OPERATIONS MANUAL
SECTION 6-4
PROPELLER

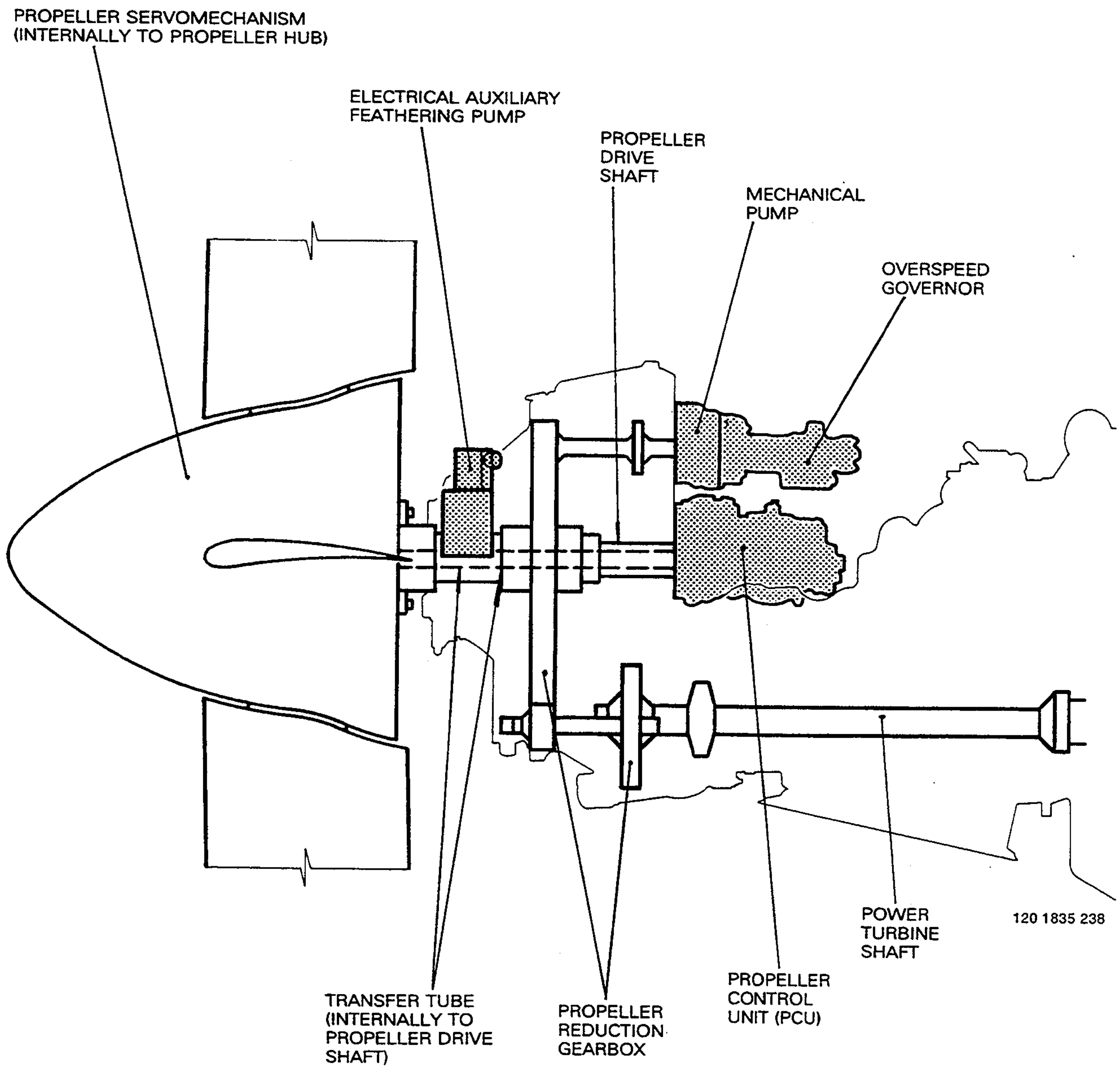
Index

GENERAL DESCRIPTION

The EMB-120 BRASILIA is equipped with two Hamilton Standard, model 14 RF-19 Propellers.
The propellers are mechanically actuated by the power turbines of the relevant engines, at a reduction rate of 15:1 (20000 RPM of the power turbine corresponds to approximately 1300 RPM of propeller), the pitch being hydraulically controlled by the propeller control unit (PCU).
The oil used to control the propeller comes from engine lubrication system and it is supplied through oil auxiliary tank, which feeds both the mechanical pump and the electrical auxiliary feathering pump.
In case of engine lubrication system failure or with engine inoperative, the auxiliary tank always keeps a minimum oil level, capable of ensuring propeller full feathering through the electrical auxiliary feathering pump.
In normal operating conditions, only the mechanical pump will be operative.
Propeller maximum governed speed varies from 1300 to 1309 RPM (100% – 100.7% N_P), and pitch adjustment range varies from + 79.2° (Feather) down to – 15.0° (Reverse), measured in blade station N° 42.
EMB-120 propeller system incorporates the following components in each propeller assembly:

- 01 Hamilton Standard, four-blade, model 14 RF-9, clockwise rotation (as viewed from behind), variable pitch, tractor, reversible and feathering propeller.
- 01 mechanical pump actuated by the power turbine shaft through the reduction gearbox accessory section, which is responsible for high pressure oil supply (780 ± 30 PSI) to the PCU, overspeed governor and propeller servomechanism.
- 01 electrical auxiliary feathering pump which will supply high pressure oil (820 ± 30 PSI) for propeller feathering.
  The electrical pump can be activated by one of the following means: the electrical or the automatic feathering systems, the fire extinguishing system handle or the pump test button.
- 01 propeller control unit (PCU) which will control propeller pitch and speed.
- 01 overspeed governor which provides propeller maximum speed control, in case of PCU failure.
- 01 flight low pitch secondary backstop system.

Additionally, the EMB-120 propeller system incorporates an automatic feathering system and a synchronization system which actuates simultaneously on both propeller assemblies.



PROPELLER CONTROL SYSTEM COMPONENTS

PROPELLER PITCH MECHANISMS

PROPELLER CONTROL UNIT

The PCU is the main component installed in the propeller system, responsible for controlling speed and selecting the propeller pitch.
The PCU is commanded by both the condition and the power levers installed in the airplane cockpit.
By means of the PCU, the condition lever controls propeller speed (N_P) in flight and its mechanical feathering, as the power lever controls the flight low pitch lock schedule, and propeller pitch during taxi and reverse operations.
On the ground, during the takeoff run, depending the on wind velocity, the PCU characteristics may cause an N_P oscillation on the digital N_P indicator. This oscillation may vary from ± 1.0% N_P (calm headwind conditions) up to ± 2.0% N_P (crosswind, tailwind, gust, or strong headwind conditions). The oscillation is acceptable if the nominal set value is within the range of 100.0 to 100.7% N_P.
An inflight N_P oscillation of ± 1.0% is acceptable when it noticed during gust or turbulence, or when it occurs occasionally, i.e, sporadic uncommanded N_P changes.
The PCU incorporates the following units: speed governor section, least selector valve, beta valve, mechanical feathering valve, feathering solenoid valve, flight low pitch microswitch, piston and pitch change screw.
The PCU piston and pitch change screw are connected to one of the transfer tube ends. The opposite end is connected to the pitch change screw/selector valve in the propeller servomechanism.

TRANSFER TUBE

The transfer tube is a metallic tube which transfer the pitch change commands from the PCU to the propeller servomechanism. The transfer tube is housed within the propeller shaft and, by means of the selector valve, releases oil pressure to one of the servomechanism chambers whenever pitch changes are commanded.

PROPELLER SERVOMECHANISM

The propeller servomechanism is a hydromechanical assembly located inside the propeller hub and incorporates the following components:

- A piston to which the propeller blade eccentric pins are fitted.
- A pitch change screw, responsible for changing the rotational movement variation of the transfer tube into axial displacement of the selector valve.
- A selector valve, connected to the transfer tube, which release oil pressure to the chambers.
- A pitch decrease and a pitch increase chambers which, when subjected to oil pressure, displace the piston forwards or backwards, thus providing the propeller pitch change, as selected.

PITCH CHANGE OPERATION

The propeller pitch change is controlled by the PCU. The PCU, actuating on the transfer tube, controls the pitch change in the propeller servomechanism.

PCU Actuation

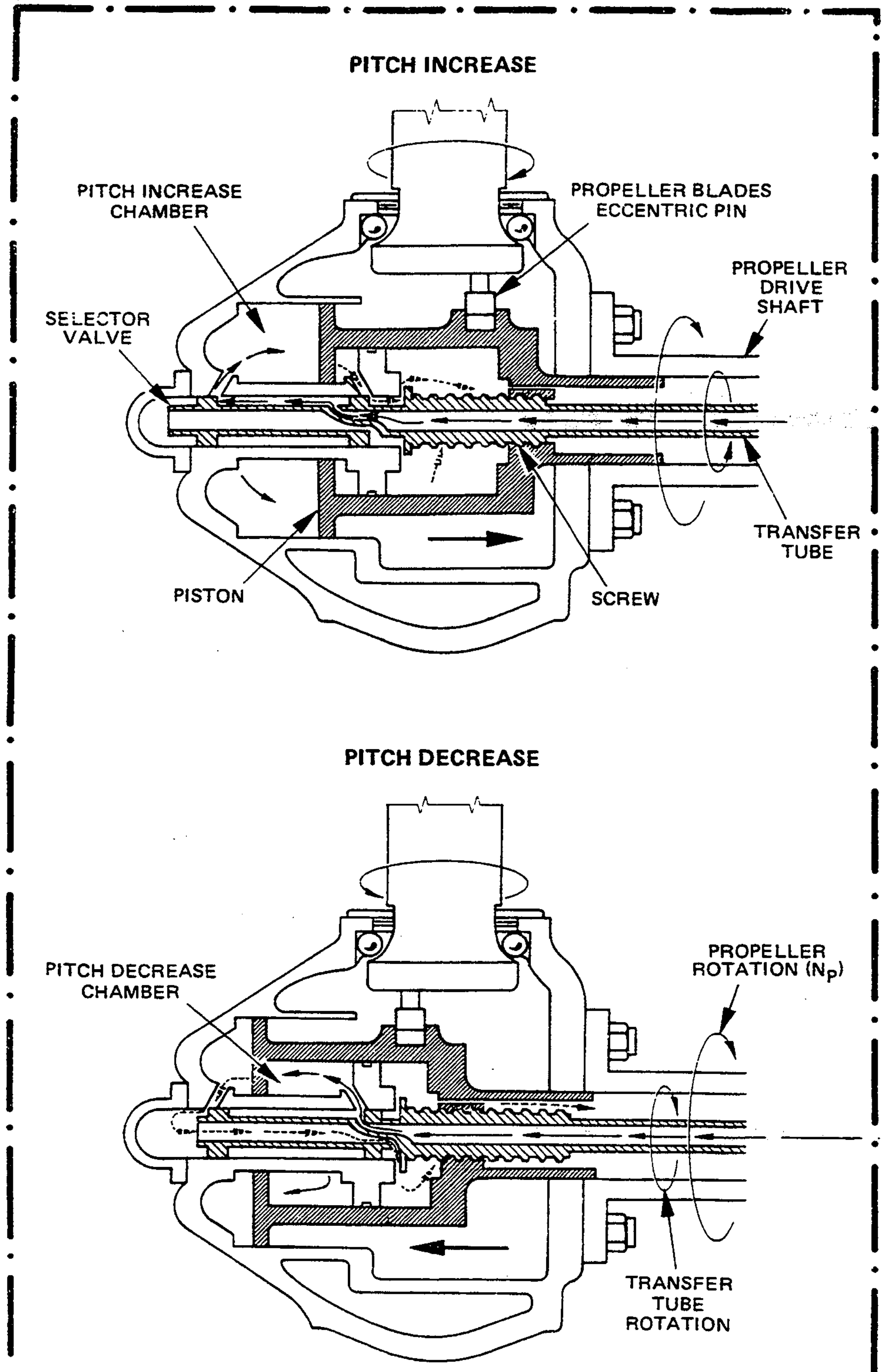
The transfer tube normaly rotates at the same speed of the propeller. When a pitch change is commanded, the PCU changes the transfer tube rotation, either slower or faster than the propeller speed. This rotation change is obtained by means of the action of two distinct hydraulic pressures which actuate upon each side of the PCU piston: supply pressure (Ps) and control pressure (Pc). The supply pressure is directly supplied by the mechanical pump (780 ± 30 psi), or should it fails, by the electrical auxiliary feathering pump (820 ± 30 psi). The control pressure is controlled by the PCU, and its value is half the supply pressure value, approximately. The area upon which the control pressure actuates is twice the area upon which the supply pressure actuates. The supply pressure actuates in order to increase the propeller pitch, and the control pressure actuates in order to decrease the propeller pitch. The PCU either draining or releasing Pc, controls the resultant of forces which actuate on the piston as well as its displacement. When moved, the PCU piston rotates the pitch change screw, thus changing the transfer tube rotation.
The Pc control, in the PCU, is carried out either by the speed governor section or by the beta valve, as selected by the reverse valve.

Propeller Servomechanism Actuation

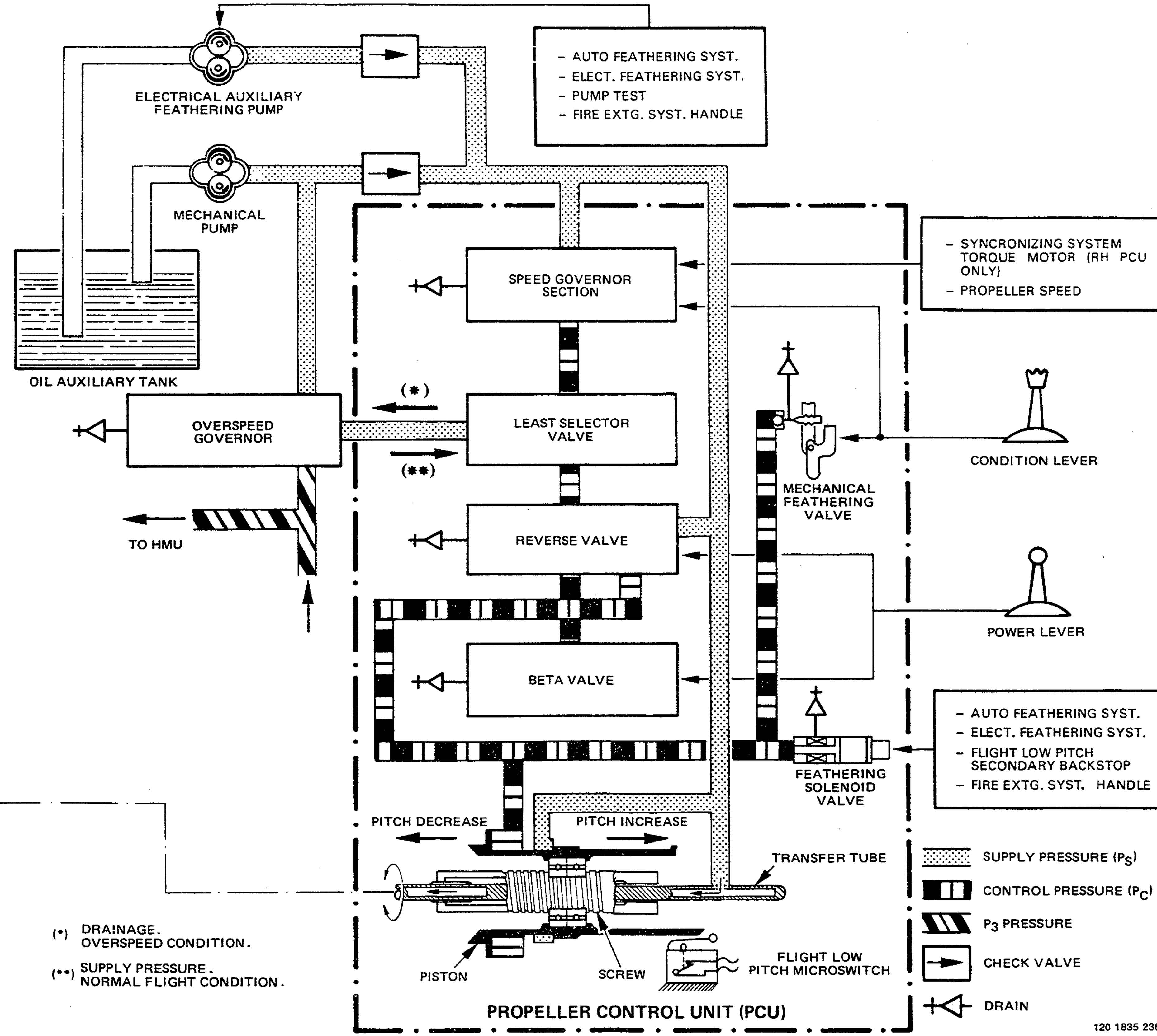
In the servomechanism, the screw changes the transfer tube rotational variation into a selector valve displacement; It is positioned in a way that one of the servomechanism chamber is in contact with the supply pressure line, as well as the other chamber is in contact with the drain line. In this way, the servomechanism piston will move until the propeller selected pitch is reached.
When the selected pitch is reached, the transfer tube returns to its normal rotation, the selector valve returns to its balanced position and the servomechanism and the PCU pistons will stop their displacement.

PITCH LOCK

The pitch lock is a protection device assembled to the propeller servomechanism, with the function of locking the propeller pitch in flight, if oil pressure which feeds propeller servomechanism is lost.
The pitch lock limits the propeller pitch decrease in approximately 1° of blade angle in relation to effective pitch when oil pressure is lost. In the consequency of the pitch decrease, the propeller speed will increase in approximately 2% Np.
When the pitch lock is actuated, the condition lever has no more action on pitch changes, the propeller start to operate with fixed pitch, and the propeller speed variations (Np) will occur thanks to only power and speed changes of the airplane.
If a failure occurs in the left propeller (master), when the propeller synchronization system is on, the 2% Np change will also occur in the right propeller (slave).
The actuation of this mechanism does not require any pilot's action.



PROPELLER SERVOMECHANISM, DURING PITCH CHANGE OPERATIONS



PROPELLER SYSTEM SCHEMATIC DIAGRAM

PCU COMPONENTS

REVERSE VALVE

The reverse valve, controlled by the power lever, selects either the speed governor section or the beta valve to control the pressure Pc and, consequently, the propeller pitch.
For power lever positions, from FLT IDLE up to MAX PWR (typical in-flight positions), the reverse valve allows the governor section to act on the propeller pitch, up to the limit of the flight low pitch backstop.
For power lever positions from FLT IDLE down to maximum reverse (typical on ground positions), the reverse valve hydraulically blocks the speed governor section, and the propeller pitch control is performed by means of the beta valve.

CAUTION: NEVER SET THE POWER LEVER BELOW FLT IDLE IN FLIGHT.

In flight, the power lever operating range must be limited to positions equal to or above FLT IDLE. It will assure governing blade angles (speed governor section controlling the propeller pitch) that are far above those ones commanded by the beta valve. The actuation of the reverse valve in flight (power lever below FLT IDLE) disables the governor section as well as the overspeed governor protection and makes the propeller blades pitch angles follow the beta valve schedule (minimum blade angle schedule). The beta schedule angles are much lower, towards flat pitch, than the angles scheduled by the speed governor section. This reduced blade angle in flight causes the propeller to extract energy from the airstream, driving the power turbine shaft to very high overspeed; it may result in serious damage to the engine and in excessive propeller drag.

PROPELLER SPEED GOVERNOR SECTION

This section, commanded by the condition lever, has the function of controlling, in flight, both the propeller pitch and speed.
When the condition lever acts on the speed governor section, it increases or decreases the propeller pitch, until the speed (N_P) selected by the condition lever in the cockpit is reached.
Engine operations with governed propeller set a correspondence where for every condition lever position, between MIN and MAX RPM, there is a specific propeller speed, and that for every power lever position, from FLT IDLE up to MAX PWR, there is a predetermined minimum blade angle (flight low pitch).
The flight low pitch control is carried out by the beta valve, which limits action of the speed governor section, with the function of not allowing propeller pitch values below the minimum ones established.
The speed governor section is operational with propeller speed above 80%.

BETA VALVE

The beta valve is commanded by means of the power lever. During the flight, it controls the primary low pitch backstop, and when the airplane is on ground, it controls the propeller pitch for taxi and reverse operations.

On ground, the propeller operates in the beta mode (pitch control by means of the beta valve), and for every power lever position, from maximum reverse to below FLT IDLE there is the correspondence of a predetermined blade angle.

During taxi and reverse operations, the EEC controls the propeller speed (Np).

With the condition lever positioned at MAX RPM, and with the power lever positioned between FLT IDLE and 10°PLA (positioned just below GND IDLE), the EEC assures a minimum speed of 65% Np.

With the condition lever positioned at MAX RPM and with the power lever positioned between 10° PLA and maximum reverse, the EEC assures an increasing minimum speed of 65% Np (10° PLA) up to a maximum of 80% Np (maximum reverse).

With the condition lever positioned between MAX and MIN RPM, and for every power lever position, the EEC assures a minimum speed of 50% Np. With EEC OFF, the propeller speed will depend on pressure altitude and density of air.

In flight, and with the power lever positioned from FLT IDLE up to MAX PWR, the beta valve acts as a propeller pitch backstop, thus assuring that the blades will not reach angles values lower than the minimum pre-established ones. At FLT IDLE, the low pitch is of 17.6° (measured at propeller blade station N°. 42), varying in an increasing way to power lever positions above FLT IDLE.

With the power lever positioned below FLT IDLE, the propeller blades are positioned below the flight low pitch, and this condition is indicated by the BETA lights illumination on the glareshield panel. The BETA light illumination is commanded by the flight low pitch microswith actuation, in the PCU, whenever the propeller blades are in angular positions equal to or lower than 12.6° (5° below the flight low pitch corresponding to FLT IDLE position). During taxi and reverse operations, the BETA lights are normally illuminated.

NOTE: The BETA light illumination in flight is abnormal and indicates beta valve failure in limiting the flight low pitch or indicates a failure in the beta indication circuit.

FLIGHT LOW PITCH SECONDARY BACKSTOP

This system prevents the relevant propeller from assuming angular values below the flight low pitch, which would tend to an in-flight flat or reverse pitch, thanks to a primary backstop (beta valve) failure.
The flight low pitch backstop system is composed of the following items:

- A flight low pitch microswitch actuated by the PCU piston. This switch is closed whenever the propeller blade angle is below 12.6° (5° below the flight low pitch corresponding to FLT IDLE position).
- A secondary low pitch backstop microswitch, located within the control pedestal. This switch is closed whenever the power lever is positioned at FLT IDLE or above (normal flight position).

The system is automatically actuated whenever the power lever is positioned at FLT IDLE or above and the propeller pitch decreases to angular values below 12.6°.
When actuated, the flight low pitch secondary backstop system causes the BETA light to illuminate, and energizes the feathering solenoid valve in the PCU. When energized, the solenoid valve provides the drainage of the control pressure (Pc) line, causing the propeller pitch to increase up to angular values above 12.6°. At this point, the system is deactivated by the opening of the low pitch microswitch, with subsequent BETA light extinguishment.
In this way, if the propeller pitch decreases again, the process is repeated, and the propeller pitch will be cycling around 12.6°.

NOTE: A low pitch microswitch in-flight failure (locking in the closed position) will suddenly feather the propeller. This condition will be indicated by a Np decrease and by a torque increase. In this case, reduce the power lever to FLT IDLE position and open the affected engine BETA circuit breaker, located on the circuit breaker panel.

PROPELLER FEATHERING

The propeller feathering can be performed by means of mechanical or electrical controls.

MECHANICAL FEATHERING

The propeller mechanical feathering is commanded by the condition lever (FEATHER position), which acts upon the mechanical feathering valve in the PCU. When actuated, this valve drains the control pressure (Pc) line, thus causing the propeller pitch to increase up to its feathered position.

NOTE: Await until propeller is fully feathered (Np reduction to 20% approximately), prior to performing an in-flight engine shutdown. If the engine is shut down with the propeller not feathered, the only way to feather it is by means of the auxiliary electrical feathering pump.

ELECTRICAL FEATHERING

The propeller electrical feathering is controlled by the automatic and the electrical feathering systems and by the fire extinguishing handle. These three systems act upon the feathering solenoid valve in the PCU and upon the auxiliary electrical feathering pump.

AUXILIARY ELECTRICAL FEATHERING PUMP

The auxiliary electrical feathering pump supplies oil pressure for propeller feathering independently of the engine lubricating circuit and of the mechanical oil pump.
When actuated, the auxiliary electrical feathering pump is on for 20 seconds, turning off automatically, thus providing sufficient time until the propeller is fully feathered, even if the propeller is positioned in reverse pitch.
The auxiliary electrical feathering pump may be activated by one of the following controls:

- ELEC FEATHER switch, of the electrical feathering system.
- Automatically by means of the automatic feathering system.
- Fire extinguishing handle, of the fire protection system.
- PROP AUX PUMP test button.

ELECTRICAL FEATHERING SYSTEM

The electrical feathering system provides means for propeller feathering in the following conditions: engine oil pressure loss, engine inoperative or engine shutdown due to fire.
The electrical feathering system is on either by means of the ELEC FEATHER switch (guarded), located on the overhead panel, or by means of the fire extinguishing handle.
The electrical feathering system is normally off with the ELEC FEATHER switch lowered. By lifting ELEC FEATHER switch, or pulling the fire extinguishing handle will cause the electrical feathering system to energize both the PCU feathering solenoid valve and the auxiliary electrical feathering pump, at the same time it interrupts the automatic feathering system control circuit for the opposite propeller.

The actuation of the feathering solenoid valve in conjunction with the electrical pump will cause the propeller to feather.
The electrical feathering system, when turned off, will be available for a new operation, provided the oil auxiliary tank is supplied with sufficient oil for the electrical pump actuation.

NOTE: The oil auxiliary tank may be replenished by an engine dry motoring.

AUTOMATIC FEATHERING SYSTEM

The auto-feathering system will automatically feather the propellers whose relevant engine undergoes a power loss during take off or go-around.
The system acts upon the feathering solenoid valve and upon the auxiliary electrical feathering pump, by means of the electrical feathering system electrical circuit.
The system is composed of:

- SCU's (Torque signal conditioning units) of both engines.
- Two-position (ON/OFF) AUTO FEATHER switch, located on the overhead panel.
- Two microswitches, located within the control pedestal which are energized whenever the power levers are positioned above 62° PLA (Typical takeoff power setting).
- Two test buttons, one for each propeller, which enable the system to be tested. Each test button, when pressed, simulates both an engine high torque condition and the power levers positioning at takeoff.
- A green indicating light bearing the inscription ARMED, which indicates whether the system is armed or not.

In this way, the system is armed when the following conditions are met simultaneously:

- AUTO FEATHER switch at ON.
- Torque of both engines above 62.0 ± 1.4%.
- Both power levers positioned above 62° PLA.

Under these conditions the system is ready to operate, as the ARMED indicating light illuminates. A synthesized voice (TAKEOFF-AUTOFEATHER) will warn the crew, 8 seconds after the power levers are positioned above 62° PLA, if the auto-feathering system is not armed during takeoff. The automatic feathering system is activated whenever torque of one of the engines drops below 23.6 ± 2.5%. In this case, the ARMED indicating light extinguishes and the relevant propeller is feathered. Simultaneously, the automatic feathering control circuit is interrupted for the opposite propeller, thus preventing it from feathering, in the event its engine undergoes a power loss also.

NOTE: After the automatic feathering system actuation, propeller unfeathering will only be possible with the AUTO FEATHER switch positioned to OFF.

PROPELLER SYNCHRONIZATION SYSTEM

This system has the purpose of equalizing the speed of the right propeller (slave) with the left propeller (master), as well as of maintaining the slave propeller at a determined and constant phase angle in relation to the master propeller. This system is aimed at reducing vibrations and noise caused by the propellers.

The synchronization system is composed of a synchrophaser, two pulse generators (one for each engine), and a torque motor installed in each PCU (right PCU torque motor connected only).

The synchronization system is commanded by means of the PROP SYNC two-position (ON/OFF) switch, located on the overhead panel, and is only effective when both propellers are operating in the governed mode ($Np > 80\%$).

The synchronization system is actuated when the PROP SYNC switch is positioned to ON and the Np of both engines is above 80%. In this condition, both the master propeller (LH) and the slave propeller (RH) pulse generators send electrical signals, which correspond to their speed, and angular position, to the synchrophaser, where they will be both processed and compared.

If required, the synchrophaser transmits a corrective signal to the right PCU torque motor; this torque motor, acting upon the speed governor section, adjusts the speed and angular position of the RH propeller so as to maintain it synchronized with the LH propeller. This correction is performed without no change in the corresponding condition lever position.

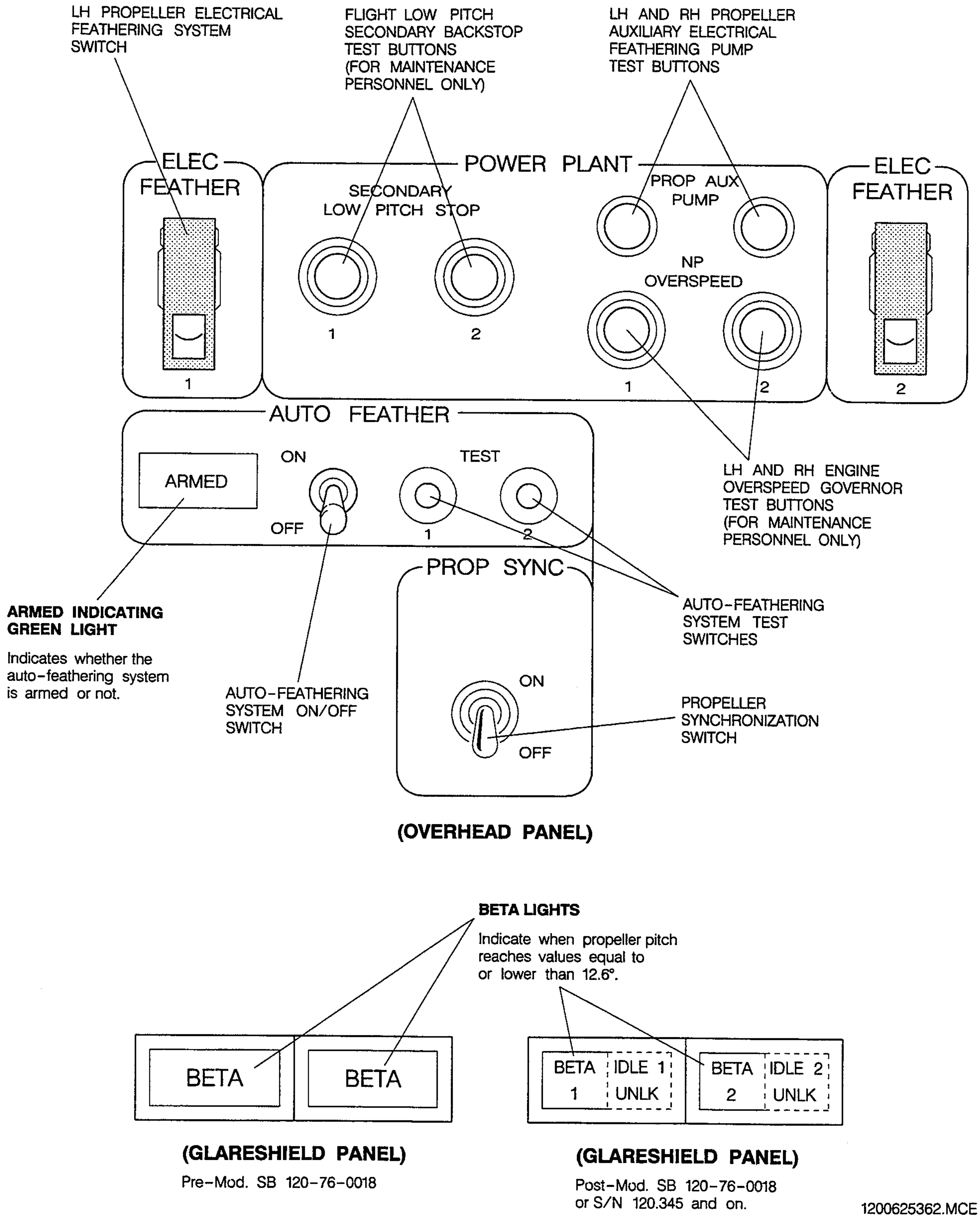
The synchronization system has authority over the speed governor section for corrections up to ± 2.5% Np, and is capable of maintaining the phase angle within ± 5° in relation to the reference angular value.

Speed differences above 2.5% Np will cause the system to disengage. Automatic reengagement will occur if, the propellers speed are back within the operational limits of the system actuation; this feature enables an in-flight feathering of the LH propeller (master), without causing the RH propeller (slave) to be feathered also.

OVERSPEED GOVERNOR

The overspeed governor is a hydromechanical unit which automatically actuates on the PCU, in the event a propeller overspeed condition occurs.
The least selector valve, installed in the PCU, will be responsible for selecting either the speed governor section actuation (normal condition), or the overspeed governor (overspeed condition).
Under normal flight conditions, the least selector valve isolates the overspeed governor, allowing only the speed governor section to act on the propeller pitch.
In the event of a propeller overspeed condition, when the value of 103% Np is reached, the overspeed governor starts acting upon the least selector valve, draining the control pressure Pc line and causing a propeller pitch increase with subsequent reduction of Np.
In this way, if the propeller speed continues increasing, and a value of 108% Np is reached, the overspeed governor starts bleeding the high pressure compressor discharge pressure (P3) also. By acting upon (P3), the overspeed governor reduces fuel flow supplied to the engine, thus reducing the speed of the engine power shaft, and, consequently, reducing Np.
The overspeed governor actuation is an automatic action and does not depend upon any action taken by the pilots.

NOTE: The overspeed governor is deactivated whenever the corresponding power lever is positioned below FLT IDLE.



PROPELLER SYSTEM CONTROLS AND INDICATORS