**ON A/C ALL

61–00–00–001

PROPELLERS, GENERAL

Introduction

The propeller is a six bladed, constant speed, variable pitch propeller which can be feathered and used in reverse pitch. The propeller is installed on the gearbox/propeller driveshaft flange and turns clockwise when seen from the rear.

An overspeed governor, a pitch control unit and a feathering pump supply synthetic lubricating oil to operate the pitch control mechanism. The beta tubes supply the synthetic lubricating oil from the pitch control unit to the propeller operating cylinder and piston.

General Description

Refer to Figures 1 and 2.

The Dowty Aerospace Propellers CR408/6–123–F/17 propeller converts the PW150A engine torque into thrust for aircraft propulsion in flight and during ground manoeuvres.

The propeller can be described by its model number as follows:

- C – Civil
- R – Dowty Aerospace Propellers
- 408 – Aircraft type identification
- 6 – Number of blades
- 123 – Blade root end size in mm.
- F – Flange mounted
- 17 – Function / Installation characteristics

The propeller has 6 all composite blades and is 13.5 ft (4.11 m) in diameter. The blade pitch is varied from full feather to full reverse by an electronically controlled hydraulic pitch actuation system.

Pitch change is accomplished by metered oil pressure. The oil pressure originates from the related engine and is supplied to a pump which is part of the Overspeed Governor (OSG) installation. The Overspeed Governor and Pump are mounted on, and driven by, the reduction gearbox of each engine.

The propeller blades are counter weighted to move towards coarse pitch in the event of oil pressure failure.

The major components of the propeller are:

- Blades
- Hub
- Crosshead
- Beta Tube Assembly
- Pitch Change Cylinder and Piston
- Blade Bearings
- Blade Counterweights

The spinner provides an aerodynamic fairing that covers the hub assembly.

The propeller deicing system is covered separately (Refer to SDS section 30–61–00–001).

The propeller system has the following subsystems:

- Propeller (61–10–00)
- Propeller Controlling (61–20–00)

Detailed Description

Refer to Figure 3.

The propeller is flange mounted on the front of the engine reduction gearbox, aligned by three dowels and a central mounting spigot on the propeller shaft.

Torque is transmitted from the reduction gearbox, approximately 50% through the dowels and 50% through friction of the flange interface.

A composite shim is interposed between the RGB and the propeller flange. The dowel holes are lined with composite material to limit fretting.

Propeller Electronic Control Unit

The Propeller Electronic Control (PEC) is mounted on the spine above the engine between the center and front engine support frames.

The PEC is electronically connected to the following components: Refer to Figures 4 and 5.

- Condition lever
- Power lever (through FADEC)
- Magnetic Pick–up Unit (MPU),
- Beta Feedback Transducer (BFT)
- Pitch Control Unit (PCU)
- Full Authority Digital Electronic Control (FADEC)

The Propeller Electronic Control (PEC) is a dual channel microprocessor–based controller which uses inputs from the aircraft, propeller control system sensors, and the engine control system to control propeller pitch and speed. The PECs for both propeller systems are mounted in their respective engine nacelles.

Each unit has an independent circuit that performs a number of safety functions including Autofeather and Automatic Underspeed Propeller Control (AUPC). It also provides an UPTRIM command to the Automatic Take–Off Power Control System (ATPCS) of the remote engine. All of these functions are isolated from the basic control functions of the PEC.

Pitch Control Unit

The Pitch Control Unit (PCU) is mounted on the rear face of the reduction gearbox, and is connected to the propeller by a dual concentric beta tube assembly.

The propeller Pitch Control Unit (PCU) is a hydromechanical device that interfaces with the propeller. Commanded electrically by the PEC, the PCU meters high pressure engine oil to a two stage servo valve mounted on the PCU and controls the flow of high pressure oil into the fine or coarse pitch chambers of the propeller pitch change cylinder as directed by the PEC so that the blades move in the desired direction. The PCU provides:

- Governed Constant Speed Operation

- Power Lever Controlled Beta Range (Flight Idle to Reverse)
- Manual Feather
- Unfeather
- Propeller Synchrophasing

High Pressure PCU Pump and O/S Governor

The High Pressure PCU Pump/Propeller Overspeed Governor Unit provides the PCU with high pressure oil from the engine gearbox. The High Pressure pump is a fixed displacement gear pump, driven from the reduction gearbox. The Propeller Overspeed Governor Unit is an independent mechanical system used to protect the propeller from overspeeding. The O/S Governor is a flyweight design, driven directly from the driver gear of the pump.

Auxiliary Feathering Pump

The Auxiliary Feathering Pump Unit provides an independent means of feathering the propeller in the event of a failure of the primary means of feather. The auxiliary pump consists of an electrical motor driving an external gear pump which supplies a secondary source of pressurized oil for feathering the propeller.

Propeller Modes

The PCU provides for governed constant speed operation through a propeller governor controlled by the condition levers. The power levers control blade angle in the beta range. The manual feather mode is controlled by the condition levers or by the autofeather/alternate feather system.

Constant Speed Mode

Refer to Figure 6.

During in–flight constant speeding operation, the PEC directs the servo valve to meter sufficient HP oil into propeller fine pitch to balance the net coarse–seeking moment applied to the blades by the blade forces to achieve the selected propeller RPM. These blade forces are dominated in flight by the blade counterweight effort, which is coarse–seeking at in–flight blade angles. Should the HP supply be lost, the blades will 'autocoarsen' to a safe, high–pitch, underspeeding condition, associated with low windmilling drag. Should the propeller underspeed for reasons other than loss of oil supply or servo valve failure, the servo valve will direct more HP oil into fine pitch to restore propeller speed. Should the propeller exceed the demanded speed, the servo valve will direct HP oil into coarse pitch to reduce propeller speed. This is somewhat simplified, since the PEC responds to acceleration as well as rpm error. (During a slam acceleration, when propeller rpm is underspeeding yet accelerating rapidly to the selected speed, the PEC will direct the servo valve coarse, so that the propeller can absorb more power.)

Constant speeding mode is entered when the propeller speed reaches 850, 900 or 1020 rpm, according to which speed is selected by the Condition Lever. HP oil for constant speeding passes through the OSG before it reaches the servo valve. Should the servo valve stick at a fine pitch selection, propeller rpm will increase until approximately 104%, when the OSG will start to isolate the propeller control system from HP oil. Rpm will then drop due to propeller counterweight action, the OSG will reconnect HP supply and a stable governing condition at 104% will be quickly achieved. Safe overspeed governing is therefore provided, regardless of failures in the servo valve, PEC or electrical supply.

The OSG can be tested on the ground by operating the PROP O'SPEED GOVERNOR test switch on the Pilots Side Panel on the flight deck.

Beta Mode

The Beta range is from a power lever position above FLIGHT IDLE (called flight beta) to the full reverse (MAX REV) position. When the propeller is in the Beta mode, blade angle is set by the power lever input.

Beta Range

Refer to Figure 7.

During on–ground 'beta control' (Power Lever below Flight Idle), the PEC directs the servo valve to meter oil into fine or coarse pitch to achieve the desired blade angle as indicated by a dual Power Lever Angle (PLA) RVDT on the Power Lever quadrant. The PEC receives PLA signals via the FADEC. In effect the system operates in closed loop blade angle control. Provision is made to limit the rate of change of blade pitch to prevent overtorques and over and underspeeding during transients. At high landing speeds, the propeller may windmill at high rotational speeds, possibly overspeeding. To reduce the magnitude of any overspeed, the beta schedule is biased in the fine direction. A pitch versus PLA schedule is programmed into the PEC and extends down to full reverse.

It should be noted that during approach, when airspeed is relatively low and at low power settings, it is possible for the propeller to enter beta control (flight beta), although entry into the ground beta range is prevented. As soon as propeller speed increases, the PEC automatically re–enters constant speeding mode.

The fine pitch in the in–flight, constant speeding mode is limited to approximately 16° . This hydraulic cut–off of pressure oil constitutes the flight fine 'stop' interlock. The function of the Flight Fine Stop is to maintain a minimum pitch consistent with a positive counterweight effort towards coarse pitch, thus ensuring the effectiveness of the OSG throughout the in–flight pitch range. In addition to this 'hard' protection is a 'soft' flight fine 'stop' of approximately 16.5 degrees that is programmed into the PEC and is operative while the Power Lever is at or above Flight Idle, in normal in–flight operation, pitch does not fall below 16.5 degrees. To enable lower blade angles than 16 degrees, the Power Lever must be brought back below Flight Idle.

Bringing the Power Levers below Flight Idle and enabling blade angles lower than 16° causes the PROPELLER GROUND RANGE lights to turn on. A detent on the Power Lever quadrant prevents unintentional movement of the lever below Flight Idle during flight.

Movement into ground beta also causes the OSG to be by–passed. This is so that transient overspeeds as the propeller moves through flat pitch (0°) in ground operation do not interfere with pitch control by isolating the HP supply and thereby causing pitch hang–ups. Failure of the spool to move to its in–flight position (causing loss of overspeed protection) is indicated by a scheduled OSG test.

When the Power Lever is in the beta range, propeller speed is generally governed by the FADEC and engine fuel system at 660 rpm (NP underspeed governing). It should be noted that propeller speed protection on the ground is by the engine, since speed here is engine driven rather than airspeed driven. FADEC overspeed protection may operate in–flight, but would naturally be effective only in limiting overspeed due to runaway of the normal engine fuel governor. Since the FADEC controls fuel flow to the engine according to a power schedule with torque and engine speed limits according to Power Lever position, it is able to protect the engine and propeller from the high torque that would result from an inadvertent propeller feather.

Reverse Speed Control

In this mode the system operates in closed loop propeller RPM control, maintaining the propeller speed between 660 and 950 rpm. The engine schedules fuel based on a power schedule versus PLA, with a maximum limit of 1500 SHP. At low airspeeds it is possible that the propeller could reach the maximum reverse stop, the propeller rotational speed is then controlled by the engine OSG and can increase up to 1020 RPM.

This mode is similar to forward speed control, except that it operates in reverse, i.e driving more negative to absorb more power and reduce propeller RPM.

Propeller Overspeed Governing

The OSG controls blade angles hydraulically when prop rpm exceeds approximately 1060 rpm. During an overspeed condition propeller rpm is reduced by increasing blade angles. When propeller rpm decreases below the overspeed point, the overspeed governor restores normal propeller governor control. If the propeller goes back to an overspeed condition, the cycle is repeated, resulting in a continuous fluctuation in prop rpm in and out of overspeed until the cause is removed.

In the event that the OSG fails to control a propeller overspeed condition, FADEC will reduce engine fuel, at approximately 1122 Np, which will cause the Np to decrease.

Propeller Synchrophasing System

When the speeds of both propellers are within a predetermined difference of each other in flight, the PEC enters a synchrophasing mode to reduce propeller noise. Synchrophasing acts to reduce cabin noise by ensuring that the relative position, or phase difference, between the slave propeller and master propeller is controlled to a demanded angle. The phase angle is calculated by timing the differences between the master and slave propeller Magnetic Pickup Unit (MPU) signals over a complete propeller revolution. The phase demand is determined from either the condition lever angle (CLA) position, or the output from the Active Noise and Vibration Suppression System (ANVS).

Propeller Feathering Systems

Propeller feathering systems provide:

– Autofeathering
– Alternate feathering and unfeathering
– Manual feathering.

Autofeather

Refer to Figure 8.

The autofeather system provides automatically initiated propeller feathering, and good operating engine power uptrim following an engine failure during take off. Autofeather is selected on for take off only, using the AUTOFEATHER switchlight on the engine instrument panel. This causes the SELECT light to turn on, and displays A/F SELECT on the engine display (ED). The ARM light will turn on when both engine torques exceed a minimum value of 50% and both power levers are advanced beyond 60º PLA.

Uptrim is triggered (regardless of autofeather selection) when:

- Torque of the local engine falls below 25%, or
- NP (as indicated by the torque sensor) falls below 80%, and
- PLA is in the rating detent, and
- MTOP is not set.

Either of the first two conditions must be confirmed by both torque sensor signals. The low speed condition accommodates the failure case of a propeller autocoarsening or inadvertently feathering, causing loss of thrust but not low torque. Uptrim is also directly signalled when an autofeather occurs. Dual uptrim signals are sent to the FADEC of the surviving engine to increase its power by 10%. The effect of this is to replace normal takeoff power (NTOP) with maximum takeoff power (MTOP).

Autofeather is triggered from the armed state when the torque of the local engine, as indicated by both torque signals, falls below 25% for at least three seconds. Following a 3–second delay, an overriding drive coarse signal is input on both active and standby Control Lanes, and the servo valve will select coarse pitch. When one propeller is autofeathered, the autofeather function of the other propeller is automatically disarmed. The auxiliary feathering pump is also activated for approximately 30 seconds. This makes sure adequate oil pressure is available for propeller feathering. The auxiliary feather pump provides a backup source of oil pressure to the propeller pitch–change mechanism. The pump is supplied with oil from an auxiliary oil reservoir built into the propeller RGB to permit autofeather in the event of loss of engine oil pressure. The respective feathering pump advisory light in the FTHR switchlight turns on when the auxiliary feathering pump is producing pressure. The autofeather system can be disarmed by:

- Pushing OFF the autofeather switchlight
- Retarding one or both power levers to flight idle
- Both engine torques dropping below approximately 50%.

The propeller speed (NP) underspeed cancel signal prevents the FADEC from raising engine speed (NH) (if the engine is running in the case of an unscheduled feather command) in an attempt to maintain propeller rpm, as the feathered propeller decreases below 660 rpm.

Autofeather test is automatic on selection.

Alternate Feather

Back–up/alternate feathering is accomplished by operating the #1 or #2 ALT FTHR switch on the PROPELLER control panel, with the Condition Lever at Start/Feather or Fuel Off. This directly energizes the electrical auxiliary Feathering Pump with opposite secondary 28V DC bus power through a 30–second relay.

Pressure oil from the Feathering Pump operates a back–up feather valve in the Pitch Change Unit (PCU). This ensures the propeller can be feathered regardless of failures in the normal control system. The Feathering Pump is mounted on the Propeller Reduction Gearbox, which has internally a dedicated oil volume available for backup feathering.

The feathering pump is provided for the following reasons:

- Give a back–up feather function when the primary feathering system is inoperative

- Enable the propeller to be feathered when the gearbox rpm is too low to maintain oil supply to and from the High Pressure (HP) pump
- Enable the propeller to be unfeathered on the ground for maintenance purposes.

Manual Feathering

Propeller manual feathering is used during engine shutdown by selecting the appropriate condition lever to the START & FEATHER and/or FUEL OFF. This system can also be used if the autofeather system malfunctions.

Automatic Underspeed Protection Circuit

Software error as well as electronic hardware failure in the PEC could result in an unsolicited coarse pitch demand with consequential propeller underspeed in flight. Being common to both PECs (as well as to both control lanes), software error could conceivably cause a simultaneous underspeeding of both propellers with potentially catastrophic effect.

Automatic Underspeed Protection Circuit (AUPC) is included in the PEC to allay concerns that even the highest level of software discipline is insufficient protection against catastrophic events. In the event of an underspeeding of the propeller due to a common mode software error in the PEC, the respective AUPC will send a drive fine signal to the PCU. Should this occur in both PECs simultaneously the AUPC will ensure that total aircraft thrust loss will not fall below the thrust of a single engine. Moreover, thrust loss in this case will be symmetrical, unlike thrust loss associated with a single engine failure.

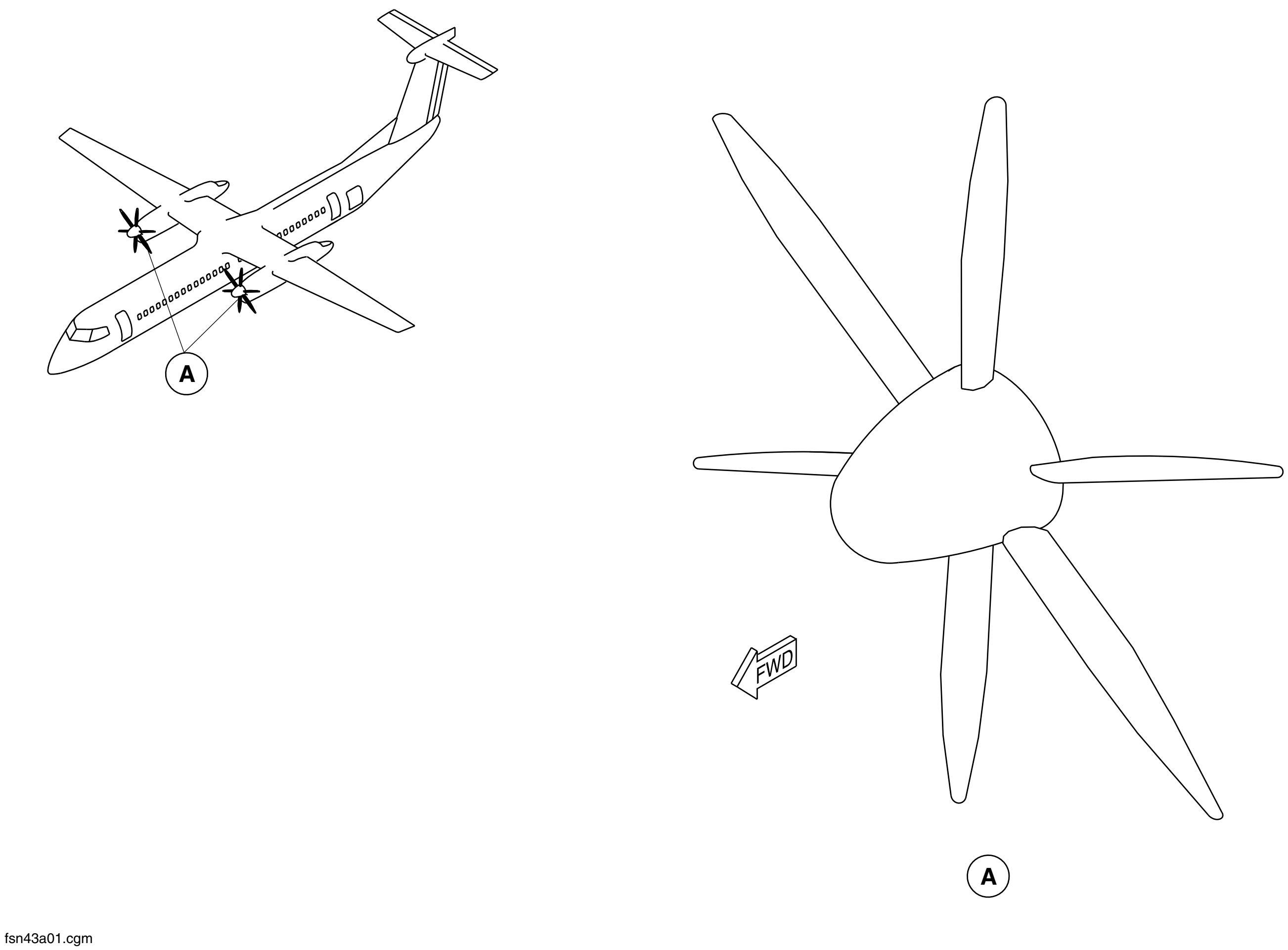
AUPC is armed with PLA at or above FLIGHT IDLE, CLA above START & FEATHER, torque above 50% and NP above 816 rpm, providing both Autofeather and Alternate Feather are inactive. It is triggered if NP drops below 816 rpm while torque remains above 50%. AUPC activation is annunciated by #1 or #2 PEC caution light.

When AUPC triggers, an unmodulated drive fine signal is sent to the PCU servo valve. At higher airspeeds, this will result in speed governing on the OSG. At lower airspeeds pitch change will be arrested by the hydraulic flight fine stop in the PCU. A trigger latch prevents loss of AUPC at low torque once it has triggered, providing arming conditions are maintained.

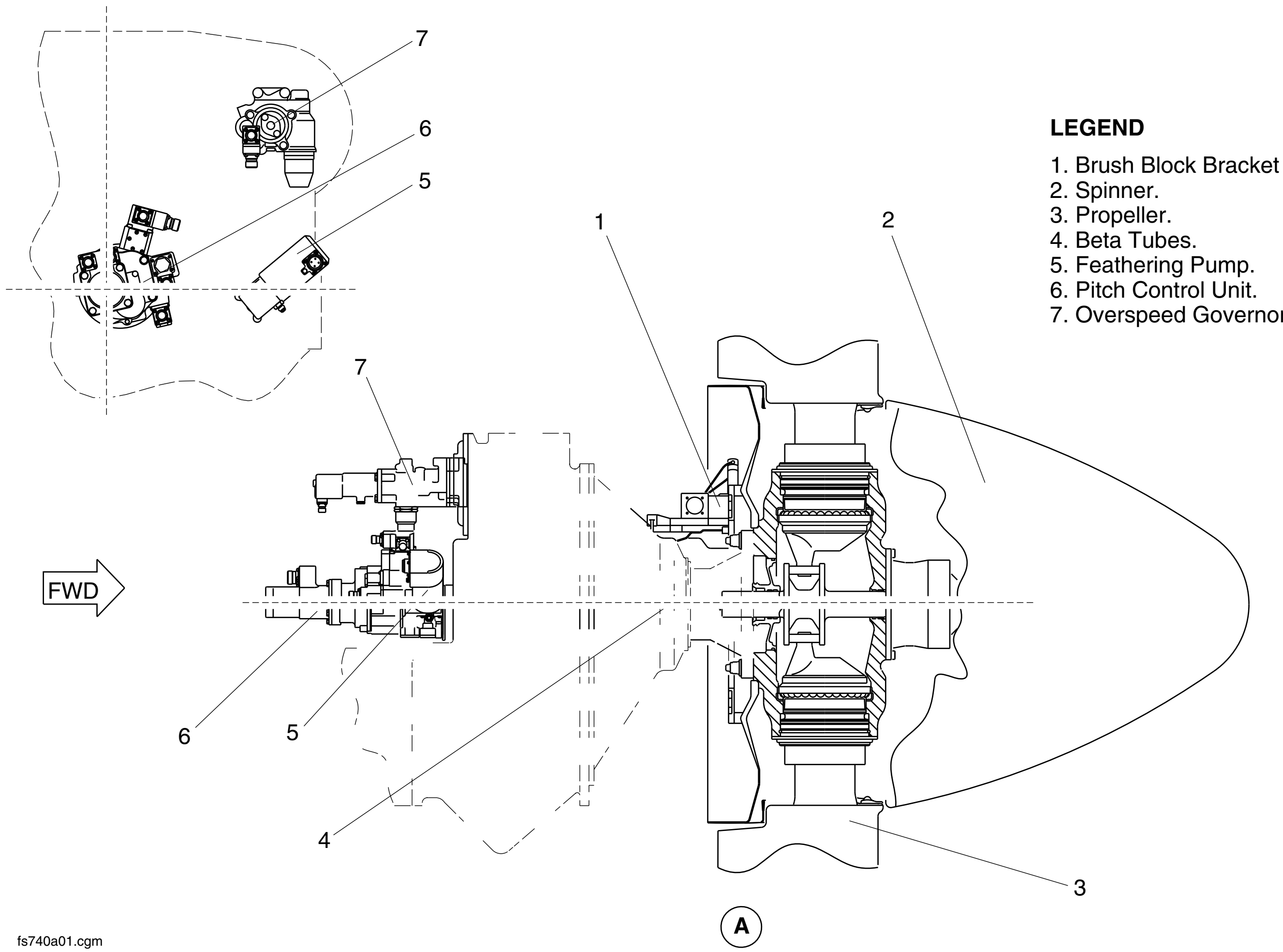
AUPC will not trigger below 50% torque. Should a software problem cause a drive coarse signal to the PCU servo valve at low power the propeller will feather. Under this condition, an increase in PLA to above the 50% Tq level will activate AUPC which will then latch, and the propeller will operate on the OSG or hydraulic flight fine stop as appropriate.

During autofeather, the autofeather drive coarse input is configured downstream of the AUPC drive fine input, therefore the AUPC can not override the autofeather function.

The AUPC incorporates test logic to simulate the appropriate inputs and confirm the correct outputs. Testing is automatically accomplished during autofeather test, and is confirmed (or otherwise) via the appropriate autofeather test message on the ED.



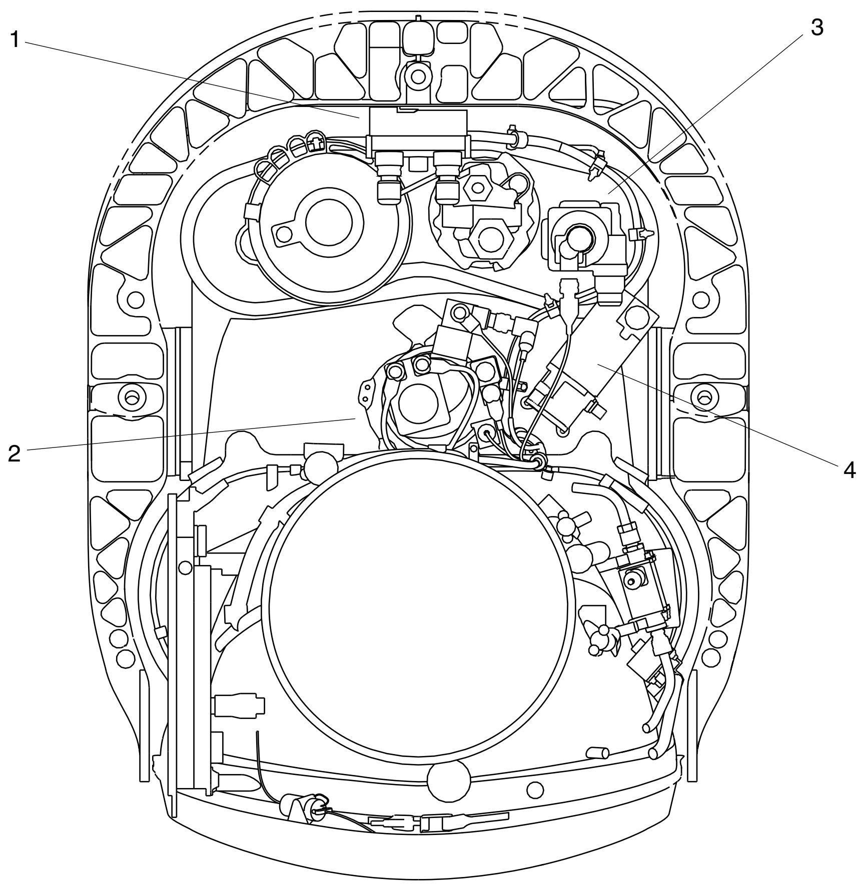
Propeller Locator
Figure 1



LEGEND

1. Brush Block Bracket Unit.
2. Spinner.
3. Propeller.
4. Beta Tubes.
5. Feathering Pump.
6. Pitch Control Unit.
7. Overspeed Governor and Pump.

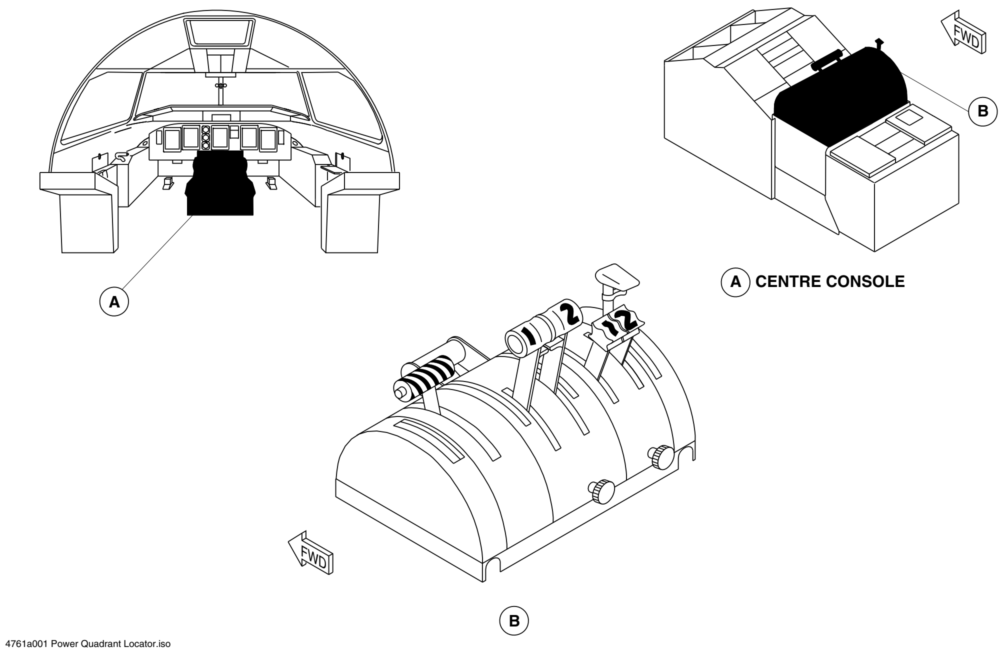
Propeller Control Units
Figure 2



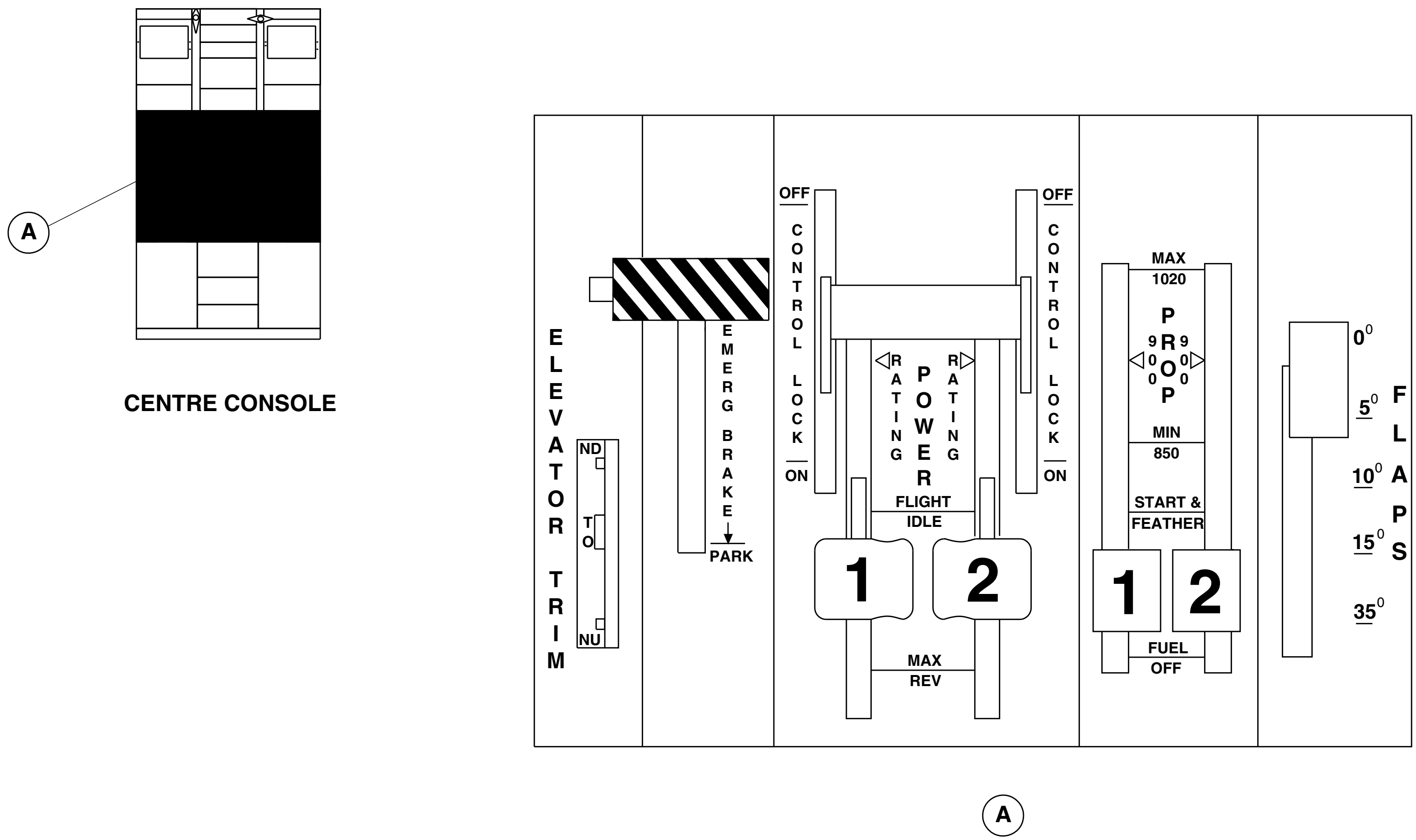
LEGEND

1. Propeller Electronic Control.
2. Propeller Control Unit.
3. Overspeed Governor and PCU Pump.
4. Auxiliary Feather Pump.

Propeller Control Units Locations
Figure 3



Condition Levers
Figure 4



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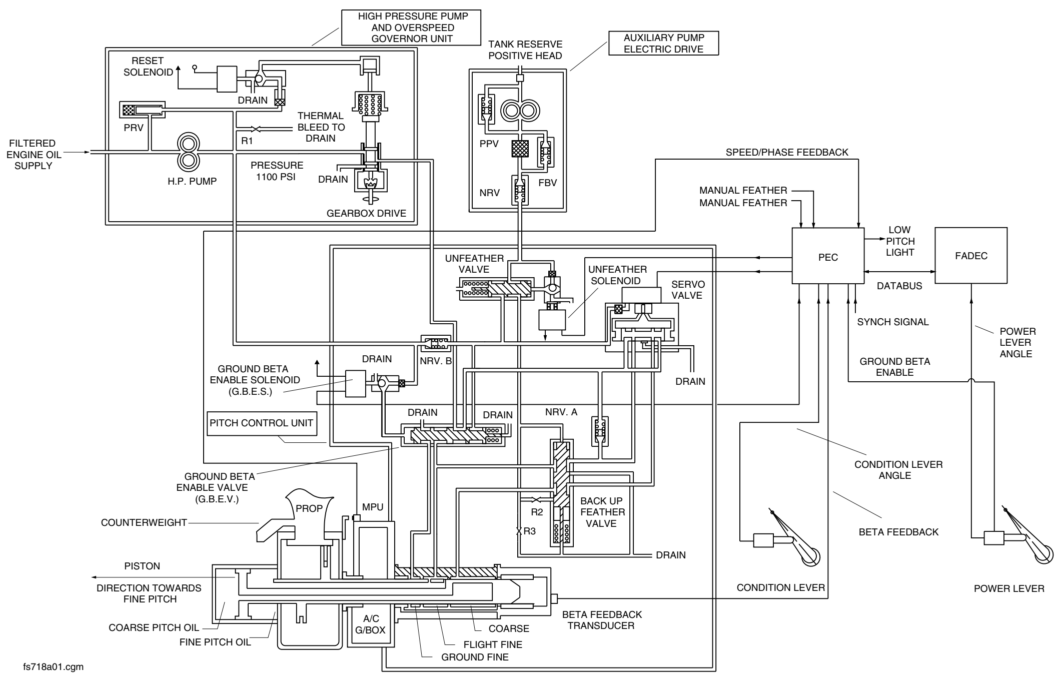
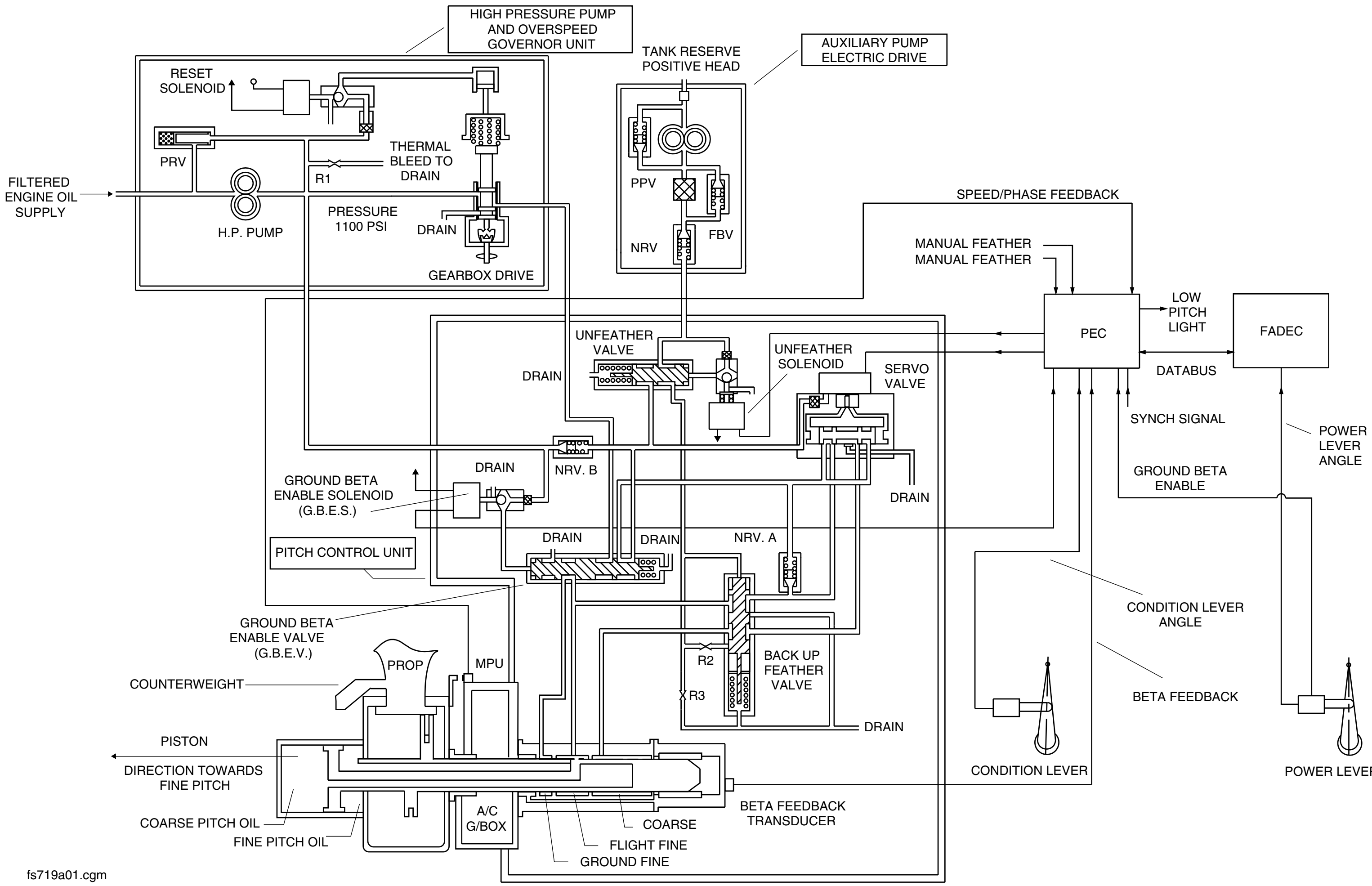
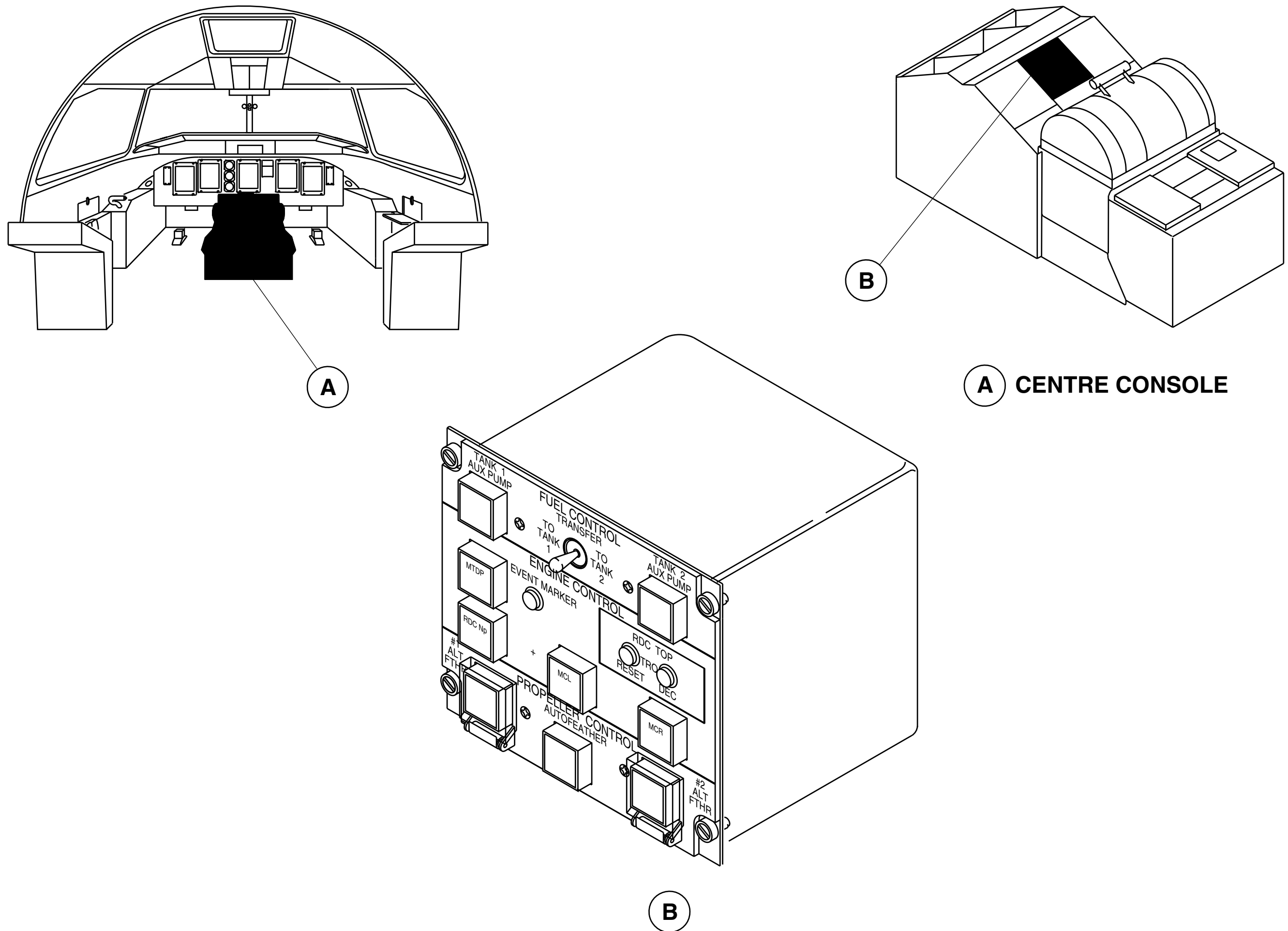
Power Levers
Figure 5



Prop Control in Steady State Flight
Figure 6



Prop Control in Beta Range Page 1
Figure 7



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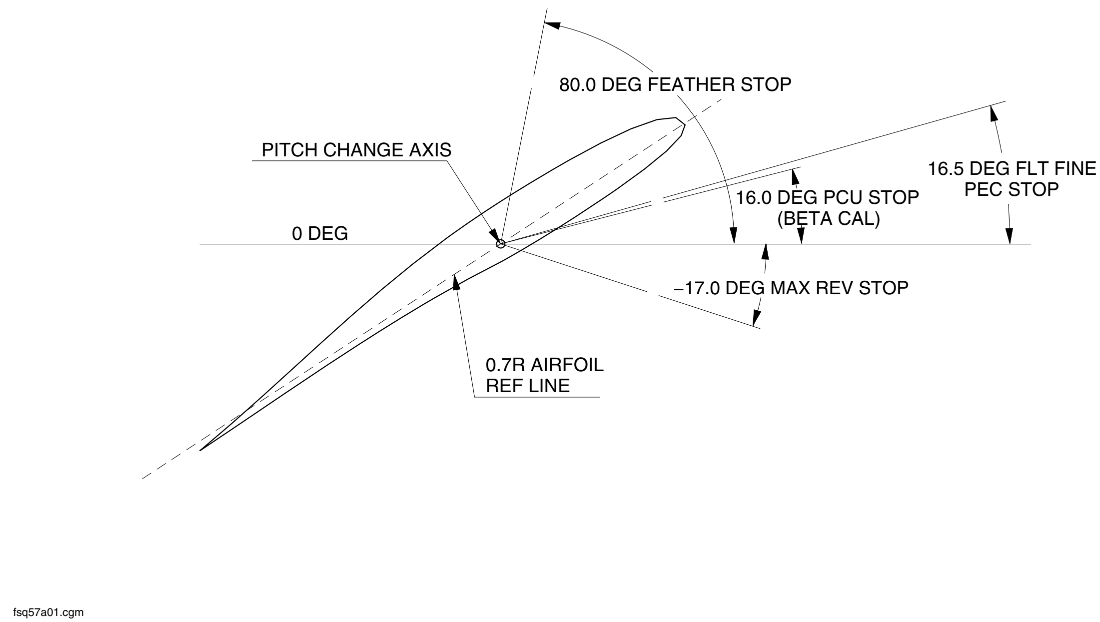
Prop Control in Beta Range Page 2
Figure 8



Propeller Blade Angles
Figure 9

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61–10–00–001

PROPELLER

Introduction

The propeller assembly converts engine supplied power into usable thrust for aircraft propulsion during flight and ground manoeuvers.

General Description

Refer to Figure 1.

The Pitch Control Unit supplies oil to control propeller pitch, in response to signals from the Propeller Electronic Controller (PEC). Blade pitch change is controlled by the PCU scheduling high pressure oil to the fine or coarse side of the pitch change piston through beta tube assemblies.

The propeller assembly has the components that follow:

- Propeller Blade Assembly (61–10–01)
- Hub Assembly (61–10–06)
- Spinner Assembly (61–10–11).

Detailed Description

Refer to Figure 2.

The six bladed propeller is constant speed, variable pitch, with full feathering and full reverse capabilities. The propeller is installed on the engine reduction gearbox propeller drive flange by 15 threaded studs and nuts. The three location dowels help with the correct propeller installation and transmit some of the drive torque. The blades are installed in a flange mounted aluminum hub. Installed on the hub is a cylinder assembly which houses the pitch change actuator. A spinner is attached to the propeller composite backplate.

Propeller Blade Assembly

Refer to Figures 3 and 4.

Each blade is an all composite aerofoil construction with a steel outer root sleeve. The aerofoil has a foam core and twin carbon fibre spars with an overall braided carbon/glass fibre shell. A polyurethane spray coat for erosion protection is applied to the complete blade surface. A nickel leading edge guard is installed for blade erosion protection. A heater element to de–ice 70% of the blade radius is installed on the blade leading edge. A front–mounted aluminum alloy piston and cylinder and steel crosshead/shaft change blade pitch. The operating pins on the base of each blade engage between the faces of the crosshead, to give blade rotation.

Hub Assembly

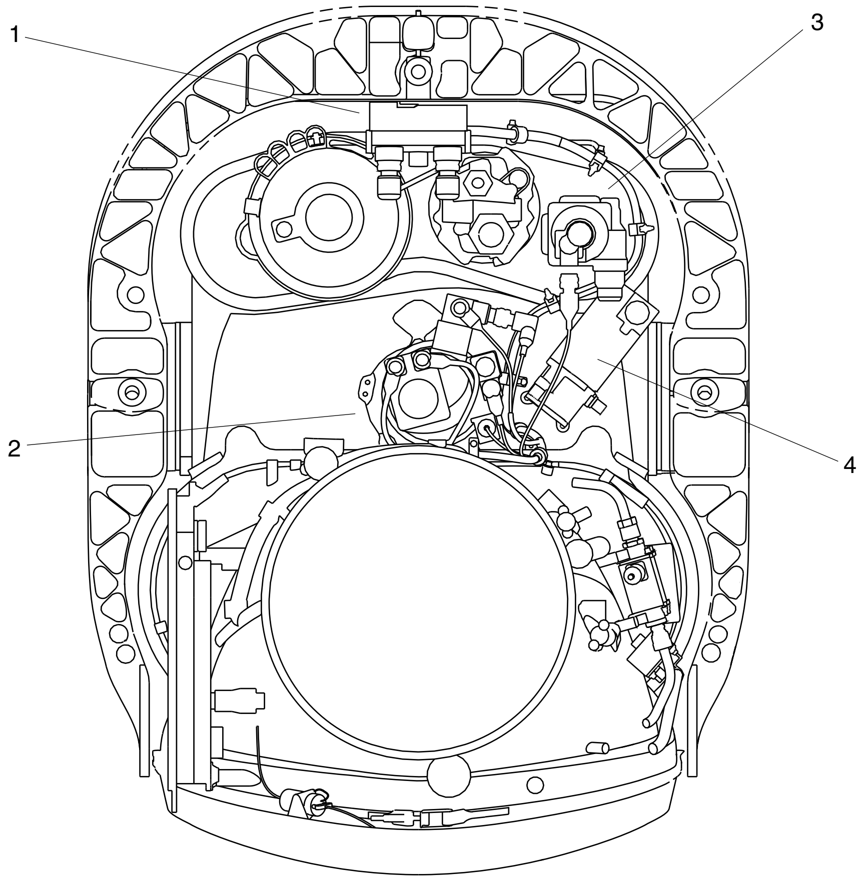
Refer to Figures 5 and 6.

The hub assembly has a one piece aluminum hub, with 15 integral steel mounting studs and 3 location/drive dowels. The hub supports six blades and has six pairs of blade root bearings. The lower bearing is an angular contact ball race, and the upper bearing is a taper roller race. A backplate constructed of carbon fibre composite, and attached to the hub forms the aerodynamic interface between the spinner and engine nacelle. A slipring is used to transfer electrical power for blade deicing. The slip ring is installed directly onto the backplate and has an aluminum alloy housing with three bronze rings in a plastic moulding. The target screws that supply propeller speed and phase angle feedback are located on the external diameter of the slipring.

Spinner Assembly

Refer to Figure 7.

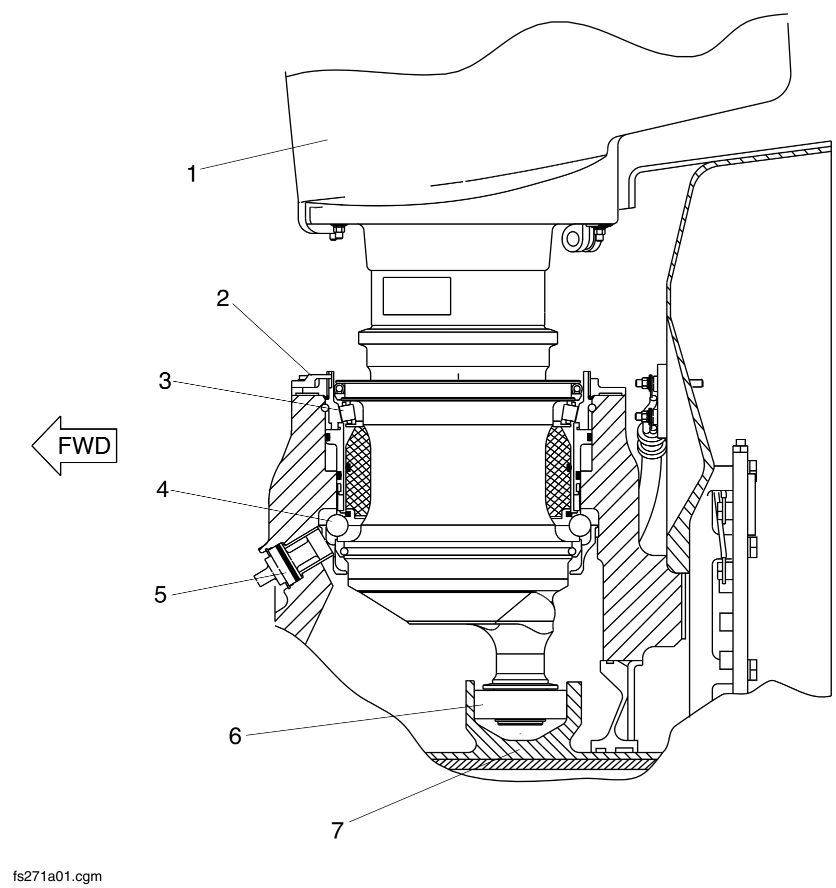
The spinner gives an aerodynamic fairing over the front end of the propeller. It is constructed of spun aluminum alloy and made in three pieces. The cone has front and rear sections riveted together. The spinner is attached to the propeller backplate with 12 quick release fasteners. A centralizing/support diaphragm on the pitch change cylinder makes sure that the spinner runs correctly, when rotating with the propeller.



LEGEND

1. Propeller Electronic Control.
2. Propeller Control Unit.
3. Overspeed Governor and PCU Pump.
4. Auxiliary Feather Pump.

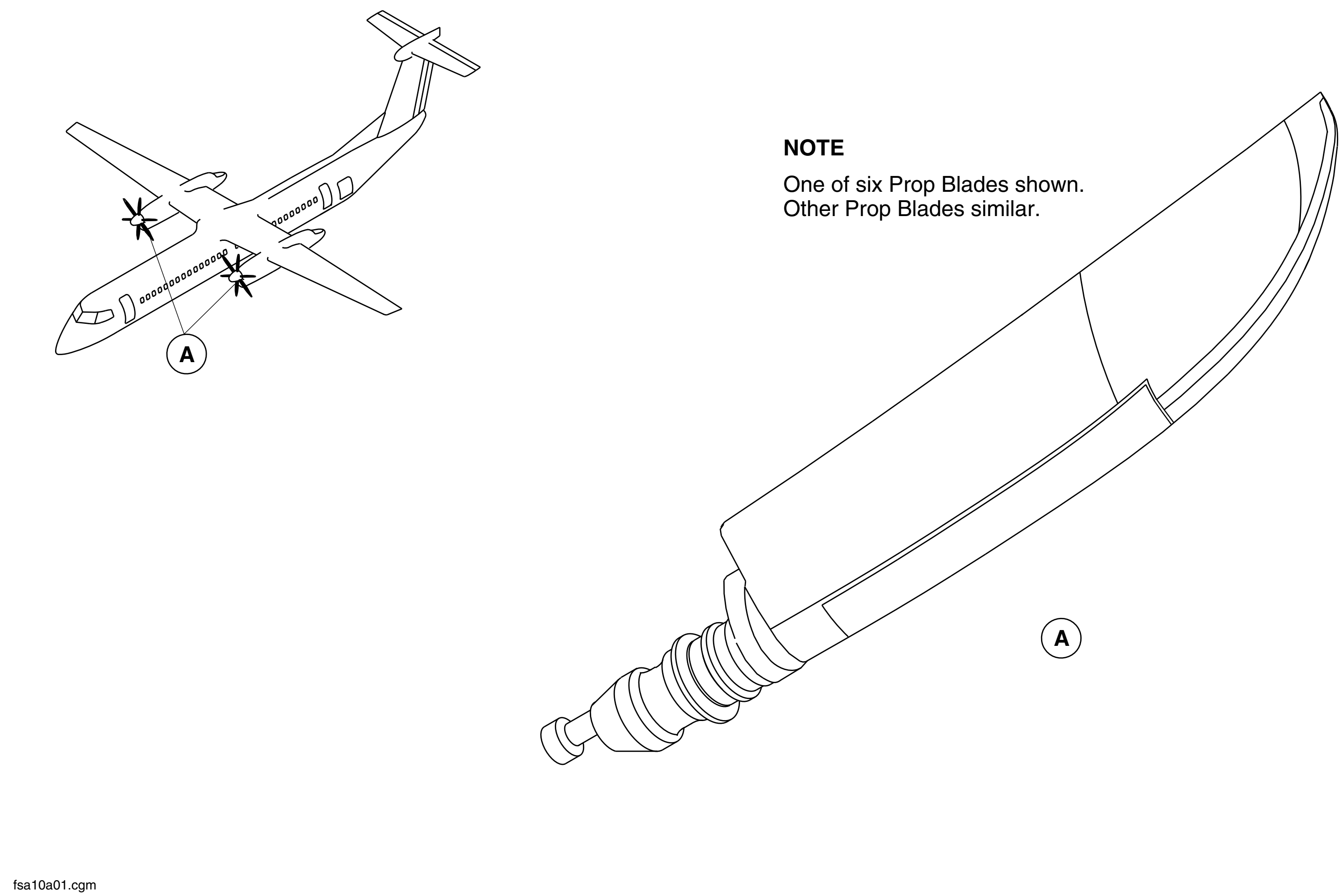
Propeller Control Units Locations
Figure 1



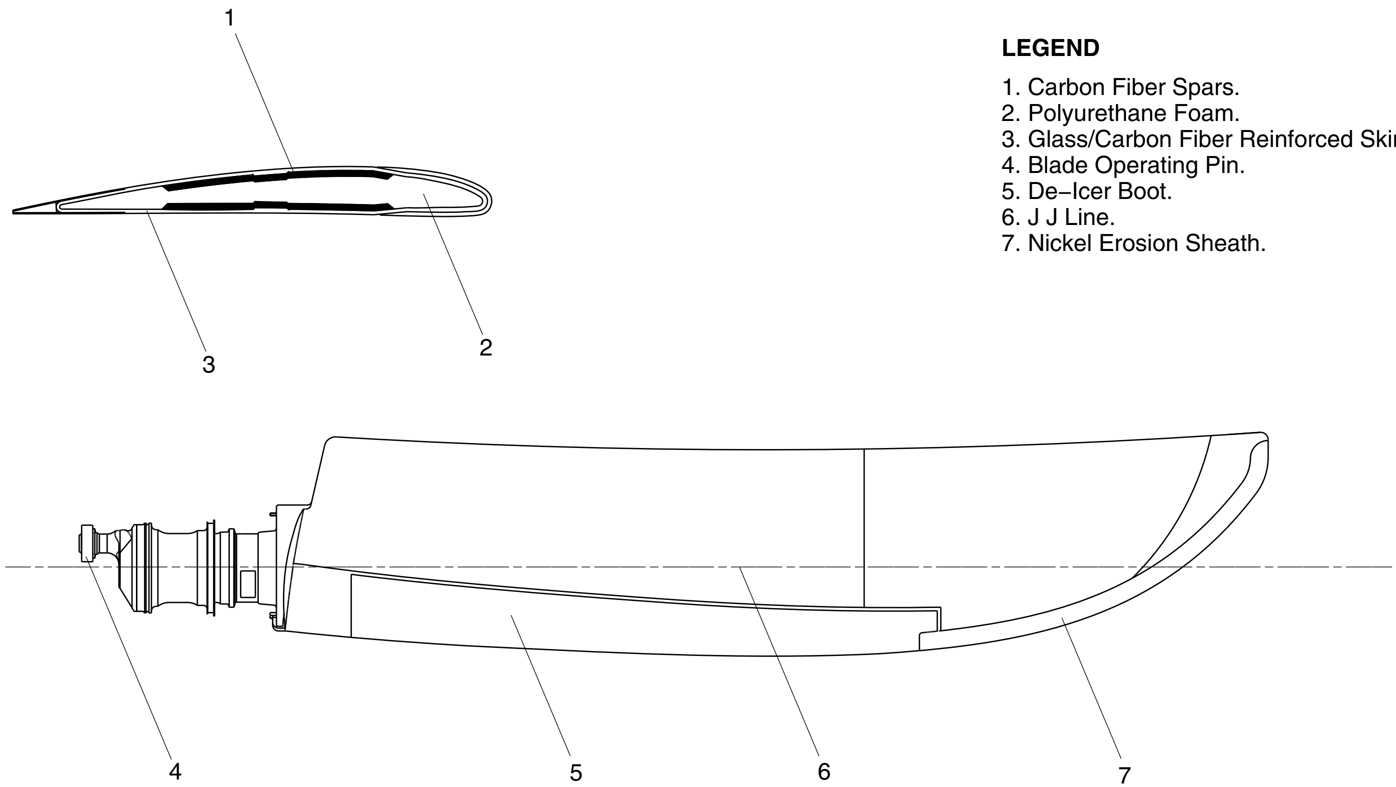
LEGEND

1. Blade.
2. Lockpiece.
3. Outer (Roller) Bearings.
4. Inner (Ball) Bearings
5. Plug.
6. Track Roller.
7. Crosshead.

Propeller Blade Installation Location
Figure 2



Propeller Blade Location
Figure 3



LEGEND

1. Carbon Fiber Spars.
2. Polyurethane Foam.
3. Glass/Carbon Fiber Reinforced Skin.
4. Blade Operating Pin.
5. De−Icer Boot.
6. J J Line.
7. Nickel Erosion Sheath.

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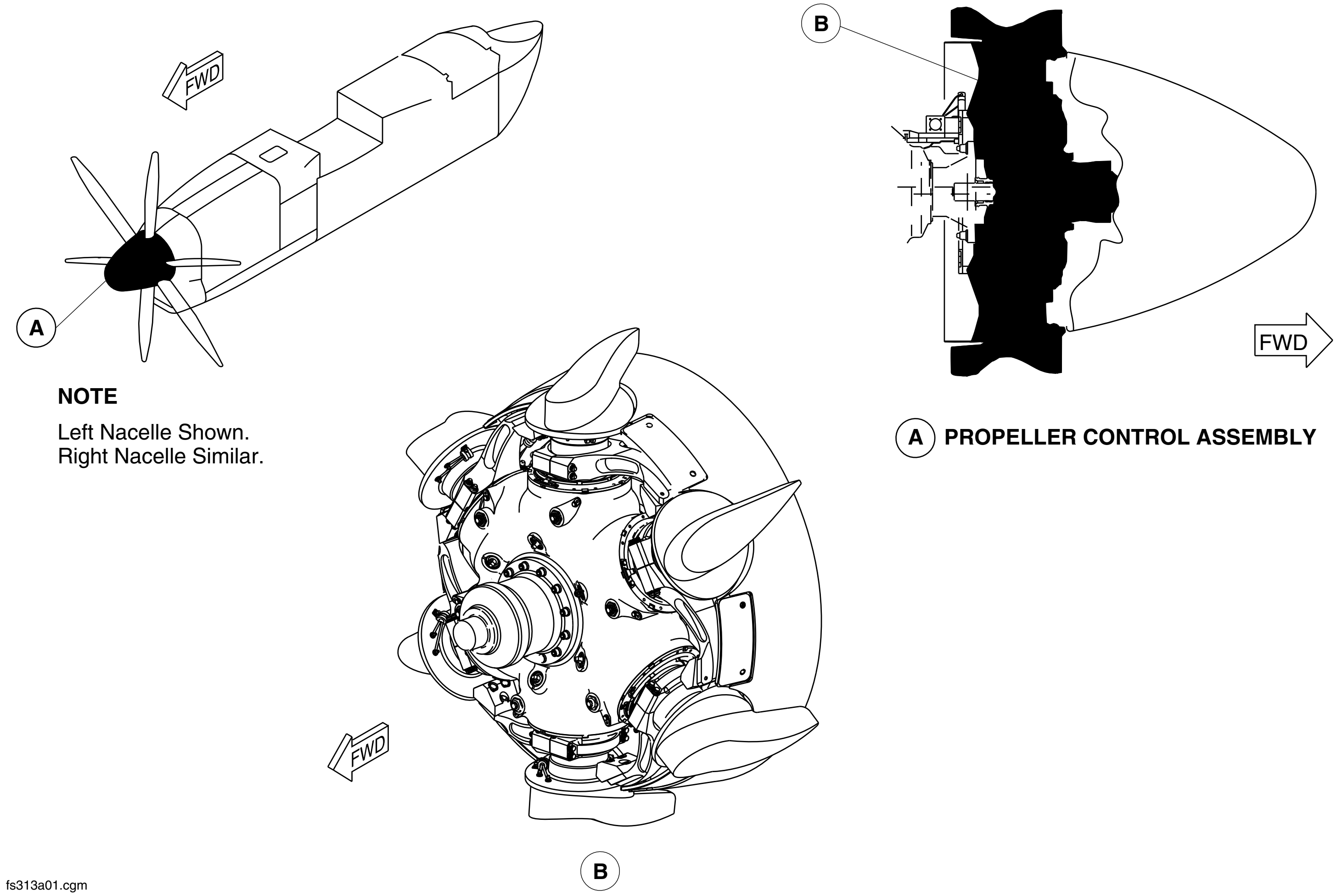
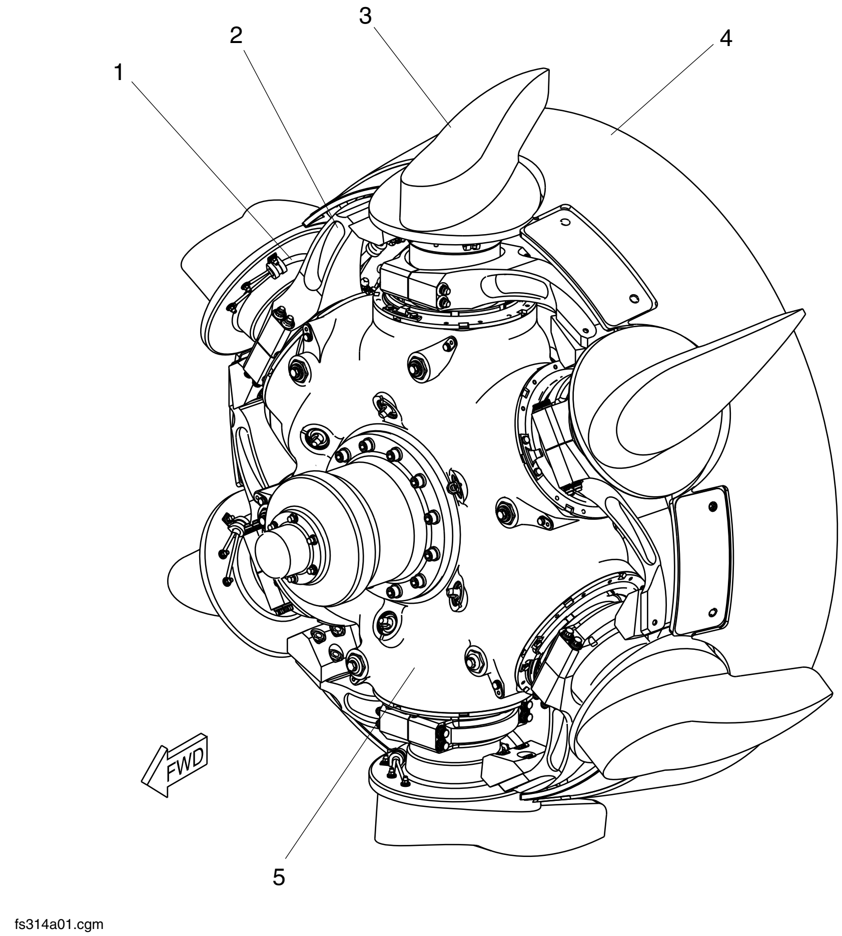
Propeller Blade Assembly Detail
Figure 4



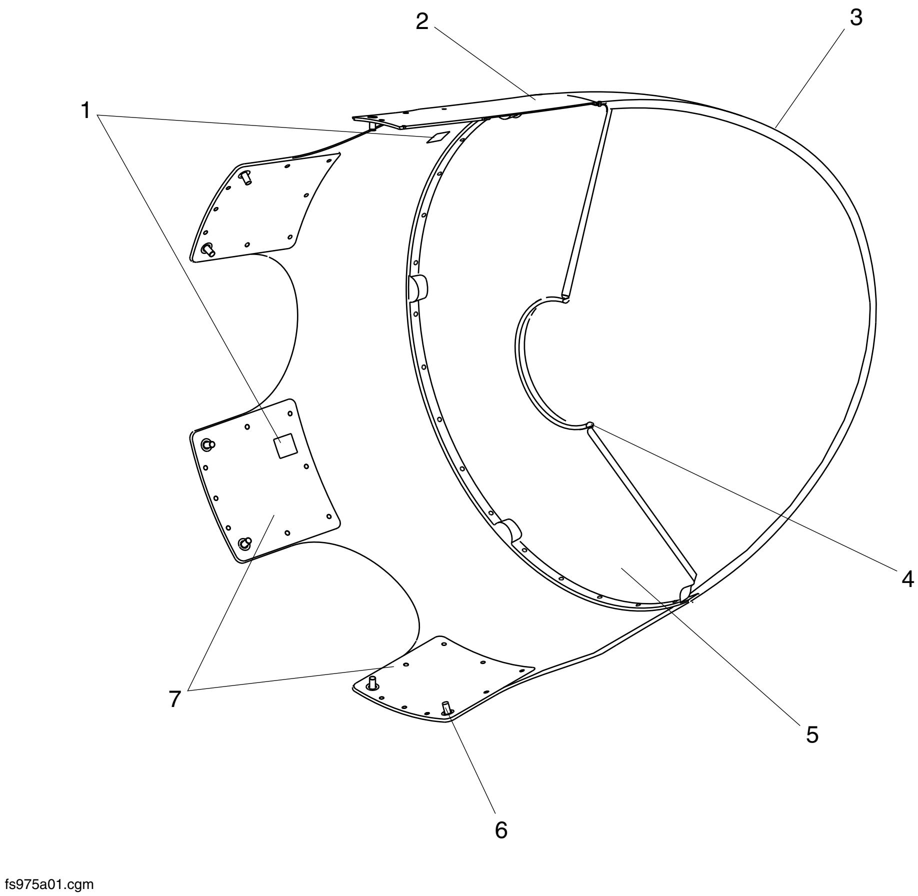
Propeller Hub Assembly Locator
Figure 5



LEGEND

1. De−icing Cable Harness.
2. Counterweight Assembly.
3. De−iced Blade Assembly.
4. Slip Ring and Backplate.
5. Hub and Actuator Assembly.

Propeller Hub Assembly Detail
Figure 6



LEGEND

1. Rubber Sheets (Balancing).
2. Spinner Shell.
3. Front Shell.
4. Rubber Ring.
5. Shell Support.
6. Sleeve Bolt.
7. Stiffening Plates.

NOTE

Portion of Spinner removed for clarity.

Propeller Spinner
Figure 7

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61–20–00–001

PROPELLER CONTROLLING

Introduction

The propeller control system modulates blade angle or pitch, to achieve the necessary propeller RPM (Np) in flight and control pitch/thrust on the ground. The propeller control system also feathers the propeller, when the engine is shut down.

General Description

Refer to Figures 1 , 2 and 3.

The power levers are used to control the propeller pitch, the condition levers are used to set Np and to feather the propellers. The Propeller Electronic Controller (PEC) supplies the current to the servo valve drive, through a dual line hydromechanical actuation system, to change the blade pitch.

The main modes of propeller operation for control during flight and on the ground are:

- Constant Speed Mode (Power Lever between Flight Idle and MAX Power)
- Beta Control Mode (Power Lever below Flight Idle to Max Reverse)
- Reverse speed control mode
- Synchrophase control mode.

Refer to Figures 11 and 15.

Propeller RPM is shown on the Engine Display (ED). PROPELLER GROUND RANGE lights on the left glareshield panel show when the blade angles are in the ground operating range.

Refer to Figures 4 , 5 and 6.

The propeller control system has the components that follow:

- Beta Tube Assembly (61–20–01)
- Magnetic Pick–up Unit (61–20–06)
- Pitch Control Unit (61–20–11)
- Ground Beta Enable Solenoid (61–20–16)
- Unfeather Solenoid (61–20–21)
- Overspeed Governor— High Pressure Pump (61–20–26)
- Feathering Pump (61–20–31)
- Propeller Electronic Control Unit (61–20–36)
- Propeller Control Panel (61–20–41)

Detailed Description

The two main modes of control for propeller operation during flight and on the ground are:

- Constant Speed
- Beta Control

Constant Speed

Refer to Figures 6 and 7.

During in−flight "constant speeding" operation, the Propeller Electronic Control Unit (PEC) directs the servo valve to meter high pressure oil into the propeller fine pitch chamber. This is to balance the coarse−seeking moment applied to the blades, so that the propeller stays at the selected speed (Np). If there is a loss of high pressure oil supply, the blades will "autocoarsen" to a safe high pitch underspeeding condition, to give low windmilling drag.

For underspeeding conditions, other than loss of oil pressure or servo valve failure, high pressure oil is sent to the fine pitch chamber to restore propeller speed. If the Np is greater that the demanded speed, the servo valve will send the oil pressure to the coarse pitch chamber to reduce propeller speed.

Constant speed mode is entered when propeller speed reaches 850, 900 or 1020 rpm, depending on the condition lever selection.

High pressure oil for constant speeding flows through the Overspeed Governor (OSG) before it reaches the servo valve. A spool in the OSG is held at either end by the opposing forces of a spring and the toes of a pair of flyweights. The flyweights are held in a carrier which is driven round with the high pressure pump by the Propeller Reduction Gearbox (PRG).

If the servo valve sticks at the fine pitch selection, Np will increase to approximately 104%. The OSG spool will then isolate the propeller control system from the high pressure oil supply. Np will decrease due to propeller counterweight action. The OSG will then reconnect the high pressure oil supply and a stable governing condition at 104% Np will be quickly achieved.

The OSG spool spring is located in a cylinder, on a piston, that is connected to the high pressure oil supply, through a solenoid operated pilot valve. The solenoid is energized by the PROP O/SPEED GOVERNOR TEST switch on the pilot's side console. A Weight−On−Wheels (WOW) input to the PEC prevents test operation during flight.

The Propeller Electronic Control (PEC) is a dual lane control device, that supplies the servo valve drive current, to drive two motor coils in the servo valve. A number of failure conditions will cause the propeller to go into coarse pitch automatically. The coarse pitch bias was chosen because, total loss of electrical power will cause fuel supply to the engine to be shut off, so it is appropriate in this condition to feather the propeller.

The failure conditions are as follows:

- Total loss of electrical power
- Loss of output from both PEC control lanes
- Failure of both servo valve torque motor coils

Beta Control

Refer to Figure 8.

During on−ground "Beta Control" (power lever below flight idle), the Propeller Electronic Control (PEC) directs the servo valve to meter oil into the fine or coarse pitch chamber to achieve the required blade angle. The blade angle is set by the dual Power Lever Angle (PLA) Rotary Variable Differential Transformer (RVDT), located on the power lever quadrant. The PEC receives PLA signals through the Full Authority Digital Electronic Control (FADEC).

NOTE

During approach, when airspeed is relatively low, it is possible for the propeller to enter beta control. This occurs when the blade angle drops below the pitch PLA schedule and propeller RPM equals the set RPM. As soon as propeller RPM increases, the PEC automatically re−enters the constant speed mode.

The position of the ports in the PCU/Beta tubes make sure that fine pitch in the in−flight constant speed mode is limited to a blade angle of 16 degrees. This hydraulic cut−off of oil pressure is specified as the “hydraulic flight fine stop” interlock.

The flight fine stop keeps a minimum pitch consistent with positive counterweight effort driving towards coarse pitch, to make sure the OSG is effective throughout the in−flight pitch range.

A "soft" flight fine stop at approximately 16.5 degrees is programmed into the PEC. This stop makes sure the blade angle does not drop below 16.5 degrees while the power lever is at, or above flight idle in flight. This is specified as a “software flight fine stop”.

A power lever switch which closes below a PLA of 33 degrees, energizes the Ground Beta Enable Solenoid (GBES), if the blade angle is less than a predetermined minimum and the aircraft is on the ground. A detent on the power lever quadrant stops unintentional movement of the lever below flight idle during flight.

When the GBES is energized, a pilot valve vents the chamber at the end of the Ground Beta Enable Valve spool (GBEV) to drain. The spring at the other end moves to its ground position. Fine pitch oil pressure then enters another chamber in the PCU, which allows for ground beta blade angles down to reverse. Failure of the GBEV spool to move to its in−flight position (causing loss of overspeed protection) can be proved by doing an OSG test.

Actual engine power is set as a function of rating, air inlet temperature, inlet pressure, aircraft velocity, compressor bleed selection and power turbine speed. Maximum power selected either on the Engine Control Panel or power lever, gives 100% Np irrespective of Np selected by the condition lever.

Three discrete speeds 850, 900, and 1020 rpm are set by the condition lever.

When the power lever is in the beta range, propeller speed is usually governed by the FADEC and engine fuel system at 60% RPM.

NOTE

Propeller speed protection on the ground is supplied by the engine, since speed is engine driven rather than airspeed driven.

FADEC overspeed protection may operate in flight, but is effective only in limiting overspeed due to runaway of the engine fuel governor. The FADEC controls fuel flow to the engine to protect the engine and propeller from high torque conditions that would result from an inadvertent propeller feather.

Reverse Speed Control

Refer to Figure 9.

In this mode the system operates in closed loop propeller RPM control to maintain the propeller speed between 660 and 950 RPM. The engine schedules fuel based on a power schedule versus PLA, with a maximum limit of 1500 SHP. At low airspeeds it is possible that propeller could reach the maximum reverse stop, the propeller rotational speed is then controlled by the engine OSG and can increase up to 1020 RPM.

This mode is similar to forward speed control, except that it operates in reverse, i.e driving more negative to absorb more power and reduce propeller RPM.

Synchrophase Control

Refer to Figure 17.

In this mode the system operates in closed loop propeller speed and propeller phase control. Synchrophasing acts to reduce cabin noise, by making sure the phase difference between the slave propeller and the master propeller is controlled to a demanded angle.

The phase angle is calculated by timing the differences between the master and slave propeller MPU signals over a complete propeller revolution. The phase demand is controlled from the condition lever position. Synchrophasing will give phasing accuracy of better than plus or minus 1 degree.

Routine Feather

Refer to Figure 10.

Routine feather is set when the condition lever is moved to either the START/FEATHER or FUEL OFF detent. A routine feather signal commands the PEC to drive the servo valve towards coarse pitch.

Autofeather

Refer to Figure 19.

The autofeather function is installed in the PEC hardware and has cross–wing communication with the remote PEC, to prevent both engines autofeathering simultaneously. Two torque signals are needed from the respective engine showing less than 25% torque for three seconds before the system autofeathers.

The system is armed when both power levers are at the rating detent, and autofeather is selected by the AUTOFEATHER switchlight on the PROPELLER CONTROL panel. When armed, an A/F ARM indication is shown on the Engine Display. The system is disarmed by either releasing the switchlight, or when both power levers are moved below the rating detent.

An Automatic Takeoff Thrust Control System (ATTCS) gives protection against engine failure during the critical phase of takeoff. The system automatically uptrims the operating engine, and autofeathers the failed engine’s propeller. When the ATTCS senses a failure, the A/F ARM indication light goes out.

Alternate Feather

The alternate feather is set when the condition lever is moved to the START/FEATHER or FUEL OFF detent and the applicable ALT FTHR switchlight, on the PROPELLER CONTROL panel, is pushed. The auxiliary pump starts and supplies pressure to enable the Back–up Feather Valve and drive the propeller to coarse pitch. The electrical circuit for the alternate feather mode has a switch located on the condition lever. The switch closes at, or below the START/FEATHER position, to make sure that the flight crew must try the normal feather mode before selecting alternate feather. The alternate feather function gives an independent method of feathering the propeller and can override the authority of the PEC.

Maintenance Unfeather

On the ground, a static propeller can be unfeathered, by selecting the applicable MAINTENANCE UNFEATHER switch on the maintenance panel to ON. This energizes the auxiliary pump and the unfeather solenoid, scheduling oil pressure to the servo valve. The PEC controls the servo valve output to drive the propeller towards fine pitch if all of the following are true:

- There is no propeller rotation
- Maintenance mode is selected
- Weight–On–Wheels input signals are detected.

The components used for the various control modes are as follows:

Beta Tube Assembly

The beta tubes are used to transfer fine and coarse pitch oil pressure from the Pitch Control Unit to the propeller pitch change mechanism. The tubes also monitor the blade pitch angle for beta control.

Magnetic Pickup Unit (MPU)

The speed and phase of the propeller is sensed by a Magnetic Pickup Unit and a set of 7 targets on the deicing slip ring. Six targets give speed signalling inputs and one acts as a master reference for balancing purposes.

The MPU is a dual channel device located on the front of the reduction gearbox.

Pitch Control Unit (PCU)

Refer to Figure 13.

The PCU controls the flow of oil pressure to the fine and coarse pitch sides of the propeller pitch change mechanism. This is done by the modulation of high pressure oil supplied by the Overspeed Governor (OSG) using a servo valve. The servo valve receives electrical signals from the PEC and directs oil pressure through a transfer sleeve and beta tubes, to the coarse/fine sides of the propeller pitch change piston.

The PCU has the components that follow:

- Servo valve
- Ground Beta Enable Solenoid Valve
- Unfeather valve
- Back up Feather Valve
- Beta Feedback Transducer

The PCU rear case gives the interface with the beta feedback transducer (BFT). The Ground Beta Enable Solenoid Valve (GBEV), the Unfeather Solenoid Valve, the servo valve, and the Beta Feedback Transducer (BFT), are not line replaceable units. The PCU is located on the rear face of the reduction gearbox and is attached to the gearbox by a V–band clamp.

Servo valve

The servo valve is a two stage nozzle flapper design, that is used to control blade pitch in all control modes. The torque motor drive on the first stage has two coils, connected to each PEC lane. Opening the valve schedules high pressure oil to one line, while venting the other line to drain. The valve is biased such that the propeller is driven towards coarse pitch in the event of an interruption of the electrical drive signal from PEC.

Ground Beta Enable Solenoid Valve (GBEV)

The Ground Beta Enable Valve stops the propeller entering the reverse pitch range during flight. The valve is controlled by the Ground Beta Enable Solenoid. When energized it vents the enable valve end chamber to drain letting spring pressure move the valve from the flight position into the ground position.

In the flight position (solenoid de–energized), the ground fine chamber in the PCU is vented to drain. This stops the propeller being driven below the flight fine stop, which is set just below flight idle pitch. The OSG is connected into the hydraulic system with the valve in this position.

In the ground position (solenoid energized), the ground fine chamber is connected to the fine pitch oil line. This lets the propeller be driven into the ground blade pitch range. The OSG is isolated from the system to prevent potential coarse pitch hang ups during selection of maximum reverse after touchdown, or full power from the reverse position. The engine fuel valve controller gives overspeed protection with the valve in this position.

NOTE

For maintenance feathering and unfeathering, where there is no propeller rotation and no output from the high pressure pump, a spring in the Ground Beta Enable Valve makes sure that the valve is in the ground position.

The GBEV is installed in the PCU.

Unfeather Valve and Solenoid

The valve is enabled when the unfeather solenoid and auxiliary pump are energized. When enabled the valve directs oil from the auxiliary pump to the PCU servo valve. The unfeather solenoid is activated by a maintenance switch, and is monitored by the PEC, although PEC has no control over the valve.

Overspeed Governor and High Pressure Pump (OSG)

Refer to Figure 12.

The unit has two primary functions:

- Increase the pressure of engine supplied oil, to a pressure suitable for propeller actuation
- Control the supply of oil to the propeller during flight.

If an overspeed occurs, at approximately 104% Np, the oil supply from the PCU will be vented to drain. This lets the propeller move towards coarse pitch by action of the blade counterweights, reducing Np. The unit has a reset solenoid which sets the governor to a lower value, approximately 80% Np, when doing functional checks.

The OSG has a gear pump and fly weight governor driven by the reduction gearbox. The governor controls the position of a spring loaded spool. When an overspeed condition occurs the spool will move against the spring, to vent the PCU supply line to drain.

The unit is a two piece aluminum constructed body housing the gear pump case and governor/spool. The governor/spool body houses the reset solenoid valve and a pressure relief valve which limits pump maximum output pressure to 1100 psi (758.4 kPa). The reset solenoid and pressure relief valves are line replaceable items. The OSG and pump are attached to the reduction gearbox by four studs and nuts. Correct installation is assured by one dowel. A bonded seal plate provides sealing against the gearbox casing for four oil ports.

On Post SB 84–61–02 overspeed governors, the seal plate is replaced with four O–rings which install into seal grooves in the face of the pump adapter of the OSG.

Feathering Pump

Refer to Figure 12.

The feathering pump feathers the propeller independently of the normal control system and achieves full feather (zero windmilling). The pump supplies feathering or unfeathering oil pressure if the engine supply is not available.

It gets its oil supply from the auxiliary oil tank in the reduction gearbox (refer to SDS 79–20–00). The feathering pump is the only supply from the bottom of the auxiliary oil tank (all other supplies are from the top), which reserves the tank volume for the feathering pump when the engine is not running. When energized, the pump supplies unmodulated oil pressure to the PCU, which will feather or unfeather the propeller blades.

The pump is energized during:

- Autofeather
- Alternate feather
- Maintenance unfeather

The unit has a gear pump and 28V DC electric motor. The electric drive to the pump has a run time protection relay to prevent damage to the unit. The pump has an aluminum body that contains a gear pump and a reduction gearbox, a filter, filter bypass valve, and a pressure relief valve.

The pump is located on the front case of the reduction gearbox and is attached by four studs and nuts. Two oil transfer bobbins and “O” ring seals give the sealing for the supply and outlets ports of the pump.

Propeller Electronic Control Unit (PEC)

Refer to Figures 14 and 15.

The Propeller Electronic Controller (PEC) controls the various modes of the propeller system. The modes are as follows:

- Speed control in–flight
- Ground beta control
- Reverse thrust speed control
- Autofeather/Engine uptrim command
- Synchrophasing

The PEC also does numerous BITE and pilot initiated tests and has comprehensive fault management software. The unit has two control lanes, one active and one on standby, with automatic transfer to the standby lane in the event of a fault. An autofeather module is also installed, and is independent of engine control (FADEC) and control lane modules in the PEC.

The PEC does the functions that follow:

- Control mode and Control function selection
- Servo valve control

- Ground Beta Enable and Overspeed Governor reset solenoid control
- Unfeather solenoid monitoring
- Low pitch indication
- Fault management:
- Fault detection
- Fault accommodation
- Fault storage
- Fault annunciation
- Automatic underspeed protection circuit (AUPC)
- Automatic Takeoff Thrust Control System

PEC output is isolated when both lanes are faulty or all electrical power is lost.

The control lanes get 28V DC electrical power from the left and right essential busses, the active lane also has power from the engine Permanent Magnet Alternator (PMA). The autofeather module is also powered by the essential bus and PMA.

Serial bus links are used to exchange information with the Full Authority Digital Electronic Controller (FADEC). The serial bus links also send maintenance data to the aircraft, through FADEC and the Engine Monitoring Unit (EMU).

The PEC continuously monitors itself and connected equipment for failures. Fault codes are sent to the FADEC and can be shown on the Audio Radio Control and Display Unit (ARCDU) or the Engine Display (ED). Detected faults can be advisory or cautionary. These faults will normally be annunciated on request to the maintenance crew only and are not displayed to the pilots. For faults that are considered non–dispatchable a NO DISPATCH message will be shown on the multi–function display.

Cautionary faults need pilot action. PEC fault discrete will cause the #1 or #2 PEC caution light, or the PROPELLER GROUND RANGE light to come ON during flight.

The PEC is installed in the forward nacelle of each engine, on the spine between the forward and mid frames. Anti–vibration mounts are used at all mounting points, and all connectors point vertically downwards.

Propeller Control Panel

Refer to Figure 16.

The PROPELLER CONTROL panel is installed in the flight compartment, on the centre console, forward of the power quadrant. The panel has the switchlights that follow:

- #1 ALT FTHR
- #2 ALT FTHR
- AUTOFEATHER SELECT

PEC Control Modes

Refer to Figure 17.

The system will operate continuously in the control modes that follow:

- Beta
- Forward speed

- Reverse speed
- Synchrophase

The required control mode is determined from the state of the blade angle and rotational speed inputs. If a system function is required, the current control mode is overridden. The system reverts to the active control mode when the control function is no longer required.

Beta Control

Refer to Figure 8.

In this mode the system operates in closed loop blade angle control. The measured blade pitch is determined from the Beta Feedback Transducer (BFT) output signal and the required blade angle, is determined from a schedule against Power Lever Angle (PLA). The system includes provision to limit the pitch change rate. This is in order to match the rate of change of torque absorption of the propeller, to the rate of change of engine torque. This will reduce propeller overspeeds and underspeeds during power lever transients. The rate limit is based on blade pitch and direction of blade pitch change.

Limited Speed Control in Beta

Movement of the PLA into the region between Flight Idle (FI) and Ground Idle (GI) at high airspeeds or high power can cause potentially high overspeeds. This is because the blade angle is close to flat pitch and is absorbing power from the airstream (windmilling). A blade angle biasing device is included within beta control that drives the blades fine towards GI in the event of a large overspeed. The blade angle biasing is deactivated when PLA is moved above FI or below GI.

Forward Speed Control

Refer to Figure 7.

In this mode the system operates in closed loop propeller RPM control. Propeller Rpm (Np) is calculated from the propeller Magnetic Pickup Unit (MPU) output by timing a complete revolution.

Three discrete speeds 850, 900 and 1020 Np can be selected from Condition Lever Angle (CLA). Changes in forward speed request, NPREQ, are passed through a small first order lag to give a smooth speed response. In the event of the PLA being moved into the over–travel position, NPREQ is set to 100% Np. this speed's latched until the CLA is moved to the 1020 Np position, or the start/feather position. NPREQ is set 120% whenever the PLA is below FI and the conditions for energizing the Ground Beta Enable Solenoid (GBES) are met, this forces the system into beta control.

Synchrophase Control

In this mode the system operates in closed loop propeller speed and propeller phase control. Synchrophasing acts to reduce cabin noise by ensuring that the relative position, or phase difference, between the slave and master propellers is controlled to a demanded angle. The phase angle is calculated by timing the differences between master and slave propeller MPU signals over a complete revolution. The phase demand is controlled from the condition lever position.

Reverse Speed Control

In this mode the system operates in closed loop propeller RPM control, maintaining the propeller speed between 660 and 950 Np. The FADEC schedules fuel based on a power schedule versus PLA, with a maximum limit of 1500 SHP. At low airspeeds it is possible that the propeller could reach the maximum reverse stop, the Np is then controlled by the engine OSG and can increase up to 1020 RPM.

This mode is similar to forward speed control, except that it operates in reverse, i.e drive more negative to absorb more power and reduce propeller RPM.

Automatic Underspeed Protection Circuit (AUPC)

The AUPC prevents the feathering of the two propellers (loss of thrust) to protect against a common software error in PEC1 and PEC2. This function is implemented in hardware independently of the PEC control lane software. This would result in a drive coarse signal on both propellers and loss of thrust on take−off. In the event of an underspeed being detected on both Npt sensors, a drive fine signal is generated and the Np will increase. The propeller speed increase will be arrested by the Overspeed Governor (OSG). This function overrides the authority of the control lane software but is, in turn, overridden by the autofeather function.

The propeller underspeed governor (AUPC) is armed as follows:

– Power lever (PLA) is set to more than flight idle
– Condition lever (CLA) is set to more than START & FEATHER
– No manual feather selection
– No autofeather.

AUPC is activated when the conditions that follow are set for more than 1 second:

– Propeller speed (NP) is less than 816 RPM
– Torque (TRQ) is over 50%
– CLA is selected to START/FEATHER in flight, then selected to speed governing with the engine power at cruise or higher.

The AUPC activation disables the PEC speed governing and beta control and sends an unmodulated drive fine signal to the PCU.

AUPC activation is indicated as follows:

– Propeller pitch decreases
– Propeller speed increases to 1060/1070 rpm and the propeller speed stays at this value unless the propeller is feathered or the blade angle goes to the fine pitch stop during the landing
– PEC caution lights come on
– POWERPLANT advisory lights come on in the engine display.

NOTE

These indications are latched and the propeller will not unfeather until reset by electrical power interruption of the PEC.

AUPC is disarmed as follows:

– PLA moved below FI
– CLA moved to Start/Feather
– Autofeather or manual feather demanded.

The AUPC activation will cause the propeller to go to the flight fine stop or to overspeed governing if the airspeed is high. The AUPC function is tested during Autofeather Test

Automatic Take–Off Thrust Control System

The Automatic Take–Off Thrust Control System (ATTCS) gives the necessary protection against engine failure during the critical part of the take–off roll. The system causes an auto–feather on the failed powerplant and an uptrim of the remote powerplant. Any erroneous feather of the local propeller will cause an uptrim of the remote powerplant. The ATTCS has two sub–systems as follows:

- Autofeather
- Uptrim

Autofeather

Refer to Figure 19.

The autofeather function is implemented in PEC hardware and includes cross–wing communication with the remote PEC, to prevent both powerplants autofeathering simultaneously. Two torque signals are needed to show less than 25% torque for three seconds before the system autofeathers.

Autofeather is armed when both the engine torques exceed a minimum value of 50%, both the power levers are set to more than 60 degree PLA and the AUTOFEATHER SELECT switch is selected ON. When both powerplants are armed, an A/F ARM indication is shown on the Engine Display (ED).

Autofeather is disarmed by either de–selecting the AUTOFEATHER SELECT switch, or moving both PLAs below the rating detent.

An autofeather will cause the PEC to:

- Output a servo valve drive coarse signal
- Energize the auxiliary pump relay.

At this point the A/F ARM indication is removed from the ED.

When the propeller is autofeathered, the system can only be disarmed by either, de–selecting the AUTOFEATHER SELECT switch, or moving both PLAs below the rating detent.

A detected failure in the ATTCS results in the system inhibiting the A/F ARM indication.

Uptrim

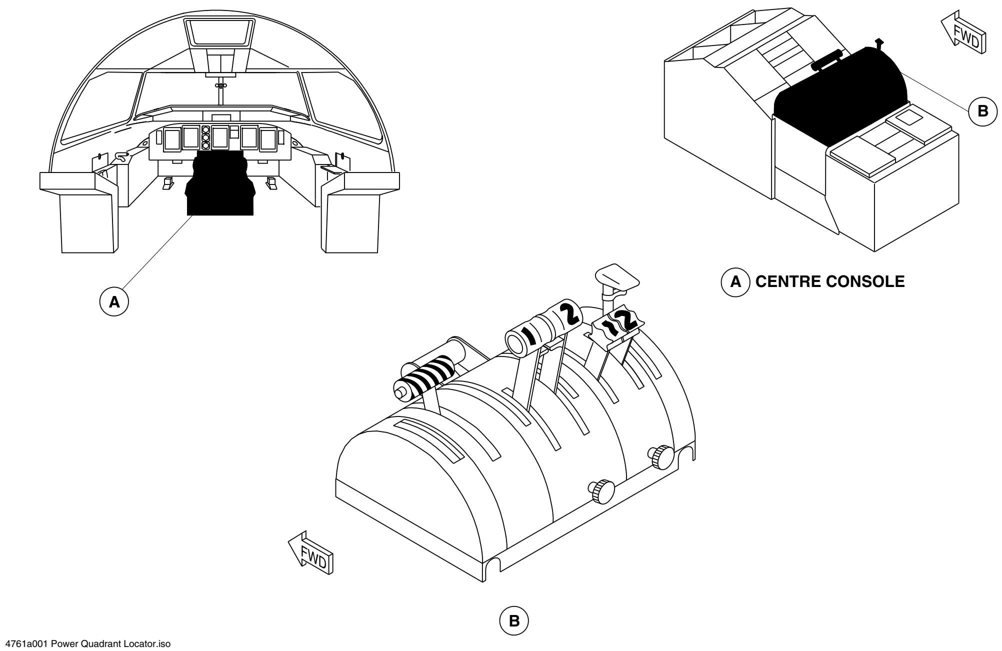
Refer to Figure 18.

The uptrim function is implemented in the PEC hardware, with cross–wing communication from the local PEC to the remote FADEC. Uptrim is armed by moving both PLAs to the rating detent. Uptrim is disarmed by moving either PLA below the detent.

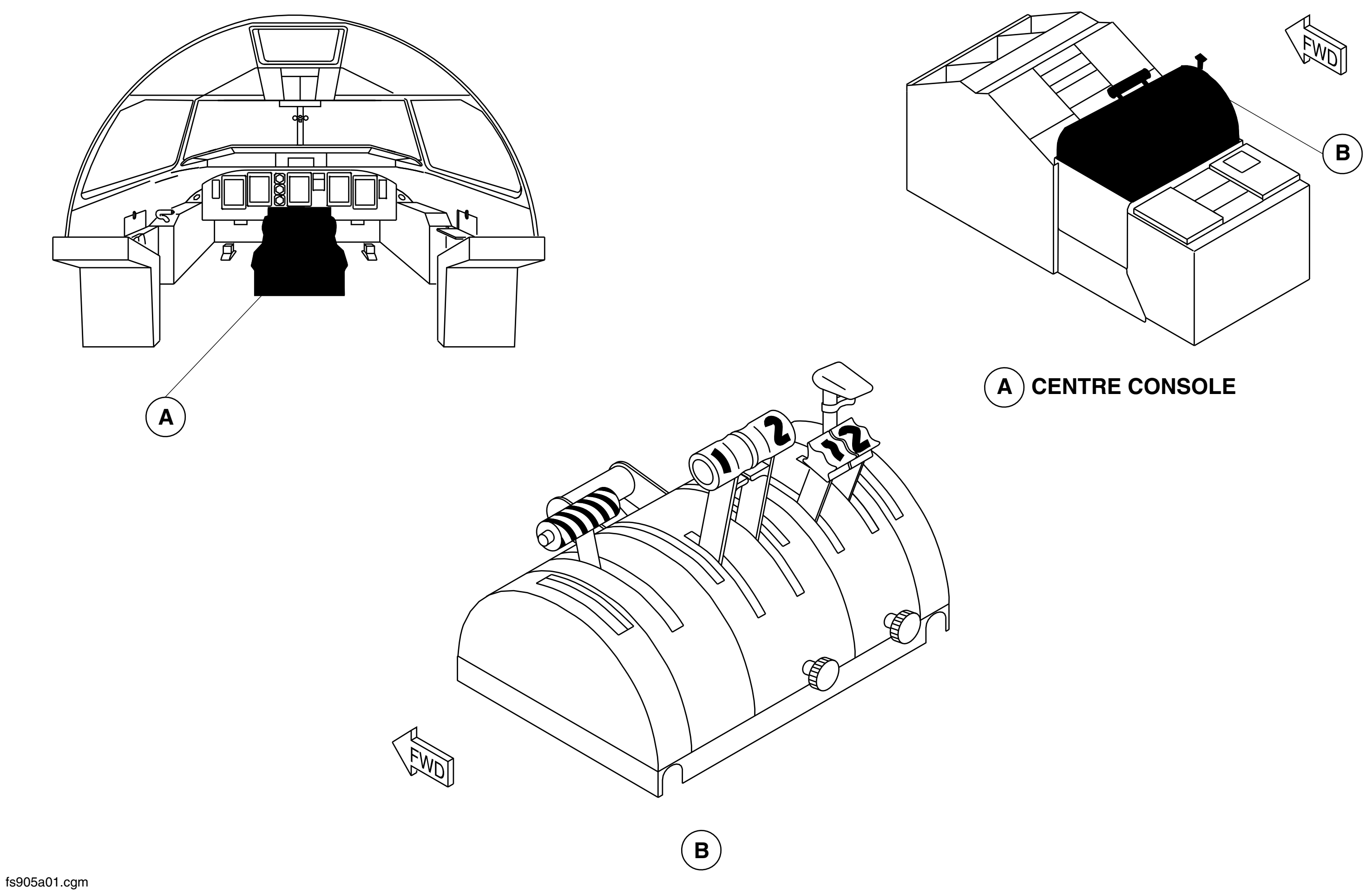
When the system is armed an uptrim will occur if:

- Both torque signals drop below 25%
- Or
- Both torque sensors show a speed of less than 80%

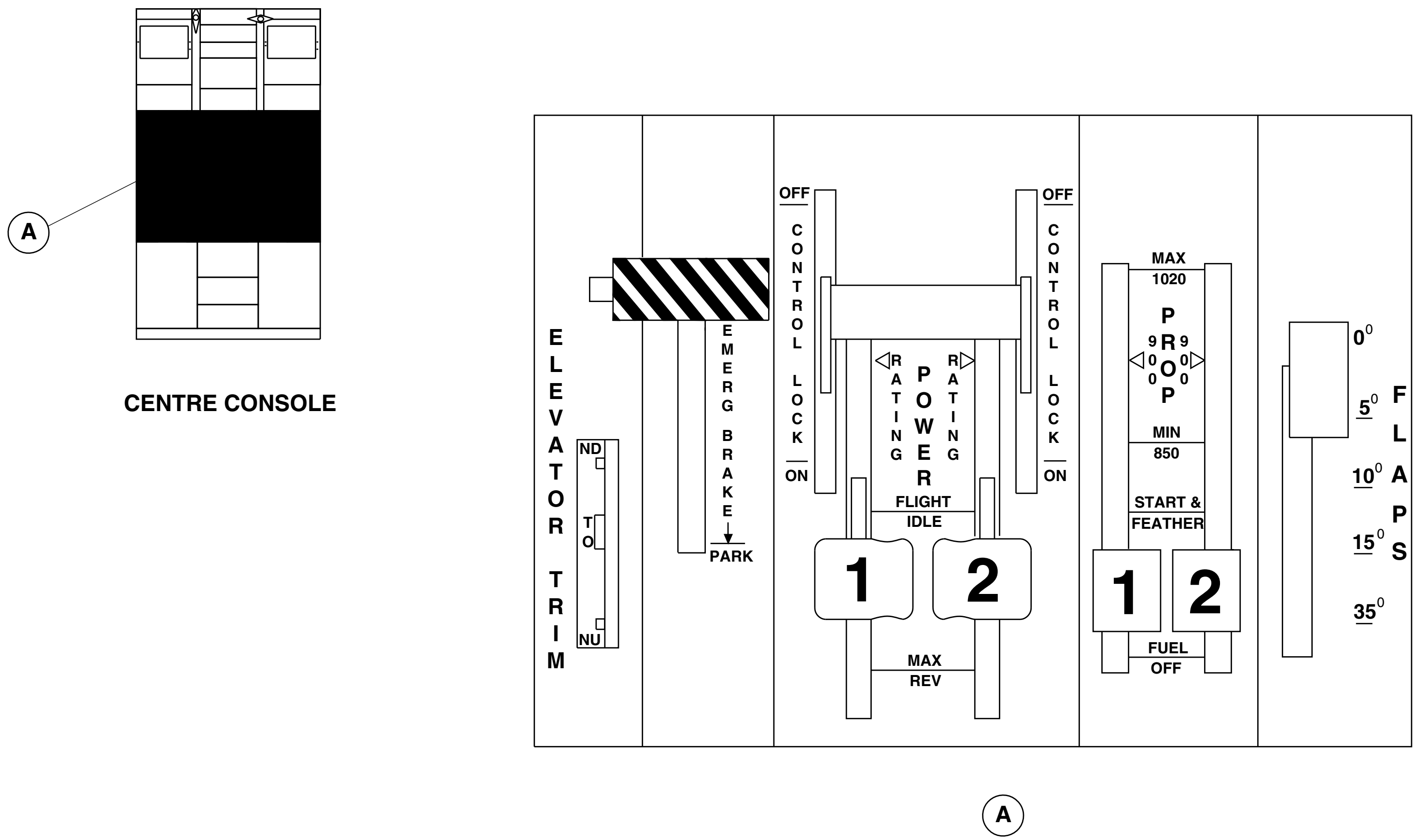
An uptrim will cause the PEC to command the FADEC to change from the Normal Take–Off Power (NTOP) schedule, to the Maximum Take–Off Power schedule. An UPTRIM message will appear on the ED.



Power Quadrant Locator
Figure 1



Power Quadrant Detail, Condition Levers
Figure 2



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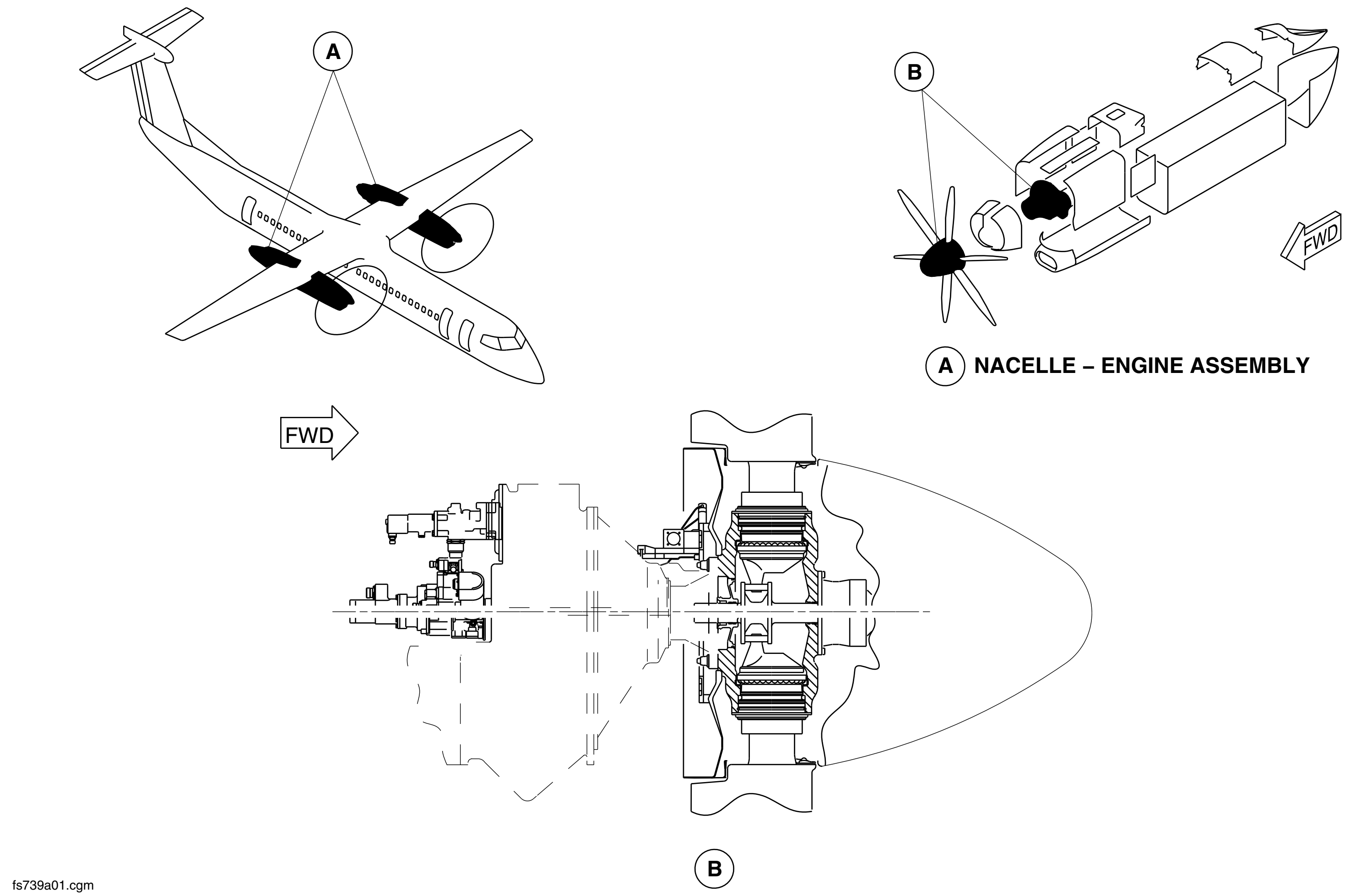
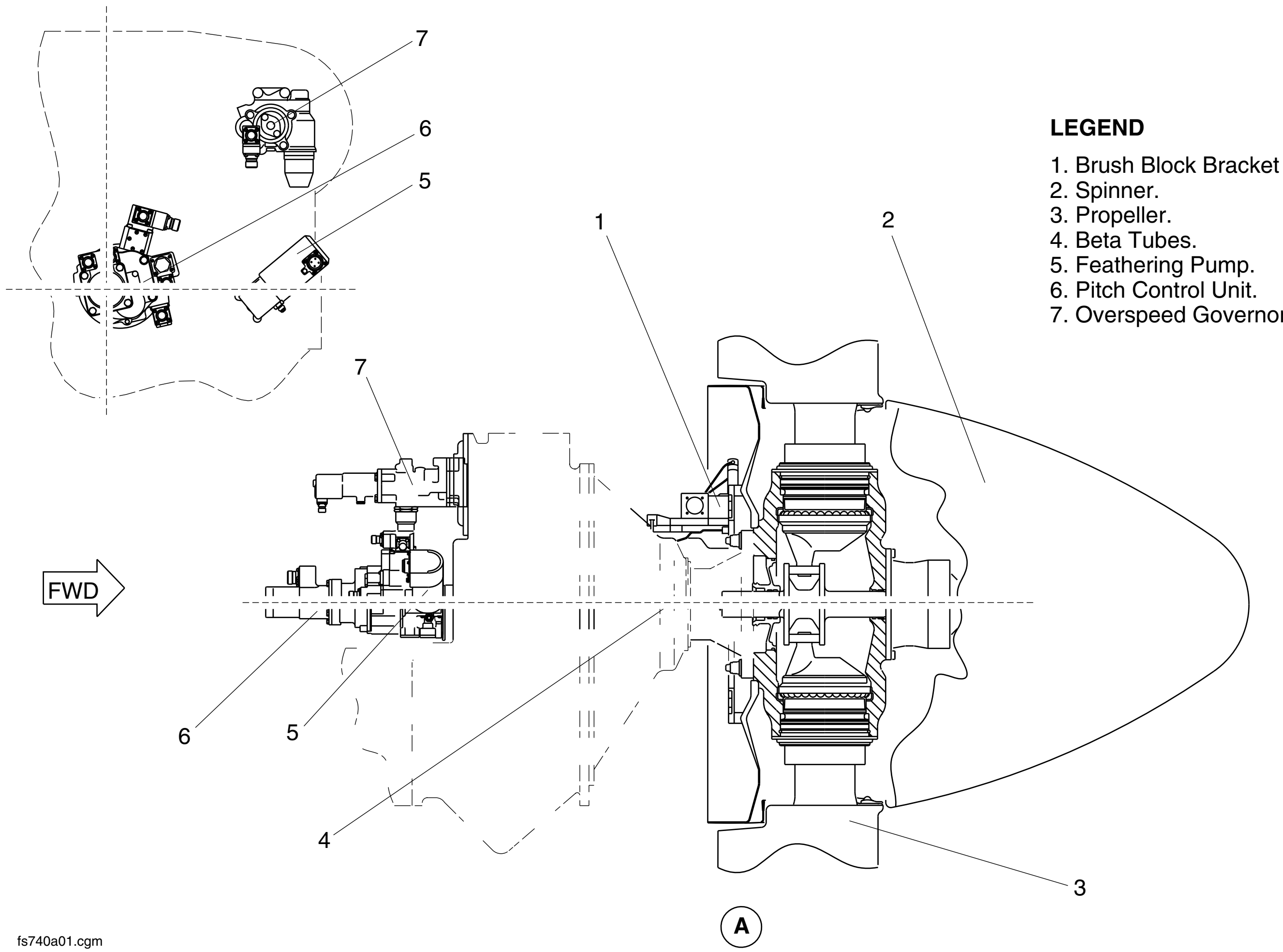
Power Quadrant Detail, Power Levers
Figure 3



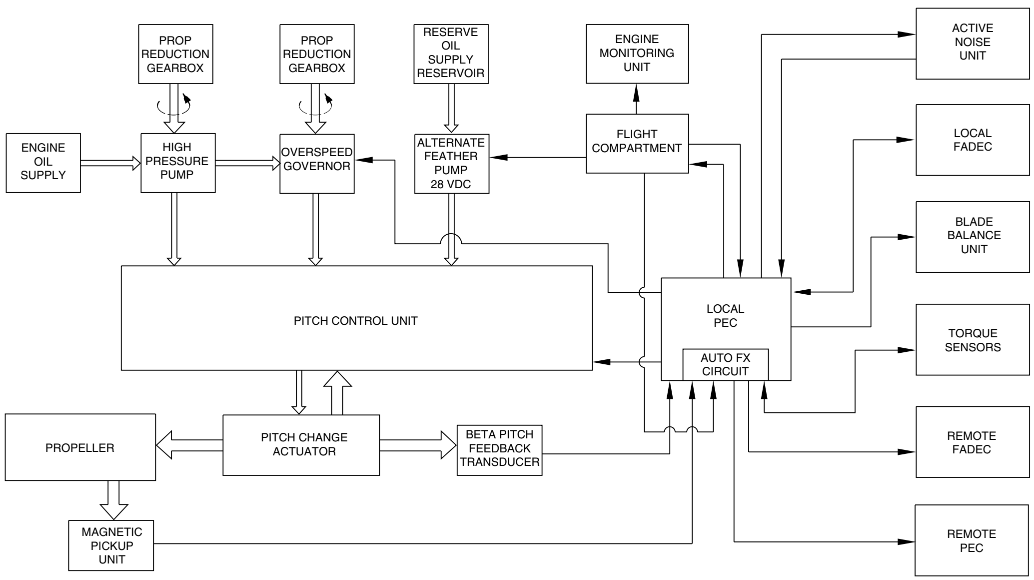
Propeller Control System Location
Figure 4



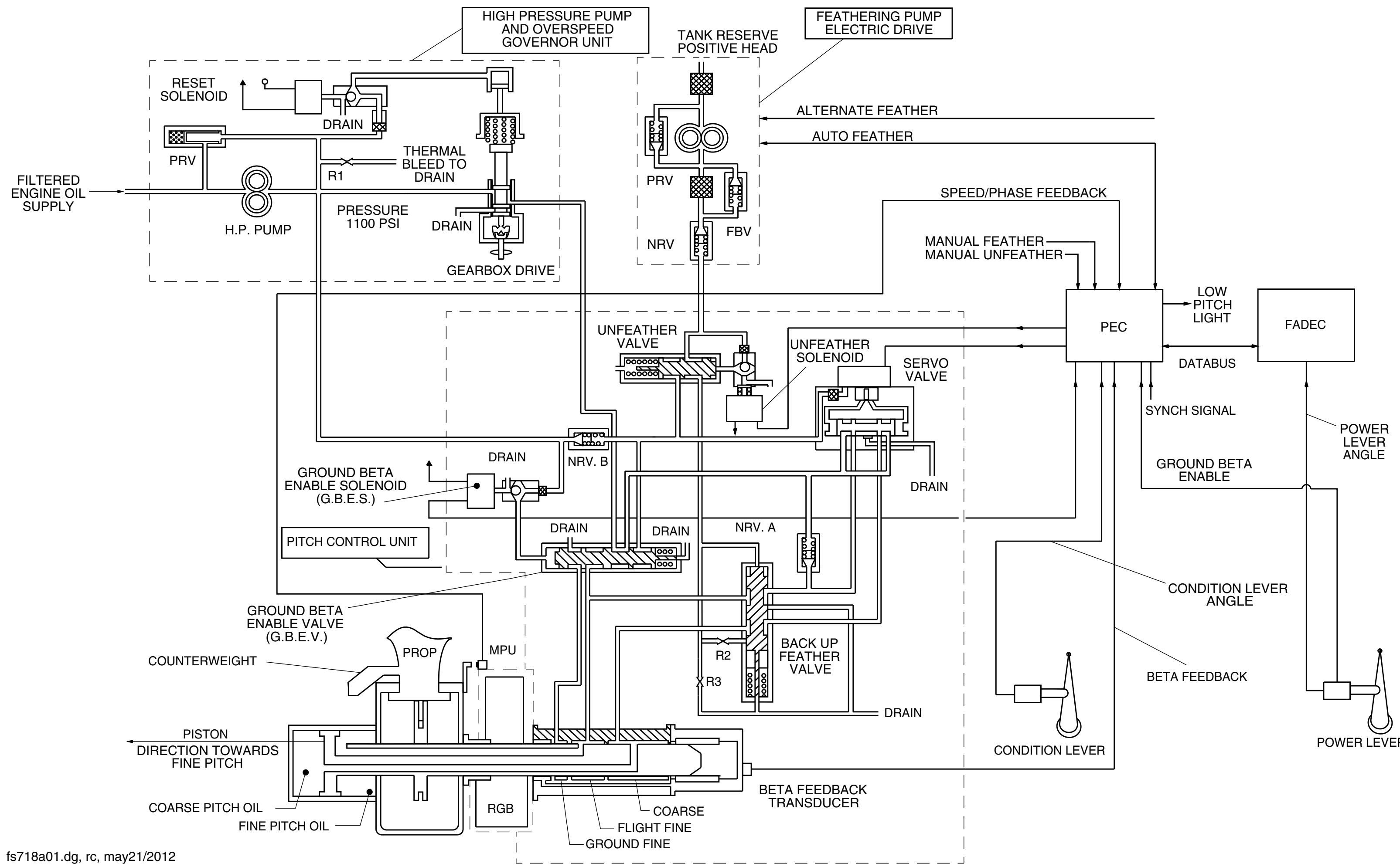
LEGEND

1. Brush Block Bracket Unit.
2. Spinner.
3. Propeller.
4. Beta Tubes.
5. Feathering Pump.
6. Pitch Control Unit.
7. Overspeed Governor and Pump.

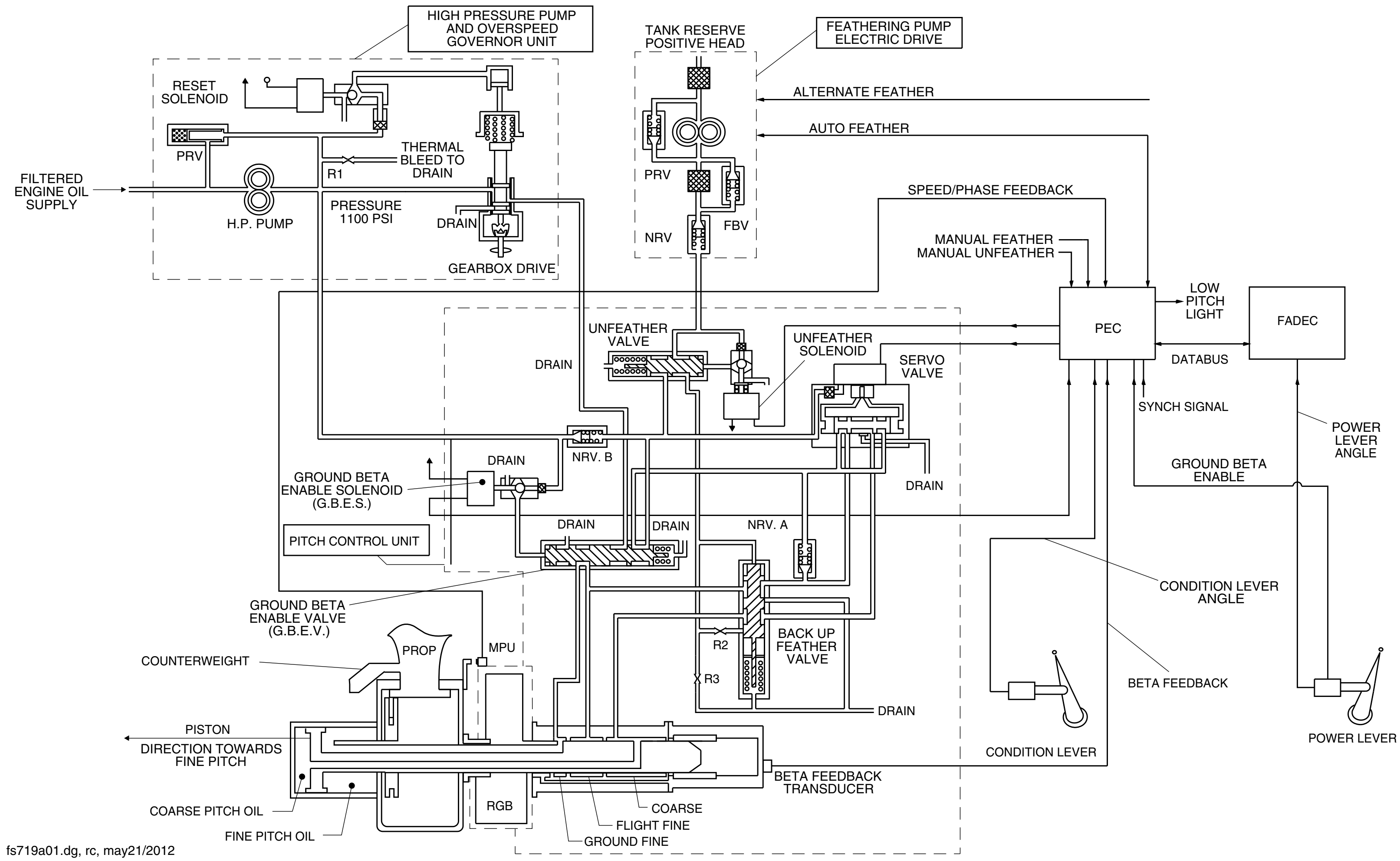
Propeller Control System Detail
Figure 5



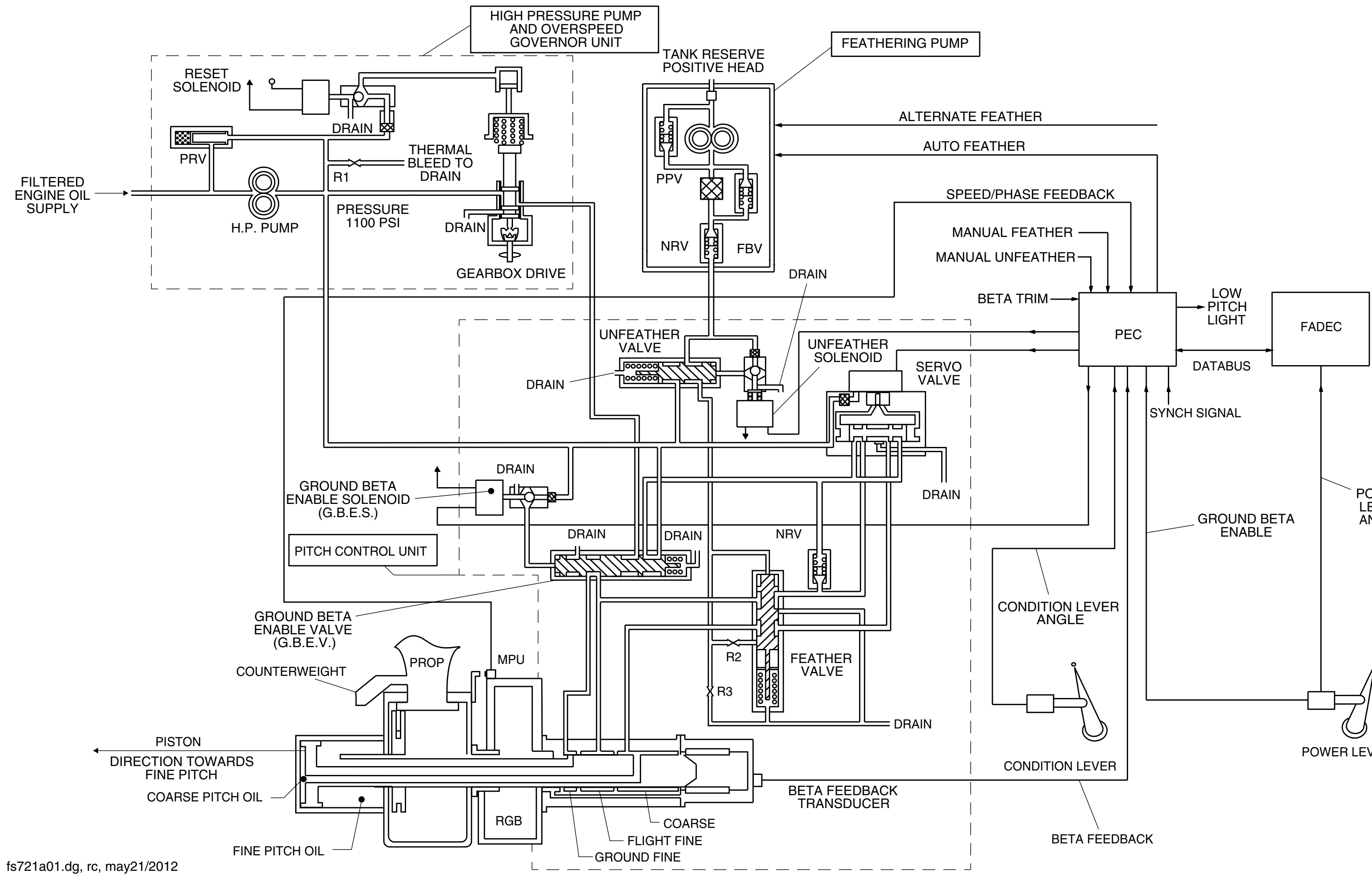
Propeller Control Block Diagram
Figure 6



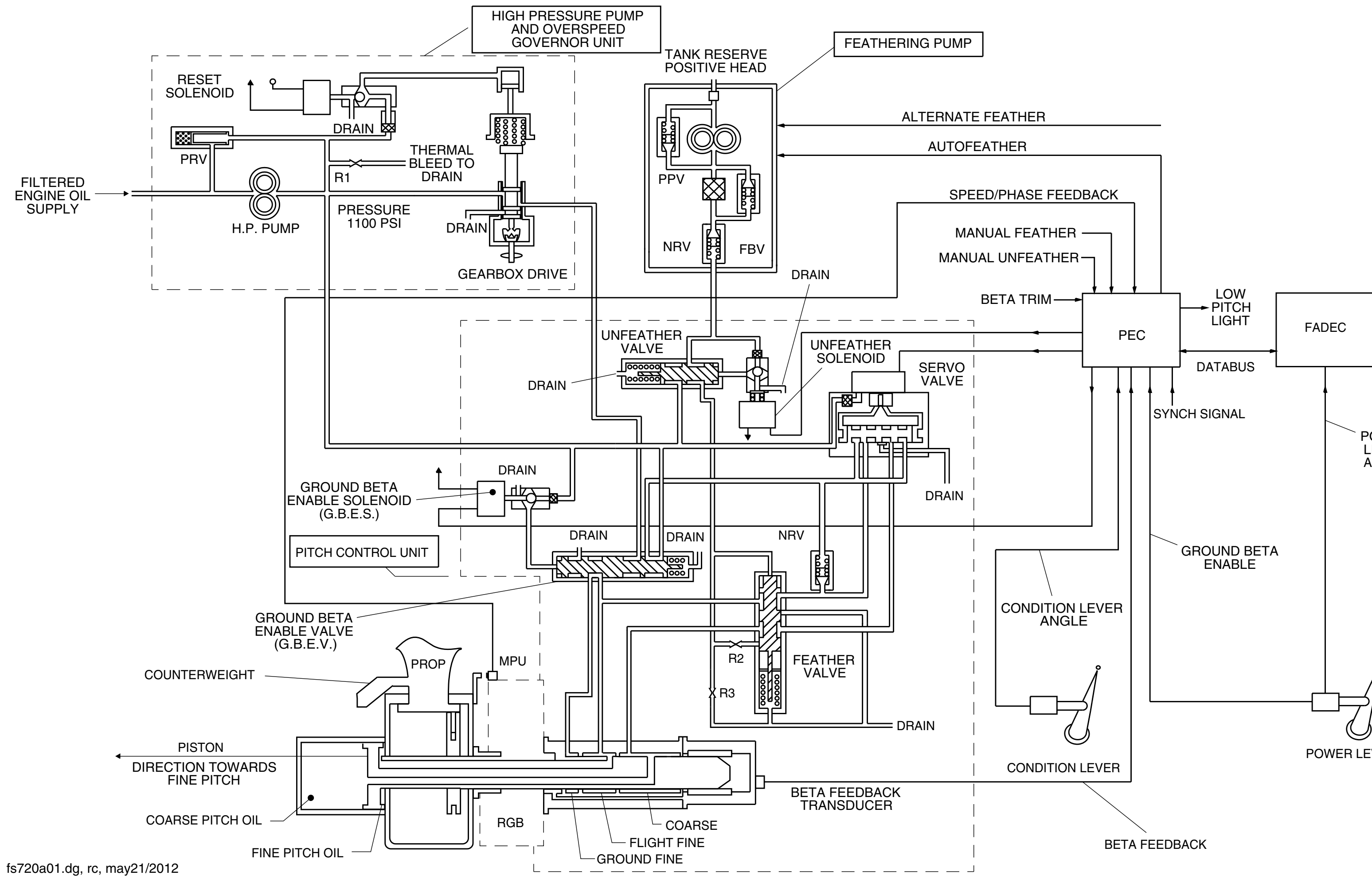
Prop System Shown in Steady State Constant Speed Control
Figure 7



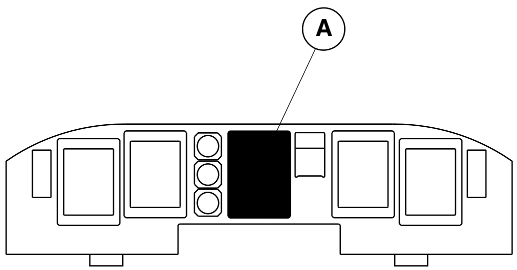
Prop System Shown in Ground Beta Mode
Figure 8



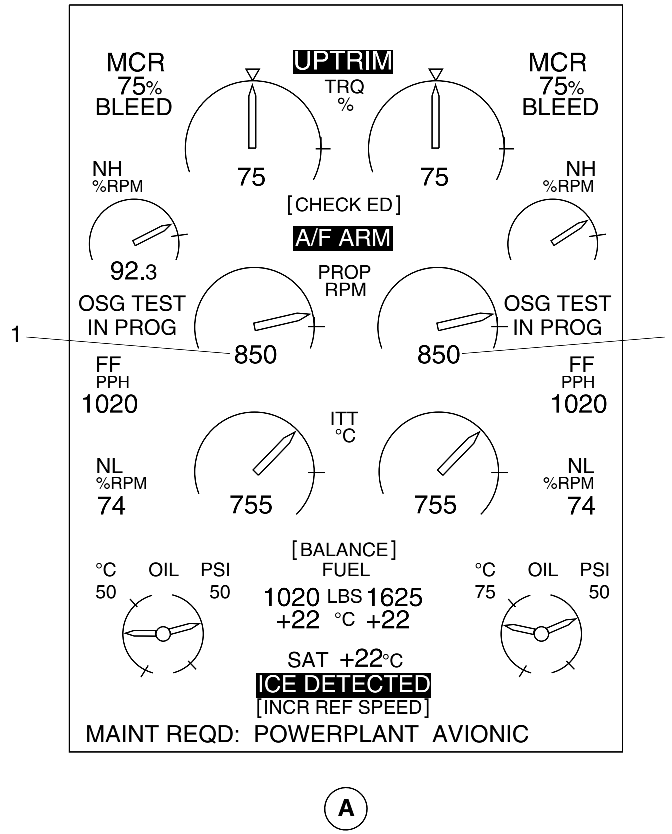
Prop System Shown in Unfeather
Figure 9



Prop System Shown in Feather
Figure 10



MAIN INSTRUMENT PANEL



LEGEND

1. Left/Right Propeller Speed Indication.

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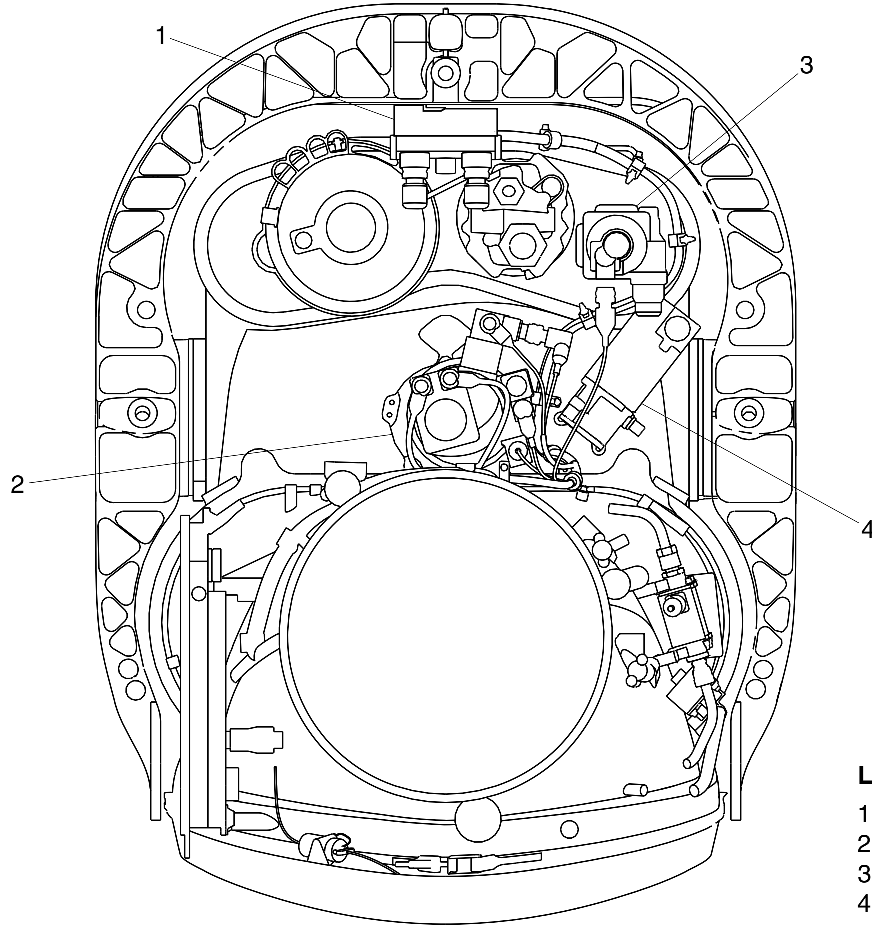
Propeller Speed (Np) Indications
Figure 11



LEGEND

1. Propeller electronic control.
2. Pitch control unit.
3. Overspeed governor and high pressure pump.
4. Auxiliary feather pump.

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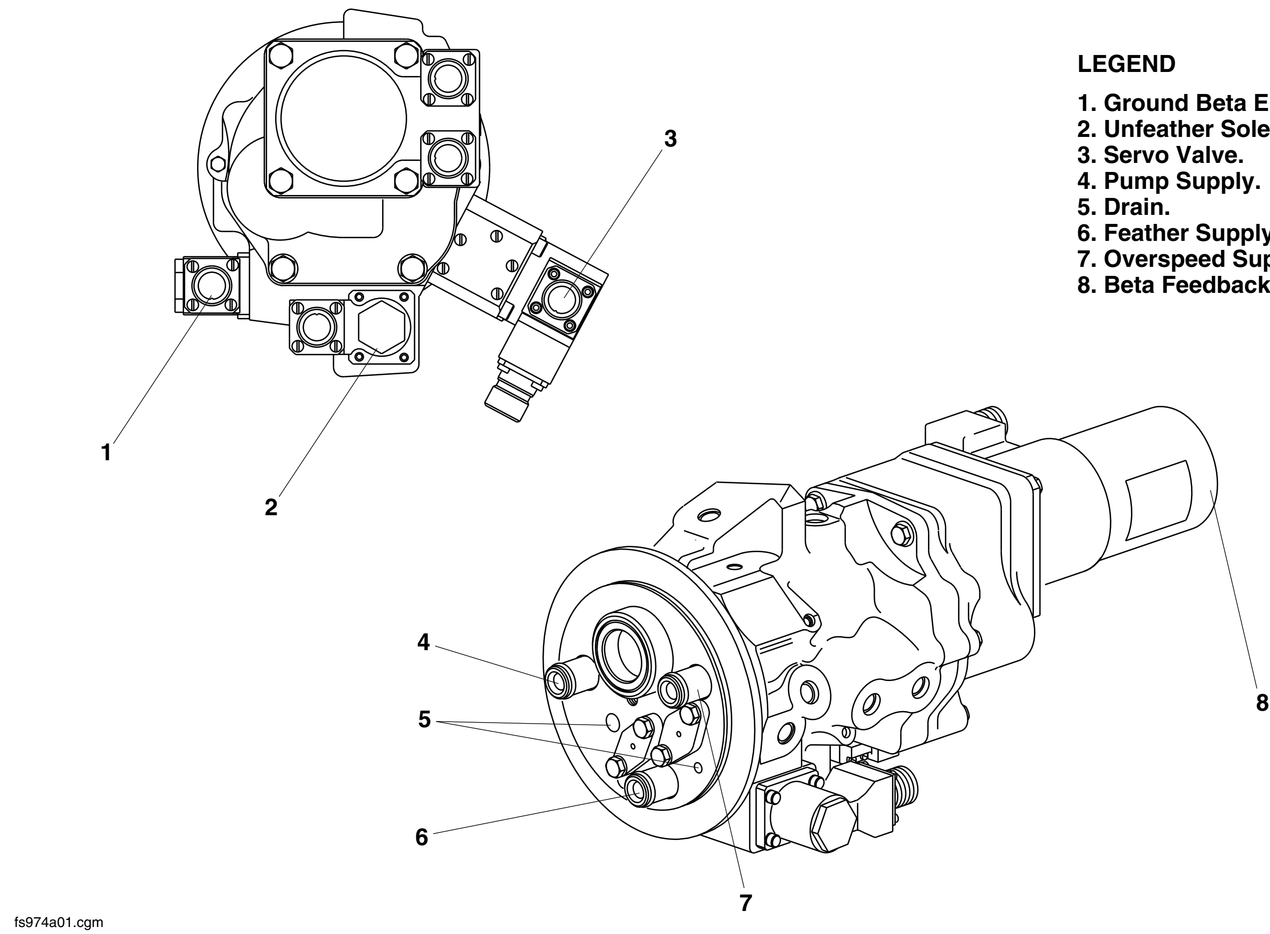
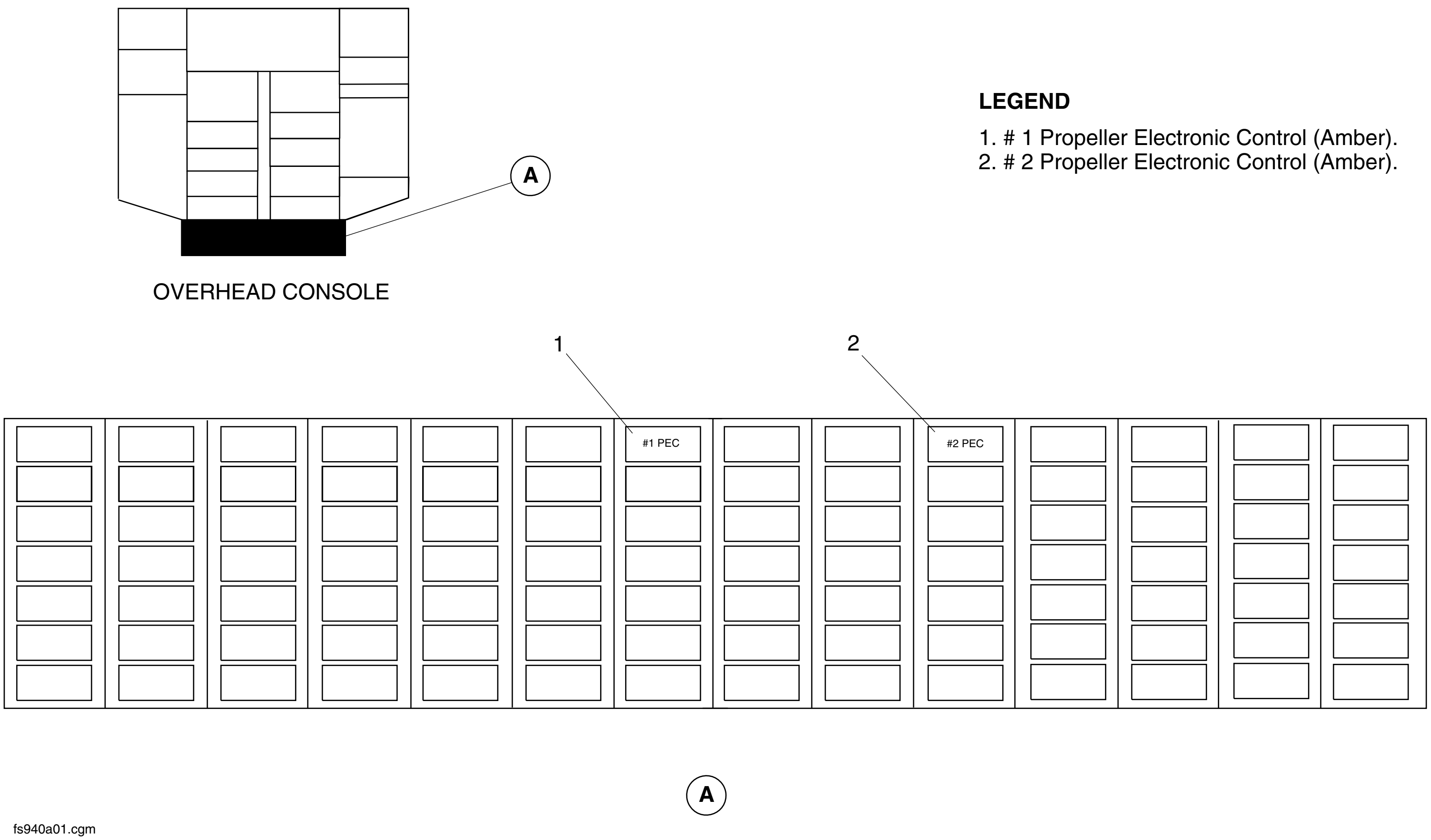
PEC/PCU/OSG and Auxiliary Feather Pump Detail
Figure 12



LEGEND

1. Ground Beta Enable Solenoid Valve.
2. Unfeather Solenoid.
3. Servo Valve.
4. Pump Supply.
5. Drain.
6. Feather Supply.
7. Overspeed Supply.
8. Beta Feedback Transducer.

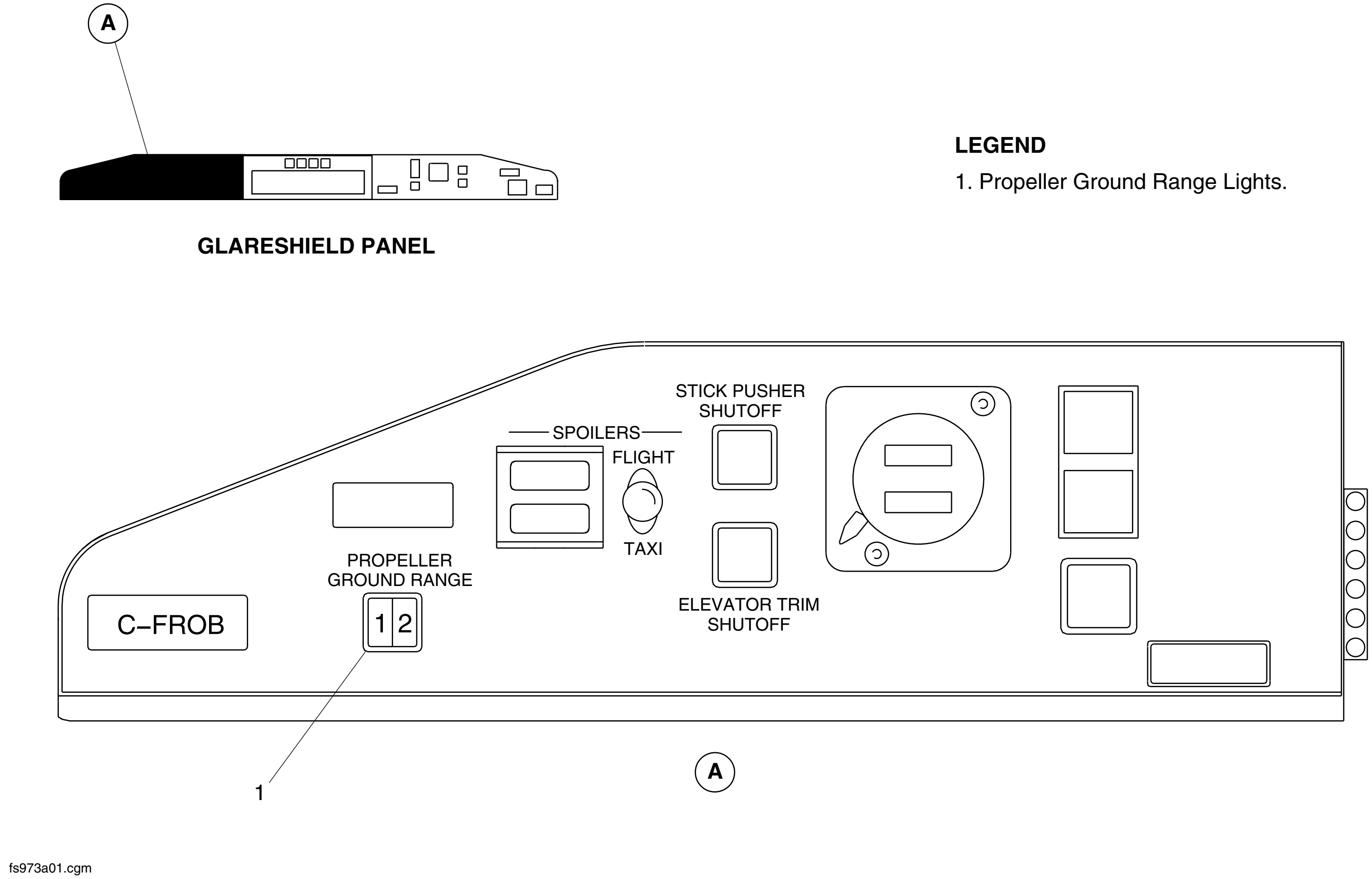
Pitch Control Unit Detail
Figure 13



LEGEND

1. # 1 Propeller Electronic Control (Amber).
2. # 2 Propeller Electronic Control (Amber).

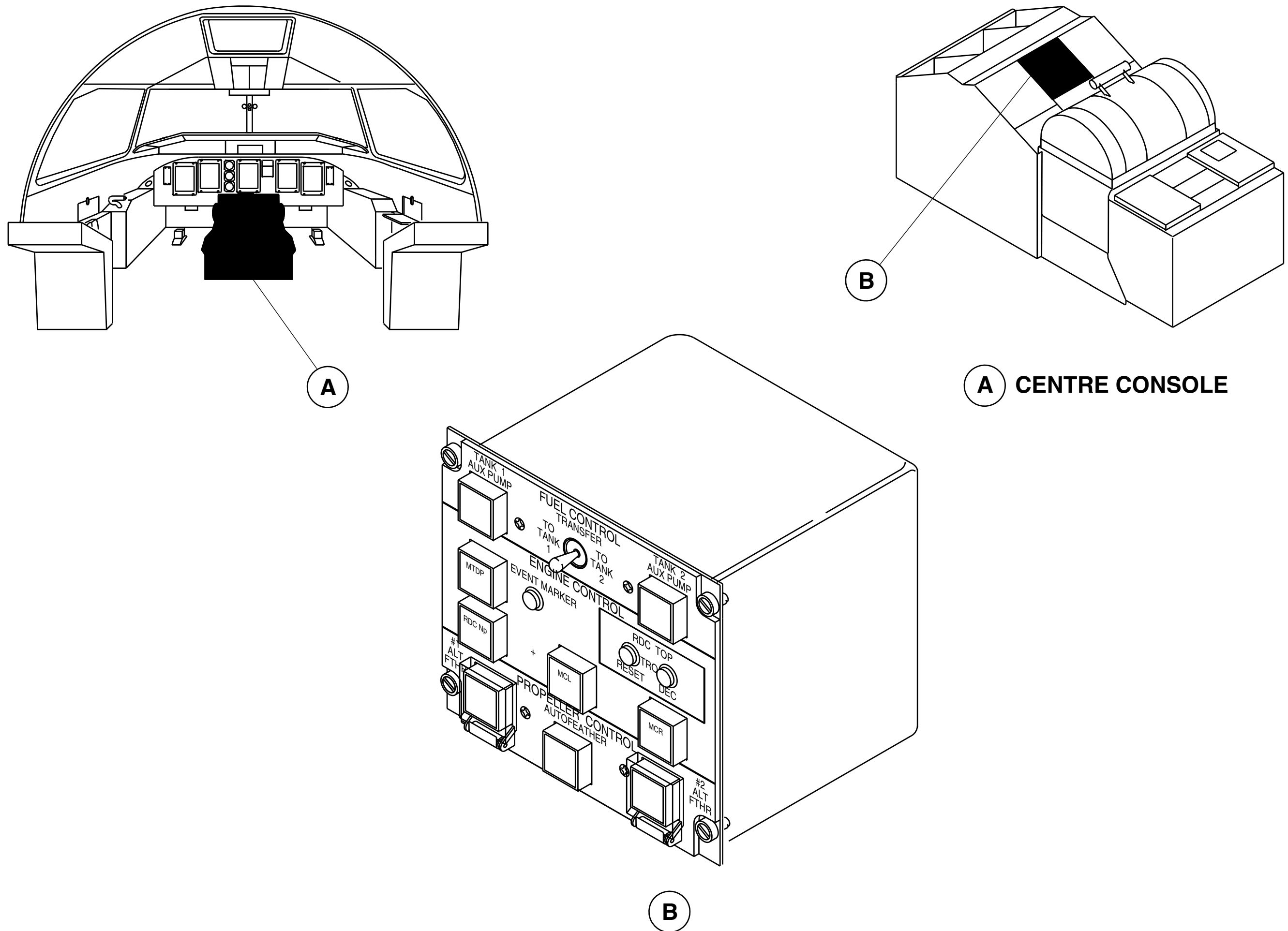
PEC Caution Lights
Figure 14



LEGEND

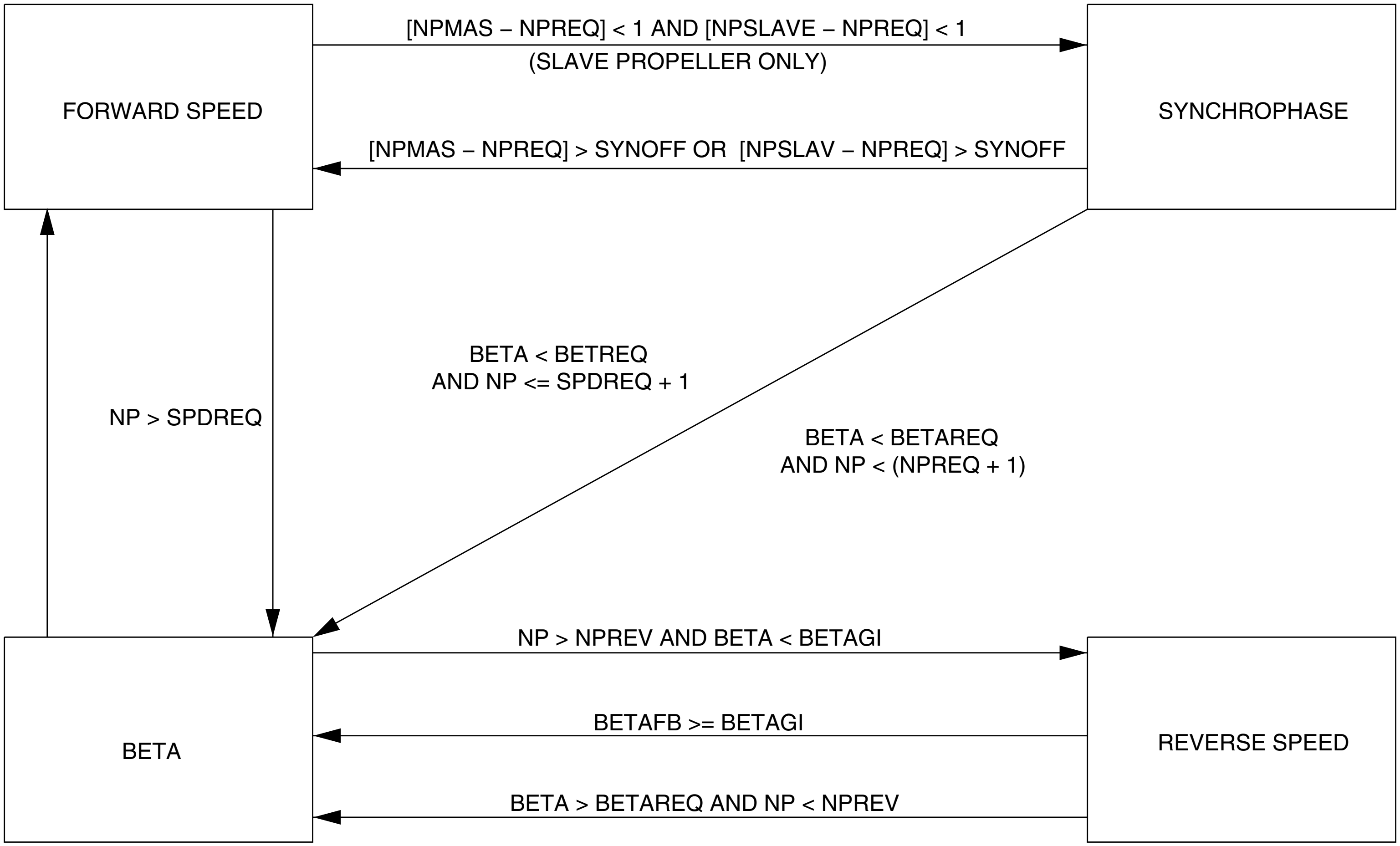
1. Propeller Ground Range Lights.

Propeller Ground Range Lights
Figure 15



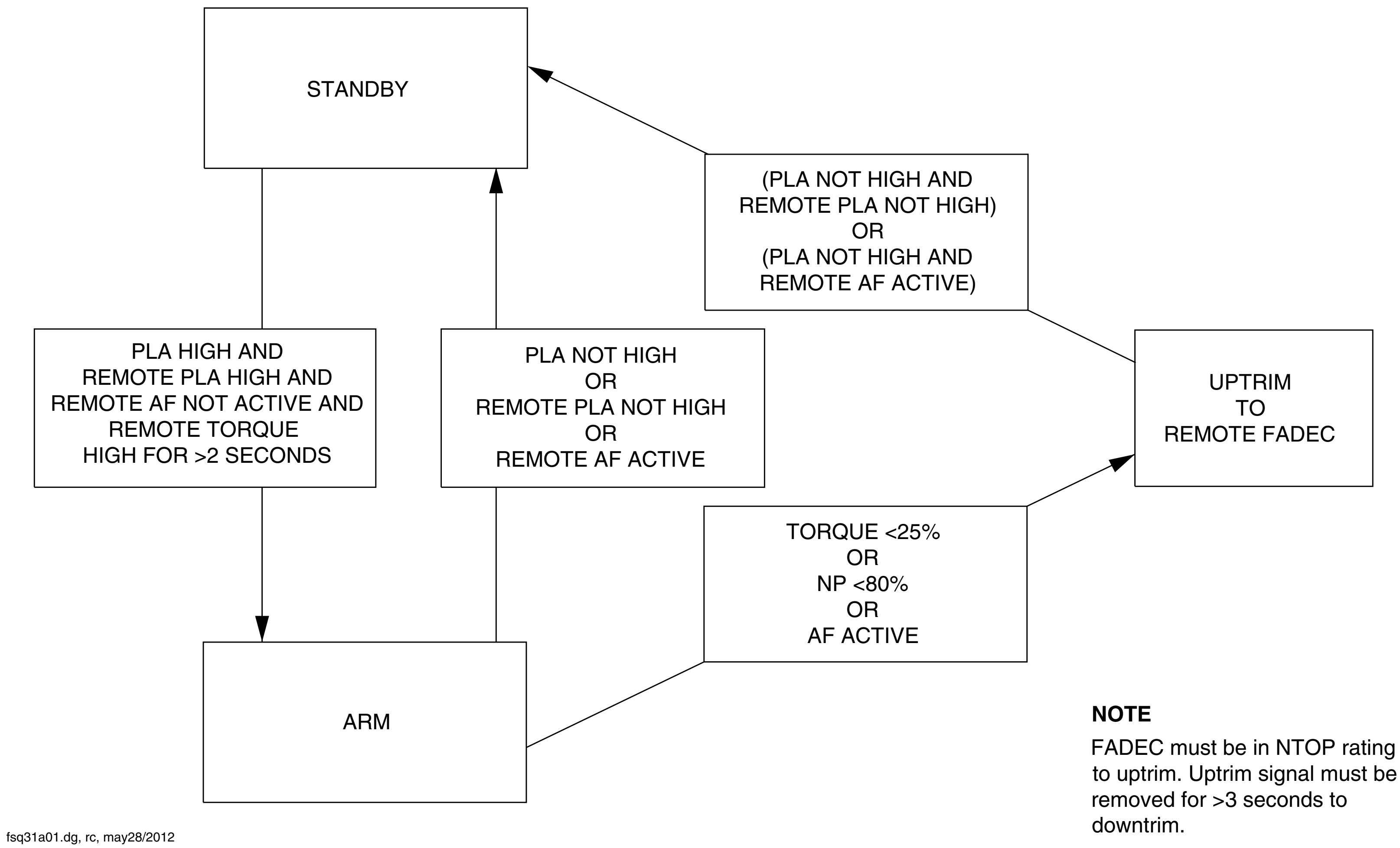
fsa98a01.cgm

Propeller Control Panel Locator
Figure 16

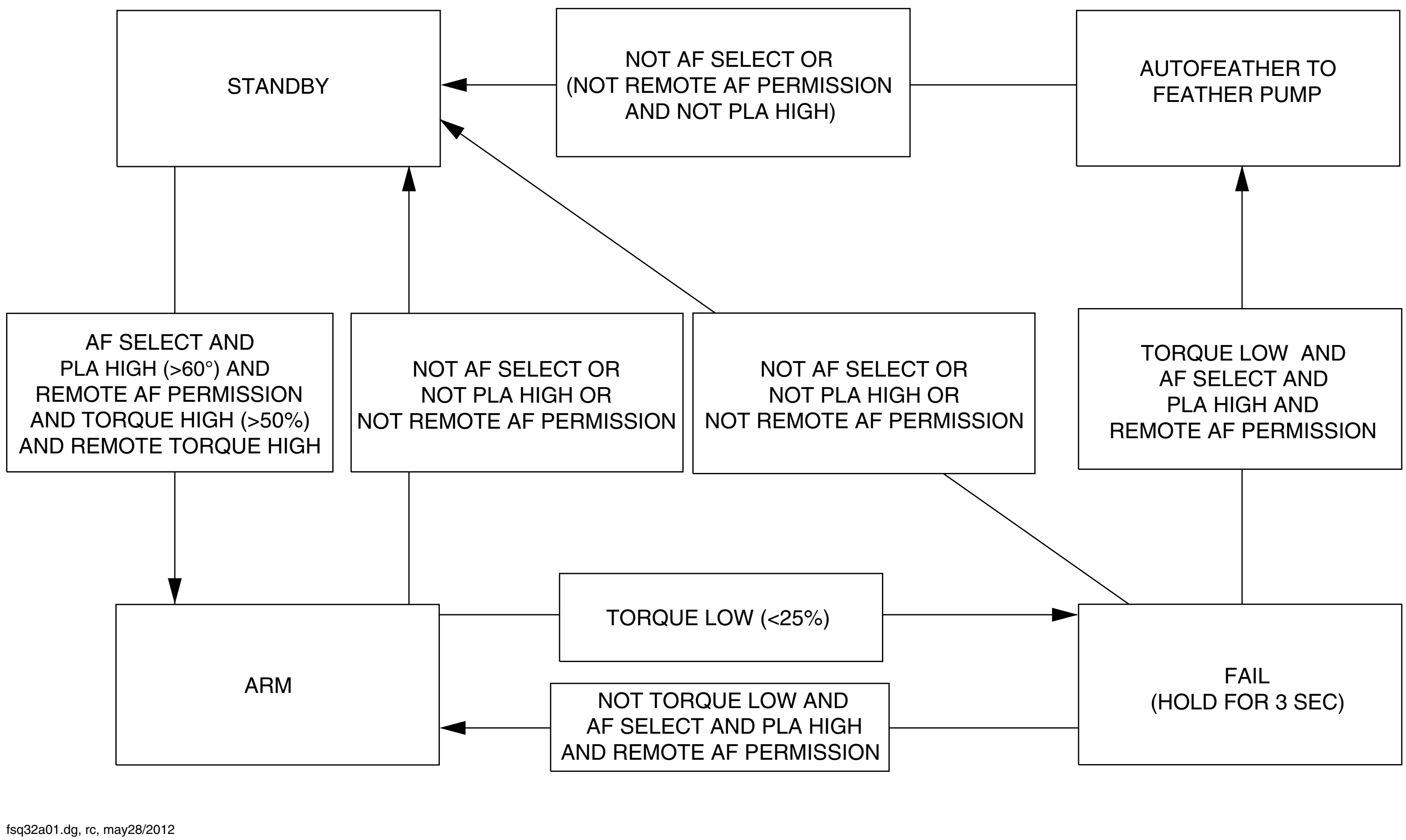


fsq33a01.dg, rc, may28/2012

PEC Control Mode Transitions Including Synchrophase
Figure 17



Uptrim for Low Np or Low Torque
Figure 18



Autofeather State Transitions
Figure 19

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