

**17.10 GENERAL**

**17.20 FUEL SYSTEM**

**17.30 OIL SYSTEM**

**17.40 AIRBLEED SYSTEM**

**17.50 THRUST REVERSER SYSTEM**

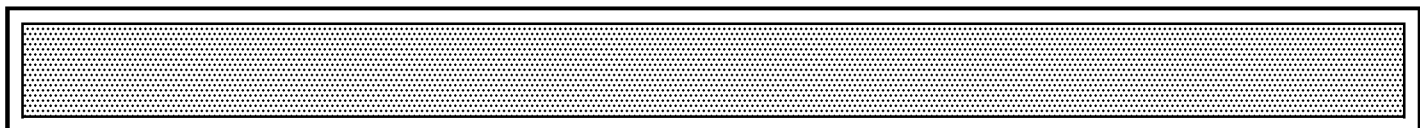
**17.60 IGNITION and STARTING**

**17.70 INDICATING**

**17.80 THRUST COMPUTATION and CONTROL**

**R 17.90 MAINTENANCE PANEL**

PW Eng. : All



R The PW 4000 is a dual rotor, axial flow turbofan with a compression ratio of approximately 29.7 to 1. The engine has a fan air to primary air bypass ratio of 4.8 to 1.

Bleed ports are provided between the LP and HP compressors (station 2.5) and after the 9<sup>th</sup> stage of HP compressor to assist in maintaining overall compressor section stability.

**LOW PRESSURE COMPRESSOR / TURBINE (LP)**

The low speed rotor (N1) consists of one fan stage and four compressor stages driven by four low pressure turbine stages.

The rotor heating control system controls the flows of the 9<sup>th</sup> stage compressor bleed air to the interior of the HP compressor rotor.

The exterior surface of the low pressure turbine case is cooled with engine fan discharge air to control turbine tip clearance.

Twelfth stage compressor bleed air is used to provide regulated cooling air for the HP turbine (blades and vanes).

The HP turbine case is cooled like the LP turbine case.

In addition the HP compressor provides eighth and fifteenth stage bleed air pneumatic requirements.

**HIGH PRESSURE COMPRESSOR / TURBINE (HP)**

The high pressure compressor (N2) is composed of eleven stages and is driven by two high pressure turbine stages.

**COMBUSTION CHAMBER**

An annular diffuser combustion chamber is fitted with 24 dual aerating fuel injectors. Two igniter plugs are also located in this module.

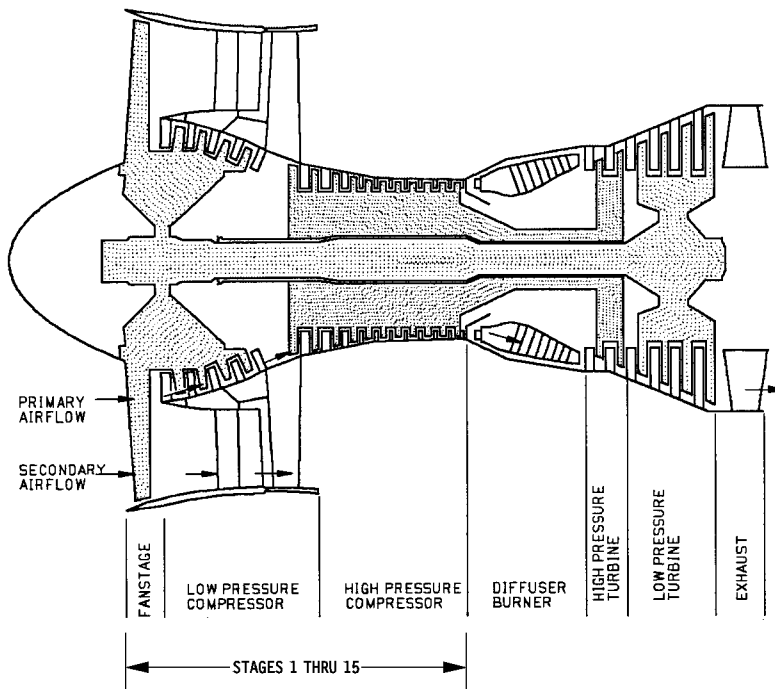
Variable stator vanes, automatically positioned by an hydraulic actuator are incorporated in the first four stages to provide optimum efficiency and stability.

**ACCESSORY GEARBOX**

The accessory gearbox is located at the rear of the HP compressor case, and contains mount pads for accessories required for air frame use.

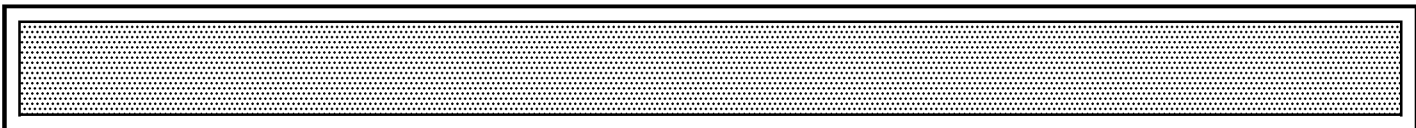
**BLEED AIR OFF-TAKES**

For defining bleed air off-takes locations, LP and HP compressor stages are identified 1 thru 15, starting from the Fan stage.

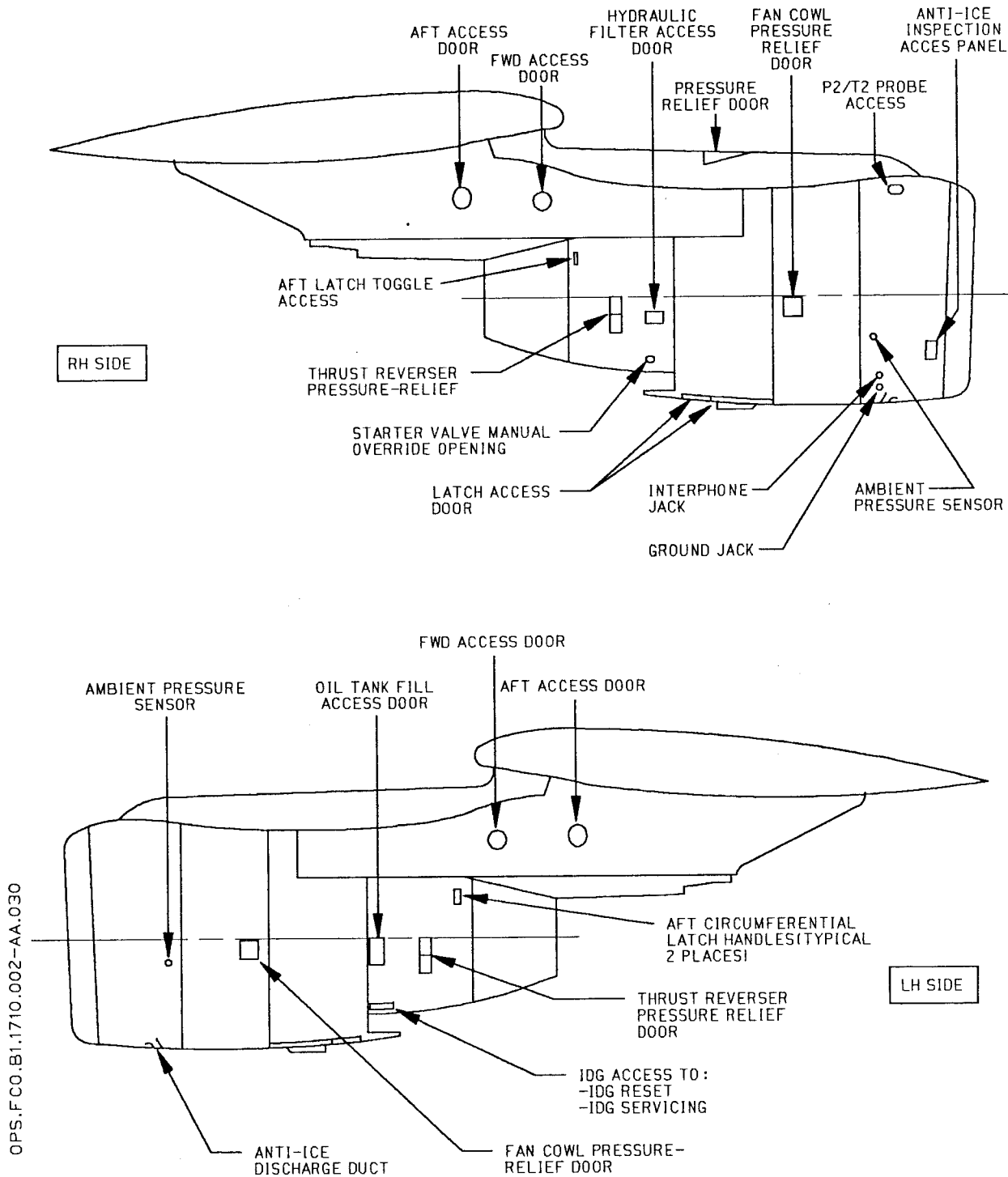


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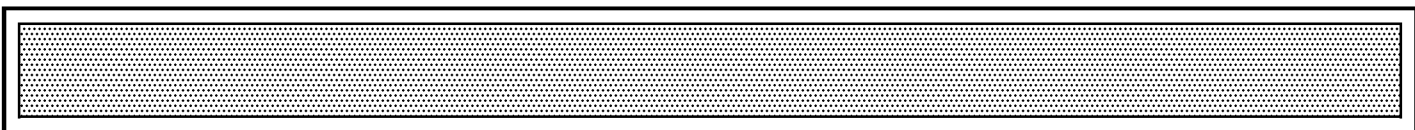


**NACELLES AND PYLONS**



R

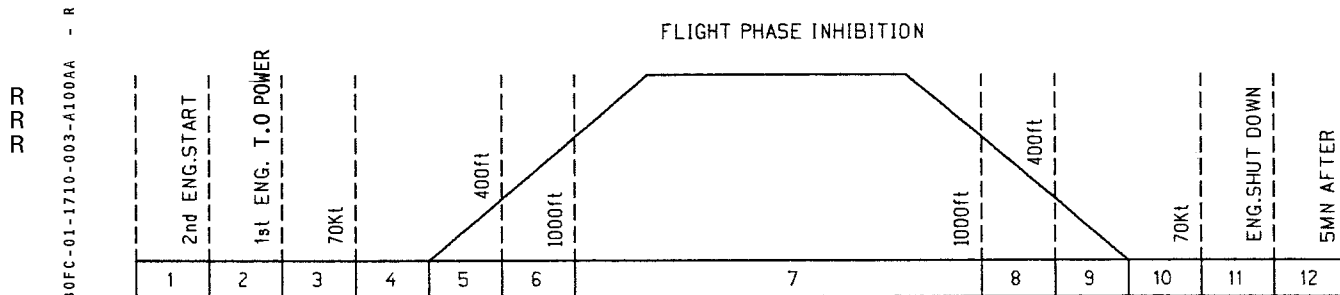
PW Eng. : 4000



**ECAM Indications and Warnings**

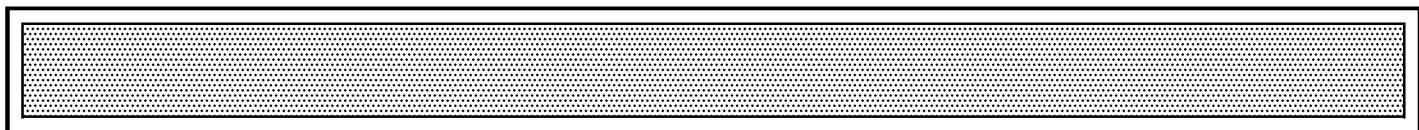
Warning Eng 1/Eng 2	Source	Warn Threshold	Warn Sound	Warn Light	Flt Phases Inhibition
Oil Lo Press	Pressure switch	≤ 70 PSI	CRC	MW	4
Oil Filter Clog	Pressure switch	ΔP ≥ 50 PSI	SC	MC	4, 5, 9, 10
Over Limit N1	Indicator	≥ 111,4 %	SC	MC	4, 9, 10
Over Limit N2	Indicator	≥ 104 %	SC	MC	4, 9, 10
Over Limit EGT	Indicator	≥ 625°C	SC	MC	4, 9, 10
Fuel Filter Clog	Pressure switch	ΔP ≥ 5.5 PSI	SC	MC	4, 5, 9, 10
Eng. shut down	HP fuel Lever + Fire Handle	-	SC	MC	-
Oil Temp HI	SDAC-FADEC	≥ 163°C + 20 Min or ≥ 177°C	SC	MC	4, 5, 6, 8, 9
Reverse Unlk	Switches or FADEC	-	SC	MC	1, 2, 4, 5
EPR Mode Fault	FADEC	-	SC	MC	4, 5, 6
Over speed Det.	FADEC	-	SC	MC	-
Oil Temp Low	FADEC	≤ 50°C	SC	MC	1, 4 to 10, 12
Eng. Fail	FADEC	-	SC	MC	Not during shut down or start
Throttle Fault LV (Last Value)	FADEC	-	SC	MC	2, 3, 4, 5
Throttle Fault IDLE	FADEC	-	SC	MC	-
FADEC Channel A and B Fault	FADEC	-	SC	MC	4 to 10
Engine below IDLE	FADEC	-	SC	MC	-
Engine at IDLE	FADEC	-	SC	MC	-
Engine N1 Mode	FADEC	-	-	-	1, 4, 5, 10, 12
FADEC MINOR FAULT	FADEC	-	-	-	2 to 10
FADEC OVHT	FADEC	≥ 105°C	SC	MC	1, 4, 5, 6, 12

SC : Single Chime  
 CRC : Repetitive Chime  
 MW : Master Warning  
 MC : Master Caution



Mod. : 7380

PW Eng. : 4152



**SYSTEM GENERAL**

Fuel is supplied from tank booster pumps via the LP shutoff valve to the engine fuel pumps. The fuel passes through a centrifugal stage of the fuel pump, then into IDG and engine fuel/oil coolers and fuel filter, before going into a single gear stage pump.

The requisite quantity of fuel for combustion is metered within the Fuel Metering Unit, excess fuel being returned to pump interstage.

The Fuel Metering Unit responds to commands received from the Full Authority Digital Engine Control (FADEC).

From this Fuel Metering Unit, which contains as well the HP FUEL shut off valve, the fuel flows through the fuel flowmeter, the fuel divider valve and then through 8 manifolds to 24 injectors.

**FUEL HEATING**

Ice formation in the fuel system is prevented by heating the fuel before it passes through the fuel filter and Fuel Metering Unit. The heat absorbed in fuel/oil heat exchangers provides cooling for the engine and IDG oil supplies. When fuel temperature exceeds 127° C (260° F), the engine oil flow to the fuel/oil heat exchanger is bypassed.

**FUEL FILTER**

The fuel filter protects the engine fuel system from damage. In case of filter clogging, a bypass valve will open if the pressure drop across the filter is greater than 9 psi. When the pressure drop across the filter reaches 5.5 psi, the FUEL CLOG amber warning is triggered, associated with ECAM activation.

**PUMP UNIT**

The centrifugal pump boosts fuel pressure to a maximum pressure 320 psi above aircraft fuel supply pressure.

The main gear stage supplies high pressure fuel to Fuel Metering Unit.

**FUEL CONTROL**

The fuel control includes the Full Authority Digital Engine Control (FADEC) and the Fuel Metering Unit.

The FADEC system operates in response to the pilot command thrust settings as transmitted by the throttle lever position.

Engine fuel flow is commanded to establish the engine pressure ratio (EPR) corresponding to the commanded power setting.

The control laws used in scheduling fuel flow also consider acceleration and deceleration response, transient and, steady state stability requirements and engine protection.

The Fuel Metering Unit incorporates the fuel shut off function, a maximum fuel flow stop and a minimum fuel flow stop.

**FUEL DISTRIBUTION**

The fuel flow transmitter measures the fuel mass flow from the Fuel Metering Unit for indication of fuel flow rate and fuel used.

The fuel divider valve subdivides scheduled engine fuel flow from the fuel metering unit equally to eight fuel manifolds, each of which in turn feeds three fuel injectors.

**IDLE CONTROL**

**General**

- . The PW4000, features a multiple idle concept as follows :
  - modulated minimum idle ;
  - flight/approach idle.

**Modulated Minimum Idle**

- . The modulated minimum idle is meant to assure three requirements :
  - \* prevent the IDG's from dropping off-line : minimum N2 concept,
  - \* preventing the engine from flaming-out : minimum fuel ratio concept,
  - \* assuring the bleed requirements for air conditioning, engine anti-ice and wing de-ice : minimum burner pressure concept.
- . The minimum idle value is driven by the highest of the three above requirements.
- . The minimum idle is a function of the altitude.

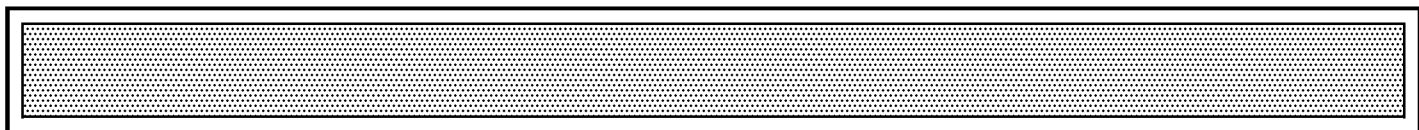
**Flight/Approach Idle :**

- . The flight/approach idle concept is meant to assure the engine acceleration requirements for Go-Around.
- . The flight/approach idle is selected when the following conditions are met :
  - \* aircraft in flight,
  - \* slats extended. (lever position).
- . The flight/approach idle is a function of the altitude and total temperature Tt2.

**Selection of flight/approach idle**

- . When selecting the approach idle, at slats extension, the amount of N1 and N2 increase will be a function of the minimum idle level prevailing at the time of the selection.

Code : 0114



**OVERSPEED PROTECTION**

Each channel of the FADEC incorporates an overspeed detection and protection.

The overspeed protection features two levels of N1 and N2 speeds protection, as follows :

- N1 and N2 redlines limiting function (N1 and N2 topping loops) :
  - This function is part of the normal engine control loops and will not allow the N1 and N2 to exceed their respective redlines.
  - The topping loops apply a fuel cut-back as soon as the associated red line limit is reached. A slight overshoot may exist before the N1 (respectively N2) is controlled on its limit.
- Overspeed protection :
  - Should the above N1 and/or N2 topping loops fail to control the N1 (N2) on the applicable limit, a second line of defence is available and will be activated if the red line is exceeded by approximately 5 %.
  - The overspeed protection is not a software control law but a wired logic activating the overspeed solenoid of the FMU and reducing the fuel flow to a preset MIN FLOW value.
  - In flight, the MIN FLOW does not permit to sustain idle operation and will result in a sub-idle operation or in an engine flame out.

Both the N1 (N2) redlines limiting function (topping loops) and the overspeed protection are available in both EPR and N1 modes.

**FUEL INDICATING**

- Fuel pressure :

A pressure tapping, provided at the engine pump interstage level supplies a transmitter which delivers an electrical signal to the SDAC which processes it to display the fuel pressure on ECAM.

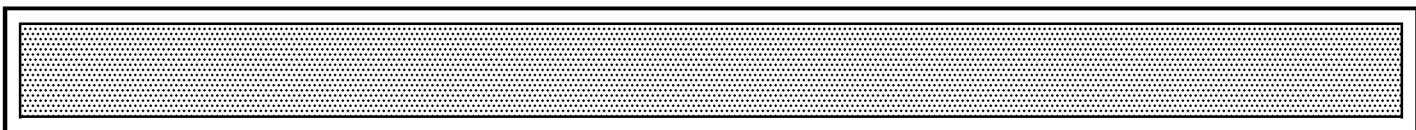
- fuel flow/fuel used :

The fuel flow transmitter is located in the fuel line upstream of the fuel divider valve. This transmitter is a fluid driven rotor referencing to a turbine sensitive to fluid angular momentum.

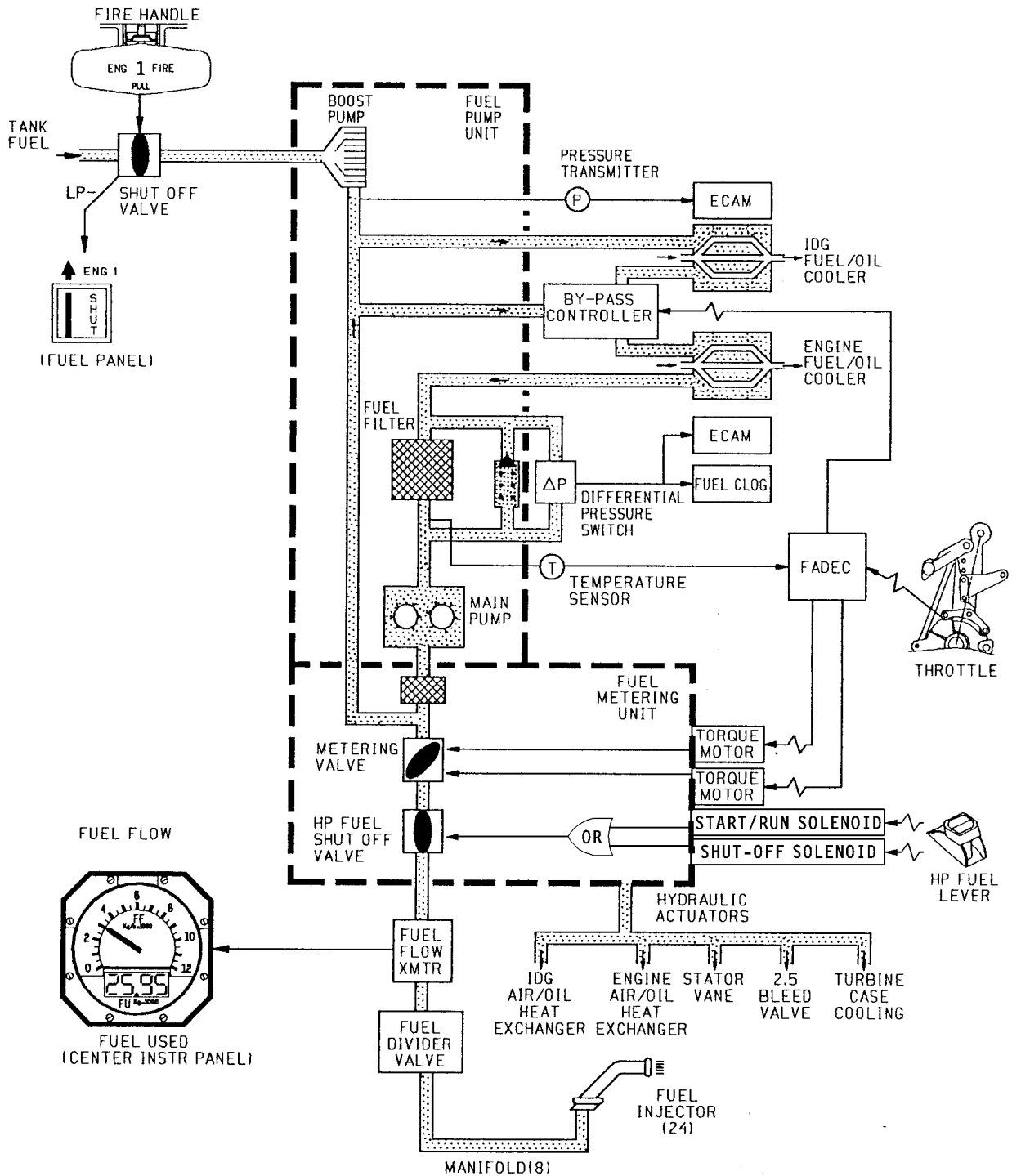
This rotor produces a pulsed signal whose frequency is proportional to mass flow. The pulsed signal is processed to provide information to an indicator of fuel flow.

Fuel used is calculated and displayed as an integration of fuel flow.

PW Eng. : 4000



**SYSTEM GENERAL**

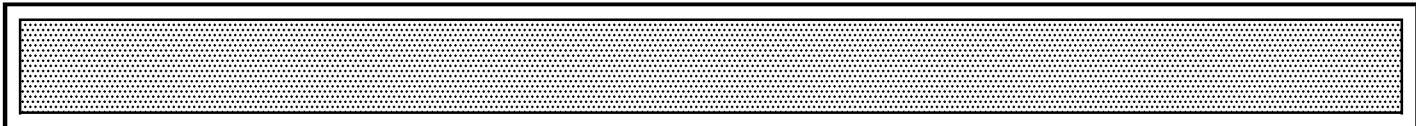


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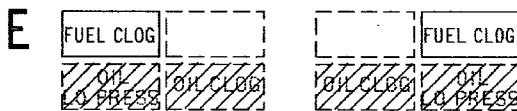
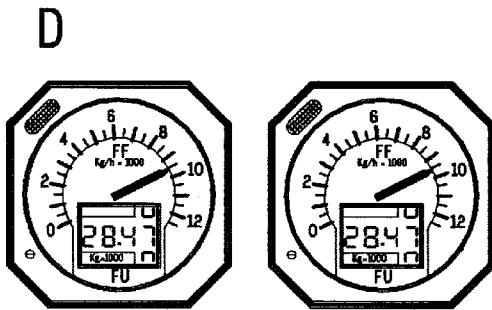
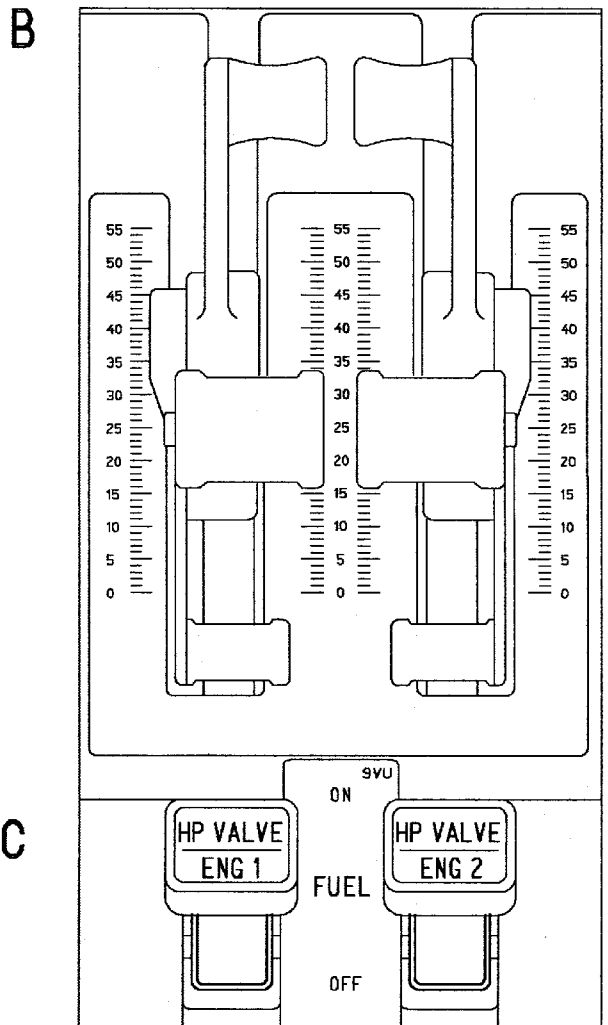
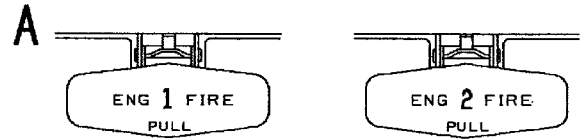
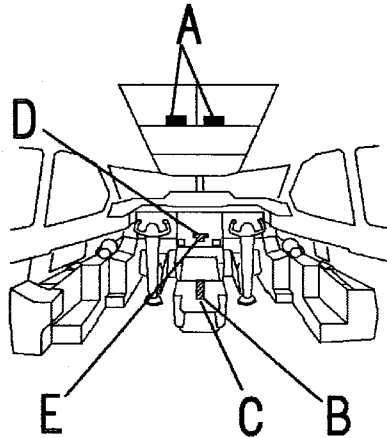
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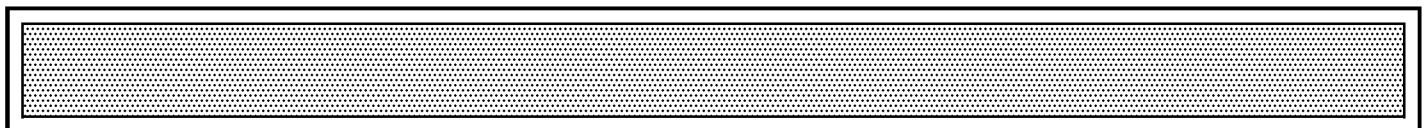
LOCATION OF CONTROLS



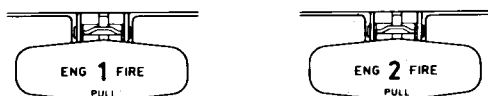
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PW Eng. : 4000

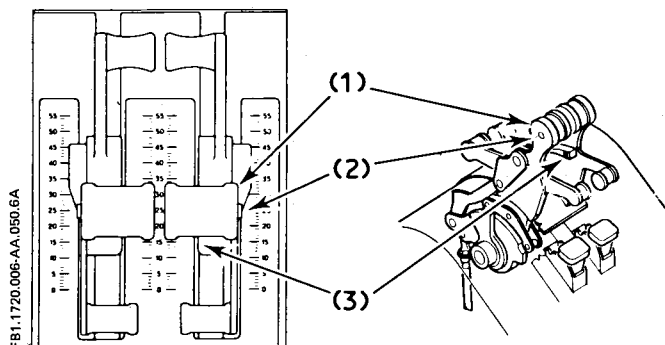


**A. ENG FIRE HANDLES**



When an ENG FIRE handle is pulled, the ENG 1 (ENG 2) LP SHUT OFF VALVE closes (FUEL).  
For detailed information on other resulting actions refer to chapter FIRE PROTECTION.

**B. THROTTLE LEVERS**



**(1) Throttle Levers**

Operation of throttle levers controls the related fuel control units and FADEC to obtain the desired thrust from idle to maximum - I.E., throttle lever position commands power setting.  
Change over from flight idle to ground idle occurs automatically in the fuel metering unit without throttle lever movement.

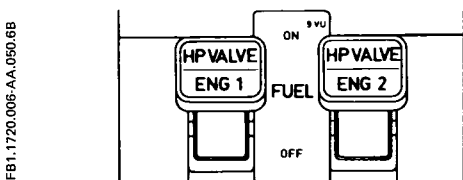
**(2) Autothrottle Instinctive Disconnect Pushbutton**

When depressed the autothrottle system is disconnected. Thrust setting must be performed manually.  
For detailed information refer to chapter AUTO-FLIGHT SYSTEM.

**(3) Go Levers**

Actuation of go levers engages the autothrottle system in the THRUST mode, on ground for takeoff and during landing approach for go-around.  
For detailed information refer to chapter AUTO-FLIGHT SYSTEM.

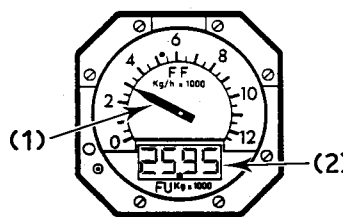
**C. ENG FUEL LEVERS**



The ENG 1/ENG 2 FUEL levers control the HP fuel shutoff valves in the fuel metering units and the ignition activation. A red fire warning light with the indication HP valve is integrated into the lever handle.

- **ON**  
HP valves open, admitting fuel to fuel manifolds and injectors.  
Ignition is activated as preselected and scheduled.
- **OFF**  
HP valves closed. Ignition is deactivated.
- **HP VALVE**  
The light illuminates red and HP valve is readable in case of :  
· Engine fire as long as the ENG FUEL lever is in ON position.  
· or, disagree between the lever and the actual valve position.

**D. FUEL FLOW/FUEL USED INDICATOR**



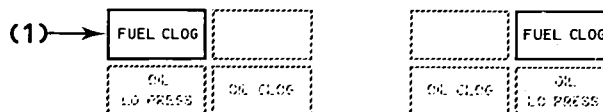
**(1) Pointer**

Indicates the fuel flow rate in kg/h × 1000.

**(2) Digital indicator**

Displays fuel used in kg × 1000.  
The reset of the fuel used indicator is obtained automatically when the « START » p/b is depressed (on ground only).

**E. FUEL CLOG WARNING**



**(1) FUEL CLOG It. :**

Comes on amber associated with ECAM, when the differential pressure in the filter exceeds  $5.5 \pm .7$  psi by increasing value and extinguishes when the differential pressure decreases below  $3.5 \pm 1$ psi.



# POWER PLANT

## FUEL SYSTEM

1.17.20

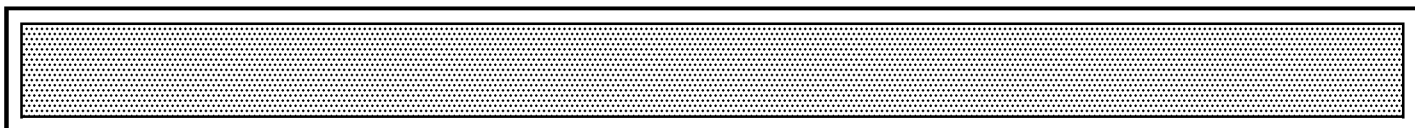
PAGE 7

REV 26

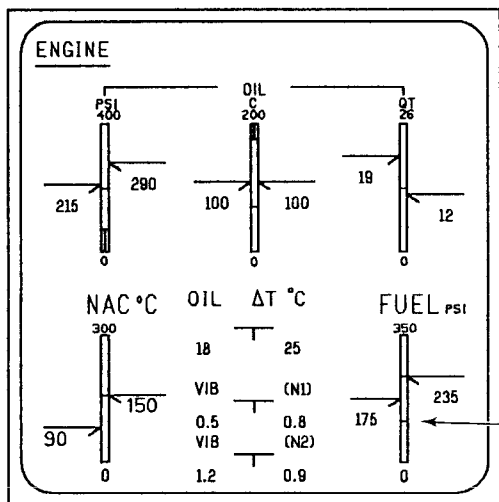
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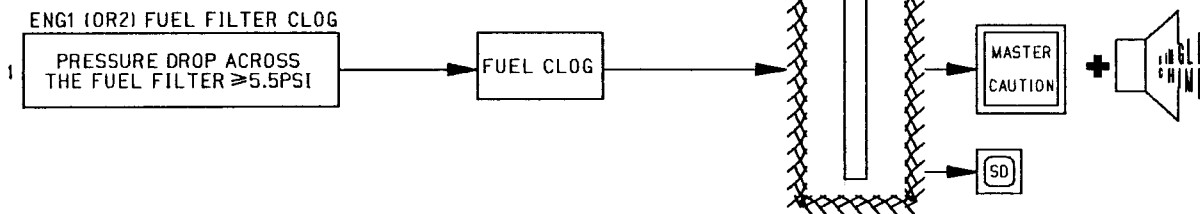
**SYSTEM DISPLAY – ENGINE PAGE**



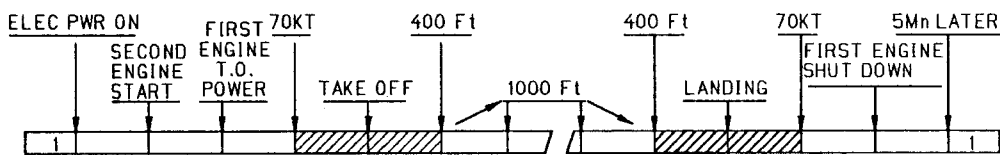
**(1) FUEL Pressure Indication (green)**

The FUEL pressure, measured at fuel pump interstage, is displayed on an analog scale graduated from 0 to 350 psi.

*Note* : Same indication is provided on the ENGINE START PAGE.



ECAM AUTOMATIC FLIGHT PHASE INHIBITION



B0FC-01-1720-008-A035FA - R

**SYSTEM GENERAL**

The engine oil system provides the lubrication and cooling of engine and accessory gearbox bearings and gears. The self-contained engine oil system consists of :

- Supply circuit, distributing oil to lubricated points and areas.
- Scavenge circuit, recovering oil after lubrication and returning it to the oil tank.

The main components of the oil system are :

- an oil tank,
- an oil pressure pump with associated filter, and bypass valve
- an air/oil heat exchanger with a bypass valve,
- a fuel/oil heat exchanger with a bypass valve,
- a temperature bypass valve,
- scavenge pumps,
- a deoiler and a deaerator.

**SUPPLY CIRCUIT**

The oil tank has a maximum oil capacity of 34,4 quarts (8.6 gallons or 36,77 liters).

From the oil tank, the single stage oil pressure pump forces oil through the main filter. If the pressure drop across the filter goes above 50 psi, the « OIL CLOG » light illuminates on the center pedestal associated with ECAM. The oil by-pass is set to open at 90 psi.

The oil is then passed through an air/oil cooler and through a fuel/oil cooler. Pressure tappings at fuel/oil cooler outlet are used to detect high or low oil pressure conditions. Acceptable limits for oil temperature are between 163° C and 177° C for less than 20mn, or 177° C in transient conditions.

The FADEC commands the temperature bypass valve, which causes engine oil to bypass the fuel/oil cooler.

**SCAVENGE CIRCUIT**

Oil is returned to the oil tank by the scavenge circuit. Oil collecting in the main bearing compartments and gearboxes is returned to the oil tank by use of individual scavenge pumps.

At the inlet of each pump is a chip detector. The scavenge oil passes through a deaerator to remove the entraine air.

**INDICATING**

- oil quantity

A transmitter located in the oil tank, sends an analog signal to the indicator. A recopy of the indicator is sent to the SDAC, where it is processed to be displayed on ECAM.

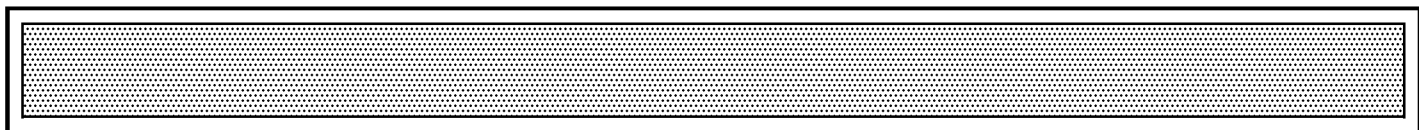
- oil pressure :

A pressure tapping is provided at the fuel/oil cooler outlet, this pressure is sensed by a transmitter supplying a signal to the indicator and to the SDAC which processes it to display the oil pressure on ECAM

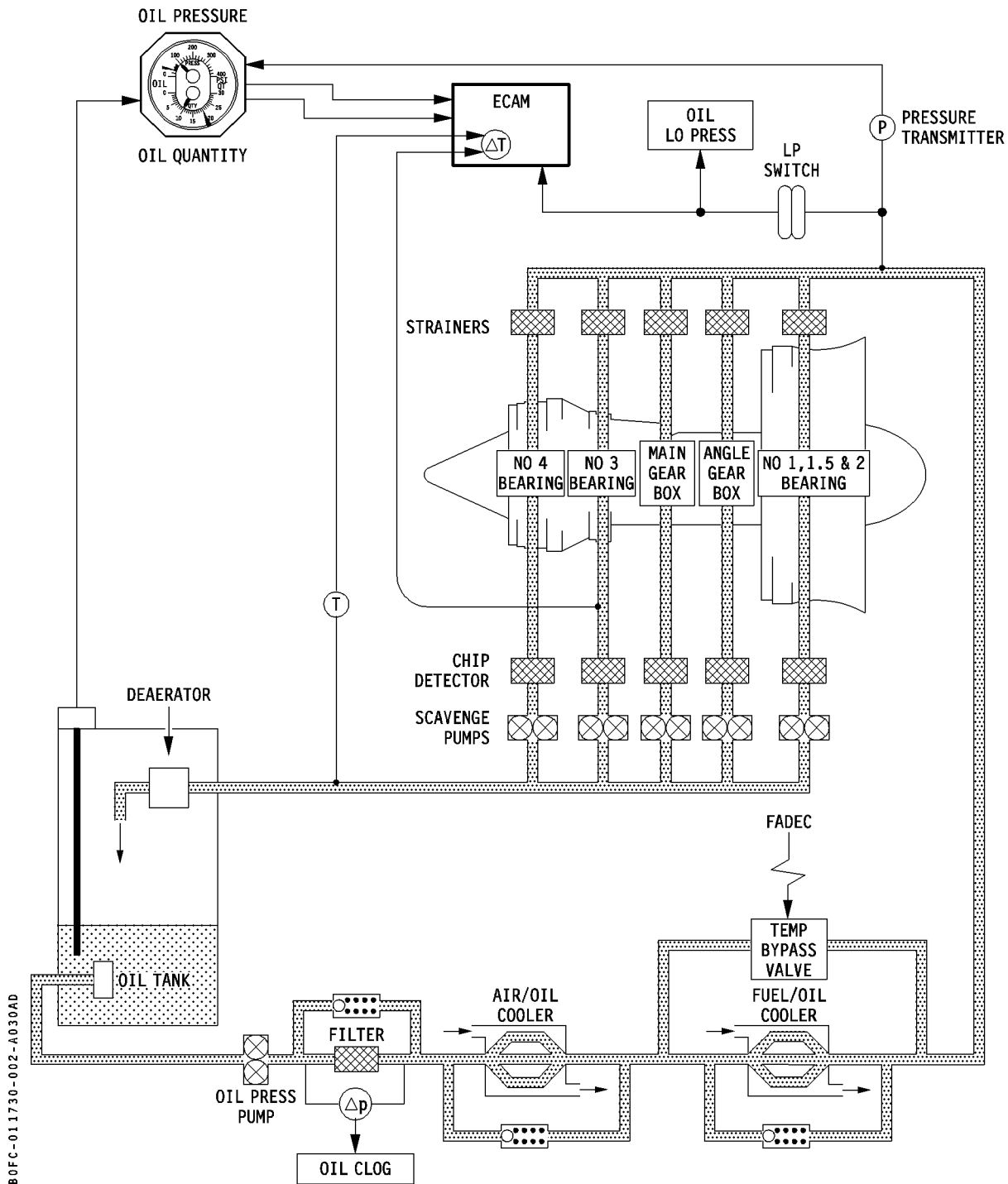
- oil temperature :

Two immersed resistance probes are installed, one at the outlet of the n° 3 bearing compartment and one on the scavenge line out of the engine.

The probes resistance varies linearly with temperature. These signals are used by the SDAC and the SGU to generate digital signals displayed on the ECAM.



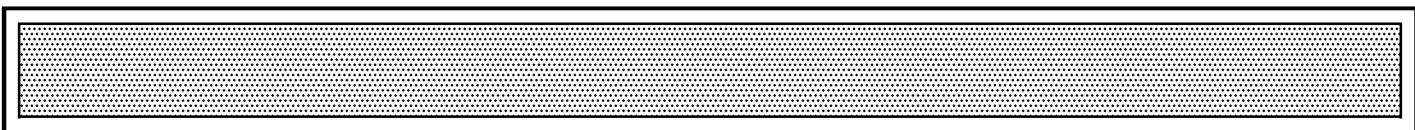
**SYSTEM GENERAL**



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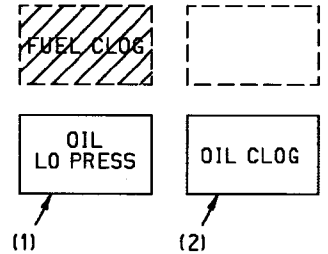
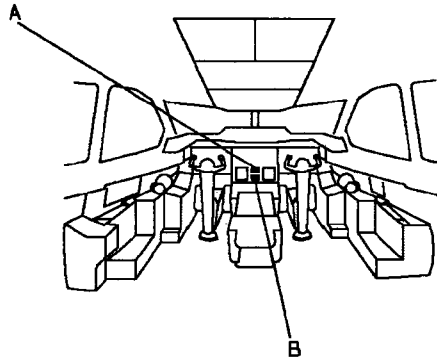
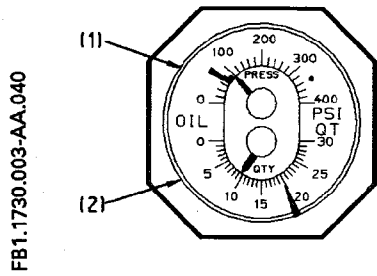
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PW Eng. : 4000



**A. OIL QUANTITY AND PRESSURE INDICATOR**

**B. OIL WARNING**



**(1) Oil Pressure Indicator**

Displays oil pressure of corresponding engine.  
 A red line indicates minimum oil pressure (70 PSI).

**(2) Oil Quantity Indicator**

Displays oil quantity in quarts (graduated from 0 to 30, effective range 0 to 26).  
 A white bug allows oil consumption to be monitored.

- Note :*
- After engine start, the oil distribution to various engine parts results in a decrease in the indicated oil quantity (phenomenon known as the "oil gulping" effect).
  - Compared to the pre-start indicated oil quantity, the following typical decrease in oil quantity readings can be observed :
    - Idle operation : 6 to 8 quarts
    - Flight operation : 9 to 14 quarts.

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**(1) OIL LO PRESS It.**

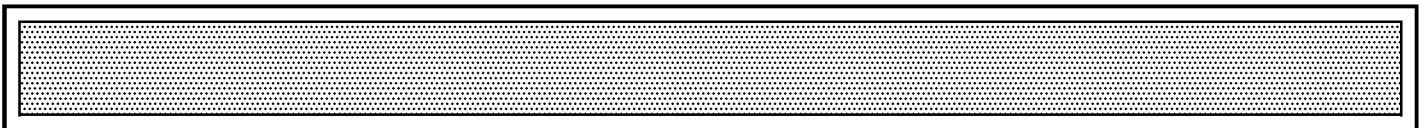
Comes on red, associated with ECAM, when the oil pressure reaches 70 psi ± 3 (decreasing pressure). It extinguishes when the pressure reaches 80 psi ± 3 (increasing pressure).  
 Inhibited when HP fuel valve lever on OFF position.

**(2) OIL CLOG It.**

Comes on amber, associated with ECAM, when oil filter differential pressure exceeds 50 ± 2 psi by increasing value. It extinguishes when the differential pressure decreases below 40 psi ± 2.

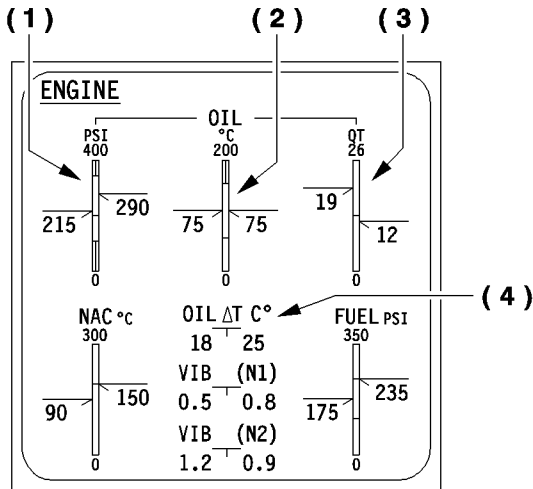
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PW Eng. : 4000



**SYSTEM DISPLAY – ENGINE PAGE**

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**(1) Oil Pressure (green)**

Oil pressure, (measured at the fuel / oil cooler outlet) is displayed on a linear scale from 0 to 400 psi. It flashes when the pressure is  $\leq 75$  psi. It becomes red when the pressure is 70 PSI or less.

*Note : Engine 1 indication is replaced by amber "XX" if the associated input signal is lost.  
 Engine 2 indication drops to 0 if the associated input signal is lost.*

**(2) Oil Temperature (green)**

Oil temperature, (measured on the scavenge line) is displayed on a linear scale from 0 to 200° C. Above 163 C the indication flashes (green). Above 177° C, the indication becomes amber.

*Note : Same indication is given on the CRUISE PAGE.*

**(3) Oil Quantity (green)**

Oil quantity is displayed on a linear scale from 0 to 26 US quarts. Below 4 QTS the indication flashes.

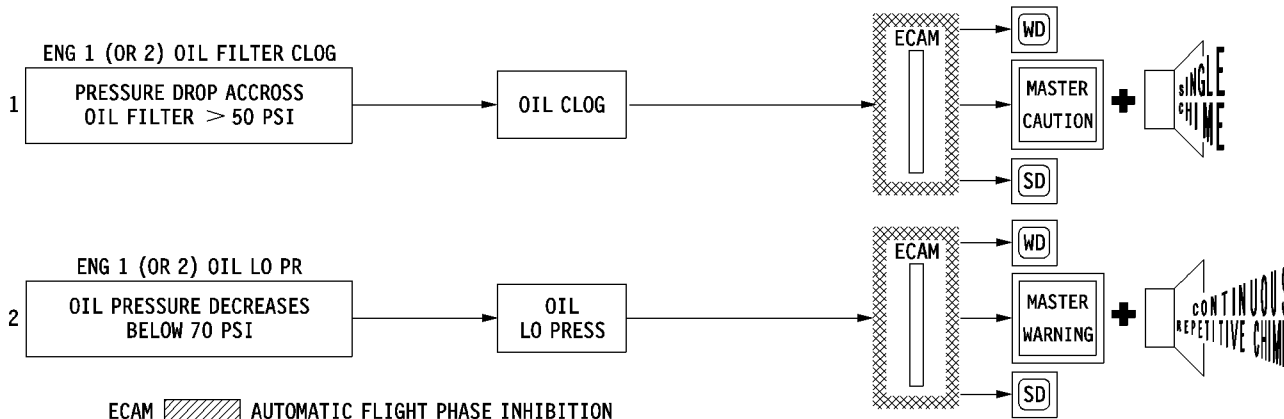
*Note : Indication is replaced by amber "XX" if the associated input signal is lost.*

**(4) Oil Delta Temperature (green)**

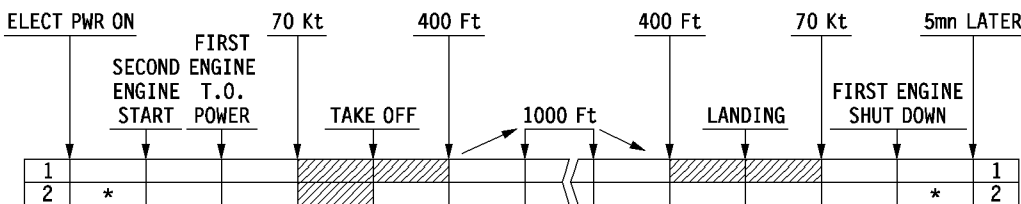
Oil Delta Temperature (measured between the oil outlet temp of the n° 3 bearing compartment and scavenge oil temp of the engine) is displayed in digital format. Above 44° C the indication flashes.

*Note : All above indications are given on the ENG START PAGE.*

**WARNING LOGIC**



ECAM AUTOMATIC FLIGHT PHASE INHIBITION



\* INHIBITED BY RELATIVE ENGINE SHUT DOWN.

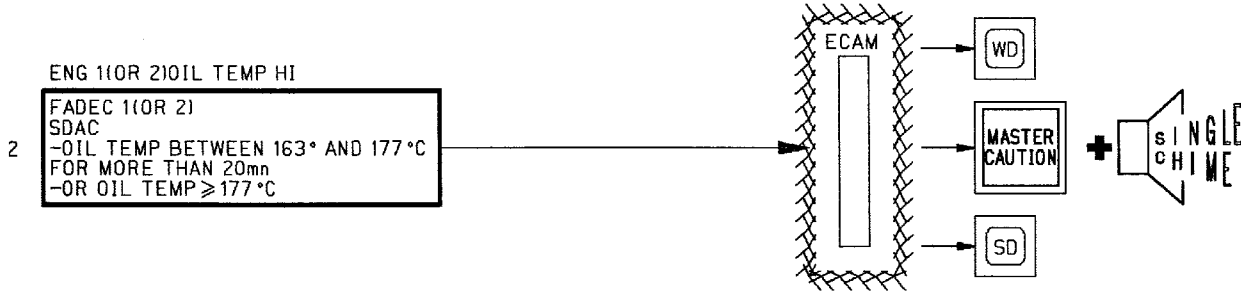
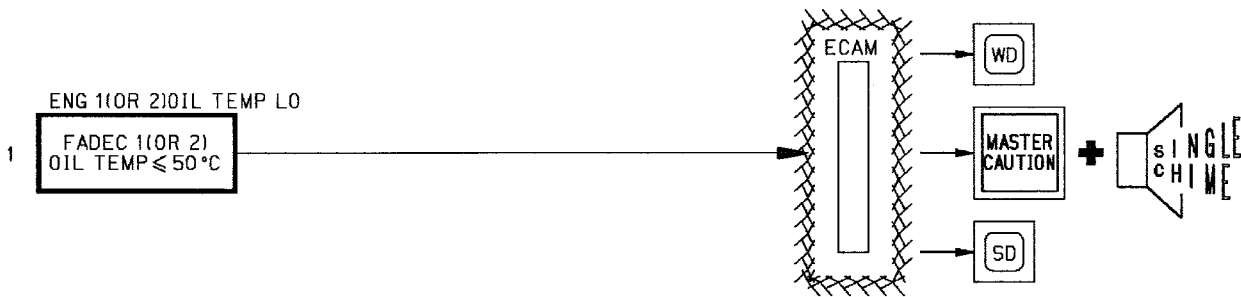
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Mod. : 5051 + 5448 + 7259

PW Eng. : 4000

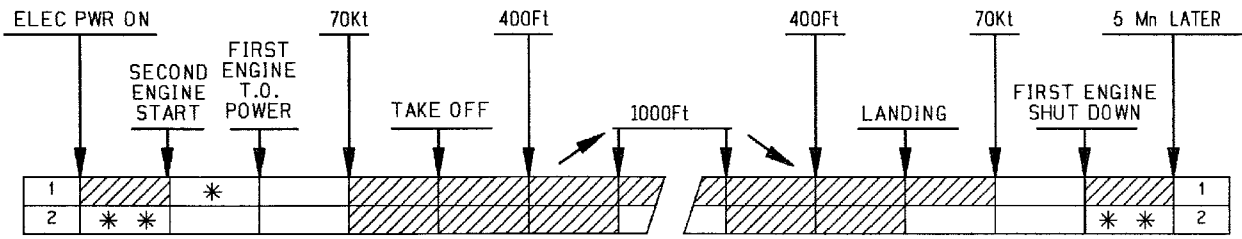


**WARNING LOGIC (CONT'D)**

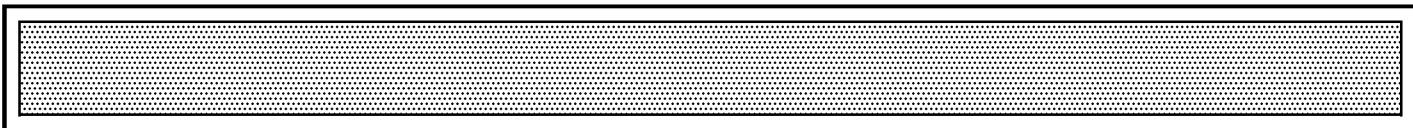


ECAM AUTOMATIC FLIGHT PHASE INHIBITION

OPS.F.CO.B1.1730.005-AB.040



\* \* INHIBITED BY RELATIVE ENG. SHUT DOWN.  
 \* INHIBITED IF T.O. CONFIG P/B NOT PRESSED



**SYSTEM GENERAL**

Bleed air is provided for three separate systems :

- Engine service,
- Engine surge protection,
- Airframe service.

**TURBINE CASE COOLING**

The exterior surface of the HP and LP turbine cases are cooled with engine fan discharge air to control turbine tip clearance. The Turbine Case Cooling Actuator position is scheduled as a function of altitude and high rotor speed (N2) by the Full Authority Digital Engine Control (FADEC).

*Note : In the event of an electrical or pneumatic failure, the system is design to fail safe in the closed position so that no fan air is discharged on the turbine cases.*

**HP TURBINE COOLING**

12<sup>th</sup> stage HP compressor air is used for internal cooling of HP turbine blades and vanes.

**ENGINE SURGE PROTECTION**

Bleed ports are provided between the LP and HP compressors (Station 2.5) and after the 9<sup>th</sup> stage of the HP compressor to assist in maintaining overall compressor section stability during transients and steady state operation. The bleeds are scheduled as a function of Thrust Lever Angle, LP rotor speed (N1), HP rotor speed (N2), Mach number, engine inlet total temperature (T2) and altitude by the FADEC.

The two 9<sup>th</sup> stage Compressor Stability Bleeds are used to facilitate engine starting. The bleeds are controlled as a function of HP rotor speed (N2) and engine inlet total temperature (T2) by the FADEC.

**VARIABLE STATOR VANE SYSTEM**

The variable Stator Vane system positions the compressor variable vanes to the angles necessary to provide optimum compressor efficiency at all engine speeds.

Fuel pressure is used as the hydraulic power to operate the stator vane actuator. The FADEC controls this system as a function of LP rotor speed, HP rotor speed and engine inlet total temperature.

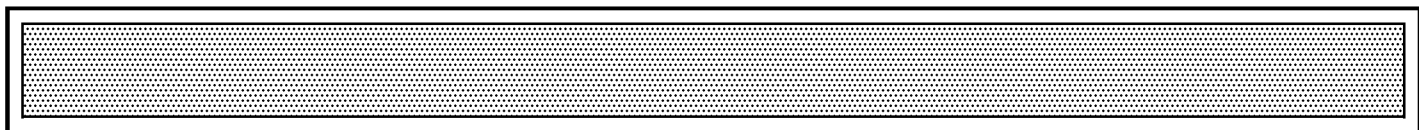
**ROTOR HEAT CONTROL MANAGEMENT**

The Rotor Heat Control system controls air flow to the interior of the HP compressor rotor. The flow of 9<sup>th</sup> stage compressor air to the rotor interior is controlled as a function of HP rotor speed (N2) and altitude by the FADEC.

**INDICATING**

- *Nacelle Temperature Indicator*

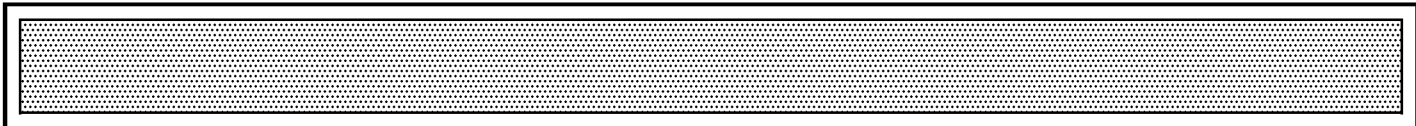
Nacelle temperature is provided by sensing elements which generate a signal to the SDAC. This signal is processed to be displayed on the ECAM except during starting when it is replaced by bleed pressure.



LEFT INTENTIONALLY BLANK

R

PW Eng. : 4000

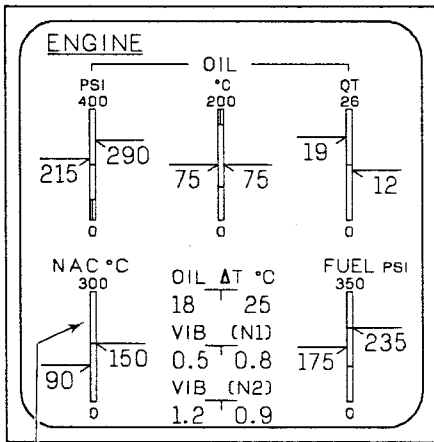


**SYSTEM DISPLAY – ENGINE PAGE**

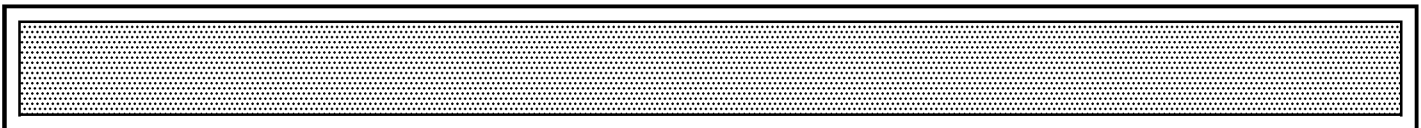
**(1) Nacelle temperature (green)**

The nacelle temperature is displayed on a vertical scale, in ° C. Above 230° C, the indication flashes.

OPS.F.CO.B1.17.40.003-AB.120



(1)



**POWER PLANT**  
**AIRBLEED SYSTEM**

1.17.40

PAGE 4

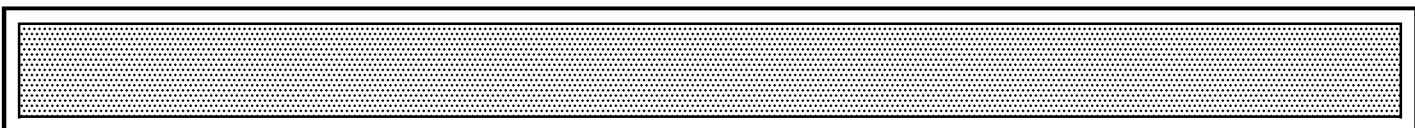
REV 24

SEQ 030

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PW Eng. : 4000



Reverse thrust is obtained by reversing the fan airstream. It can be used on ground only and is controlled from the cockpit by operation of the reverse thrust control levers.

The FADEC interfaces with the Thrust Reverse System to provide Thrust limiting during any reverser transition. It maintains engine power setting at idle as long as the reverser is in transition or in case of inadvertent deployment or stowage.

In case of an uncommanded thrust reverser deployment, two safety features are available :

- An auto-restow function which immediately opens the pressure regulating and shut off valve to pressurize the thrust reverser system and restow the reverser as soon as any reverser sleeve leaves the stow position.
- Automatic fuel cut back to idle as soon as the sleeve deployment is detected by the FADEC.

The thrust reverser system employs a two position (stowed/deployed) pneumatically actuated translating sleeve/cascade/blocker door type reverser.

Pneumatic power for thrust reverser operation is provided by 15th stage HP compressor bleed air.

When reverse thrust is selected the locks of each reverser master actuator are released and both translating sleeves on the engine are moved aft on tracks by the airmotor and the actuators, exposing the fixed position cascade. Simultaneously, twelve blocker doors are extended into the fan air stream to block the normal fan air flow path.

With the blocker doors deployed, the fan air flow is directed outboard through the fixed cascades which deflect the flow in an outward and forward direction.

After receipt of a reverser stow signal from the reverse thrust control lever, the translating sleeves, with attached blocker doors, move forward to cover the cascades resulting in the normal forward thrust fan air flow and cowl configuration.

For indication of reverser status « REV » (reverser deployed) and a « REV UNLK » (reverser unlocked) lights for each engine are provided on the center instrument panel.

**OPERATING SEQUENCE**

The translating sleeves are held in the stowed position by a brake in the pneumatic drive unit, which prevents air motor rotation and resulting reverser translation. Normally the brake release chamber is depressurized and in addition, the brake is spring-loaded in the brake applied position.

A system secondary locking function is incorporated into each reverser master actuator. The master actuator locks function only in the reverser stowed position. The pressure regulating and shutoff valve and the rotary valve are closed. The system is vented.

In addition, an independent electrically controlled locking device is fitted on the reverser system.

One lock is fitted on each sleeve. Locks are commanded by a dedicated aircraft wiring independent from the other reverser controls.

When scheduled operating conditions for reverse thrust are met – aircraft on ground/throttle levers at idle – the reverse thrust control lever is unlocked and can command the thrust reverses operation.

- Compressed air is routed to the rotary valve :
- to the latch operating valve in order to unlatch the air motor and
  - to the latch actuators in order to unlatch the translating sleeves.

Unlatching of any of the three latches will cause the « REV UNLK » light to come on.

The electrical locks are released to permit reverser operation when all conditions are met :

- throttle lever selected to the reverse position, and
- aircraft on ground.

The translating sleeves are driven to the deployed position by the air motor and flexshafts, uncovering the cascade vanes and rotating the blocker doors into the fan air duct.

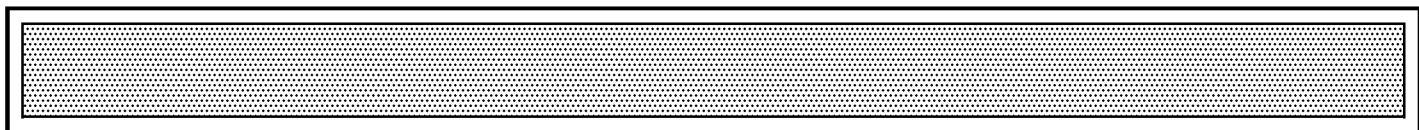
The FADEC restricts engine power to idle while the reverser travels from the stowed position to a position beyond the null thrust point. From this point the FADEC allows a progressive increase in engine power. Once the reverser is 90 % or more deployed, the FADEC schedules power in accordance with the reverse thrust control levers setting.

When both translating sleeves are accurately stopped in the deployed position, electrical signals are sent by the reverser to activate the « REV » green light, while the « REV UNLK » light is switched off.

To terminate reverse thrust operation the reverse thrust control lever is placed in the forward thrust position (Forward full down). The translating sleeves are driven to the stowed position, rotating the blocker doors back into their recesses and covering the cascade vanes. They are latched at the end of travel.

During stowage the « REV » light goes off and the « REV UNLK » light comes on until the three latches are engaged and both stow switches signal the stowed position.

In normal reverser stow operation, the FADEC restricts engine power to idle while the reverser travels from the deployed position to a position less than the null thrust point. From this point the FADEC allows, a progressive increase in engine power if the throttle levers are in the forward region. Once the reverser is less than 10 % deployed, the FADEC will schedule forward thrust in accordance with the thrust control levers setting.



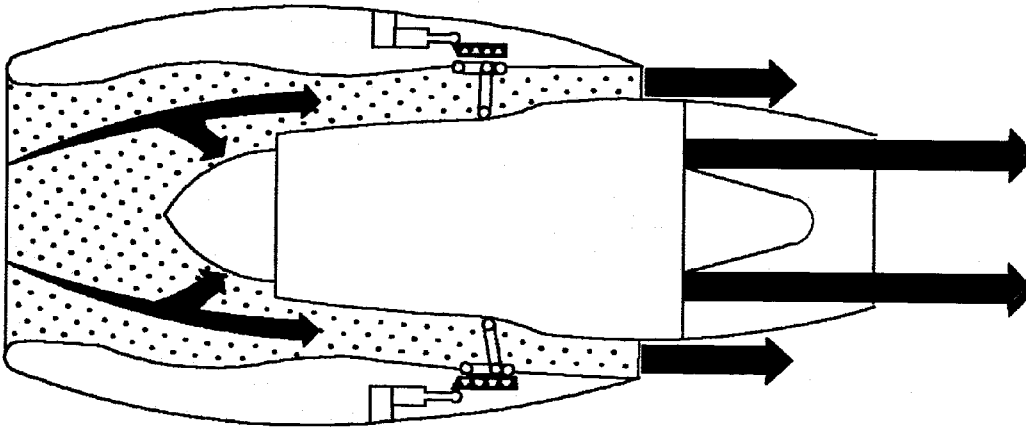
**POWER PLANT**  
THRUST REVERSER SYSTEM  
SCHEMATICS

1.17.50

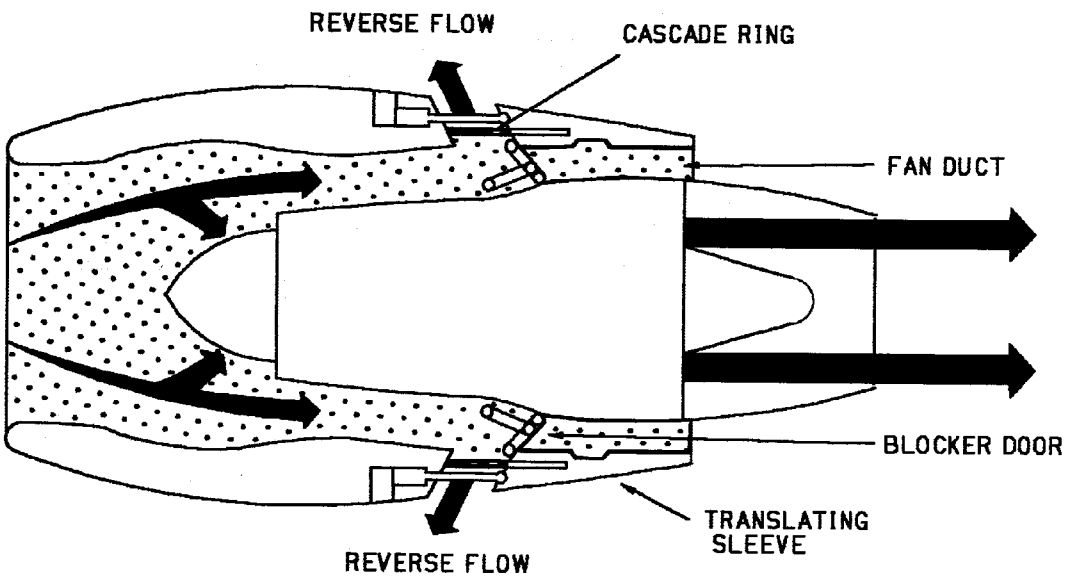
PAGE 2

REV 16

SEQ 020



STOWED (VIEW LOOKING DOWN)

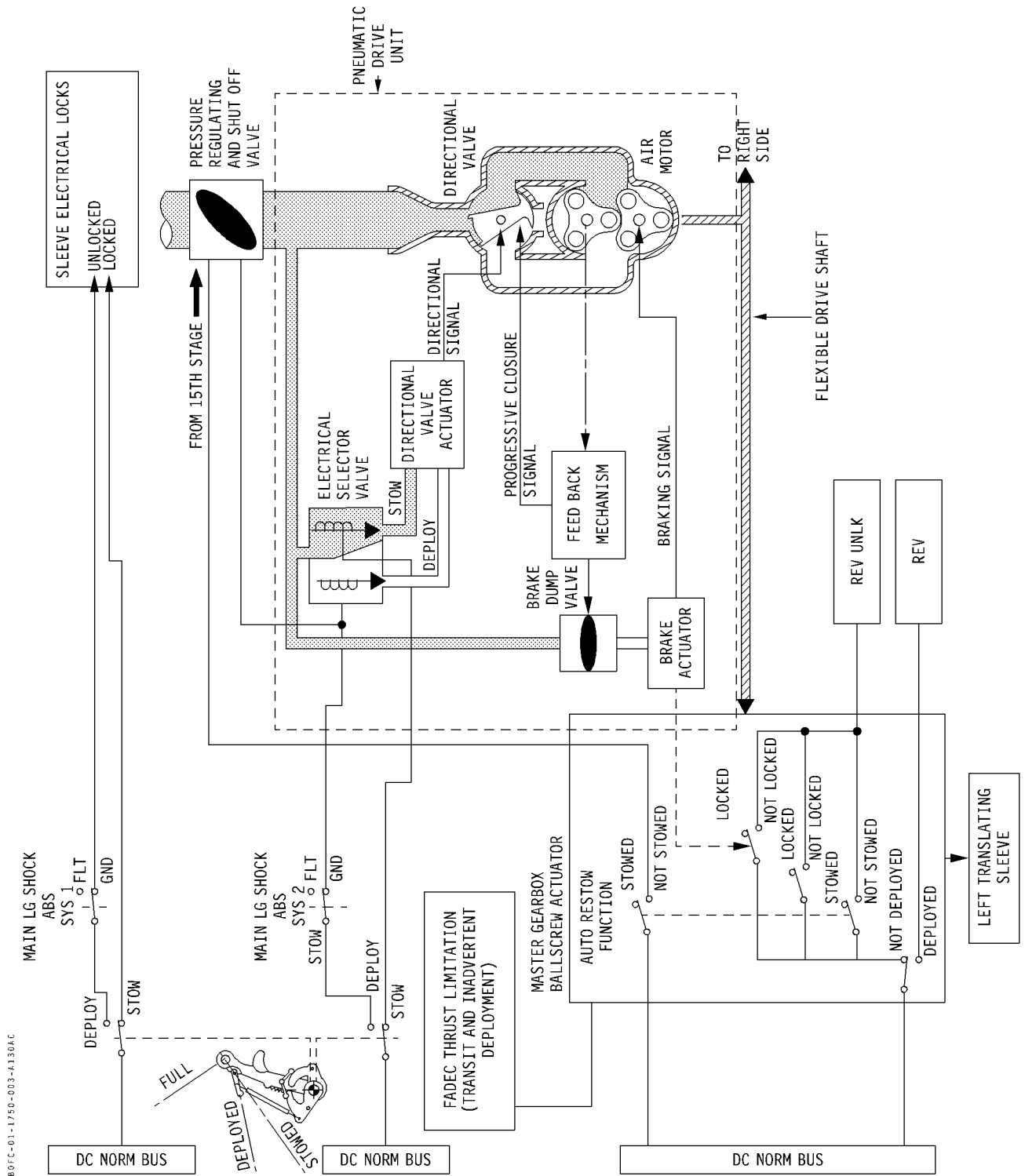


DEPLOYED (VIEW LOOKING DOWN)

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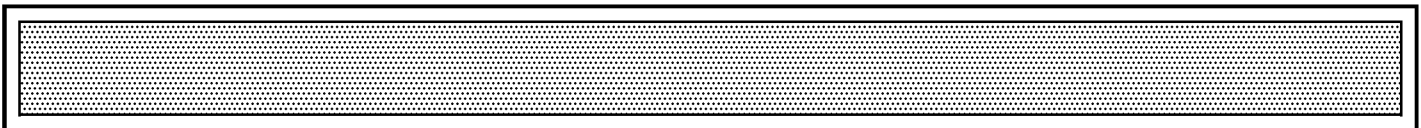
PW Eng. : All

**SYSTEM GENERAL**



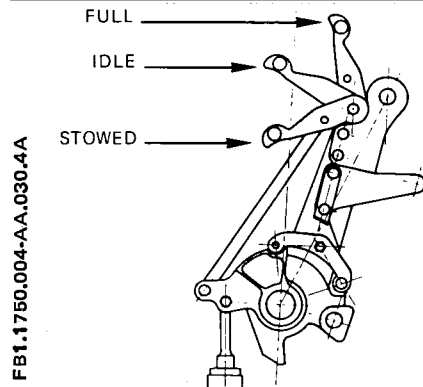
Mod : 12262

PW Eng. : 4000





**A. REVERSE THRUST CONTROL LEVERS**



When the throttle levers are not at idle, the reverse thrust control levers are mechanically locked in the stowed position. A movement of the levers when the aircraft is not on ground, is ineffective.

When throttle levers are at idle an action on the unlocked reverse thrust control levers is possible to command the thrust reversers operation.

A « hard point » is incorporated in the throttle linkage to indicate to the crew the reverse idle position.

In this position, with main landing gear struts compressed :

- translating sleeves move rearward,
- REV UNLK lights come on.
- The FADEC logic maintains an approach idle.

For reverse thrust application the reverse thrust control lever is pulled rearward as required. The FADEC restricts engine power to idle while the sleeves travel from the stowed position to a position beyond the null thrust point, then it allows a progressive increase in engine power.

Once the translating sleeves are 90 % deployed :

- REV lights come on,
- REV UNLK lights go off.
- The FADEC schedules power in accordance with the throttle levers position.

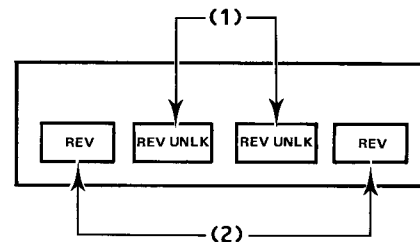
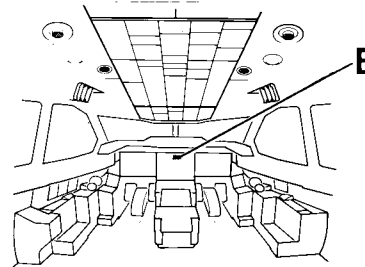
For stowage of thrust reversers the levers are moved forward then pushed down. During translating sleeve travel,

- REV lights go off,
- REV UNLK lights come on.
- the FADEC restricts engine power to idle.

When the translating sleeves are in the stowed position and the thrust reverser system is latched, the REV UNLK lights go off.

*Note : The FADEC will restrict the power to idle, if thrust reversers are not stowed, whatever the position of reverse thrust control lever is.*

**B. THRUST REVERSER LIGHTS**



The thrust reverser lights indicate the operation status of the thrust reverser systems. When all lights are off, the translating sleeves are in the stowed position, the systems are latched.

**(1) REV UNLK Lights**

A light comes on amber when,

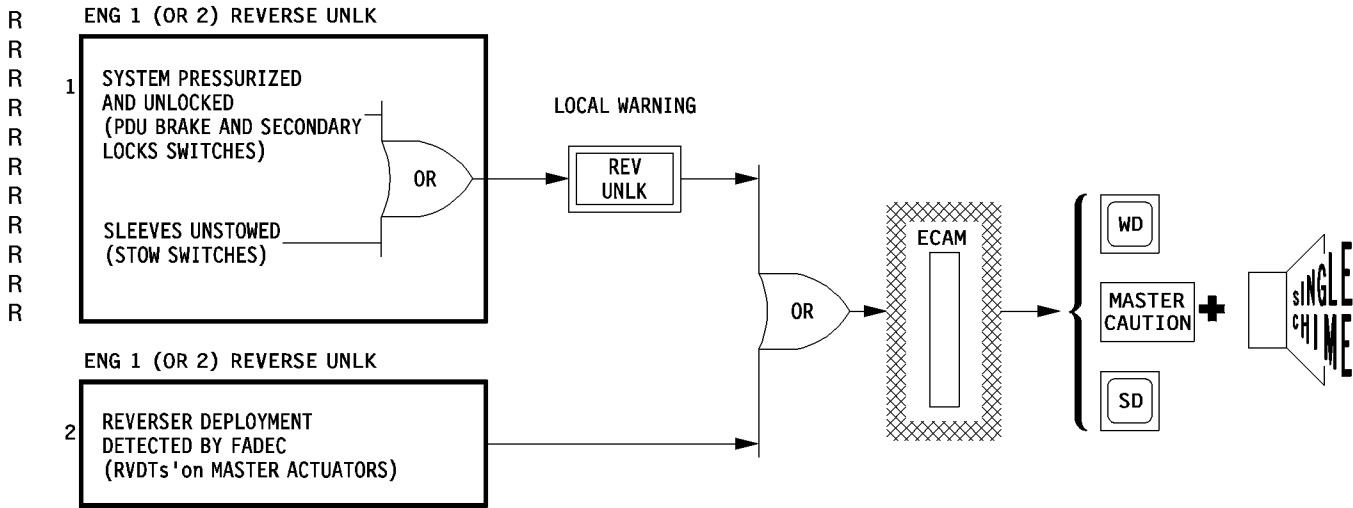
- the related thrust reverser system is unlatched
- the translating sleeves travel between the stowed position and 90 % of their travel or vice versa.

**(2) REV Light**

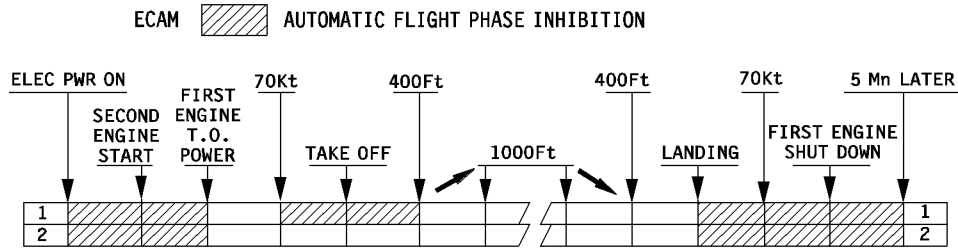
A light comes on green when,

- the translating sleeves of the related thrust reverser system are beyond 90 % of their travel.

**WARNING LOGIC**

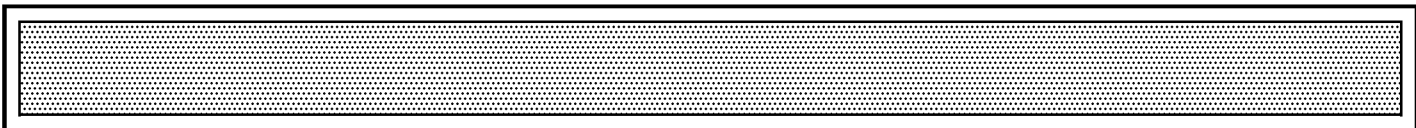


B0FC-01-1750-005-A070AA



Mod. : 5051

PW Eng. : 4000



**ENGINE IGNITION SYSTEM**

The ignition system initiates or sustains combustion of the fuel / air mixture in the annular combustion chamber.

The system consists of two physically and electrically independent identical circuits.

Each system (A or B) is composed of :

- A high energy ignition exciter,
- An exciter-to-igniter plug lead,
- An igniter plug.

A system is electrically supplied by AC normal bus, B system is electrically supplied by the AC emergency busbar.

Monitoring of ignition system is done from the ENG panel on the overhead panel. An ignition selector allows the crew to select either one or both systems, as required, provided that the corresponding HP fuel lever is in ON position. The switching is as follows :

- With IGNITION selector in OFF or CRANK position no ignition system is powered for any engine, the OFF position is the normal position while CRANK is used for wet or dry motoring.
- With IGNITION selector in START A position, A systems for engine 1 and 2 are activated, provided that the corresponding HP fuel lever is in ON position and N2 below 45 %.
- With IGNITION selector in START B position and the same conditions as above, B systems for engine 1 and 2 are activated.
- With IGNITION selector in CONT RELIGHT position, both A and B systems of each engine are activated, provided that the HP fuel lever is in ON position. Selection of continuous relight is recommended every time the operating conditions can cause an engine flame out and for inflight relight. But to prolong the service life of the ignition system components, it is recommended to limit the usage of continuous relight. The CONT RELIGHT position is indicated on the MEMO page of the ECAM system.

**ENGINE STARTING SYSTEM**

Each engine is equipped with an air turbine starter and a start valve. The starter drives the HP rotor for engine starting or for ventilation. The start valve admits air supplied by the pneumatic system to operate the starter, whereas the pneumatic power source can be :

- Either an external ground power unit
- or the APU
- or the other operating engine (via the pneumatic cross bleed valve).

The start valve is opened when the related « START » switch is depressed, provided that the IGNITION selector has been set. The start valve open position is indicated by the blue light « OPEN » in the related « START » switch.

When the FUEL LEVER is selected « ON » ignition and fuel flow is initiated, and the engine continues to accelerate (provided that the ignition selector position is A, B or CONT RELIGHT).

When N2 reaches 45 %, the start valve will be commanded to close, and the starter disengaged. Latest the engine reaches ground idle, the start valve will be fully closed.

On ground, as long as the IGNITION selector position is START A, START B or CRANK, the pack valves are closed. In flight, pack valves are closed only when a start valve is open.

This situation is indicated to the crew by the ARM lights, which extinguish during starting sequence but illuminate again when both engine N2 are above 45 %.

If the selector position is CONT RELIGHT, the pack valves are closed by the latching of one of the two START pushbuttons. In this case, each ARM light is illuminated when the relevant N2 is lower than 45 % (except if the relevant start valve is controlled open).

In case of latching failure, the START button can be manually maintained depressed.

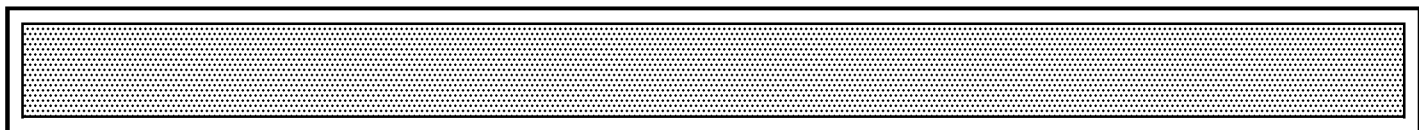
On the ground, the start valve can be manually operated in case of start valve solenoid failure.

Starting air pressure indication is provided by the « PRESS » indicator on the air bleed section of the overhead panel.

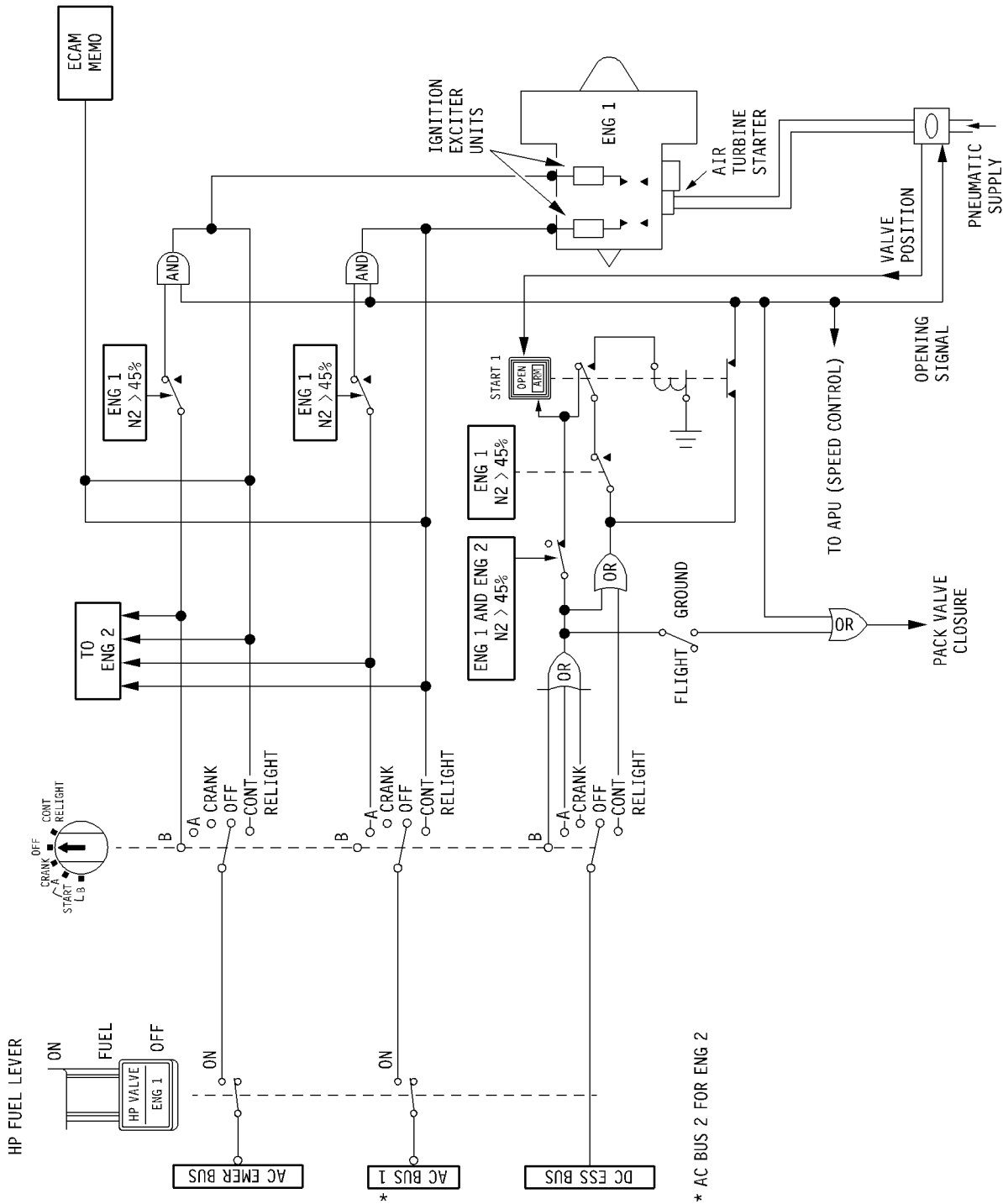
The FADEC schedules operation of the Compressor Stability Bleed Valves to aid starting and schedules fuel flow during an engine start.

**STARTING SEQUENCE**

	START 1 (2) PB SWITCH	Ignition	Start valve	Pack valves	Remarks
IGNITION SELECTOR Start A or Start B	ARM illuminates	off	closed	closed on ground, open in flight	Authorizes START 1, START 2 pb sw LATCHING
ENG START ON	pb sw latched, OPEN illuminated, ARM extinguished	off	open	closed	- APU accelerates - N2 increases
FUEL LEVER ON	ditto	on	open	closed	Fuel flow
N2 45 %	ARM illuminated (if both engine N2 above 45 %)	off	start to close	closed on ground, start to open in flight	
Engine AT G.I.	OPEN extinguished	off	closed	closed on ground, open in flight	
IGNITION SELECTOR OFF OR CONT RELIGHT	pb sw trips ARM extinguished	off	closed	open	
	ditto	on	closed	open	



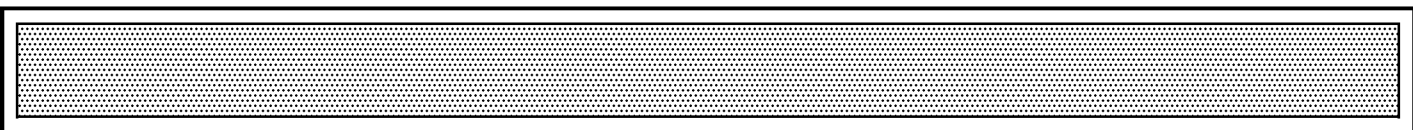
**SYSTEM GENERAL**



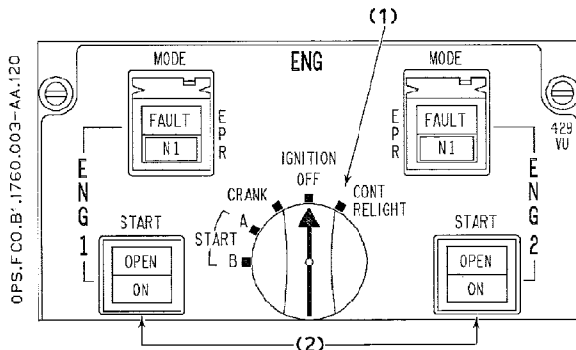
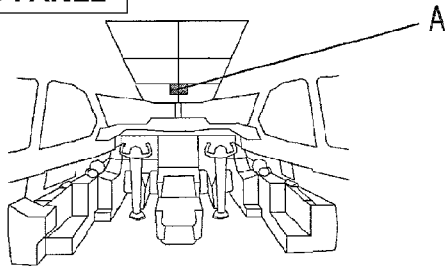
80FC-01-1760-002-A050AB

Code : 0008

PW Eng. : 4000



**A. ENG PANEL**



**(1) IGNITION Selector**

The setting of the IGNITION selector is a precondition for the activation of the starting or motoring sequence, and selects the ignition mode. The START switches will only be magnetically latched, when the IGNITION selector is in an appropriate position.

On ground, if the IGNITION selector is on START A, START B or CRANK position, the pack valves are controlled closed.

- **CRANK** : Ignition inhibited, START switches latching authorized. Engine can be ventilated.

*Note* : After an unsuccessful start attempt on ground, the selector is set to CRANK position to inhibit ignition. Engine to be ventilated to evacuate fuel vapors.

- **START A (B)** : Ignition circuit A (B) selected. START switches latching authorized. The white « ARM » light illuminates on each « START » switch. Ignition is energized when the ENG FUEL lever is set to ON in the starting sequence. Ignition is automatically deactivated, when N2 reaches 45 %.
- **CONT RELIGHT** : Ignition circuits A and B selected for continuous ignition, which is energized as long as the ENG FUEL lever is in ON position. If an engine is below 45 % N2, the relevant START switch latching is authorized and related ARM light illuminates.
- **OFF** : Ignition circuits de-energized. Starting sequence disarmed or interrupted. If START switches were latched, they automatically trip.

**(2) START pb switches**

- No light (switch released-out) latching inhibited.
- **ARM light** (switch released-out) illuminates white before starting sequence when :  
The IGNITION selector is not in OFF position. The switch can be latched.
- **OPEN light** (switch depressed-in) illuminates blue :  
The starting sequence of the relevant engine is initiated by opening its start valve. The switch trips when the start valve is controlled closed, i.e., when N2 is above 45 %. The light extinguishes when the start valve is fully closed.

- **ARM light** (switch released-out) illuminates after starting sequence when :

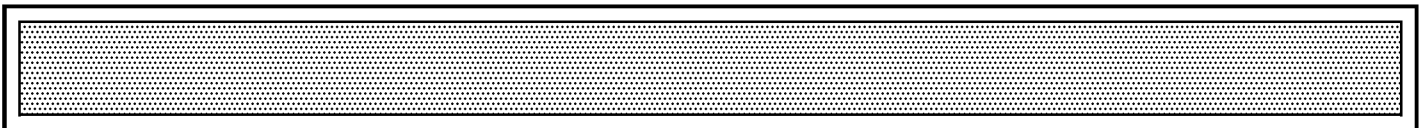
. The IGNITION selector is on START A, START B or CRANK position and both engine N2 are 45 %. (Both ARM lights illuminate then together).

or

. The IGNITION selector is on CONT RELIGHT position and the relevant N2 is lower than 45 %. This indicates the starting sequence of the relevant engine was not successful.

*Note* : With start valve OPEN, pressing and releasing out the pb switch closes the selected start valve and allows pack valves re-opening (regardless of the achieved N2 during start sequence).

R  
R  
R  
R



**EPR indication :**

The primary parameter for engine thrust control is the actual Engine Pressure Ratio (EPR). This is the ratio of turbine discharge total pressure (PT4.95) to compressor inlet total pressure (PT2).  
 The two PT4.95 probes are manifolded together to give an averaged PT4.95.  
 This pressure is routed along the engine to a PT4.95 inlet port on the FADEC.  
 In the fan inlet, at top dead center, a combined PT2/TT2, probe measures the fan inlet total pressure PT2. This pneumatic signal is routed to the PT2 inlet port of the FADEC.  
 These pneumatic signals are sensed by pressure transducers which convert them into frequency signals. These signals are processed internally by the FADEC to provide, a digital signal proportionnal to actual EPR : PT4.95/PT2.  
 Two signals are supplied to the EPR indicator, by both channels of the FADEC. A logic is implemented in the indicator to select the source of information.

**EGT indication :**

The total temperature of the Low Pressure discharge gas flow (TT4.95) is indicated as exhaust gas temperature (EGT). A thermocouple is fitted in each of the four TT4.95 probes. Readings from the thermocouples are collected at a common junction box, and averaged.  
 The averaged signals are provided to both channels of the FADEC.  
 These signals are processed by the FADEC to give two digital signals proportional to the EGT, to the indicator. A logic is implemented in the indicator to select the source of information.

*Note :* *The EGT indication is not available when FADEC is not power supplied, i.e :*

- *During engine start, between action on START push-button until engine reaches 5 % N2,*
- *5 minutes after the 2<sup>nd</sup> engine shutdown.*

**RPM indicating :**

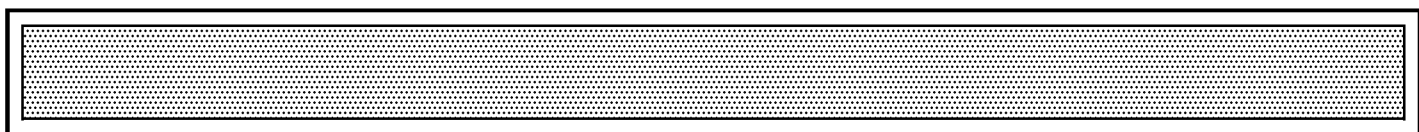
The rotational speeds of LP rotor (N1) and HP rotor (N2) are indicated as percentage of defined nominal RPM values.

**N1 :**  
 A sensor, installed on the fan case generates a frequency signal proportional to the fan blade passage. This signal is sent to each channel of the FADEC. Channel B analog output is sent to the N1 indicator (100 % N1 = 3 600 RPM).

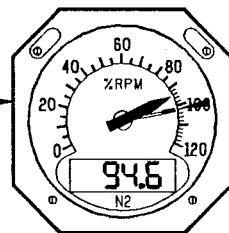
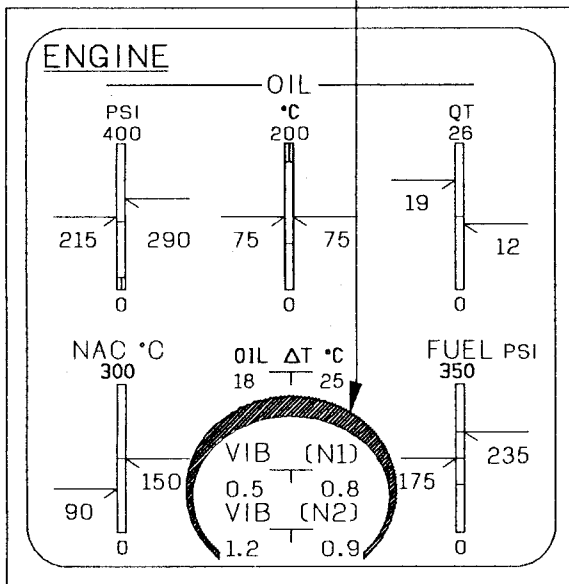
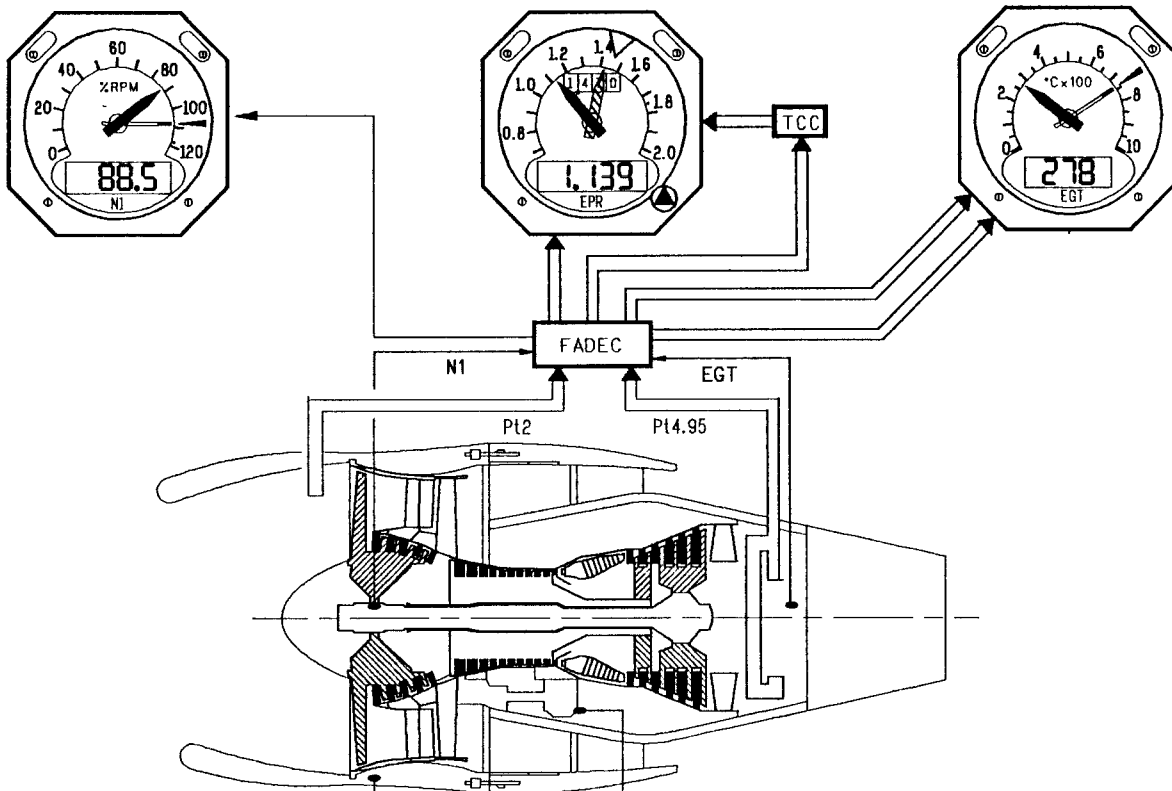
**N2 :**  
 The HP rotor speed is provided by the FADEC Permanent Magnet. Alternator (PMA), mounted on the accessory gearbox, through a dedicated winding.  
 The signal is directly sent to the N2 indicator (100 % N2 = 9 900 RPM).

**Vibration monitoring**

An accelerometer is fitted on the fan case and senses the vibrations induced by both Low and High rotor assemblies. The signal is transmitted by coaxial cable to an amplifier located in the electronics bay.  
 This amplifier also receives both N1 and N2 signals coming from the relevant transducers. These speed signals are used to set the central frequencies of narrow band filters which process the accelerometer signal and give two analog signals to be used by the SDAC as input for the ECAM display.



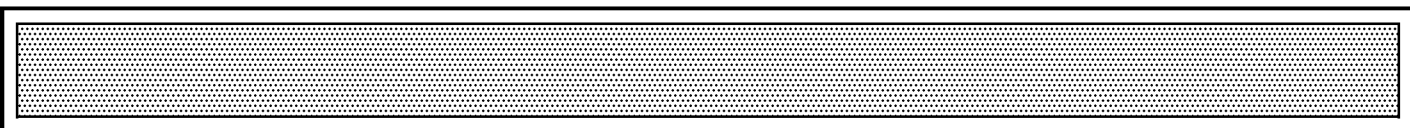
**ENGINE INDICATING**



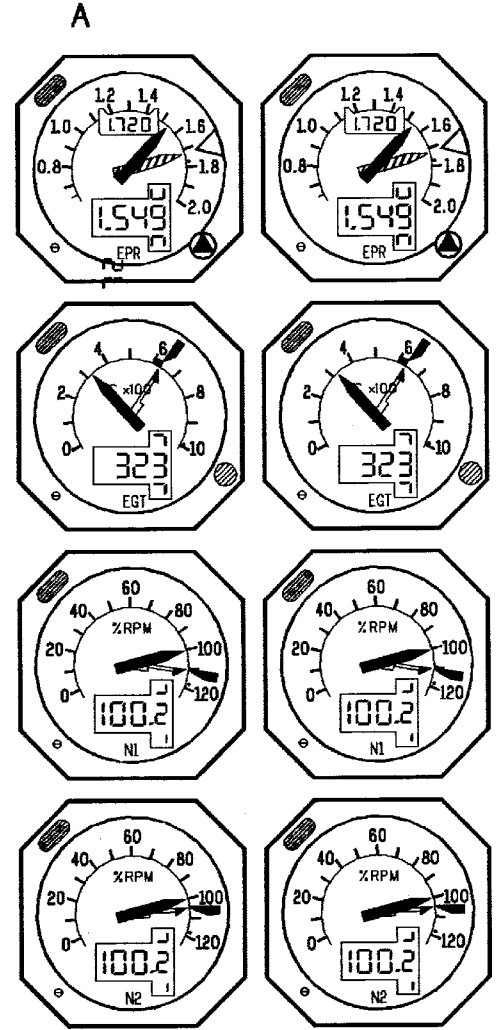
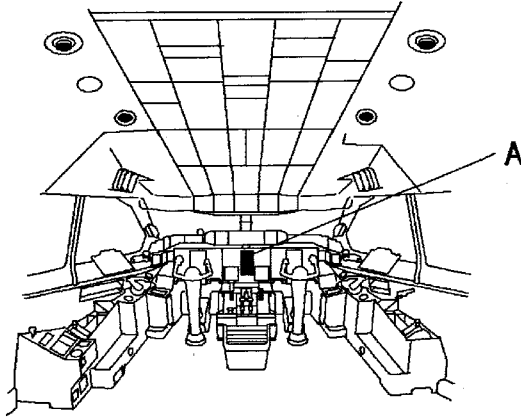
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R

PW Eng. : 4000



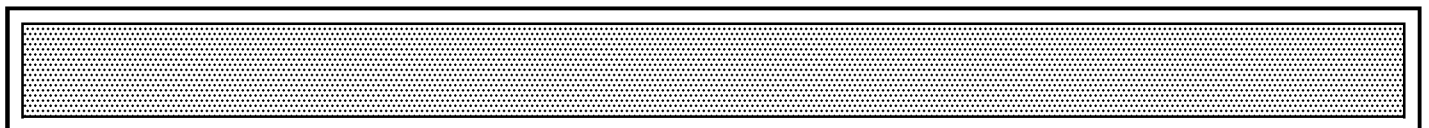
LOCATION OF CONTROLS



OPS.FCO.B1.1770.003-AB.030

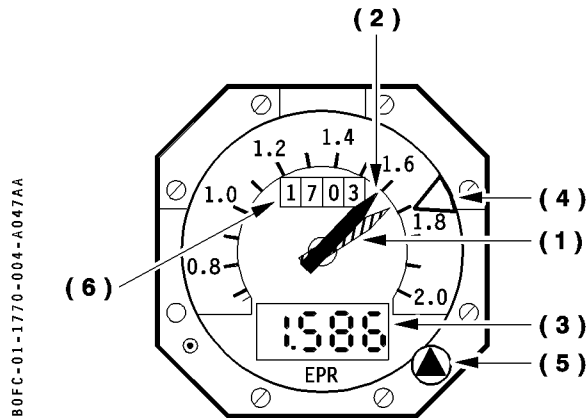
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PW Eng. : 4000





**EPR INDICATOR**



**(1) EPR command pointer :**

EPR command (TLA position) is displayed by a black and white pointer.

**(2) Actual EPR pointer :**

Actual EPR is displayed by a white pointer.

**(3) Lower digital counter :**

Actual EPR is displayed.

**(4) EPR LIMIT index :**

EPR limit is indicated by the yellow bug.

In manual mode, the bug is controlled by the index Mode Selector Knob (5), which is pulled out.

In this case EPR limit is displayed in digital format by the upper counter (6).

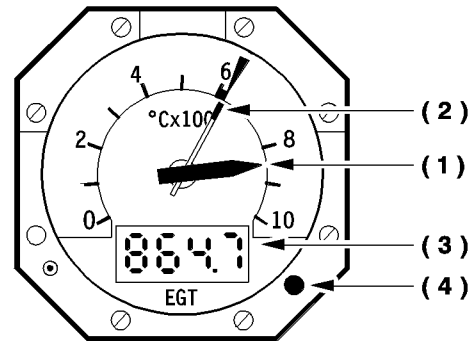
In automatic mode, the bug is controlled by the TCC. The knob is pressed in and the upper counter is blank.

*Notes :* – In case of electrical power supply failure, EPR command pointer and EPR limit index remain in last position ; EPR actual pointer is at the lowest value (0.65), the counter is blank.

– In case of signal failure both pointers show the lowest value (0.65).

– In case of EPR limit signal loss the code AF (Auto Fail) is displayed on the upper counter (6).

**EGT INDICATOR**



The analog scale is marked by a yellow arc from 600°C to the limit temperature and a red radial at limit temperature (625°C).

**(1) Pointer :**

Displays EGT (Shows the lowest value in case of electrical power supply failure or signal failure).

**(2) Overtemperature pointer :**

Normally on the red radial, indicates the maximum EGT obtained in case of overtemperature.

It is reset by pressing the MAX pointer reset pushbutton on the maintenance panel.

**(3) Digital counter :**

Displays EGT.

**(4) Warning light :**

Illuminates amber, associated with ECAM, when EGT reaches 625°C.

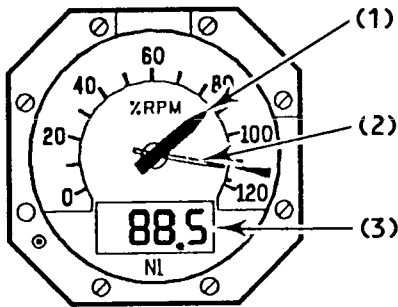
*Note :* Due to the design of the EGT indication system, the warning light may illuminate starting from 621°C.

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PW Eng. : 4152

**N1 – N2 INDICATORS**

The scale is marked by a red radial at 111.4 % for N1  
 104 % for N2 ]

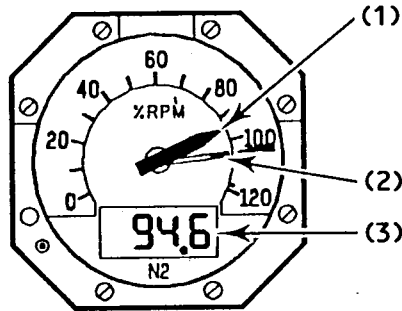


**(1) Pointer**

Indicates N1 (N2).

**(2) Overspeed pointer**

Normally on the red line, indicates the maximum value obtained on case of overspeed. It is reset by pressing the MAX pointer reset button on the maintenance panel. In case of N1 or N2 overspeed, the ECAM is activated.

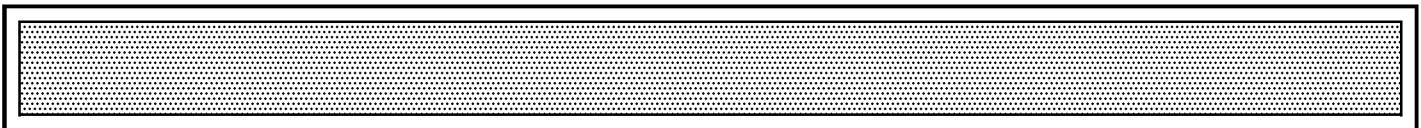


**(3) Digital counter**

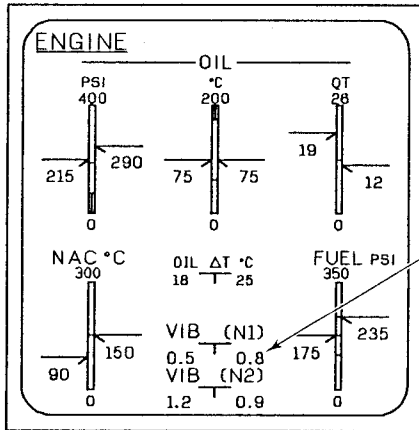
Displays N1 (N2).

FB1.1770.005-AA.040

PW Eng. : 4152



**SYSTEM DISPLAY – ENGINE PAGE**



**(1) Vibration Indication (green) :**

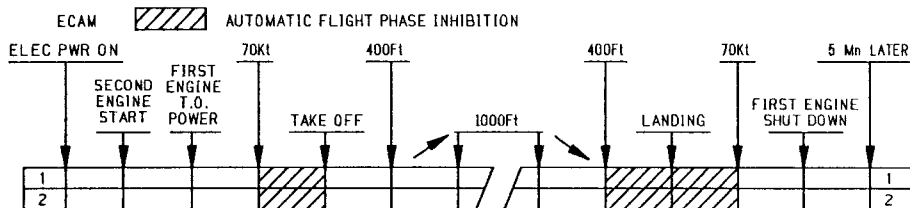
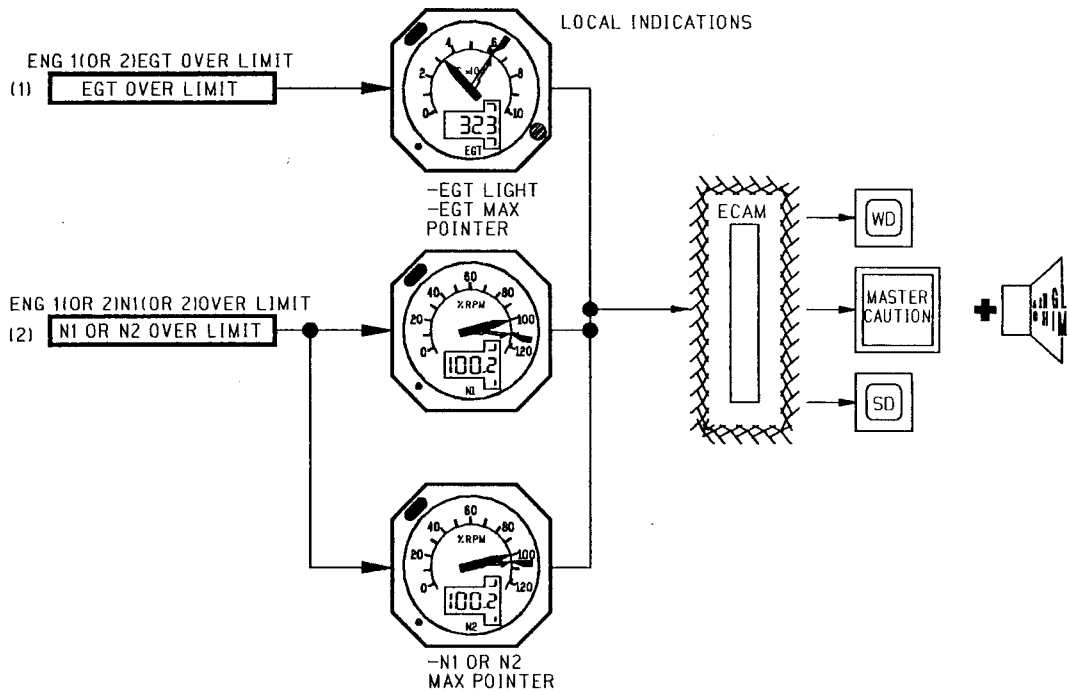
The engine vibration is displayed with two digital values from 1 to 10.

- N1 VIB : value sensed by the N1 tracking filter. Above 3, the indication flashes.
- N2 VIB : value sensed by the N2 tracking filter. Above 5, the indication flashes.

10 corresponds to a velocity of displacement of 6 in./s

*Note : Same indication is displayed on the ENG START PAGE, and on the CRUISE PAGE.*

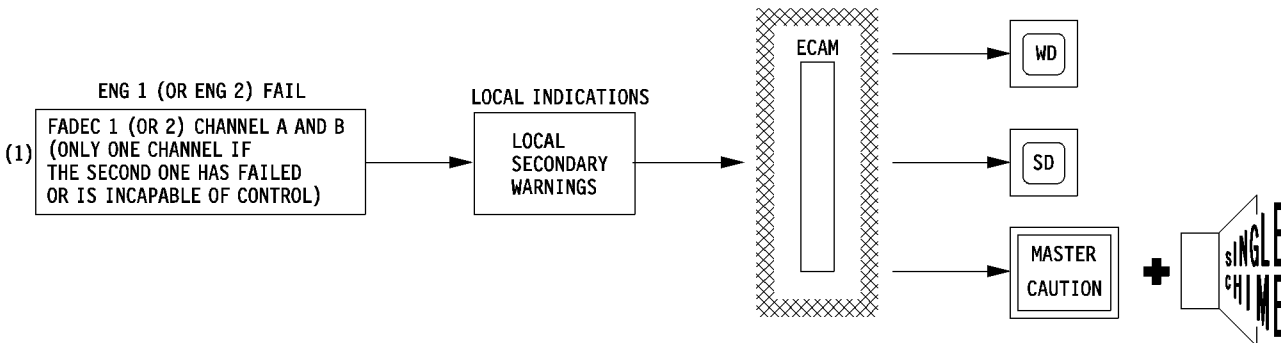
**WARNING LOGIC**



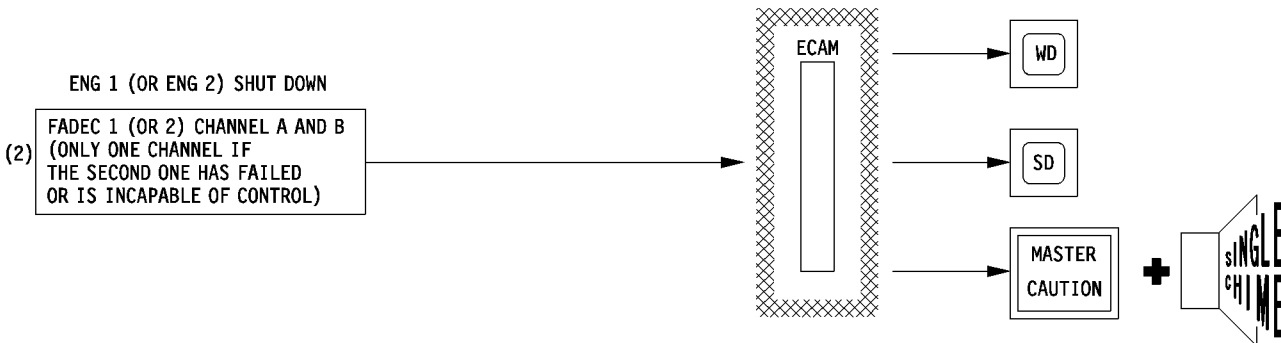
OPS.FCO.B1.1770.006-AA.100

**WARNING LOGIC**

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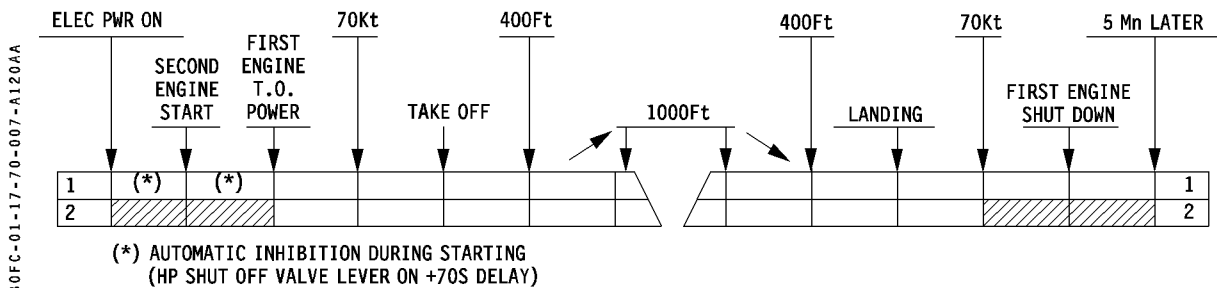
R  
R  
R  
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R



R

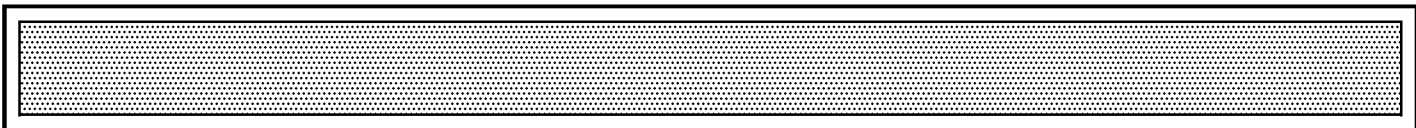
ECAM AUTOMATIC FLIGHT PHASE INHIBITION

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R  
R



R Mod.: 5051 + 5725

PW Eng.: 4000



**THRUST CONTROL COMPUTER**

The TCC is included in the Automatic Flight System. It computes the EPR limit according to the mode selected on the TRP, and takes into account the following parameters : Altitude, Mach number, Total Air Temperature, anti-ice and airbleed conditions. TCC displays this EPR limit on the TRP, and sets the limit bug on the EPR indicators.

The autothrottle is controlled by TCC signals. When it has been armed and A/THR is selected on the FCU, the following modes are available :

- a SPEED/MACH mode (allowing acquisition and then holding of the reference value).
- a THRUST mode (slaving the EPR to the EPR limit computed by the TCC, or to the EPR target given by FMC),
- a RETARD mode (which commands the throttle retraction on idle position).

**FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC)**

The FADEC is a fan case mounted air cooled and vibration isolated control system.

The FADEC assembly includes two independent control channels (A and B). Each channel has its own inputs, outputs and power supply, but data are crosstalked between the two channels for comparison and redundancy.

The FADEC is electrically supplied by a dedicated dual-output Permanent Magnet Alternator (PMA) mounted on the accessory gearbox. In addition two aircraft generated 28 Volt DC inputs are provided to each channel, one is used to power various solenoids, the other is used to power the FADEC for test purpose when the engine is not running.

The FADEC provides :

- basic engine control functions (starting, idle, acceleration, deceleration, stability and thrust control).
- optimized engine efficiency (anti-surge bleeds, variable stator vanes, compressor clearance control, automatic turbine rotor clearance control, cooling airflow).
- engine accessory control (heat exchanger valves).
- engine protection (critical speed and pressure limiting, thrust limiting, and overboost protection, surge detection, accomodation and recovery).
- maintenance information.

R  
R

It ensures also its self testing.

The FADEC system is able to work without any aircraft data or signal, including power supply, with the exception of the throttle lever position necessary to modulate the thrust.

Code : 1780C

**Self test and fault isolation**

The FADEC system can accommodate both single and multiple failures with no loss in performance or operational capability. This is possible by use of redundancy in all critical functions, by detection of hardware and software faults, by validation test of each input and by logic which accommodates detected faults by reconfiguring the system to use redundant features.

**Modes characteristics**

Each channel of the FADEC has two control modes.

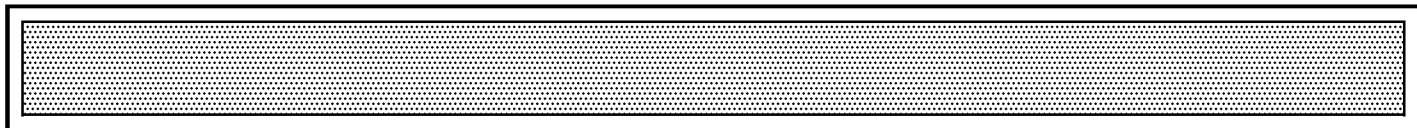
The primary control mode normally used is the EPR mode. In this control mode the FADEC contains all the engine thrust setting curves to provide automatic thrust ratings. In case of inability for the system (after failure) to control in primary control mode, an alternate mode is used : N1 mode. This mode is non rating mode with the power setting done manually.

**Thrust management and rating control.**

According to the Thrust Lever Angle (TLA) signal coming from the throttle lever, the FADEC computes the EPR CMD, based on T2, altitude, Mach number, and air conditioning and anti-icing bleeds status.

On the other hand the FADEC ensures slaving of EPR actual to EPR CMD by modulating fuel flow.

An EPR modifier assures a consistent thrust/EPR relationship.



**POWER PLANT**  
THRUST COMPUTATION CONTROL  
DESCRIPTION

1.17.80

PAGE 2

REV 24

SEQ 030

**OPERATING**

The system includes two loops :

- a loop for the determination of EPR CMD,
- a loop for the slaving of actual EPR to EPR CMD.

**Determination of EPR CMD :**

- TCC computes the EPR limit according to the mode selected on the TRP and external conditions.
- The throttle lever is set by the TCC.
- The FADEC receives the TLA from a resolver.
- The FADEC computes the EPR CMD according to the TLA and external conditions.
- The FADEC sends the EPR CMD signal to the TCC as a feedback.
- The TCC actuates the throttle levers, according to the difference between EPR CMD and EPR limit.

*Note : When speed mode is selected, the TCC receives a selected speed signal, and an actual speed signal.  
It computes a speed difference value, which is translated in EPR difference value.*

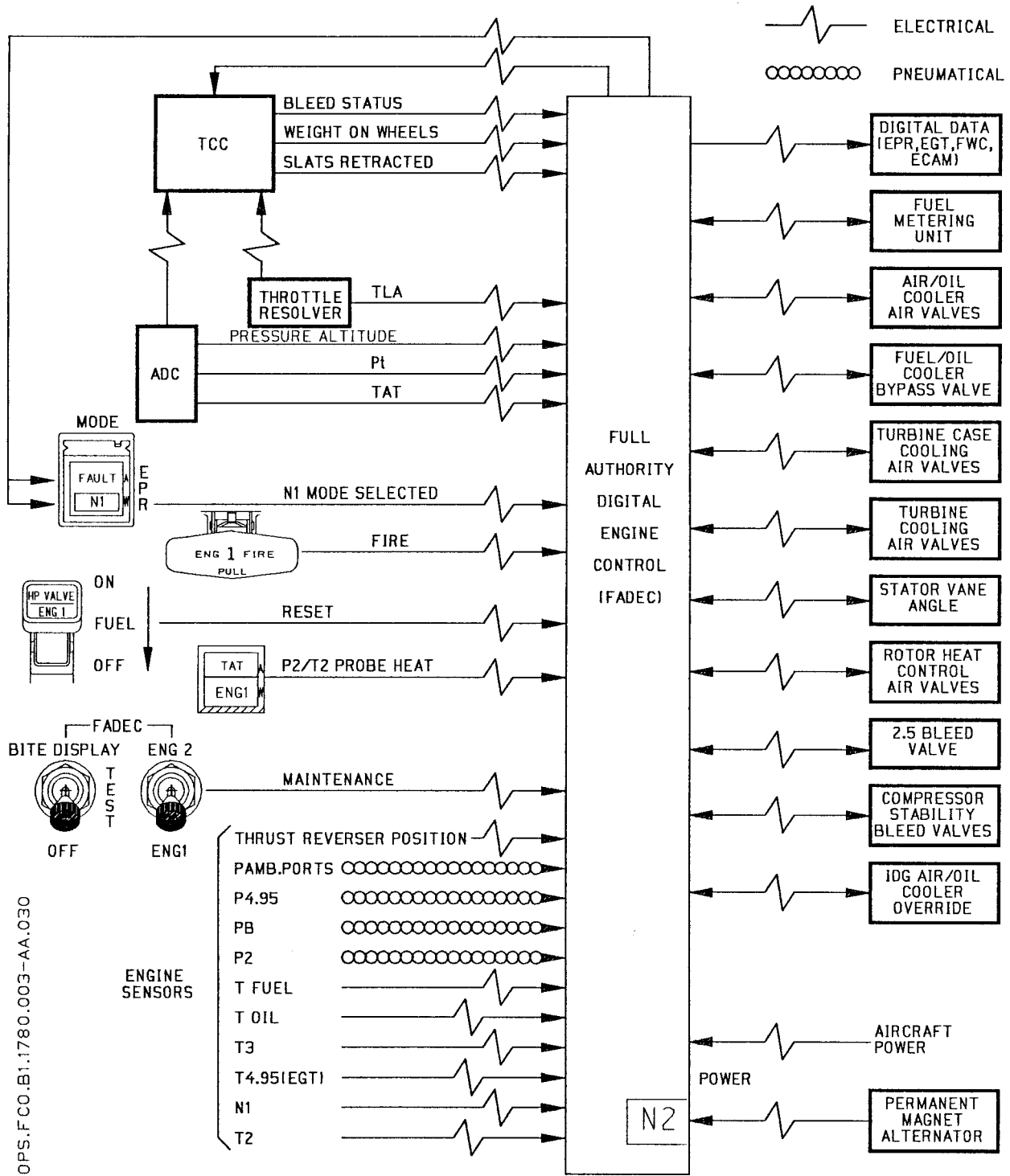
**Slaving of actual EPR to EPR CMD**

- The FADEC receives TLA from the throttle lever.
- The FADEC controls the fuel flow, through the Fuel Metering Unit.
- The actual EPR obtained is computed by the FADEC, which receives PT4.95 and PT2.
- The FADEC compares actual EPR and EPR CMD.
- The FADEC actuates the torque motor in the Fuel Metering Unit to obtain actual EPR = EPR CMD.

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PW Eng. : 4000

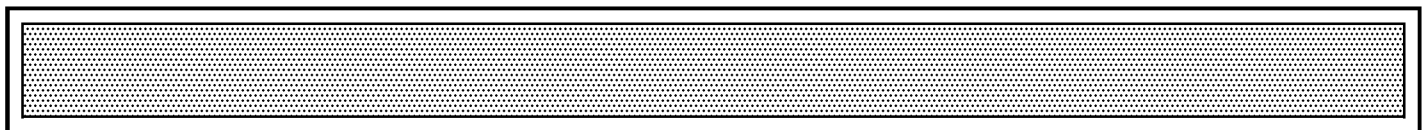
**FADEC INTERFACE**



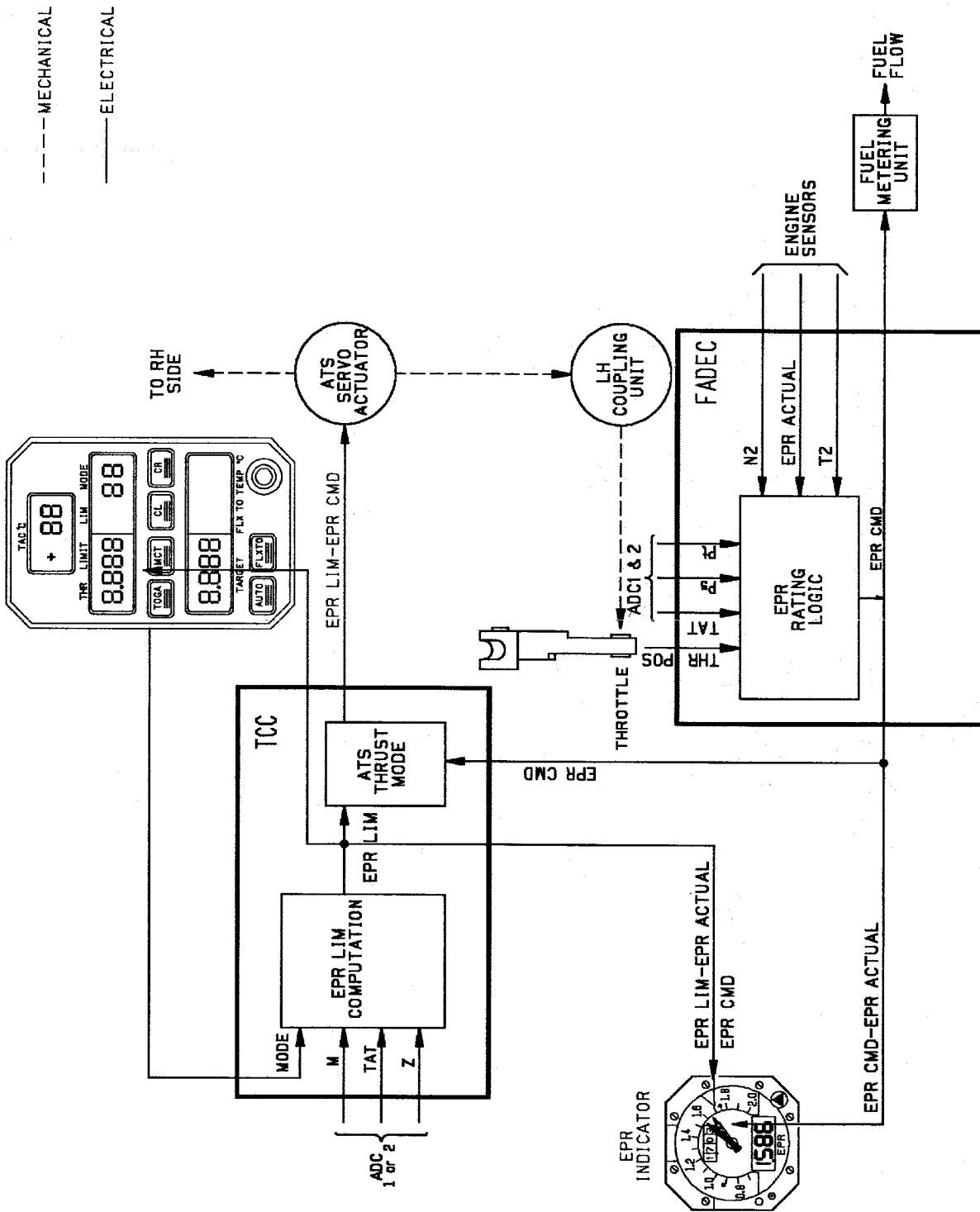
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PW Eng. : 4000



**THRUST COMPUTATION BLOCK DIAGRAM**



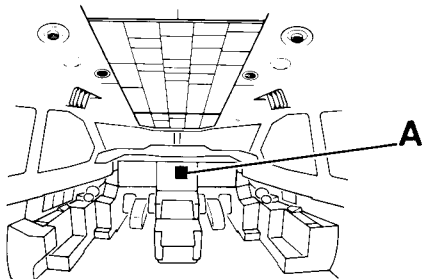
OPS.FCO.B1.1780.004-AA.030

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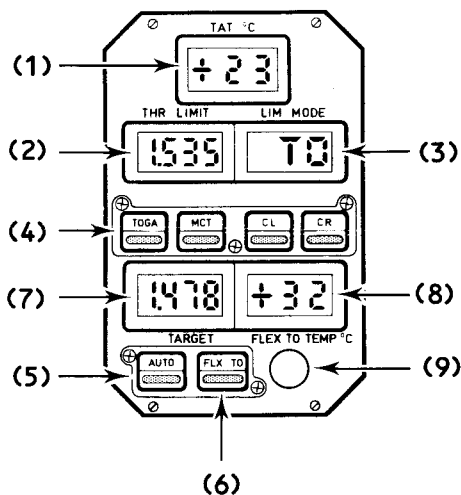
PW Eng. : 4000



**A. THRUST RATING PANEL (TRP)**



FB 1.1780.005-AA-020



**(1) The TAT (Total Air Temperature) display :**

Shows the value normally transmitted by the armed TCC, and directly taken from ADC 2 data bus in case of TCC failure.

**(2) THR LIMIT display**

The limit thrust corresponding to the selected mode is displayed. The only exception is when FLEX TO is selected. In this case MAX TO thrust is displayed in the THR LIMIT window, TO in the LIMIT MODE window and FLEX TO in the TARGET window.

**(3) LIM MODE display :**

Indicates the limit mode :

- TO,
- GA,
- CL,
- CR,
- MCT,

Manually controlled by the crew by pressing one of the five keys (4) and (6). Automatically controlled by the FMC when the AUTO key (5) has been selected.

**(4) (5) (6) Mode selector keys :**

The keys are springloaded to return to the neutral position and a second action has no effect. When a switch is pressed, three stripes come on and a signal is sent to the TCC.

**(7) THR TARGET display**

If PROFILE mode is not engaged, the limit thrust displayed in the THR LIMIT window is recopied (except for FLEX TO as explained above) if THRUST mode is active in the ATS.

Nothing is displayed if SPD/MACH mode is active in the ATS. I-L is displayed if throttles are on idle in descent with LVL/CH mode.

If PROFILE is engaged, TARGET THRUST calculated by the FMC is displayed whatever the mode is (P THR or SPD/P MACH). I-L is displayed if idle thrust is requested by the FMC.

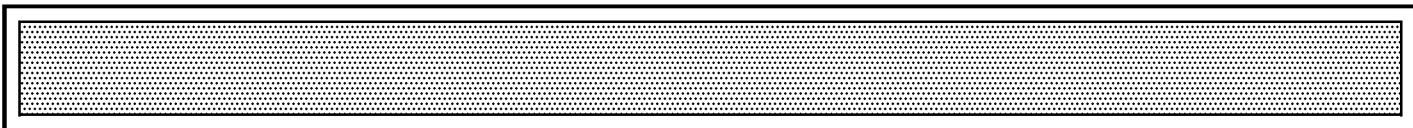
**(8) The FLX TO temperature display**

Indicates the temperature selected with the knob (9).

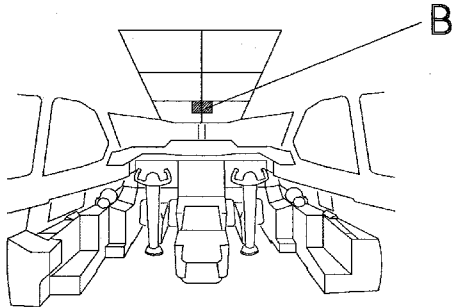
**(9) The FLX TO temperature knob**

Is equipped with a notch mechanism with 32 clicks per turn each click corresponding to 1 ° C. This selected temperature is transmitted to the TCC. Any selection of a FLX TO value lower than the TAT value results in « --- » in the FLX TO display.

R  
R



**B. MODE SELECTOR**



**(1) MODE SELECTOR pb switch (guarded)**

▪ **Normal (pb switch is out)**

FAULT and N1 extinguished. The FADEC controls the engine in EPR mode.

▪ **FAULT**

The light illuminates in amber accompanied by an ECAM warning.

The FADEC has reverted to N1 mode due to its inability to control the engine in primary mode EPR. This automatic reversion is smooth, thrust is maintained and parameters are unchanged. This smooth transfer is known as a "lock-up" logic.

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R  
R

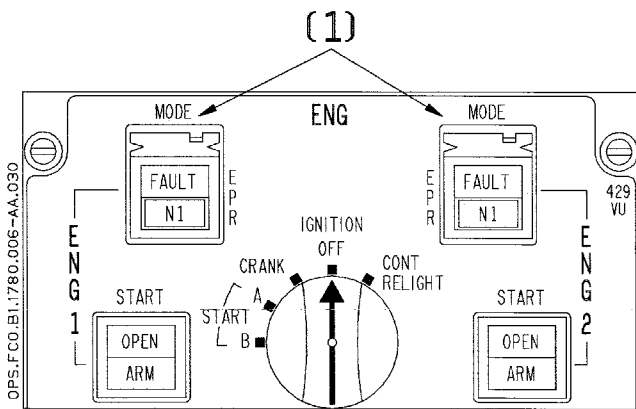
▪ **N1 (pb switch pressed-in)**

The light illuminates in white.

Alternate control mode N1 selected.

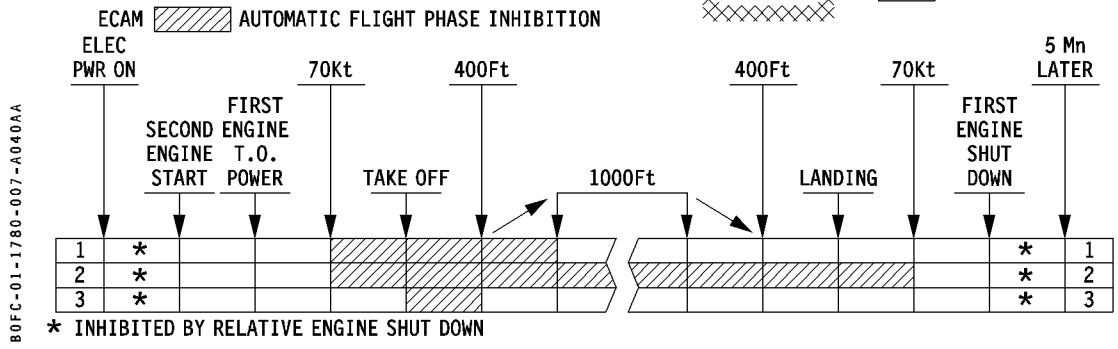
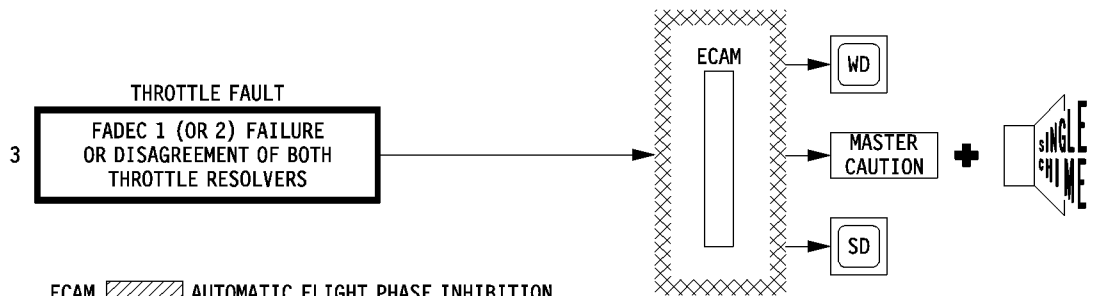
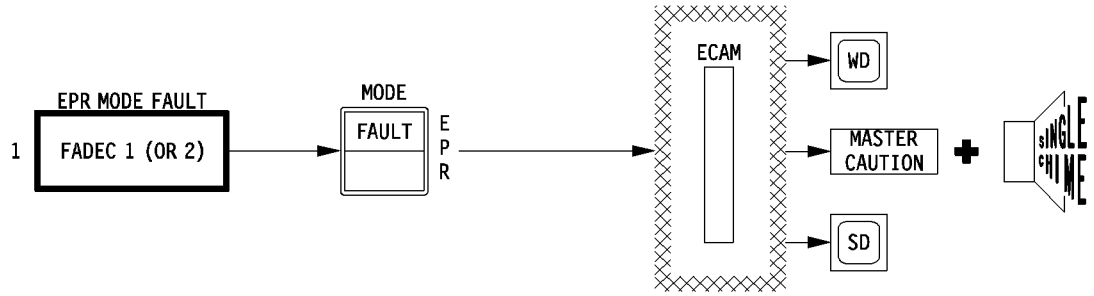
Upon manual selection of N1 mode after automatic reversion, the "locked-up" logic is removed and the N1 schedule is followed.

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R



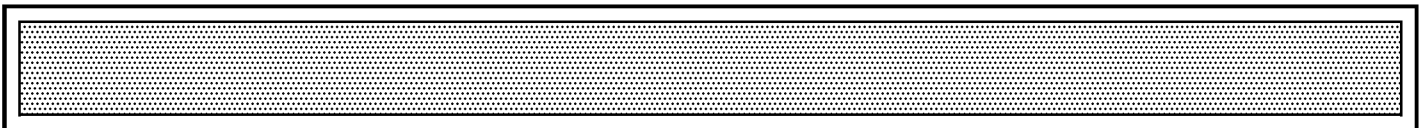
PW Eng. : 4000

**WARNING LOGIC**

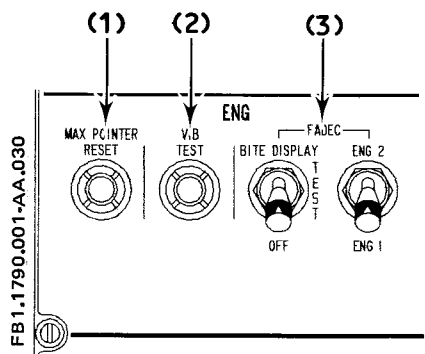


R Mod. : 5051

PW Eng. : 4000



**A. MAX POINTER RESET-TEST SWITCHES**



**(1) MAX POINTER RESET Push-button**

Push-button is used to reset the overlimit needles to the red lines for N1, N2, EGT of both engines.

**(2) VIB TEST Push-button**

The push-button, is used on ground to test the vibration system.  
 When activated, the engine page will be displayed on the system CRT and both VIB (N1) (N2) indication show 8 for both engines.

**(3) FADEC SWITCHES**

- On ground it is possible :
- to test the FADEC of each engine (TEST position) when initiated the test allows display on the ECAM system of parametric data, status and maintenance words from the two channels of the selected FADEC.
  - to display on the ECAM the maintenance words encoded from the non-volatile memory (BITE DISPLAY position)

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PW Eng. : 4000

