

## Chapter I      POWER UNIT

### LIST OF CONTENTS

DESCRIPTION AND OPERATION	Para.	SERVICING—cont.	Para.
General ... ..	1	Lubrication ... ..	16
Engine mounting ... ..	3	<b>REMOVAL AND ASSEMBLY</b>	
Engine cowlings ... ..	4	Power unit removal... ..	17
Starting system ... ..	5	Preliminary operations ... ..	18
Engine-driven accessories ... ..	6	Disconnection procedure ... ..	19
Controls ... ..	7	Removal from airframe ... ..	20
Instruments ... ..	8	Securing to the stand ... ..	21
Air supply connections ... ..	9	Removal of compressor ... ..	22
<b>SERVICING</b>		Removal of hydraulic pump ... ..	23
Engine cowlings ... ..	10	Installing the power unit ... ..	24
Setting the controls... ..	11	Refitting the compressor ... ..	25
Throttle ... ..	12	Refitting the hydraulic pump ... ..	26
High-pressure fuel cock ... ..	13	Post installation checks ... ..	28
Low-pressure fuel cock ... ..	14	Final assemblies and checks ... ..	29
Ground running the engine ... ..	15		

### LIST OF ILLUSTRATIONS

	Fig.		Fig.
Engine mounting ... ..	1	Low-pressure fuel cock control setting ... ..	8
Engine-driven accessories ... ..	2	Fuel and oil pressure check points ... ..	9
Engine cowlings ... ..	3	Break points ... ..	10
Engine control box ... ..	4	Engine change guide plate ... ..	11
Engine controls ... ..	5	Power unit sling and stand ... ..	12
Throttle control, setting ... ..	6	Engine centre attachment ... ..	13
High-pressure fuel cock control setting ... ..	7	Alignment and air-intake ducts ... ..	14

### DESCRIPTION AND OPERATION

#### General

1. The aircraft is powered by a Ghost Mk. 103 single stage turbo-jet engine, mounted on a tubular steel support frame at the rear of the fuselage. Air entering the main plane ducts passes through the bifurcated air-intake of the engine to the single sided compressor impeller, which is mounted on the same shaft as the single-stage axial flow turbine. The compressed air passes to the ten combustion chambers, where it mixes with injected fuel and is ignited, and the resultant gases expand with high velocity through the stationary nozzle guide blades on to the blades of the turbine

wheel, which has the function of extracting the power to drive the compressor. From the turbine, the gases are led by the converging exhaust cone and eject at a high velocity from the propelling nozzle, thus producing the forward thrust. Cooling air is supplied to the combustion and exhaust systems and the turbine disc, and to the rear bearing, which has also a pressure oil cooling circulation.

2. In front of the impeller are two accessory drive shafts driven through bevel gears from a forward extension of the mainshaft which

drive, through a chain of spur gears, the various accessories mounted on the top and bottom wheelcases. The lubrication system is completely self-contained within the engine, the oil being carried in a sump attached to the underside of the bottom wheel case. Minor general servicing requirements are outlined in Sect. 2, Chap. 2, of this volume, and details of the various accessory units mounted on the engine will be found in the relevant Chapter of Sect. 3 and 5. Full descriptive and servicing details of the engine, together with its constituent systems, which are outside the scope of this Volume, are given in A.P.4320A, Vol. 1.

### Engine mounting (fig. 1)

3. The power unit is attached to the engine mounting by four eye-bolts on the front diffuser casing, and to eye-bolts on bulkhead No. 4 by two central fittings mounted vertically one above the other. This bulkhead serves as a firewall and separates the engine bay from the fuselage fuel tank. Alignment of the engine mounting and the inner attachment eye-bolts is effected by shimming with special mild steel washers. When rigging a new engine mounting to an airframe, laminated brass shims may be used initially to obtain the correct setting of the engine mounting. Remove the engine mounting attachment eye-bolts and with a micrometer, obtain the thickness of the

brass shims. Select mild steel shims to give the approximate thickness required and file as necessary until correct thickness is obtained (fig. 1). It is essential that the faces of the washers are parallel and flat after filing. Use *thin* Duralac compound for final assembly.

### Engine cowlings (fig. 3)

4. The power unit is completely enclosed, from bulkhead No. 4 to the propelling nozzle, by the upper and lower front and rear cowlings panels and the rear cone. The cone, which shrouds the exhaust assembly, is built up of a number of circular formers and longitudinal stringers covered with light-alloy skin and is secured by screws to the top and bottom surfaces of the main planes. The four cowling panels are supported on rails mounted at the forward end of the rear cone, on the engine diffuser casing and on the aft face of bulkhead No. 4 respectively. The panels are secured on each side by three toggle-type fasteners which engage with adjustable loop-ended tie-rods pivoted from rib No. 1 on each main plane. The engine bay is ventilated through scoops on the lower forward cowlings and exhaust louvres on the two upper cowlings.

### Starting system

5. Equipment for starting the engine comprises a twin breech, cartridge-operated, Rotax turbo starter, and a high-energy igniter system, controlled by an automatic sequence operated from the cabin. The starter firing circuit, which supplies a high voltage current to the surface discharge plugs fitted in No. 3 and 10 combustion chambers, is described in Sect. 5, Chap. 1. The turbo starter is mounted on the upper engine wheel case, forward of the d.c. generator, and the exhaust gases are conveyed by a duct to atmosphere through an opening

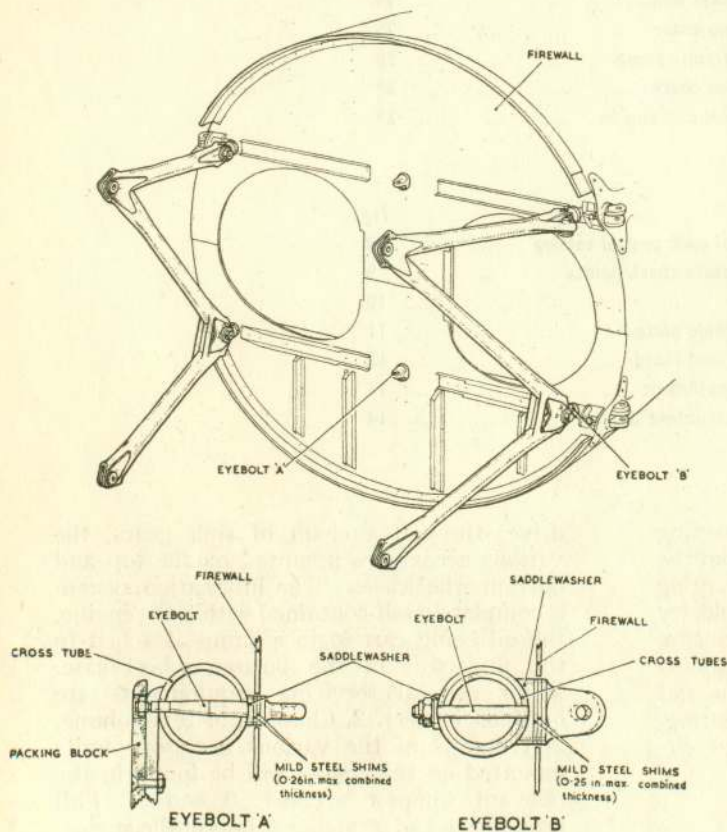


Fig. 1. Engine mounting

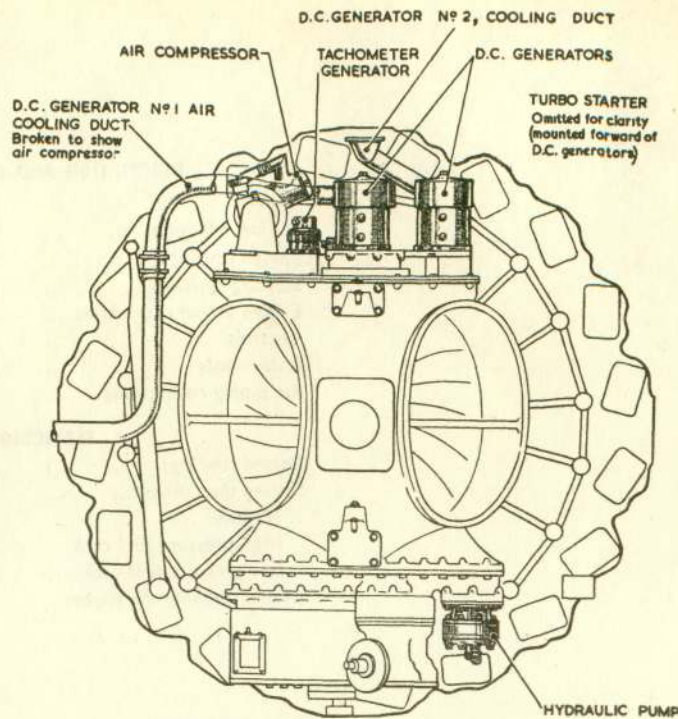


Fig. 2. Engine-driven accessories

in the upper, forward cowlings panel. Provision is made to store four spare cartridges in the port inner flap shroud and two replacement starter bursting discs on the turbine access door. A full description of the starter, the servicing and the procedure for loading the cartridges, No. 8, Mk. 1, Stores Ref. 12D/1198, is given in A.P.1181, Vol. 1 and 6, Part 1, Sect. 4, Chap. 2, and detailed information on the cartridges will be found in A.P.1661F, Vol. 1, Sect. 2, Chap. 2.

### Engine-driven accessories (fig. 2)

6. At the front of the engine are the wheel cases on which the various engine-driven accessories are mounted. On the *upper* wheel case are the turbo starter, the tachometer generator, the two d.c. generators and the air compressor. On the *lower* wheel case is mounted the hydraulic pump and components of the engine oil and fuel systems. The d.c. generators are cooled by air supplied

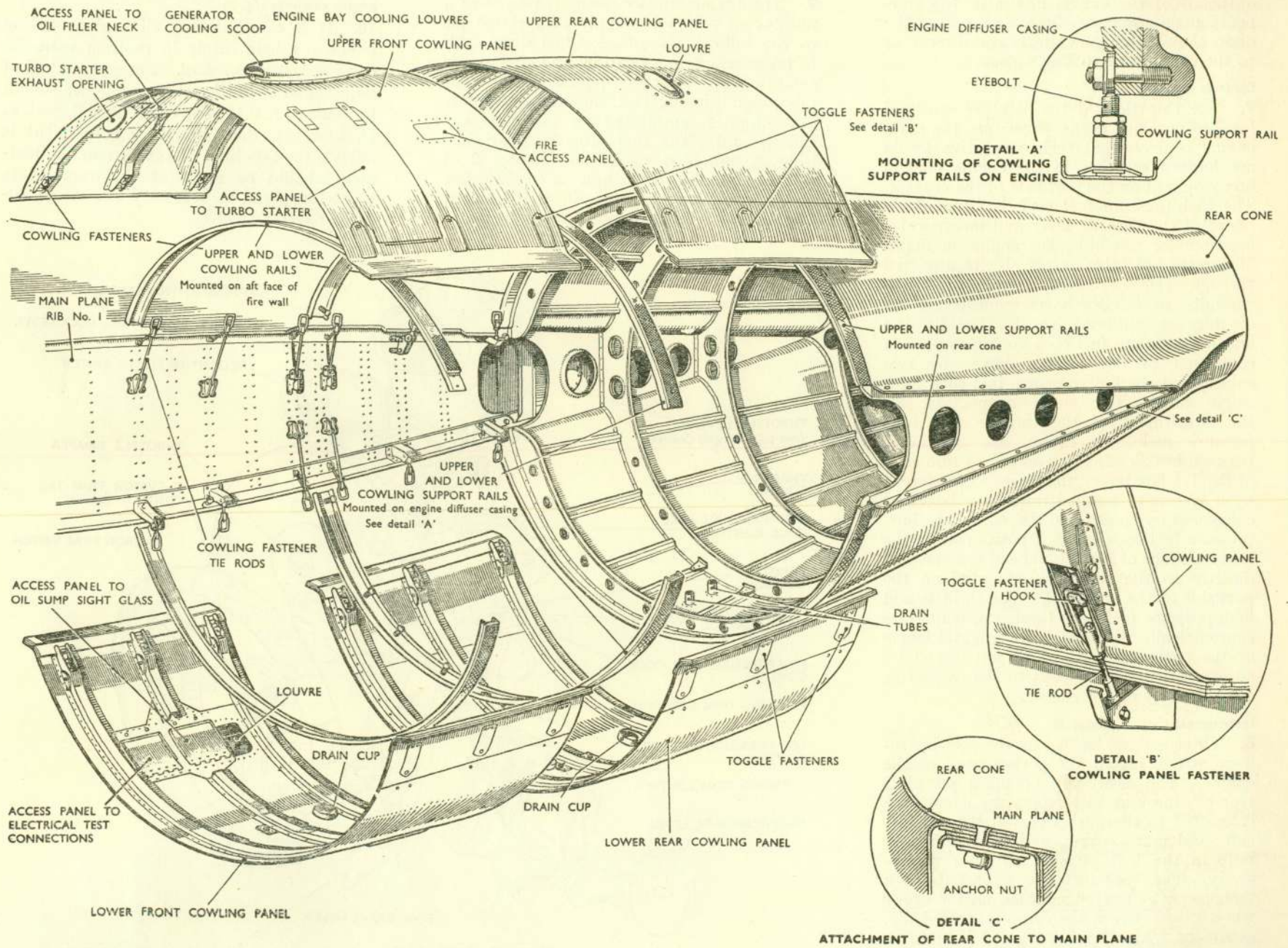


Fig. 3. Engine cowlings

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through a duct from an intake immediately outboard of the engine intake in the starboard main plane. A branch pipe from the duct, close to the generators, also directs air to the compressor cooling shroud.

#### Controls (fig. 4)

7. The throttle and the high-pressure and low-pressure fuel cocks, constitute the main engine controls and their respective levers are located together in the engine control box mounted on the port side of the cockpit. The high-pressure fuel cock is situated in-board of the throttle lever and incorporates a switch for relighting the engine in flight. Movement of the levers is transmitted through Teleflex cables, running in rigid conduits, to Teleflex boxes mounted on the aft face of bulkhead No. 4. The throttle and low-pressure fuel cock controls are each connected to the Teleflex boxes by two cables, and the high-pressure fuel cock by a single cable. Turnbuckle connectors, for the adjustment of the throttle and low-pressure fuel cock cables, are positioned between bulkheads No. 2 and 3. From each of the Teleflex boxes, the drive is transferred by a system of parallel transverse layshafts connected by chains and tie-rods. The low-pressure fuel cock layshaft positioned on the lower aft face of No. 4 bulkhead is connected directly to the fuel cock mounted on the port side of the bulkhead. The throttle and high-pressure fuel cock layshafts, which are concentrically mounted, have integral levers at the outboard ends which are linked by adjustable connecting-rods to the respective control levers on the engine.

#### Instruments (Sect. 5, Chap. 2)

8. Three gauges, located on the port instrument panel, record the performance of the engine. The electrically-operated jet pipe, rear bearing and oil temperature gauges are connected to thermo-couples in the exhaust cone and rear bearing, and to a resistance bulb in the high-pressure oil filter respectively. The tachometer is operated by a tachometer generator mounted on the upper wheel case between the compressor and d.c. generator. An oil pressure gauge is fitted on some early aircraft and instructions for fitting one on later aircraft for ground test purposes are given in para. 15.

#### Air supply connections

9. The engine diffuser casing is tapped at a number of points to supply compressed air to the following systems:—fuel drop tank to pressurising, gun heating, and cockpit air conditioning. A branch pipe from the cockpit air-conditioning duct, close to the tapping, also supplies compressed air to inflate the canopy seal. The fuel drop tank pressurising system is described in Chapter 2 of this Section, and the cockpit air conditioning and gun heating systems in the relevant Chapters of Sections 3 and 7 respectively.

#### SERVICING

##### Engine cowlings (fig. 3)

10. It is *essential* that all engine cowling panels are held firmly in position with the cowling fasteners *locked*. For the method of adjustment of the fasteners, reference should be made to A.P.1464B, Vol. 1, Part 2, Sect. 6. If, however, the amount of adjustment is outside the safe limit of any fastener, adjustment should be made at the appropriate tie-rod loop-end as necessary *and all adjustments relocked securely*.

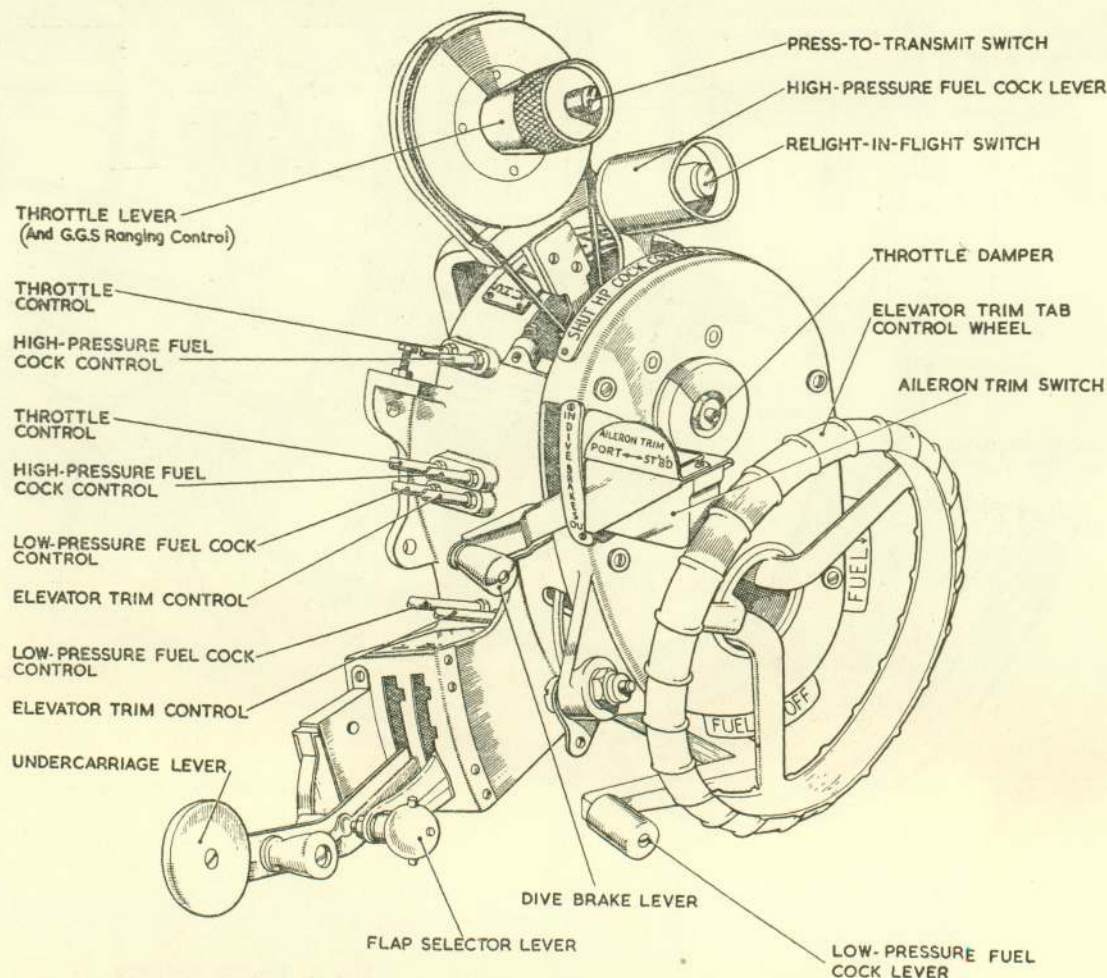


Fig. 4. Engine control box

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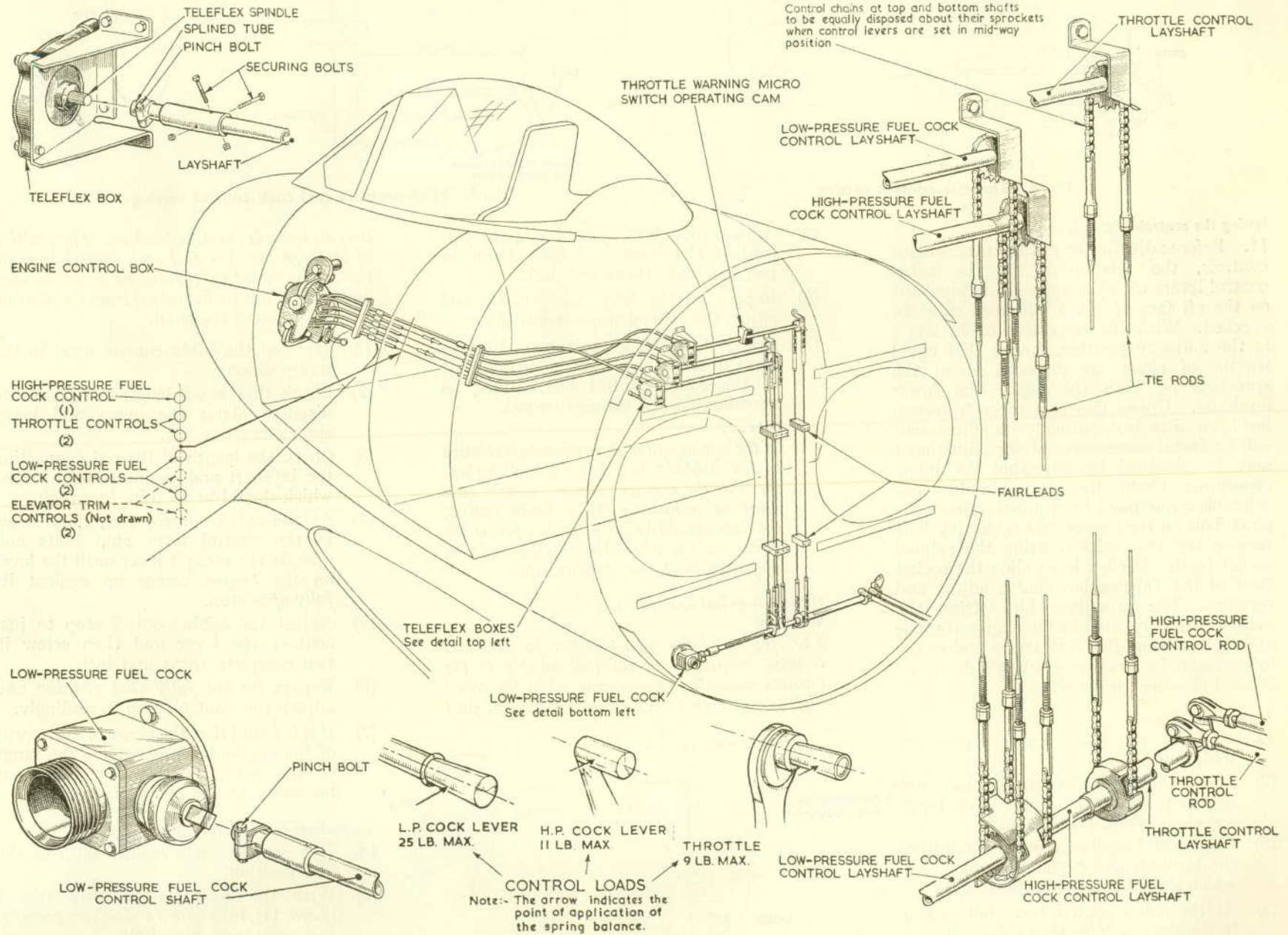


Fig. 5. Engine controls

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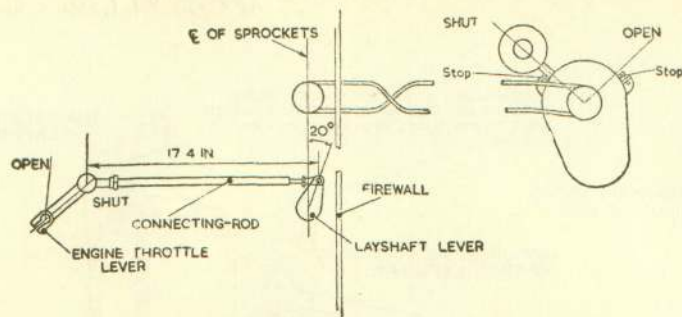


Fig. 6. Throttle control setting

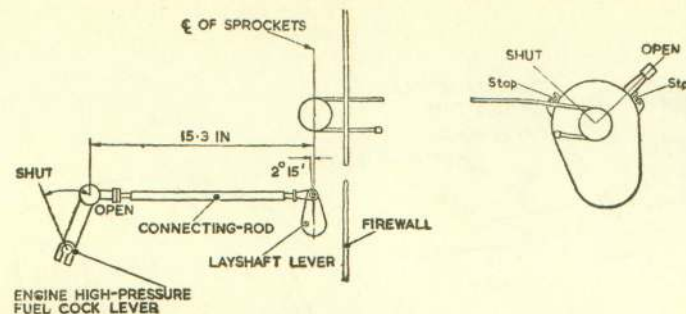


Fig. 7. High-pressure fuel cock control setting

**Setting the controls (fig. 6, 7, and 8)**

11. Before adjusting any of the three engine controls, the relationship of the cabin control levers with the appropriate layshafts on the aft face of No. 4 bulkhead must be checked. With the respective cabin levers in the mid-way position, ensure that equal lengths of chain are disposed about the sprockets on both the upper and lower layshafts. Unless this part of each system has been disturbed, normally no adjustment will be found necessary. Minor adjustment may be obtained by adjusting the inter-connecting chain tie-rods. Should considerable adjustment be required, release the pinch bolt on the appropriate upper layshaft remove the two bolts securing the splined socket to the Teleflex box; slide the socket clear of the Teleflex box shaft; adjust and resecure. The procedure for setting the cabin controls relative to the engine throttle and high-pressure fuel cock levers and to the low-pressure fuel cock respectively is described in the following paragraphs.

**Throttle (fig. 6)**

12. (1) Set the cabin control lever in mid-position.
- (2) Check that equal lengths of chain are disposed about the upper and lower sprockets (para. 11).
- (3) Check the length of the rod connecting the layshaft and engine control levers, which should be 17.4 in. (nominal).
- (4) At the cabin control box, fully screw in the throttle lever stop bolts and open the throttle until the lever on the engine comes up against its fully open stop.

- (5) Adjust the cabin control stop to just contact the lever and then screw in two complete turns and lock.
- (6) Repeat for the fully shut position and adjust the control stop accordingly.
- (7) If it is found that the range of movement of the engine lever is outside that of the cabin control box, adjust as necessary at the connecting-rod.

**Note . . .**

*If the setting of the upper layshaft relative to the Teleflex box has been disturbed, the throttle warning micro switch cam must be adjusted. As a basic setting, the cam should be adjusted to operate the micro switch when the throttle lever is approximately one quarter open.*

**High-pressure fuel cock (fig. 7)**

**WARNING**

*The rigging of the high-pressure fuel cock is critical, restriction of the fuel supply to the burners normally commencing when the cabin high-pressure fuel cock lever is 0.25 in. past*

*the gate towards the shut position. The position of the high-pressure fuel cock control lever on the engine is set by the engine manufacturer, and it must not be disturbed from its position on the splines of the shaft.*

13. (1) Set the cabin control lever in the mid-position.
- (2) Check that equal lengths of chain are disposed about the upper and lower sprockets (para. 11).
- (3) Check the length of the rod connecting the layshaft and engine control levers, which should be 15.3 in. (nominal).
- (4) At the cabin control box, fully screw in the control lever stop bolts and operate the cockpit lever until the lever on the engine comes up against its fully open stop.
- (5) Adjust the cabin control stop to just contact the lever and then screw in two complete turns and lock.
- (6) Repeat for the fully shut position and adjust the control stop accordingly.
- (7) If it is found that the range of movement of the engine lever is outside the range of the cabin control box, adjust as necessary at the connecting-rod.

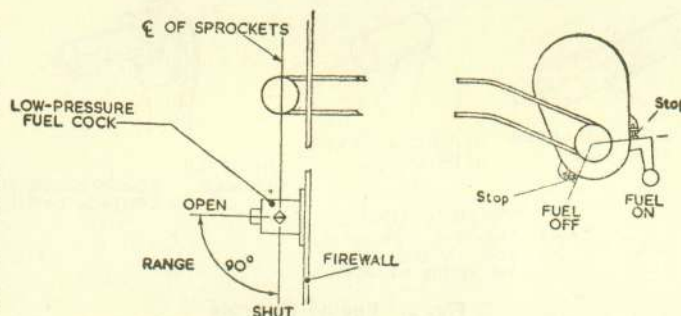


Fig. 8. Low-pressure fuel cock control setting

**Low-pressure fuel cock (fig. 8)**

14. (1) Set the cabin control lever in the mid-position.
- (2) With the layshafts correctly aligned (para. 11), fully screw in the low-pressure fuel cock lever stop bolts.
- (3) Close the cabin lever until the fuel cock comes up against its fully shut stop.

- (4) Unscrew the cabin lever stop bolt until it just contacts the lever, and then back off two complete turns and lock.
- (5) Move the cabin lever to the FUEL ON position until the fuel cock comes up against its *fully open* stop.
- (6) In a similar operation to (4) unscrew the cabin lever stop bolt until it just contacts the lever, then back off two complete turns and lock.

#### Ground running the engine

15. Full details for ground running the engine are given in A.P.4320A & C, Vol. 1. Since a fuel burner pressure gauge is not fitted in the aircraft, a suitable gauge and transmitting line should be connected to the union at the forward end of No. 1 burner to obtain the necessary readings. Similarly, an oil pressure gauge and transmitting line should be connected to the engine oil pressure gauge connection (fig. 9).

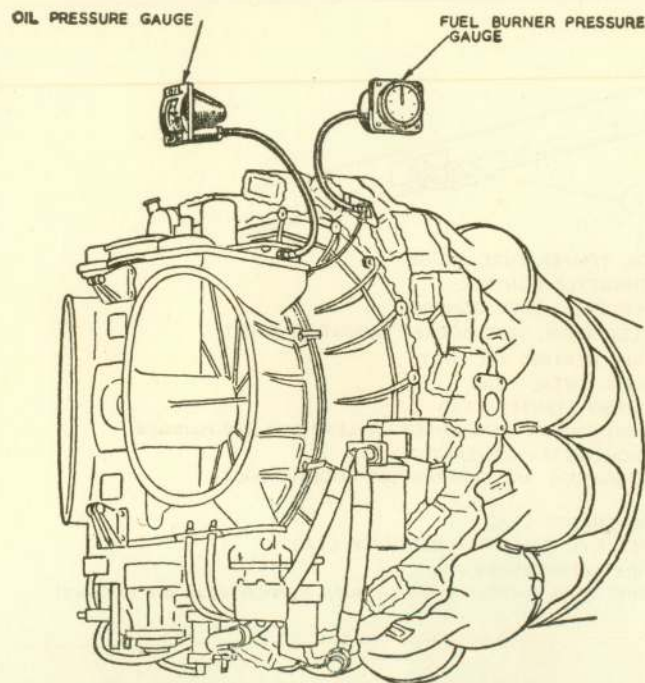


Fig. 9. Fuel and oil pressure check points

#### Lubrication

16. At the periods laid down in Vol. 4, the engine control Teleflex cables should be lubricated (Sect. 2, Chap. 4) with a grease gun at the nipples on the port side of the cabin; to do this it will be necessary to remove the punkah louvre from its securing clip. The throttle warning micro switch cam and the throttle and high-pressure fuel cock connecting-rod attachments to the engine levers should also be lightly lubricated.

### REMOVAL AND ASSEMBLY

#### Power unit removal

17. Before removal from the airframe, the power unit must be prepared in accordance with the instructions given in A.P.4320A & C, Vol. 1. This is particularly important since certain requirements cannot be carried out with the power unit removed. The power unit should be removed as a complete unit, i.e., with the fireguard, exhaust cone and propelling nozzle assembled. It is most important that the correct slinging tackle (Sect. 2, Chap. 4) only is used in order that the lifting eyes on the power unit are not subjected to any side or bending loads.

#### Preliminary operations

18. With the aircraft resting on the ground, ensure that the wheels are securely chocked and the brakes locked ON. Check that the turbo starter is unloaded, and that the master and turbo starter switches are at OFF then disconnect the aircraft battery. On *early* aircraft, the complete fuel system must be drained (Chap. 2) before attempting the removal of the power unit. *Later* aircraft embody maintenance cocks at the supply connections from main plane tanks No. 1 by which the entire contents of the main plane fuel tanks can be isolated. In each case, ensure that the high-pressure and low-pressure fuel cocks are in the SHUT and FUEL OFF positions respectively.

#### Disconnection procedure

19. It should be noted that the order for disconnecting the items listed in the key to

fig. 10, may be modified to suit particular requirements, but it is *essential* that all disconnections are made at the correct break points and that all items listed in the Engine Change Unit Schedule are transferred *with* the power unit. Blanking devices or covers *must* be fitted to all pipe ends, adapters, etc., as they are disconnected or detached from the installation. When making disconnections beneath the engine, it is advisable that use be made of a servicing creeper (Sect. 2, Chap. 4).

#### Note . . .

*The throttle and H.P. cock connecting-rods must NOT be left hanging down from the engine bulkhead layshafts during engine installation or removal. Both connecting-rods must first be disconnected from the engine end, then unscrewed completely from the fork ends on the engine bulkhead; they must be removed before the power unit is taken out and replaced after the power unit is installed.*

- (1) With the main plane flaps lowered to avoid damage, remove the four engine cowling panels (fig. 3).
- (2) At the forward end of the rear cone, disconnect the electrical leads to the flame switches, and remove the rear cone. The two forward drain cups must be removed first, to avoid fouling the jet pipe and fireguard drain pipes.
- (3) At rib No. 1 on each main plane, remove the rear four upper cowling panel tie-rods and hinge brackets to obtain clearance when the engine is removed.
- (4) Remove the exhaust duct from the turbo starter exhaust flanges and fit the blanking covers to the starter exhaust and emergency outlets.
- (5) Remove the turbo starter and secure the blanking cover to the engine mounting face as instructed in A.P.4320A, & C, Vol. 1.
- (6) Referring to fig. 10, disconnect or uncouple all items listed in the key which link the power unit to the airframe at the break points indicated in the illustration.

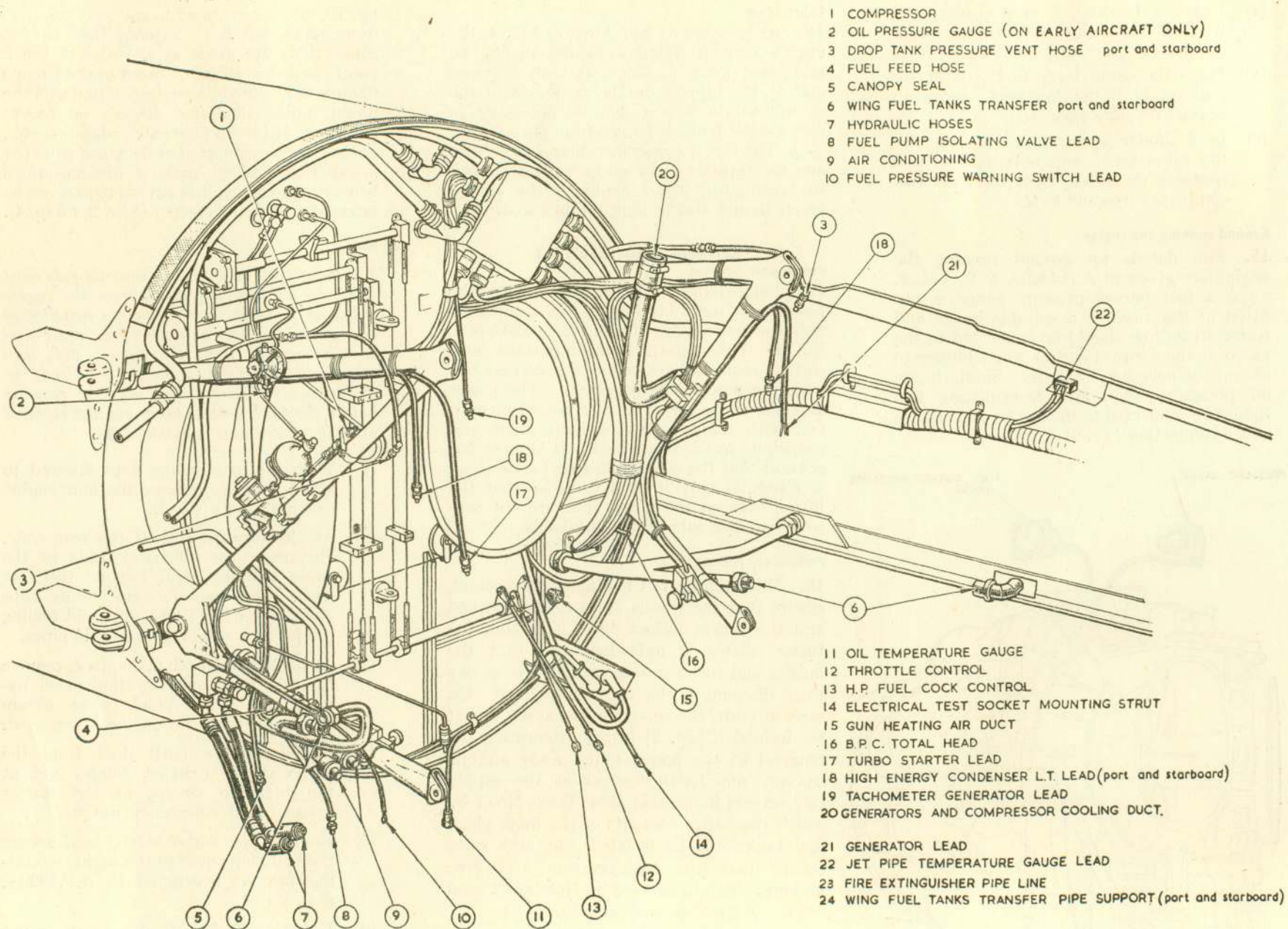


Fig. 10. Break points (I)

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- (7) At rib No. 1 on the starboard main plane, remove the mounting bracket complete with the terminal block for the jet pipe temperature gauge leads (*item 22*).

*Removal from airframe*

**20.** After ensuring that all connection between the power unit and the airframe have been broken :—

- (1) Tie all pipes, hoses and cables clear.
- (2) Detach the top tie-rods adjacent to the fitting position of the engine, by sliding the tie-rod and bracket in a downward direction. Place the guide plate in

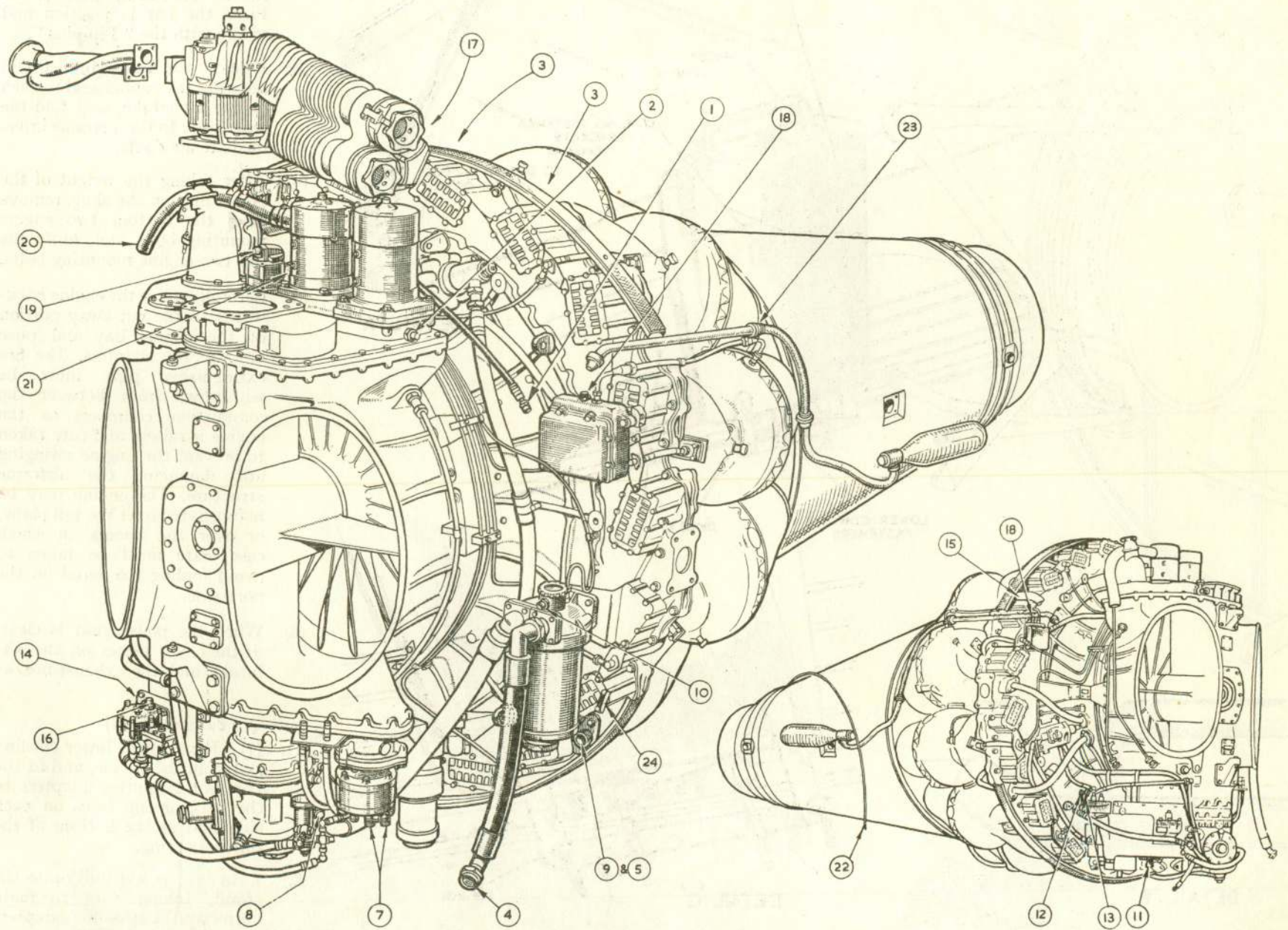


Fig. 10. Break points (2)

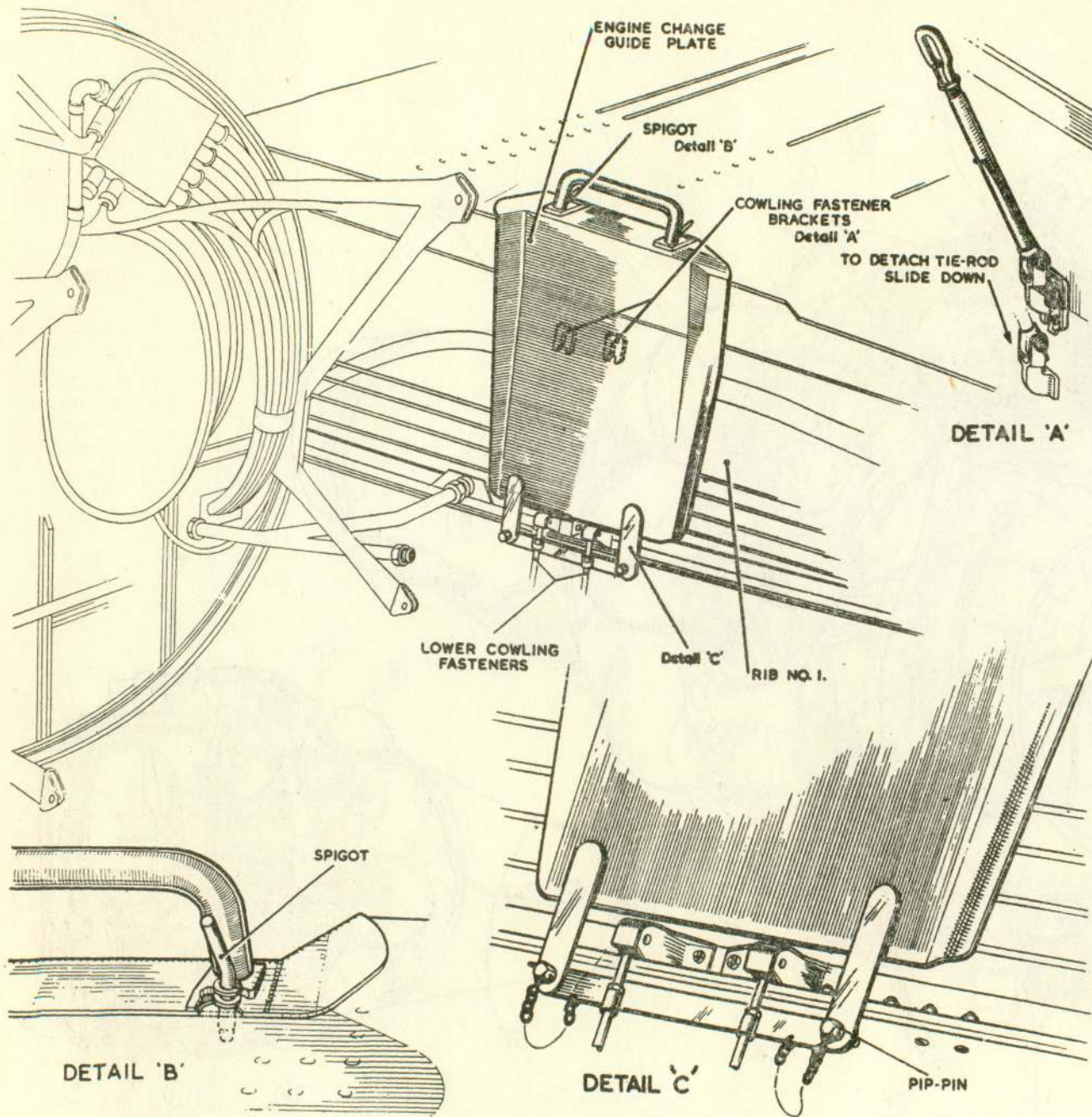


Fig. 11. Engine change guide plate

position (fig. 11), dropping the two floating spigots on the plate into their respective holes on the top skin of the main plane. Place the bar in position and secure with the "Pip-pins".

- (3) Release the large Jubilee clip securing the rubber seal to each engine air-intake, and fold the seals back to the airframe intermediate air ducts.
- (4) After taking the weight of the power unit on the sling, remove the bottom two engine mounting bolts and, *lastly* the top two engine mounting bolts.
- (5) Carefully move the engine backwards to the cut-away portion of the engine bay and raise clear of the airframe. The fire extinguisher pipe must be withdrawn from between the combustion chambers as the engine is raised, and care taken to prevent the engine swinging and damaging the airframe structure. The engine may be manoeuvred over the tail plane, or over the booms, in which case, care must be taken to avoid fouling the aerial on the port side.
- (6) When the power unit is clear, fit the cover plates on the air-intake and the exhaust nozzle.

Securing to the stand (fig. 12)

21. (1) Remove the lower cowling rail from the engine, and fit the trunnion mounting adapters to the attachment faces on each side and at the bottom of the diffuser casing.
- (2) Lower the power unit on to the stand, taking care to mate correctly the trunnion adapters with the stand housings, and secure.

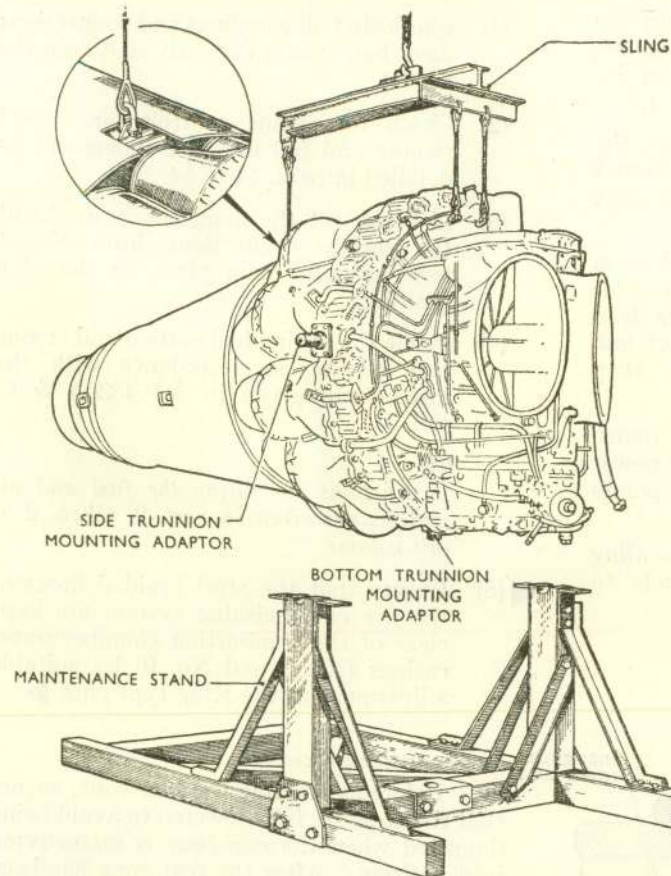


Fig. 12. Power unit sling and stand

- (3) When secured, remove all items of airframe equipment not listed in the Engine Change Unit Schedule. For details of electrical accessories, refer to Sect. 5, Chap. 1.

#### Removal of compressor (fig. 2)

22. Disconnect the air cooling duct and the compressed air delivery pipe, then remove the cooling shroud from the compressor. Remove the six plain nuts and spring washers which hold the unit to the compressor drive housing, then withdraw the compressor quill drive shaft from the drive in the housing. Fit the appropriate blanking covers to the unit and drive housing.

#### Removal of hydraulic pump (fig. 2)

23. Unscrew the six nuts which hold the pump to the wheel case mounting, and lower the unit to disengage the shaft splines from the wheel case drive. Fit the appropriate blanking caps and covers to the pump and pump mounting on the accessory drive case.

#### Installing the power unit

24. Before installation, the power unit must be prepared in accordance with the instructions given in A.P. 4320A & C, Vol. 1, and the safety precautions, outlined in para. 17 and 18 above, complied with in full. Check that all items listed in the Engine Change Unit Schedule and relevant items of airframe equipment are fitted while the power unit is on the stand. Ensure that the aircraft firewall has been cleaned and that all pipes, joints and adapters are serviceable. Check that the intermediate air-intake ducts are clean and that the rubber seals are folded back clear of the duct lips.

#### Refitting the compressor

25. Remove the blanking caps and covers and check that the spring-loaded quill shaft is correctly fitted to the compressor and retained by the circlip. Check that the mating surfaces of the compressor and drive housing are clean and undamaged, and that the gasket oil feed hole correctly aligns with the hole in the drive housing. Mount the compressor on the housing at an angle of 60 deg. inboard of the vertical position, and ensure that the quill shaft splines engage correctly with the drive in the housing. Fit the cooling shroud and connect the air cooling duct, then re-connect the compressed air delivery pipe.

#### Refitting the hydraulic pump

26. Ensure that the pump quill shaft and splined sleeve are in position in the lower gear-case, and correctly retained by the

circlips. Check that the mating surfaces of the pump and mounting adapter are clean and undamaged, and ensure that the sealing ring is correctly positioned. Ensure that the splined shaft on the pump engages correctly with the drive in the wheel case; if necessary turn the impeller by hand to rotate the drive and so facilitate engagement. Fit plain and spring washers and secure with the six nuts.

27. After the power unit has been lifted off the stand:—

- (1) Remove the trunnion mounting adapters and fit the lower cowling rail.
- (2) Immediately prior to manœuvring the power unit into position, remove the cover plates from the engine air-intake ducts then, when in position, lower the unit vertically until the respective mounting fittings line up. When lowering the engine, to line up the attachment lugs with the mountings, care should be taken that the spigots on the engine front centre lugs line up with the eye-bolts on the firewall and enter easily. Assemble the top two engine mounting bolts *first*, and then the bottom bolts.
- (3) The engine mounting attachments, port and starboard, and the central attachments on the fireproof bulkhead, are assembled to the structure in the initial manufacturing stage with special steel shims. These shims bring the engine attachment points on the mounting into alignment with the eye-bolts on the engine and if any of the six eye-bolts are changed during the life of the aircraft, the original shims must be replaced. If an engine mounting is changed, it may be necessary to alter the original shimming to align the mounting with the engine, using *thin* Duralac compound when assembling the shims. If new shims are fitted, care must be taken that they conform with the limits laid down in fig. 1. If any of the engine mounting frame eye-bolts (fig. 1, eye-bolt B) are dismantled, they must be re-tightened in position to a

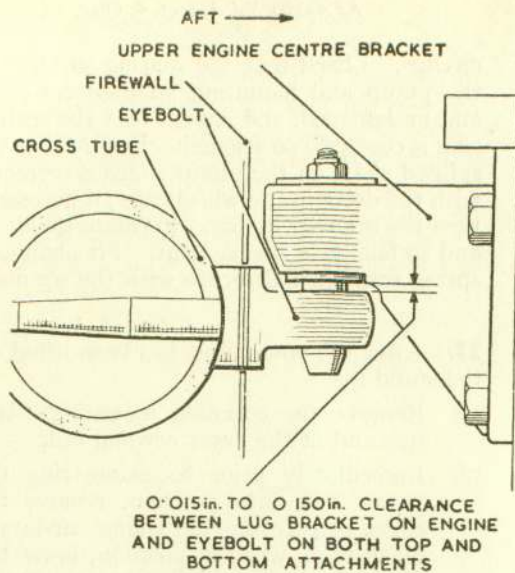


Fig. 13. Engine centre attachment

torque loading of 500 lb. in.; the thickness of shims used under the engine mounting frame eye-bolts, and the central eye-bolt attachment points, must not be less than 0.080 in. After the engine has been bolted into position, release the weight of the power unit from the sling, and check there is a clearance of 0.015 in. to 0.150 in. between the face of both the upper and lower centre eye-bolts on the firewall and their respective lug brackets on the engine (fig. 13).

Note . . .

*Bullet shaped caps* (Table 1, Sect. 2, Chap. 4) should be used to facilitate assembly of the engine mounting bolts.

- (4) Check the alignment and clearance of the air-intake ducts (fig. 14).

- (5) Assemble the rubber seals and secure the large Jubilee clips.
- (6) Remove the blanking cover from the starter mounting face on the engine, and mount the turbo starter as instructed in A.P. 4320A & C, Vol. 1.
- (7) Remove the blanking covers from the starter exhaust and emergency outlet flanges, and assemble the exhaust duct with the Heldite gaskets.
- (8) At rib No. 1 on the starboard main plane, secure the mounting bracket for the jet pipe temperature gauge lead terminal block. Remove the port and starboard engine guide plates, then replace the four top tie-rods.
- (9) Connect or couple up all the items, listed in the key, which link the power unit to the airframe at the break points indicated.
- (10) Reassemble the rear four upper cowling panel tie-rods and hinge brackets to rib No. 1 on each main plane.

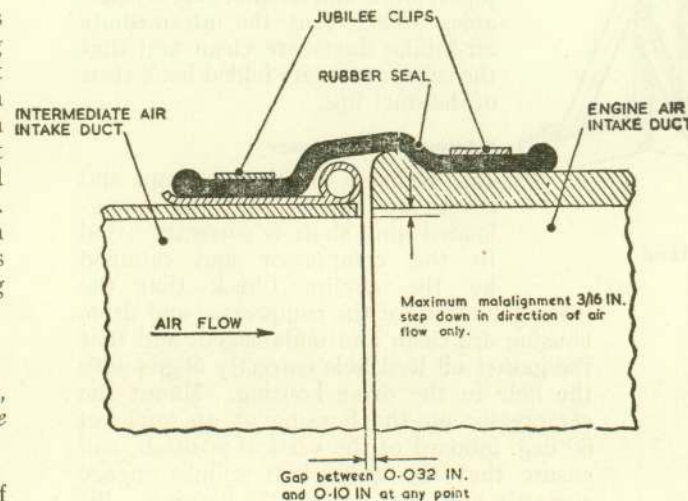


Fig. 14. Alignment of air-intake ducts

#### Post installation checks

28. After the engine has been installed :—

- (1) Check that all couplings and connections have been made correctly and securely locked.
- (2) Check the engine controls for correct rigging and full and free movement as detailed in para. 11 to 14.
- (3) If fitted, set the maintenance cocks at the supply connections from No. 1 tank in each main plane in the open position.
- (4) Prime the engine fuel system and engine rear bearing in accordance with the instructions given in A.P.4320A & C, Vol. 1.

Note . . .

*Instructions for filling the fuel and oil systems are given in Sect. 2, Chap. 2 of this volume.*

- ◀ (5) Ensure that the steel braided hoses of the fire extinguishing system are kept clear of the combustion chamber outer casings (No. 3 and No. 9) by suitable adjustment at the King type clips.▶

#### Final assemblies and checks

29. Before assembling the rear cone, ensure that the flaps are fully lowered to avoid being damaged when the rear-cone is manoeuvred into position. After the rear cone has been secured, check that the propelling nozzle is centrally positioned, and connect up the electrical leads to the fire extinguisher flame switches. When assembling the cowling panels, ensure that the front and middle panels bear evenly on the upper and lower engine cowling rails. Check the adjustment of the toggle fasteners. If necessary, adjust the sleeve on the starter exhaust duct so that the sealing ring bears against the panel with all the fasteners secured.

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