

# SECTION 5

## CONTENTS

- 1 ENGINE INSTALLATION
- 2 JET PIPE INSTALLATION
- 3 SETTING OF CONTROLS
- 4 FILLING THE OIL TANK
- 5 BLEEDING THE FUEL SYSTEM
- 6 REMOVAL OF E.C.U.
- 7 INTRODUCTION TO  
AIRCRAFT FUEL SYSTEM
- 8 COCKPIT LAYOUT
- 9 FIRE EXTINGUISHERS
- 10 ENGINE RUNNING  
INSTRUCTIONS

ENGINE INSTALLATIONGeneral

Before an engine is removed or installed, the rigging angle of the aircraft must be checked, the procedure being as follows : -

- (1) Gain access to the undercarriage bay where two spaced  $\frac{3}{8}$  inch diameter holes will be found drilled in the inboard rib.
- (2) Insert a  $\frac{3}{8}$  inch diameter steel rod in each hole and lay across them a straight edge.
- (3) Using a Clinometer check the aircraft rigging angle which, although normally is plus  $5^{\circ}$ , will vary according to surface level, tyre pressure etc.
- (4) This rigging angle should be recorded as when the engine is installed, the sum of the aircraft angle plus 2 degrees 45 minutes, becomes the true aircraft/engine linearity. e.g. if the aircraft rigging angle is found to be four degrees 17 minutes then the true angle would be 7 degrees 02 minutes. Inversely, if the aircraft rigging angle is 5 degrees 41 minutes then the true engine angle would be 8 degrees 26 minutes.
- (5) When it is necessary to change an engine already installed, a simplified procedure would be to check the engine angle prior to removal. This enables the new engine to be installed in the original position.

Preparation of engine for installation

The engine should be mounted in a mobile stand, securely fastened during transport, and lined up beneath the engine bay into which it is to be installed.

(Note: the present type of engine winch calls for the E.C.U. to be mounted in a high mobile stand due to the length of winch cable which does not provide for the aircraft being on hydraulic jacks.)

(1) Engage the hooks at the top of the winches with the attachment points provided in the engine bay. The winches should be engaged with the front hooks facing rearwards, and the rear hooks facing forward, whilst the winding end of the winches should face 'away' from the engine. At this stage the front winches must be positioned in front of the air intake casing.

(2) With a suitable number of personnel stationed at each winch and another man to act in a supervisory capacity, the E.C.U. may be lifted from its stand by giving each winch a simultaneous number of turns, taking special care that the common engine breather pipe and other engine attachments do not foul the stand whilst lifting is in progress. When the E.C.U. has been raised high enough the stand may be removed.

(3) When the stand has been removed the fixed trunnion bearing can be assembled, the procedure for this being as follows : -

- (a) Fit a .3 inch distance piece on the trunnion ensuring that the bore radius is nearest to the engine.
- (b) Lubricate the trunnion and fit the phosphor bronze bearing.
- (c) Fit spacing washer. The Contractor supplies a range of .202 - .206 inch spacing washers, to ensure that the bearing is being 'nipped'
- (d) Assemble the end plate, tab washer and bolt to the threaded portion of the trunnion, ensuring that the tap of the locking washer has fully engaged with the hole provided in the trunnion.

With a .....

- (e) With a  $\frac{3}{4}$  inch spanner tighten the complete assembly and turn back the locking tab in the usual manner.
- (f) Fit the free floating phospher bronze bearing to the trunnion on the opposite side of the engine, no distance piece or spacing washers being required.

(NOTE: The fixed bearing when attached to the engine bay centre rib is positioned on the port side of Nos. 2 and 4 engines, and the Starboard side of Nos. 1 and 3).

#### Installation of E.C.U.

At the call of the operator in charge of the E.C.U. installation, each winch is given a simultaneous number of turns, and just before the E.C.U. enters the engine bay the front winches, port side first, should be brought from the front of the air intake casing and positioned behind the front mounting trunnions.

The E.C.U. is now brought into the engine bay in easy stages, half or quarter turns only being given on the winches careful attention being paid to those items which are likely to foul aircraft fittings.

With the E.C.U. approximately half way into the bay the front winches only are given 18 full turns in order that the angle of the E.C.U. will become approximately parallel to that of the aircraft, and this can be checked by the use of a Clinometer. At the same time it is necessary for one man to position himself above the engine in order to observe that the E.C.U. bulkheads are engaging correctly with those of the aircraft.

(Note: The figure of 18 turns given above is based on an aircraft angle of  $5^{\circ}$ , for a greater or lesser angle the number of turns must be proportional)

The E.C.U. is now raised slightly above its correct position and the fixed bearing trunnion housing swivelled into position to mate up with the engine phosphor bronze bearing. The bottom housing bolt is now fitted, and the engine lowered until the fixed bearing is seated in its housing. With the aid of a torch and mirror ensure that the bearing is seating correctly.

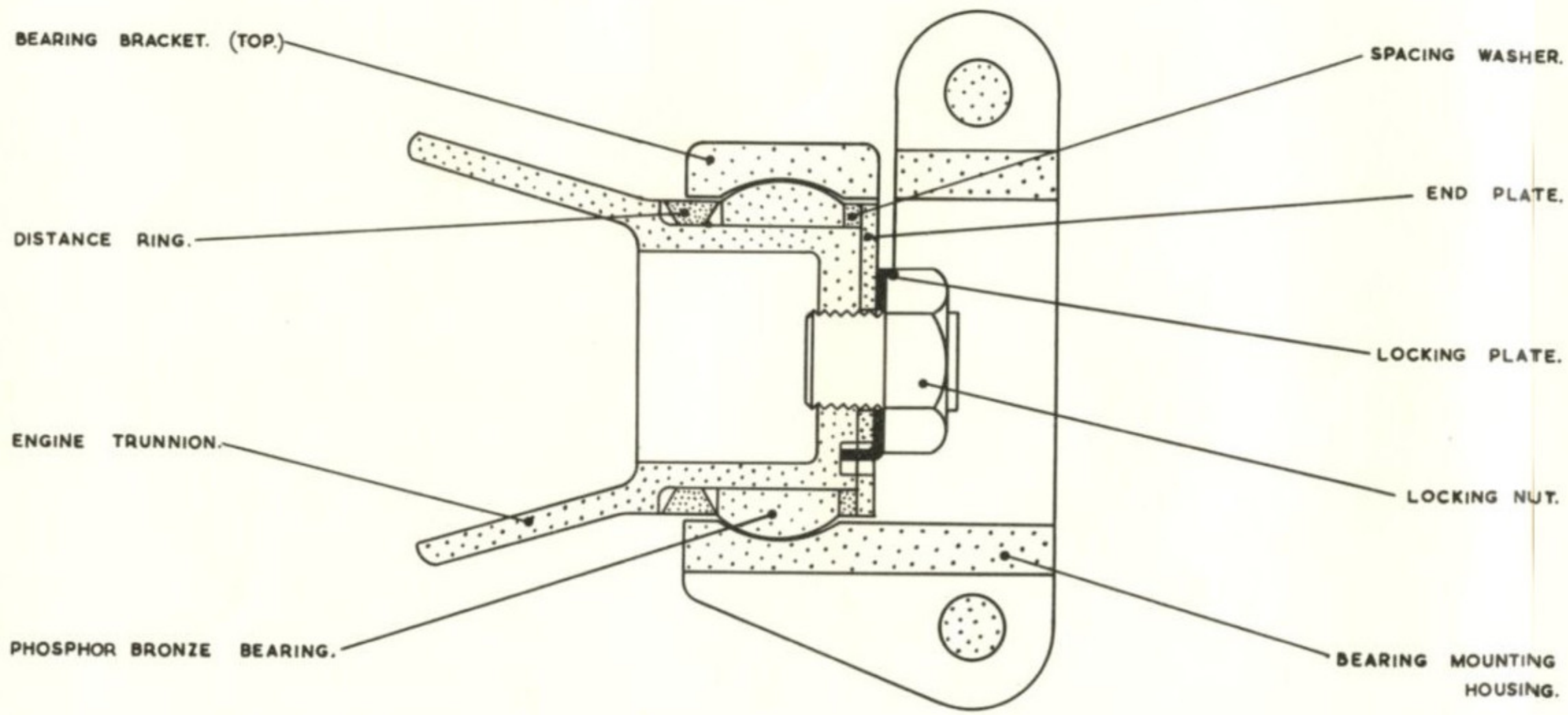
The same procedure is now adopted for the free floating bearing, and after ensuring that both bearings have seated correctly, the top halves of the bearing housings should be bolted into position. (Note: Experience has shown that by fitting the fixed bearing in its housing first, the amount of engine manoeuvring is reduced to a minimum).

The front suspension link may now be fitted, making sure that (a) the flange of the floating bush is outside the mounting bracket, and (b) there are an equal number of threads visible either side of the turnbuckle.

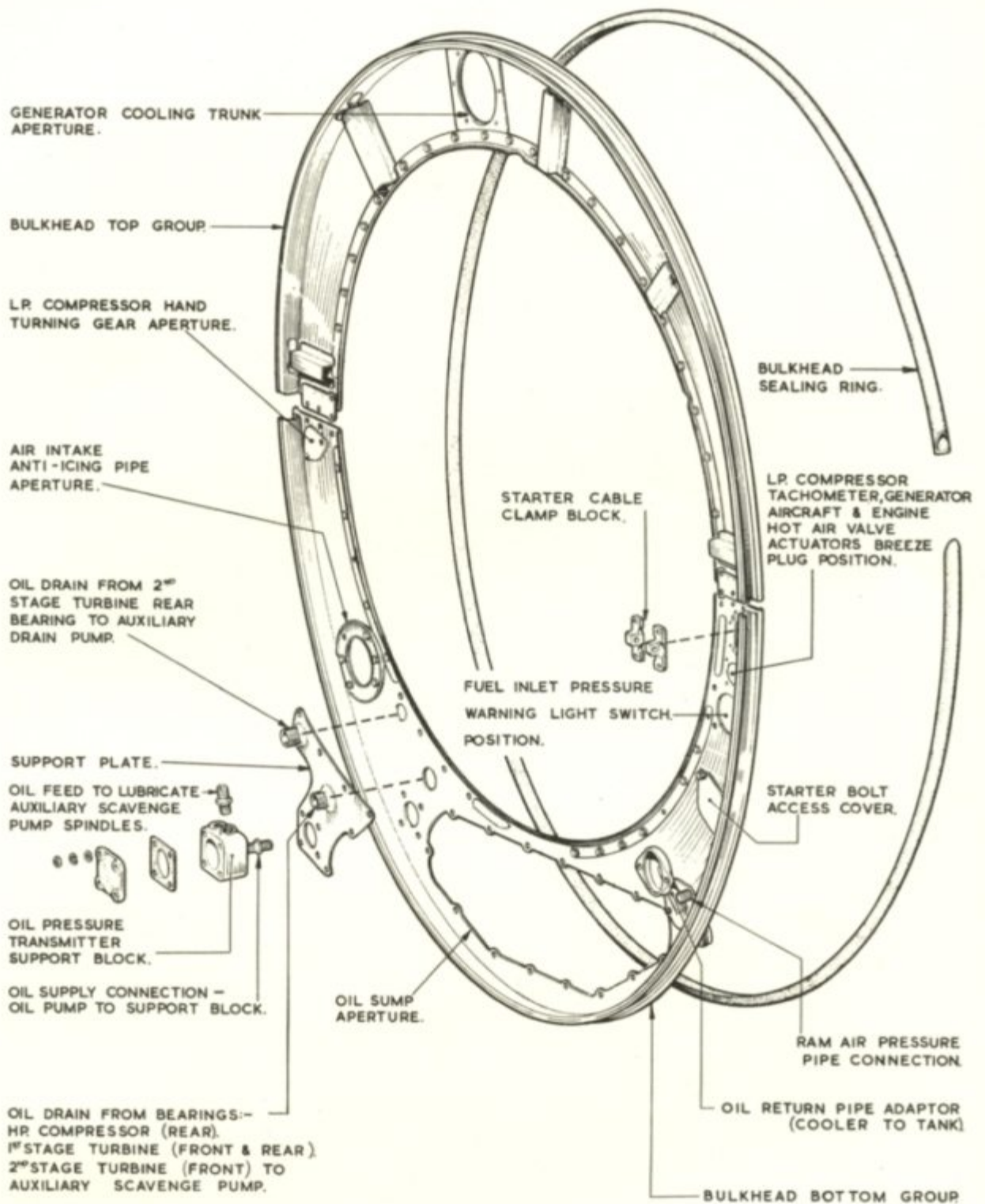
The four hoisting winches may now be removed.

Place a straight edge across the front face of the air intake casing, and with the use of a Clinometer check the angle of the engine and make such adjustments to the front suspension link which may be found necessary in order to obtain the required angle as described in the 'General'.

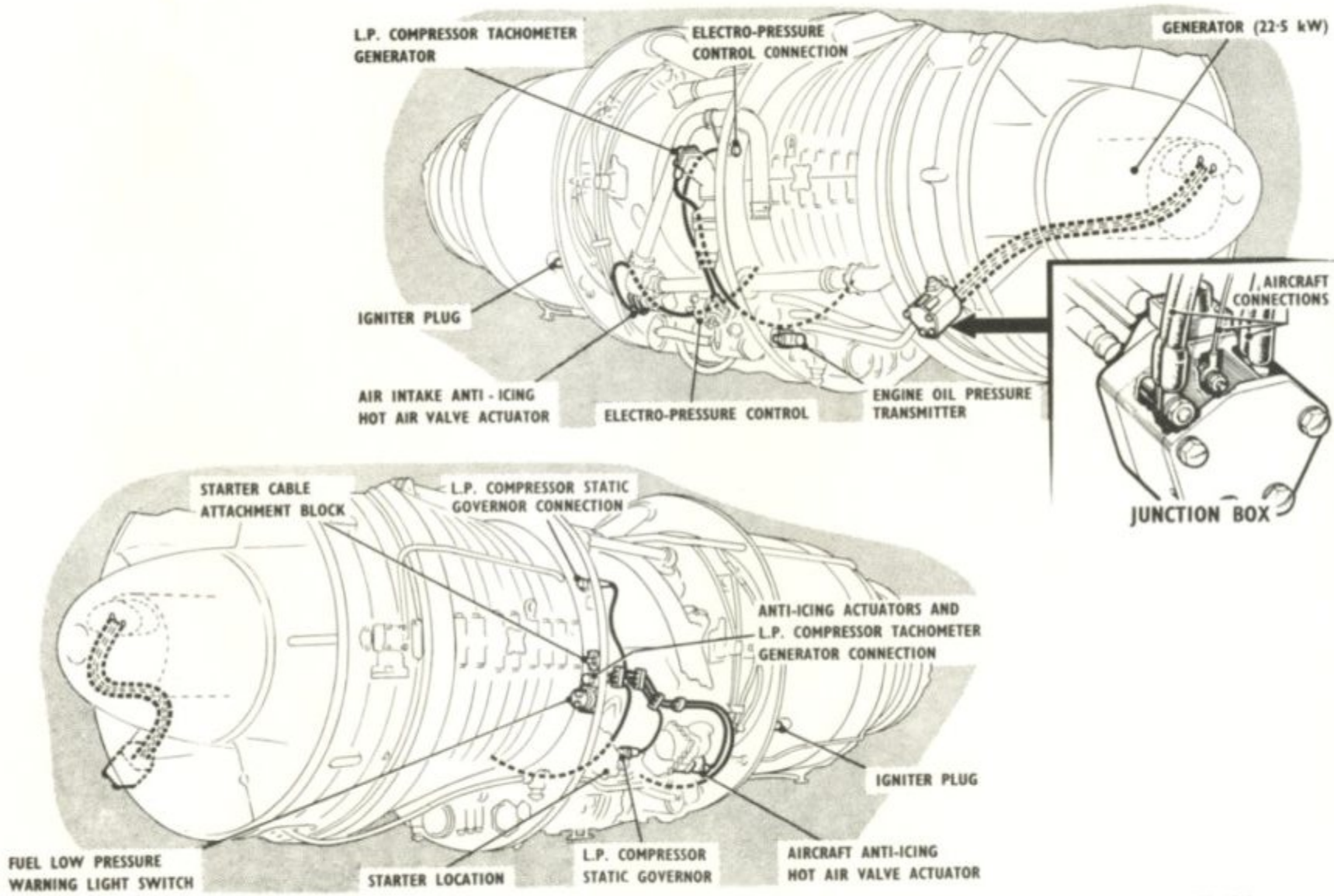
After the angle of the engine has been set, finally ensure that the front link is in safety, the lock nuts tight, and the turnbuckle wire-locked and sealed. The rear trunnion bearing housings and mounting bracket bolts should be checked for tightness and split-pinned.



ARRANGEMENT OF FIXED TRUNNION.



OLYMPUS 101.  
FRONT BULKHEAD.



**ELECTRICAL SYSTEM**

REMOVAL OF E.C.U.

Open and remove the engine bay doors ensuring that the jury strut is in position.

Unlock the three toggle fasteners of the ducted air intake, and remove both halves of the intake complete with sealing rings.

After closing the low pressure cocks and using the appropriate 'C' spanner, undo the nut of the main fuel feed pipe fitted to the 'King' coupling on the E.C.U. and also the nut of the pipe joint on the engine bay rib. Disconnect the pipe from the support bracket on the front of the L.P. compressor and remove the pipe.

Disconnect the starter leads from the engine bay rib, one lead being connected to an earthing stud, and the other to a junction box, the cover of which is secured by two screws.

Loosen the four nuts of the generator cable junction box on the E.C.U. and, after removing the cover, undo the three cable connections in the box and also disconnect the Breeze plug on the outside of the box. Replace the cover.

Disconnect the three Avery couplings of the hydraulic pump pipes from the bracket on the engine bay rib.

Loosen and remove the three Breeze plug connections on the front face of the E.C.U. bulkhead. These plugs carry the cables for the (a) fuel warning light, (b) oil pressure indicator, and (c) hot air valve actuator, engine anti-icing actuator and L.P. compressor R.P.M. indicator.

On the R.H. side of the aircraft bulkhead are the union nut connections for the recuperator system pipe. Undo the connections on both sides of the bulkhead.

The front bulkhead may now be taken off by (a) removing the 2 BA bolts running parallel and vertical with the bay rib, (b) the 2 BA bolts holding the fair leads for the engine control rod and igniter plug leads, and (c) the 3/16 B.S.F. nuts securing the two halves of the bulkhead together.

Beginning in zone 2A, undo the nut of the recuperator system pipe at the bracket on the engine bay rib and remove the pipe. Remove the two clips securing the flexible pipe (bracket to E.C.U.) on the bay rib and disconnect the union nut. Leave the flexible pipe attached to the E.C.U. the reason for this being that it simplifies fitment when an E.C.U. is being re-installed.

The hydraulic reservoir flexible pipe is next removed by disconnecting the union nut on the engine H.A.V. casing.

Remove the manacle clamp securing the aircraft anti-icing and cabin heating pipe to the E.C.U. and also the manacle clamp at the first joint of the pipe which will be found situated on the engine bay rib. Remove this section of the pipe entirely.

On the opposite bay rib is the bay inlet cooling pipe which is held in position by two bolts and two dowels. Remove the bolts and take away the pipe.

Remove the control rod between the Full Range Flow Control throttle lever and the engine bay rib bell-crank by disconnecting the bolts at either end. The control rod from the other side of the

bell-crank.....

bell-crank and running parallel with the bay rib to a bolted joint in the bay 1 is also removed entirely after a small shield over one portion of the rod has been removed. The reason for removing this rod is because it will be fouled by the E.C.U. installation or removal winch.

On either side of the rear bulkhead are fair leads for the igniter plug cables, held in position by four 2 BA bolts. Remove the bolts, disconnect the cables from the igniter plugs, and pass them through the bulkhead.

The rear bulkhead is now taken off by removing the 2 BA bolts running parallel and vertical with the bay rib and the 3/16 B.S.F. nuts securing the two halves of the bulkhead together.

Gain access to the aircraft pyrometry leads through a trap door at the top rear end of the jet pipe tunnel and disconnect the leads, following which the jet pipe to E.C.U. attachment can be broken down by a reversal of the procedure given in the notes under the heading of 'Preparation of Jet Pipe Assembly'.

Attach the four winches to the links provided in zone 1 and zone 2 B and the cables to the appropriate lifting eyes on the L.P. compressor and turbine annulus, and take the weight of the E.C.U.

Remove the E.C.U. by a reversal of the procedure given in the notes under the heading 'Installation of E.C.U.'

INSTALLATION OF JET PIPE

Using the approved web sling place the jet pipe in a mobile stand designed to carry the pipe on its fore and aft rollers, on which they are free to slide into the jet pipe tunnel. The stand has four ratchet type adjustable jacks which are used for carrying the angle of the jet pipe to suit the angle of the aircraft.

After placing the stand in position ease the jet pipe into the tunnel, locating the rollers on the guide rails and pushing the jet pipe into a position approximately three inches from the end of the E.C.U.

It is to be noted that the top roller is also used on the outboard installations their use being to counteract side thrust, whilst the centre rollers of all jet pipes must be 'proud' of the guide rails when in position, their sole use being to facilitate the fitting or removal of the jet pipe.

Remove the blank from the end of the E.C.U. and then (a) disconnect the exhaust cone shroud securing wires and remove the top half of the shroud, (b) push the bellows joint assembly towards the front of the engine as far as possible, (c) apply Squires High Temperature jointing compound to the jet pipe flange and also to that of the bellows joint flange.

With two men at the nozzle end of the jet pipe and two others at the attachment end, push the jet pipe forward until there is full engagement with the exhaust cone flange, and providing that the E.C.U./aircraft

linearity has been set accurately, no difficulty should be encountered.

Fit the two retaining channels and hold in position by hand, pull the jet pipe rearwards where a movement of .4 inches must be observed; the effect of this movement will be to 'nip' the retaining channels.

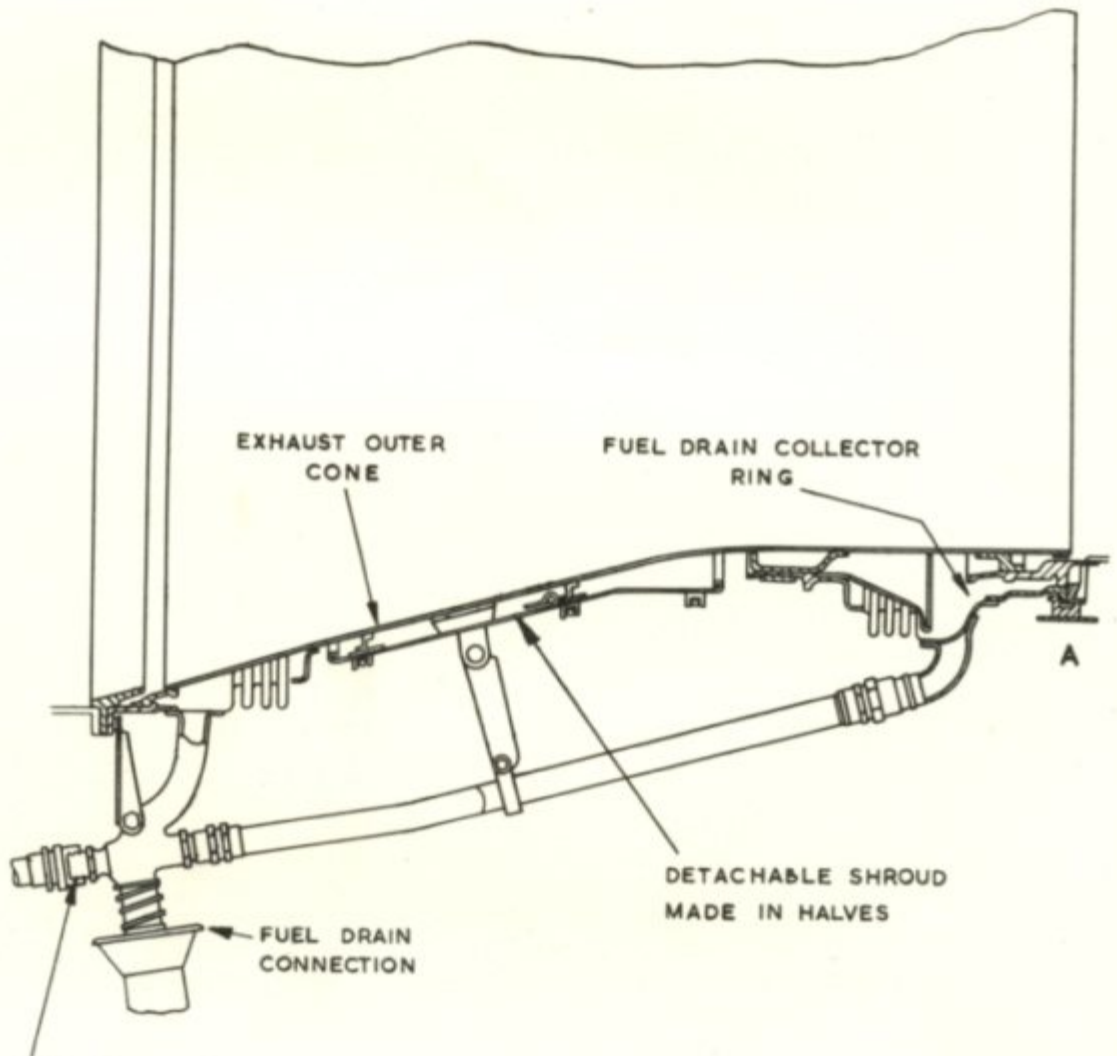
After ensuring that this .4 inch movement is positive leave the jet pipe in the rear position. The bellows joint can now be pushed back over the retaining channels to mate up with the jet pipe flange ensuring that the 3/16 inch dowel in the bellows joint flange engages correctly with the hole in the jet pipe flange.

Fit the double manacle clamp and tighten the tensioning bolts sufficiently to hold the assembly in position. The front bellows single manacle clamp is now fitted and the tensioning bolt tightened. It is now necessary to torque load both sets of clamps, this should be carried out using an appropriate torque spanner set at 80.lbs.ins., after which the bolts are to be wire locked.

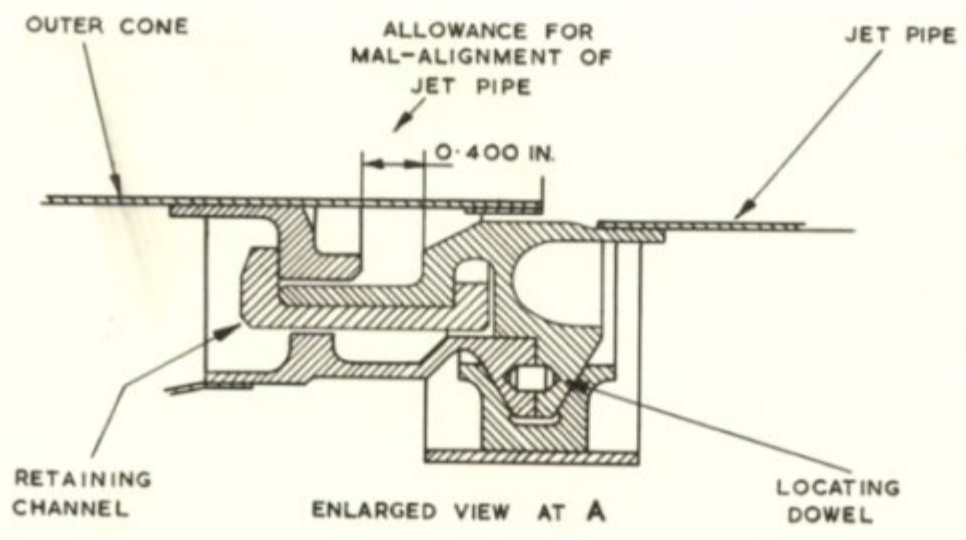
Check that the jet pipe is still free to move, and that the fore and aft rollers are resting on the guide rails. The original .4 inch movement will now only become effective when jet pipe expansion or contraction takes place under engine running conditions, but a certain amount of free movement of the bellows joint can be felt.

Refit the exhaust cone shroud ensuring that the correct securing wires are in their appropriate positions, the longest wire being placed in the front channel.

Fit a blank to the jet pipe nozzle and connect the flexible fuel drain pipe to the adaptor provided on the bellows joint and wire-lock.



FUEL DRAIN CONNECTION FROM COMBUSTION CHAMBERS AND TURBINE ANNULUS.



OLYMPUS 101

EXHAUST OUTER CONE AND SHROUD

SETTING THROTTLE CONTROLS

The aircraft throttle control system is made up of push-pull rods and  $90^{\circ}$  bell cranks, whilst the only control adjustment on the engine is the throttle lever assembly on the Full Range Flow Control.

Setting

Position the pilots' throttle lever in the mid-position and attach the control rod from the centre engine bay rib to the throttle lever arm on the Full Range Flow Control.

Operate the pilots' throttle lever from the H.P. cock Shut position to the Take-Off position and check that contact is made on the stops at each end of the F.R.F.C. with throttle spring of .250 inches at both H.P. cock Shut and Take-Off positions on the throttle quadrant.

In order to obtain this setting it will be necessary to :

- (a) Make adjustments to the angle of the lever on the F.R.F.C. by means of the vernier coupling.
- (b) Alter the length of the fork end at the first bell crank in the aircraft control system, situated at the centre wall of Zone 2A. This adjustment will increase or decrease the arc of travel.
- (c) Alter the length of the aircraft control rod, which will alter the relation of the throttle movement in the cockpit with that on the F.R.F.C.

Whenever any adjustment is made it is essential that complete locking is made and no final locking left to a later stage.

On satisfactory ...

On satisfactory completion of this operation move the throttle lever to the idling gate and check that the H.P. cock operating dowel is clear of its slot.

Repeat this procedure on all engines making every effort to keep the throttles aligned at the H.P. cock shut and full throttle positions only, for the idling stops are set at a later stage.

FILLING THE OIL TANK

The oil tank is pressure filled via the Avery coupling of the common filler and drain connection on the oil sump, the oil being forced along the exterior rigid pipe, and through the duct in No.2 air intake casing vane, into the tank. The level of the oil in the tank actuates a float valve, which is connected to the downward facing indicator at the outer end of No.4 air intake casing vane. To prevent over filling the tank, an overflow connection is fitted in the oil cooler to tank return pipe, and when filling the tank the cap of this connection must be removed. On removal of the cap, approximately half a pint of oil will flow from the pipe, no more oil will then flow until the tank is over-filled, when pressure filling must cease and the cap be refitted.

When the engine has been standing idle for prolonged periods, oil may drain from the oil tank into the engine sump, via the check valve in the oil pump. This results in a low or zero reading of the contents gauge., therefore before starting the engine or before refilling (with the consequent possibility of over-filling) the engine sump should be drained or a dry motoring cycle carried out.

## BLEEDING THE ENGINE

### FUEL SYSTEM

Always bleed the engine fuel system under the following conditions to remove all air from the system :

1. Before starting the engine after installation.
2. When de-inhibiting the engine.
3. When a fuel system defect is suspected.
4. After any part of the system has been disconnected.
5. When the L.P. cocks have been closed inadvertently before the engine ceases to rotate.
6. Following the draining and subsequent re-filling of the fuel tanks.

### FUEL FILTER

- (1) The fuel filter bleed valve is situated at the top of its housing, remove the locking wire and screw out the bleed union one complete turn. Attach a suitable rubber hose pipe to the bleed union to drain fuel away from the engine.

Switch on the main fuel tank booster pumps to "Manual" and wait until bubble free fuel flows from the bleed. Screw in the bleed valve one complete turn, and wire lock.

### ENGINE FUEL PUMP

- (2) The main fuel pump bleed is situated above the H.P.C. governor adjustment and the procedure is the same except that the H.P. compressor must be rotated by means of a 2BA socket spanner fitted to the hexagonal end of the starter motor shaft.

### CRUISE GOVERNOR

- (3) During the bleeding operation of the cruise governor the L.P. compressor must be rotated. To turn the compressor insert a suitable turning bar through the access panel in the front bulkhead and fit it to the hexagon on the end of the L.P. compressor tachometer generator drive shaft. Use a socket spanner to rotate the bar and compressor.

Then proceed to open the bleed valve on cruise governor.

### L.P. COMPRESSOR GOVERNOR

- (4) Open up the bleed valve and again turn the L.P. Compressor during the bleeding.

When bleeding has been completed ensure that the four bleed valves have been re-tightened and wire locked.

NOTE : Although the cruise governor is no longer in use and is electrically disconnected, it still remains part of the fuel system and must therefore be included in the bleeding operation.

AIRCRAFT FUEL SYSTEM

The tanks are located five in each wing and four in the fuselage. They are arranged symmetrically about the aircraft centre line and are numbered one to seven on each side.

The seven tanks on each side of the aircraft are divided into engine groups comprising tanks 1, 4, 5 and 7 to the outboard and tanks 2, 3 and 6 to the inboard engines.

A cross-feed cock is provided between each group and between port and starboard side of the aircraft. Thus any one tank can feed any engine in an emergency.

Due to the shape of the aircraft the fuel tanks are dispersed forward and aft of the aircraft centre of gravity, it is therefore important that fuel balance is maintained throughout a flight. This is provided for by the incorporation of two sequence timers, by use of which a small quantity of fuel is pumped from each tank in turn. The quantity of fuel pumped from each tank during one cycle of the sequence timers is proportioned to the tank capacity, and thus the fuel centre of gravity is kept constant.

A sequence timer consists of seven pairs of contacts operated by seven irregularly profiled cams, mounted on a shaft which is rotated at a constant speed by an electric motor. Four of the cams control the tank pump motors of No.1 engine tank group whilst the remaining three cams control the motors of No.2 engine tank group. Each cam is profiled so that the contacts break for a part of each revolution of the cam shaft and make for the remaining part. The motor wiring is connected so that when the contacts are broken the motor runs at full speed, and a reduced

speed when the .....

speed when the contacts are made. The two groups of cams are arranged on the shaft so that for each revolution of the cam shaft each pair of contacts break for a set period, thus only one tank pump motor in each group will be running at full speed at any particular time.

The controls for the fuel system are arranged on a console located between the 1st and 2nd pilots seats, and are grouped to represent a plan view of the aircraft fuel system. All fuel tanks and pipelines are shown diagrammatically in contrasting colours to distinguish the various tank groups. The colour code is as follows:-

|       |   |      |        |      |       |   |           |      |
|-------|---|------|--------|------|-------|---|-----------|------|
| BLUE  | - | No.2 | engine | tank | group | - | port      | side |
| "     |   | No.3 | "      | "    | "     |   | starboard | side |
| AMBER | - | No.1 | "      | "    | "     |   | port      | side |
| "     |   | No.4 | "      | "    | "     |   | starboard | side |

Blue and Amber - Transfer - Fuel trim No.1 to No.7 tank on each side.

#### Tank Pump Switches and Tank Contents Switches

Positioned in the diagrammatical representation of each fuel tank are two switches, one press button switch for selecting a fuel contents reading for the tank concerned and one ON/OFF toggle switch controlling the pump motor of the same tank.

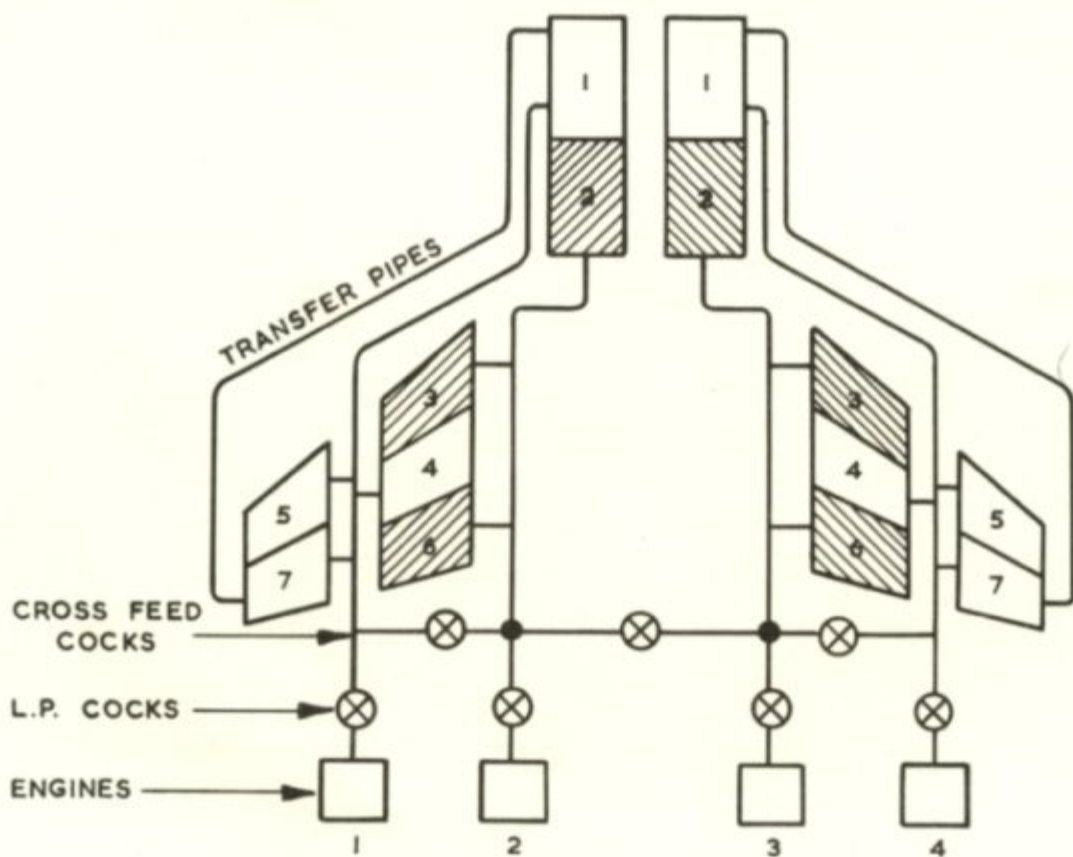
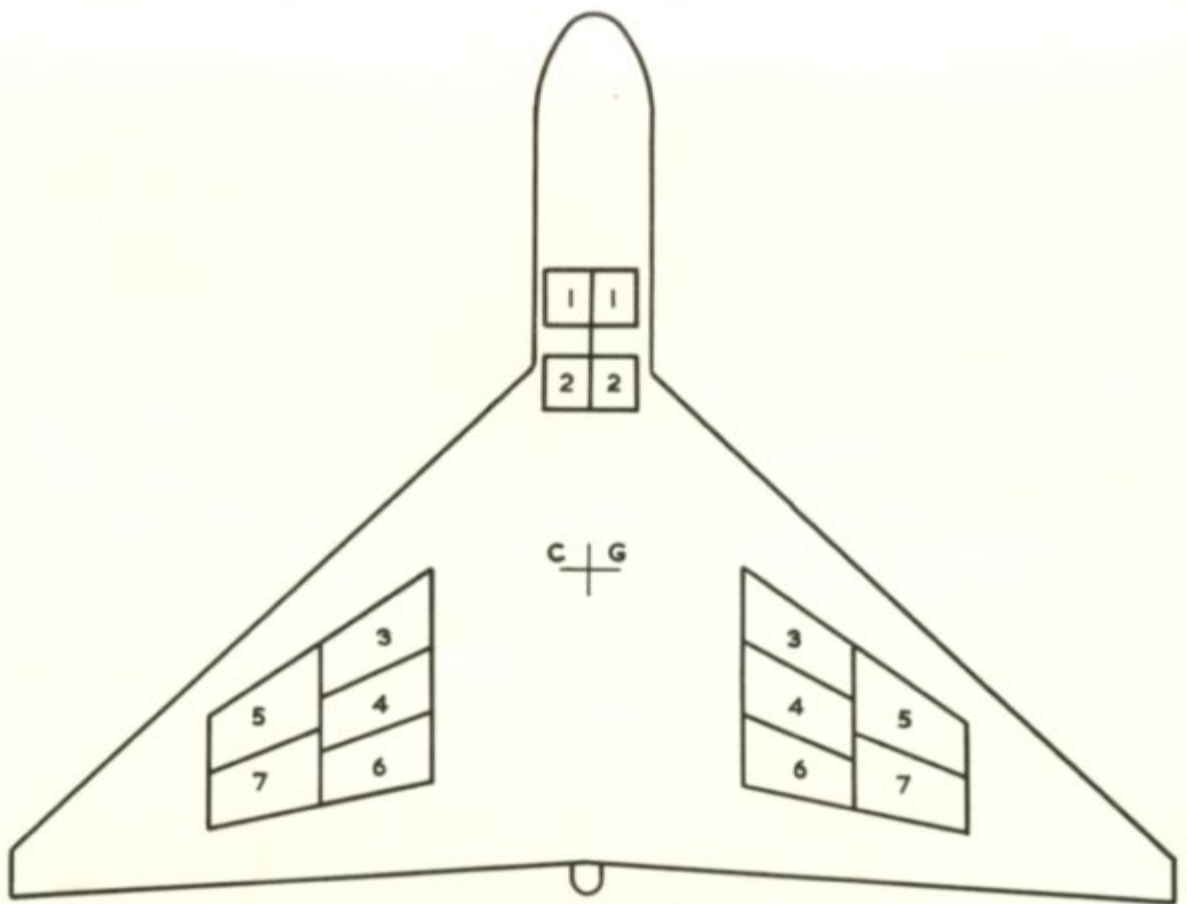
#### Rate of Fuel Flow Switches

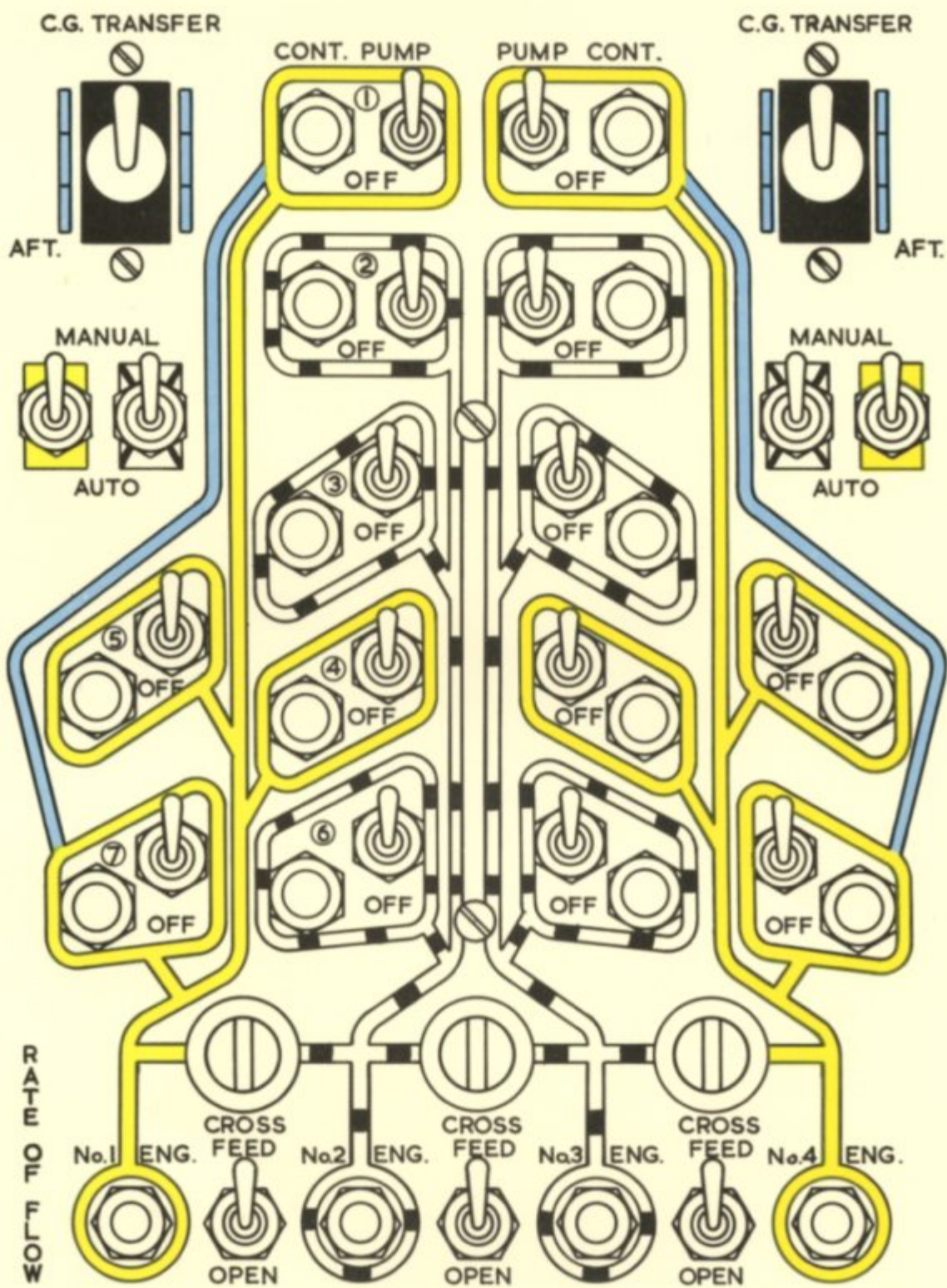
The four press button switches operate a fuel flow indicator, situated on the 2nd pilots instrument panel, which indicates the rate of fuel flow in lbs/hr for each particular engine.

#### Cross Feed Switches and Indicators

Three two position toggle switches with magnetic indicators are positioned on the console between the rate of flow selector switch.

They control and .....





TP.3253.

### AVRO-VULCAN FUEL PANEL

Figure 5.

COCKPIT LAYOUTKEY TO ENGINE AND FUEL SYSTEM CONTROLS

1. J.P.T. datum switch.
2. Fuel system control panel.
3. Engine MASTER switch.  
Forward - ON - starter button (7) operative.  
Rearward - OFF.
4. Magnetic indicator.  
White - on - indicates that 24V battery has been  
linked to 96V battery thus permitting  
emergency start.
5. Engine starting rotary selector.
6. Ignition isolation switch (guarded)  
Forward - ON - places ignition in circuit.  
Vertical - OFF - ignition system isolated.
7. Engine starter button.  
Press to operate.
8. Oil pressure gauges.
9. Engine r.p.m. tachometers
10. Jet pipe temperature gauges.
11. Engine control indicator  
operated by item (1)
12. L.P. cock switches (guarded)  
Forward - ON.  
Rearward - OFF.
13. Engine fire indicator/operating switches (guarded)  
Illuminated red when engine bay temperature is  
excessive; press to operate (pull to test  
filament)
14. Fuel low pressure indicators  
Low - pressure below 5.lb. per sq. in.  
HIGH - pressure above 5.lb. " " "

15. Fuel flow indicator

Indicates rate-of-flow for any engine when relevant switch selected on fuel control panel.

16. Fuel C.G. indicator.

17. Fuel tank contents panel houses four contents gauges, one to each group of tanks, i.e. No.1 and 3 groups (No.1, 4, 5 and 7 tanks) No.2 and 4 groups (No.2, 3 and 6 tanks). Outer ring indicates group totals. Inner ring indicates individual tank contents when relevant switch on fuel control panel (item 2) is depressed.

18. Probe de-icing switch.

19. Nitrogen purge switch.

20. Master switch, flight refuelling.

21. Tanks full indicator.

22. Tank pressurisation control switch.

23. Throttle friction adjuster.

24. Throttle levers

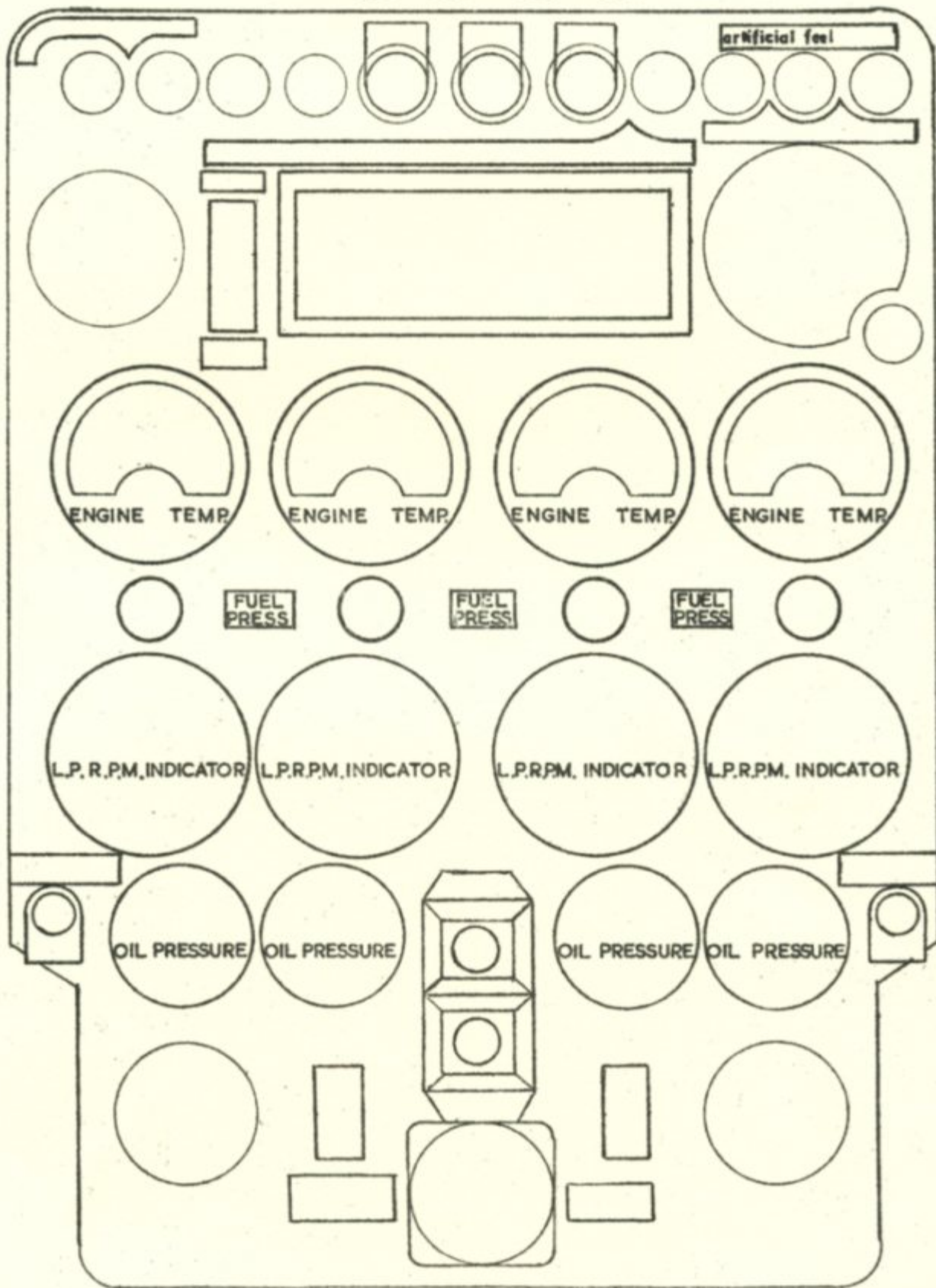
(Initial movement through the gate operates the engine H.P. cock)



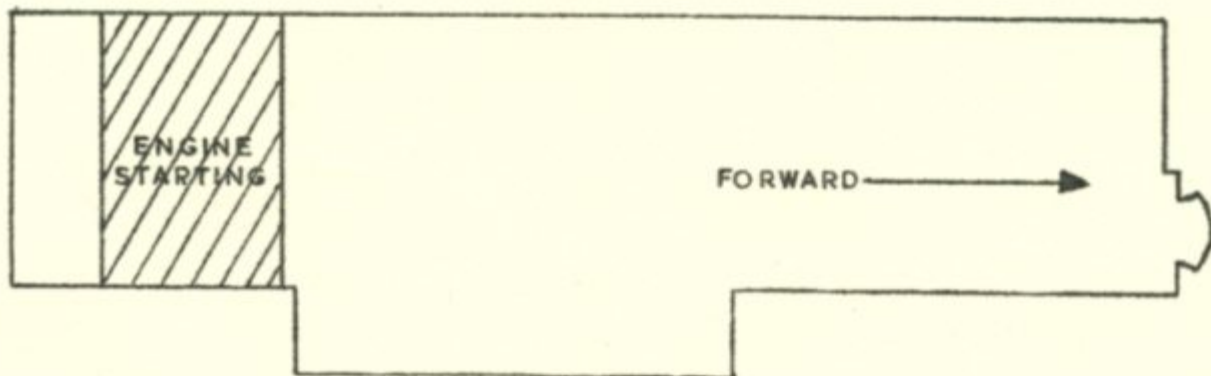
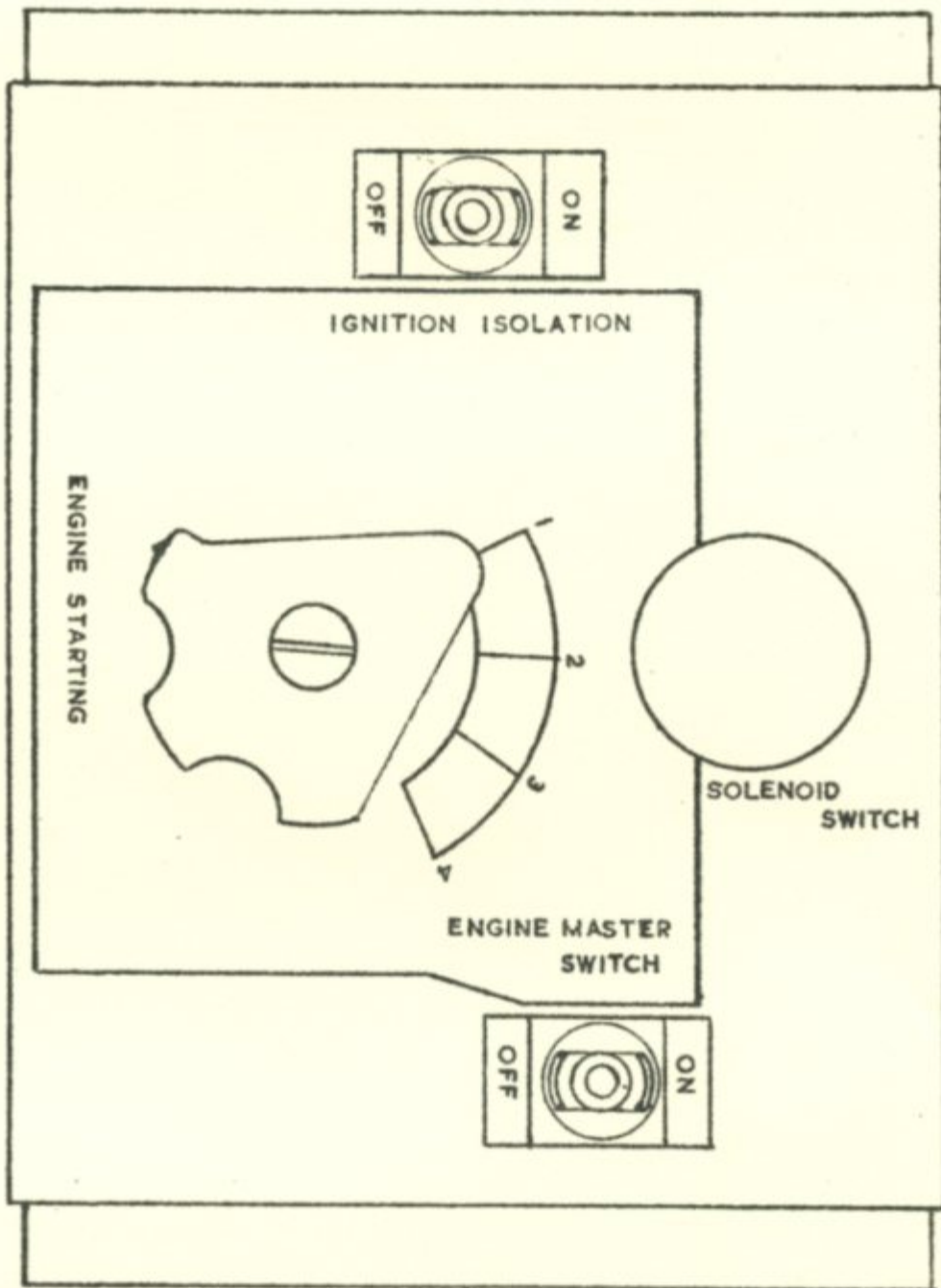
ENGINE FIRE INDICATORS



L.P. COCK SWITCHES



CENTRE PANEL. A.E.S.306/1



PORT CONSOLE A.E.S.306

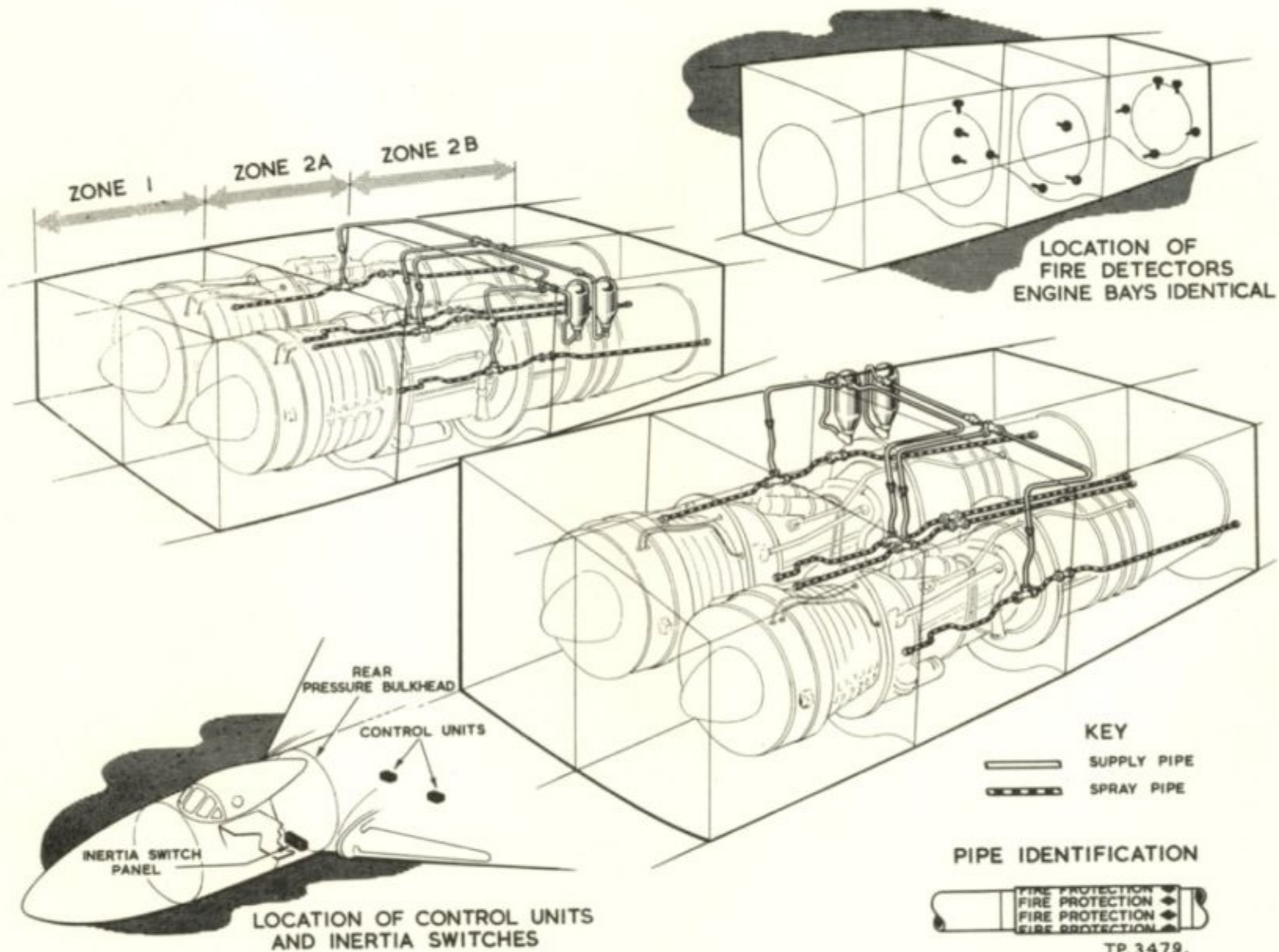
ENGINE FIRE-EXTINGUISHERS

There are two fire extinguisher bottles on each side of the bomb bay, one for each engine, each supplying fore and aft sprays on the sides of the engine bay. Four guarded fire extinguisher push buttons, each incorporating a red warning light, are at the top of the engine instruments panel. When any of the fire detector switches in the engine, or jet pipe zones, close due to fire, the appropriate warning light will come on. The fire-extinguisher bottle for that engine is discharged into the engine bay and jet pipe zones by pressing the push button. The warning light should go out when the fire is extinguished. Once the bottle for any engine has been discharged, there is no means of extinguishing a further outbreak in the same engine, and therefore no attempt should be made to restart an engine once its fire extinguishing bottle has been discharged.

The warning lights may be tested by gently pulling out the fire extinguishing push button, when the lights should come on. The buttons will return by spring action, but must not be allowed to return by force, and must not be pushed in. These push buttons must be treated with care as they are very sensitive.

The engine fire warning circuit and thermocouple chain may be test-functioned by operating the test switch on the 28-volt fuse panel on the starboard wall of the cabin. All four engine detector circuits will be tested simultaneously and the four warning lights should come on. The test buttons, one for each pair of engines, in the nosewheel bay, are provided for ground testing purposes.

Before operating a fire-extinguisher push button, the H.P. and L.P. fuel cocks for that engine should be closed.



TP. 3479.

FIRE PROTECTION SYSTEM - ENGINES

ENGINE RUNNING INSTRUCTIONSGENERAL.

1. Engine ground running should be restricted to a minimum to avoid fouling the compressor with dust laden air.
2. Position the aircraft so that the jet efflux is away from tarmac-covered surfaces, buildings, or other aircraft.
3. Remove all intake, outlet and all breather blanks, etc., from each engine as necessary and check that the engine oil and fuel tanks have been replenished.
4. Ensure that there are no loose objects, paper etc., in the area in front of the aircraft.
5. Inspect air intake tunnels for suspect rivets etc., also air brake access panel screws.
6. Keep a check on compressor blade cleanliness.
7. Keep a check on compressor or turbine-blades, for any signs of cracks, or nicks etc.
8. Check that zone 2A collector tanks are drained.
9. Check that the aircraft fuel system has not been broken down to rectify any snag, if so, and cross-feeds have not been operated, bleed the engine fed by that particular fuel tank group. If in doubt at any time, re-bleed all engines.
10. If for any reason the engine bay access doors are to be left open for checks during engine runs, check that all jury struts are in position.

11. Check that all aircraft starting checks have been made, i.e. brakes on, chocks in position, etc.etc.,
12. Initial run or whenever an engine or jet pipe has been replaced.
  - (a) Carry out two wet motoring cycles to check the bellows seal. During this operation ensure that there is an oil pressure gauge reading.
  - (b) Carry out a motoring cycle to check the H.P. cock for sticking in the open position.

These cycles will be carried out in accordance with the instructions given later in these notes, but must always be carried out before lighting engine. If only jet pipe has been replaced, check on belcoows seal only.

Ensure that.....

COCKPIT CHECKS

1. Ensure that the two safety pins are fitted to the ejector seat.
2. Ensure that the D/V windows are locked.
3. Ensure that the canopy is locked.
4. Ensure that the four Teddington gate valves are in the closed position.
5. Check that all anti-icing switches are in the closed position
6. Check that the fuel tank pressurisation and nitrogen switches are in the closed position.
7. Check that the parking brake is in the 'ON' position, and there is hydraulic pressure.
8. Check that the throttles are in the H.P. closed position.
9. Check that automatic starting panel, ignition and master switches are switched 'OFF'.
10. Pull out the main control console, which houses the fuel system controls, flying controls etc.,
11. Check that the L.P. cocks are in the 'OFF' position.
12. Check that the fuel system is set to manual.
  - that all booster pumps are switched off.
  - " that transfer cocks from No. 1 to No. 7 tanks are closed
  - that the cross feed cocks are closed.
  - " that flying controls are out of operation.
  - " that the air brakes are closed.
13. Check each fuel group for fuel contents - i.e. the total reading against individual tank contents, and record the readings. Check that .....

14. Check that the generators are out of operation
15. Ensure that the electrical ground supply for 112 and 28V is in operation, and that all electrical services for the ground runs are in operation. Do not load the generators, i.e. keep on ground supply.
16. Ensure that L.P.W. doll's eyes show low pressure.
17. Ensure that the intercom is in operation and that contact is made with the ground crew.
18. (a) Select No.1 tank 'ON' in No.1 group with control at manual.  
(b) Open No.1 L.P. cock; L.P.W. doll's eye should change to normal.  
(c) Open the cross feed cock from 1 to 2 groups, and open No.2 L.P. cock; the L.P.W. doll's eye should change to normal.  
(d) Open port to starboard cross feed cock and open No.3 L.P. cock; the L.P.W. doll's eye should change to normal.  
(e) Open the cross feed cocks from 3 to 4 groups, and open No.4 L.P. cock; the L.P.W. doll's eye should change to normal  
i.e. with only one pump in operation you have checked : -
  - i. L.P.W. doll's eyes
  - ii. L.P. cocks
  - iii. Cross feed cocks  
(f) Now close all cross feed cocks  
(g) Switch each fuel group to 'AUTO'  
(h) Switch on all fuel pumps.

MOTURING CYCLE.

This is required either to clear an engine of fuel after an unsuccessful start, or for ground maintenance purposes and the following procedure should be carried out

1. Operate battery isolation switch to "off" and plug in ground supply battery.
2. L.P. fuel cocks and tank pumps "on" (To avoid "cavitation" in L.P. fuel system).
3. Starting master switch "on".
4. Set Engine selector switch to appropriate engine.
5. Igniter isolating switch to "off".
6. Check that throttle is at "H.P. Cock shut" position.
7. Press starter button (This will hold in 30 seconds). Ensure that there is an oil pressure gauge reading.

### WET MOTORING CYCLE

Make a leakage check of the outer cone unit bellows joint in the following manner.

With the engine cold, carry out two wet motoring cycles consecutively and check for leakage from the cone clamp of the bellows joint. If leakage exceeds 0.5.c.c. per second, fit a new strap and bolt assembly and repeat the test.

CAUTION : The strap bolts must never be retightened.

1. Operate battery isolation switch to "off" and plug in ground supply battery.
2. L.P. Fuel cocks and tank pumps "on".
3. Starting master switch "on"
4. Set engine selector switch to appropriate engine.
5. Check that igniter isolation switch is "off" and avoid pressing relight buttons on top of the throttle levers.
6. Throttle open to Idling gate.
7. Press starter button (This will hold in for 30 seconds).
8. Close H.P. cock when starter panel button throws out.

Note:- To clear inhibitor oil from the fuel system of an engine that has been inhibited, one or more wet motoring cycles must be carried out.

N.B. After three successive operations of the starter, the starter motor must be allowed to cool off for fifteen minutes, before another start is made, also on initial engine runs, when these false starts etc., are being carried out, see that the starter panel buzz bar in the power bay does not overheat.

Check that all surplus fuel has been drained from the engine, and jet pipe tunnel end caps, etc.

ENGINE STARTING

(a)

|                           |       |
|---------------------------|-------|
| No. 3 Inverter            | ON    |
| L.P. Fuel Cocks           | ON    |
| Crossfeed Cock switches   | SHUT  |
| Ignition Isolation Switch | ON    |
| Engine Starting Selector  | NO.1. |
| Engine Master Switch.     | ON.   |

(b)

Switch on all fuel booster pumps and ensure that the fuel pressure indicators move to black.

Ensure that No.1 engine throttle lever is in the H.P. cock shut position.

Press the starter button for two seconds. The button should remain in during the starting cycle until thrown out by the overspeed relay. As soon as the engine begins to turn, indicated by rising oil pressure, move the throttle very slowly to the IDLING position, and observe the following conditions:-

|                           |                          |
|---------------------------|--------------------------|
| Engine fire warning light | Out                      |
| J.P.T. gauge              | Temperature below 600° C |
| Oil pressure              | Registering              |
| R.P.M.                    | 2,100.                   |

(c)

If the J.P.T. rises to 600° C on starting, and continues to rise, immediately set the throttle to the H.P. Cock shut position. The starter motor should be isolated by switching the master switch off. When the engine has

come to.....

come to rest the cause should be investigated.

Select the engine starting selector to No.2, 3 and 4 engines repeating the above starting operation each time.

#### WARNING

If an engine fails to start, the next attempt to start must not be made until a MOTORING CYCLE has been carried out to clear the engine of unburnt fuel.

#### ACTION IN THE EVENT OF FIRE.

#### ENGINE FIRE

Engine fire will be indicated by the red warning light in the head of the fire extinguisher push-button.

Close the H.P. cock.

Switch off the L.P. cock.

Press the fire extinguisher push-button.

Set the engine air valve, closed.

Switch fuel tank booster-pumps off.

Switch the generator off.

The warning light should go out when the fire is extinguished.

FIRST ENGINE RUN AFTER INSTALLATION

When the installation of the engine has been completed carry out the following checks and adjustments during the first run.

Check the re-light system before starting engine.

With the engine running at idling r.p.m. (the stop will be set at a later stage) check for signs of oil or fuel leaks. Close the engine bay doors to stabilise the bay temperature, and bring the 22½ K.W. generator "on line".

Select Take-Off on the governor control switch, ensuring that the Doll's Eye shows BLACK.

Move the throttle to take-off for 10 seconds observing the engine speed and J.P.T.

Retract the throttle lever to the idling condition and make necessary adjustments to the Driven Governor.

Select Cruise J.P.T. on the control switch, ensuring the Dolls eye shows white.

Move the throttle to the take-off position and note engine speed and J.P.T. Retract throttle to idling. Any adjustments on the J.P.T. Limiting System must be made in conjunction with the ULTRA TEST SET QE.2230.

Synchronisation of Throttles

All four throttle levers must be synchronised at 80% R.P.M. and above, therefore open up each engine to 80% R.P.M. and check for throttle stagger. If necessary adjustment may be carried out on the vernier of the F.R.F.C. throttle lever.

Slam Acceleration Check .....

### Slam Acceleration Check

With the governor switch at Take-Off move the throttle lever from idling to take off in one second, ensuring that the engine accelerates to maximum condition within seven seconds. Retract throttle to idling gate. Select Cruise J.P.T. on the governor switch and move throttle to Take-Off position in one second, observe engine J.P.T. and speed.

### Setting Idling Condition

With the throttles set to obtain  $31\frac{1}{2}\%$  -  $33\frac{1}{2}\%$  R.P.M., set the stops on the throttle quadrant where a small amount of throttle stagger may be found unavoidable. (It has been found preferable to set the idling R.P.M. within  $\frac{1}{2}\%$  of each other)

### Shutting down procedure

Close throttle to H.P. cock shut position.

When the H.P. compressor has ceased to rotate - i.e. after approximately 5 minutes, switch off the booster pumps. Leave the L.P. cock open.

After stopping the engines, check that during the run-down there has been no throttle creep forward sufficient to open the H.P. cocks as throttle quadrant spring is lost on engines No: 2 and 4 at take-off, and gained on engines No: 1 and 3 at the H.P. cock shut position.

When all the heat is dissipated the controls will return to normal. Do not attempt to control the creep by means of the friction damper in the throttle box as this will cause the control rods to bend.



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