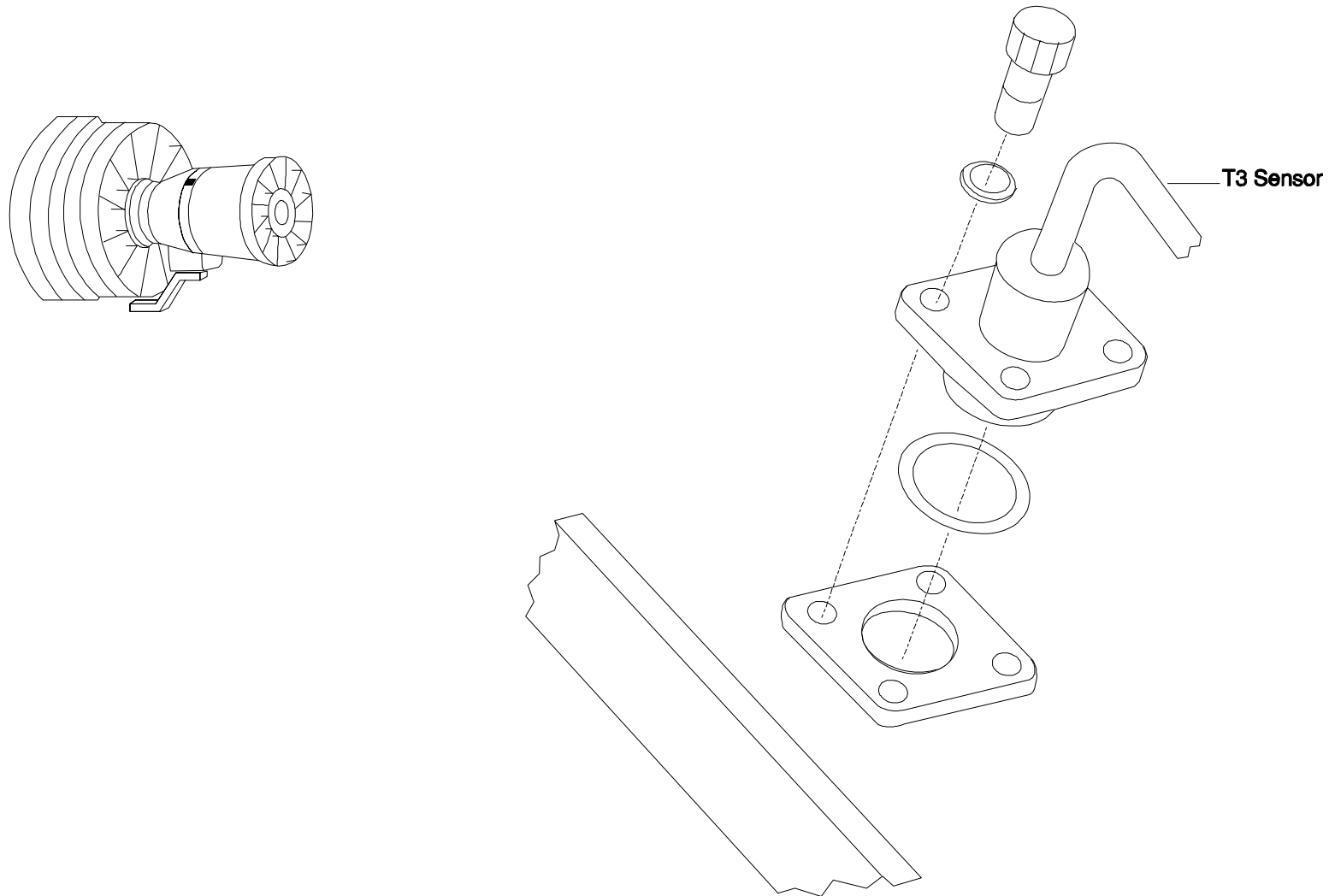
COMPONENT DESCRIPTION

The T3 temperature sensor is located at 11:30 on the compressor rear frame.

The T3 sensor contains two thermocouples installed in the high pressure compressor discharge airflow. The output of the thermocouples is sent through separate ECU cables to the individual channels.

REMOVAL / INSTALLATION

The sensor is fitted by means of bolts to the compressor rear frame.



FQW4200 GE Metric

P49

FIN / ZONE

FIN : 5103 EB

Zone : 213-223

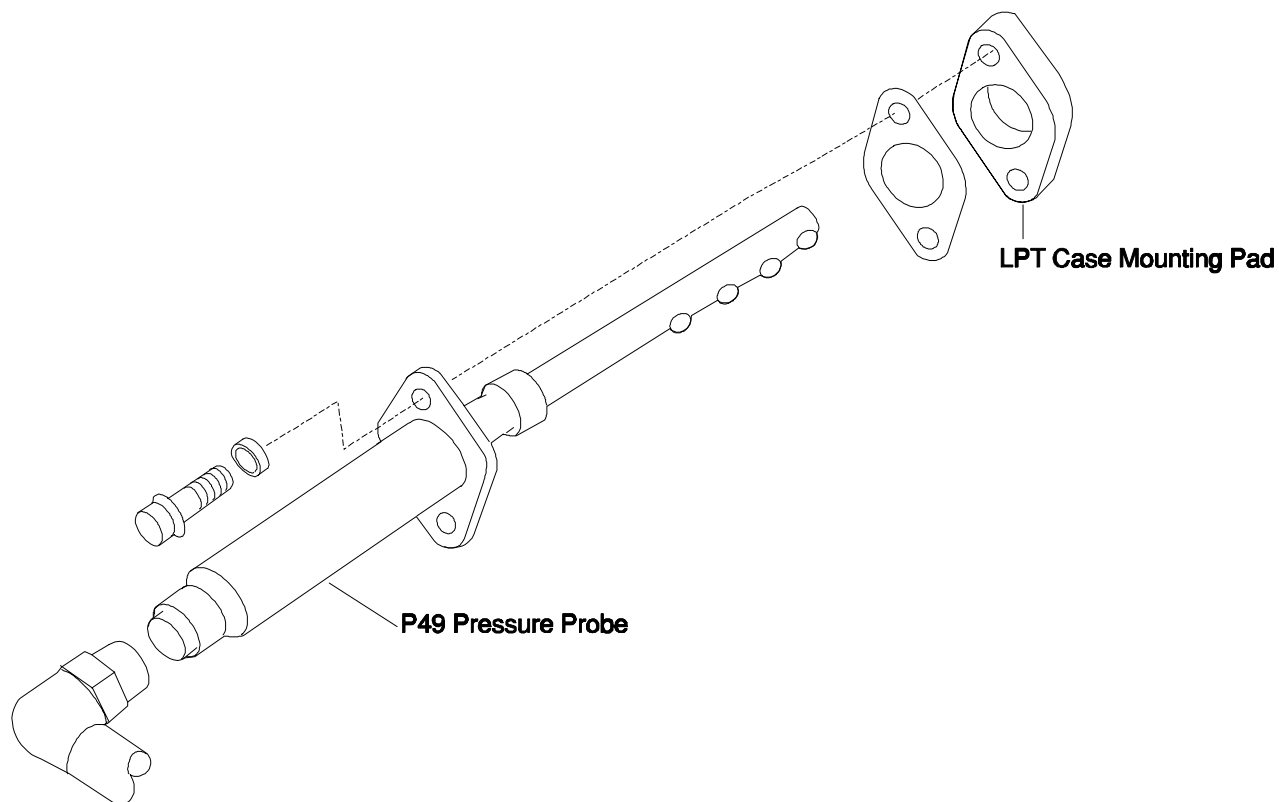
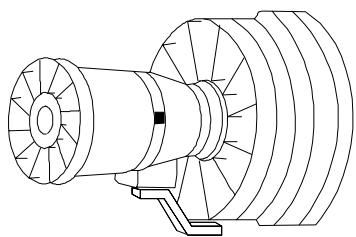
COMPONENT DESCRIPTION

The probe is inserted in the LPT inlet air flow.

Ports on the leading edge of the P49 probe direct air pressure through an external line to an ECU pressure transducer. The P49 probe provides the total pressure of the low pressure turbine inlet airflow to the ECU.

REMOVAL / INSTALLATION

The probe is fitted to the low pressure turbine case mount pad by means of two bolts.



T5 PROBE

FIN / ZONE

FIN : 4046 KS

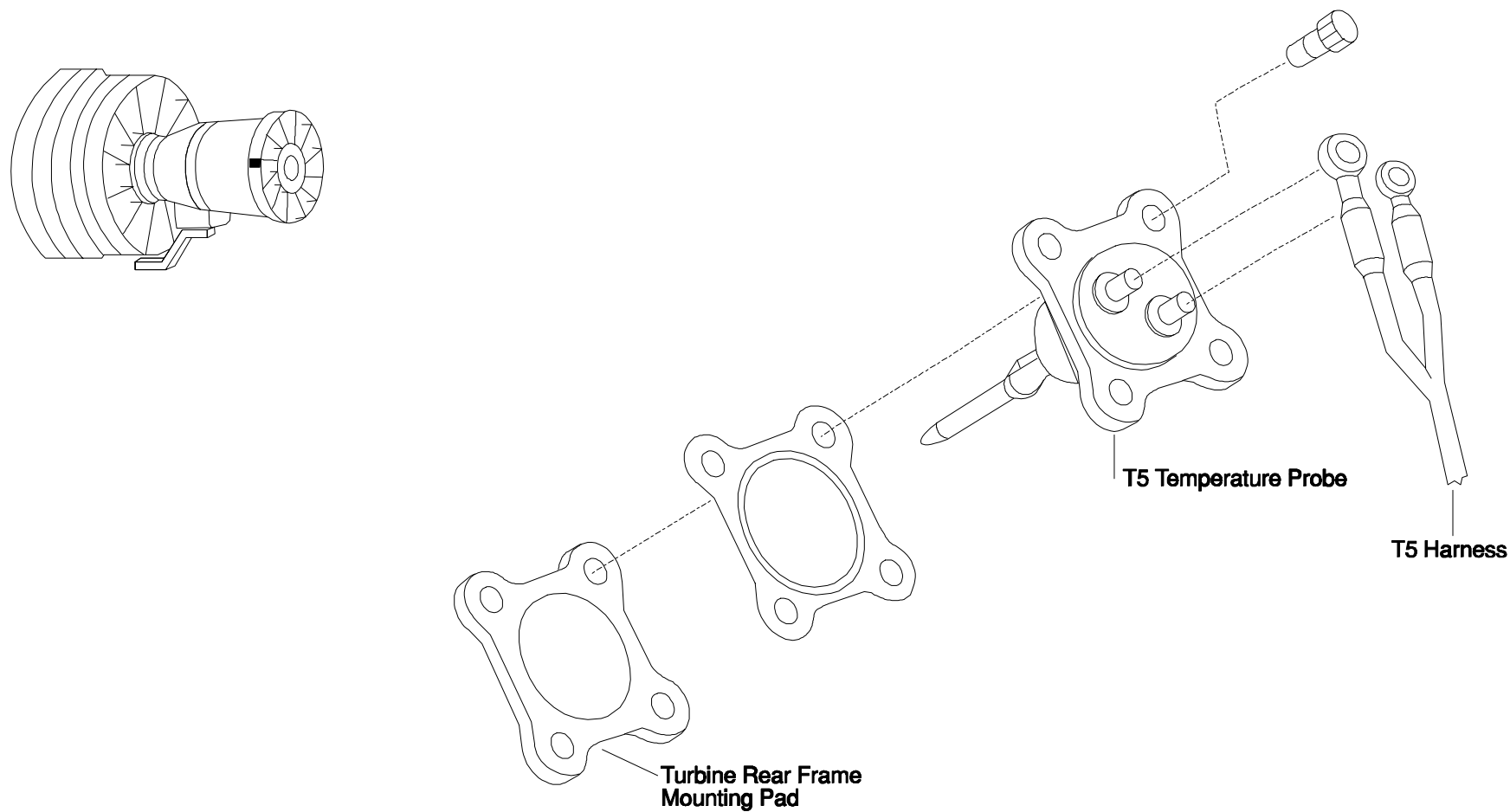
Zone : 213-223

COMPONENT DESCRIPTION

The T5 sensor contains two thermocouples inserted at different depths in the LPT exhaust stream. The average of the two thermocouples is sent to the ECU. This signal represents LPT outlet temperature.

REMOVAL / INSTALLATION

The T5 thermocouple is fitted to the turbine rear frame by means of 4 bolts.



T5 HARNESS

FIN / ZONE

FIN : 4270 KS

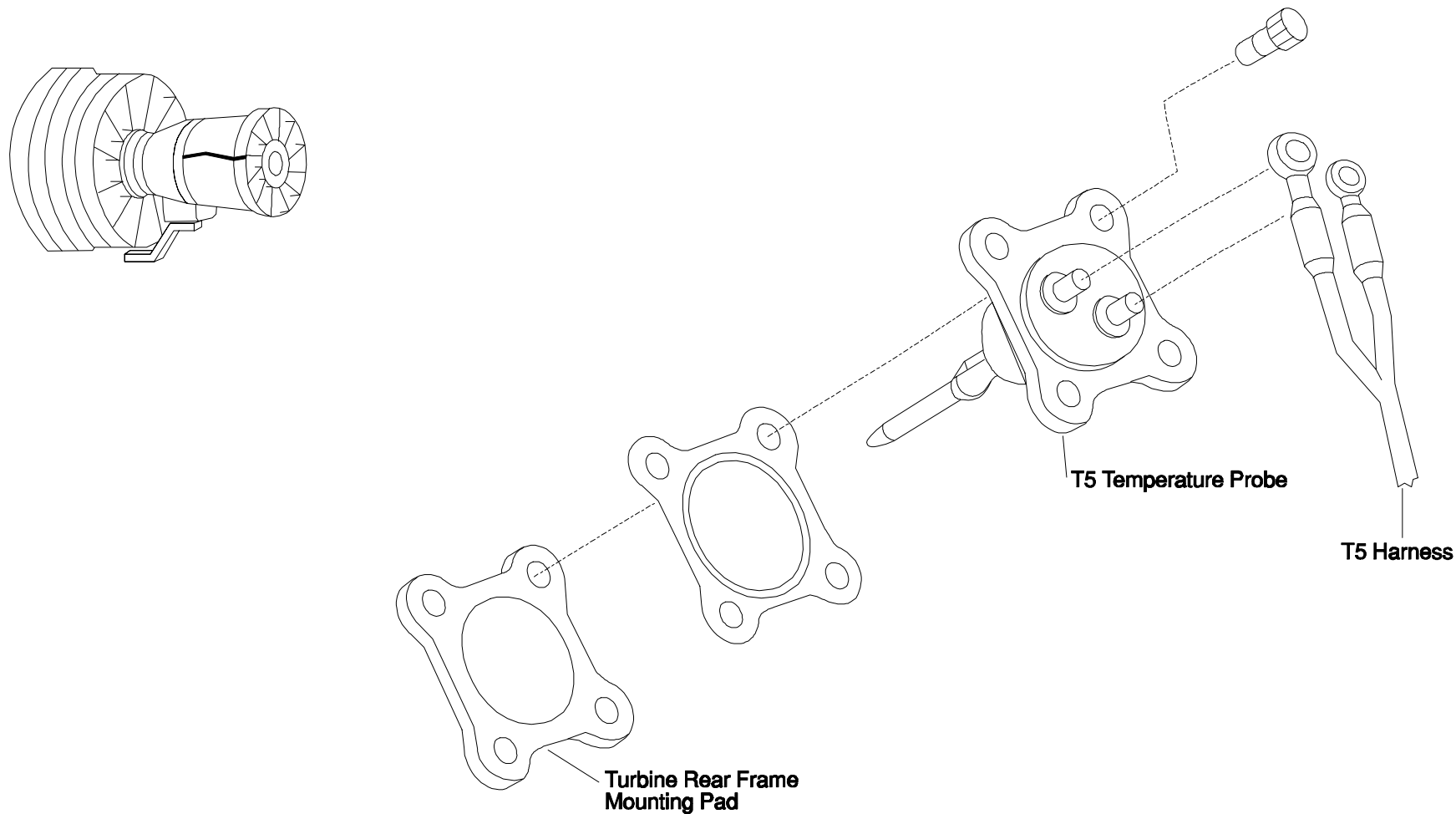
Zone : 213-223

COMPONENT DESCRIPTION

The T5 Harness cable runs from the cable connector bracket to the T5 Probe.

REMOVAL / INSTALLATION

The T5 Harness cable is attached to different brackets by means of clamps. On the LPTACC cooling air tube, do not bend or twist the T5 Harness cable when you remove it.



STUDENT NOTES

FQW4200 GE Metric

THRUST REVERSER PRESENTATION

- Reverse Design
- Pneumatic Supply
- Actuation
- Reverser Control
- Indication
- Maintenance Practice

REVERSE DESIGN

The thrust reverser system is of the aerodynamic blockage type.
It consists of two translating cowls, blocker doors and cascade vanes to redirect fan discharge airflow.
Thrust reverser operation is possible on ground only.

PNEUMATIC SUPPLY

The Center Drive units are pneumatically operated by bleed air from 8th or 14th compressor stages.

ACTUATION

There are two Center Drive Units per engine, one for each translating cowl. Each Center Drive Unit drives three ballscrew actuators, one directly and the two others via mechanically linked gearboxes.

REVERSER CONTROL

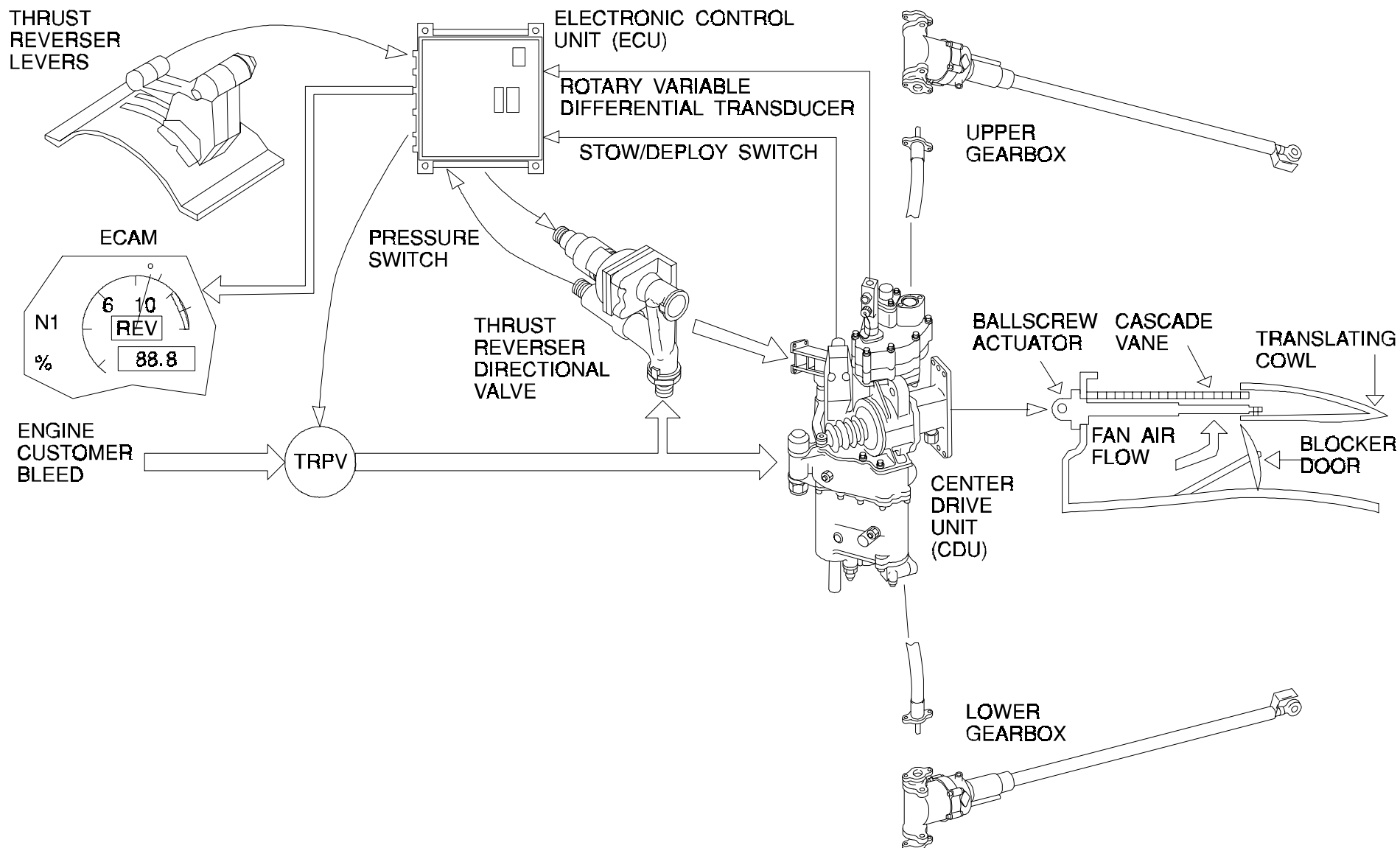
The thrust reverser system is controlled from the two reverser levers through the Electronic Control Unit.
The Thrust Reverser Pressurizing Valve supplies pneumatic pressure to the Center Drive Unit.
The Thrust Reverser Directional Valve selects deploy or stow mode.

INDICATION

The actual state of the thrust reverser system is shown on the engine page of the ECAM, the signal comes from the stow and deploy switches.
Reverse thrust is allowed when reversers are deployed, this interlock is performed through the Rotary Variable Differential Transducers. The Thrust Reverser Pressurizing Valve (TRPV) condition is monitored by the pressure switch.

MAINTENANCE PRACTICE

To help trouble shooting, a reverser test can be performed through the MCDU.
To increase aircraft dispatch, a thrust reverser system can be deactivated and locked in the stow position.



STUDENT NOTES:

FQW4200 GE Metric

THRUST REVERSER D/O

Initial Position
Deploy Sequence
Stow Sequence
Protection
Fault Detection
Maintenance Mode

INITIAL POSITION

The rest position of the system is air available at the Thrust Reverser Pressurizing Valve(TRPV), directional valve spring loaded in the stow position with cone brake engaged and disk brakes engaged. Both Thrust Reverser Pressurizing Valve(TRPV) and Thrust Reverser Directional Valve(TRDV) solenoids are de-energized, the Center Drive Unit(CDU) stow/deploy switches confirm the stow position : "not stow sw" open, "not deploy sw" closed.

DEPLOY SEQUENCE

The reverse thrust levers are pulled into the reverser thrust position. The EIVMU contact will close supplying 28 Volts dc to the TRDV winding. The FCPC controls the supply of the disk brake solenoids to release them. If the following conditions are true : ENG running, TRA < 7.2°, A/C on ground, the ECU closes TRDV and TRPV contactors.

The TRPV solenoid will energize then the TRPV will supply regulated airflow to the system. This air will go directly to the Center Drive Units and to the pressure switch.

The TRDV is energized, allowing the air to pressurize the CDU directional control valve piston. As a result, the directional control valve rotates and the internal cone brake is released, enabling the air motor to operate.

The gear box and CDU ballscrew actuators deploy the transcowls and the RVDT signal to the ECU will indicate transcowl movement.

As soon as either transcowl position increases to 2% of stroke, its stow switch is actuated : REV is displayed in amber on the EWD.

When the CDU actuators approach the deploy position, the CDU feedback rods are engaged forcing the directional control valves to the neutral position. Air motor speed is then reduced prior to impact with the deploy stops.

When the transcowls reach more than 98% deployed, the deploy switch will be actuated. Once both deploy switches have been actuated, the ECU will send the signal which causes the green REVERSE indication on the EWD.

In addition, the ECU opens the TRPV contactor causing the TRPV to close. Increase in power to Max Reverse is progressively available from 70% of stroke to fully deployed position.

STOW SEQUENCE

Reverse thrust levers are pushed completely down to the forward thrust position. The ECU will open the TRDV contactor and close the TRPV contactor and the FCPC maintains the disk brake power supply for 15 seconds.

The TRPV solenoid energizes, then the TRPV supplies regulated airflow to the system. The air goes directly to the CDUs and to the pressure switch. The TRDV is not energized, therefore the directional control valves are not pressurized.

The directional control valves are spring loaded to the stow position, so the thrust reverser will begin to stow.

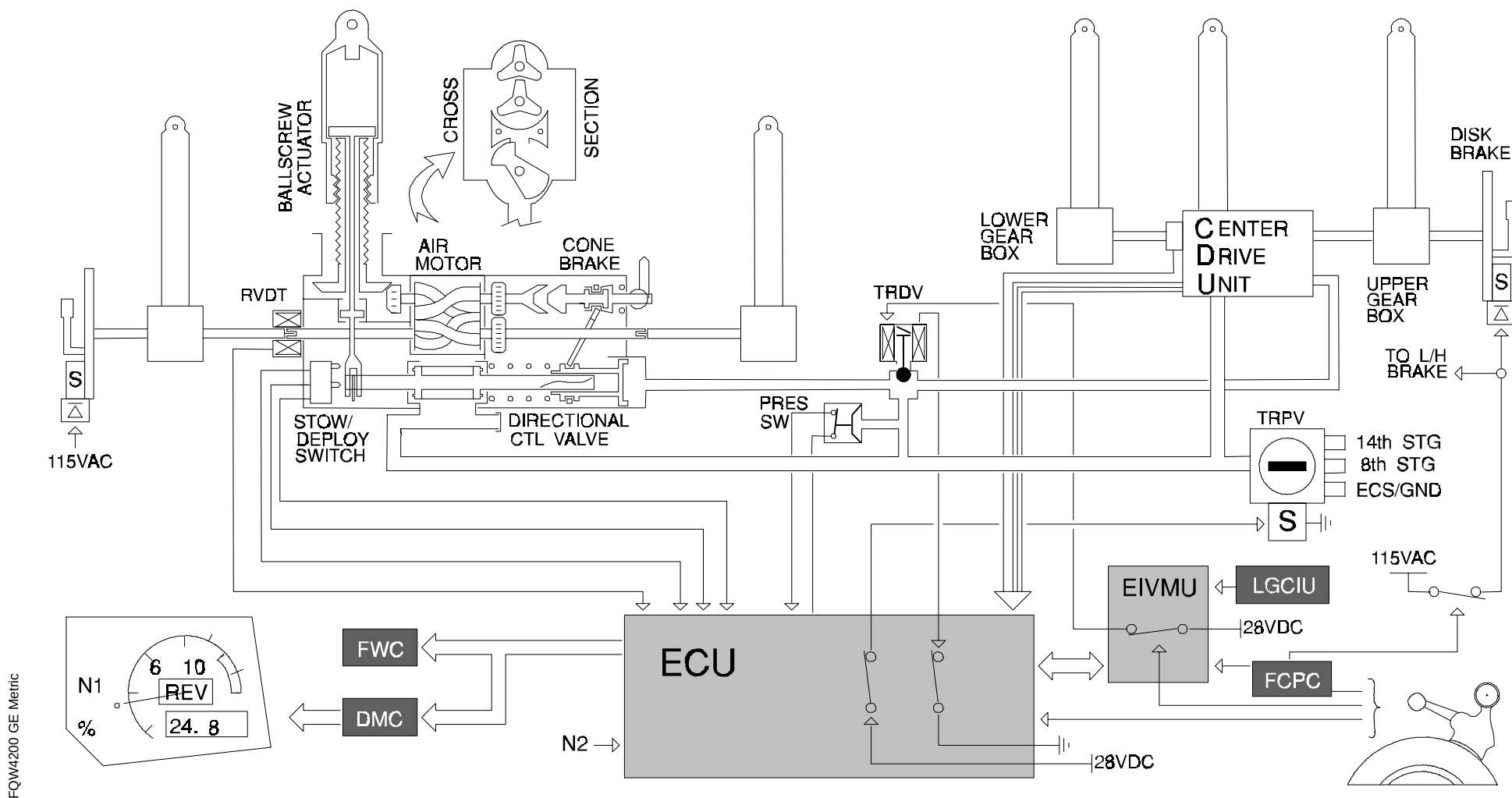
The internal cone brakes are engaged but free spinning in the stow direction. The RVDT signal to the ECU will indicate transcowl movement.

As soon as either transcowl position decreases to less than 98%, its deploy switch will actuate causing amber REVERSE indication on the EWD.

The feedback rods gradually move the directional control valves to the neutral position in order to reduce the motor speed.

When the transcowls reach less than 2% deployed, the stow switch will actuate. Once both stow switches have actuated, the ECU will send the signal which removes the REVERSE indication on the EWD.

In addition the ECU opens the TRPV contactor causing the TRPV to close and the disk brakes are engaged under FCPC control.



PROTECTION

When there is no valid request for deployment and the thrust reverser is determined to be unstowed by more than 15%, the ECU limits the engine speed to the selected idle level.

The system is provided with the 3 following lines of defence against unwanted deploy mode :

- 1 : the CDU unidirectional cone brake,
- 2 : the CDU directional control valve spring loaded in the stow position,
- 3 : the solenoid actuated disk brake controlled by FCPC 1 and 3.

The RVDTs provide continuously the position of the reversers to the ECU. This information is compared with the signals from the stow/deploy switches and is also used to limit thrust during deployment.

FAULT DETECTION

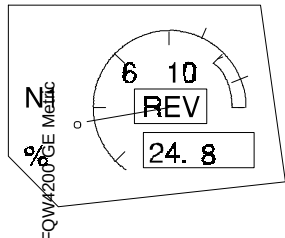
The fault detection is eased by internal built in test equipment. The results are sent via the EIVMU through data bus.

Fault detection consists of monitoring of the stow/deploy switches, RVDTs, pressure switch for TRPV position, TRDV and TRPV contactor control circuit failures, monitoring of A/C 28 VDC power supply and disk brake supply.

MAINTENANCE MODE

The ECU provides a FADEC test mode which allows the thrust reverser to be deployed and stowed when the aircraft is on the ground, engine not running.

On ground for maintenance purposes, it is possible to inhibit the deployment of the reversers by disconnecting the TRDV connector. This action provides two discrete inhibit signals to the ECU(one per channel).



STUDENT NOTES:

FQW4200 GE Metric

WARNINGS (REVERSE AND THRUST CONTROL)

REVERSER FAULT
REV INHIBITED
REV UNLOCKED
REV PRESSURIZED
THR LEVER FAULT
THR LEVER DISAGREE
THRUST LOCKED

REVERSER FAULT

This happens when :

- The thrust reverser is inoperative due to a TRDV or TRPV relay failure in open position on the active channel.
- Or when there is a thrust reverser level 1 fault (RVDTs and switches disagreement for example).
- Or the aircraft 28 VDC power for TRDV is available and no request for deploy has been received.

TRDV : Thrust Reverser Directional Valve

TRPV : Thrust Reverser Pressurizing Valve.

REV INHIBITED

This appears when the reverser is blocked in the stowed position by maintenance action.

REV UNLOCKED

This happens if one of the reversers is unstowed or all reverser halves are fully deployed without being commanded. Note that in this case the thrust is automatically controlled to idle.

REV PRESSURIZED

This happens when the thrust reverser system is pressurized without deployment order. Note that in this case the thrust is automatically controlled to idle.

THR LEVER FAULT

This happens when both TRAs on the local and the cross channels have been declared faulty by the ECU.

Depending on the last valid TRA, the default TRA corresponding to the available power can be IDLE, MCT or T/O.

If the available power is MCT or T/O the thrust can be controlled by the autothrust system provided it is available.

TRA : Throttle Resolver Angle.

ECU : Electronic Control Unit.

THR LEVER DISAGREE

This appears when there is a TRA disagree failure detected between the two valid channel TRA inputs to the ECU.

Depending on the default TRA, the maximum available power can be : IDLE or MCT.

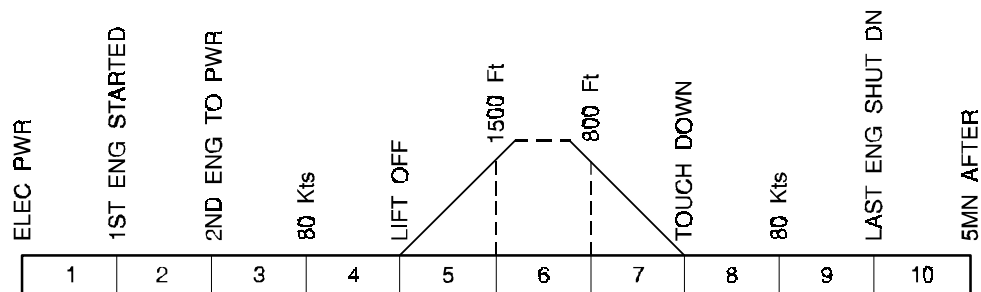
If the available power is MCT, the thrust can be controlled by the autothrust system if available.

TRA : Throttle Resolver Angle.

ECU : Electronic Control Unit.

THRUST LOCKED

This appears when the autothrust system disengages and the ECU is in memory thrust mode. This means that the ECU locks the thrust (N1 actual) at the level it had at the time of the autothrust mode deactivation. A manual action on the thrust levers gives a new N1 target to the ECU in manual mode.



E/WD : FAILURE TITLE	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLT PHASE INHIB
REVERSER FAULT	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 5
REV INHIBITED	NIL	NIL	NIL	NIL	3, 4, 5 6, 7, 8
REV UNLOCKED	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 5, 8, 9
REV PRESSURIZED	SINGLE CHIME	MASTER CAUT	NIL	NIL	1, 8, 9, 10
THR LEVER FAULT	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 5, 8
THR LEVER DISAGREE	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 5, 8
THRUST LOCKED	SINGLE CHIME	MASTER CAUT	NIL	NIL	2, 3, 4 8, 9

STUDENT NOTES

FQW4200 GE Metric

THRUST REVERSER COMPONENTS

Center Drive Unit (CDU)
Stow/deploy Switch
Rotary Variable Differential Transducer (RVDT)
Angle Gearbox And Ball Screw Actuator
Thrust Reverser Pressurizing Valve
Thrust Reverser Directional Valve And Pressure Switch
Flexible Shaft
Thrust Reverser Junction Box
Thrust Reverser Brake

SAFETY PRECAUTIONS

- Do not start the engine.
- Make sure that the engine has been shut down for at least 5 minutes.
- Make sure that the ENG FADEC GND PWR pushbutton is OFF.
- Make sure that the master lever is in the OFF position.

STUDENT NOTES

CENTER DRIVE UNIT

FIN/ZONE

FIN: 5048EG1, 5048EG2

Zone: 417 - 418, 427 - 428

COMPONENT DESCRIPTION

The Center Drive Unit is bolted to the thrust reverser support structure at the horizontal centerline, and attached to the transcowl with a single retaining pin. The CDU is equipped with a manual brake release for maintenance purposes.

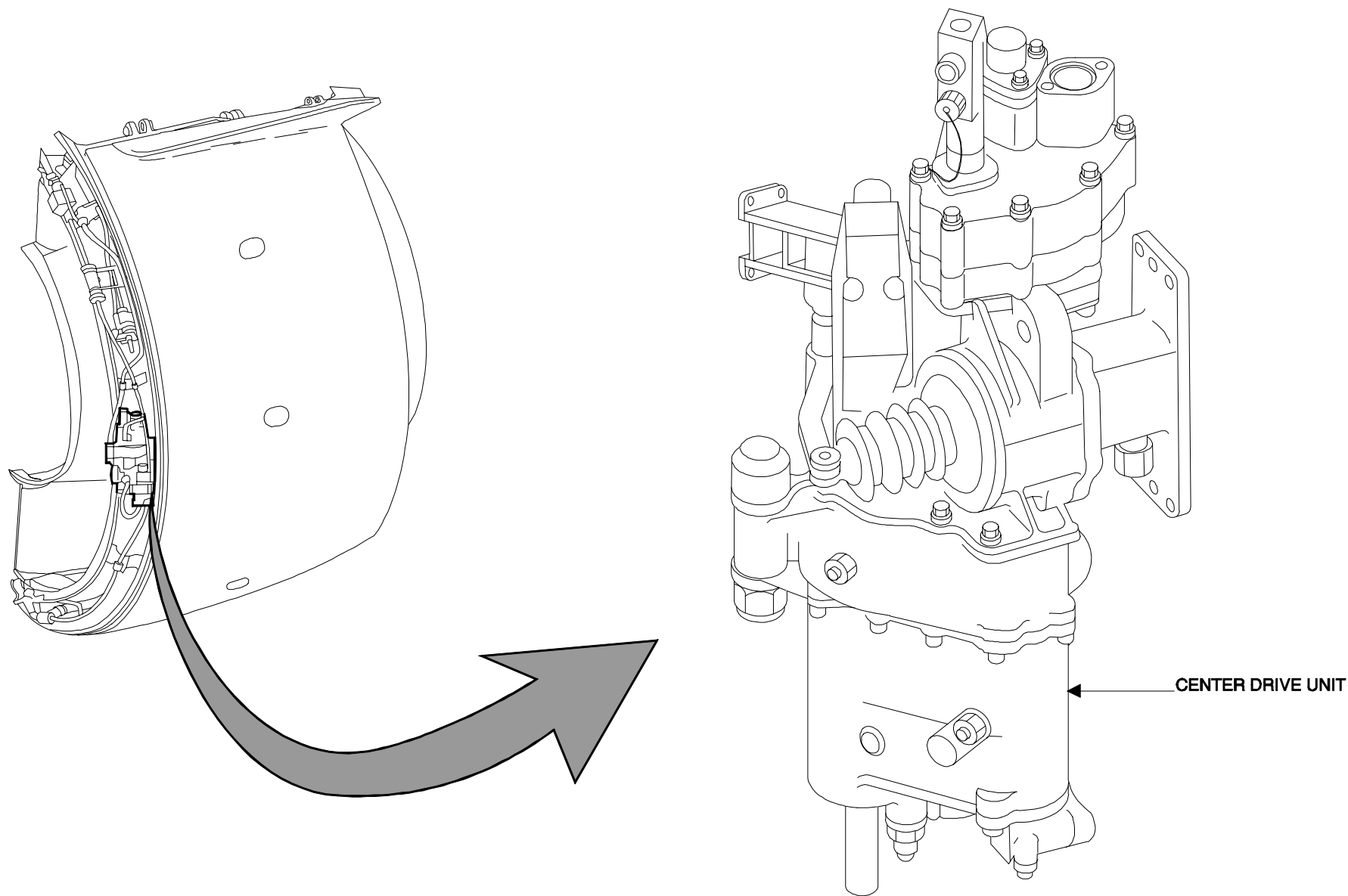
SAFETY PRECAUTIONS

CAUTION: Do not let the upper flexible drive shaft move out of the outer case. Be careful with the flexible drive shafts to prevent damage to the flexible drive shafts.

CAUTION: Do not remove the clevis pin retaining clip bolt.

Loosen the bolt until the retaining clip can rotate.

Removal of the bolt will damage the nutplate.



FQW4200 GE Metric

STOW/DEPLOY SWITCH

FIN/ZONE

FIN: 4104KS1, 4104KS2

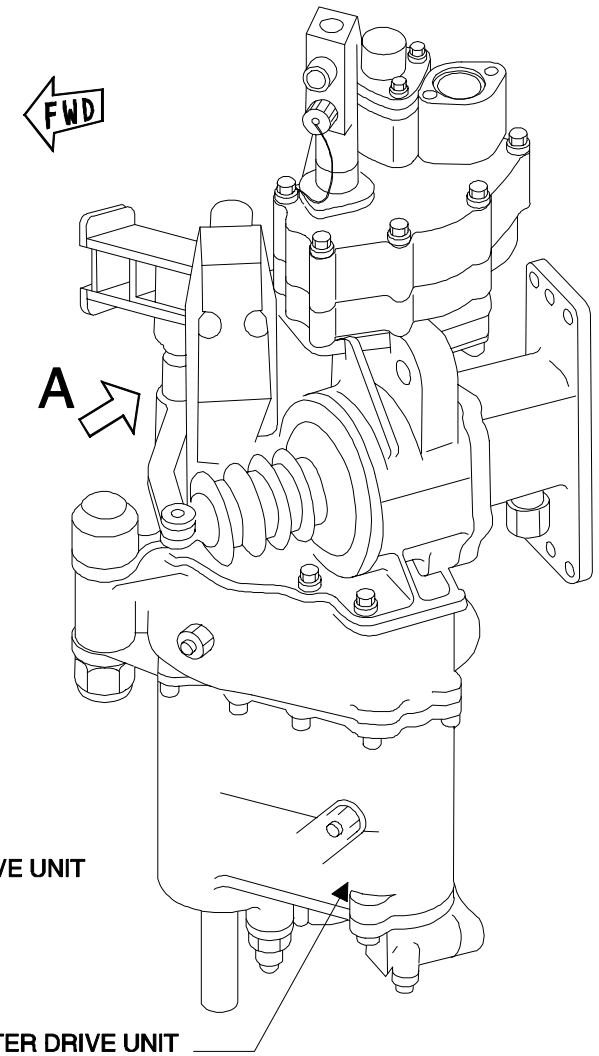
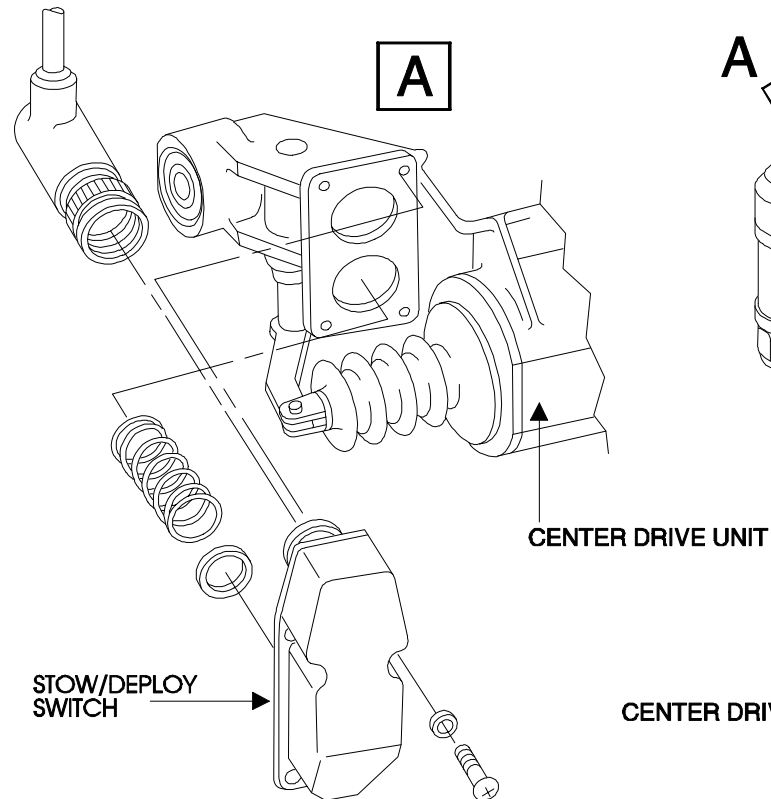
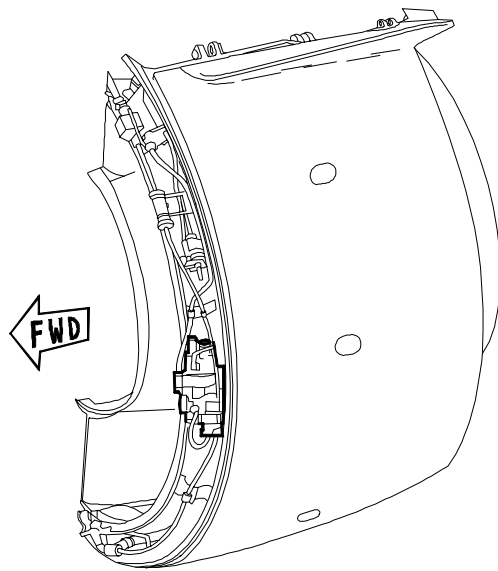
Zone: 417 - 418, 427 - 428

COMPONENT DESCRIPTION

The stow/deploy switch is used to provide end of travel information to the ECU. The stow switch contacts will go from open to closed when the transcowl position is < 2% deployed. The deploy switch contacts will go from "not deployed" to "deployed" when the transcowl position is > 98% deployed. The stow/deploy switch module is replaceable separately from the CDU, and does not require rigging.

SAFETY PRECAUTIONS

WARNING: Make sure you deactivate the thrust reverser half for ground maintenance. Failure to deactivate the thrust reverser could cause accidental operation and injury to personnel and/or damage to aircraft/equipment.



ROTARY VARIABLE DIFFERENTIAL TRANSDUCER (RVDT)

FIN/ZONE

FIN: 4003KS, 4004KS

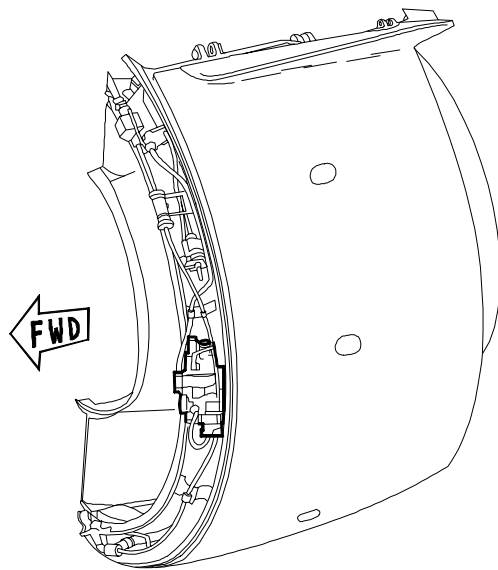
Zone: 417 - 418, 427 - 428

COMPONENT DESCRIPTION

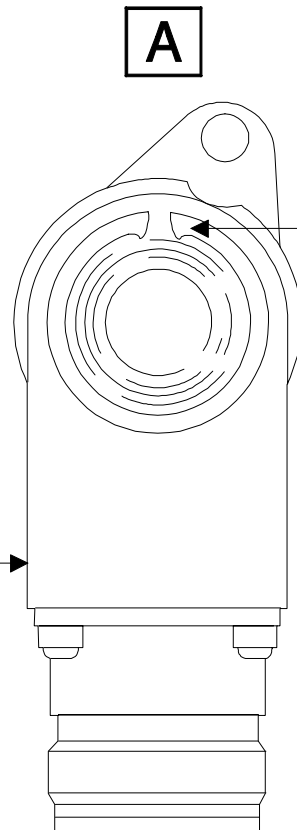
The Rotary Variable Differential Transducer (RVDT) is an electronic position feedback sensor that is used by the ECU to monitor transcowl position at all times. The RVDT is equipped with a sight glass that is used for rigging the RVDT to the CDU. The RVDTs may be changed separately from the CDU, but must be rigged prior to installation.

SAFETY PRECAUTIONS

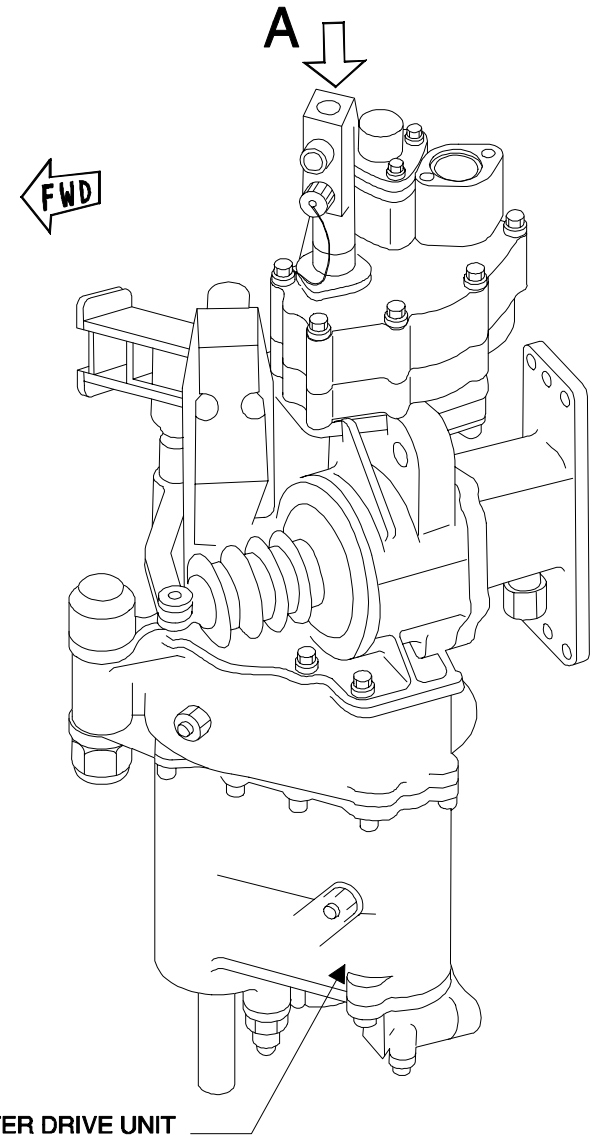
WARNING: Make sure you deactivate the thrust reverser half for ground maintenance. Failure to deactivate the thrust reverser could cause accidental operation and injury to personnel and/or damage to aircraft/equipment.



R V D T



SIGHT
GLASS



CENTER DRIVE UNIT

ANGLE GEARBOX AND BALL SCREW ACTUATOR

FIN/ZONE

FIN: 5044EG1, 5044EG2, 5044EG3, 5044EG4

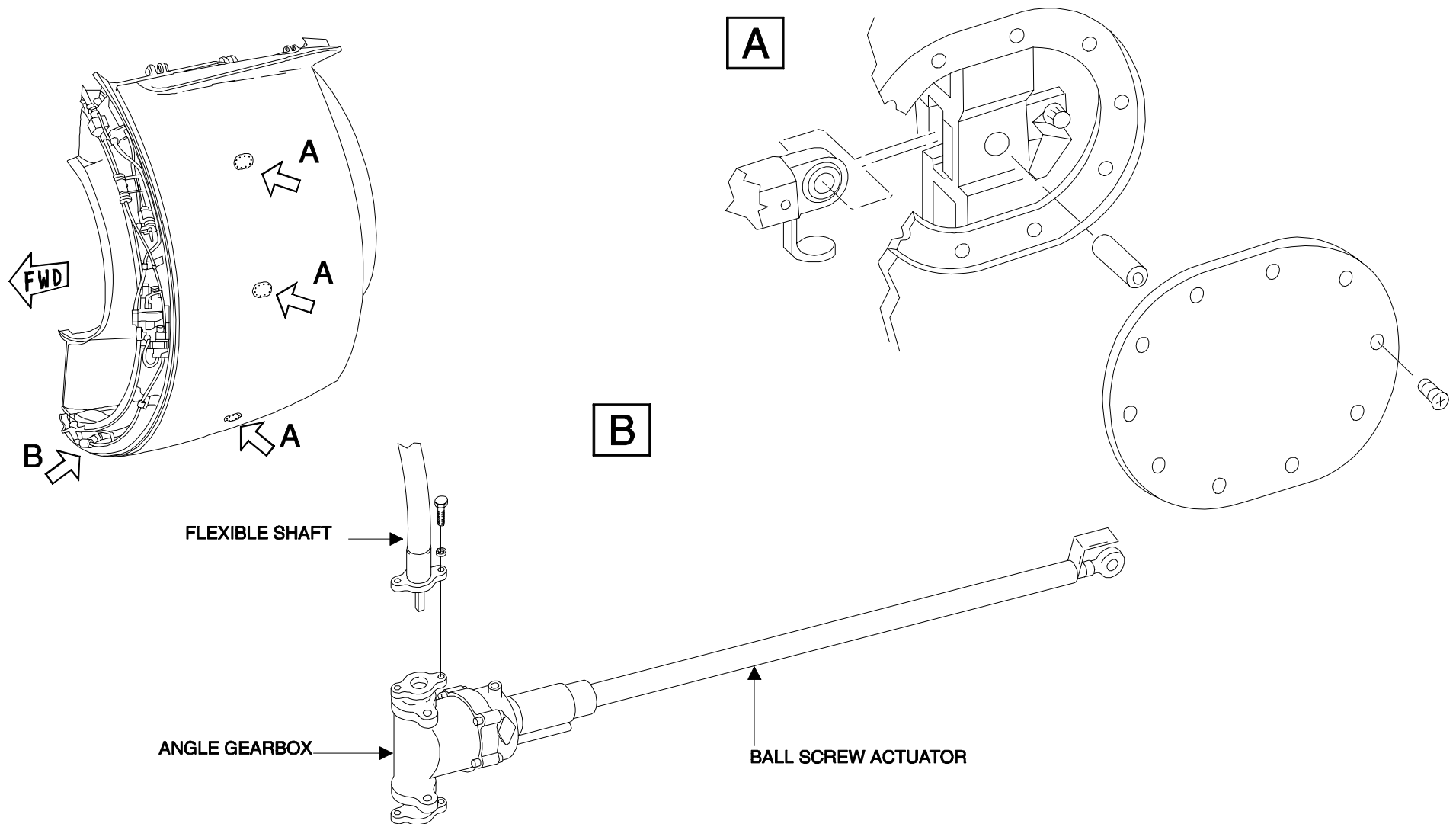
Zone: 417 - 418, 427 - 428

COMPONENT DESCRIPTION

The 2 angle gearbox and ballscrew actuators are driven by the CDU through the flexible shafts to move the transcowl. Each angle gearbox is attached to the thrust reverser support structure by a gimbal mount. The ballscrew actuator adjustable rod end is pinned to the transcowl clevis.

SAFETY PRECAUTIONS

WARNING: Make sure you deactivate the thrust reverser half for ground maintenance. Failure to deactivate the thrust reverser could cause accidental operation and injury to personnel and/or damage to aircraft/equipment.



FQW4200 GE Metric

THRUST REVERSER PRESSURIZING VALVE

FIN/ZONE

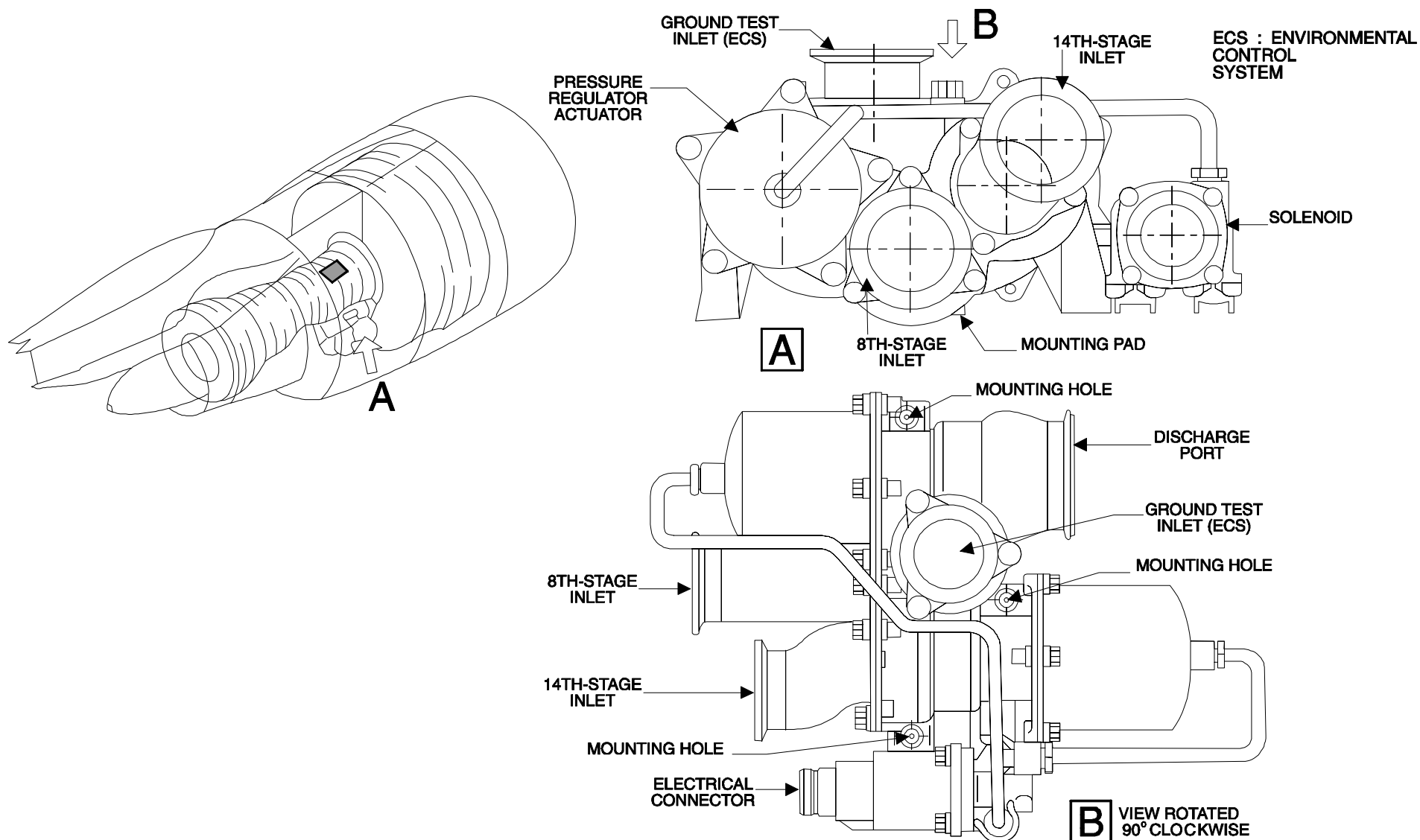
FIN: 4113KS

Zone: 413 - 423

COMPONENT DESCRIPTION

The thrust reverser pressurizing valve is connected to three separate air sources and will automatically switch between them to ensure consistent air output pressure. The three input sources are:

- 14th stage air (directly from 14th stage manifold)
- 8th/14th stage (from intersect duct)
- Environmental Control System (ECS) air (from APU, another engine or ground source).



THRUST REVERSER DIRECTIONAL VALVE AND PRESSURE SWITCH

FIN/ZONE

FIN: 4112KS

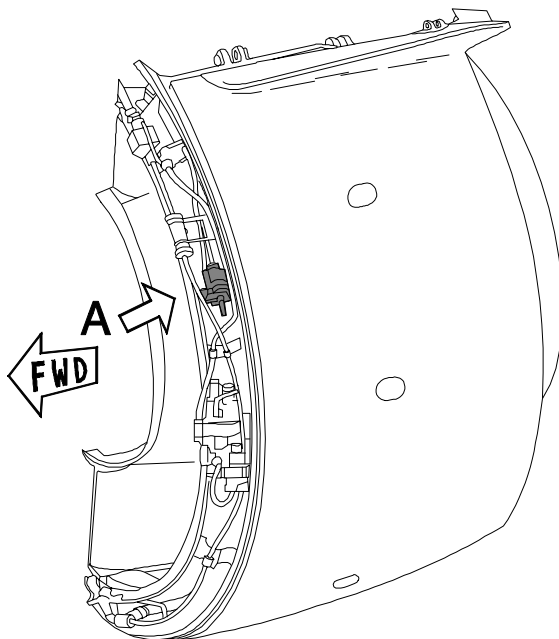
Zone: 413 - 423

COMPONENT DESCRIPTION

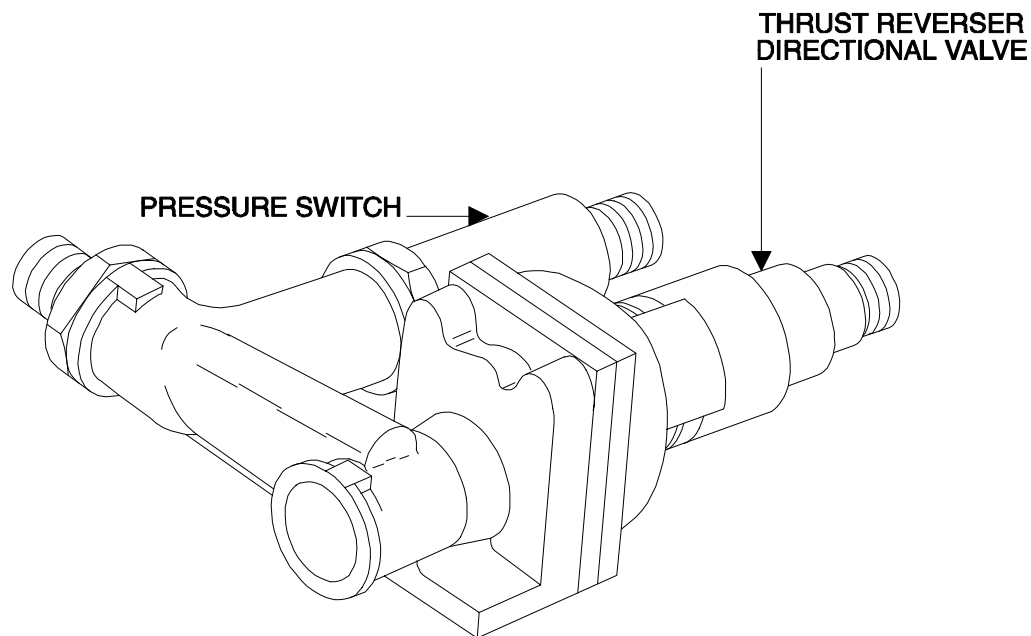
The thrust reverser directional valve is mounted onto the structure and the pressure switch screws into the directional valve body. Each component has an individual electrical connector. The directional valve is a solenoid operated valve that changes the ECU electrical signal into a muscle air signal. The directional valve muscle air is sent to both CDUs when the ECU commands a thrust reverser deploy sequence.

SAFETY PRECAUTIONS

WARNING: Make sure you deactivate the thrust reverser half for ground maintenance. Failure to deactivate the thrust reverser could cause accidental operation and injury to personnel and/or damage to aircraft/equipment.



A



FQW4200 GE Metric

FLEXIBLE SHAFT

FIN/ZONE

FIN: 5043EG1, 5043EG2, 5043EG3, 5043EG4

Zone: 417 - 418, 427 - 428

COMPONENT DESCRIPTION

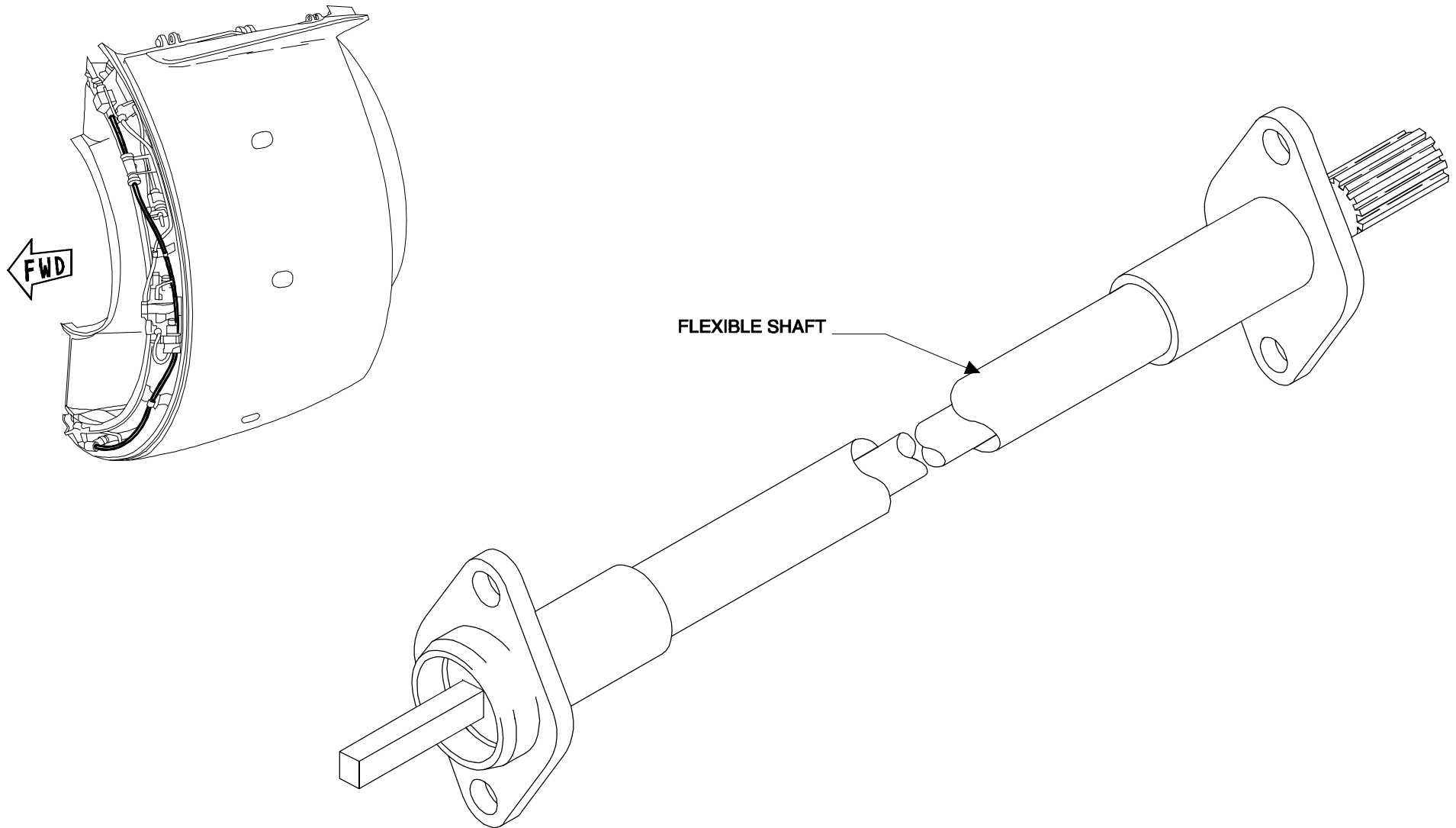
The thrust reverser flexible shafts are used to transmit mechanical force from the CDU to the upper and lower angle gearbox/ballscrew actuator assemblies. Each flexible shaft is splined at the CDU end and has a square drive at the ballscrew actuator end.

REMOVAL/INSTALLATION

CAUTION: replace both flexible shafts if one flexible shaft is damaged on a thrust reverser half because of too much torque.

SAFETY PRECAUTIONS

WARNING: Make sure you deactivate the thrust reverser half for ground maintenance. Failure to deactivate the thrust reverser could cause accidental operation and injury to personnel and/or damage to aircraft/equipment.



FQW4200 GE Metric

THRUST REVERSER JUNCTION BOX

FIN/ZONE

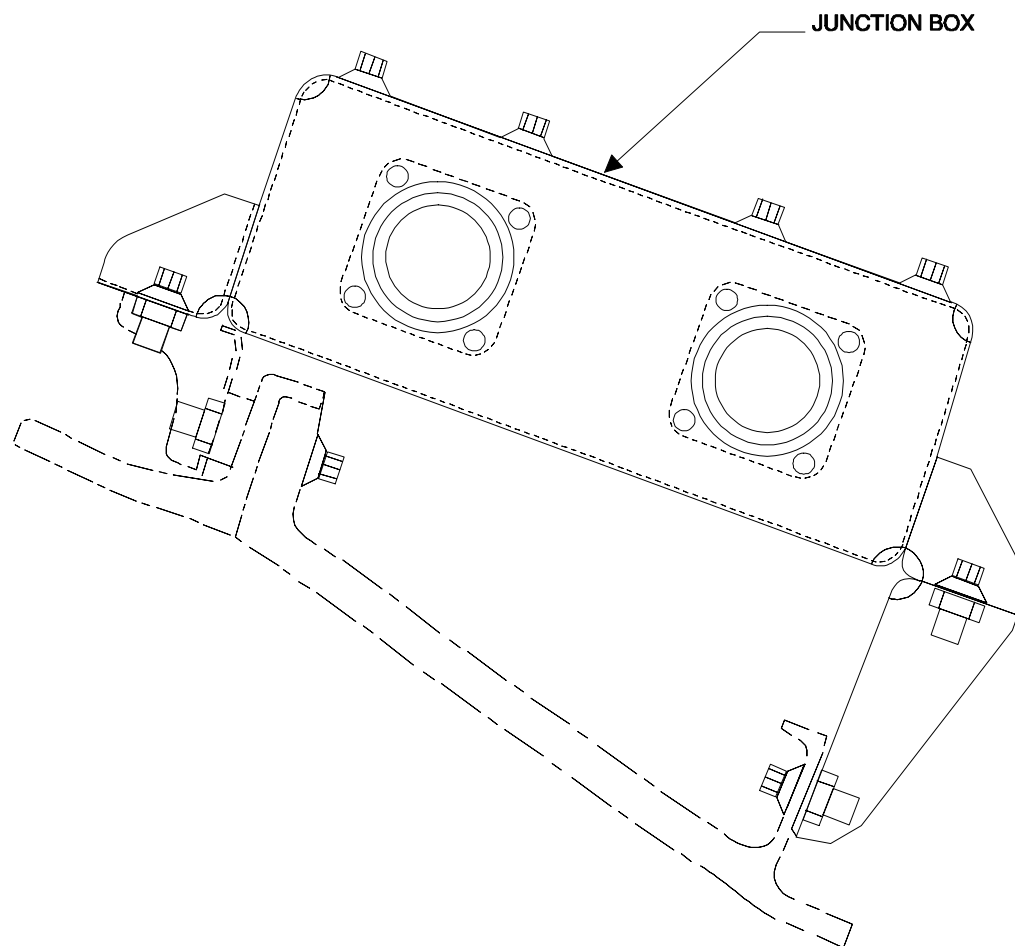
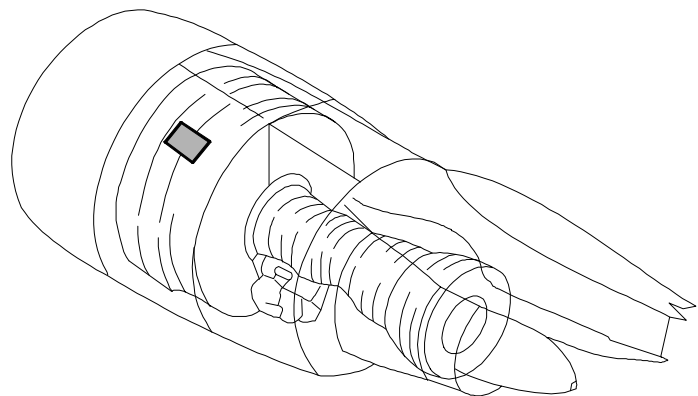
FIN: 4110KS

Zone: 413 - 423

COMPONENT DESCRIPTION

The thrust reverser junction box is located at the 10:00 position of the aft fan case. It allows either channel of the ECU to control and receive feedback from the thrust reverser components. The following signals are split within the box:

- Pressure switch (input to the ECU)
- TRDV output signal (from ECU)
- TRPV output signal (from ECU).



FQW4200 GE Metric

THRUST REVERSER BRAKE

FIN/ZONE

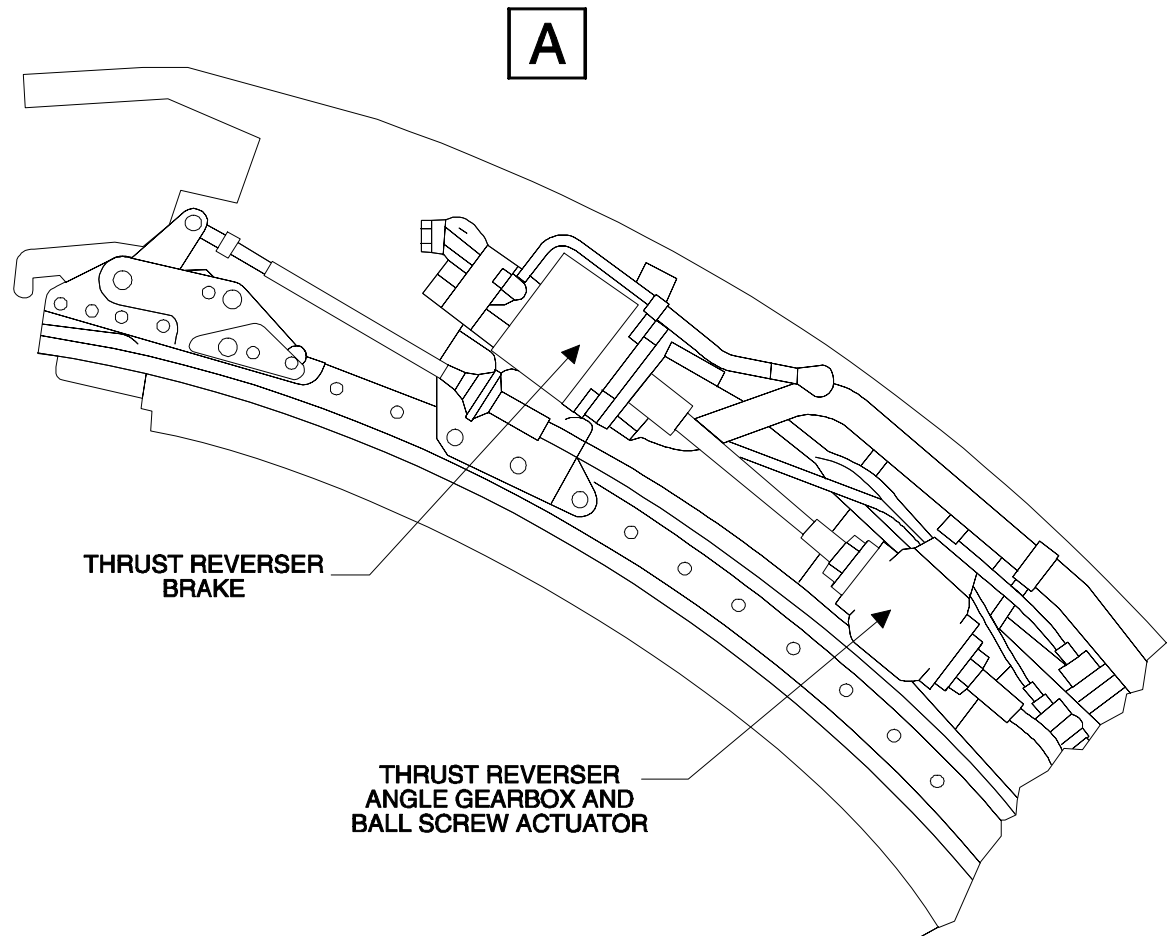
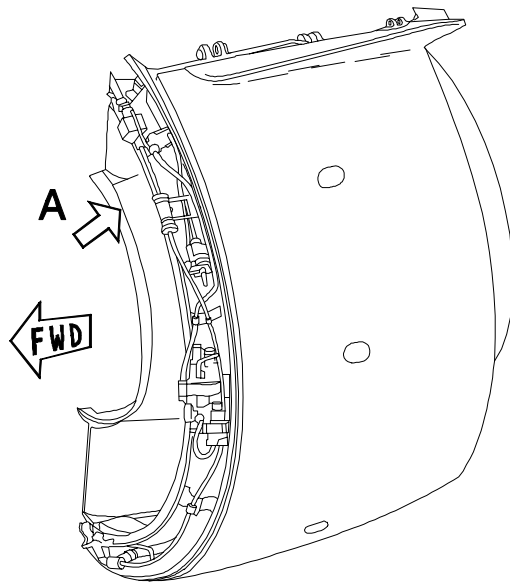
FIN: 4010EG1 - 4110EG2

Zone: 417 - 418, 427 - 428

COMPONENT DESCRIPTION

The thrust reverser brake is mounted onto the thrust reverser support structure just above the upper angle gearbox/ballscrew actuator on each thrust reverser half.

It is connected to the upper angle gearbox by a short flexible shaft. The thrust reverser brake is used to lock the thrust reverser in the stowed position. It is a solenoid actuated disk type, brake assembly. The thrust reverser is equipped with a manual brake release handle for maintenance purposes.



FQW4200 GE Metric

STUDENT NOTES

FQW4200 GE Metric

OIL SYSTEM PRESENTATION

- General
- Oil Storage
- Lube Element
- Bearings & Gears
- Oil Scavenge
- Master Chip Detector
- Fuel / Oil Heater Exchanger
- Scavenge Filter
- Indicating
- Monitoring

GENERAL

The self contained oil system lubricates, cleans and cools the engine bearings and gears.

OIL STORAGE

The oil tank provides oil storage. The tank is of the pressurized type and is provided with ports for servicing and indication.

LUBE ELEMENT

The oil is pressurized by a single lube element and then supplied to the bearings.

BEARINGS & GEARS

Lube oil is supplied to bearings and gears through supply nozzles and is monitored by a low oil pressure switch and two oil pressure transducers. The engine bearings are mounted in pressurized sumps.

OIL SCAVENGE

Separate scavenge pump elements remove all the oil from each engine cavity and return the oil to the tank.

MASTER CHIP DETECTOR

Mounted on the scavenge line, is a chip detector to monitor engine deterioration.

Note that all the oil pump inlets are equipped with debris screens and optional chip detectors.

FUEL / OIL HEATER EXCHANGER

The fuel/oil heat exchanger transfers heat from the scavenge oil to the fuel. This is done to cool the engine oil and prevent fuel icing.

SCAVENGE FILTER

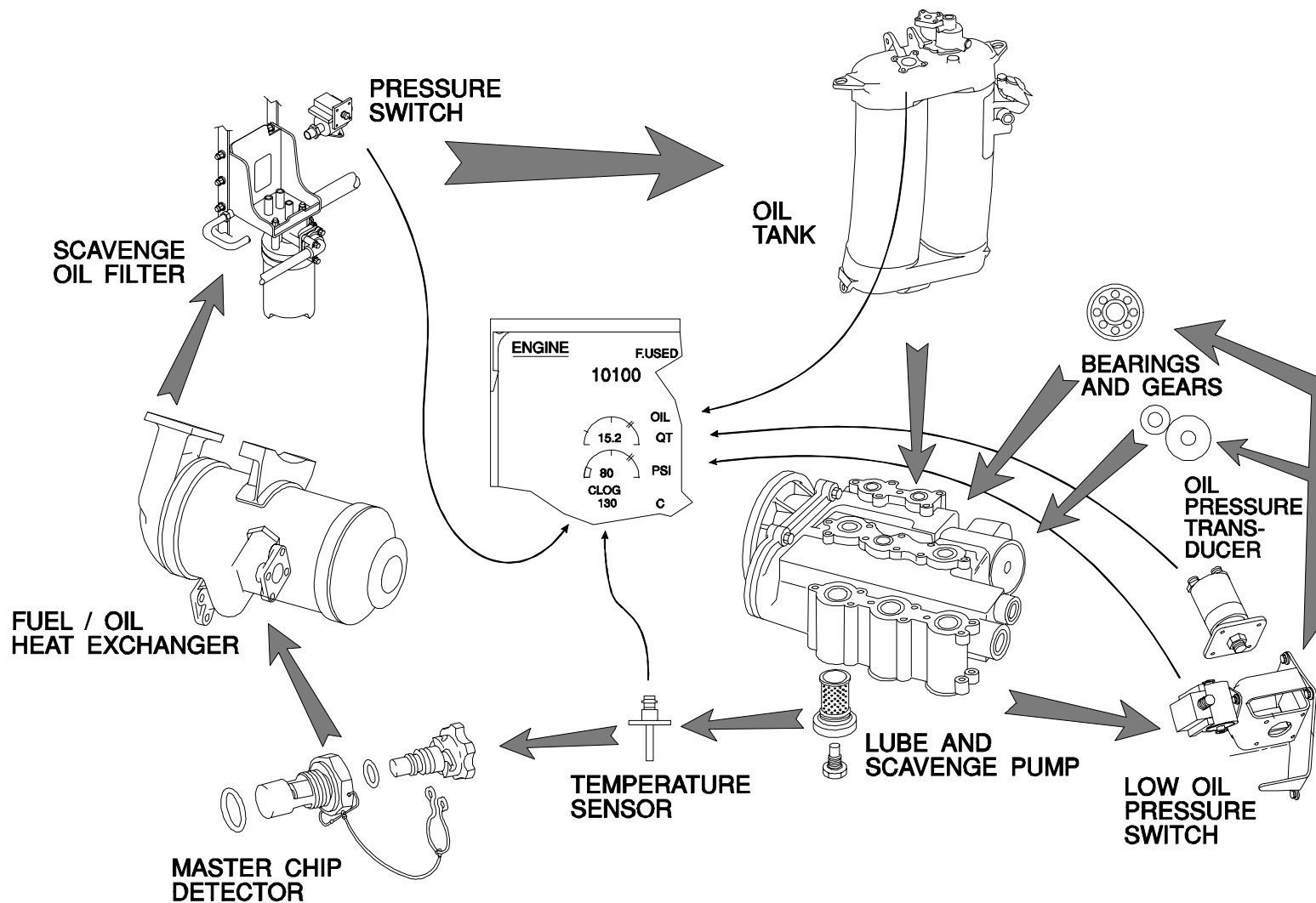
Scavenge oil has a dedicated filter which is the primary filter for the oil system.

INDICATING

The following indications are available on the ENGINE ECAM page : oil quantity, oil pressure and oil temperature.

MONITORING

Proper operation of the oil system is monitored by a low oil pressure warning, a scavenge filter clogging indication and a high oil temperature warning.



FQW4200 GE Metric

STUDENT NOTES:

FQW4200 GE Metric

OIL SYSTEM DESCRIPTION OPERATION

- General
- Oil Tank
- Lube Element
- Oil Pressure Transmitter
- Low Oil Pressure Switch
- Bearings and Gears
- Scavenge Pumps
- Oil Temperature Sensor
- Master Chip Detector
- Oil Cooling
- Scavenge Oil Filter
- Differential Pressure Switch
- Oil Vent

GENERAL

The engine oil system includes :

- a supply circuit,
- a scavenge circuit,
- a vent circuit.

It lubricates the bearings in the A,B,C and D sumps.
It also lubricates bearings and gears in the gearboxes.

OIL TANK

The oil tank is slightly pressurized (approximately 10 PSi) to ease the oil flow to the lube and scavenge pump.

The oil level is provided by a magnetic float type oil level sensor which has two separate sensing circuits, one for each channel.

LUBE ELEMENT

The lube and scavenge pump is shaft driven by the accessory gearbox and will provide oil flow any time the core engine is turning.

Before exiting the pump the oil passes through a static leak check valve whose purpose is to prevent oil leakage from the oil tank to the gearboxes after engine shutdown.

OIL PRESSURE TRANSMITTER

Upstream of the static leak check valve, a tap is provided to sense the lube system pressure.

The signal is transmitted from two piezoresistive transducers, one for each channel, referenced to the sump vent internal pressure.

LOW OIL PRESSURE SWITCH

The low oil pressure switch is a normally closed switch.

At engine start up, when oil pressure is low, the switch will send a signal to the EIVMU and to the Flight Warning Computers (FWCs) for low pressure indicating.

When oil pressure reaches 14 PSi, the switch opens and the signal is no longer applied.

BEARINGS AND GEARS

Oil is sprayed out to the bearings and gears by means of nozzles.

A small amount of pressurized oil is sent to the pump spline for lubrication.

SCAVENGE PUMPS

The oil from the sumps, transfer and accessory gearboxes is sucked by 5 scavenge pumps.

Each pump inlet is equipped with debris screens and optional chip detectors.

The C sump scavenge pump is kept wet with oil flow tapped after the static leak check valve to maintain pumping capability.

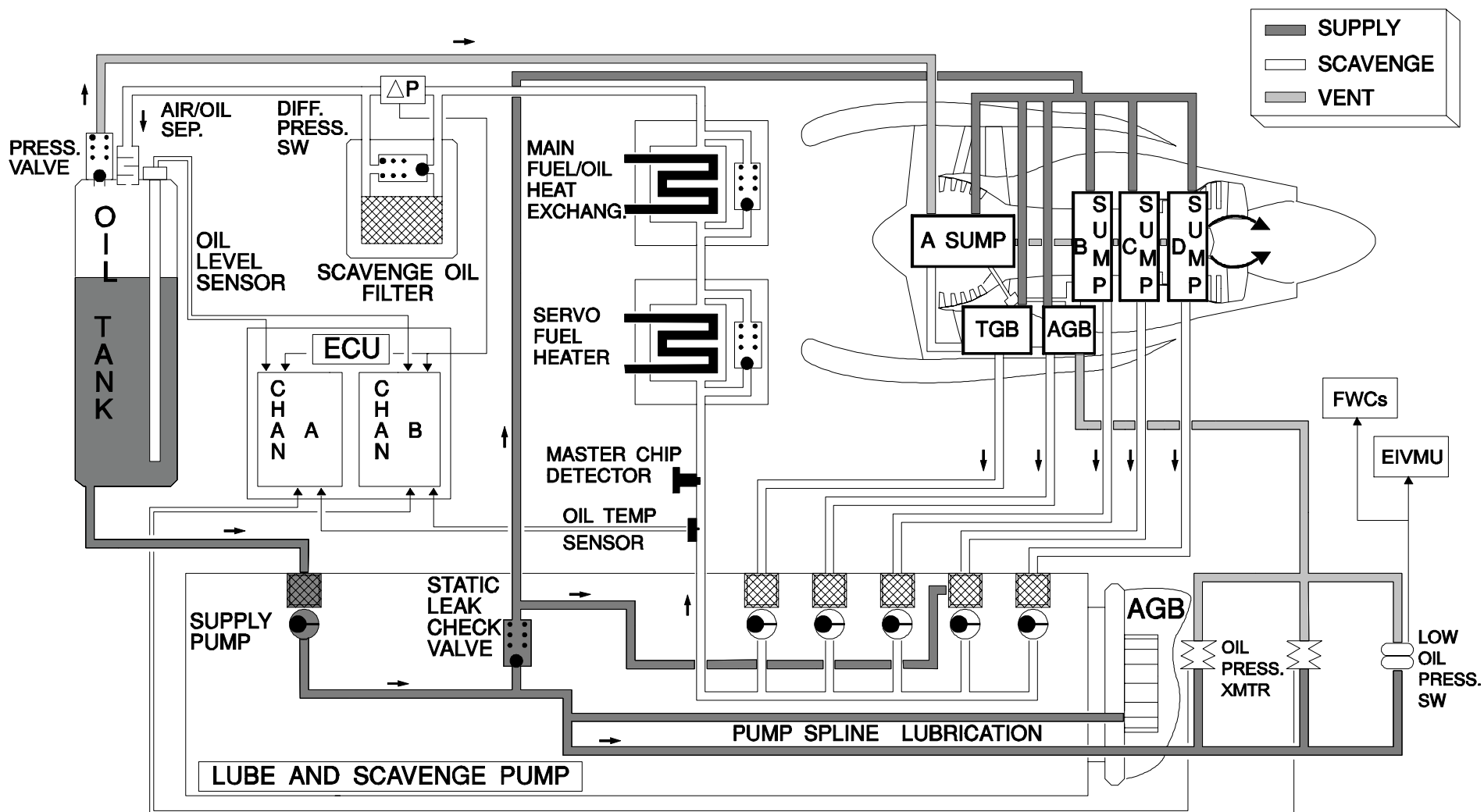
OIL TEMPERATURE SENSOR

The oil temperature sensor is a dual thermocouple type device.

It has two separate sensing elements, one for each channel.

MASTER CHIP DETECTOR

The oil passes through the master chip detector which is accessible through the left thrust reverser inner cowl hatch.



FQW4200 GE Metric

OIL COOLING

Oil is cooled down when it passes through the servo fuel heater and the main fuel oil heat exchanger.

Both of them have an internal bypass valve for cold weather conditions or if an exchanger becomes clogged.

SCAVENGE OIL FILTER

The scavenge oil filter is used to remove contaminants from the engine oil before returning to the oil tank.

It has a removable filter bowl and a disposable filter element.
The scavenge oil filter is equipped with a bypass valve which opens in case of clogging.

DIFFERENTIAL PRESSURE SWITCH

When the filter is clogged, the scavenge oil filter differential pressure switch closes at approximately 30 PSi, sending a signal to each channel.

The scavenge oil finally returns on the top of the oil tank.

OIL VENT

The air mixed with the scavenge oil is separated in the tank by a air/oil separator. Part of the air pressurizes the tank, the remaining is vented to A sump.

The sumps are connected together by the center vent tube, which vents them to the outside air.

WARNINGS (OIL)

OIL LO TEMP
OIL HI TEMP
OIL LOW PRESS
OIL FILTER CLOG

OIL LO TEMP

This happens when the aircraft is on ground, the engine oil temperature is less than -10 °C (14 °F) and N2 is greater than 6000 rpm (61% N2).

OIL HI TEMP

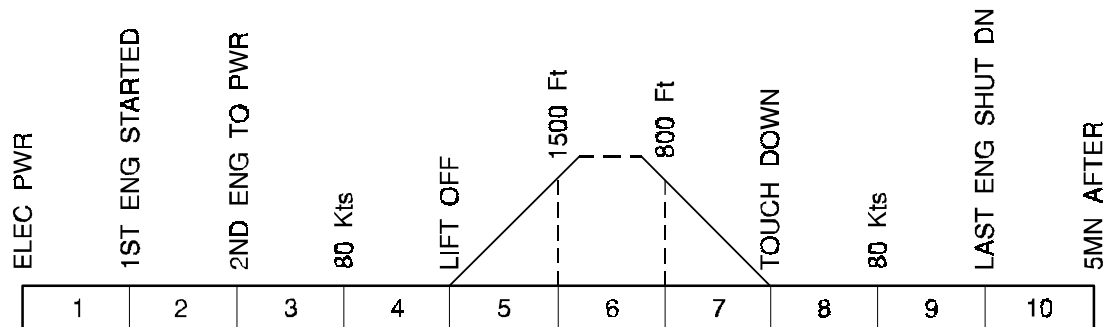
This happens when the engine oil temperature exceeds 160 °C (320 °F) for more than 15 minutes or, it exceeds 175 °C (347 °F) at any time.
The corrective action is to shut down the engine.

OIL LO PRESS

This happens when the engine is running at N2 above minimum idle, and the oil pressure drops below 10 psi with a 30s time delay.
The corrective action is to shut down the engine.

OIL FILTER CLOG

This happens when the engine is running and the oil filter differential pressure is near the bypass condition. When the differential pressure reaches 29 psi the switch closes. Note that the filter bypass will open only when the differential pressure reaches 40 psi.



E/WD : FAILURE TITLE	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLT PHASE INHIB
OIL LO TEMP	SINGLE CHIME	MASTER CAUT	ENG	NIL	3, 4 5, 6, 7 8, 9
OIL HI TEMP	SINGLE CHIME	MASTER CAUT	ENG	NIL	4, 5, 7, 8
OIL LO PRESS	CONTINUOUS REPETITIVE CHIME	MASTER WARN	ENG	NIL	1, 10
OIL FILTER CLOG	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 5 7, 8

STUDENT NOTES

OIL SYSTEM COMPONENTS

Safety precautions
Oil tank

SAFETY PRECAUTIONS

Wait at least 5 minutes after engine shut down before removing the oil cap to allow tank pressure to bleed off.

Hot oil gushing from tank could cause severe burns.

STUDENT NOTES

FQW4200 GE Metric

OIL TANK

FIN/ZONE

FIN : 5000 EN
ZONE : 410/420

DESCRIPTION

The oil tank stores 24.6 liters of oil supplied to the pump to lubricate and cool the bearings and gears.

LOCATION

The oil tank is installed at 3 o'clock position on the fan case and supported by 3 isolation mounts.

SERVICING

Put the access platform in position. Open the oil tank access door. For servicing, the tank is fitted with a floating ball sight, a gravity fill cap, a scupper drain port, pressure fill/overflow ports.

LEVEL CHECK

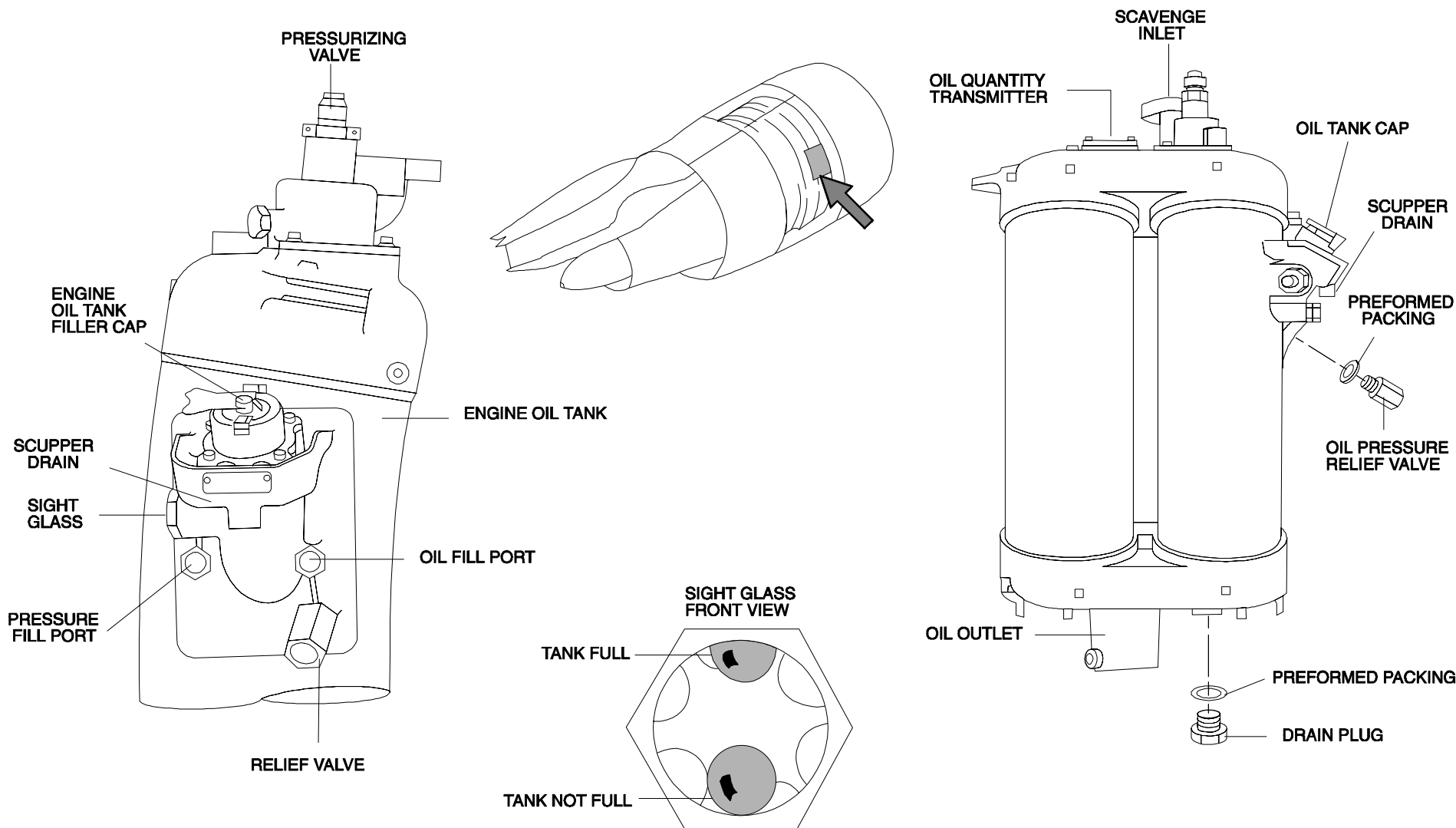
To check the oil level with accuracy, perform servicing within 30 minutes after engine shut down. Otherwise, too much oil will be drained into the pump, causing the tank level to drop. The high level is reached when the ball is at the top of the glass.

MANUAL FILLING

- Remove the oil tank filler cap
- Add oil slowly until the oil runs out of the neck of the tank.
- Install the filler cap and check for looseness and positive locking.

PRESSURE FILLING

- Connect the engine oil servicing cart lines to both the pressure fill port and overflow port on the tank by removing the port caps and attaching quick disconnect line fittings.
- Fill the tank until oil runs out of the overflow port.
- Disconnect the engine oil servicing cart lines, being careful to replace and secure the port caps.



FQW4200 GE Metric

STUDENT NOTES

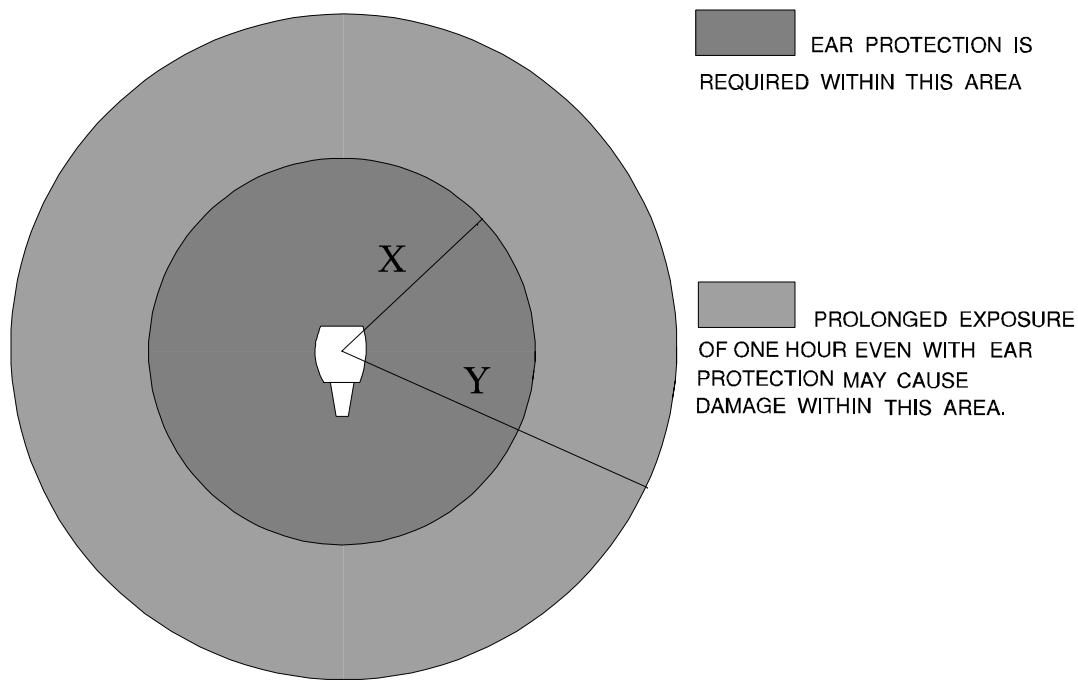
FQW4200 GE Metric

SAFETY ZONES

Noise Danger Areas
Engine Danger Areas, Minimum Idle
Engine Danger Areas, Take-off Thrust

NOISE DANGER AREAS

FQW4200 GE Metric



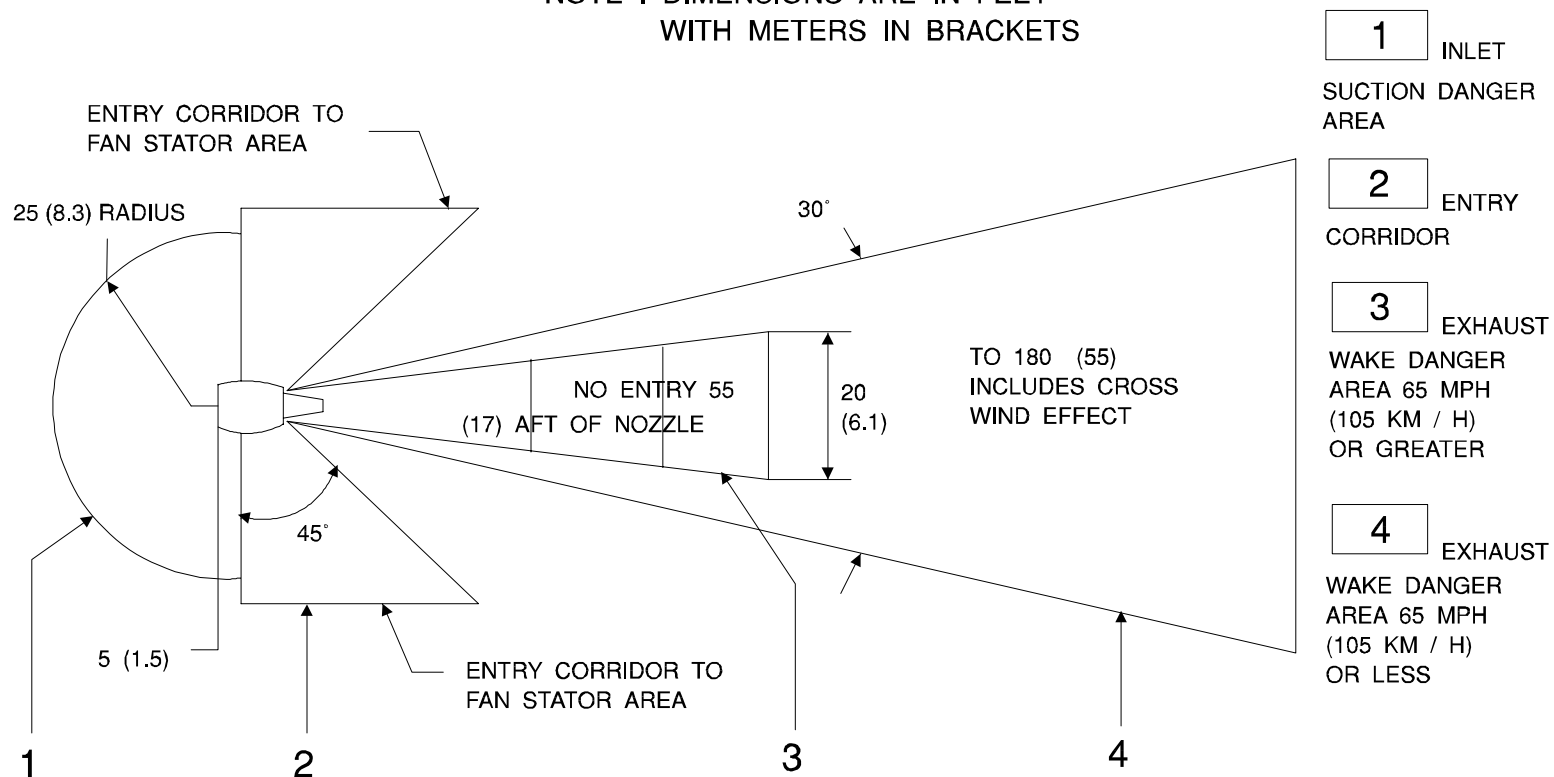
Distances are in feet (meters)

POWER SETTINGS	RADIUS X	RADIUS Y
GROUND IDLE	75 (25)	300 (91)
TAKE-OFF THRUST	100 (30)	2400 (727)

ENGINE DANGER AREAS, MINIMUM IDLE

FQW4200 GE Metric

NOTE : DIMENSIONS ARE IN FEET
WITH METERS IN BRACKETS

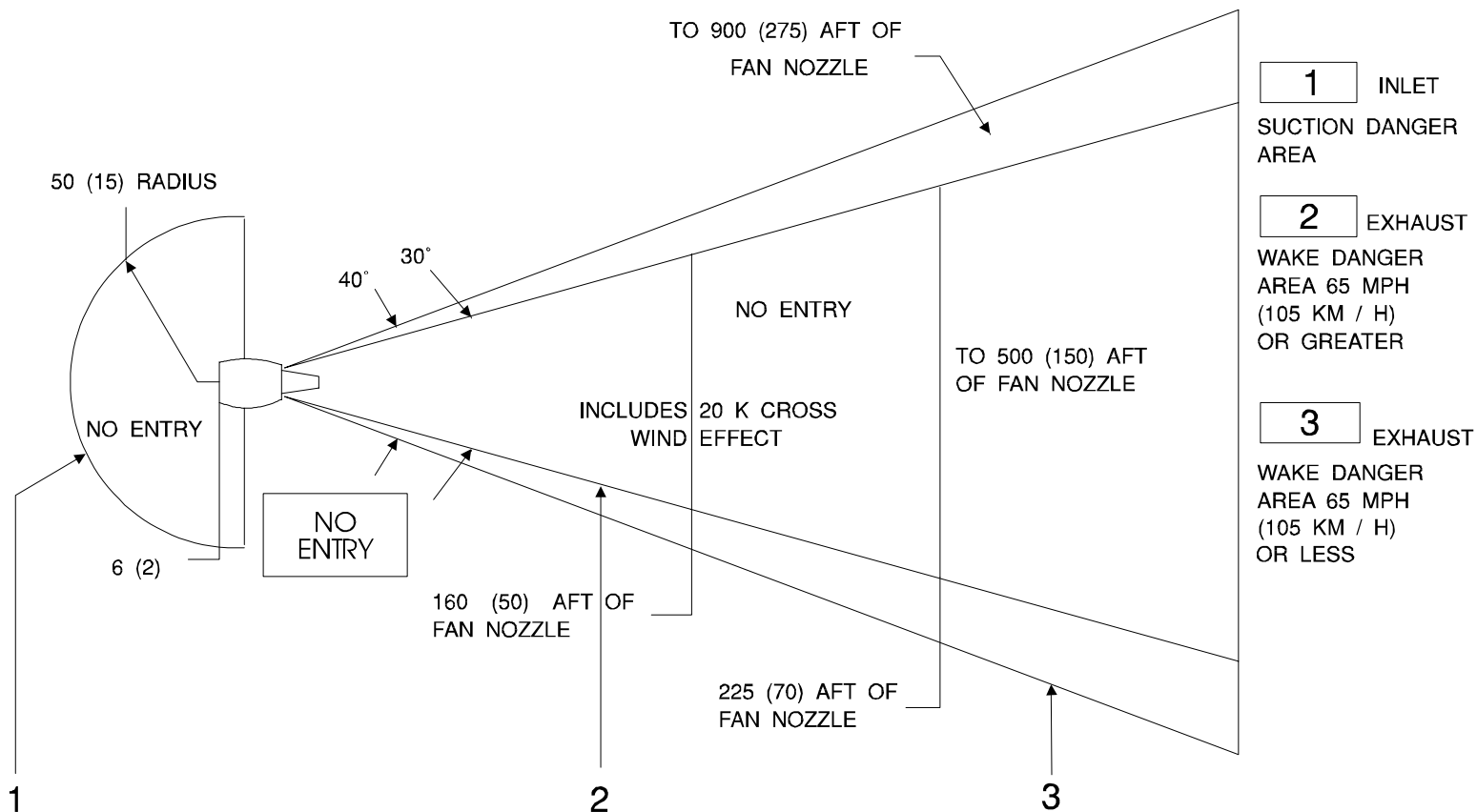


FQW4200 GE Metric

ENGINE DANGER AREAS, TAKE-OFF THRUST

FQW4200 GE Metric

NOTE : DIMENSIONS ARE IN FEET
WITH METERS IN BRACKETS.



FQW4200 GE Metric

STUDENT NOTES

FQW4200 GE Metric

CMS SPECIFIC PAGE PRESENTATION (FADEC)

ACCESS TO ECU MENU

SYSTEM TEST

ENGINE TESTS

MOTORING TEST

THRUST REVERSER TEST

IGNITION TEST

ENGINE RUNNING TEST

DISPLAY TEST

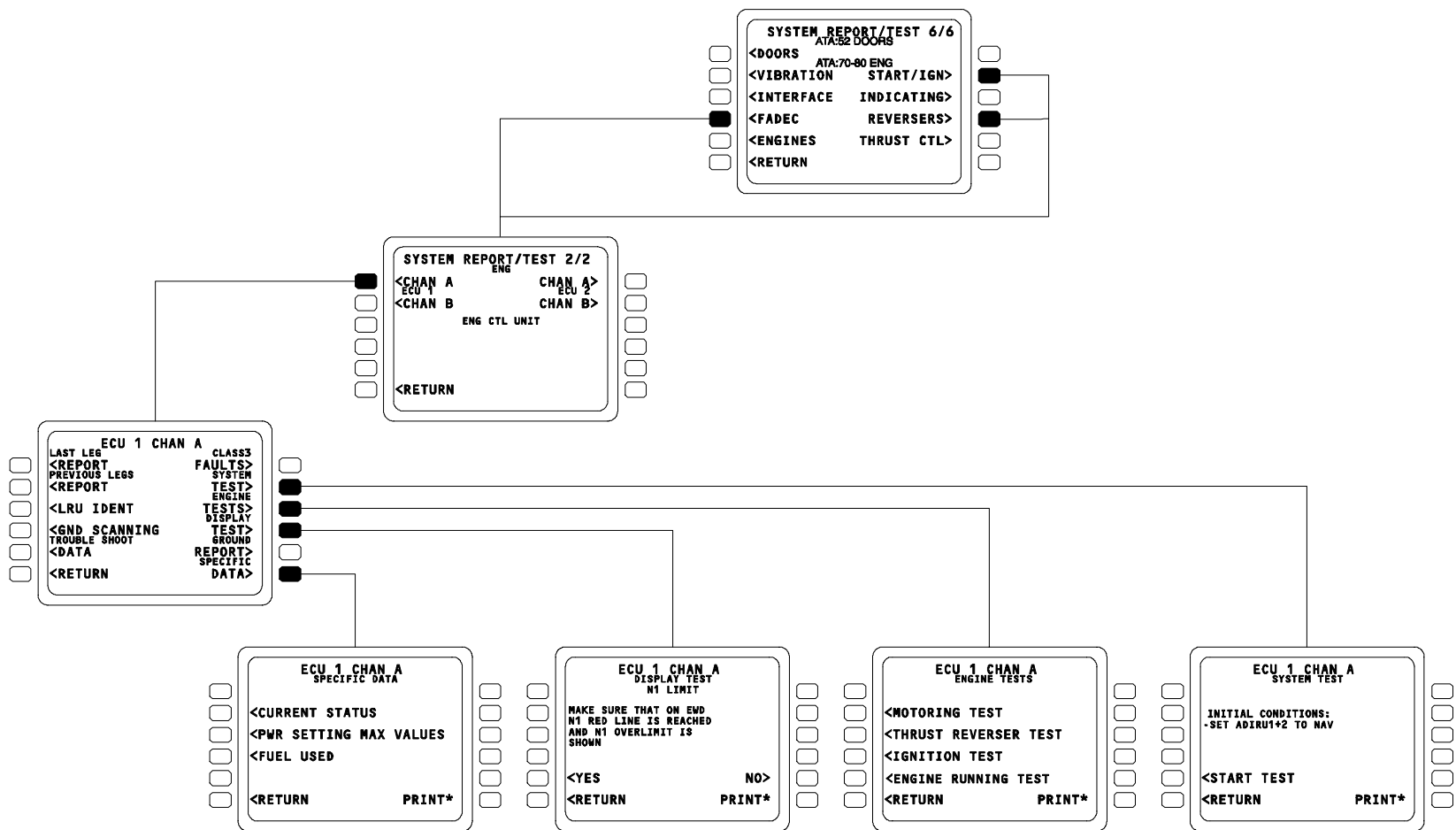
SPECIFIC DATA

CURRENT STATUS

PWR SETTING MAX VALUES

FUEL USED

ACCESS TO ECU MENU



SYSTEM TEST

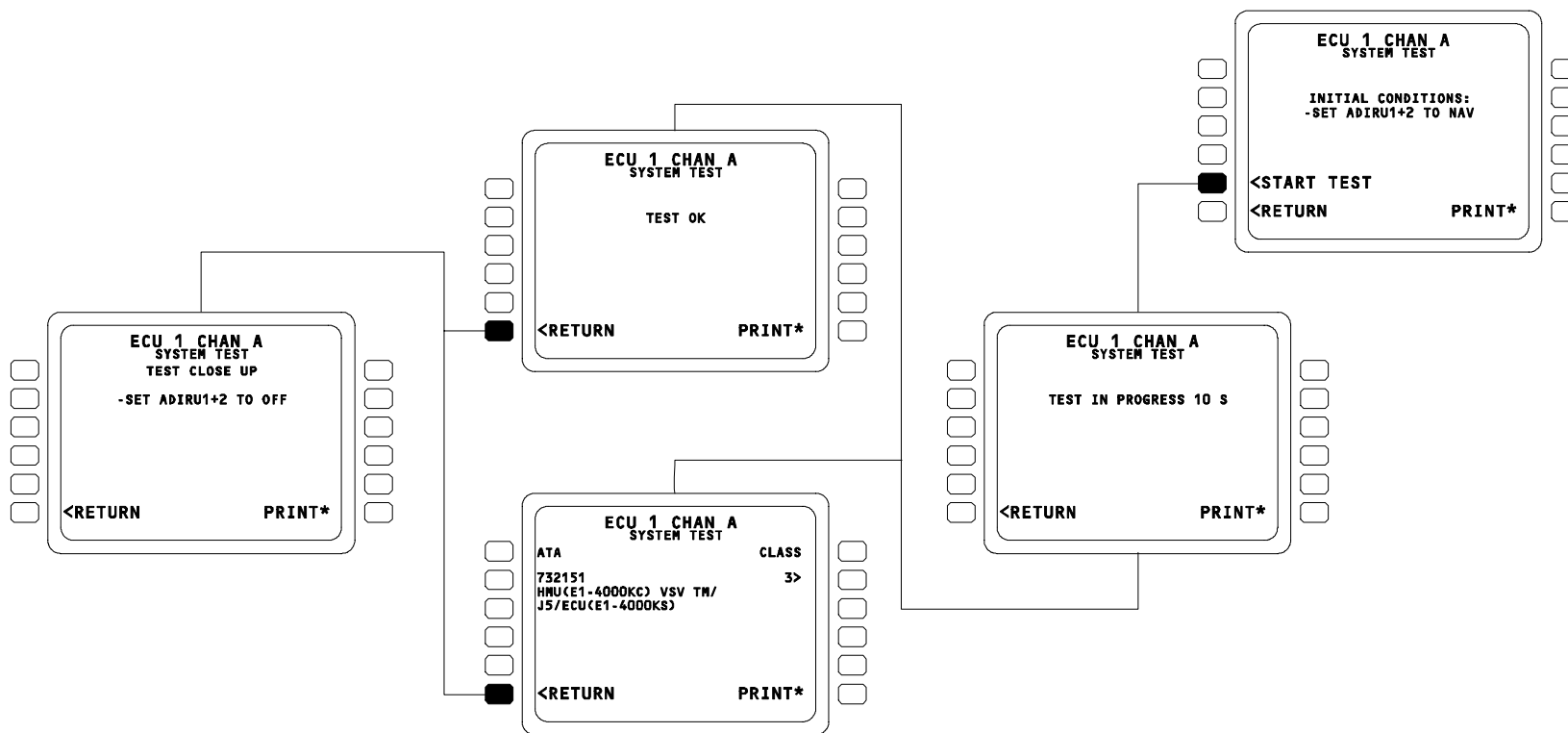
The system test is used to instruct the ECU to report on the current status of the FADEC system. It is a static check of the various ECU sensors and connections and will only report faults present at the time the line select key was pressed.

The test shall be aborted if the "RETURN" key is selected.

Fault information is displayed identical to "LAST LEG REPORT" screen format, refer to ATA 45 chapter.

If the test is positive (no faulty LRUs), then the "TEST OK" message is displayed.

On completion of the test, a test close up screen is displayed to ensure that the function is exited with the appropriate controls left in a safe condition.



MOTORING TEST

During the motoring test, the engine is dry cranked with starter air pressure applied. The various actuators and valves are commanded to certain positions for loop tests.

You have to confirm start of test.

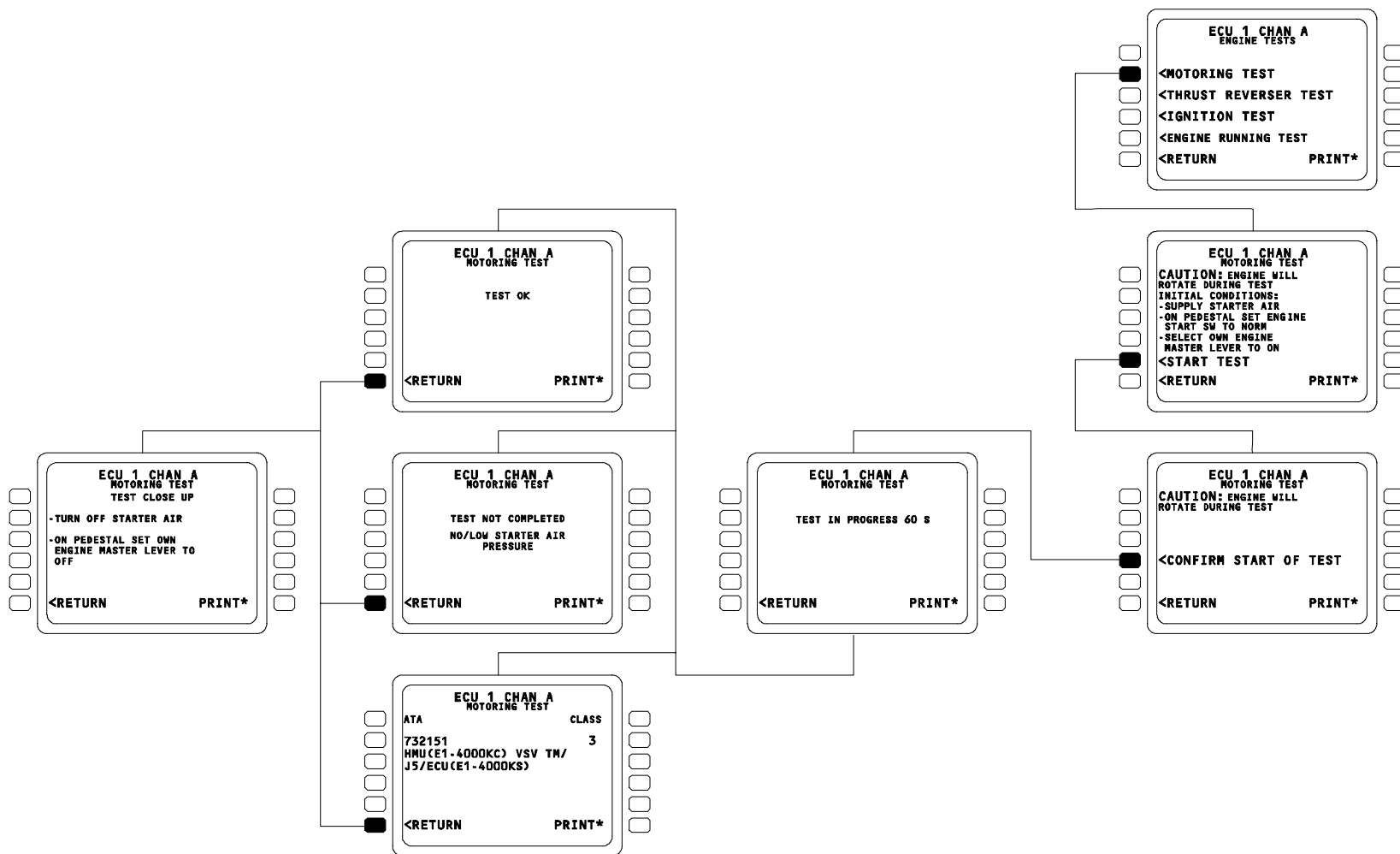
The test shall be aborted if the "RETURN" key is selected.

If no (or insufficient) starter air pressure is applied, the test cannot be completed.

Fault information is displayed identical to "LAST LEG REPORT" screen format, refer to ATA 45 chapter.

The "TEST OK" message is displayed if the test is positive (no faulty LRUs).

On completion of the test, a "TEST CLOSE UP" screen is displayed to ensure that the function is exited with appropriate controls left in a safe condition.



FQW4200 GE Metric

THRUSTER REVERSER TEST

During this test, pneumatic pressure is supplied to the Thrust Reverser system, the reverser is deployed and stowed by moving the throttle in the reverse and forward regions. The inhibition circuits and EIVMU relays are checked.

You have to confirm start of test.

During the test, operator instructions are displayed.

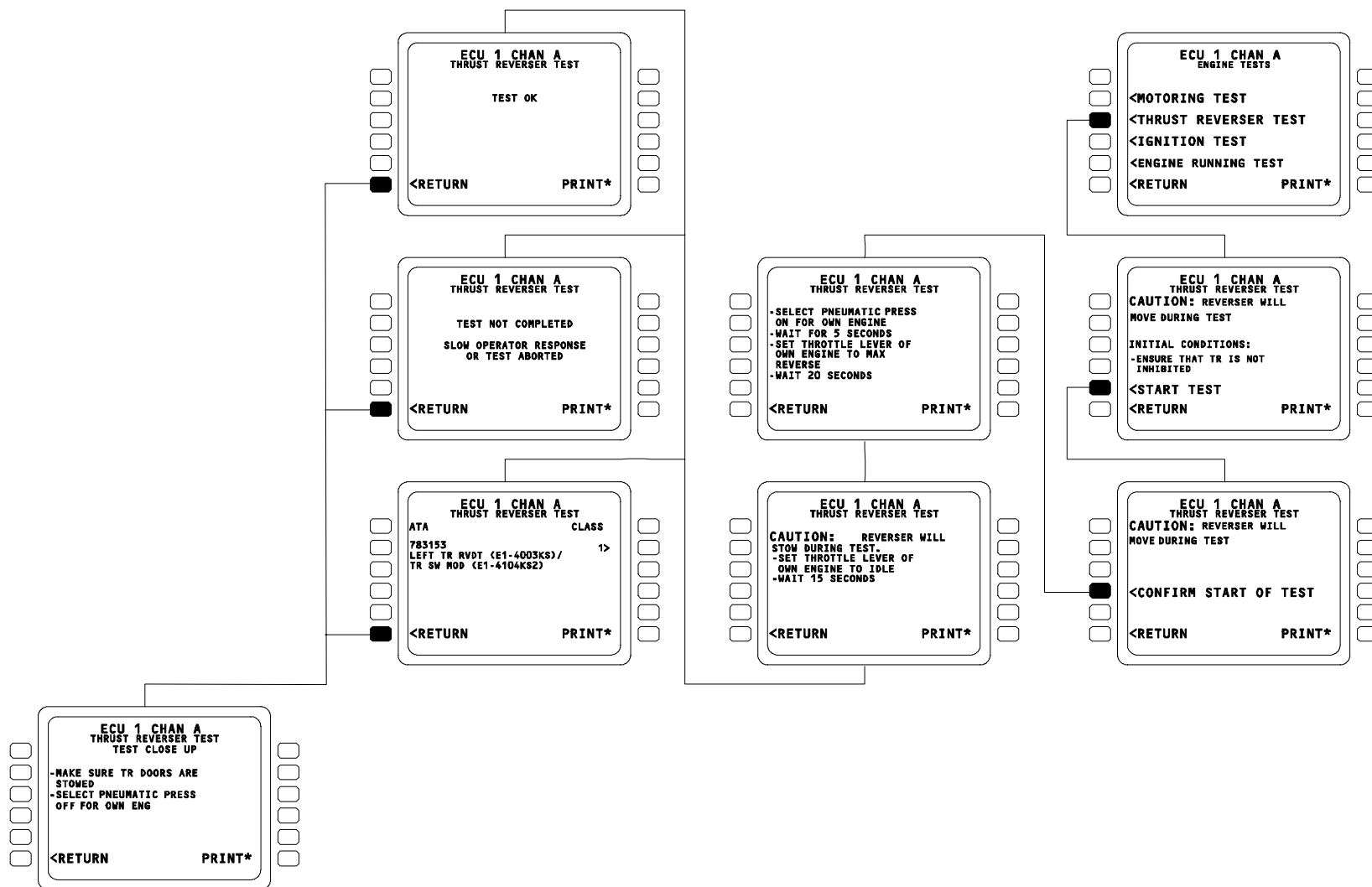
The test shall be aborted if the "RETURN" key is selected.

The test not completed screen appears if the operator does not follow the instructions in time.

Fault information is displayed identical to "LAST LEG REPORT" screen format, refer to ATA 45 chapter.

The "TEST OK" message is displayed if the test is positive (no faulty LRUs).

On completion of the test, a "TEST CLOSE UP" screen is displayed to ensure that the function is exited with appropriate controls left in a safe condition.



FQW4200 GE Metric

IGNITION TEST

This test consists in cycling ignitor A for 10 seconds, waiting 5 seconds, then cycling ignitor B for 10 seconds. Prior to cycling ignitors, the availability of the aircraft 115V power supply is checked.

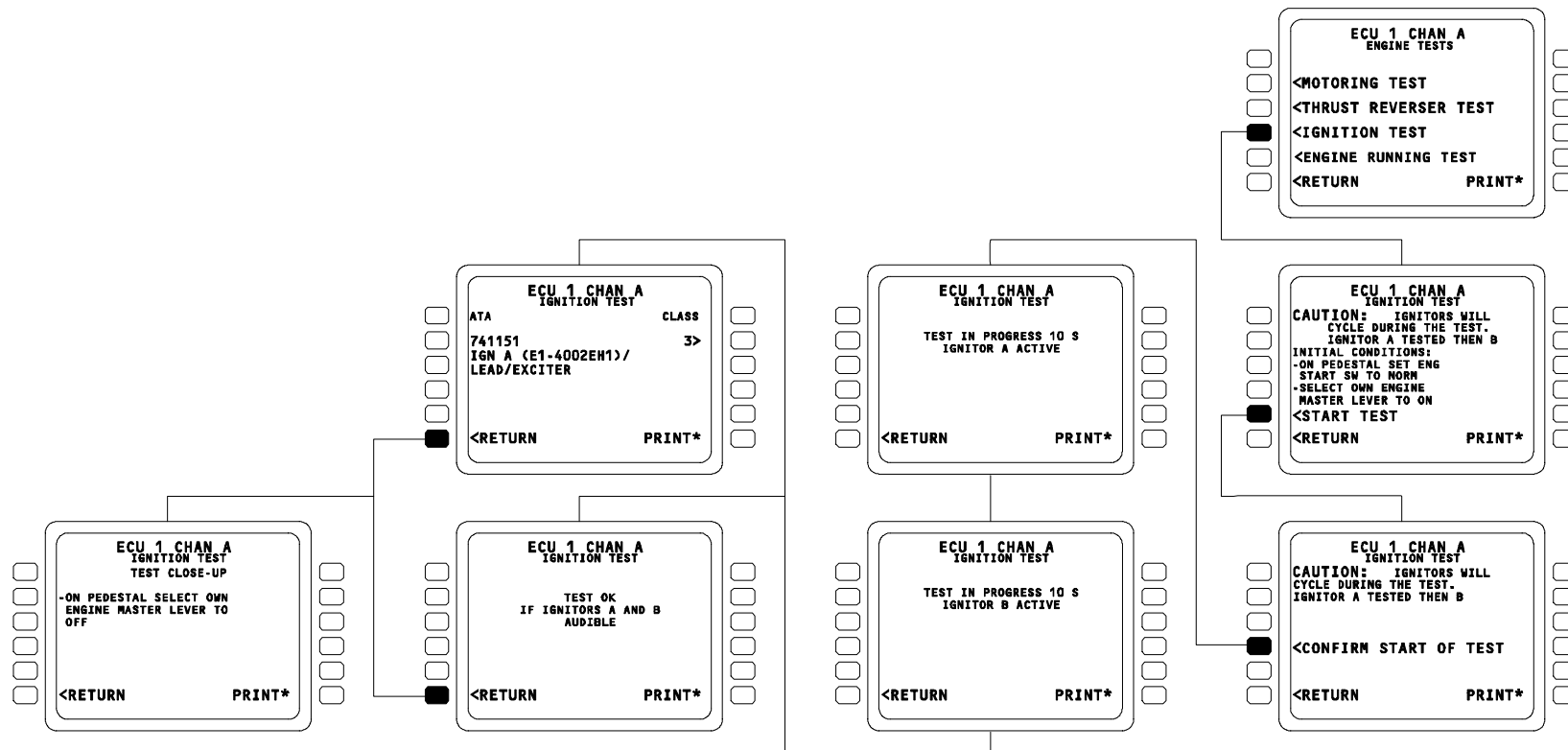
You have to confirm start of test.

The test shall be aborted if the "RETURN" key is selected.

Fault information is displayed identical to "LAST LEG REPORT" screen format, refer to ATA 45 chapter.

The "TEST OK" message is displayed if the test is positive for the ECU (no faulty LRUs), provided you confirm that the ignitors were audible from somebody near the engine.

On completion of the test, a "TEST CLOSE UP" screen is displayed to ensure that the function is exited with appropriate controls left in a safe condition.

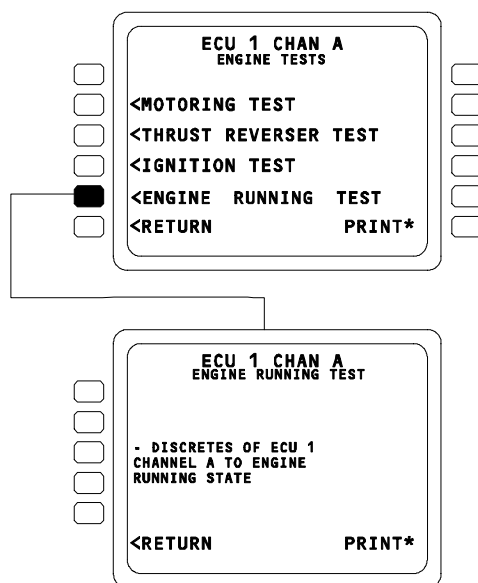


FQW4200 GE Metric

ENGINE RUNNING TEST

During the engine running test, the engine run relay will be set to the running state to validate the aircraft engine running discrete.

If "return" is not pressed within 10 minutes, the CMC will logout the ECU, the ECU will return to normal mode.



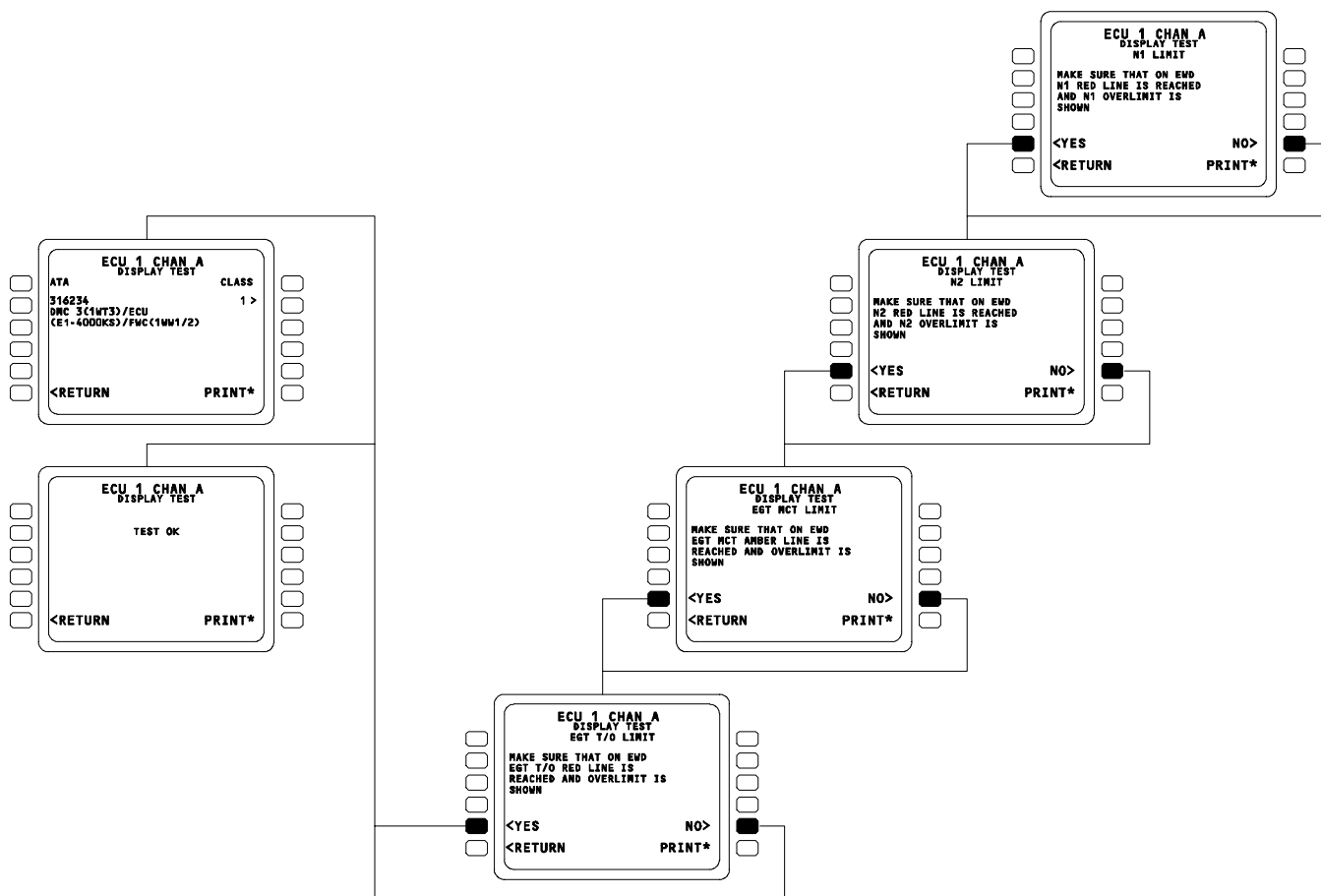
DISPLAY TEST

The display tests check the Engine Warning Display (EWD).

Each test requires an acknowledgement of the operator indicating whether or not the selected parameter is displayed on the EWD with an indication of overlimit.

If all the four tests are successful, a "TEST OK" message is displayed.

If the test is not OK, the fault message is displayed to identify the DMC and ECU as the likely LRUs causing the fault.

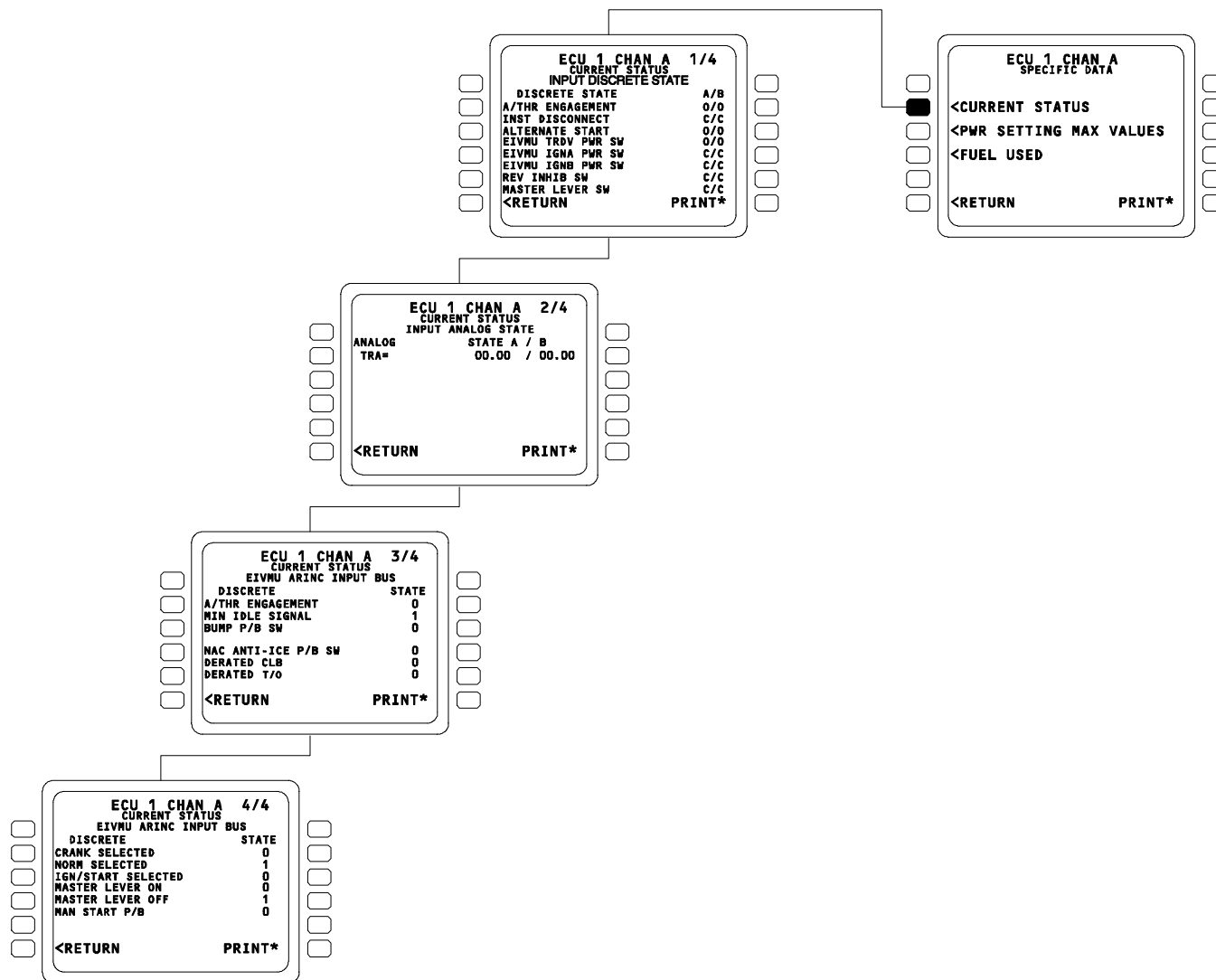


FQW4200 GE Metric

SPECIFIC DATA

CURRENT STATUS

This screen is used to display the local and cross channel status of aircraft input switches, TRA values and some EIVMU discrete ARINC input information.



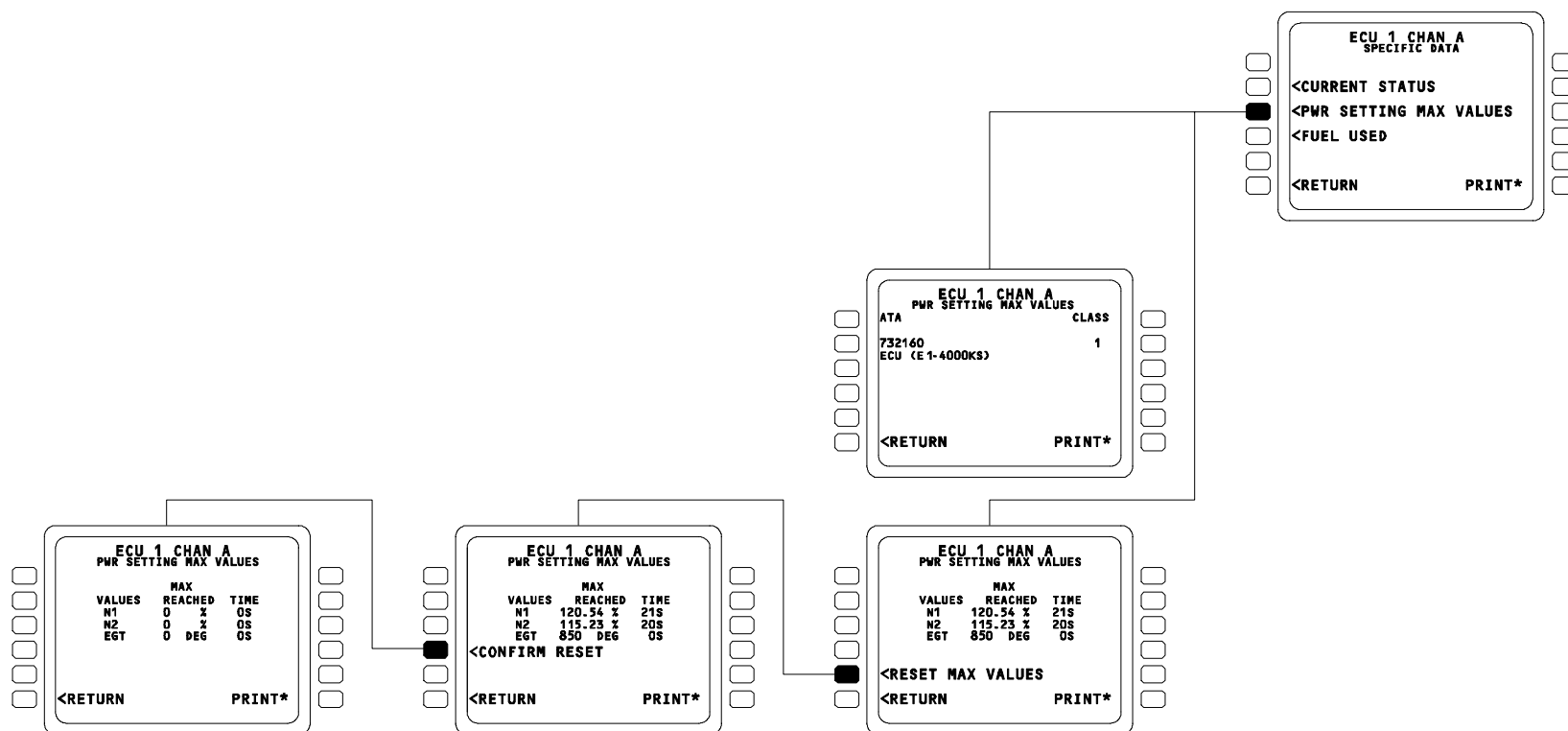
PWR SETTING MAX VALUES

This screen is used to display the maximum values of N1, N2 and EGT reached during last operation of the engine.

To reset, you have to confirm.

The reset values are displayed.

If there is a Non Volatile Memory failure, the fault message identifies the ECU as the faulty LRU.



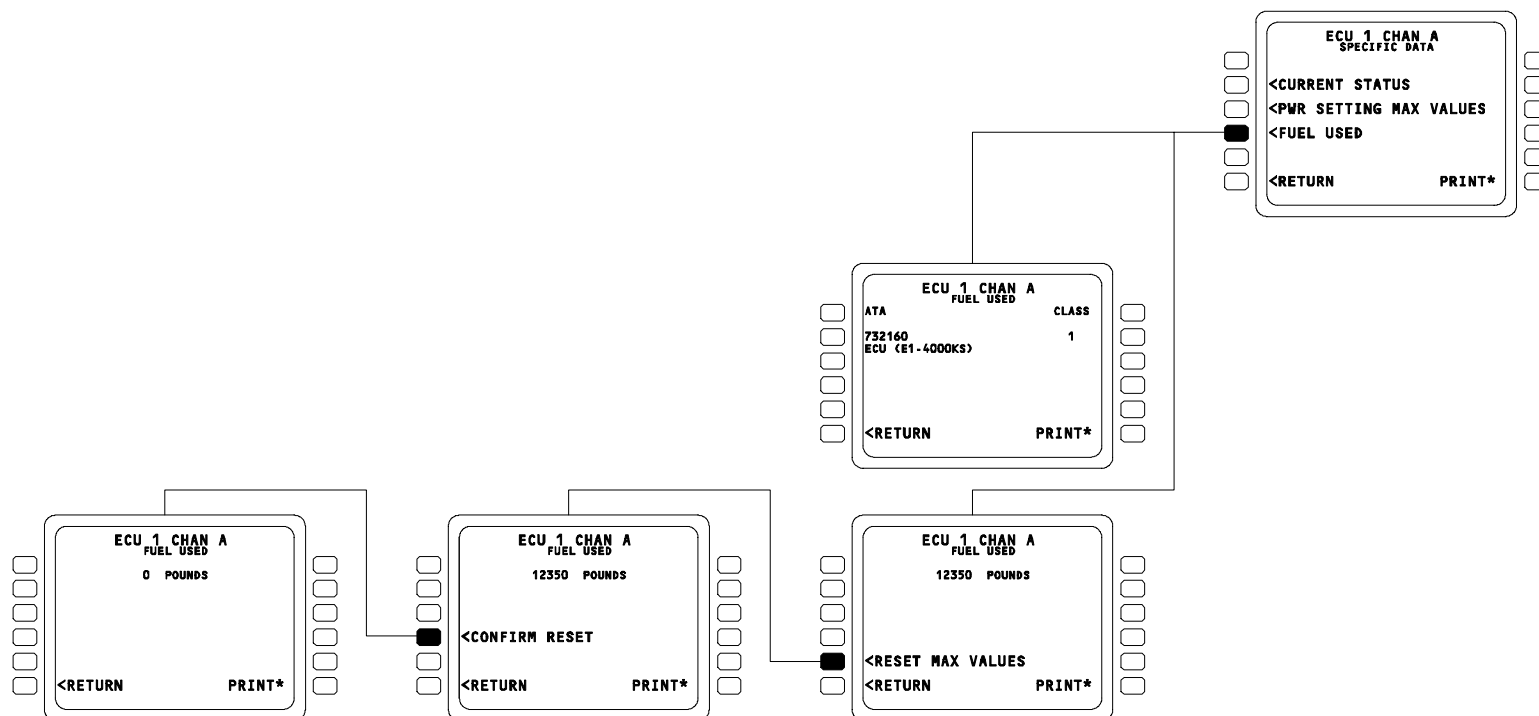
FUEL USED

This screen is used to display the fuel used during last operation of the engine.

To reset, you have to confirm.

The reset value is displayed.

If there is a Non Volatile Memory failure, the fault message identifies the ECU as the faulty LRU.



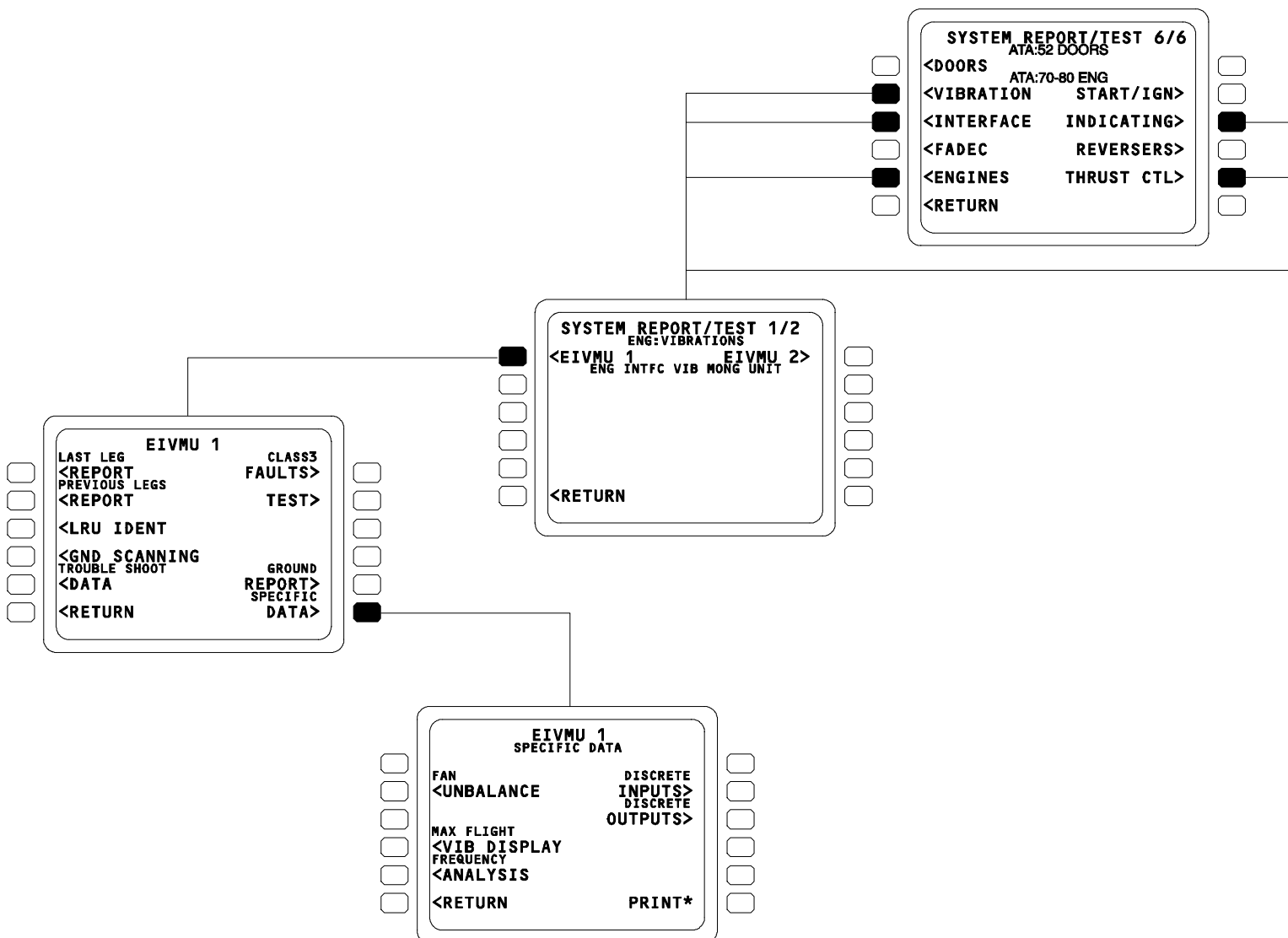
STUDENT NOTES

CMS SPECIFIC PAGE PRESENTATION (EIVMU)

ACCESS TO EIVMU MENU
FAN UNBALANCE
MAX FLIGHT VIBRATION
FREQUENCY ANALYSIS
DISCRETE INPUTS/OUTPUTS

ACCESS TO EIVMU MENU

FQW4200 GE Metric



FQW4200 GE Metric

FAN UNBALANCE

GROUND RUN ACQN :

This screen enables vibration data to be acquired during engine run on ground via a display updated every 3 seconds.

FLT N1 SPD SETS :

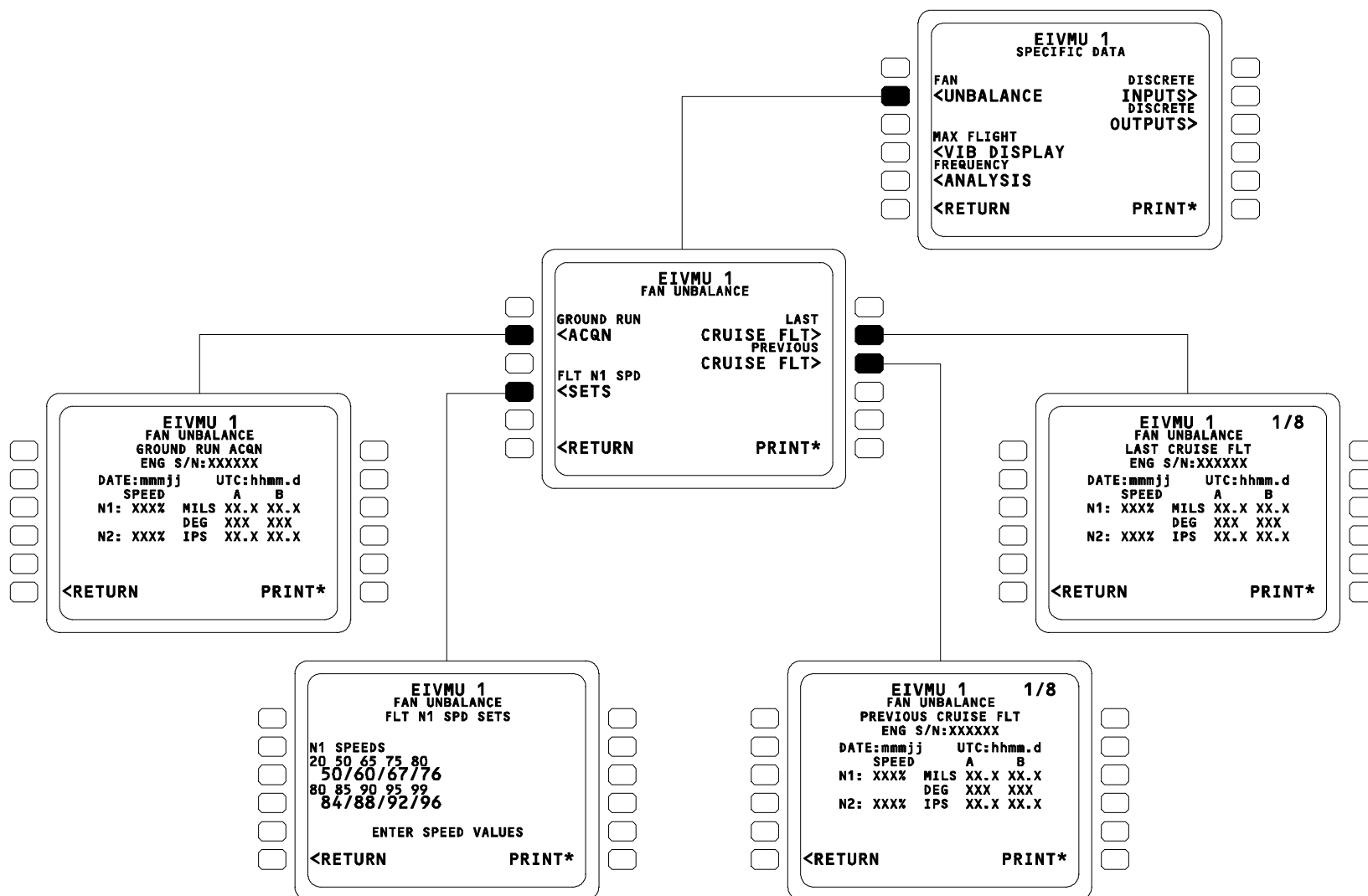
This menu allows eight N1 speeds to be selected in 8 given speed ranges for in-flight acquisition of vibration data.

LAST CRUISE FLT :

This screen displays vibration data acquired in stabilized flight conditions for 8 different engine speeds during the last cruise.

PREVIOUS CRUISE FLT :

This screen displays vibration data acquired in stabilized flight conditions for 8 different engine speeds during the previous cruise.



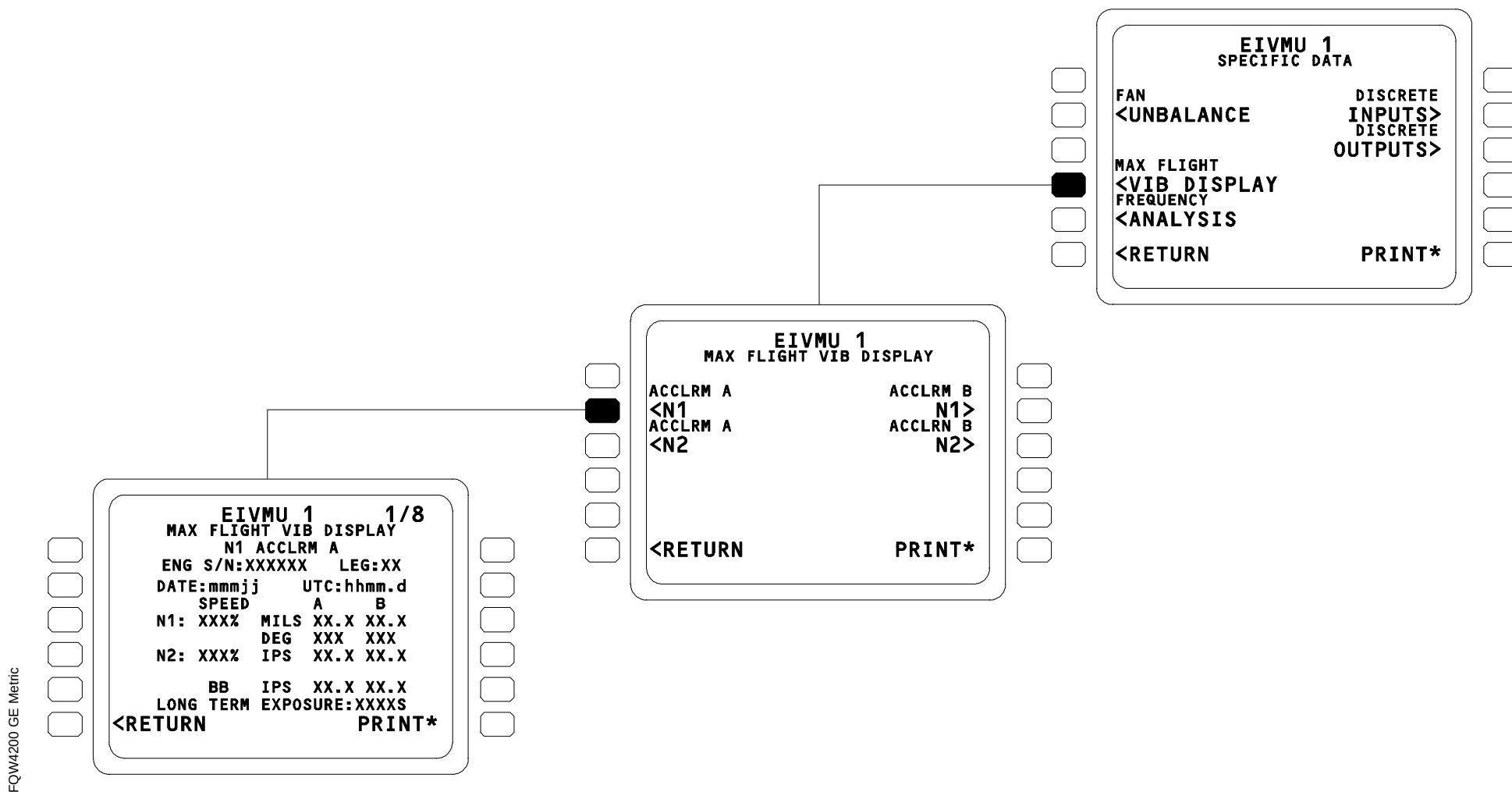
MAX FLIGHT VIBRATION

MAX FLIGHT VIB DISPLAY :

This menu is used to select MAX VIB displays for each speed/accelerometer couple.

N1 ACCLRM A :

This screen displays maximum vibration data acquired during the last 8 cruises from the chosen speed/accelerometer couple.



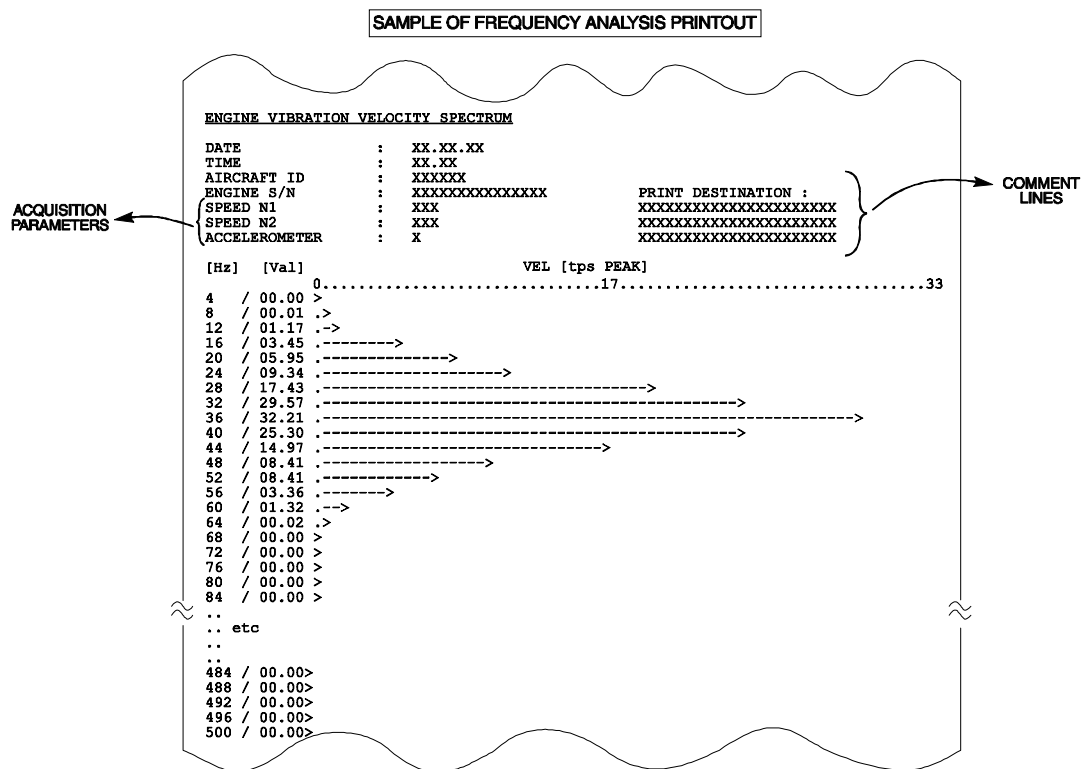
FREQUENCY ANALYSIS

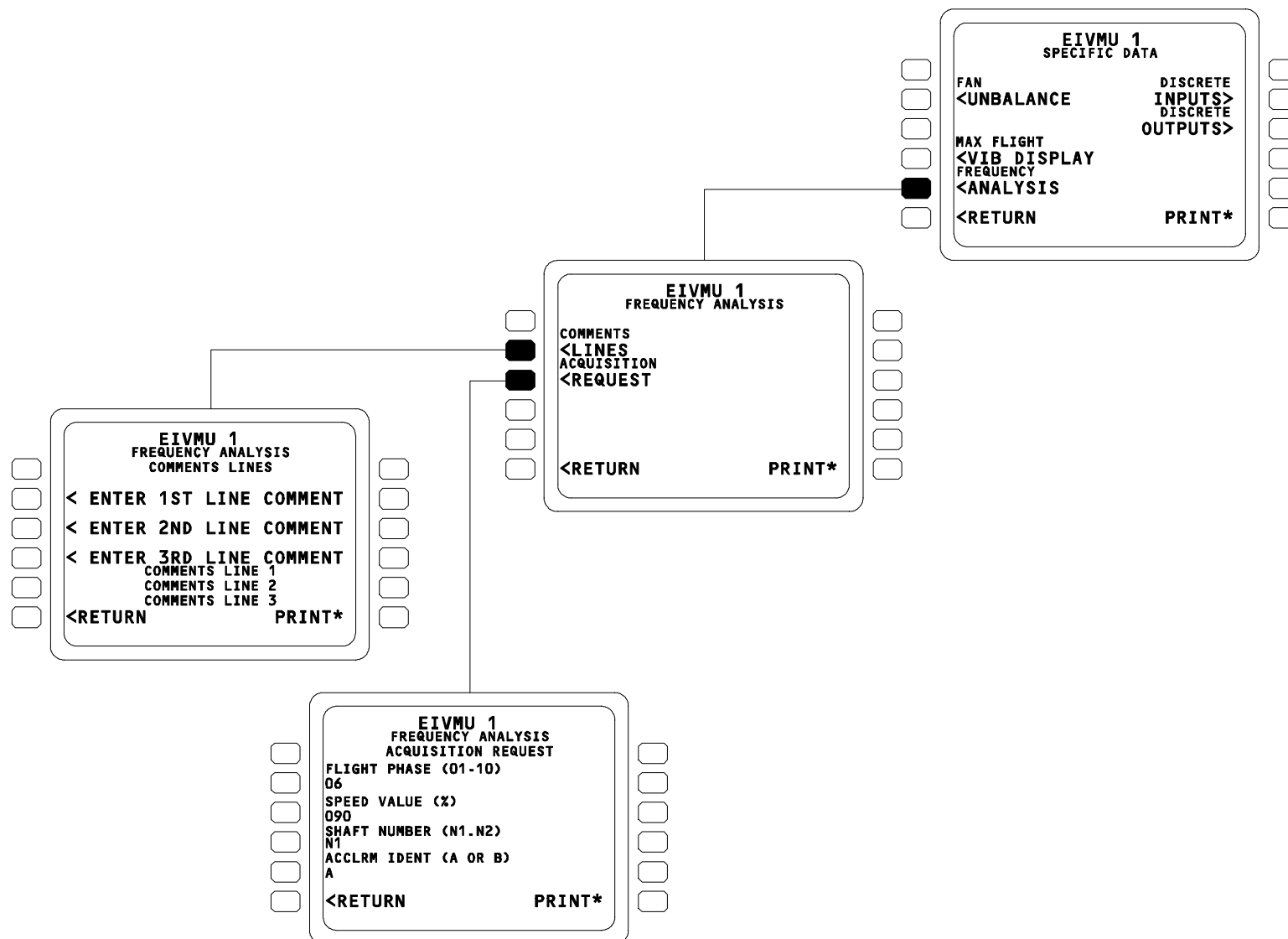
COMMENTS LINES :

This menu is used to insert up to 3 comment lines for the frequency analysis printout.

ACQUISITION REQUEST :

This menu is used to set acquisition conditions (flight phase, speed value, shaft and accelerometer) of a frequency analysis, on request.





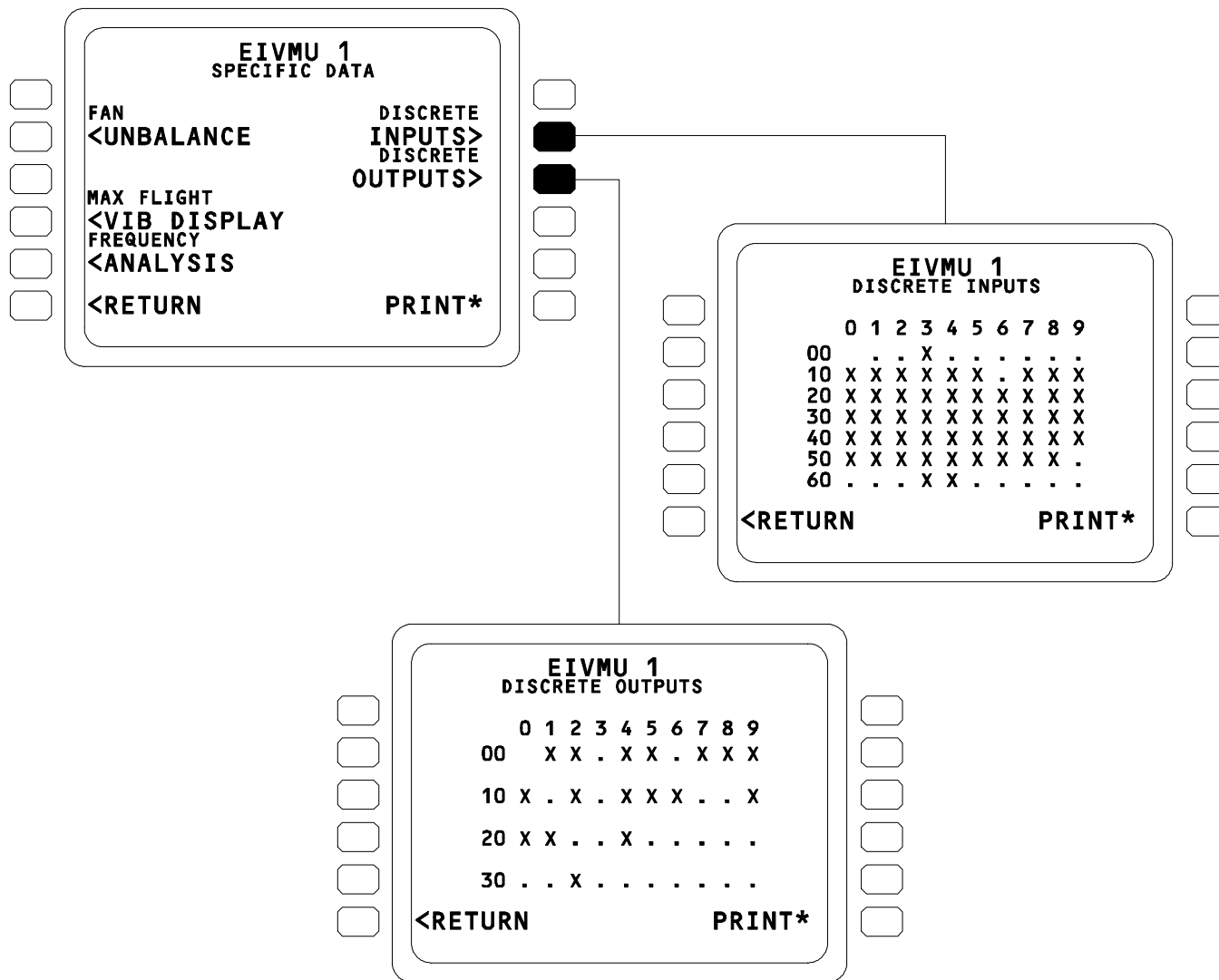
DISCRETE INPUTS/OUTPUTS

DISCRETE INPUTS :

This screen gives the status of the EIVMU discrete inputs.
(X=0 or X=1 depending on the status)

DISCRETE OUTPUTS :

This screen gives the status of the EIVMU discrete outputs.
(X=0 or X=1 depending on the status)



FQW4200 GE Metric

STUDENT NOTES

ENGINE COWL DOORS OPERATION (FILM)

Opening of the Fan Cowl Doors
Opening of the Thrust Reverser Cowl Doors
Opening of the Core Cowl Doors
Closing of the Core Cowl Doors
Closing of the Thrust Reverser Cowl Doors
Closing of the Fan Cowl Doors

CAUTION : Do not open any cowl door if the ground wind velocity is higher than 40 knots. Do not leave the doors open if the ground wind velocity is higher than 60 knots.

OPENING OF THE FAN COWL DOORS

You must first follow the safety precautions and prepare the aircraft to operate on engines.

To open the fan cowl doors, disengage each fan cowl door latch as follows:

- push the trigger of the fan cowl door latch, this will release the latch handle,
- pull the latch handle down until the latch hook is fully disengaged from the clevis.

CAUTION : Make sure all latch handles are fully open before you open the fan cowl doors. If you try to open the doors with one or more latches engaged, you can damage the latches or the doors.

WARNING : Get sufficient aid from two or more persons or from equipment to lift or lower the fan cowl door. Each fan cowl door weighs approximately 60 kg (130 lbs). The fan cowl door can cause injury to persons and damage to equipment if it falls.

Lift the fan cowl door sufficiently to get access to the hold open rods.

Engage the hold open rods on the fan cowl doors as follows :

- pull on the retention locks on the hold open rods,
- disengage the hold open rods from their retention brackets on the fan cowl door,
- extend the hold open rods fully to the locked position,
- make sure the locks are fully in their slots.

Engage the retention locks of the hold open rods with the engine detents.

Engage the forward rod first, then the aft one.

Make sure the locks are fully engaged before you release the weight of the door.

OPENING OF THE THRUST REVERSER COWL DOORS

You must first follow the safety precautions and prepare the aircraft to operate on engines.

The fan cowl doors have already been opened and the thrust reverser made unserviceable to apply this procedure.

Refer to the Aircraft Maintenance Manual procedures.

Open the blowout and access doors.

Release the mounting ring latch assembly by accomplishing the following steps :

- rotate the upper latch handle out and up to the fully released position,
- rotate the lower latch handle out and up to the fully released position.

CAUTION : Make sure that the latch ring upper latch handle is in the fully open position before you open the thrust reverser. Damage can occur if the upper latch hook is not fully disengaged from the U-bolt during opening. Release the three lower latches of the thrust reverser.

CAUTION : Make sure all latch handles are fully open.

Remove the dust cover from the quick disconnect connector fitting of the multiple connector.

Attach the hose from the the hydraulic pump to the fitting.

CAUTION : Do not actuate the hydraulic pump until the thrust reverser halves have been opened a small amount by hand. Damage can occur if the thrust reverser halves are not separated.

Actuate the hydraulic pump until the thrust reverser cowl door is raised up.

Release the thrust reverser hold open rod from its bracket.

Raise the thrust reverser cowl door sufficiently to install the thrust reverser hold open rod onto the fan case brace.

WARNING : Make sure that the hold open rod ball lock is installed with the plunger button and the T-handle in the upward position. Serious injury can occur if the thrust reverser cowl doors close suddenly.

Slowly open the hydraulic pump valve and release the hydraulic pressure. Disconnect the hydraulic pump hose from the fitting and install the dust cover.

OPENING OF THE CORE COWL DOORS

You must first follow the safety precautions and prepare the aircraft to operate on engines.

Open the fan cowl doors.

Make the thrust reverser unserviceable.

Open the thrust reverser doors.

Refer to the Aircraft Maintenance Manual procedures.

Disengage each core cowl latch as follows :

- push the trigger of the latch ; this will release the latch handle,
- pull the latch handle down until the latch hook is fully disengaged from the clevis.

CAUTION : Make sure all latch handles are fully open before you open the core cowl doors. If you try to open the doors with one or more latches engaged, you can damage the latches or the doors.

WARNING : Get sufficient aid from two or more persons or from equipment to lift or lower the core cowl door. Each core cowl door weighs approximately 30 kg (65 lbs).

Open the core cowl door sufficiently to get access to the hold open rods. Pull down on the collar on the hold open rod. Disengage the hold open rod from its retention bracket on the core cowl door.

Engage the ball lock of the hold open rod in the engine detent. Make sure the ball lock is fully engaged in the engine detent before you release the weight of the door.

Extend the hold open rod fully to the locked position.

WARNING : When the hold open rod is engaged in the detent, make sure the primary lock red band does not show. Also make sure the secondary lock on the hold open rod is fully engaged. If the hold open rod locks are not fully engaged, the core cowl door can fall and cause injury or damage.

CLOSING OF THE CORE COWL DOORS

WARNING : Get sufficient aid from two or more persons or from equipment to lift or lower the core cowl door. Each core cowl door weighs approximately 30 kg (65 lbs).

Hold the core cowl door.

Disengage the hold open rod as follows :

- retract the hold open rod,
- disengage the rod from the engine detent,
- engage the rod in its retention bracket on the core cowl door.

CAUTION : Lower the door slowly to prevent damage to the stop fittings on the core cowl and the primary exhaust nozzle.

Lower the core cowl door.

Push the left and right core cowl doors together until each latch hook engages in its clevis.

Engage each core cowl door latch as follows :

- push up each handle until the trigger engages,
- pull the end of each latch handle down with sufficient force to make sure the trigger holds the latch handle.

Complete the procedure according to the Aircraft Maintenance Manual.

CLOSING OF THE THRUST REVERSER COWL DOORS

WARNING : Do not remove the hold open rod or lift sling until the hydraulic pump has taken the load off of the support device. Serious injury can occur to persons if the thrust reverser cowl doors close suddenly.

CAUTION : Make sure that the upper latch handle is in the fully open position during closing. Damage can occur to the U-bolt spring retainer if the upper latch handle is not fully open.

Remove the dust cover from the quick disconnect connector fitting of the multiple connector.

Attach the hydraulic pump hose to the fitting.

Actuate the hydraulic pump until the load on the hold open rod is removed.

Remove the hold open rod from the fan case brace and stow it.

Slowly open the hydraulic pump valve and let the thrust reverser cowl door lower down. With the valve fully open, the cowl door should operate in a smooth closing direction and close in approximately 15 seconds from the fully open position.

Close the mounting ring latch assembly.

WARNING : Make sure that the upper latch ring hook is engaged in the U-bolt clevis when the thrust reverser is closed.

Close and secure the three main latches.

Close the blowout and access doors. Make sure that there is no preload on the blowout door when latched.

Disconnect the hydraulic pump hose from the fitting and install the dust cover on the multiple connector.

Make the thrust reverser serviceable.

Complete the procedure according to the Aircraft Maintenance Manual.

CLOSING OF THE FAN COWL DOORS

WARNING : Get sufficient aid from two or more persons or from equipment to lift or lower the fan cowl door. Each fan cowl door weighs approximately 60 kg (130 lbs). The fan cowl door can cause injury to persons and damage to equipment if it falls.

Disengage the hold open rods as follows :

- lift the weight of the fan cowl door off the hold open rods,
- disengage the rods from the engine detents,
- pull on the retention locks,
- retract the rods,
- make sure the locks fully engage in the slots in the closed position,
- engage the rods in their retention brackets on the fan cowl door.

Lower the fan cowl door.

Close the fan cowl doors latches as follows :

- engage each fan cowl door latch hook in its clevis,
- push up each handle until the trigger engages.

Complete the procedure according to the Aircraft Maintenance Manual.

THRUST REVERSER DEACTIVATION/REACTIVATION (FILM)

FQW4200 GE Metric

THRUST REVERSER DEACTIVATION

You must first follow the safety precautions and prepare the aircraft to operate on engines.

The fan cowl doors have already been opened to apply this procedure.

Refer to the Aircraft Maintenance Manual procedure.

WARNING : You must deactivate each thrust reverser half to make sure the thrust reverser system does not operate.

To make the thrust reverser unserviceable : at each Center Drive Unit (CDU), remove the lock-out plate, invert it and reinstall it with the square drive engaging in the drive pad.

Torque the bolts to the appropriate value.

Remove the three red warning plates from the fixed structure of each thrust reverser half that will be deactivated.

Make sure the translating cowl is in the fully stowed position.

Put a red warning plate in position on the translating cowl at the location of each ballscrew actuator.

Install two bolts through each red warning plate, translating cowl, fixed structure and into the lock-out plates.

Torque the bolts at the appropriate value.

NOTE : Each translating cowl has three lock-out plates that extend under the fixed structure in the stowed position.

When the six red warning plates on each engine are in position, disconnect the electrical connector from the Directional Pilot Valve (DPV).

Remove the dust cap from the storage bracket on the fixed structure next to the DPV.

Connect the electrical connector for the DPV to the storage bracket on the fixed structure.

Install the dust cap on the opening for the electrical connector of the DPV. Do the close-up procedure.

Make sure that the Engine Warning Display shows the message ENG 1(2) REV INHIBITED.

Complete the procedure according to the Aircraft Maintenance Manual.

THRUST REVERSER REACTIVATION

You must first follow the safety precautions and prepare the aircraft to operate on engines.

Fan cowl doors have already been opened to apply this procedure.

Refer to the Aircraft Maintenance Manual procedure.

Disconnect the electrical connector for the Directional Pilot Valve (DPV) from the stowage bracket on the fixed structure.

Remove the dust cap from the opening for the electrical connector of the DPV.

Install the dust cap on the stowage bracket on the fixed structure.

Connect the electrical connector to the DPV.

Tighten the electrical connector by hand plus 1/8 turn more with soft-jawed pliers.

At each Center Drive Unit, remove the CDU lock-out plate, invert it and reinstall it with the square drive away from the drive pad.

Torque the bolts to the appropriate value.

Remove the two bolts from each red warning plate that is attached to the translating cowl.

Attach the three red warning plates to the fixed structure of each thrust reverser half that was deactivated.

Complete the procedure according to the Aircraft Maintenance Manual.

ENGINE MAINTENANCE ITEMS (FILM)

Inlet cowl Removal/Installation
Fan blade Removal/Installation
Fuel nozzles Removal/Installation

INLET COWL REMOVAL/INSTALLATION

To get access to the anti-ice duct, open the fan cowl doors.

WARNING: Make sure that the anti-ice system is cool. The anti-ice system operates at approximately 700 deg.F (371 deg.C). Serious injury to persons can occur if you touch the anti-ice system when it is hot.

Disconnect the AFT interface of the forward anti-ice duct. Then disconnect the forward interface of the forward anti-ice duct.

Loosen the strap that holds the cuff on the forward anti-ice duct.

Move the cuff aft on the forward anti-ice duct to get access to the bolts.

Remove the bolts that attach the forward anti-ice duct to the inlet cowl aft bulkhead.

Remove the bolts, the washers and the nuts that hold the forward anti-ice duct on the support links.

Remove the forward anti-ice duct.

Disconnect the electrical connector from the inlet cowl.

Put the protective covers on the connector and the receptacle.

Remove the filler screws from the four hoist points of the inlet cowl. Keep the filler screws.

Attach the inlet cowl sling to the inlet cowl with the pads and the bolts.

Two slings are dedicated for the aft hoist points and two for the forward hoist points.

Tighten the bolts.

Lift the sling until the sling holds the weight of the inlet cowl.

Remove the thirty-six bolts, the spacers, the washers and the nuts that attach the inlet cowl to the fan case.

WARNING: Control the movement of the inlet cowl. The inlet cowl weighs approximately 570 lbs (259 kg). If you do not control the inlet cowl, it can cause injury to persons or damage to equipment.

Pull the inlet cowl forward until the index pins are out of the fan case.

If the inlet cowl is put on the inlet cowl dolly, refer to the Aircraft Maintenance Manual for the procedure.

Lift the inlet cowl so that it is in front of the engine.

Put the index pins of the inlet cowl into the fan case.

Attach the inlet cowl to the fan case with the bolts, the spacers, the washers and the nuts. Put the bolt heads and the spacers on the forward side of the flange. Put the washers and the nuts on the aft side of the flange.

Torque the nuts in the sequence detailed in the Aircraft Maintenance Manual. Repeat the sequence a second time.

Remove the bolts and the pads from the inlet cowl.

Remove the inlet cowl sling.

Install the filler screws in the hoist points of the inlet cowl.

Tighten the filler screws.

Remove the protective covers from the electrical connector and the receptacle.

Connect the electrical connector to the inlet cowl.

Turn the connector ring until it locks.

Install the forward anti-ice duct in the inlet cowl aft bulkhead.

Make sure the mount brackets on the forward anti-ice duct align with the support links. Attach the forward anti-ice duct to the inlet cowl with the bolts.

Tighten the bolts.

Move the cuff forward until it covers the bolts. Tighten the strap to attach the cuff to the forward anti-ice duct.

Attach the support links to the forward anti-ice duct with the bolts, the washers and the nuts. Tighten the nuts.

Complete the procedure according to the Aircraft Maintenance Manual.

FAN BLADE REMOVAL/INSTALLATION

Before removal of the fan blade, the fan rotor spinner must be removed.

NOTE: When you remove only one fan blade, it is necessary to remove the blade retainer, spacer and key from the adjacent blade. The removal of blade retainer, spacer and key will permit enough blade movement to disengage the midspan shroud.

Remove the bolt for the fan blade to be removed.

Remove the bolt for the adjacent anticlockwise fan blade to be removed.

Matchmark each fan blade with its retainer and spacer.

Use the stage one fan blade spacer preload fixture to relieve the pressure on the spacer. Remove the key.

Remove the spacer.

Remove the retainer.

Use the stage one fan blade preload fixture to remove the key of the adjacent fan blade.

Then remove the spacer and the retainer.

Prior to removing the fan blade, turn it to the 12 o'clock position to prevent any free turning of the fan.

Move the adjacent fan blade radially inward to disengage the midspan shroud.

Remove the fan blade.

According to the Aircraft Maintenance Manual add or remove balance weights to keep the fan rotor system in balance if the replacement blade has a significantly different moment weight.

Apply two coats of lubricant to the following areas:

- Mating surfaces of the fan blade.
- Fan blade midspan shroud.
- Retainers, spacers and keys.
- Slots of the disk.

Permit the lubricant to dry for a minimum of ten minutes.

Install the new fan blade.

Install the retainer.

Install the spacer.

Move the adjacent fan blade radially outward to engage the midspan shroud.

Install the retainer.

Install the spacer.

To facilitate the installation, turn the fan blade to 6 o'clock.

Use the stage one fan blade spacer preload fixture to preload the spacer and install the key.

Repeat the operation for the other fan blade.

Make sure that the key and retainer are both aligned.

Move the spacer to insert the screw and tighten the bolt.

Repeat the operation for the other fan blade.

Tighten roughly with the appropriate tools.

Torque the bolt to the appropriate value.

Repeat the operation for the other fan blade.

Visually inspect the fan blades to make sure they are in the correct position in the fan disk.

If more than ten blades have been replaced perform the tip-to-shroud clearance check according to the Aircraft Maintenance Manual. Complete the Procedure according to the Aircraft Maintenance Manual.

FUEL NOZZLES REMOVAL/INSTALLATION

To get access to fuel nozzles 15 and 16, the air starter duct has to be removed. Refer to Aircraft Maintenance Manual procedure. Before removing the fuel nozzles, drain the fuel supply manifold according to the Aircraft Maintenance Manual procedure.

The two fuel nozzles installed at the No. 15 and 16 positions of the compressor rear frame are identified with a purple band.

The fuel nozzles are referred to in a clockwise direction with the No. 1 fuel nozzle located at the 12 o'clock position and the No. 15 fuel nozzle located at 6 o'clock position aft looking forward.

Remove the lockwire of the three bolts that attach each fuel nozzle to the compressor rear frame.

Disconnect the fitting nut that attaches the drain manifold to the drain shroud of the applicable fuel nozzle.

Turn the drain shroud 1/4 of a full turn. Align the lock tabs of the drain shroud and slots of the fuel nozzle. Move the drain shroud in the aft direction. Disconnect the fitting nut that attaches the fuel supply manifold line to the fuel nozzle.

Remove the three bolts that attach the fuel nozzle to the compressor rear frame.

Install protective caps in the opening of the fuel nozzle and the fuel lines. Carefully remove fuel nozzle No. 15 and gasket from the compressor rear frame.

Carefully remove fuel nozzle No. 16 and gasket from the compressor rear frame.

Protect the compressor rear frame openings from any foreign objects.

Remove the preformed packing from the fuel supply manifold and discard it.

Remove the preformed packing from the fuel nozzle and discard it.

Examine the gasket for damage. Keep the gasket if it is serviceable or otherwise discard it.

Apply a layer of oil to the two preformed packings. Refer to the Aircraft Maintenance Manual for oil designation.

Remove the protective caps from the openings of the fuel nozzles, fuel lines and compressor rear frame.

Install a serviceable gasket on the fuel nozzle flange of the compressor rear frame.

Carefully install fuel nozzle No. 16 into the opening of the compressor rear

frame.

Remove the protective cap from the opening of fuel nozzle No. 16.

Install the preformed packing on the fuel nozzle.

Install the preformed packing on the fuel supply manifold line.

Attach the fuel nozzle to the compressor rear frame with the three bolts.

Torque the bolts to the appropriate value.

After five minutes torque the bolts again and after five more minutes torque the bolts once more.

Carefully install fuel nozzle No. 15 into the opening of the compressor rear frame.

Remove the protective cap from the opening of fuel nozzle No. 15.

Remove the protective cap from the fuel line and install the preformed packing on the fuel nozzle and fuel supply manifold line.

Attach fuel nozzle No. 15 to the compressor rear frame with the three bolts. Torque the bolts to the appropriate value.

After five minutes, torque the bolts again. And after five more minutes torque the bolts once more.

Connect the tube fitting from the fuel supply manifold line to the fuel nozzle. Torque the tube fitting to the appropriate value. Refer to the Aircraft Maintenance Manual for the correct torque sequence.

Do a leak check of the fuel supply manifold connections according to the Aircraft Maintenance Manual procedure.

Move the drain shroud in a forward direction and engage the locking tabs of the drain shroud into the slots of the fuel nozzle.

Turn the drain shroud 1/4 of a full turn to lock it in position.

Connect the tube fitting from the fuel manifold drain line to the drain shroud. Torque the tube fitting to the appropriate value. Refer to the Aircraft Maintenance Manual for the correct torque sequence.

Do a pressure decay check of the fuel nozzle drain manifold according to the Aircraft Maintenance Manual procedure.

Secure the three bolts of the fuel nozzles with the lockwire.

Check that the lockwire is correct.

Complete the procedure according to the Aircraft Maintenance Manual.