COCKPIT INDICATION AND CONTROL

1. Normal Indications.

   a. Pressure: The gauge, graduated in pounds per square inch receives an electrical signal of the pressure on the delivery side of the pressure pump via a trans=mitter mounted on the RH wheelcase.

   b. Temperature: The gauge, graduated in ^{o}C, receives an electrical signal of the temperature from a thermometer probe located in the inlet of the pressure pump.

2. Warning Indications.

   a. Low Pressure: A warning lamp is illuminated when a switch, mounted on the RH wheelcase, closes as the pressure falls below the acceptable value.

   b. Internal Overheat: A warning lamp is illuminated when a temperature sensitive switch, located in the breather outlet pipe, closes at a predetermined air outlet tem=perature above normal; this should give sufficient time to stop the engine before excessive damage occurs.

   c. HP Turbine Bearing Temperature: A gauge, graduated in ^{o}C, receives an electrical signal of the scavenge oil temperature from the bearing. A rise is temperature to a predetermined maximum provides early warning of deterioration.

3. Control.

   a. Oil Cooler Override: This is a switch which permits the normal automatic or the 'failed safe' action of the oil cooler to be overridden; it provides greater con=trol over the oil or fuel temperature under certain operating conditions.

LUBRICATION SYSTEM

1. Study of Components. Further details of the location and mechanical arrangements of the lubrication system components are presented in the following order:

   a. Oil Tank.

   b. Oil Pumps.

   c. Pressure Filter.

   d. Relief Valve.

   e. Scavenge Filters.

   f. 'TENDECO' Magnetic Chip Detector.

   g. Oil Pressure Transmitter.

   h. Oil Pressure Warning Light Switch.

j. Oil Temperature Bulb.

k. HP Turbine Bearing Temperature Bulb.

i. Oil Tank: The tapered rear end of the air intake outer casing is encased by a fabricated steel sleeve, the annular space between these two compo= nents forms the oil tank. The oil tank filler is on the right hand side of the oil tank. On all installations a dipstick is provided next to the filler graduated in Imperial pints, American pints, or Litres, to fill. The filter housing is an in= clined cavity integral with the intake casing, a hole at the top passing oil into the centre of the filter element. A self sealing coupling enables the feathering pump ipe to be disconnected with= out losing oil from the tank. A tank drain valve is incorporated in the external connection.

ii. Oil Pumps: These are all gear pumps, the assembly consisting of one pressure and six scavenge pumps housed in a cylindrical casing mounted inside the right hand wheelcase. They are dirven through a train of gears and an inclined drive from the HP compressor.

iii. Pressure Filter: The filter is a Puralator element, wire wound to a 0.003" mesh. It is in a magnesium casing integral with the right hand wheelcase and incorporates a 50 psi by-pass valve and a drain valve.

iv. Relief Valve: This is a non-adjustable spring loaded disc valve contained in a housing at the top of the oil tank. The disc has a hole through the centre to prevent syphoning of the oil when the engine is stationary. The valve will operate when the oil pressure exceeds 75 psi.

v. Scavenge Filters: There are six wire gauze scavenge filters as follows:

aa. Reduction Gear.

bb. Internal wheel case.

cc. RH wheel case.

dd. Tail bearing.

ee. HP turbine bearing.

ff. Location bearings.

vi. 'TERDECO' Magnetic Chip Detector (Mod 1173). This is a permanent magnet situated in the oil outlet connection of the fuel heater. The magnet is se= cured in its housing by a simple bayonet fastening and a self sealing valve prevents loss of oil when the magnet is removed for inspection.

vii. Oil Pressure Transmitter: An electrical trans= mitter is mounted on a bracket attached to the rear face of the RH Wheelcase. It senses the oil pressure in the wheelcase distribution gallery.

viii. Oil Pressure Warning Light Switch: This switch is fitted on the same bracket as the pressure trans= mitter and senses the same oil pressure. The switch is pressure operated. When the oil pres= sure falls below 30 psi contacts in the switch complete a circuit for a warning light in the cockpit.

ix. Oil Temperature Bulb: The temperatures bulb is situated in the suction pipe from the oil tank to the RH wheelcase. It provides an electrical signal of oil inlet temperature.

x. HP Turbine Bearing Temperature Bulb (Mod 958). The temperature bulb is located in the scavenge oil outlet connection on the compressor outlet casing. It provides an electrical signal of HP turbine scavenge oil temperature.

xi. Breather system: Loss of air through the bearing seals tends to build up pressure in the internal compartments. This is prevented by venting them to atmosphere in the following manner:

(a) All main shaft bearings with the exception of the tail bearing and compressor front bearing are vented to the internal wheelcase.

(b) The internal wheelcase vents into the air space in the oil tank.

(c) The air space in the tank and also the reduc= tion gears are vented to the RH wheelcase where the centrifugal breather separates and returns oil to the wheelcase before discharg= ing the air to atmosphere.

xii. Hot Oil Anti-Icing: From a common output the oil is pumped through the fuel heater to the left hand side of the oil tank. Commencing with No 2 strut an arrangement of pipes and passages convey the oil through the leading edges of No 2, 1, 7 and 6 struts. From the right hand side of the tank external pipes convey the oil to the cooler and back to the deaerator tray.

xiii. Thermostatically Controlled Oil Cooler:

(a) Purpose: To ensure that at low ambient air temperatures the temperature of the scavenge oil supplied to the fuel heater will always be sufficient to prevent the formation of ice in the fuel.

(b) General: A butterfly valve in the oil cooler outlet duct controls the airflow through the matrices. Its position depends upon the outlet temperature of the oil from the cooler. At temperatures above 90°C it is fully open and will gradually close as the oil temperature drops below 90°C; it is fully closed at 70°C. From the scavenge pumps the oil flows through the fuel heater and intake struts to the cooler. On entering the cooler it first passes through a back pressure valve which is housed in the upper space formed by the two adjacent circular matrices. The back pressure valve produces a 15 psi pressure drop across the cooler to provide sufficient hydraulic pressure to operate the ram which controls the throttle.

TORQUEMETER AND AUTOMATIC DRAG LIMITING SYSTEM

1. Requirements of System.

   a. Torquemeter: To provide the means for assessing satisfactory take-off power from the hydraulic oil pressure required to balance the torque load of the reduction gear annulus.

   b. ADLS: Provide a primary flight safety device by initiating propellor pitch coarsening in the event of power failure and so limit drag. In the event of a negative torque condition, a lever actuated by the annulus gear will mechanically operate the ADLS servo valve in the PCU.

   NB: Although their duties are separate, the torquemeter and engine components of the ADLS are mechanically interdependent units.

COCKPIT INDICATIONS AND CONTROL

1. Indications:

   a. Torquemeter: A torque pressure gauge, graduated in pounds per square inch, indicates the hydraulic pressure balancing the annulus load.

   b. ADLS: Illumination of two amber lamps on the main engine instrument panel. There is one warning lamp per power unit.

OPERATION OF SYSTEMS

1. Torquemeter.

   a. Static Conditions: Annulus gear is on the positive stops of the stop ring. Master cylinder spill valve is in the closed position. ADLS relief valve is closed with the power lever at Ground Idle.

   b. Engine Start Up: As the engine accelerates, the torquemeter pump supplies oil to the spill valve of the master piston through scallops in the cylinder wall.

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i. With the spill valve closed, oil pressure increases in the positive cylinders to move the annulus gear off the positive stops.

ii. Movement of the annulus is transmitted to the mas= ter piston via the bell crank to open the spill valve.

iii. The spill valve progressively opens to hold the hydraulic pressure in the positive cylinders at a value which will balance the annulus load.

iv. When this state exists the spill valve will be positioned to pass the full flow of the torque= meter pump and the annulus will be held in balance between the positive and negative stops.

c. Increasing Engine Power: This results in a greater torque load being applied to the annulus which attempts to move it on to its positive stops.

i. Under the influence of hydraulic load due to master piston differential area, the piston fol= lows the annulus movement and the spill valve tends to close.

ii. This, in combination with the rising torquemeter pump output with increasing rpm, will increase the pressure in positive torquemeter cylinders to oppose the annulus load.

iii. The hydraulic force required to balance the annulus load is registered on a gauge in the cockpit and at take-off rpm, this provides an indication from which satisfactory performance is assessed.

AUTOMATIC DRAG LIMITING SYSTEM

1. Operation During Take-Off and Cruise. With the power lever advanced well into the 'Flight' range the ADLS relief valve is open.

a. If engine power fails the negative torque resulting from the propellor windmilling will rotate the annulus in reverse.

b. The NTS master piston will move past the scallops into the plain section of the cylinder, the torquemeter pump output passing through the open ADLS relief valve and out through the fully open spill valve.

c. As the annulus moves towards the negative stops, a lug on its phiriphery operates, via linkage, the ADLS servo valve in the PCU.

d. The valve will direct PCU oil pressure to coarsen the propellor pitch and limit drag; the propellor will assume a near feathered position.

e. When the ADLS valve in the PCU is operated, it closes a switch to illuminate the cockpit warning system.

2. Operation on Descent and in the Beta Range. At the legiti= mate negative torque condition existing when the power is moved to the Flight Idle position in flight and into the Beta range on touch down, the normal tendency of the ADLS to coarsen propellor pitch is prevented by the action of the variable datum ADLS relief valve.

a. The movement of the power lever towards Flight Idle changes the datum of the relief valve by the action of a roller lever; this closes the valve and progres= sively increases the load of the spring as the Beta range is selected.

b. Under the resulting negative torque condition, movement of the annulus causes the NTS master piston to try and move forward into the plain section of the cylinder and so restrict the free flow of oil from the torquemeter pump.

c. Due to the increased load on the relief valve, it remains closed despite the increasing pressure and per= mits the pump output pressure to maintain sufficient load on the master piston and its slaves to balance the negative torque.

d. While this balanced condition exists the annulus is prevented from rotating far enough to operate the ADLS and during any normal operation within this lower lever range the characteristics of the variable datum ADLS relief valve has been designed to give a hydraulic load always greater than is necessary to balance the normal negative torque load.

3. Unfeathering (Air Relight). With the power lever positioned at Flight Idle and the Condition lever (HP cock) set to unfeather the propellor, when feathering pump is energized by pressing the feather pump button.

a. As the propellor unfeathers and commences to windmill, the negative torque load applied to the annulus should be supported on the NTS pistons as the ADLS relief valve is heavily loaded onto its seat.

b. However, any loss of oil from the front of the NTS pistons during the feathered period, could render the NTS incapable of supporting the load and the ADLS will re-feather the propellor.

c. To replace this lost oil, a pump is placed in tandem with the feathering pump; it draws its oil from the suction pipe of the main oil pump and delivers it, via a non-return valve, to the front face of the NTS pistons.

d. As the LP rpm rise, the torquemeter pump output pres= sure increases to a value which can support the negative torque load.

e. When the pressure difference across the non-return valve becomes less than 4.5 psi the valve will close, preventing torquemeter oil from leaking into the feathering supply.

WATER/METHANOL SYSTEM

1. Requirements of System. To maintain the Take-Off PSHP at a predetermined value by (restoring the loss of SHP which occurs when the OAT exceeds ISA).

OPERATION OF SYSTEM

2. Basic Presentation. The loss of power which occurs when the OAT exceeds ISA is due to the reduction in air mass flow and the necessary reduction in fuel flow (by trimming) to keep TGT within the limit.

a. Power is restored by injecting a controlled flow of W/M mixture into the LP compressor's "O" stage.

b. The mass of water methanol, which is vapourized by the heat of compression, restores the total mass flow.

c. Being a fuel the methanol is combusted, the relation= ship of methanol to water being so arranged that the TET will be correct in relationship to the increased mass flow.

d. Operation of the system is initiated by a cockpit switch which controls the W/M tank pump and feed cock. Satis= factory functioning of these units is indicated by lights and magnetic indicators.

e. The quantity of W/M supplied to the engine is automati= cally controlled by the W/M control unit which receives signals of torque pressure, atmospheric pressure and power lever position. The unit converts these into a control signal to the metering valve to determine its position.

f. The feed cock is automatically closed when signals of low torque and manual feather are received.

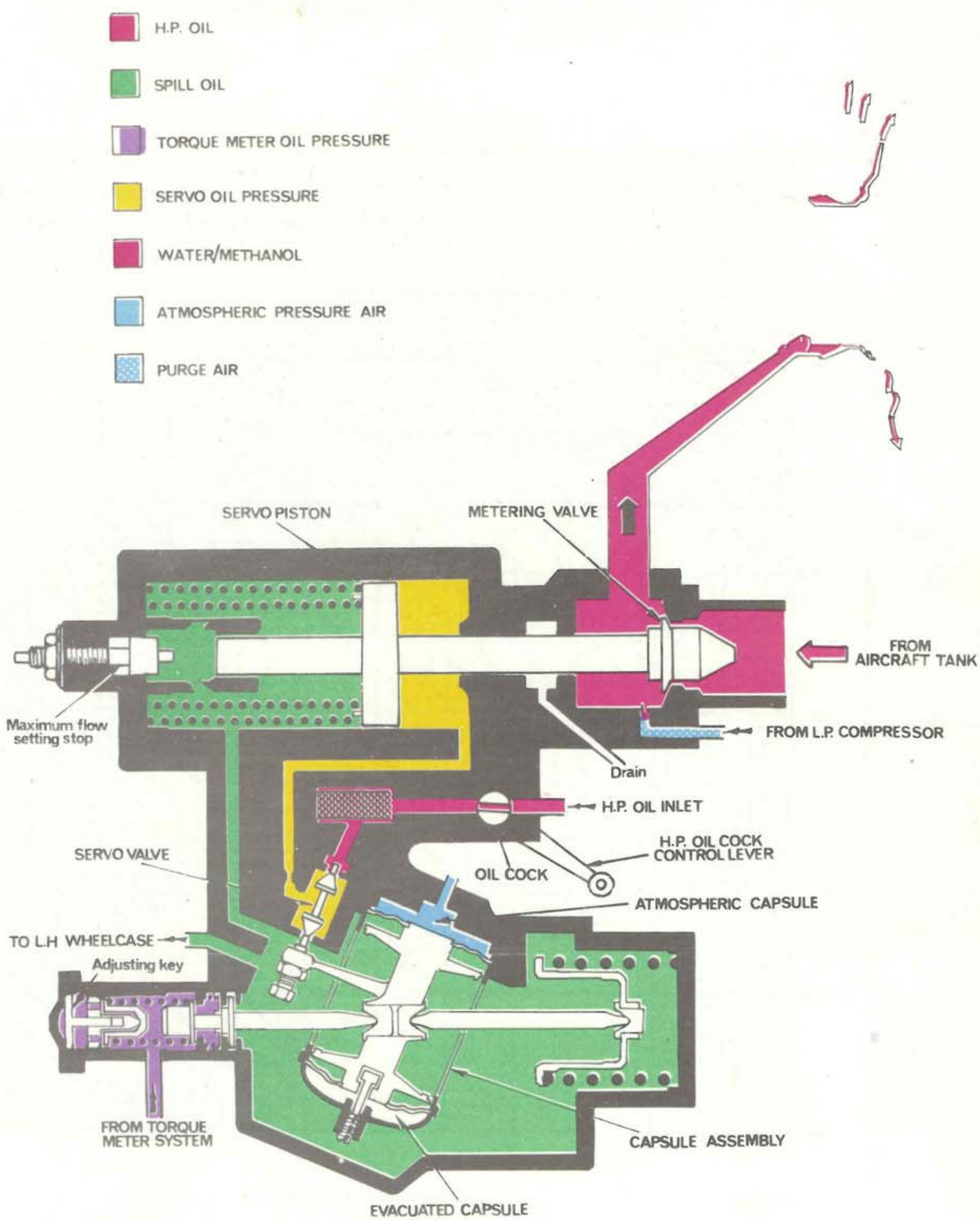
g. The amount of W/M supplied at the "O" stage of the LP compressor is controlled by the W/M regulator which is subjected to the following factors:

i. The PL mechanically opens the HP oil cock when the PL is between 14800 - 15250 LP rpm directing eng oil pressure which acts as a servo pressure to control the opening of the metering valve.

ii. Torque meter system oil pressure acting on a cap= sule push rod, linked to the servo control valve, which in turn regulates servo press to the metering valve.

iii. A capsule subjected to atmospheric conditions, positions the servo control valve which will regu= late the servo press, to the metering valve.

3. Purge Air Supply. To prevent corrosion, a supply of air is tapped from the compressor intermediate casing to purge all resi= dual W/M from the control unit and supply passage to the compressor A mechanical stop in the metering valve assembly determines the max flow of W/M.



WATER/METHANOL SYSTEM

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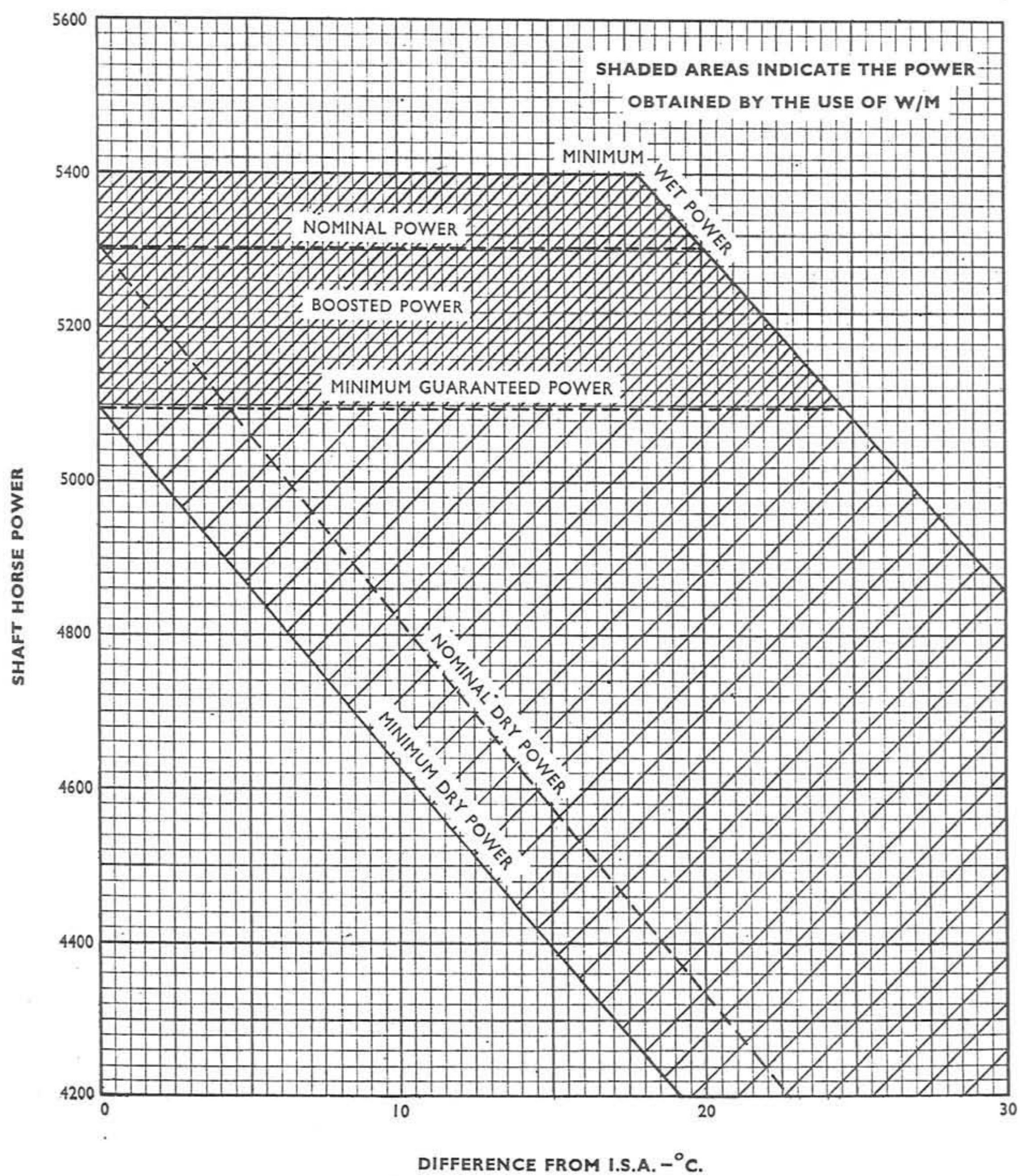
WATER/METHANOL SYSTEM



WET PERFORMANCE, STATIC, S.L.

a. A mechanical stop in the metering valve assembly deter= mines the max flow of W/M.

STARTING SYSTEM

CIRCUIT OPERATION (TRANSAFF)

1. Engine Starting (No 1 Engine)

a. Starter Master Switch. (Will remain where positioned). Move to "Start" current will energize the Interlock Relay via the No 2 Start Relay and No 1 Start Relat respectively.

i. Current for the HE boxes and air valve solenoids for both engines is made available at their re= spective Start Relays.

b. Starter Switch. Move to 'Start' current; via the No 1 switch of the Interlock Relay and the No 1 Starter Cut-out Switch, will energize the No 1 Start Relay solenoid.

i. This opens the switch through which the Interlock Relay was energized and this in turn opens the switch by which the No 1 Start Relay was energized.

ii. However, the rate at which the energy of the Inter= lock Relay decays is slower than the energy build up of the Start Relay; the Interlock switch will therefore remain closed until an alternative sup= ply is provided via the Master Switch No 1 Start Relay and the Starter Cut-out Switch.

iii. The HE units and the Air Valve solenoid are also supplied via the Master Switch and the No 1 Start Relay.

NB:i. When the Master Switch is operated, the Interlock Relay solenoid closes two switches, which in effect arms the circuit of both engines. It then depends on which Starter Switch is operated as to which Start Relay is energized.

ii. A switch not shown in the starter circuit, is operated by the Idling Throttle lever. Only when the lever is at 'Start' will the switch be closed to pass current to the appropriate Starter Switch; this avoids an abortive start by ensuring correct fuel flow.

iii. When the HP rpm reaches 5,800 the cut-out switch opens, de-energizes the Starter Relay which in turn de-energizes the Starter Air Valve, the igniter units and extinguishes the indicator lamp.

c Blow-out (Motoring the engine): This is a repetition of the starting sequence except that, having put the master switch to 'Dry Run', no current is supplied to the igniter units.

d. Air Relight: When the Starter Switch is moved to

'Relight' current is supplied to the igniter units and the indicator lamp.

PROPELLORS

1. General. Each turbo-prop engine is equipped with a HAWKER SIDDELEY DYNAMICS 4/8000/6 four bladed propellor having a diame= ter 5.486m (18 ft) and an activity factor of 120.

a. A spinner encloses the hub, which includes the pitch change mechanism and safety devices. Eng oil is used as a hydraulic control fluid. The propellor is con= trolled by the power lever in the Ground Range (Beta) and Flight Range. (Constant Speeding).

2 Propellor Features.

a. Constant speeding in the flight range.

b. Blade scheduling in the ground range (Beta).

c. Feathering by means of two independent methods ie Mechanical and Electrical.

d. An automatic frag limiting system. ADLS.

e. Mechanical and hydraulic pitch locks which are sensi= tive to both loss of oil pressure and eng overspeed.

f. A mechanical flight fine pitch stop.

g. A secondary safety device operated by the Beta feedback system.

h. A synchrophasing and synchronizing system.

j. Blade and spinner electric thermal de-icing.

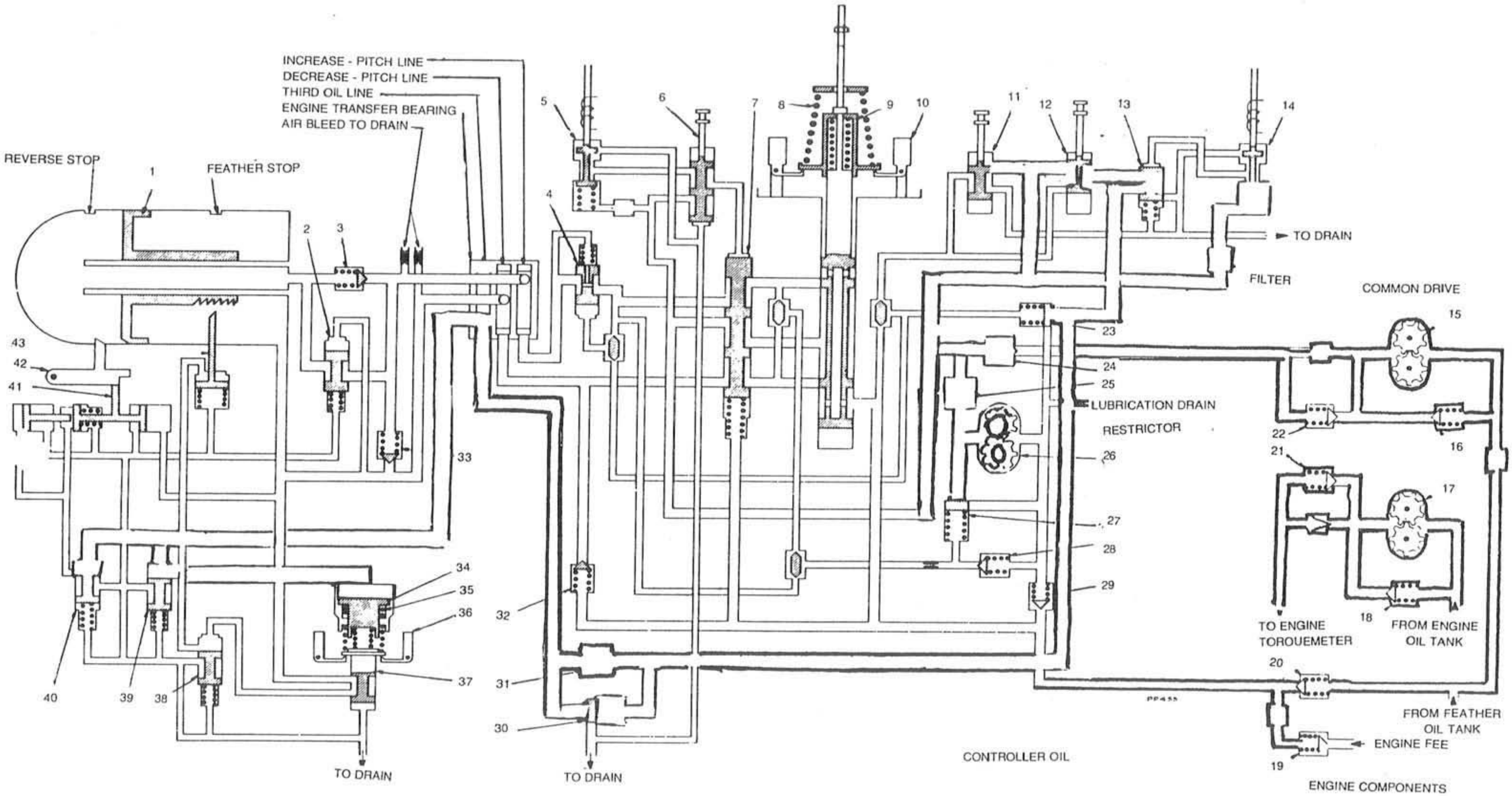
OPERATION

1. Pitch Change Mechanism. The main components of the pitch change mechanism consists of a dome, a piston, two cylindrical cams and a bevel gear ring. The dome acts as a hydraulic cylin= der within which a double walled piston slides when the oil is delivered to either side of it. Coaxially mounted between the walls of the piston are two cylindrical cams. The outer being stationary in relation to the prop hub and the inner free to rotate.

a. The gear ring is attached to the rotating cam and transmits its motion to producing a blade angle propor= tional to the piston movement. Two fixed stops limit the piston travel to the feather and reverse positions.

b. A retractable stop limits piston travel in the flight range below flight fine pitch position backed up by a secondary safety device in the case of a malfunction.

2. Propellor Governing in the Flight Range. The power lever is positioned for a certain rpm setting in the flight range. This propellor speed is then maintained at the selected rpm by means



ROPELLER

CONTROLLER

FEATHERING PUMP

of the main control valve (9) in the controller unit, (PCU) and is called a "ON SPEED" condition. The pitch-change mechanism is unable to move because it is trapped between two columns of oil. Under these conditions the out-put of the engine driven pump (26) incorporated in the controller is circulated through a relieve valve (27).

a. Should the propellor speed exceed the selected rpm a centrifugal governor (10) lifts the control valve, permitting oil under pressure from the pump to pass through the increase-pitch line and act on the piston in the pitch-change mechanism, to increase the pitch of the blades, thereby increasing the load on the engine and reducing the propellor speed.

b. In case of a decrease in rpm the flyweights will move inwards under spring pressure (8); the main control valve is lowered, reducing the oil press in the increase pitch line, and directing oil pressure, to the decrease= pitch line, assisting the twist movement caused by the centrifugal force acting on the blades.

c. This decrease in blade angle will increase the propellor rpm until it is "ON SPEED". A restrictor valve (4) is fitted in the increase pitch line to prevent the blades from turning too rapidly to a fine pitch.

3. Pitch Contol in the Beta Range.

a. When the power lever is in the Beta range it directly controls the prop blades angle. By moving the PL, the speed set cam (a) increases or decreases the compression of the main spring. (8) in the main governor (9). This movement is transmitted directly to the main control valve lowering or lifting it, directing oil press, to the decrease or increase pitch line. This action is cancelled by means of the Beta follow up mechanism. Transmitting blade angle movement through the Beta Feed Back Cam (d) to the Beta set cam. (b) The Beta control beam (Q) will centralise the main control valve when the selected blade angle is reached. When the propellor blades are in the Beta range a micro seitch is energized by a cam (r) and illuminates an amber light on the instr panel. The blade angle is controlled between Max Reverse by the power lever.

4. Mechanical Pitch Lock. This safety device in the propellor is a rachet type of pitch lock (43) which in the event of over speed or loss of hydraulic pressure, engages to prevent the blades from turning into finer pitch with consequently increased over= speeding. Because of the ratched design of the lock, there is no restriction on movement for the blades towards the feathered position.

a. The lock is normally held out of engagement by oil pressure acting on its springloaded piston; loss of oil pressure due to a failure in the control system immediately allows the lock to engage under spring pressure.

b. Should an overspeed condition occur, a centrifugal-

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governor-control-valve (37) moves against spring pres= sure and cuts off oil pressure to engage the pitch-lock.

c. The overspeed governor datum is set to operate either slightly above cruising. RPM (14,800 LP) or slightly above max rpm at (16,000 LP).

d. Engagement of the lock is inoperative in the last 10° towards feathering, and prevented in the ground range (Beta).

e. To test the pitch lock for proper operation set the power lever to a high datum value (15,000 rpm). By pressing the appropriate engine "OVERSPEED TEST" button, it energizes a solenoid valve (14) which isolates oil pressure in the third oil line. This returns the go= vernor setting to a low datum which induce a pitch lock. By reducing the trim (cond lever) LP rpm should follow if lock is engaged.

5. Hydraulic Pitch Lock. This is an additional safety feature which hydraulically locks the main piston (1) towards fine pitch in case of oil pressure drop. The hyd pitch lock (2) is normally held open by oil press from the decrease pitch line and is situa= ted in the increase pitch line.

a. Should a failure of press occur the hyd pitch lock (2) will close under spring press, thus trapping the oil in the increase pitch line, preventing the blades from decreasing pitch to prevent overspeeding.

b. A check valve (3) by-passes the hyd pitch lock (2) and allows oil from the tandem feather pump to reach the pitch change mechanism to feather the propellor.

c. The purpose of the hyd pitch lock is to prevent damage to the mech pitch lock, in case of overspeeding or oil press LOSS, by operating first.

6. Mechanical Flight Fine Pitch Stop : (FFPS). The flight fine pitch stop (42) limits the travel of the main piston (1) towards decrease pitch beyond F Idle.

a. A mechanical stop called the Air/Ground lever prevents the power lever to be retarded from flight idle into the Beta range. When the Air/Ground lever is in the Ground position it allows the power lever to be retarded into the Beta range. When the power lever is retarded into the Beta range it operates a cam which actuates a FFPS valve (2) which directs high pressure oil via a shuttle valve to the third oil line. This high oil press, moves the FFPS servo valve (40) permitting oil to the zervo pistons (41) which allows the links of the FFPS (42) to fall out of engagement allowing the piston (1) to move into the Beta range.

b. When the power lever is returned to the flight range the cam lowers the FFPS with drawel valve (2) opening the third oil line to drain which allows servo piston (41) to return to its normal position under spring action.

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c. A press relief valve (3) makes it impossible for the stop to be withdrawn in flight, in the event of an inter-line oil leak.

7. Secondary Safety Device and Indication. A secondary safety stop is set to operate 2° to 3° below the setting of the FFPS in the event of accidental withdrawal due to failure.

a. Operation of this system is initiated when micro switches actuated by the Beta feed back mechanism, energizes the coarse pitch solenoid valve which directs oil press to the increase pitch line. As the pitch increases the micro switches are de-energized, and the cycle is repeated, causing a hunting effect of the propellor indicated by a flashing Beta light. This action is so small and rapid that it has no noticeable effect on the A/C.

b. When the power lever is retarded into the Beta range, this system is de-energized by means of micro-switches actuated by the power lever.

8. Automatic Drag-Limiting System (ADLS). This system performs a primary safety function in flight by increasing the prop pitch in case of eng or prop failure, in order to avoid a high and sudden drag increase.

a. This system is actuated by movement of the annulus gear in the eng reduction gear. This movement takes place at different eng torque valves according to power lever positions.

b. The movement of the annulus gear is mechanically trans= mitted to the servo valve (6) which in turn hydrauli= cally controls the opening of the increase pitch valve (7) and directing main pump oil pressure to the in= crease pitch line.

c. The ADLS servo valve (6) actuates a micro switch (c) which illuminates a ADLS light on the instr panel. This system is actuated as long as an ADLS condition exists.

d. When the PL is in flight idle or the Beta control range the datum is varied to permit the necessary approach and landing drag to be obtained.

e. In case of an eng failure the drag is limited, due to a rapid coarsening of the blades towards feather.

9. Feathering. When the condition lever (H) is placed in the "PROP" feather position it mechanically raises the main control valve (9) to the "increase pitch" position, at the same time a micro switch is made by the condition lever energizing the coarse pitch solenoid valve (5) which hydraulically positions the coarse pitch valve (7) porting main pump oil press to the increase pitch line. Output of main oil pump decreases with eng rpm.

a. By depressing the "Prop feather pump" push buttons it energizes the electric feather pump which supplies the pressure required to complete the sequence.

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b. In case of fire or in the event of a failure of the condition lever control, the foregoing operations can be initiated simultaneously by pulling the fire handle of the concerned engine. By turning this handle it de-energizes the pump and discharges the fire ext bottles.

c. Provision is made to energize the coarse pitch solenoid valve in the controller unit by pressing the coarse pitch test buttons behind the condition levers.

10. Unfeathering. By placing the cond lever in the HP closed position, the coarse pitch solenoid valve is de-energized and main control valve is mechanically lowered to the decrease pitch position, under action of the governor spring (8). When depres= sing feather, pump push button, oil pressure from the feathering pump is directed to the decrease pitch line holding the mechanical and hyd pitch locks open, allowing the propellor blades to de= crease pitch thus unfeathering.

a. A secondary pump driven in tandem with the feathering pump supplies adequate oil press to the eng torque meter and ADLS system during unfeathering.

11. Synchrophasing System. A synchrophasing system is incorpo= rated to maintain synchronization and blade relationship between the two propellors, to reduce noise level and virbration during flight. A synchrophasing alternator on each eng, driven at 4 times propellor speed produces a reference signal for the syn= chrophasing computer which senses and compares the signals from the two propellors and operates the trim servo motor mounted on the PCU of No 2 eng thereby maintaining synchronization and blade relationship.

12. The system is inoperative under the following conditions:

a. If the rpm differs by more than 150 LP rpm.

b. A power surge of $\pm$ 15 HP.

c. When the PL is in the "TAKE OFF" position.

d. Condition lever in the "PROP FEATH" position.