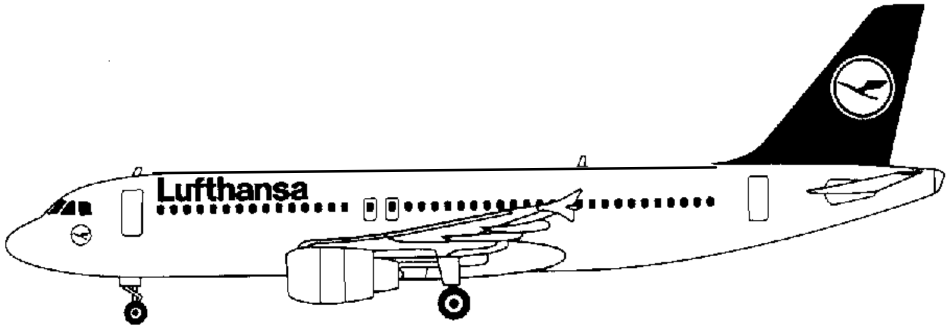

Lufthansa Technical Training

Training Manual
A319 / A320 / A321

ATA 71-80
ENGINE CFM56-5A
ATA 30-21
AIR INTAKE ICE PROTECTION
LEVEL 3

PART-2

Book No: A319/320/321 71-80CFM L3 e
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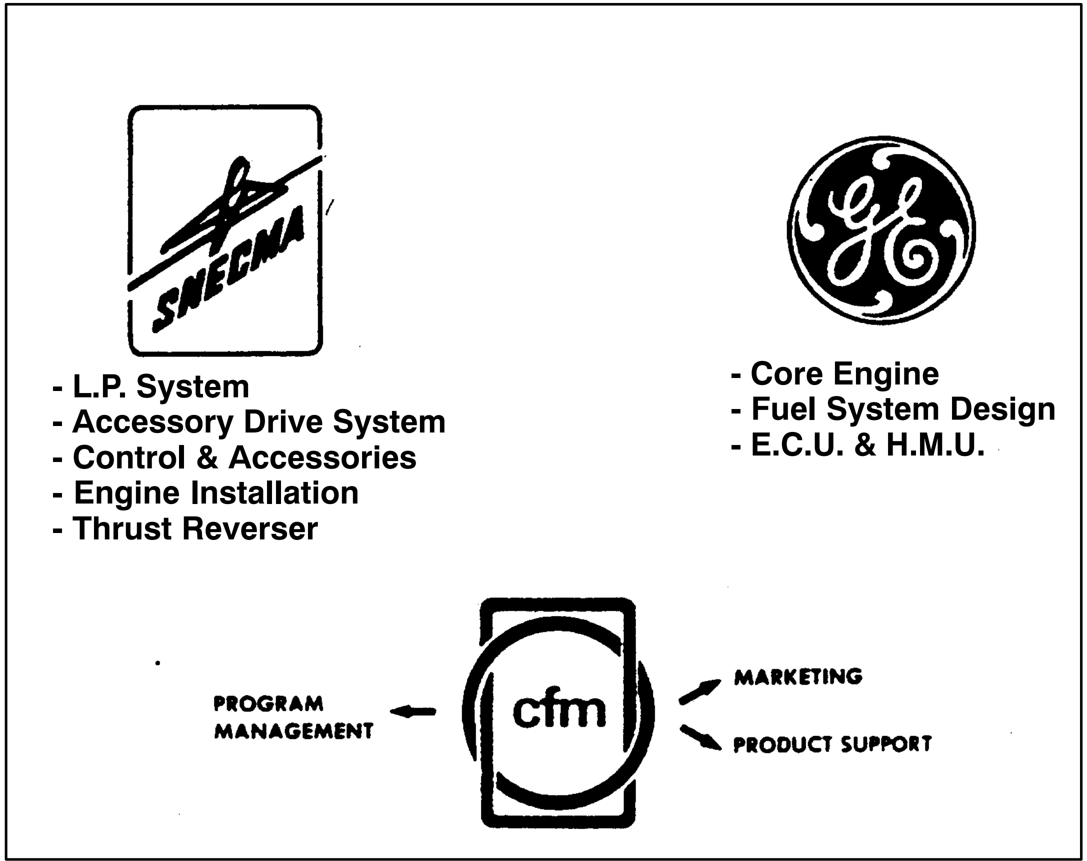
ATA 71 POWER PLANT

71-00 INTRODUCTION

CFM 56 CONCEPT

The CFM 56 turbofan engine family is a product of **CFMI** (Comercial Fan Motor International). CFM International is a company jointly owned by "General Electric" of the USA and "Societe Nationale d'Etude et de Construction de Moteurs d'Aviation" (SNECMA) of France.

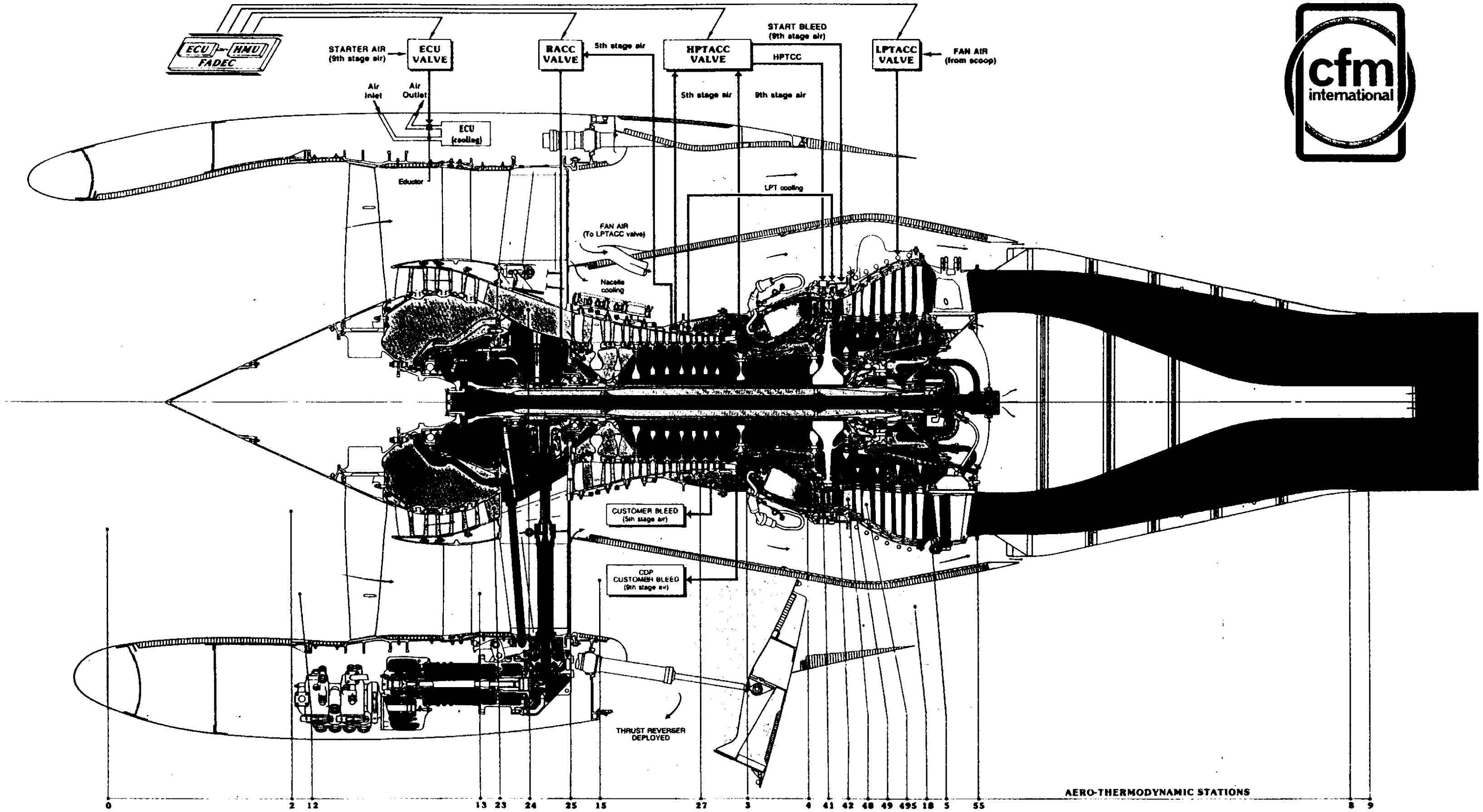


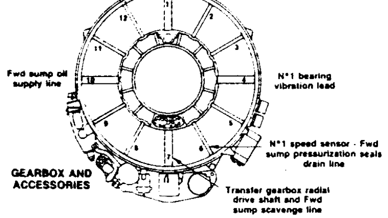
CFM 56-5 FAMILY MODELS

Family Models	CFM 56-5A1	CFM 56-5A3	CFM 56-5A4	CFM 56-5A5	CFM 56-5B1	CFM 56-5B2	CFM 56-5B4	CFM 56-5B5	CFM 56-5B6
AIRCRAFT TYPE	A320	A320	A319	A319	A321	A321	A320	A319	A319
THRUST	25000 lb	26500 lb	22000 lb	23500 lb	30000 lb	31000 lb	27000 lb	22000 lb	23500 lb
FLAT RATED TEMPERATURE (DEG C / DEG F)	30°/86°	30°/86°	30°/86°	30°/86°	30°/86°	30°/86°	45°/113°	45°/113°	45°/113°
BYPASS RATIO	6 : 1	6 : 1	6.2 :1	6.2 : 1	5.5 : 1	5.5 : 1	5.7 : 1	6 : 1	5.9 : 1
MASS FLOW	852lb/sec	876lb/sec	816lb/sec	842lb/sec	943lb/sec	956lb/sec	897lb/sec	818lb/sec	844lb/sec
OVERALL PRESS. RATIO	31.3	31.3	31.3	31.3	35.5	35.5	32.6	32.6	32.6
EGT (DEG C)	890°/915°	915°	890°/915°	890°/915°	950°	950°	950°	950°	950°
N1 (RPM)	5100	5100	5100	5100	5200	5200	5200	5200	5200
N2 (RPM)	15183	15183	15183	15183	15183	15183	15183	15183	15183

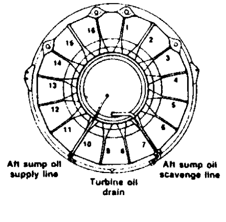
ENGINE CHARACTERISTICS

Family Models	CFM 56-5A1	CFM 56-5A3	CFM 56-5A4	CFM 56-5A5	CFM 56-5B1	CFM 56-5B2	CFM 56-5B4	CFM 56-5B5	CFM 56-5B6
LENGTH (INCH)	95,4	95,4	95,4	95,4	102,4	102,4	102,4	102,4	102,4
FAN DIAMETER (INCH)	68,3	68,3	68,3	68,3	68,3	68,3	68,3	68,3	68,3
BASIC DRY WEIGHT (lb)	4995	4995	4995	4995	5250	5250	5250	5250	5250
FAN / LP / HP STAGE NUMBERS	1+3+9	1+3+9	1+3+9	1+3+9	1+4+9	1+4+9	1+4+9	1+4+9	1+4+9
HP / LP TURBINE STAGE NUMBERS	1+4	1+4	1+4	1+4	1+4	1+4	1+4	1+4	1+4





FAN FRAME (AFT LOOKING FWD)



TURBINE FRAME (AFT LOOKING FWD)

AIRFLOW LEGEND

INLET	FAN MID-SHAFT CAVITY
FAN DISCHARGE	CENTER VENT DISCHARGE
BOOSTER DISCHARGE AND SUMP PRESSURIZATION	SUMP VENT
BOOSTER DISCHARGE BLEED FOR HPC-HPT-LPT COOLING	HPT-LPT INTERFACE
COMPRESSOR DISCHARGE	AFT LPT ROTOR COOLING
HPT CLEARANCE CONTROL	VENT / DRAIN TUBE
CORE COMPARTMENT VENTILATION	COMBUSTION GAS
	LPT FRAME HUB COOLING

ENGINE STATION IDENTIFICATION

0	Free stream ambient conditions	24	Booster variable bleed valve discharge
2	Fan inlet front frame hub section	25	HP compressor inlet
3	HP compressor discharge	27	HP compressor 5th stg. bleed ext. station
4	Combustor discharge	41	HP turbine rotor inlet
5	Low pressure turbine discharge	42	HP turbine discharge
8	Primary exhaust nozzle throat	48	Low pressure turbine inlet
9	Primary exhaust nozzle discharge	49	Low pressure turbine rotor inlet
12	Fan inlet front flange tip section	55	LP turbine frame EGT exit
13	Fan OGV discharge	495	Exhaust gas temperature measuring plane
15	Fan frame discharge		
18	Bypass exhaust nozzle throat		
23	Booster discharge		

Figure 1 CFM 56 -5

DIFFERENCES CFM 56-5A1 /5A5

The Engine CFM 56-5A5 is prepared for dual thrust-rating.

- Basic rating is 23500 lbs with FLEX rating to max. climb thrust.
- Alternate rating is 22000 lbs, no FLEX rating.

The selection of the thrust rating can be done via MCDU.

The letter "D" near to the N1 indication on the EWD indicates, that the alternate rating is selected (as soon as the ECU is powered).

Engine Commonality

After the embodiment of some CFMI service bulletin's, a upgrading of the CFM56-5A1 (A320 standard) to the CFM56-5A5 (A319 standard) is possible. See also " ECU intermix".

ATA 73 ENGINE FUEL AND CONTROL

ECU intermix A320 / A319.

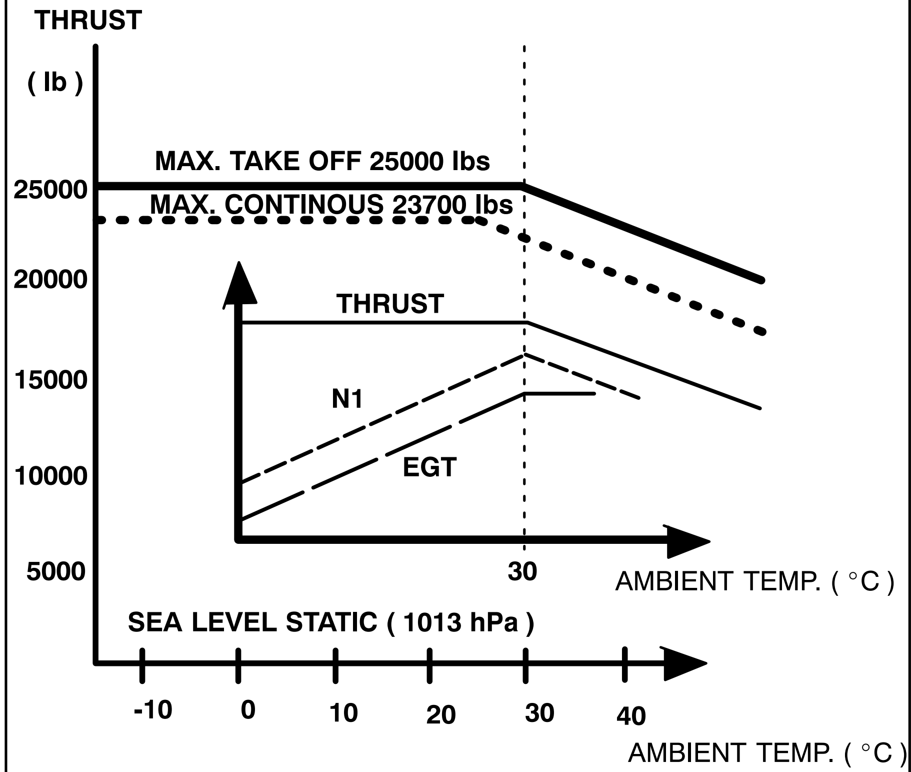
When the ECU software P25 (P26) is installed the ECU's are interchangeable.

ATA 75 AIR

- Rotor Active Clearence Control System (RACC).
- ECU Cooling System.

Both systems are not installed on the A319.

FLAT RATED THRUST RATING



CFM 56-5A1 ENGINE DATA (LUFTHANSA CONFIG)

Take OFF Thrust (Sea Level Static) Time Limit 5 min: Flat Rated Ambient Temperature Max Continous (Sea Level Static) Flat Rated Ambient Temperaturen	**25000 lbs = 11120 daN** **86° = 30°C** **23700 lbs = 10500 daN** **77°F = 25°C**
Airflow (Take off)	**852 lbs/sec = 426 kg/sec**
By - Pass Ratio	**6 : 1**
Compressor Pressure Ratio (overall,Take Off, SLS)	**26,5 : 1**
Fan Pressure Ratio (Take Off, SLS)	**1,55 : 1**
Fan Thrust / Core Thrust (At Take Off)	**80% / 20%**
Turbine Inlet Temperature (T41) (Take Off -Hot Day)	**2311°F = 1265°C**
EGT (T49,5) RED LINE MAX CONTINOUS ENG. START	**890°C** **855°C** **725°C**
N1 & N2 Direction of Rotation	**Clockwise** (aft looking forward)
N1 Design Speed 100% N1 MAX. 102%	**5000 min -1** **5100 min -1**
N2 Design Speed 100% N2 MAX. 105%	**14460 min -1** **15183 min -1**
TSFC (Standart, Static) Take Off MAX. Contious 75%	 **0,343 lbs/lbs x h** **0,339 lbs/lbs x h** **0,326 lbs/lbs x h**
TSFC (MACH 0,8) Altitude 35000 ft, Std. Day	**0,596 lbs/lbs x h**
Engine Weight	**4734 lbs = 2150 Kg**

71-00 ENGINE HAZARD AREAS

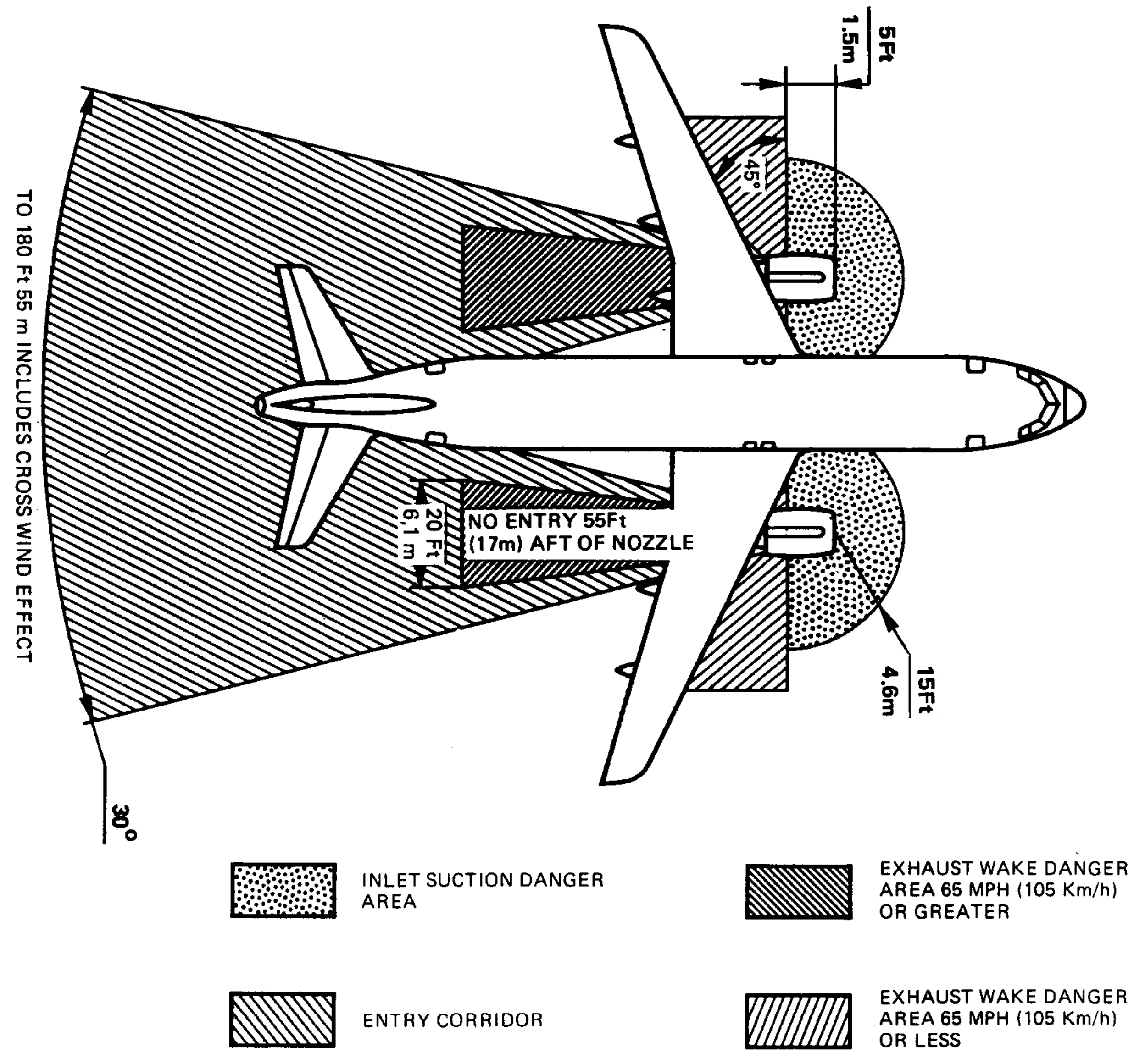


Figure 2 Engine Hazard Areas

ATA 73 ENGINE FUEL AND CONTROL

73-20 FADEC GENERAL

FADEC PRESENTATION

FADEC : Full Authority Digital Engine Control.

GENERAL

The Full Authority Digital Electronic Control **(FADEC)** system provides full range control of the engine to achieve steady state and transient performance when operated in combination with aircraft subsystems.
The engine control is built around a Full Authority Digital Engine Control system, which serves as an interface between the aircraft and the engine control and monitoring components.

The FADEC system of each engine consists of a dual channel Electronic Control Unit (ECU), with its associated peripherals.

ECU : Electronic Control Unit.

NOTE:
There are no adjustments possible on the FADEC system (e.g.Idle,Part Power etc.)

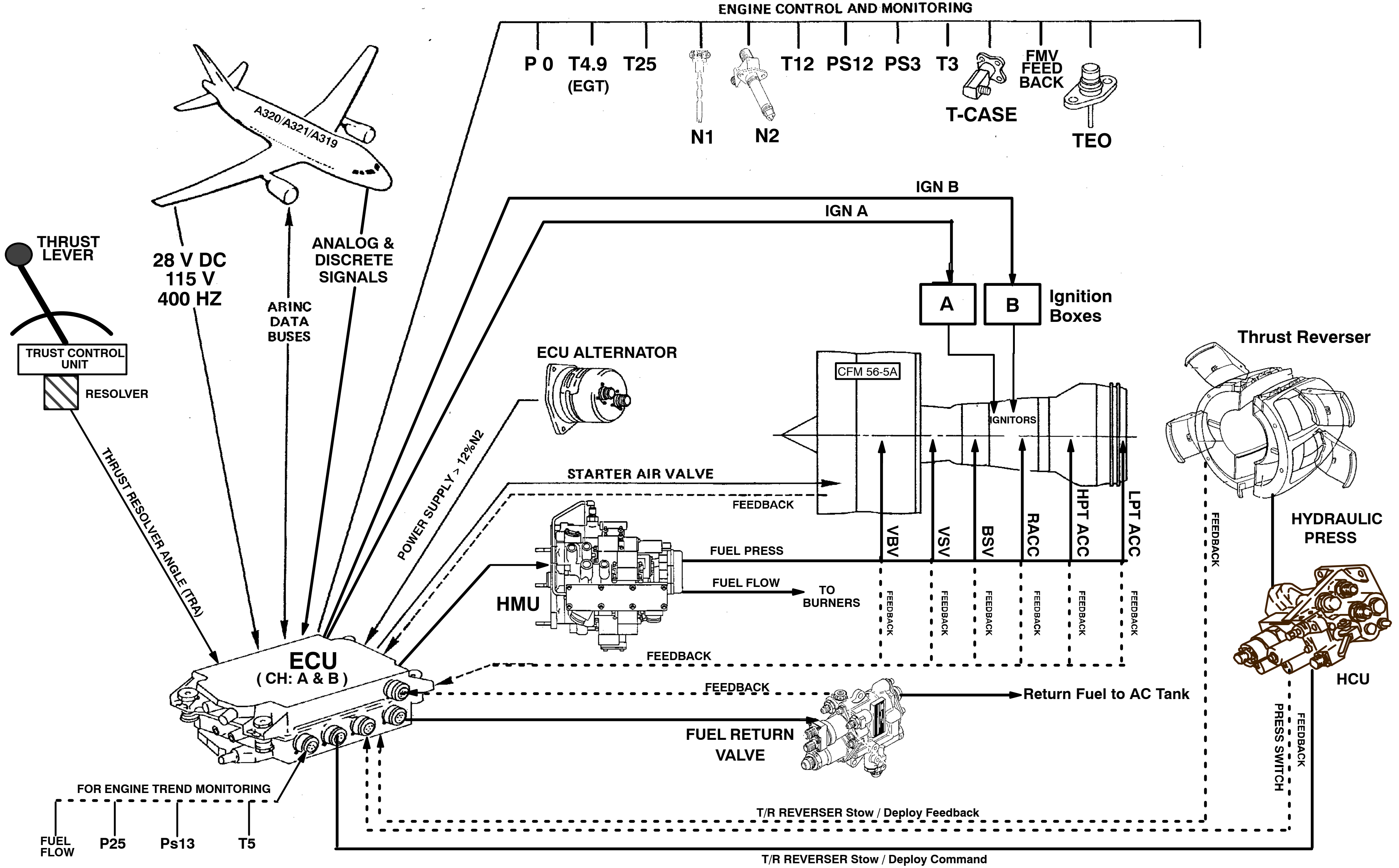


Figure 3 FADEC Presentation CFM 56-5A

FADEC FUNCTIONS

Full Authority Digital Engine Control (FADEC)

The FADEC consists of the Engine Control Unit (ECU), Hydromachanical Unit (HMU) and its peripheral components and sensors used for control and monitoring.

FADEC Definition

Each engine is equipped with a duplicated FADEC system. The FADEC acts as a propulsion system data multiplexer making engine data available for condition monitoring.

FADEC Controls

The FADEC provides the engine sytem regulation and scheduling to control the thrust and optimize the engine opration.

The FADEC provides:

- Fuel control regulation
- power management
- gas generator control
- Turbine active clearance control
- flight deck indication data
- Engine maintenance data
- Contitioning monitoring data
- engine limit protection
- thrust reverse control
- feedback
- automatic engine starting
- Fuel return control for IDG cooling

Power Management

The FADEC provides automatic engine thrust control and thrust parameters limits computation.
The FADEC manages power according to two thrust modes:

- manual mode depending on thrust lever angle (TLA)
- Autothrust mode depending on autothrust function generated by the auto flight system (AFS).

The FADEC also provides two idle mode selections:

- Approach Idle: it is obtained when slats are extended in FLT.
- Minimum Idle: it can be modulated up to approach idle depending on:
  - Air conditioning demand
  - Engine anti ice demand
  - Wing anti ice demand
  - Temperature Engine Oil (TEO for IDG cooling).

Engine Limit Protection

The FADEC provides overspeed protection for N1 and N2, in order to prevent engine exceeding certified limits, and also monitors the EGT.

Engine Systems Control

The FADEC provides optimal engine operation by controlling the:

- Fuel Flow
- Compressor air flow and turbine clearence.

Thrust Reverse

The FADEC supervises entirely the thrust reverse operation.
In case of a malfunction, the thrust reverser is stowed.

Start and Ignition Control

The FADEC controls the engine start sequence. It monitors N1, N2 and EGT parameters and can abort or recycle an engine start.

Power Supply

The FADEC system is self-powered by a dedicated permanent magnet alternator when N2 is above 15%, and is powered by the aircraft for starting, as a backup and for testing with engine not running.

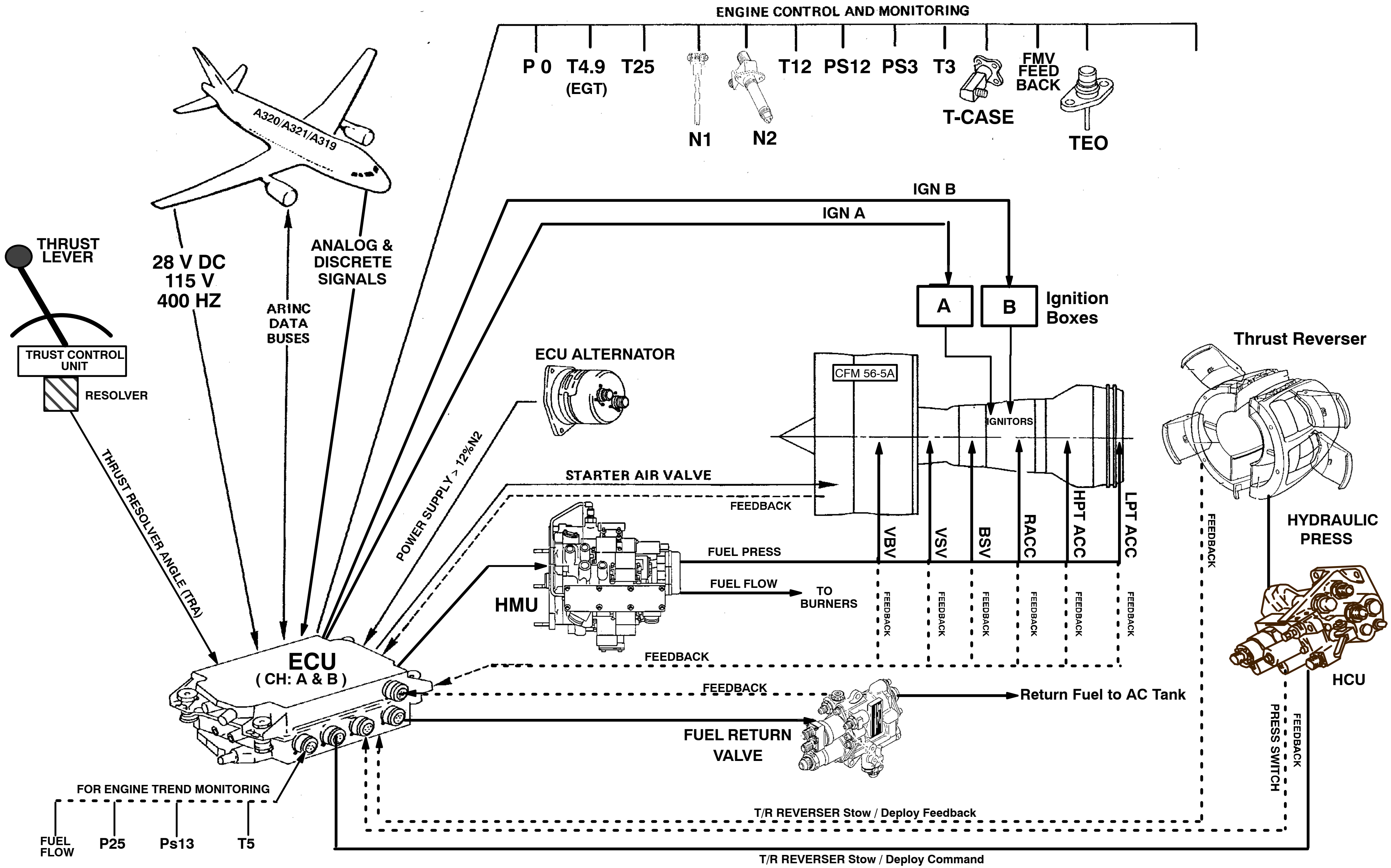


Figure 4 FADEC Presentation CFM 56-5A

ENGINE CONTROL P/B'S AND SWITCHES

Engine Mode Selector

Position **CRANK** :

- selects FADEC power.
- allows dry and wet motoring (ignition is not availiable).

Position **IGNITION** / **START** :

- selects FADEC power
- allows engine starting (manual and auto).

Position **NORM :**

- FADEC power selected OFF(Engine not running)

Engine Master Lever

Position **OFF** :

- closes the HP fuel valve in the HMU and the LP fuel valve.
- resets the ECU

Position **ON** :

- starts the engine in automatic mode (when the mode selector is in IGNITION / START).
- selects fuel and ignition on during manual start procedure.
- opens the LP-fuel valve and deenergizes the HP-fuel shut-off valve in the HMU.

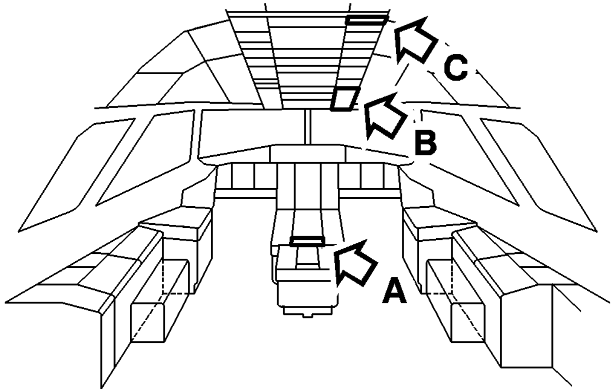
Manual Start P/B

- controls the start valve (when the mode selector is in IGNITION / START or CRANK position).

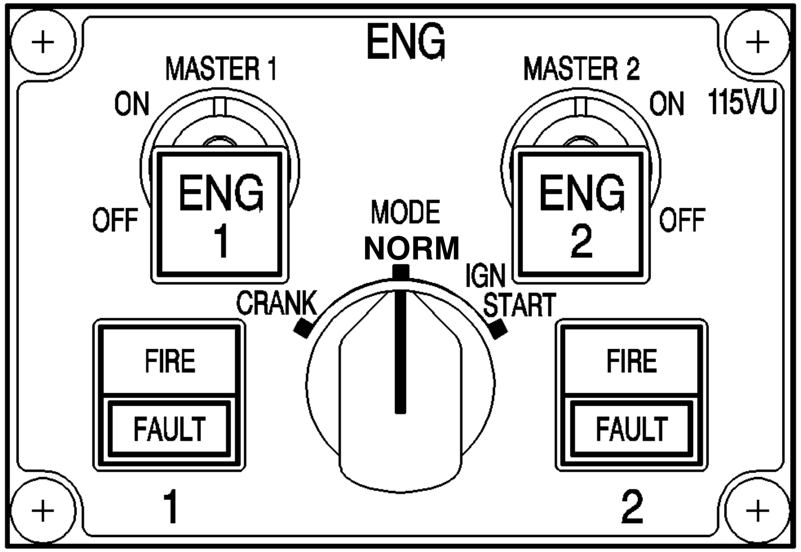
FADEC GND PWR P/B

Position **ON :**

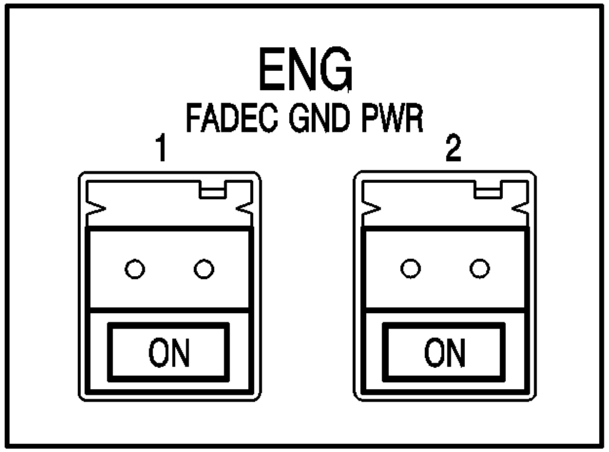
- selects FADEC power



A CENTRAL PEDESTAL 115VU



C MAINTENANCE PANEL 50VU



B OVERHEAD PANEL 22VU

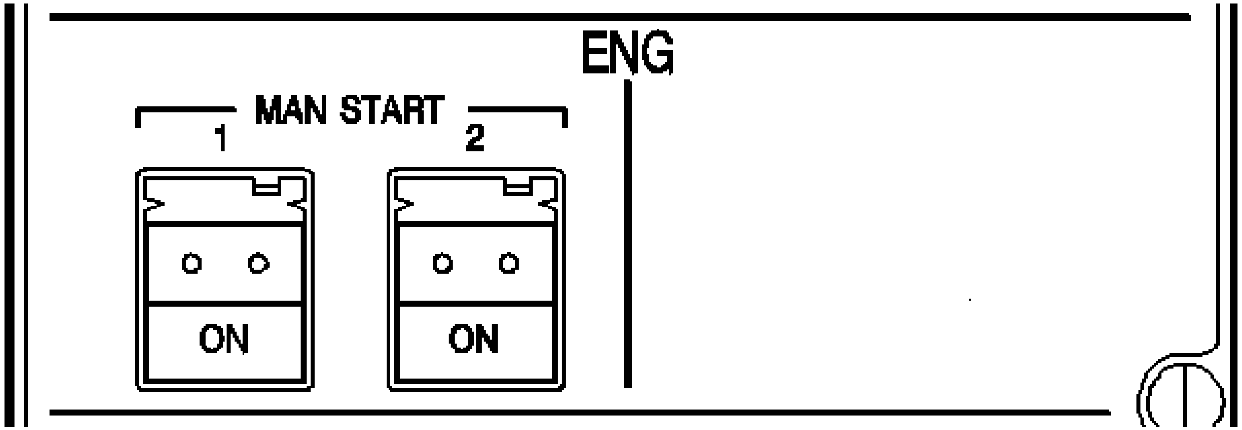
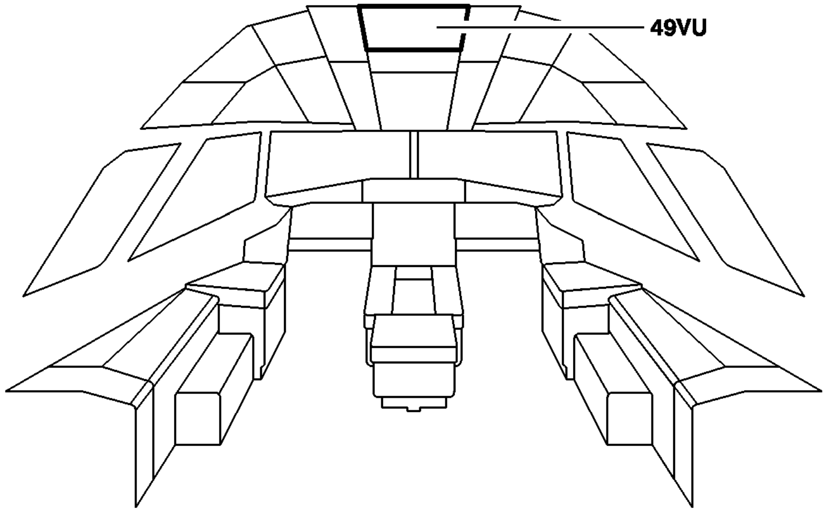


Figure 5 Engine Control P/B's and Switches



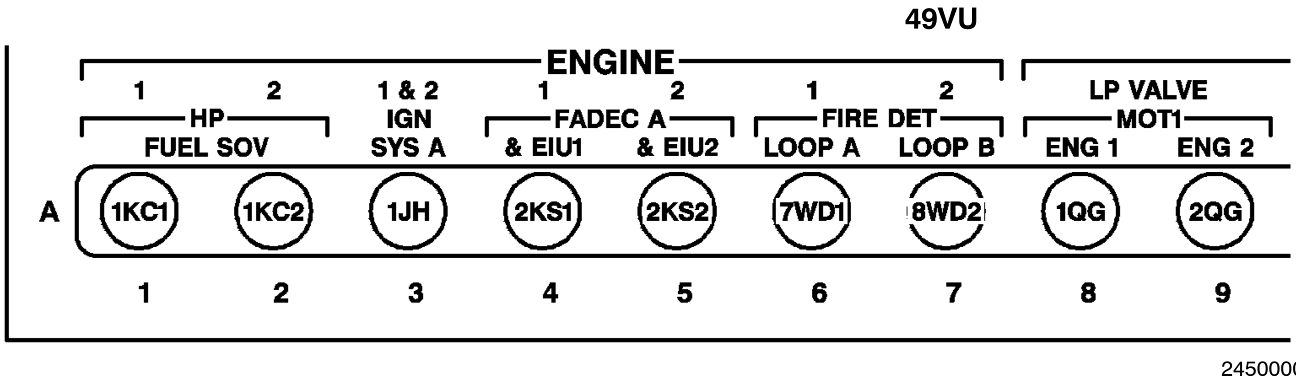
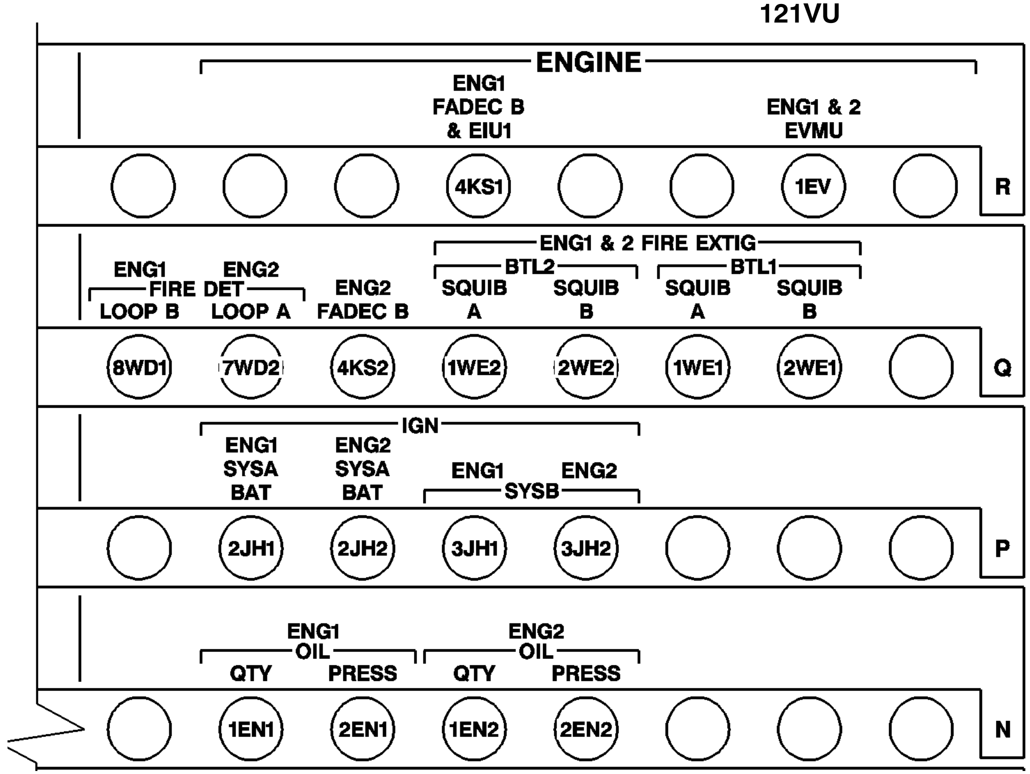


Figure 6 Engine Circuit Breakers



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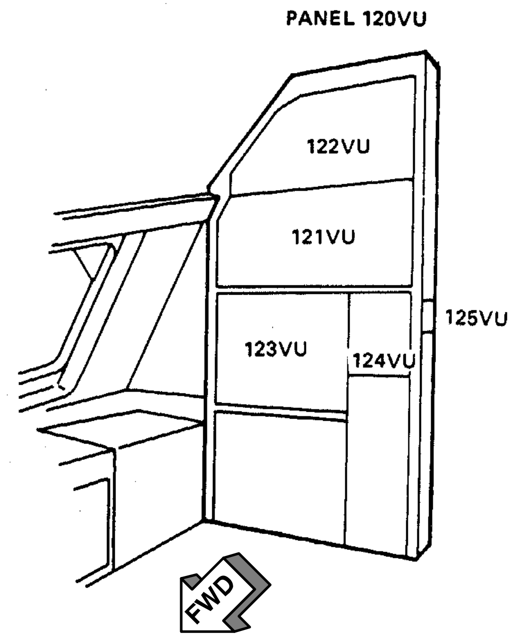

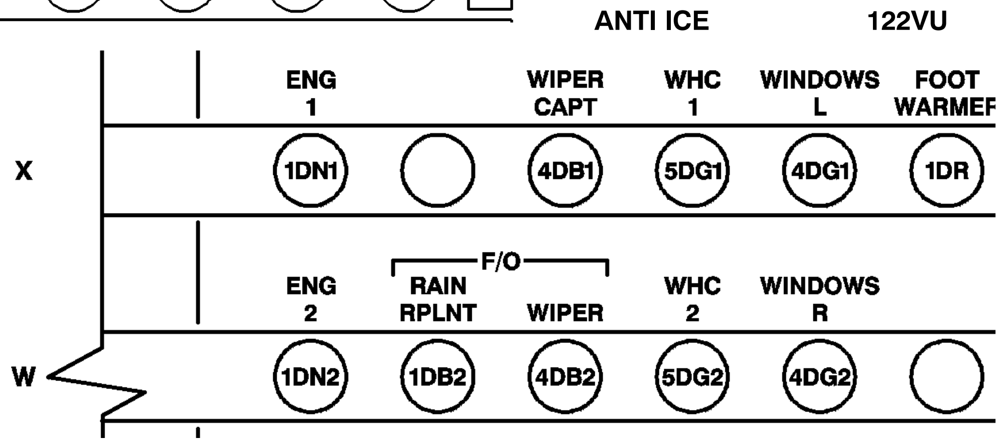

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Figure 7 Engine Circuit Breakers

ATA 77 INDICATING
77-00 ENGINE INDICATING PRESENTATION

INDICATION GENERAL

Primary Engine Display

The primary engine parameters listed below are permanently displayed on the Engine and Warning display (E / WD) :

- **N1 (low rotor speed)**
- **Exhaust Gas Temperature (EGT)**
- **N2 (high rotor speed)**
- **FF (fuel flow)**

After 5 min of the power up test the indication is displayed in amber and figures are crossed (XX). Normal indication can be achieved by using the FADEC GRD power switches, one for each engine at the maintenace panel or by the MODE selector switch on on the Engine panel at the pedestal in CRANK or IGN / START position for both engine.

If a failure occurs on any indication displayed, the indication is replaced by amber crosses, the analog indicator and the marks on the circle disappear, the circle becomes amber.

Only in case of certain system faults and flight phases a warning message appears on the Engine Warning Display.

Secondary Engine Display

The lower display shows the secondary engine parameters listed below. The engine page is available for display by command, manually or automatically during engine start or in case of system fault :

- Total FUEL USED
  For further info see ATA 73
- OIL quantity
  For further info see ATA 79
- OIL pressure
  For further info see ATA 79
- OIL temperature
  For further info see ATA 79
- Starter valve positions, the starter duct pressure and during eng start up, that operating Ignition system (ONLY ON ENGINE START PAGE)
- In case of high nacelle temperature a indication is provided below the engine oil temp. indication.
- Engine Vibration - of N1 and N2

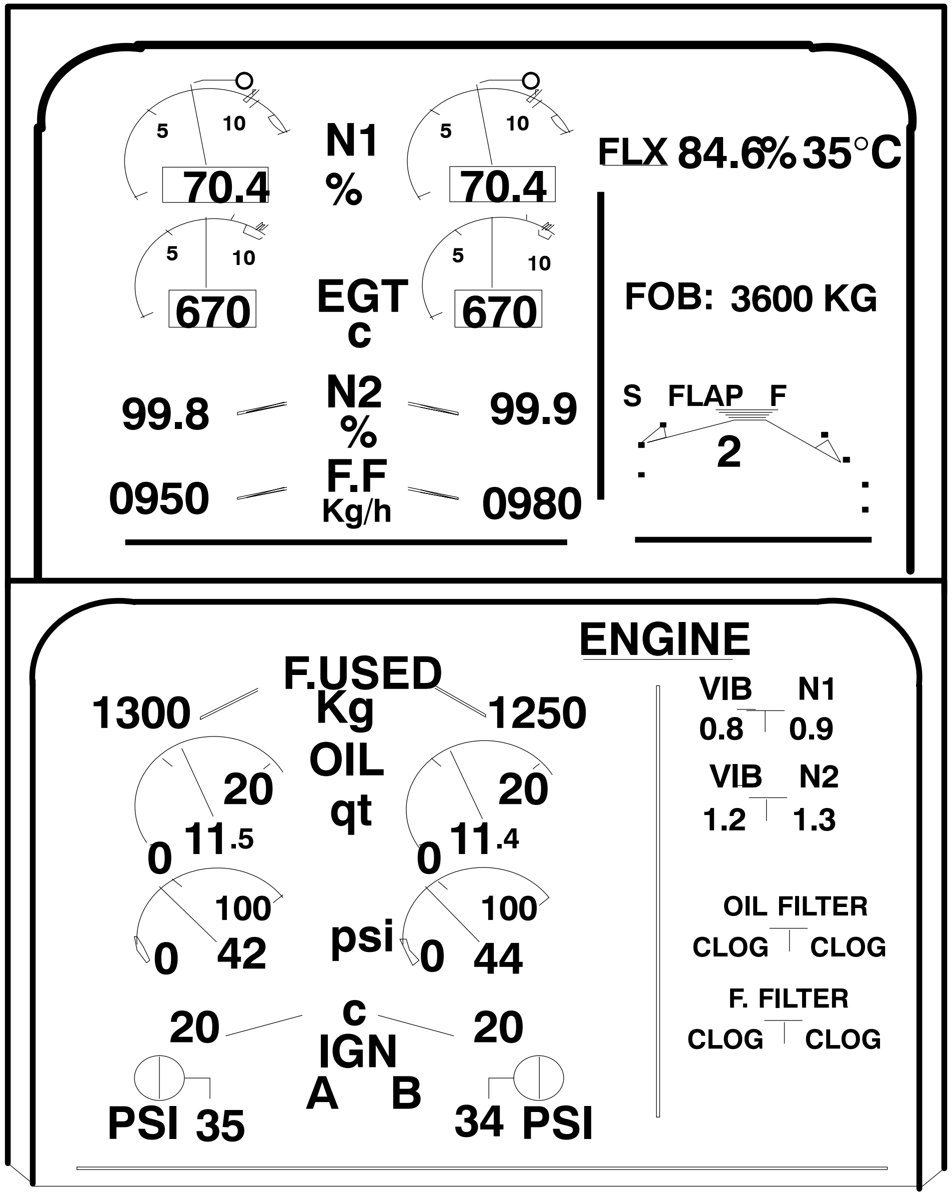
- As warnings by system problems only :
  - OIL FILTER CLOG
  - FUEL FILTER CLOG

Some engine parameters also displayed on the CRUISE page:

- F USED
- OIL QT
- VIB (N1 + N2)

UPPER ENG.
ECAM DISPLAY
UNIT

LOWER ENG.
ECAM DISPLAY
UNIT



NAC temp. indication:

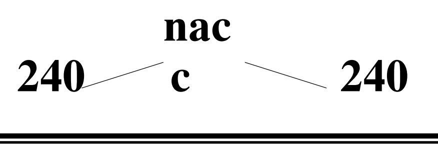


Figure 8 Engine ECAM Displays

STAGE NUMBERING CFM56-5A

STAGES :	COMPONENT :	STAGE NUMBER :	NOTES :
1	FAN	1	Fan air used for ACC
1 2 3	LOW PRESSURE COMPRESSOR (BOOSTER)	1 2 3	 VBV
1 2 3 4 5 6 7 8 9	HIGH PRESSURE COMPRESSOR	1 2 3 4 5 6 7 8 9	VSV (& IGV) VSV VSV VSV CUST. BLEED, Eng. Anti Ice (A/I) CUST. BLEED Muscle Press A/I Start Bleed
	COMBUSTION CHAMBER		20 Fuel Nozzles,2 Ignitor Plugs
1	HIGH PRESSURE TURBINE	1	ACTIVE CLEARANCE CONTROL
1 2 3 4	LOW PRESSURE TURBINE	1 2 3 4	ACTIVE CLEARANCE CONTROL
	EXHAUST NOZZLE		

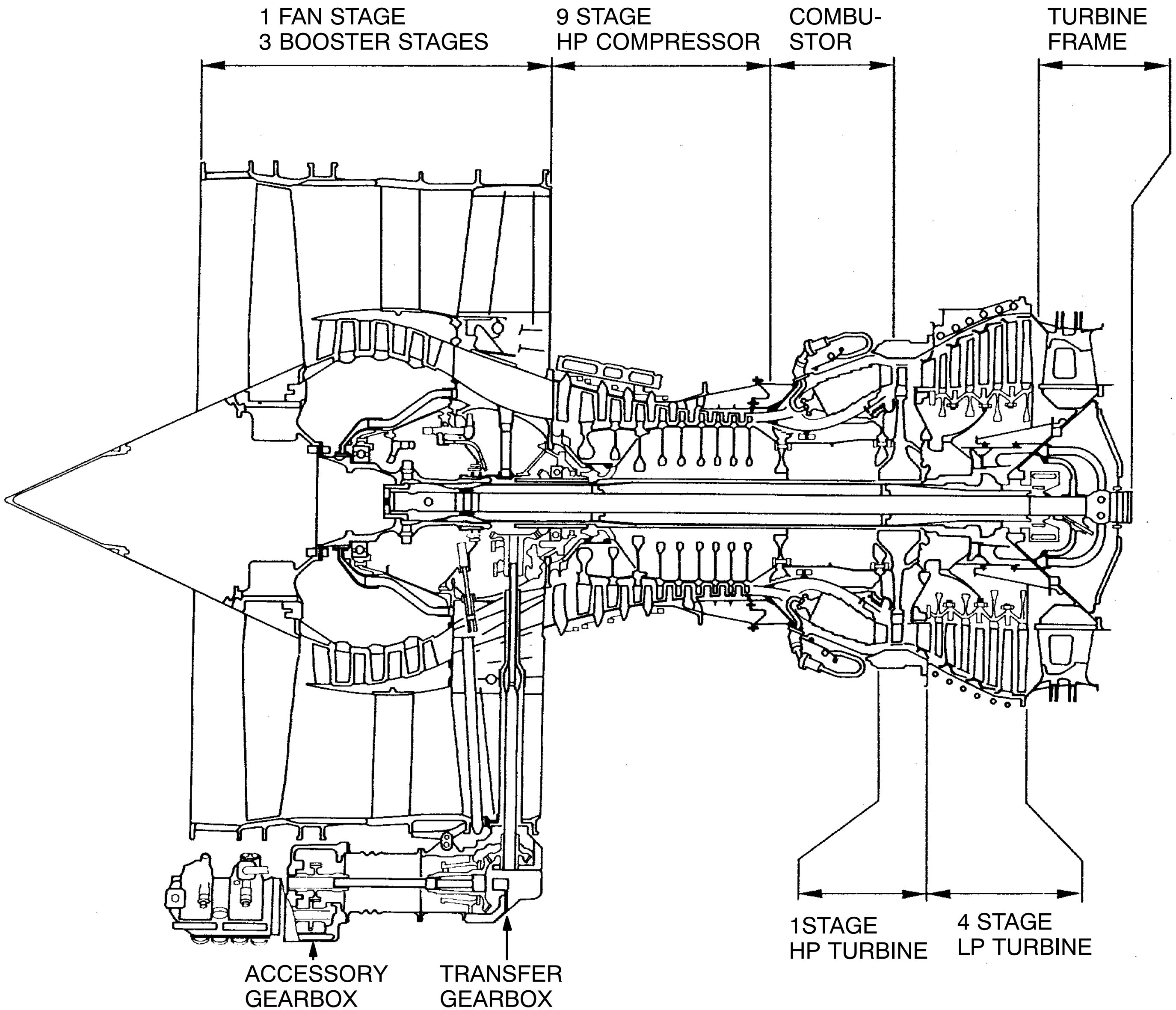


Figure 9 Engine Stages

ENGINE STATIONS CFM 56-5A

AERODYNAMIC STATION :	STATION LOCATION :	STATION USED FOR:
0	**AMBIENT**	**P0** = Ambient Static Pressure used for FADEC.
10	**INTAKE / ENGINE INLET INTERFACE**	
12	**FAN INLET**	**T12** = Fan (Booster Inlet Temp.) used for FADEC. **P12** = Fan (Booster) Inlet Press. (PT2) used for FADEC.
13	**FAN EXIT**	**PS13** = Static Pressure of Fan Bypass Air Flow used for Monitoring.
25	**L.P. COMPRESSOR (BOOSTER EXIT)**	**T25** = High Pressure Compressor Inlet Temp. (CIT) used for FADEC.**P25** = High Pressure Compressor Inlet Press. used for FADEC
30	**H.P. COMPRESSOR**	**T3** = High Pressure Compressor Discharge Temp. (CDT) **PS3** = Compressor Discharge Pressure (CDP) used for FADEC
40	**COMBUSTION SECTION EXIT**	
42	**H.P. TURBINE EXIT**	**T case** = HPT Shroud Support Temperature used for HPT Active Clearance Control
49	**L.P. TURBINE STAGE 2 INLET**	**T49.5** = Exhaust Gas Temp. (EGT) used for Cockpit Indication.
50	**EXHAUST**	**T5** = Total Temp. Turbine Rear Frame Plane used for Monitoring.

Flowpath aerodynamic stations have been established to facilitate engine performance assessment and monitoring.
As the CFM 56-5 is a high bypass engine,its airflow path features a primary and a secondary airflow.

Therefore manufacturer differentiates between:

- **Primary Stations** and **Secondary Stations**

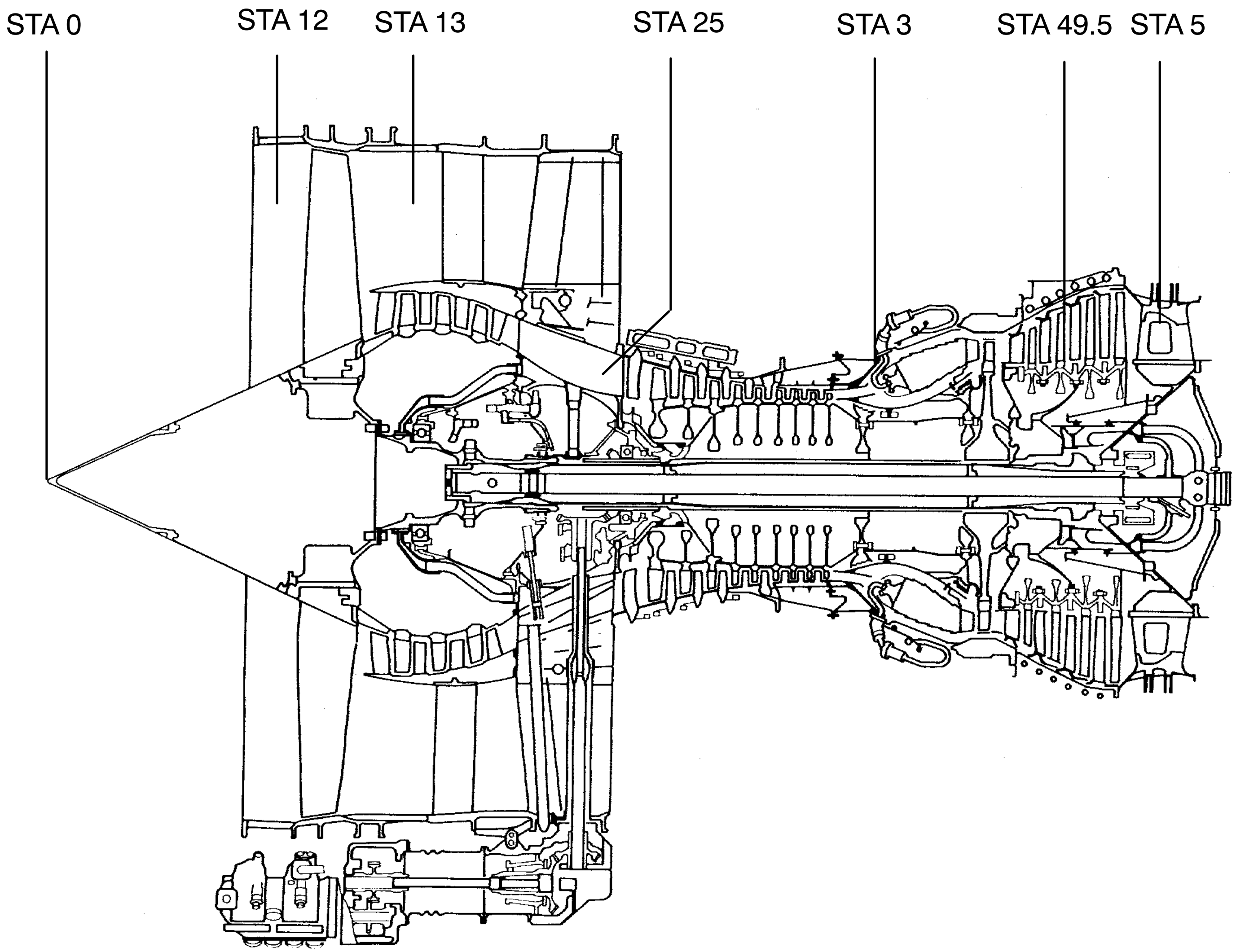


Figure 10 Aerodynamic Stations

ATA 72 ENGINE

72-00 GENERAL ARANGEMENT

ENGINE MODULES

Purpose

The engine is of modular design,thus enabling maintenance to be performed by maintenance work shops having limited repair capability.Modular maintenance is concerned primarily with replacement of modular assemblies and parts.

Major Modules

The engine has four major modules:

- **Fan and Booster major module**
- **Core major module**
- **Low pressure turbine major module**
- **Accessory drive module**

ENGINE MAIN BEARINGS

The rotors are supported by 5 bearings mounted in two engine sumps for lubrication system simplicity.

Bearings

The engine rotors are supported by bearings installed in the sump cavities provided by the two frames.
The forward sump is in the fan frame and is the location of bearings No. 1, No. 2 (fan/booster shaft) and No. 3 (HPshaft forward part).
The aft sump is in the turbine rear frame where are bearings No. 4 (HPshaft aft part) and No. 5 (LP shaft aft part).

Oil Distribution

The bearings must be lubricated and oil is distributed to these components by nozzles. However, the oil must be retained within the engine, so seals of various types are provided to confine the oil and directs its recirculation.

Seals Arrangement

The arrangement of oil and air seals, the provisions for oil supply, oil scavenge, seal pressurization, sump vent subsystems produce a system known as a dry sump.
Engine sumps are vented to ambient pressure through the ”center-vent” tube which is contained in the LP shaft.

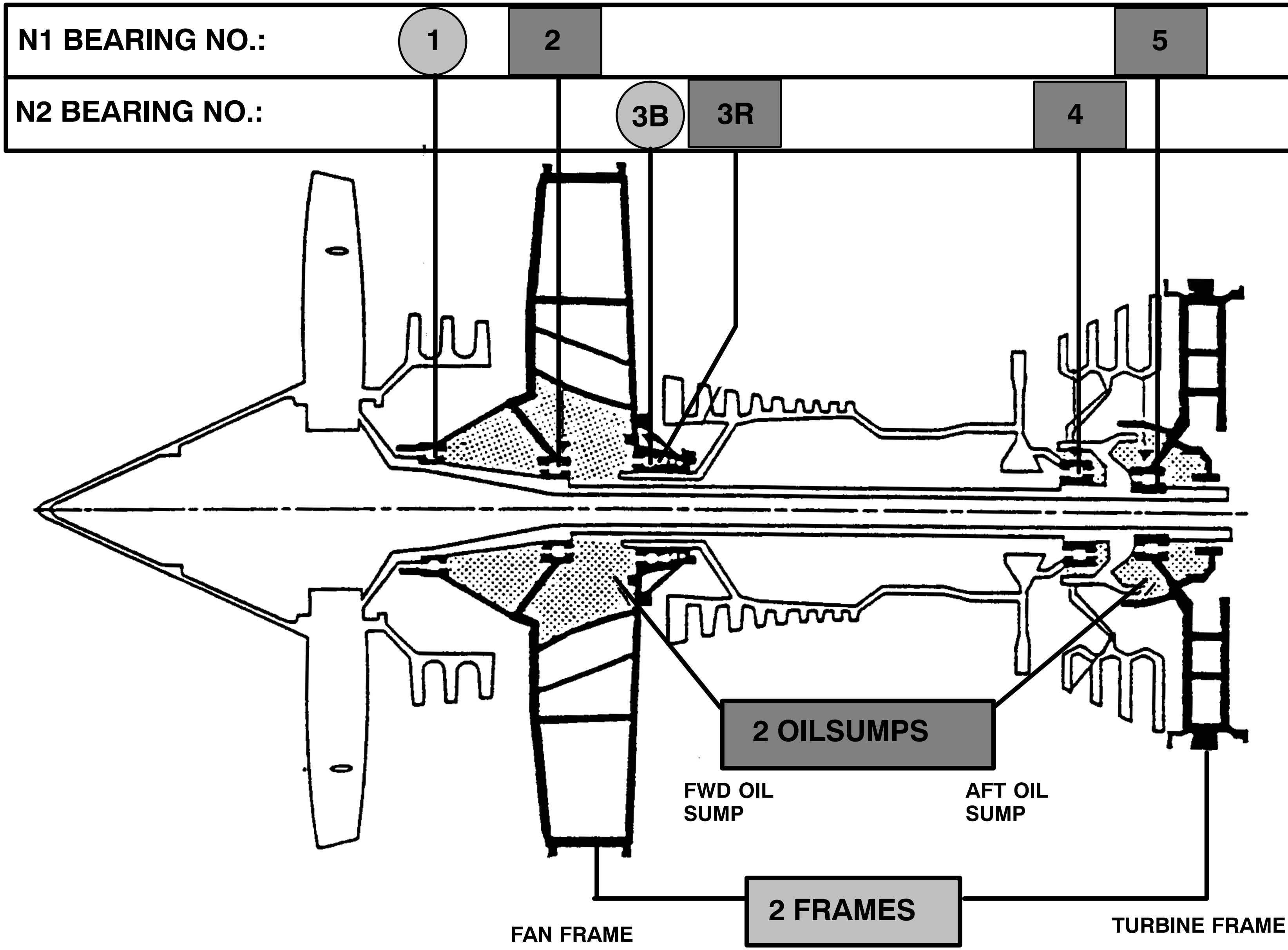


Figure 11 Engine Construction

FRAMES AND CASES

The two main load carring cases are called frames.The load from the rotorsystems and from the other cases are transfered to the frames.The frames transfer the load to the engine mounts.

ENGINE FLANGES

Flanges are located on the engine for attachment of brackets,claps,bolt,etc.

Physical Description

The external flanges of the engine have been assigned letter designations alphanumerical from A to U.The letters I,O and Q are not used.The letter designations are used for flange identification whenever it is necessary to be explicit about flange location.

Horizontal flanges are identified by:

Front stator case horizontal left flange.
Front stator case horizontal right flange.

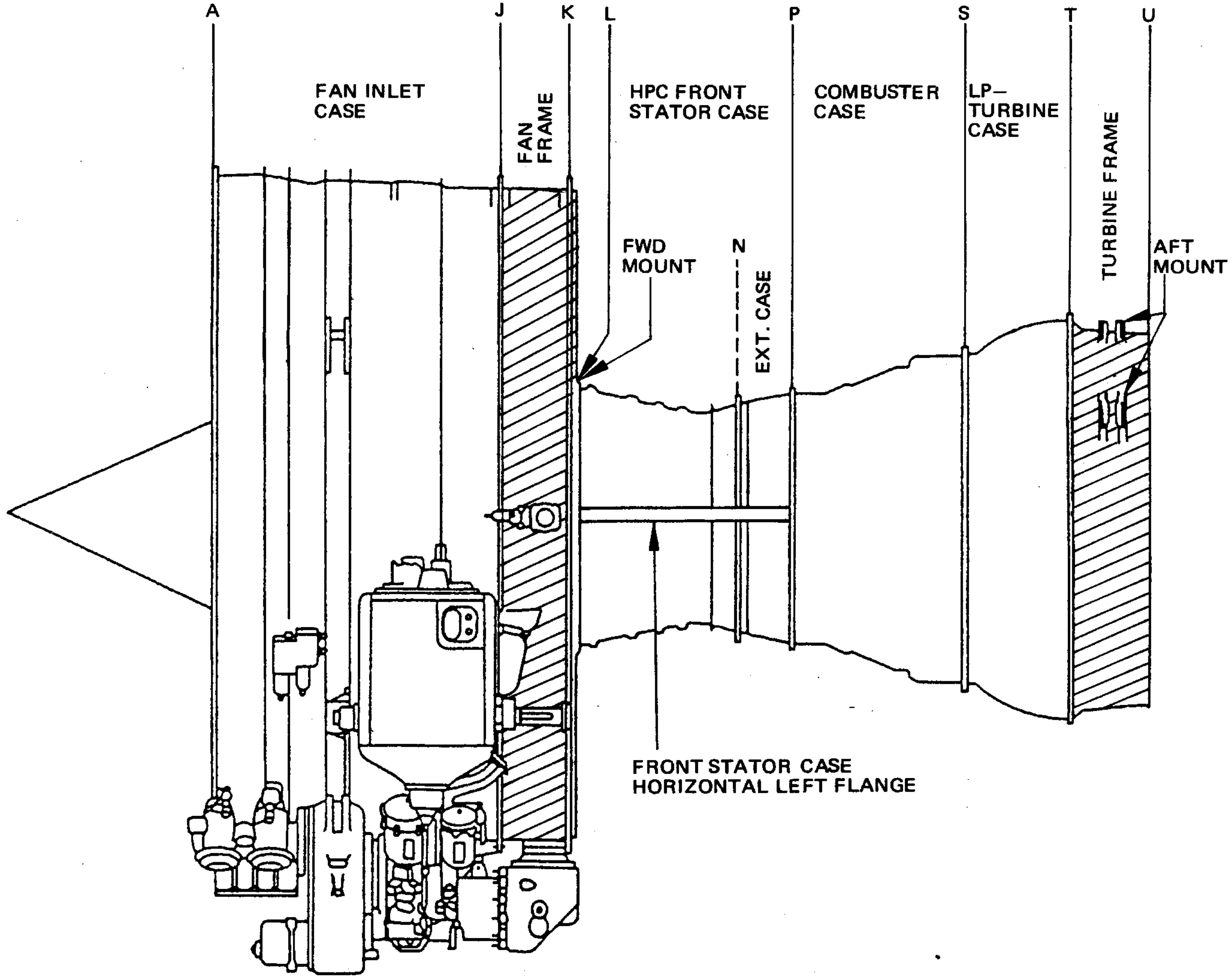


Figure 12 Engine Frames

72-20 FAN AND BOOSTER ASSEMBLY

FAN AND BOOSTER MODULE

Purpose

The fan and booster (LPC) module is driven by the low pressure turbine and provides two seperate air streams.
The primary (or inner) air stream flows through the fan and booster section where the air is compressed for introduction into the high pressure compressor.The secondary (or outer) air stream is mechanically compressed by the fan as it enters the engine and is ducted to the outside of the core engine.this secondary air stream adds to the propulsive force generated by the core engine.

Description

The fan and booster module consists of a single stage fan rotor and a 3-stage axial booster, cantilever-mouted at the rear of the fan disk.

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

- Spinner rear and front cones.
- Fan disk.
- Fan blades.
- Booster rotor.
- Booster vane assemblies.

Spinner Front Cone
The spinner front cone is made of composite material. Its design precludes the need for an engine nose anti-icing system. The front cone is bolted to the rear cone.

Spinner Rear Cone
The spinner rear cone is made of aluminum alloy. Its rear flange is bolted to the fan disk and is part of the fan blades retention system.The outer rim of rear flange is provided with tapped holes for trim balance bolts. The front flange provides for attachment of the spinner front cone.

Fan Disk
The fan disk is a titanium alloy forging. Its inner rear flange provides attachement for the fan shaft and its outer rear flange is bolted to the booster rotor. The outer front flange provides attachment for the spinner rear cone.

The disk outer rim has 36 recesses designed for fan blade retention.

Fan Blades
There are 36 titanium alloy, mid-span shrouded fan blades approximately 23in. (590 mm) long. Each of the blades has a dovetail base that engages in disk rim recess.Blades are individually retained by a spacer that limits radial movement,a blade retainer that limits forward axial movement and by the booster spool front flange that limits axial movement rearward.

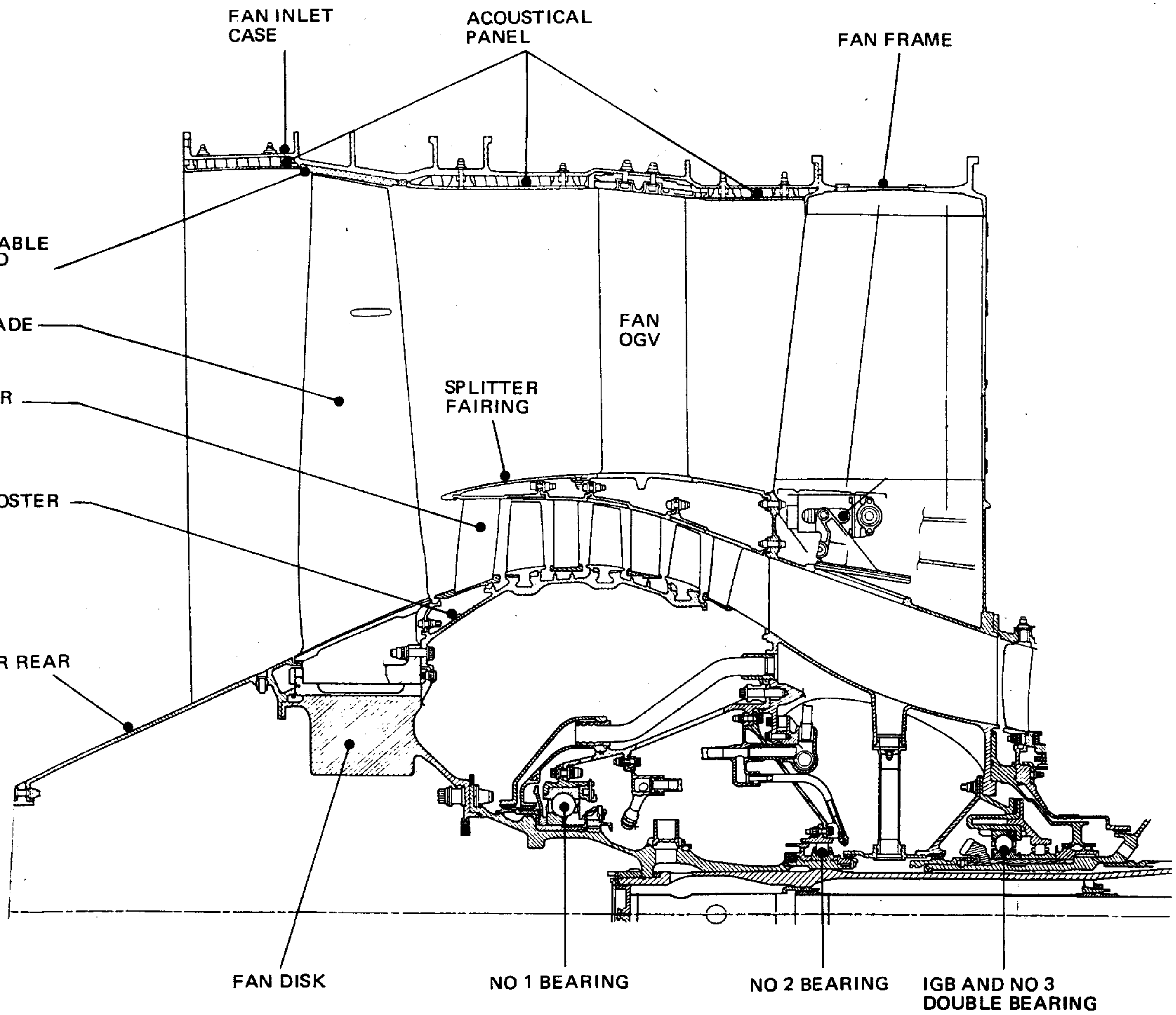


Figure 13 Fan and Bosster Assembly

FAN FRAME ASSEMBLY

The fan frame module provides front handling mounts and is the main forward support for mounting the engine to the aircraft. Its purpose is to support the fan, booster and high pressure compressor (HPC) rotors, and to provide ducting for primary and secondary airflows.
The fan frame module consists of the following major assemblies:
- Fan frame assembly.
- Fan outlet guide vane (OGV) assembly.

Functions.
The Fan Frame and Fan Case perform the following primary functions:

Fan Frame.
- An inlet airflow path to the core engine.
- A support for loads of the fan stator, fan rotor and fan reverser.
- Containment of accessory drive power take off gearing and shaft.
- A variable bypass valve system.
- Housing for service lines for lubrication of bearings, inlet gearbox and scavenge of the FWD oil sump.
- Support for the fan OGV's and fan inner flowpath acoustic panels.

Fan Case.
- Provides for attachment of the engine inlet cowl and the support and transmission of attachment loads from this point to the fan frame.
- Provides fan blade containment.
- Provides attachment points for acoustical panels.
- Provides an abradable microballon shroud for fan blade tips.

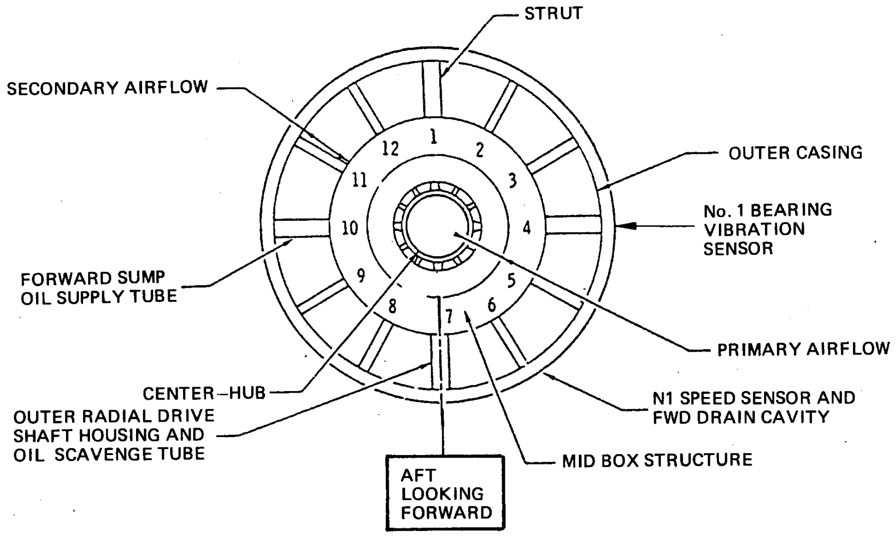
RADIAL STRUTS

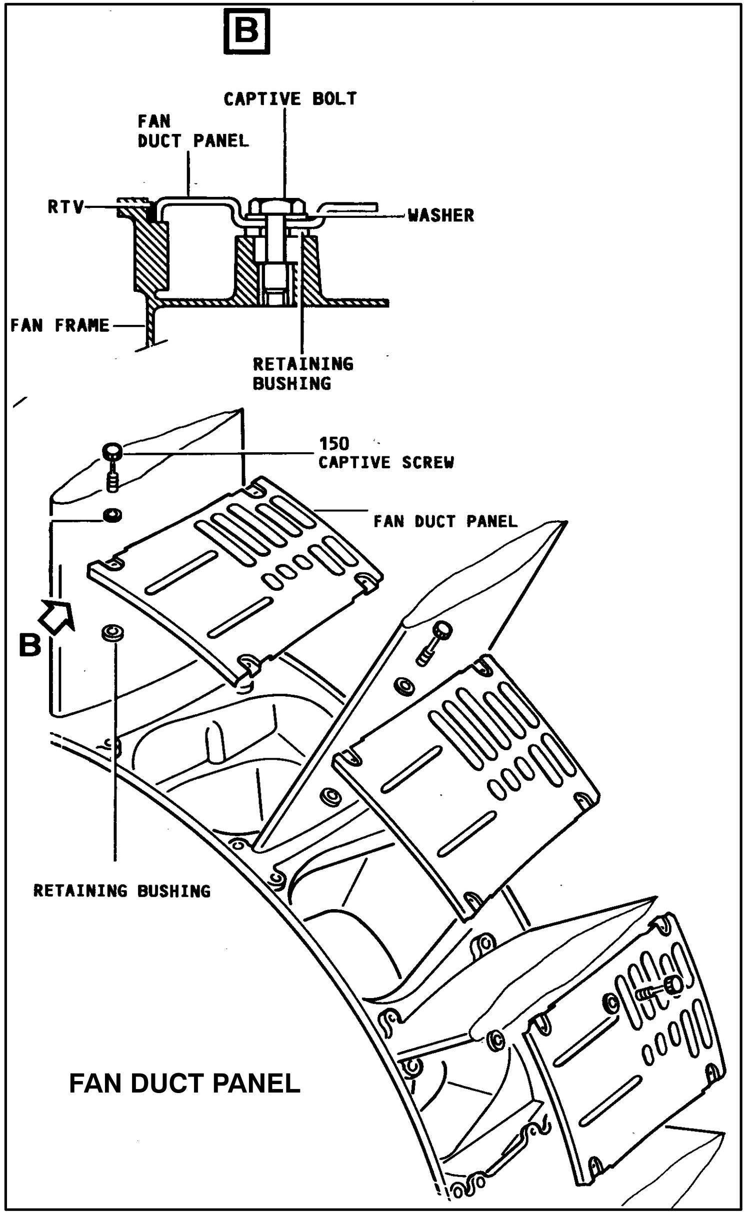
Fan Frame Assembly
The fan frame assembly is a frabicated structural weldment constructed of concentric rings connected by radial struts. It consists of the basic fan frame structure and the fan inlet case.
The basic fan frame structure is made of steel alloy. It consists of a hub, mid box structure and outer casing interconnected through 4 thick and 8 thin radial struts.

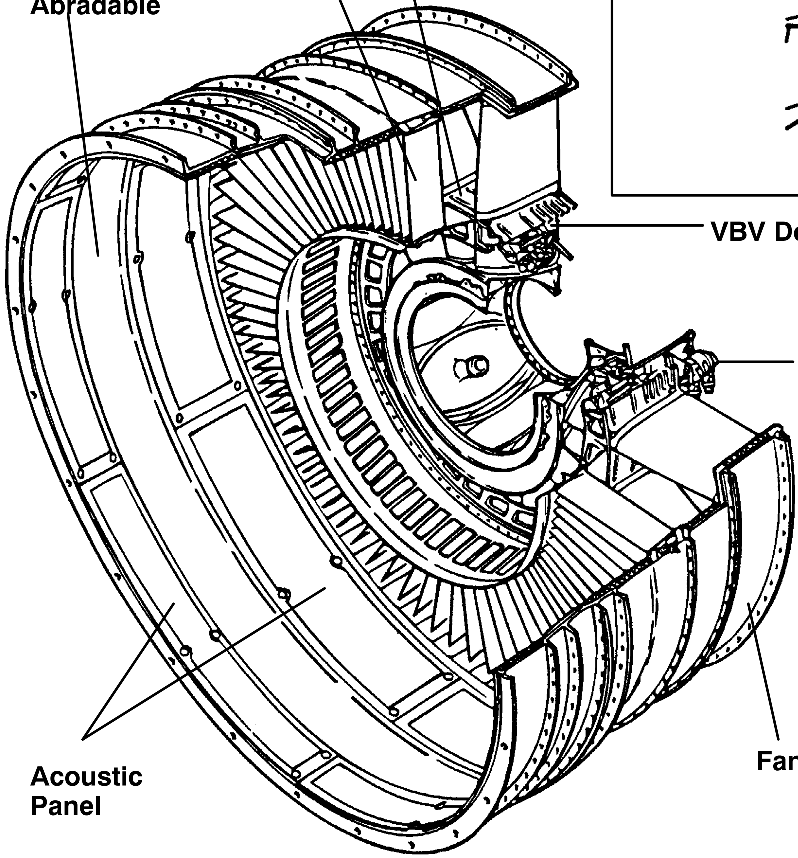
Structural strength for the fan frame is obtained from the 12 struts. The struts are hollow and provide passage for the following equipment :

- No. 1 bearing vibration sensor cable (No. 4 strut).
- N1 speed sensor and FWD sump cavity drain (No. 6 strut).
- Transfer gearbox (TGB) radial drive shaft and scavenge tube (No. 7 strut).
- Forward sump oil supply tube (No. 10 strut).

Radial Struts







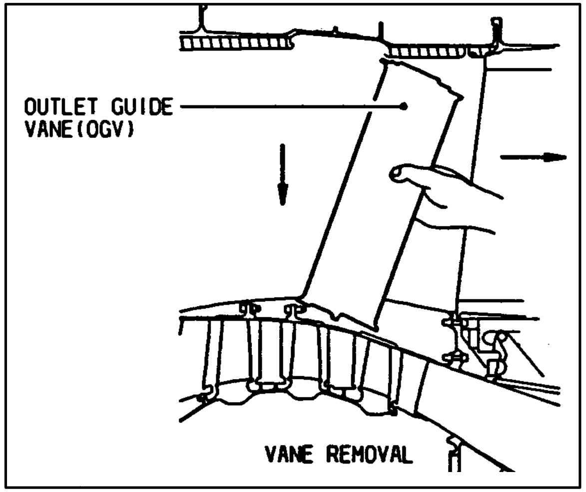


Figure 14 Fan Frame Assembly

72-21 FAN ROTOR BLADES

FAN BLADE REPLACEMENT

Sometimes it is neccessary to change fan blades if they are damaged.Single or pairs of spare blades can then be installed.
The spare blades are grouped in pairs so that the difference between the moment weights is limited to 200 cm.g.
However, you must do the checks and corrections described below before and after blade installation to limit the engine vibration level and optimize its operation.
3 cases can exist:

- If you must replace 3 pairs of fan blades or less and if the resultant static imbalance is less than 80 cm.g no correction is necessary.
- If you must replace 3 pairs of fan blades or less and if the resultant static imbalance is between 80 cm.g and 400 cm.g, only a static correction of imbalance is necessary.
- If you must replace more than 3 pairs of fan blades or if the resultant static imbalance is greater than 400 cm.g, a new fan blade distribution by hand method a computer method and a static correction of imbalance are necessary.

NOTE :
In all replacement cases: 1,2,3....or more pairs of fan blades and for individual fan blade replacement, do a vibration check after the static correction if the aircraft is at the main base or as soon as the aircraft returns to the base .Results from the vibration survey will determine if the trim balance is necessary.

Record location of each blade to be replaced and of each blade opposite.

CAUTION :
FOR EACH PAIR OF FAN BLADES, INSTALL THE HEAVIER SPARE BLADE AT THE POSITION OF THE HEAVIER BLADE TO BE REMOVED.

Remove damaged fan blades and install spare blades.

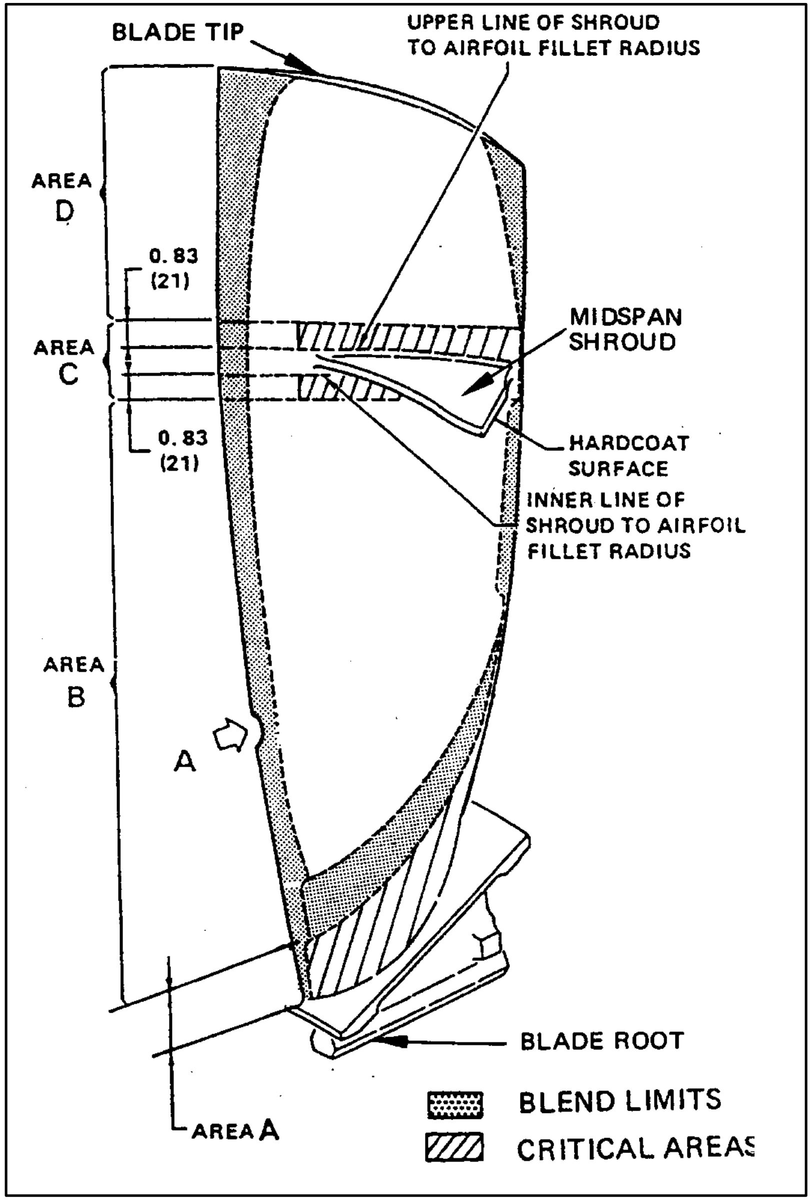
Determine the resultant vector length and direction, then select balance screws to provide a correction returning the fan to its initial balance condition as follows.

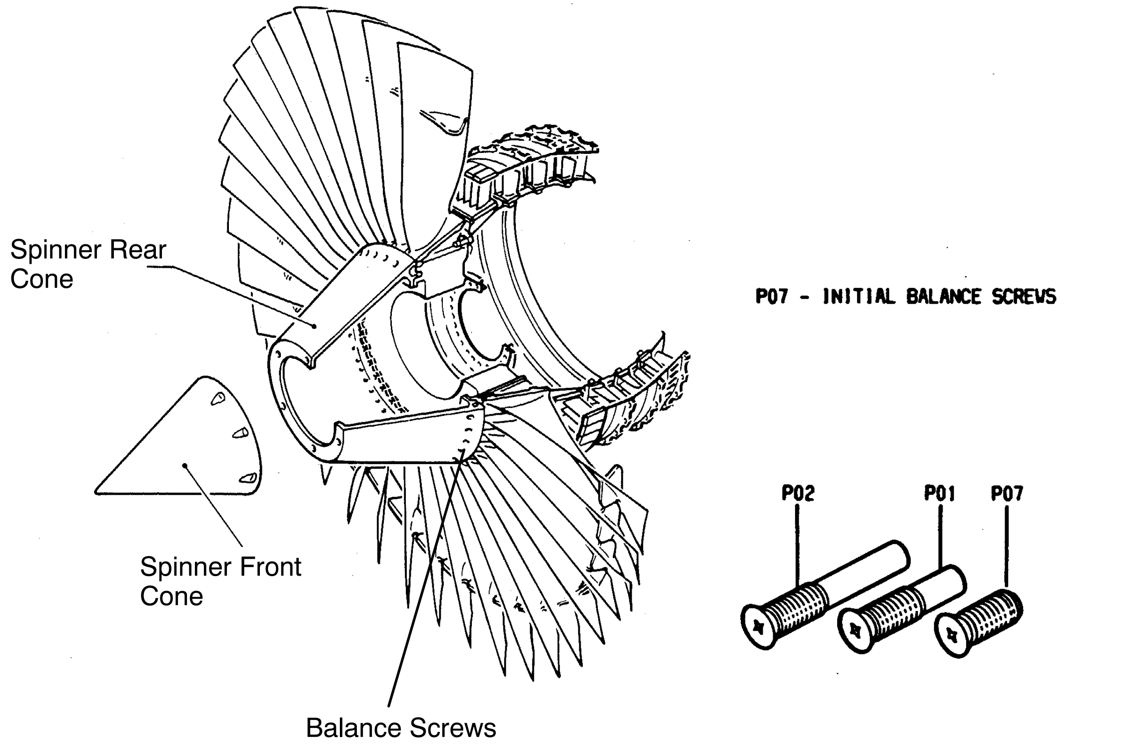
NOTE :
It is advisable to limit the number of balance screws on the spinner due the complexity and the risk of confusion when performing further corrections, and to install only one set of balance screws.This requires the construction of a vector diagram for determining the sum of the corrections. An example is given in (Ref. TASK 72-21-00-300-006).

Balance Screws
Balance screws are identified by a number corresponding to their moment weight (P01-P02-P03-P04-P05-P06-P07) engraved on screw head.
As it may be difficult to read the numbers due to erosion and pollution, the relationship between the screw reference and screw length is shown in inches.

Fan Blade Moment Weight and Classification Code

The moment weight (cm.gram), is the weight of the fan blade multiplied by the distance ”centre of gravity to centre of rotation”
The moment weight is engraved on the lower side of the fan blade root.
Weight and centre of gravity of fan blades is different due to manufacturing tolerances.





BALANCE SCREWS			
PO MARKED ONE SOCKET HEAD		TOTAL LENGTH	
THREADS / TOTAL LENGTH	PO	mm	(in.)
	P07	20,3	0.8
	P01	33	1.3
	P02	45,7	1.8
	P03	58,4	2.3
	P04	71,1	2.8
	P05	83,8	3.3
	P06	96,5	3.8

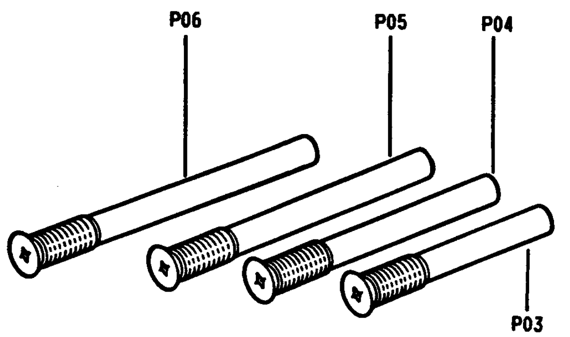


Figure 15 Fan Blade Damage Limit

SPINNER FRONT / REAR CONE REM./INST.

AMM Procedure 72-21-00

CAUTION:

On the panel 115VU, put a warning notice to tell the persons not to start the engine 1(2).
Make sure that the engine 1(2) is shut down for at least 5 minutes.
On the panel 50VU, make sure that the ON legend of the ENG FADEC GND PWR 1(2) pushbutton switch is off and install a warning notice.

Removal of Spinner Front /Rear Cone

- Remove the bolts which attach the spinner front cone to the spinner rear cone .
- Move the spinner front cone apart from the spinner rear cone with the 3 jackscrews from the tool set TOOL SET JACKSCREW, (856A1130P08).
- Remove the bolts which attach the spinner rear cone to the fan disc.
- Remove the spinner rear cone from the fan disk with the 6 jackscrews from the tool set, TOOL SET JACKSCREW (856A1130G09).

Installation of the Spinner Rear Cone

Make sure that the aircraft is in the same configuration as for the removal task.

Procedure

- Apply a thin layer of engine oil (Material No. CP2442) to the 3 PIN,GUIDE - SPINNER REAR CONE (856A3409).
- Install the 3 guide pins, equally spaced, on the forward flange of the fan disk. Install one of the pins in the offset hole.

Install the spinner rear cone as follows:

- Apply a thin layer of graphite grease (Material No. CP2101) to the threads of the bolts .
- Increase the temperature of the aft flange of the spinner rear cone to 60 deg.C (140.00 deg.F) with a heat gun.
- Install the spinner rear cone on the fan disk forward flange with the offset holes aligned.

NOTE :
The offset hole in the spinner rear cone is identified by a spherical indentation on its rear flange.

- Attach the rear cone to the disk with 3 bolts and washers.Make sure it is correctly seated.
- Let the assembly return to the ambient temperature.Then remove the guide pins.Replace the guide pins (856A3409) with the bolts and the washers.
- TORQUE the bolts to between 95 and 115 lbf.in (1.07 and 1.29 m.daN).

Do a check of the clearance (gap) between the rear edge of the spinner rear cone and the fan blades with a filler gage set.

Spinner Rear Cone to Fan Blade Clearance Limits.

NOTE : This clearance (gap) must be comprised between 0.012 in.(0.3047 mm) and 0.043 in. (1.0921 mm).

In case of incorrect clearance, remove the rear cone, and make sure that the fan blades are correctly installed.

Installation of the Spinner Front Cone

- Apply a thin layer of engine oil (Material No. CP2442) to the 3 PIN,GUIDE - SPINNER REAR CONE (856A3409).
- Install the three guide pins equally-spaced on the front flange of the spinner rear cone . Install one of the pins in the offset hole of the flange.
- Increase the temperature of the front flange of the spinner rear cone to approximately 80 deg.C (176.00 deg.F) with a heat gun.
- Install the spinner front cone on the spinner rear cone .Carefully align the offset holes.
- Apply a thin layer of engine oil (Material No. CP2442) to the threads of the 6 bolts, and attach the spinner front cone with the bolts.Tighten the bolts by hand, and let the mating parts return to the ambient temperature.
- TORQUE the bolts to between 95 and 115 lbf.in (1.07 and 1.29 m.daN).

Close-up

Make sure that the work area is clean and clear of tool(s) and other items.

Remove the warning notices from the panels 115VU and 50VU.

Remove the access platform(s).

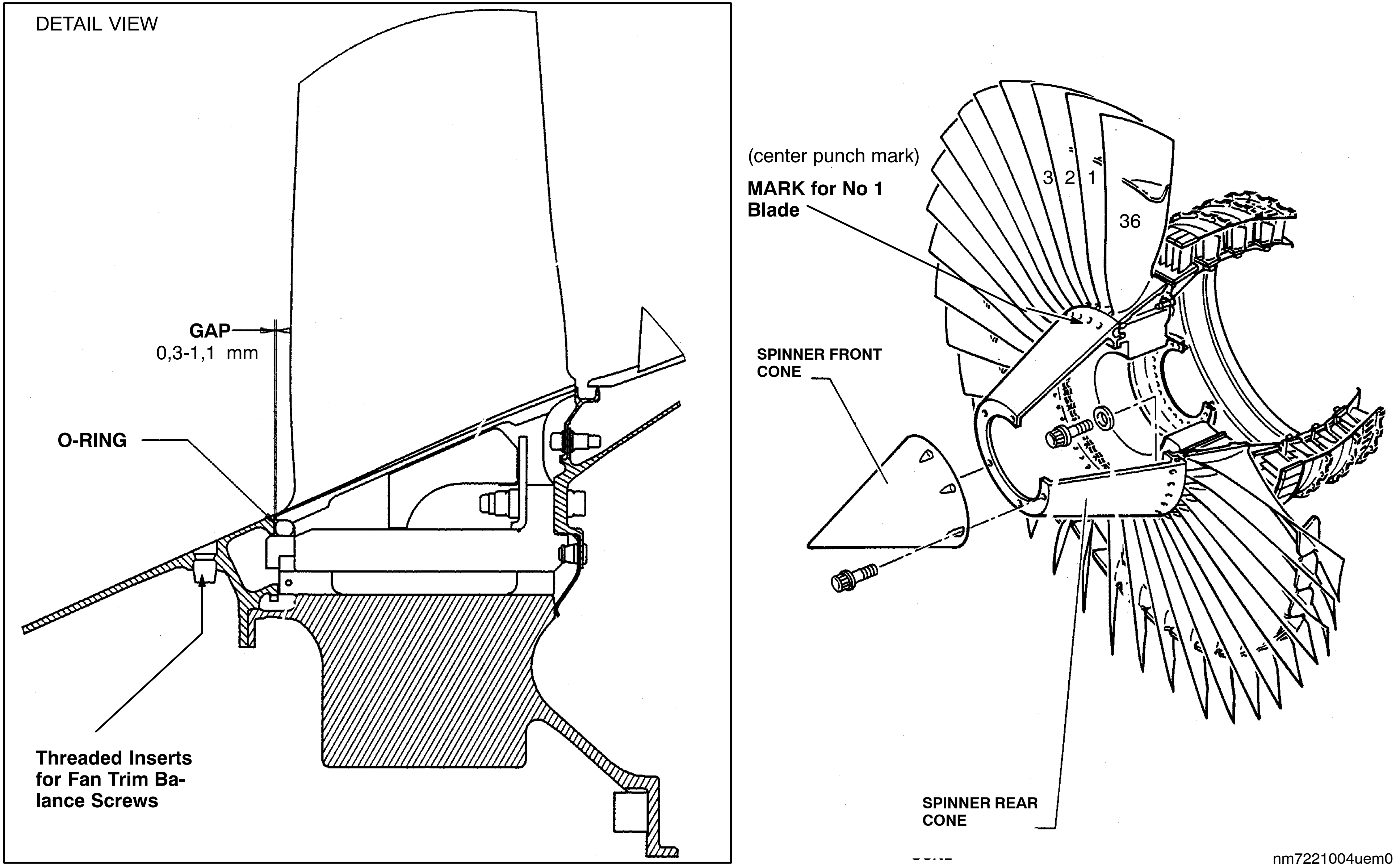


Figure 16 Spinner Cone Installation/Removal

AMM FAN BLADE REMOVAL / INSTALLATION

CAUTION :
ALL FAN ROTOR BLADES SHALL BE MATCHMARKED OR NUMBERED FOR ASSEMBLY IN ORIGINAL ALIGNMENT AND POSITION USING ONLY APPROVED MARKING MATERIAL.

CAUTION :
USE ONLY APPROVED MARKING MATERIAL TO PREVENT DAMAGE TO THE BLADES.

- **On the panel 115VU, put a warning notice to tell the persons not to start the engine 1(2).**
- **Make sure that the engine 1(2) is shut down for at least 5 minutes.**
- **On the panel 50VU, make sure that the ON legend of the ENG FADEC GND PWR 1(2) pushbutton switch is off and install a warning notice.**

Removal of the Fan Rotor Blades

Remove spinner front cone. (Ref. TASK 72-21-00-000-001)

- Remove spinner rear cone. (Ref. TASK 72-21-00-000-002)

Procedure

NOTE: Removal will be easier if fan blade to be removed is placed at the 12 o'clock position.

Remove the blade retainers as follows:

- Remove, partially or completely, the O-ring located between the fan blade platform and the fan disk.
- Slide the spacer toward the front of the disk with the ADAPTER,PULLER - FAN BLADE SPACERS (856A2700G01) , until the blade retainer is released
- Slide down the blade retainer located in the fan disk. Remove the blade retainer.

Remove the fan blades as follows:

Move the blade radially inward to disengage the mid-span shroud.Then slide the blade forward until it comes out of the dovetail slot.Remove the blade damper.

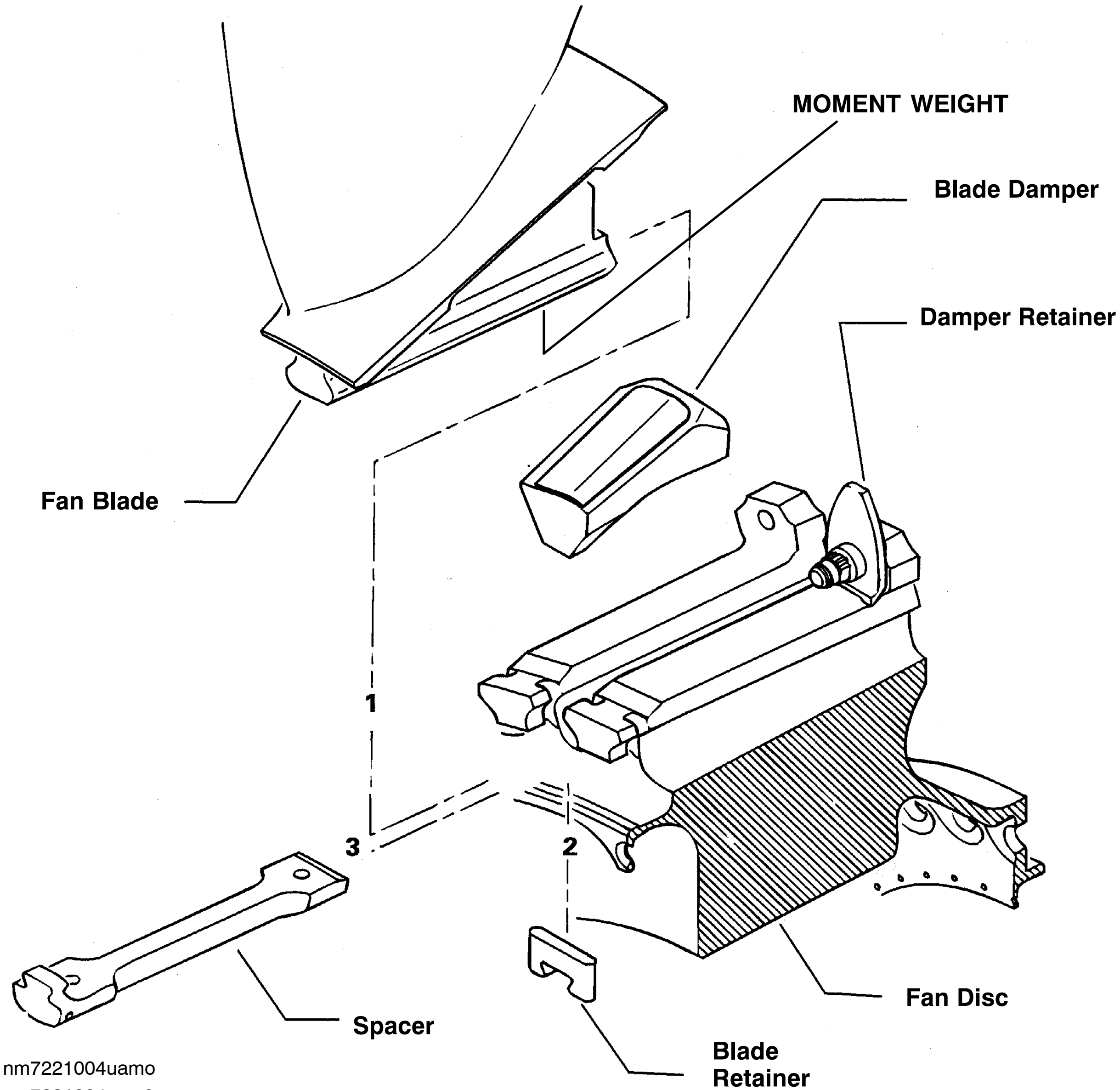
Slide the adjacent blades forward, if necessary, as follows:

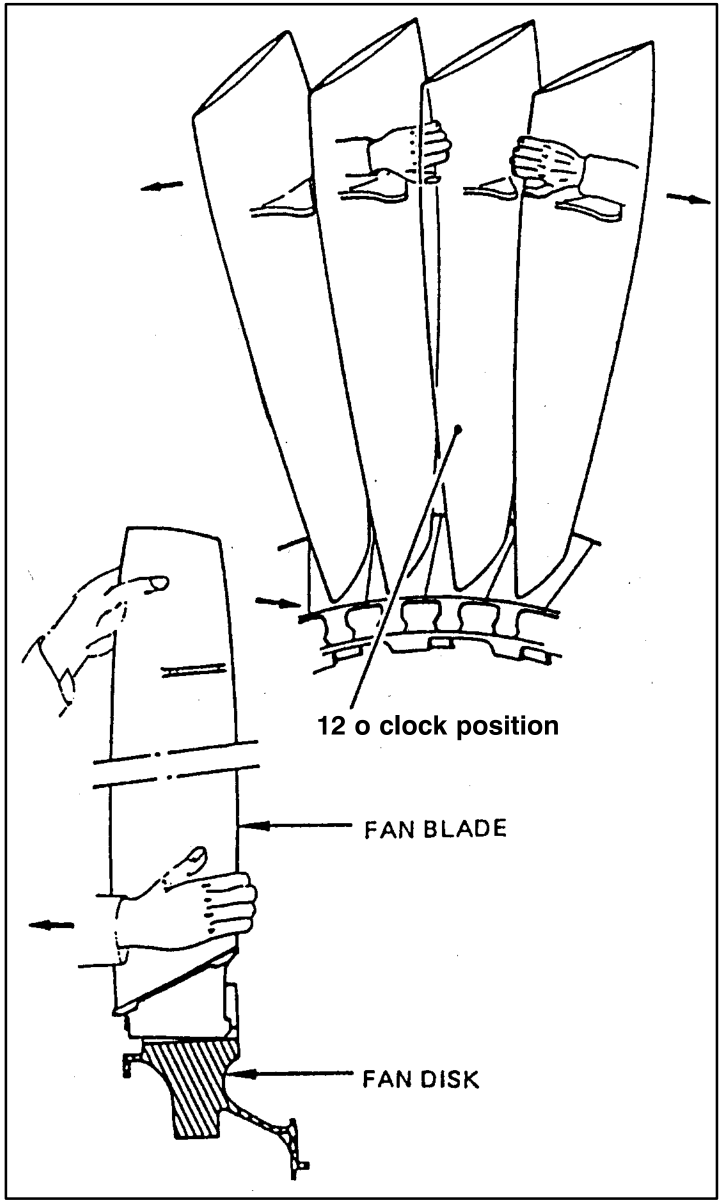
(a) Pull the spacer under the adjacent blade forward with the ADAPTER, PULLER - FAN BLADE SPACERS (856A2700) and snap-on puller slide hammer CG240-9 and snap-on puller rod without end CG-240-8. Slide down and remove the retainer.

(b) Move the blade radially inward to disengage the mid-spanshroud.Then slide the blade forward until it comes out of the dovetail slot.

(c) Remove blade damper from the disk.

(d) Do the steps (a), (b) and (c) for the other adjacent blade.





nm7221004uamo
nm7221004ucm0

Figure 17 Fan Blade Removal / Installation

AMM FAN BLADE REMOVAL / INSTALLATION

CAUTION :
DO NOT DISSOCIATE FAN BLADE PAIRS MATCHED DURING ORIGINAL ASSEMBLY. BLADES FROM A SAME PAIR MUST ALWAYS BE LOCATED 180 DEGREES APART.

CAUTION :
WHEN YOU INSTALL THE FAN BLADES, MAKE SURE THAT ALL DAMPERS ARE CORRECTLY INSTALLED UN DER EACH BLADE PLATFORM.

Installation of the Fan Rotor Blades

Make sure that the aircraft is in the same configuration as for the removal task.

Procedure

NOTE :
Installation will be easier if the fan disk blade recess into which the blade is to be installed is placed at the 6 O'clock position.

Install the blades as follows:

- Apply a thin layer of molycote graphite (Material No. CP2104) or molycote 321 R (Material No. CP2007) to the mid-span shrouds, the roots, the plat-form mating surfaces under the platform, the antiwearshields of dampers and the disk slots.
- Move the blade rearward into the disk slot. Then, move the blade radially outward to engage the mid-span shroud with the adjacent blades.

Install blade retainer as follows:

(1) Slide the blade retainer into the related disk slot.

(2) Slide the blade spacer into the disk recess until the spacer lug goes through the retainer slot.

(3) Install the fan blade damper under the blade platform before you install the next blade in its disk slot.

NOTE:
Before installation of the last blade, you must make sure that all fan blade dampers are installed.

(4) Install the other blades, retainers, spacers and fan blade dampers.

NOTE :
The midspan shroud section of the blades must engage and mate with the related midspan shroud sections of the adjacent blades.

CAUTION :
MAKE SURE THAT ALL THE 36 BLADES, RETAINERS, SPACERS AND DAMPERS ARE CORRECTLY INSTALLED.

Make sure the O-ring is not damaged.

If the O-ring is serviceable, apply a thin layer of engine oil (Material No. CP2442). Install it by hand between the blade platform and the disk.

Close-up

- Install spinner rear cone. (Ref. TASK 72-21-00-400-002)
- Install spinner front cone. (Ref. TASK 72-21-00-400-001)
- Make sure that the work area is clean and clear of tool(s) and other items.
- Remove the warning notices from the panels 115VU and 50VU.

Test

Subtask 72-21-00-710-050

Perform a vibration check (Ref. TASK 71-00-00-710-009).

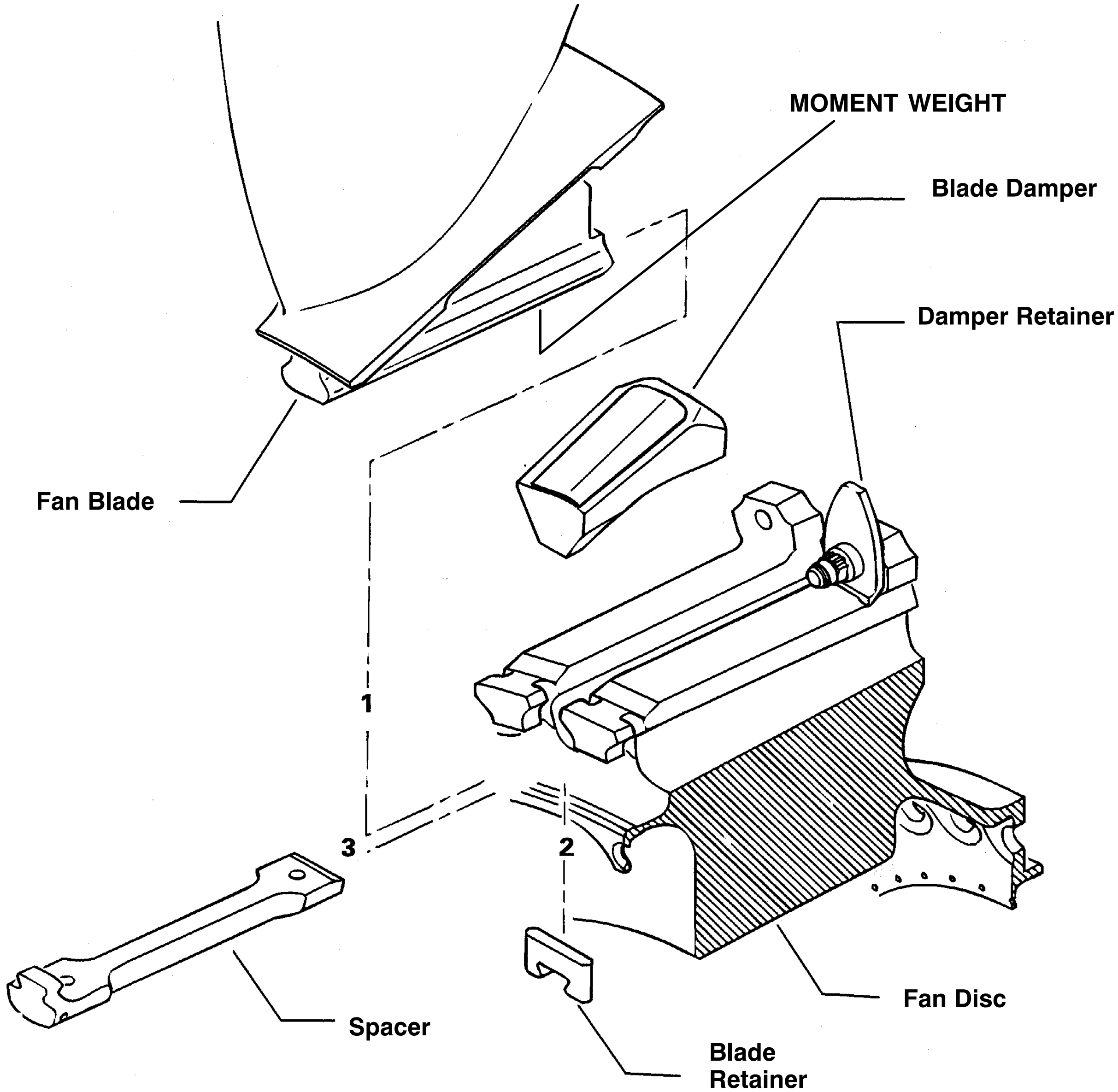


Figure 18 Fan Blade Removal / Installation

INDIVIDUAL FAN BLADE REPLACEMENT:

If difference between moment weights "D" is within 80-800 cm.g, correct the imbalance as in the example which follows:

- Assume a blade with moment weight of **162750 cm.g** is to be replaced in any position.
- A spare blade is provided with moment weight of **163296 cm.g.**
- Calculate the difference between the moment weights as below:
  163296 - 162750 = 546 cm.g.
- Select balance screws as follows:

To determine the solutions closest to above difference of 546 cm.g. One centered screw P05 and 2 lateral screws P01 = 541 cm.g.
This solution permits a satisfactory correction for returning the fan close to its initial balance condition.

Locate balance screws as follows:

- As the new blade is heavier than the removed blade, install balance screws close to the opposite blade.

NOTE : If the new blade is lighter than the removed blade, install balance screw close to the removed blade.

Perform a trim balance operation. (Only if difference between moment weights is within 400 and 800 cm.g).

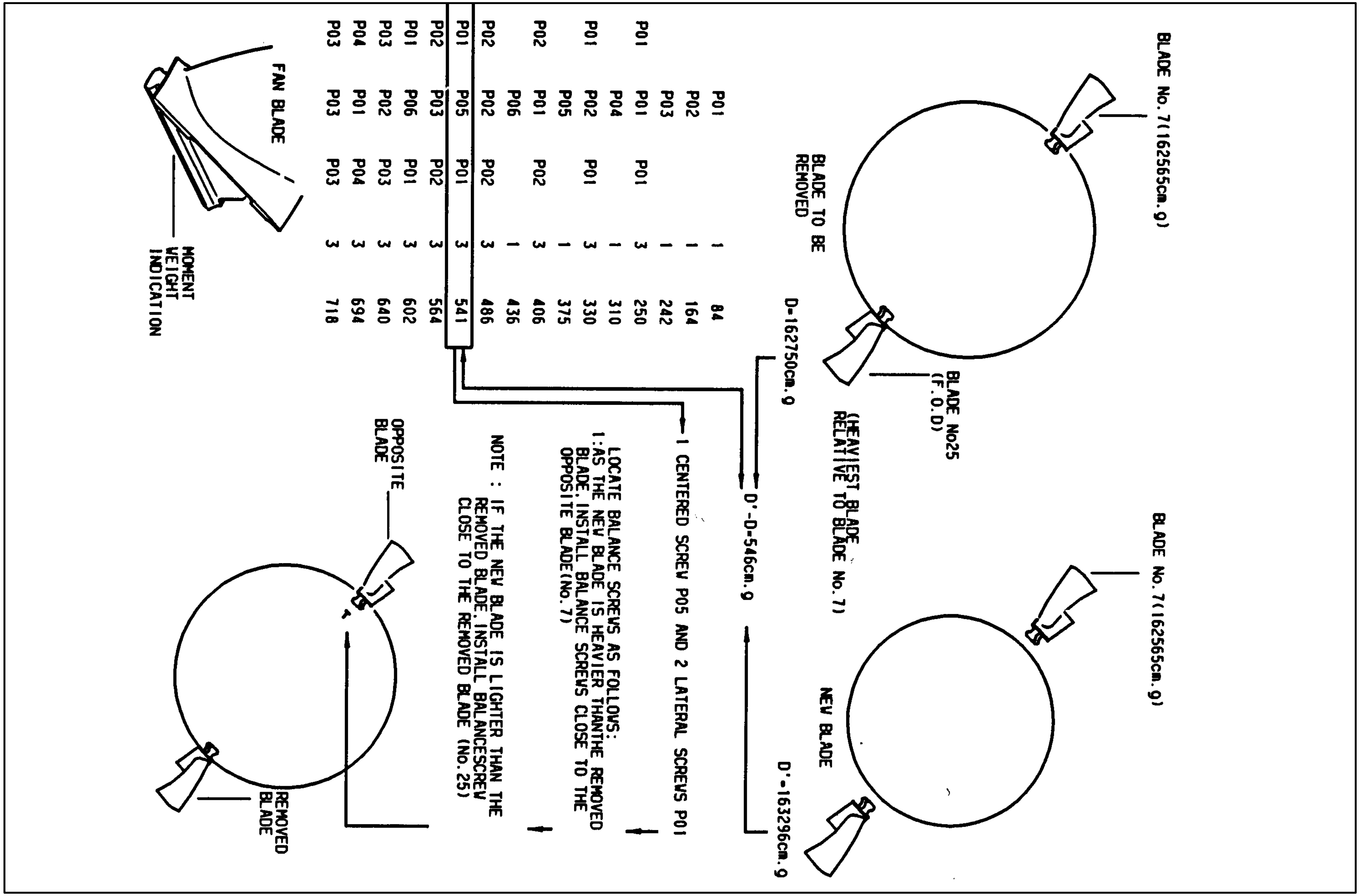


Figure 19 Individual Fan Blade Replacement

72-30 HP-COMPRESSOR

HP COMPRESSOR DESCRIPTION

The major Components of the compressor are: Compressor rotor and compressor stator. The front of the compressor stator is supported by the fan frame and the front of the compressor rotor is supported by the No 3 bearing in the fan frame.

The rear of the compressor stator is attached to the combustion case and the rear of the compressor rotor is attached to the HPT rotor to form the core rotor. The rear of the core rotor is supported by the No. 4 bearing.

A portion of the fan discharge airflow passes thru the booster to the compressor. Compression is progressive as the primary airflow moves from stage to stage through the axial compressor. Air passes through successive stages of compressor rotor blades and compressor stator vanes, being compressed as it passes from stage to stage.

After passing through 9 stages of blades, the air has been compressed.
The inlet guide vanes and the first 3 stages of the stator are variable, and change their angular position as a function of compressor inlet temperature and engine speed. The purpose of this variability is to optimize efficiency and stall margin for engine speed, compressor inlet temperature and pressure conditions.

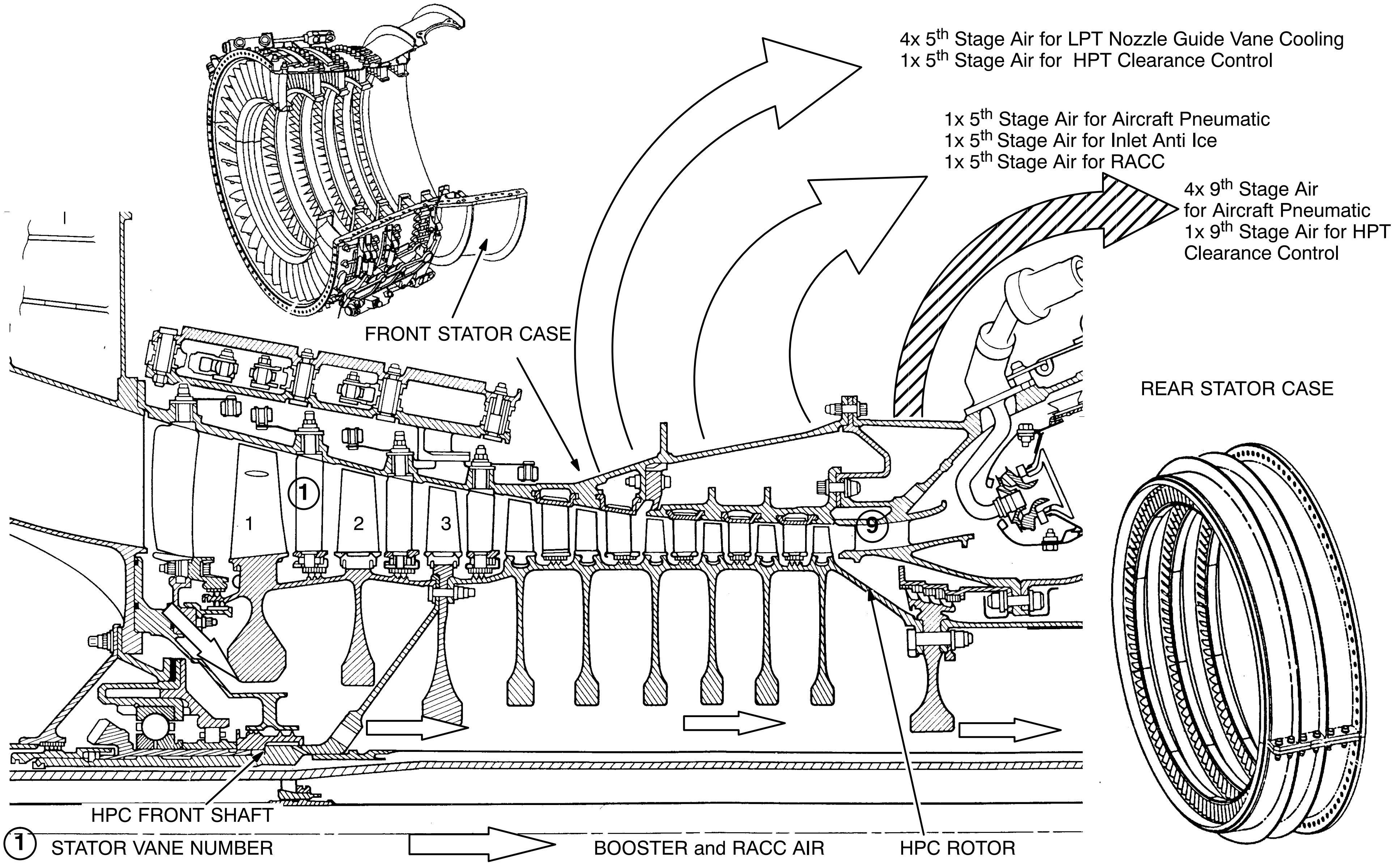


Figure 20 HP Compressor

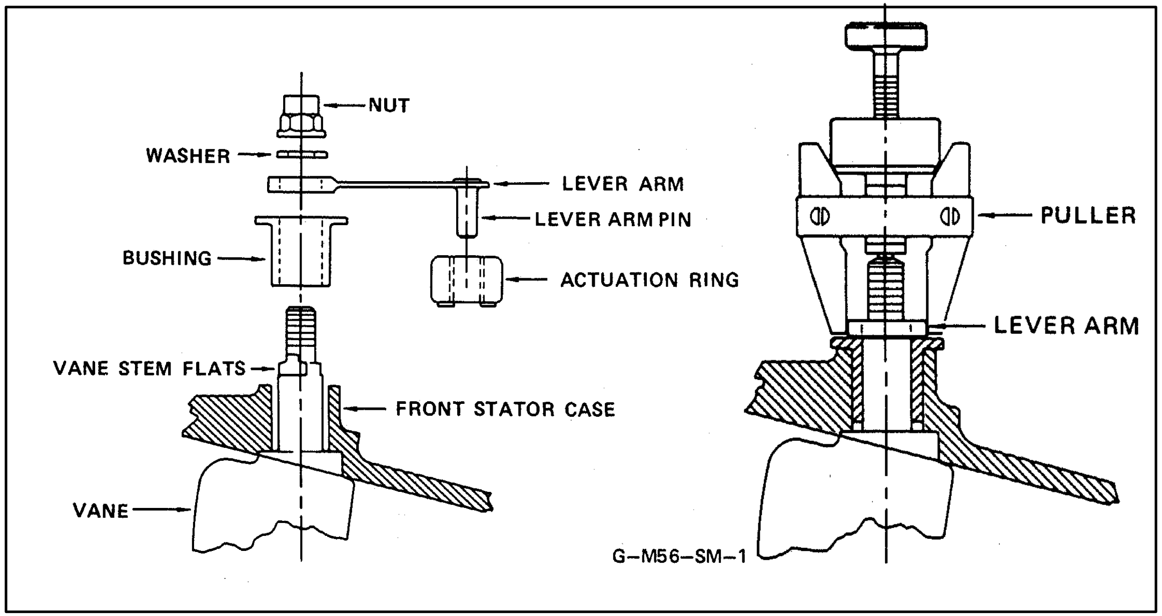
HP COMPRESSOR STATOR ASSEMBLY

General
The compressor front stator consists of the front casing halves, the inlet guide vanes (IGV), and the first 5 stages of stator vanes.

Front Stator Casing
The front case halves are made from steel forging. Bleed air is taken from the pads on the front case for the use of the customer. The bleed air is also used for high pressure turbine cooling and clearance control and for low pressure turbine cooling.

Vanes
The IGV and the stages 1 through 3 vanes are variable ; the stages 4 and 5 vanes are fixed. All vanes are made of steel. All stages of vanes have honeycomb shrouds on their inner diameter. The shrouds together with the rotor seal teeth, form interstage seals to prevent flowpath recirculation.

Variable Vane Actuation
Actuation of the variable vanes is accomplished with hydraulically actuated bellcranck assemblies mounted on the front compressor stator at the 2 and 8 o'clock positions.
Fixed linkages connect the bellcrancks to actuation rings. Lever arms attached to the variable vanes connect to the actuation rings.Fuel from the hydromechanical unit (HMU) operates the hydraulic actuators.



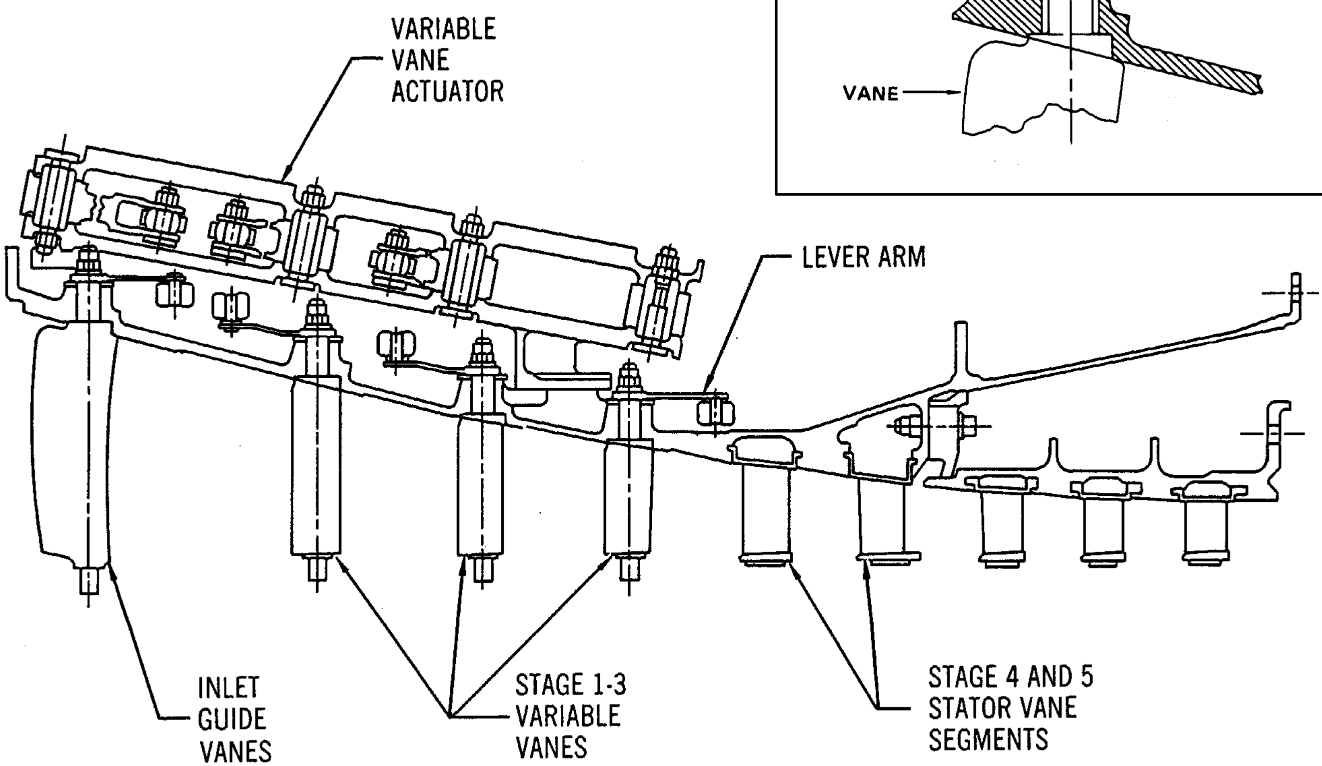


Figure 21 HP Compressor Stator Assembly

72-40 COMBUSTION SECTION

COMBUSTION SECTION DESCRIPTION

General

The combustion case is a fabricated structural weldment located between the high pressure compressor (HPC) and the low pressure turbine (LPT). It provides the structural interface, transmits the engine axial load, and provides gas flow path between the compressor and LPT. The case incorporates the compressor outlet guide vanes (OGV) and a diffuser for the reduction of combustion chamber sensitivity to the compressor air velocity profile.

Components

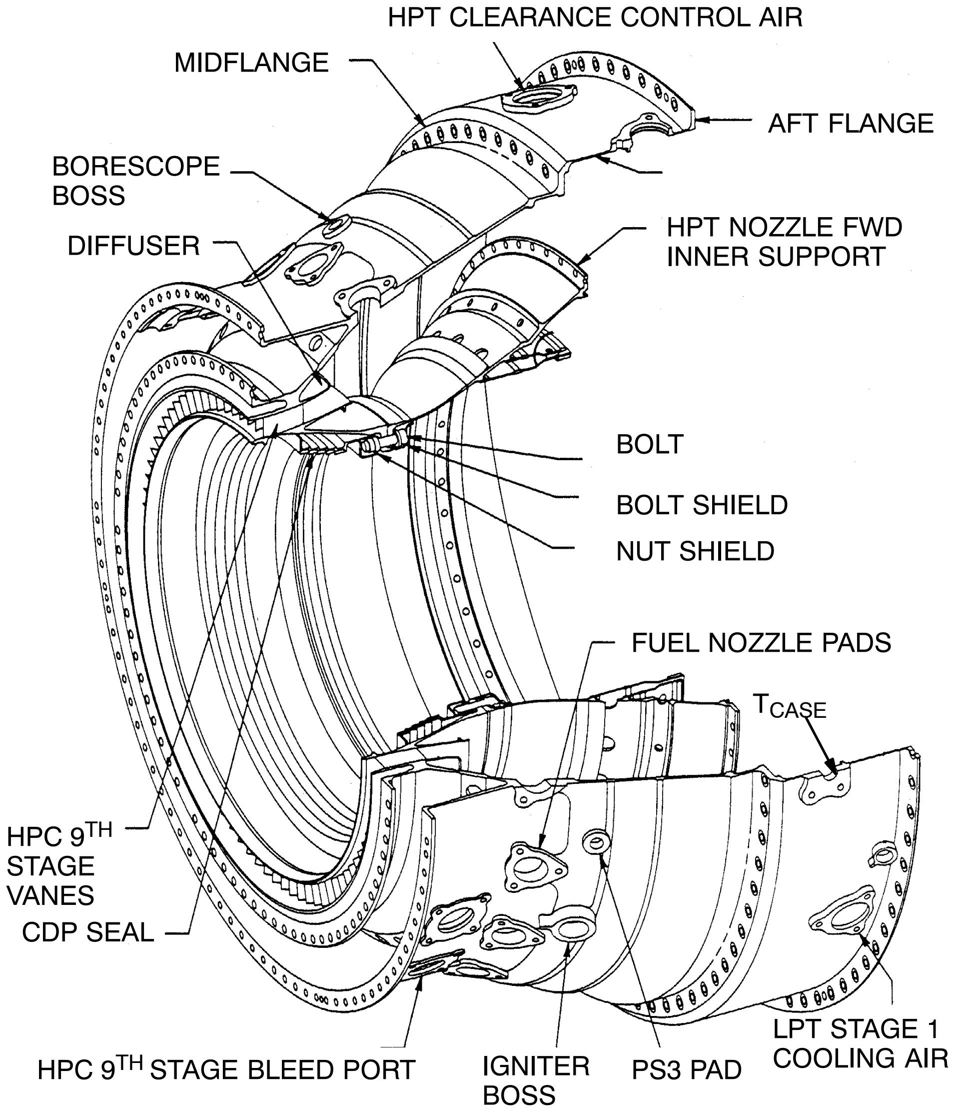
The combustion case encloses the combustion chamber and high pressure turbine (HPT) components. The combustion chamber, compressor rear stationary (CDP) seal, HPT nozzle assembly, and HPT shroud/stage 1 LPT nozzle assembly are mounted in and structurally supported by the combustion case.
The case mounts and positions the 20 fuel nozzles, 2 igniters, and fuel manifold.The fuel manifold system is composed of a fuel supply manifold (Y tube), 2fuel manifolds halves, 3-piece drain manifold, and overboard drain tube.

Ports

There are 6 borescope ports ; 4 for inspection of the combustion chamber and HPT nozzles and 2 for inspection of the HPT blades and shrouds and the stage 1 LPT blades. The case has 4 ports for extraction of compressor discharge air for customer use, 4 ports for introduction of stage 5 compressor air forLPT nozzle guide vane cooling, 2 for introduction of air to the shrouds). There is also one port for the following : start bleed dump, P3 sensor, T3 sensor, and CDP air. There are 2 ports for the spark igniters and 2 ports for turbine clearance control thermocouples.

HIGH PRESSURE TURBINE

The HPT consits of a 1-stage nozzle and rotor.The nozzle are supported by the HPT case,the rotor is attached to the high pressure compressor rotor.
The vanes and platforms are cooled by compressor discharge air entering the vane compartments through inserts in the inner and outer ends of vanes and exiting through the vane leading and trailing edges.
An air cavity between the shroud/nozzle support and the combustion case directs mixed 5th and 9th stage compressor bleed air onto the support .This cooling air maintains closer tip clearance between the shrouds and the rotor blades.



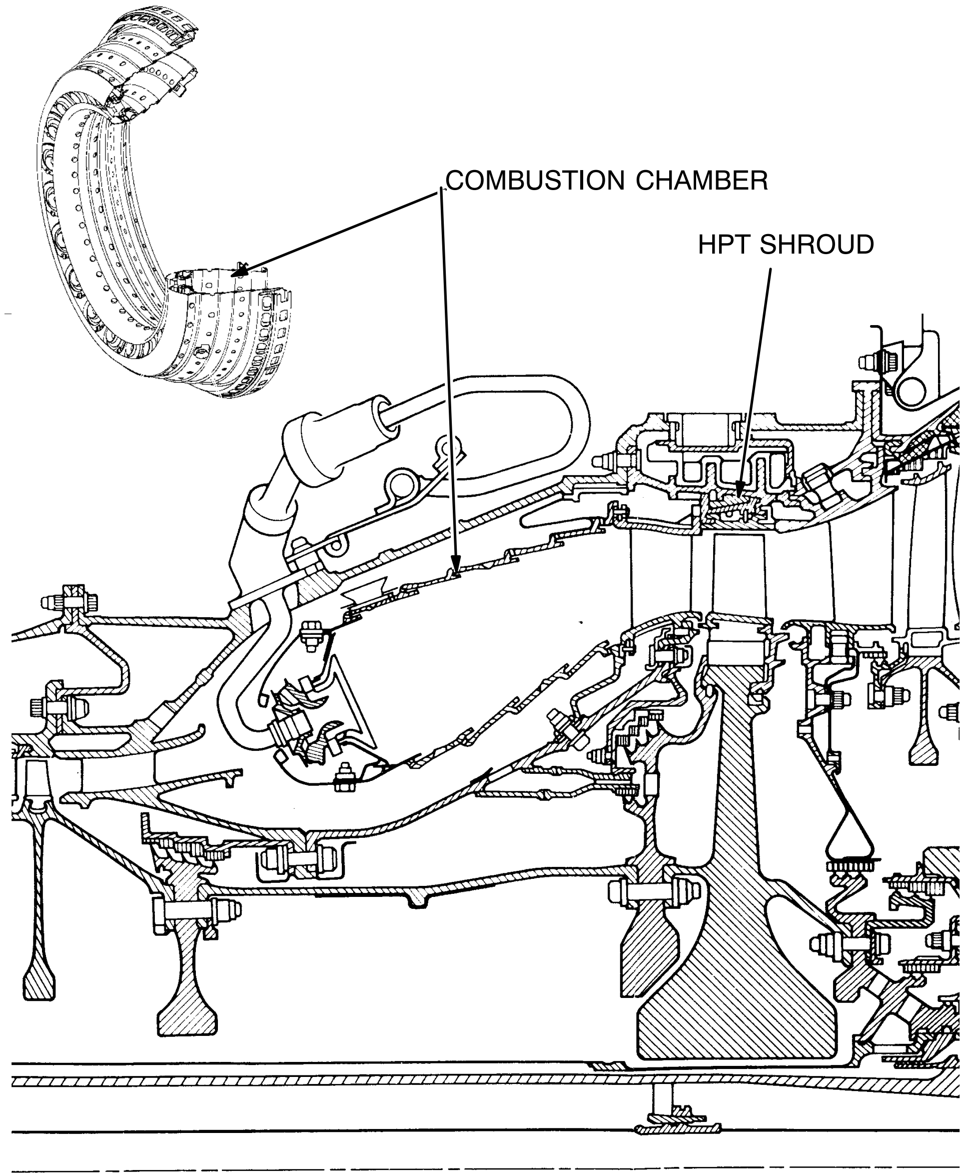


Figure 22 Combustion Case

72-50 TURBINE SECTION

LPT ROTOR & STATOR MODULE

The modules of the turbine are the high pressure turbine and the low pressure turbine.

High Pressure Turbine

The HPT consits of a 1-stage nozzle and rotor.The nozzle are supported by the HPT case,the rotor is attached to the high pressure compressor rotor.
The vanes and platforms are cooled by compressor discharge air entering the vane compartments through inserts in the inner and outer ends of vanes and exiting through the vane leading and trailing edges.
An air cavity between the shroud/nozzle support and the combustion case directs mixed 5th and 9th stage compressor bleed air onto the support .This cooling air maintains closer tip clearance between the shrouds and the rotor blades.

Low Pressure Turbine

The LPT module consits of a 4 - stage turbine,rotor,nozzle,statorcase and rear frame.The rotor is connected to the fan.Surrounding the stator case is a clearance control manifold system.
Stage 2 LPT nozzle assembly have holes to house the 9 EGT probes.

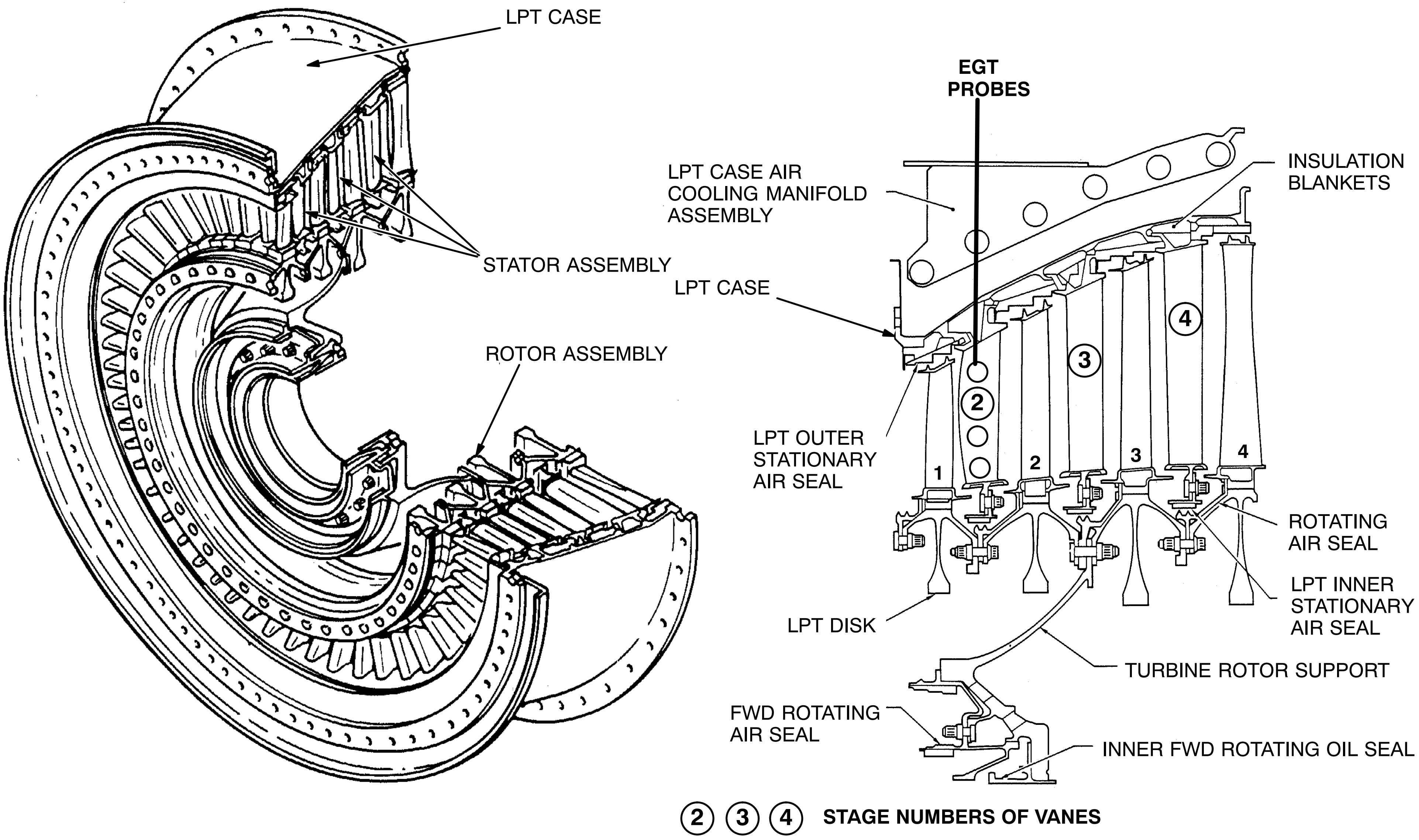
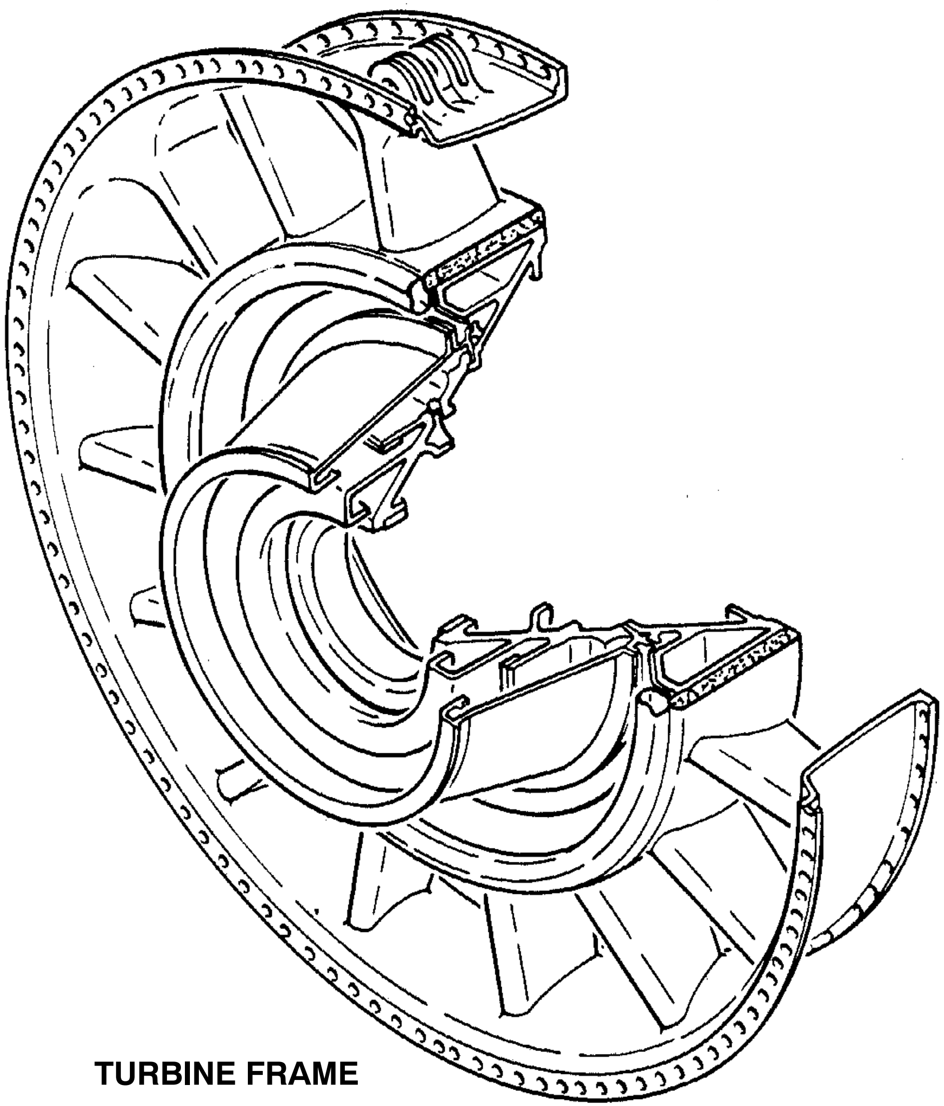


Figure 23 LPT Rotor & Stator Module

TURBINE FRAME MODULE

The turbine frame consits of:

- **Turbine Frame**
- **No.5 Bearing Support with Oil Sump Assy**
- **Oil Inlet Cover**
- **Flange assy**
- **Flame Arrestor**
- **16 Radial Stuts**



TURBINE FRAME

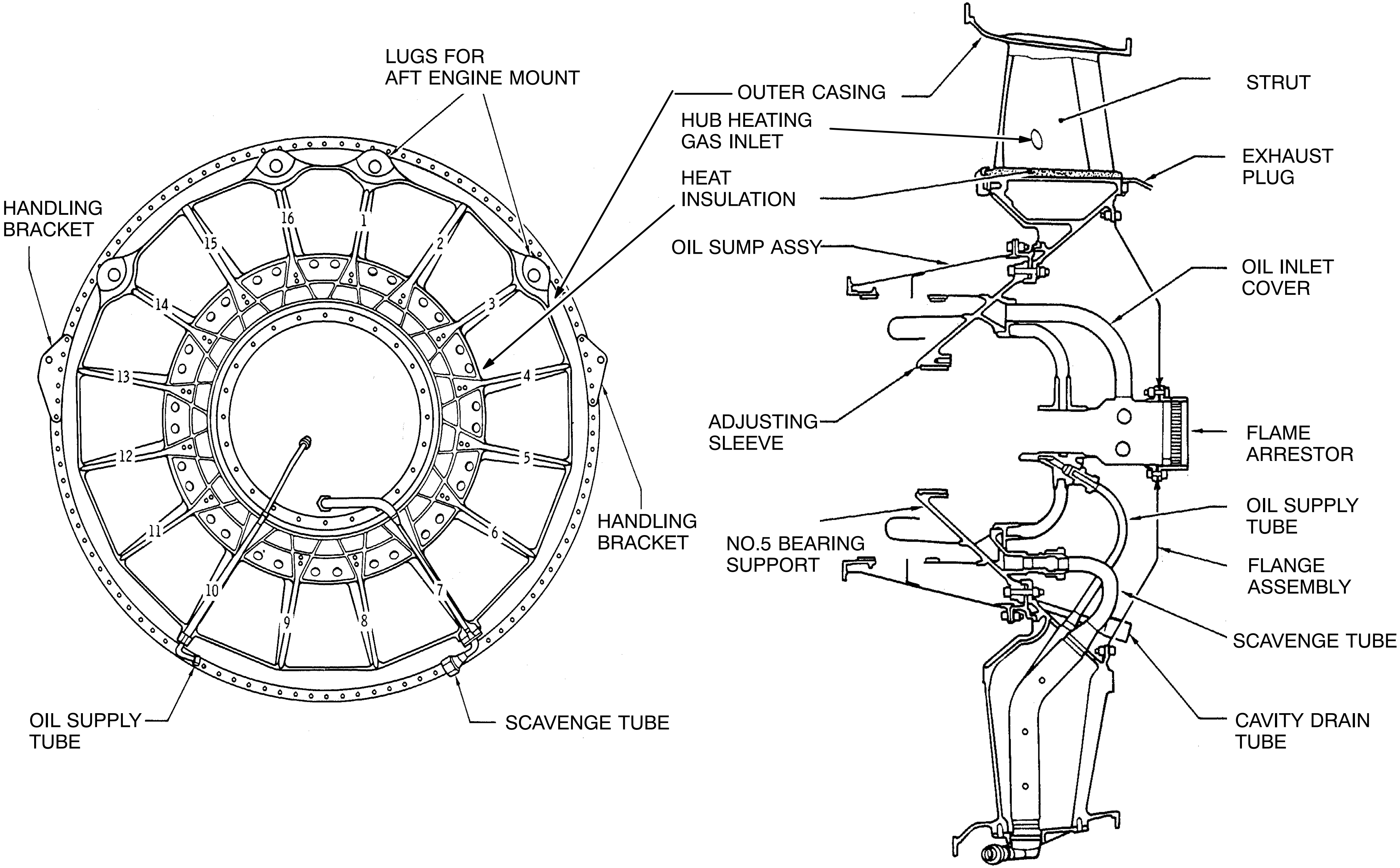


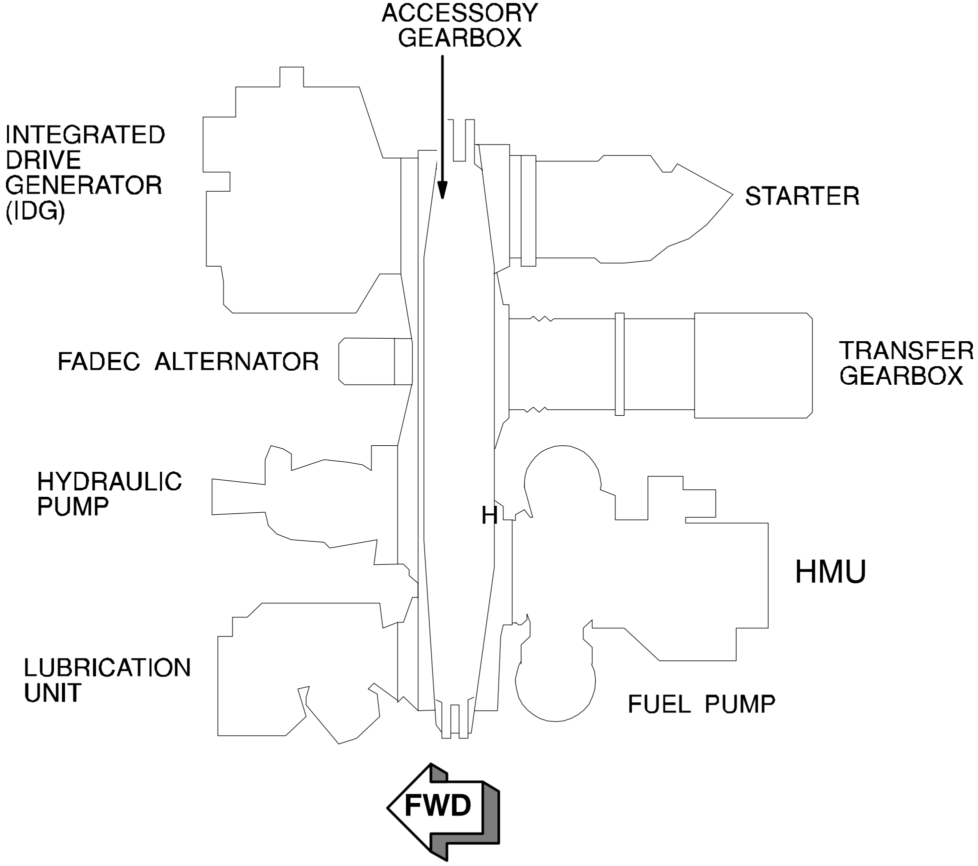
Figure 24 Turbine Frame Module

72-60 ACCESSORY DRIVE SECTION

ACCESSORY GEARBOX

Power for both engine and aircraft accessories is extracted thru a system of gearboxes and shafts. The accessory gearbox, which is supported by the compressor case, takes power from the core engine compressor stub shaft. An inclined radial drive shaft transmits this power to the transfer gearbox, mounted below the compressor stator casing.
A horizontal drive shaft then transmits the power to the core mounted accessory drive gearbox.
The accessory gearbox drives the following equipment :

IDG (electrical power generation) .
FADEC Control Alternator
Hydraulic pump (hydraulic power generation).
The fuel pump and HMU .
lubrication unit (lube pump) .



Top View Of Accessory Drive Section
Arrangement Of The Accessories

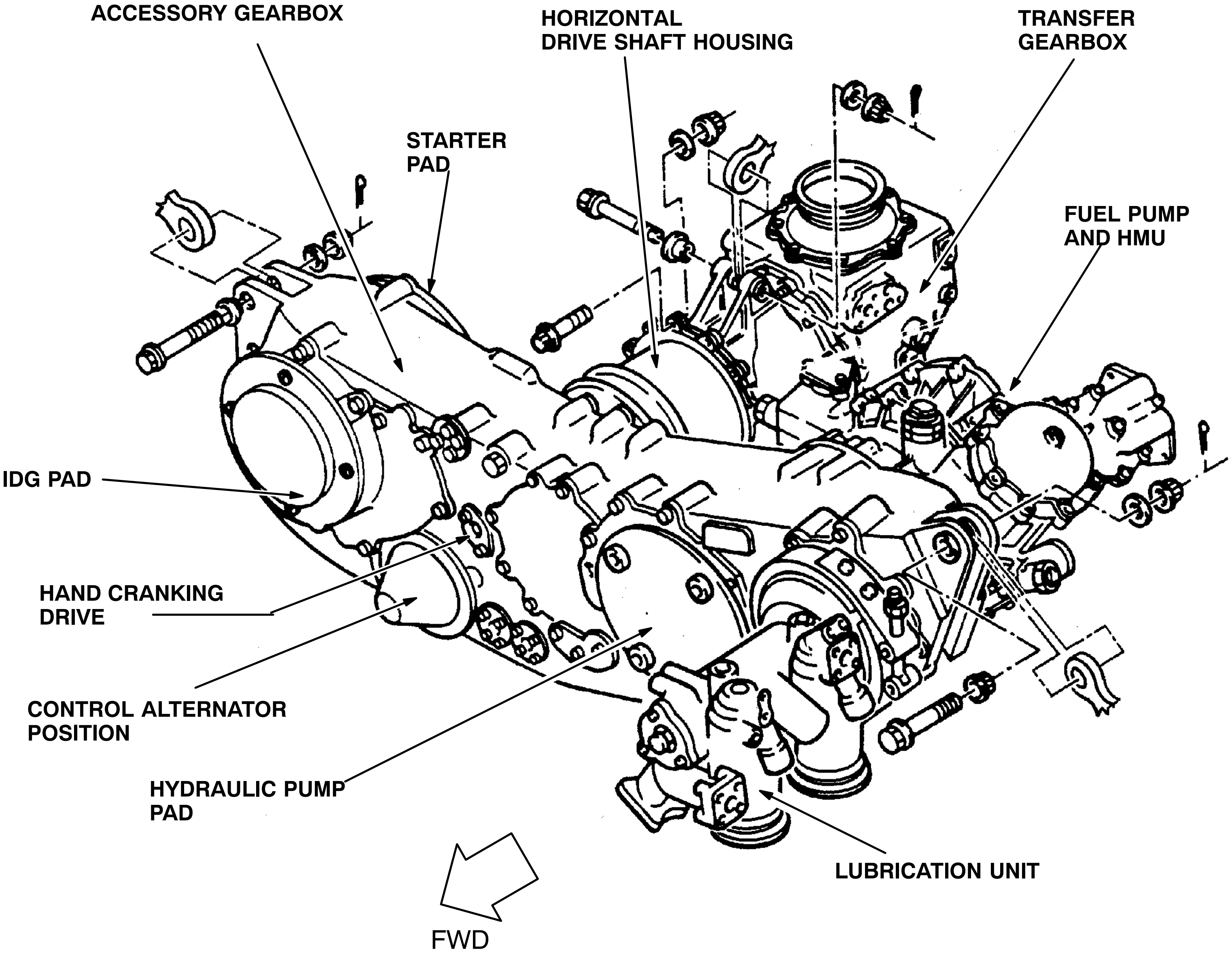


Figure 25 Accessory Gearbox

ACCESSORY GEARBOX SEALS

There can be two seal types used:
The magnetic seal and the sealol seal.They are interchangeable

The magnetic seal (Option)

consists of a nonmagnetic seal housing,
a magnetic seal with a glazed face and a carbon seal held by the magnet on the rotating part.The pull of the magnet maintains constant contact with the magnetic seal glazed seal face.
This seal is used for the starter and the IDG drive pad.

The magnetic seals are matched assemblies.If one of the components is damaged,replace the complete seal!

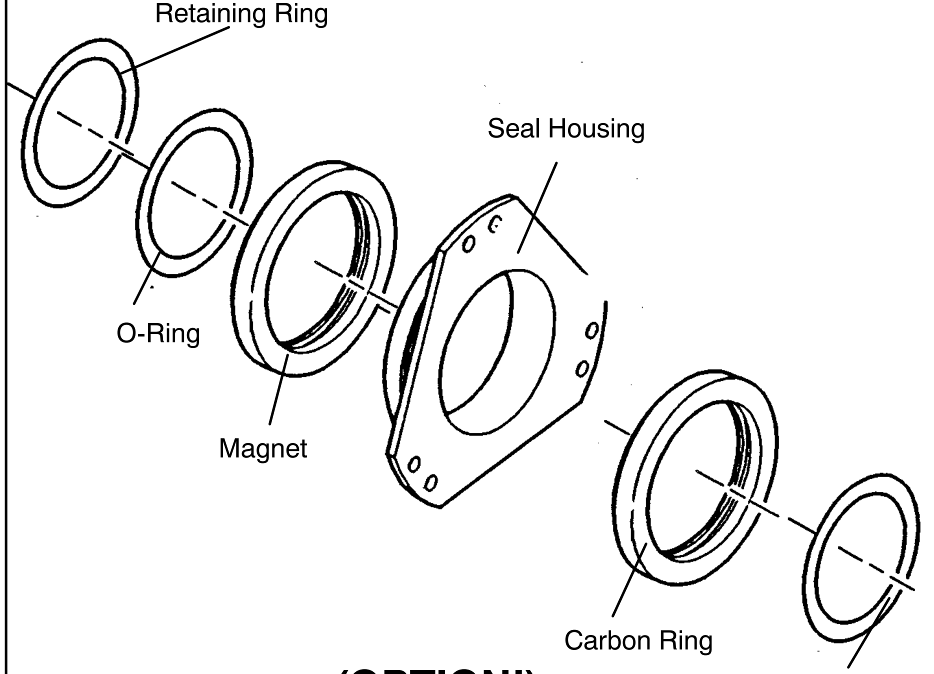
Note: This seal is not used any more by Lufthansa.

The sealol seal

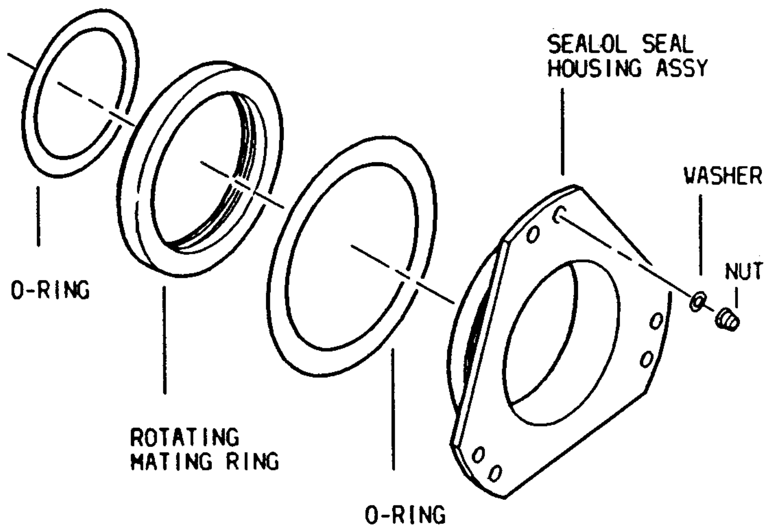
consists of the following parts:

- A mating ring (glazed face) with four lugs engageing the four corresponding slots in the gearshaft ball bearing.
- A cover,secured to the bearing housing with nuts , to ensure constant contact between the glazed face and the static part of the seal.

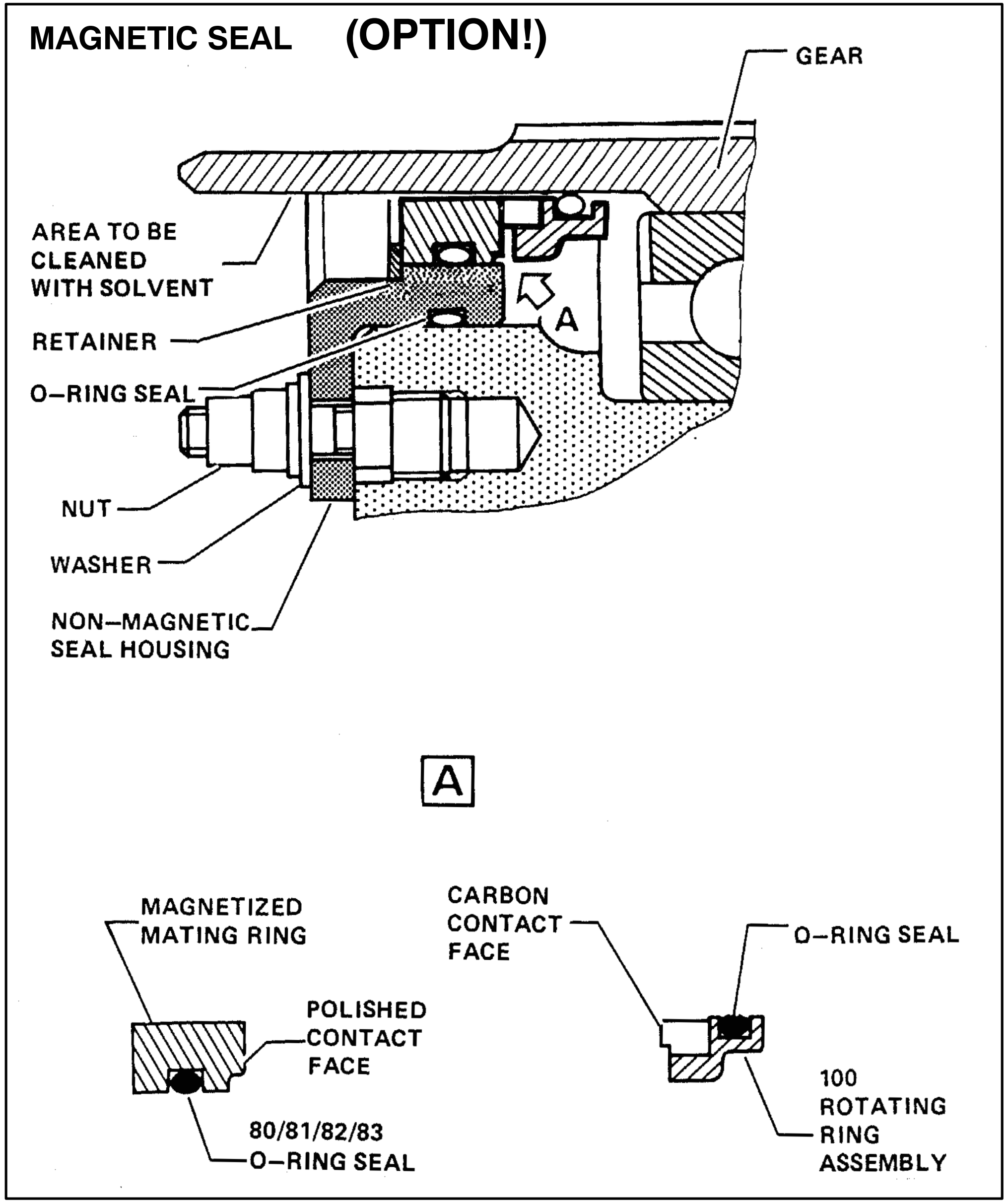
The sealol seals are matched assemblies.If one of the components is damaged,replace the complete seal!



MAGNETIC SEAL (OPTION!)



SEALOL SEAL



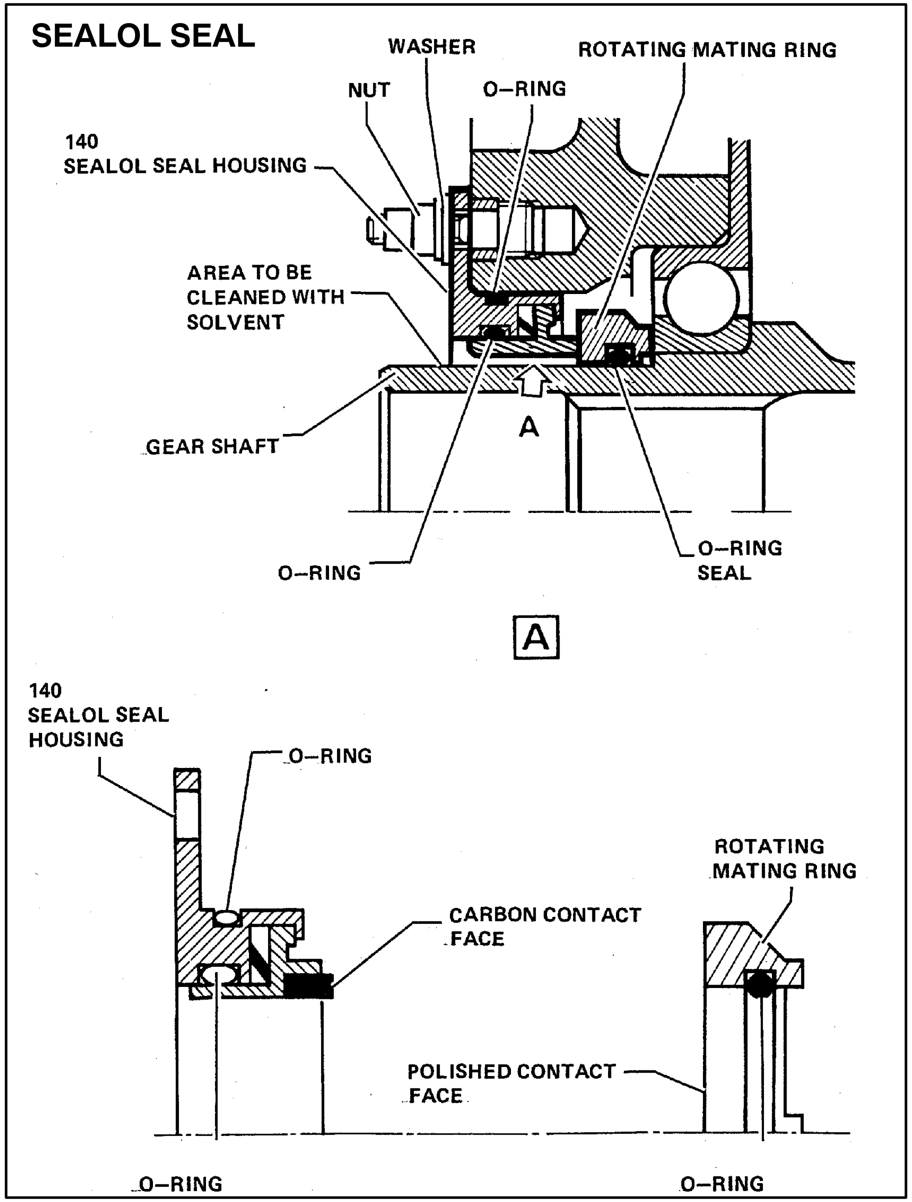


Figure 26 Accessory Drive Seals

72-21 BORESCOPE INSPECTION

BORESCOPE PORTS

Purpose

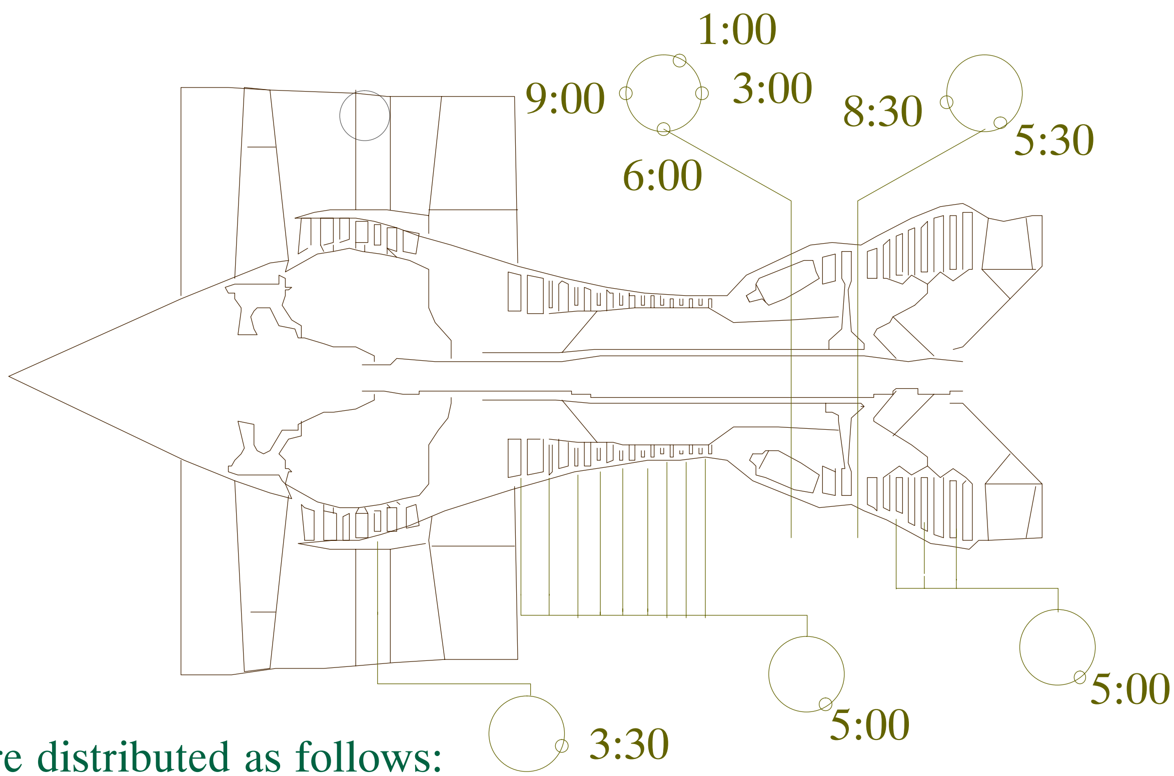
The borescope provides a system for visually inspection of the various internal parts of the engine.

General Component Locations

Borescope locations are provided fof inspetion of the fan area,booster,high pressure compressor,combustion chamber,high and low pressure turbines.

General Operation

Inspection preparation requires removal of borescope plugs in certain areas and rotation of the engine for checking of individual blades.The leading edges of the fan blades and the trailing edges of the last stage turbine blades can be inspected without the use of the borescope.



Aft Looking Forward
view, clockwise.

19 ports are distributed as follows:

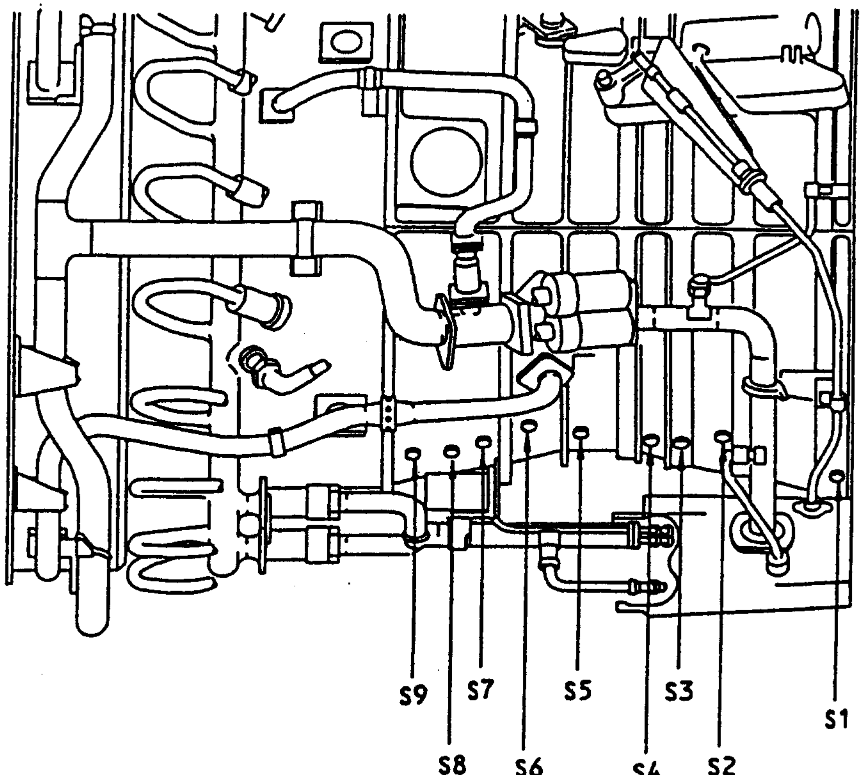
- LP compressor 1
- HP compressor 9
- combustion chamber 4 (+2)*
- HP turbine 2
- LP turbine 3

*Note: The HP Turbine blade leading edges can be inspected through the ignitor holes.

Figure 27 Borescope Ports

HP COMPRESSOR SPECIAL BORESCOPE PLUGS

The borescope plugs S7,S8,and S9 are special double plugs.Install borescope plugs finger tight.Ensure contact between boss on inner liner and plug cap. Compress spring load on outer cap and apply recommended torque.



HPC - ROTOR BORESCOPE INSPECTION PORTS

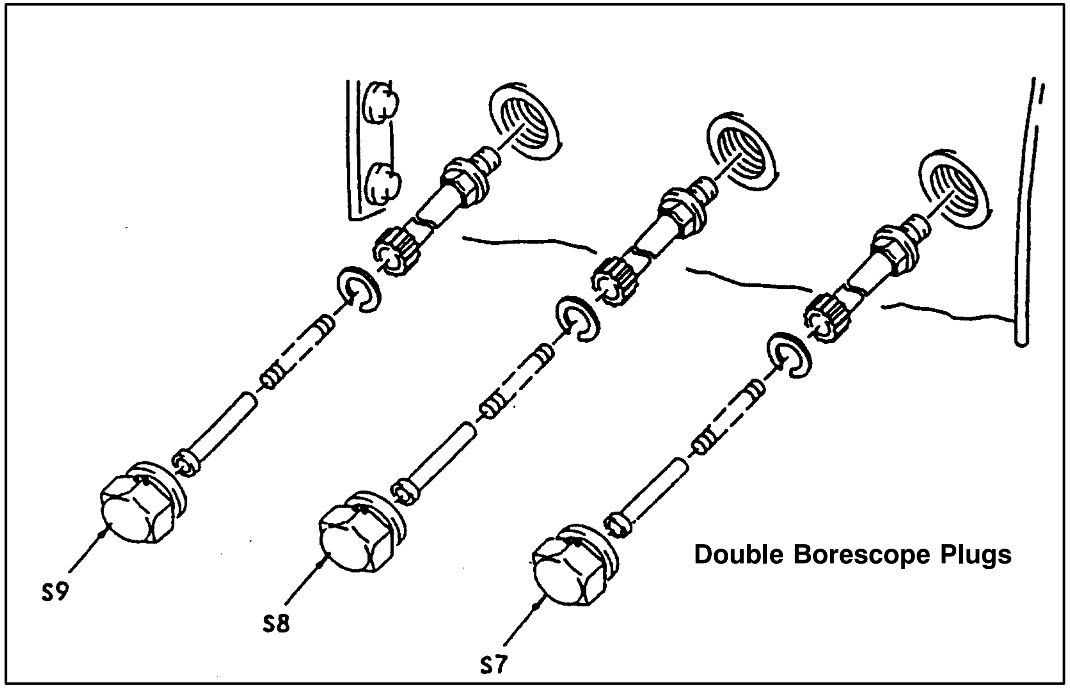


Figure 28 Special Borescope Plugs

N2 ROTOR ROTATION PAD COVER

Inspection

The use of the borescope for inspection of the compressor and turbine blades requires rotation of the core engine.This is accomplished by removing the cover plate, useing a slide hammer, from the core engine rotation pad located on the forward face of the accessory gearbox above the Control Alternator.

Install 3/4 inch square drive tool into the drive pad and rotate the engine.

Note.
This port can also be used to check if the core engine turns freely.

CAUTION:
Do not exceed recommended torque or engine parts may be damaged.

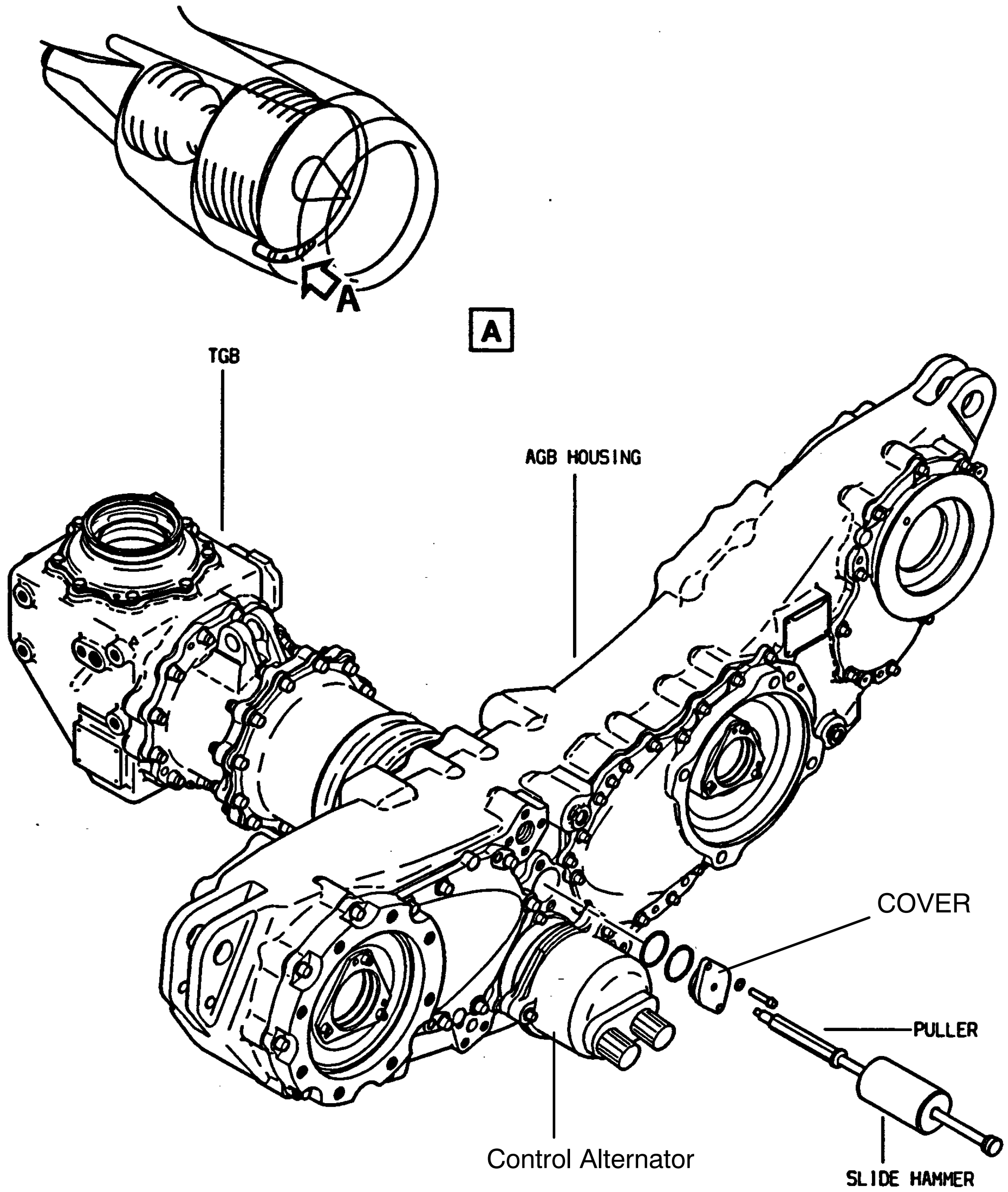


Figure 29 Handcranking Pad

71-20 ENGINE MOUNTS

GENERAL

The engine mounts support the engine by transmitting loads from the engine case to the pylon structure.
They allow thermal expansion of the engine without inducing additional load into the mount system.
Each engine mount design provides dual load paths to ensure safe operation if one member fail.

The engine/pylon connection is achieved by means of a two-mount system :
- the forward mount :
it is attached to the engine via the intermediate casing. It takes the X loads (thrust), Y loads (lateral) and Z loads (vertical).
- the aft mount :
it is attached to the engine via the exhaust casing. It takes the loads in a plane normal to the engine centerline i.e.: Y loads (lateral), Z loads (vertical) and Mx (engine rotational inertia moment + Y load transfer moment).

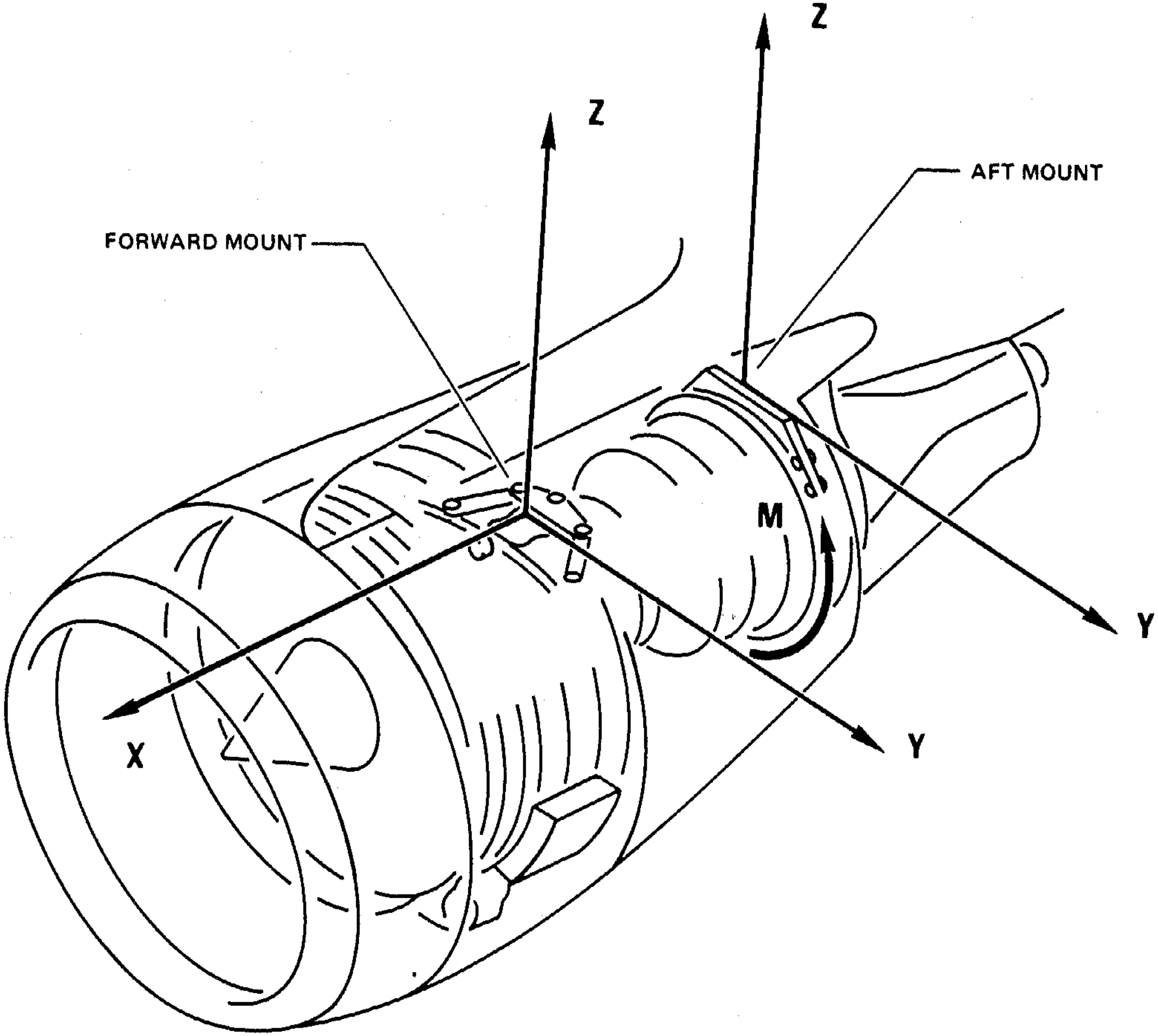


Figure 30 Mounts and Loads

FWD MOUNT

The forward mount connects the engine aft fan case with the engine pylon forward structure. The forward mount is a damage tolerant design.
It consists of :
- the support beam assembly : for pylon connection via 4 tension bolts and 2 alignment pins.
This fail-safe designed fitting is an assembly of 3 components :
2 half-fittings and 1 plate.

AFT MOUNT

The aft mount connects the engine turbine rear frame with the engine pylon via a beam.
The aft mount takes the loads in the plane normal to the engine centerline, i.e. y, z loads and Mx. The aft mount is a damage tolerant design.
It consists of 3 links and a crossbeam assembly.
There is a possibility of axial translation movement between the engine casing and the pylon since :
- the three links are located in the same plane normal to the engine centerline
- the link end have bearings.
There is a possibility of axial translation movement between the engine casing and the pylon.
This allows for casing expansions of about 0.236 in. (6 mm) in cruise and 0.295 in. (7.5 mm) at maximum thrust.
The aft mount consists of :
- 3 fail-safe links.
Each link is a triple element stacked assembly.
The cross beam has a mating face for connection with the engine pylon.
This attachment is made through 4 tension bolts and 2 shear pins.
One of the two shear pins is a back-up pin also used as an alignment pin.
The cross beam fitting is a fail-safe design : it consists of two lateral parts linked by shear pins.

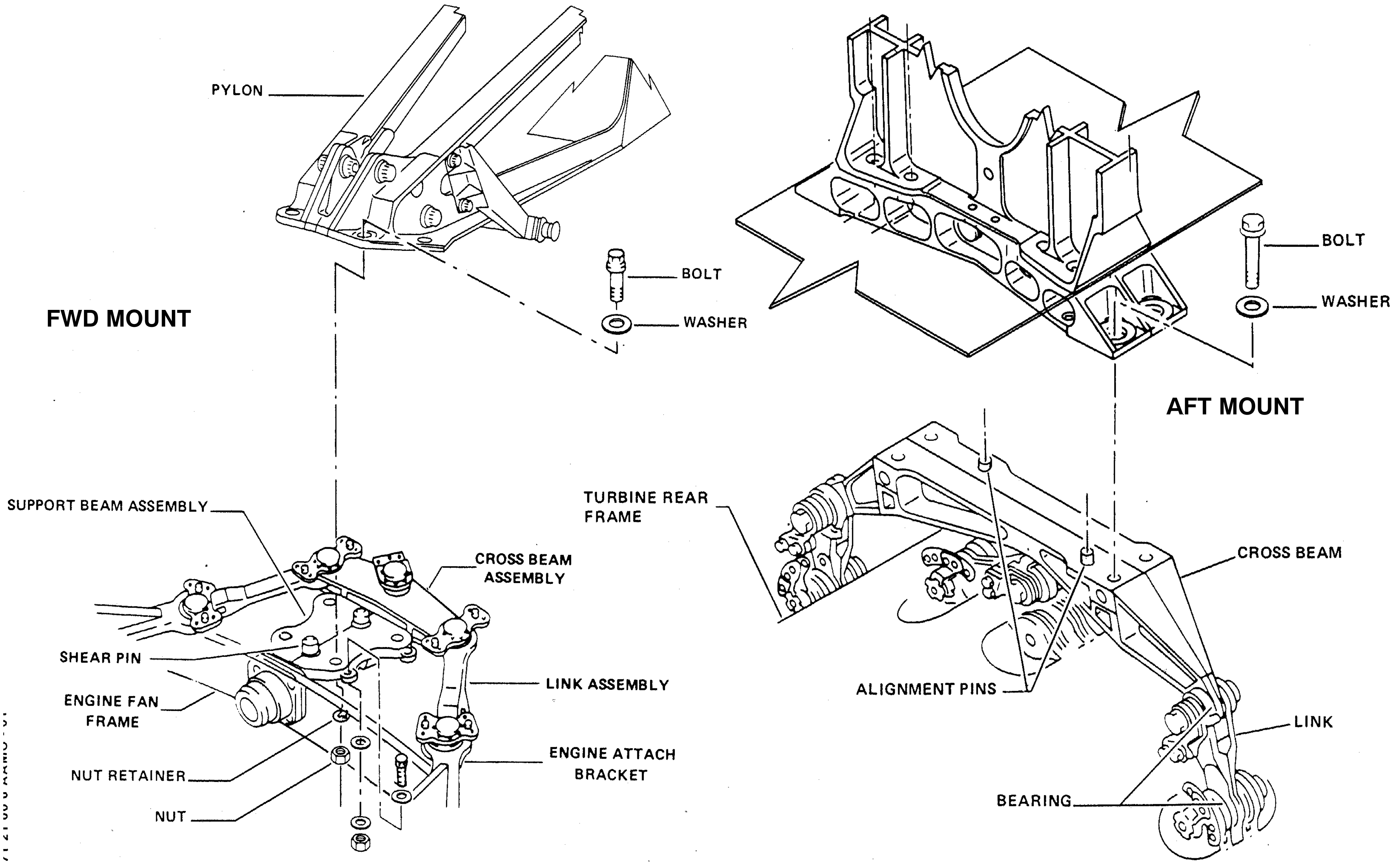


Figure 31 FWD / AFT Mount

ATA 71 POWER PLANT

71-10 NACELLE ACCESS DOORS & OPENINGS

NACELLE GENERAL

The cowls enclose the periphery of the engine so as to form the engine nacelle.
The nacelle provides:

- protection for the engine and the accessories,
- ensures airflow around the engine during its operation,
- lightening protection,
- Hirf and EMI attenuation.

Note:The fan thrust reversers and the primary exhaust are covered in 78-00-00.

ACCESS DOORS & OPENINGS

The fan cowl doors enclose the engine fan case between the air intake cowl and fan thrust reverser. Three hinges at the pylon support each assembly. The door assemblies are latched along the bottom centerline with three adjustable tension hook latches.
To improve take-off performance, aerodynamic strakes have been installed on the inboard fan cowl of each nacelle, on some aircraft configurations.

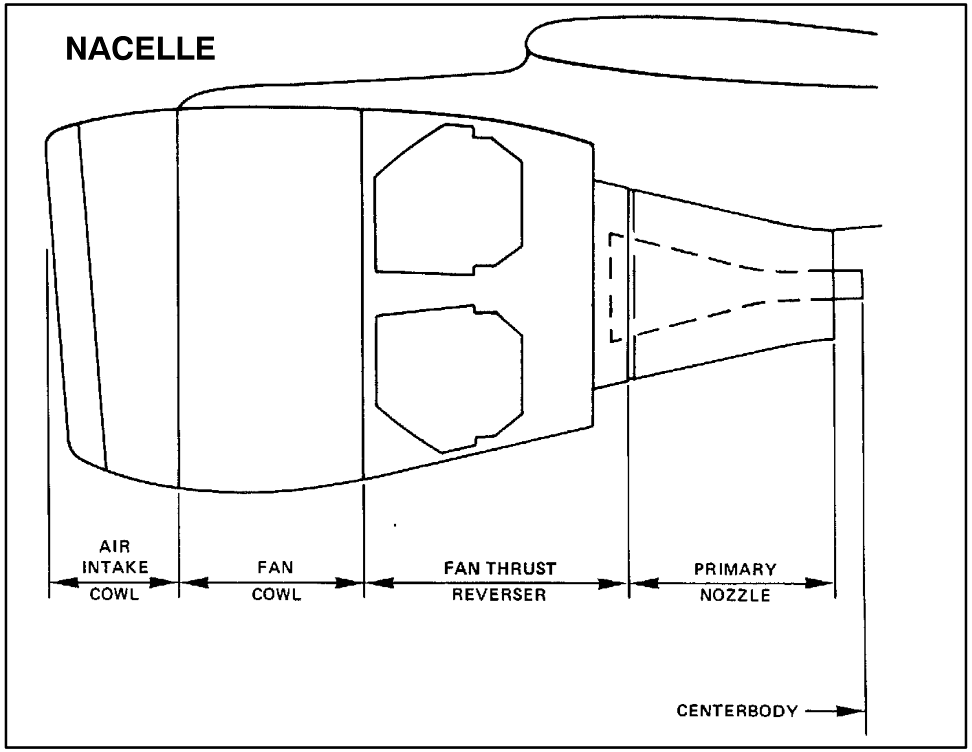
The fan cowl doors are :
- fire proof with external air flow
- fire proof without external air flow above 45 degree radial
- fire resistant without external air flow below 45 degree radial.

The plus or minus 45 degree fire proof protection is accomplished by epoxy layers.

Fan Cowl Structure
The internal pressure loads and external air loads are reacted through the honeycomb structure. They are transmitted into the pylon through the hinge fittings.

Access door 438CR (448CR),
in the right fan cowl door provides access to the starter valve manual override.
Access door 437BL (447BL) in the left fan cowl provides access for :
- engine oil service and
- inspection of the hydraulic filter clogging.

Pressure Relief Door 438BR (448BR)
A pressure relief door located in the right cowl door limits compartment pressure to a maximum of 4 psig. In addition, a compartment cooling air inlet is located in the lower quadrant of the left cowl door.
The air inlet directs air toward the accessory gearbox. In the upper quadrants of the left and right cowls there are five resistant air outlet vents.



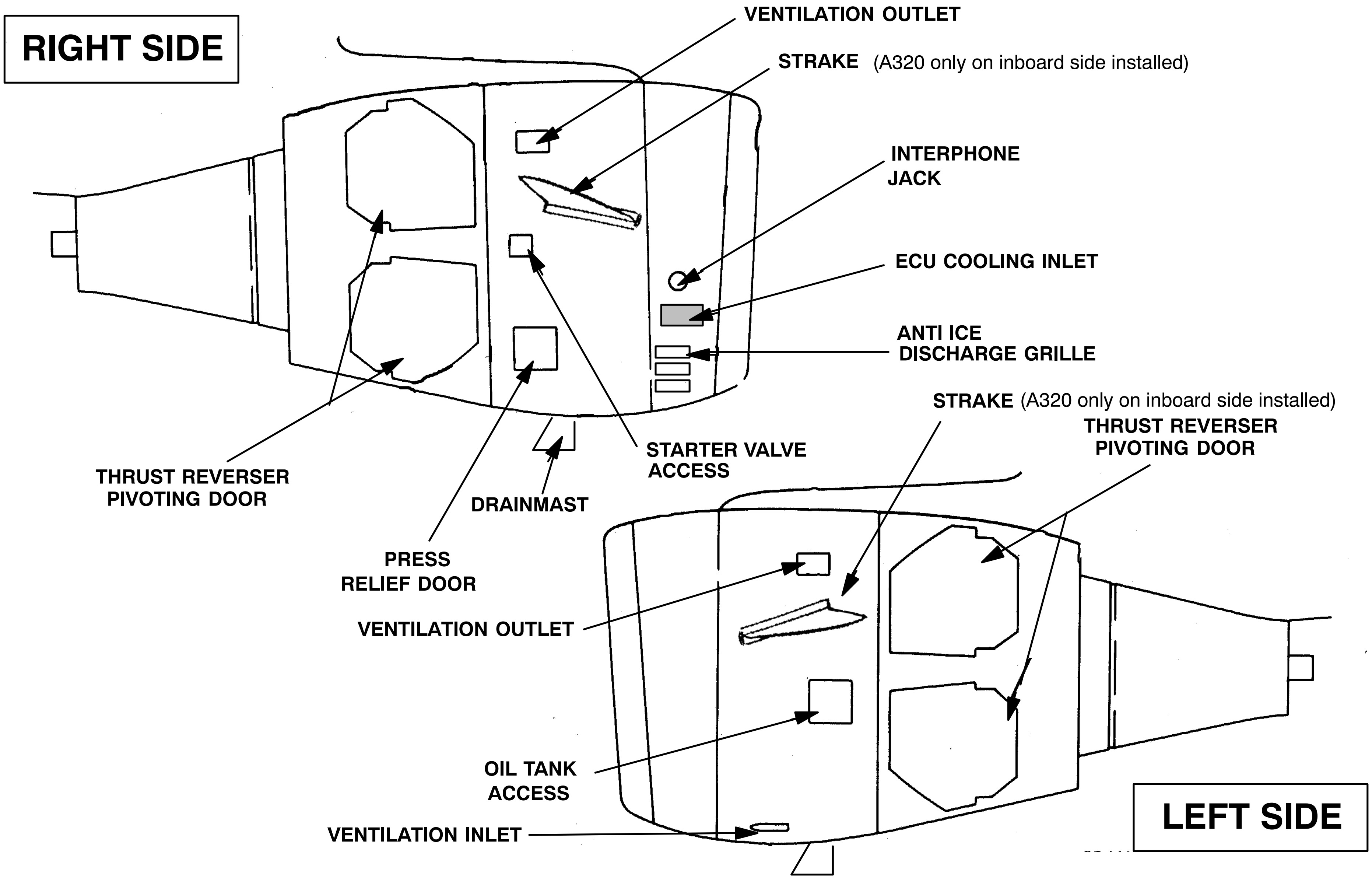


Figure 32 Nacelle Access Doors / Openings

FAN COWLS

The fan cowl doors enclose the engine fan case between the air intake cowl and fan thrust reverser. Three hinges at the pylon support each assembly. The door assemblies are latched along the bottom centerline with three adjustable tension hook latches.
To improve take-off performance, aerodynamic strakes have been installed on the inboard fan cowl of each nacelle, on some aircraft configurations.

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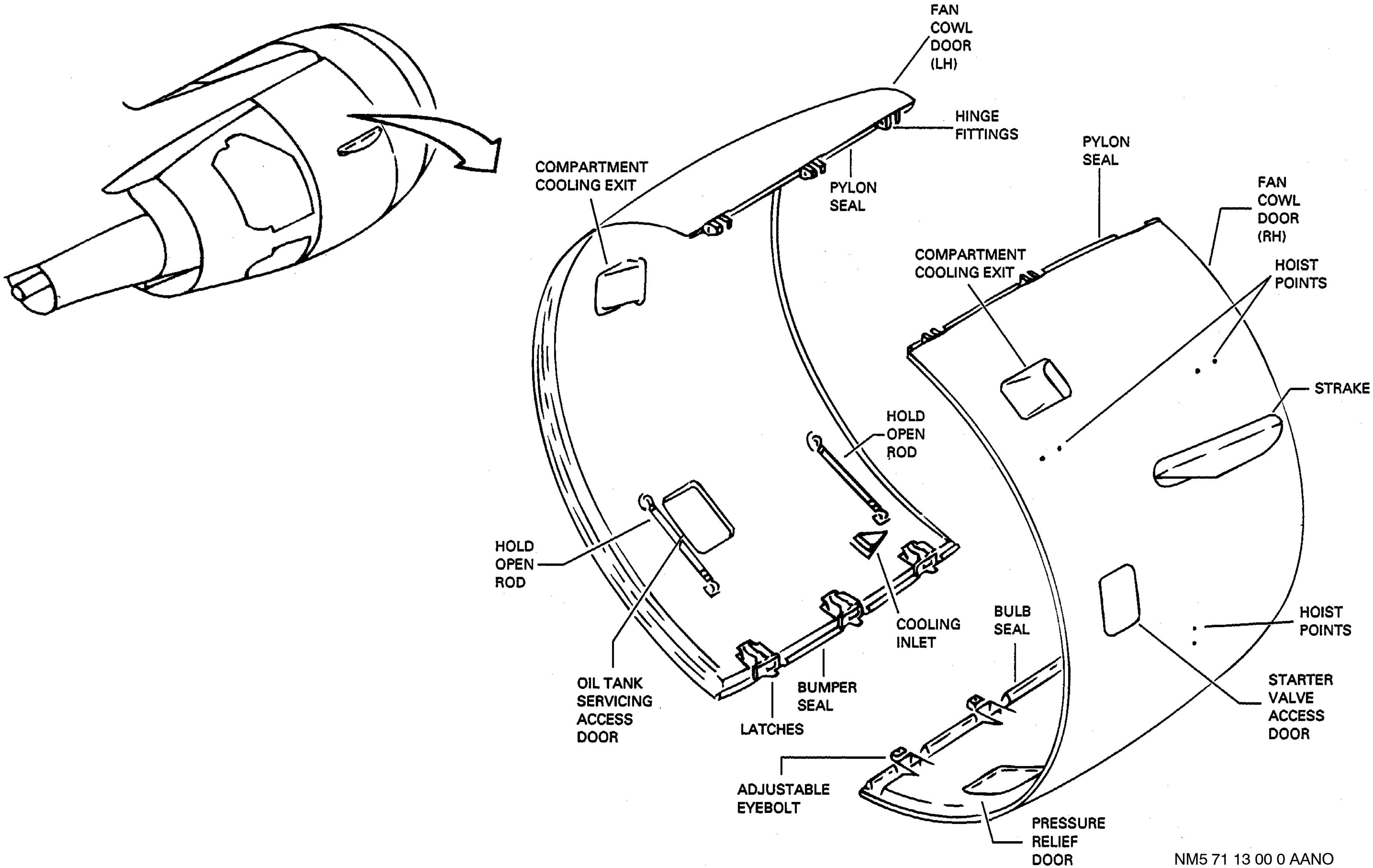
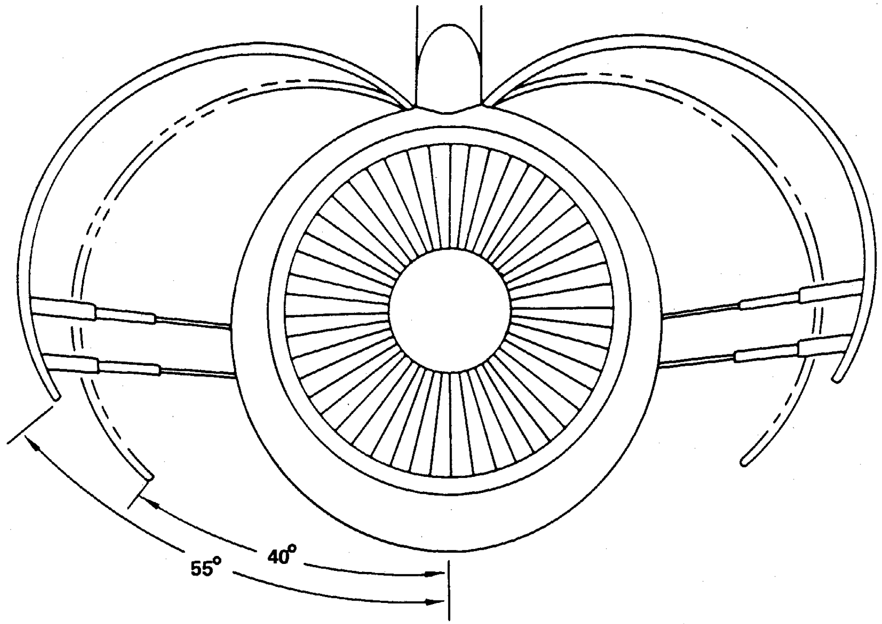


Figure 33 Fan Cowl Doors

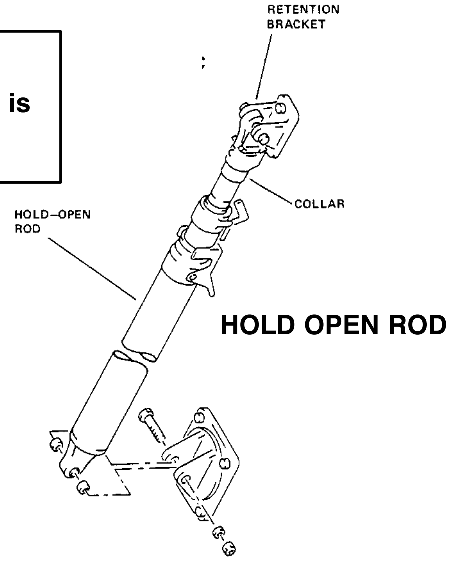
FAN COWL OPENING / CLOSING

There are two telescopic hold open rods on each door.
The hold open rods lock to brackets on the engine fan case. They support the fan cowl doors in the open position. A 40-degree position serves for routine maintenance and a 55-degree position serves for increased access.

Note:
Engine Idle run with fan cowl doors open in the 40 degree position is allowed to perform maintenance tasks.



Caution:
Do not open cowlings if wind speed is more than 65 knots or if engine is running.



Opening:

Unlock the three latches of fan cowlings.

Release the hold - open rods from the stow brackets.

Extend the hold open rods to the 40 or 55 degree position and attach them to the brackets on the engine.

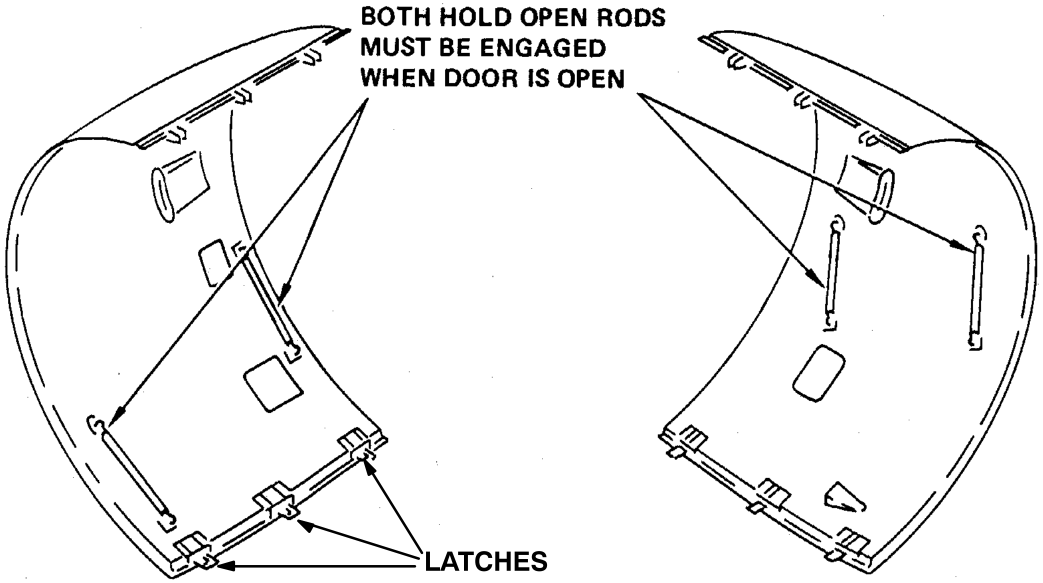


Figure 34 Fan Cowl Door Opening

FAN COWL ADJUSTMENT

TASK 71-13-00-800-040

Adjustment/Test of the Fan Cowl

CAUTIONS:

- **On the panel 115VU:**
  put a warning notice to tell persons not to start the engine 1(2).
- **Make sure that the engine 1(2) has been shut down for at least 5 minutes.**
- **On the panel 50VU:**
  make sure that the ON legend of the ENG/FADEC GND PWR/1(2) pushbutton switch is off.Install a warning notice.

Procedure

- Measure the gap between the fan cowl doors at the bottom with the closed. If the gap is more or less than 1.02 to 4.06 mm (0.040 to 0.160 in.) adjust the fan cowl doors as follows :

Open the fan cowl doors:

- Remove the bolt (5), the nuts (10) and (15), the washers (20) and (25), the shear pin (30), remove also the shims and the retainers from the latch housing on the door.
- Close the doors and engage the front and the rear latches only.
- Adjust the latches so that a force of 4.44 to 11.12 daN (10 to 25lb.) is required to close them. Measure the force at the tip of the latch handle with a push-pull gage.
- Measure the gap between the doors at the bottom.
- If the gap is more or less than 1.02 to 4.06 mm (0.040 to 0.160 in.), open fan cowl doors and install the shims and the retainers as necessary in front and rear latches (see paragrah A.).
  This must bring the gap to within the specified range.

NOTE :
The gap may taper from the front to the rear as long as it is within the specified range.

- Install the shims and the retainers on the front and the rear latch housings with the bolts (5), the nuts (10) and (15). Install also the washers (20) and (25), and the shear pins (30).TORQUE nuts to between 50 and 70 lbf.in (0.56 and 0.79 m.daN)
- Put the shims and the retainers as necessary in the center latch. This must fill gap between the latch keeper and the latch housing.
- Install the shims and the retainers on the center latch housing with the bolt (5), nuts (10) and (15). Install also the washers (20) and (25), and the shear pin (30). TORQUE the nuts to between 50 and 70 lbf.in (0.56 and 0.79 m.daN)

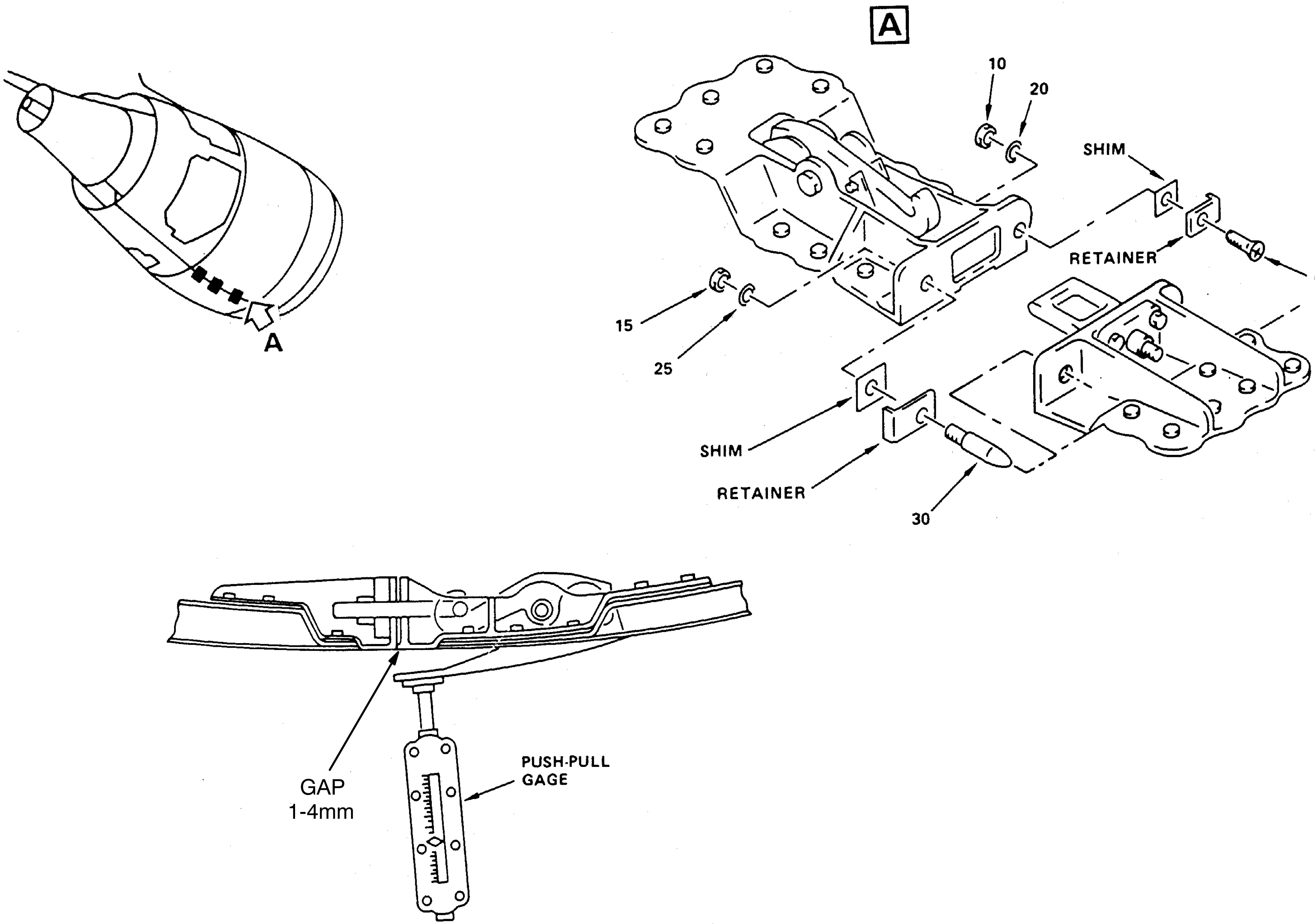


Figure 35 Fan Cowl Adjustment

ATA 78 EXHAUST

78-30 REVERSER COWL DOORS

OPENING AND CLOSING OF THRUST REVERSER COWLINGS

Caution
Before opening:

1. **Wing slats must be retracted and deactivated.**
2. **All 3 latches must be released.**
3. **Deactivate Thrust Reverser Hydraulic Control Unit (HCU)**
4. **FADEC power ”OFF”**
5. **Put Warning Notices in the Cockpit**

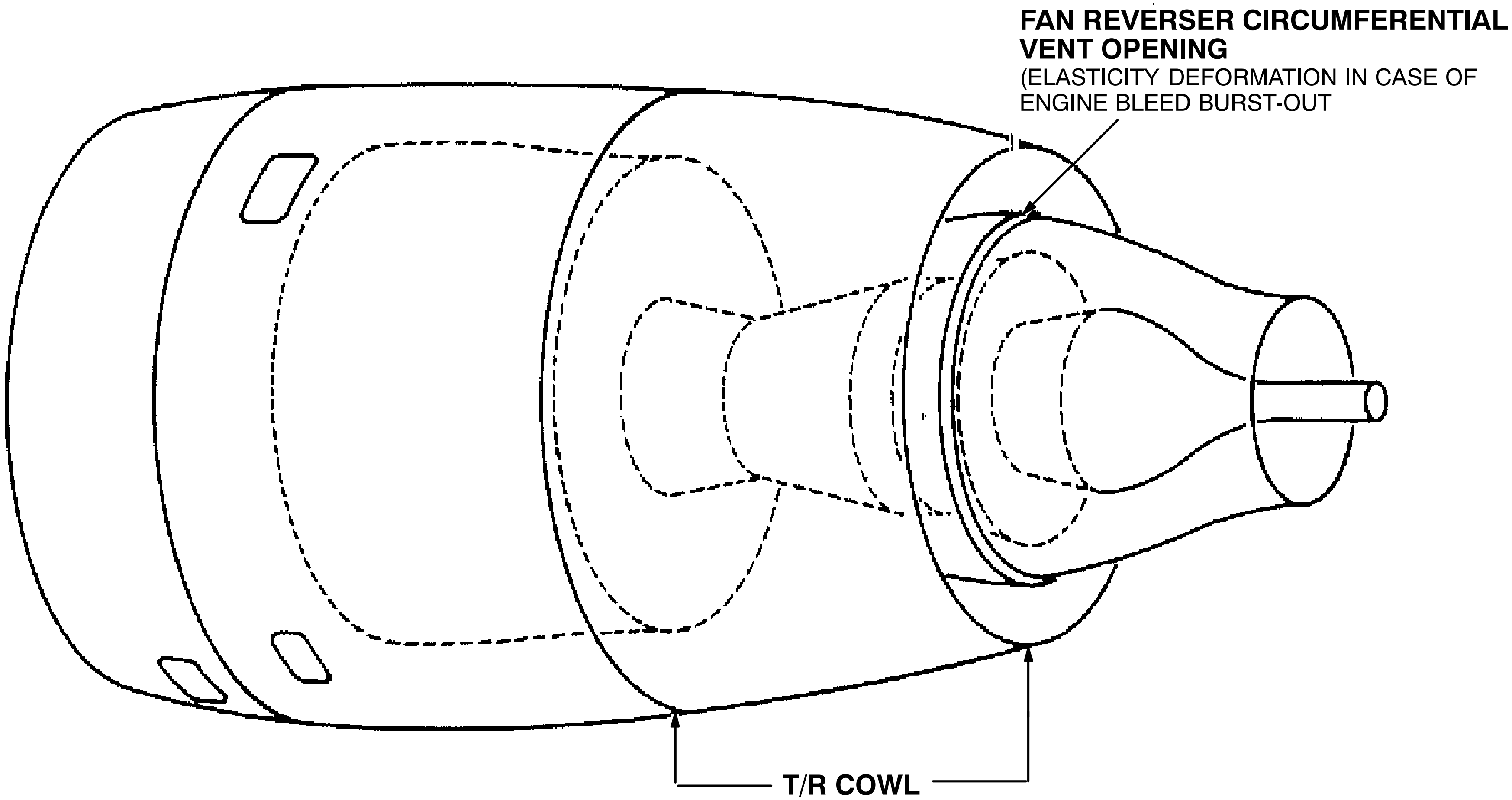


Figure 36 T/R Cowl Opening / Closing

OPENING AND CLOSING OF THRUST REVERSER COWLINGS

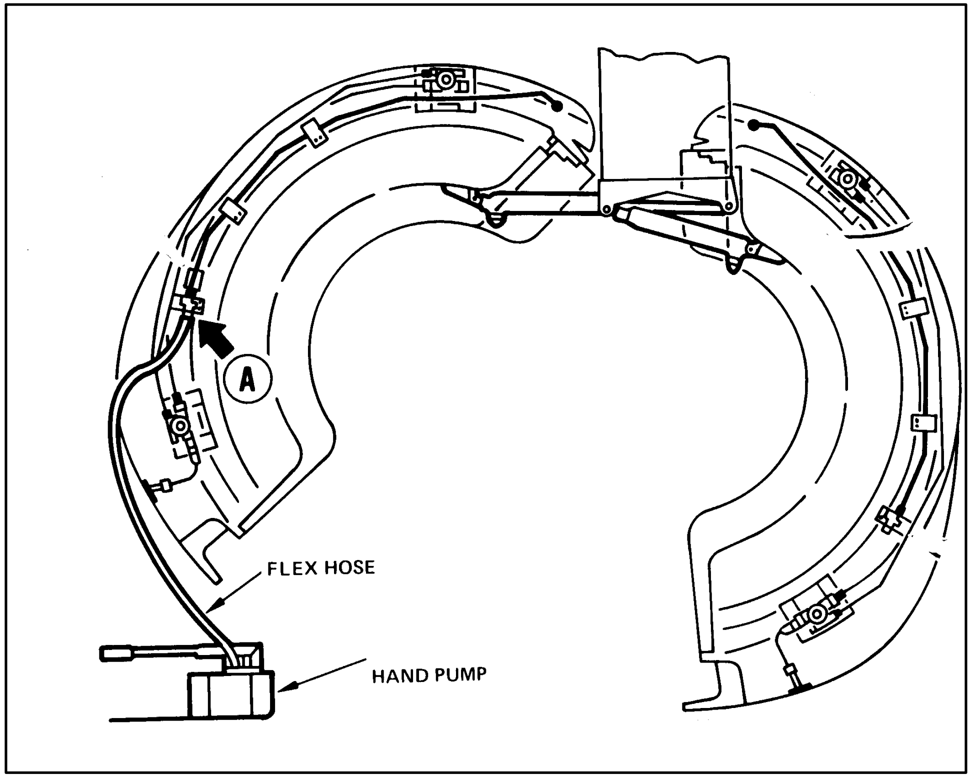
CAUTION
Do not open the thrust reverser cowlings if the wind speed is more than 40 knots.Make sure that the thrust reverser can not be operated. Deactivate Thrust reverser system. Make sure the slats are retracted.

Opening of the Thrust Reverser Cowlings

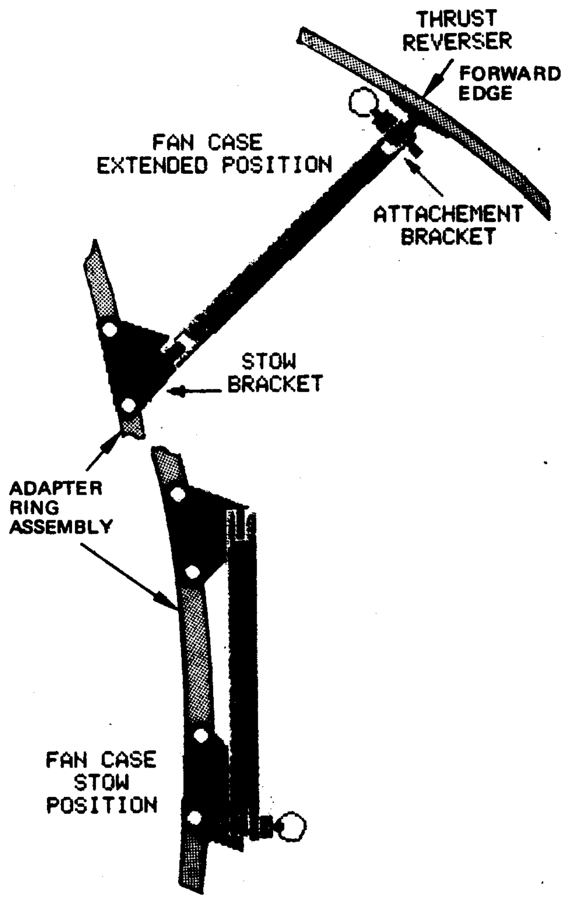
- Open the fan cowlings.
- Unlock the four latches along the lower edge of the cowls.
- Connect the hand pump.
- Operate the hand pump to open the half cowling to the normal maintenance position. The doors can be opened to 33 degrees with the wing leading edge slats extended. However, beyond the 33 degree position they interfere with the wing leading edge slats when extended and thus can cause damage. Maximum opening is 45 degrees.

Closing of the Thrust Reverser Cowlings

- Operate the hand pump to pressurize the opening actuator to take the load of the hold-open rod.
- Remove the hold-open rod.
- Open the hand pump relief valve to let the cowling close.
- Close the-four latches.
- Cowling pump must be connected for some time to allow a retunflow of the oil from the opening actuator to the pump.(to prevent oil leckage of the opening actuators when the engine operates and the oil expands due to heat.)



Hold Open Rod



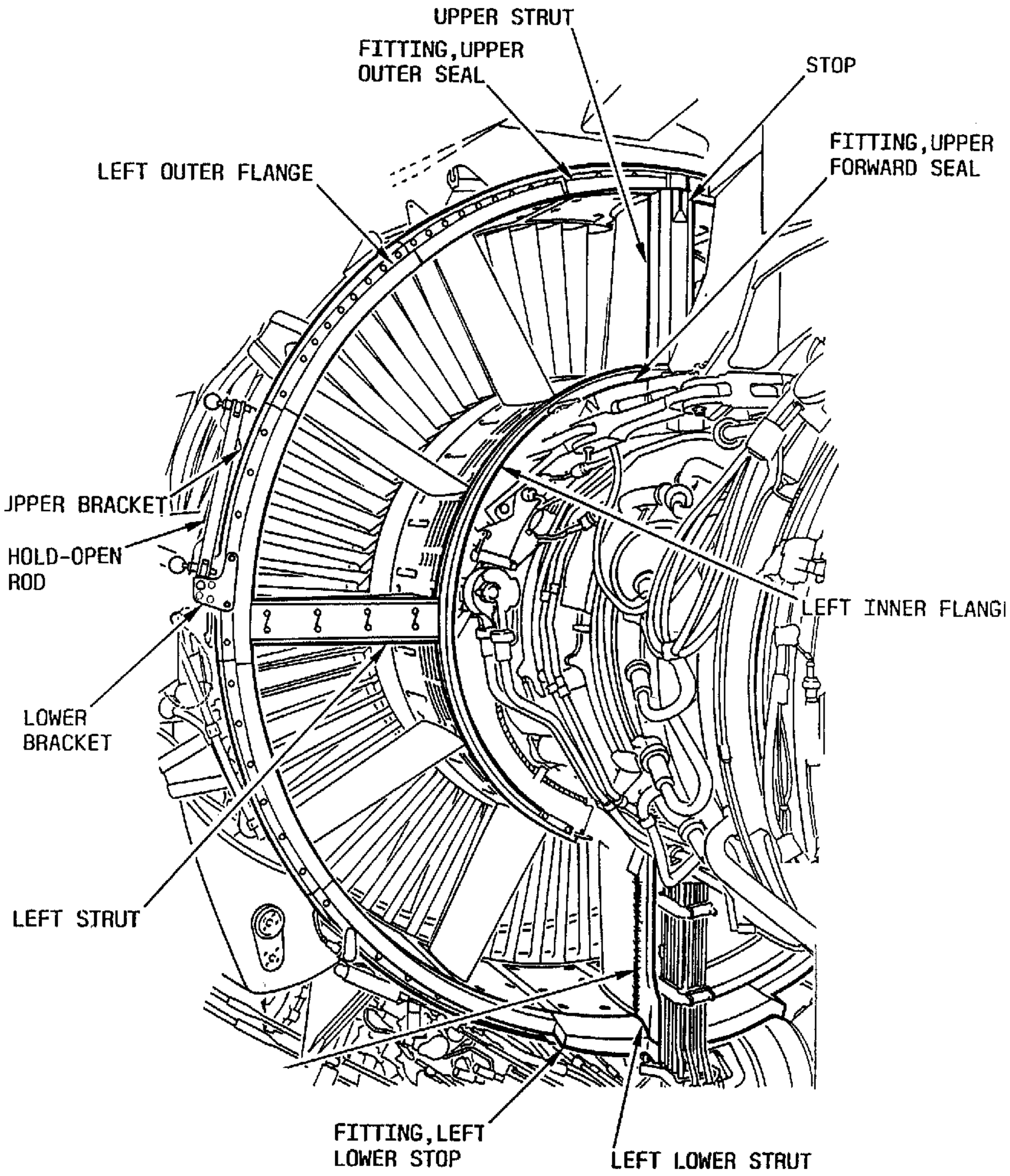


Figure 37 T/R Cowl Opening / Closing

THRUST REVERSER COWL ADJUSTMENT

TASK 78-36-41-820-040- 01

CAUTION:
Make sure that the engine 1(2) has been shutdown for at least 5 minutes.

On the panel 50VU :
-Make sure that the ON Legend of the ENG/FADEC GND PWR/ 1(2) pushbutton switch is off
- Install a warning notice
-Make the thrust reverser unserviceable

PROCEDURE:
Open the fan cowl doors

- Fasten all latches

CAUTION:
ALL LOCATING PINS MUST BE IN FULL CONTACT WITH BUSHINGS OR DAMAGE COULD OCCUR TO REVERSER.

- Make sure of the full contact between each bushing and locating pin.

Adjust latches:

NOTE : You must apply this procedure after the installation of a complete thrust reverser or after changing a reverser half door on the aircraft.

(1) Open the forward latch.

(2) Remove the screw which attach the lockwasher.

(3) Remove the lockwasher.

(4) Tighten with your hand the latch tension nut and put it in a position which permits the installation of the lockwasher.

(5) Measure the force on the latch handle tip with the push gage: range 30.27 to 41.09 lbs (14 to 19 daN) which is necessary to lock it.

(6) The recorded force must be between 14 daN (31.4732 lbf) to 19 daN (42.7136 lbf).

(7) If the recorded force is not within tolerances turn the latch tension nut to obtain the force indicated.

NOTE : Turn the tension nut by twelth of a turn to keep the position which permits the installation of the lockwasher.

(8) Install the lockwasher and screw which attach the latch tension nut.

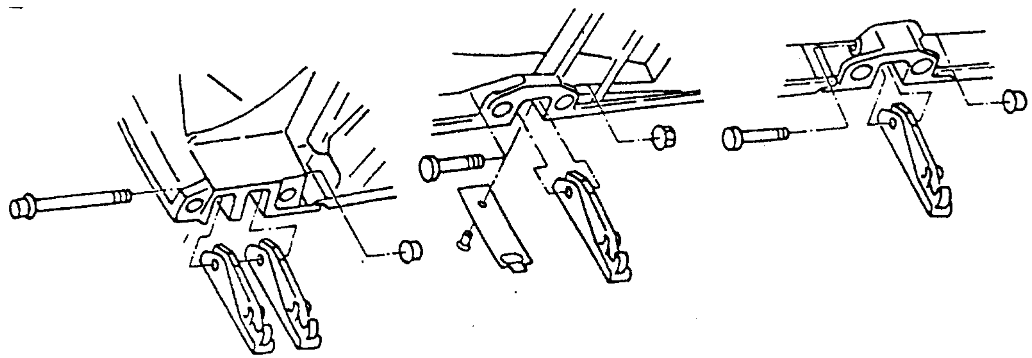
(9) TORQUE the screw to between 35 and 45 lbf.in (0.39 and 0.50 m.daN).

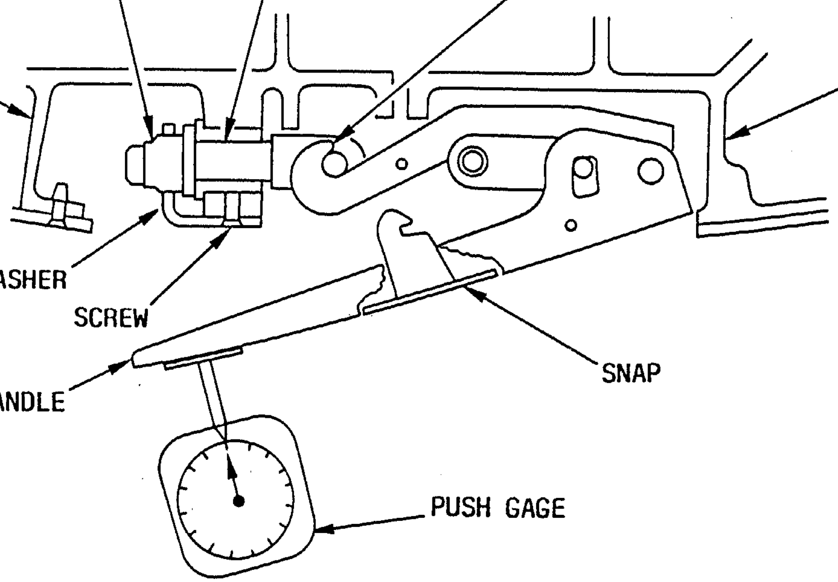
(10) Adjust the three other latches with the same procedure step 1 to step9.

(11) Do a check of each latch from the front to the rear. The force applied on the latch handle tip must be between 14 daN (31.4732 lbf) to 19 daN (42.7136 lbf).

4. Close-up

- Make sure that the aircraft is in the same configuration as for the removal task.
- Make the thrust reverser serviceable
- Close fan cowl doors
- Remove the warning notices from the panels 115VU and 50VU.





	Force to apply on the latch handle tip
ALLOWED VALUE	14 To 19 daN (30.27 To 41.09 lbs)

Figure 38 Check of Latch adjustment

ATA 79 OIL

79 - 00 GENERAL

SYSTEM PRESENTATION

General Description

- a Supply Circuit
- a Scavenge Circuit
- a Vent Circuit

It Lubricates and cools the Bearings of the Forward and Aft Sumps.

It also lubricates Bearings and Gears in the Transfer and Accessory Gear Boxes.

The Major Components of the Oil System are:

- The Oil Tank
- The Lubrication Unit
- The Servo Fuel Heater
- The Main Fuel Oil Heat Exchangers.

Indicating and Monitoring is provided by the Detectors and Sensors shown on the Schematic.

Oil Supply Circuit

The Oil from the Tank passes through the Supply Pump and Supply Filter to lubricate the forward and aft Sumps, and also the Accessorys and Gearboxes.

On the Oil Supply Line a Visual Filter Clogging Indicator, an Oil Temperatur Sensor, an Oil Low Pressure Switch and an Oil Pressure Transmitter are provided for Indication and Monitoring.
Also an Oil Quantity Transmitter is provided on the Oil Tank.
Note the Installation of the ECU Oil Temperatur Sensor for the Fuel Return Valve.

Oil Scavenge Circuit

The Oil from Bearings, Transfer Gearbox and Accessory Gearbox returns to the Tank by means of four Scavenge Pumps protected upstream by Strainers and Chip Detectors.

To keep Oil Temperatur within Limits, the Oil is cooled through the Servo Fuel Heater and the Fuel/Oil Heat Exchanger.

In Case of Scavenge Filter Clogging, an Oil Differential Pressure (Delta P) Switch signals it to the Cockpit and its Clogging Indicator shows it on the Engine system page with a message on E/WD accompanied by a single chime

Oil Vent Circuit

Some Air entrained in the Scavenge Oil is separated in the Tank by a Dearator and is vented to the Forward Sump through the Transfer Gearbox and Radial Drive Shaft.

The Sumps are vented Overboard through the Low Pressure Turbine Shaft to prevet Overpressure in the Sump.

Air entrapped in the Scavenge Oil Pressurizes the Tank and provides adequate Oil Pressure to the Supply Pump.

<u>System Monitoring and Limitations</u>

The operation of the engine oil system may be monitored by the following flight deck indications.

- **engine oil pressure**
- **engine oil temperature**
  - MIN.PRIOR EXCEEDING IDLE : **-10^{0}C**
  - MAX CONTINIOUS: **140^{0}C**
  - MAX TRANSIENT: **155^{0}C**
- **oil tank contents** **24 US quarts**

In addition warnings may be given for the following non normal conditions:

- **low oil pressure**
  - RED LINE LIMIT: **13 PSI**
- **high oil pressure**
  - ADVISORY: **90 PSI**
- **scavenge filter clogged.**

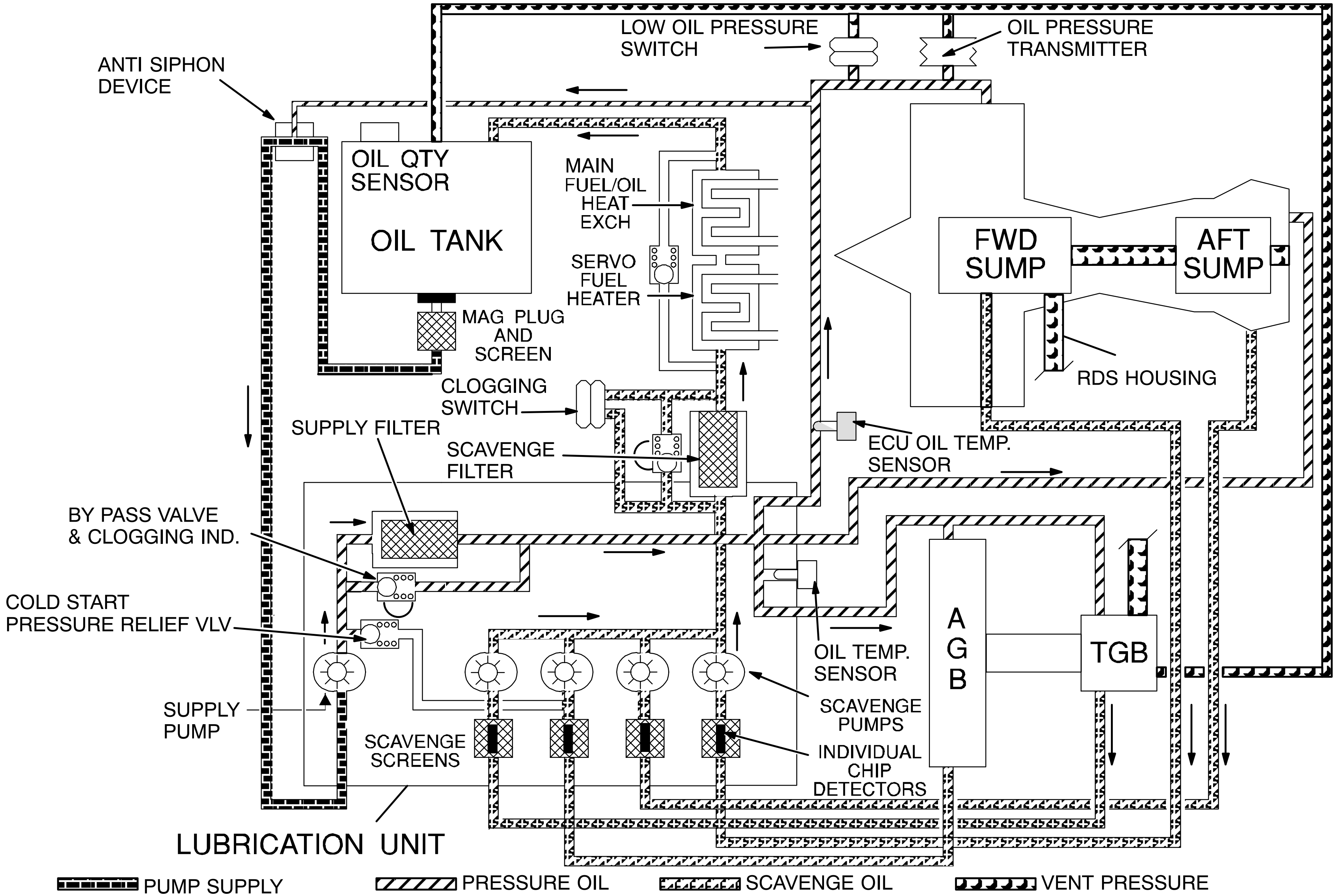


Figure 39 OIL SYSTEM SCHEMATIC

79-30 0IL INDICATING

DESCRIPTION

ECAM System Page

- 1.Oil Temperature Indication
  Flashes Green (Advisory) when Temp $\geq$ 140° C
  Is amber when155°C or 15min >140°C
- 2.Oil Pressure Indication
  Color turns red (Warning) when Pressure <13 PSI
- 3.Oil Quantity Indication
  Flashes Green (Advisory) when QTY < 4 Quarts
- 4.Oil Filter Clog
  (White and Amber)Warning appears on the Screen when the Engine
  Scavenge Filter is Clogged

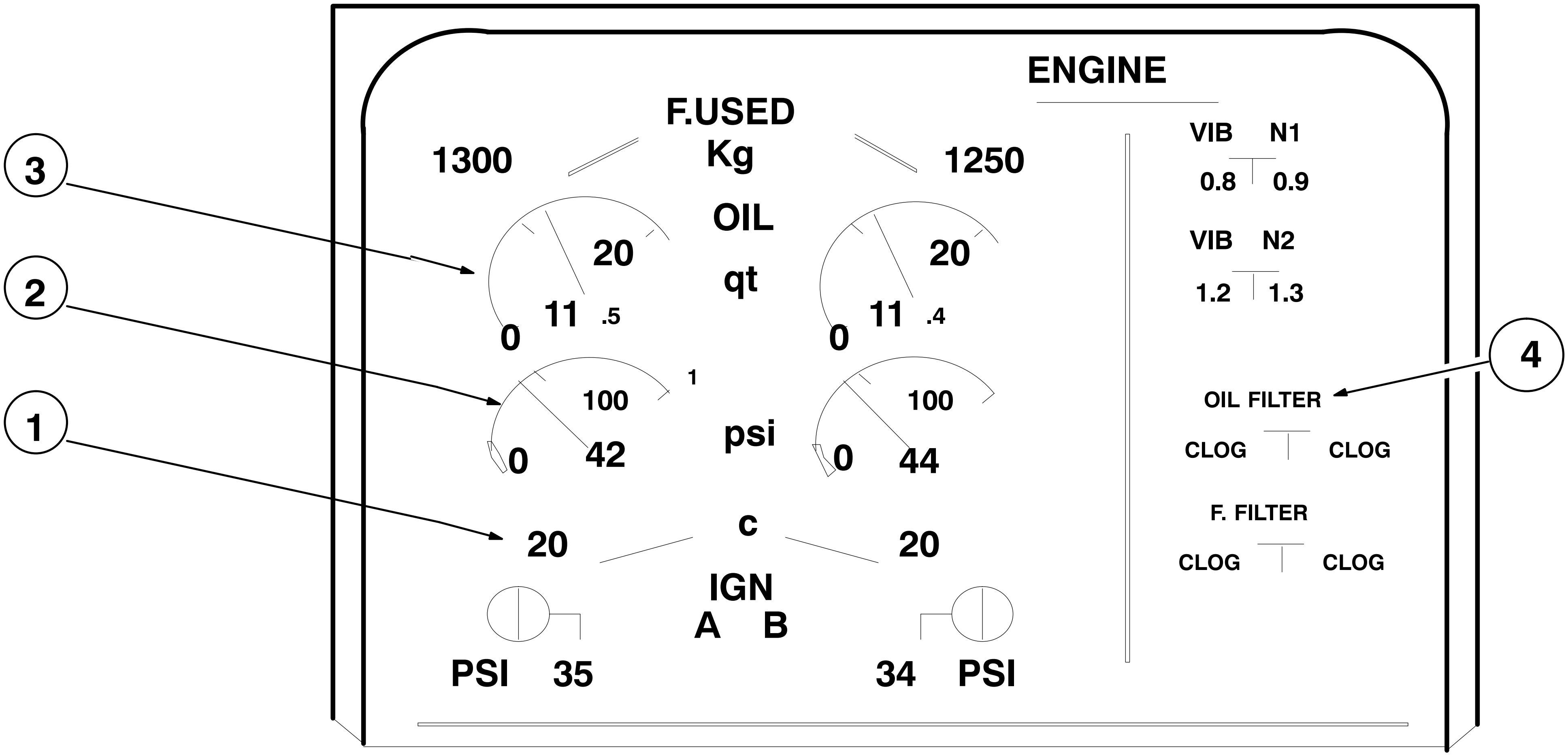


Figure 40 ECAM System Page

TEMPERATUR ENGINE OIL (TEO)

This sensor is used for the IDG cooling system control(Fuel return).The oil temperature is sensed by a dual resistor unit. The unit consists of a sealed, wire-wound resistance element(Chromel/alumel). This element causes a linear change in the DC resistance when exposed to a temperature change.
Temperature measurement range :- 70 deg.C to 300 deg.C
Both signals (channel A and B) are routed to the ECU.

OIL PRESSURE INDICATION

The analog signal from the oil pressure transmitter is sent to the SDAC1, SDAC2 and the EIU which transforms the analog signal into a digital signal. The digital signal is then transmitted to the ECAM through the FWCs and the DMC.

OIL FILTER DIFFERENTIAL PRESSURE SWITCH

When the differential pressure through the oil scavenge filter is higher than 25.5 plus or minus 1 PSID increasing pressure, the switch closes.The signal is send to the SDACs to the FWCs and the DMCs.In result :
- the MASTER CAUTION (amber) comes on
- ENG page on the lower display unit of the ECAM appears :
OIL FILTER CLOG indication (White and Amber)

OIL TEMPERATURE SENSOR

The oil temperature is sensed by a dual resistor unit. This element causes a linear change in the DC resistance when exposed to a temperature change.
Temperature measurement range :- 70 deg.C to 300 deg.C
Both signals (channel A and B) are routed to the EIU which transforms this analog signal to a digital signal.The signal is send to the FWCs and DMCs and then displayed on ECAM.

OIL QUANTITY TRANSMITTER

The oil quantity transmitter probe (tube portion) is a capacitor. The signal from this capacitor is rectified and sent to the electronics assembly on top of the transmitter.The analog signal is sent to the SDACs and EIU which transforms it into a digital signal.The signal is sent to the FWCs.
The system is power supplied with 28VDC from busbar 101PP (202PP),through circuit breaker 2EN1 (2EN2).

LOW OIL PRESSURE SWITCHING

When the oil pressure drops down 13 PSID plus or minus 1 PSID (decreasing) the pressure switch closes ; in result :
- The master warning (red) located on the glare shield comes on.
- The audio warning is activated
- The ENG page appears on lower display unit of the ECAM system :
Oil pressure indication flashes red.
- Warning messages appear on the upper display unit :
ENG1 (2) OIL LOW PRESS
THROTTLE 1 (2) IDLE
The low oil pressure information is send to different aircraft systems.
Two different switchings are possible:

Low Oil Pressure Switching (via relay)

- To Steering (32-51)
- Door Warning (52-73)
- To FWC (31-52)
- FAC (22-)
- TO FMGC (22-65)
- To IDG SYSTEM CONTROL(24- 21)

Low Oil Pressure Switching <u>via EIU</u>

- To CIDS (23-73)
- To DFDRS INTCON Monitoring (31-33)
- To CVR power Supply (23-71)
- To Avionics Equipment Ventilation (21-26)
- To WHC (30-42)
- To PHC (30-31)
- To FCDC (27-95)
- To Blue Main Hydraulik PWR(29-12)
- To Green Main HYD PWR RSVR Indicating (29-11)
- To Yellow Main HYD PWR RSVR Indicating (29-13)
- To Blue Main HYD PWR RSVR Warning / Indicating (29-12)

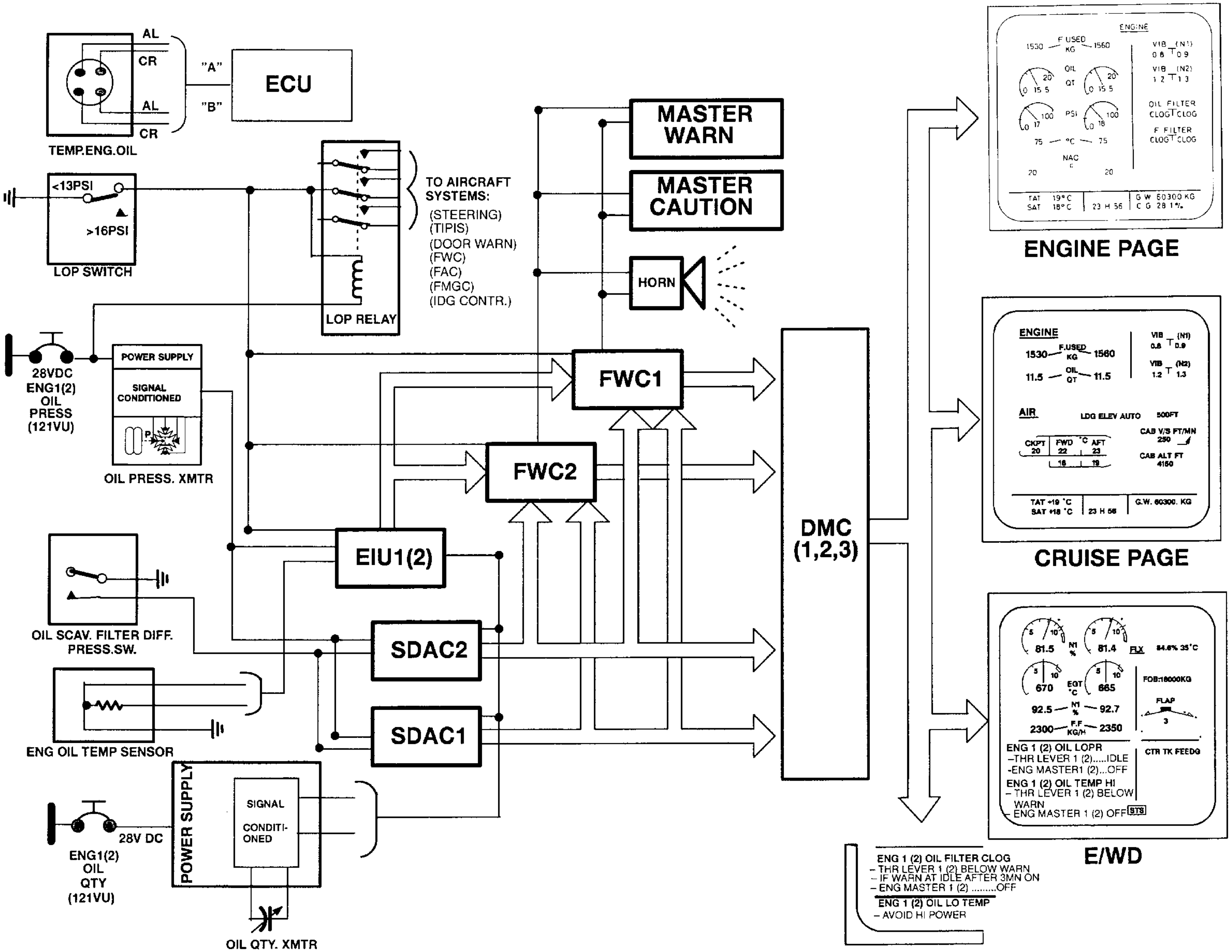


Figure 41 Basic Schematic

79-00 OIL SYSTEM COMPONENTS

OIL TANK

The tank is located on the left side of the fan case at the 8 o'clock position, and above the main oil/fuel heat exchanger.The oil tank is attached to the fan frame at 3 points.It is a fabricated light alloy weldment.The tank is treated externally with a flame-resistant coating to meet fireproof requirements

Features:

- **oil qty. transmitter**
- **pressure and gravity fill ports**
- **sight glass for level indication**
- **static air and oil separator**
- **magnetic drain plug**
- **oil scupper to drain oil spills during filling**

Oil Tank Characteristics

	US Quarts	Liters
Max Unuseable Quant.	2.5	2.35
Max gulping effects	8	7.56
Min useable oil volume	10	9.46
Max oil total capacity	21,9	20.7
Total tank volume	24	22.7

Minimum Oil QTY on ground (ECAM INDICATION)

Before engine start:

- 11 quarts + estimated consumption (0,3qts/h)

Engine at ground idle:

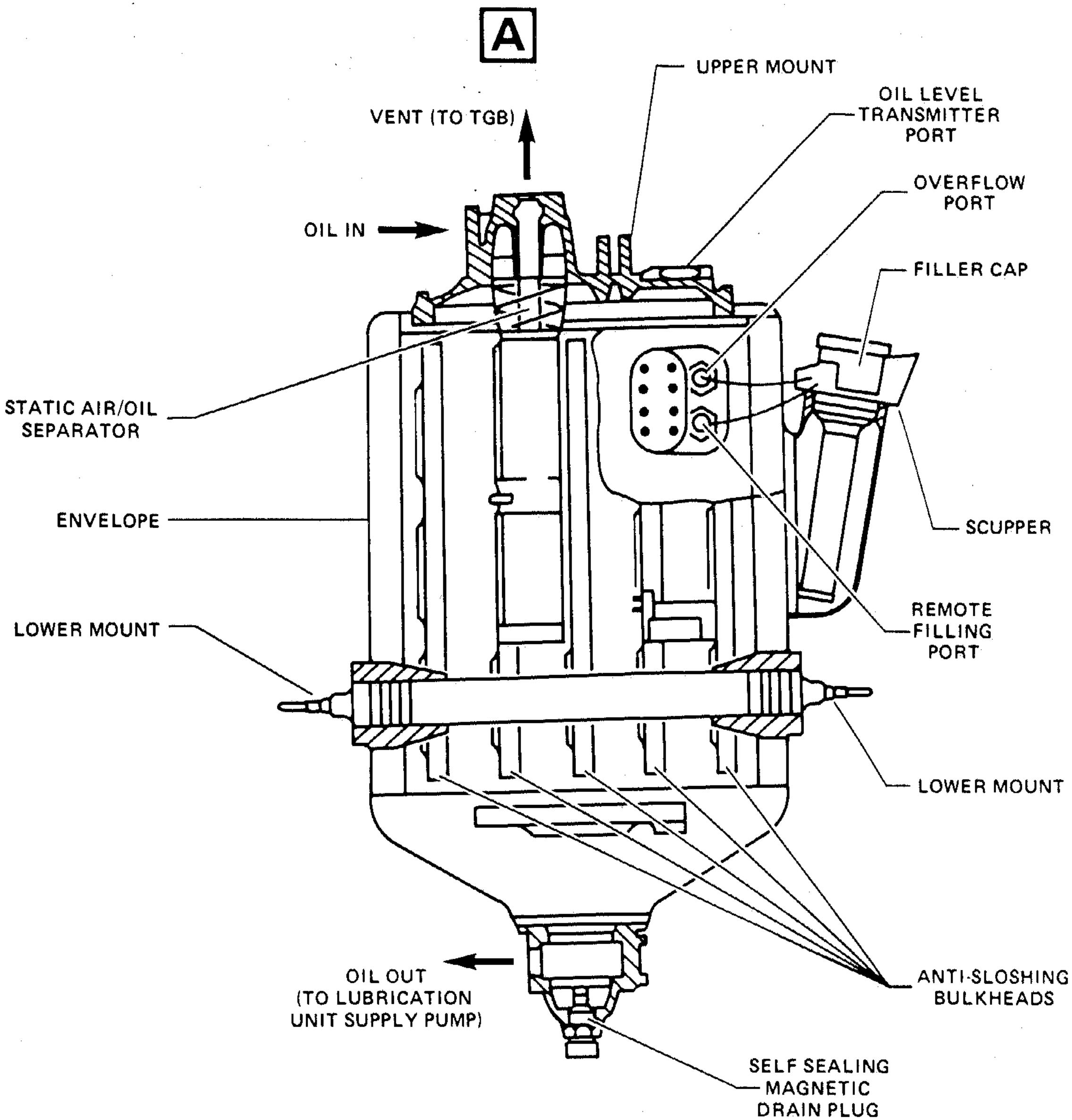
- 5 quarts + estimated consumption (0,3qts/h)

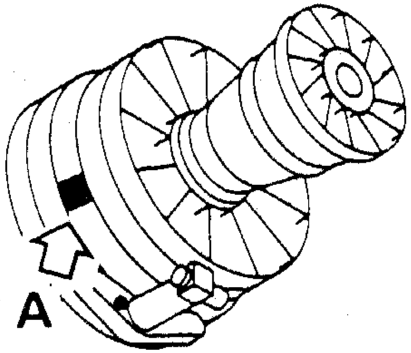
Oil Tank Pressurization and Venting

In normal operation, the tank is pressurized by the air included in the scavenge oil. The pressurizing air in the tank is up to 0.8 bar above the external pressure.The oil-in tube port discharges tangentially into a cavity connected with the tank vent and directing the air/oil mixture to a static air/oil separator.
During engine shut down, the pressurizing air is vented overboard, thus enabling the oil level to be checked five to thirteen minutes after engine shut down by opening the gravity filler cap or by looking at the cockpit indication.
The tank is vented to the forward sump through the transfer gearbox and radial drive shaft housing. Thus, oil tank pressure is adequate to provide pressurization of the supply pump inlet.
When engine N2 RPM increases from idle to take-off the quantity of oil in the tank may decrease to between 6 US Quarts (5.7 liters) and 8 US Quarts (7.6 liters) due to gulping effect.

ENGINE OIL SERVICING

Wait and let the pressure in the tank decrease for at least 5 minutes after engine shut down,before opening the filler cap.
In case of using the pressure fill port,open also the overflow port to make sure that the oil system will not be overfilled.The correct level can be checked on the sight glass.
NOTE:
The oil system can be refilled any time.





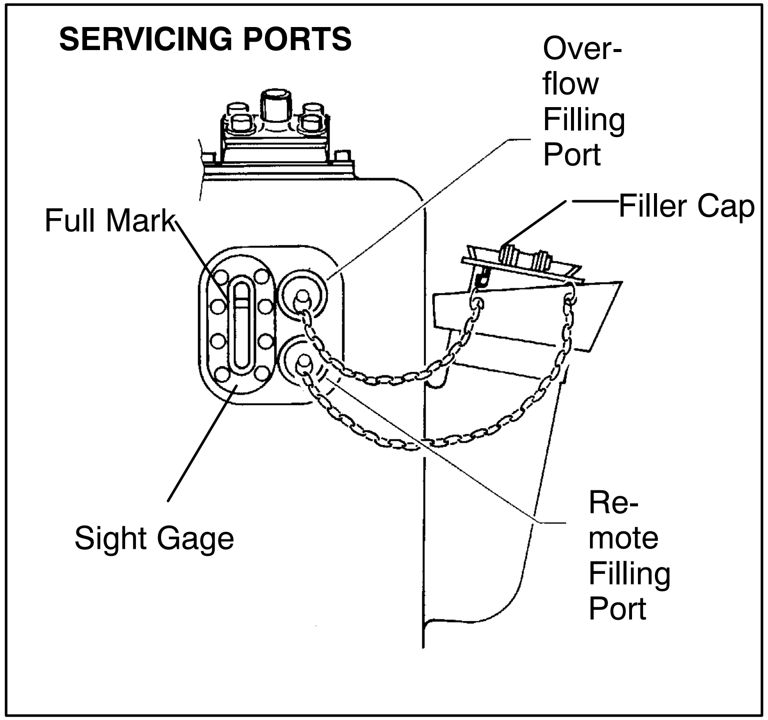


Figure 42 Oil Tank

LUBRICATION UNIT

General
The lubrication unit provides oil under the required pressure for lubrication and for scavenge of the oil after lubrication and circulation to the oil/fuel heat exchanger and oil tank. The lubrication unit its mounted on the AGB front face.

Description
The lubrication unit has a single housing containing the following items :

- Five positive displacement pumps(Gear Type, one oil supply and 4 scavenge pumps).
- Six filters (one oil supply filter, 4 chip detectors and scavenge pump filters).
- One relief valve (305 psi, on oil supply pump discharge side).
- Two clogging indicators (one for the oil supply filter and one for the main scavenge filter).
- Two bypass valves (one for the oil supply filter and one for the main scavenge filter).

Anti siphon System
The supply lines from the oil tank to supply the pump has an antisiphon device to prevent the drainage of the lube tank into the gearboxes and sumps when the engine is shut down for extended periods.

Lube pump supply filter
Downstream of the supply pump, the oil flows through the supply filter assembly. The filter has the following components.

- One filter (15 microns)
- One clogging indicator subjected to the upstream and downstream pressures of the supply filter.The indicator has a red warning indicator and is rearmed manually (2 bars to 2.3 bars) (29 PSID to 33 PSID).
- One bypass valve which opens if the supply filter clogs (2.50 bars to 2.70 bars) (36 PSID to 39 PSID).
- Two capped provisions for a pressure gage upstream of the filter,and a temperature sensor.

Scavenge filter
The flows from the 4 scavenge pumps are mixed together at the scavenge common filter inlet. This filter assembly consists of the following :

- One 25 micron filter
- One clogging indicator, similar to the one on the supply filter (2 bars to 2.3 bars) (29 PSID to 33 PSID).
- An upstream and a downstream provision for measurement of filter pressure loss as a function of clogging.Filter clogging is indicated on the ECAM system.
- One bypass valve which opens if the filter clogs.(2.5 bars to 2.7 bars) (36 PSID to 39PSID)

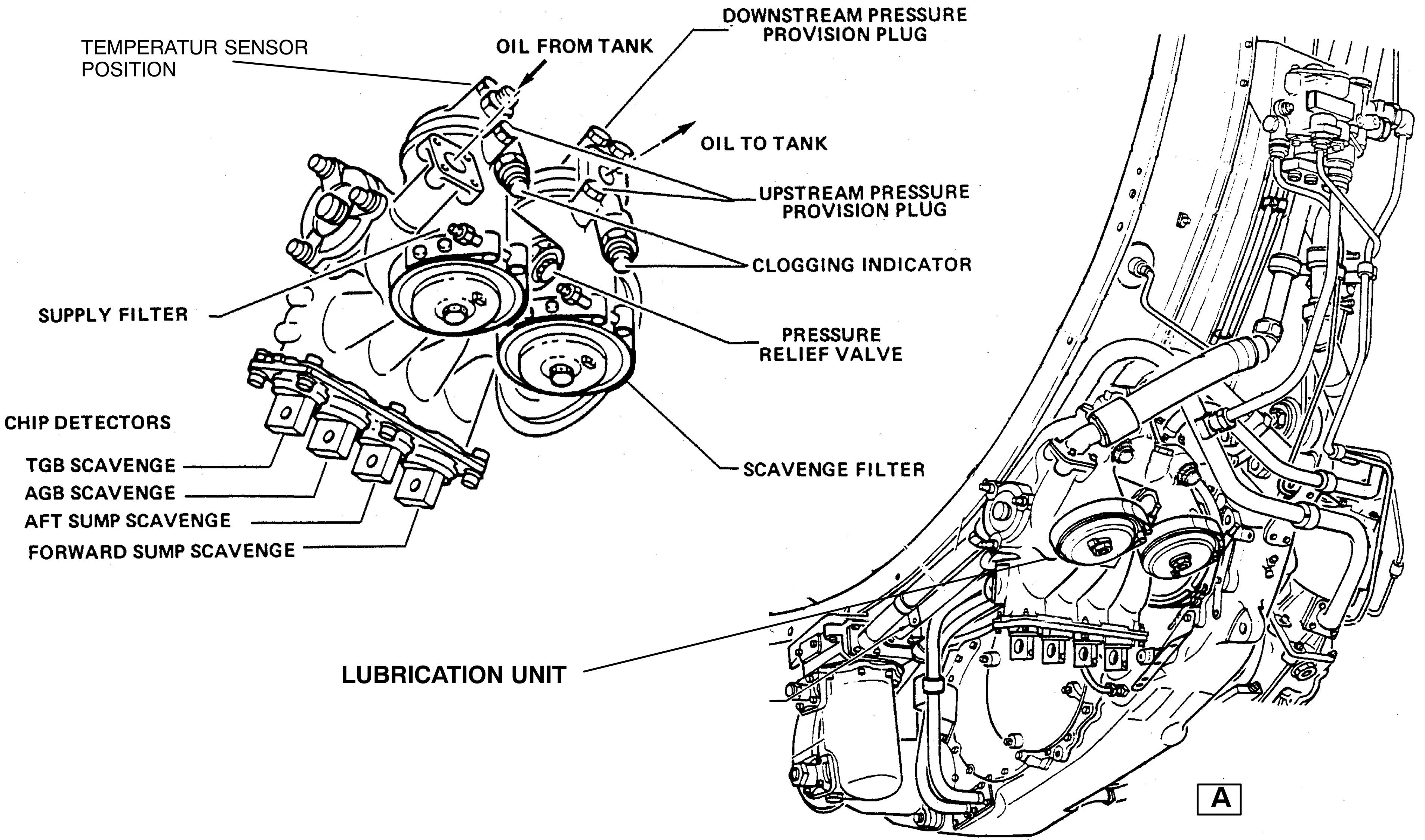


Figure 43 Lubrication Unit

CHIP DETECTORS

The oil which has lubricated the engine bearings, accessory gearbox and TGB is scavenged by 4 pumps protected by a strainer equipped with a magnetic chip detector.
The air/oil mixtures are passed through the chip detectors and the scavenge filters, and then to the specific scavenge pump.
4 Chip Detectors installed on the Lube unit:

- **TGB Scavenge Chip Detector**
- **AGB Scavenge Chip Detector**
- **AFT Sump Scavenge Chip Detector**
- **FWD Sump Scavenge Chip Detector**

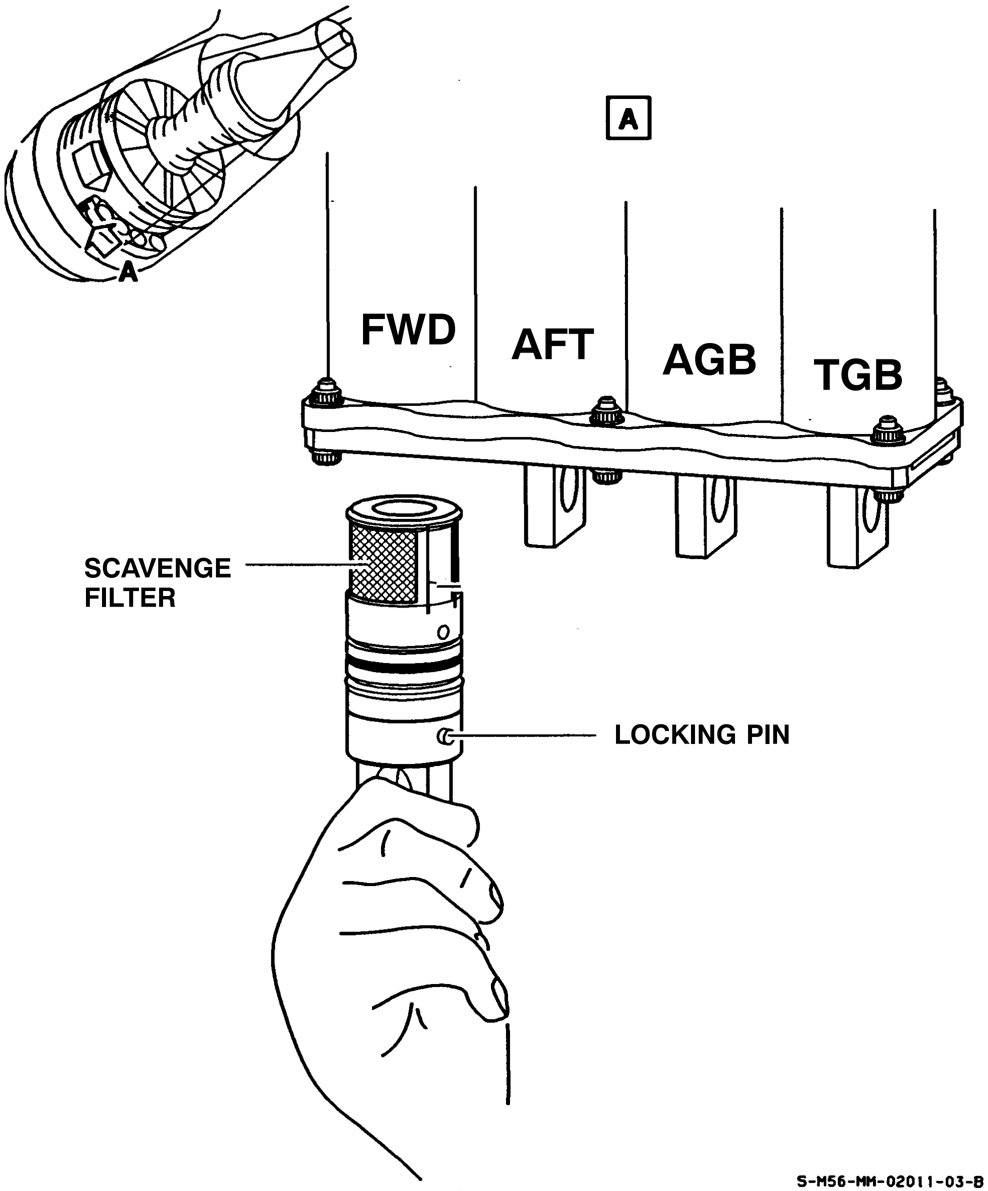
Chip Detector Removal

Chip detector assembly can be removed by depressing it and rotating it one - quarter of a turn counter-clockwise (CCW)

Chip Detector Installation

Align plug keys of magnetic plug with sleeve keyways and rotate a quarter of a turn clockwise to complete engagement of keys in keyways.

Ensure chip detector and magnetic plug assembly has snapped down into its lock position by pulling detector down,while lightly rotating from side to side.Flats of handle must be perpendicular to the centerline of lube unit.Magnetic plugs are provided with a red point on plug handle.The red point must face the filters.



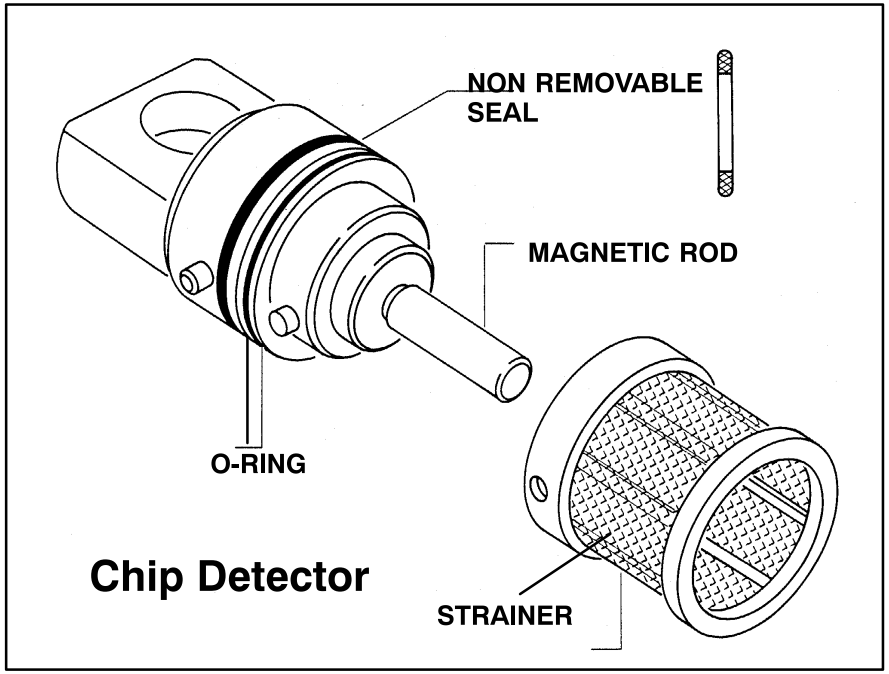


Figure 44 Chip Detectors

MAIN FUEL OIL HEAT EXCHANGER

Purpose:

The oil/fuel heat exchanger cools the oil by using fuel as a cooling medium. The oil to fuel heat transfer is achieved through conduction and convection within the exchanger where both fluids are circulated.Fuel from the fuel pump and from HMU enters the inlet.
Oil from the scavenge system enters the oil inlet.

Location:

The oil/fuel heat exchanger is installed on the fuel pump, between the AGB aft face and the servo fuel heater at the 9 o'clock position, aft looking forward.

Description

The oil/fuel heat exchanger is of tubular type. It consists of a removable core, housing and cover.

The housing contains the core of the oil/fuel heat exchanger.The following items are located on the outside of the oil/fuel heat exchanger housing :

- One oil pressure relief valve and one fuel pressure relief valve.
- One drain port which collects possible fuel leaks from core and inner seal cavities and prevents fuel from leaking into the oil cavity and contaminating the oil system.
- One attaching flange for the servo fuel heater.
- One flange for attachment to the fuel pump.
- One port on fuel-in for fuel returned from HMU after circulating through the IDG oil cooler.

SERVO FUEL HEATER

Purpose:

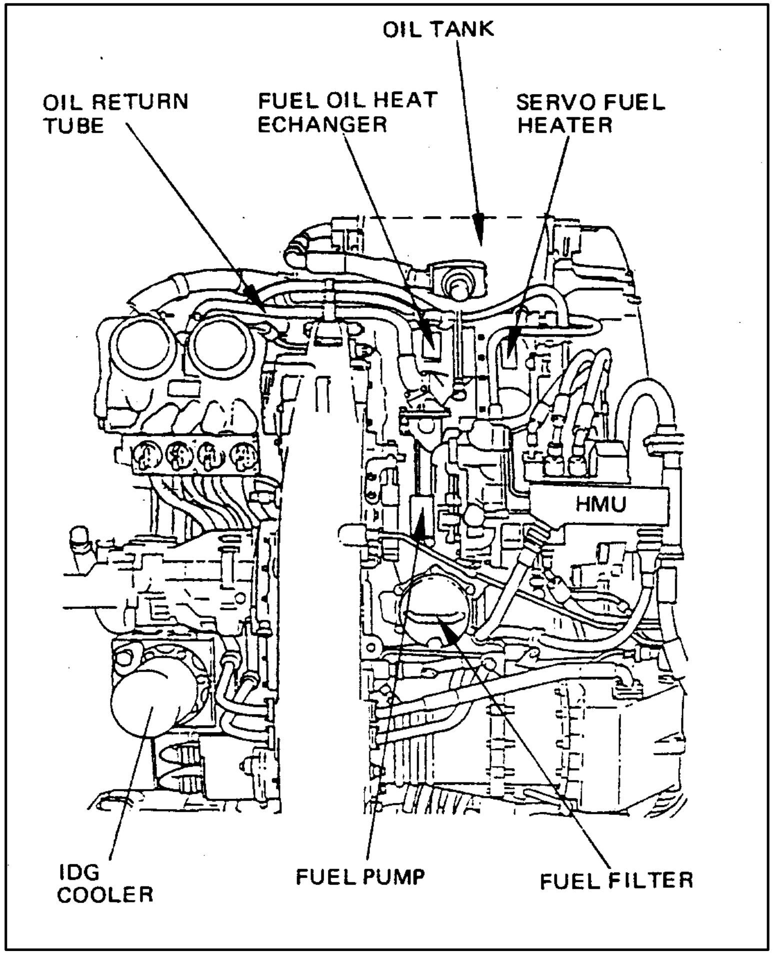
The servo fuel heater raises the temperature of the fuel. This prevents ice from entering the control servos inside the hydromechanical fuel unit (HMU).

Location

The servo fuel heater is mounted on the aft section of the main oil/fuel heat exchanger located on the accessory gearbox (AGB) aft face, between the oil tank and the fuel pump/HMU package.

Description

The servo fuel heater is a heat exchanger using oil as its heat source.
Heat exchange between oil and fuel occurs by conduction and convection inside the unit. The 2 fluids circulate in the servo fuel heater through separate flowpaths.



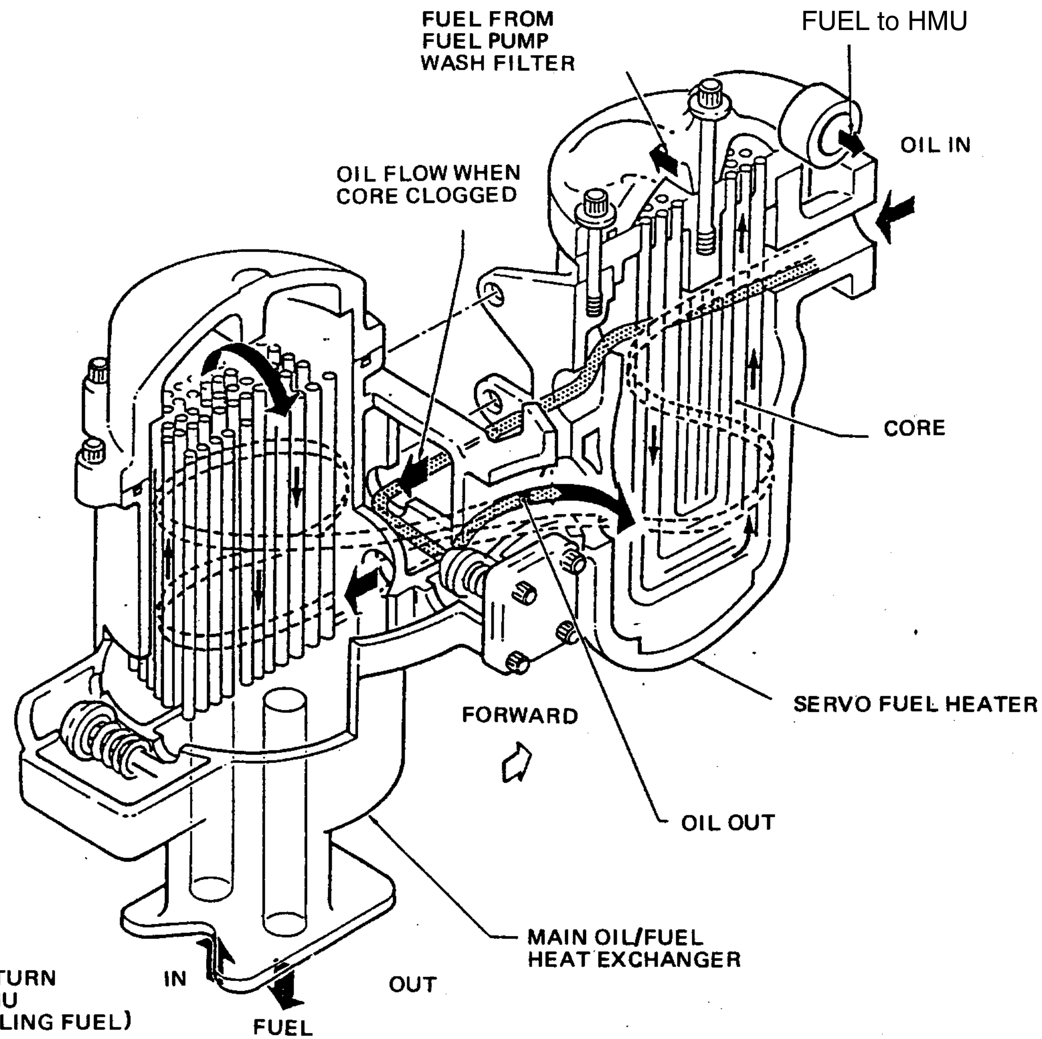


Figure 45 Main Fuel Oil Heat Exchanger

79-30 0IL INDICATING COMPONENTS

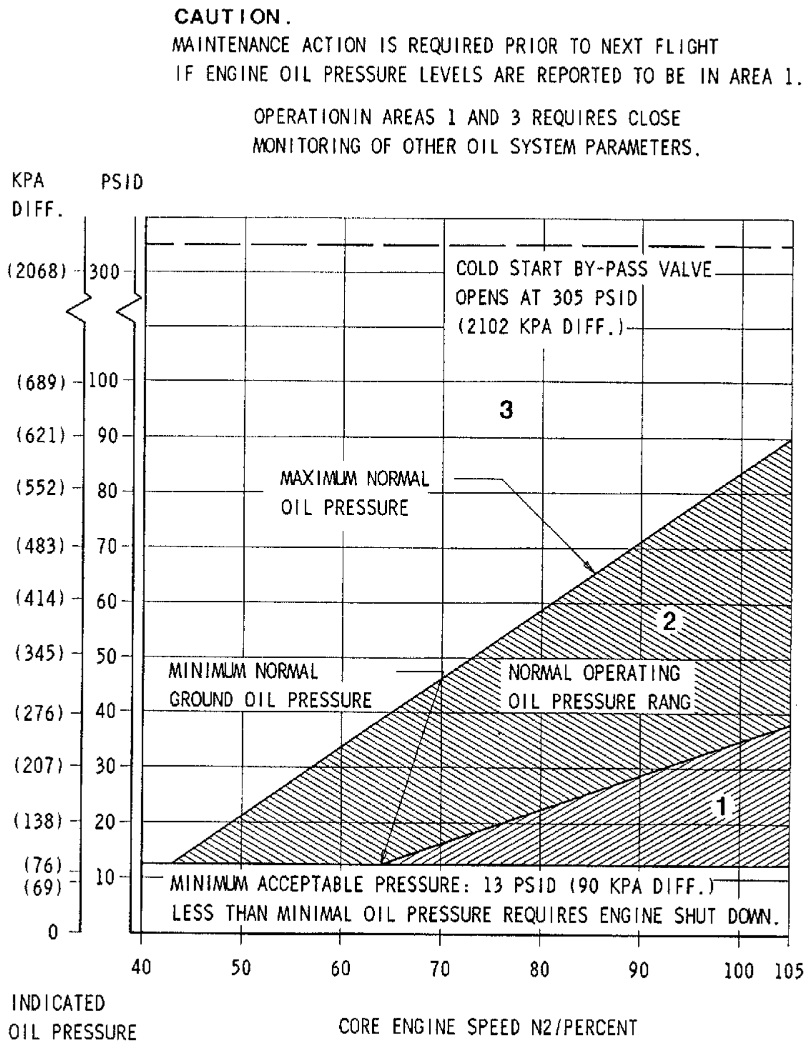
OIL PRESSURE TRANSMITTER

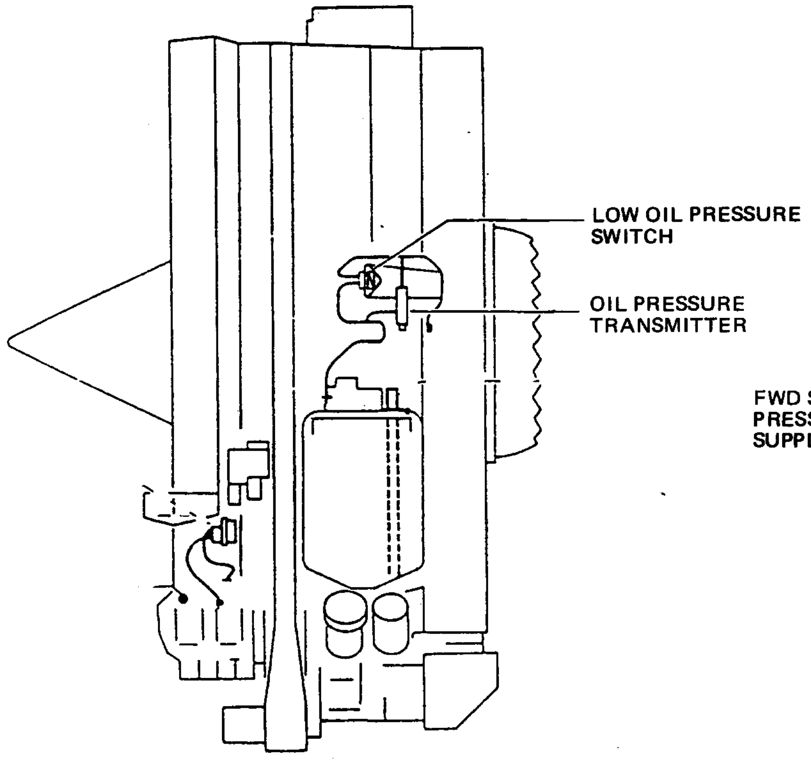
The oil pressure transmitter is located on the lubrication unit outlet line.
- **Power supply :** 28VDC from busbar 202PP.
- **Pressure range :** 0 to 100PSID.
- **Output voltage :** 1VDC to 9VDC varying linear with pressure from 0 to 100PSID.

Operation
The pressure transmitter operates on the principle of measuring a pressure by sensing the strain induced in a mechanical element, (in this case a dual cantilever beam). Deflection of the beam causes a change in resistance in the four strain gages connected as a wheatstone bridge.
These resistance changes result in a DC output voltage which is proportional to the applied pressure.

LOW OIL PRESSURE SWITCH

The low oil pressure switch is located on the lubrication unit outlet line.
Actuation of the low pressure switch is at :
16 PSID increasing pressure
13 PSID plus or minus 1 decreasing pressure





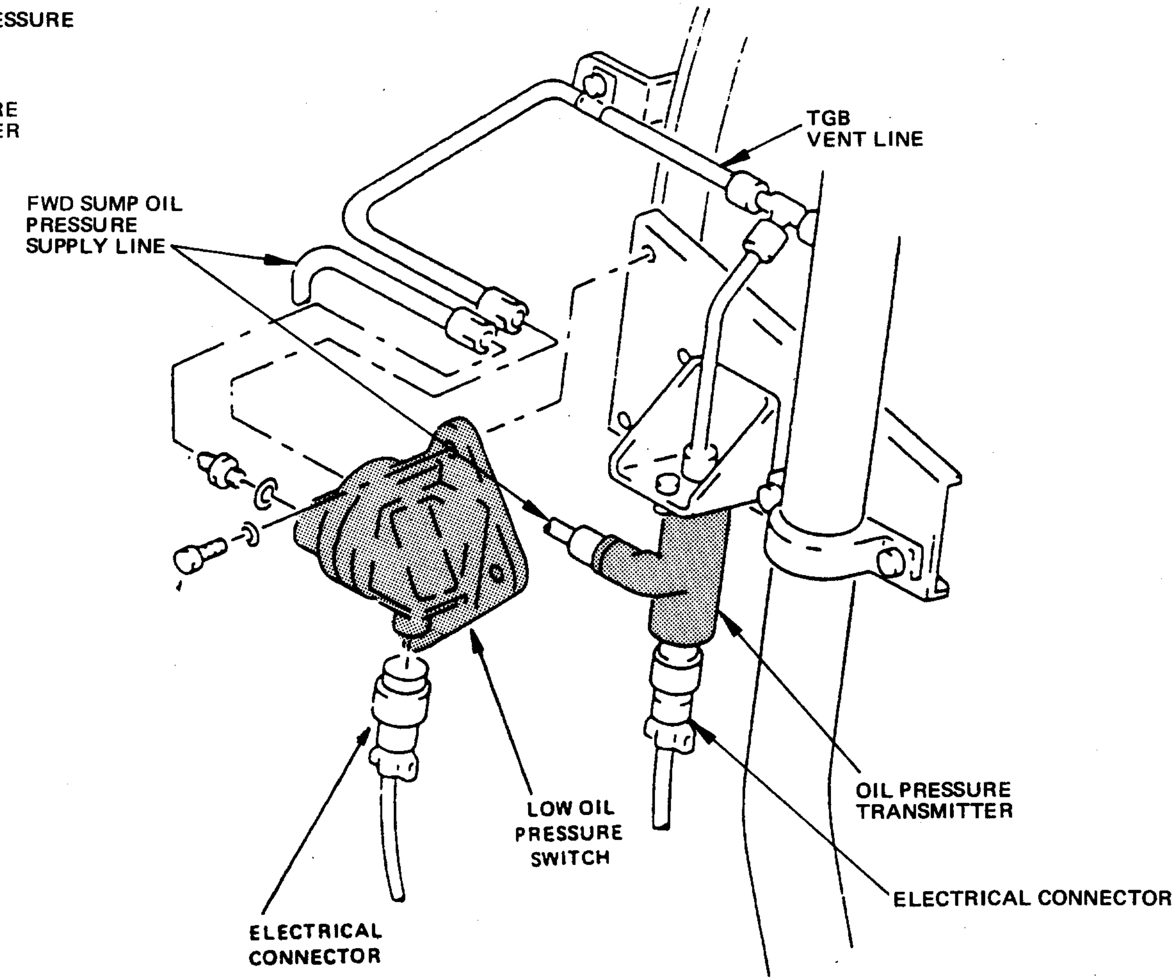
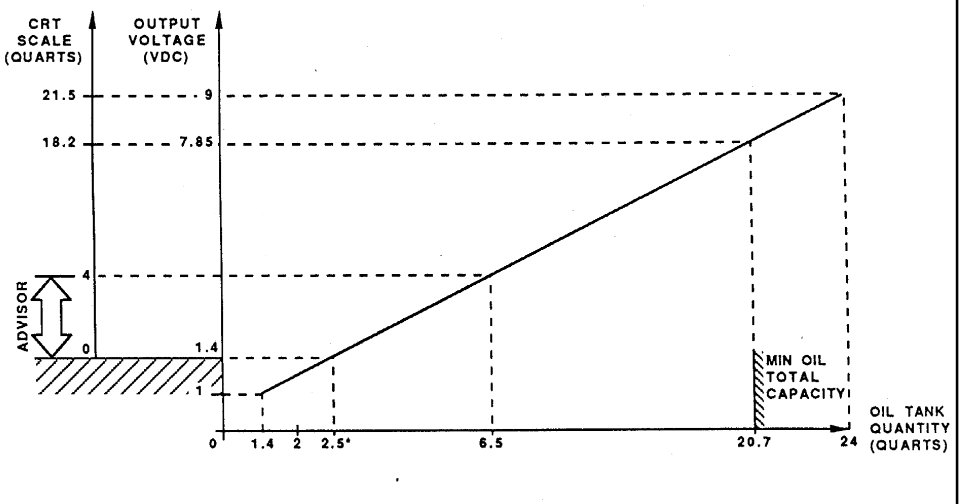


Figure 46 Oil Press. & Low Oil Press.

OIL QUANTITY TRANSMITTER

The oil quantity transmitter is located in the oil tank.
The oil quantity transmitter probe (tube portion) is a capacitor formed by two concentric tubes.

Transmitter specification :
Output voltage : 1VDC to 9VDC varying linearly with true oil quantity from 1.4 to 24 quarts
Accuracy : plus or minus 0.5 quarts



* THIS VALUE INCLUDES THE COCKPIT INDICATING ACCURACY (0.65 QUARTS) WHICH IS ALSO APPLICABLE IN THE OIL TANK QUANTITY RANGE.

TEMPERATUR ENGINE OIL (TEO)

This sensor is used for the IDG cooling system control(Fuel return).The oil temperature sensor is installed on the No. 1 and 2 bearing oil supply tube.

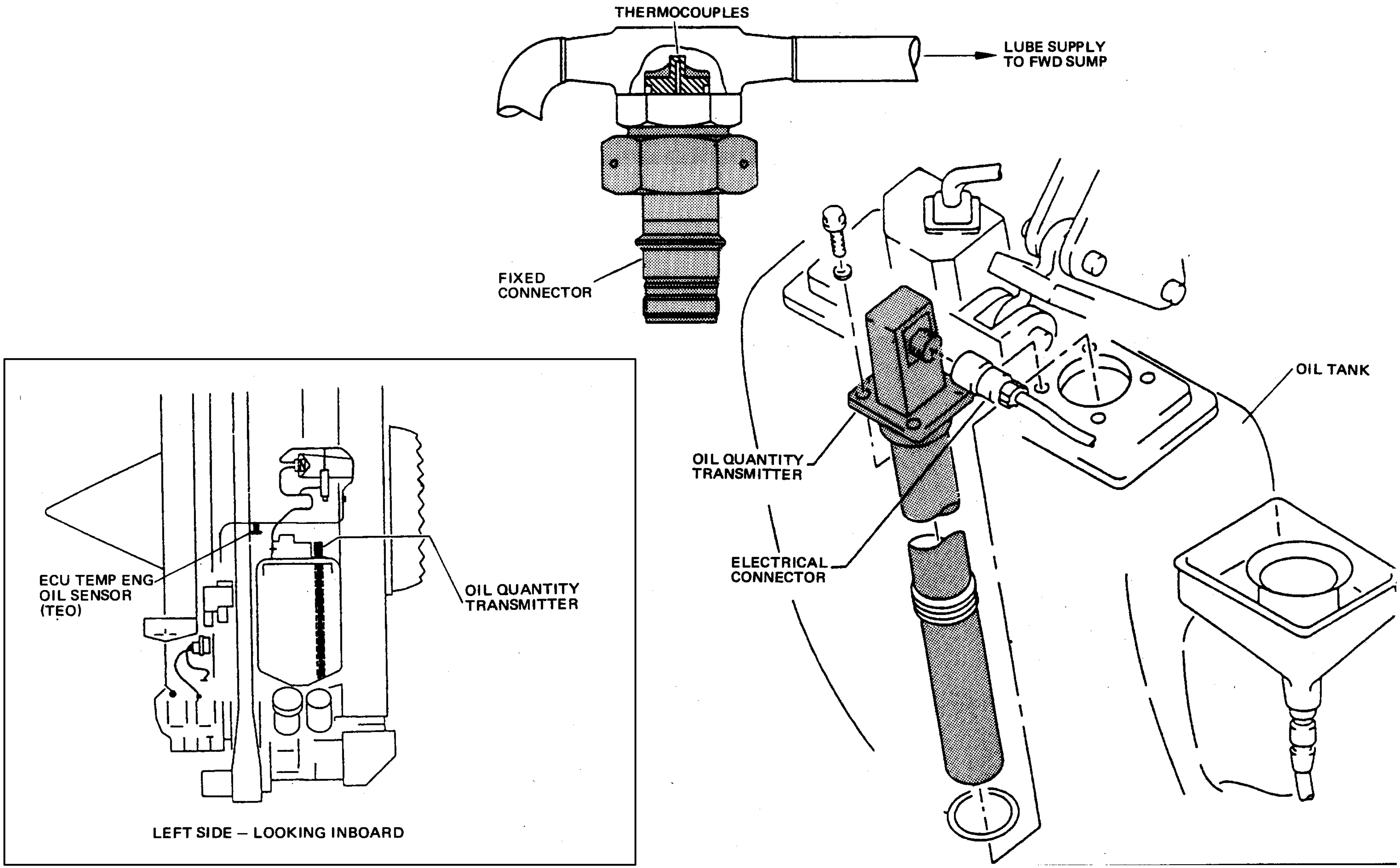


Figure 47 TEO & OIL QTY Transmitter

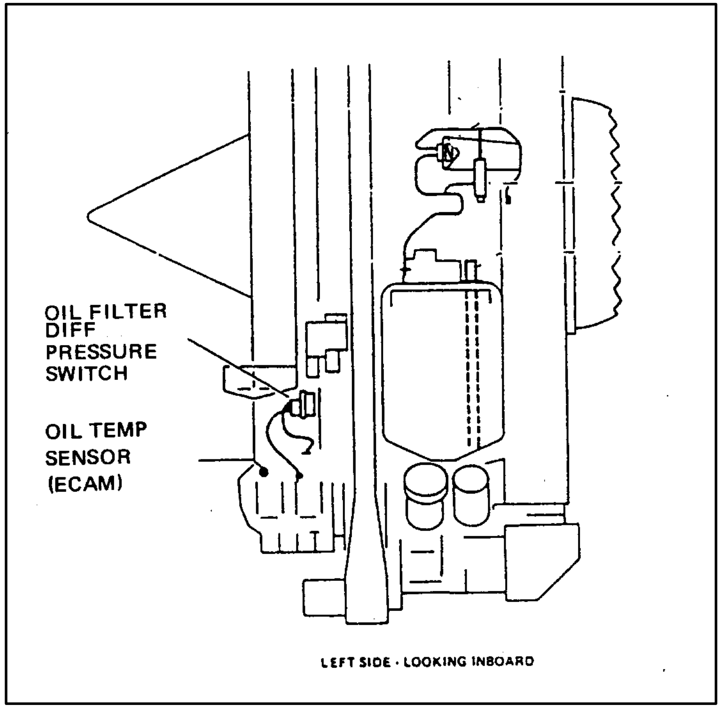
OIL FILTER DIFFERENTIAL PRESSURE SWITCH

The oil differential pressure switch is located on a bracket on the engine above the scavenge filter. Lines are routed to the switch from bosses on the scavenge filter.

Actuation of the differential pressure switch is at :
25.5 plus or minus 1 PSID increasing pressure 22 PSID decreasing pressure.

OIL TEMPERATURE SENSOR

The oil temperature sensor is located on the oil pressure filter downstream of the pressure pump.The oil temperature is sensed by a dual resistor unit.



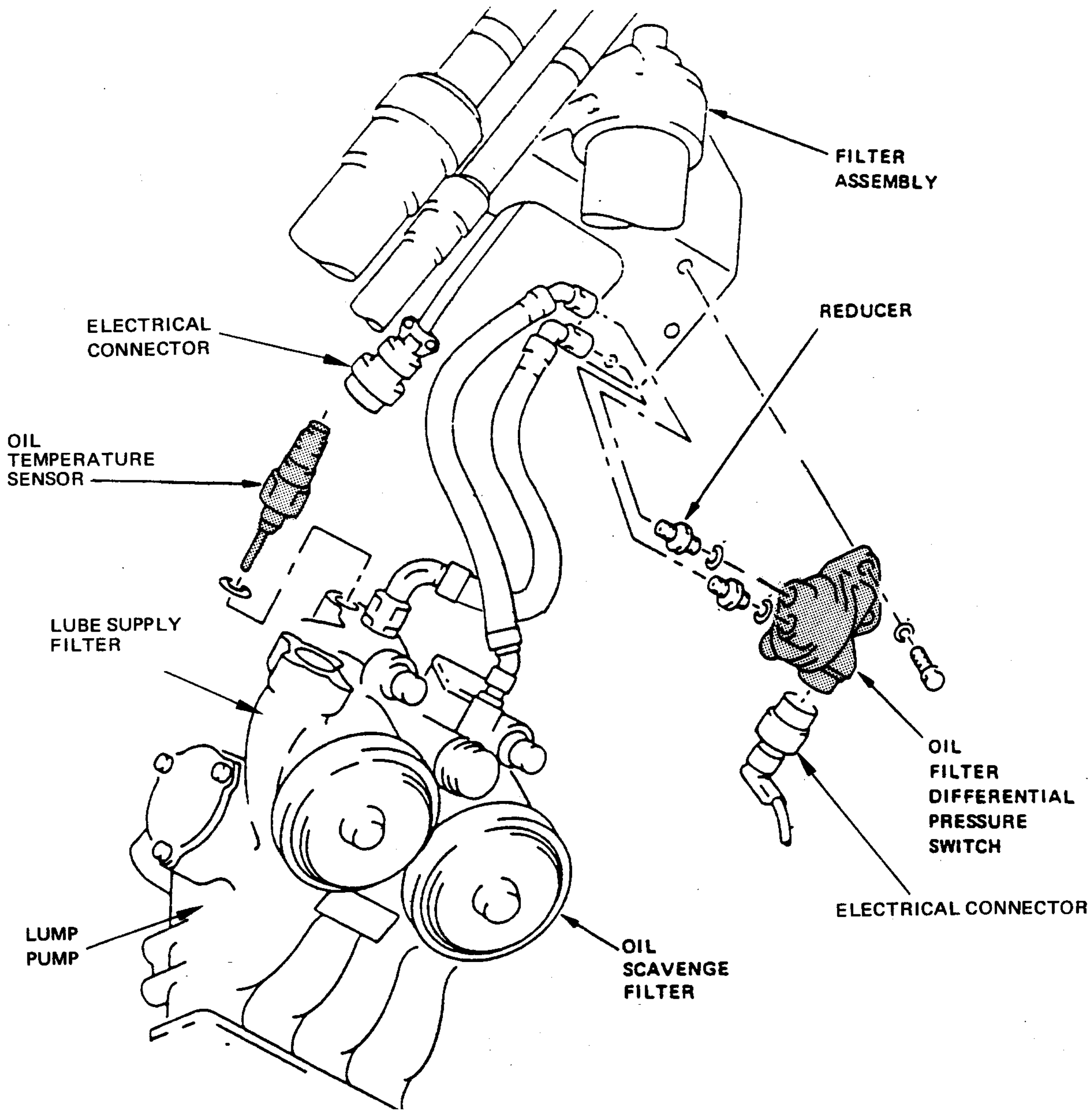


Figure 48 Temp. Sensor & Diff. Press. Switch

ATA 73 ENGINE FUEL AND CONTROL

73-00 FUEL SYSTEM PRESENTATION

ENGINE FUEL SYSTEM DESCRIPTION

General

The engine fuel system is designed to provide fuel flow into the combustion chamber and servo fuel for compressor and engine clearence system actuation.

Fuel Feed

The fuel coming from the aircraft tanks supplies the main fuel pump and is heated by the engine oil scavenge line before entering into the hydromechanical unit (HMU).
A fuel differential pressure switch provides indication to the cockpit if the filter is clogged.

Metered Fuel

The fuel from the main pump passes through a fuel metering valve and HP fuel shut-of f valve included into the hydromechanical unit which provides the fuel flow to the nozzles.
A burner staging valve controlled by ECU supplies either 10 or 20 nozzles at lower or higher power.
The fuel metering valve is controlled by the ECU and provides the adequate fuel flow.
The fuel flow is measured by a flow meter for the cockpit indication.
The LP and HP Fuel shut off valves closes when the ENG MASTER lever is set to OFF.

Servo Fuel

Filtered fuel from the wash filter passes through a servo-fuel heater and to the servo valves of the hydromechanical unit and the fuel return valve.
In the hydromecanical unit the servo valves are hydraulically driven through torque motors by the ECU to provide the operations of:

- Variable Stator Vanes (VSV)
- Variable Bleed Valves (VBV)
- Rotor Active Clearance Control (RACC) (not installed on new engines)
- HP Turbine Clearance Control (HPTACC)
- LP Turbine Clearance Control (LPTACC)
- Burner Staging Valve
- Fuel Metering Valve

Fuel Return

A part of the fuel is recovered to provide IDG oil cooling before returning to the fuel circuit at the LP pump stage. When the thermal exchange is not sufficent, the fuel return valve will be opened by the ECU, according to a given temperature.
Wen the engine oil temperature exceeds 93 degrees C the ECU sends a signal to open the fuel return valve. The signal is inhibited at Take-Of f, Climb and when the A/C tank temperatures are high or there is fuel in the vent tank. A hydraulic signal from the HP fuel SOV closes the valve at engine shutdown.

ECU Control

The ECU sends electrical signals to the torque motor servovalves of both the HMU and the fuel return valve. Thus, it provides the commanded position for the slave systems.
For each valve of VBV, VSV, RACC, HPTACC, LPTACC, and fuel systems the ECU has a control schedule. If a schedule is no longer operational, the corresponding valve goes to a fail safe position. For example: VBV open, VSV close, burner staging valve opens, fuel metetring valve closes (engine shutdown).

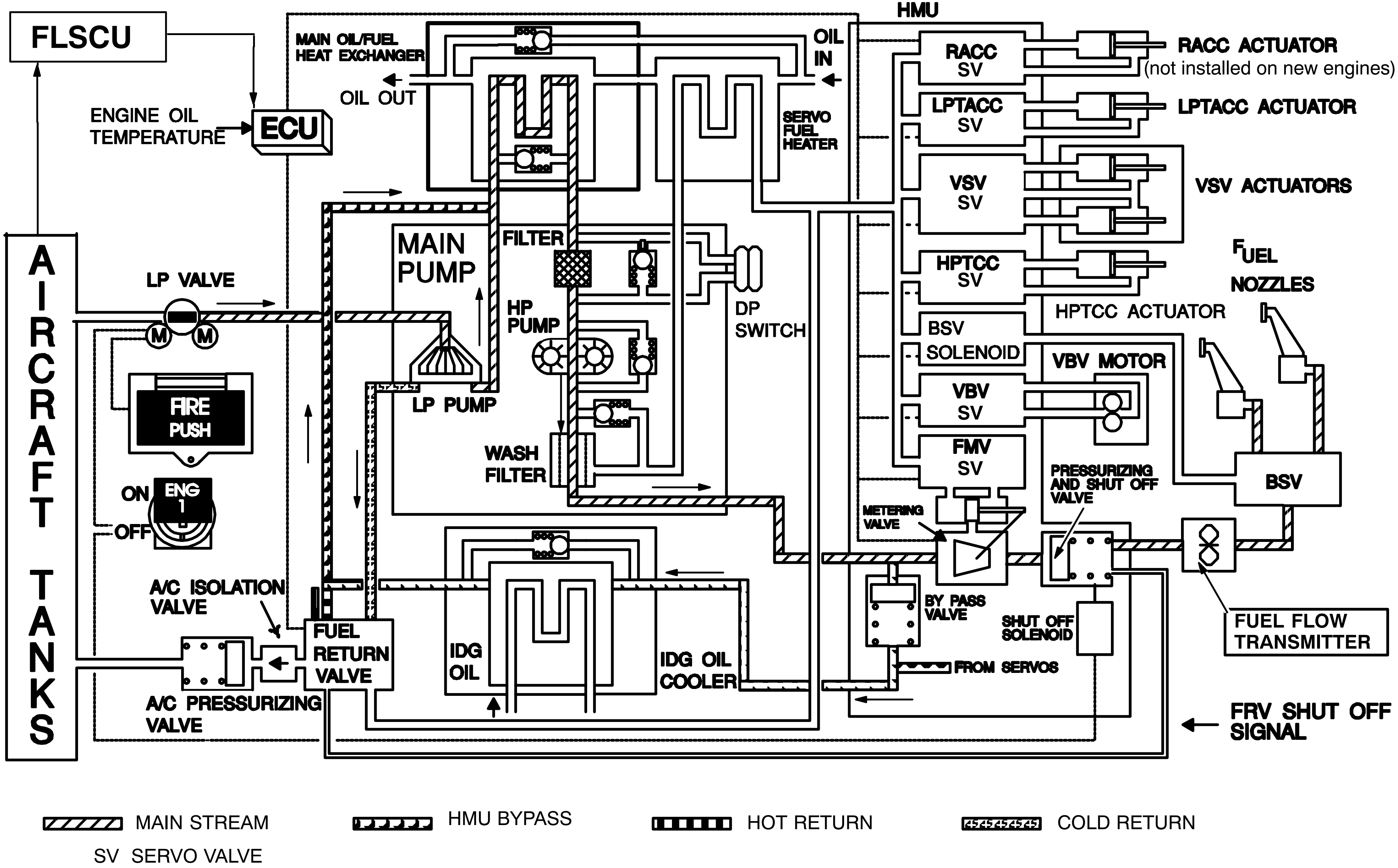


Figure 49 Fuel System Schematic

73-10 FUEL DISTRIBUTION COMPONENTS

FUEL PUMP

The fuel pump and HMU are mounted as a unit.
The fuel pump drive system consists of the following :

Fuel pump LP stage

The LP stage of the fuel pump is of the centrifugal type. It delivers a boost pressure to the HP stage to avoid pump cavitation.
The LP stage general characteristics at takeoff power are as follows :

- Discharge pressure : 174 psi (1200 kPa).
- Speed rating : 6250 RPM.

Fuel pump HP stage

The HP stage hydraulic power is supplied by a positive displacement (gear-type) pump. For a given number of revolutions, the pump delivers a constant fuel flow regardless of the discharge pressure.
A pressure relief valve connected in parallel with the HP pump protects the pump.

The HP stage general characteristics at takeoff power are as follows :

- Discharge pressure : 870 psi (6000 kPa)
- Speed rating : 6250 RPM
- Fuel flow : 57 US gal/min. (13000 l/h).

Location

The fuel pump is located on the accessory gearbox (AGB) (aft face on the left side of the horizontal drive shaft housing, aft looking forward).

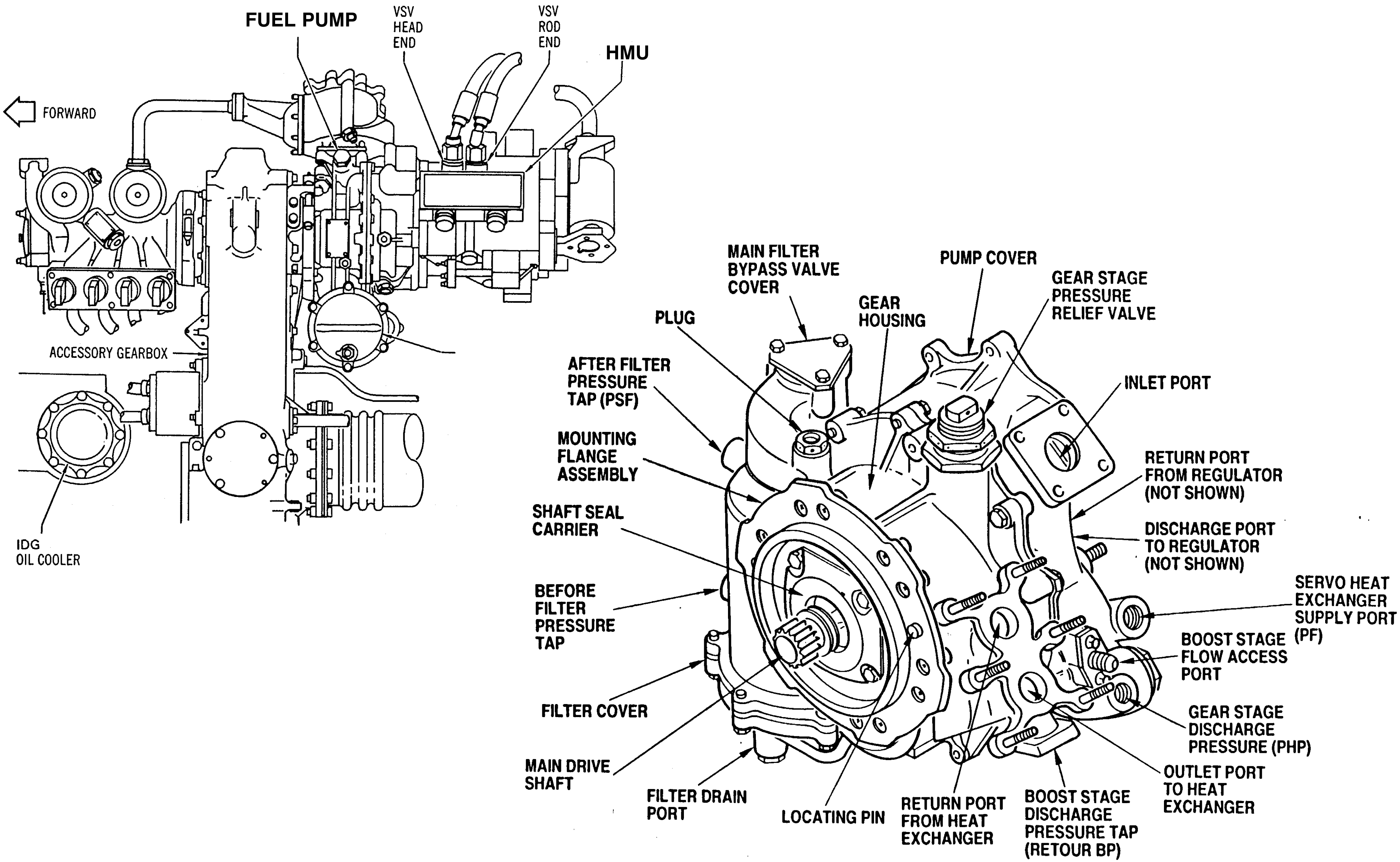


Figure 50 Fuel Pump & Fuel Filter

FUEL FILTER

General

The fuel filter protects the HMU from particles in suspension in the fuel.

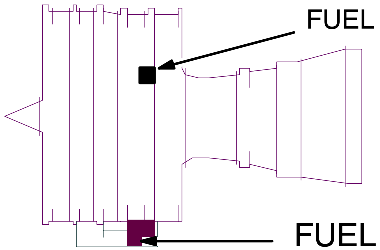
The fuel filter consists of a disposable filter cartridge and a pressure relief valve. The filter cartridge is installed in a cavity on the pump body.
The fuel circulates from the outside to the inside of the filter cartridge.
In case of a clogged filter, a pressure relief valve bypasses the fuel to the HP stage.

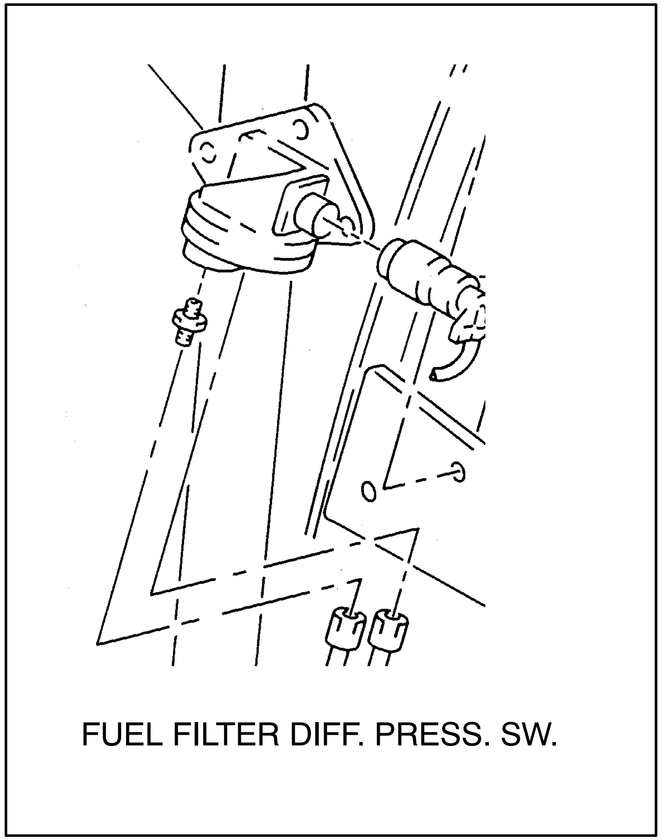
Location

The fuel filter is located between the main oil/fuel heat exchanger and fuel pump HP stage.

FUEL FILTER DIFF PRESSURE SW.

The fuel filter differential pressure switch is located on the fan case.
The switch sends a signal to the SDAC when the differential pressure increases to a certain level when the fuel filter clogs.
The fuel filter clog indication is provided on the lower ECAM display unit.





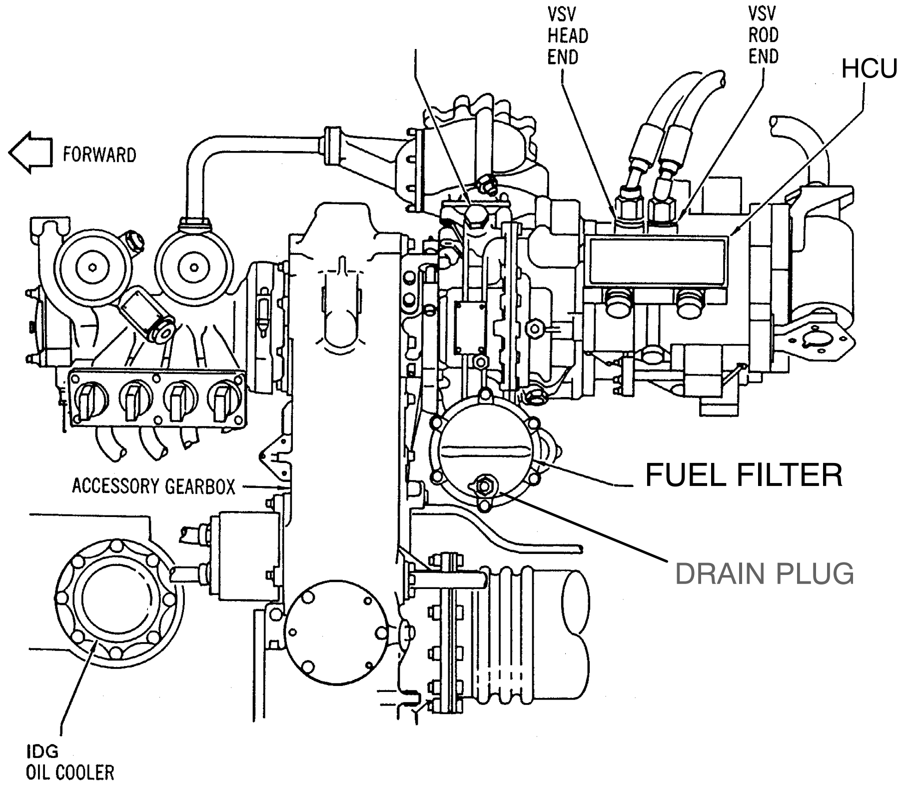


Figure 51 Fuel Filter

HYDROMECHANICAL CONTROL UNIT

General
The hydromechanical unit (HMU) is installed on the aft side of the accessory gearbox at the extreme left hand pad.
It receives electrical signals from the electronic control unit (ECU) and converts these electrical input signals through torque motors/servo valves into engine-fuel flow and hydraulic signals to various external systems.
Engine fuel is used as hydraulic media.

NOTE:
No maintenance adjustments (eg. idle,part power etc.) can be performed at the HMU!

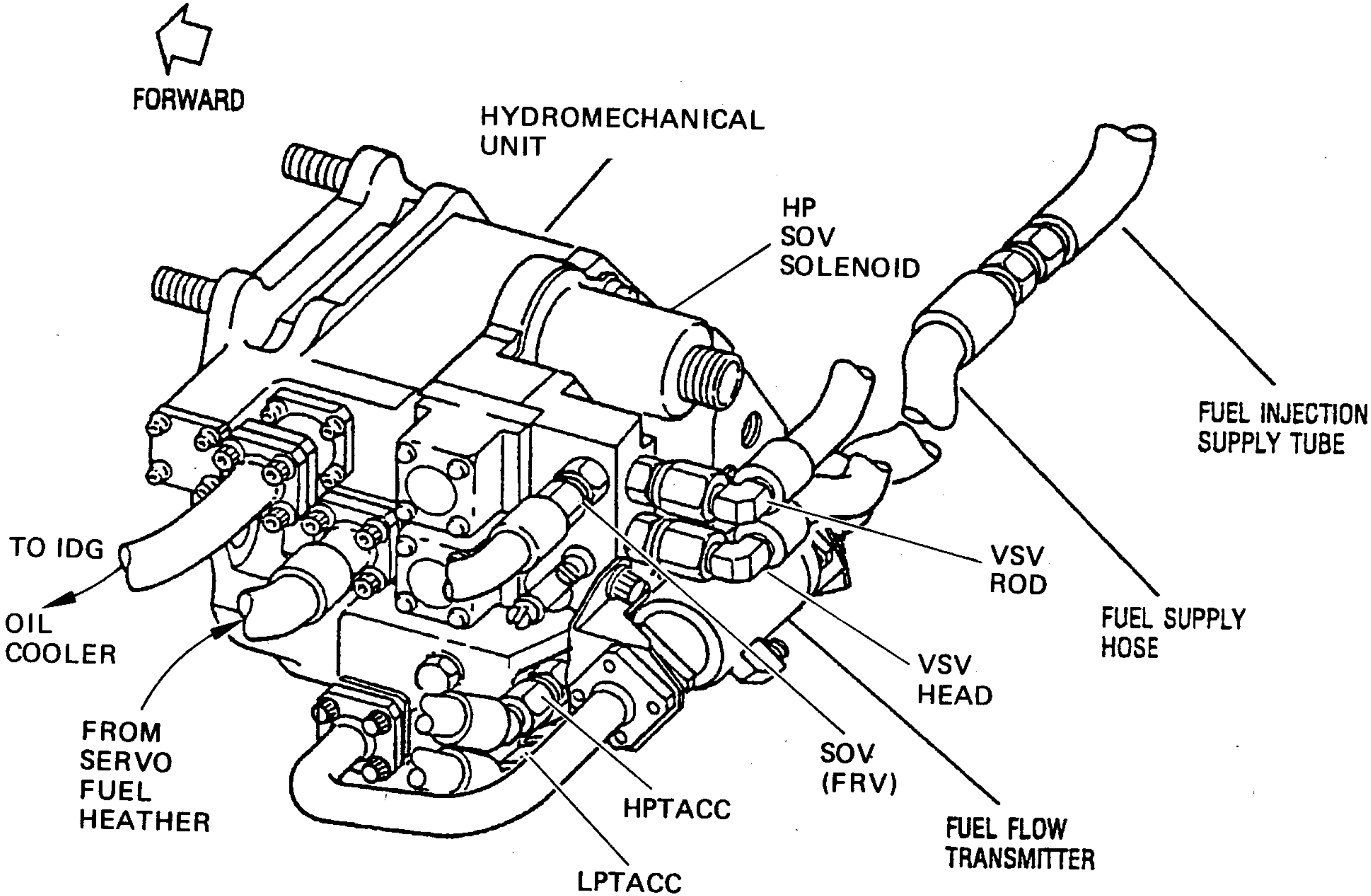


Figure 52 HMU

FUEL METERING OPERATION

The HMU is divided in the following systems:

- Servo Pressure Regulator System
- Fuel Metering System
- Overspeed Governor System
- Pressurizing Valve (HP Fuel SOV)
- Pump Unloading and Shutdown System
- Servo Flow Regulation System.

Fuel Metering Valve
The fuel metering valve is hydraulically driven through a torque motor/ servo valve by the ECU. The torque motor contains two electrically isolated, independent coils, one dedicated to Channel A,the other to Channel B of the ECU. Two fuel metering valve position resolvers, one dedicated to each channel in the ECU, produce an electrical feedback signal in proportion to fuel metering valve position. The ECU uses this signal to compute the current required at the fuel metering valve torque motor for achieving closed loop electrical control.

At engine shutdown the Metering valve is completly closed.

Delta P Valve
A differential pressure regulating valve maintains a constant pressure drop across the metering valve. As a result, fuel flow varies proportionally with metering valve position.

High Pressure Fuel shut-off valve

The valve is driven by a solenoid. The Valve closed / not closed position is indicated to the ECU by two electrical limit switches.

The fuel shut off valve shuts off fuel flow to the engine commanded by the master switch (solenoid energized by aircraft 28VDC from busbar 3PP).

The HP fuel shut off valve is open when all three following conditions are met :
- command to open from A/C (soleinoid de-energized)
- engine rotation speed above 15% N2
- fuel pressure.

NOTE:
It has to be noted that the HP fuel shut off valve shut off signal by the Master switch also closes the LP fuel valve.

Overspeed governor
The overspeed governor is of the fly ball type. It is designed to prevent the engine from exceeding a steady state speed in excess of 106.3% N2.
A pressure switch sends a signal to the ECU if the overspeed governor fails when the engine is started (OVSPD Protection fail)

Motive flow modulation
The HMU contains 5 additional torque motors/ servo pilot valves that modulate hydraulic signals to the following :
1 - Low Pressure Turbine Clearance Control Valve
2 - High Pressure Turbine Clearance Control Valve
3 - Rotor Active Clearance Control System *(not installed on new engines)*
4 - Variable Stator Vane Actuators
5 - Variable Bleed Valve Actuators.
Each torque motor contains two electrically isolated, independent coils.
One is dedicated to channel A, the other to channel B, of the ECU.
They provide flow and pressure at an HMU pressure port in response to electrical commands from the ECU.

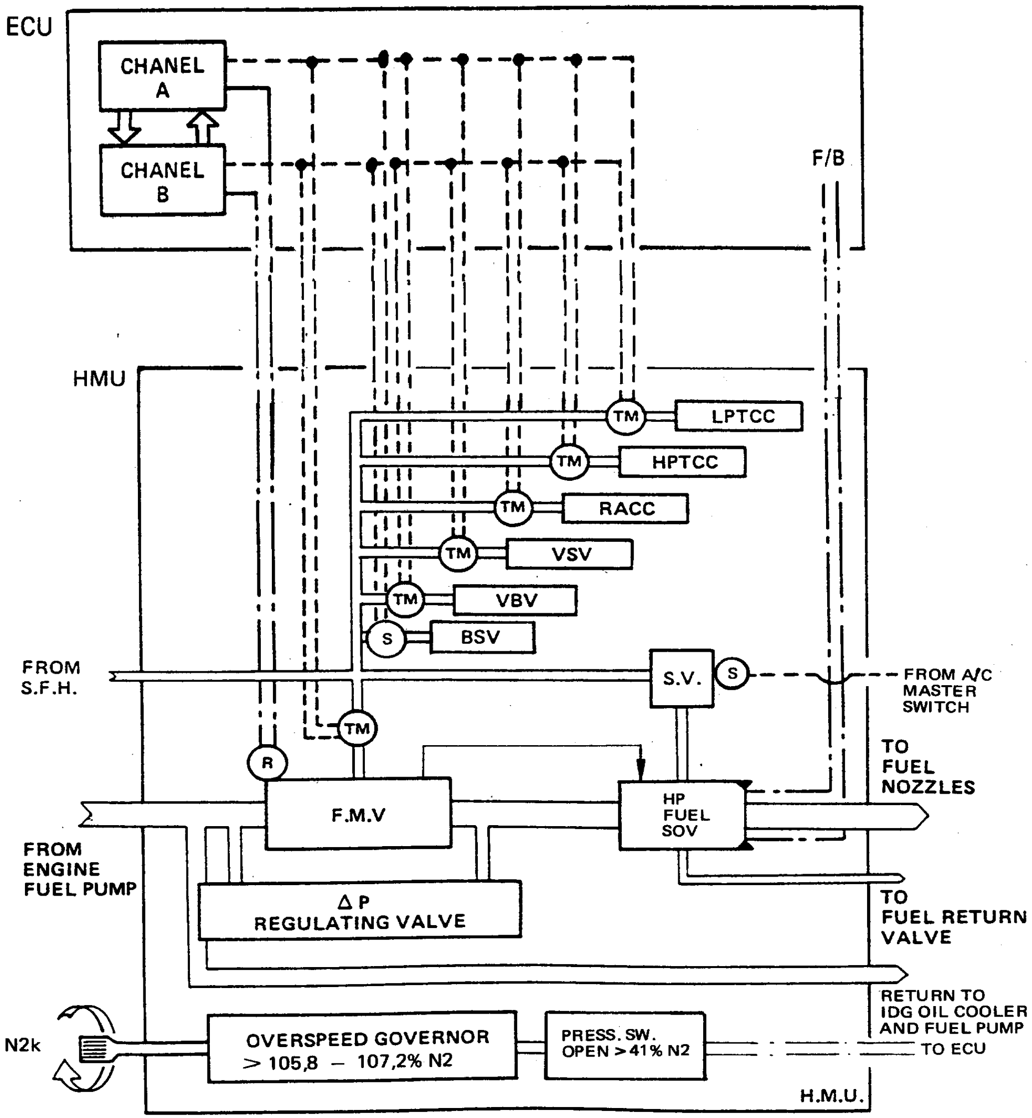


Figure 53 HMU

HP & LP FUEL SOV CONTROL

The HP fuel shut off valve control is fully electrical. It is performed from the engine panel in the cockpit as follows :
Opening of the HP fuel SOV :
it is controlled by the ECU : the ECU receives the commands from the MASTER control switch and mode selector switch.
Closure of the HP fuel SOV :
it is controlled directly from the MASTER control switch in OFF position

HP Fuel Shut Off Valve Control

The FADEC control system contains two fuel shut-off means, which act through pilot valves to close the high pressure fuel shut off valve.

A fuel shut-off which is direct-hardwired to the MASTER control switch. This solenoid operated pilot valve is powered by the 28VDC.It is closed when energized.

When the metering valve is positioned below a minimum fuel flow position a mechanically operated pilot valve in the HMU closes the pressurizing valve. This function is software logic inhibited to prevent operation at and above idle operation.
The fuel shut off valve meets the following concepts.

- The pressurizing valve does not actuate open with boost pressure (even if both pilot valves call for "ON") until the HP fuel pump provides sufficient pressure to open it.
- Loss of power supply does not lead to change the selected HP fuel shutoff valve position.
- When HP fuel shutoff valve is selected closed (open) a spurious transient voltage to open (close) does not lead to a permanent opening (closure) of the fuel valve
- The cockpit commanded OFF coil has priority over the ECU command.

The cockpit control interfaces directly with the HP fuel shut-off solenoid. The valve contains a coil which operates the HP shut-off closed when energized. The solenoid is of a latching type. It latches either open or closed until a reversing signal is applied. The open function is an hydraulic trip with a magnetic latch. A closed signal has priority.

LP Fuel Shut Off Valve Control

The function of the LP fuel shut-off valve is to control the fuel supply at engine-to-pylon interface.
The valve is located on the engine supply system in the wing leading edge.

Valve Operation
The LP fuel shut off valve is controlled :

- From the flight compartment overhead panel by means of the ENG FIRE pushbutton switch
- From the flight compartment center pedestal by means of the MASTER control switch on engine control panel.

NOTE:
It is commanded open via the relay 11QG when the C/B of the HP Fuel SOV is pulled.

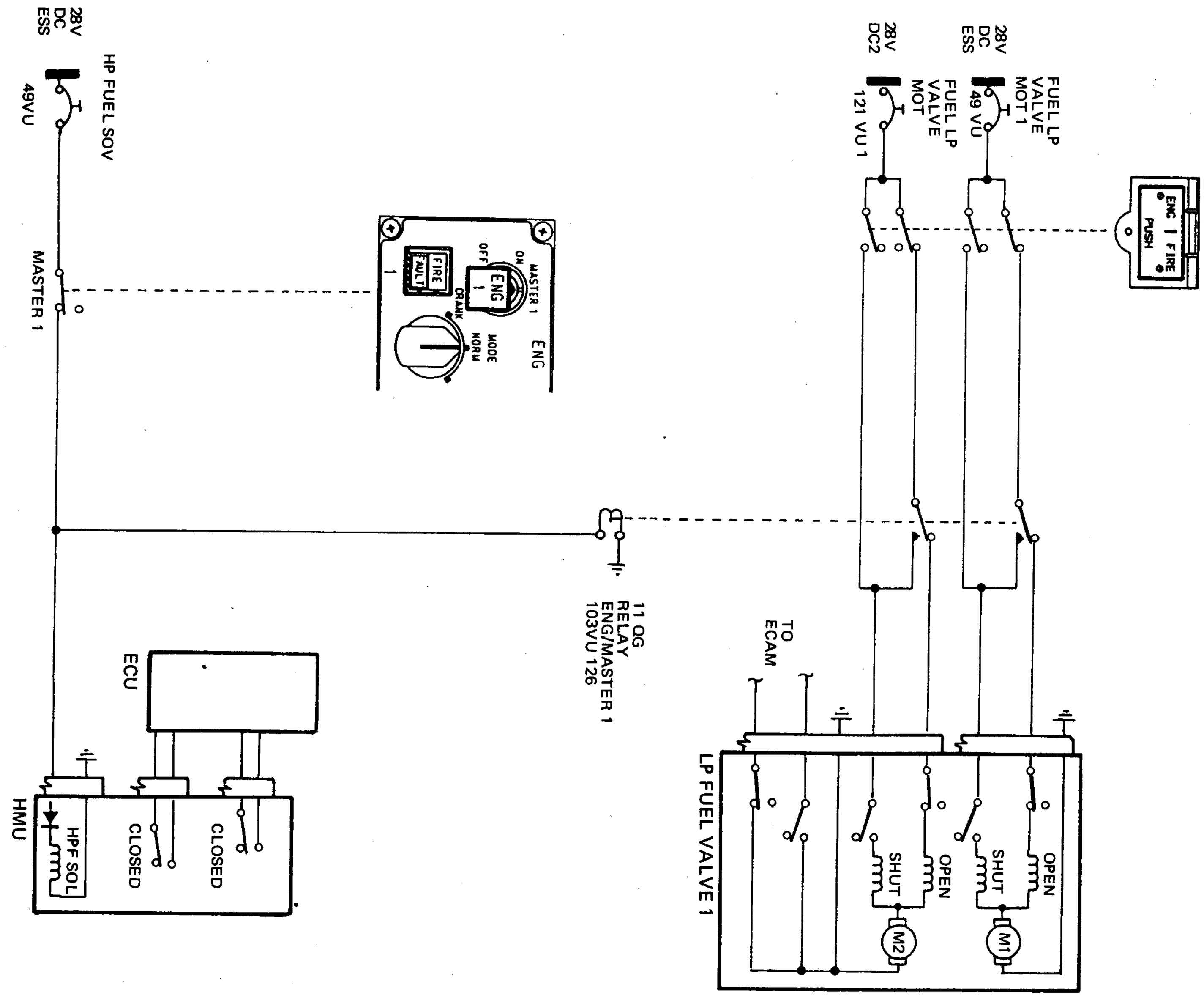


Figure 54 HP Fuel SOV Control

The engine fuel supply system has two fuel shut off valves.

- **one PRSOV in the HMU**
- **One LP - fuel shut off valve on the front wing spar.**

LOW PRESSURE FUEL SHUT OFF VALVE

The LP fuel - valve 12QM (13QM) is in the fuel supply line to its related engine. The LP fuel - valve is usually open and in this configuration lets fuel through to its related engine. When one of the LP fuel - valves is closed, the fuel is isolated from that LP fuel valve's related engine.
The LP fuel - valve is installed between the engine pylon and the front face of the wing front spar (between RIB 8 and RIB 9).

Each LP valve has an actuator 9QG (10QG). The interface between the actuator and the LP valve is a valve spindle. When the actuator is energized, it moves the LP valve to the open or closed position. A V - band clamp 80QM(81QM) attaches the actuator to the LP valve.

Each actuator has two motors, which get their power supply from different sources :
- the 28VDC BATT BUS supplies the motor 1
- the 28VDC BUS 2 supplies the motor 2.

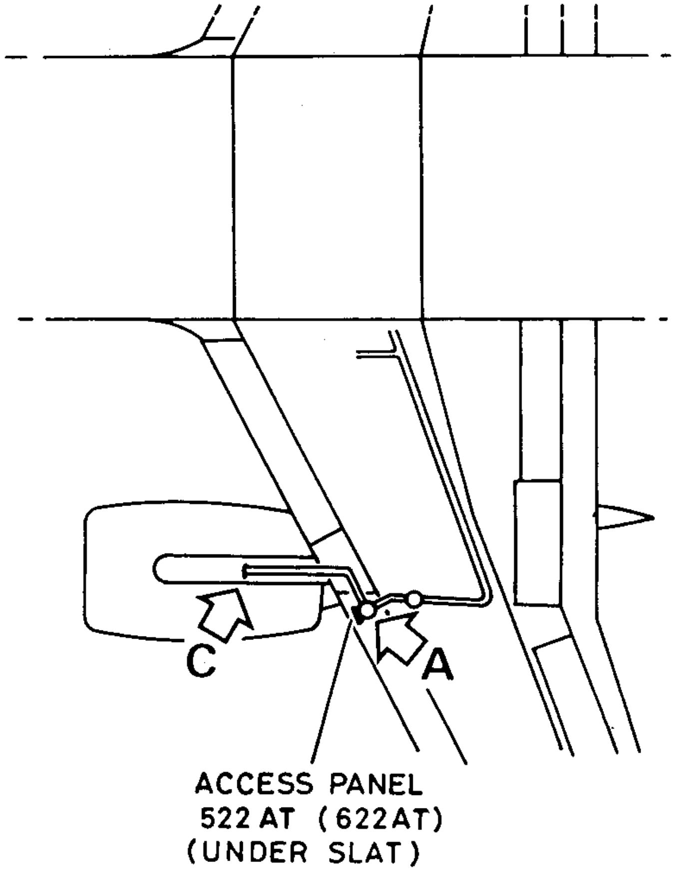
If damage occurs to the electrical circuit, it is necessary to make sure that the valve can still operate. Thus the electrical supply to each motor goes through a different routing. The routing for motor 1 is along the front spar.
The routing for motor 2 is along the rear spar and then forward through the flap track fairing at RIB 6.

The actuators send position data to the System Data - Aquisition C oncentrators (SDAC1 and SDAC2). The SDACs process the data and send it to the ECAM which shows the information on the FUEL page.

Component Description

The LP fuel - valve has:
- a valve body
- a ball valve
- a valve spindle
- a mounting flange.

The LP fuel - valve actuator has two electrical motors which drive the same differential - gear to turn the ball valve through 90 deg. The limit switches in the actuator control this 90 deg. movement and set the electrical circuit for the next operation. One of the two motors can open or close the valve if the other motor does not operate.
The actuator drive shaft has a see/feel indicator where it goes through the actuator body. The see/feel indicator gives an indication of the valve position without removal of the fuel LP fuel valve.



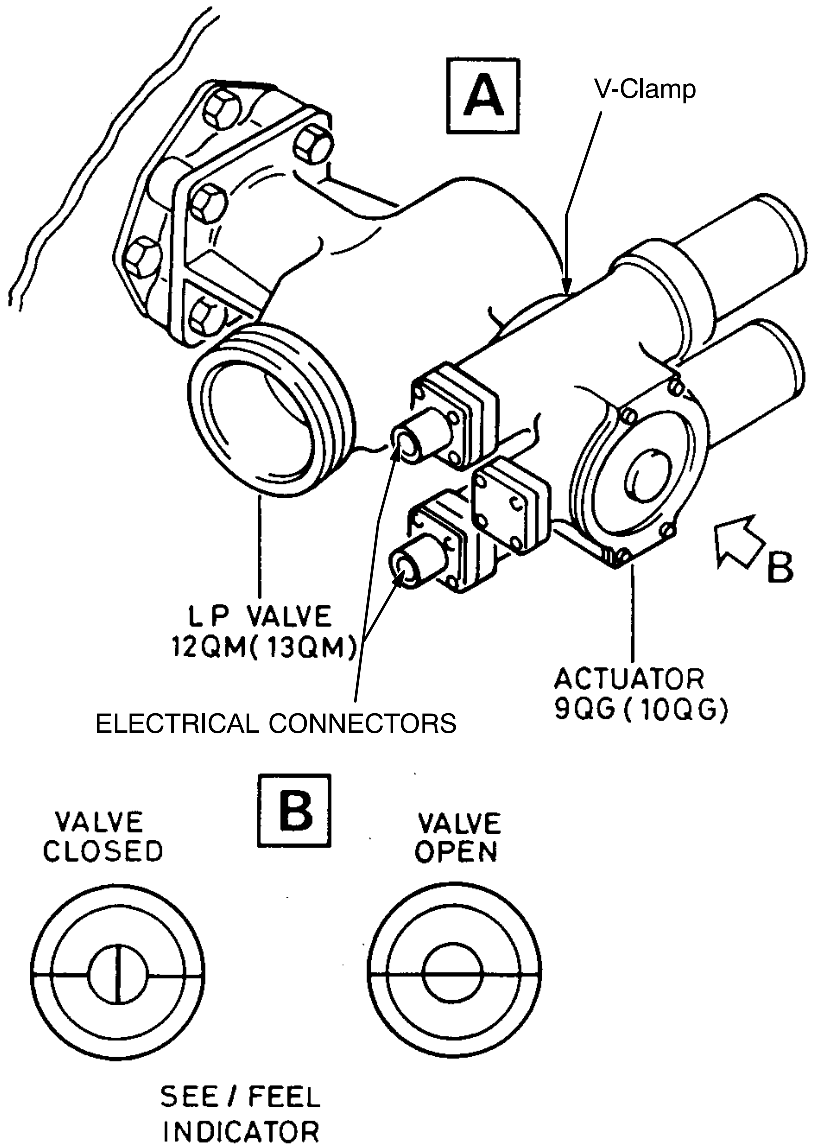


Figure 55 LP Fuel Shut-Off Valve

FUEL RETURN SYSTEM COMPONENTS

General Description

Oil/Fuel Temperature Control

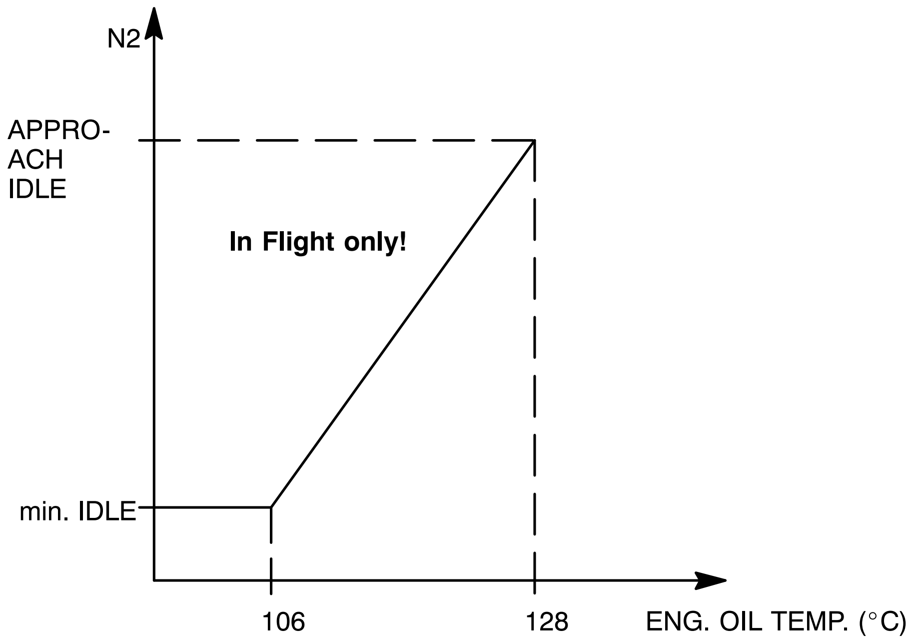
The IDG oil shall be cooled by engine fuel through an oil/fuel heat exchanger which is installed in the fuel bypass line.

For some aircraft operation, extra heat rejected in fuel shall be carried out of the engine fuel system through the valve fuel return valve (FRV) in order not to exceed defined temperature limits (either engine fuel/oil temperature or IDG oil temperature) .

FADEC performs this temperature control using the engine oil temperature and engine fuel measurement.

FADEC hase two actions depending upon the temperature values and the aircraft flight conditions :

- **command the FRV in order to permit a fuel return to the aircraft tank**
- **increase the engine speed when oil temp is 106 deg. C.(which leads to decrease the temperature of the cooling fuel flow).**
  This function is inhibited when the aircraft is on ground.



The Fuel Level Sensing Control Unit (FLCSU) sends also FRV-Inhibition signal to the ECU, if:

Fuel Tank Temp. high
Low Fuel Level in the Tanks
Fuel in Surge Tank
Gravity Feed .

FUEL RETURN VALVE

The purpose of the fuel return valve is to return fuel flow to the tank.
The return fuel flow is controlled at the IDG oil cooler outlet by :

- **the engine oil temperature (signal from TEO)**
- **the fuel temperature**

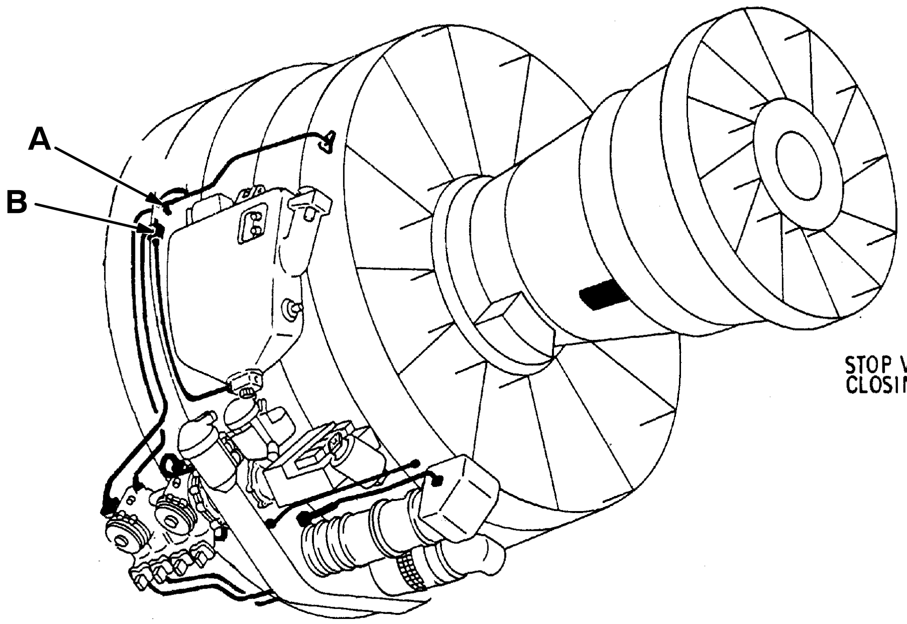
Shut Off Function

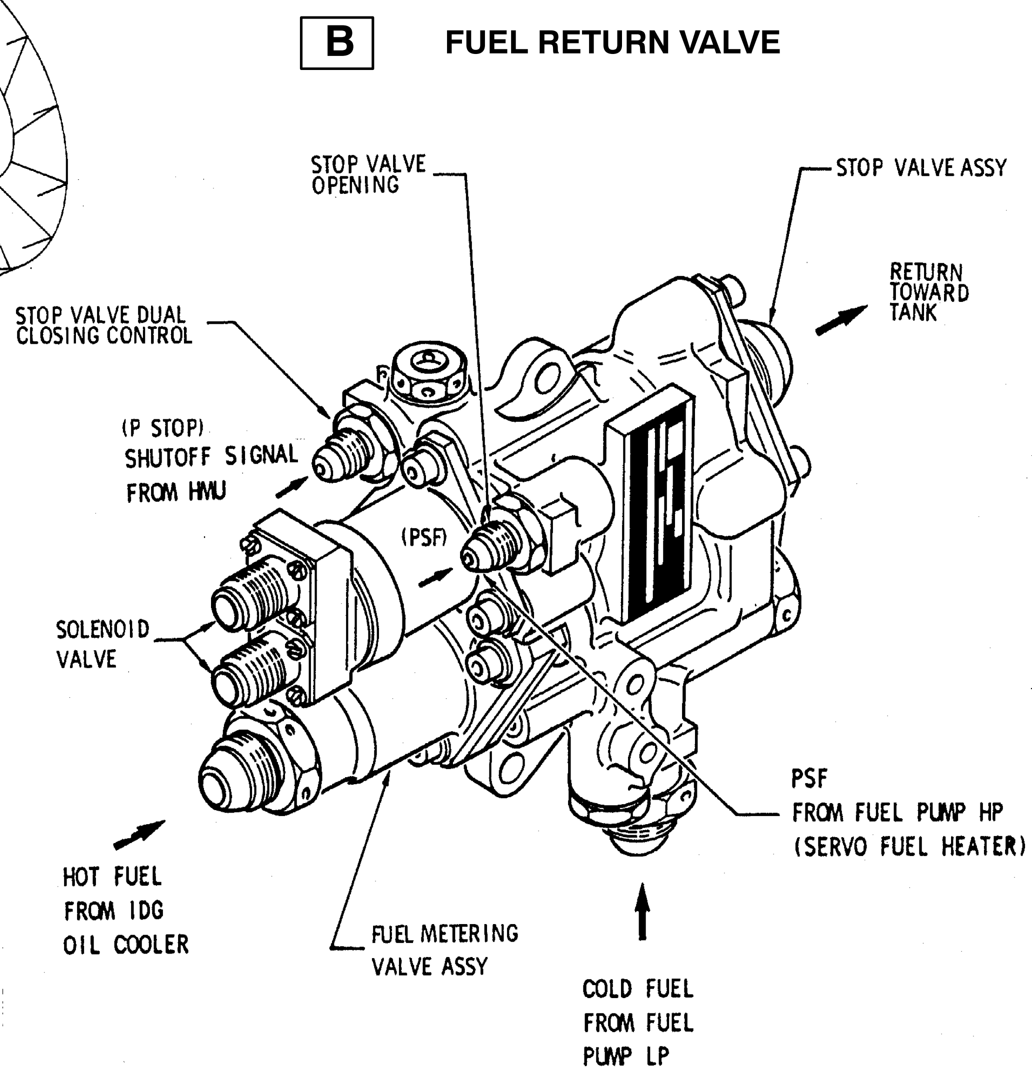
The fuel return valve has a shutoff function when the engine is shutdown. (solenoid de-energized) from the ENG/MASTER control switch .

The signal transits through the Arinc bus and ECU and overrides the engine ”oil in” temperature command.

In case of high fuel flow conditions the electrical open signal is overrided by a hydraulic signal from the HMU and the shutoff valve is closed.

A ”close” command from the HMU interrupts both fuel flows to the aircraft





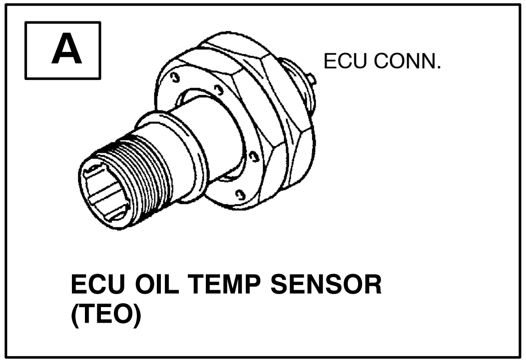


Figure 56 Fuel Return System

FUEL RETURN VALVE

Operation

The fuel return valve controls 2 flow levels :

The first level (300 kg/h) is controlled by the engine ”oil in” temperature when the temperature is higher than 93 deg C.
The V1 solenoid valve is energized by the electronic control unit (ECU) .

The second level (which adds approximately 300 kg/h to the first flow level) is controlled by the IDG oil cooler ”fuel out” temperature when higher than130 deg C (269 deg F).
The V2 thermostatic valve is controlled by the ”fuel out” temperature.

Return fuel temperature limitation.

The fuel return valve mixes :
- a cold fuel flow (from the engine LP fuel pump) with
- the hot fuel flow (calibrated to maintain a temperature of 214 deg F (100 deg C) in the return line.

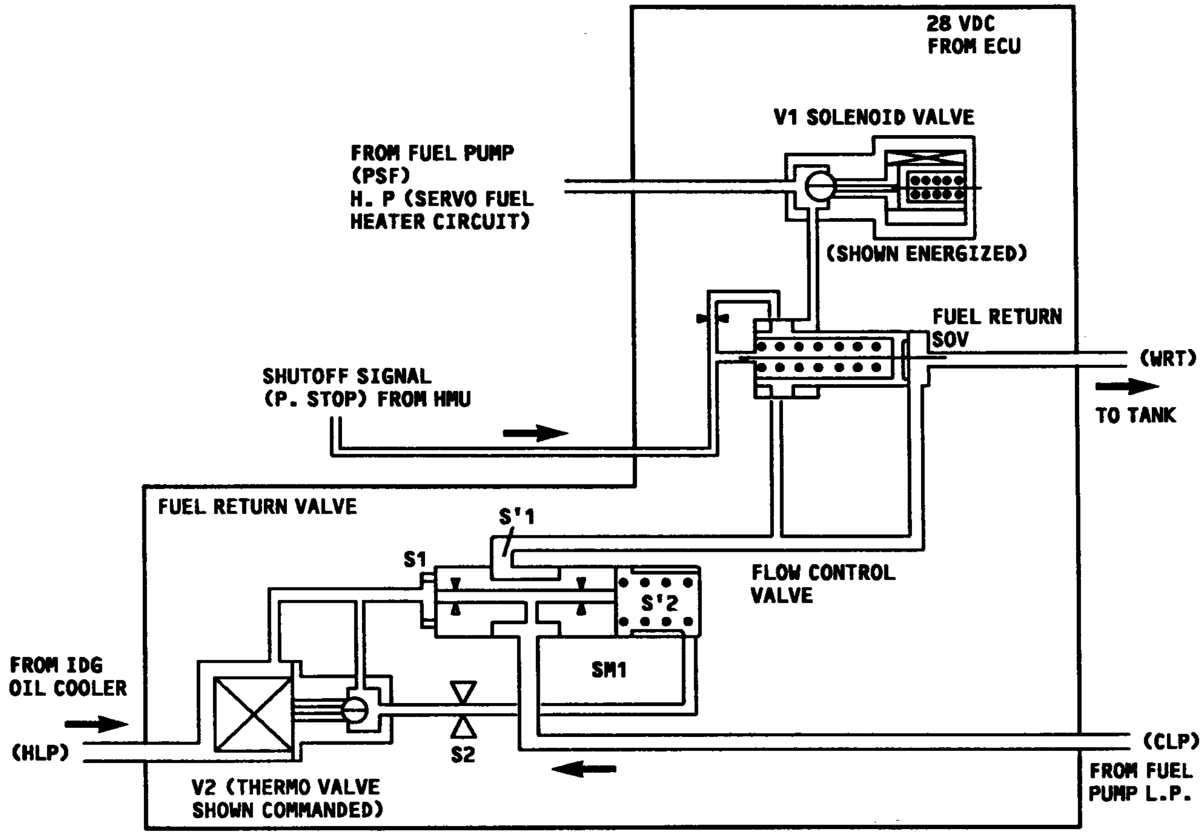
The mix is as follows:

- Fuel out temp. below 130 deg C-
  - 200 kg/h cold flow with 300 kg/h hot flow.
- Fuel out temp. above 130 deg C-
  - 400 kg/h cold flow with 600 kg/h hot flow.

A signal from the ENG/MASTER control switch to FADEC permits to override the V1 opening signal if :

- Engine oil temperature is higher than 93 deg C during take off or climb or specific operating conditions .
- A hydraulic signal from the HP fuel shutoff valve closes the V1 valve at engine shutdown.

Note:
A functional check (refer. to AMM 73-11-50) of the fuel return valve can only be done with a engine idle run.
A test set is used to simulate a temperature >93 deg. C.
Also a flow gage must be fitted in the fuel return line.
When the valve opens the gage indicates a positive reading (fuel returns to tank).



OIL TEMP.	IDG COOLER FUEL TEMP.	HOT FUEL FLOW RETURN	COLD FUEL FLOW RETURN	TOTAL FUEL RETURN TO TANK
T < 93°C	-	0	0	0
T > 93°C	T < 130°C	300 Kg/h	200 Kg/h	500 Kg/h
T > 93°C	T > 130°C	600 Kg/h	400 Kg/h	1000 Kg/h

Figure 57 Fuel Return Valve

IDG FUEL COOLED OIL COOLER

Purpose:

The purpose of the cooler assembly is to cool oil coming from the Integrated Drive Generator (IDG). The heat generated is transfered to the fuel coming from the HMU and returning to the oil/fuel heat exchanger.

Description

The oil cooler is of tubular type. It consists of a removable core,housing and cover.

A fuel pressure relief valve is connected in parallel with the fuel inlet and outlet ports.

Oil system

The oil circulates through the stainless steel tube bundle brazed at both ends. This extracts the calories and transfers them to the engine fuel. The oil outlet temperature varies between (-54 deg C and 160deg C).

Fuel system

The fuel circulates inside the tubes that evacuate the calories released by the oil.If the pressure drop inside the heat exchanger core increases :
- the pressure relief valve opens and bypasses the heat exchanger core.

Location

The IDG oil cooler is located on the front face of the AGB at 5:30 o'clock position, aft looking forward.

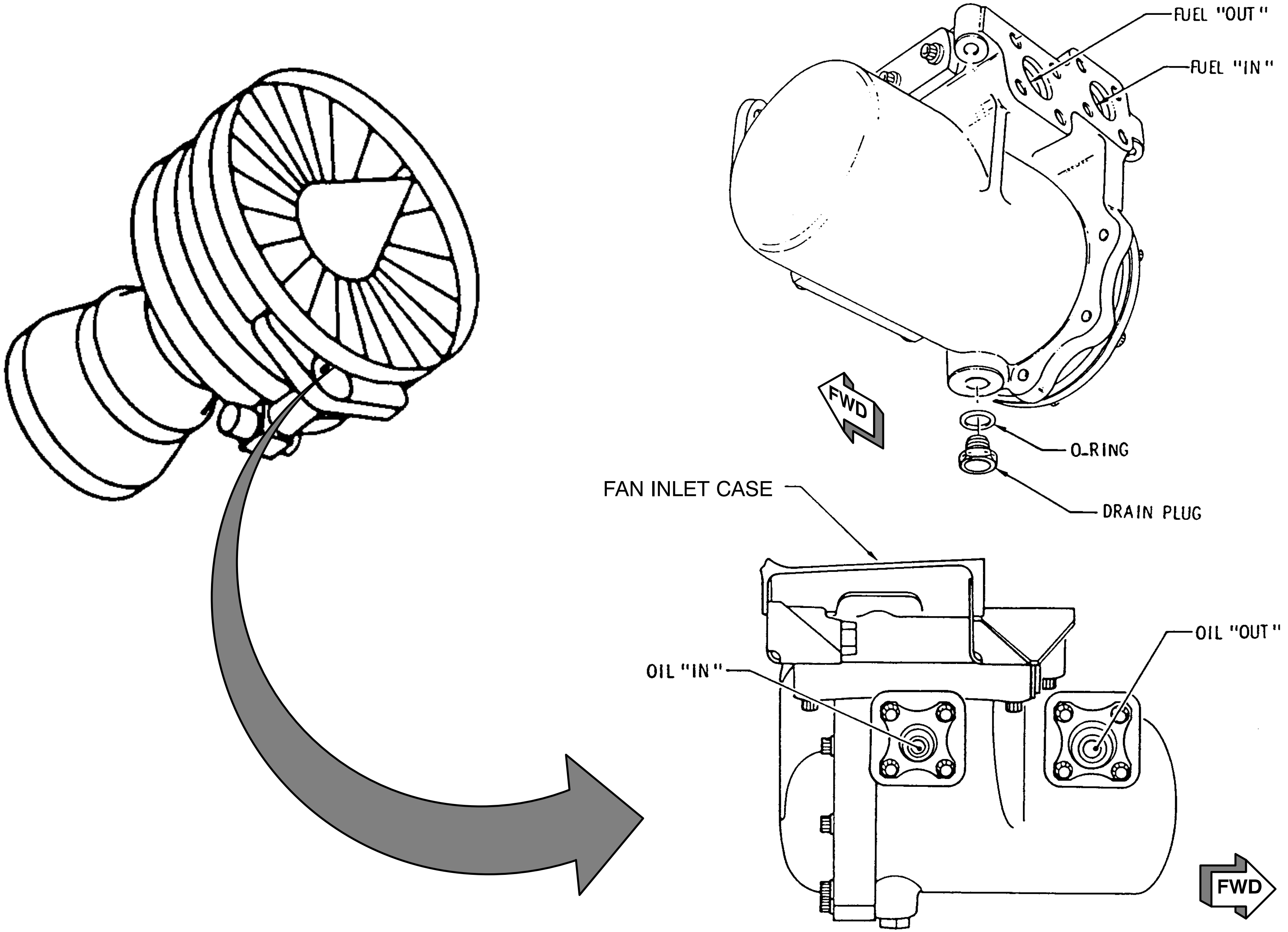


Figure 58 IDG oil Cooler

BURNER STAGING VALVE

Purpose:

The purpose of the Burner Staging Valve (BSV) is to shutoff 10 of the 20 fuel nozzles as commanded by the ECU .
The burner staging valve stages on 10 nozzles when a lower Fuel Air Ratio (FAR) is required by the ECU. This ensures that there is adequate deceleration capability in the deceleration schedule.
The 10 nozzles are also switched off to maintain a adequate flame out margin.
Note:
10 fuel nozzles are always on when the engine is in operation.

Description and Operation

The BSV is a poppet type shutoff valve that is opened or closed by fuel pressure (PC or PCR) from the HMU based on ECU logic.
The main poppet valve allows metered fuel delivery to the staged manifold and under most conditions is set to the open (unstaged) position to assure that all 20 fuel nozzles are used at the following power operations:

-N2K > 80%

-Approach Idle

-BSV Feedback Signal Failure

- ECU or HMU Command signal failed it is opening by hydraulic pressure at 200-300 psi .

Dual switches in the BSV monitor the position of the valve and transmit a feedback indication to the ECU. The switches are open when the valve is open (unstaged).
After the ECU logic has determined that a lower FAR is required, the BSV is staged to 10 nozzles through the HMU BSV solenoid.
If the ECU receives a valid signal from the BSV feedback switches that the BSV did stage, the ECU then lowers the FAR in the deceleration schedule to ensure a constant rate of engine deceleration.
In operating conditions where a low FAR is required, the design of the fuel nozzles provides the necessary spray pattern to ensure that the engine will decelerate properly and that adequate flame out margin is maintained.

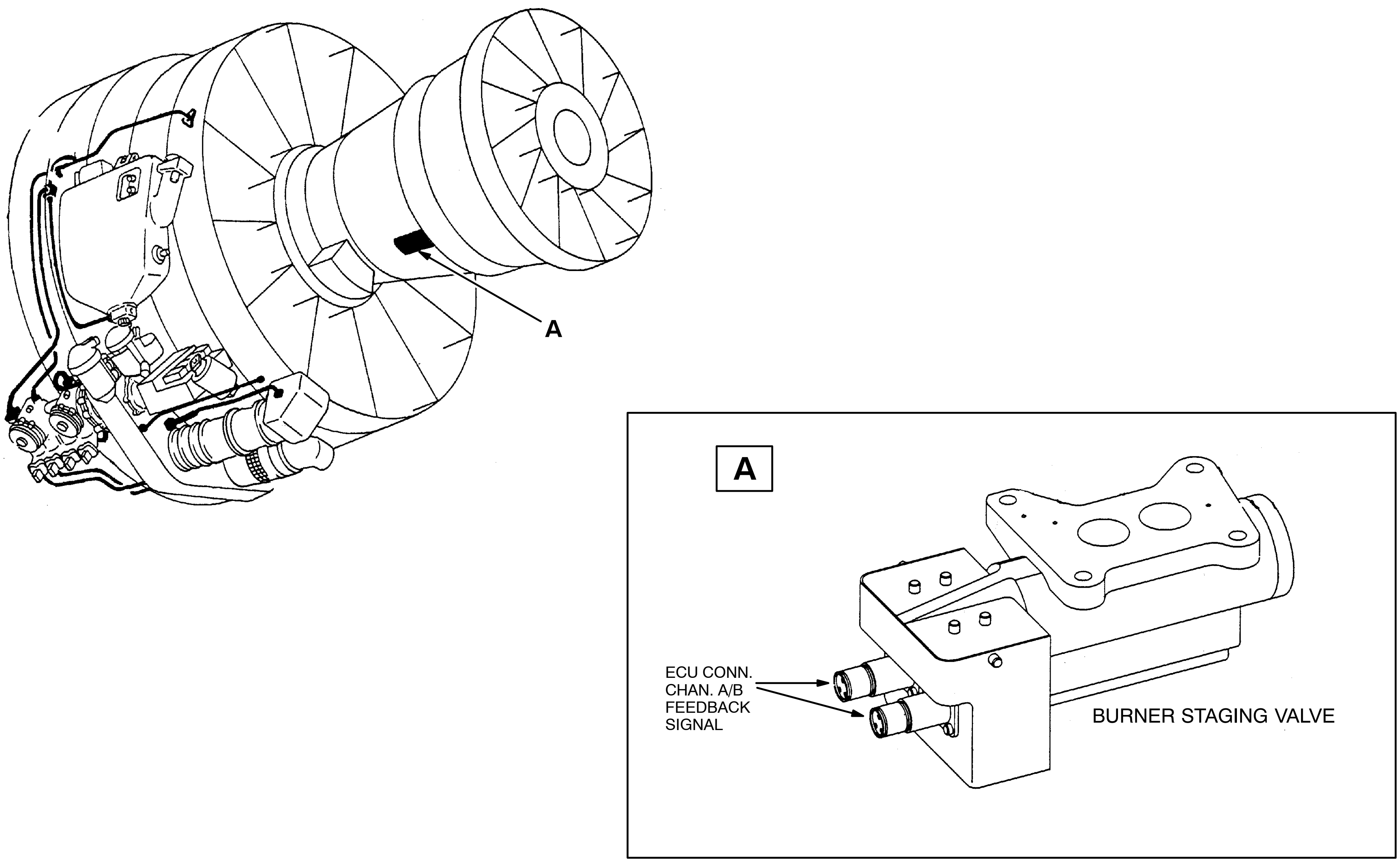


Figure 59 Burner Staging Valve

FUEL NOZZLES

Purpose:

The fuel nozzles are installed into the combustion case assembly. They are connected to the fuel manifold assembly. The 20 fuel nozzles deliver fuel into the combustor in a spray pattern. This provides good light-off and efficient burning at high power.

Operation

The fuel nozzles contain both primary and secondary fuel flow passages.
As the engine is started :
- the fuel passes through the inlet, and
- accumulates in the portion of nozzle that houses the valves.

The low pressure primary flow :
- is directed through the check valve
- passes through the primary passage of the nozzle tube and tip,
- enters the combustion chamber as an uniform density spray

The high pressure secondary flow activates the flow divider valve.
This fuel passes through the secondary passage of the nozzle tube and tip.
Then it enters the combustion chamber as an uniform density, cone shaped spray. The cone of the secondary spray is wider than that of the primary, therefore, surrounding the primary spray pattern.

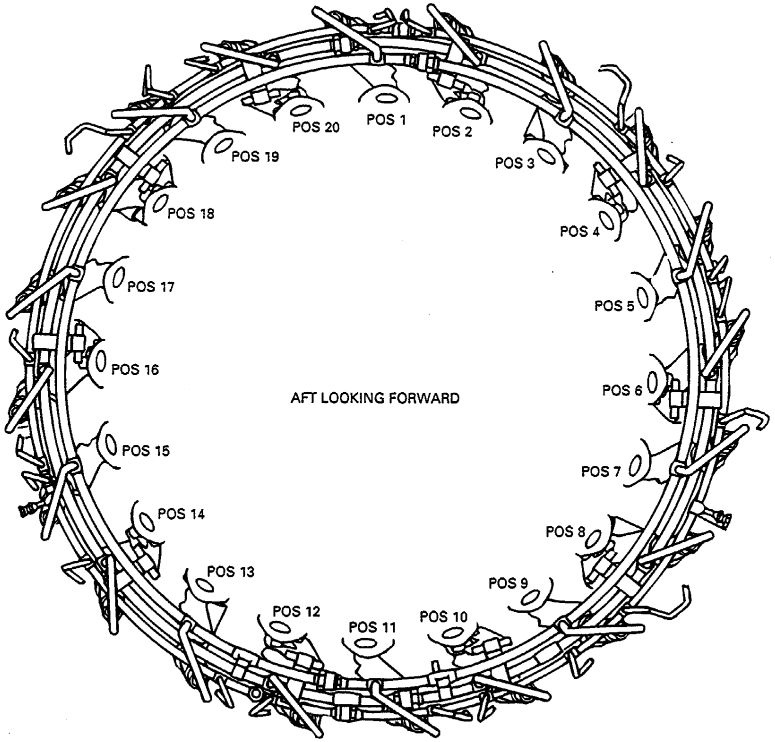
FUEL MANIFOLD

Purpose:

The fuel manifold supplies metered fuel to the twenty fuel nozzles and drains any fuel that may leak from the fuel supply connection lines.

Description and Operation

The fuel manifold consists of a manifold supplying fuel to ten fuel nozzles that is unstaged or staged (depending on BSV position), a staged manifold that always supplies fuel to the remaining ten fuel nozzles when the engine is in operation, and a drain manifold. Fuel nozzles on the two fuel manifolds are located in an alternating pattern. Each manifold is divided into two segments joined by connecting nuts at the 6 and 12 o'clock positions.
The fuel supply manifold halves are connected to supply lines from the BSV at the 5 and 6 o'clock positions. Each of the connections has individual drain lines. This fuel supply splitting limits fuel pressure drop across lines and facilitates removal/installation operations.
A drain function is performed at each fuel nozzle connection by a shroud sealed by two o-rings. The shrouds are connected to the main drain manifold by fifteen integral and five removable drain lines. The five removable drain tubes are to facilitate access to borescope ports. A drain line connected to the aircraft drain mast is attached to the drain manifold at the 7 o'clock position.



Fuel Nozzle Arrangement

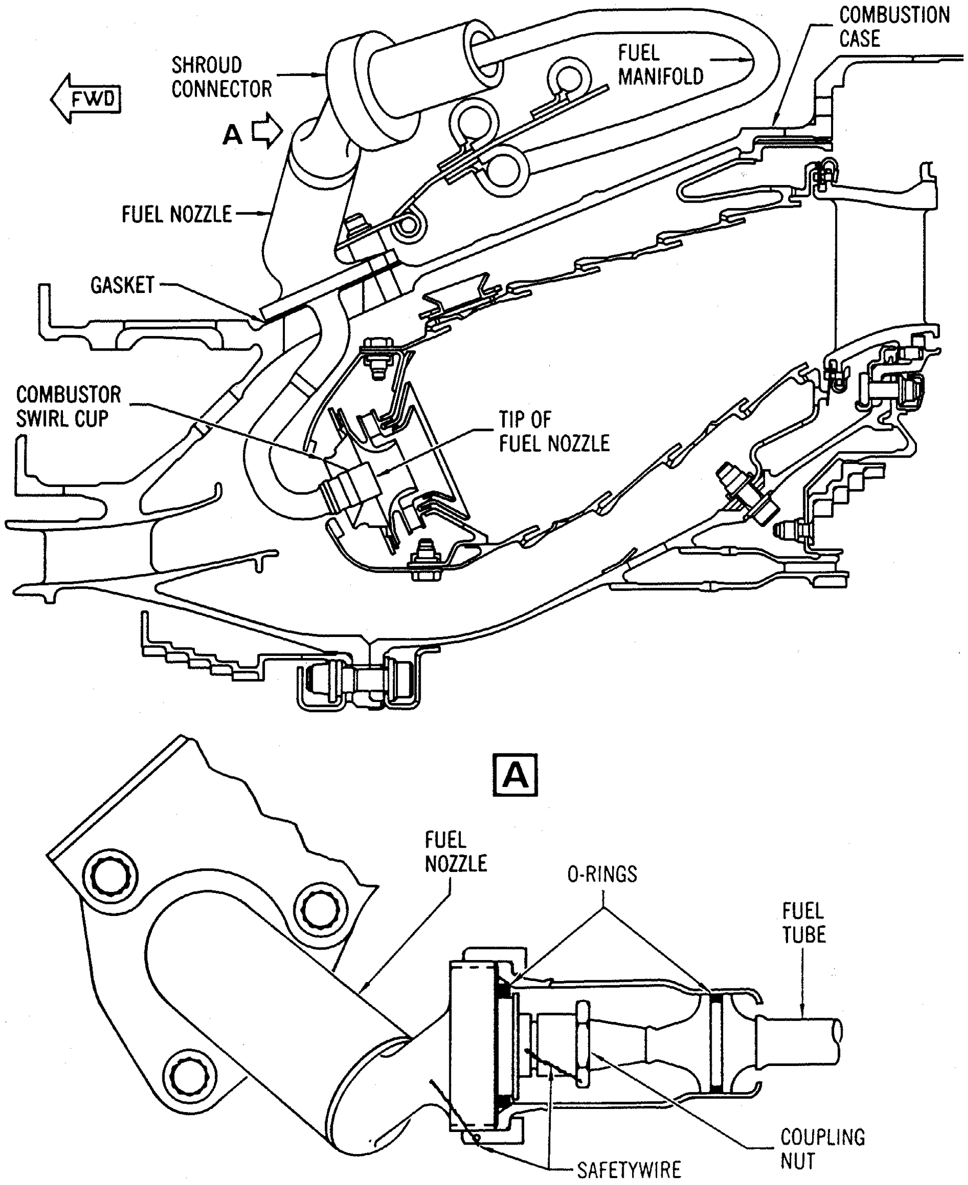


Figure 60 Fuel Nozzles

73-30 ENGINE FUEL INDICATING

FUEL FLOW TRANSMITTER

General
The fuel flow transmitter is installed in the fuel line between the HMU and the burner staging valve. It is mounted on the lower left-hand side of the fan case, rearward of the LP/HP fuel pump.

The fuel flow transmitter is made of these primary assemblies:
- the transmitter body,
- the inlet fitting and clamps
- the turbine assembly,
- the measurement assembly.

FUEL FLOW INDICATION, FUEL USED

The Fuel Flow Transmitter is installed at the HMU. The signals are routed to the ECU and via the DMCs to the ECAM.

The Fuel Used-is calculated in the DMCs .

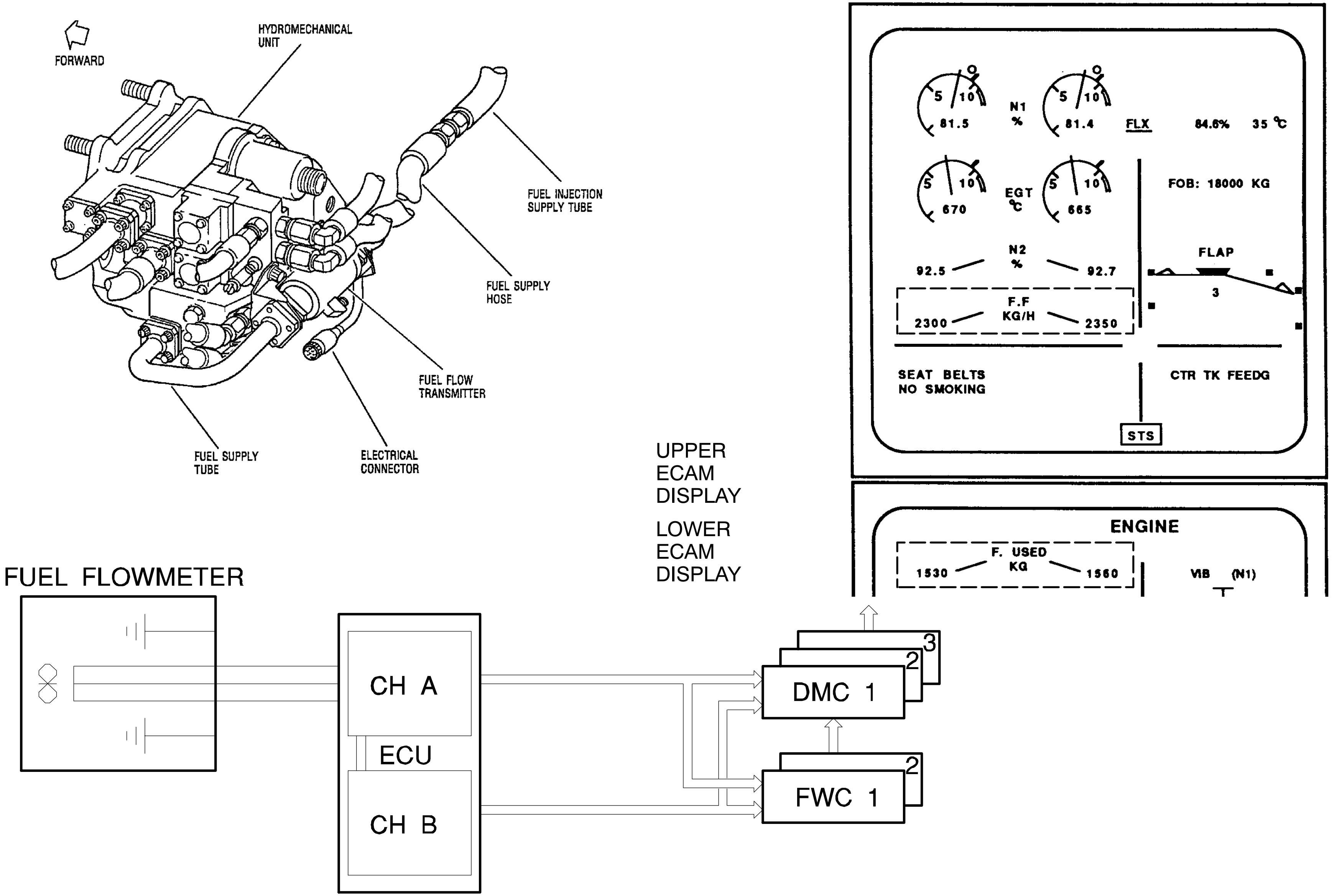
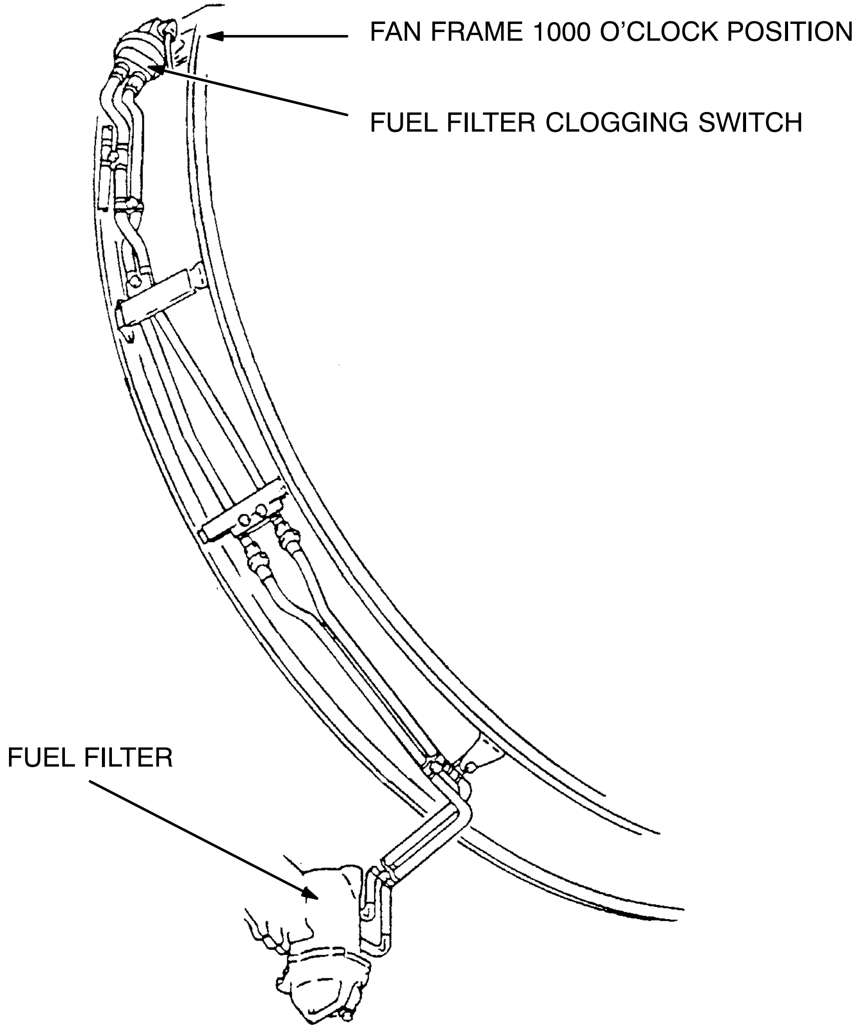


Figure 61 Fuel Flow /Fuel Used Indication

FUEL FILTER CLOGGING INDICATION

The fuel filter clogging switch is installed at 10 o' clock position at the L/H fan frame.



FUEL FILTER CLOGGING SWITCH LOCATION

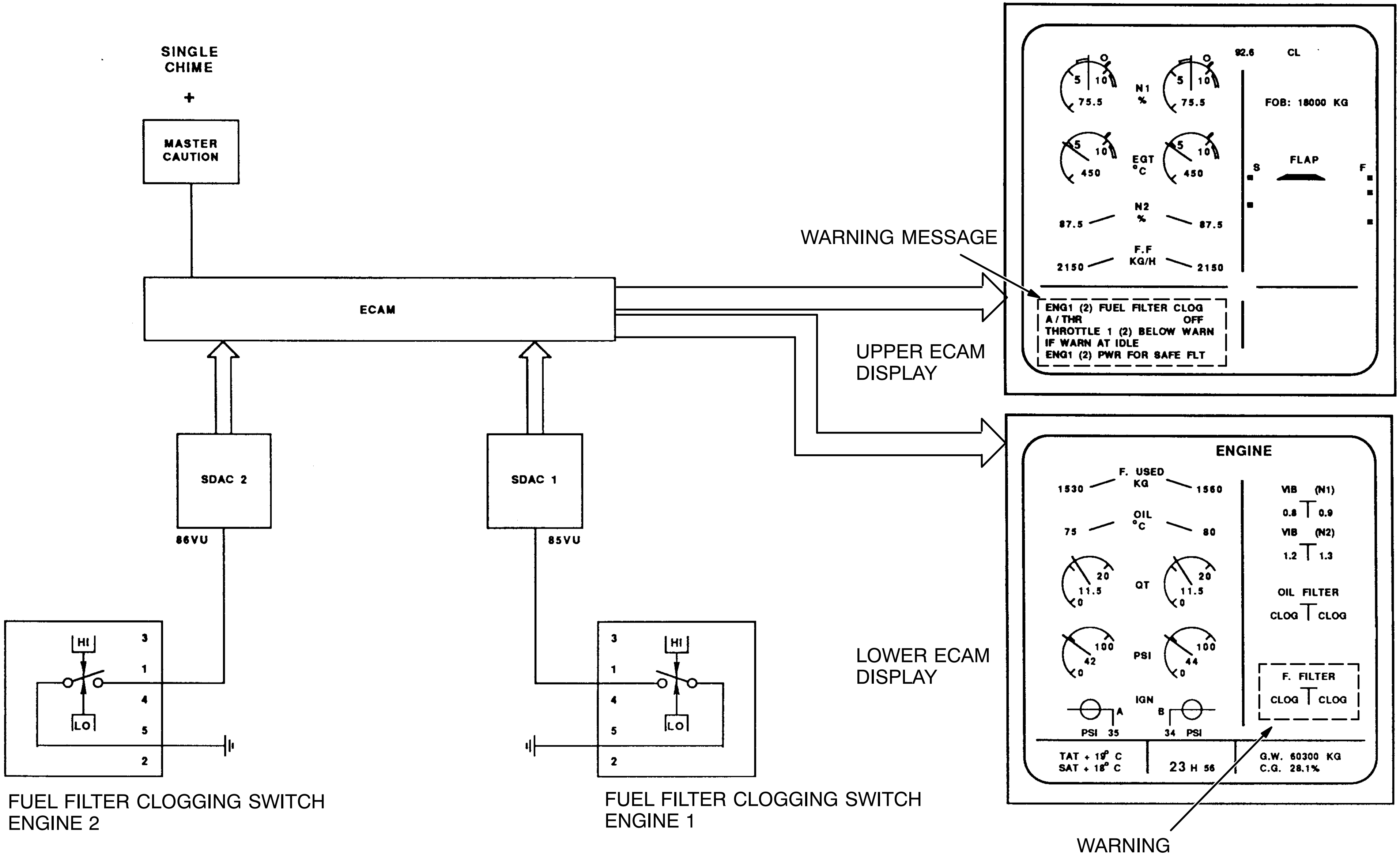


Figure 62 Fuel Filter Clogging Indication

ATA 71 POWER PLANT

71-70 DRAINS

PYLON AND ENGINE DRAINS

Engine Drains

Drain lines are provided on the engine to collect and carry overboard waste fluids and vapors from engine systems and accessories.

This drain system consists of a drain collector with 4 manual drain valves for trouble shooting, a drain module and a drain mast.

DRAIN MODULE

System Operation
The collector retains drain fluids until expelled in flight. The module assembly discharges fluids directly overboard through the drain mast. The drain mast which protrudes through the fan cowl door into the airstream is the channel through which the fluids are discharged overboard except for the fuel shroud drain which discharges fluid directly overboard through an independent drain tube.
Each accessory seal (starter, IDG, hydraulic pump, fuel pump) has a separate drain to the collector in which leakage is contained. Manual drain valves in the bottom of each collector enables the determination of excess leakage.
Each collector is labeled with the accessory seal drain to which it isconnected. These individual collectors overflow into the fuel/oil holding tank or a hydraulic fluid/oil holding tank.
Leakage is contained in the holding tank until the aircraft reaches an airspeed of 200 Knots.
When the airspeed reaches 200 Knots a pressure valve in
the module assembly admits ram air. The ram air pressurizes the holding tanks and any accumulated fluid is discharged overboard through the drain mast. discharged directly overboard, except for the fuel shroud pipe which has its own drain tube.

- the oil tank scupper
- the forward sump
- the fan case
- the oil/fuel heat exchanger
- the VBV
- the VSV
- the TCC
- HMU
- the aft sump
- the fuel shroud pipe (individual drain tube)

Use of Drain System to Monitor Accessory Seals Leakage Rate.
Each drain collector has been sized to collect the maximum acceptable leakage from the accessory seal for a flight of 240 minutes duration, based on the following leak rates:
- Starter (20cc/hour)
- Hydraulic pump (20cc/hour)
- IDG (20cc/hour)
- Fuel pump (30cc/hour)

The procedure for determining the leakage rate, without a specific engine ground run is:
- Prior to flight departure, drain fluid from all four (4) accessory seal drain collectors.
- After one flight, of about one hour, drain fluid from drain collectors into a measured container.

- For fuel or oil leakage limits (Ref. 71-00-00 P. Block 500)

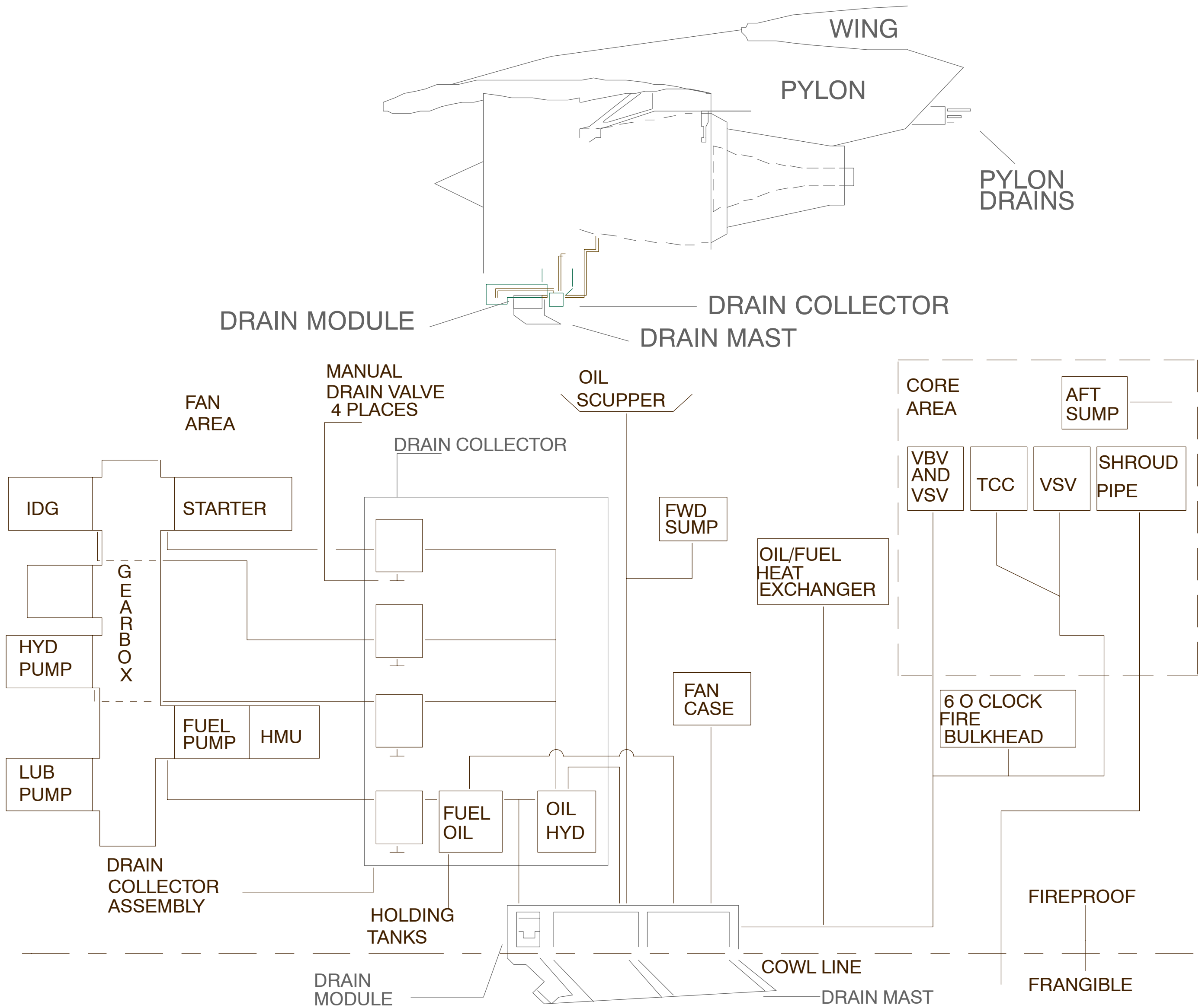


Figure 63 Engine Drains

Use of Drain System to Monitor Accessory Seals Leakage Rate.
Each drain collector has been sized to collect the maximum acceptable leakage from the accessory seal for a flight of 240 minutes duration, based on the following leak rates:
- Starter (20cc/hour)
- Hydraulic pump (20cc/hour)
- IDG (20cc/hour)
- Fuel pump (30cc/hour)

The procedure for determining the leakage rate, without a specific engine ground run is:
- Prior to flight departure, drain fluid from all four (4) accessory seal drain collectors.
- After one flight, of about one hour, drain fluid from drain collectors into a measured container.

Use of Drain System to Isolate an Abnormal High Leakage Rate.
If an abnormally high leakage rate from one seal pad is experienced, it can cause a backflow and fill other drain collectors and holding tanks. When this happens the following procedure is recommended to isolate which accessory-seal has the abnormally high leakage.
- Drain fluid from all four (4) accessory seal drain collectors.
- Perform a short duration engine ”idle” run, five (5) minutes or less, and shut down the engine.
- Check each of the four accessory seal drain collectors by draining the fluid into a measured container. The pad seal with an abnormally high leakage rate will be evident.

NOTE :
If more than one collector is full after step 3, restart the procedure with a two minute or less engine ”idle” run.

CFM 56

A320/A321
AIRCRAFT MAINTENANCE MANUAL

TASK 71-00-00-790-002

Fuel or Oil Leakage Limits

1. Job Set-up Information

A. Referenced Information

REFERENCE	DESIGNATION
29-11-51-000-040	Removal of the Engine Pump (1030GK)
29-11-51-400-040	Installation of the Engine Pump (1030GK)
71-00-00-710-003	Engine Automatic Start
71-00-00-710-027	Engine Shutdown
71-13-00-010-040	Opening of the Fan Cowl Doors
71-13-00-410-040	Closing of the Fan Cowl Doors
72-60-00-000-002	Removal of the Magnetic Seal
72-60-00-000-003	Removal of the Sealol Seal
72-60-00-400-002	Installation of the Magnetic Seal
72-60-00-400-003	Installation of the Sealol Seal
73-11-10-000-001	Removal of the Fuel Pump and Filter Assembly
73-11-10-400-001	Installation of the Fuel Pump and Filter Assembly
73-11-40-790-001	Leak Check of the Fuel Nozzles
73-11-70-000-001	Removal of the Burner Staging Valve (BSV)
73-11-70-400-001	Installation of the Burner Staging Valve (BSV)
73-21-10-000-001	Removal of the Hydromechanical unit (HMU)
73-21-10-400-001	Installation of the Hydromechanical Unit (HMU)
75-21-10-000-001	Removal of the High Pressure Turbine Clearance Control (HPTCC) Valve
75-21-10-400-001	Installation of the High Pressure Turbine Clearance Control (HPTCC) Valve
75-22-10-000-001	Removal of the LPT Active Clearance Control Valve
75-22-10-400-001	Installation of the LPT Active Clearance Control Valve
75-23-10-000-001	Removal of the Rotor Active Clearance Control (RACC) Valve
75-23-10-400-001	Installation of the Rotor Active Clearance Control (RACC) Valve
75-31-10-000-001	Removal of the Bleed Valve Fuel Gear Motor Assembly
75-31-10-400-001	Installation of the Bleed Valve Gear Motor Assembly
75-32-10-000-001	Removal of the Variable Stator Vane (VSV) Actuators
75-32-10-400-001	Installation of the Variable Stator Vane (VSV) Actuators
79-21-20-000-001	Removal of the Oil/Fuel Heat Exchanger
79-21-20-400-001	Installation of the Oil/Fuel Heat Exchanger

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71-00-00 Page A568
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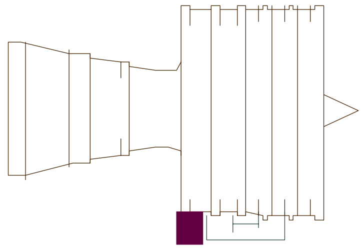
Vacbi File: ENGINE DRAIN LRU'S



- 4 manual

drain valves.

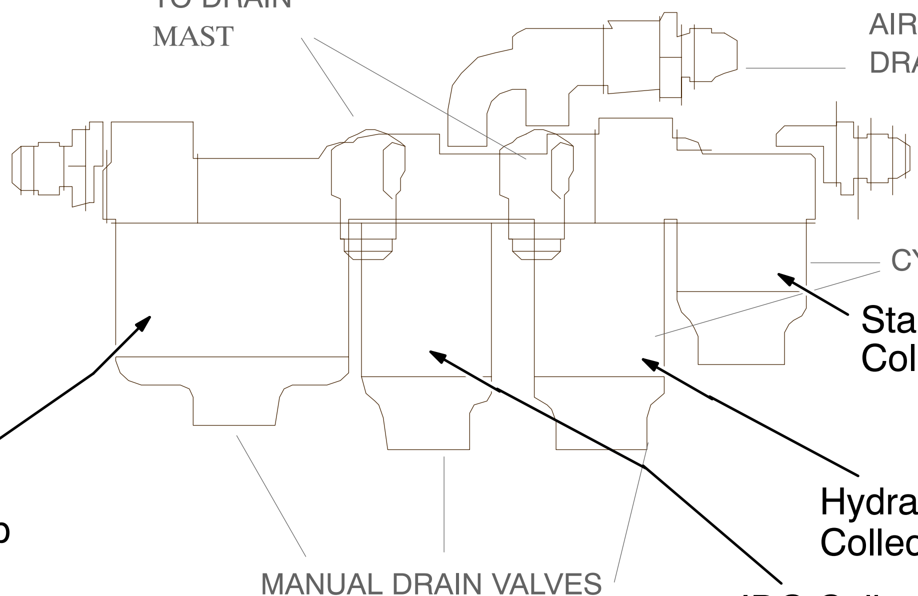


Figure 64 Drain Module

REFERENCE	DESIGNATION
TSM 79 PB 101	
R 71-00-00-991-011	Fig. 523

2. Job Set-up

Subtask 71-00-00-010-050

A. Open the fan cowl doors (Ref. TASK 71-13-00-010-040):
FOR 1000EM1
437AL, 438AR
FOR 1000EM2
461AL, 462AR

Subtask 71-00-00-030-050

B. If an abnormal leak occurs at the drain mast assembly, disconnect each of the possible leak sources.

C. Install plastic bottles and tubes on the sources.

3. Procedure

Subtask 71-00-00-790-051

WARNING : - ENGINE OPERATION MUST NOT EXCEED MINIMUM IDLE WHEN PERSONNEL ARE IN ENTRY/EXIT CORIDOR.
- POSITIVE COMMUNICATION BETWEEN FLIGHT COMPARTMENT AND PERSONNEL IN ENTRY/EXIT CORIDOR IS NECESSARY.
- INLET AND EXHAUST HAZARD AREAS MUST BE STRICTLY OBSERVED BY PERSONNEL IN ENTRY/EXIT CORIDOR.

R (Ref. Fig. 523/TASK 71-00-00-991-011)

A. To check for oil leaks start the engine (Ref. TASK 71-00-00-710-003) and stabilize it at 70 percent N1 for 5 minutes. Shut down the engine (Ref. TASK 71-00-00-710-027).

B. To check for fuel leaks start the engine (Ref. TASK 71-00-00-710-003) and stabilize it at minimum idle for 5 minutes. Shut down the engine (Ref. TASK 71-00-00-710-027).

C. Measure the individual leak amounts and look for the items that follow:

INSPECT/CHECK	MAXIMUM SERVICEABLE LIMITS	REMARKS
1. The oil source		
- The starter pad	20 ml/hr (1cc/3min) (7 drops/min)	Replace the seal (Ref. TASK 72-60-00-000-002) and (Ref. TASK 72-60-00-400-002) or (Ref. TASK 72-60-00-000-003) and (Ref. TASK 72-60-00-400-003).
- The AGB rear hydraulic pump pad	20 ml/hr (1cc/3min) (7 drops/min)	Replace the seal (Ref. TASK 72-60-00-000-002) and (Ref. TASK 72-60-00-400-002) or (Ref. TASK 72-60-00-000-003) and (Ref. TASK 72-60-00-400-003).
- The AGB fuel pump pad	20 ml/hr (1cc/3min) (7 drops/min)	Replace the seal (Ref. TASK 72-60-00-000-002) and (Ref. TASK 72-60-00-400-002) or (Ref. TASK 72-60-00-000-003) and (Ref. TASK 72-60-00-400-003).
- The lube unit pad	0	
- The main oil/fuel heat exchanger	20 ml/hr (1cc/3min) (7 drops/min)	Replace the main oil/fuel heat exchanger (Ref. TASK 79-21-20-000-001) and (Ref. TASK 79-21-20-400-001).
- The AGB/IDG pad	20 ml/hr (1cc/3min) (7 drops/min)	Replace the seal (Ref. TASK 72-60-00-000-002) and (Ref. TASK 72-60-00-400-002) or (Ref. TASK 72-60-00-000-003) and

Figure 65 Leakage Limits

INSPECT/CHECK	MAXIMUM SERVICEABLE LIMITS	REMARKS
		(Ref. TASK 72-60-00-400-003).
- The forward sump	60 ml/hr (1cc/min) (21 drops/min)	Replace the engine.
- The aft sump (flooding drain)	Lightly wet	If a large amount of oil is present (Ref. TSM 79 PB 101).
2. The fuel source		
- The fuel manifold assembly	No leaks allowed	Perform a leak check at the manifold assembly (Ref. TASK 73-11-40-790-001).
- The VSV actuator	120 ml/hr (2cc/min) (40 drops/min)	Replace the actuator (Ref. TASK 75-32-10-000-001) and (Ref. TASK 75-32-10-400-001).
- The VBV fuel gear motor.	120 ml/hr (2cc/min) (40 drops/min)	Replace the fuel motor (Ref. TASK 75-31-10-000-001) and (Ref. TASK 75-31-10-400-001).
- The fuel pump at the drive pad	90 ml/hr (1.5cc/min) (30 drops/min)	Replace the fuel pump (Ref. TASK 73-11-10-000-001) and (Ref. TASK 73-11-10-400-001).
- The heat exchanger	40 ml/hr (2cc/3min) (14 drops/min)	Replace the main oil/fuel heat exchanger (Ref. TASK 79-21-20-000-001) and (Ref. TASK 79-21-20-400-001).
- The HMU	180 ml/hr (3cc/min) (60 drops/min)	Replace the HMU (Ref. TASK 73-21-10-000-001) and (Ref. TASK 73-21-10-400-001).

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INSPECT/CHECK	MAXIMUM SERVICEABLE LIMITS	REMARKS
- The HPTCC valve	180 ml/hr (3cc/min) (60 drops/min)	Replace the HPTCC valve (Ref. TASK 75-21-10-000-001) and (Ref. TASK 75-21-10-400-001).
- The BSV	180 ml/hr (3cc/min) (60 drops/min)	Replace the BSV (Ref. TASK 73-11-70-000-001) and (Ref. TASK 73-11-70-400-001).
- The LPTCC valve	180 ml/hr (3cc/min) (60 drops/min)	Replace the LPTCC valve (Ref. TASK 75-22-10-000-001) and (Ref. TASK 75-22-10-400-001).
- The RACC valve	180 ml/hr (3cc/min) (60 drops/min)	Replace the RACC valve (Ref. TASK 75-23-10-000-001) and (Ref. TASK 75-23-10-400-001).
3. The hydraulic source		
- The hydraulic pump pad	5 ml/hr (0.25cc/3 min) (2 drops/min)	Replace the hydraulic pump (Ref. TASK 29-11-51-000-040) and (Ref. TASK 29-11-51-400-040).

4. Close-up

Subtask 71-00-00-430-050

A. Reconnect the drain lines.

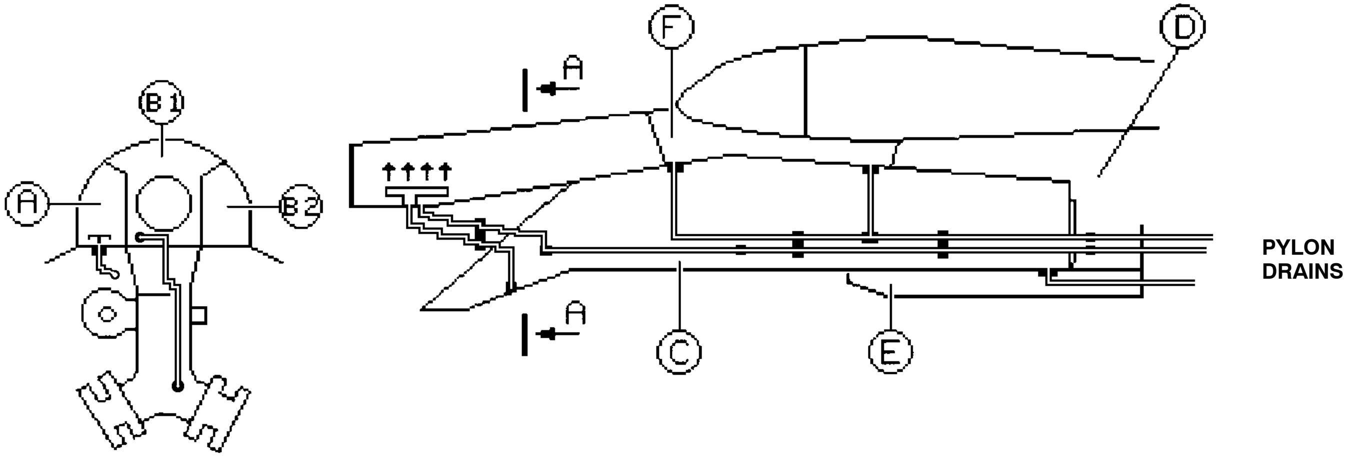
Subtask 71-00-00-410-050

B. Close the fan cowl doors: (Ref. TASK 71-13-00-410-040)
FOR 1000EM1
437AL, 438AR
FOR 1000EM2
447AL, 448AR

Figure 66 Leackage Limits

PYLON DRAINS

The engine pylon is divided into 7 compartments.Various systems are routed through these areas.
Any leckage from fluid lines is drained overboard through seperate lines in the rear of the pylon.



DESIGNATION	ZONE	SYSTEMS
Forward fairing	A B1 B2	Flammable fluids (Fuel, hydraulics) Bleed Air (Hi and lo temperatures) Electrics
Pylon Box	C	Hydraulics without couplings Fire extinguisher bottles.
Rearward secondary structure	D	Hydraulics Limited electrics
Lower Fairing	E	None
Pylon to wing center fillets	F	Fuel (Zero-leakage couplings) Electrics Bleed Air (Low temperature)

Figure 67 Pylon Drains

ATA 76 ENGINE CONTROLS

THROTTLE CONTROL SYSTEM

General

The throttle control system consist of :

- the throttle control lever
- the throttle control artificial feel unit (Mecanical Box)
- the thrust control unit
- the electrical harness.

The design of the throttle control is based upon a fixed throttle concept : this means that the throttle control levers are not servo motorized.

Thrust Control Unit

The Thrust Control Unit contains two resolvers, each of which sends the thrust lever position to the Engine Control Unit.The extraction current for the resolvers is provided by the ECU.

Autothrust Disconnect pushbutton.

The autothrust instinctive disconnect pushbutton can be used to disengage the autothrust function.

THRUST LEVERS

General

The thrust levers comprises :

- a thrust lever which incorporates stop devices and autothrust instinctive disconnect pushbutton switch
- a graduated fixed sector
- a reverse latching lever.

The thrust lever is linked to a mechanical rod. This rod drives the input lever of the throttle control artificial feel unit (Mechanical Box).

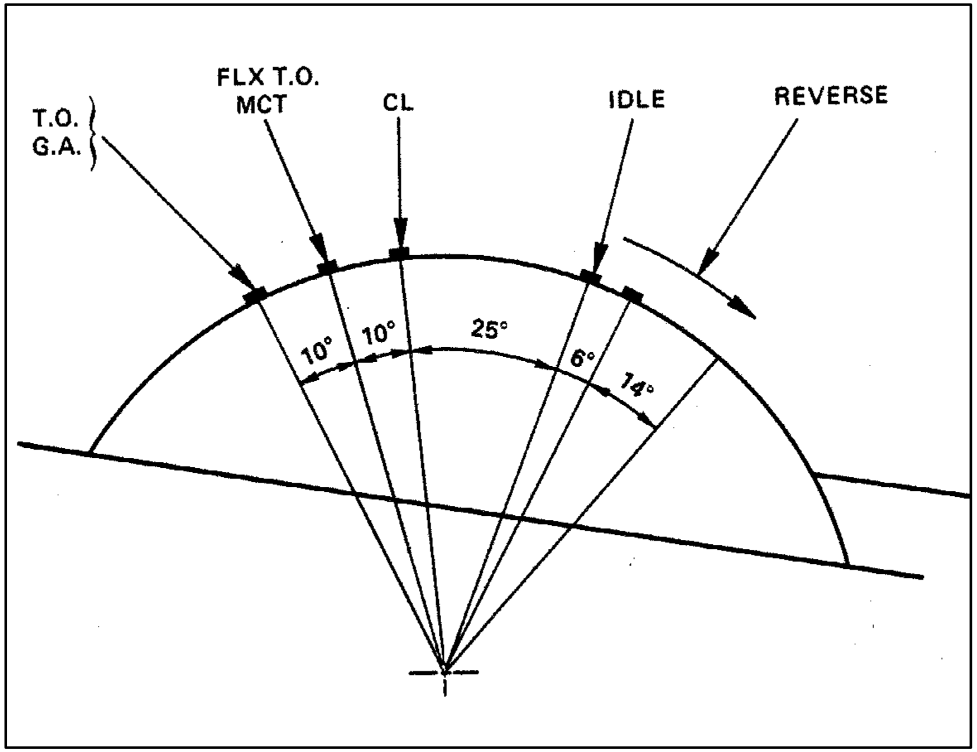
The thrust lever has 3 stops at the pedestal and 3 detents in the artificial feel unit:

- **0° STOP** = FWD IDLE THRUST-**IDLE**
- **-20° STOP** = FULL REVERSE THRUST-**MREV**
- **45° STOP** = MAX .TAKE OFF THRUST-**TOGA**

- **DETENT** $\boxed{1}$ = (REVERSE) IDLE THRUST-**REV**
- **DETENT** $\boxed{2}$ = MAX.CLIMB- **CL**
- **DETENT** $\boxed{3}$ = MAX. CONTINOUS-**MCT/FLX T/O**

Reverse Thrust Latching Lever

To obtain reverse thrust settings, the revers thrust laching lever must be lifted



ENGINE THRUST LEVER CONTROL

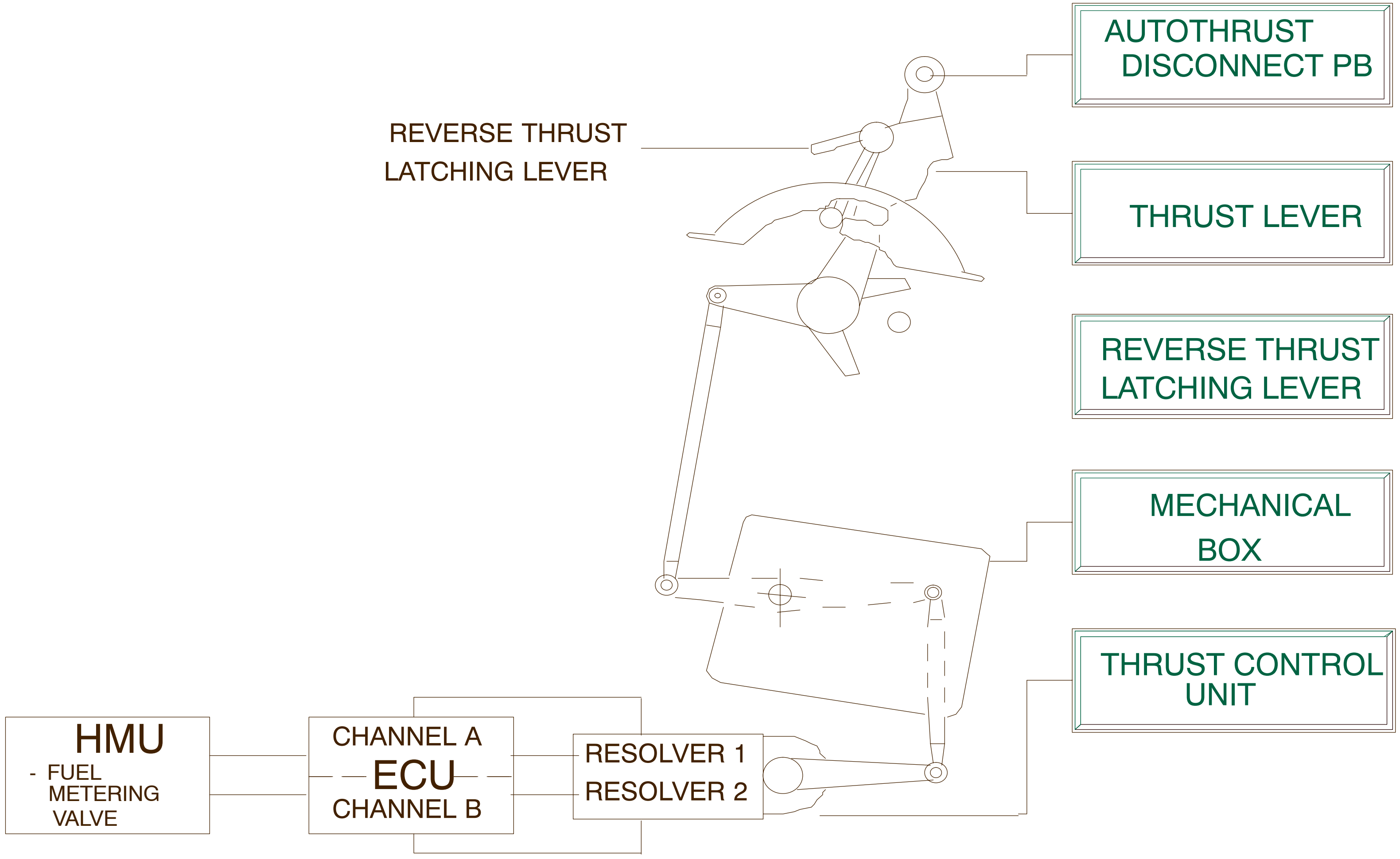


Figure 68 Engine Thrust Lever Control

BUMP RATING PUSH BUTTON

This Push Buttons are optional equipment.
In some cases the throttle control levers are provided with "BUMP" rating push buttons,one per engine.This enables the ECU to be re-rated to provide additional thrust capability for use during specific aircraft operations.

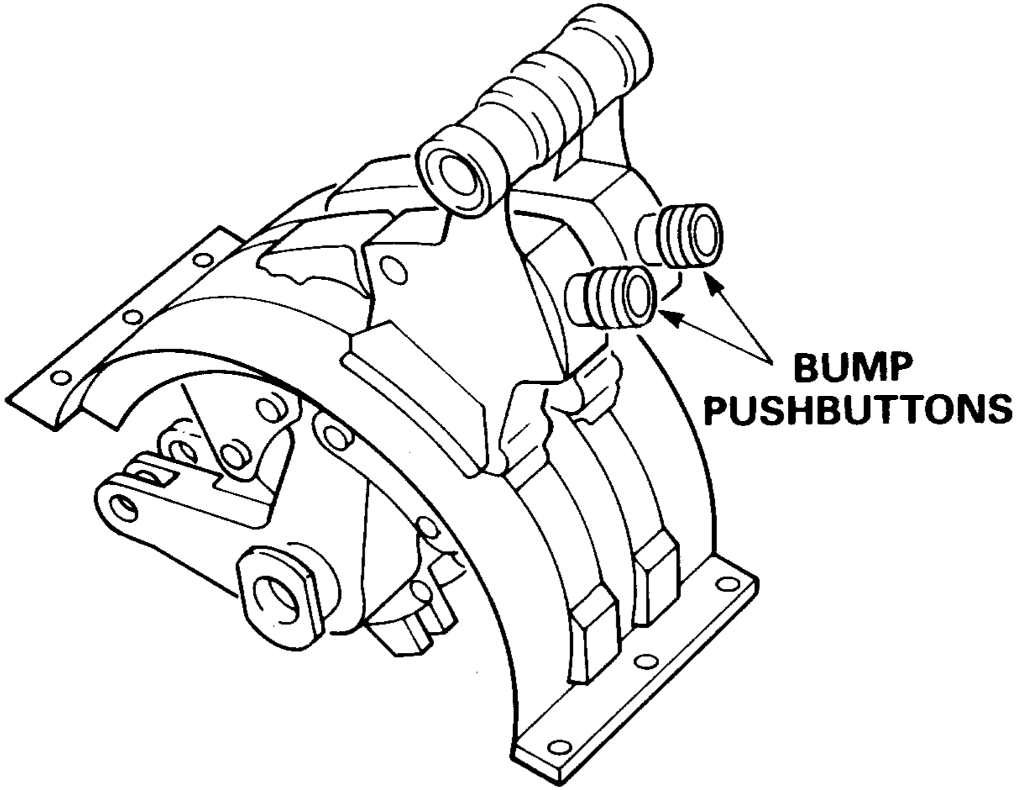


Figure 69 Bump Push Bottons

ARTIFICIAL FEEL UNIT(MECANICAL BOX)

The Throttle control artificial feel unit is located below the cockpit center pedestal. this artificial feel unit is connected to engine 1(2) throttle control lever and to the engine 1(2) throttle control unit by means of rods.
The artificial feel unit is a friction system wich provides a load feedback to the throttle control lever.
This artificial feel unit comprises two symetrical casings, one left and one right. Each casing contains an identical and independent mechanism.
Each mechanism is composed of:

- **a friction brake assembly**
- **a gear assembly**
- **a lever assembly**
- **a bellcrank assembly**

Throttle lever travel is transmitted to the to the artificial feel unit and to the throttle control unit.
The linear movement of the throttle levers is transformed into a rotary movement at the bellcranck which turns about the friction brake assembly shaft. This movement rotates a toothed quadrant integral with the shaft.
This toothed quadrant causes inverse rotation of a gear equipped with a disk which has three detent notches. Each notch corresponds to a throttle lever setting and is felt as a friction point at the throttle levers.

MECHANICAL BOX(ES)

An adjustment screw is provided at the lower part of each mechanical box to adjust the artificial feel.

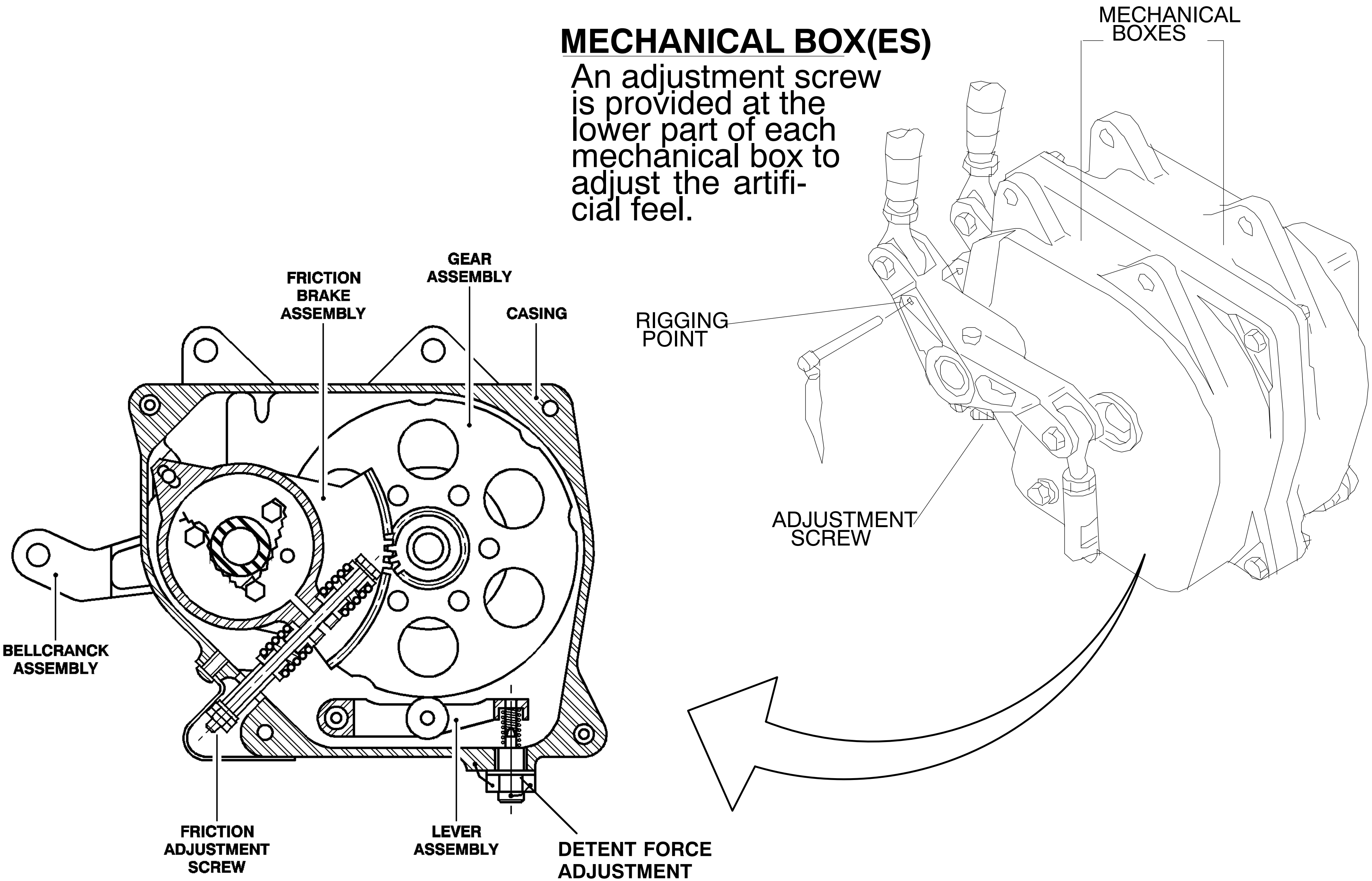


Figure 70 Mechanical Boxes

THROTTLE CONTROL UNIT

The throttle control unit comprises :

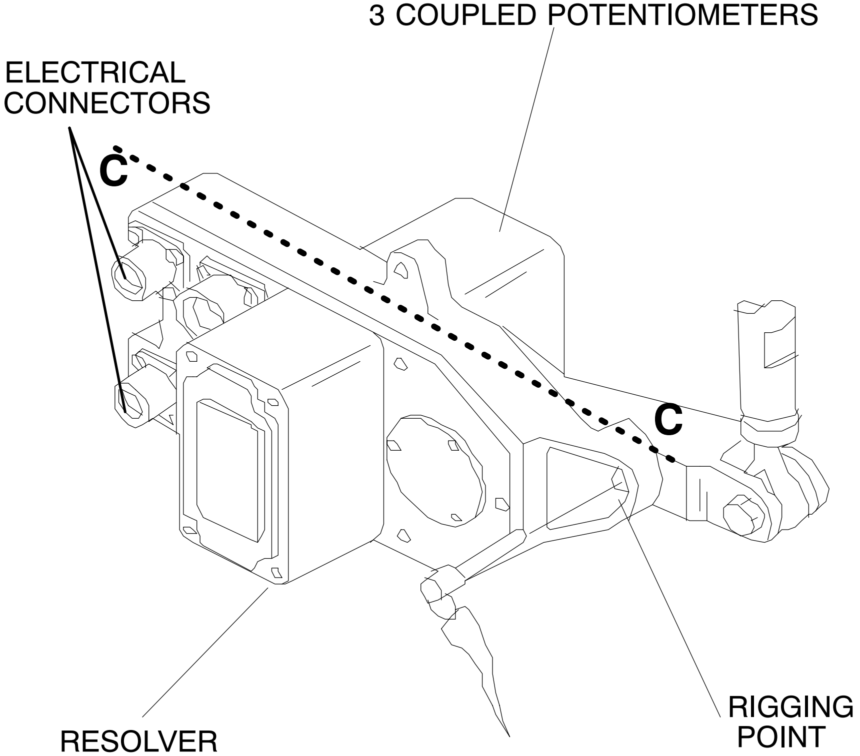
- an input lever
- mechanical stops which limit the angular range
- 2 resolvers whose signals are dedicated to the ECU (one resolver per channel of the ECU)
- 6 potentiometers fitted three by three. Their signals are used by the flight control system and the thrust reverser control system
- a device which drives the resolver and the potentiometer
- a pin device for rigging the resolvers and potentiometers
- a safety device which leads the resolvers outside the normal operating range in case of failure of the driving device
- two output electrical connectors.

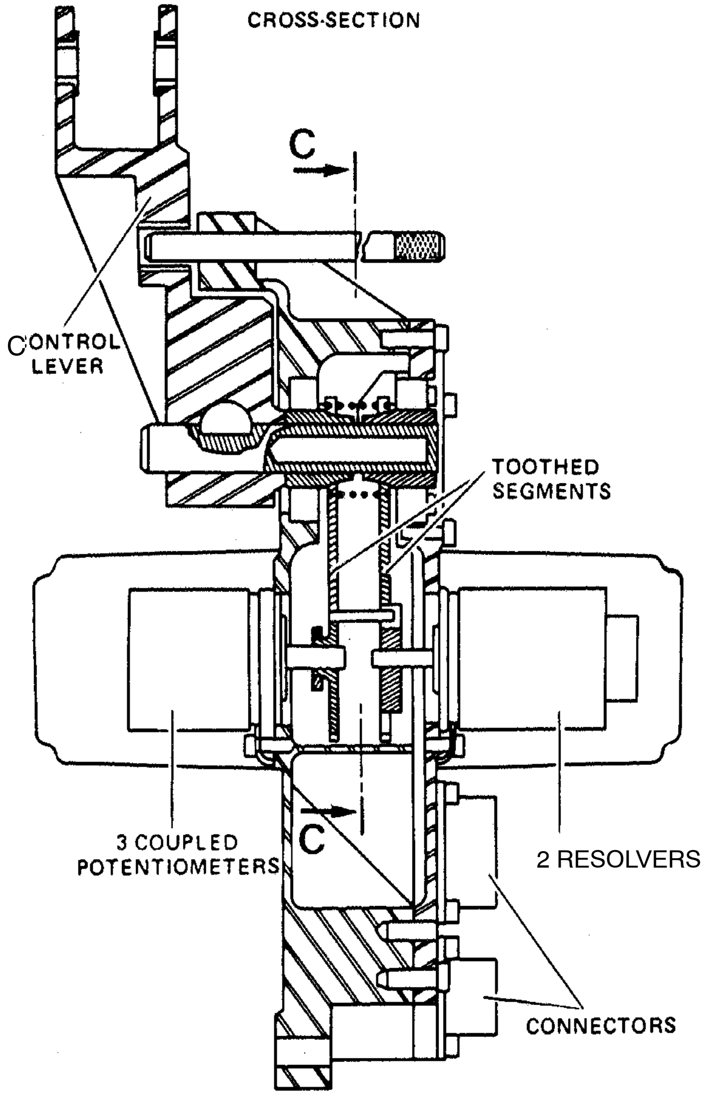
The input lever drives two gear sectors assembled face to face. Each sector drives itself a set of one resolver and three potentiometers.

Relation between TRA and TLA:
The relationship between the throttle lever angle (TLA) and throttle resolver angle (TRA) is linear and : 1 deg. TLA = 1.9 TRA.
The accuracy of the throttle control unit (error between the input lever position and the resolver angle) is 0.5 deg. TRA.

The maximum discrepancy between the signals generated by the two resolvers is 0.25 deg. TRA.
The TLA resolver operates in two quadrants :
the first quadrant serves for positive angles and the fourth quadrant for negative angles.
Each resolver is dedicated to one channel of the ECU and receives its electrical excitation from the ECU.
The ECU considers a throttle resolver angle value :
- less than -47.5 deg. TRA or
- greater than 98.8 deg. TRA as resolver position signal failure.

The ECU incorporates a resolver fault accomodation logic. This logic allows engine operation after a failure or a complete loss of the throttle resolver position signal.





THRUST CONTROL UNIT(S)

- 2 units

Each unit consists of :

- 2 resolvers
- 6 potentiometers.

Figure 71 Thrust Control Units

RIGGING

The throttle control levers must be at the idle stop position to perform the rigging procedure.

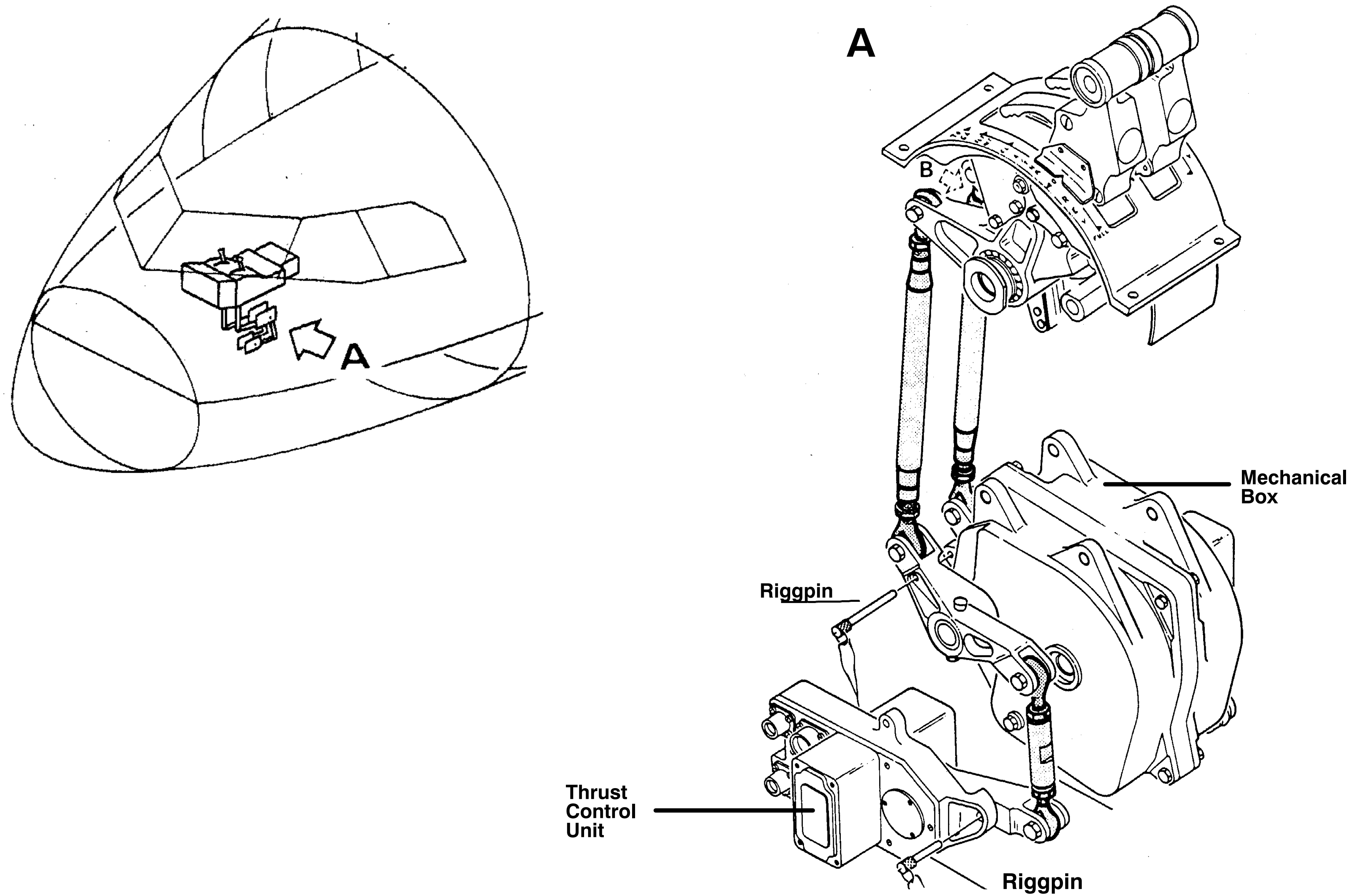


Figure 72 Thrust Control System Rigging

AIDS ALPHA CALL UP OF TLA

Using the AIDS- Alpha call up it is possible to check both TLA (Thrust Lever Angle)

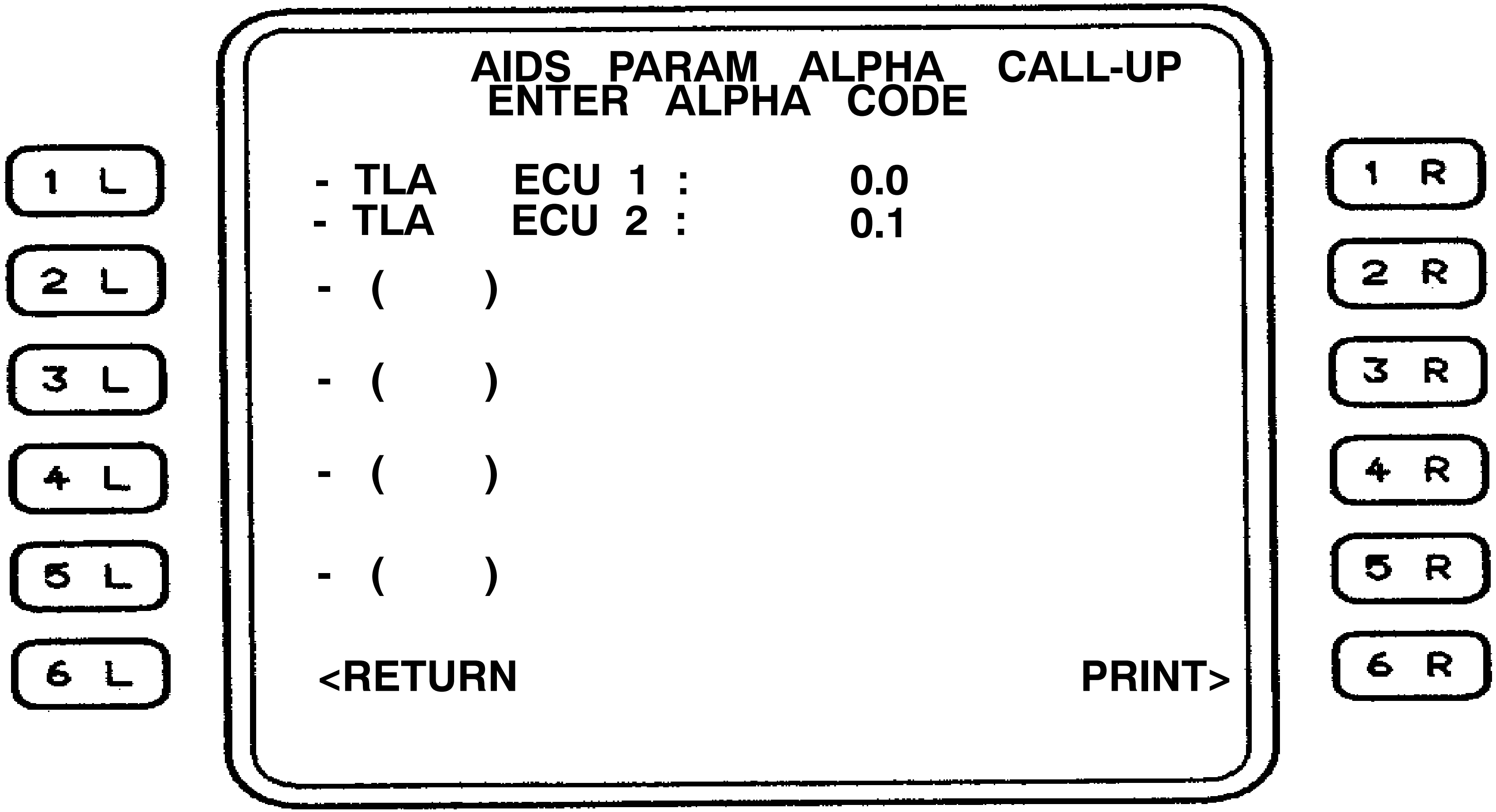


Figure 73 Alpha Call-up TLA

ATA 77 ENGINE INDICATING

77-00 ENGINE INDICATING GENERAL

ECAM UPPER DISPLAY

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

The trust limit is shown in % on the left side for:

- **TO/GO** = Take Off / Go Around Power
- **CL** = Climb Power
- **MCT** = Max Continius Power
- **Flex** = Flex Take Off (The Temperature is shown behind the limit) Flex can be initiated via the MCDU REF. page. A temperature above 30 deg. C will reduce the Power.
- **M/REV** = Max Reverse Power

ECAM LOWER DISPLAY

The secondary parameters are displayed on the ECAM lower display (ENGINE Page) when automatically or manually selected.

Engine Warnings

- LOW N1
- OVERLIMIT EGT.N1 .N2.
- THRUST LEVER DISAGREE
- THRUST LEVER FAULT
- OIL LOW PRESSURE
- OIL HIGH TEMPERATURE
- OIL FILTER CLOG
- FUEL FILTER CLOG.

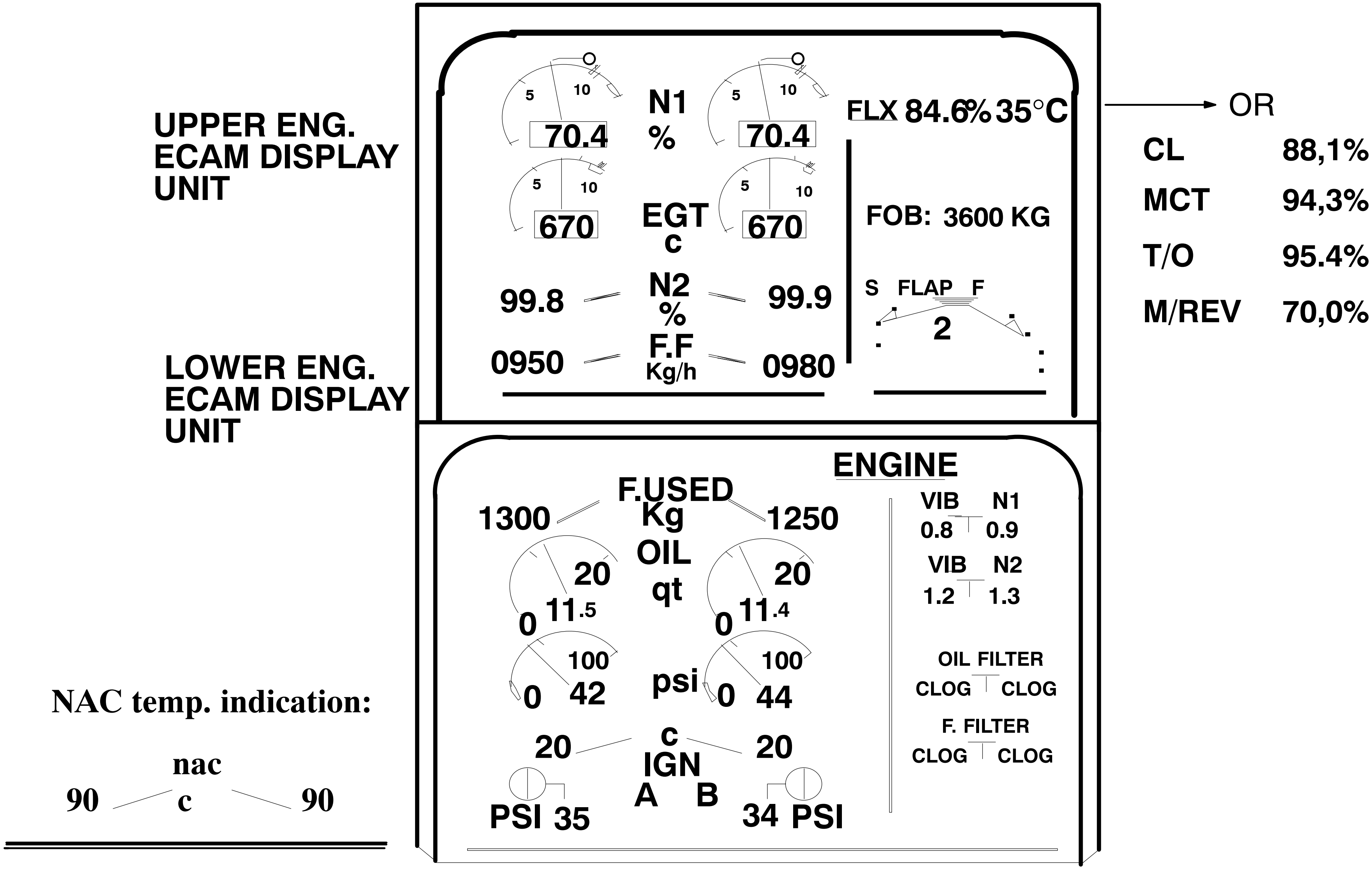


Figure 74 Engine ECAM Displays

77-10 POWER INDICATION

N1 INDICATION SYSTEM

N1 Speed Sensor

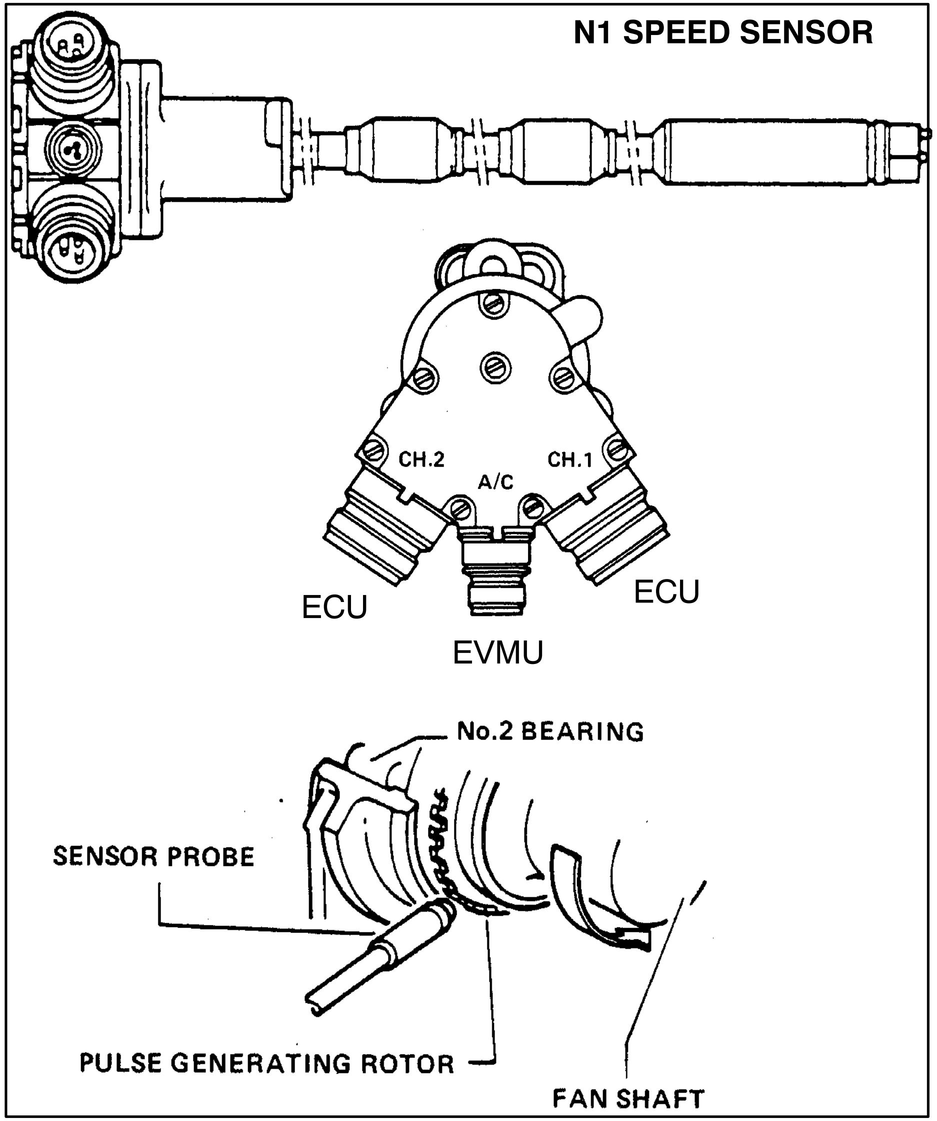
The N1 speed sensor :
- detects the low pressure assembly rotational speed
- transmits the corresponding signals to the Engine Vibration Monitoring Unit and the Electronic Control Unit, Channel A & Channel B.

General

The N1 speed sensor is installed on the fan frame strut at the 5:00 o'clock position. It is secured to the fan frame with 2 bolts.
This sensor is an induction type tachometer. It consists of 3 independent sensing elements which are magnetically and electrically insulated from one another. A sensor ring mounted on the fan shaft is provided with 30 teeth.
The passage of each tooth in front of the magnetic head modifies the lines of magnetic force of the magnets. This creates a flux variation in the coils.
The flux variation generates an alternating electromotive force proportional to the rotational speed of the LP rotor assembly.
NOTE : The sensor ring has one tooth thicker than the 29 others.This tooth generates a signal of greater amplitude used as phase reference for trim balance (processed in the EVMU).
When the N1 speed sensor is installed on the engine you can only see these components :
- the three-connector receptacle
- the connector head
- the sensor securing flange.

The N1 speed sensor consists of the following :
- a three-connector receptacle (ch. A - airframe - ch. B).
- a flange for attachment of the sensor to the engine
- a rigid metal tube including two bonded damping rings, a magnetic head (sensor probe) which includes 3 windings, 3 permanent magnets and the pole pieces and three pairs of shielded lead wire providing the electrical signals from the sensing elements to the connectors.

The N1 indication is displayed on the upper display unit of the ECAM system :
- in the analog form, by a pointer deflecting in front of a dial,
- in the digital form, in the lower section of the dial.



(A) **ACTUAL N1:** N1 NEEDLE AND N1 DIGITAL INDICATION ARE NORMALLY GREEN. THE NEEDLE PULSES AMBER WHEN THE ACTUAL N1 IS ABOVE THE N1 MAX. BOTH NEEDLE AND DIGITAL INDICATION PULSE RED WHEN THE ACTUAL N1 IS ABOVE THE N1 RED LINE(102%). WHEN N1 IS DEGRADED (BOTH N1 SENSORS FAILED),THE LAST DIGIT OF THE DIGITAL DISPLAY IS AMBER DASHED.

(B) **N1 COMMAND:** N1 CORRESPONDING TO THE ATS DEMAND, LIMITED BY THE THRUST LEVER POSITION. NOT DISPLAYED IF A/THR OFF.

(C) **TRANSIENT N1(BLUE ARC):** SYMBOLIZES THE DIFFERENCE BETWEEN THE N1 COMMAND AND THE ACTUAL N1. NOT DISPLAYED IF A/THR OFF.

(D) **N1 TLA:** N1 CORRESPONDING TO THE THRUST LEVER POSITION (PREDICTED N1).

(E) **MAX N1:** AMBER INDEX AT THE VALUE CORRESPONDING TO THE FULL FORWARD POSITION OF THE THRUST LEVER.

(F) **N1 EXCEEDANCE:** IF 100.3% IS EXCEEDED, A RED MARK APPEARS AT THE MAX VALUE ACHIEVED. IT WILL DISAPPEAR AFTER A NEW START ON GROUND OR AFTER MAINTENANCE ACTION THROUGH THE MCDU.

(G) **REVERSE:** APPEARS AMBER WHEN ONE REVERSER IS UNLOCKED. IT CHANGES TO GREEN WHEN THE DOORS ARE FULLY DEPLOYED. IF UNLOCKED IN FLIGHT,THE INDICATION FLASHES FOR 9 SECONDS AND THEN REMAINS STEADY.

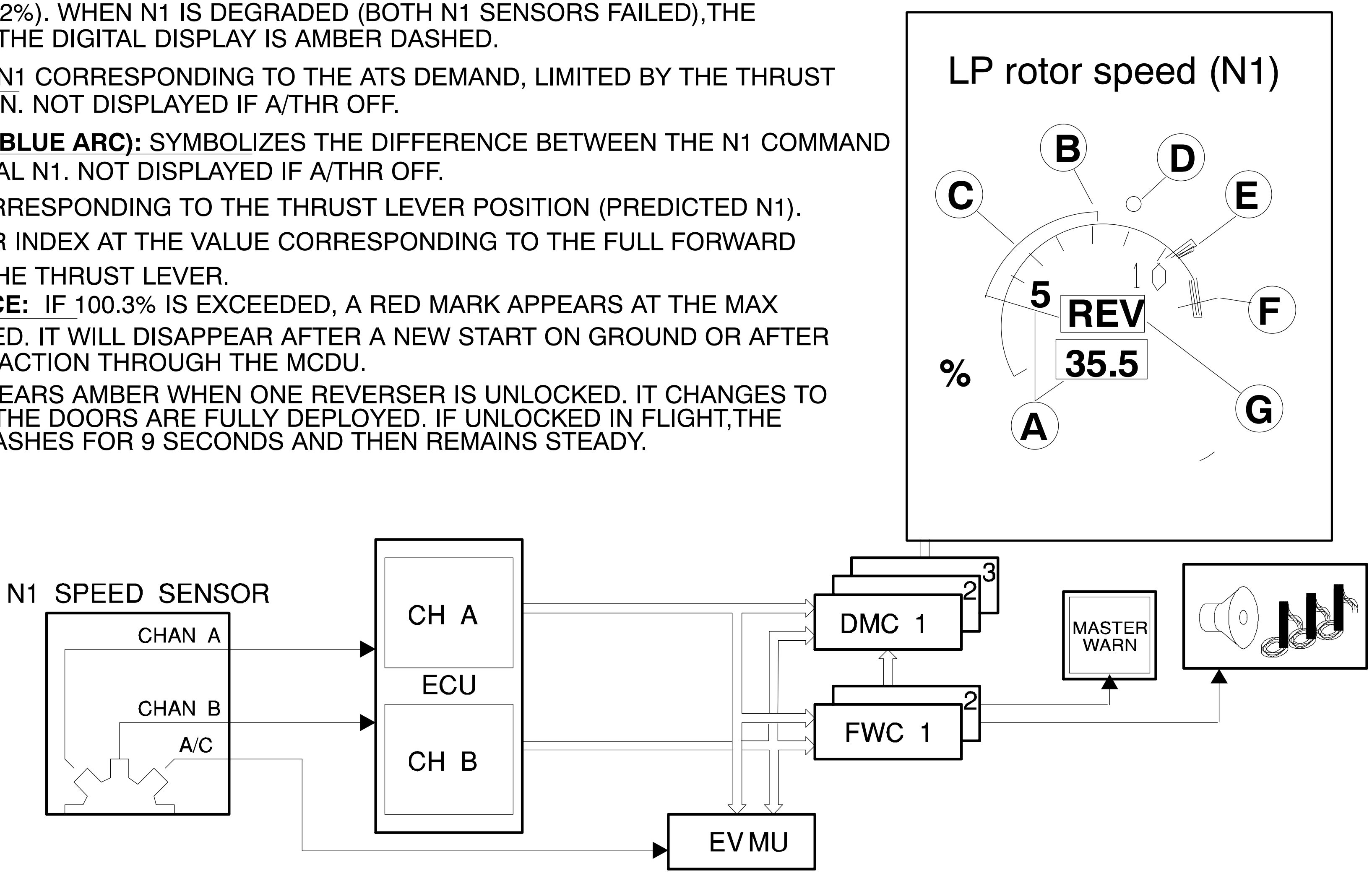


Figure 75 N1 Indication

N2 INDICATION SYSTEM

N2 Speed Sensor

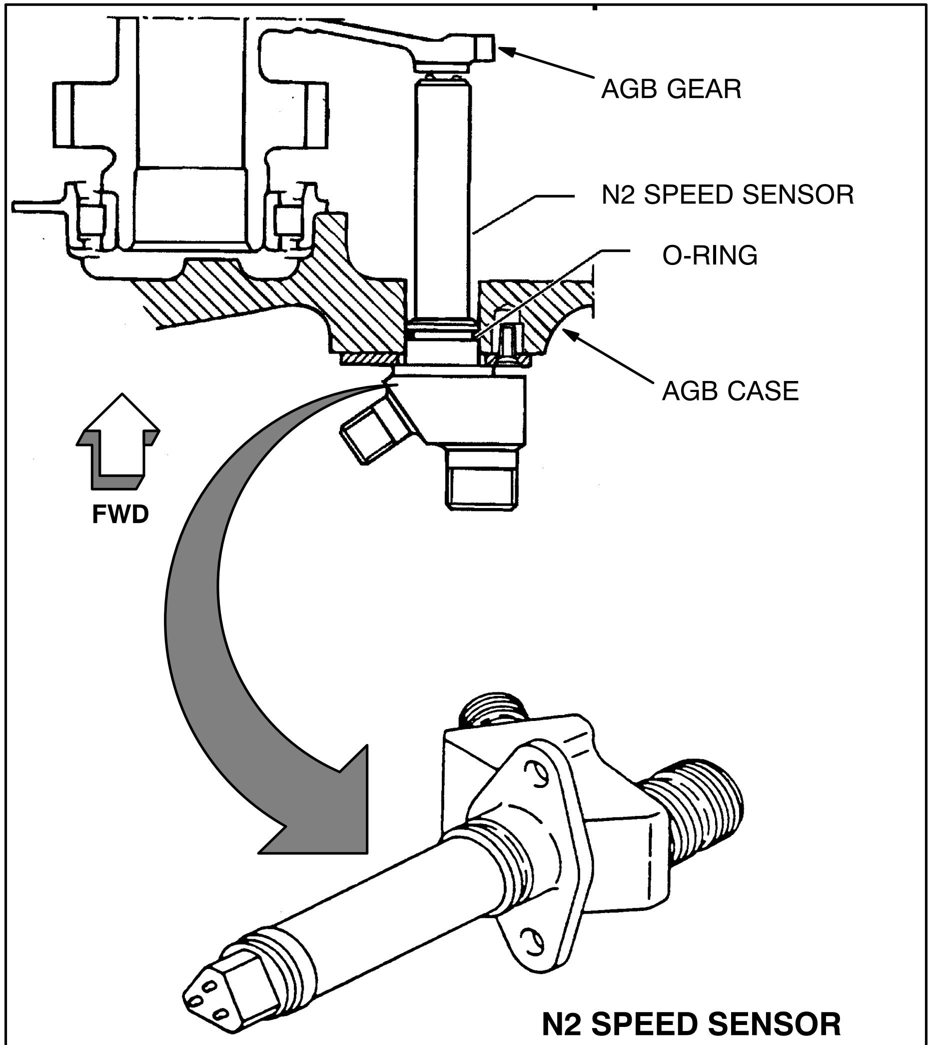
The N2 speed sensor detects the rotational speed of the HP rotor assembly. It transmits the signal to the following equipment :
- Engine Vibration Monitoring Unit (EVMU)
- ECU (channel A)
- ECU (channel B)

This sensor is an induction tachometer type. It comprises 3 sensitive elements.
Each element is magnetically and electrically isolated from the other.
Each sensitive element includes a magnet, a coil and a polar mass.
These sensitive elements are hermetically sealed in a stainless steel housing.
A magnetic wheel, part of the AGB drive system, is provided with 71 teeth on its web. The passage of each tooth in front of the magnetic head modifies the lines of magnetic force of the magnets. This creates a flux variation in the coils.
The flux variation generates an alternating electromotive force proportional to the rotational speed of the HP rotor assembly.

The N2 speed sensor is installed at 6:30 o'clock on the accessory gearbox (AGB) rear face with 2 bolts.
When the sensor is installed, only the 3 fixed connectors and sensor body are visible.

The N2 speed sensor consists of the following :
A body including :
- three fixed connectors
- a flange for attachment to the AGB.
- a groove which accommodates a seal for tightness between sensor and AGB.

The N2 indication is displayed on the upper display unit of the ECAM system.
The N2 indication is provided in the digital form.



N2 SPEED SENSOR

THE HP ROTOR SPEED DIGITAL INDICATION IS NORMALLY GREEN. DURING THE START SEQUENCE THE INDICATION IS GREEN ON A GREY BACKGROUND.

WHEN N2 EXCEEDS 105.8 % A RED CROSS APPEARS NEXT TO THE DIGITAL INDICATION. IT WILL DISAPPEAR AFTER A NEW TAKE OFF OR AFTER MAINTENANCE ACTION.

WHEN THE N2 VALUE IS DEGRADED (IN CASE OF BOTH N2 SENSORS FAILURE) THE LAST DIGIT IS AMBER DASHED.

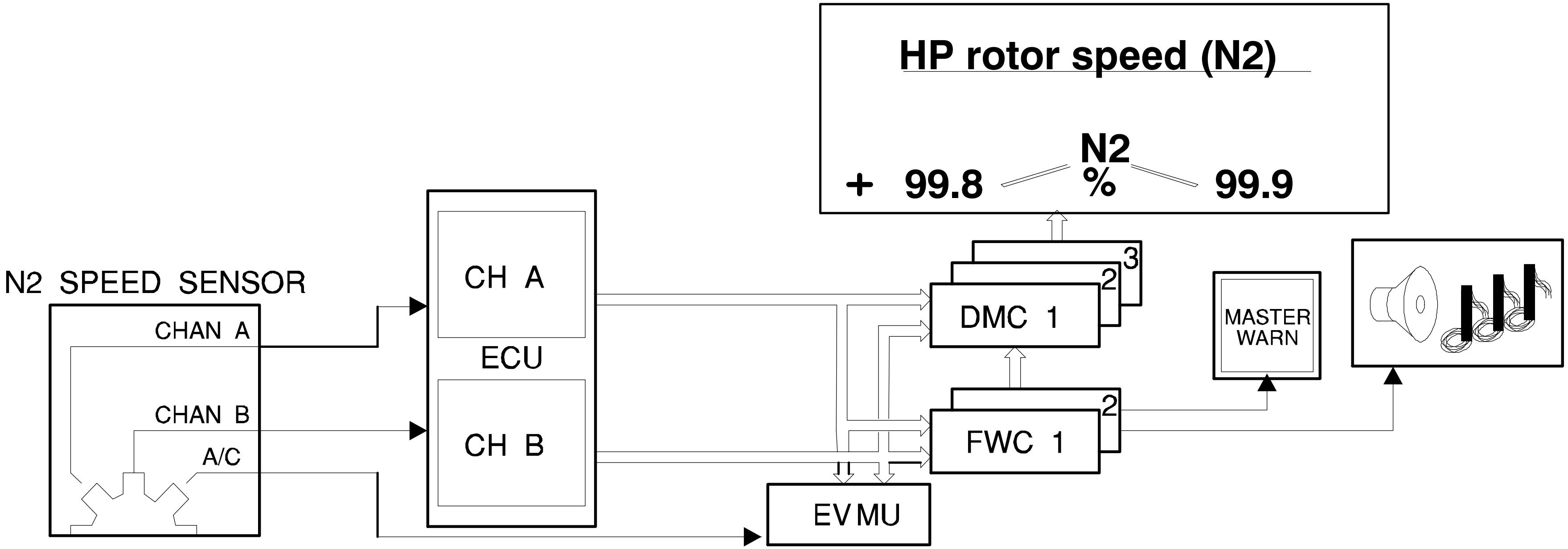


Figure 76 N2 Indication

77-20 TEMPERATURE

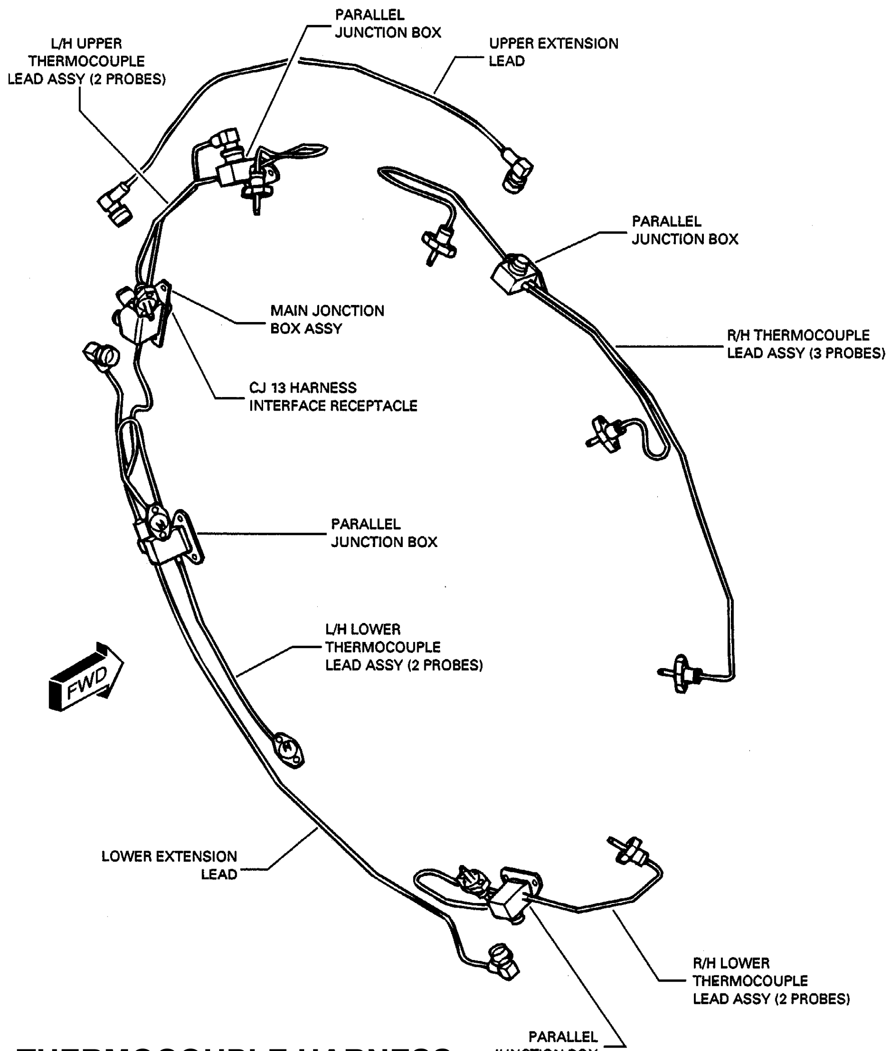
EGT INDICATION

The engine Exhaust Gas Temperature (EGT) is sensed and averaged by 9 thermocouple probes (chromel/alumel) located in the T495 plane of Low Pressure Turbine (LPT) stage 2 nozzle assembly.

The T49,5 thermocouple wiring harness consists of:
- Three identical and interchangeable thermocouple lead assemblies with two probes.
- One thermocouple lead assembly with three probes.
- One upper extension lead.
- One lower extension lead.
- One main junction box assembly.

The electromotive force is averaged first in each of the individual lead assembly (2 probes and 3 probes), then in the main junction box assembly at the level of the interface connector.The resultant averaged electromotive force is then sent to the ECU through the HCJ13 harness and the HJ13 harness.

The EGT indication appears on the upper display unit of the ECAM system.
The ECAM provides the EGT indication :
- in analog form thru a pointer which deflects in front of a dial,
- in digital form, in the lower section of the dial.



THERMOCOUPLE HARNESS

ACTUAL EGT: NORMALLY GREEN.

POINTER PULSES AMBER AND NUMERIC VALUE IS GREEN WHEN EGT IS HIGHER THAN 855.C, OR 725.C DURING THE ENGINE START SEQUENCE.
BOTH PULSE RED WHEN EGT EXCEEDS 890.C.

MAX EGT (AMBER INDEX): 725.C AT ENGINE START THEN 855°C (MCT).

EGT EXCEEDANCE(RED INDEX): IF 890C IS EXCEEDED, A RED MARK APPEARS AT THE MAX VALUE ACHIEVED. IT WILL DISAPPEAR AFTER A NEW TAKE OFF OR AFTER MAINTENANCE ACTION THROUGH THE MCDU.

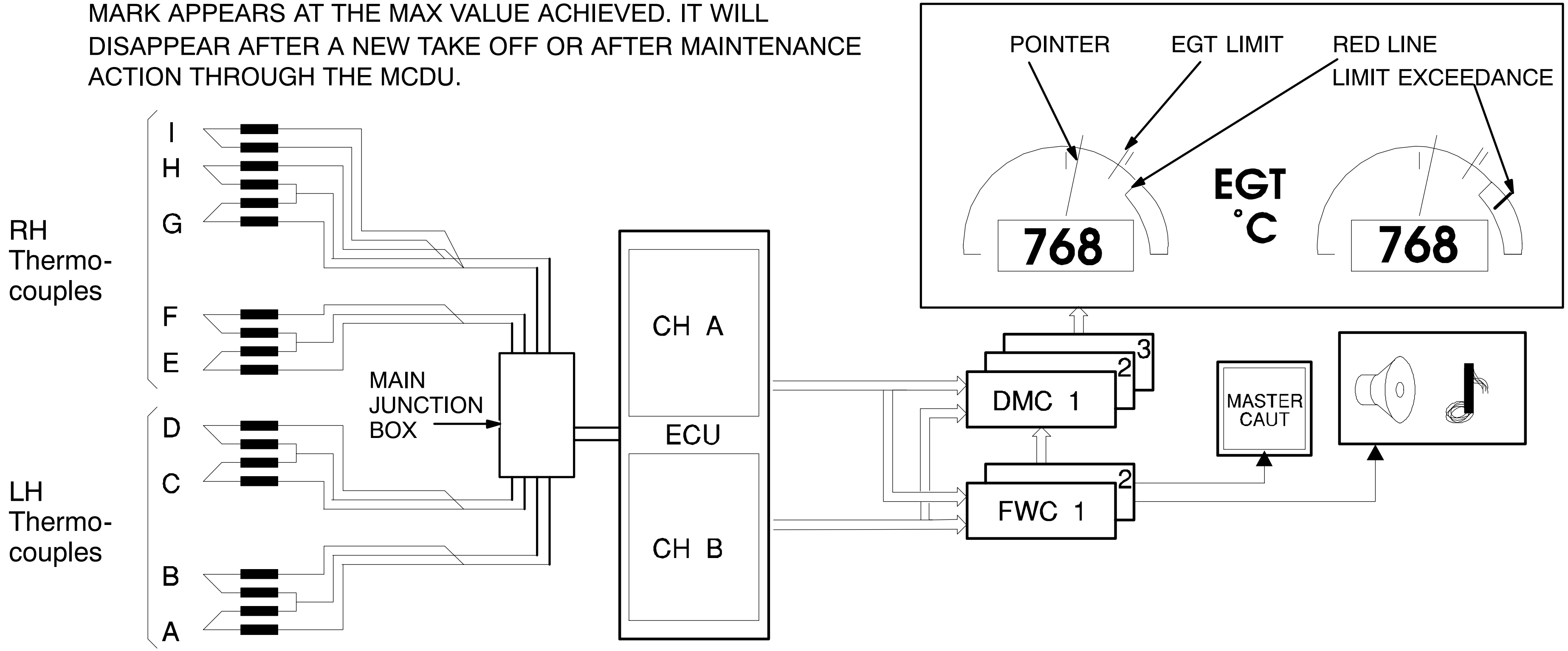


Figure 77 EGT Indication

E / WD : FAILURE TITLE conditions	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNINGS	FLT PHASE INHIB
ENG DUAL FAILURE	CRC	MASTER WARN	ENG	Associated with GEN FAULT lts and PACK FAULT lt	NIL
ENG 1 (2) OIL LO PR oil low pressure triggered at 13 psi by the oil press switch.				NIL	1, 10
ENG STALL	SINGLE CHIME	MASTER CAUT			3, 4, 5, 7, 8
ENG 1 (2) HP FUEL VALVE HP fuel valve failed closed				Associated FAULT lt on ENG panel on pedestal (exception case of starter time exceeded)	
ENG 1 (2) START FAULT start fault due to : • no light up or • eng stall or overtemp or • starter time exceeded					
ENG 1 (2) START VALVE FAULT position disagree					
ENG 1 (2) THR LEVER DISAGREE disagree between both resolvers of a thrust lever				NIL	4, 5
ENG 1 (2) OIL HI TEMP oil temp between 140 and 155°C more than 15 mn or oil temp above 155°C					4, 5, 7, 8
ENG 1 (2) FADEC FAULT both channels failed					
ENG 1 (2) LOW N1 No N1 rotation during start					1, 4, 5, 6, 7, 8, 9, 10
ENG FLEX TEMP NOT SET flex temp has not been entered on FMS MCDU			NIL		
ENG 1(2) FADEC HI TEMP					3, 4, 5, 7, 8
ENG 1 (2) THR LEVER FAULT both resolvers on one thrust lever failed					5
ENG 1 (2) FAIL eng core speed below idle with master sw ON and fire pb not pushed.					1, 10
ENG 1 (2) SHUT DOWN eng master at off in phases 3 to 8 or eng fire pb pushed in phases 1, 2, 9 and 10.					

Figure 78 ECAM warning Messages

E/WD : FAILURE TITLE conditions	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNING	FLT PHASE INHIB
ENG 1 (2) REVERSE UNLOCKED one or more reverser door not locked in stowed position in flight or on ground with no deploy order	SINGLE CHIME	MASTER CAUT	NIL	NIL	1, 2, 4, 5 8, 9, 10
ENG 1 (2) REV PRESSURIZED reverser system is pressurized while rev doors are stowed and locked with no deploy order	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 5, 8
ENG 1 (2) COMPRESSOR VANE variable bleed valve sys or variable stator vane sys fault	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 5, 7, 8
ENG 1 (2) N1 or N2 or EGT OVER LIMIT N1 above 102.1 % N2 above 105.1 % EGT above 891°C	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 8
ENG 1 (2) IGN A + B FAULT both ignition circuits are failed	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 5, 7, 8
ENG 1 (2) CTL VALVE FAULT burn stag valve failure or HPTC or RAC system failure	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 5, 7, 8
ENG 1 (2) FUEL CTL FAULT Fuel metering valve position disagree	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 5, 7, 8
ENG 12 (2) SENSOR FAULT PS 3 or T 25 or T3 or N1 or N2 data not available on both channels	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 5, 7, 8
ENG 1(2) PROBES FAULT T 12 or PO PT 2 data not available on both channels	SINGLE CHIME	MASTER CAUT	NIL	NIL	4, 5, 7, 8
ENG 1(2) N1 (N2, EGT, FF) DISCREPANCY Discrepancy between real and displayed values	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 5, 8
ENG 1(2) BLEED STATUS FAULT Bleed, X Bleed pack anti ice valves position status not received by FADEC active channel	SINGLE CHIME	MASTER CAUT	NIL	NIL	3, 4, 5, 7, 8
ENG 1(2) FUEL FILTER CLOG	NIL	NIL	ENG	NIL	4, 5, 7, 8
ENG 1(2) OIL FITER CLOG	NIL	NIL	ENG	NIL	4, 5, 7, 8
ENG VIB SYS FAULT failure of vibration detection system	NIL	NIL	NIL	NIL	3, 4, 5, 6, 7, 8, 9
ENG 1 (2) OVSPD PROT FAULT loss of overspeed protection	NIL	NIL	NIL	NIL	4, 5, 7, 8
ENG 1 (2) IGN A(B) FAULT ignition circuit A or B failed	NIL	NIL	NIL	NIL	3, 4, 5, 7, 8
ENG 1 (2) FADEC ALTERNATOR loss of electrical auto supply of either FADEC channel	NIL	NIL	NIL	NIL	3, 4, 5, 7, 8
ENG COMPRESSOR VANE Eng 1 and 2 VBV or VSV Fault	NIL	NIL	NIL	NIL	3, 4, 5, 7, 8

Figure 79 ECAM Warning Messages

E/WD : FAILURE TITLE conditions	AURAL WARNING	MASTER LIGHT	SD PAGE CALLED	LOCAL WARNING	FLT PHASE INHIB
ENG 1 (2) FADEC A(B) FAULT one FADEC channel failed	NIL	NIL	NIL	NIL	4, 5, 7, 8
ENG 1 (2) EIU FAULT Data bus between EIU and ECU failed.	NIL	NIL	NIL	NIL	1, 3, 4, 5 7, 8, 10
ENG 1 (2) REVERSER FAULT loss of thrust reverser on one engine	NIL	NIL	NIL	NIL	3, 4, 5
ENG 1 (2) REV SWITCH FAULT	NIL	NIL	NIL	NIL	3, 4, 5, 6, 7, 8
ENG 1 (2) ONE TLA FAULT	NIL	NIL	NIL	NIL	3, 4, 5, 6, 7, 8

MEMO DISPLAY

IGNITION is displayed in green when the continuous ignition is activated on either engine.

ATA31 INDICATING

MAX POINTER RESET (N1, N2 & EGT)

Monitoring of the relevant display of the engine parameters

N1 , N2, EGT, and FF indications of both engines are monitored internally and externally .The DMC compares the N1 signal received from the EEC 1 with the feedback signal which reflects the displayed position of the N1 needle -

In order to grant dissimilarity with the engine 2 monitoring process the DMC compares the N1 signal from the EEC 2 with the feedback signal representing the N1 digital value.

The same applies to the EGT parameters indications, but with the displayed position of the engine 2 EGT needle and the engine 1 EGT digital feedback value.

As for the N2 and FF parameters, the DMC compares the direct signal from the EEC with the displayed digital value.

In case of detected discrepancy, a CHECK amber message is displayed just below the relevant parameter indication .

In addition the FWC,s perform an external monitoring between the feedback signals (that correspond to the displayed values and the signets that are directly received by the FWC's from the EEC's

Should a descrepancy occur, for one or more parameters, a CHECK amber message is displayed under the relevant indication

The FWC's generate a caution

- single chime
- master caution Light
- message on the upper ECAM DU : ENG 1 (2) N1(N2/EGT/FF) DISCREPANCY

Max pointer Reset (N1, N2 & EGT)

The Max pointers for N1, N2 and EGT can be reset using the CFDS menu INSTRUMENTS. The menu for the EIS 1,2,3,(DMC 1,2,3) must be selectet. The memory cells which store the possible exceedance are reset either by pressing the GENERAL RESET line key or automatically at the next take off.

Read-out/Reset of the Engine Red Line Exceedances

The DMC connected to the upper ECAM DU monitors primary parameter indications of both engines.

Should an exceedance occur, the DMC memorizes in its BITE memory the maximum value reached during the Last Flight Leg

The values of the N1, N2, EGT red lines and transitory overlimit values are stored in 2 independent tables, one per engine.

Read out of this engine parameter exceedance can be performed via the DMC MCDU menu.With the function engines the parameters can be selected either for engine 1 or 2.

Note:

A reset of the red line limits have to be performed on all 3 DMCS.

N1 RED LINE Exceedance

The N1 red line is represented by an arc shaped red ribbon situated at the end of the scale.

If the N1 actual value exceeds the N1 red line (even for a short period of time), a small red line appears across the N1 scale and then stays at the maximum value which has been reached.

This indicates a N1 exceedance condition.Should this condition occur, the small red line disappears only after a new take-off or after a maintenance action through the MCDU DMC reset.

N2 RED LINE Exceedance

The N2 indications are displayed in digital form only. 100% N2 correspond to 14460 RPM.Should N2 actual exceeds the N2 red line value,a red cross appears next to the digital indication. This red cross disappears only after a new take off or a DMC reset.

EGT RED LINE Exceedance

The EGT indications are provided in the same form as for the N1 indications.The same applies to changes in color and EGT exceeding indications.However it has to be noticed that the amber linie (EGT MAX) is variable.725 deg. C at engine start and 855 deg. C afterwards.Red line Limit is 890 deg.C.

REFER TO ADDITIONAL PAGES !

Figure 80 Max Pointer Reset

77-30 ANALYZERS

VIBRATION

General
The engine vibration measurement system comprises :
- two transducers (piezoelectric accelerometers)
- an Engine Vibration Monitoring Unit
- two vibration indications N1 and N2.
The engine vibration system provides the following functions :
- vibration indication due to rotor unbalance via N1 and N2 slaved tracking fil ters
- excess vibration (above advisory levels)
- fan balancing (phase and displacement)
- shaft speed (N1 and N2)
- storage of balancing data
- initial values acquisition on request
- BITE and MCDU communication
- accelerometer selection
- frequency analysis when the printer is available (option).

Accelerometers

Two accelerometers installed on each engine permit N1 and N2 vibrations to be measured.

The first is fitted on the number 1 bearing, the second on the turbine rear frame.

- Number 1 bearing accelerometer, normal pick-up, provides N1 and N2 vibration frequencies.
- The turbine rear frame (TRF) accelerometer is in standby and also used with the first to analyse results for engine balancing.

<u>No. 1 Bearing Vibration Sensor</u>

The No. 1 bearing vibration sensor (piezo-electric type) permanently monitors the vibrations from No. 1 bearing. It also senses vibrations from LPT and HPT shafts,though it is less sensitive to LPT and HPT shaft vibrations. It is also used for trim balance operations.

The accelometer part of the vibration sensor is located at the 9:00 o'clock position on No. 1 and No. 2 bearing support (near No. 1 bearing).

The sensor cable is routed through the fan frame. It comes out at the 3:00 o'clock position on fan frame mid-box structure aft face.

NOTE:
The No 1 bearing accelerometer is not a LRU.It can not be changed on line maintenance.It can only be changed when the fan module is removed in the shop.

<u>Turbine Rear Frame Vibration Sensor</u>

The Turbine Rear Frame (TRF) vibration sensor (piezo-electric type) used in conjunction with the No. 1 bearing vibration sensor to monitor and, if necessary, reduce the engine vibration level using the trim balance procedure.
The vibration signal is used by the aircraft Engine Vibration Monitoring Unit (EVMU).

The TRF vibration sensor is installed at 12 o'clock (ALF) on the front flange of the turbine rear frame.It consiste in a hermetically sealed housing that encloses the sensing element. A flange with two holes is used to attach the housing to the engine. One electrical connector at the end of semi-rigid cable provides the interface with an aircraft harness.

<u>Engine Vibration Monitoring Unit (EVMU)</u>

The Engine Vibration Monitoring Unit (EVMU) is located in the avionics compartment shelf 86VU.
The EVMU has 2 channel modules.Each channel module processes the signals from the two engine accelerometers and from the two speed signals N1 and N2 : this enables extraction from the overall vibration signal, of a component due to rotor first order unbalance.Only one accelerometer is used at any particular time. The second accelerometer is selected manually via MCDU ACC. Reconfiguration MENU or automatically at the next power up due to a failure of the N1 BEARING ACCEL.The N1 and N2 signals are used :
- to drive the tracking filters, and
- slave their center frequencies at the shaft rotational speed.

The accelerometer signals pass through these tracking filters which extract the N1 and N2 related fundamental vibration. The acceleration signal is then integrated in order to express the vibration in velocity terms.

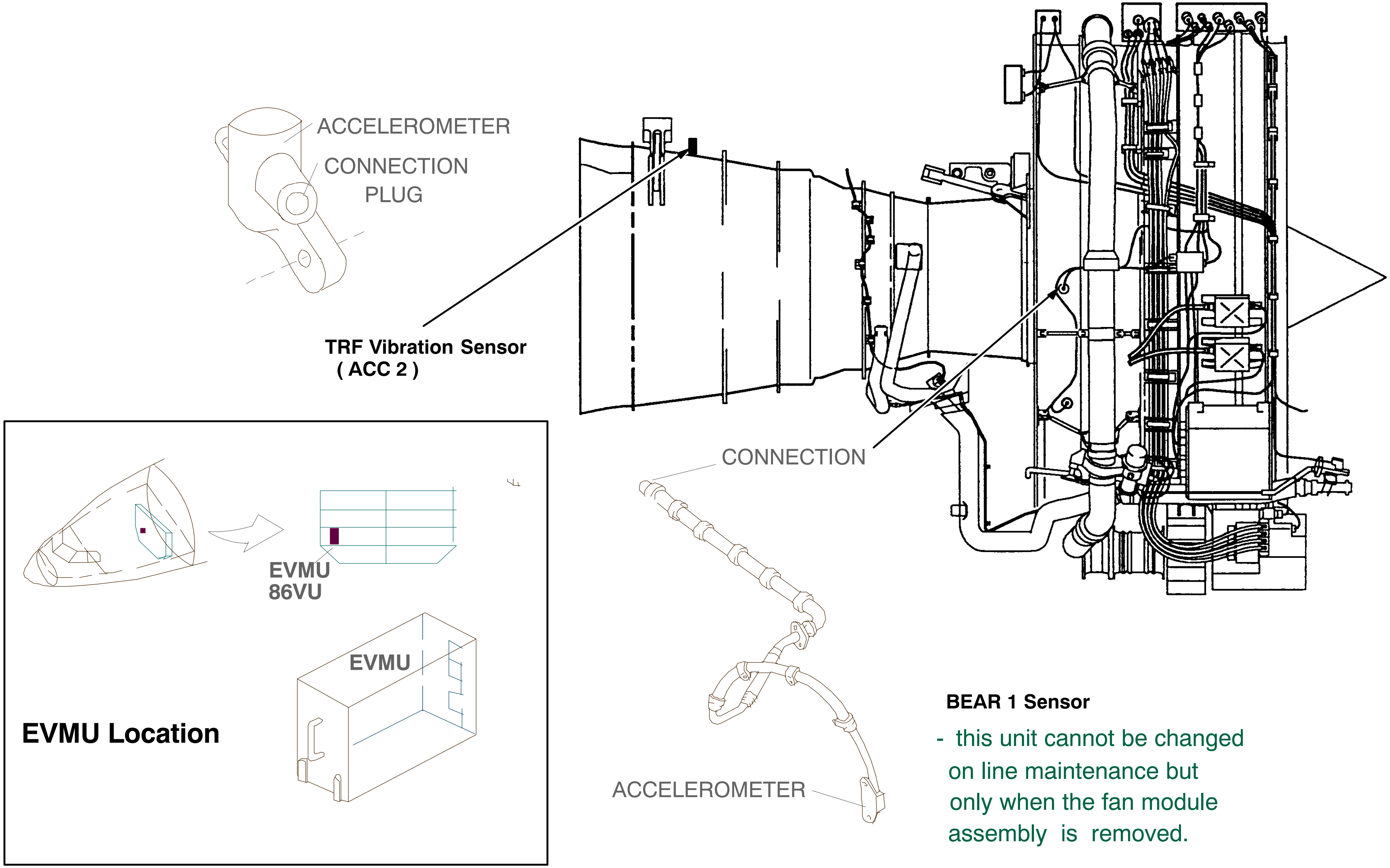


Figure 81 Vibration Sensors

ENGINE VIBRATION MONITORING UNIT (EVMU)

An engine vibration monitoring unit monitors the N1 and N2 levels of both engines.

The EVMU receives analog signals from :
- the 4 engine accelerometers (2 per engine)
- and the N1 and N2 speed sensors of each engine.

It also receives digital input from CFDS through ARINC 429 data bus.
The EVMU sends signals through the digital ARINC 429 data bus to :
- SDAC1 and 2 for cockpit indication
- the CFDIU
- the DMU
- and printer (if installed) for maintenance purposes.

BITE maintenance and fault information

The EVMU contains a BITE to detect internal and external failure.
During the execution of the cyclic BITE sequence, the following parts of the EVMU are checked :
- the non-volatile memory
- the timers
- the analog-to-digital converter
- the ARINC 429 transmitter and receivers
- the real tacho generators.

During the power-up sequence of the BITE, the following parts of the EVMU system are checked :
- N1 and N2 NB velocity
- unbalance data
- N1 and N2 tacho frequencies
- accelerometer signals.

Any detected failure is stored in the non-volatile memory with GMT,date and other reference parameters.

Interfaces

The EVMU interfaces with the ECAM and the CFDS

CFDS interfaces: Maintenance fault messages.

VIBRATION INDICATION

The N1 and N2 vibrations of the left and right engines are displayed on the engine and cruise pages.

Displayed values are up to 10 units range.

Note:

1 unit = 0,3 inch/sec

1 MIL = 1/1000 inch

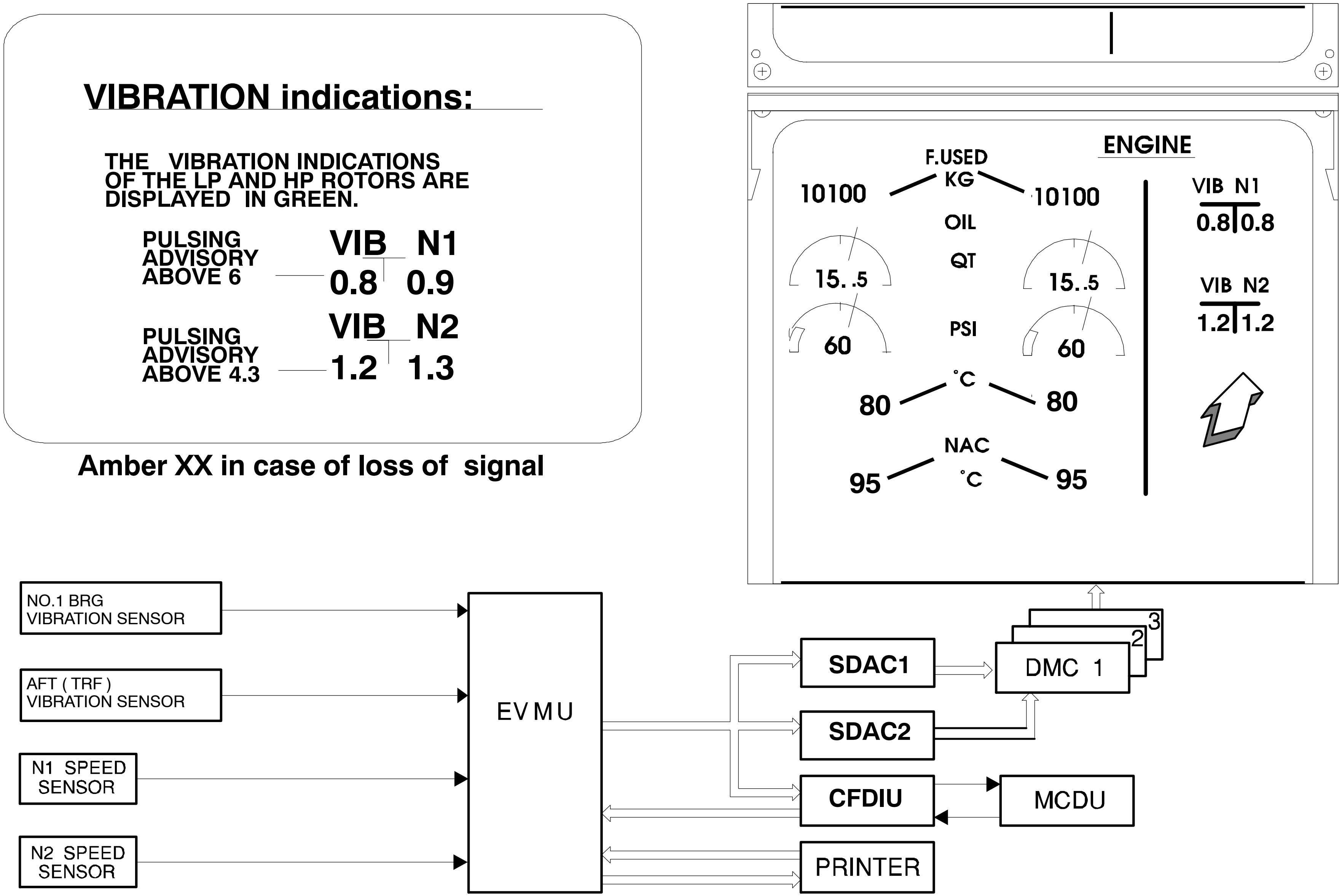


Figure 82 Vibration Indication

CFDS INTERFACE

The Centralized Fault Data System (CFDS) enables access to the systems. The CFDS gives, maintenance information and initiates tests through the system BITE.
When the maintenance personnel needs information on the condition of the EVMU, the CFDS operates in menu mode. The first menu sent to the MCDU is the main menu. The various functions are detailed here after.

Last leg report

The EVMU sends the list of the LRUs which have been detected faulty during the last leg. During the flight the following faults can be detected :

- **EVMU**
- **N1 SPEED SENSOR, L**
- **N1 SPEED SENSOR, R**
- **N2 SPEED SENSOR, L**
- **N2 SPEED SENSOR, R**

Previous leg report

The EVMU sends the list of the LRUs which have been detected faulty during the legs (maximum 62) previous to the last leg. The faults detected are the same as for the last leg report.

LRU identification

The EVMU sends the EVM unit part number and manufacturer

Ground failures

The EVMU sends the list of the LRUs which have been detected faulty during a ground test. Only the three last detected failures are displayed. The following LRUs are tested :

- **EVMU**
- **N1 BEAR VIB SENSOR, L**
- **N1 BEAR VIB SENSOR, R**
- **TRF VIB SENSOR, L**
- **TRF VIB SENSOR, R**

Test

The test item allows initiation of a complete check of the EVM system.
If no failure has been detected, the message ”TEST OK” is displayed.
If any failure has been detected the failed LRU is displayed.
Checked LRUs are the ones listed in ”Ground failures” item.

refer to Additional Pages !

Figure 83 MCDU EVMU Menue

CFDS INTERFACE

EVMU - Initial Values MENU

Initial value storage
The initial value is the actual value when the engine is new or rebalanced. At each engine serial number corresponds an initial value.
The initial value is stored in the equipment :
- either automatically after request to the MCDU
- or point by point from the FCDU keyboard.

An initial value is defined every 5 % of RPM :
- from 20 % to 125 % for N1 vibration
- from 50 % to 125 % for N2 vibration.

When stored, the initial values are taken into account for advisory calculation (Limit 2).

In that menu, ten sub-menus may be selected by the operator, which allows :
- command of the initial values acquisition during the next flight
- cancelling of the initial values acquisition demand
- reading of the initial values taken
- direct loading modification of the existing values.

Accelerometer reconfiguration

This menu allows selection of the accelerometer (Fan No. 1 bearing or TRF) to be used for the next flights. The EVMU also indicates which accelerometer is in operation.

Engine unbalance

This menu allows selection, per engine, of five different engine speed, (from 50 % to 100 % N1 RPM) at which unbalance data will be stored. It also permits reading of the unbalance data which were acquired during the previous command and to effectuate balancing for both engines with both accelerometers.
The EVMU measures the position and the amplitude of the rotor unbalance of each engine. It provides these information to the output bus when available.

Frequency analysis

This menu offers the possibility to request a frequency analysis of the acceleration signal to be performed on the ground.

The EVMU does the analysis at a selected N1 or N2 speed and uses any valid accelerometer. The maximum frequency analysis is 500 Hz and the frequency increment between adjacent spectral lines is 4 Hz.

refer to Additional Pages !

Figure 84 MCDU EVMU Menue

73-20 CONTROLLING

Vacbi File: FADEC PRESENTATION
Vacbi File: FADEC PRINCIPLE

FADEC

Full Authority Digital Engine Control (FADEC)

The FADEC consists of the Engine Control Unit (ECU), Hydromachanical Unit (HMU) and its peripheral components and sensors used for control and monitoring.

FADEC Definition

Each engine is equipped with a duplicated FADEC system. The FADEC acts as a propulsion system data multiplexer making engine data available for condition monitoring.

FADEC Controls

The FADEC provides the engine sytem regulation and scheduling to control the thrust and optimize the engine opration.

The FADEC provides:

- gas generator control
- flight deck indication data
- engine limit protection
- power management
- thrust reverse control
- feedback
- automatic engine starting
- Fuel return control for IDG cooling

Power Management

The FADEC provides automatic engine thrust control and thrust parameters limits computation.
The FADEC manages power according to two thrust modes:

- manual mode depending on thrust lever angle (TLA)
- Autothrust mode depending on autothrust function generated by the auto flight system (AFS).

The FADEC also provides two idle mode selections:

- Approach Idle: it is obtained when slats are extended in FLT.
- Minimum Idle: it can be modulated up to approach idle depending on:
  - Air conditioning demand
  - Engine anti ice demand
  - Wing anti ice demand
  - Temperature Engine Oil (TEO for IDG cooling).

Engine Limit Protection

The FADEC provides overspeed protection for N1 and N2, in order to prevent engine exceeding certified limits, and also monitors the EGT.

Engine Systems Control

The FADEC provides optimal engine operation by controlling the:

- Fuel Flow
- Compressor air flow and turbine clearence.

Thrust Reverse

The FADEC supervises entirely the thrust reverse operation.
In case of a malfunction, the thrust reverser is stowed.

Start and Ignition Control

The FADEC controls the engine start sequence. It monitors N1, N2 and EGT parameters and can abort or recycle an engine start.

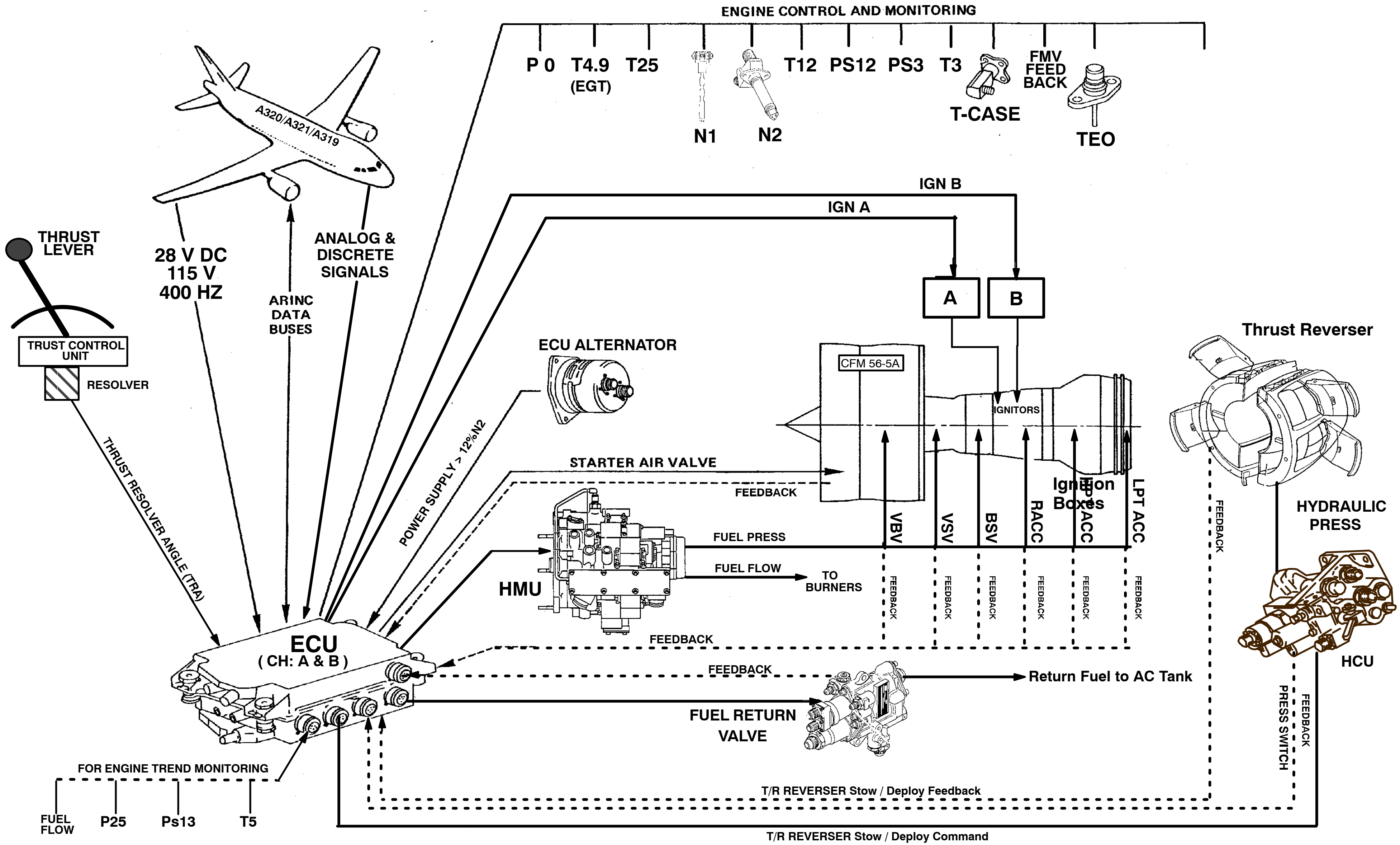


Figure 85 FADEC System Schematic

FADEC LRU'S

Vacbi File: FADEC ARCHITECTURE

Vacbi File: FADEC LRU'S

ECU

The Engine Control Unit (ECU) is the computer of the FADEC system.
The ECU consists of two channels (A and B) with a crosstalk. Each channel can control the different components of the engine systems.
The channels A and B are permanently operational. In case of failure on one channel, the sytem switches automatically to the other. During engine start the ECU is supplied with 28 VDC by the A/C network then by its own generator, mounted on the accessory gearbox, when N2 reaches 15%.

Additional Notes:

ECU Interfaces General

The electronic control unit (ECU) is a dual channel digital electronic control with each channel utilizing a microprocessor for main control functions, an microcontroller for pressure transducer interface functions and a microcontroller for ARINC communication function.
The ECU receives engine inlet condition data from the aircraft Air Data Computers (ADCs) and operational commands from the Engine Interface Unit (EIU) in the aircraft on ARINC 429 data busses. It also receives operating condition data from the various dedicated engine sensors such as T12, PS12,P0, N1, N2, PS3, T25, T3 and TC, and computes the necessary fuel flow, VSV,VBV, HPT clearance control, LPT clearance control, and rotor active clearance control valve positions.
The ECU provides the necessary current to the torque motors in the hydromechanical unit to control the various modulating valves and actuators.
The ECU performs an On/Off control of the Ignition Relays, Starter Air Valve Solenoid, the Aircraft Thrust Reverser Directional Valve and the Thrust Reverser Pressurizing Valve.
The ECU provides digital data output in ARINC 429 format to the aircraft for engine parameter display, aircraft flight management system and the aircraft maintenance data system.
ECU hardware and software is designed so that the two channels operate normally with a set of internal inputs and outputs with access to cross channel data inputs. Each channel can also operate independently without cross channel data.
Fault tolerance enables the engine to continue operation in the event any or all of the airframe digital data is lost.
The ECU is powered by a three-phase engine alternator.
Aircraft power is required up to 15% N2 above which the alternator is able to self-power the unit. Two independent coils from the alternator provide the power to the two separate ECU channels.
The ECU is a vibration isolated single unit mounted on the fan case and is forced air cooled.

Engine Condition Parameters Transmission

Engine condition monitoring will be possible, by the ability of the FADEC to broadcoast the engine parameters through the ARINC 429 bus output.
The basic engine parameters available are :

- P0, PS12, PS3, T12, T25, T3, TC, TOIL, T49, N1, N2, WF
- VSV, VBV, HPTCC, RACCS, and LPTCC valve or actuator positions
- status and maintenance words, engine serial number and position.

In order to perform a better analysis of engine condition some additional parameters are optionally available. These are P13, P25 and T5.

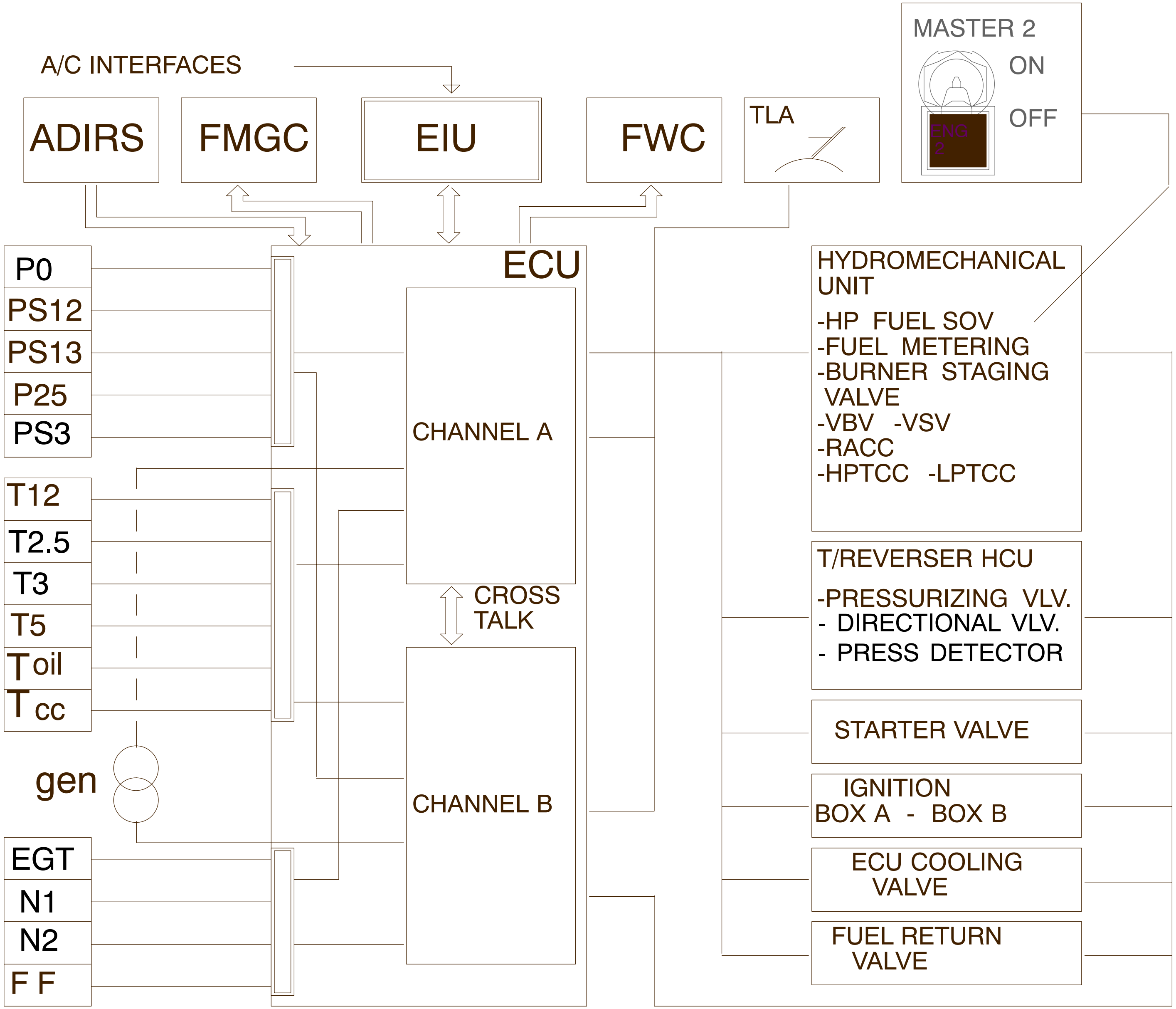


Figure 86 FADEC LRU'S Schematic

FADEC LRU'S

Engine Interface Unit EIU (1/2)

Each EIU, located in the avionics bay, is an interface concentrator between the airframe and the corresponding FADEC located on the engine.
There is one EIU for each engine. It interfaces with the corresponding Engine Control Unit (ECU).

ECU Generator (Alternator)

The ECU generator located on the accessory gearbox front side provides ECU power supply when N2 reaches 15%.
It generates 2 seperated 3 phase electrical power outputs to the ECU.

Electrical Harnesses

Low temperature harness
wire strand:

- HJ 7
- HJ 8
- HJ 9
- HJ 10
- HJ 11
- HJ 12
- HJ 13

High temperture harness
wire strand:

- HCJ 11 L
- HCJ 11 R
- HCJ 12 L
- HCJ 12 R
- HCJ 13

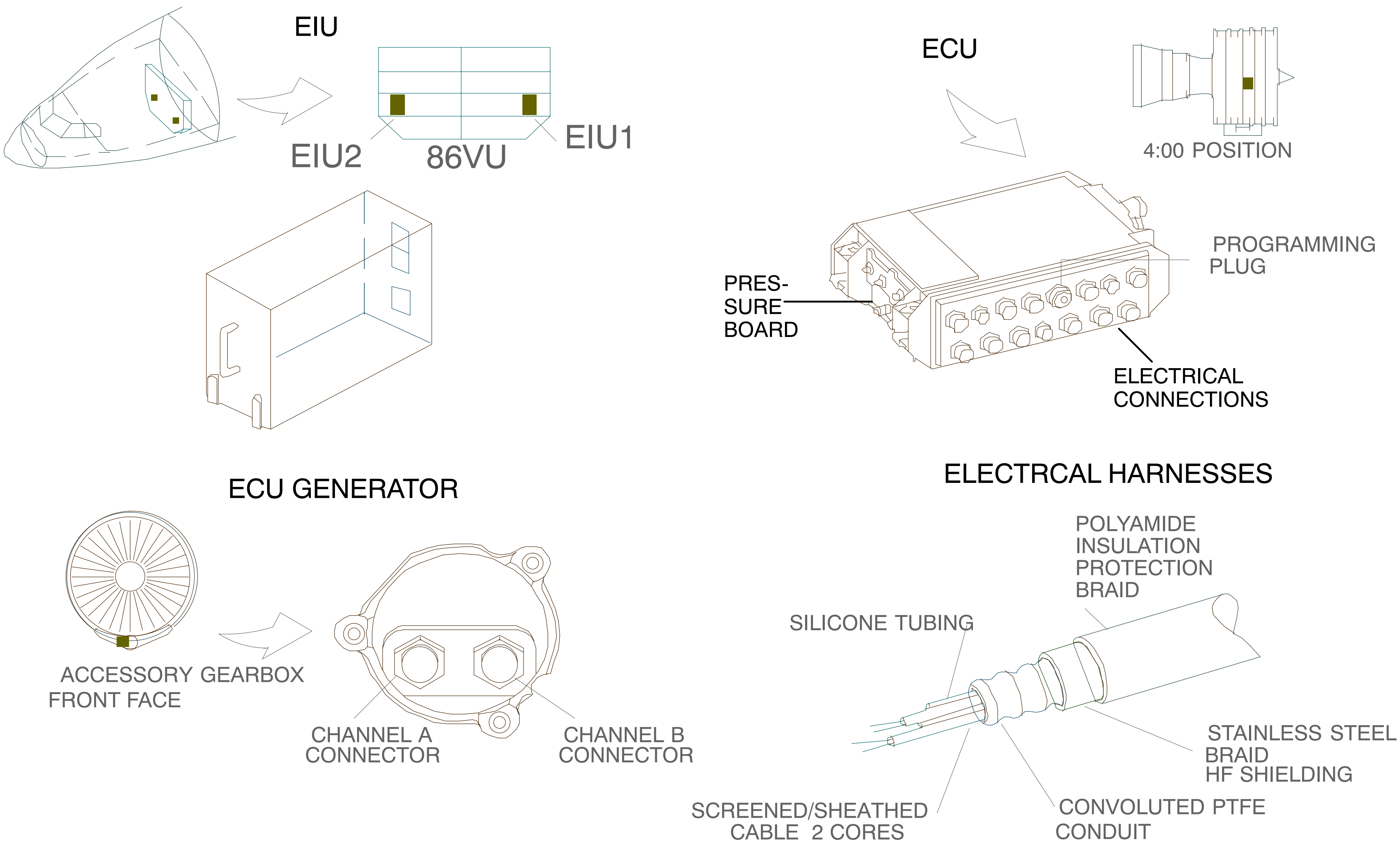


Figure 87 FADEC LRU'S Components

73-20 ENGINE SENSORS

FADEC SENSORS

Sensor T12:

- Electrical sensor, installed at 1:00 o‘clock on the fan case.

Sensor PS12:

- 3 Sensors which provides an average pressure.

Sensor PS 13:

- Fan air discharge pressure sensor installed at 2:00 o‘clock on the fan case.

Sensor T 25:

- Resistor probe type, installed at 5:30 o‘clock in the fan frame.

Sensor P 25:

- Installed at 6:00 o‘clock in the fan frame.

Sensor T 3:

- Thermocouple sensor installed at 11:00 o‘clock on the HP compressor case.

Sensor PS 3:

- Pick-up of compressor discharge pressure installed at 9:30 o‘clock on the HP compressor case.

Sensor T 49.5:

- 9 EGT thermocouples
- 4 parallel junction boxes
- 1 main junction box.

Sensor T 5:

- Thermocouple sensor
- Installed at 3:00 o‘clock on the turbine rear frame.

Sensor N 1:

- N1 speed tachometer
- Entirely removable unit
- 3 connctors (CHA-CHB-AC- EVMU)
- Installed at 5:00 o‘clock on the fan case.

Sensor N 2:

- N2 speed tachometer
- Installed at 6:30 o‘clock on the accessory gearbox rear side
- 3 Connectors (CHA-CHB-AC- EVMU).

Sensor T case:

- HPT Case Temperature
- Installed at 3:00 o‘clock and 9:00 o‘ clock on the HPT Case
- 2 Sensors (CH A, CH B)

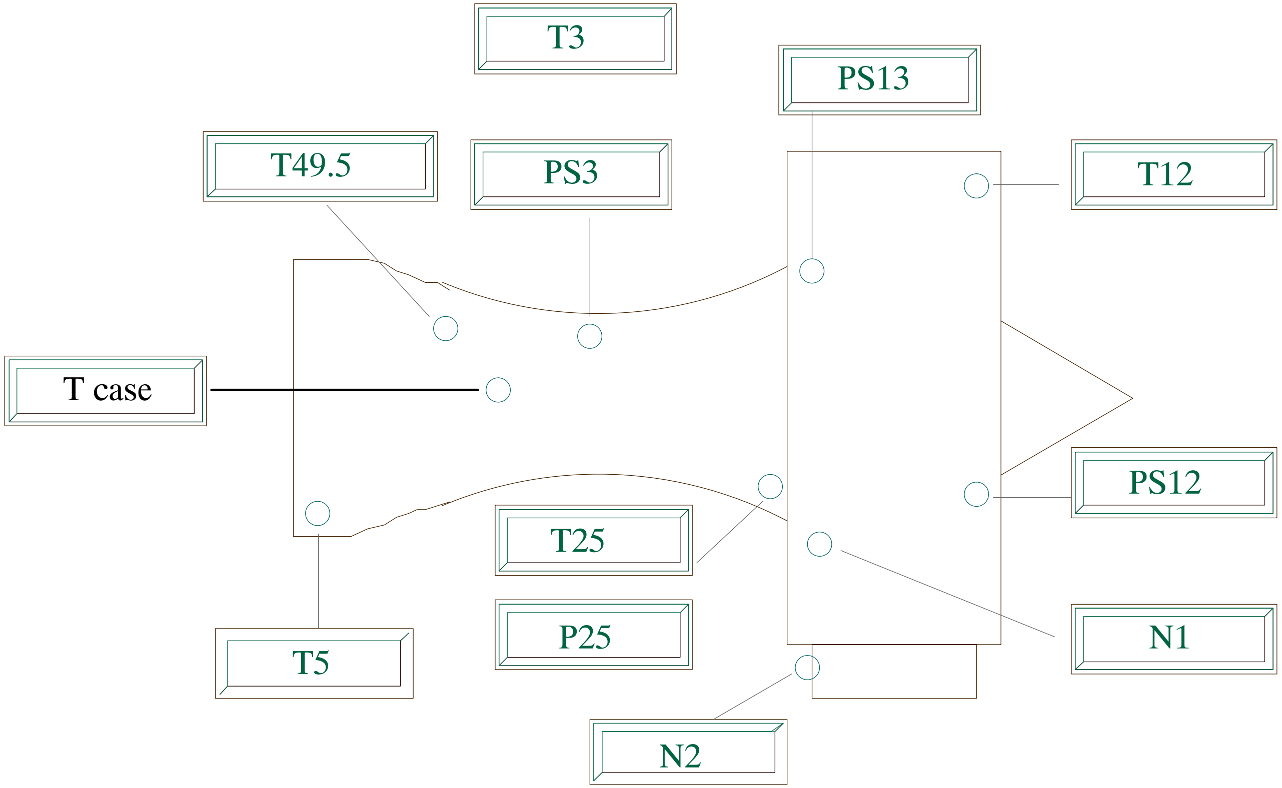


Figure 88 FADEC LRU'S Sensors

T12 SENSOR

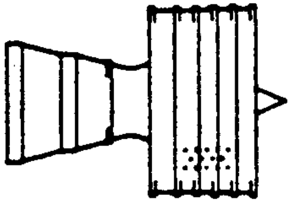
The T12 sensor is made to measure the engine intake air temperature.
It is installed on the air inlet cowl at the 1:00 o'clock position.

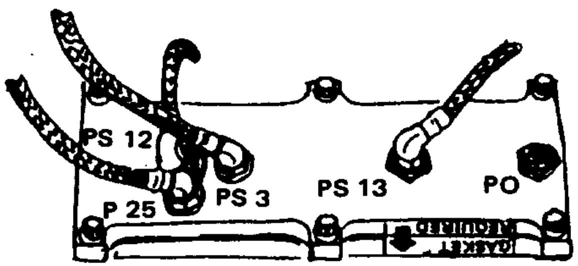
The T12 temperature sensor has 2 components: the sensing element and the housing.

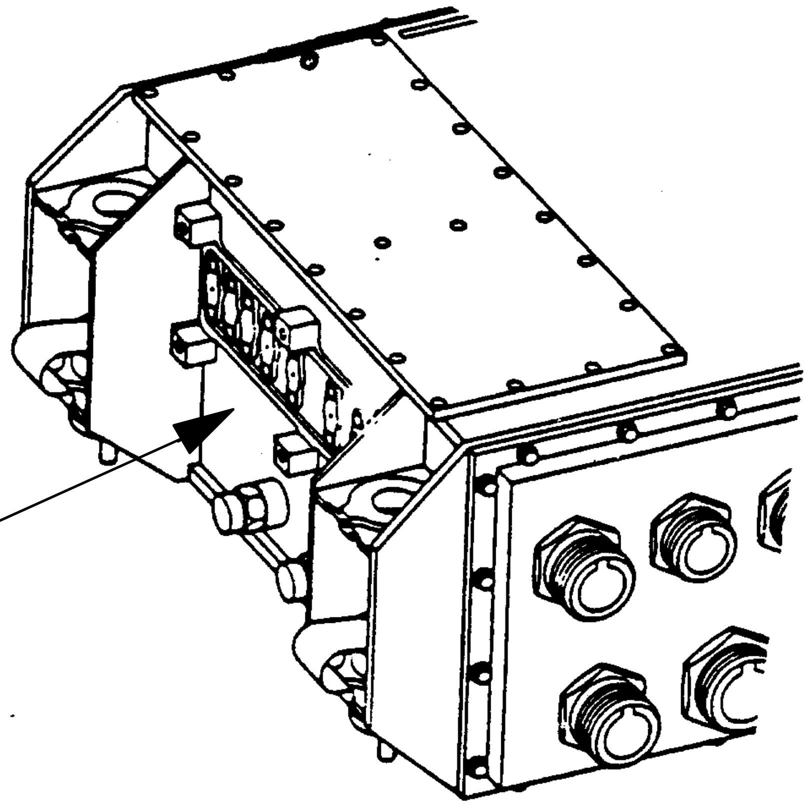
PS 12

PS13

P0 SENSOR







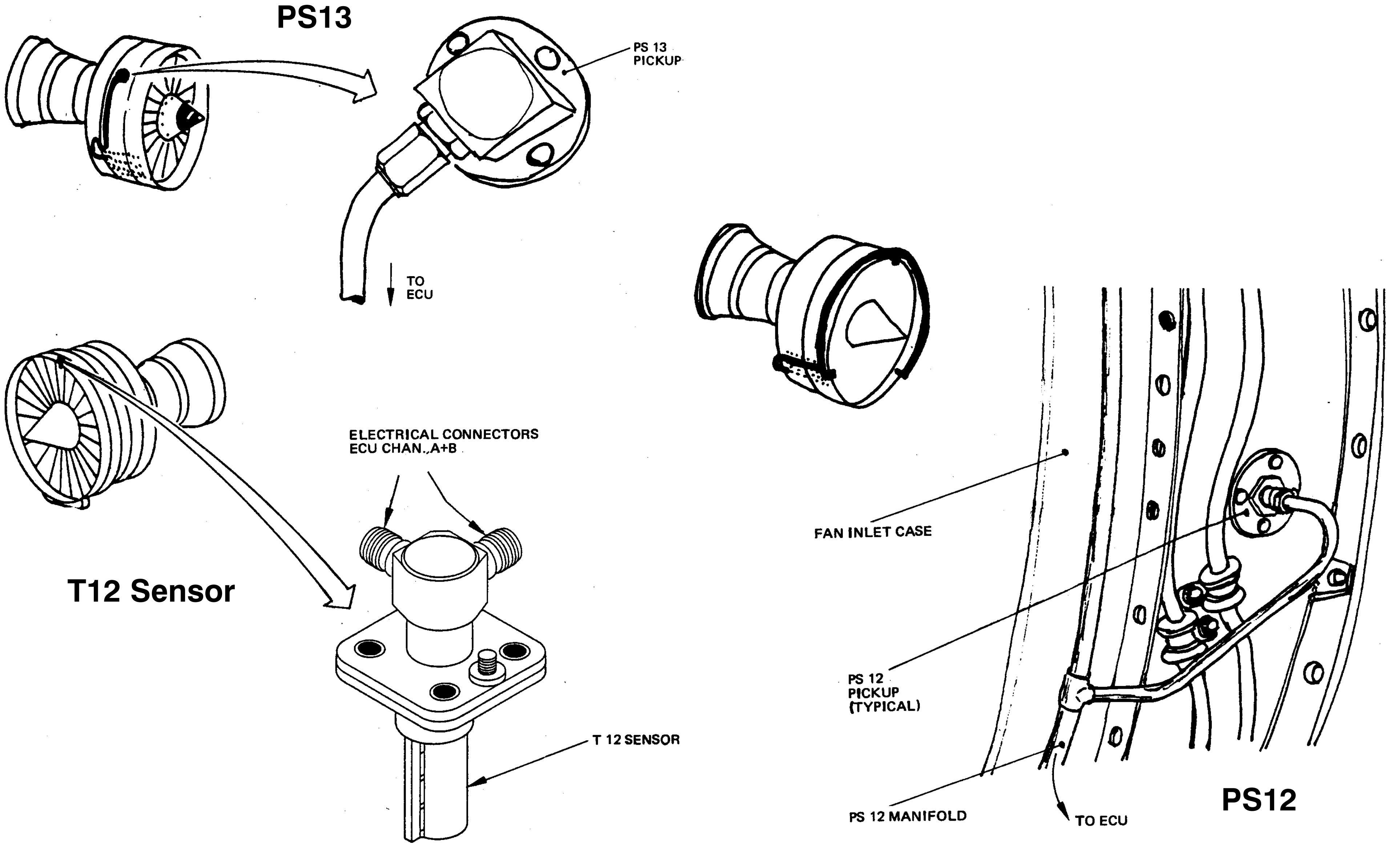


Figure 89 T12 Sensor, PS12

T25 SENSOR

The T25 sensor is located at 5:45 o'clock upstream of variable bleed (VBV) in fan frame. The sensor measures the air temperature downstream of the booster. This dual sensor is of the resistor probe type (platinum).

Operation
The operating principle of the sensor is based on the properties inherent to metals (in this case platinum), being that their resistance varies in relation to temperature.
A current generated by the ECU supplied to the probe resistor has its signal modified by the temperature surrounding the probe.

P25

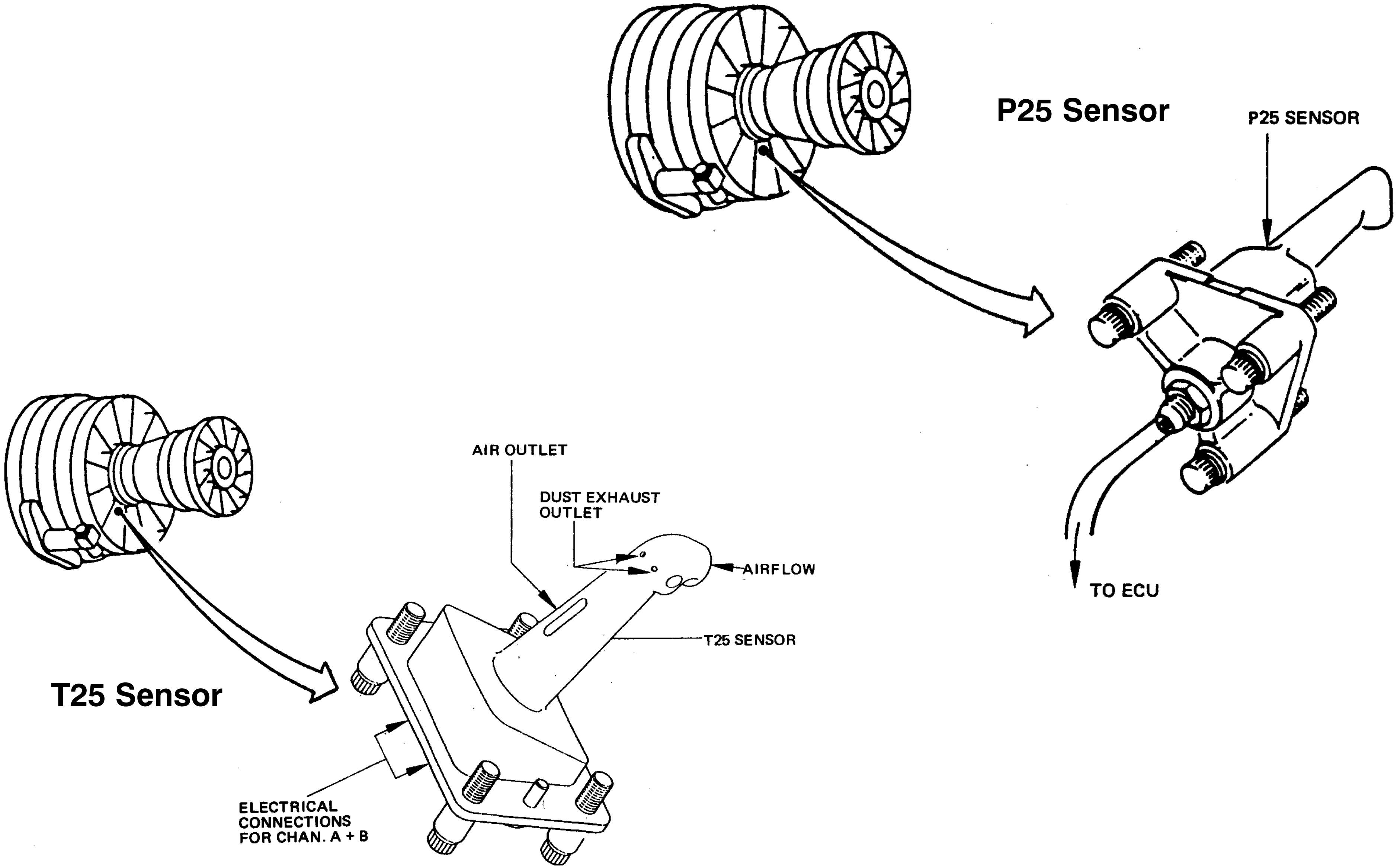


Figure 90 T25, P25 Sensor (CIT)

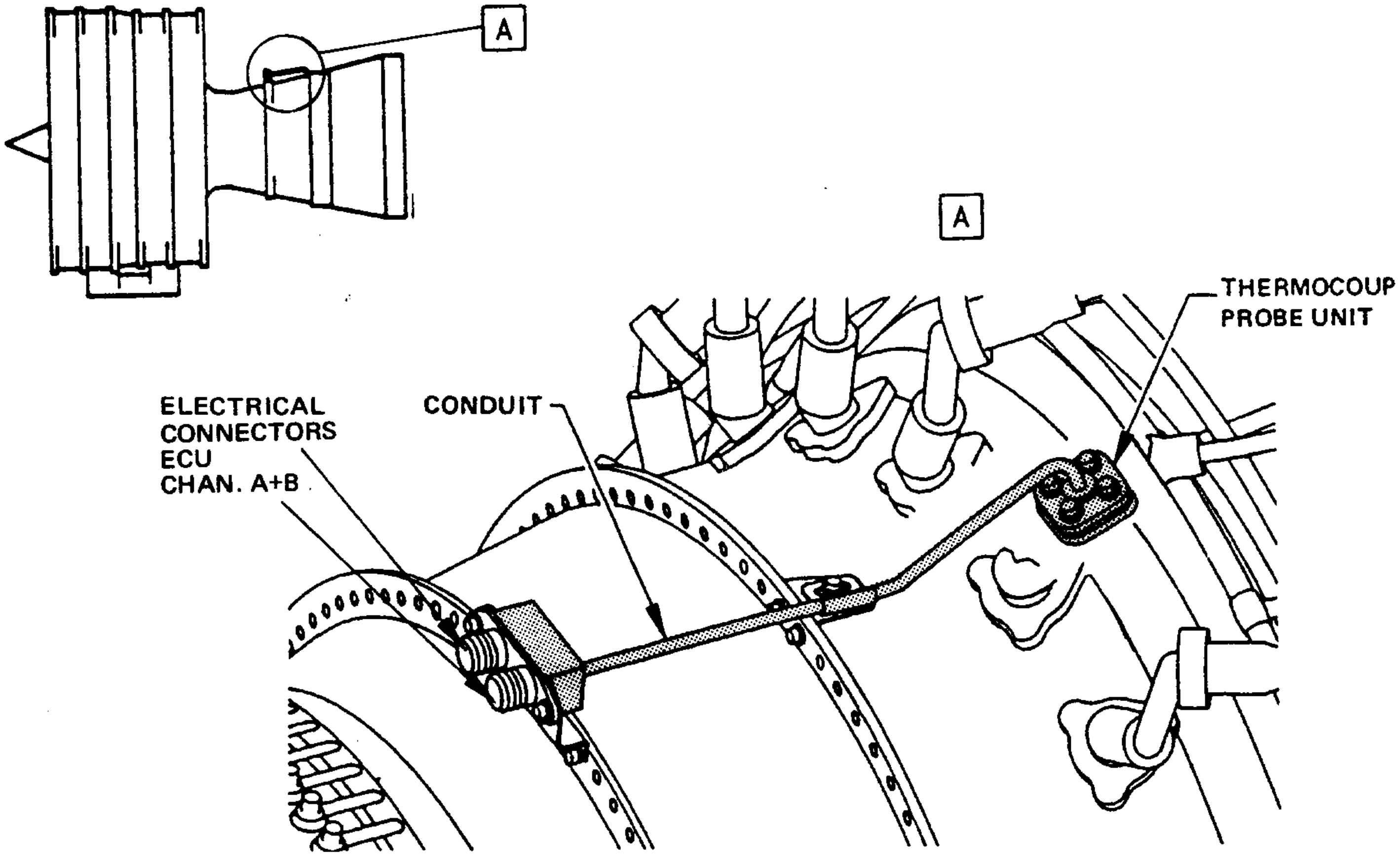


Figure 91 T3 Sensor

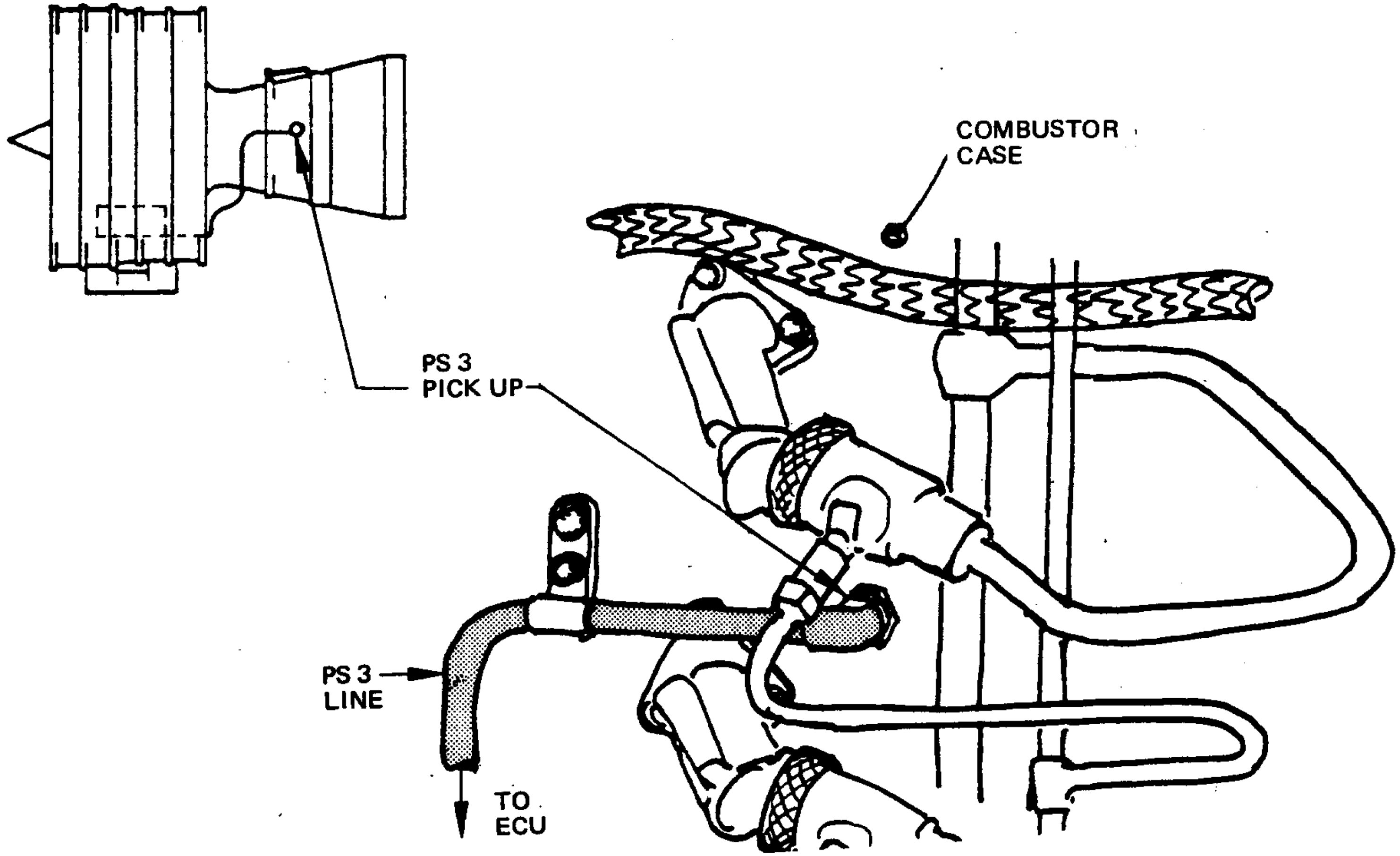
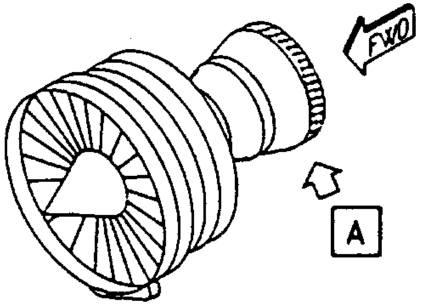


Figure 92 PS 3 Sensor (CDP)

STUDENT NOTES:



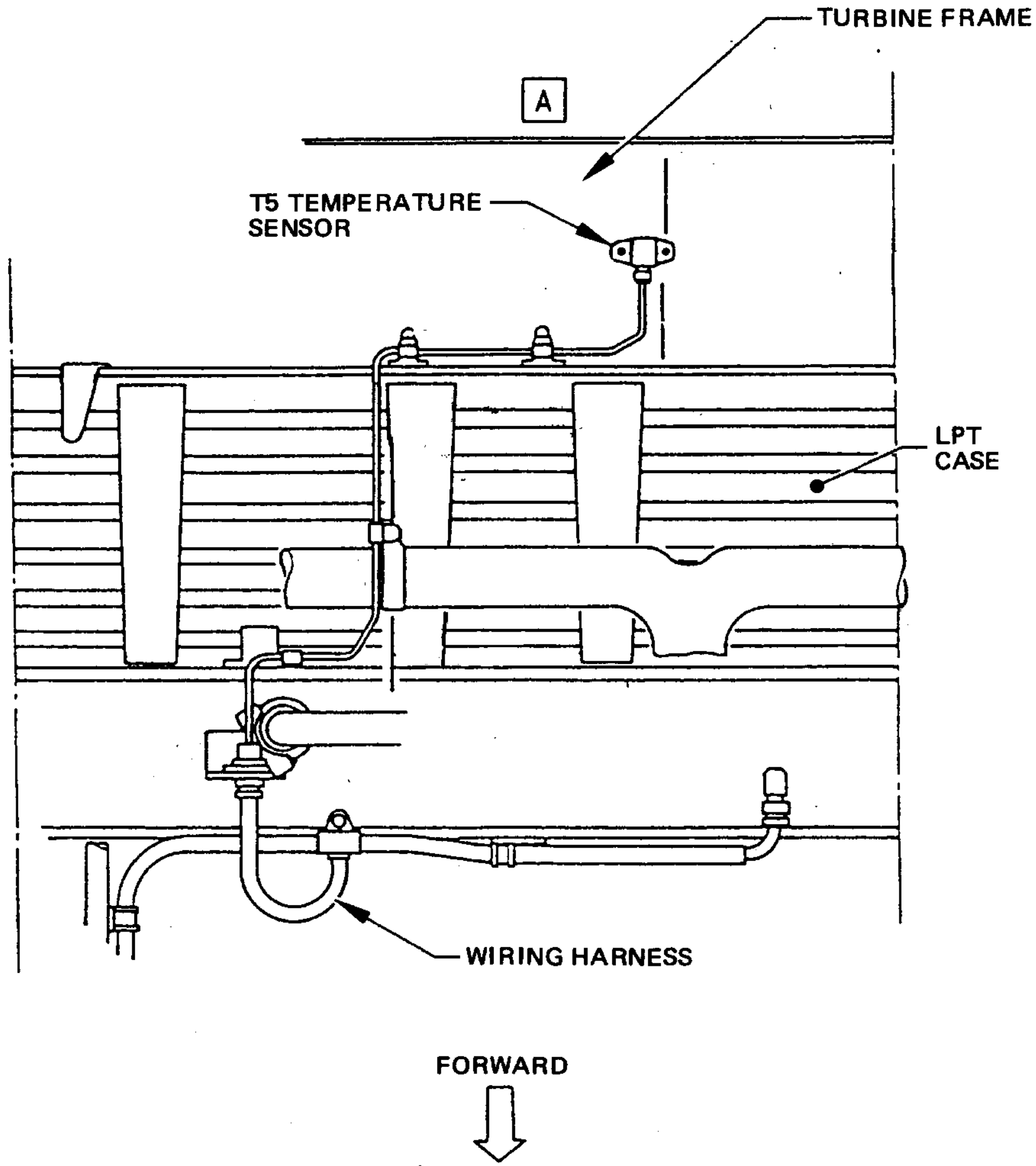


Figure 93 T5 Sensor

73-20 ECU DESCRIPTION

ECU SOFTWARE MAIN FUNCTIONS

Ground test of electrical and electronic parts is possible from cockpit with engines not running through the CFDS.
The FADEC provides engine control system self-testing to detect problem at LRU level.
FADEC is such that no engine ground run for trim purposes is necessary after component replacement.

ECU CONNECTIONS

Pressure Inputs

Five pneumatic pressure signals are supplied to pressure sub-systems A and B of the ECU.These are converted into electric signals by pressure transducers inside the ECU.
The 3 pressures used for engine control (P0,Ps12,P3) are supplied to both channels.
The two optional monitoring pressures are supplied to a single channel (Ps13 to CH. A,P25 to CH.B)

The pressure sub-system shear plate serves as the interface between the pneumatic lines and the ECU.The shear plate is bolted onto the ECU chassis.A metal gasket with integral O-rings is installed between the plate and ECU. Correct orientation of the assembly is assured by an alignment pin on the chassis and corresponding holes in the gasket and the shear plate.

Electrical Connectors

Fifteen threaded electrical connectors are located on the lower panel of the ECU.Each has a unique key pattern which acceps only the correct corresponding cable.
Connector identification numbers from J1 to J15 are marked on the panel.
All engine inputs and command outputs are double and routed to and from channel A and B through seperate cables and connectors.

IDENTIFICATION CONNECTOR (J14)

The engine identification plug acts as an ”electronic nameplate” for the ECU.
It is connected to the J14 ECU fixed connector.
The mobile connector transmits the following electric coded signals to the Electronic Control Unit (ECU):

- **Engine serial number**
- **Engine family**
- **Engine bump/overboost rating**
- **Engine nominal rating**

It is coded in the factory during installation of new engine, and is inseparable from the engine.

Channel A Connectors	Channel B Connectors	Function
J 1	J2	Power Supply 28V, Ignition Power Supply 115VAC
J 3	J4	Input / Output to / from Aircr., TLA Input
J 5	J6	Connection to Thrust Reverser
J 7	J8	HMU, N2 Sensor, FRV, ECU Cooling Valve
J 9	J10	Control Alternator, SAV, T12, N1 Sensor,
J11	J12	Feed Back Sensors, BSV Pos. Switches, T25
J14	J14	Engine Identification Plug
J13	J13	T3, Tcase, Toil, T5, EGT, Fuel Flow
J15	J15	Test Interface

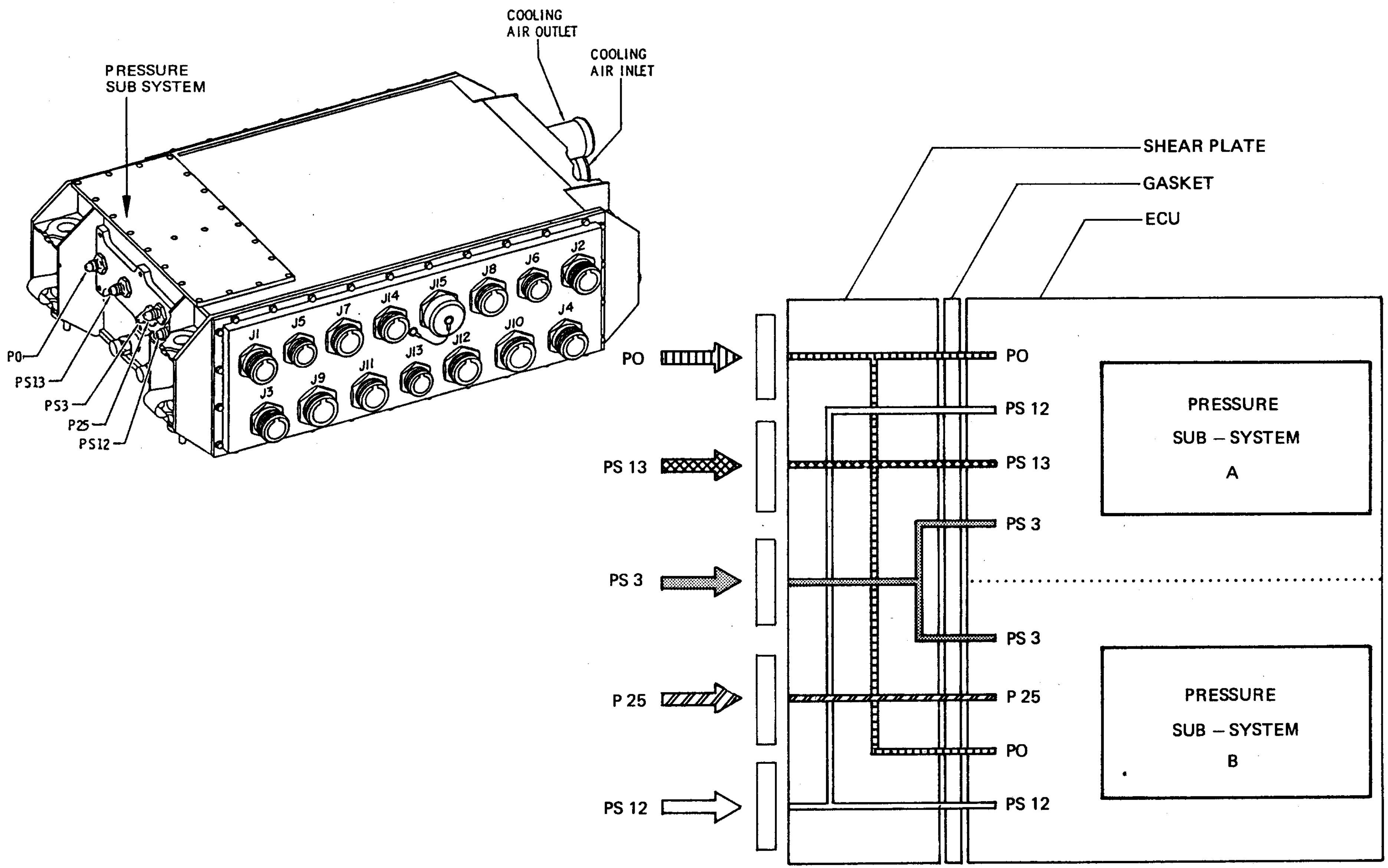


Figure 94 ECU Pressure Connections

73-20 FADEC POWER SUPPLY

FADEC POWER SUPPLY

EIU Power supply

The EIU is powered from the aircraft electrical power, no switching has to be done.

Engine Control Unit (ECU) Power Supply

The ECU is supplied from the aircraft electrical power when engine is shut-down, then from the ECU generator when the engine is running.

- aircraft electrical power when N2 <12%.
- ECU generator power when N2 >12%.

Powering N2 <12%

Each channel is independently supplied by the aircraft 28 volts through the Engine Interface Unit.

A/C 28 VDC permits :

- automatic ground check of FADEC before engine running
- engine starting
- powering the ECU while engine reaches 12% N2.

Note that EIU takes power from the same bus bar as ECU.

Powering N2 >12%

As soon as engine is running above 12% N2, the ECU generator can supply directly the ECU.
The ECU generator supplies each channel with three-phase AC. Two TRU's in the ECU provides 28VDC to each ECU channel.

Auto Depowering

The FADEC is automatically depowered on ground, through the EIU after engine shutdown.

ECU automatic depowering on ground :

- after 5 mn of A/C power up.
- after 5 mn of engine shutdown.

Note that an action on the ENG FIRE P/B provides ECU power cut off.

FADEC Ground Power Panel

For maintenance purposes and MCDU engine tests, the FADEC Ground Power Panel permits FADEC power supply to be restored on ground with engine shut down.
When the corresponding **ENG FADEC GND POWER** P/B is pressed ON the ECU takes again its power supply.
Note that also the FADEC is repowered as soon as the engine MODE SELECTOR or the MASTER LEVER (auto power shutoff after 5 min.) is selected.

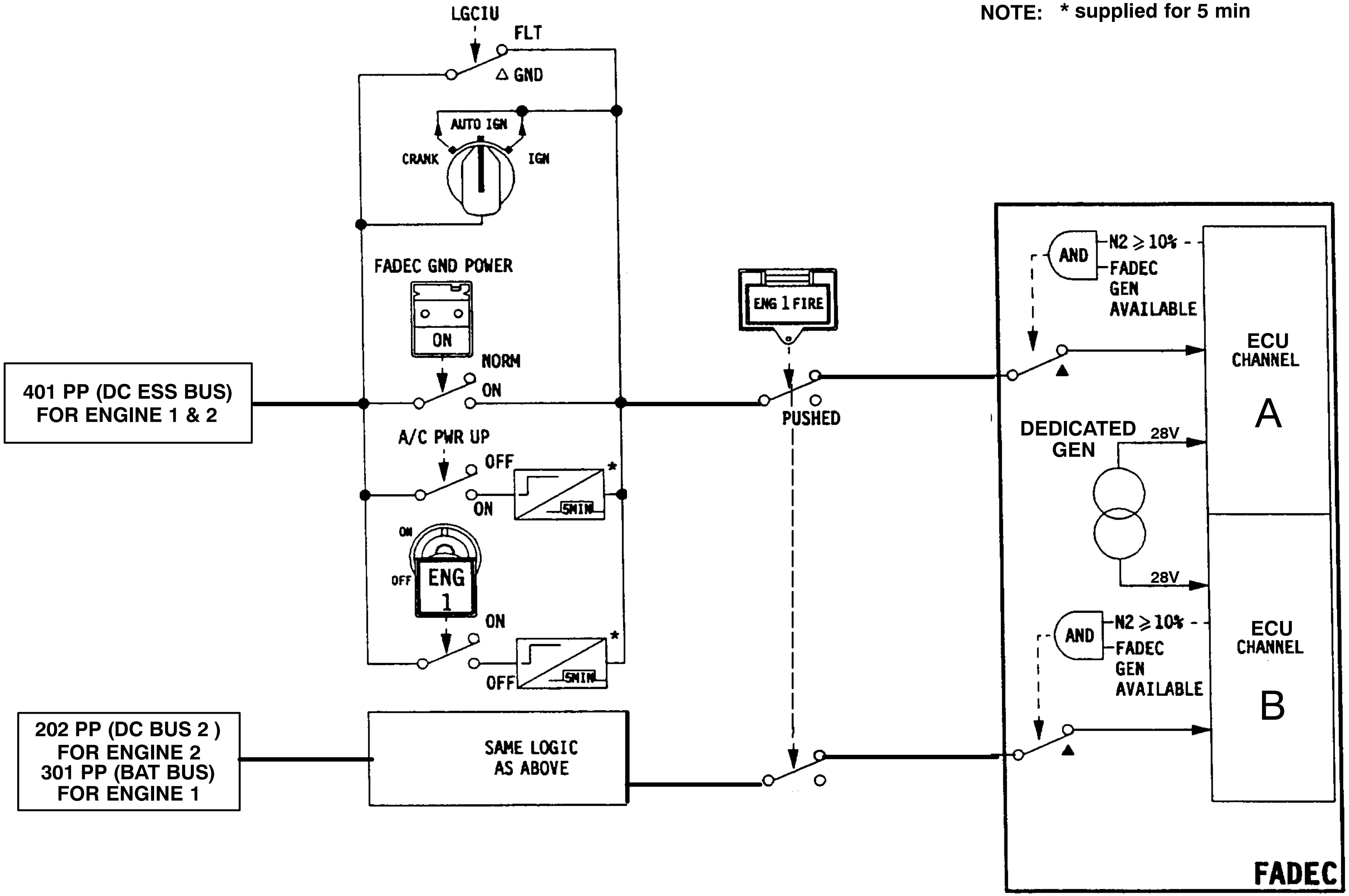


Figure 95 FADEC Power Supply

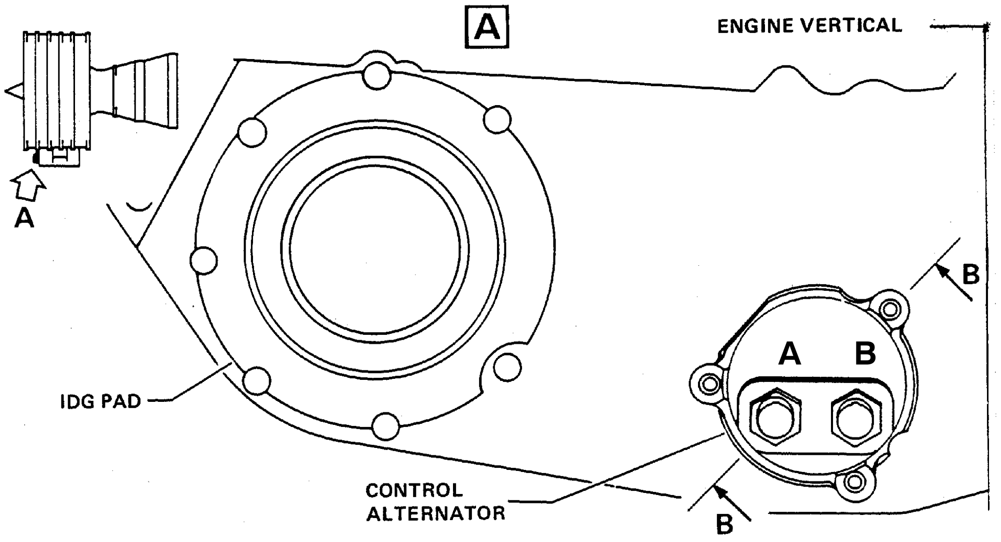
CONTROL ALTERNATOR

The control alternator is a high speed bearingless device that generates 3-phase electrical power for use by the engine control system.
The output is sufficient for engine needs above 12% N2.

The alternator is located on the left forward side of the accessory gearbox. It consists of a separate interchangeable rotor and a separate interchangeable stator. The rotor contains permanent magnets and is piloted on the accessory shaft which has 3 equally spaced drive flats. The rotor is retained by a nut. The stator has dual 3-phase windings and is bolted to the accessory pad. Sealing is provided by an O-ring.

Control Alternator Characteristics

- Max. power output: 136 W
- Min. voltage: 14 VAC (10 - 15% N2)
- Max. voltage: 300 VAC (100 % N2)



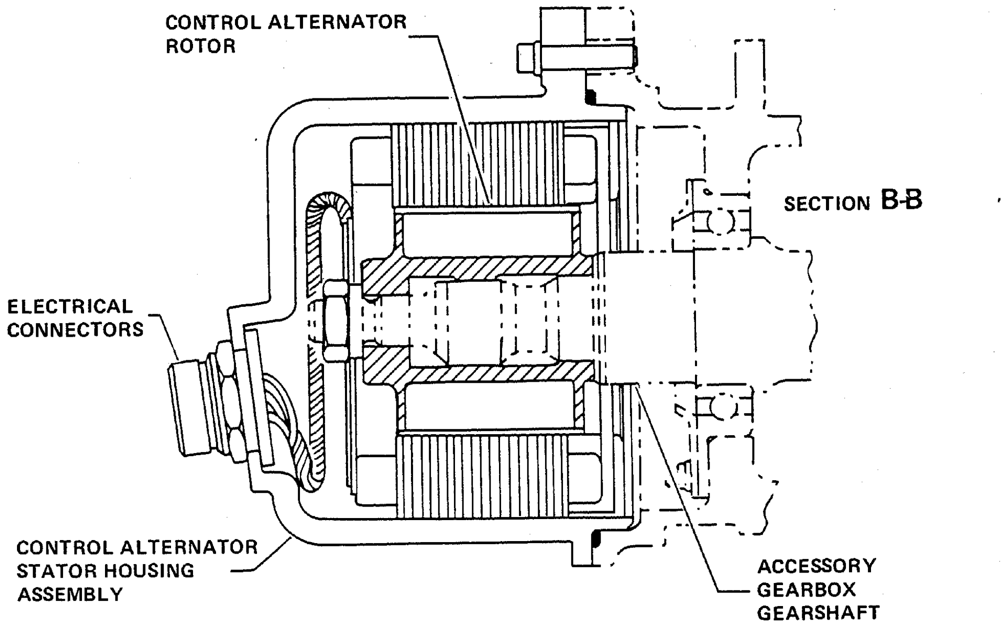


Figure 96 Control Alternator

73-20 POWER MANAGEMENT

GENERAL

Thrust Limit mode selection
Throttle lever is used as a rating mode selection device. By receiving the throttle lever position signal, the FADEC computes permanently thrust limit ratings, shall select the corresponding limit value and send it to the cockpit.When the throttle lever is positioned between two unique positions, the FADEC will select the limit of the higher mode for display

Two thrust setting mode are available, the autothrust mode and the manual mode. The mode selection is depending on throttle lever position and upon the autothrust activation/deactivation logic.

Autothrust Mode

The autothrust mode is only avalible between idle and maximum continuous thrust (MCT) when the aircraft is in flight. The autothrust function (ATHR) can be engaged or active. The engagement logic is done in the FMGC and the activation logic is implemented into the ECU.(The activation logic in the ECU unit is based upon two digital discretes ATHR engaged, ATHR active, from the FMGC,plus an analog discrete from the instinctive disconnect pushbutton on the throttle.)
The ATHR function is engaged automatically in the FMGC by auto pilot mode demand and manually by action on the ATHR push button located on the flight control unit (FCU).

After take-off the lever is pulled back to the maximum climb position. The autothrust function will be active and will provide an N1 target for:

- Max climb thrust
- Optimum thrust
- An aircraft speed (Mach number)
- A minimum thrust.

The ATHR de-activation and ATHR disengagement are achieved by action on the disconnect pushbutton located on the throttle levers or by depressing the ATHR pushbutton provided that the ATHR was engaged. Selecting the TLA in IDLE or in reverse range will also disengage the ATHR function.
Alpha Floor Condition
If the Alpha Floor condition is not present, setting at least one throttle lever forward of the MCT gate leads to ATHR deactivation but maintains ATHR engaged ; the thrust is controlled by the throttle lever position and ATHR will be activated again as soon as both throttles are set at or below MCT gate.
If the Alpha Floor condition is present, the ATHR function can be activated regardless of throttle position.
When ATHR is deactivated (pilot's action or failure), the thrust is frozen to the actual value at the time of the deactivation. The thrust will be tied to the throttle lever position as soon as the throttles have been set out of the MCT or MCL positions.

The thrust is frozen to the N1 actual if (memo thrust setting) :

1 ATHR was active in the FADEC unit
- and throttle is in MCT gate or MCL gate
- and one of the deactivation conditions is present ATHR not engaged (from the ECU)
- or N1 target not valid
- or instinctive disconnect condition.

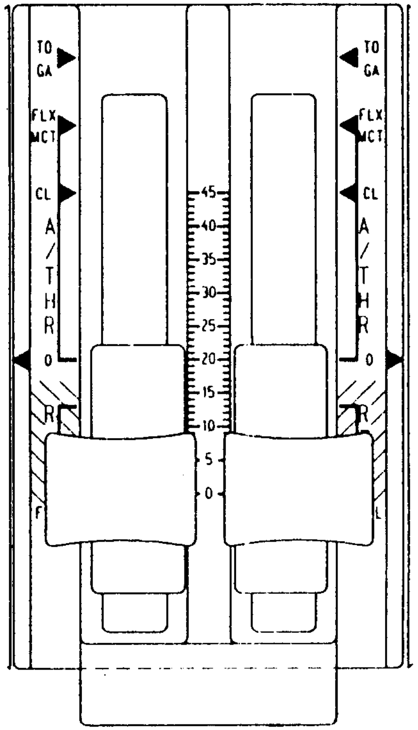
2 Thrust was frozen
- and condition to switch to manual thrust setting not present
- and condition to switch to automatic thrust setting not present.

Manual Mode

The thrust is controlled manually (i.e., function of TLA position) if the throttles are not in the ATHR area.
This mode is also entered any time the conditions for autothrust or memo modes are not present. In this mode, thrust lever sets an N1 value proportional to the thrust lever position up to maximum take-off thrust.
TLA versus rated thrust is consistent regardless of ambient conditions.
TAKE-OFF/GO-AROUND ratings are always achieved at full forward throttle lever position (except in Alpha-floor mode).
Other ratings (MAX CONTINUOUS, MAX CLIMB. IDLE, MAX REVERSE) are achieved at constant throttle lever positions.FLEXIBLE TAKE-OFF for a given derating is achieved at constant retarded throttle lever position.

Flexible take-off rating

FLEXIBLE TAKE-OFF rating is set by the assumed temperature method with the possibility to insert an assumed temperature value higher than the maximum one certified for engine operation to provide for the maximum derate allowed by the certifying Authorities.



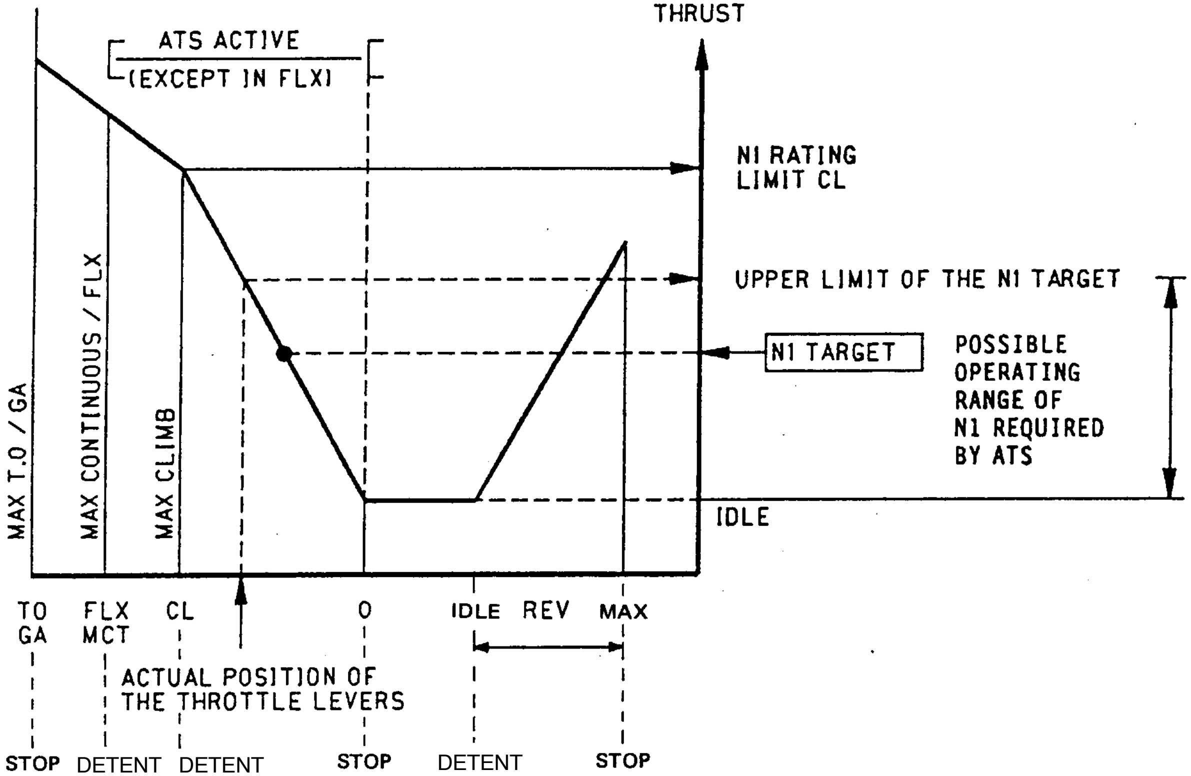


Figure 97 Thrust Lever Positions

IDLE CONTROL

- **Minimum idle (58,8 % N2)** is corrected for ambient temp >30°C
  Then the N2 will increase.
  The minimum idle should never be below 58,3% N2

- **Approach idle (approx.70% N2)**
  It varies as a function of Total Air Temperature (TAT)and altitude.
  This idle speed is selected to ensure sufficiently short acceleration time to go around thrust and is set when the aircraft is in an approach configuration.(Flap Lever Position -” NOT UP”)

- **Bleed Idle** = Bleed demand.
  Bleed Idle command will set the fuel flow requested for ensuring correct aircraft ECS system pressurization ,wing anti ice and engine anti ice pressurization (Pb-”ON” or valves not closed) .

- **Reverse Idle (approx.70% N2)** = Approach Idle + 1000 RPM
  FADEC sets the engine speed at reverse idle when the throttle is set in the reverse idle detent position .

- **IDG Idle Bias (Min Idle - Approach Idle)** = The min idle speed will increase to maintain the engine oil temperature within max limits**(in flight only)**,when the engine oil temperature reach > 106 deg C (signal from TEO sensor).The speed can increase up to approach idle.

- **Weater Idle Speed**
  On the ECU software P28 / P15 the new weater idle speed will be incorperated (SB 73-131) .The purpose of this software eliminates the FCOM requirement that the pilot must manually select Nacelle Anti -Ice prior to penetrating moderate to heavy precipitation weather conditions in order to establish the minimum idle to 45% N1 .This software reduces pilot work load.

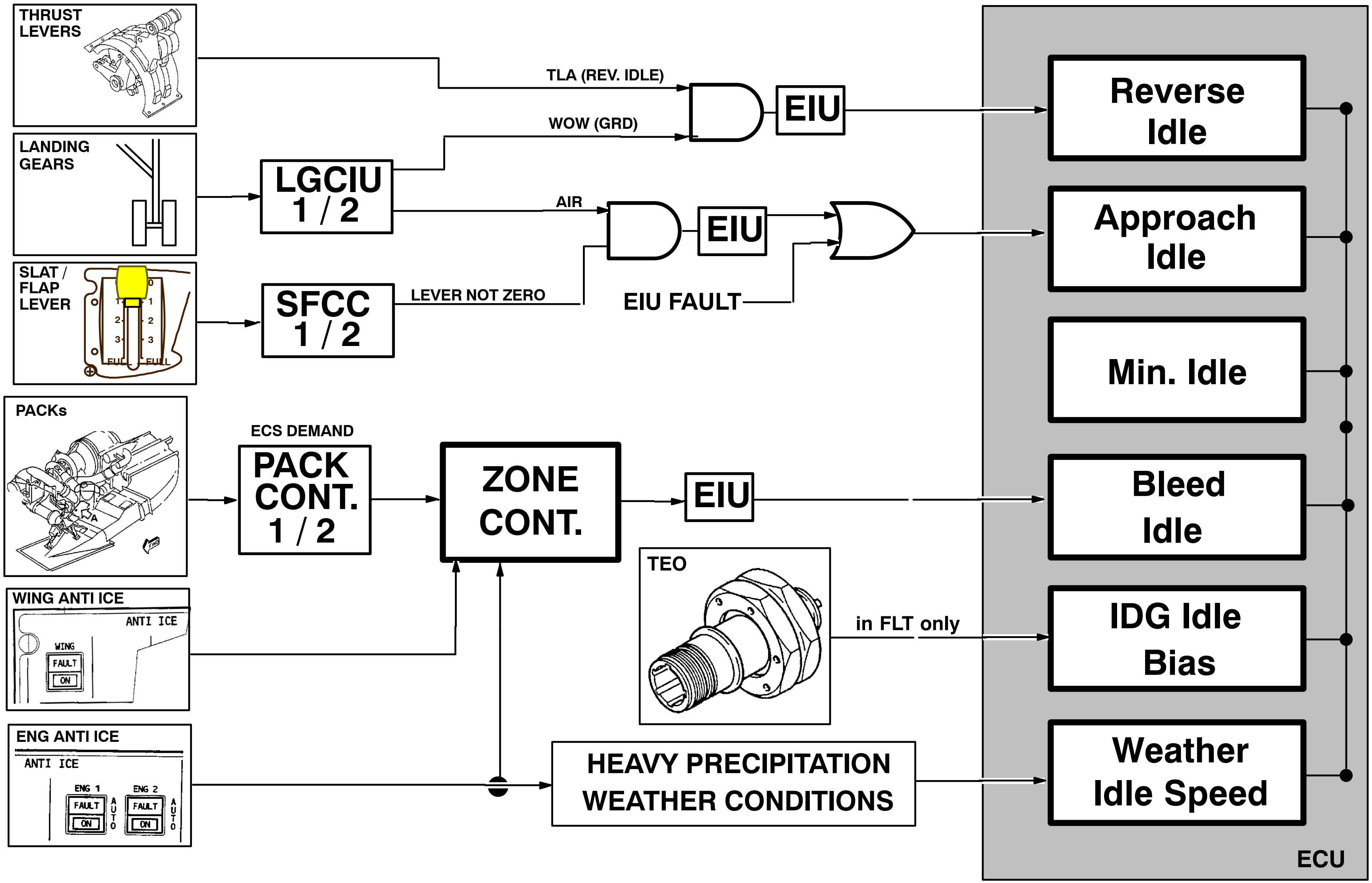


Figure 98 Idle Setting

73-20 FADEC TEST

CFDS SYSTEM REPORT/TEST FADEC 1 (2)

The system report/test menu for the FADEC has eight options:

- **LAST LEG REPORT**
- **PREVIOUS LEGS REPORT**
- **LRU IDENTIFICATION**
- **CLASS 3 FAULTS**
- **TROUBLE SHOOTING REPORT**
- **IGNITION TEST**
- **THRUST REVERSER TEST**
- **FADEC TEST**

To get access to the FADEC CFDS menu the FADEC ground power switch on the maintenance panel must be ”ON” ,otherwise ”NO RESPONSE” is displayed on the MCDU.

LAST LEG REPORT

This report gives a list of the LRUs which have been detected faulty on the last flight leg.

PREVIOUS LEGS REPORT

This report lists all the LRUs which have been detected faulty during the previous flight legs (max 62).

LRU IDENTIFICATION

This menu shows the ECU part number.The last digit of the number shows the software standard (e.g. P02)

CLASS 3 FAULTS

This menu shows the class 3 faults.

TROUBLE SHOOTING REPORT

This report presents a snapshot at the time a fault occured.It shows the time of occurence and gives additional parameter infos.

- N1 Actual Selection (N1ACTSEL)
- N2 Actual Selection (N2 ACTSEL)
- EGT Selection (T49.5SEL)
- Thrust Lever Angel Selection (TLASEL)
- CDP Selection (PS3SEL)
- Fuel Metering Valve Selection (FMVSEL)
- VSV Selection (VSVSEL)
- VBV Selection (VBVSEL)
- Ambient Static Pressure Sel.(P0SEL)
- TAT Selection (TATSEL)
- Mach Outside (MO)
- N1 Command (N1CMD)

IGNITION TEST

This test allows to perform a ignition test via the MCDU.

REVERSER TEST

This test allows to operate /test the reverser .

refer to additional pages !

Figure 99 FADEC CFDS Menu

CFDS SYSTEM REPORT/TEST FADEC 1 (2)

For the Test procedure refer to AMM TASK 73-29-00-710-040

FADEC TEST

This test allows to test the FADEC system , by seperate selection of channel A or channel B.
A motoring or a non motoring test can be performed,depending if bleed air is supplied or not.
When a motoring test is done the valves are driven with fuel press and all electrical circuits are checked.
A non motoring test is only a static electrical test.

NOTE.:
For the versions of the FADEC without the Bleed Bias System installed,the class 3 message ”WB3 SENS,J15,ECU” or BLD SENSOR,J15, ECU will be displayed on each channel of the FADEC test report.This message must be disregarded if the Bleed Bias System is not installed!

refer to additional pages !

Figure 100 FADEC Test

73-25 ENGINE INTERFACE UNIT

EIU PRESENTATION

Two EIUs are fitted on each aircraft, one for engine 1, one for engine 2

Each EIU, located in the electronics bay 80VU, is an interface concentrator between the airframe and the corresponding FADEC located on the engine, thus reducing the number of wires. EIUs are active at least from engine starting to engine shutdown, they are essential to start the engine.

The main functions of the EIU are:
- to concentrate data from cockpit panels and different electronic boxes to the associated FADEC on each engine,
- to insure the segregation of the two engines,
- to select the airframe electrical supplies for the FADEC,
- to give to the airframe the necessary logic and information from engine to other systems (APU, ECS, Bleed Air, Maintenance).

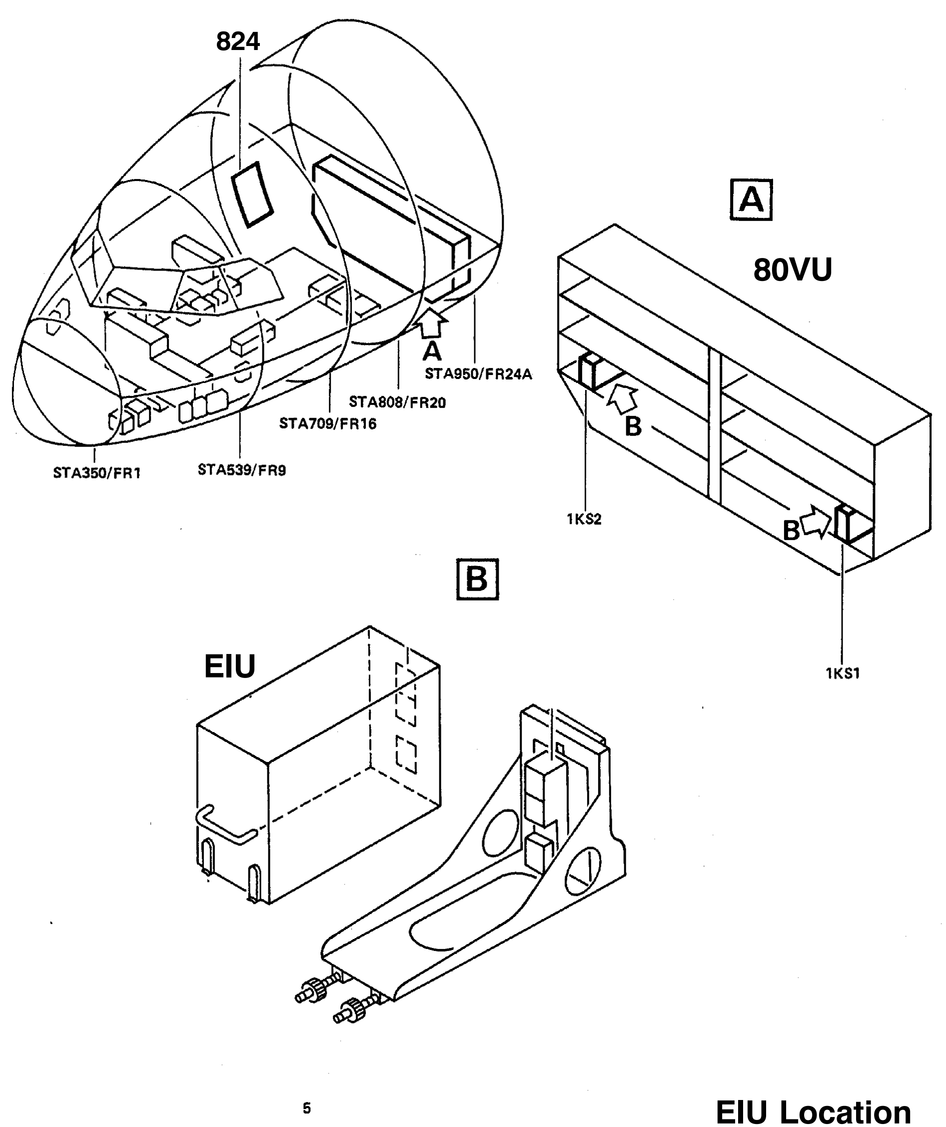
EIU INPUT DESCRIPTION

EIU input from the ECU

The EIU acquires two ARINC 429 output data buses from the associated ECU (one from each channel) and it reads data from the channel in control. When some data are not available on the channel in control, data from the other channel are used.
In the case where EIU is not able to identify the channel in control, it will assume Channel A as in control.
The EIU looks at particular engine data on the ECU digital data flow to interface them with other aircraft computers and with engine cockpit panels.

EIU output to the ECU

Through its output ARINC 429 data bus, the EIU transmits data coming from all the A/C computers which have to communicate with the ECU, except from ADCs and throttle which communicate directly with the ECU.
There is no data flow during EIU internal test or initialization.



EIU Location

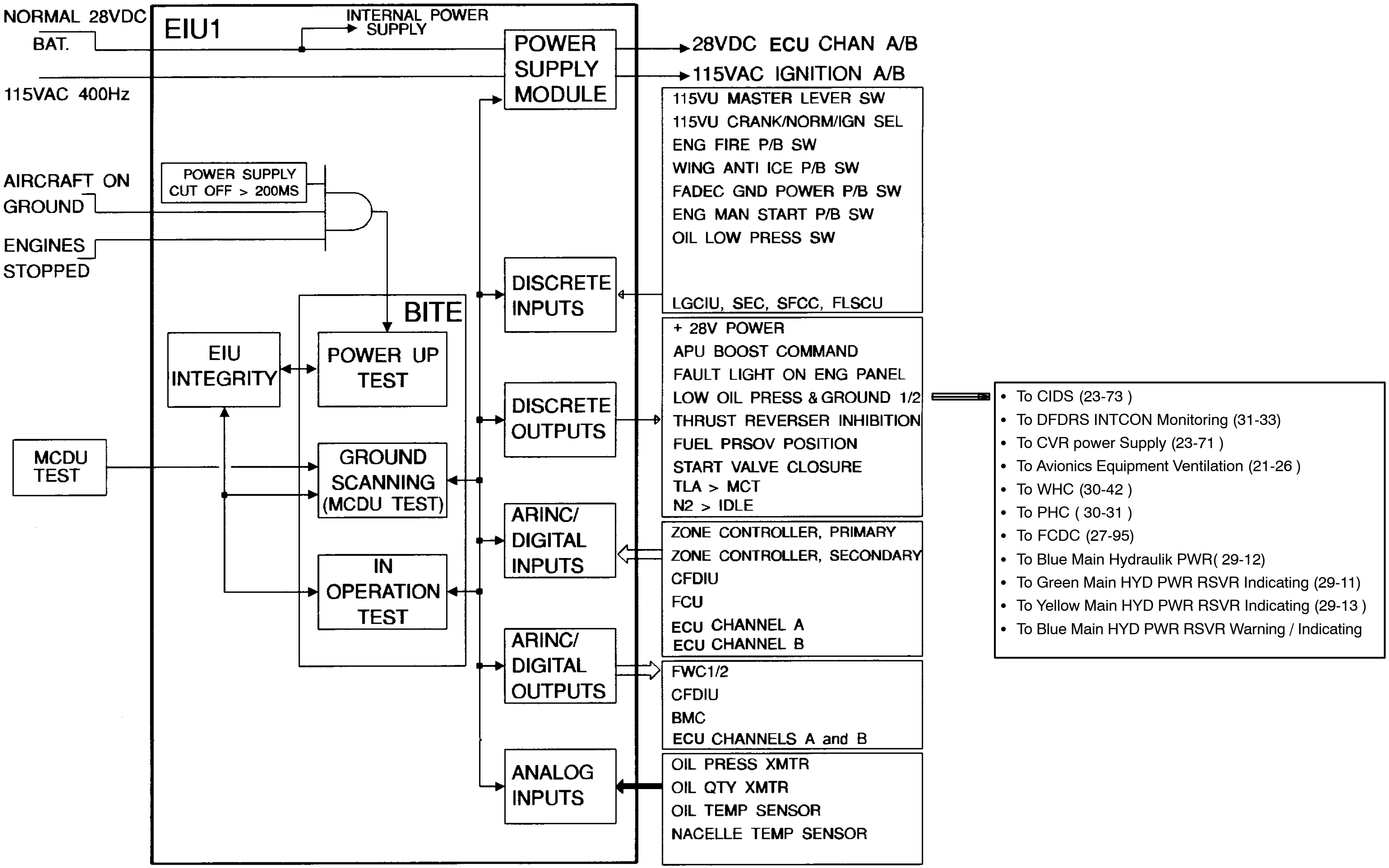


Figure 101 EIU Schematic

EIU INTERFACES

SIGNALS	PURPOSE
WING ANTI-ICE SWITCH	ENGINE BLEED COMPUTATION LOCIG
ENGINE FIRE P/B SIGNAL	FADEC ENGINE SHUTDOWN LOGIC
LOW OIL PRESSURE SWITCH (AND GROUND)	-COCKPIT WARNING SIGNALS -HYDRAULIC MONITORING -WINDOW AND PROBE HEATING SYSTEM -AVIONIC VENTILATION SYSTEM -RAIN REPELLENT SYSTEM -CIDS,CVR,DFDR
FADEC GROUND POWER P/B	FADEC POWER SUPPLY LOGIC
LGCIU 1 AND 2 (GROUND SIGNAL)	THRUST REVERSER AND IDLE LOGIG
SFCC 1 AND 2	ENGINE FLIGHT IDLE COMPUTATION LOGIC
SEC 1 ,2 AND 3	THRUST REVERSER INHIBITION CONTROL
FLSCU 1 AND 2	FUEL RETURN VALVE CONTROL
ENGINE SELECTED	ENGINE 1 OR 2 INDENTIFICATION
OIL PRESSURE,OIL QUANTITY AND OIL TEMPERATURE	INDICATION ECAM
NACELLE TEMPERATURE	INDICATING (ECAM)
START VALVE POSITION (FROM EEC)	ECS FOR AUTOMATIC PACK VALVE CLOSURE, DURING ENGINE START
N2 GREATER THAN MINIMUM IDLE (FROM ECU)	FUNCTIONAL TEST INHIBITION OF THE RADIO ALTIME-TER TRANSCEIVER -BLUE HYDRAULIC SYSTEM PUMP CONTROL
ENGINE START FAULT SIGNAL	ILLUMINATION OF FAULT LIGHT ON THE ENGINE START PANEL
APU BOOST DEMAND SIGNAL (EIU)	MAIN ENGINE START MODE TO THE APU ELECTRONIC CONTROL BOX

EIU INTERFACES CONT.

SIGNALS	PURPOSE
TLA IN TAKE-OFF POSITION (MIN. T/O N2, FROM ECU)	PACK CONTROLLER FOR INLET FLAP CLOSURE -AVIONIC EQUIPMENT VENTILATION CONTROLLER (CLOSED CIRCUIT CONFIGURATION) -CABIN PRESSURIZATION COMPUTER PRE-PRESSUR- IZATION MODE
THRUST REVERSER (FROM SEC 1,2 AND 3)	THRUST REVERSER INHIBITION RELAY

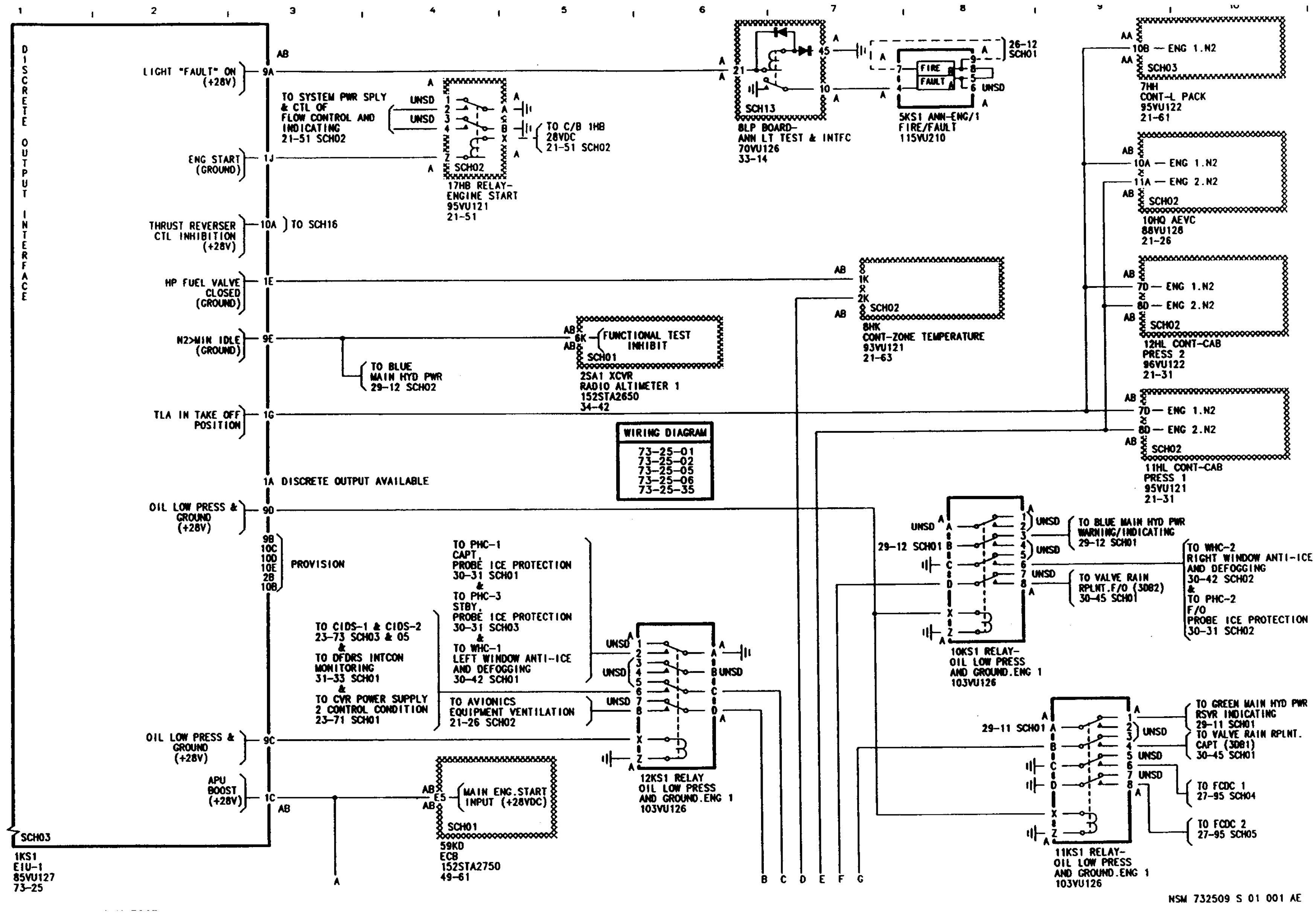


Figure 102 EIU Schematic

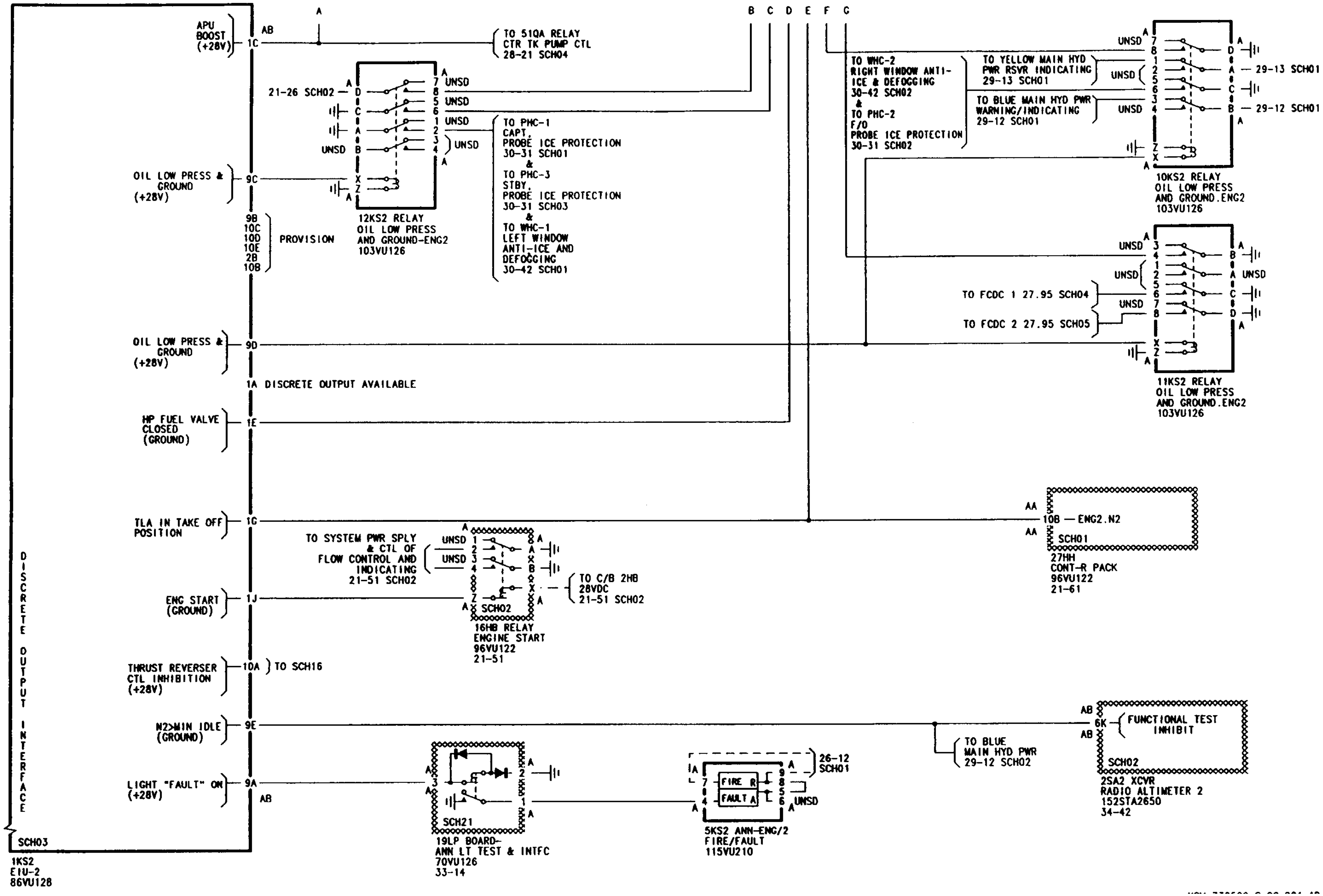


Figure 103 EIU Schematic

73-25 EIU CFDS TEST

CFDS SYSTEM REPORT/TEST EIU

This Page shows the menu of the Engine Interface Unit (EIU)

The EIU is a Type 1 System.
The EIU is availlable in CFDS back up Mode.

The following menu options are available for the EIU 1 (2):

LAST LEG REPORT
PREVIOUS LEGS REPORT
LRU IDENTIFICATION
CLASS 3 FAULTS
GROUND SCANNING

Last leg Report

Here are Displayed the Internal EIU Faillures that Occured during Last Flights.

Previous legs report

The EIU sends a list of the LRU's which have been detected faulty during the previous 62 flight legs.

LRU Indentification

Shows the EIU part number.

Class 3 faults

This menu shows all class 3 faults present.

Ground scanning

This Page gives the EIU Faillures still presend on Ground.

- **RTOK** means Re - Test Ok, you can ignore this Fault

refer to additional pages

Figure 104 EIU Menu

ATA 75 ENGINE AIR
75-20 ENGINE CLEARANCE CONTROL SYSTEMS,

GENERAL

Das CFM56-5A has 3 Clearance Control-Systems.These are:

- **the Rotor Active Clearance Control System (RACC)**
- **the HPT Active Clearance Control System (HPTACC)**
- **the LPT Active Clearance Control System (LPTACC)**

Every system has a valve which controls the airflow.The valves are positioned by fuel servo pressure controled by a servo valve installed on the HMU.
Every servo valve is equipped with a position feedback .The servo valves are controlled by the ECU according a schedule.

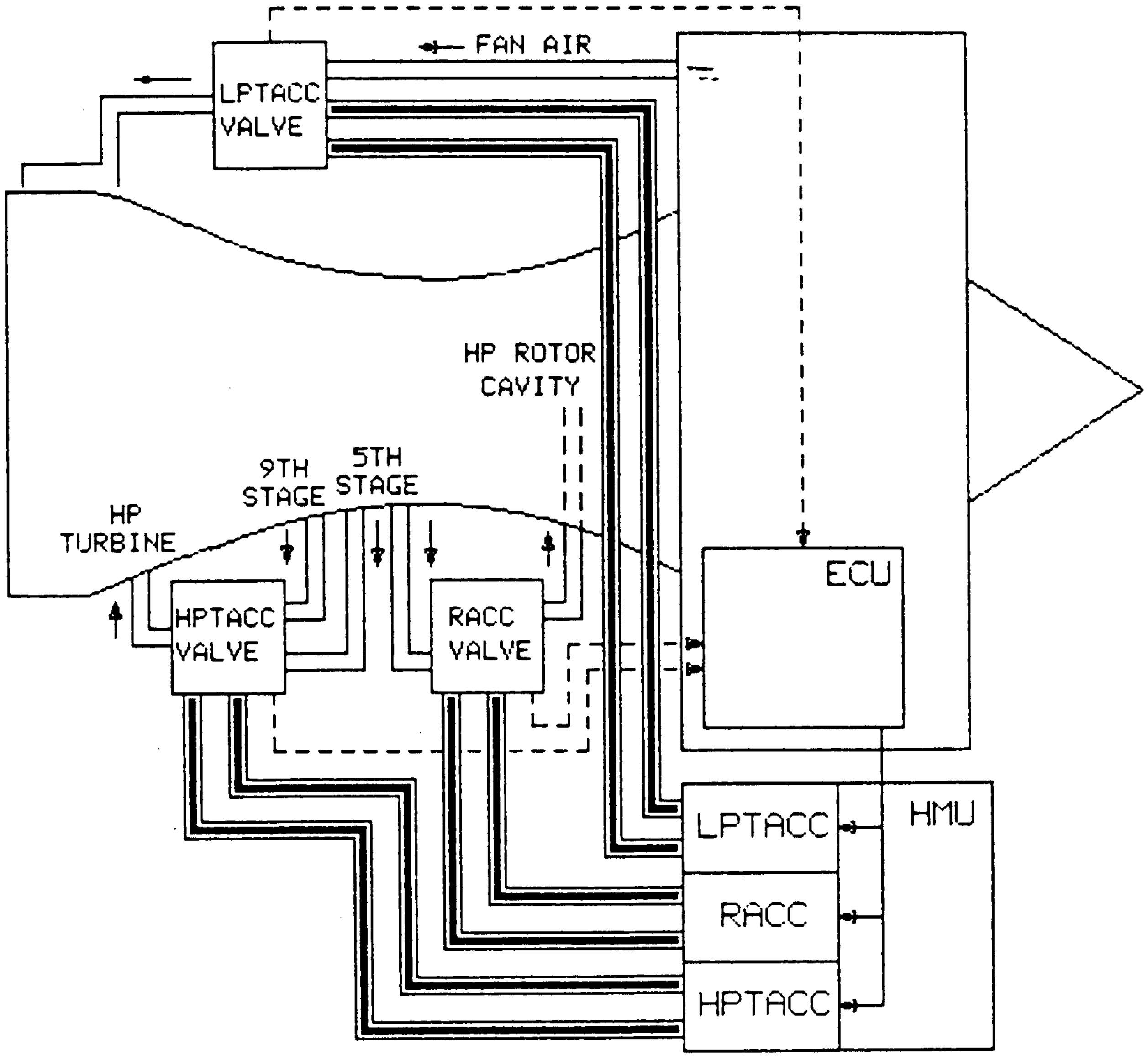


Figure 105 Active Clarance Control Systems

ROTOR ACTIVE CLEARANCE CONTROL SYSTEM

Note: Not installed on new CFM 56 engines!

Purpose

The rotor active clearance control system (RACC) is controlled by the FADEC system which maintains HPC rotor blade clearance relative to HPC stator compressor case.

The RACC system modulates the fifth stage high pressure (HP) compressor bleed air into the compressor rotor bore to vary and control the clearances. The air flow to the rotor is mixed with the booster discharge air. By heating the compressor rotor with fifth stage bleed air, the compressor clearances are reduced and improve the efficiency of the compressor and improving the overall Specific Fuel Consumption (SFC) of the engine.
When the RACC valve is closed, the total air flow through the rotor is from the booster discharge air and the clearances are maximized.
As the RACC valve opens, the amount and temperature of the air through the rotor is increased due to the introduction of fifth stage bleed air, and the clearances are closed to optimize performance.

The ECU needs the following control signals to position the RACC valve:

- N2
- P0 (Altitude)
- T3
- M0

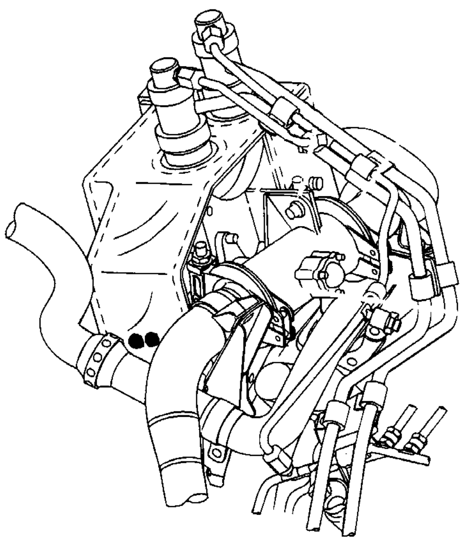
The valve stays in the closed position:

- M0<0,3 and
- T3>530° C

ROTOR ACTIVE CLEARANCE CONTROL VALVE

The rotor active clearance control (RACC) valve is a butterfly valve with one inlet port and one outlet port.
The valve has a RACC port and a PCR (case preesure from HMU) port and consists of an outer housing, a rotating plate, and an integral fuel powered actuator with dual independent transducers for position feedback.
The inlet port receives 5th stage compressor bleed air which is modulated by rotating the plate.
The RACC valve outlet port supplies modulated bleed air. The RAC valve is located on the HPC compressor case at 12:00 o'clock.

RACC Control Valve



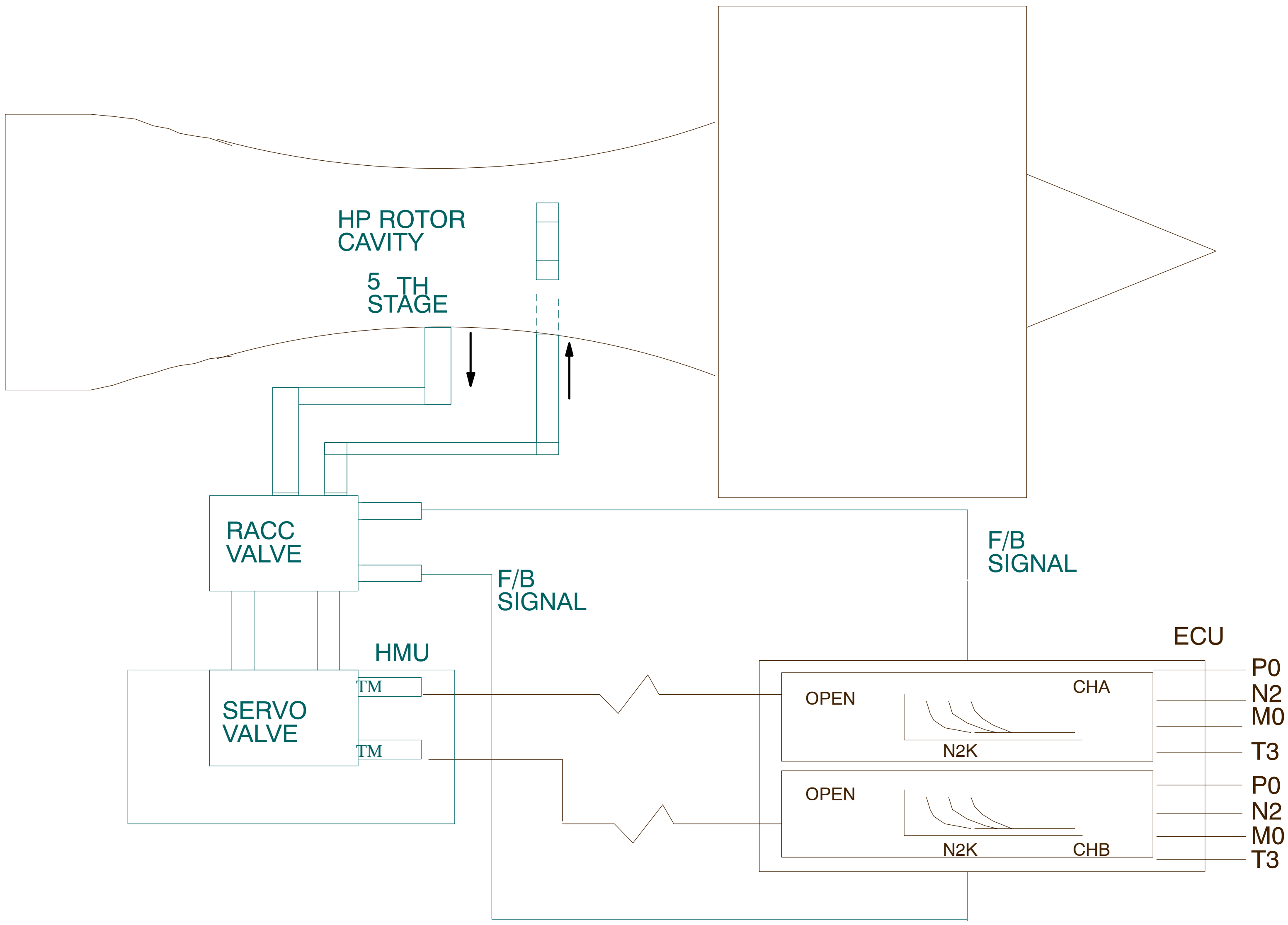


Figure 106 RACC System Schematic

HP TURBINE CLEARANCE CONTROL SYSTEM

Purpose

The CFM56 engine high pressure turbine (HPT) clearance control system uses high pressure compressor (HPC) bleed air from stages 5 and 9 to obtain maximum steady-state HPT performance and to minimize exhaust gas temperature (EGT) transient overshoot during throttle bursts. Air selection is determined by fuel pressure signals from the hydromechanical unit (HMU).The bleed air is ducted from the valve to a manifold surrounding the HPT shroud. The temperature of the air controls the HPT shrouds clearance relative to the HPT blade tips.

Description

The clearance control system supplies HPC bleed air from the 5th and 9th stage air to the HPT shroud support to control the thermal expansion of the shroud support structure. The bleed air is modulated by the electronic control unit (ECU) in response to the shroud temperature sensed by the turbine clearance control (TCC) sensor.
On engine start the HPTCC valve ports 9th stage air to unload the compressor and enhance engine acceleration. At ground idle power setting, the air flow to the HPT shroud is essentially from the HPC stage 9 bleed. When the throttle is advanced or retarded to change the core engine speed, the air flow is regulated to maintain the optimum HPT shroud to blade tip clearance.
When the engine is shut down, the hydraulic actuator valve rod is retracted to the start position.

The HPT Clearance Control Systems uses the following control signals:

- N2
- T3,
- Tcase

The valve has 3 control schedules and is also used as a start bleed valve.
The 3 schedules are:

1. Steady State Schedule
2. Acceleration Schedule
3. Deceleration Schedule

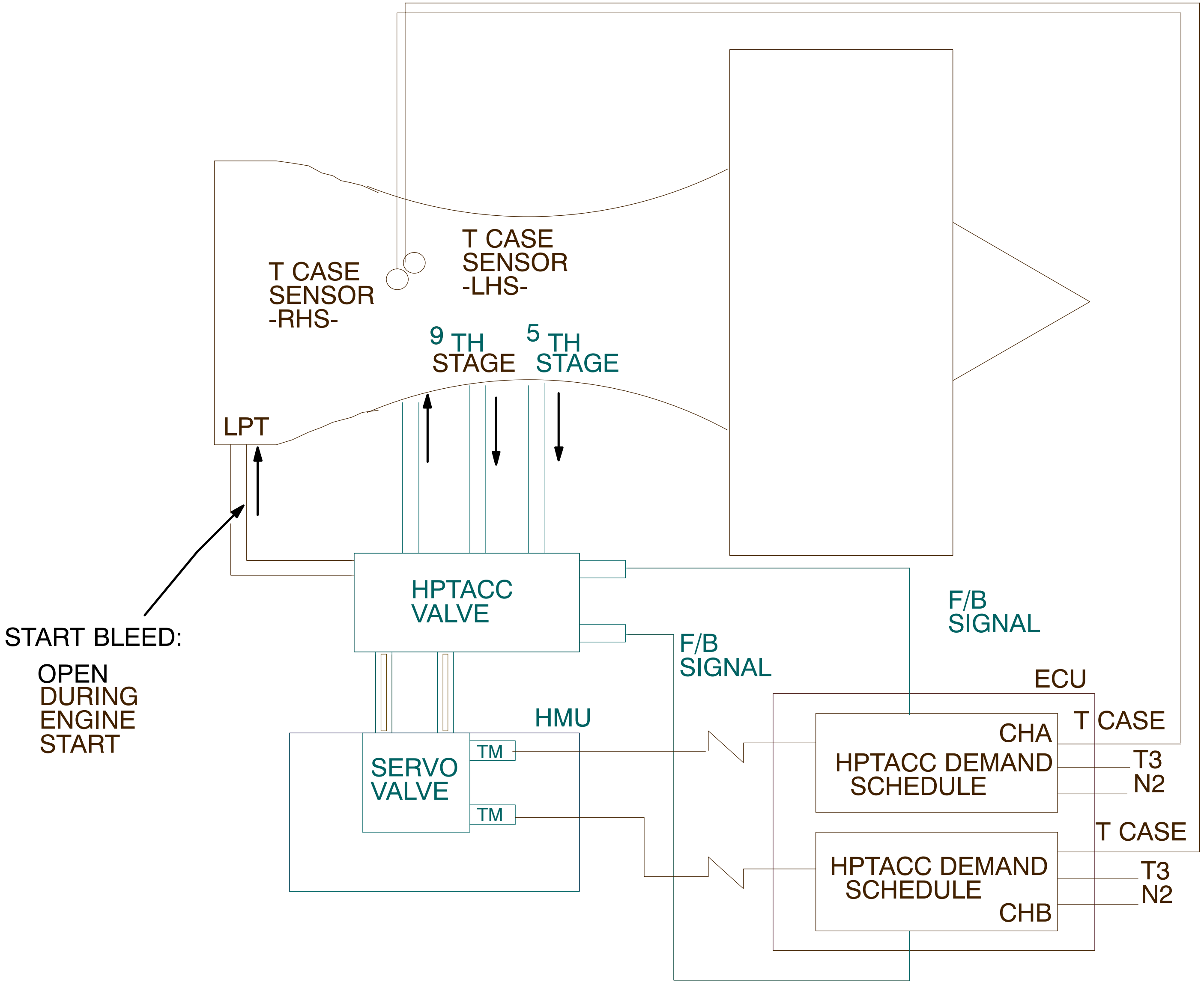


Figure 107 HPTACC System Schematic

HPT CLEARANCE VALVE

The high pressure turbine clearance control valve is a three-way valve with two inlet ports, 5th and 9th stage, and two outlet ports. One outlet port provides a start bleed function and the other outlet port flows a mixture of 5th and 9th stage air to the turbine case. The valve consists of an outer housing, two metering plates, an axial moving contoured piston, and an integral fuel powered actuator with dual independent transducers for position feedback. The piston and the metering plates constitute variable orifices that achieve the proper mix of 5th and 9th stage air.

T-Case Sensor

The 2 T-case sensors measure the temperatures in the HP Case and send this signal to the ECU.The ECU then decides which air supply (5th or 9th stage) must be used (cooling or heating)

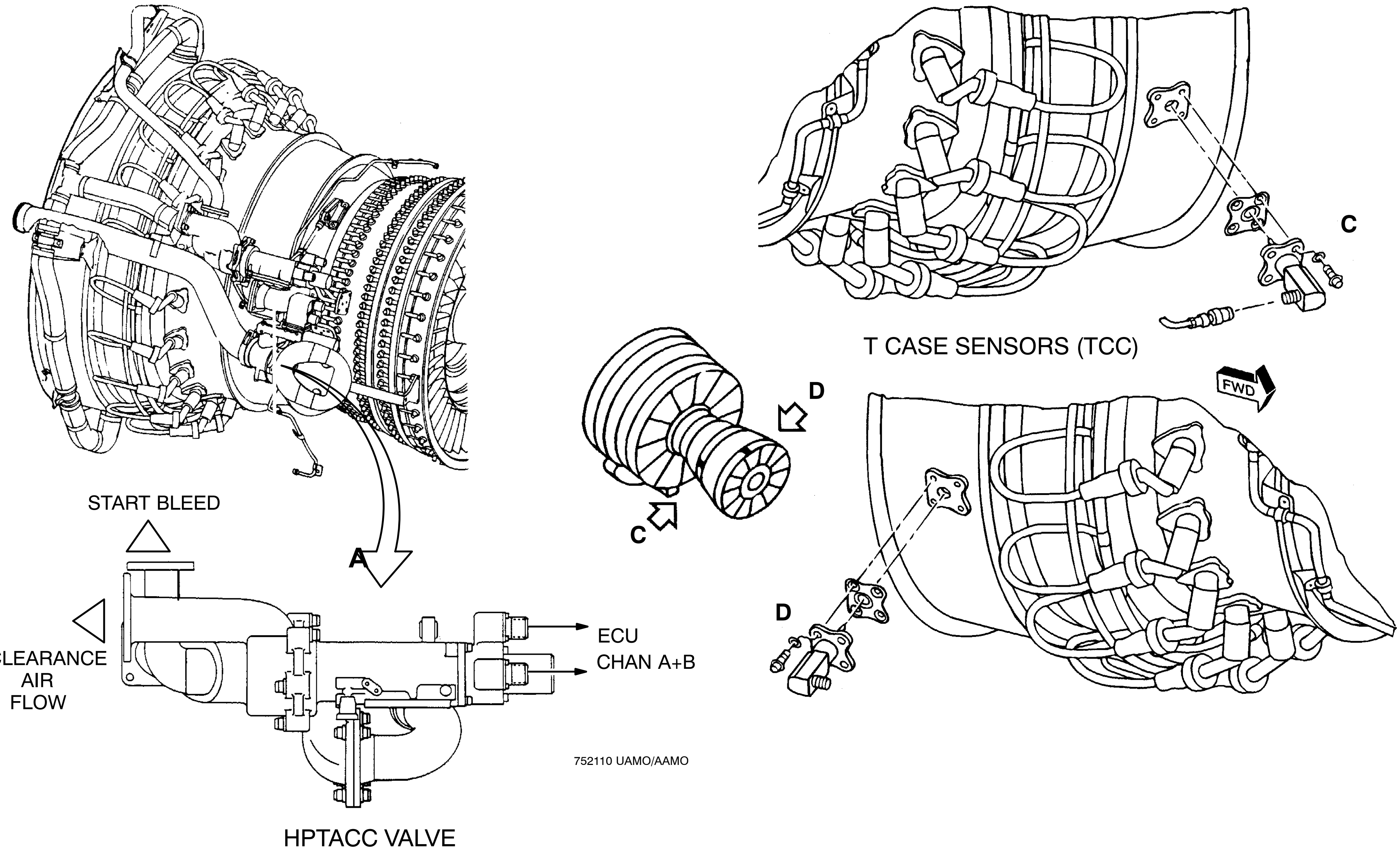


Figure 108 HPTCC Valve, Location and Bottom View

LPTCC SYSTEM

Purpose

The low pressure turbine casing is cooled by fan discharge air sprayed through an array of piping and small air jets that impinge on the outside surface of the casing.
The LPT active clearance control system controlled by a valve through FADEC system maintains LPT case shroud clearances relative to LPT rotor blade tips.

Operation

The ECU modulates the pressure of one of the piston chambers through the HMU.
The HMU supplies a reference pressure to the second chamber.
The ECU controls the travel of the piston and valve butterfly according to the engine parameters.
The butterfly of the valve opens when the engine rating increases and closes when it decreases.
When the engine is shut down, the valve butterfly is fully open.

LPT cooling air flow, controlled by LPTACC valve depends on the operating conditions and engine characteristics. Flow functions defined are validated for ventilation calculation purpose.

The fan bleed air flow is modulated by ECU according to the following engine operating conditions.

- N1
- P0
- TAT
- PT2
- T12

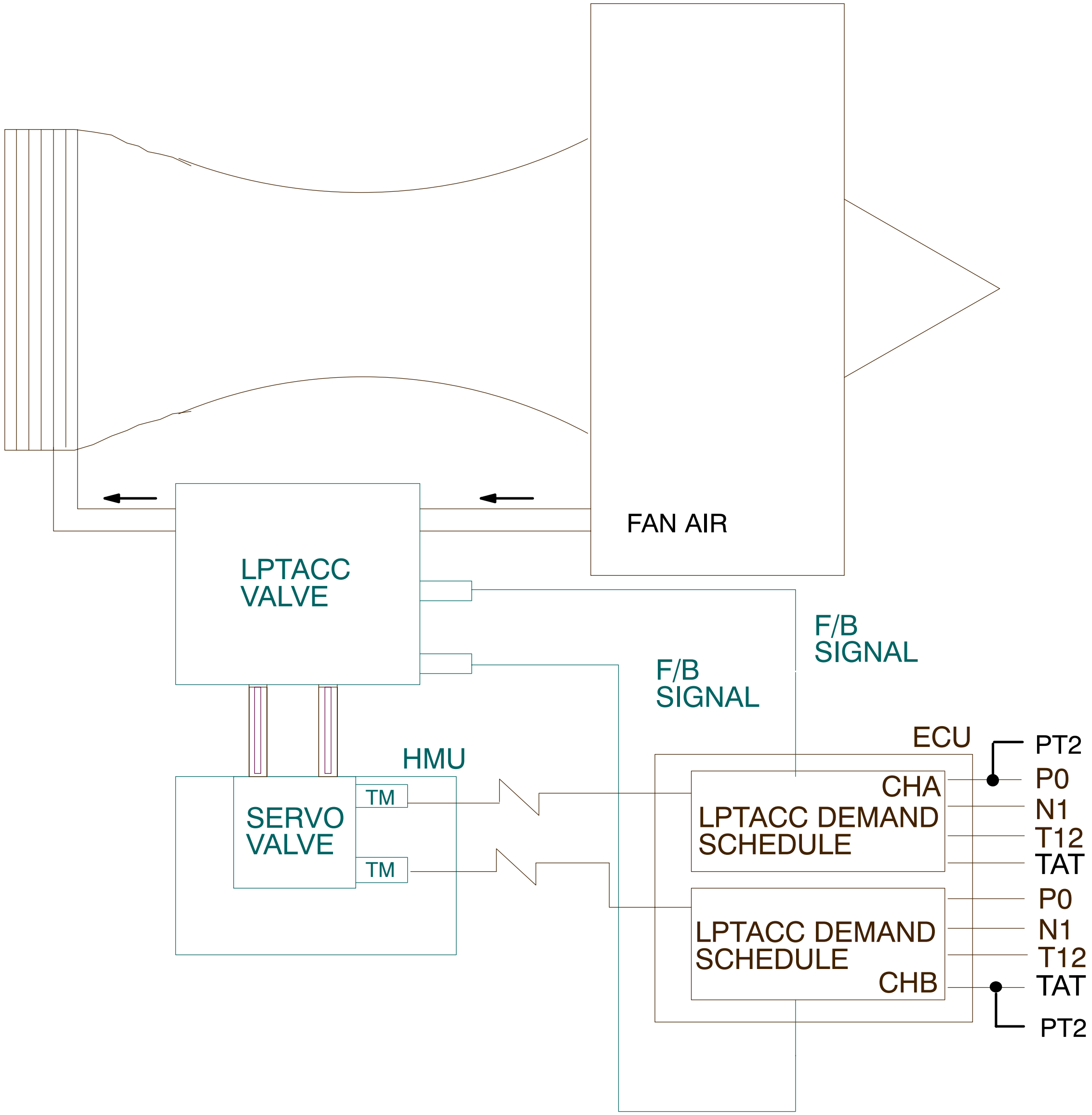


Figure 109 LPTACC System Schematic

LPT CLEARANCE CONTROL VALVE

LPT clearance control valve is a butterfly valve, the valve consists of an outer housing, a control plate, a linear actuator, 2 RVDT sensors for feedback signals and a butterfly valve actuation.
Under control of the PCR pressure applied at its head end and a PC/PB modulated pressure applied at its rod end, the linear actuator moves a rack controlling both the opening and closing of the butterfly valve which regulates the amount of air required for cooling the turbine as a function of the engine operating configuration (engine rating).

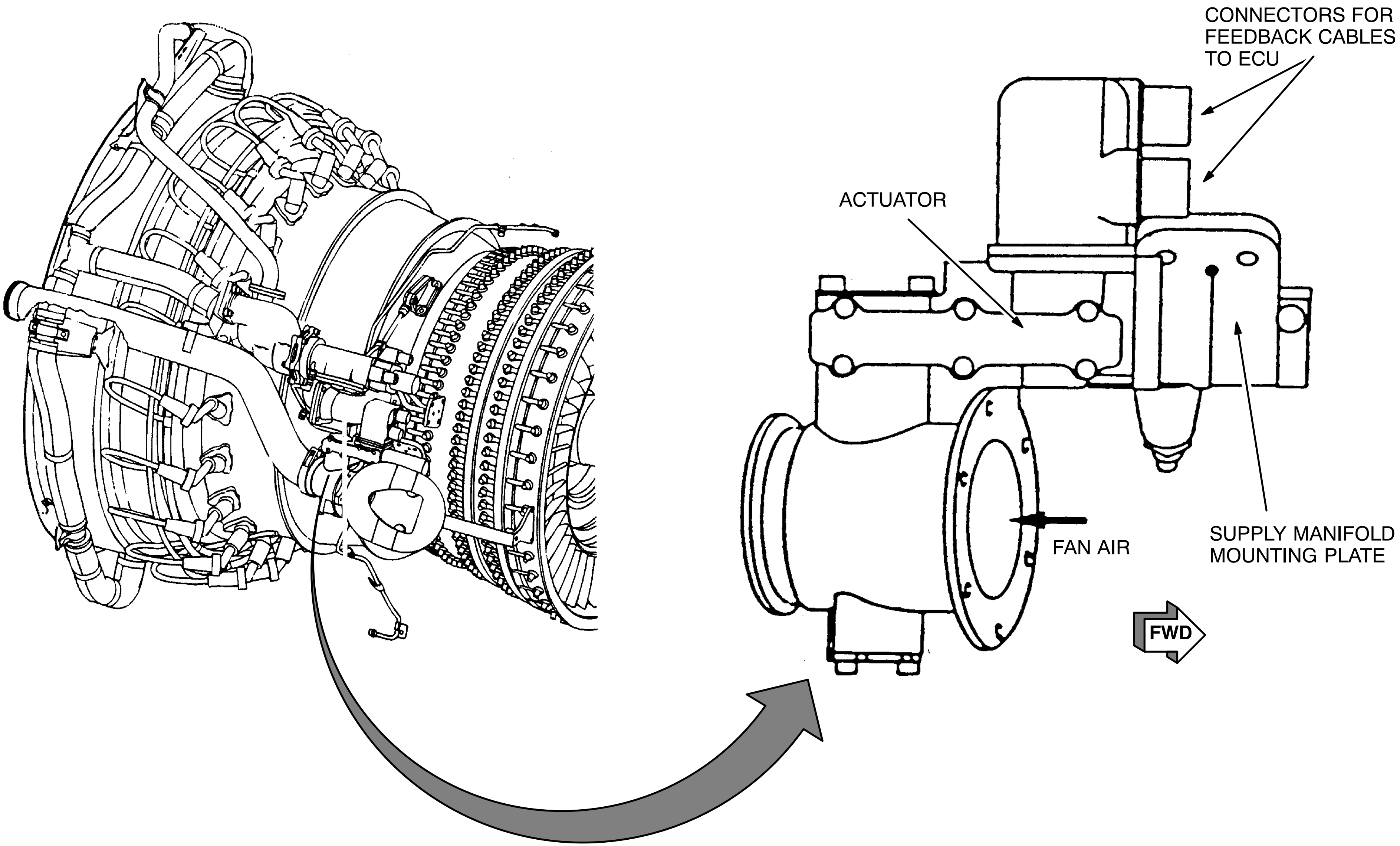


Figure 110 LPTCC Valve

75-30 COMPRESSOR CONTROL

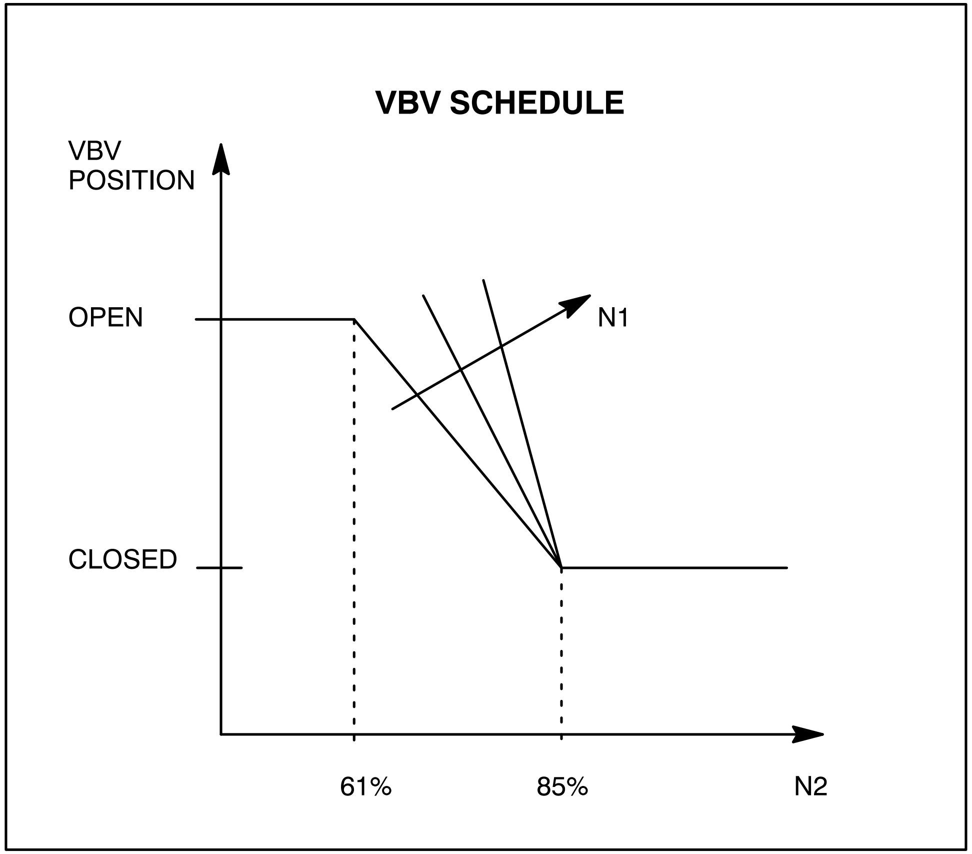
VARIABLE BLEED VALVE SYSTEM

The variable bleed valve (VBV) position is related to the high pressure compressor (HPC) operation. It is directly controlled by the angular setting of the variable compressor stator vanes at steady-state operation and during acceleration. The bleed valves open during low and transient operations to increase the booster mass flow and to improve booster and HPC matching. The bleed valves are fully open during fast decelerations. The bleed valve control system includes the following:

- The Electronic Control Unit (ECU) which controls the VBV position and sends electrical signals to the Hydromechanical Unit (HMU).
- An hydromechanical servo, integrated within the HMU, which supplies high pressure fuel signals to a gear motor.
- A power unit, which is a fuel-powered hydraulic gear motor. It operates under high pressure fuel from the HMU.
- A mechanical transmission system which includes:
  - A stop mechanism
  - A bleed valve main flexible shaft assembly located between the master ballscrew actuator and fuel gear motor.
  - A master bleed valve with a master ballscrew actuator.
  - 11 compressor bleed valves with ballscrew actuators
  - 11 flexible shafts between the ballscrew actuatores.
  - A position sensor (RVDT) connected to the master bleed valve.

The following control signals are used to position the VBV:

- N1
- N2
- VSV-Position



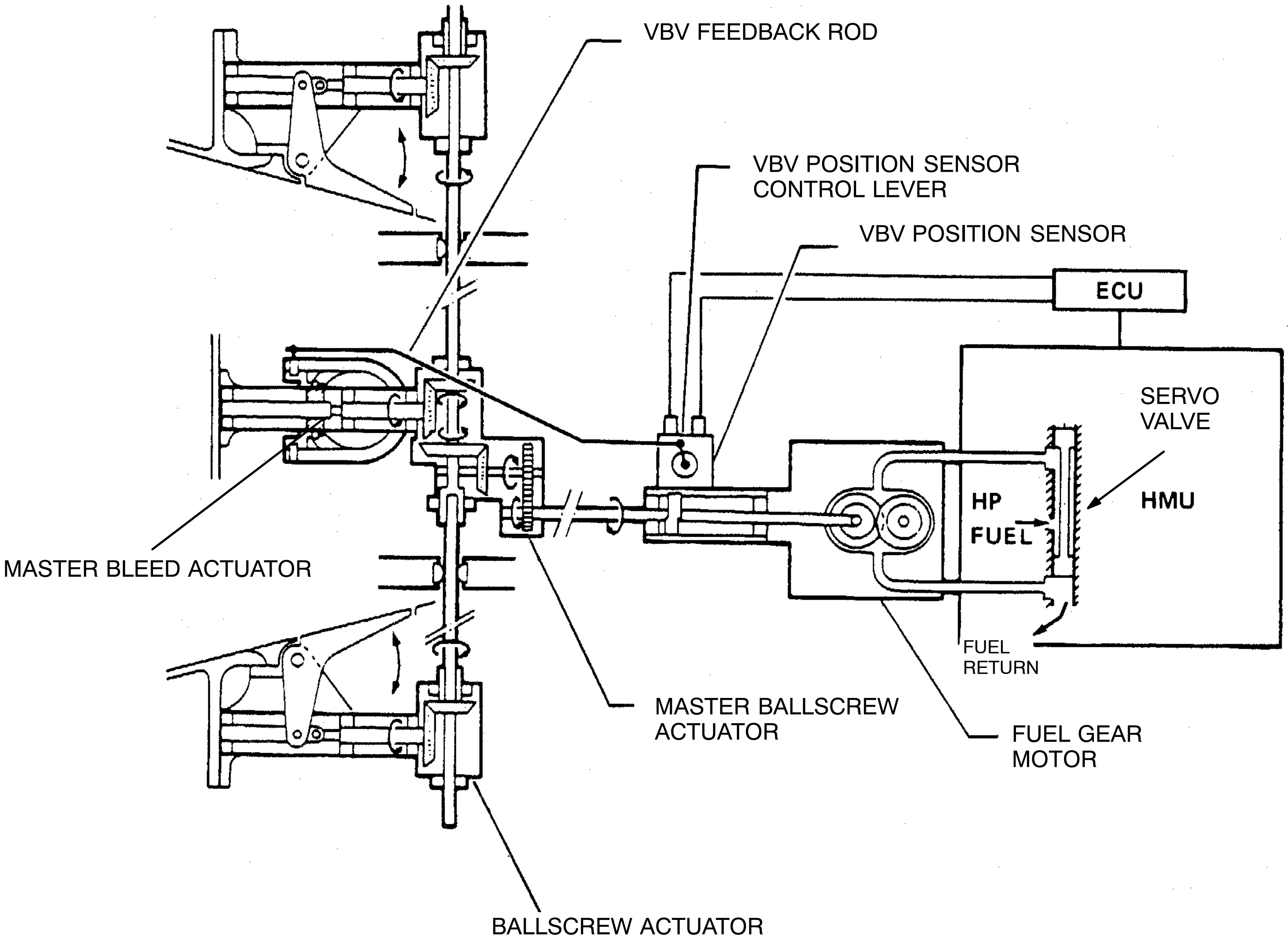


Figure 111 VBV System, VBV Schedule

VBV SYSTEM

The VBV actuation system provides an angular output through fuel gear motor assembly, master ballscrew actuator assembly and 11 ballscrew actuator assemblies. The system is interconnected by 11 flexible shaft assemblies. Eleven ferrules are installed in the engine struts to provide support for the flexible shaft assemblies.The system is designed to open, close, or modulate the 12 VBV doors to an intermediate position in response to an input command signal. The VBV's remain fully synchronized throughout their complete stroke by the continuous mechanical flexible shaft arrangement. High pressure fuel hydraulically activates the VBV actuation system. The VBV position sensor provides VBV position bias to the ECU. The master ballscrew actuator assembly is connected by a push-pull feedback rod to the VBV position sensor.

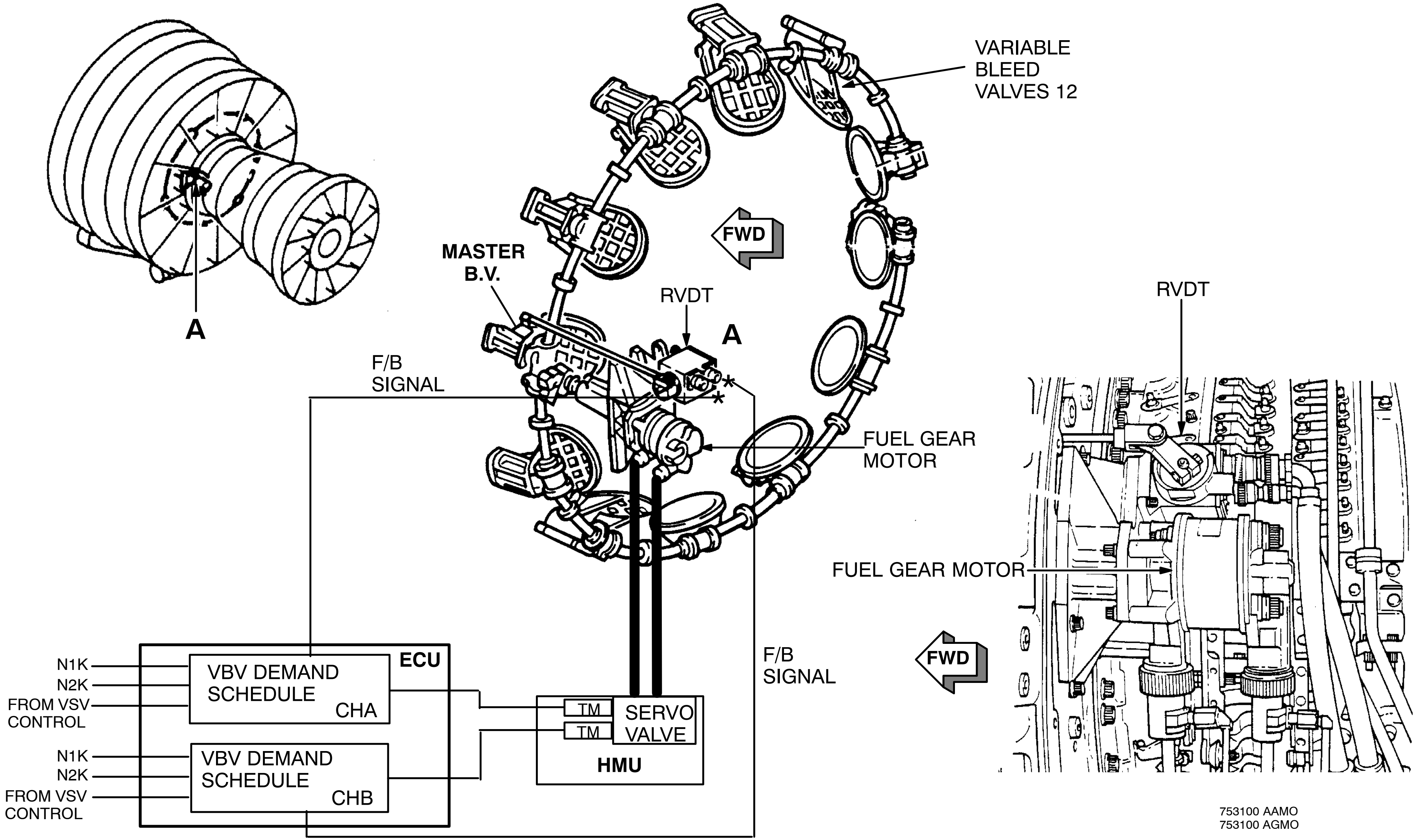


Figure 112 VBV System

VBV SYSTEM OPERATION

Modulating Operation
The motor, actuated by the HMU, drives the system to the commanded position with the required power. The pressure across the motor is reduced as the system approaches the commanded position. The electrical position feedback to the ECU directs the fuel control valve to its null position or minimum opening needed to neutralize the bleed valve loads.

Bleed valves closing.
The feedback electrical mechanism relays the bleed valve position to the ECU as the system approaches the commanded closed ECU position.The fuel control valve is moved towards the null position as the bleed valve approaches the end of its stroke. This reduces motor speed and allows the motor to engage the end-of stroke stops at a low impact force.
The closed bleed valve position is within 0.3 percent of the stroke of the ballscrew actuator assembly utilizing the mechanical stops.

Bleed valves opening
The feedback electrical mechanism relays the bleed valve position to the ECU as the system approaches the commanded open position. The fuel control valve is positioned to decelerate the motor.
The same type of mechanical stops are used at the opening end of the stroke. The open bleed valve position is within one percent of the stroke of the ballscrew actuator assembly utilizing the mechanical stops. All the 12 bleed valves are mechanically synchronized.

Stop Mechanism

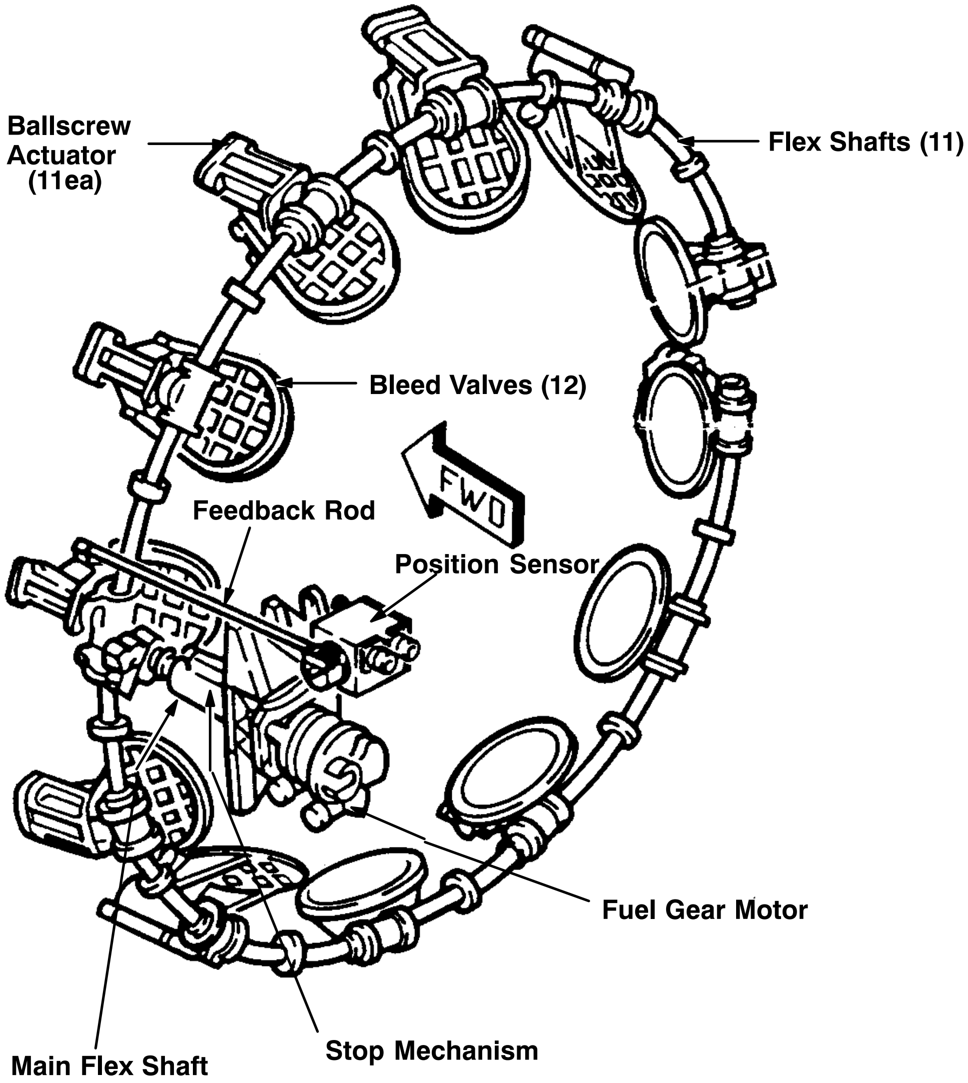
The bleed valve stop mechanism assembly is a component of the Variable Bleed Valve (VBV) actuation system. It is located between the bleed valve fuel gear motor and master ballscrew actuator, on the aft face of the fan frame at the 9' o'clock position, aft looking forward.

Description

The function of the bleed valve stop mechanism assembly is to limit the number of revolutions of the bleed valve fuel gear motor to the exact number required for a complete cycle (opening-closing) of the VBV doors. This limiting function supplies the reference position for installing and adjusting the VBV actuators.

The bleed valve stop mechanism consists of a housing for a hollow screw which is driven by the bleed valve fuel gear motor. This hollow screw shaft holds the main VBV flexible shaft which connects the bleed valve fuel gear motor to the master ballscrew actuator. A follower nut runs along the screw and stops the rotation of the bleed valve fuel gear motor when it reaches the ends of the screw threads.

A location is provided on the aft end of the bleed valve stop mechanism for installation of a Rotary Variable Differential Transformer (RVDT).



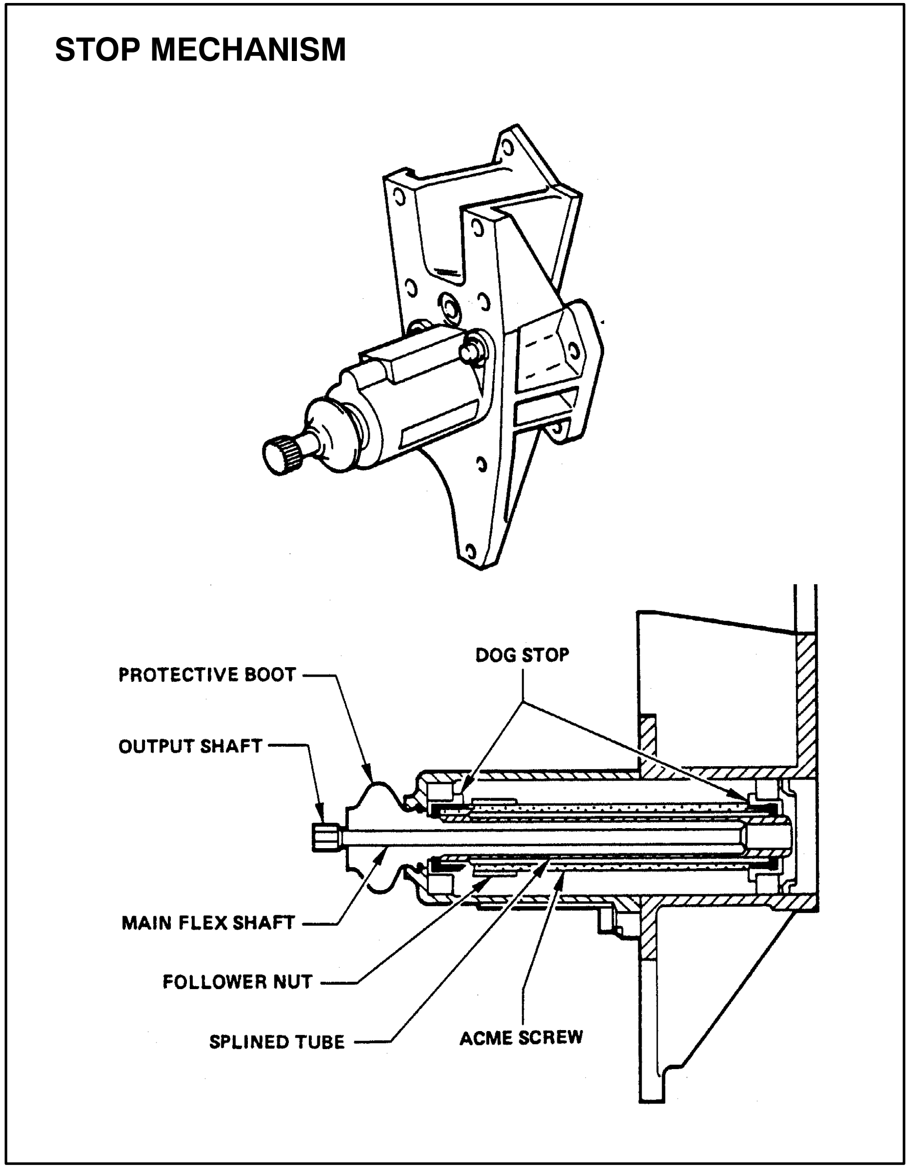


Figure 113 VBV System Components

VBV DOORS & FLEX SHAFTS

VBV Doors

To improve the flowpath and hail ingestion capacity 12 VBV cast doors are installed (except the VBV door in front of the T25 sensor, at the 4:30 o'clock position).Eleven scoops and 9 slides are attached to the fan frame.
The VBV's remain fully synchronized throughout their complete stroke by the continuous mechanical flexible shaft arrangement.

Flexible Shafts (11)

The flexible shaft assembly is an unshielded power core which has a hexagon fitting on one end and an 8-point fitting on the other. A spring is attached to the hexagon end. The spring holds the shaft assembly in position during operation and also permits easy removal of the shaft assembly.

Main Flexible Shaft (1)

The main flexible shaft assembly is an unshielded power core which is installed between the stop mechanism and the main ball screw actuator. It has a hexagon fitting on one end and a splined end fitting on the other. A spring is attached to the spring end. The spring holds the shaft assembly in position during operation and also permits easy removal of the shaft assembly.

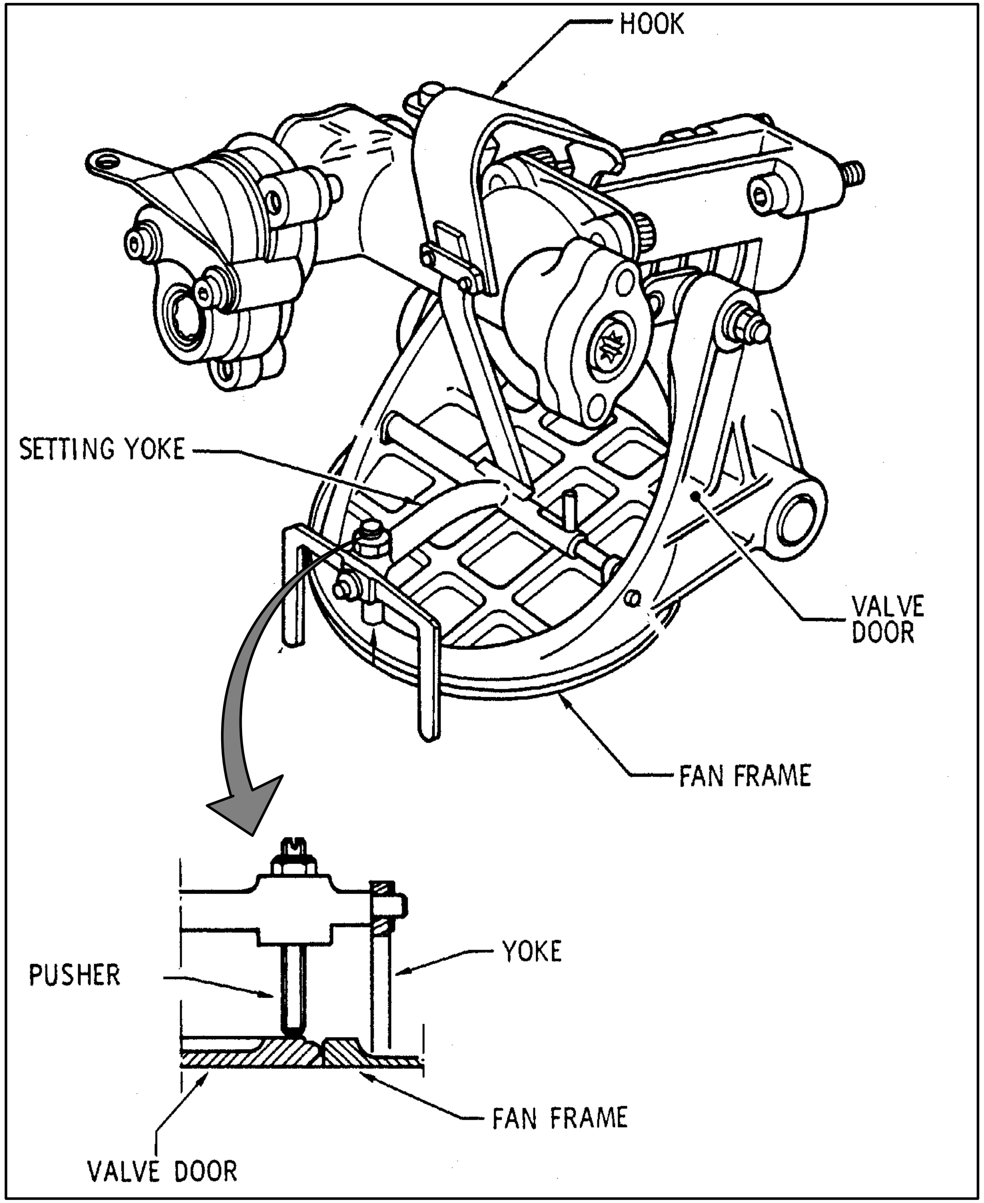
Bleed Valve and Master Ballscrew Actuator Assembly

The master ballscrew actuator is located on the fan frame under fan duct panel at the 9:00 o'clock position, aft looking forward.

The master ballscrew actuator is the unit which transfers the driving input from the bleed valve fuel gear motor to the ballscrew actuator system. It consists of a speed- reduction gearbox and a ballscrew actuator linked to a hinged door. Speed reduction is consecutively carried out through one pair of spur gears and then by 2 pairs of bevel gears. The last set of bevel gears drives the ballscrew.A lever, integral with the door, is connected to the position sensor. The output motion of the first pair of bevel gears is transferred to the 10 other ballscrew actuators through flexible shafts driven by 2 ends of the output gear of this pair of bevel gears.

VBV System Rigging

The rigging has to be done in the bleed valve closed position,which is established by using a setting yoke.
Refer to AMM Task 75-31-00-720 Adjustment/Test of the VBV System.



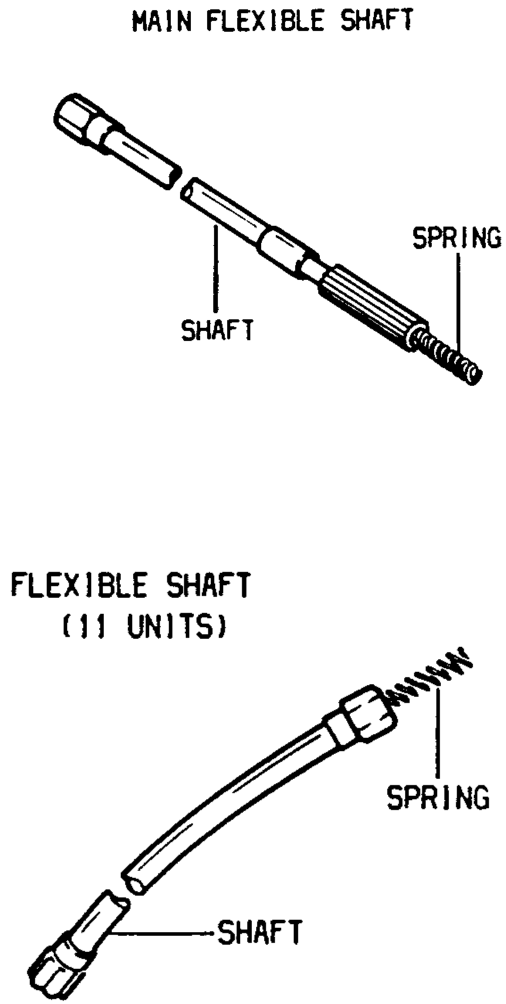


Figure 114 VBV Door Rigging & Flex Shaft

VBV POSITION SENSOR

General

The VBV position sensor is of the Rotary Variable Differential Transducer (RVDT) type. It is installed on the VBV stop mechanism.
It is electrically supplied provided by the Electronic Control Unit (ECU).
The Rotary Variable Differential Transformer (RVDT) senses the angular position of the entire VBV system and sends a corresponding signal to the ECU.

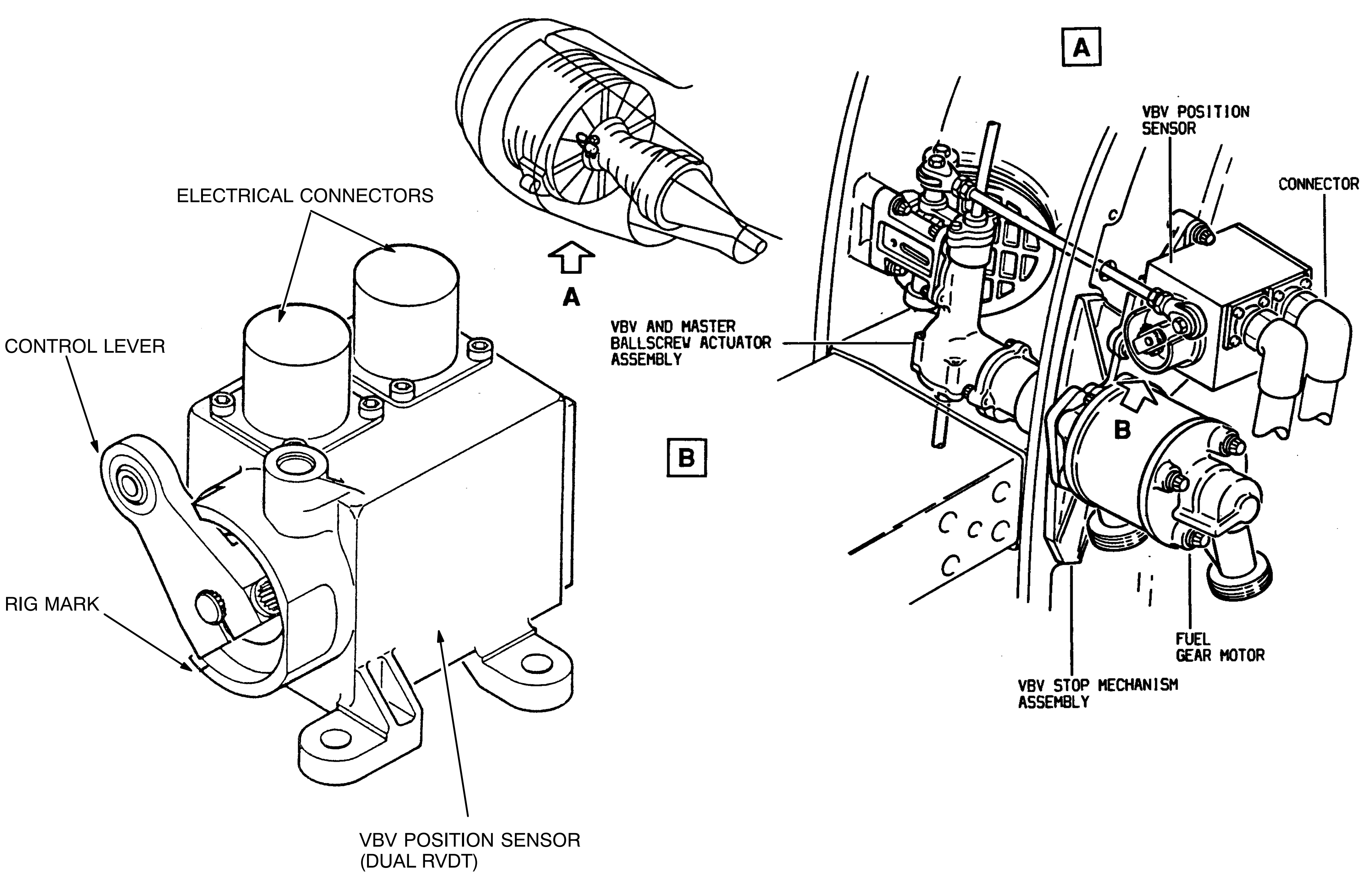


Figure 115 VBV Position Sensor / Rigging

VARIABLE STATOR VANES

The variable stator vane (VSV) actuation system consists of 2 VSV hydraulic actuators with dual independent transducers (LVDT) for position feedback, and 2 actuation mechanisms and linkages. Fuel pressure from the hydromechanical unit is the hydraulic medium used to operate the VSV actuators.

Description

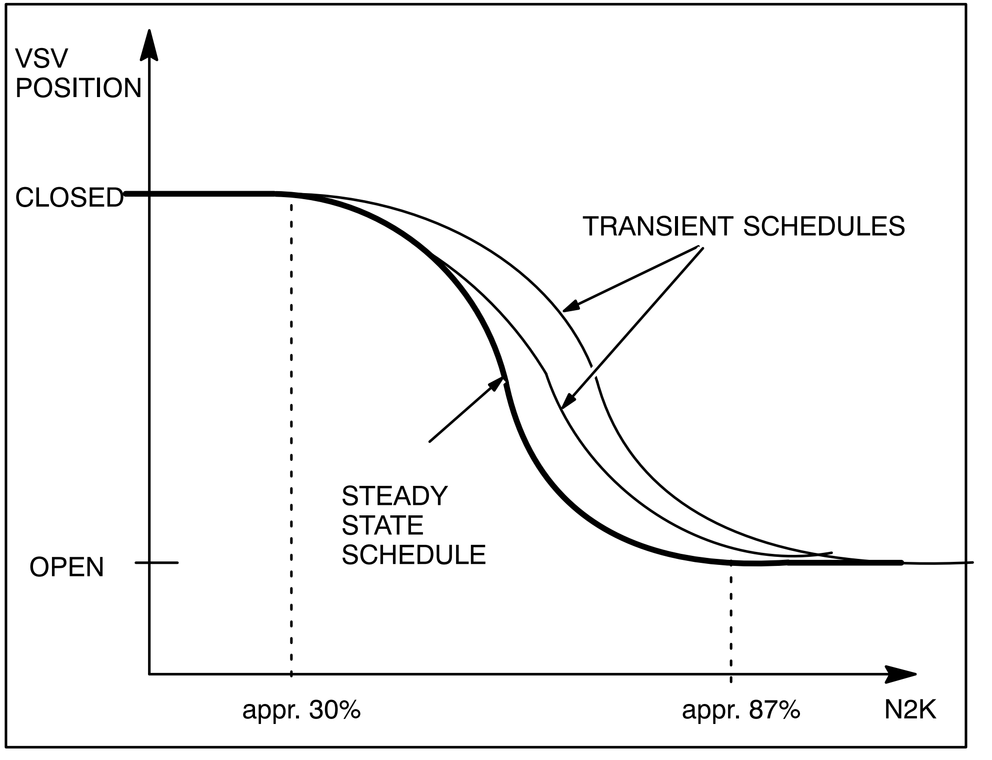
The VSV system positions the compressor variable stator vanes (IGV through stage 3) to the angles necessary to provide optimum compressor efficiency at steady state and provide adequate stall margin for transient engine operation. Stator vane angle is a function of core engine speed (N2) and compressor inlet temperature (T25).

The electronic control unit (ECU) schedules the VSV's by controlling the VSV actuation valve torque motor in the hydromechanical unit (HMU). The HMU ports high pressure fuel to the rod end or head end of the VSV actuators and vents the other end to bypass pressure. The actuator's position transducer (LVDT) transmits a feedback signal of actual vane position to the ECU for comparison to scheduled position.

Each VSV actuator is connected through a clevis link and the stage 3 bellcrank to a master rod. Linkages connect the variable vane actuation rings to bellcranks that are connected to the master rod.

Connections between the actuator, clevis links, and master rod are made with bolts and bushings for stability. All other linkages are connected with bolts and uniballs to eliminate misalignment or binding.

The actuation rings, which are connected at the horizontal split-line of the compressor casing, rotate circumferentially about the horizontal axis of the compressor. Movement of the rings is transmitted to the individual vanes through vane actuating levers.



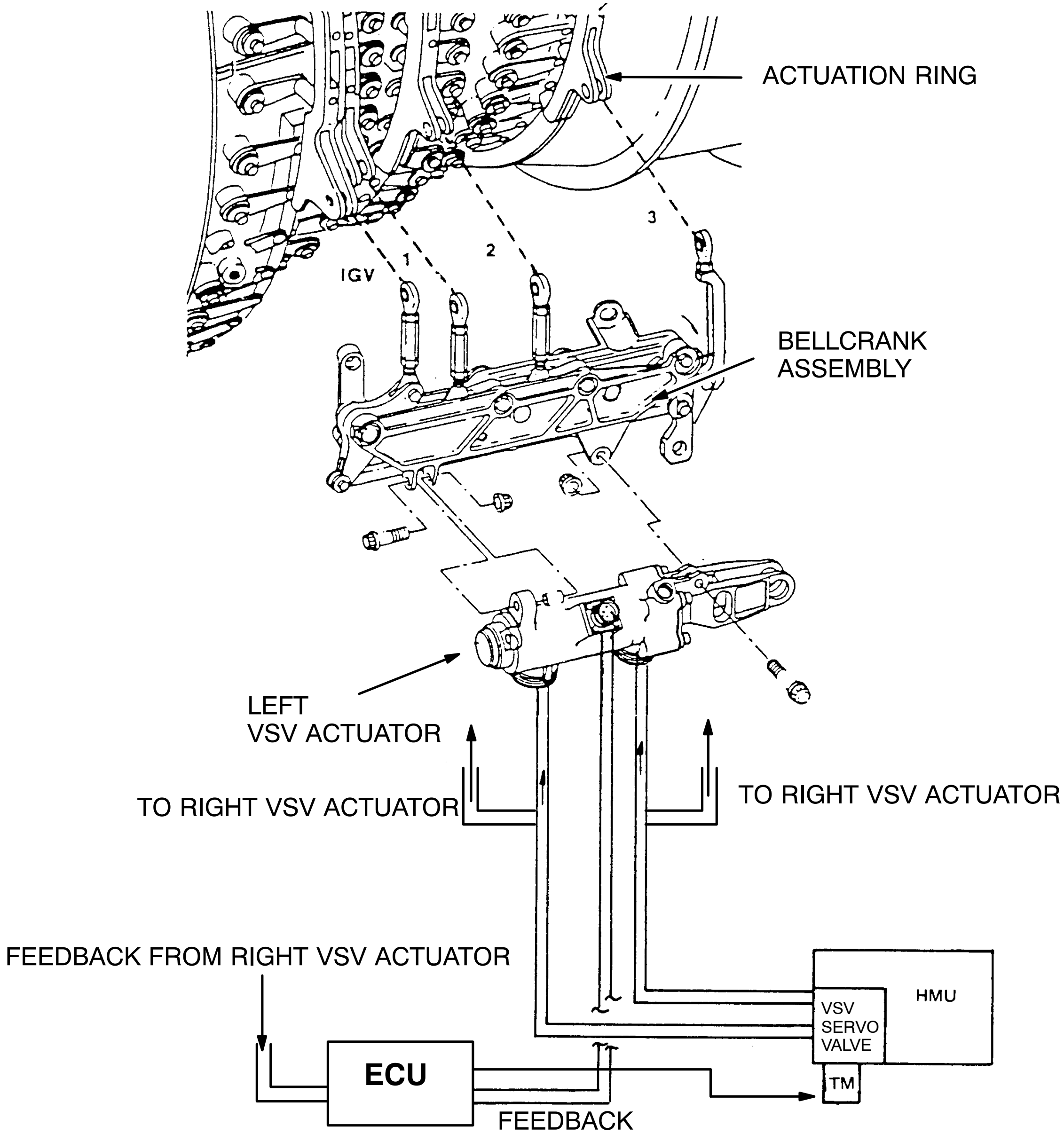


Figure 116 VSV System, VSV Schedule

NACELLE COOLING

The nacelle installation is designed to provide cooling and ventilation air for engine accessories mounted along the fan and core casing.

The nacelle is divided in three major areas:

- the engine air inlet
- fan compartment
- core compartment

The function of the nacelle components are:

- Sufficient airflow to offset the effects of engine case heat rejection and engine flange air leackage,thereby maintaining an acceptacle compartment temperature level.
- Cooling of temperature critical components.
- Cowling pressure load limiting in the event of pneumatic duct failures.
- Ventilation of compartment during engine shutdown.
- Ventilation of combustible fluid vapors to prelude fires.

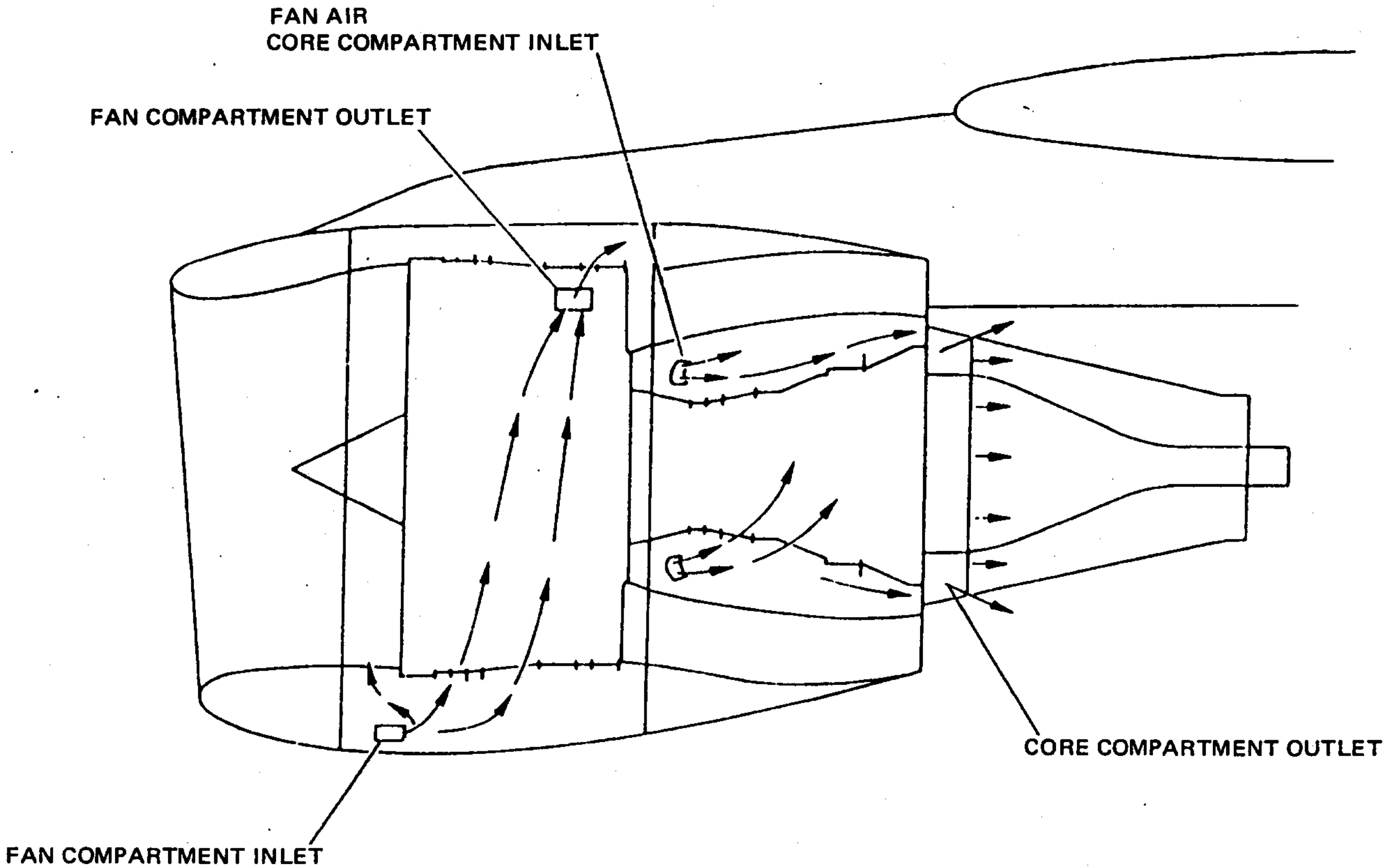


Figure 117 Nacelle Cooling

75-40 NACELLE TEMPERATURE

NACELLE TEMPERATURE GENERAL

Purpose

A nacelle temperature probe measures core compartment temperature. It will indicate overtemperature resulting from loose or broken air ducts or from loose flanges, worn VSV bushings etc.

Description

The nacelle temperature indicating system is composed of a probe and an indicator on the ECAM. The nacelle temperature probe has a measurement range of -55 deg. C to 300 deg. C (-67 deg. F to 572 deg. F).
The signal is fed to the EIU which transforms the analog information into digital form. Then the EIU transmit the data to the ECAM system.
When the value reaches 240 deg. C the indication flashes (green advisory).
During engine starting, this parameter is replaced by the starter shutoff valve position, the bleed air pressure indication and the selected ignitor.

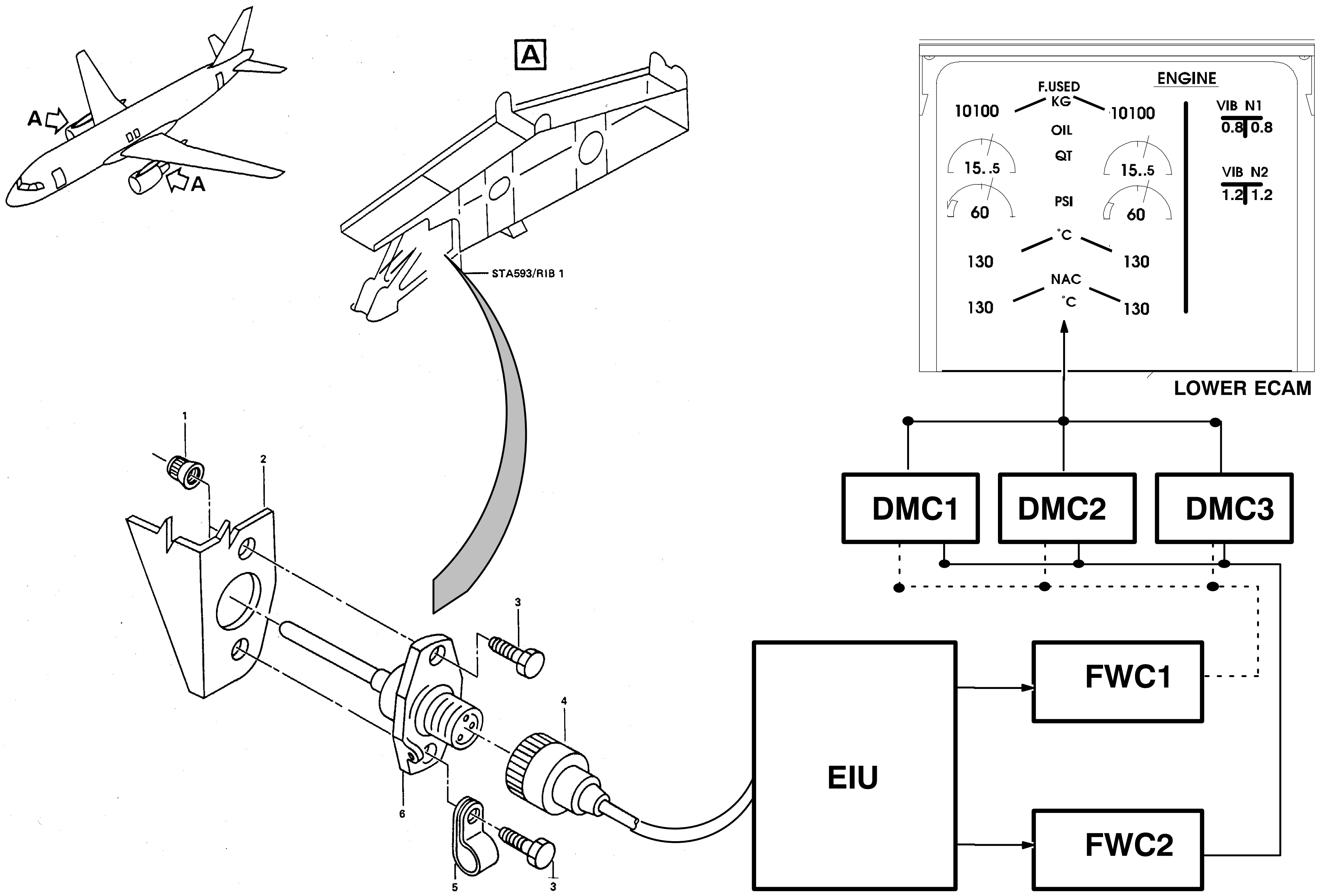


Figure 118 Nacelle Temp. Sensor / Indication

ATA 74 IGNITION

74-00 GENERAL

DESCRIPTION

The Engine Control Unit (ECU) controls and monitors the start sequence either in automatic or manual mode.

The ECU is able to abort the automatic start sequence in case of an incident:

- start valve failure
- ignition failure
- HP fuel shut off valve failure
- high EGT
- engine stall

The system consists :

- of a start valve
- an air starter
- two ignition boxes and
- igniters (A&B).

The start valve is fitted with a manual override handle for mechanic intervention on the ground.

CONTROL DESCRIPTION

Panel and Control Description

The Ignition System is controlled by:

- ENG MODE Selector Switch
- ENG MASTER Switch
- ENG MAN START Pb
- ECU
- EIU

ENGINE Control Panel

- It is installed on the Center Pedestal and comprises:
  - ENG MODE Selector Switch
  - ENG Master Switch (2)
  - Annunciator FAULT Light (2)
  - Annunciator FIRE Warning Light (2)

ENG MODE Selector Switch

-NORM Position

- Normal Position after ENG start:
  - in this Position the FADEC can select ignition automatically under the following conditions:
    - Engine Anti Ice ON
    - EIU Failure
    - Engine Flame Out Detected

-IGN/ST ART Position

has to be selected for:

- Normal Starting Procedure (Automatic)
- Alternate Starting Procedure (Manual)
- Continuous Ignition, when the engine is running.

when selected to IGN/Start :

- Both pack valves are closed.
  - If the engine start is not carried out within 30 sec the pack valves open again.
- FADEC is power supplied.

-CRANK Position

- FADEC is PWR supplied
- Ignition is inhibided,engine motoring is possible,when the ENG MAN START P/B is pressed in.

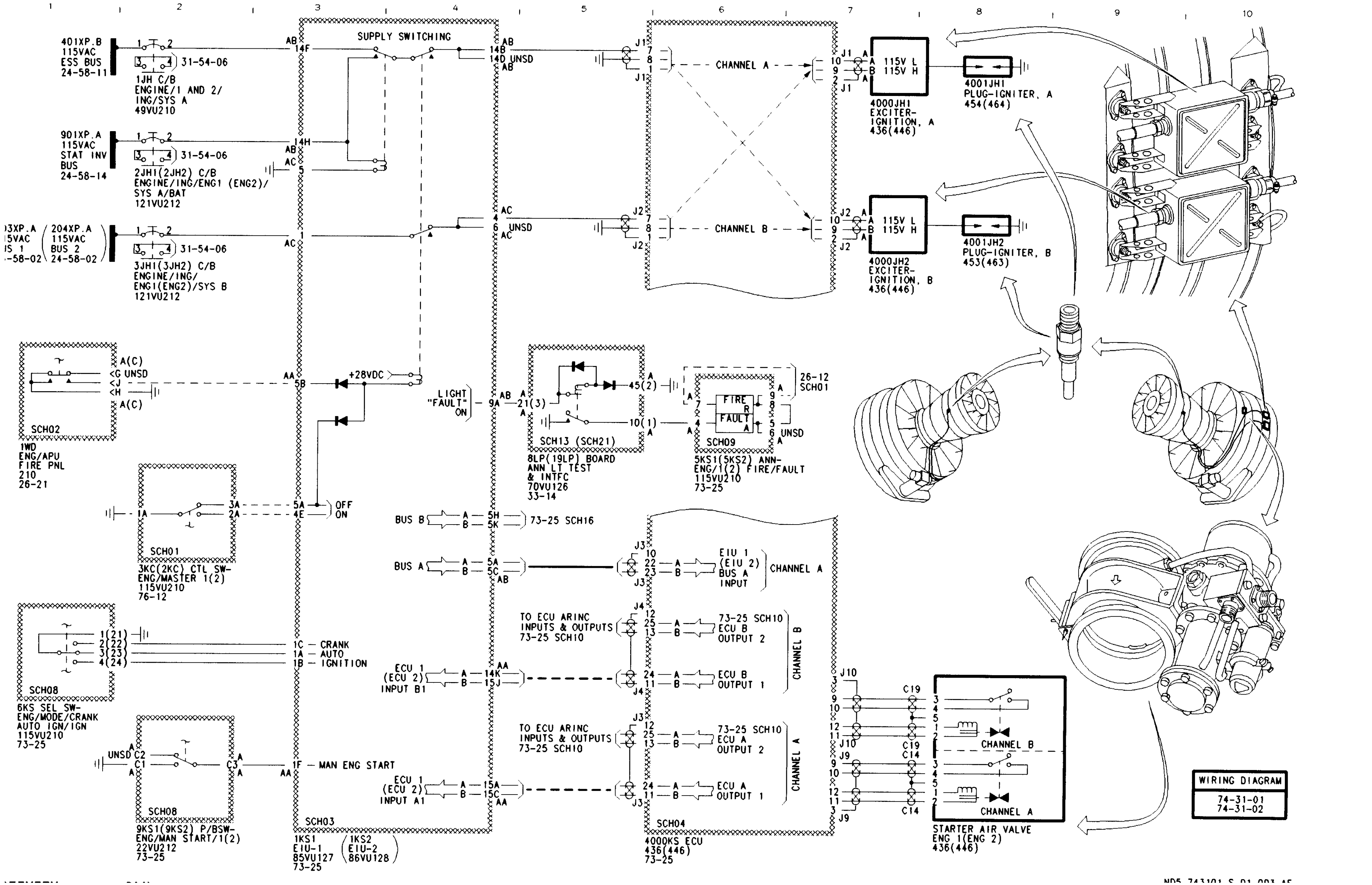


Figure 119 Ignition system schematic

GENERAL

ENG MASTER Switch (2)

has a ON and a OFF position

-ON Position

- Normal Starting Procedure (Automatic)
- Alternate Starting Procedure (Manual)
- Wet CRANKING Procedure
- Normal Engine Operation
- at Auto Start
  - EGT Limit Pointer is set to 725°C
  - N2 IND will be boxed in grey.
- LP Fuel valve opens
- HP Fuel shut off solenoid is deenergized (will be opend by fuel press)

-OFF Position

Resets the FADEC .

- LP Fuel valve closes
- HP Fuel shut off solenoid is energized to close position.

3.Annunciator FAULT Light (2) Amber

- installed on the 115 VU panel
- each engine has Fault Light
- triggert by the EIU
- illuminated if there is a disagree between the position of the Master Switch and the HP Fuel Sov (Pressurizing VLV) and after automatic start abort.

ENG MAN START PB's (2)

- are installed on the Overhead Panel, 22VU,
- One P/B for each engine.

-ON (blue) Position

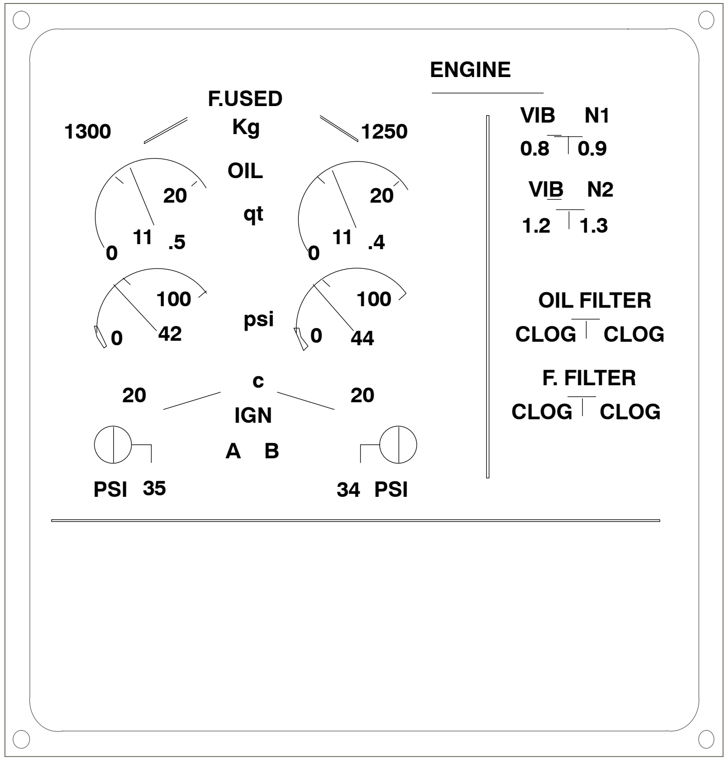
- aktivation of the opening signal for the starter air valve

at manual start:

- Manual Starting Procedure in the FADEC system.
- EGT Limit Pointer will be set to 725'C
- N2 Indication will be boxed in grey.

- OFF Position

- Starter Air VLV Closed.



ENGINE Start Page

- The engine start page appears when the ENG MODE Selector Switch is turned to the IGN/START or CRANK position.
- The starter valves and the duct press for each engine are displayed.
- The operating ignition system is displayed.

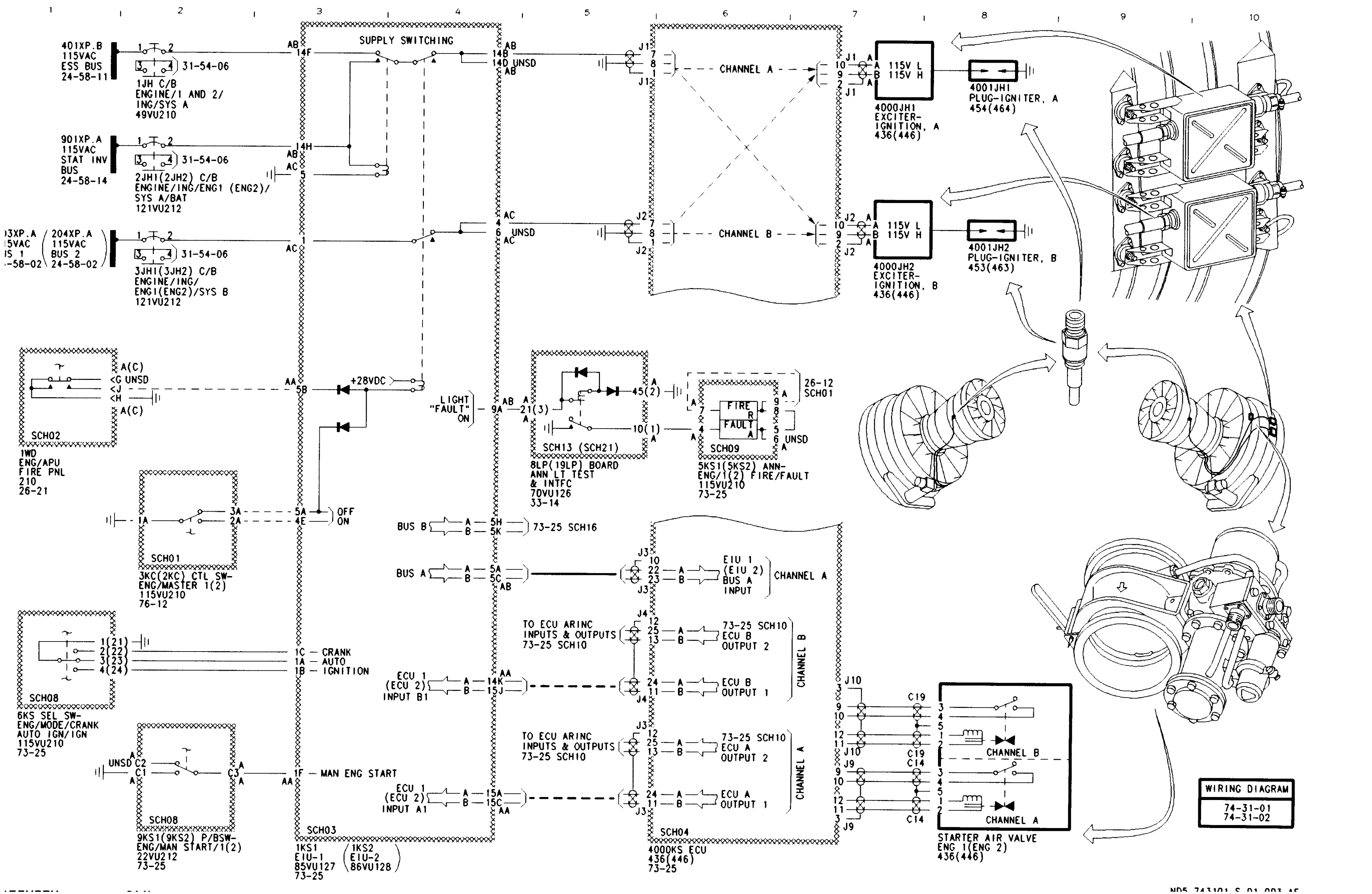


Figure 120 Ignition system schematic

IGNITION SYSTEM COMPONENTS

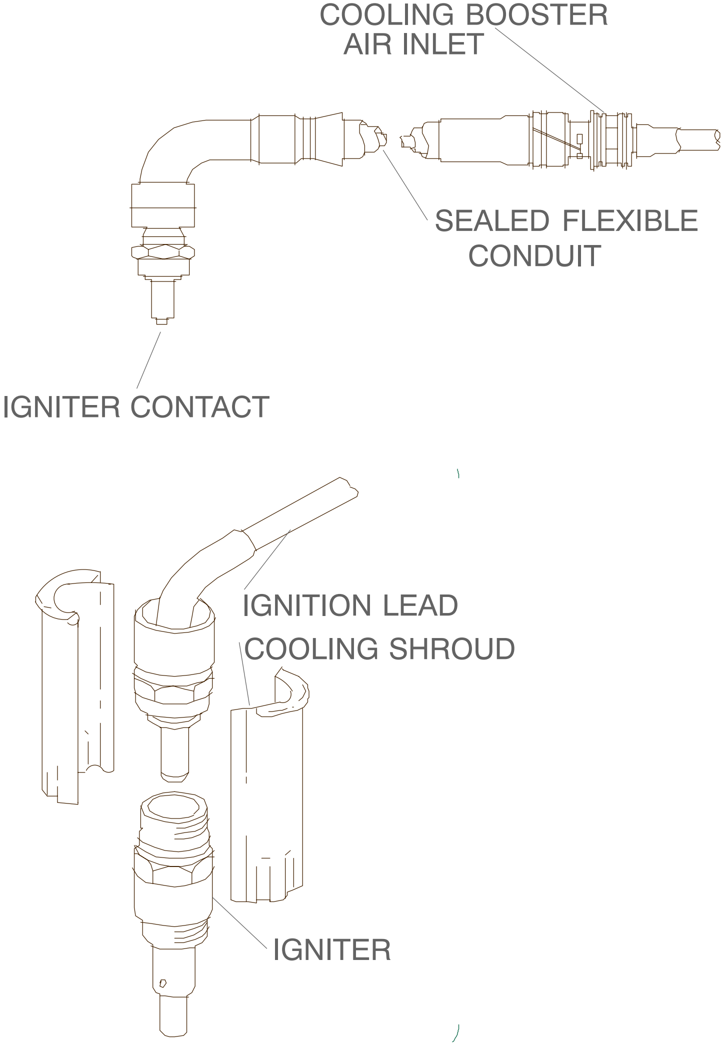
Ignition Boxes

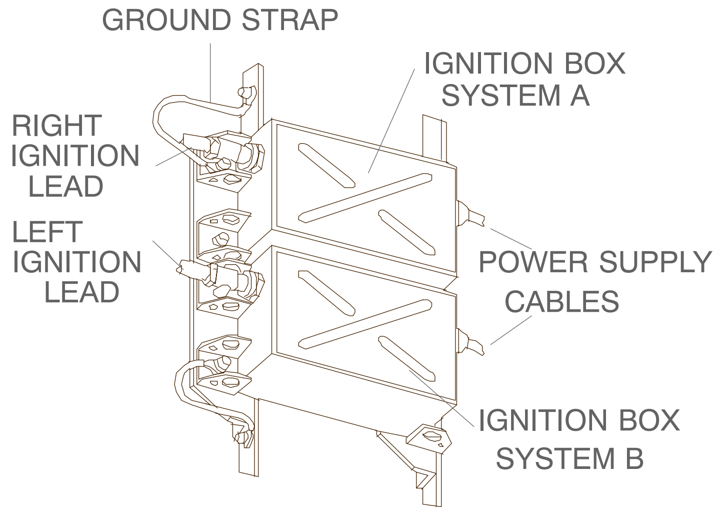
- Upper Box for system A.
- Lower box for system B.

The ignition boxes trasform 115VAC-400Hz into high voltage (15 to 20 KV),to charge internal capacitors .The discharge rate is of one per second and energy delivered is 1,5 joules.

Ignitors

- Right igniter for system A.
- Left igniter for system B.
- Precautions have to be taken before removel / installation
- An ignition test is available through MCDU menus to verfy the ignition circuit.





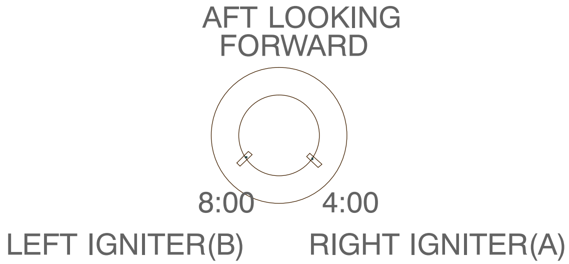


Figure 121 Ignition System Components

HIGH TENSION LEADS COOLING

Ignition Leads

The are insulated wire type and fan air cooled in the core area. They transmit electrical energy for ignition sparks.

The high tension leads are cooled by booster discharge air.

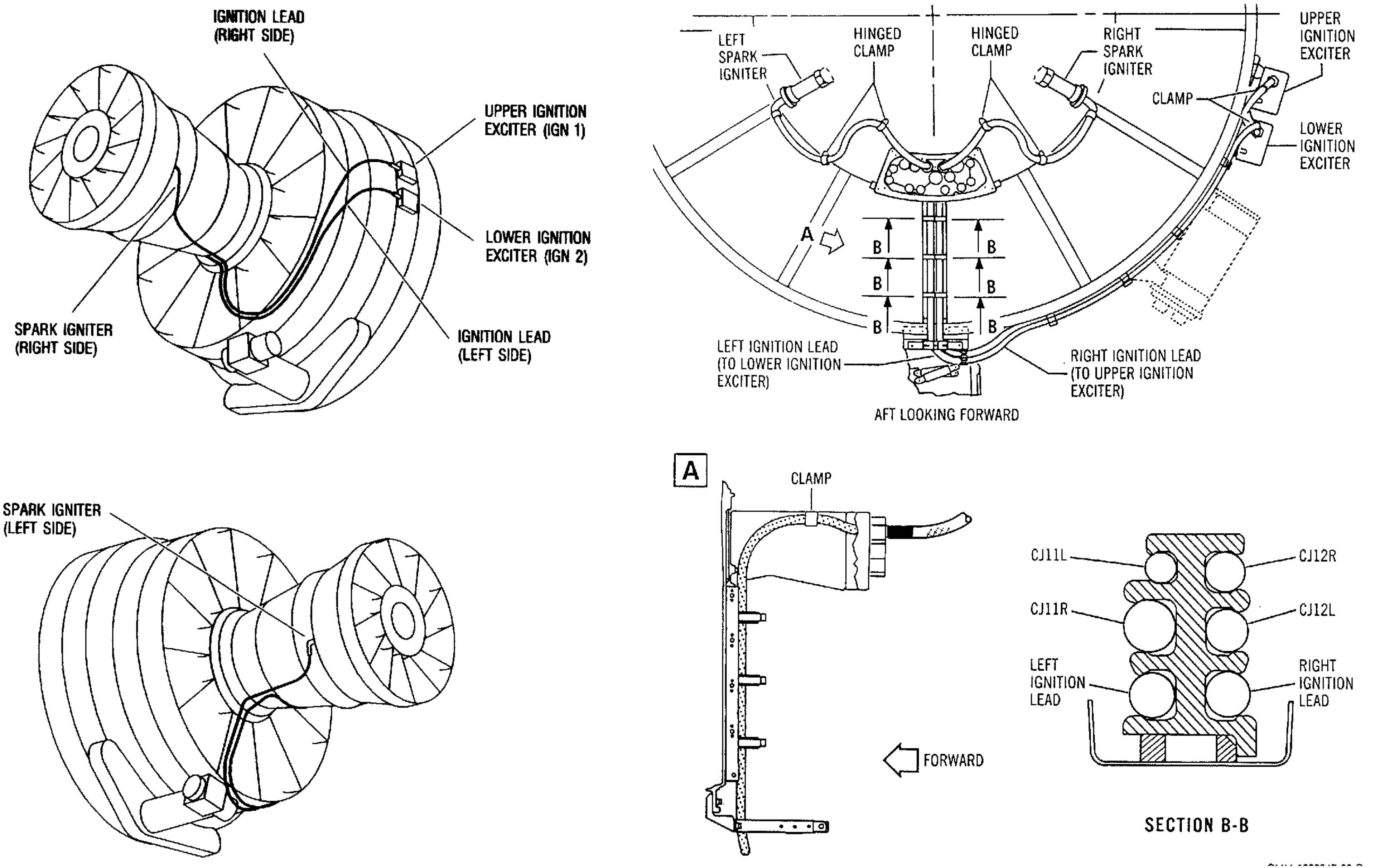


Figure 122 Ignition System Comp. Installation

IGNITION TEST WITH CFDS

TASK 74-00-00-710-040 **ON A/C ALL

refer to additional pages

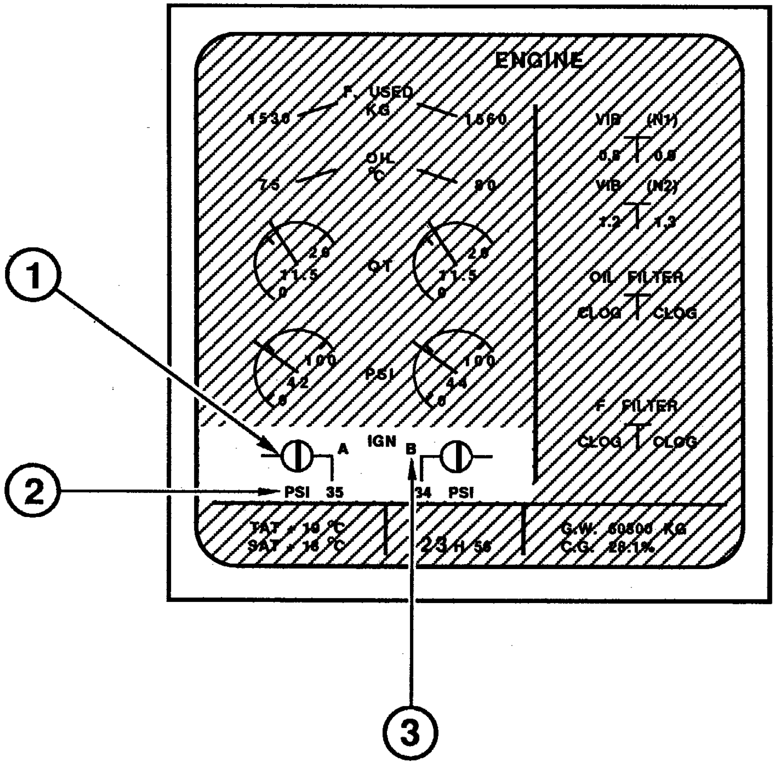
Figure 123 CFDS Ignition Test

IGNITION TEST WITHOUT CFDS

For the test procedure, refer to AMM TASK74-00-00-710-041-01

During the test,an aural check of the ignitor plug operation has to be done.

WARNING: MAKE SURE THAT THERE IS ZERO PSI AT THE STARTER VALVE INLET BEFORE YOU PUSH THE MAN START P/B. READ THE PRESSURE ON THE ECAM START PAGE.



1) POSITION OF THE STARTER VALVE
2) PRESSURE FOR THE STARTING (BLEED PRESSURE)
3) SELECTION OF THE IGNITION SYSTEM A OR B, OR A AND B (CONTINUOUS IGNITION)

IN CONFIGURATION OTHER THAN STARTING, THE BLEED PRESSURE AND IGNITION STATUS IS NOT DISPLAYED.

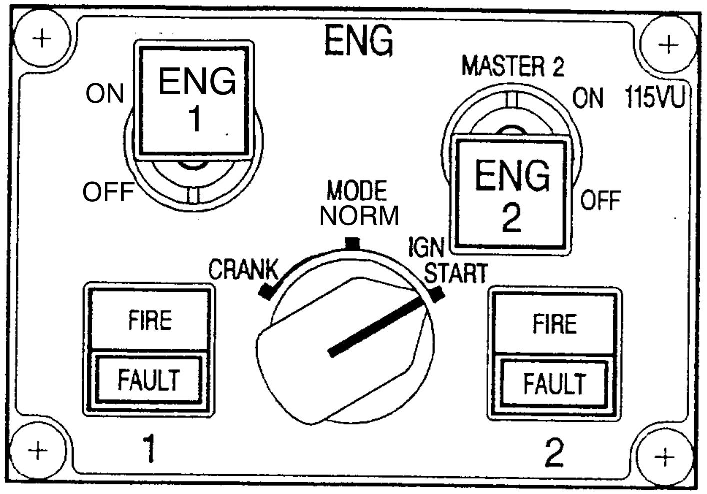
1. CHECK AIR PRESSURE AT START VALVE - **0**

2. MODE SELECTOR TO- **IGN/START**

3. MAN START P/B TO- **ON**

4. MASTER LEVER- **ON**

115VU



OVERHEAD PANEL 22VU

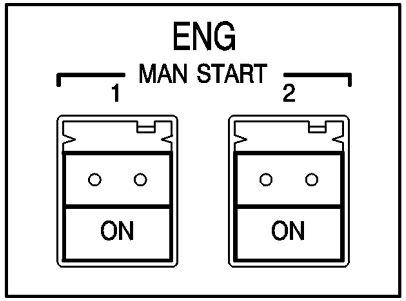


Figure 124 Ignition Test without CFDS

ATA 80 STARTING

80-00 GENERAL

The starting system of the engine utilizes pressurized air to drive a turbine at high speed. This turbine drives the engine high pressure rotor through a reduction gear and the engine accessory drive system.
The air which is necessary to drive the starter comes from :
- **either the APU**
- **or the second engine**
- **or a ground power unit.**

The starter supply is controlled by a starter shut-off valve (SOV) pneumatically operated and electrically controlled. In case of failure, the SOV can be operated by hand.
The starter valve closes when the N2 speed reaches 50 %.
The starter centrifugal clutch disengages when N2 speed is higher than 50%.
Engine starting is controlled from the ENG start panel 115VU located on center pedestal and ENG/MAN START switch on the overhead panel.

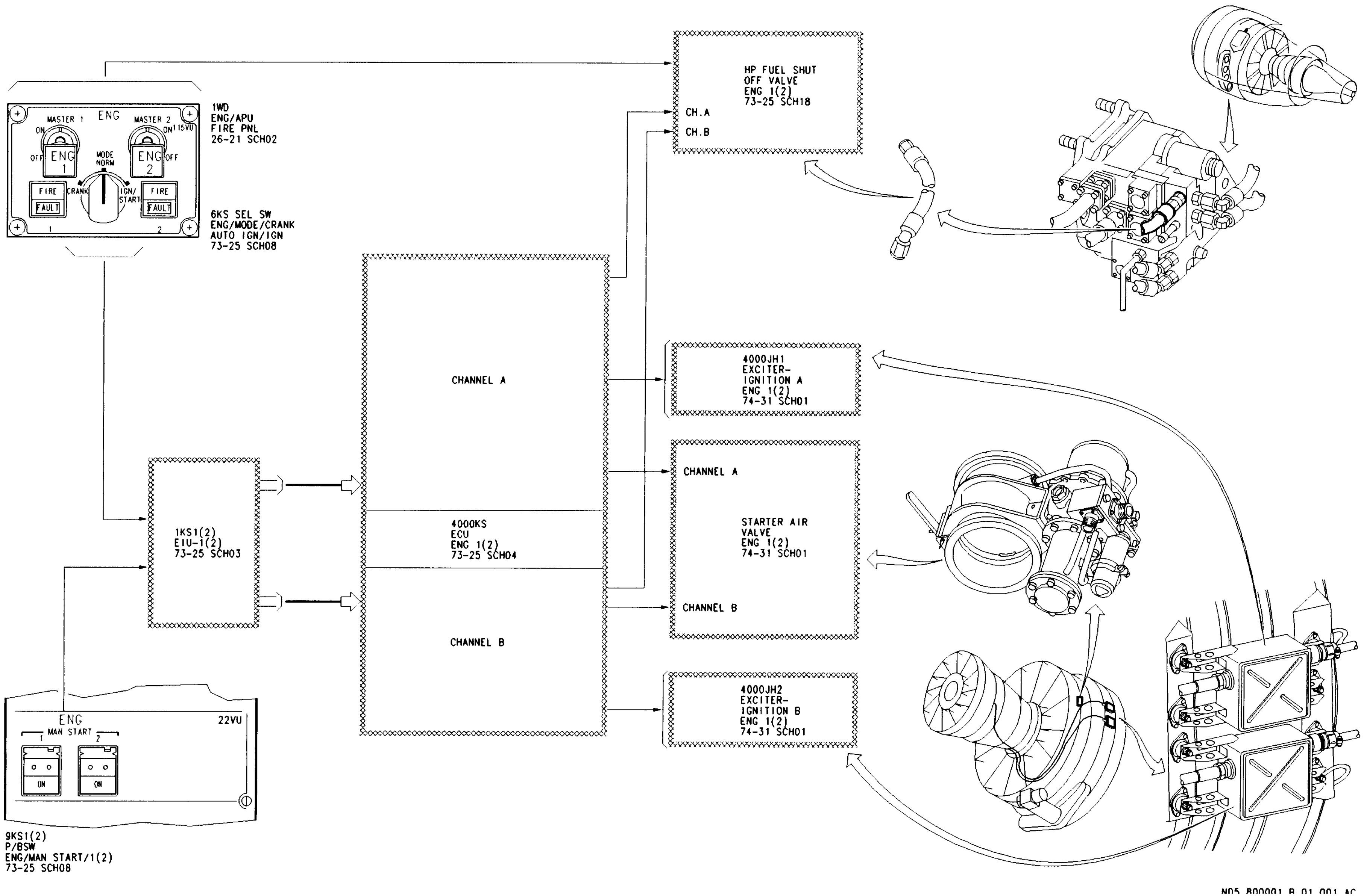


Figure 125 Starting Schematic

AIR STARTER

The starter is installed on the aft side of the accessory gearbox, in the right-hand position (aft looking forward).

The starter is filled with oel to lubricate the gears inside.

- it has a fill and overflow plug and
- a magnetic drain plug.

Starter Limits

4x2 min ON - Inbetween 20 s OFF
(15 min Cooling).

Sequence maybe Repeated.-

STARTER AIR VALVE

The starter air valve is electrical controled (by a solenoid)and pneumatic operated. (diaphram and actuator) .
It will open when the solenoid is energized (28VDC) and airpressure is available.

Visual position indicator operation
The override handle aligns with markings on the valve to provide an external indication of butterfly position.

Position switch operation
The normally open redundant electrical position switches are actuated by the closing end of the actuator to provide remote indication when the butterfly is in any position except closed.

Redundant solenoid
The solenoid has two independent coils, either one of which when energized will open the valve.

STARTER VALVE MANUAL OPERATION

TASK 80-11-00-040-041

CAUTION :
DO NOT OPERATE THE MANUAL HANDLE OF THE PNEUMATIC STARTER VALVE, IF THE STARTER SYSTEM IS NOT PRESSURIZED. IF NOT DAMAGE TO THE PNEUMATIC STARTER VALVE CAN OCCUR.

WARNING :
TAKE CARE WHEN OPERATING THE STARTER SHUTOFF VALVE WITH ENGINE RUNNING. OBEY TO SAFETY PRECAUTIONS .

Procedure:

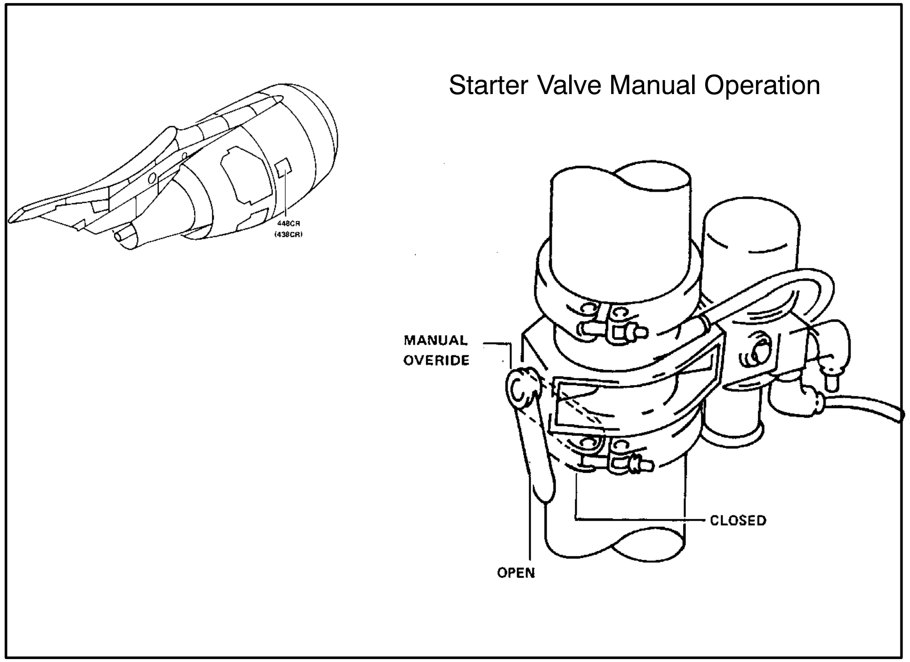
Start the engine on which the starter air valve is fully operationnal.

Using the started engine pressure.
Start the engine on which the starter air valve is deactivated by operating manually the starter shutoff valve through the access door 438CR (448CR).

After engine start cycle, check on starter valve that manual handle is in closed position.

Install a warning notice in flight compartment indicating that pneumatic starter valve system is inoperative.

Make an entry in the log book.



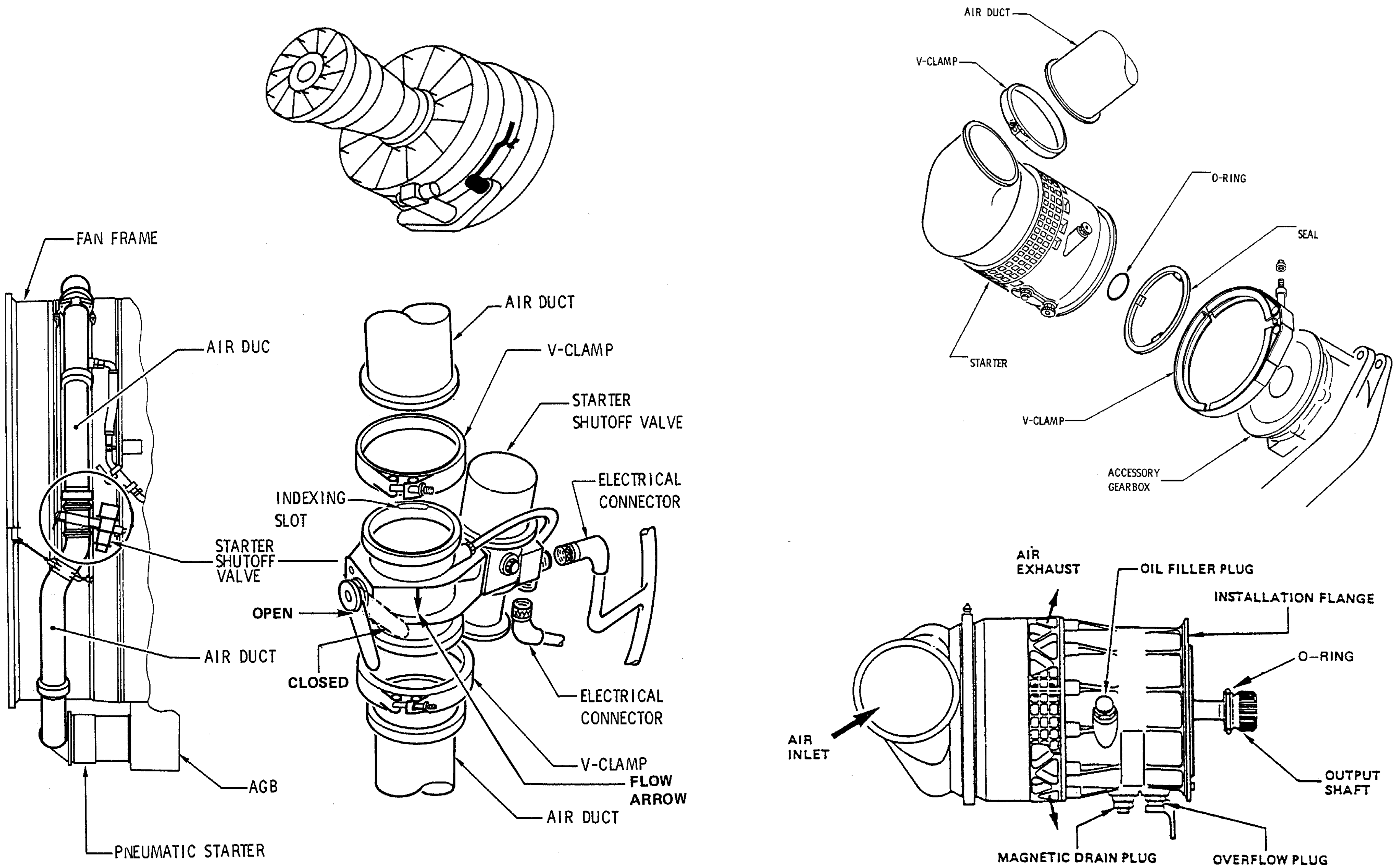


Figure 126 Starter Air Valve and Starter

CRANKING-DESCRIPTION

Air Supply
The air necessary for the starting comes from the duct connecting engine bleed and the precooler..
The air necessary for the starter is supplied by either:

- the other engine through the crossbleed system

- the APU and in that case, all the air bled from the APU is used for starting

- an external source able to supply a pressure between 30 and 40 psig.

Dry Cranking

Requirement

A dry motoring of the engine will be needed when:

- it is necessary to eliminate any fuel accumulated in the combustion chamber

- a leak ckeck of engine systems is needed.

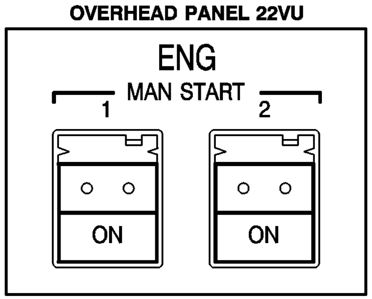
To perform this operation, the starter is engaged and the engine is motored but the HP fuel shut off valve remains closed and both ignition systems are OFF.

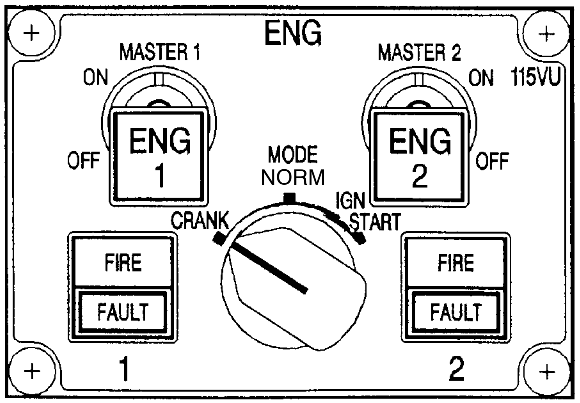
An engine dry motoring can be performed for a maximum of three consecutive cycles (4 of 2 minutes with a cooling period of 20 seconds between each cycles or 1 of 15 minute).
After three cycles or 4 minutes of continuous cranking, stop for a cooling period of 30 minutes.

Dry Cranking Control

A selector switch is located on ENG panel 115VU.

Automatic Dry Cranking
An automatic selection of dry cranking is accomplished when the starting sequence is aborted by the FADEC. This can be interrupted at any time by placing the MASTER control switch in OFF position.





PACKS OFF	
<u>PULL C/B: HP FUEL SO V(only recommended if fuel lines empty)</u>	**LP FUEL SOV OPENS (ECAM WARNING)**
PUT MODE SELECTOR TO ‘CRANK‘ POSITION	**ECAM ENG START PAGE APPEARS**
CHECK STARTER AIR PRESSURE	**MIN. 25 PSI**
PUSH ‘MAN START‘ PB TO ‘ON‘	**START VALVE OPENS**
MONITOR INDICATIONS	
	N2, N1 AND OIL PRESSURE MUST INCREASE

AFTER MAX. 2 MINUTES

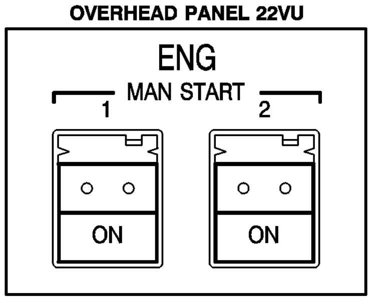
RELEASE ‘MAN START‘ PB TO OFF	**START VALVE CLOSES,ENGINE INDICATIONS -BACK TO ‘0‘**
PUT MODE SELECTOR TO ‘NORM‘ POSITION	**ECAM ENG START PAGE DISAPPEARS**
PUSH C/B: HP FUEL SOV	**LP FUEL SOV CLOSES**

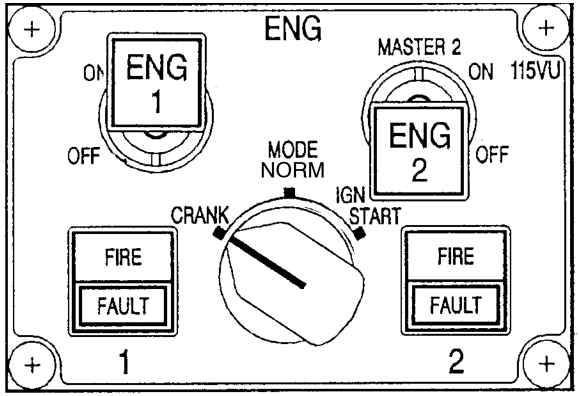
Figure 127 Dry Cranking Procedure

WET CRANKING

Wet Cranking

Requirement
A wet motoring will be needed when the integrity of the fuel system has to be checked.
If such a test is performed, both ignition systems are off and the starter is engaged to raise N2 up to the required speed of 20%. The MASTER control switch is moved to ON and the exhaust nozzle of the engine carefully monitored to detect any trace of fuel.
The wet motoring can be performed for a maximum of 4 consecutive cycles (4 of 2 minutes with a cooling period of 20 seconds between each cycles).
In all cases, the MASTER control switch will be returned to OFF and the starter is reengaged automatically at 20% N2 and a engine motoring must be at least done for 60 seconds to eliminate entrapped fuel or vapor.





PULL IGNITION SYSTEM C/B'S

PUSH ONE BOOST PUMP P/B TO 'ON'	**BOOST PUMP STARTS TO RUN**
PUT MODE SELECTOR TO 'CRANK' POSITION	**ECAM ENG START PAGE APPEARS**
CHECK STARTER AIR PRESSURE	**MIN. 25 PSI**
PUSH 'MAN START' PB TO 'ON'	**START VALVE OPENS**
MONITOR INDICATIONS	
	N2, N1 AND OIL PRESSURE MUST INCREASE

WHEN N2 SPEED IS >20%

PUT ENG MASTER SWITCH TO 'ON'	**FUEL FLOW INDICATION INCREASES**

AFTER 10-20 SECONDS

PUT ENG MASTER SWITCH TO 'OFF'	**FUEL FLOW INDICATION GOES TO '0'** **START VALVE CLOSES**

WHEN N2 SPEED REACHES 20% THE ECU RE-ENGAGES THE STARTER

AFTER 60 SECONDS MOTORING

RELEASE 'MAN START' PB TO OFF	**START VALVE CLOSES,ENGINE INDICATIONS -BACK TO '0'**
PUT MODE SELECTOR TO 'NORM' POSITION	**ECAM ENG START PAGE DISAPPEARS**

Fuel Pumps OFF

Figure 128 Wet Cranking Procedure

AUTOMATIC START

The ECU fully controls the automatic start procedure of an engine till reaching 50% N2. The ECU protects the engine up to 50% N2 in case a Hot start,Hung start,Stall or ignition fault occurs.The oil pressure is not monitored by the ECU during engine start.This must be done by the operator who starts the engine.

Note:
There must be a positive oil pressure indication before the engine reaches a stabilized ground idle.

UNSATISFACTORY STARTS DURING AUTO START

The Auto Start system has equipment that collects input on problems.
The equipment will automatically resequence the applicable control circuit to correct the unsatisfactory condition.

Usually, the FADEC system is resequenced after a total of 4 cycles. If the problem is not corrected after resequencing, the applicable diagnostic indications will be shown on the flight deck screen.

Stall or Overtemperature

For either a stall or an overtemperature, the FADEC system will do the items that follow:

- Fuel is shut off for 7 seconds.
- Starter and ignition stay ON.
- At the end of the 7 seconds, the fuel is turned back on but, the fuel schedule is reduced 7 percent.
- If another stall or overtemperature occurs, the FADEC system repeats the sequence and reduces the fuel schedule by 7percent more. The total amount that the fuel schedule has been reduced at this point is 14 percent.
- If a stall or overtemperature occurs a third time, the FADEC system will repeat the sequence and reduce the fuel schedule by 7 percent more. The total amount that the fuel schedule has been reduced at this point is 21 percent.
- If a stall or overtemperature occurs a fourth time, the start will automatically be aborted and the applicable message will be indicated on the flight deck screen.

Starter air pressure is below 20 psi (1.3789 bar)

If the acceleration is below the threshold and a stall or overtemperature is indicated, the start will be automatically aborted if in auto start mode.

The fuel will not be turned on if the starter air pressure is too low to motor the core to 22 percent N2, the start will be automatically aborted if in auto start mode.

Hung Start during Autostart

If engine acceleration ceases and there has been no reduction in the acceleration fuel schedule and there is no stall or overtemperature indication, the start will be automaticaly aborted if limits are exceeded.

If engine acceleration ceases and there has been a previous reduction in the acceleration fuel schedule and there is no stall or overtemperature indication, FADEC will automatically increase the acceleration fuel schedule to accomplish acceleration to idle.

The FADEC system is resequenced after a total of 4 cycles. If the problem is not corrected after resequencing, the applicable diagnostic indications will be shown on the flight deck screen.

Ignition Fault

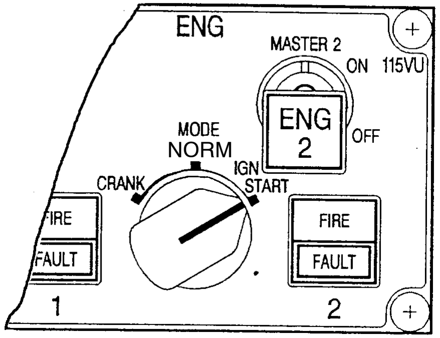
If the engine lightoff does not occur within 18 sec,the FADEC system automatically turns off the ignition,shuts the fuel flow and dry motors the engine for 30 sec.

Twenty five seconds into the dry motoring period,the FADEC system energizes both igniters and at 30 sec,turns fuel flowback on.

If on this second engine start attempt there is no light off within 13 sec,the FADEC system automatically turns off both igniters,shut off the fuel flow and turns the starter for 30 sec. to drymotor the engine.
This will result in a start abort indication on the upper ECAM.

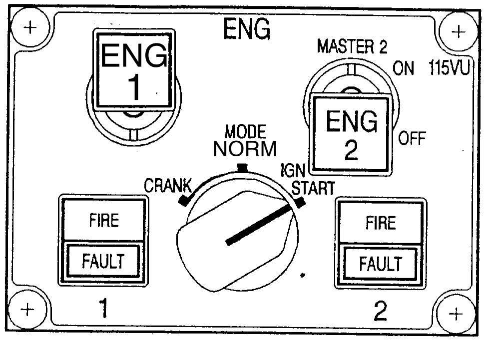
Panel 115 VU

-T urn Mode Selector to
IGN/START Position



Panel 115 VU

-Set the ENG-MASTER switch to ON



Upper ECAM

-MONIT OR: N1, N2, EGT, FF

ECAM ENG Start Page is displayed, the airpressure (HP-Connection or APU) must be 25 psi.
PACK VALVES ARE CLOSED (MAX 30 SEC)

LOWER ECAM

On the ENG Start Page:
- the starter valve symbole goes in line (open)
-at 16% N2 the A or B indication comes in to view below IGN.
-at 22% N2 FUEL FLOW indication, 180KG/H
-EGT rise (max. 20 sec. after FF).

-at 50% N2 the starter valve symbole must go to cross line (closed)
- IGN OFF
-Check Oil Pressure min. 13psi.

-record the start EGT (R/U sheet)

Panel 115 VU

-T urn Mode Selector to NORM

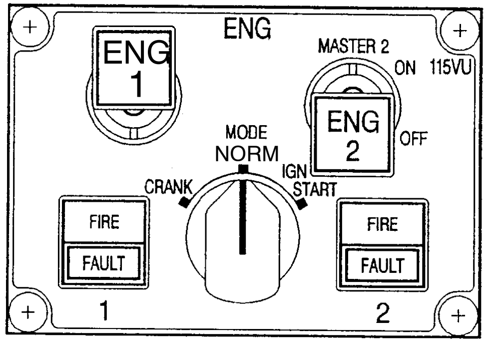


Figure 129 Automatic Start Procedure

MANUAL START

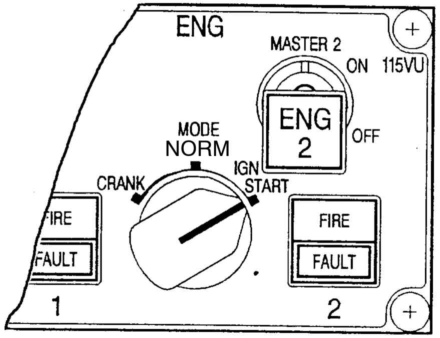
The manual start mode limits the authority of the ECU so that the pilot can sequence the starter, ignition and fuel on/off manually.
This includes the ability to dry crank or wet crank.
Pushing the manual start push button off during dry cranking closes the starter air valve and during wet cranking closes both the starter air and fuel shut off valves.
The ECU continues to provide fault indications to the cockpit.
However, during manual operation, the ECU abort feature is disabled and conventional monitoring of the start parameters is required.

The engine manual start panel, used for manual start, is located on the overhead panel and is composed of two manual start push button switches (one per engine).

The manual start procedure commences when the mode selector is set to: IGN/START,
the manual start push button switch is set to ON
and the master switch is OFF.
The starter air valve is then commanded open by the ECU.
When the master switch is turned ON during a manual start, both ignitors are energized and fuel is turned on >22%.
Intermittent mode selector position has no effect on the manual start sequence once the manual start procedure is initiated.
The starter air valve can be closed by selecting the manual start push button switch OFF at any time prior to turning the master switch ON.
Once the master switch is turned ON, the manual start push button switch has no effect on the start.
When the master switch is turned OFF, the control commands the HP fuel valve and LP-fuel valve closed, the starter air valve closed and the ignitors off.

Panel 115 VU

-T urn Mode Selector to
IGN/START Position

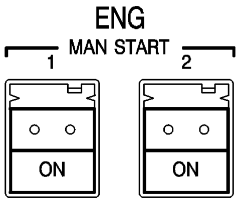


ECAM ENG Start Page is displayed, the airpreessure (HP-Connection or APU) must be 25 psi.

PACK VALVES ARE CLOSED (MAX 30 SEC)

Panel 122 VU

-Push the MAN START PB

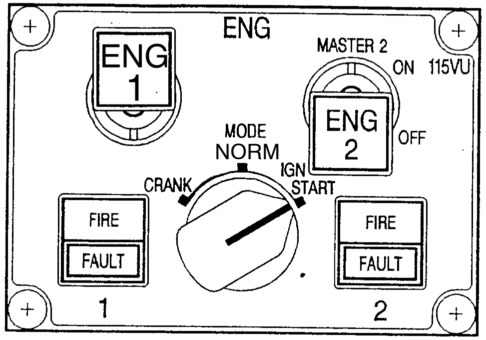


-the blue ON light of this PB comes on.

On the ENG Start Page :
-the starter valve symbole goes in line (open).
-N2, Oilpressure and N1 must increase

Panel 115 VU

-at 22% N2: set the ENG MASTER switch to ON



-A and B IGN indication comes in to view below IGN

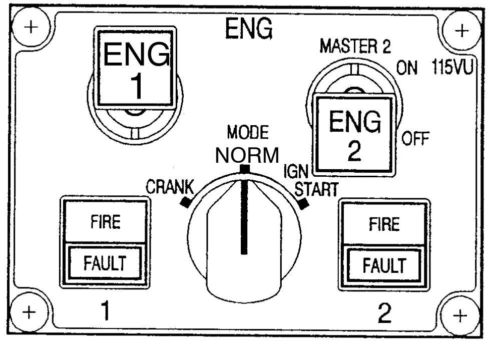
-FUEL FLOW indication 180KG/H

-EGT rise (max. 20 sec. after FF

-at 50% N2 the starter valve symbole must go to cross line (closed)
- IGN OFF
-Check Oil Pressure min. 13psi.
-record the start EGT (R/U sheet)

Panel 115 VU

-T urn Mode Selector to NORM



Panel 122 VU

-release the MAN START PB

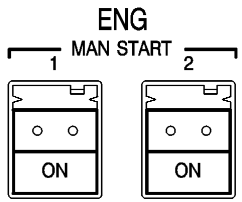


Figure 130 Manual Start Procedure

ATA 78 EXHAUST

78-30 THRUST REVERSER

INTRODUCTION

GENERAL

Thrust reverse is achieved by reversing the direction of the fan airflow using four pivoting blocker doors.

Each door is operated by a hydraulic actuator. The actuator receives fluid from a Hydraulic Control Unit which is controlled by the Electronic Control Unit.

A latch mechanism maintains each blocker door in the stowed position. The latches are hydraulically released at the beginning of the deploy sequence. Door positions are monitored by stow and deploy switches.

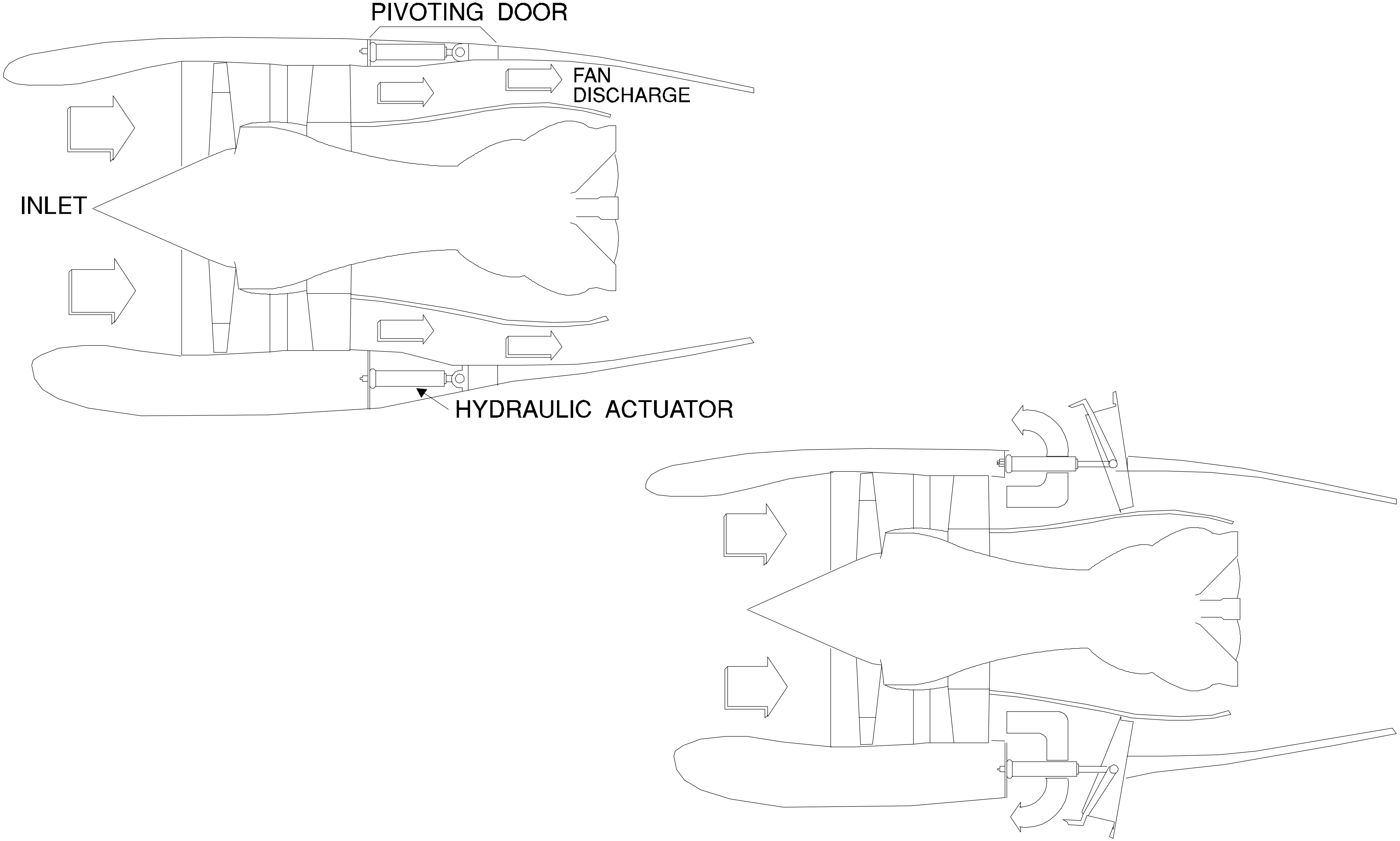


Figure 131 Thrust Reverser Fan Airflow Stow/Deploy

THRUST REVERSER CONTROL

General

The Thrust Reverser System is controlled by the ECU of each engine.
The ECU incorporates a thrust reverser command logic based on throttle control lever selection, thrust reverser feedback position and ground/flight configuration, which generates a command signal to the pressurizing valve and the directional valve in the HCU.
The signal from the ECU to the directional valve ,which is installed in the HCU, is fed to the avionics compartment, where it passes through an inhibition relay controlled by the Engine Interface Unit (EIU) according to throttle control lever position and GRD Signal from the LGCIU.
Each channel of the ECU can control and monitor the thrust reverser.
The hydraulic energy required for the actuator is supplied from the normal hydraulic system.

Thrust Reverser Control

The thrust reverser control is based on a ECU logic which is based on the following conditions:

- Thrust Control Lever Position (TLA)
- Ground/Flight Configuration
- Reverser Door Position (Stow- and Deploy switches)
- Engine RPM , N2 >min IDLE .

The Hydraulic Control Unit controls the following functions on the reverser:

- unlocking
- deploying
- stowing
- locking

Deploy Positon

The deployed position of the doors is sensed by two thrust reverser double switches .

Stow Position

For determining the stowed position of the doors, there are four thrust reverser single switches, one per door.

Thrust Reverse Indication

The thrust reverser operating sequences are displayed in the cockpit on the ENGINE AND WARNING Display in the middle of the N1 dial with a REV Indication.

- REV Indication amber = transit
- REV Indication green = all doors in deploy position.

In deployment, an amber REV indication will come in view at the middle of the N1 dial when at least one reverser door is unstowed or unlocked (stroke >1%).
If this occurs in flight, REV will flash first for 9 sec, then it will remain steady.
This indication will change to green colour when the four fan reverser doors are fully deployed and the reverse thrust can be applied.
In stowage, the indication changes to amber when one door at least is less than 95% deployed and disappears when all four doors are stowed.

Latches

There are four latches, one per blocker door. The latches hold the doors in the stowed position and are located beside the actuators on the thrust reverser forward frame. The latches are hydraulicly connected in series.

CFDS Interface

The reverser system is monitored by the CFDS.
The maintenance has the possibility to perform a reverser test via the MCDU.
With this test a engine running signal is simulated by the CFDIU.This allows a reverser deployment.

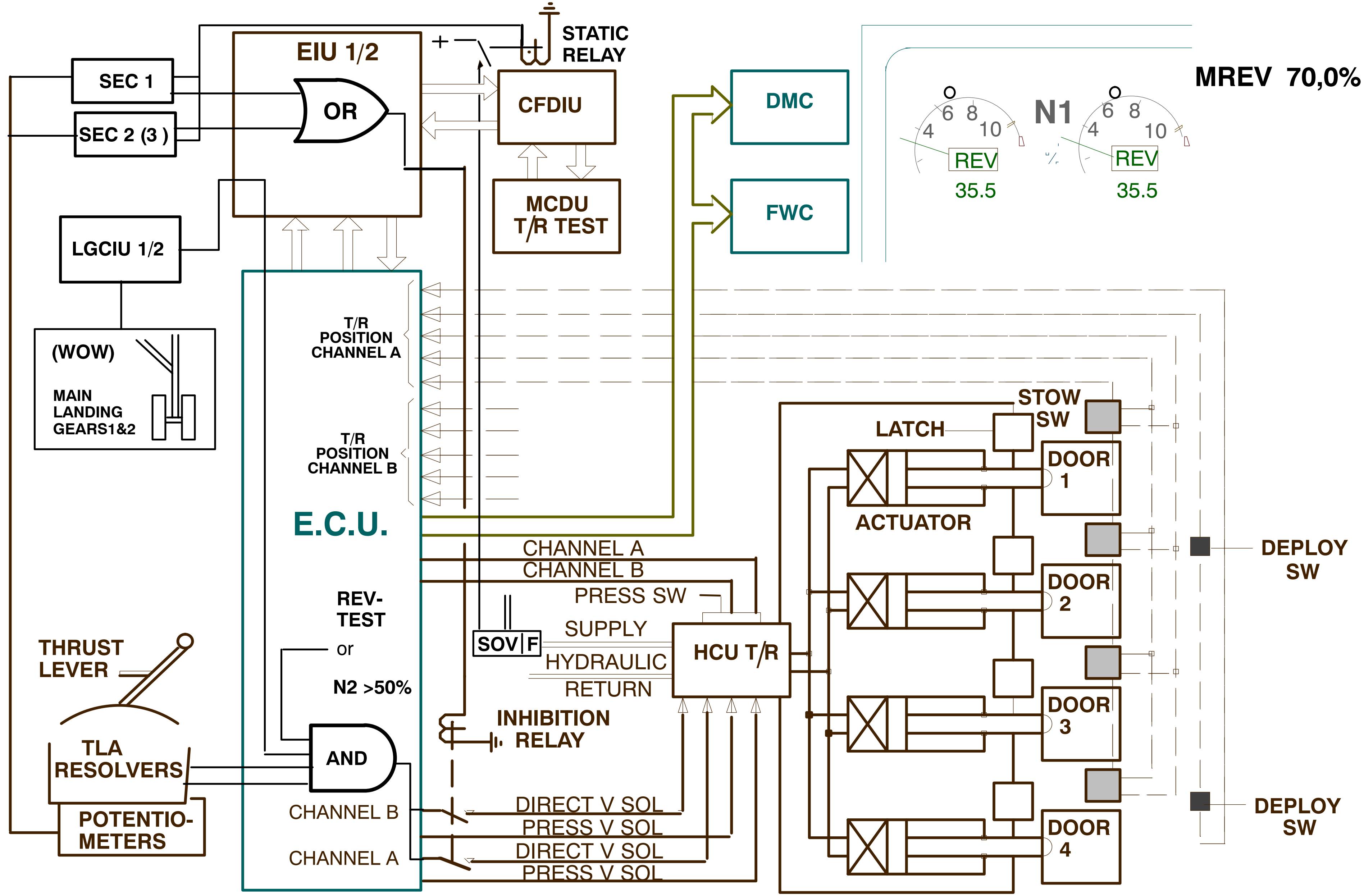


Figure 132 Reverser System Schematic

THRUST REVERSER COMPONENTS (LRU 'S)

Actuators

There are four hydraulic actuators, mounted on the forward frame by a ball joint assembly support.
They constitute a differential double-acting unit.
They are supplied by the HCU.
These hydraulic actuators have four different functions :
- to deploy doors
- to stow doors
- to assure a secondary lock in stowed position by a system of claws
- to ensure that doors rotation speed slows down at the end of the deploy phase.

The actuators comprise a manual unlocking system for maintenance.

- Hydraulic Control Unit (HCU)
- Hydraulic Actuator (4)
- Hydraulic Latch /4)
- Piviting Doors (4)
- Stow Switches (4)
- Dual Deploy Switches (2)
- Electrical Junction Box

- Reverser Cowl (2)
- Cowl Opening Actuator (2)
- Handpump Connection (2)

HCU LOCATION

The HCU is mounted on the upper forward face of the right hand thrust reverser forward frame.The hydraulic control unit controls hydraulic fluid flow to the thrust reverser latches and blocker door actuator. Control and feedbacksignals are exchanged with the engine ECU.

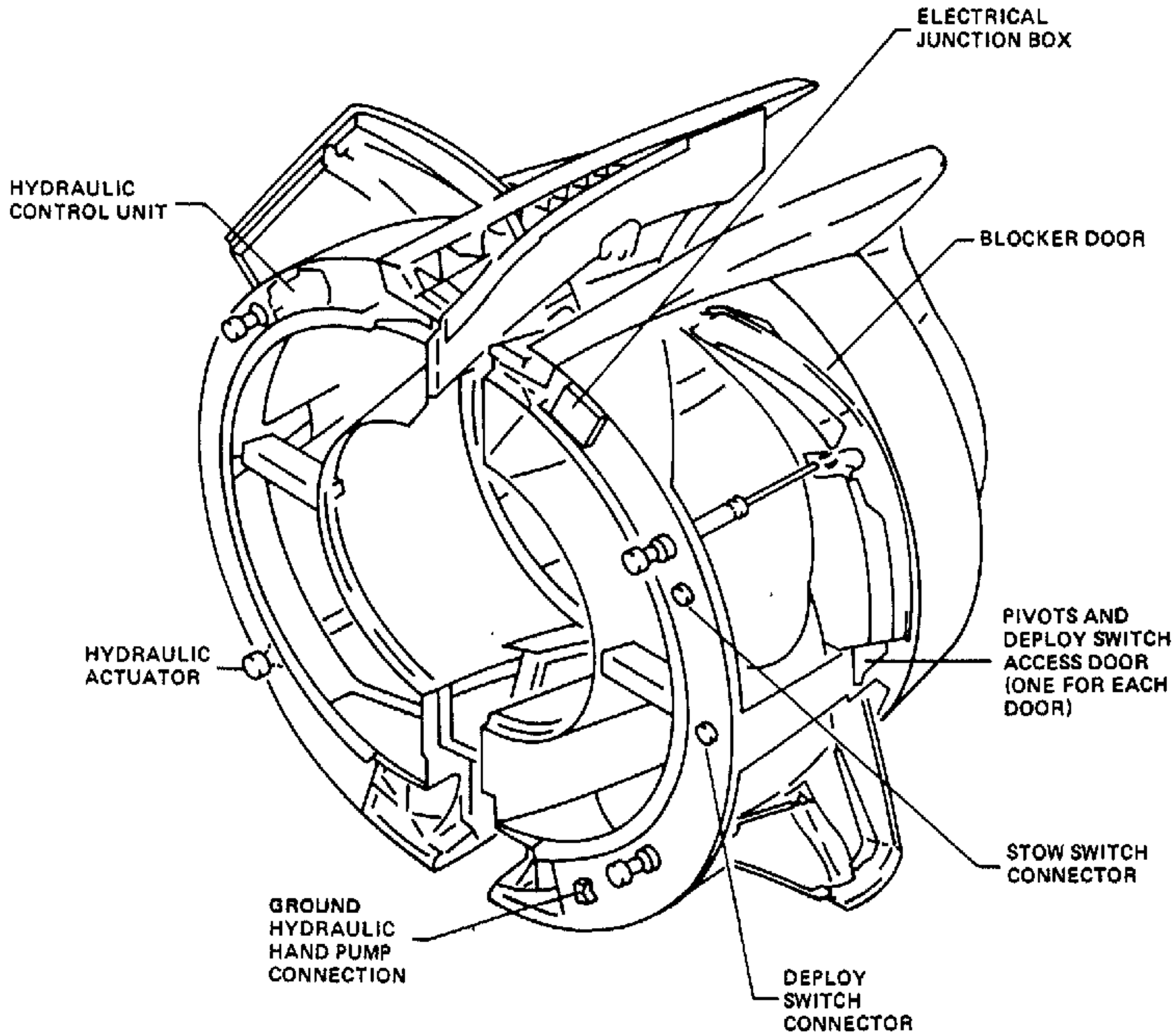


Figure 133 Engine Thrust Reverser LRU,s

REVERSER HYDRAULIC CONTROL UNIT

Reverser Hydraulic Control Unit (HCU)

General

The HCU has the following functions :

- to supply pressure to hydraulic system (pressurizing valve)
- to regulate blocker doors stowing speed (flow limiter)
- to supply latches (directional valve solenoid)
- to supply actuators (directional valve).

The HCU incorporates the following items :

- **pressurizing valve**
- **directional valve**
- **flow limiter**
- **filter and clogging indicator**
- **pressure switch**
- **bleed valve.**

The aircraft hydraulic system is used as the supply source.

Electrical characteristics :

Pressurizing valve solenoid and directional valve solenoid :
Each channel within the ECU shall interface with the thrust reverser valve solenoids.
Each solenoid contains two electrically isolated, independent coils, one dedicated to channel A and the other to channel B. Each of these windings conforms to the following characteristics :
Each solenoid winding will be connected to the ECU via a two wire cable.

Pressurizing valve

Pressurizing valve solenoid :

energized pressurizing valve open
deenergized pressurizing valve close
The pressurizing valve is a two position valve which is solenoid actuated to the open position. The valve is spring loaded to the closed position (solenoid de-energized).
The pressurizing valve can also be manually closed and pinned (inhibited) to prevent inadvertent actuation of the thrust reverser during maintenance work.
Energizing the valve solenoid opens a port . Then the hydraulic pressure is supplied to the stow side of the actuators and to the directional valve .

In the pressurizing valve, there is a time delay system which limits the closing time of the piston valve at 2 seconds minimum.

Directional Valve

Directional valve solenoid :

energized T/R deploy
deenergized T/R stow

The directional valve is a three port, two position, valve.
Energizing the valve solenoid opens a port allowing hydraulic pressure for the door latches (the HCU pressurizing valve must be opened).
When the last latch is supplied the hydraulic pressure return moves a piston valve to the deploy position.Then hydraulic pressure is ported to the deploy side of the actuator piston .

Flow limiter

The flow limiter regulates the hydraulic fluid flow returning to the HCU from the actuator piston head in order to control/limit the blocker door stowing rate under varying conditions.

Bleed valve

The bleed valve permits bleeding of the HCU.

Pressure switch

The pressure switch indicates to the ECU that hydraulic circuit is pressurized or not.Pressure switch signal is available to the ECU and can be used for maintenance purpose.

Filter and clogging indicator

The hydraulic control unit filter is used to filter the fluid supply from the aircraft hydraulic system. The filter is a flow through cartridge type filter. The clogging indicator monitors pressure loss through the filter cartridge and features a pop-out indicator to signal when it is necessary to replace the filter element.

Manual Lockout Lever

With the manual lockout lever it is possible to shut the hydraulic supply to the reverser by closing the isolation valve in the HCU.The lever can be secured in the lockout position with a pin.(this is also a part of blocking the reverser.)
This must always be done when working on the reverser system !

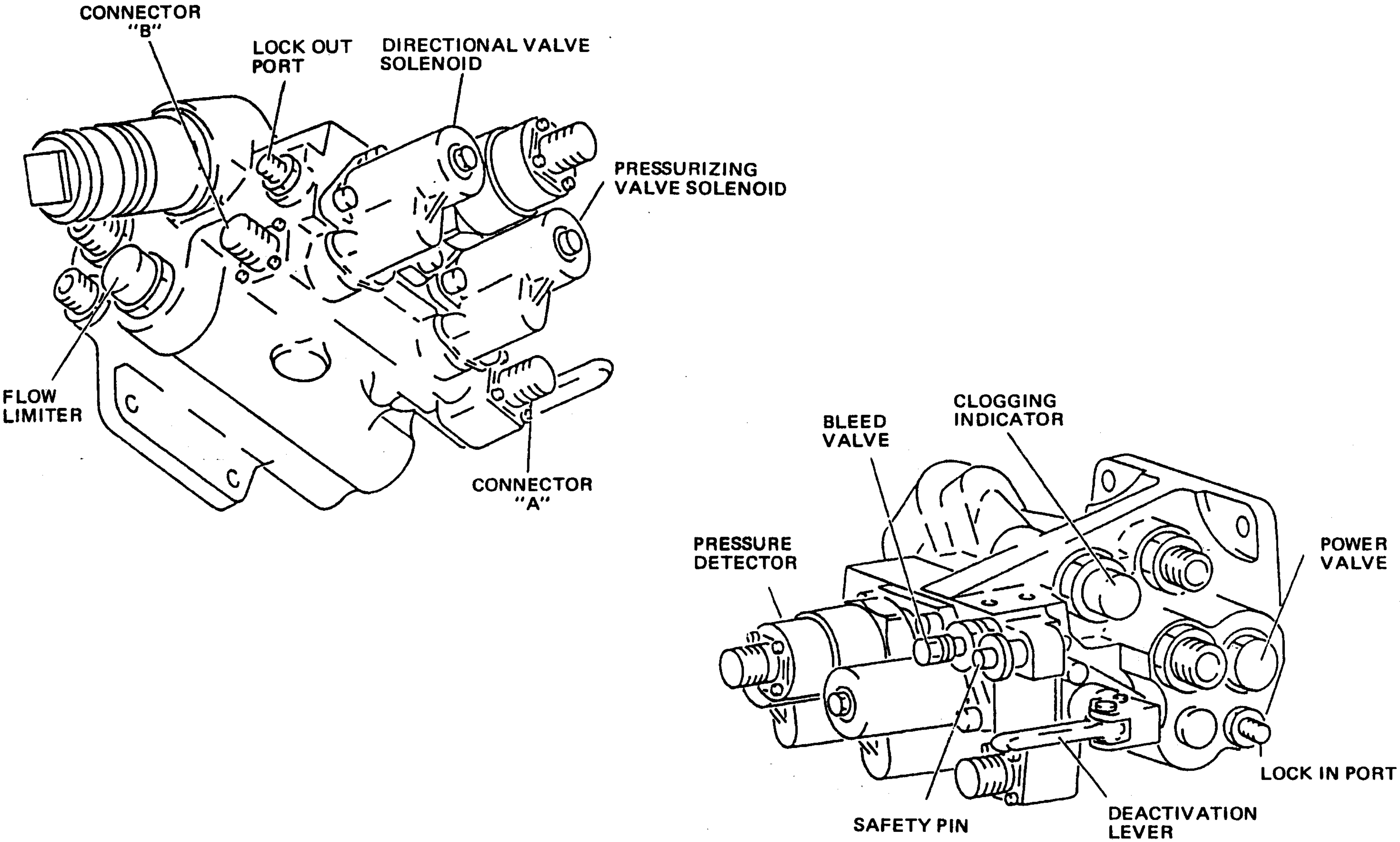


Figure 134 Hydraulic Control Unit (HCU)

REVERSER OPERATION

Selection of either stow or deploy from the cockpit sends a signal to the engine ECU which, in turn, supplies two independent signals to the thrust reverser HCU pressurizing and directional control valves.
These signals to the HCU are only provided if the ECU has correct signals e.g. reverser position engine power setting.

Stow Configuration

In the initial stowed position with the reverse stow control selected in the cockpit, the hydraulic pressure is applied to the input of the HCU.
All reverser hydraulic systems are pressurized at the return pressure as long as the aircraft is in flight and, no signal is sent to open the pressurizing valve solenoid.

Deploy sequence

When reverse thrust is selected in the cockpit, the ECU controls that deploying conditions are achieved. In that case, the electrical power (28VDC) is sent topressurizing valve solenoid and to the directional valve solenoid.

Deployed Position Selected - Latches Unlocking

A. When the pressurizing valve is opened and that the directional solenoid is energized, high pressure (HP about 3000 psi) is routed to the hydraulic actuator rod side, pressure signal is sent to aircraft system : blocker doors unlocking sequence starts.

B. When the last latch is opened, the pressure drives the directional valve which enables to supply hydraulic actuator heads with pressure.

C. As soon as one blocker door is at more than one percent of angular travel, its stow switch changes over and sends signal ”1 or 2 or 3 unstowed doors” to the ECU. In the cockpit an amber REV indication is displayed in the middle of the Signal ”unstowed doors” will not be send to the ECU until all blockers doors are at more than one percent of their angular travel .

D. Each blocker door arriving at 95 percent of its travel is slowed down until completely deployed through hydraulic actuator inner restriction: at this moment the switch is also activated.When the four blocker doors are deployed the ECU receives the ”deployed doors” information and stops pressurizing valve solenoid supply.REV indication changes to green. Latches remain in temporary doors stowing position.

Stow sequence

E. When blocker doors stowing is selected, the ECU controls that stowing conditions are achieved. In that case, the ECU reverses the electrical signals of the end of deploying sequence. Pressurizing valve solenoid is energized, directional valve solenoid de-energized. When one door is at less than 95% of his travel, REV indication changes to amber colour.

F. Pressurizing valve opens and hydraulic actuator rods are supplied. Hydraulic actuator heads are connected to return.A flow limiter controls hydraulic actuator pistons retraction speed.

G. When all blocker doors are at one percent from their stowed position they activate the switches which send the ”stowed door” information to the ECU. The REV indication disapears .

H. The ECU cuts pressurizing valve solenoid electrical supply. The pressurizing valve closure temporisation of one to two sec.enables hydraulic actuators to perform the end of stroke. The actuators actually bring the pivoting doors to an overstowed position of approximately 2 mm (0.08 in.) in order to engage the latches. Latch hooks get engaged.

I. The end of temporisation connects all circuits to return. The pressure switch transmits signal ”without pressure” to the ECU.

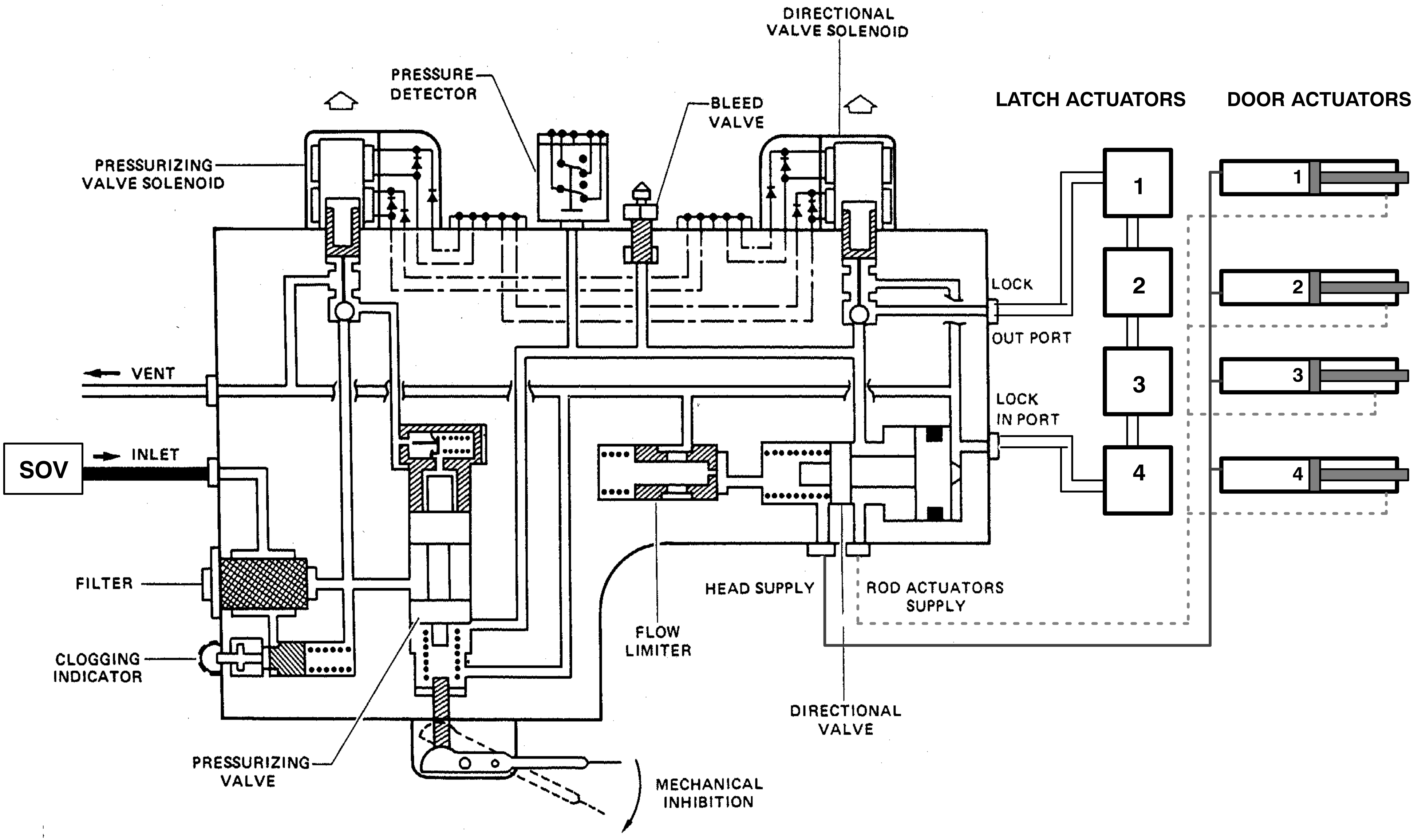


Figure 135 HCU Schematic

LATCHES

There are four latches, one per blocker door. The latches hold the doors in the stowed position and are located beside the actuators on the thrust reverser forward frame. The latches are connected in series.In case a latch fails the hydraulic actuators which deploy or stow the pivoting doors have a secondary lock.

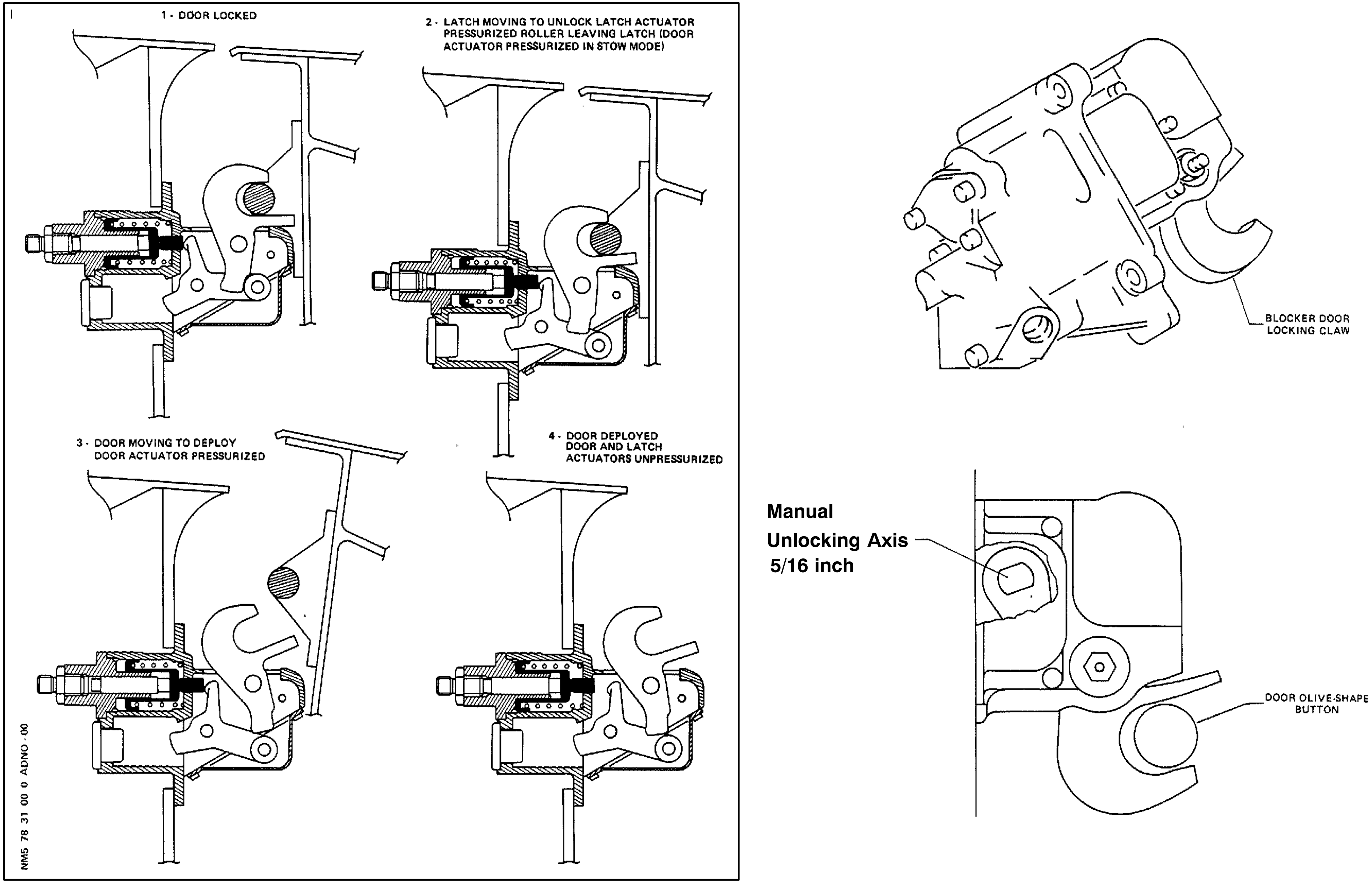


Figure 136 Latch

HYDRAULIC ACTUATOR

There are four hydraulic actuators,mounted on the forward frame by a ball joint assembly support.

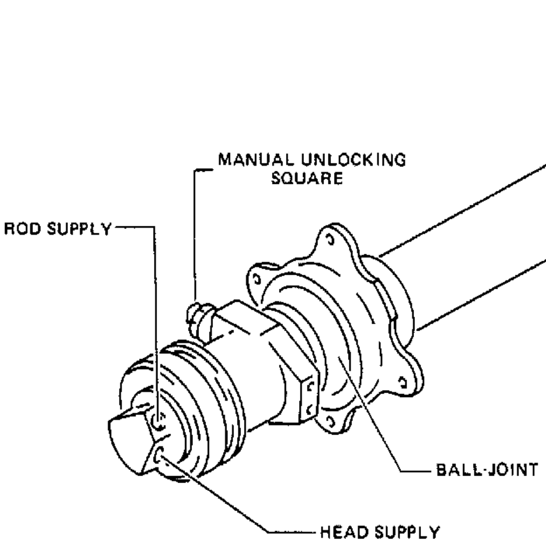
These hydraulic actuators have four different functions:

- to deploy the doors,
- to stow the doors,
- to ensure a secondary lock in stowed position,
- to ensure that the doors rotation speed slows down at the end of the deployment phase.

The actuators comprise a manual unlocking system for maintenance.

Door latch failure

If a door latch breaks, the actuator has a secondary lock. This prevents the door from moving more than 1/2 inch from the stowed position.This movement is sufficient to actuate the unstow switch to provide a warning in the cockpit.



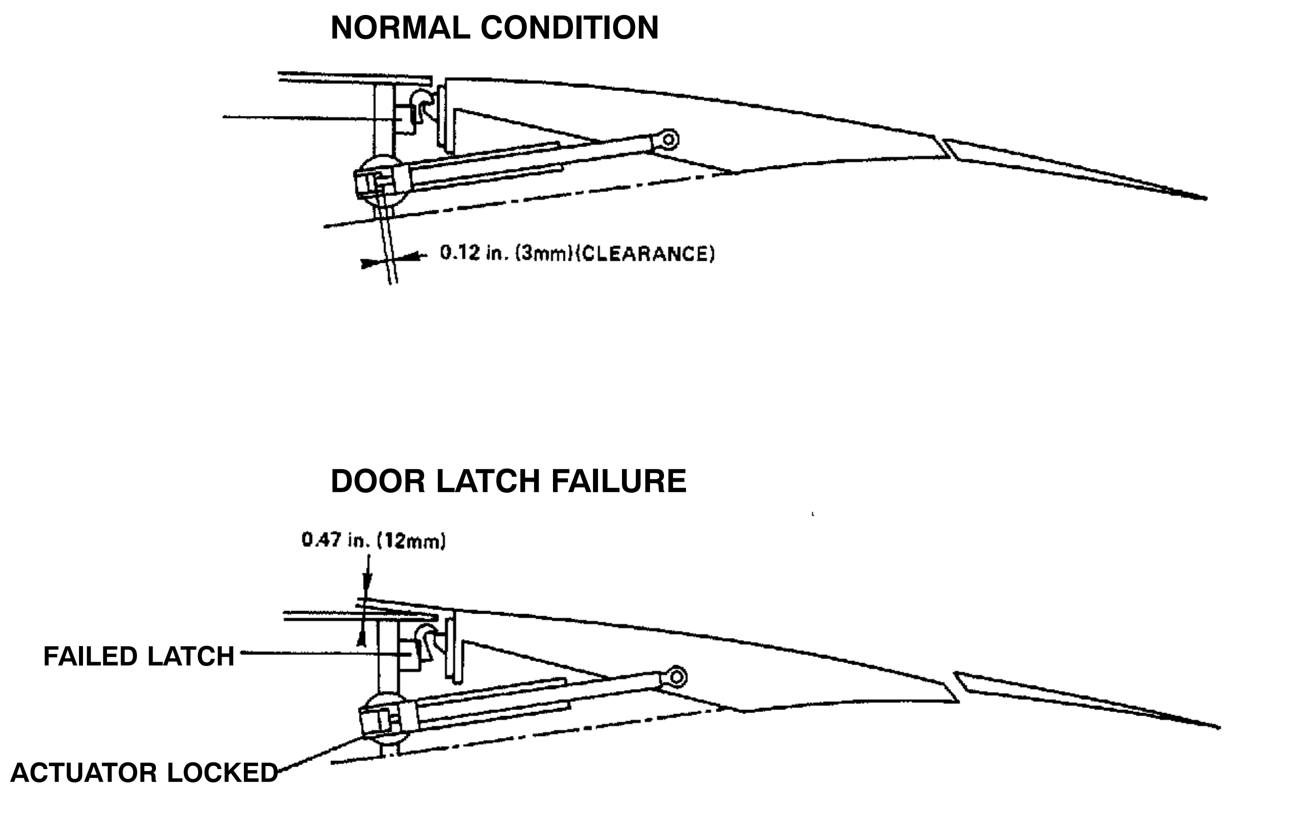


Figure 137 Hydraulic Actuators

STOW SWITCH

Stow switch (4)

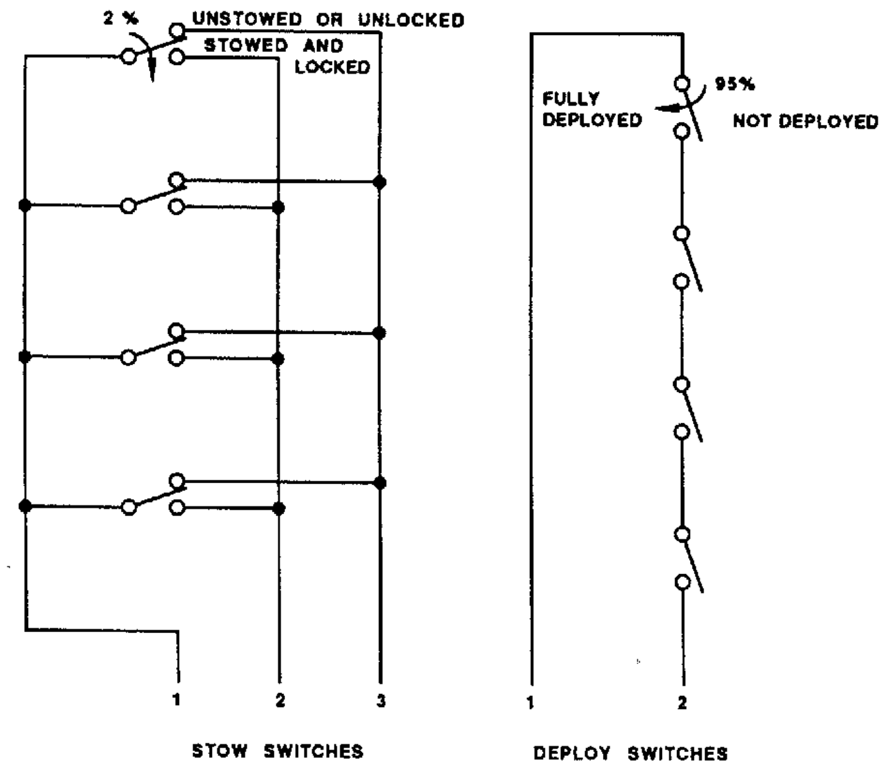
For determining the stowed position of the doors, there are four thrust reverser single switches, one per door, located onto the forward frame rear side next to the latches.The switches are dual, i.e. they include 2 cells one dedicated to each channel of the ECU. The switches are connected to the ECU via the electrical junction box.All stow switches are connected in parallel.At 0.9% of blocker doors flush position , the cells are closed .

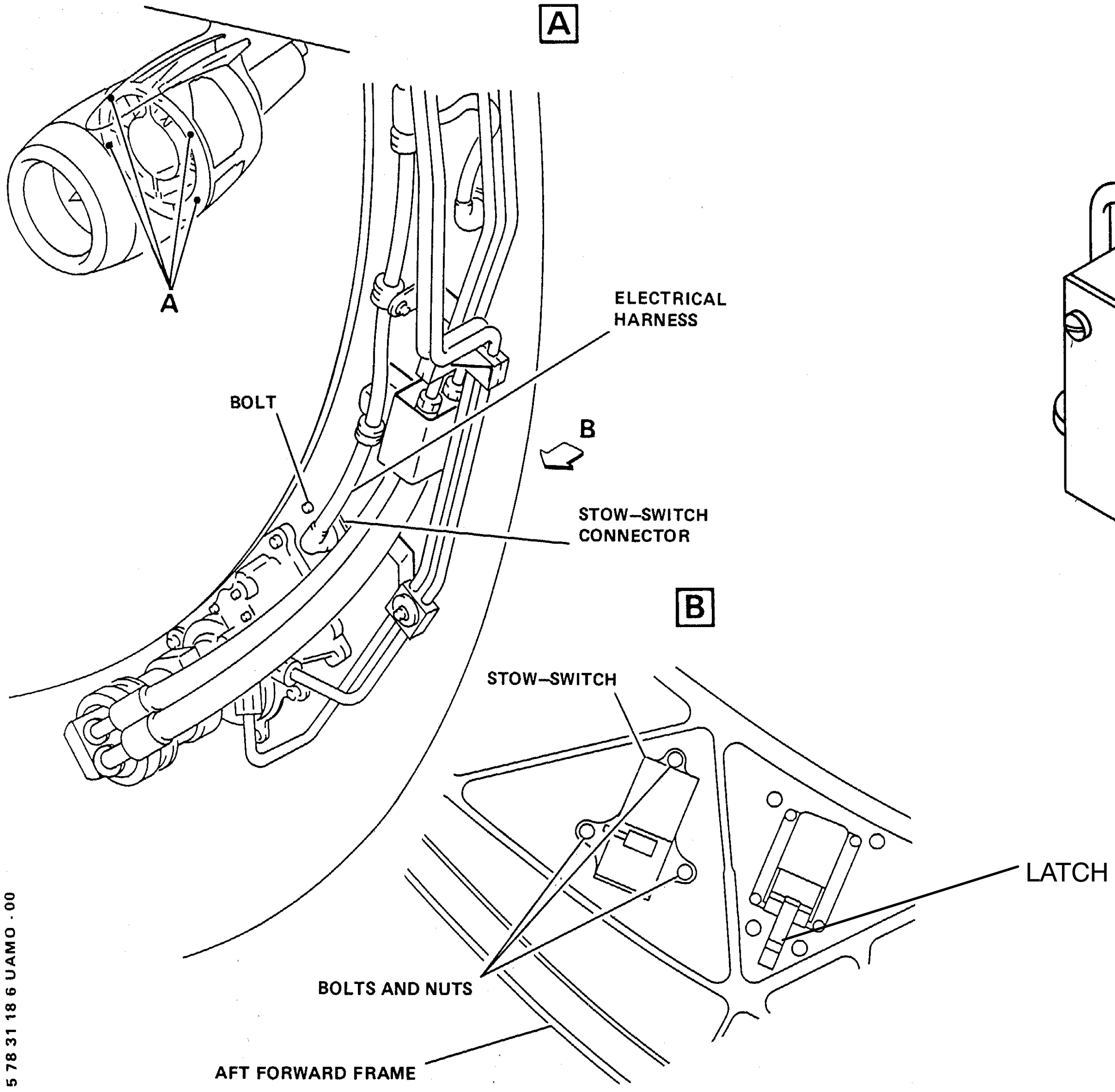
Thrust Reverse Indication

The thrust reverser operating sequences are displayed in the cockpit on the ENGINE AND WARNING Display in the middle of the N1 dial with a REV Indication.

- REV Indication amber = transit
- REV Indication green = all REV doors in deploy position.

In deployment, an amber REV indication will come in view at the middle of the N1 dial when at least one reverser door is unstowed or unlocked (stroke >1%). If this occurs in flight, REV will flash first for 9 sec, then it will remain steady. This indication will change to green colour when all the fan reverser doors are fully deployed and than the reverse thrust can be applied.
In stowage, the indication changes to amber when one door at least is less than 95% deployed and disappears when all the 4 doors are stowed.





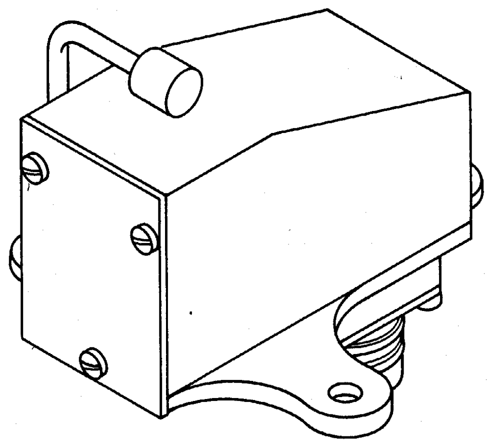


Figure 138 Stow Switch

DEPLOY SWITCH

Description

The deployed position of the doors is sensed by two thrust reverserdouble switches :
one for the two right side doors and one for the two left side doors.
They are located between the corresponding doors in 3 and 9 o'clock beams.
One single switch includes 2 cells one for each ECU channel. Junction wires inside the switch are bedded in grease to avoid friction wear problems.
The switches are connected to the ECU via the electrical junction box.
For each door, one cell is connected to ECU channel A, the other one to channel B. All doors are electrically connected in series.
Each time a door reaches 95% of its travel, the circuit closes.

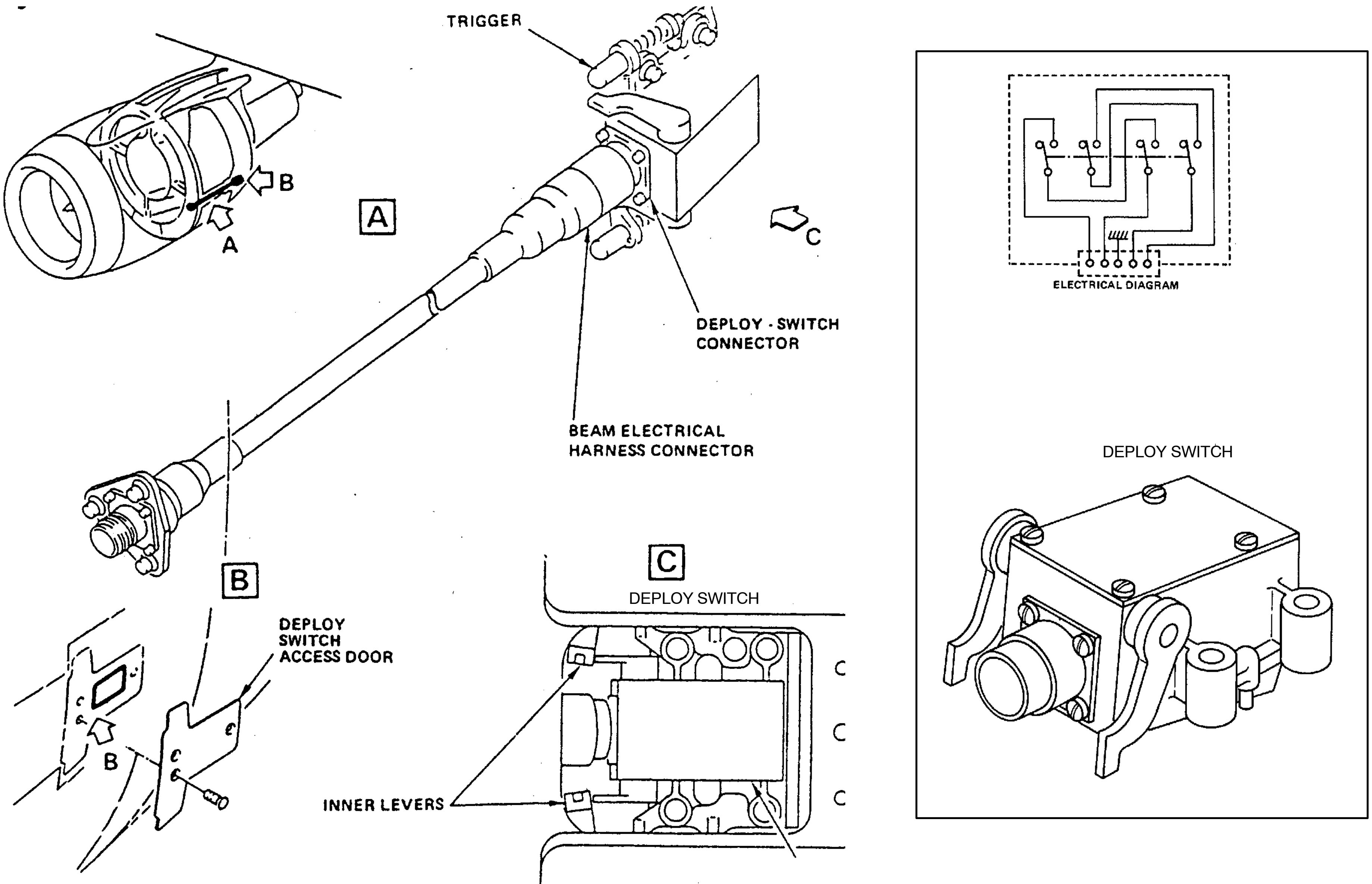


Figure 139 Deploy Switch

78-37 THRUST REVERSER IDEPENDENT LOCKING SYSTEM

"THIRD LINE OF DEFENCE"

To protect the thrust reverser system against inadvertent deployment, an additional and independent thrust reverser locking device (third line of defence) is installed on the aircraft.

For each engine, a shut-off valve is introduced between the Hydraulic Control Unit (HCU) and the associated Aircraft hydraulic unit. The shut-off valve (SOV) is installed under the engine pylon (on the FWD secondary structure in the fan compartment).

The opening / closure command of this SOV is provided through an aircraft logic, completely independent from the basic thrust reverser. FADEC command and monitoring logic/circuitry.

Each SOV opening / closure is obtained from the Throttle Control Unit (TLA signal -3.8deg.) and Spoiler Elevator Computers (SEC) which command a static relay to control 115 VAC power supply to the SOV solenoid.

The Engine Interface Unit (EIU) receives the TLA signal -3.8deg. from another position switch of the Throttel Control Unit, to energize the inhibition relay.

COMPONENT DESCRIPTION

Shut-Off Valve
The thrust reverser Shut-Off Valve (SOV) is a 3 port, two position spool valve. It is controlled by a solenoid driven 3 port, two position normally open pilot valve. Electrical power is supplied to the SOV through the fan electrical feeder box.

Filter and Clogging Indicator
It is used to filter the fluid from the aircraft hydraulic system. The filter is a flow-through cartridge-type filter. The clogging indicator monitors the pressure loss through the filter cartridge and has a pop-out indicator to signal when it is necessary to replace the filter element.
The filter assembly contains a check valve to permit the removal of the canister and the change of the filter element with a minimum of spillage.

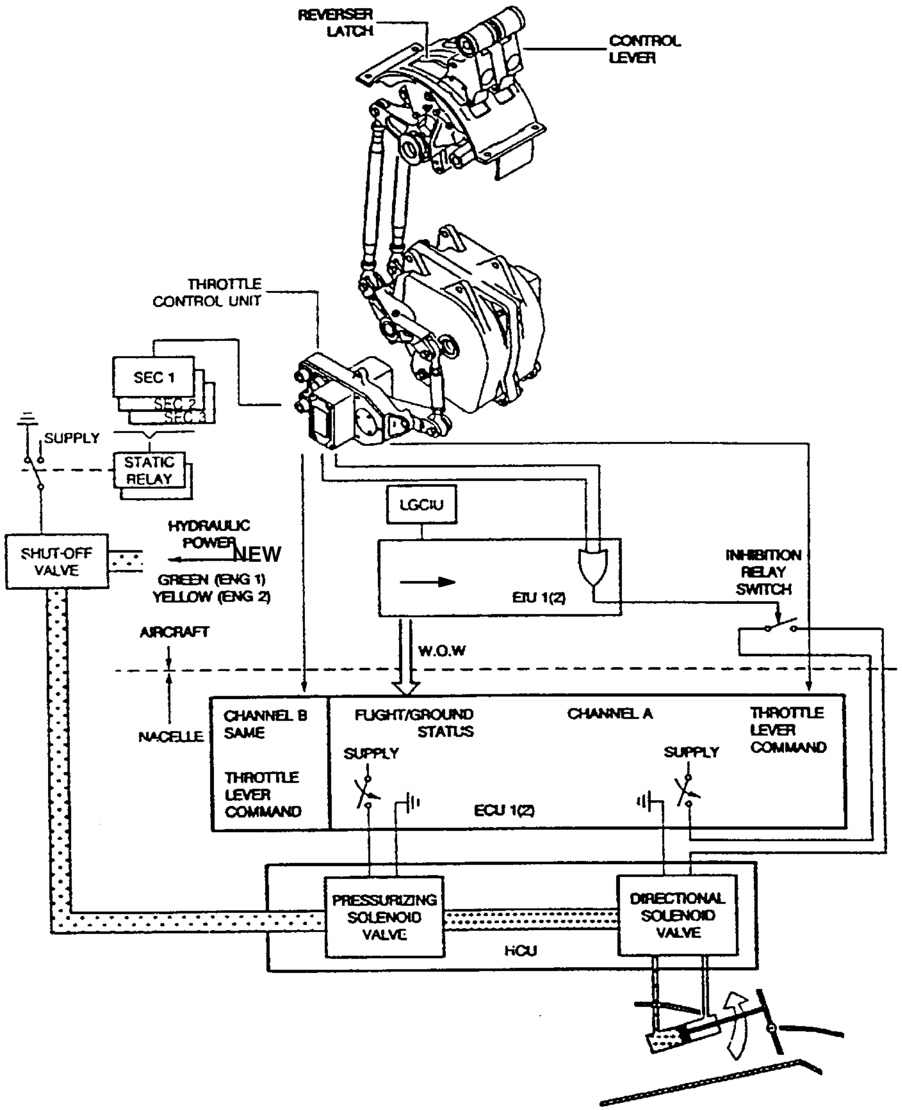
SYSTEM OPERATION

Shut-Of f Valve Opening/Closing Operation.The hydraulic power for the thrust reverser operation is obtained from the engine driven pump of the hydraulic system (ref. 29-10-00), which supplies the HCU through the filter and the thrust reverser SOV. The thrust reverser SOV is designed to isolate the thrust reverser from the aircraft hydraulic system. The solenoid valve is de-energized closed. When the supply port is closed the thrust reverser is isolated from the aircraft hydraulic system.When the solenoid is energized the valve opens.

The thrust reverser SOV is commanded in the open position when the following conditions are satisfied:

- aircraft is on ground proximity (less than 10 ft)
- reverse thrust is selected
- high forward thrust not selected on opposite engine.

The SOV valve solenoid is supplied with 115 VAC through a dedicated and physically segregated wiring. This power supply to the SOV is controlled by a power relay commanded by a static relay. The power relay coil is enegized to open the SOV and de-energized to close the SOV. Its energization/de-energization is controlled through the 28VDC static relay which is piloted by the SEC (SEC 1 or 2 for engine 1 and SEC 1 or 3 for engine 2).



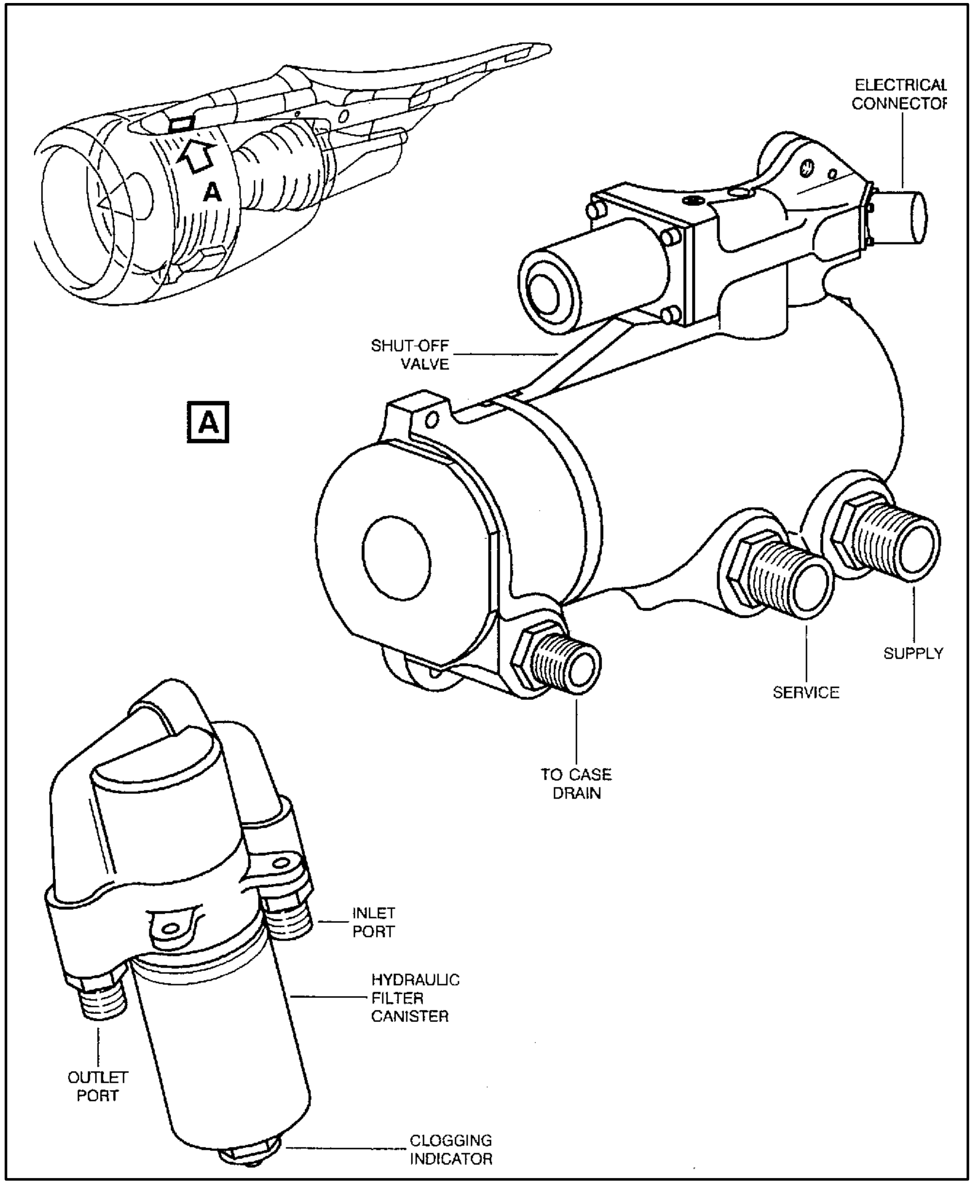


Figure 140 T/R Independent Locking System

THRUST REVERSER DEACTIVATION

Refer to MEL Maintenance Procedure 78-30-01

Thrust Reverser Deactivation

- This is done when a reverser system fault occured and the aircraft is dispatched according to MEL.
- The reverser is deactivated by turning the control lever on the HCU to ”OFF” and inserting the pin.
- And inserting the 4 lockout bolts in each blocker door to prevent it from opening.

HCU Lock-Out
is performed:

- through Deactivation Lever
  - the HCU is in Bypass Position

This must be performed,to:

- operate the Blocker Doors manually (by hand) for Maintenance Actions.
- prevent Reversersystem from unwanted operation.
- deactivate the Reverser.

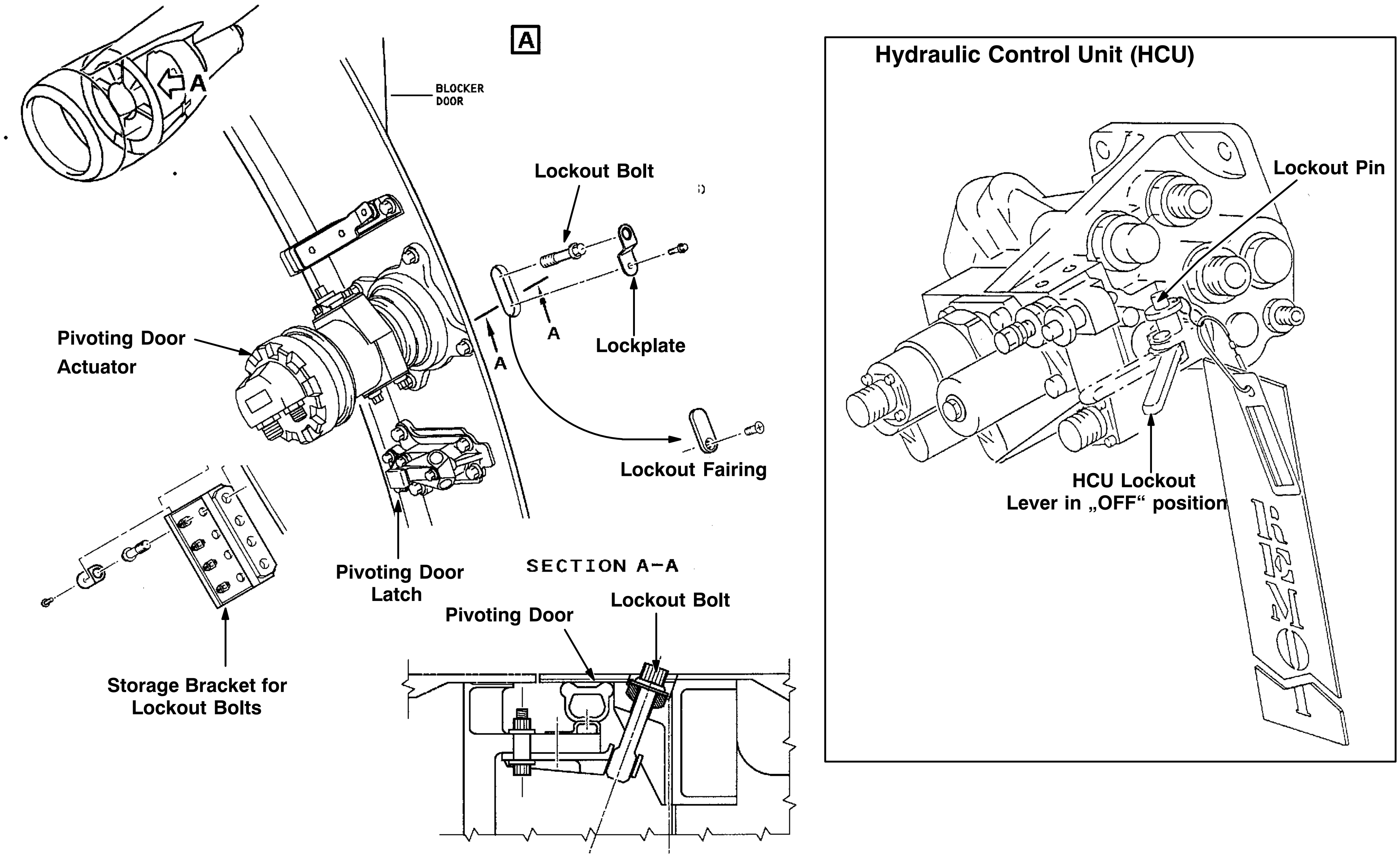


Figure 141 Thrust Reverser Deactivation

MANUAL DEPLOYMENT OF THE BLOCKER DOOR

TASK 78-32-41-860-040

A On the panel 115VU:
- Put a warning notice to tell persons not to start the engine 1(2).

B. Make sure that the engine 1(2) has been shut down for at least 5 minutes.

C. On the panel 50VU:
- Make sure that the ON legend of the ENG/FADEC GND PWR/1(2) pushbutton switch is off.
- Install a warning notice.

D. Open the fan cowl doors:

E. Put the access platform in position.

F. Make the thrust reverser unserviceable.

Procedure

A.Using a 5/16 in. wrench turn the manual unlocking knob on the latch to the unlock position.

NOTE :
The manual unlocking knob is located on slots aside of the latch.

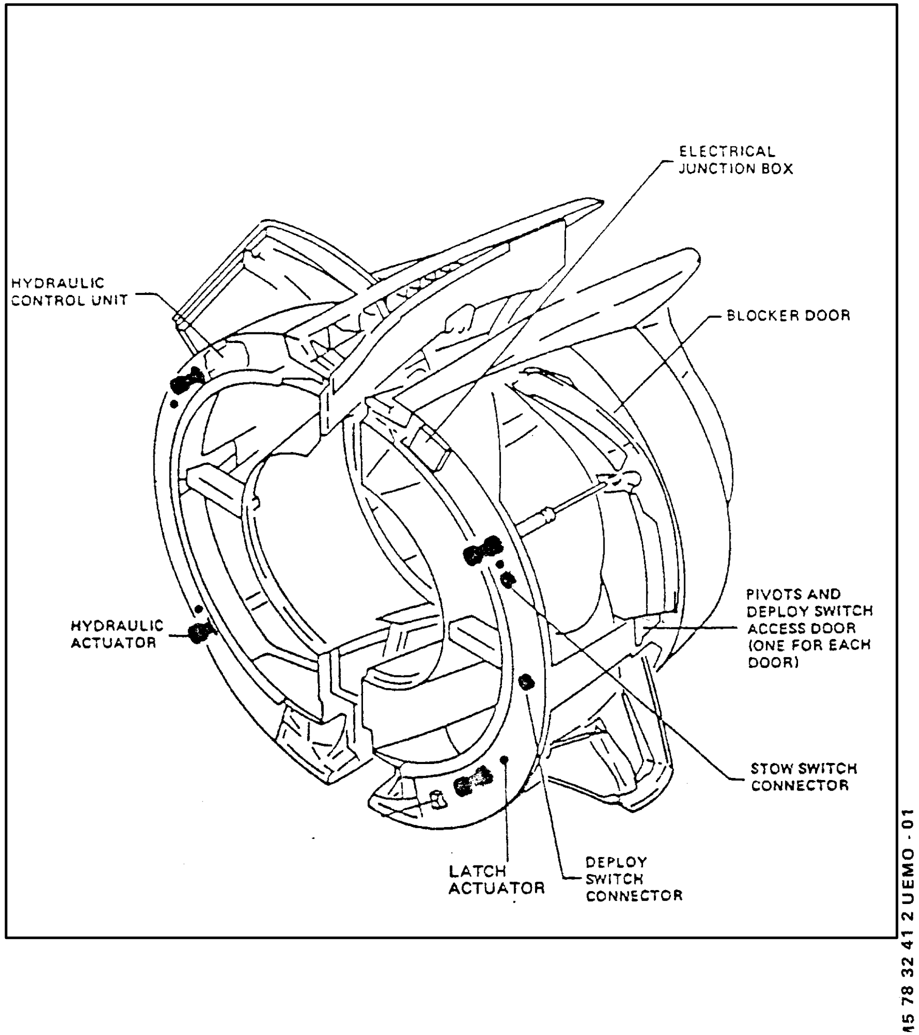
Check the secondary lock of the actuator.

B.Turn the manual unlocking square on the actuator to the unlock position.

NOTE :
The pivoting door automatically disengage from its hook.

CAUTION :
DO NOT PUSH ON THE STOW SWITCH LEVER WHEN BLOCKER DOOR IS OPENED OR DAMAGE COULD OCCUR.

C. Open the pivoting door by manually pulling on its edge.



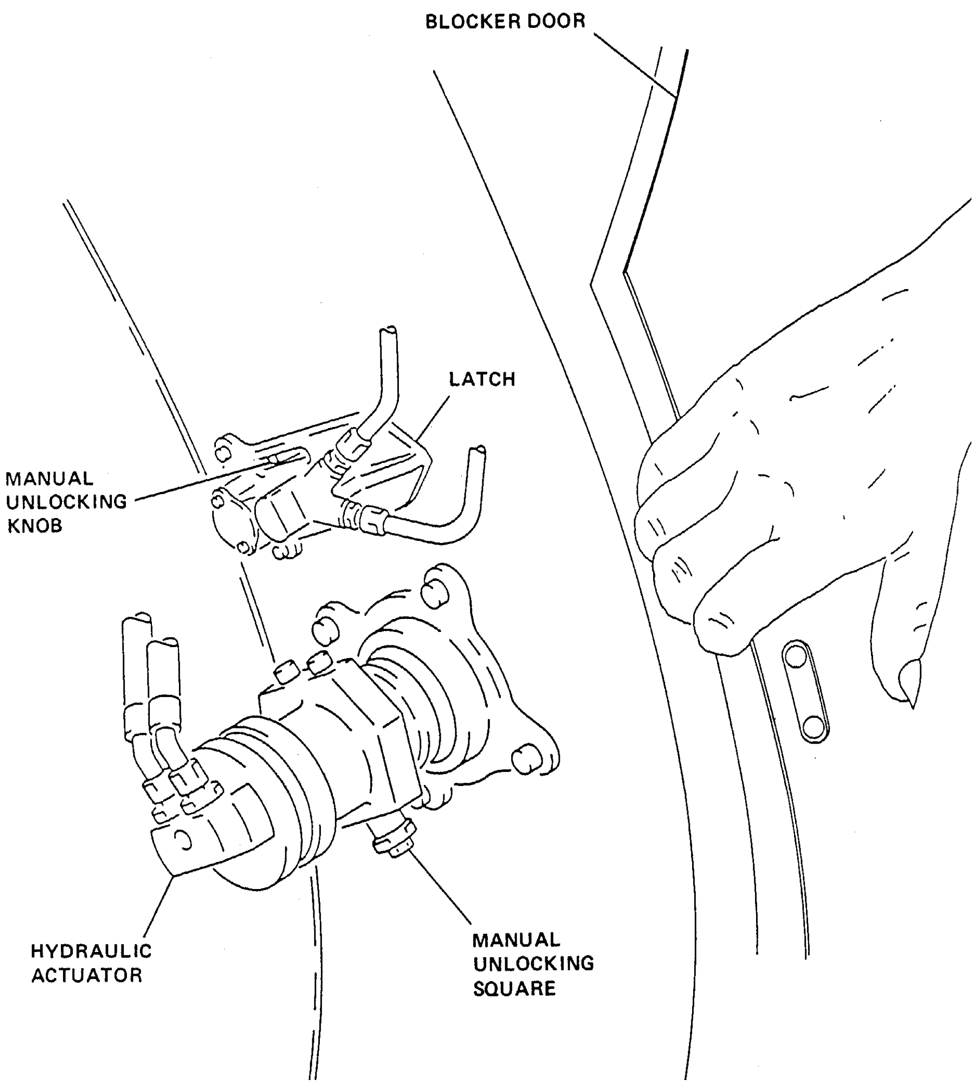


Figure 142 Manual Deployment

OPERATIONAL TEST OF THE T/R WITH CFDS

PROCEDURE:

Pressurize hydraulic system:
FOR 1000EM1 Pressurize the Green hydraulic system with the Yellow hydraulic system through the PTU .
On the lower display unit of the ECAM system:
Make sure that the HYD page shows that the pressure of the Green system is 3000 PSI.
FOR 1000EM2 Pressurize the auxiliary Yellow hydraulic system.
On the lower display unit of the ECAM system:
Make sure that the HYD page shows that the pressure of the Yellow system is 3000 psi (206.8427 bar).

On the panel 50VU:
- release the FADEC GND PWR 1 (2) pushbutton switch (on the pushbutton switch, the ON legend is on).
- release the HYD/LEAK MEASUREMENT VALVES/B/G/Y pushbutton switches (on the pushbutton switch the OFF legend comes on)

On the panel 23VU:
- make sure that the SEC1 pushbutton switch is on (on the pusbutton switch the OFF legend is off).

On the left or right MCDU, get the SYSTEM REPORT/TEST ENG page

Do this test:

NOTE : This test can be done through the channel A or B of the FADEC 1(2)

Thrust Reverser Test

ACTION:	RESULT:
Push the line key adjacent to the T/R Test indication to get in the **T/R TEST** program.	The THRUST REVERSER TEST menu comes into view.
Push the line key adjacent to the - **PUSH BUTTON TO START TEST**	The **WARNING TEST ACTIVE** indication comes into view.
Put the throttle control lever in the **IDLE REVERSE** position	- The thrust reversers of the engine 1(2) operate. On the upper display unit of the ECAMsystem: - The REV indication in the N1 indicator of the engine 1 (2) must be amber when the thrust reversers operate. - It must become green when the thrust reverser are full deployed.
NOTE : If you do not perform the subsequent step immediately install a warning notice on the throttle control lever of the engine 1(2) to prohibit any-movement of the lever	
Put the throttle control lever in the **IDLE** position	- The thrust reversers of the engine 1 (2) retard On the upper display unit of the ECAM system: -The REV indication must be amber when the thrust reversers operate. - It must go out of view when thethrust reversers are stowed andlocked.
Push the line key adjacent to the **RETURN** indication	-TR TEST REPORT comes into view.
WARNING : **YOU MUST USE THE LINE KEY ADJACENT TO THE "RETURN" INDICATION TO COMPLETE THE TEST. IF YOU COMPLETE THE TEST WITH THE "MCDU MENU" KEY, THE TEST WILL STAY IN OPERATION FOR ONE MINUTE WITH NO INDICATIONTO MAINTENANCE PERSONNEL. IF A PERSON MOVES THE THROTTLE CONTROL LEVER IN THIS ONE MINUTE, UNWANTED MOVEMENT OF THE THRUST REVERSER CAN OCCUR.**	
Push the line key adjacent to the **RETURN** indication	-The ENGINE 1(2) MAIN MENUcomes into view.
Do the procedure again for the channel B of the FADEC 1(2).	

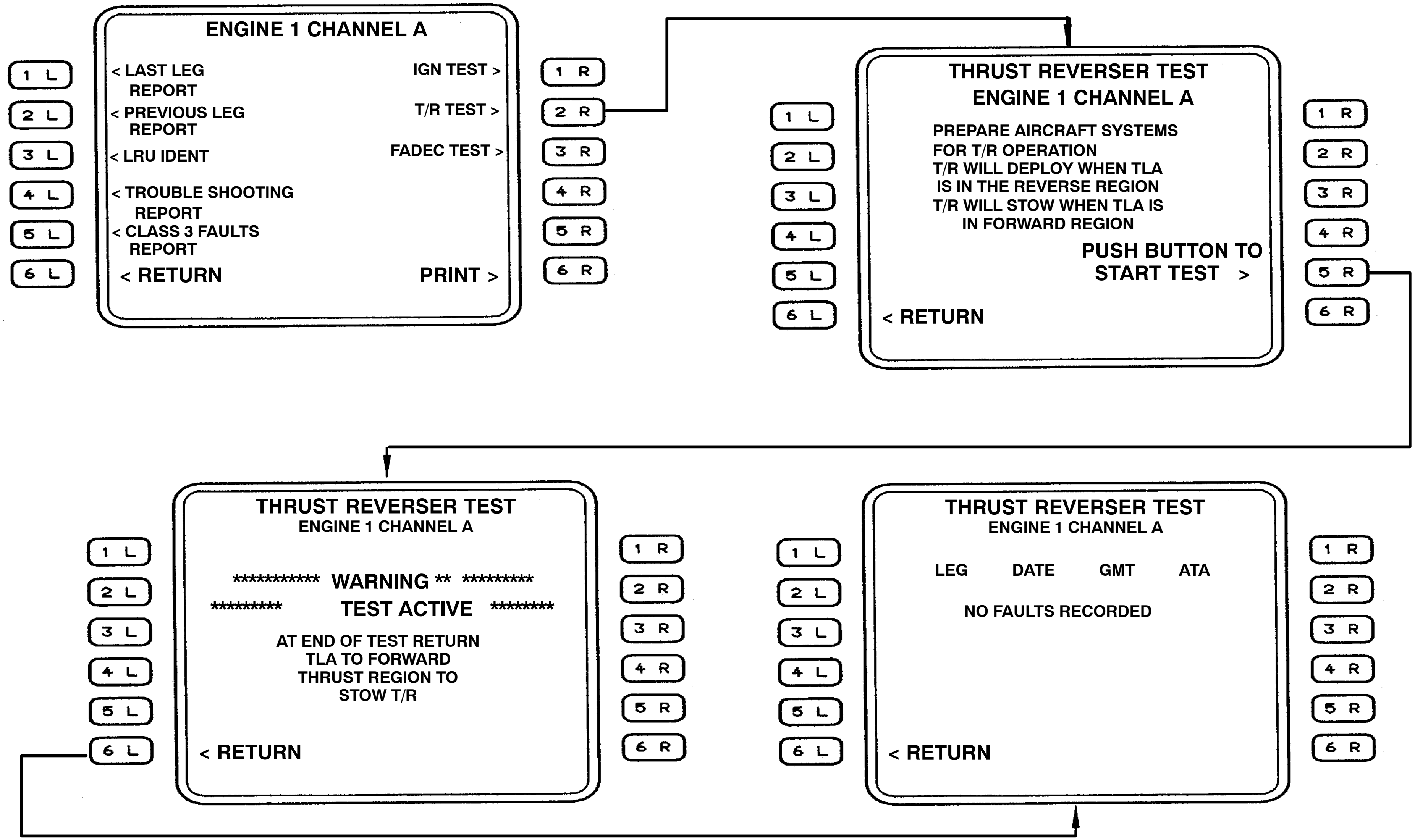


Figure 143 CFDS T/R Test

71-00 ENGINE CHANGE

ENGINE REMOVAL / INSTALLATION

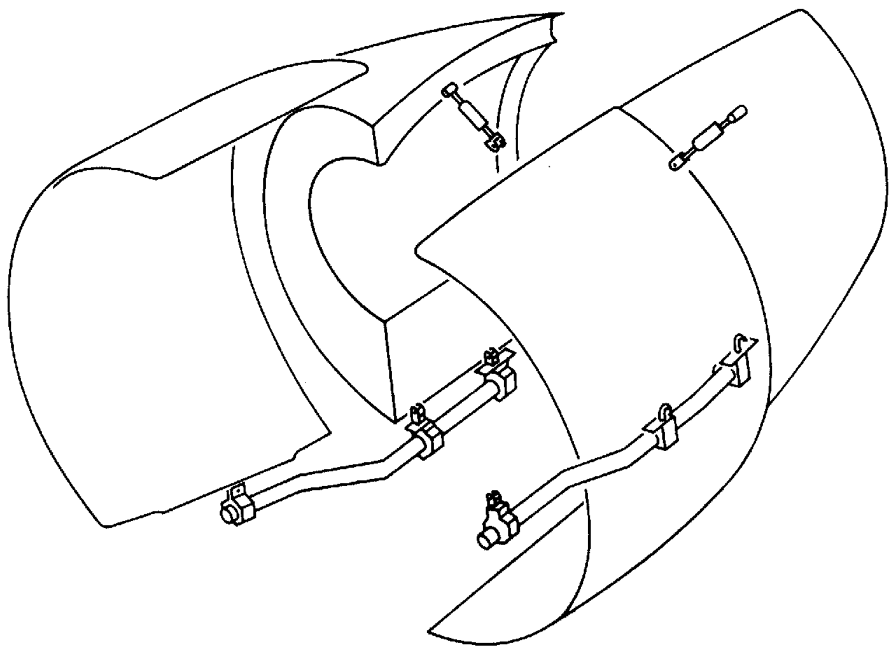
The arrangements for slinging / hoisting the engine are shown below (Bootstrap).

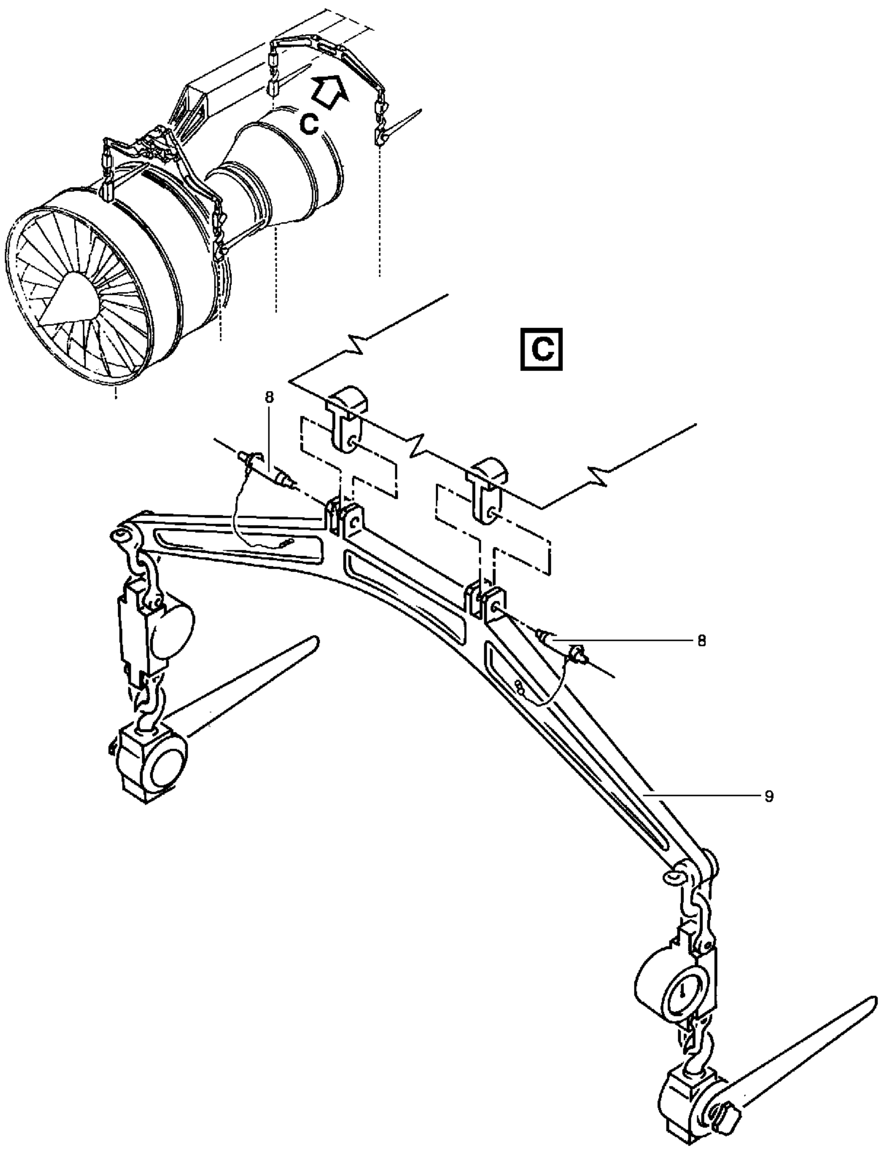
For furter information refer to AMM 71-00-00-400

After a new engine was installed different Test Tasks have to be performed:

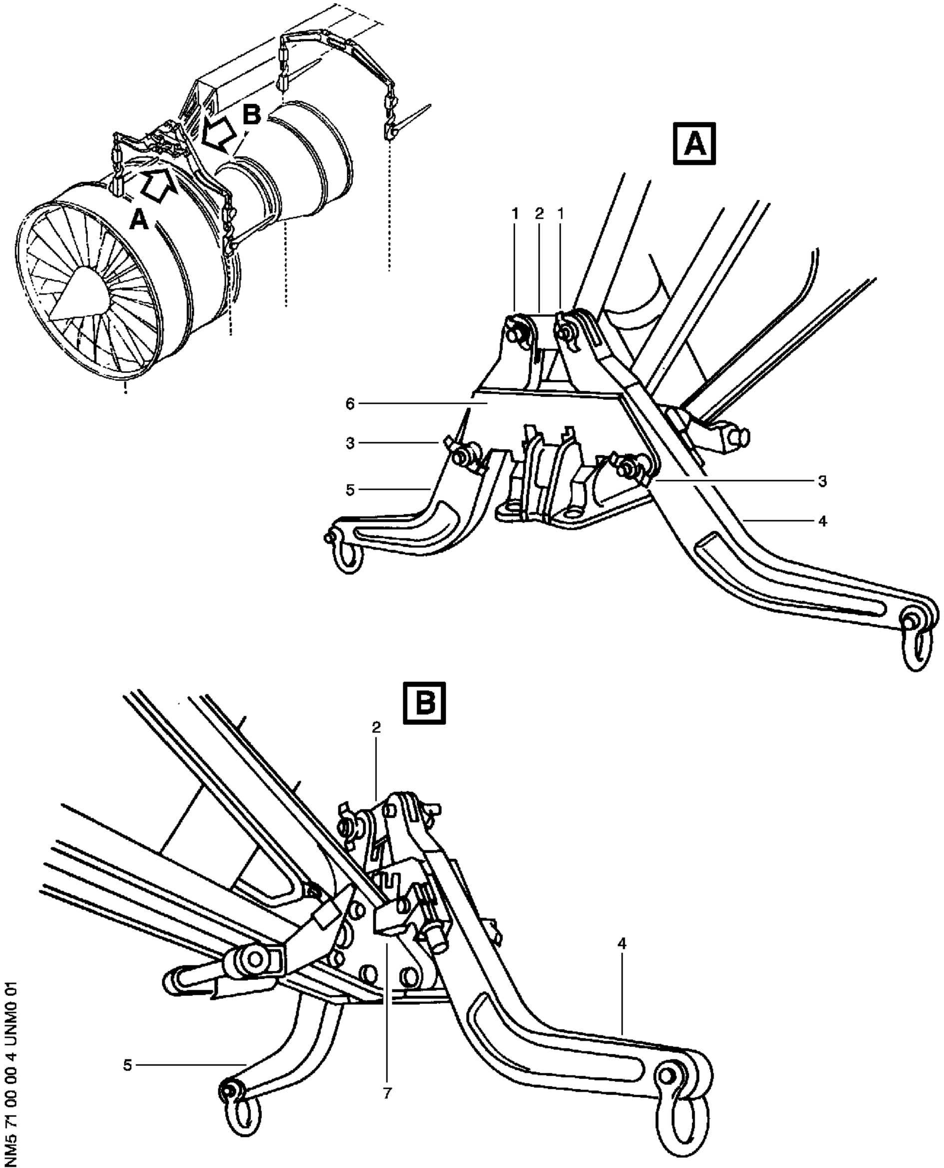
- Check of engine datas via CFDS (ESN,ECU P/N, Engine Rating, Bump level etc.) to make sure that they are the same as written on the ECU, data entry plug and engine identification plates.
- Operational Test of ECU via CFDS.
- If A/C is operated in actual CAT III conditions,a Land Test must be performed.
- Functional check of IDG disconnect system.
- Functional check of engine ice protection system.
- Dry motor leak check
- Wet motor leak check
- Idle leak check

Fan / Reverser Cowls Supports for Engine Removal





NM5 71 00 00 4 UQM0 00



NM5 71 00 00 4 UNM0 01

Figure 144 Engine Removal / Installation

STUDENT NOTES:

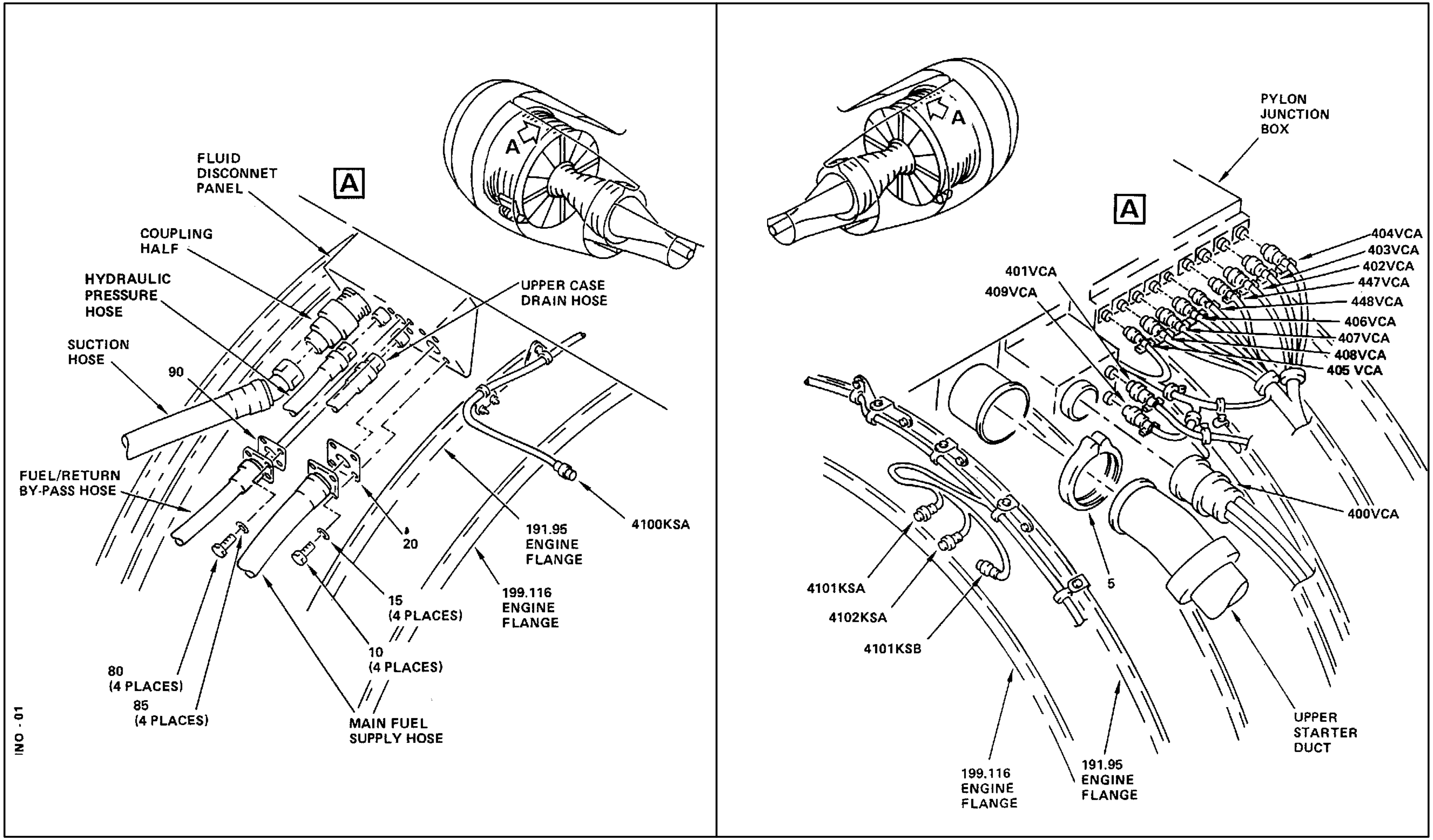


Figure 145 Engine Connections

ATA 30 ICE AND RAIN PROTECTION

Vacbi File: ENGINE ANTI ICE SYSTEM PRESENTATION

30-20 AIR INTAKE ANTI-ICE PROTECTION

ENGINE AIR INTAKE ANTI-ICE SYSTEM PRESENTATION

Source

Air is bled from High Pressure Commpressor 5th Stage of each Engine.

Valve

For each Engine, hot bleed air is ducted via an ”ON/OFF” valve.

The valve is pneumatically operated,electrically controlled and spring loaded closed.

Upon energization of the solenoid, the valve will close.

In case of loss of electrical power supply and pneumatic air supply available, the valve will open.

- It has a “Manual Override and Lock”. It can be blocked in the OPEN or in the CLOSED position.

Control

For each engine, the”ON/OFF” valve is controlled by a pushbutton.

Continuos ignition is automaticaly activated when the valve is opened.

The ”FAULT” light comes on during transit or in case of abnormal operation.

When the anti-ice valve is open, the zone controller determines the bleed air demand for the Full Authority Digital Engine Control (FADEC) system.

ECAM Page

If at least one of the two engine air intake anti-ice systems is selected ”ON”, a message appears in GREEN on the ”ECAM MEMO” display.

ON - (PB-Switch In, Blue)

The ON light comes on in blue. (valve solenoid deenergized) .

ENG ANTI ICE ON is indicated on the ECAM MEMO page.

- NI Limit is corrected

When the anti ice valve is open (valve position sw. NOT CLOSED), the zone controller sends a signal to the FADEC (ECS signal), this will:

- Modulate the Idle speed to Min.PS3 Schedule Demand for both engines.
- Switch the Cont. Ignition- ON (via EIU/ECU).

OFF - (PB-Switch Out)

Anti ice system is OFF (valve solenoid energized).

FAULT - (PB Switch In, Amber)

Fault light illuminates amber when valve not fully open.

FAULT - (PB-Switch Out, Amber)

Fault light illuminates amber.

The ECAM is activated

- - Single chime sounds
- - MASTER CAUT light ”ON”
- - Warning message:
  - <u>ANTI ICE</u> ENG 1 (2) VALVE CLSD
  - <u>ANTI ICE</u> ENG 1 (2) VALVE OPEN.

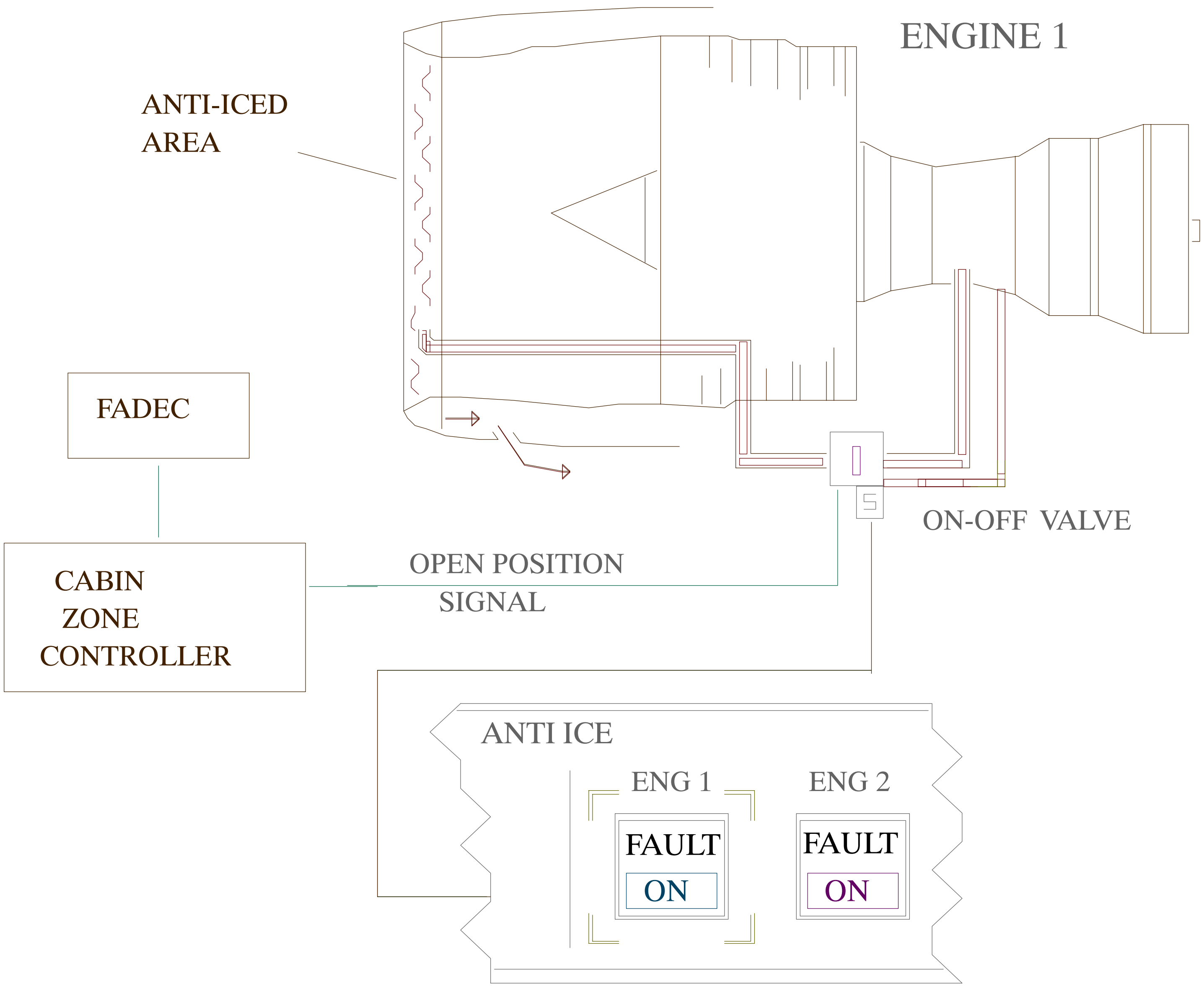


Figure 146 Engine Nacelle Anti Ice System

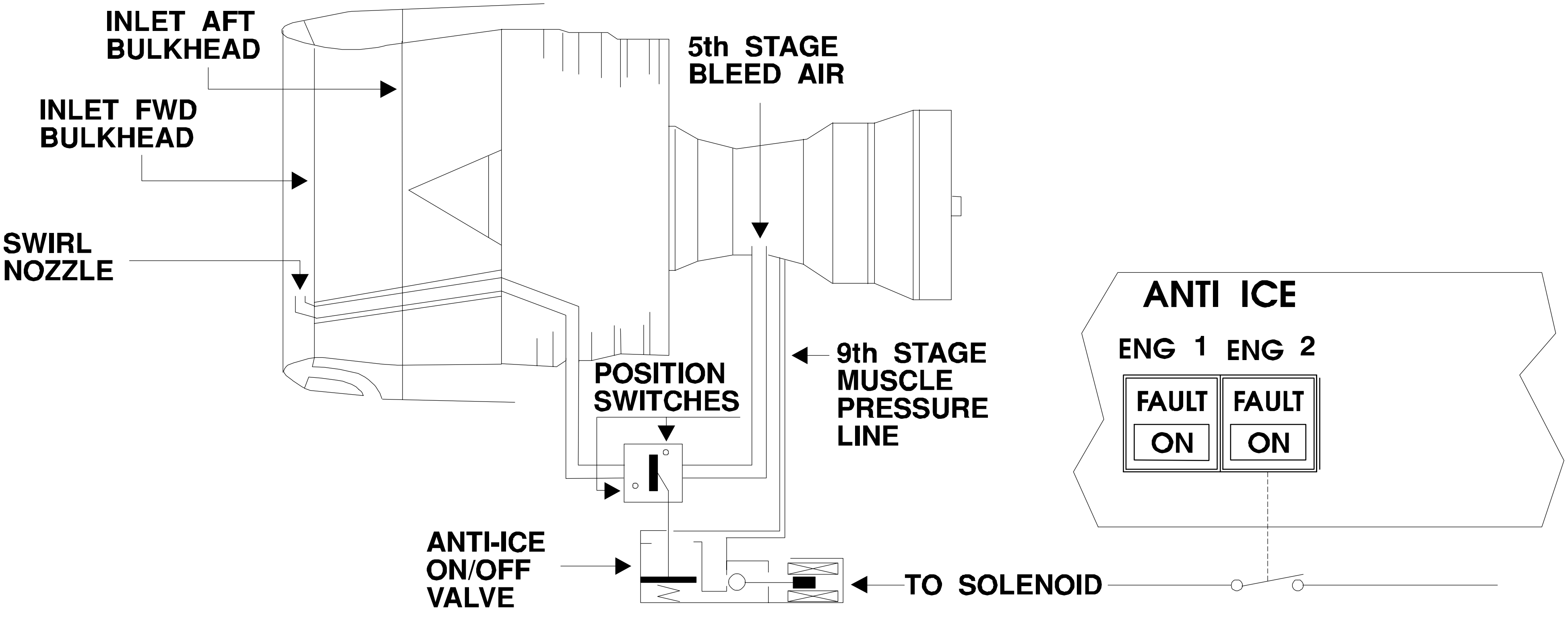
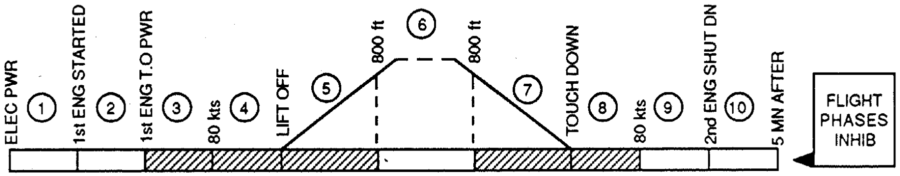


Figure 147 Engine Nacelle A/I Architecture

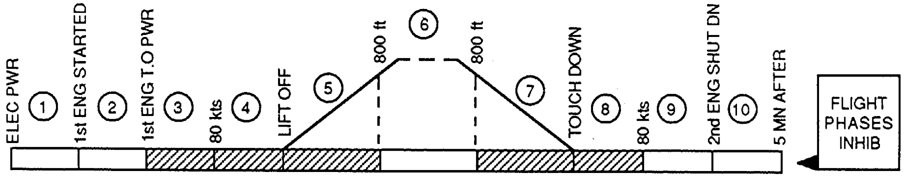
FAILURE: ANTI ICE	DETECTOR	MASTER LIGHT
ENG1 NAC VALVE NOT OPEN (2)	VALVE POSITION DISAGREE	CAUT
SYS DISPLAY PAGE CALLED NIL		AURAL WARNING SC



E: INHIBITED ON GND BY RELATED ENG SHUT DN

ACTIONS		LOCAL WARNING			DISPLAY			
		ENG1 (2) FAULT		A C C	ANTI ICE ENG1 VALVE CLSD (2) - ENG1 ANTI ICE..........ON (2) - AVOID ICING CONDITIONS			
OR		NIL			NIL			
SELECT ENG1 ANTI ICE ON (2)		ENG1 (2) FAULT ON		A C	ANTI ICE ENG1 VALVE CLSD (2) - AVOID ICING CONDITIONS			
CANCEL ANTI ICE	CLR			C	STATUS AVOID ICING CONDITIONS	INOP SYS ENG1 ANTI ICE (2)	A A	

FAILURE: ANTI ICE	DETECTOR	MASTER LIGHT
ENG1 NAC VALVE NOT CLOSED (2)	VALVE POSITION DISAGREE	CAUT
SYS DISPLAY PAGE CALLED NIL		AURAL WARNING SC



E: INHIBITED ON GND BY RELATED ENG SHUT DN

ACTIONS		LOCAL WARNING			DISPLAY			
		ENG1 (2) FAULT		A C	ANTI ICE ENG1 VALVE OPEN (2) - THRUST LIM PENALITY			
CANCEL ANTI ICE	CLR			C	STATUS THRUST LIM PENALITY			

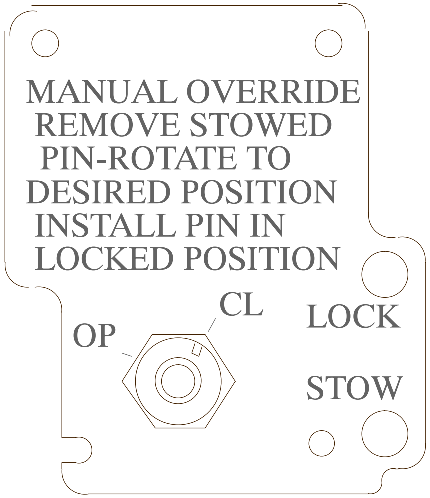
Figure 148 ECAM Messages

ENGINE NACELLE ANTI ICE VALVE OVERRIDE

refer to MEL.

Procedure

- Lock the intake anti-ice valve in the open or the closed position:
- Remove the lock-pin from the transportation hole in the valve.
- Use an applicable wrench on the nut and move the valve to the necessary position (open or closed).
- Hold the valve in the necessary position and install the lock-pin in to the valve locking hole.



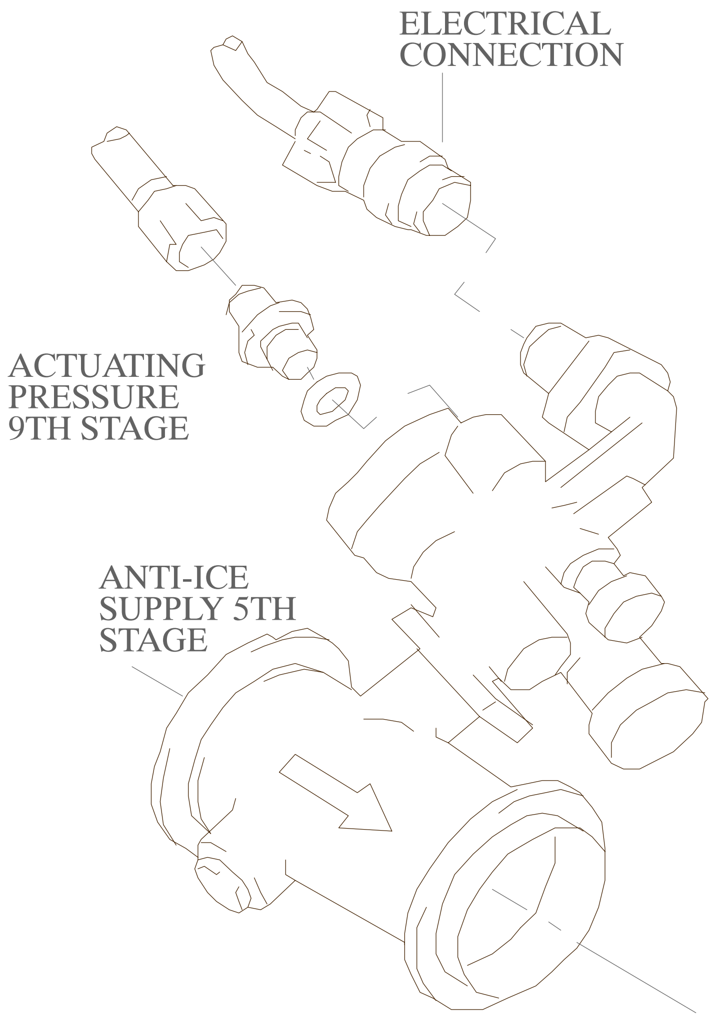


Figure 149 Engine Nacelle Anti ice Valve

STUDENT RESPONSE QUESTIONS

SELF EXAMINATION

1 **Which components belong to the FADEC system ?**

Answer:

2 **How many bearing compartments are installed ?**

Answer:

3 **What is the purpose of the ECU Alternator ?**

Answer:

4 **What is the purpose of the fuel return valve ?**

Answer:

5 **How can the fuel return valve be checked for leakage ?**

Answer:

6 **Are there any adjustments to be made on the HCU ?**

Answer:

7 **How is the Thrust Reverser actuated ?**

Answer:

8 **What is the purpose of the T-case signal ?**

Answer:

9 **Where is station 12 ?**

Answer:

10 **How can the Thrust reverser be deactivated ?**

Answer:

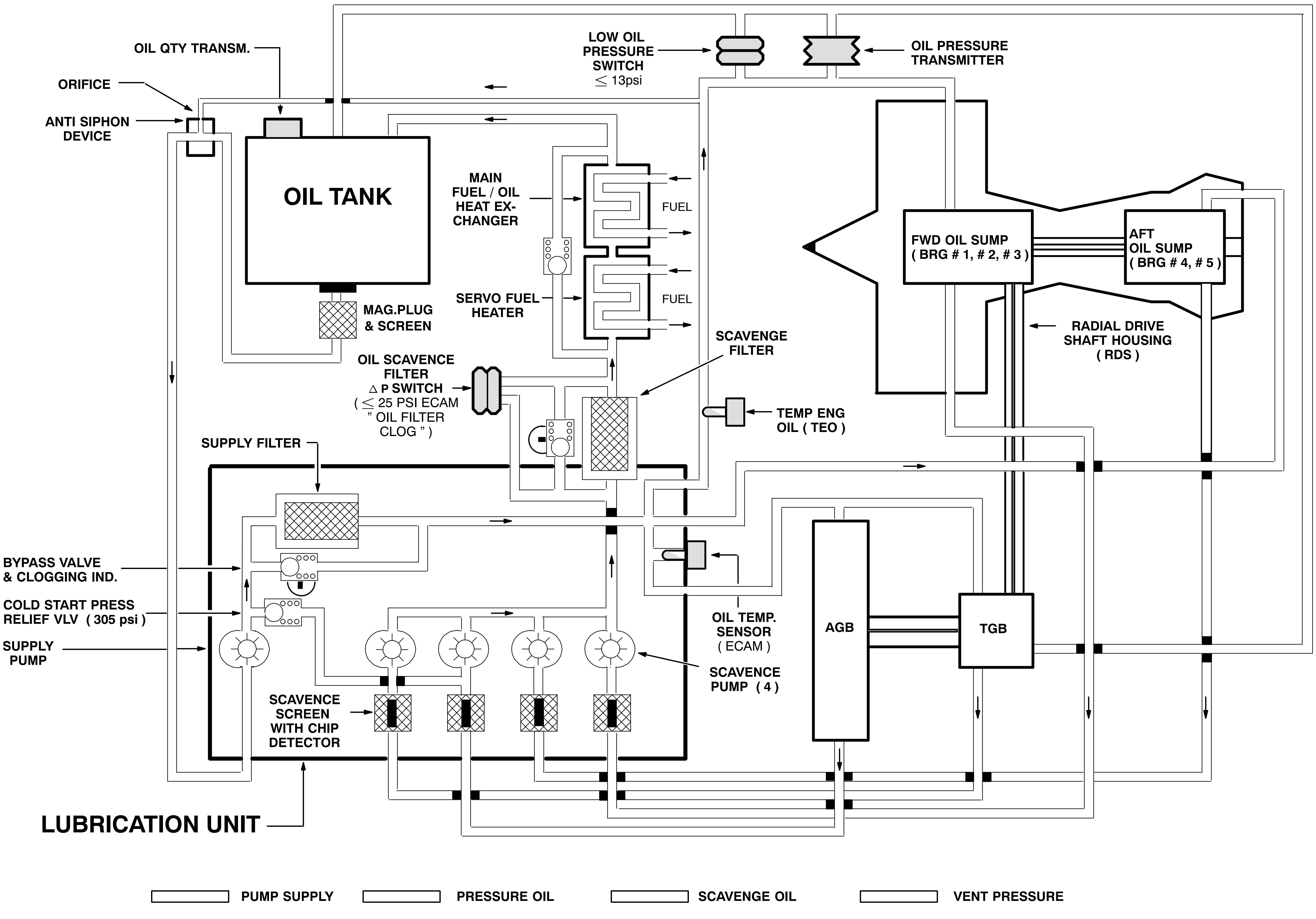


Figure A Oil System Basic Schematic CFM 56 - 5A1 / 5A5

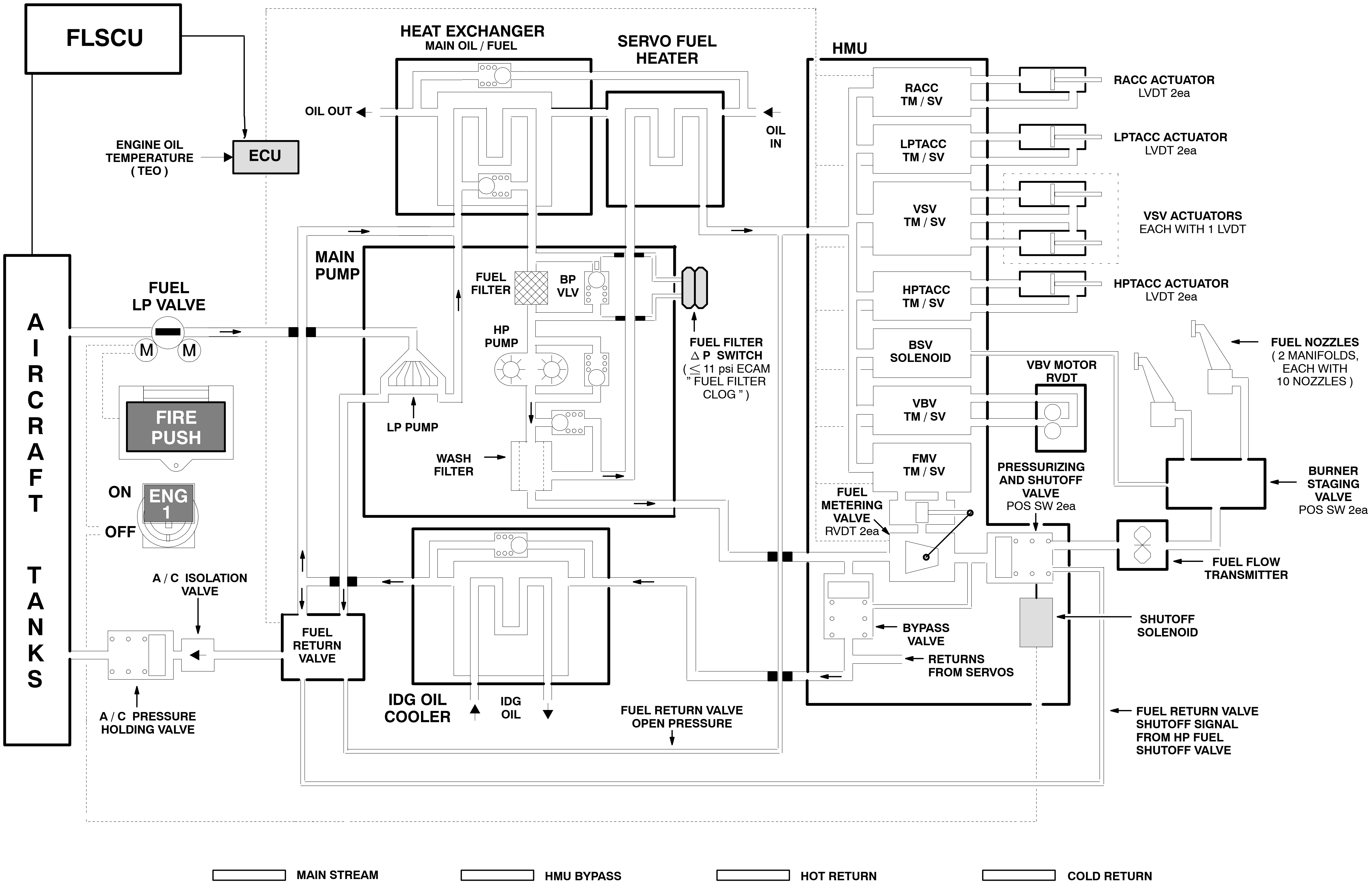


Figure B Fuel System Schematic CFM 56 - 5A1 / 5A5

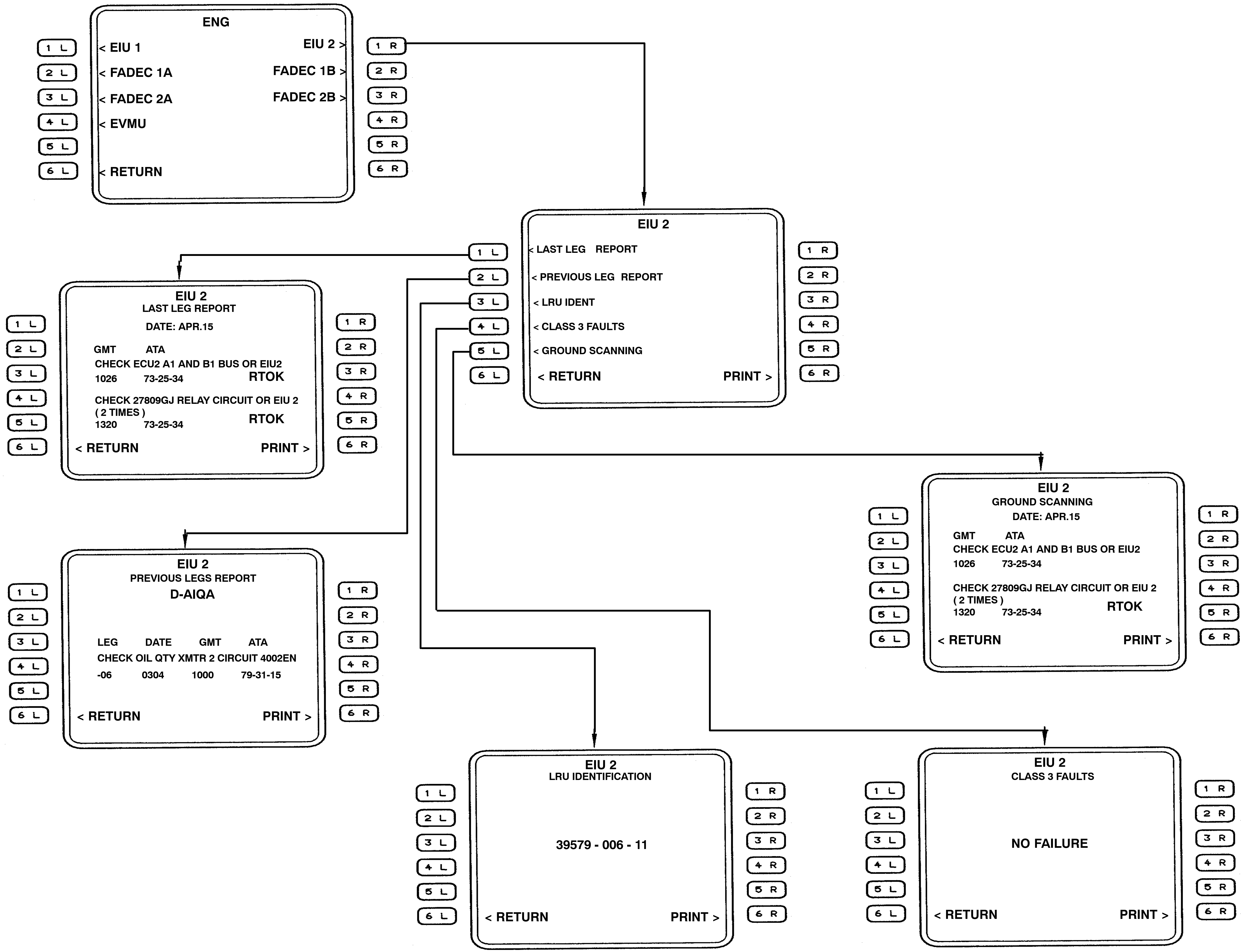


Figure C CFDS EIU Menu

NOTE:

FADEC PWR MUST BE SWITCHED "ON" OTHERWISE "NO RESPONSE" IS DISPLAYED.

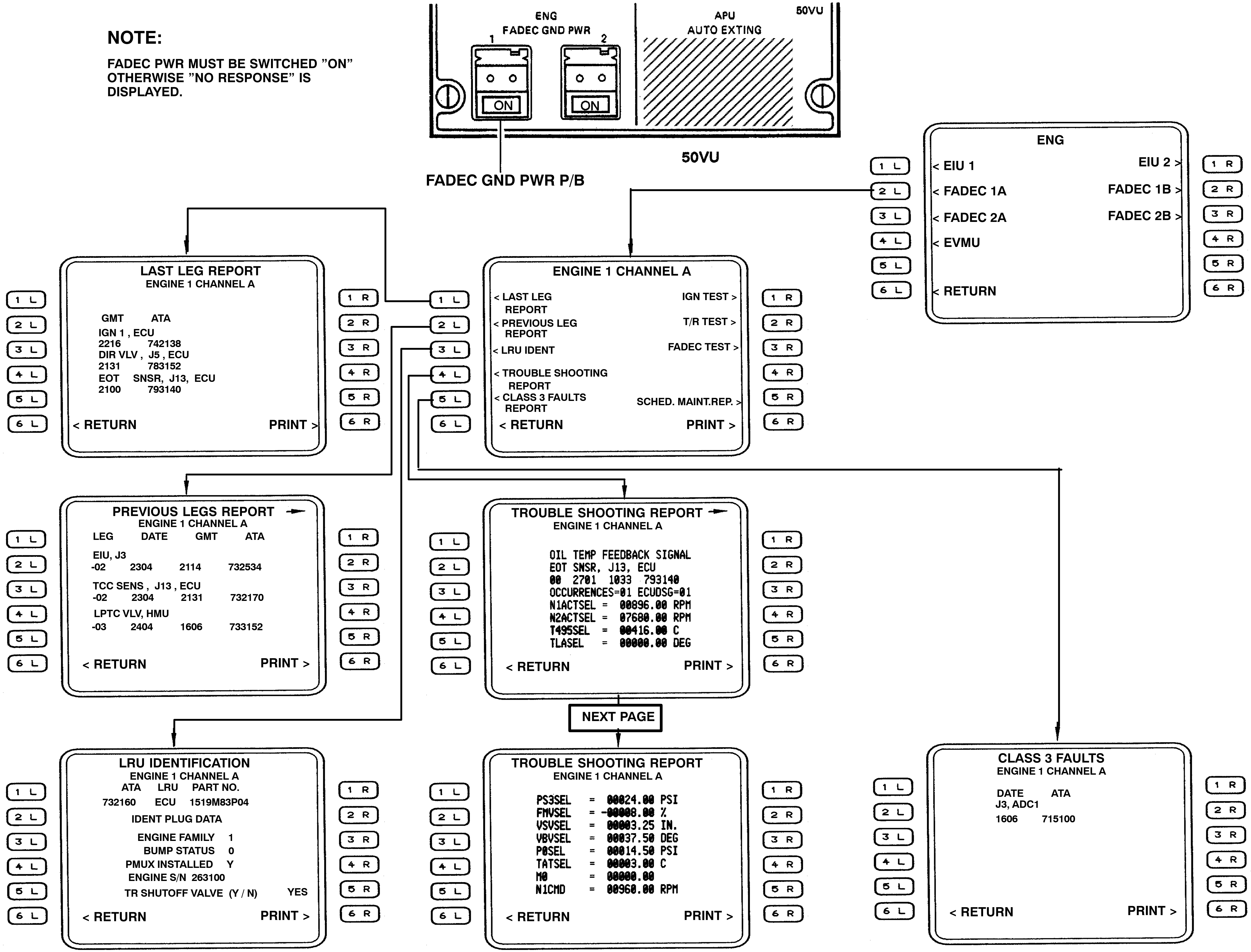


Figure D FADEC CFDS Menu

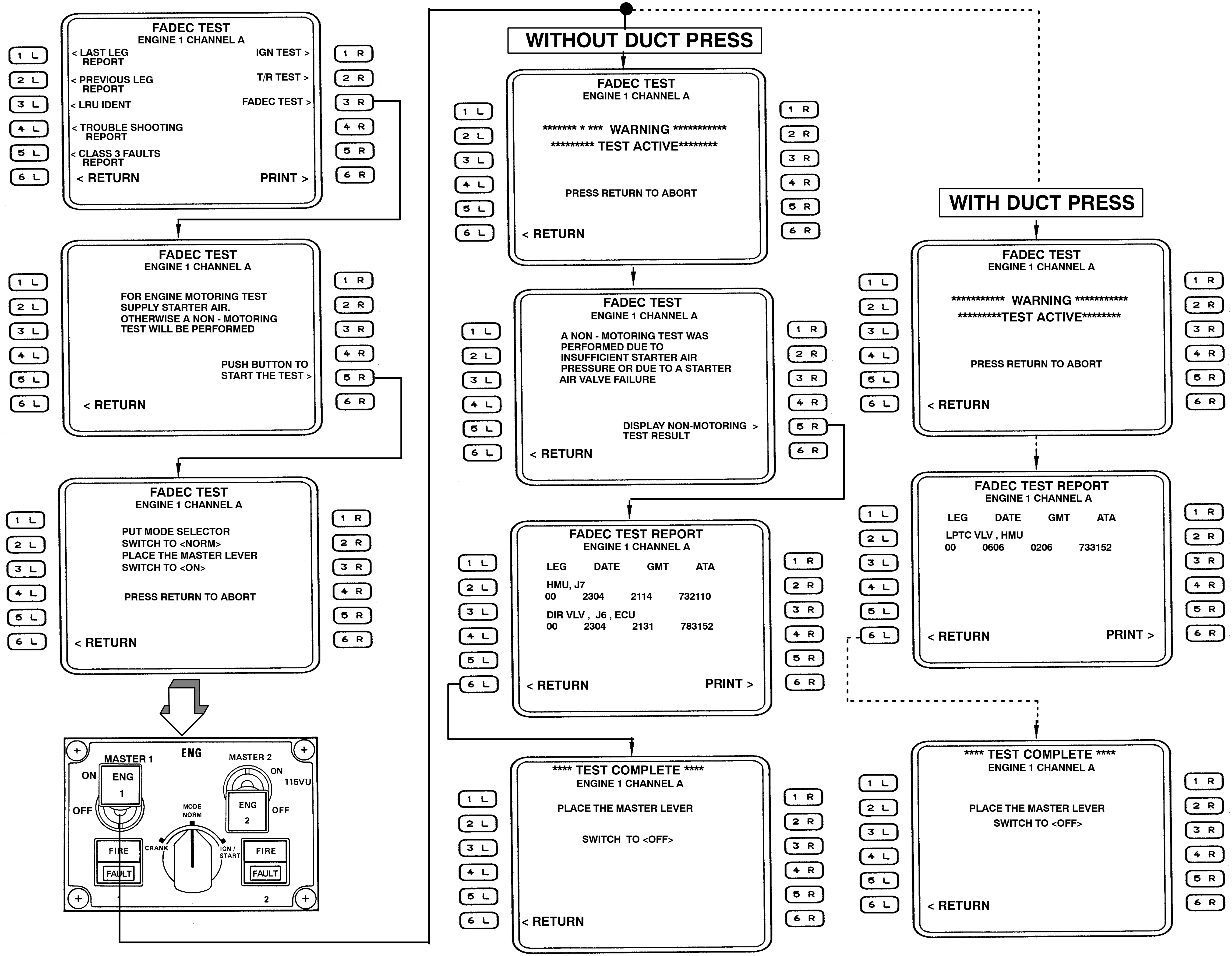


Figure E FADEC Test

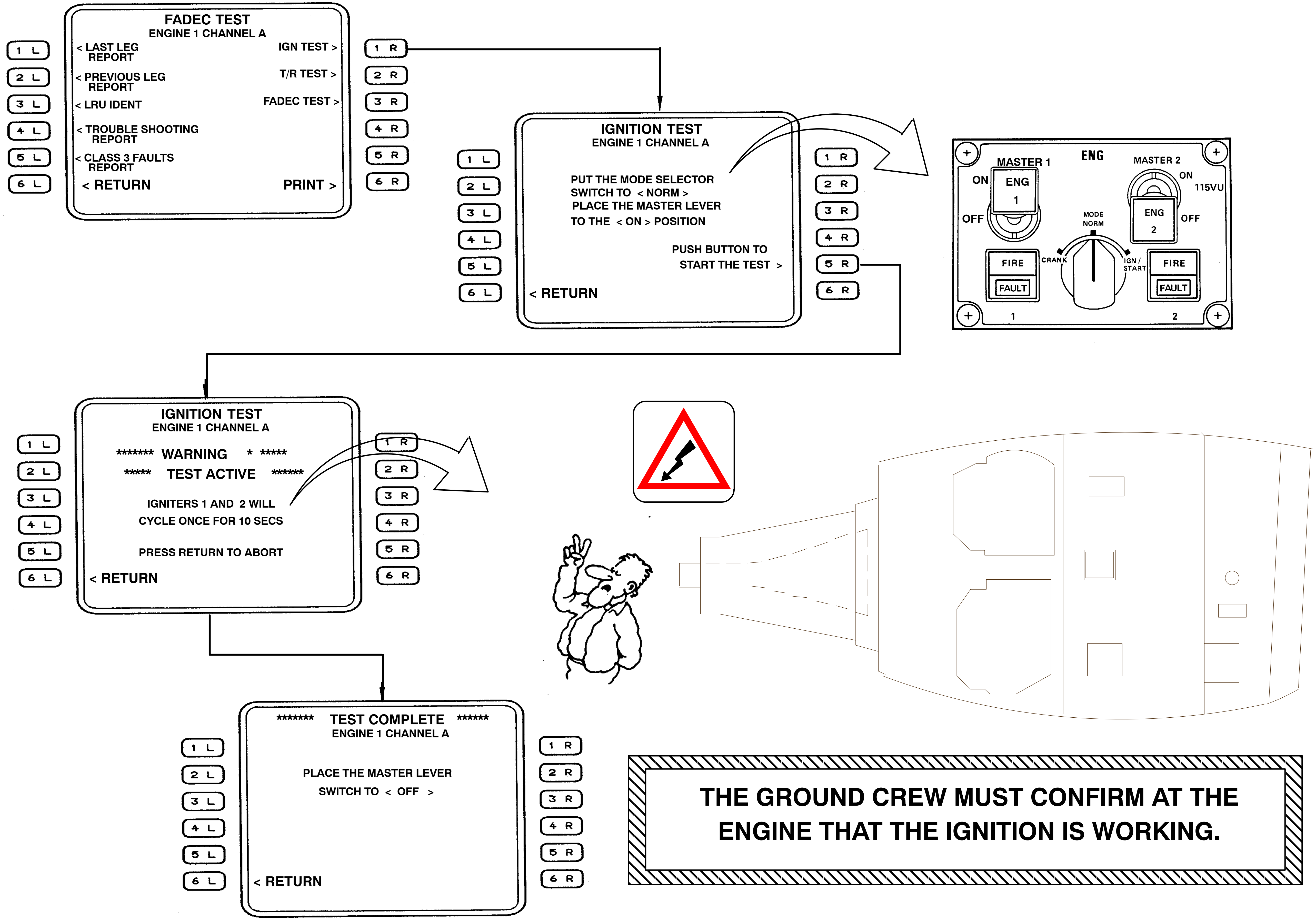


Figure F CFDS Ignition Test

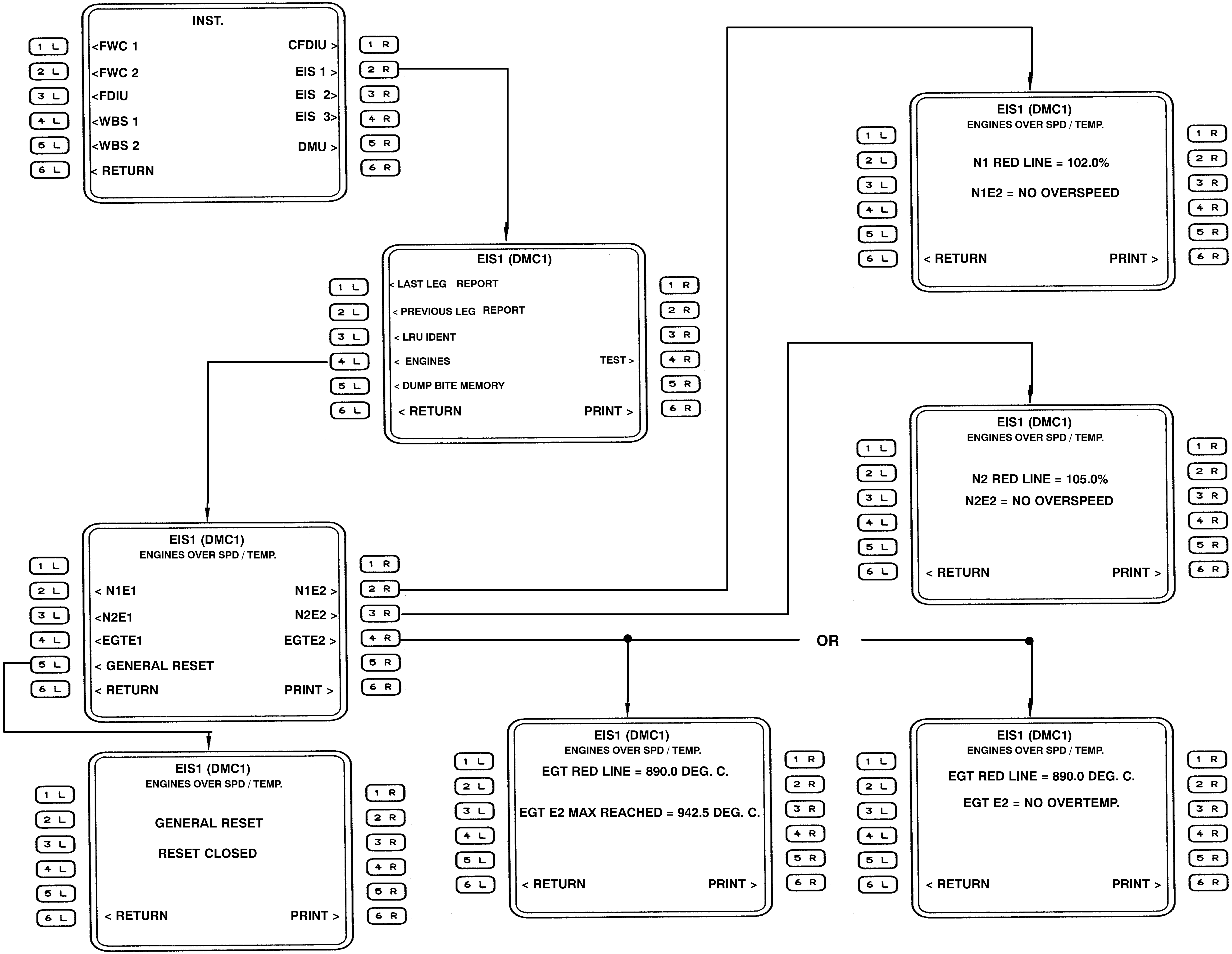


Figure G CFDS EIS Menu/Max Pointer Reset

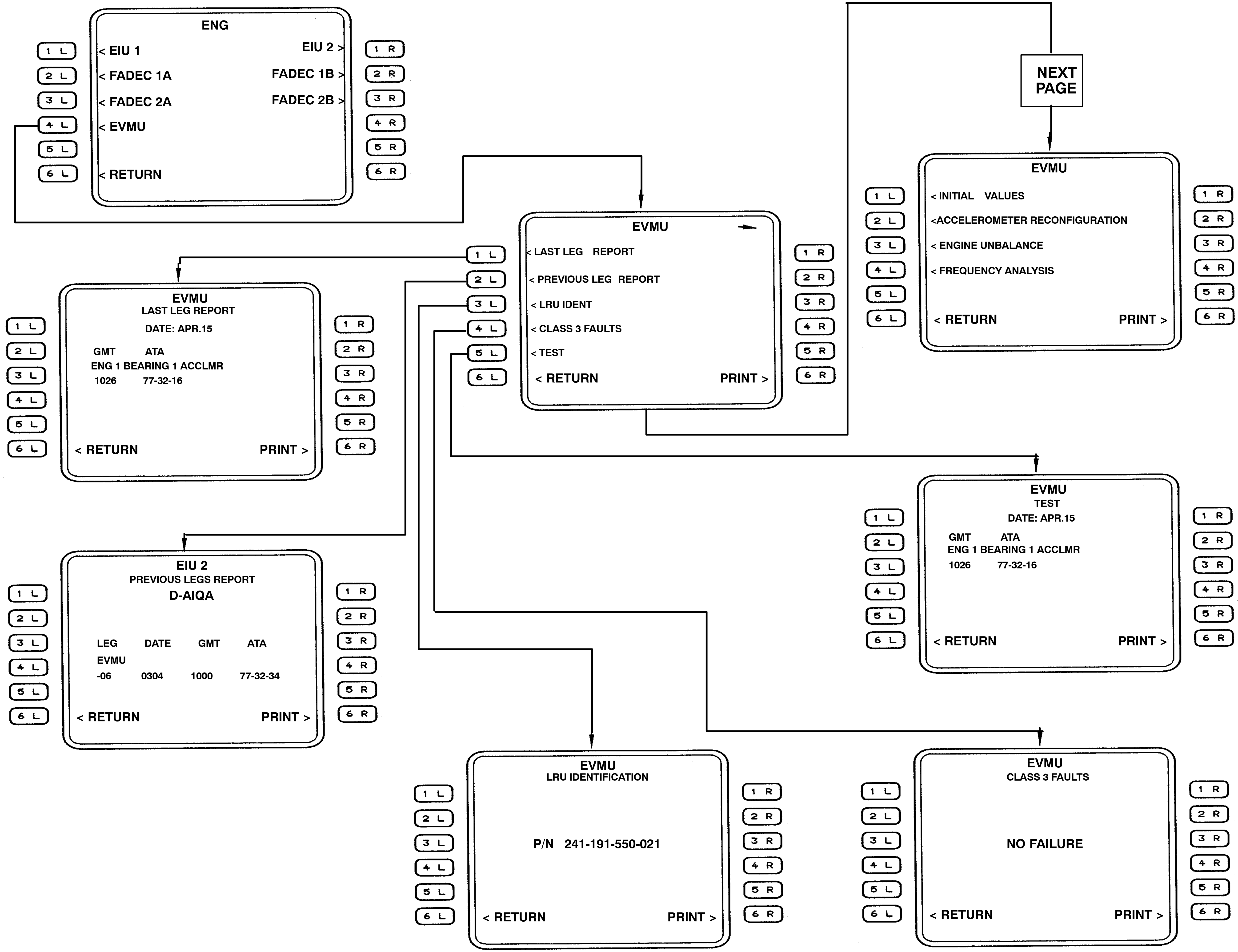


Figure H CFDS EVMU Menu

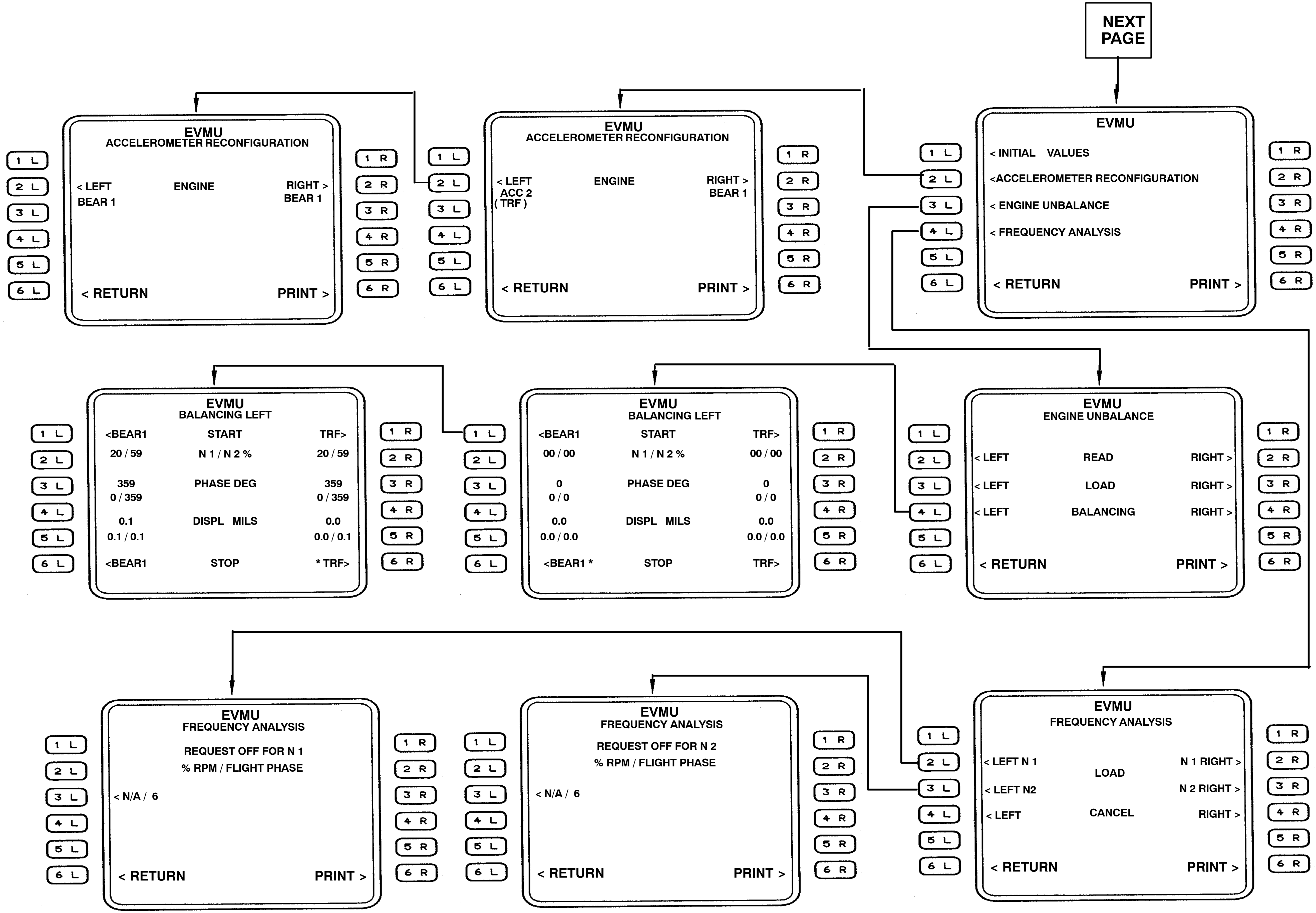


Figure I CFDS EVMU Menu

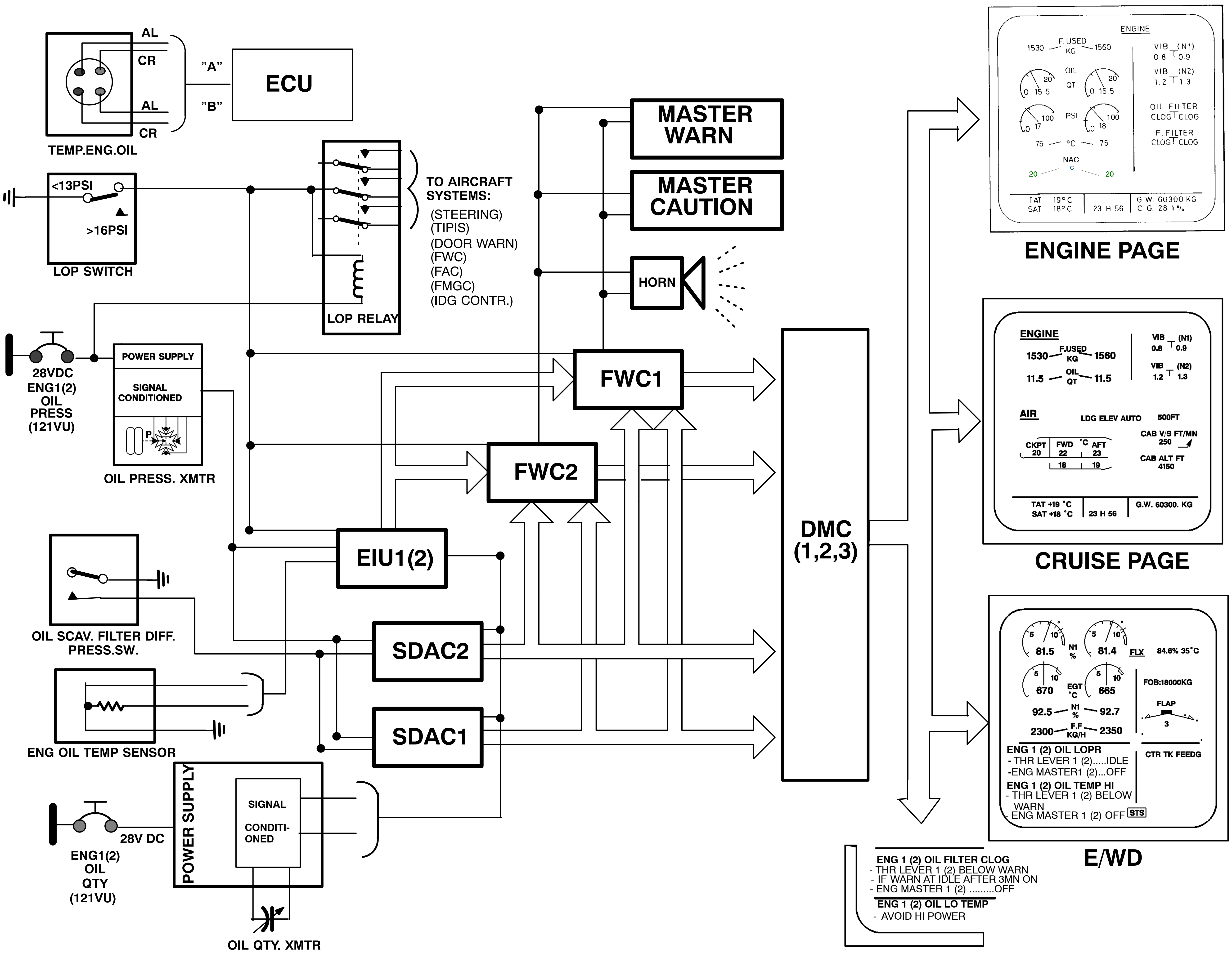


Figure J Oil Indicating Schematic