Section 1

DESCRIPTION

LIST OF CHAPTERS

Note—*A list of contents appears at the beginning of each chapter*

Chapter 1

ENGINE AND GEARBOX UNIT

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

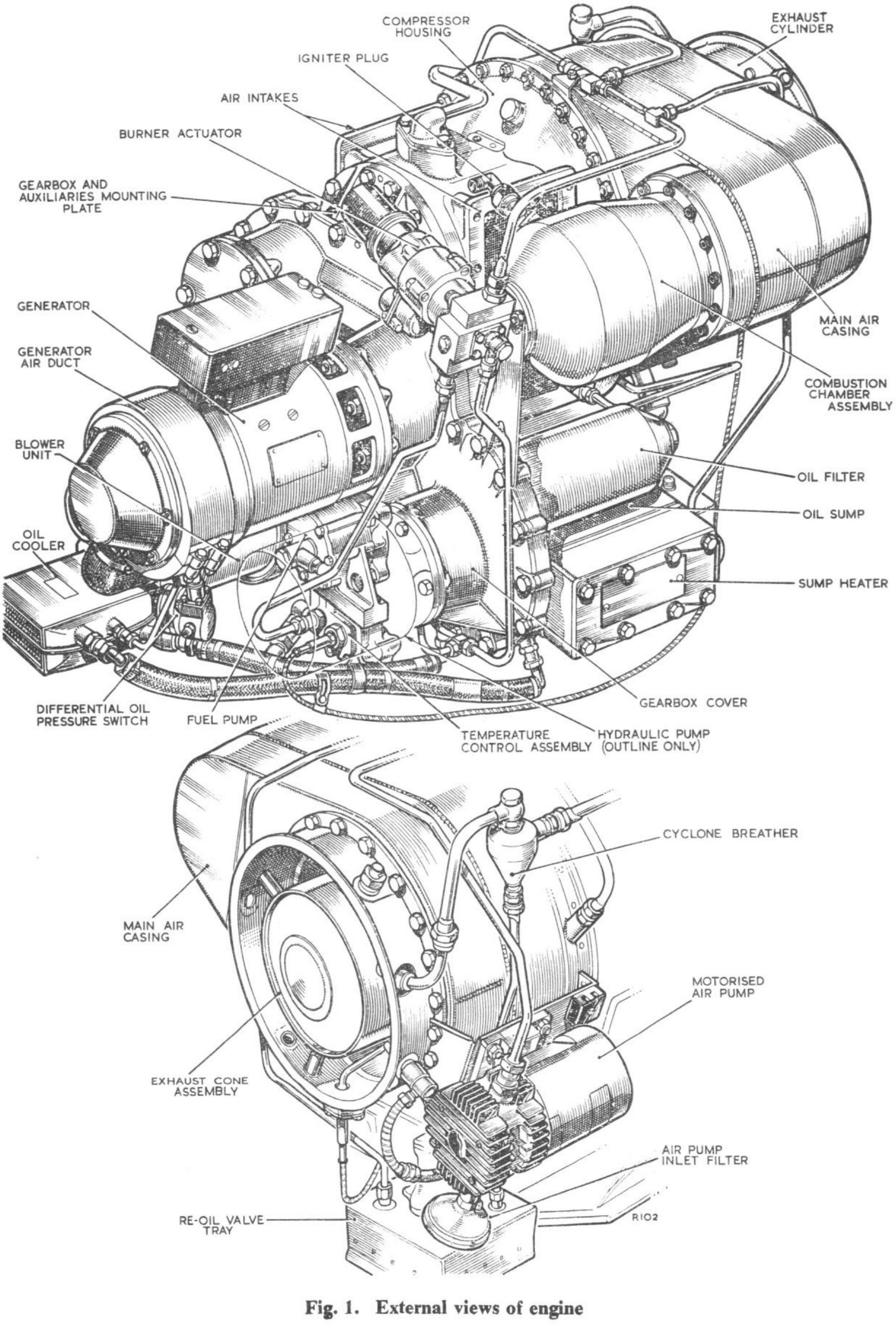


Fig. 1. External views of engine

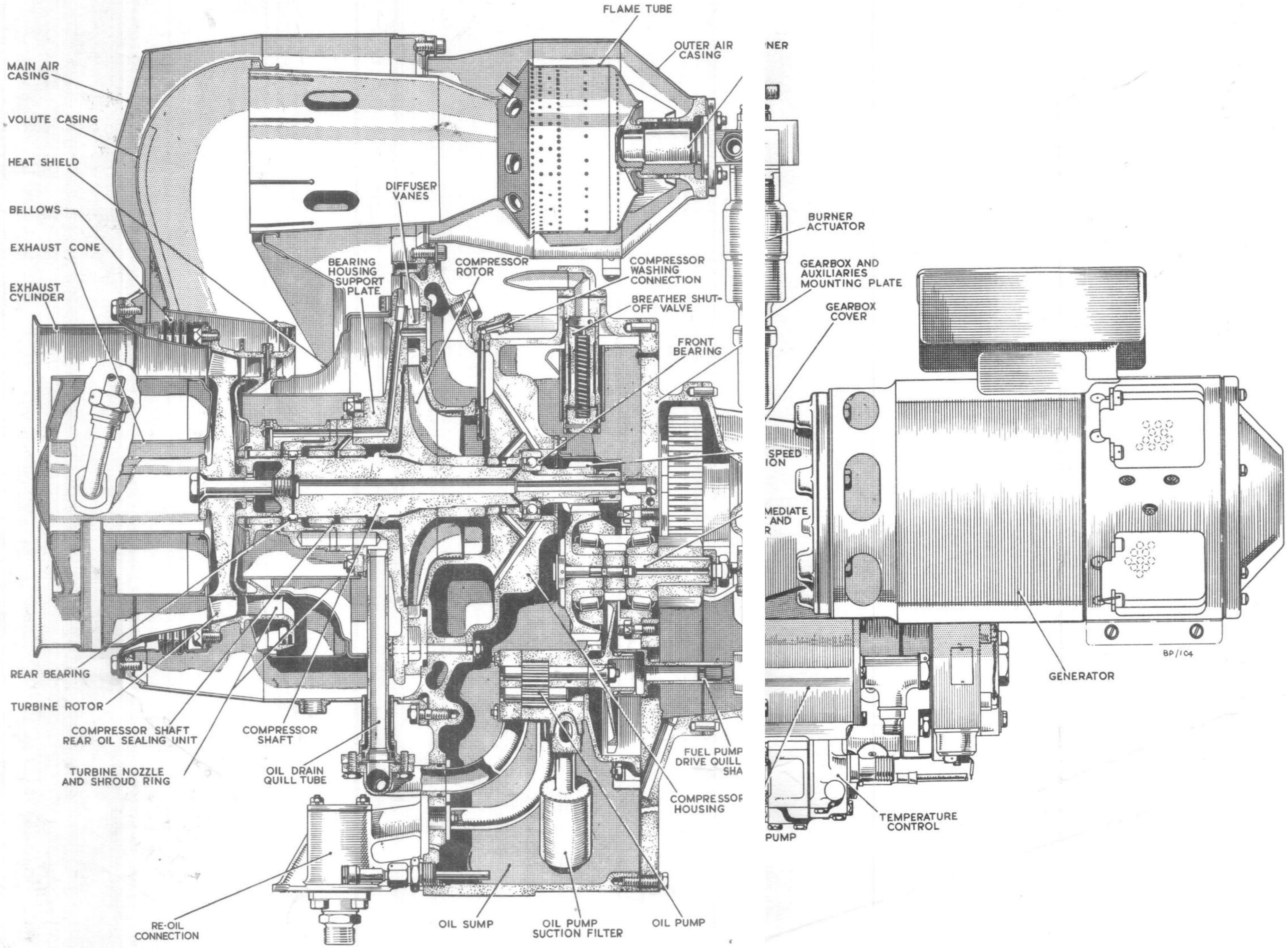


Fig.2 Sectional view of engine

General arrangement

1. The principle rotating parts of the engine consist of a single-sided centrifugal compressor rotor and a single turbine rotor on a common shaft located in two bearings. Power is transmitted through the high speed pinion mounted on the front end of the shaft.

2. The front bearing is supported by the cast aluminium alloy compressor housing that encloses the compressor rotor and the diffuser vanes. The casting also forms two side air intake passages leading to the compressor rotor and the base is utilised as the engine oil sump.

3. The rear end of the compressor shaft is supported by a roller bearing situated between two labyrinth seals. The seals and bearing are secured by through bolts to the rear face of the bearing housing support plate. The support plate is an aluminium alloy casting, bolted to the rear face of the compressor housing, immediately behind the compressor rotor and diffuser vanes.

4. The rear face of the support plate carries the heat shield and the turbine nozzle and shroud ring assembly. The heat shield, which is retained by the support plate mounting bolts, completely encloses the compressor shaft labyrinth seals and rear bearing, whilst the turbine nozzle and shroud ring assembly forms the turbine discharge nozzles. The heat shield also forms part of the inner wall of the Nimonic alloy volute casing which serves to duct the gases from the combustion chamber to the discharge nozzles.

5. The nozzle and shroud ring assembly and the volute are surrounded by the fabricated stainless steel main air casing bolted to the rear of the

compressor housing. A flexible steel bellows, which is inserted between the nozzle and shroud ring assembly and the main air casing, allows for differential expansion between these two assemblies. Flanges on the front and rear of the main air casing carry the combustion chamber outer air casing and the exhaust cone respectively.

6. Enclosing the front of the compressor housing is the magnesium alloy gearbox and auxiliaries mounting plate which carries a 'full-flow' oil filter with its associated pressure relief valves, the intermediate shaft and gear driven by the high speed pinion on the compressor shaft, and the oil pump driven from the intermediate shaft and gear. The intermediate shaft is extended through the plate to drive the generator drive gear, the hydraulic pump drive gear and a train of three idler gears.

Rotating parts assembly

7. The compressor shaft, which is of nickel chrome molybdenum steel, is the main rotating shaft of the engine and supports both the compressor and the turbine rotors.

8. A series of fine grooves is machined around the outer surface of the shaft to form part of the labyrinth sealing system for the rear bearing (para. 21). Eight spigots around the central portion of the shaft serve to locate the compressor rotor, whilst the forward end of the shaft is threaded to take the high speed pinion and its retaining nut.

9. An end-to-end drilling through the centre of the shaft is utilised as an oil duct; two sets of radial drillings are provided to feed oil to the front and rear bearings.

10. The single sided compressor rotor consists of two components:— an aluminium alloy disc with seventeen straight vanes machined radially on one face; and the rotating guide vanes formed

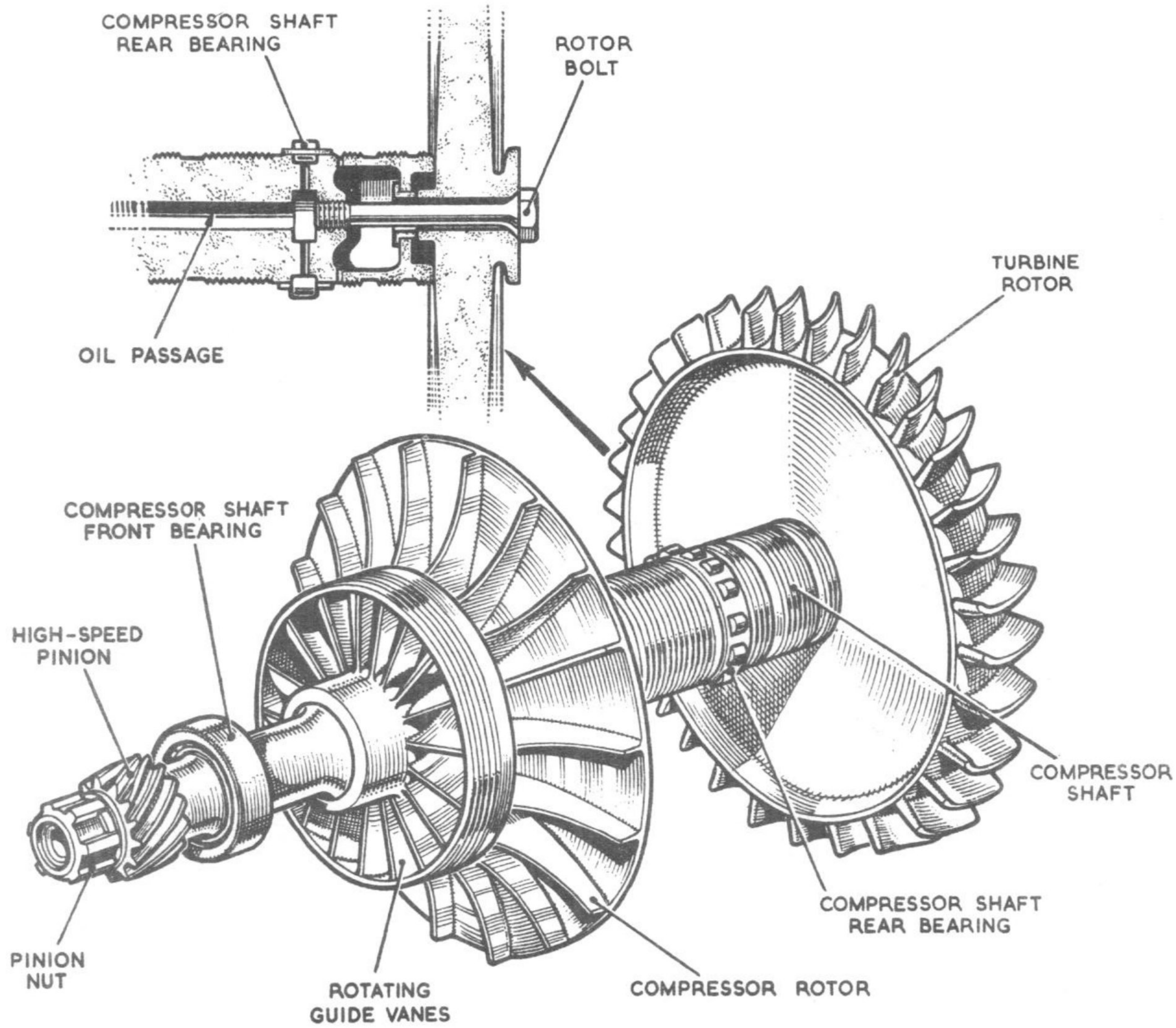


Fig. 3. Rotating parts assembly

by a steel hub having seventeen curved radial vanes machined around its circumference, and strengthened by an outer ring brazed to the vane tips. The two units are relatively aligned on a special jig and shrunk on to the compressor shaft; a collar on the rear face of the impeller locates with the spigots on the shaft.

11. Spigotted to the rear end of the shaft is the Nimonic steel turbine rotor that has thirty-one blades machined around its periphery. The rotor disc is secured to the compressor shaft by a special bolt which also serves to plug the oil duct through the shaft.

12. To minimise heat transfer from the rotor blades and prevent local distortion at running temperature, the end of the shaft is counterbored leaving only a central boss into which the securing bolt is threaded. The only contact between the bolt and the rotor is a line contact at the bolt head, the diameter of the bolt shank being reduced below the diameter of the hole in the rotor.

13. A deep groove high speed ball bearing assembly in a high tensile steel cage locates the front of the compressor shaft and serves to absorb any slight axial thrust.

14. The rear bearing, immediately behind the turbine rotor, consists of thirteen $\frac{1}{4}$ in. diameter rollers each $\frac{1}{4}$ in. long, retained by a brass cage running in a channel formed in the shaft. The

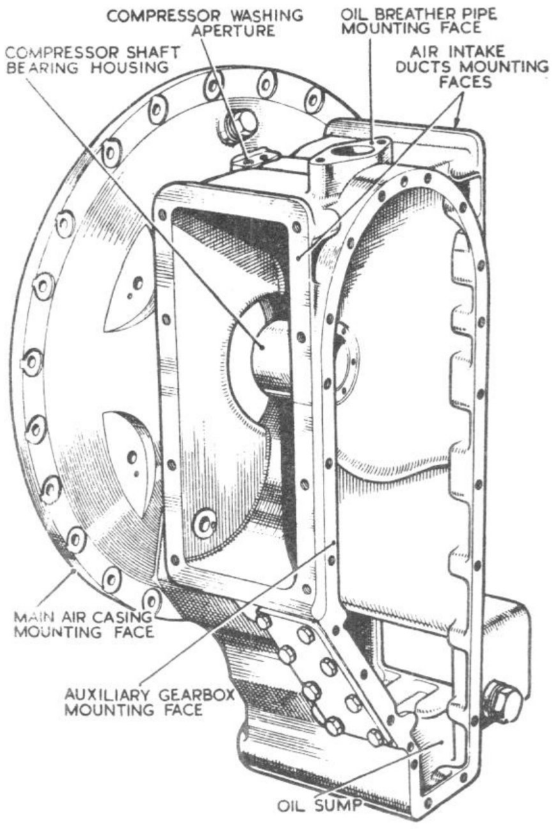


Fig. 4. Compressor housing

outer race for this bearing forms a part of the compressor shaft rear oil sealing unit referred to in para. 21.

15. The complete rotating parts assembly is statically and dynamically balanced to within very close limits; provision is made on the turbine rotor hub and on the rear face of the compressor rotor for the removal of the necessary material to effect balancing. With the exception of the ball bearing, individual replacement parts must not be fitted without the assembly being rebalanced.

Compressor housing

16. The cast aluminium alloy compressor housing forms the two side air intakes, the outer casing for the compressor rotor and, the engine oil sump. The oil sump side plate, which is secured by eight wire locked set bolts and plain washers, is formed by the mounting plate of the electric oil immersion heater (Chap. 2). The housing also contains the oil pump and the reduction gear train, secured to the gearbox and auxiliaries mounting plate (para. 56).

17. The boss in the centre of the housing is counterbored to take the light alloy front labyrinth oil seal and the compressor shaft front bearing; both components are retained by a steel ring secured to the housing by six studs, tab washers and nuts. Shims are fitted between the compressor housing and the rear face of the oil seal flange to adjust the compressor shaft position, whilst a second set of shims, between the rear face of the securing ring and the compressor housing, provides adjustment for bearing nip. Two drillings through the housing boss conduct air to the labyrinth seal from an annular reservoir cast in the thickness of the housing.

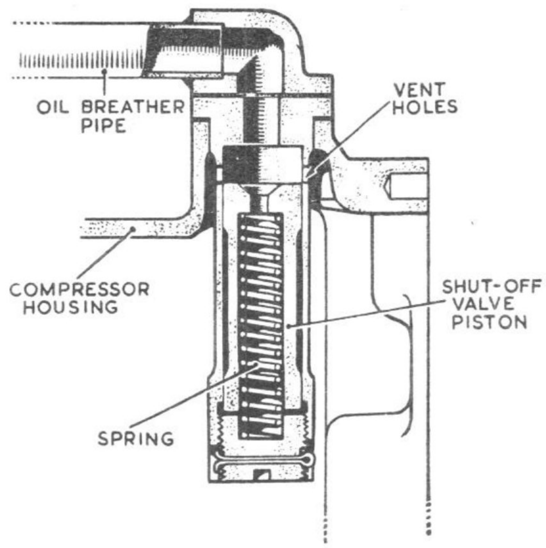


Fig. 5. Breather shut-off valve

18. A machined face on top of the compressor housing carries the oil breather pipe, which is secured by two studs and tab washers. The

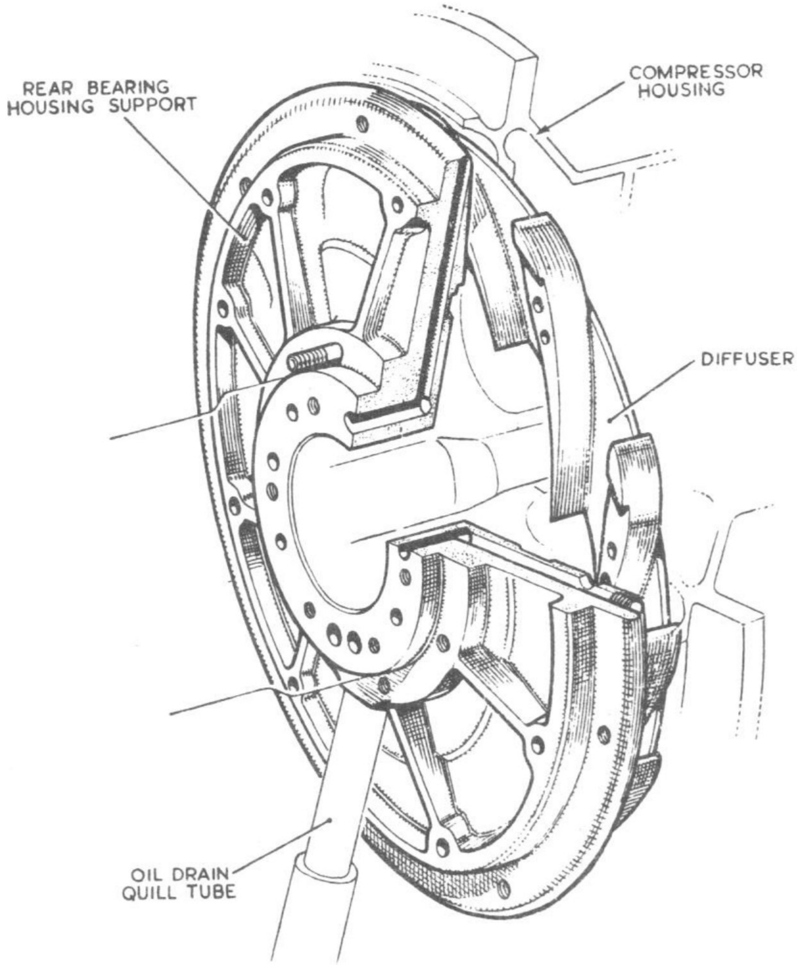


Fig. 6. Rear bearing housing support plate and diffuser vanes

entrance to the pipe is controlled by a gravity operated piston shut-off valve designed to prevent the loss of oil during inverted flight.

Bearing housing support plate

19. The aluminium alloy bearing housing support plate is secured to the rear face of the compressor housing by nine fitting bolts, tabwashers and nuts. Eight studs on the rear face of the plate provide attachment for the turbine nozzle and shroud ring assembly (para. 37), whilst six tapped holes take the long set bolts, securing the compressor shaft rear oil sealing components (para. 21).

20. A series of drillings, radially and axially through the plate, communicate with the compressor shaft sealing unit and compressor housing to form part of the sealing and cooling air system. Two of these drillings drain surplus oil from the rear bearing, to a point in the bottom of the support plate boss, where the oil drain quill tube is inserted.

Compressor shaft rear oil sealing unit

21. The compressor shaft rear oil sealing unit and turbine rotor cooling ring are secured to the rear face of the bearing housing support plate by six bolts locked by tabwashers. The sealing unit consists of the compressor shaft inner and outer seals and the rear bearing outer race. To ensure that these components are assembled in their correct angular relationship, the bolt holes are irregularly spaced.

22. The outer seal consists of a steel housing containing a carbon bush which has two rings of radial drillings aligned with two channels in the housing. When assembled in the engine, the bush mates with a series of fine grooves on the rear of the compressor shaft to form a labyrinth seal, whilst the drillings in the bush are aligned with two channels on the shaft.

23. The steel inner seal housing contains two carbon bushes that mate with a further series of

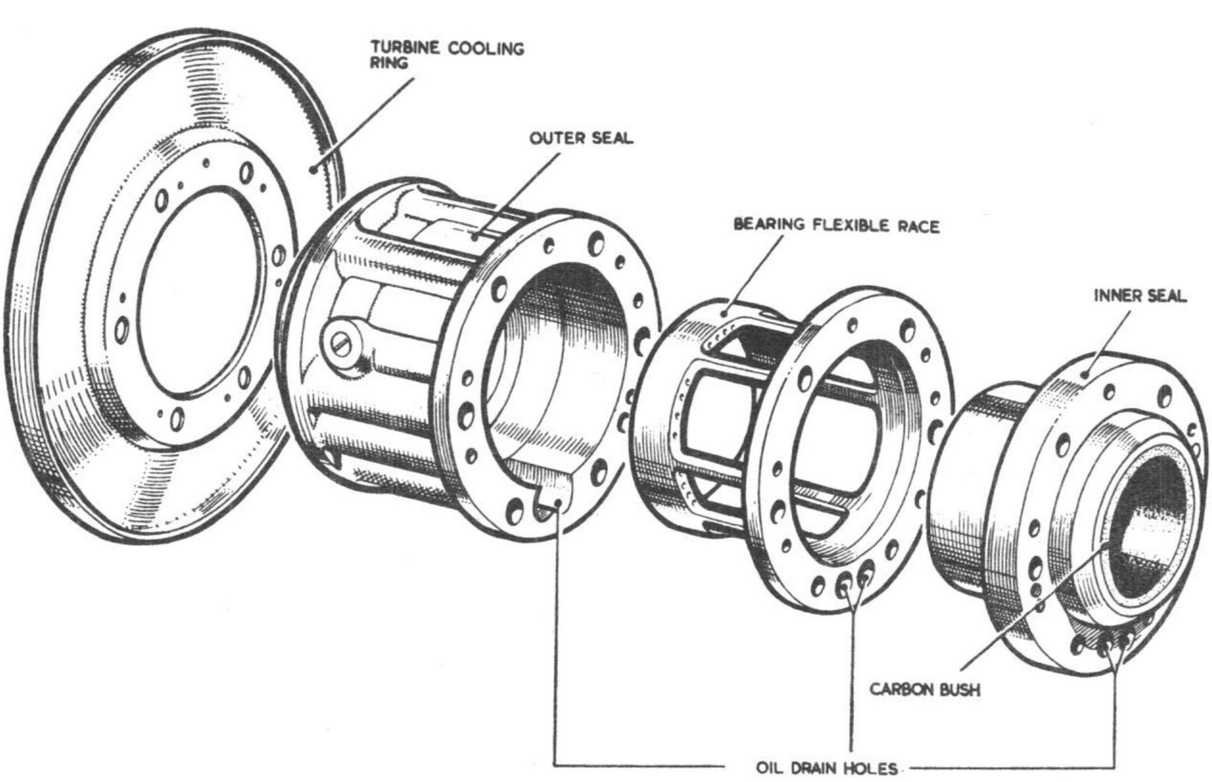


Fig. 7. Compressor shaft rear oil seal unit

fine grooves on the compressor shaft to form the inner labyrinth seal whilst the gap between these two bushes coincides with a channel on the compressor shaft. A series of drillings through the sealing unit serve as cooling and sealing air passages.

24. Sandwiched between the inner and outer seal housings is the securing flange of the outer race for the compressor shaft rear bearing. The outer race and its securing flange are formed as one unit and are interconnected by eight narrow struts; this method of manufacture allows sufficient flexibility in the bearing to damp-out resonant frequency in the compressor shaft.

25. To allow the oil from the rear of the bearing to pass forward into the drain holes in the bottom of the sealing unit, thirty-two small holes are drilled horizontally through the race.

26. The steel turbine rotor cooling disc, attached to the rear face of the outer seal housing by the sealing unit securing bolts, acts as a heat deflector for the turbine rotor and protects the sealing unit; provision is made for cooling air from the compressor to be blown in the space between the turbine rotor and the cooling disc. Steel shims fitted between the cooling disc and the outer seal housing provide adjustment for the clearance between the cooling disc and the turbine rotor.

Operation of the compressor shaft bearing sealing system

Note . . .

To assist in the identification of the various air passages, it has been assumed that an imaginary clock face is superimposed on the seal housings and bearing support plate as viewed from the turbine or rear end of the engine.

27. Air at medium pressure, about 50 per cent of compressor delivery pressure, is taken from the back of the compressor rotor and allowed to flow along the horizontal holes in the boss of the bearing housing support plate. These holes are positioned at approximately five o'clock and eight o'clock. Corresponding passages are drilled through the compressor shaft inner seal, the flange of the bearing outer race, and the compressor shaft outer seal.

28. Within the compressor shaft outer seal, air is fed into an annular groove and passes through a ring of eight holes in the carbon bush housed in the seal to enter a channel on the compressor shaft. From this channel, the air disperses in both directions along the machined grooves on the shaft which form a labyrinth seal.

29. The air escaping from the rear of the seal

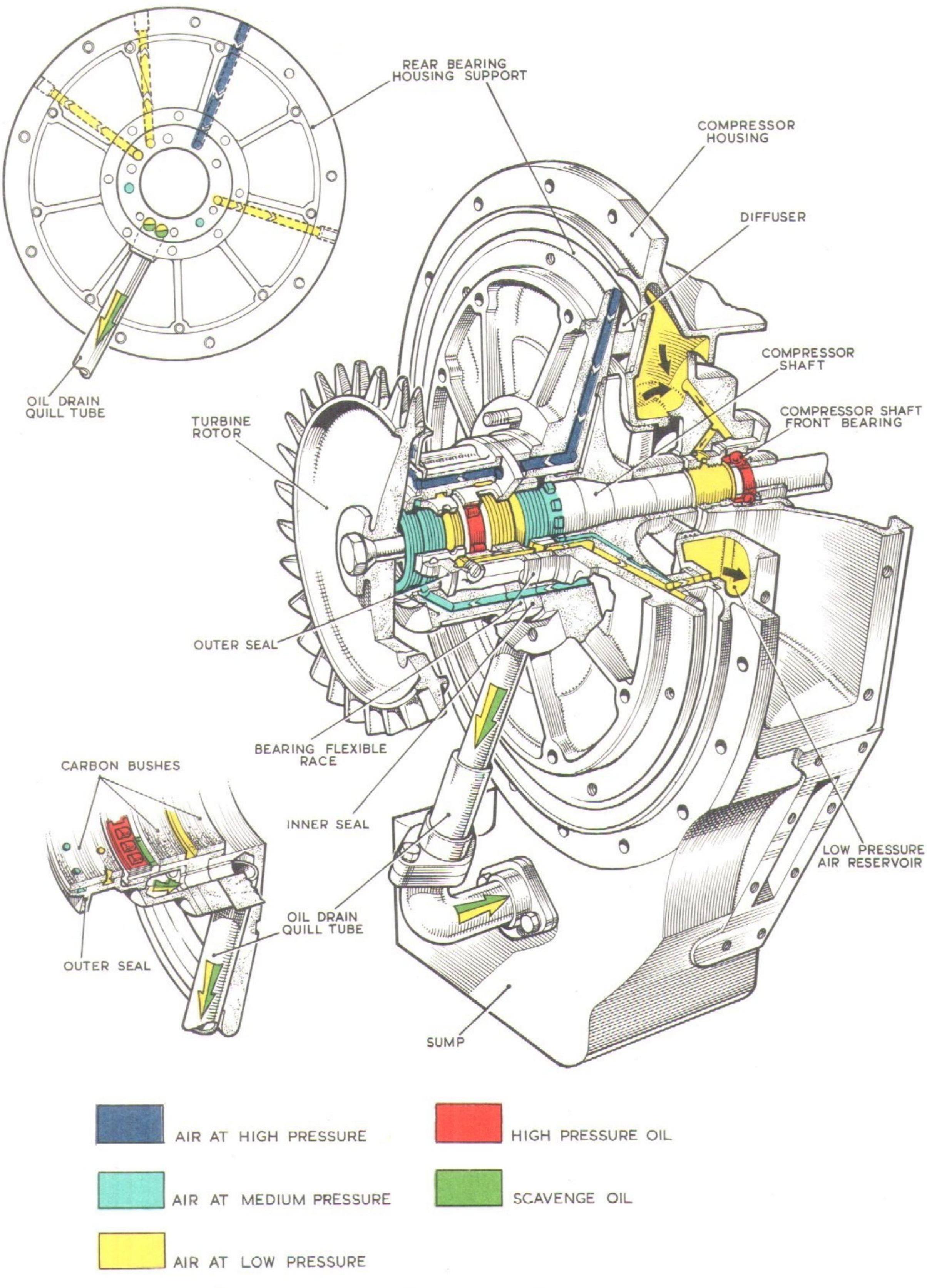


Fig.8 Compressor shaft bearing seal system

130575 Gd.161451 9/73 M.F.P.

flows over the front face of the turbine rotor disc and mixes with the main bulk of cooling air. The air flowing forward along the seal, reaches a second channel around the compressor shaft and passes into three return air passages via a second ring of eight holes drilled in the carbon bush. This arrangement prevents the escape of oil rearwards along the labyrinth seal from the turbine bearing.

30. The three return air passages referred to in para. 27 to 29 are drilled at ten o'clock, eleven o'clock and three o'clock through the compressor shaft inner and outer seals and the flange of the bearing outer race. Within the inner compressor shaft seal they communicate with a set of drillings that emerge between the two carbon bushes in the seal housing. These drillings are in alignment with the channel in the compressor shaft dividing the forward sealing grooves. A proportion of the return air reaches this channel and disperses, as in the case of the outer seal, in both directions. Air which flows to the rear along the grooves can only escape via the oil drain tube and so assists the scavenge oil to return to the sump, whilst that flowing forward serves to balance the air at medium pressure flowing along the grooves in the opposite direction from the space to the rear of the compressor rotor.

31. The residue of air remaining in the return system flows along the three drilled passages passing into the boss of the bearing housing support plate. Within the support plate casting the drillings lead radially outward and emerge on the front face of the plate at ten o'clock, eleven o'clock and three o'clock, to mate with the holes drilled through three of the diffuser vanes.

32. These holes in turn connect with three holes drilled through the compressor housing to communicate with the cast in low pressure air reservoir surrounding the compressor rotor. From this reservoir lead two drillings which supply low pressure air to a groove in the labyrinth oil seal to the rear of the front compressor shaft bearing. Air spilling out from this groove and along the labyrinth seal prevents oil flowing away rearwards from the bearing; this air finally escapes from the rear of the seal into the main air stream entering the impeller eye from the air intakes.

33. A single radial drilling at one o'clock in the bearing housing support plate collects air at compressor delivery pressure from a point just beyond the diffuser; this supply of air flows along a series of mating holes drilled through the support plate boss, the compressor shaft inner seal, the flange of the bearing outer race, and the

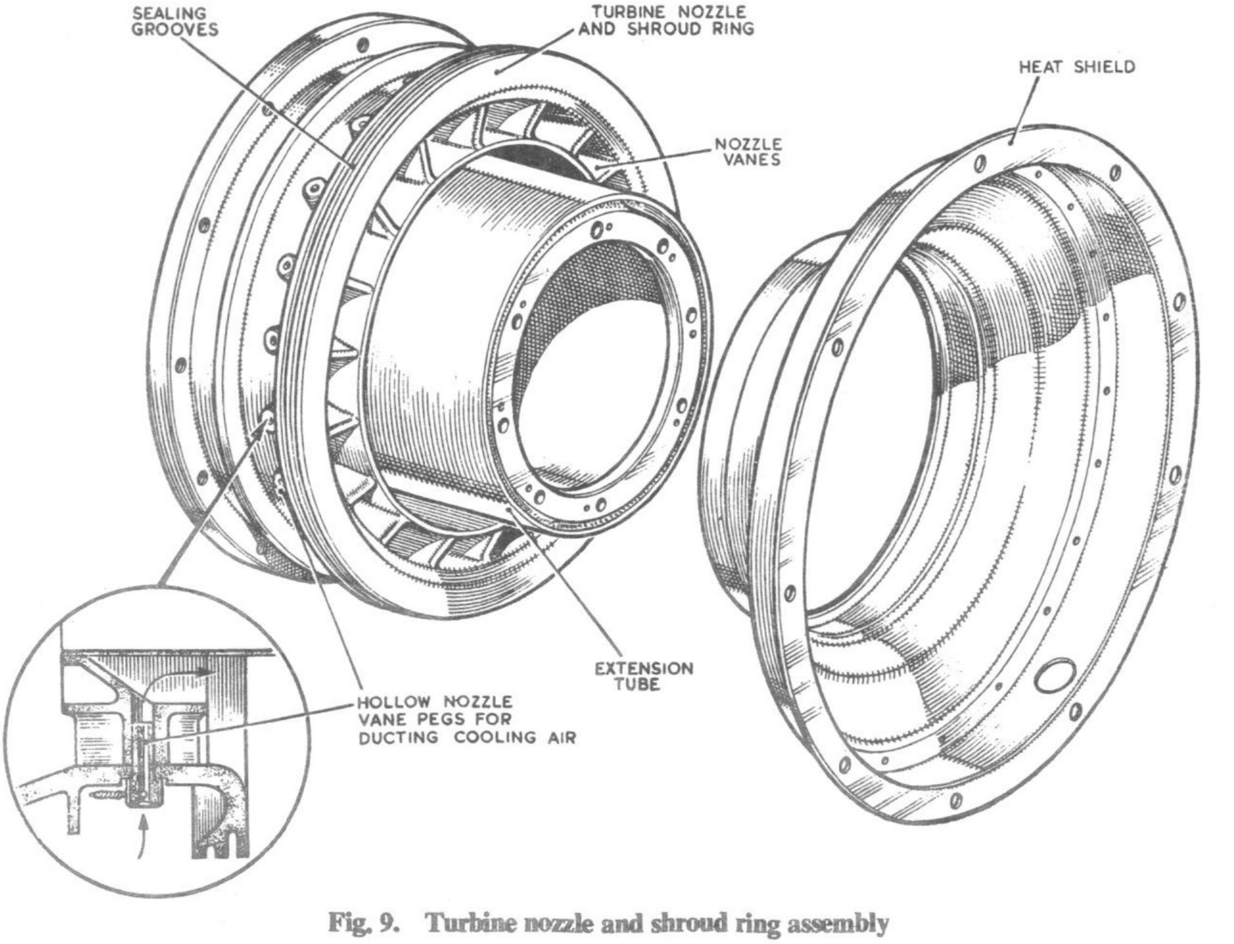


Fig. 9. Turbine nozzle and shroud ring assembly

compressor shaft outer seal to a metering hole drilled in the cooling ring. Air issuing from this hole passes over the forward face of the turbine rotor disc as a cooling medium; the air mixes with medium pressure air issuing from the rear of the labyrinth seal and then escapes into the gases passing through the turbine blades.

34. A portion of the air which flows around the outside of the flame tube and volute, within the main air casing, is fed through the drillings in the nozzle blades. This air then flows forward under the heat shield. The air escapes through a ring of holes in the face of the heat shield adjacent to the volute support ring and then flows beneath the edge of the support ring to mix with the main gas stream travelling along the volute.

35. The rear face of the turbine rotor disc is cooled by air induced from atmosphere along the exhaust cone locating tube by the rotation of the disc. This air passes forward through the inner exhaust cylinder, and then spreads outwards over the disc face to blend with the exhaust gases.

Diffuser vanes

36. The diffuser, consisting of nine vanes machined radially round the face of an aluminium alloy ring, is sandwiched between the rear of the compressor housing and the bearing housing support plate. An annular recess in the compressor housing locates the diffuser ring concentrically in relation to the compressor rotor. the nine fitting bolts securing the bearing housing support plate to the compressor housing also pass through and secure the diffuser ring.

Turbine nozzle and shroud ring assembly

37. The turbine discharge nozzles, formed by twenty-one vanes machined on a forged 'crown max' ring, welded to an extension tube, are secured to the rear face of the bearing housing support plate by eight studs, nuts and tabwashers. Light alloy packing washers and steel shims are interposed at the securing point to provide adjustment of the clearance between the turbine rotor tips and the shroud ring.

38. The 'crown max' shroud ring surrounds the nozzle vanes and is secured to each vane by a hollow peg, which serves as a cooling air duct. To assist the gas flow into the turbine rotor, the front end of the shroud ring is bell-mouthed at its junction with the volute. Grooves that are cut into the circumference of the bell-mouthed end act as a seal and prevent the air in the main air casing from entering and mixing with the hot gas in the volute.

Heat shield

39. The heat shield fabricated from Nimonic steel sheet is secured to the periphery of the rear face of the bearing housing support plate by nine wire locked cap screws. The shield forms a continuation of the volute casing although separated from it by a slight air gap. Cooling air from the main air casing passes through the nozzle vane pegs, and flows between the heat shield and the nozzle and shroud ring extension tube to protect the compressor shaft seals; the air is fed back into the main gas stream via a ring of holes in the heat shield behind the volute flange.

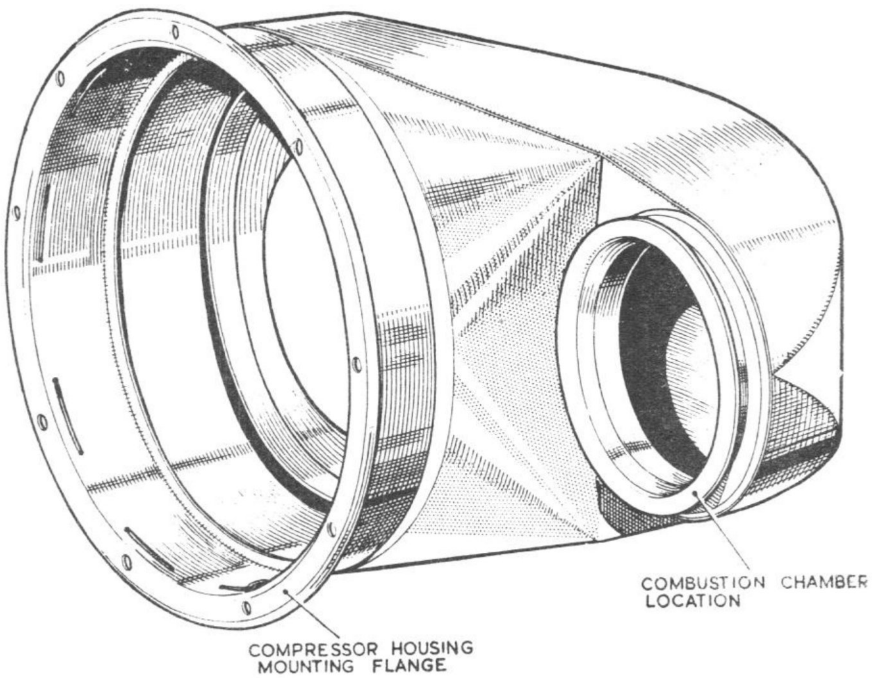


Fig. 10. Volute casing

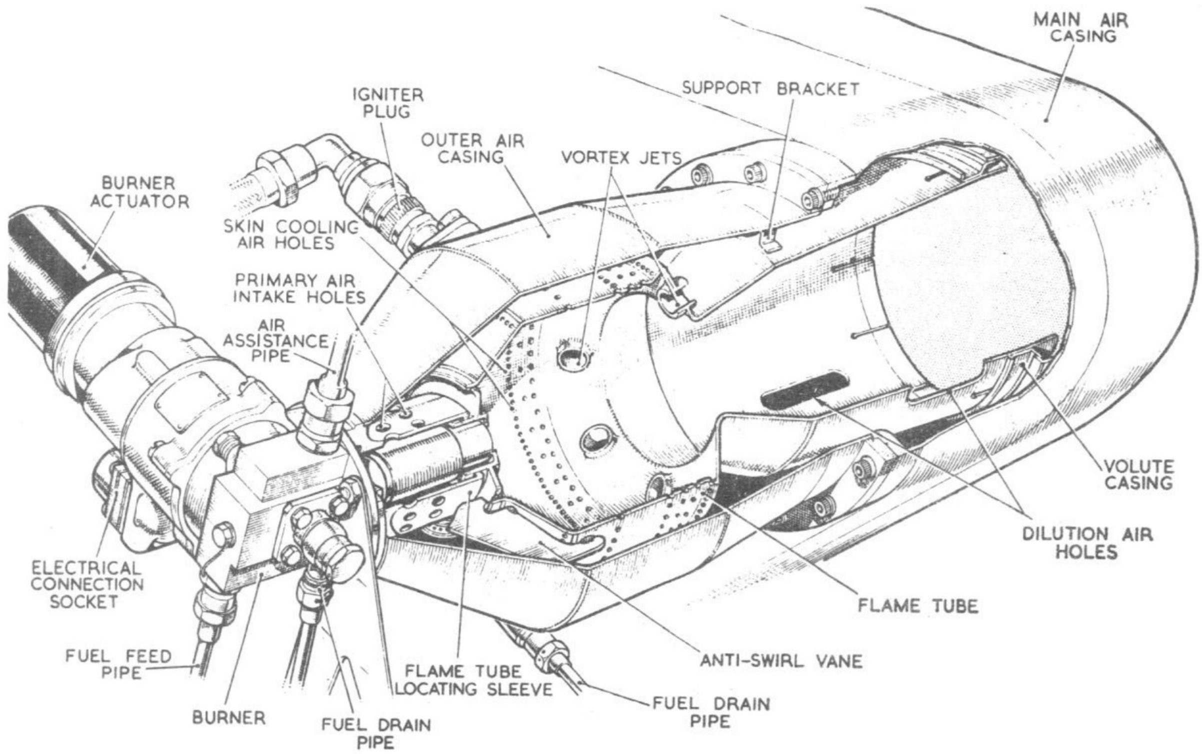


Fig. 11. Combustion chamber

Volute casing

40. The volute casing, which is fabricated from Nimonic steel sheet, forms a duct for the combustion gases from the combustion chamber to the nozzle and shroud ring. The casing, which is a sliding fit over the flame tube and shroud ring, is secured to the bearing housing support plate by the heat shield retaining cap screws.

Combustion chamber

41. The single combustion chamber consists of a stainless steel outer casing that encloses a flame tube made of Nimonic steel sheet.

42. The outer air casing is attached to the main air casing by 12 set screws and spring washers. The suspension plug, which is secured to a welded boss on the upper side of the outer air casing by two set bolts and tabwashers, houses the electrical igniter plug. A drain union, welded to the bottom of the casing, conveys any accumulation of fuel via a pipe to the drain valve.

43. The simplex burner complete with its actuator is secured to the front face of the casing, on the outside flange of the flame tube locating sleeve, by four set bolts and spring washers.

44. The necked flame tube, located centrally within the outer air casing by three support brackets, is a sliding fit in the locating sleeve at its head, and in the volute casing at the rear end. The air flow from the compressor is stabilised as is passes around the outside of the flame tube by four anti-swirl vanes welded to the flame tube head. Three rings of holes in the flame tube head and two rings of holes in the locating sleeve form primary air intake holes.

45. The cylindrical section of the flame tube, forward of the neck, has six staggered rings of holes to allow the passage of skin cooling air; the section also contains the locating sleeve through which the igniter plug is inserted. Inserted around the neck of the flame tube are the seven tubular vortex jets which admit and direct more primary air to create turbulance in the burning region. To reduce the temperature of the combustion gases, dilution air is admitted through four large elongated holes around the rear section of the flame tube.

Main air casing

46. Fabricated from stainless steel sheet, the main air casing is attached to the rear of the compressor housing by 23 studs, spring washers and nuts and completely encloses the rear half of the engine.

47. The oil drain pipe and flange, welded to the bottom of the casing, contains the oil drain quill tube. The flange serves as a mounting for the oil

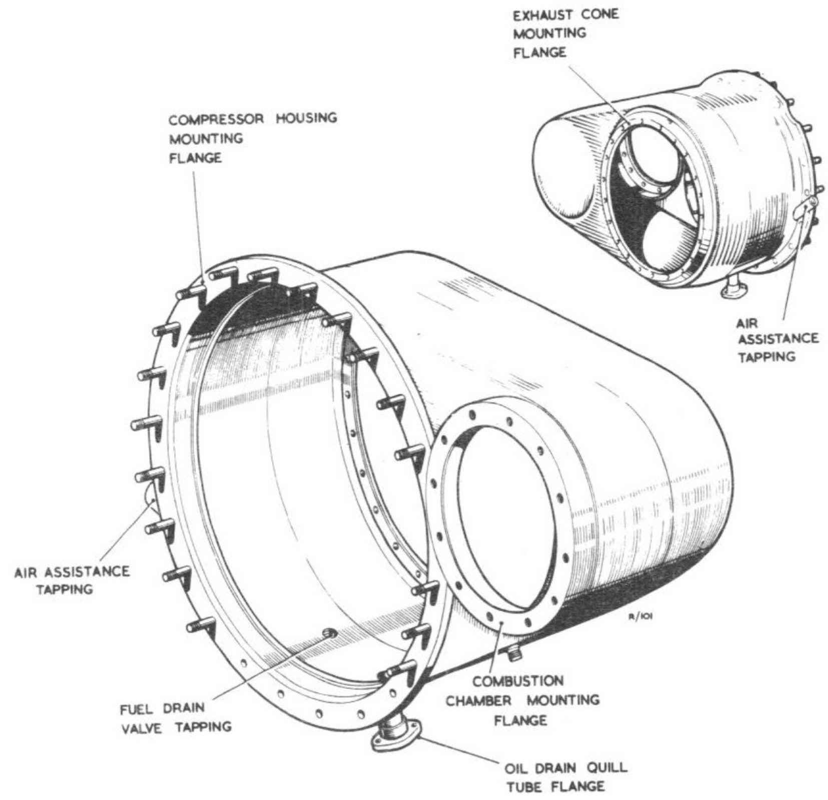
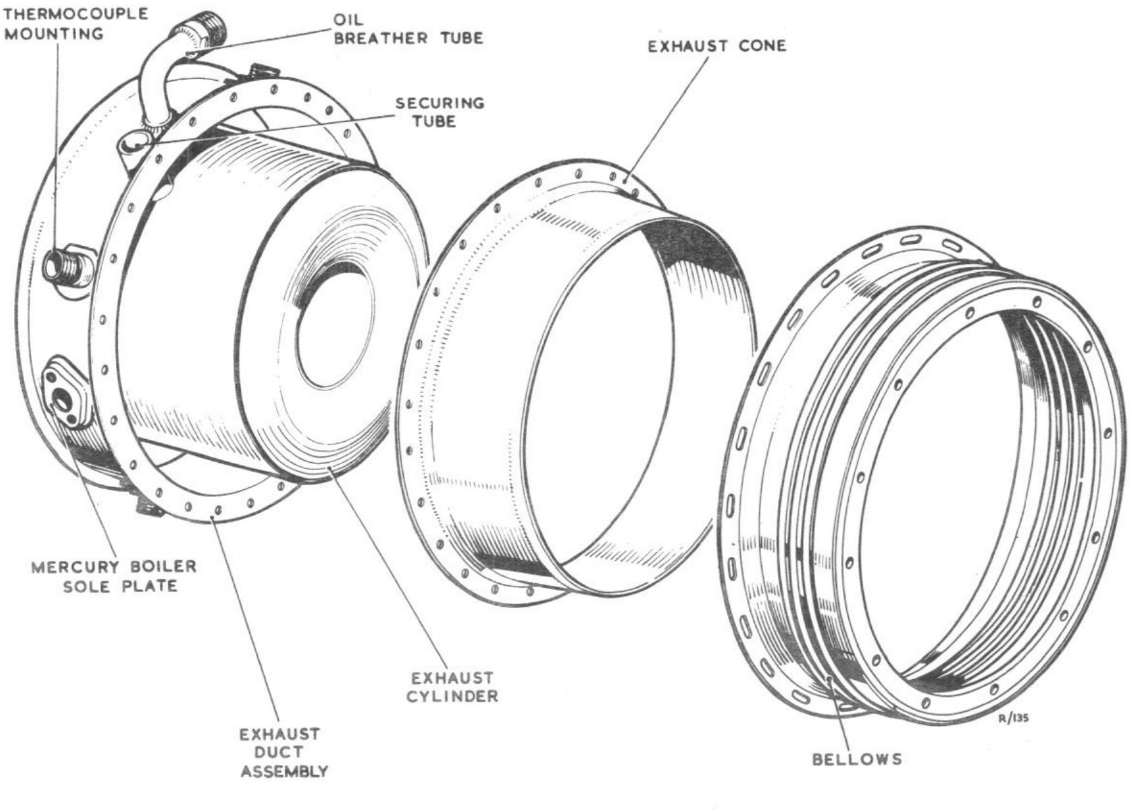


Fig. 12. Main air casing



◄ Fig. 13. Bellows, exhaust cone and exhaust duct assembly. ►

drain T-piece, secured by two wire locked set-bolts and plain washers. The lower side of the casing also supports a welded mounting boss for the fuel drain pipe.

Bellows

48. A flexible bellows, interposed between the turbine nozzle and shroud ring assembly, prevents any distortion due to differential expansion of the two components. Formed in the shape of a corrugated stainless steel cylinder, the bellows is secured to the rear flange of the main air casing by 24 set-bolts and spring washers, and to the nozzle and shroud ring assembly by twelve set screws and six lock plates.

Exhaust cone

49.◄ The stainless steel exhaust cone has an angle of fourteen degree's to match the tip angle of the turbine rotor blades, the cone fits inside the bellows assembly with its flange interposed between the bellows and exhaust duct. It is retained by the bolts securing the exhaust duct.

Exhaust duct and cylinder assembly

50. The exhaust cylinder consists of two concentric cylinders, closed at the rear end by a common end cap, and centrally located within the exhaust duct by three welded securing tubes. These tubes together with the exhaust cylinder are designed to supply cooling air to the face of the turbine rotor. Welded around the exhaust duct are four thermocouple bosses, a sole plate for the temperature control mercury boiler and a connection point for the engines oil breather pipe. The assembly is retained by twenty four bolts which connect with the main air casing by passing through and retaining the exhaust cone and bellows flanges.►

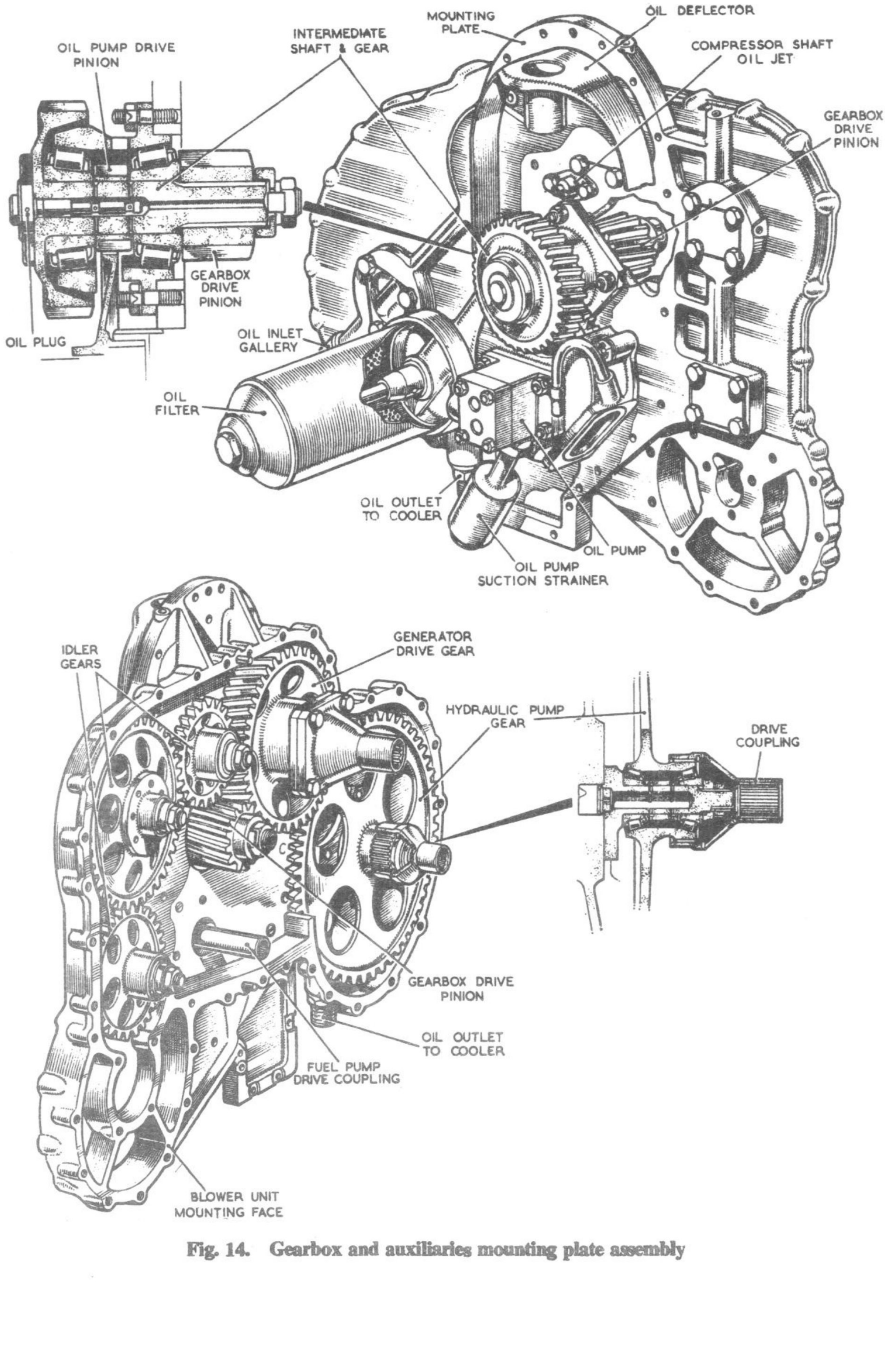


Fig. 14. Gearbox and auxiliaries mounting plate assembly

Auxiliaries drive gearbox

51. The auxiliaries drive gearbox, which is secured to the front end of the engine, can conveniently be considered in two parts:— the gearbox and auxiliaries mounting plate, and the gearbox cover.

Gearbox and auxiliaries mounting plate

52. Enclosing the front of the compressor housing, the magnesium alloy gearbox and auxiliaries mounting plate carries on its two faces the output drives for all the engine driven accessories. The plate is located on the face of the compressor housing by two dowels and secured by 21 bolts and tabwashers.

53. Secured to and extending through the mounting plate, is the integrally forged intermediate shaft and gear which forms the gearbox first motion shaft. The shaft and gear, which is driven from the high speed pinion on the compressor shaft, is supported on the rear face of the mounting plate by two taper roller bearings housed in a common outer race. Four studs in the mounting plate pass through a flange on the bearing outer race and the complete assembly is retained by four nuts and tabwashers.

54. The intermediate shaft also carries the oil pump and gearbox drive pinions. The oil pump drive pinion located between the two bearings is an interference fit on the shaft, whilst the gearbox drive pinion on the nose of the shaft is retained by a distance piece, lockwasher and locknut.

55. The bearings are fed with oil from a jet in the gearbox cover which locates in the nose of the shaft to communicate with passages drilled radially and from end to end through the shaft. The supply of oil is regulated by a restrictor inserted into the end of the drilling.

56. A cup shaped mounting bracket secured to the rear face of the mounting plate by four bolts, plain washers, nuts and split pins, carries the gear type oil pump and encloses the pump driving gear. The gear, which is driven from the pinion on the intermediate shaft, is keyed to the pump shaft and retained by a nut and tabwasher. A splined extension machined on the boss of the driving gear provides the drive for the fuel pump.

57. Oil from the pressure side of the pump passes through drillings in the oil pump body, the mounting bracket, and the mounting plate to a dished extension on the rear face of the lower port side of the plate which forms the head of the external oil filter (Chap. 2). The central boss of the filter head is threaded to receive the single special bolt securing the oil filter body, and is cross drilled to provide oil ways between the filter head, the filter body and the filter and cooler by-pass relief valves housed in the filter head.

58. After passing through the filter, the oil is delivered via external pipes to the oil cooler from whence it returns to a union on the lower port edge of the mounting plate to enter the main oil gallery running transversely across the plate. An oil jet, secured to the rear face of the mounting plate by two set-bolts, feeds oil from the gallery directly into the bore of the compressor shaft (para. 7). Oil is also fed from the main gallery to all the drive and idler gears on the forward face of the plate.

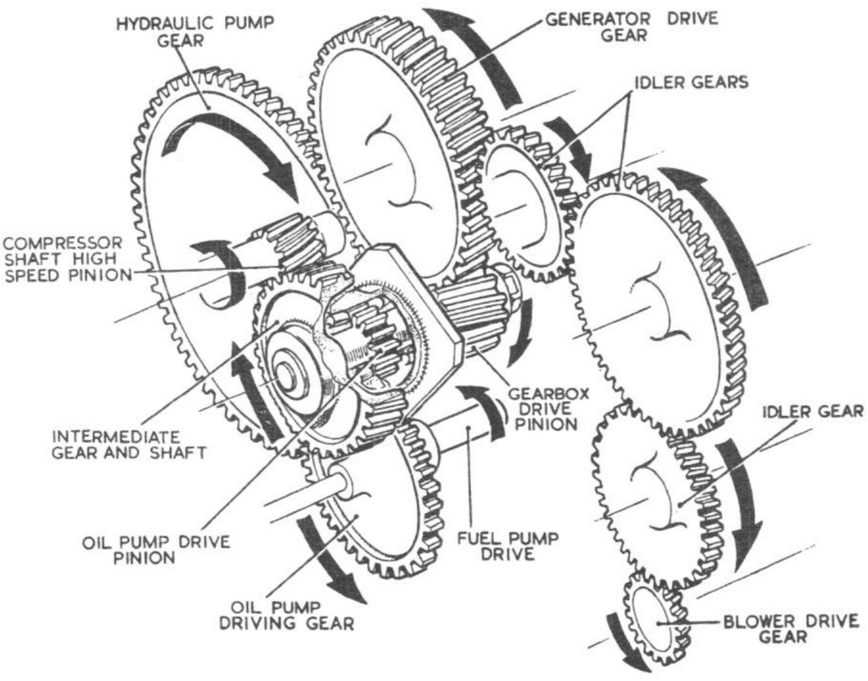


Fig. 15. Gearbox drive train

59. The gearbox drive pinion on the intermediate shaft meshes with the generator drive gear which, in turn, drives the hydraulic pump gear on the starboard side of the mounting plate. The blower drive pinion integral with the blower unit, on the port side of the plate, is also driven from the generator drive gear, via a train of three idler gears.

60. The generator drive gear is supported by two taper roller bearings and a stub shaft secured to the mounting plate by four set-bolts that are locked by tabwashers. The hub of the gear forms a common outer race for the two bearings; a distance piece and a set of shims interposed between the two bearings enable the correct degree of bearing preload to be obtained. The outer bearing is retained by a distance piece and a locknut secured by a tabwasher. The exterior of the gear hub is flanged to carry the generator driving member, which consists of an internally splined muff coupling, secured to the flange by four wire locked set-bolts and plain washers.

61. The stub shaft is counterbored and radially drilled to enable the oil supply from the main gallery to reach the bearings. A restrictor, retained in the counterbore by a circlip, controls the oil flow to the bearings.

62. The five other gears, although different dimensionally, are all retained and lubricated in a similar fashion; the principal difference is that in the case of the hydraulic pump gear, the drive coupling is carried on splines machined externally on the gear hub, whilst on the second idler gear, which is also a spare output drive, provision is made to secure a drive coupling to the web of the gear.

Gearbox cover

63. The gearbox cover, which provides a mounting face for the generator, the hydraulic pump and the fuel pump, is secured to the gearbox and auxiliaries mounting plate by 40 set-bolts, one stud and nut, 37 plain and spring washers and four tabwashers. Two dowels locate the cover in relation to the mounting plate.

64. The generator and hydraulic pump are both mounted on the starboard side of the cover and in each case are retained by six studs, plain and spring washers and nuts. To prevent the passage of oil from the gearbox to the generator, an oil seal housed in a dished plate, sandwiched between the gearbox cover and the generator mounting flange, locates on the plain diameter of the generator drive coupling. The seal is retained in the plate by a circlip.

65. The blower and oil cooler assembly is secured to the lower port side of the gearbox cover by a 'King' clamp. The joint is sealed by an O-ring recessed into an annular groove in the blower mounting flange.

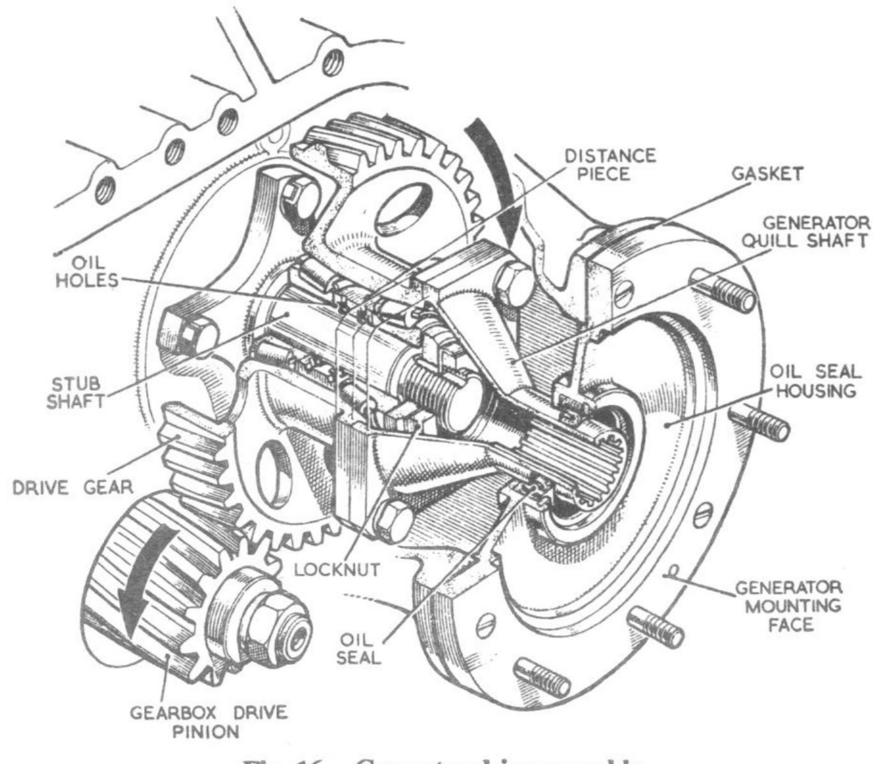


Fig. 16. Generator drive assembly

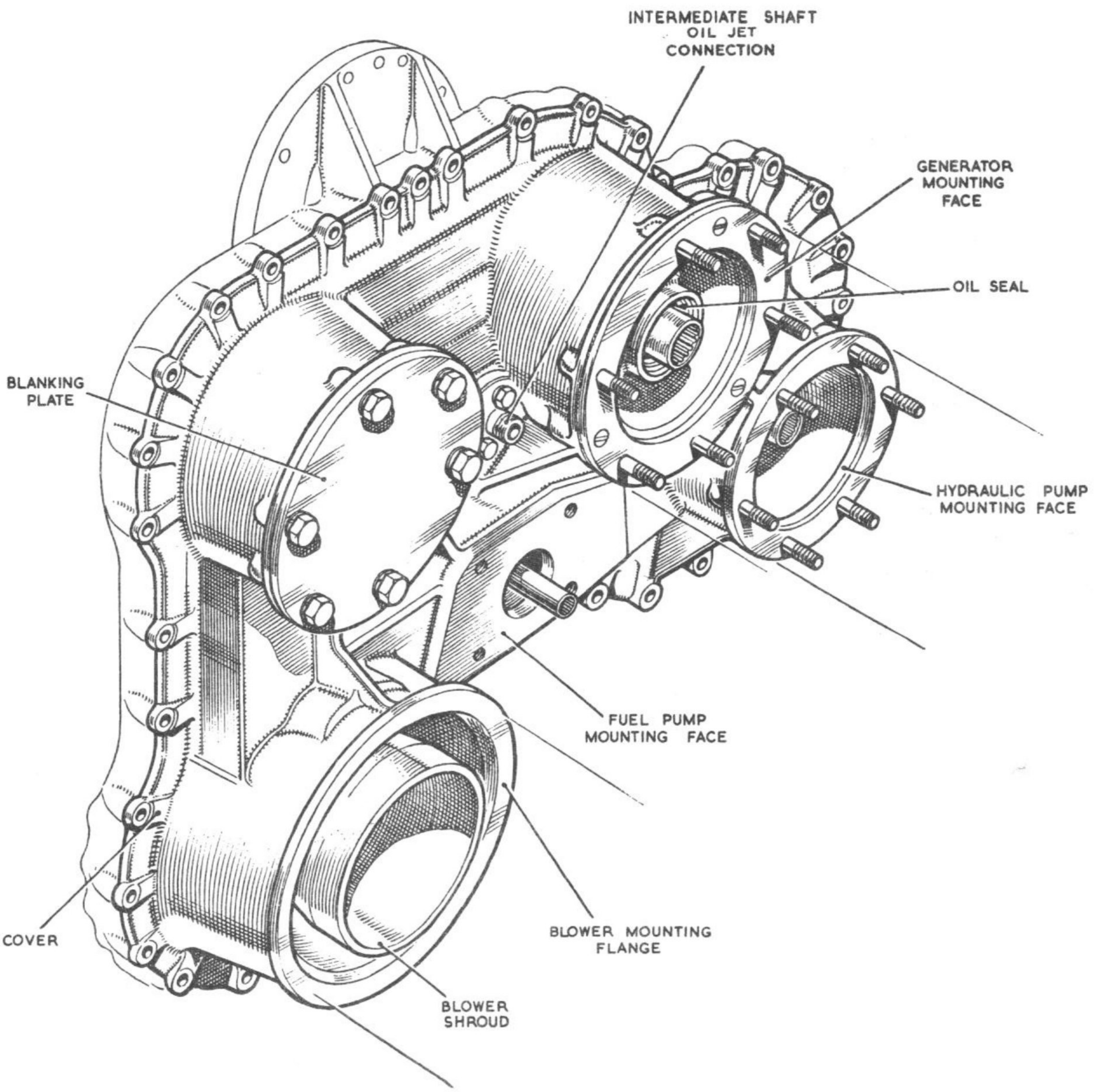


Fig. 17. Gearbox cover

66. The blower unit carries its own drive pinion on an extended drive shaft and bearing housing which enters the gearbox through an inner shroud cast integrally with the gearbox cover. The air supply for the blower is ducted from the main air intake, through the rear of the auxiliaries mounting plate and around the exterior of the inner shroud to the first compressor stage of the blower.

67. An O-ring, recessed into an annular groove on the exterior of the drive shaft bearing housing, immediately behind the drive pinion, locates on the inner wall of the shroud to prevent the egress of oil to the blower. Gearbox oil however, is free to travel along the interior of the bearing housing to lubricate the drive shaft bearings.

68. A dowel recessed into an inner web of the blower housing locates in the leading edge of the inner shroud to correctly position the blower on the gearbox cover.

69. The fuel pump, positioned centrally on the lower half of the cover is retained by four set-bolts and tabwashers. The drive for the pump is taken from the oil pump driving gear via an internally splined muff coupling.

Operation

70. The starter mechanism rotates the compressor shaft with the result that air is drawn through the intakes and compressed by the compressor rotor. The high velocity air flows from the rotor tip, and passes through the diffuser vanes where a further increase in pressure occurs.

71. The compressed air is conducted by the main air casing to the outer casing of the combustion chamber and enters the flame tube. Primary air enters via the holes surrounding the burner atomiser and at this point fuel is injected into the air stream by the simplex burner. More primary air, entering through the vortex jets in the neck of the flame tube, imparts 'swirl' to the resultant air/fuel mixture.

72. Initial ignition of the mixture is provided by an electrically operated igniter plug and provision is made to discontinue the ignition spark as soon as the engine reaches a self sustaining speed.

73. In order to reduce the temperature of the combustion gases, dilution air is admitted through four large elongated holes, equally spaced around the rear end of the flame tube.

74. Leaving the flame tube the gases enter the volute casing, which directs them through the nozzle and shroud ring assembly onto the turbine rotor to provide the driving power for the unit. The expended gases are finally exhausted to atmosphere via the exhaust cone.

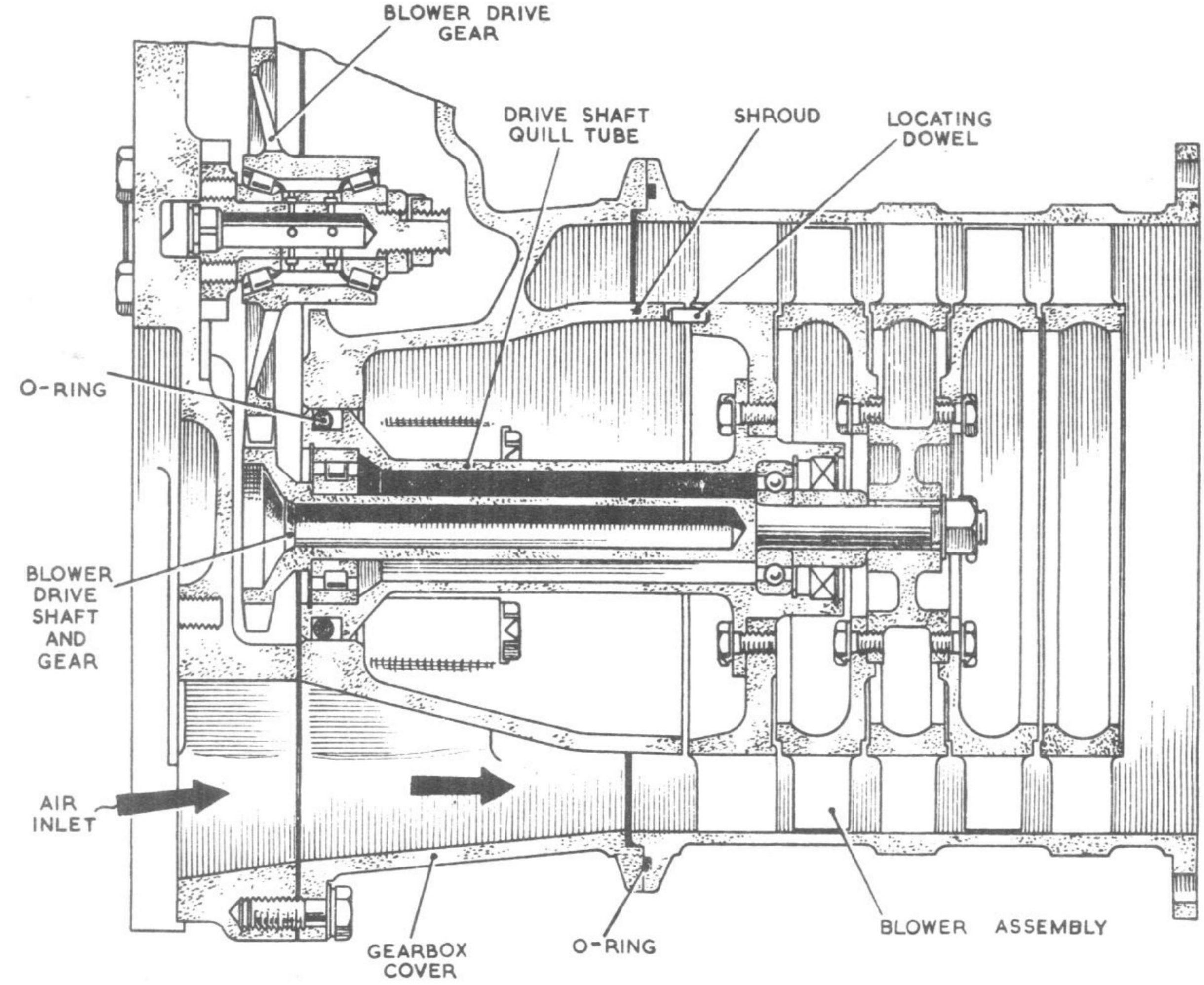


Fig. 18. Blower unit drive

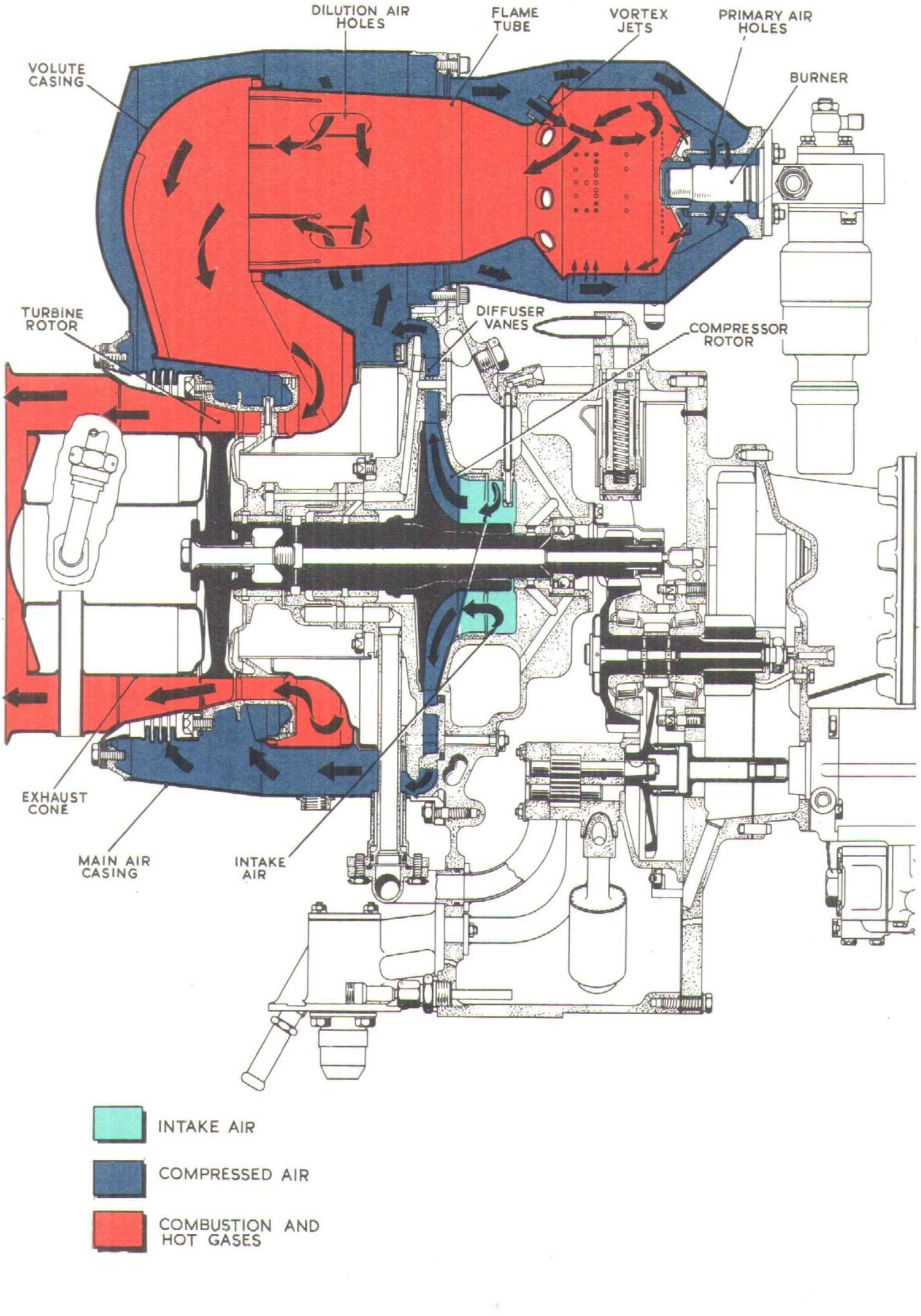


Fig. 19 Air and gas flow diagram

130575 Dd.161451 9/73 M.F.P.

Chapter 2

OIL SYSTEM

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

General

1. The engine oil supply, carried in the sump formed in the base of the compressor housing, is circulated through the engine and gearbox by a gear type pressure pump. To prevent aerated oil being drawn into the system, the pump inlet is fitted with a shrouded gauze filter.

2. From the pump, the oil flows through an internal gallery in the gearbox and auxiliaries mounting plate to the head of the external oil filter where, after by-passing a relief valve it enters an annular space formed by the filter mounting cup. The oil then passes down the outside of the filter element and through it to the central boss in the filter cup, the oil then leaves the filter and, after by-passing a second relief valve, is conducted through an external pipe to the oil cooler.

3. After leaving the oil cooler, the oil stream separates and flows in two directions: one branch is delivered, via an external pipe, to an oil jet in the gearbox cover which feeds directly into the bore of the intermediate shaft and gear. A second external pipe carries the other branch to a union on the lower port side of the mounting plate where it enters the main oil gallery running transversely across the plate.

4. If the filter element is choked, the oil will not pass through the element, but will flow around the head space and into the relief valve housing. The oil pressure is sufficient to lift the valve off its seat and this allows the oil to pass directly to the oil cooler. Should the oil flow through the cooler meet with any obstruction, the second relief valve will allow the oil to pass directly to the centre of the main gallery.

5. From the main gallery, the oil feeds into the five stub shafts supporting the gearbox drive and idler gears. Radial drillings in each shaft admits oil to the shaft bearings, the excess falling to the base of the gearbox from whence it drains back into the engine sump. An oil jet, which is secured to the rear face of the plate, feeds oil from the main gallery directly into the oilway down the centre of the compressor shaft.

6. From this oilway, the oil feeds the front and rear compressor shaft bearings via two series of radial drillings. The drillings for the rear roller bearing feed directly to the base of the roller track, whilst those for the front bearing feed the oil to an annular space behind the bearing. Oil from the rear bearing drains into a recess in the bottom of the compressor shaft outer seal and flows forward along two oil drain holes drilled in the flange of the bearing outer race, the compressor shaft inner seal and the bearing housing support plate, to reach the oil drain quill tube. Oil which is squeezed out from the rear of the rollers can pass forward to join the scavenge oil from the front of the bearing by means of a series of small drillings in the bearing outer race.

7. Oil flowing from the quill tube passes through the T-piece and into the return tube which projects upward in the base of the compressor housing, this arrangement prevents any undue splash and frothing as the oil settles in the sump.

8. Scavenge oil issuing from the front bearing, splashes over the high speed pinion and intermediate gear train before falling into the sump. Any oil which splashes into the oil pump mounting bracket is scavenged by the swirl motion set up by the gear and is driven out through the drain pipe on the side of the bracket. To prevent oil from splashing about unduly in the main part of the compressor housing, deflectors are fitted where necessary.

9. ◄An oil breather pipe is secured to the top of the compressor housing, leading into the exhaust duct via a cyclone separator. Oil drawn into the breather pipe is separated and returned to the sump through the tee-piece and return tube. To prevent any loss of oil during inverted flight the entrance to the breather pipe contains a piston type shut-off valve.►

Oil sump

10. The oil sump, formed by the base of the compressor housing, contains the oil pump complete with its own intake filter, the immersion oil heater, the oil drain stack pipe, the re-oiling overflow stack pipe and a sump temperature bulb. The immersion oil heater, secured by eight wire-locked setbolts and plain washers, forms the sump cover plate. A cork joint washer ensures an oil tight joint between the heater body and the sump.

Oil pump assembly

11. The gear oil pump is carried on the oil pump mounting bracket which, in turn, is secured to the rear face of the gearbox and auxiliaries mounting plate.

12. The dish-shaped mounting bracket, which is retained by four special fitting bolts, plain washers, split pins and slotted nuts, forms a housing for the oil pump drive gear driven from the drive pinion on the intermediate shaft and gear. An oil feed passage from the pump emerges on the front face of the bracket and communicates with the feed hole in the gearbox and auxiliary mounting plate. There is no joint washer between the bracket and the mounting plate and the feed hole is sealed by means of an O-ring. Oil splashing into the mounting bracket is driven out through a scavenge pipe on the right hand side of the bracket.

13. The oil pump body, which is secured to the mounting plate by four studs, nuts and tabwashers, is bored out to receive the driving and driven oil pump wheels and shafts. The shaft bearings are provided by the pump body and end cover which are held together by two dowels, four studs, nuts and tabwashers. The driving wheel shaft is extended forward to take the oil pump drive gear, which is keyed to the shaft and secured by a locknut and tabwasher.

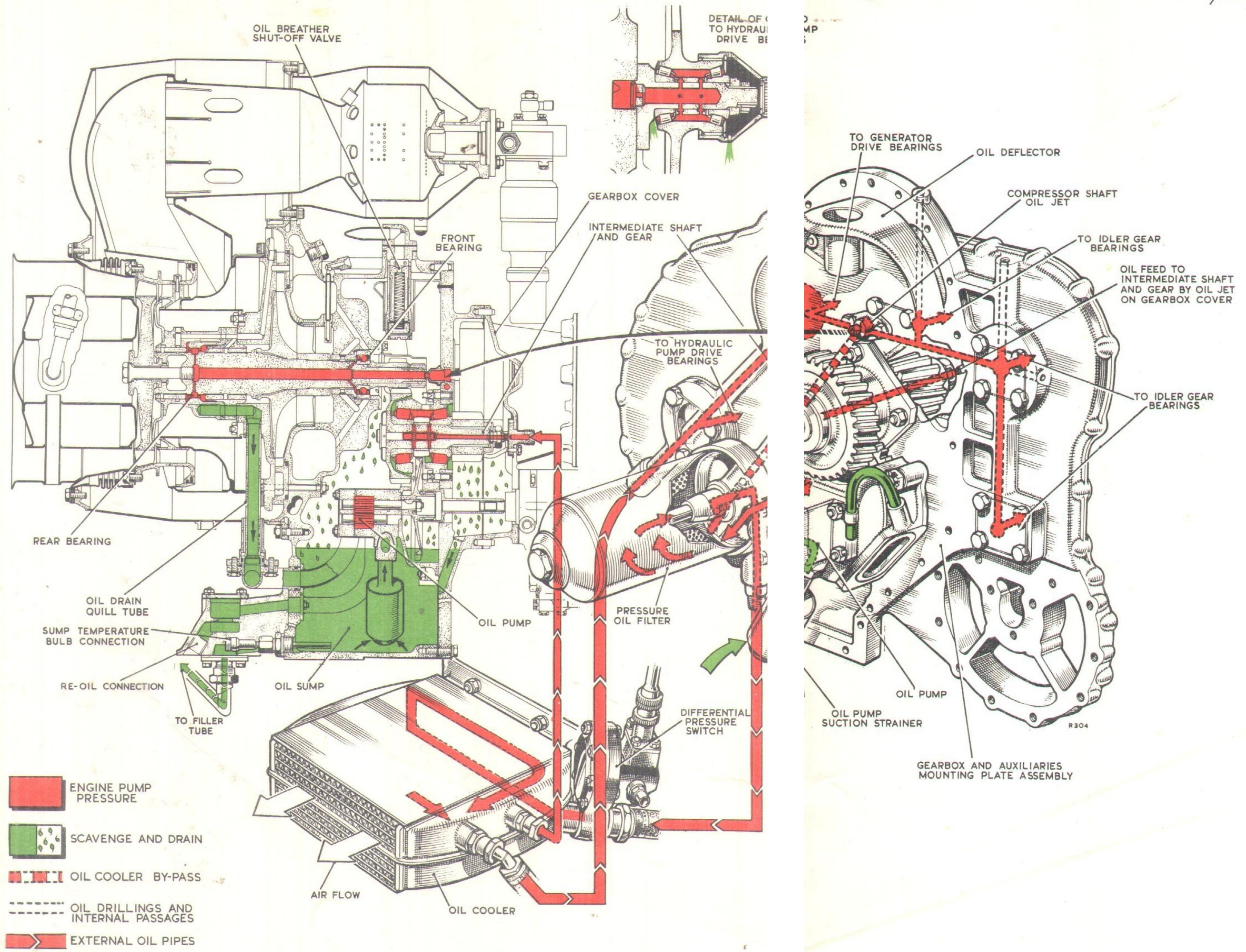


Fig. 1 Oil system diagram

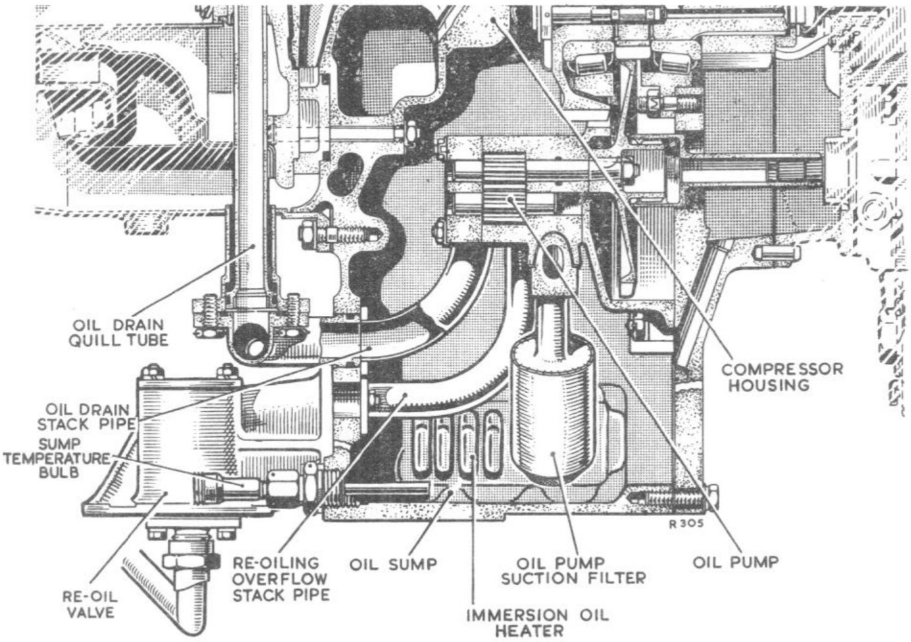


Fig. 2. Oil sump

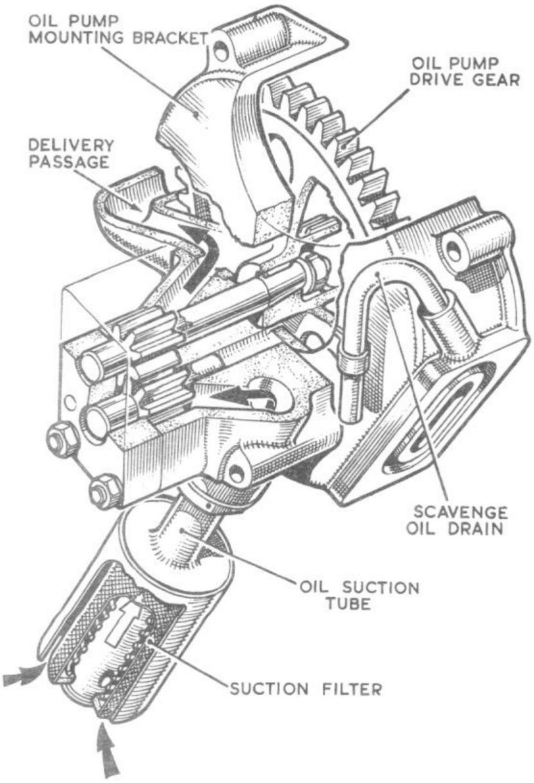


Fig. 3. Oil pump and mounting bracket

14. A small diameter cast-in passage in the oil pump body leads from the pressure side of the gears to the front face of the pump body, where it mates with the passage in the mounting bracket. A second passage communicates with the suction side of the gears and at the outer end is tapped to receive the shrouded oil suction tube and filter.

Pressure oil filter

15. The full flow pressure oil filter is mounted on the cup extension of the gearbox and auxiliaries mounting plate. The body which seats on a rubber ring is retained by a centre bolt and tube. The tube is drilled and cross drilled, so that the centre of the filter element communicates with the drilling in the centre boss of the cup. The filter itself consists of a paper element supported at each end by a dished washer.

Oil relief valves

16. The oil filter mounting cup houses the two relief valves which enable the oil flow, in the event of an obstruction, to by-pass the oil filter and/or the oil cooler.

17. The uppermost of the two valves consists of a tapered spring, circlip, valve and valve seat. The spring is inserted into the seat with the relief valve fitted into the smallest coil. Both the spring and the valve are retained within the seat by a circlip with the valve bearing against the inner face of the seat.

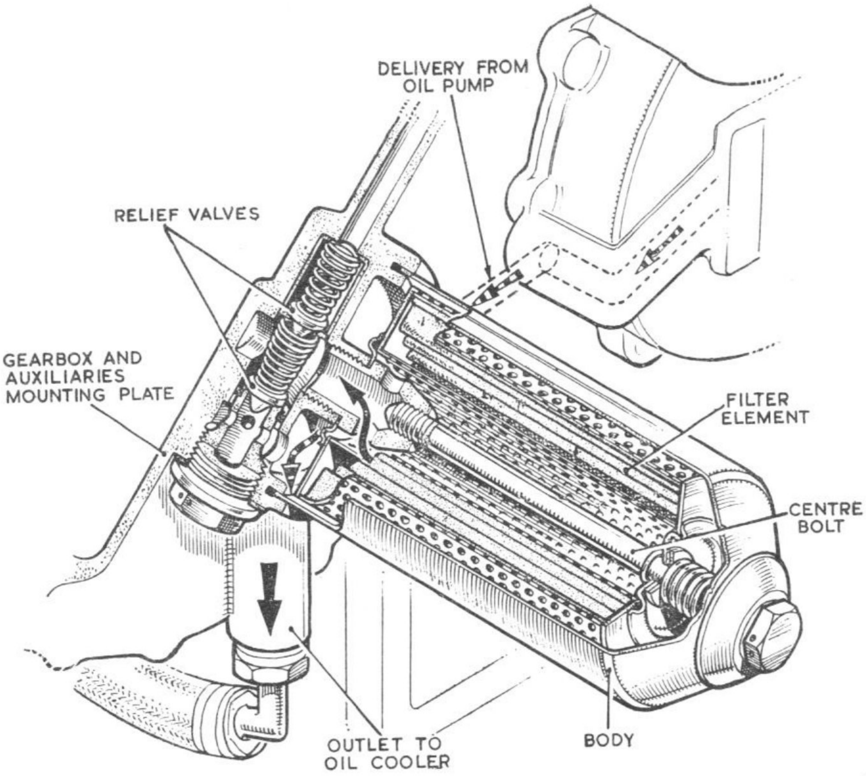


Fig. 4. Pressure oil filter and relief valves

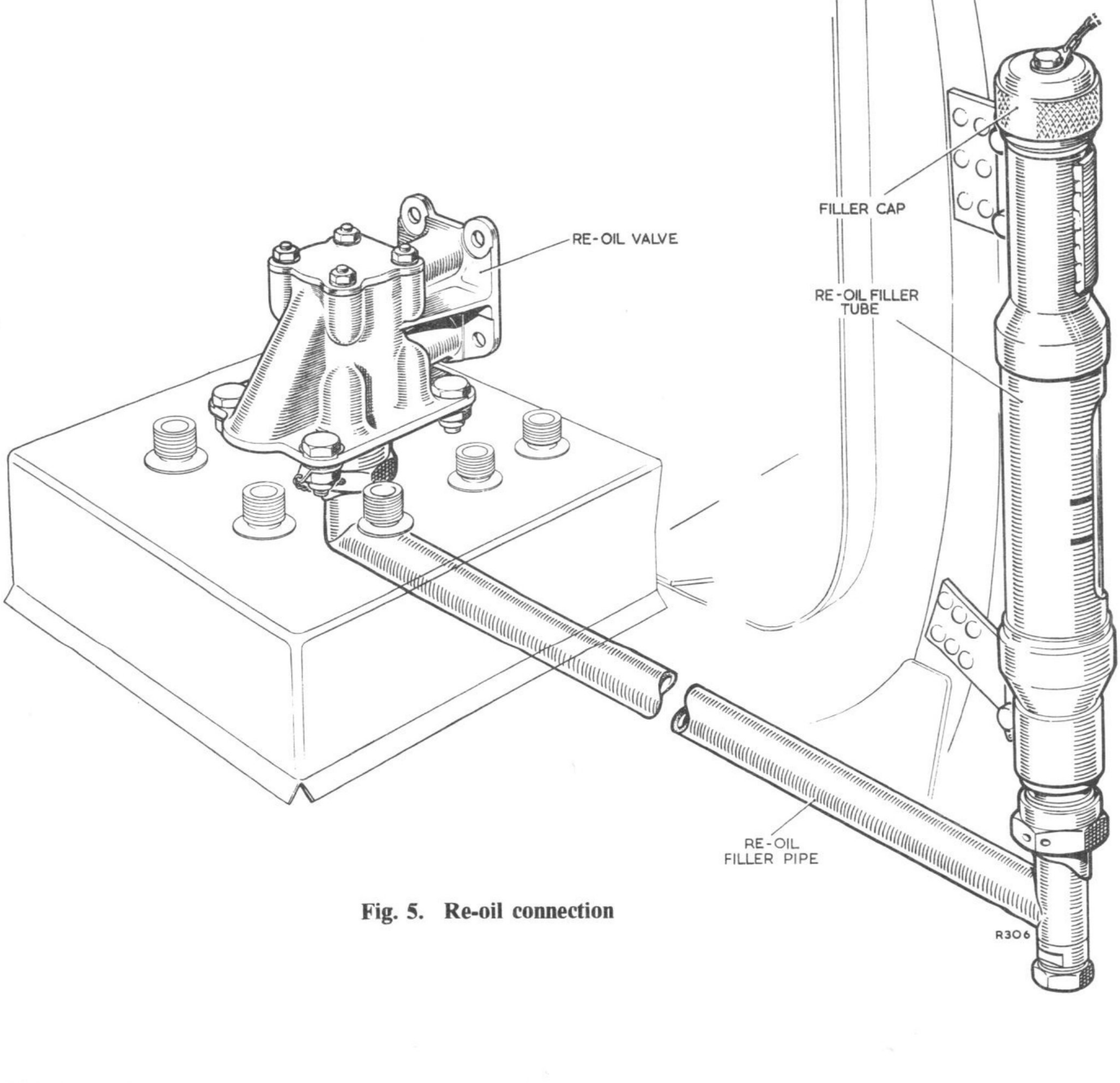


Fig. 5. Re-oil connection

18. The lower relief valve, which helps to retain the upper valve, consists of an identical valve and spring seating against an aluminium housing screwed into the filter mounting cup. The housing has a central blind hole and is cross drilled so that the oil can reach the annular space around the top of the filter element via the drilling in the mounting cup from the pump.

Oil drain quill tube

19. The oil drain quill tube, secured in the mounting flange at the bottom of the main air casing, extends upwards through holes drilled in the heat shield and the bearing housing support plate to register with the oil drain passages drilled in the seal housing and flexible bearing race. The tube is sealed at each end by an O-ring and, at the lower end, mates with the oil drain 'T' piece that connects to the oil return stack pipe in the sump.

Re-oil system

20. ◄The re-oil system comprises a re-oil valve secured to the rear wall of the engine oil sump by four studs, nuts and tabwashers and connected by a pipe to a filler tube mounted on the central beam. The filler tube incorporates a sight glass and is arranged on the central beam to indicate the correct engine oil sump level, the sight glass protection tube is marked to indicate the high and low oil levels.►

Oil cooler and blower unit

21. The oil cooler and blower unit consists of a Plannair axial blower, an aluminium alloy blower outlet adapter, and a Morris oil cooler. The complete unit is secured by a 'King' clamp to the lower starboard side of the gearbox (Chap. 1).

22. Driven from one of the gearbox idler gears, by a shaft and pinion, the blower rotates at 14,660 rev/min to provide a maximum of 580 cubic feet of air per minute at 22 in. Wg. The air is ducted to the oil cooler and generator via the blower outlet adapter.

23. The blower itself consists of a tubular light alloy casting, housing two sets of stator blades and two impeller stages. Each stator, consisting of thirty-six blades, manufactured from aluminium alloy, is retained within the housing by three bolts, tabwashers and nuts.

24. The first and second impeller stages, which are also manufactured from aluminium alloy, have thirty and thirty-one blades respectively. Both stages are secured to a common stainless steel hub by six bolts and tabwashers.

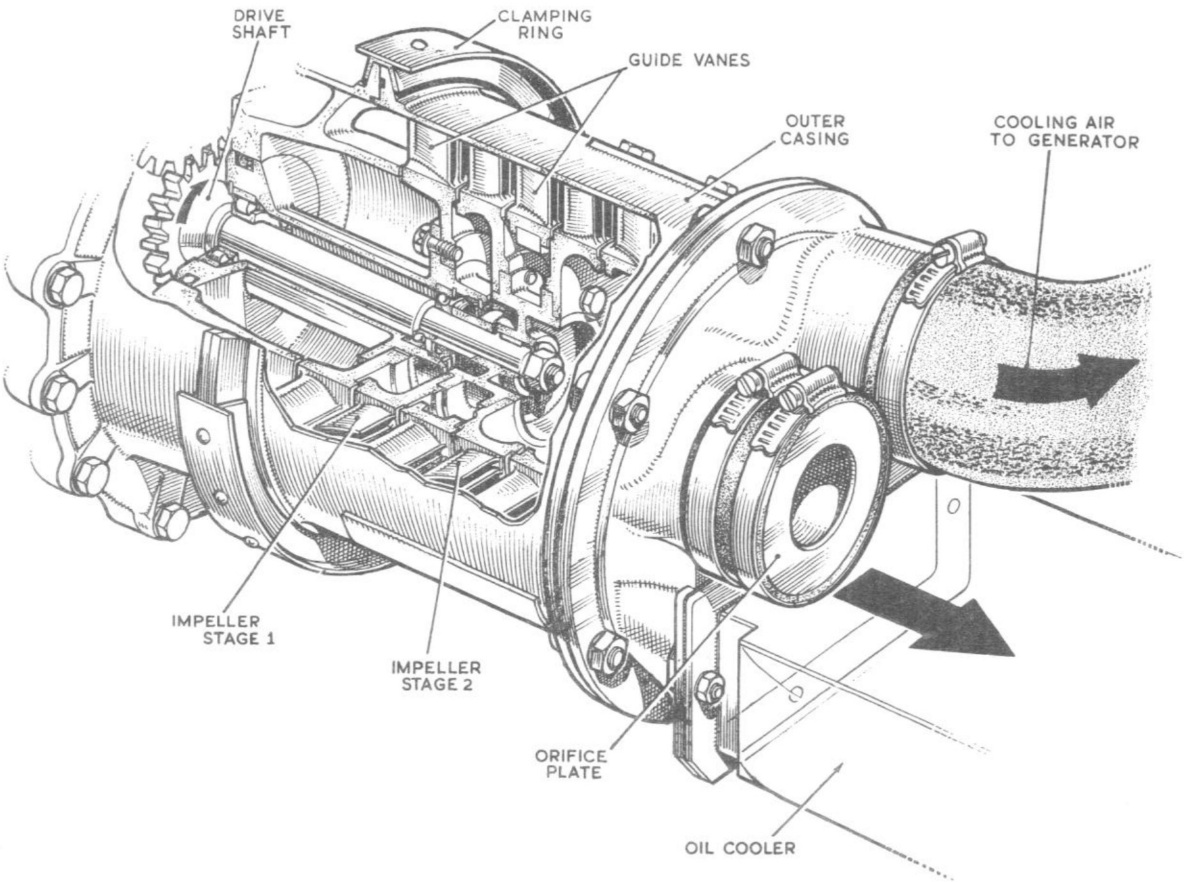


Fig. 6. Blower unit

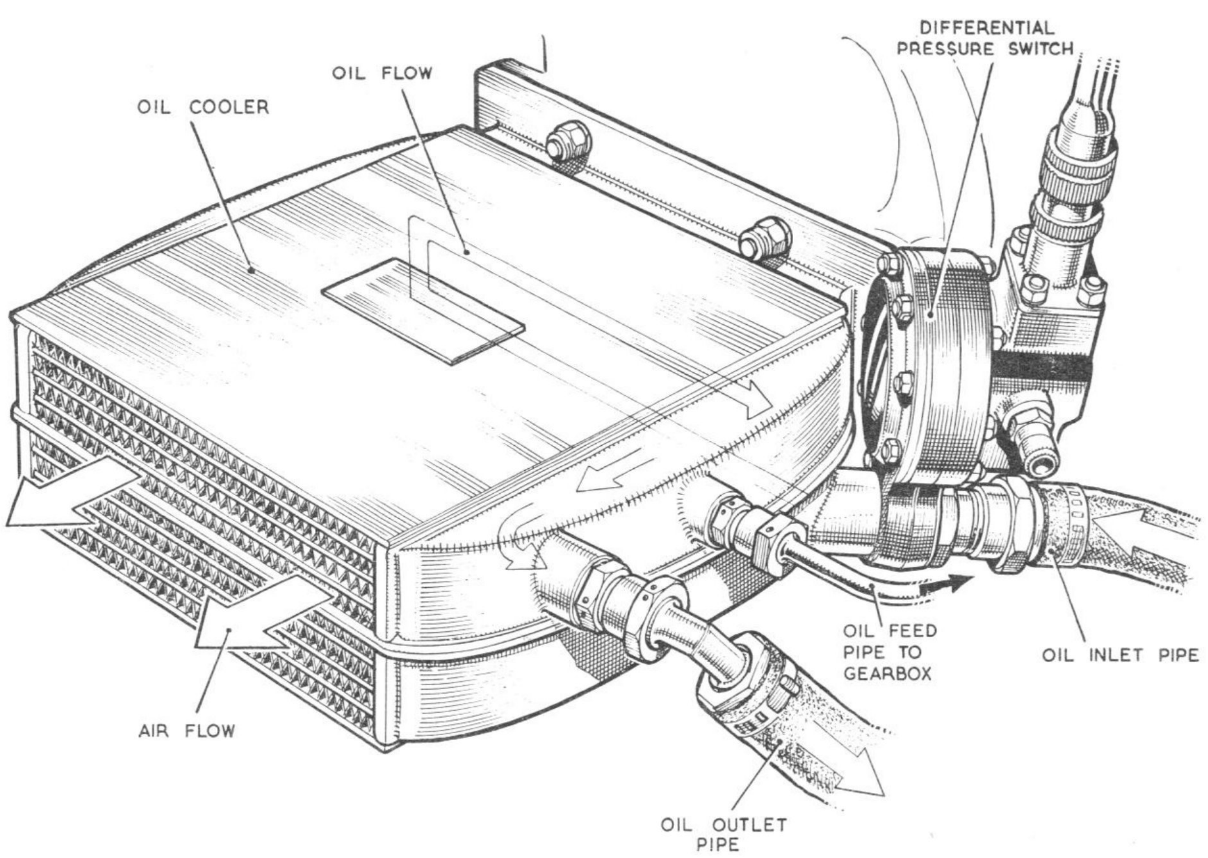


Fig. 7. Oil cooler and oil differential pressure switch

25. The blower drive shaft and pinion, forged integrally from case hardened nickel steel, is keyed to the stainless steel blower hub and retained by a slotted nut, split pin and washer. The shaft is supported by ball and roller journals within a tubular bearing housing, which is in turn, secured to an inner web of the blower housing by six bolts and tabwashers.

26. The point at which the bearing housing enters the gearbox is sealed by an O-ring recessed into an annular groove immediately behind the drive pinion. Gearbox oil however is free to travel along the interior of the bearing housing to lubricate the drive shaft bearings. The shaft itself is sealed by a Gaco lip type seal at the blower end of the bearing housing.

27. The blower outlet adapter is an aluminium alloy casting secured to the output side of the blower by six bolts, self locking nuts and plain washers. A rectangular flange on the lower half of the adapter provides a mounting point for the oil cooler whilst tubular ducts on the upper half form outlets for the package and generator cooling air.

28. The oil cooler, which is fabricated from aluminium alloy, is secured to the blower outlet adapter by six studs, self locking nuts and plain washers. The cooler will permit an oil flow of up to 150 gall per hour and a maximum air flow of 300 cubic feet per minute.

Differential pressure switch

29. A differential pressure switch, which is secured by a banjo union to the inlet union on the port side of the oil cooler, operates on a decreasing pressure. A warning lamp fitted on the a.a.p.p. control panel is operated by the switch when the oil pressure reaches the lower limit; this limit is quoted in the Leading Particulars at the front of the book.

Chapter 3

FUEL SYSTEM

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

General

1. The fuel system consists basically of a Rover Mk. VIII multi-piston fuel pump and temperature control assembly, a pressure raising valve, a Lucas air assisted simplex burner and a Lucas motorised air pump.

2. On engagement of the turbine starter mechanism, low pressure fuel entering the system is fed via a Purolator filter to the inlet side of the pump. From the pump the fuel is delivered under pressure to the simplex burner where it emergse in the combustion chamber as a finely atomised cone. Flow through the burner is controlled by an electrically actuated high pressure shut-off cock.

3. The engine maximum speed is controlled by a centrifugal leaf spring governor, integral with the fuel pump rotor. The governor under the effect of centrifugal force, progressively spills off fuel from the high pressure side of the pump until, at a predetermined speed only sufficient fuel is fed to the burner to maintain that speed.

4. A pressure raising valve situated down stream of the outlet side of the pump pre-determines the amount of back pressure in the system and prevents any engine speed variations at no-load conditions.

5. To assist in atomising the fuel, air at compressor delivery pressure P_2 is taken from the diffuser and fed into the burner atomiser assembly. During the starting cycle when P_2 value is low, the air supply is provided by a motorised air pump.

6. Both air supply sources are fed into a common manifold, two non-return valves being employed to control the flow. The first, at the entrance to the manifold prevents the escape of air from the motorised air pump into the diffuser, whilst the second at the pump itself, prevents the loss of P_2 pressure through the pump.

7. The turbine exhaust temperature is limited to a pre-determined maximum by a half-ball valve in the temperature control assembly, which is arranged to spill off fuel from the high pressure side of the pump.

8. The half-ball valve is controlled by a lever and Bourdon tube operated by mercury pressure from a boiler tube in the exhaust cone. The temperature signal opens the valve at critical temperatures and spills fuel back to the inlet side of the pump, thereby reducing flow and consequently temperature.

9. The application of the engine requires it to be operated at one pre-selected speed (47,000 rev/min), and consequently no throttle valve is required. The fuel flow is controlled entirely by the governor and temperature control valves.

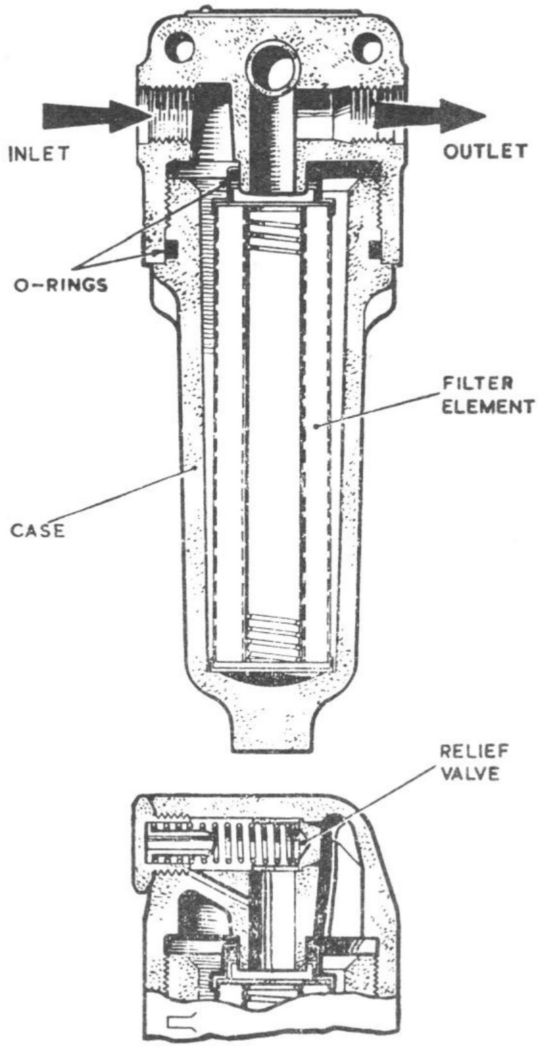


Fig. 1A. Fuel filter

Low pressure filter

10. The low pressure fuel filter, which is of the replaceable element type, is secured to the rear of the central beam by two bolts and self locking nuts. Fuel enters the filter body via a Lockheed-Avery quick-release coupling.

11. The filter body contains a pressure relief valve, which in the event of the filter element becoming blocked, allows fuel to by-pass the filter and flow directly to the fuel pump.

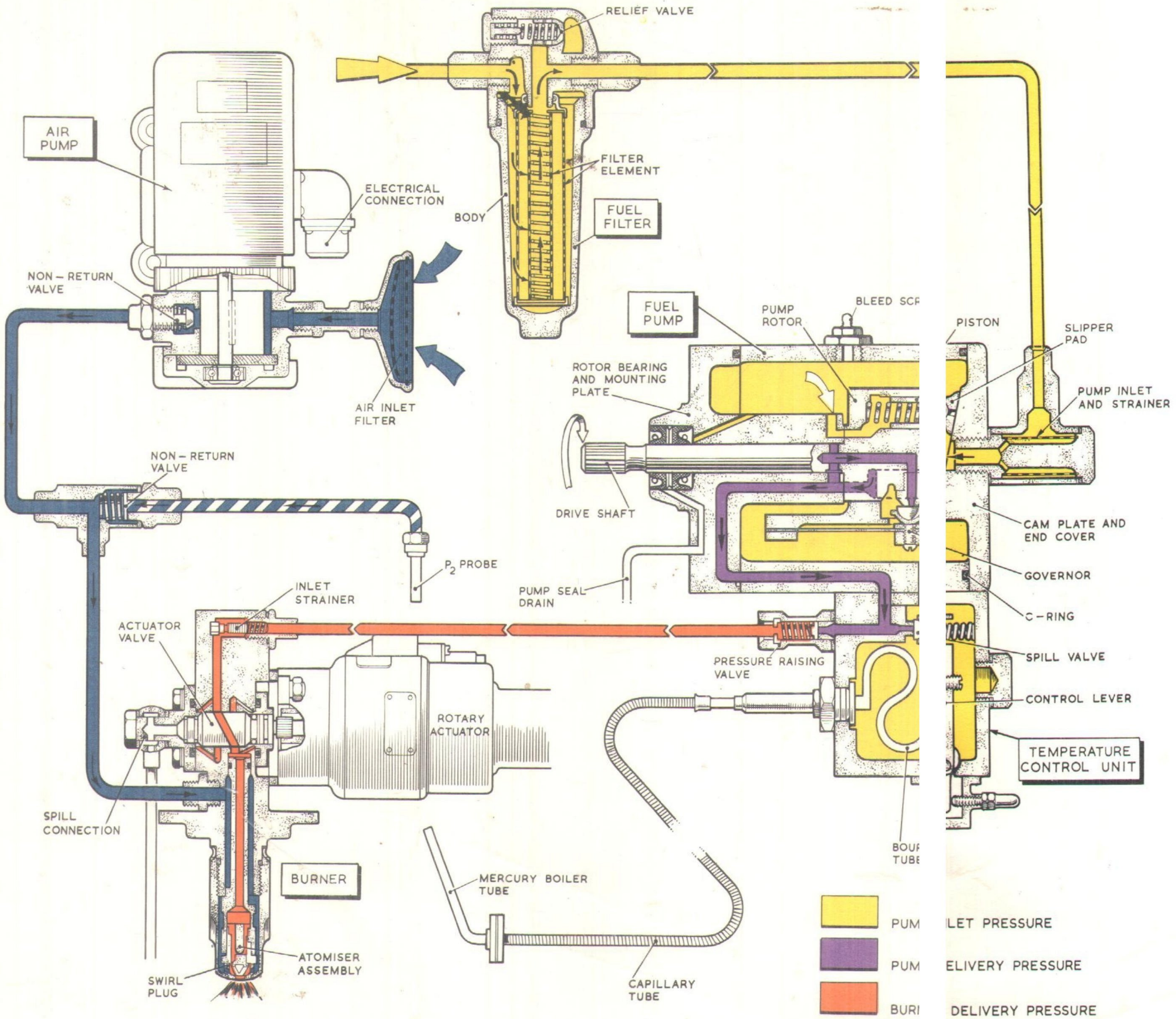


Fig. 1 Fuel system diagram

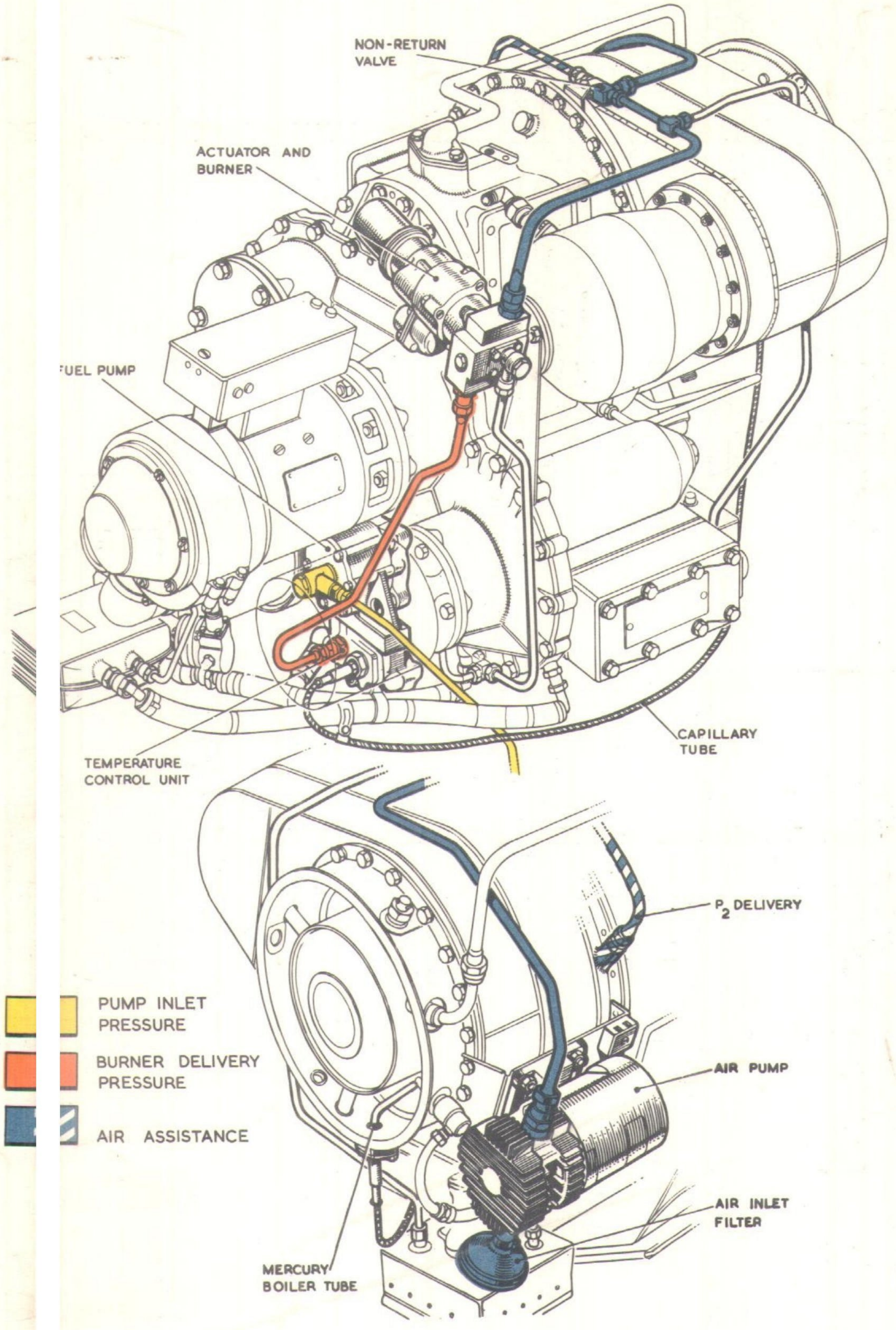


Fig. 2 Fuel system arrangement

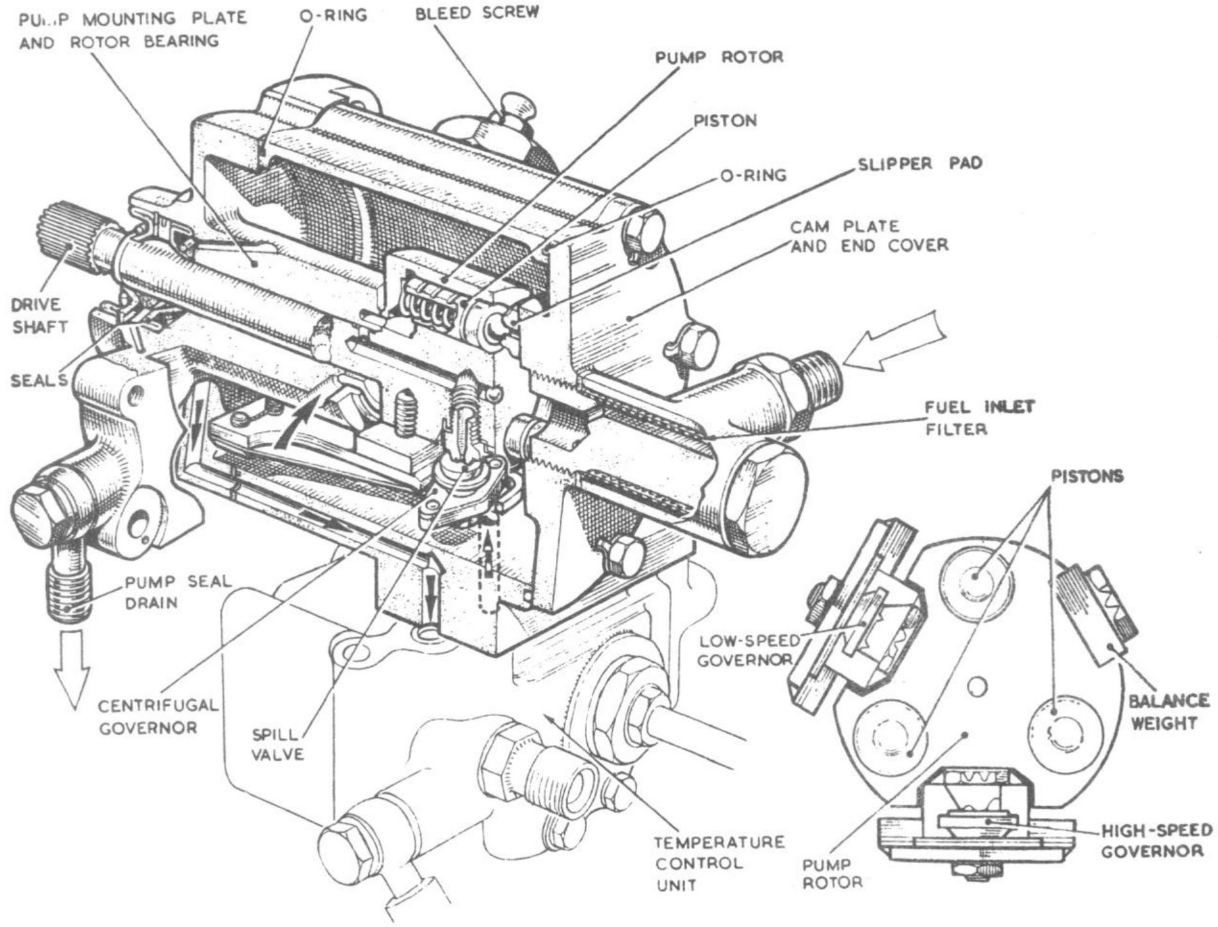


Fig. 3. Fuel pump

FUEL PUMP

12. The fuel pump, which is driven through a quill shaft from the oil pump driving gear, is secured to the auxiliaries gearbox cover by four bolts and tabwashers.

13. The pump rotor drive shaft is carried in an aluminium bronze bearing, integral with the pump mounting plate. The face of the bearing, which is silver plated to assist bedding-in, contains two semi-annular transfer ports connected via drillings in the rotor bearing and mounting plate with the high-pressure and low-pressure sides of the system.

14. The outer end of the rotor drive shaft is sealed by two Gaco spring-loaded synthetic rubber seals, recessed into a boss on the rear face of the pump mounting plate. An annular groove, which is machined in the circumference of a distance piece interposed between the two seals, forms a drainage channel that is connected via drillings in the mounting plate with the power plant drain system.

15. The pump rotor and its bearing are both enclosed by a cylindrical aluminium alloy outer casing which in turn is closed by a cadmium plated steel end cover. The centre of the end cover is drilled and tapped to receive the banjo bolt retaining the fuel inlet filter and T-piece. The outer casing and end cover are sealed by two O-rings recessed into annular grooves machined in the end faces of the outer casing.

16. The triangular shaped rotor, which is integral with the inner end of the pump drive shaft, houses three silver plated spring loaded pistons disposed in case hardened bores equi-spaced around the axis of the rotor. A case hardened track on the rear face of the rotor is connected by drillings with the piston bores; this track rotates across the face of the high and low-pressure transfer ports in the thrust face of the rotor bearing.

17. A ball bearing attached to the closed end of each piston seats in a cup shaped silver plated slipper pad; this pad, which is held by the thrust of the piston spring, rides on the inclined track of a circular cam face integral with the pump end cover. As the cam face is eccentric, the pistons are pushed towards the end cover for one half of a revolution and forced away from it for the other half. This reciprocating movement of the pistons constitutes the pumping action.

18. When the turbine starter mechanism is engaged, the fuel pump rotates, and draws fuel from the pump body into the piston bores via the inlet drilling in the bearing body, and the semi-annular low-pressure transfer port in the thrust face of the bearing body.

19. On the second half of each revolution, the fuel is discharged from the piston bores into the high pressure transfer port and flows through drillings in the bearing body and the pump outer casing to the outlet union.

Governor

20. The periphery of the fuel pump rotor carries two centrifugal governors that are arranged to operate two half-ball valves in the rotor head; one is set at a higher datum and the other at a lower datum. The lower datum opens at an engine speed of approximately 47,000 rev/min whilst the higher datum valve opens at approximately 50,000 rev/min and serves as an emergency control in the event of the lower datum failing. For all normal running conditions, the engine speed is controlled by the lower datum.

21. Each governor consists of a fixing plate, to which one end of a berylium copper leaf spring is secured by three wire locked set screws. The free end of the leaf spring carries a half-ball that is positioned to seal the mouth of an orifice screwed into the rotor. Both orifices are connected via a central drilling, with the high pressure transfer port. The rotor also carries a balance weight to counteract the offset weight of the two governors.

22. During the initial revolutions of the turbine, spring pressure retains the half-ball valve on its seat and enables the full output of the fuel pump to be delivered to the burner. As the turbine speed increases, the free end of the leaf spring moves outwards under the effect of centrifugal force and opens the valve to spill-off fuel. The spillage continues until at the pre-determined datum, only sufficient fuel is fed to the burner to maintain that speed.

Temperature control

23. The turbine temperature is limited to a predetermined maximum by a second half ball valve arranged to spill-off fuel from the burner at critical temperatures. The valve is housed in a split aluminium alloy casing secured to the underside of the fuel pump body by three bolts.

24. The half ball valve is attached to a pivoted control lever and retained on its orifice seat in the temperature control casing by a coil spring. Movement of the control lever is dependent upon the expansion of mercury in a Bourdon tube in contact with the lever and, working against the pressure of the coil spring.

25. The pivot for the control lever is eccentrically mounted on a spring loaded cam, provision being made to alter the position of the cam and thus adjust the half ball valve to the required setting. A second adjustment, by means of a trimming screw on the control lever, determines the initial clearance between the control lever and the end of the Bourdon tube.

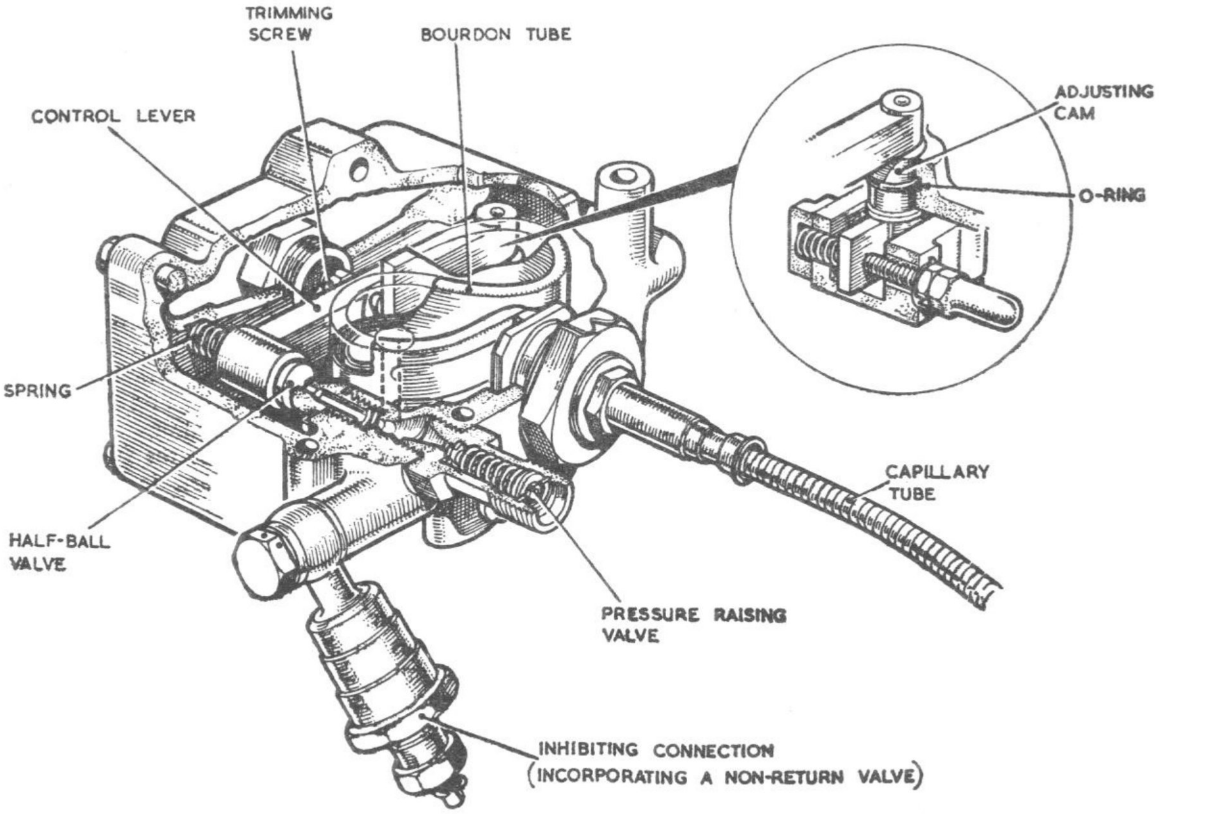


Fig. 4. Temperature control unit

26. A mercury filled boiler tube is located in the turbine exhaust stream and connected to the Bourdon tube, via a capillary tube. Therefore, should the exhaust temperature rise above the safe maximum, the mercury in the boiler will be vaporised transmitting a pressure increase through the capillary tube to the Bourdon tube. As a result of this pressure the Bourdon tube tends to straighten out and in so doing lifts the control lever and opens the valve to spill-off fuel from the burner supply. The control will continue to operate until the exhaust temperature falls to a safe level or the turbine unit shuts down.

BURNER

27. The air assisted burner, which is secured to a flange on the outer air casing of the combustion chamber by four studs, nuts and plain washers, consists of a sprayer and an electrically operated high pressure shut-off cock. The H.P. cock is operated to start or stop the engine and assists starting by keeping the fuel line primed as near the burner as possible.

28. To assist in atomising the fuel, particularly at low engine speeds, when fuel in excess of requirements is being supplied to the burner and thereby preventing good atomisation, a supply of air under pressure is admitted into the burner to provide finer atomisation of the fuel.

29. Screwed into the stem of the burner is the atomiser assembly, comprising the atomiser body which is bored to accommodate a tangentially drilled swirl plug. A retaining plug locked by a tabwasher retains the swirl plug in the body. Located over the face of the atomiser and held in position by the shroud is a swirl plate, in which is formed the delivery orifice. The shroud screws onto the burner stem.

30. Fitted in the burner body are the air and fuel inlet connections; the fuel inlet connection houses a spring-loaded strainer. A spill connection is also provided in the body to return excess fuel to the inlet when the shut-off cock is closed. The shut-off cock is of the rotary type and is situated in the fuel inlet passage. It is operated by the actuator through splined shafts and a female coupling.

31. Operation of the actuator opens the shut-off cock, and allows fuel to enter the burner, and pass down the burner stem to the swirl plug. A swirling motion is imparted to the fuel as it passes through the tangential holes of the swirl plug to the swirl chamber thence through the delivery orifice as a finely atomised conical spray.

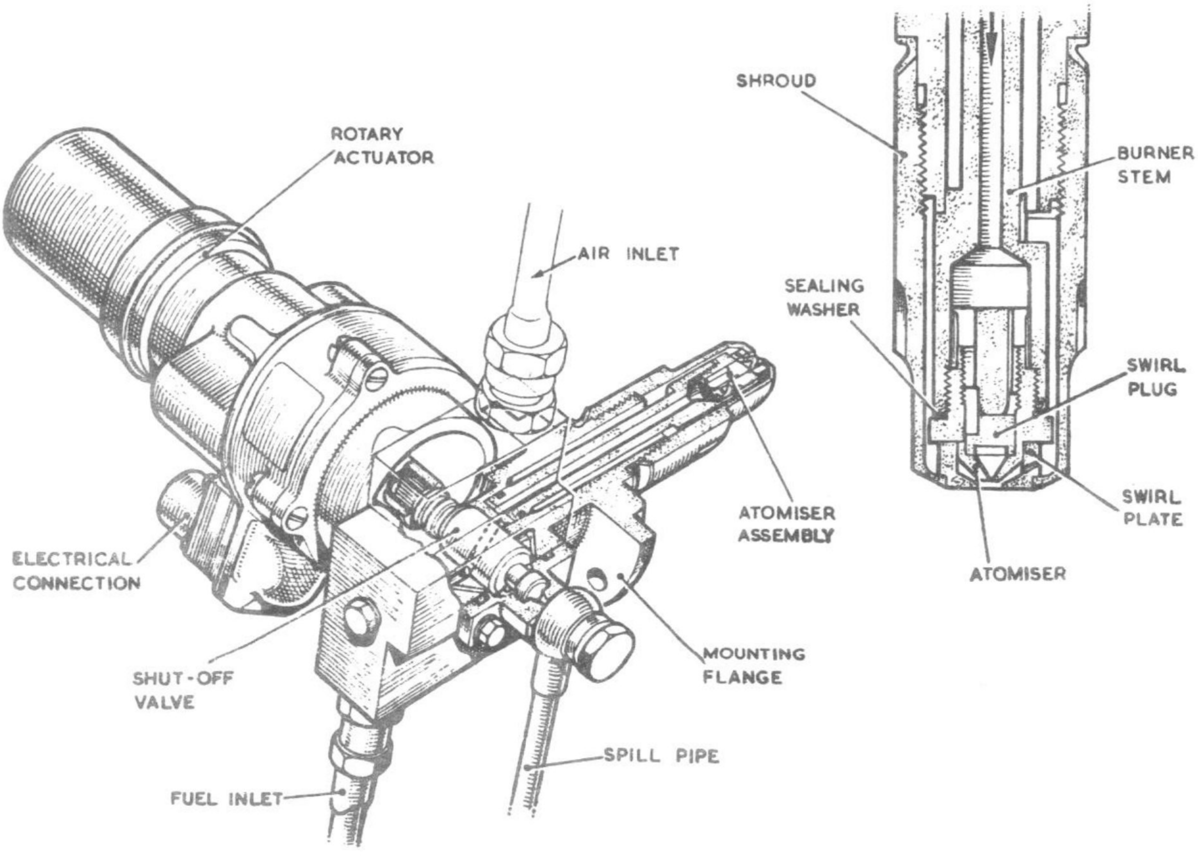


Fig. 5. Actuator and burner

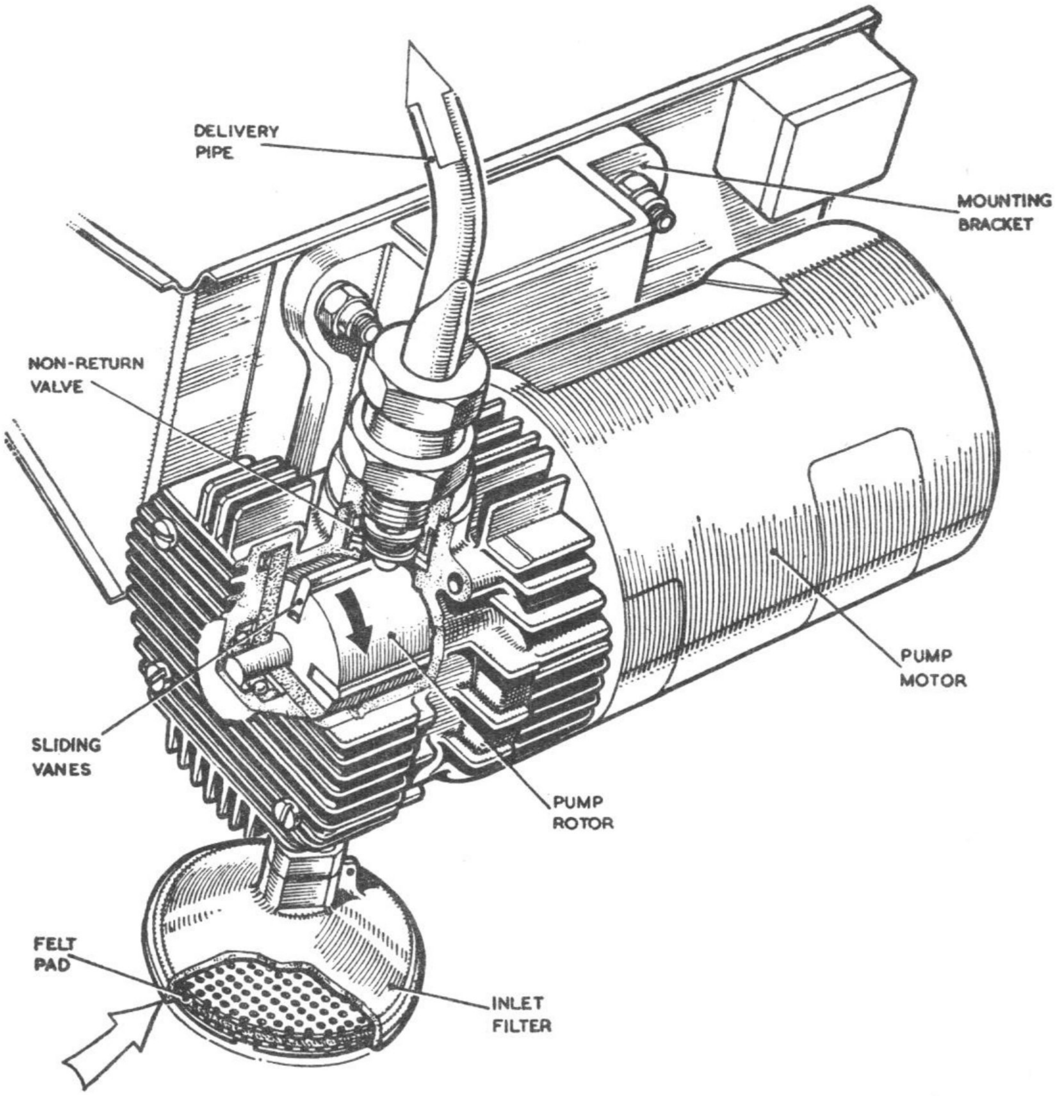


Fig. 6. Motorised air pump

MOTORISED AIR PUMP

32. The motorised air pump is a high capacity compressor, which is brought into operation during the starting cycle, when the value of P_2 air is low, to effect an increase in the supply of air to the burner. The pump is secured to a rectangular bracket on the starboard side of the engine main air casing by four bolts and self-locking nuts.

33. The d.c. pump motor, capable of an output of 4,300 rev/min at 27 volt, 12·5 amps., is a continuously rated 0·25 H.P. unit, which is fan cooled and fitted with built in radio interference suppressors. The armature shaft, which also carries the pump rotor, is mounted in three ball races, prepacked with lubricant.

34. The pump, which rotates in an anti-clockwise direction viewed from the motor end, is a positive displacement rotary vane type. The four self-lubricating sliding vanes are accommodated in a rotor mounted on the armature shaft.

35. The rotor operates in a cylindrical chamber formed eccentrically to the rotor axis; consequently, the sliding vanes alternately move outward under the effect of centrifugal force, and inward due to the eccentric position of the chamber. The result of this action is that the volume between any two adjacent vanes is alternately increasing and decreasing. It is this expansion and contraction that constitutes the pumping action.

36. The inlet and delivery ports are formed in the pump housing. The entrance to the inlet port is protected by a felt filter pad located in the bell-shaped intake by two perforated aluminium discs. The delivery port incorporates a non-return valve that prevents loss of system pressure when the pump ceases to operate.

Chapter 4

IGNITION AND ELECTRICAL SYSTEM

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. This chapter describes the ignition system and the starting system associated with the A.A.P.P., and gives details of the auxiliary electrical components and circuits contained within the power plant.

2. For a detailed description of any particular component, refer to the associated publications listed in the front of this volume, and in particular to the A.P. 4343 series.

General description

3. With the exception of the hours counter and starts counter, all the A.A.P.P. electrical and ignition components, including the generator, are enclosed with the interior of the nacelle. The hours counter and starts counter together with their connection socket are both mounted on a single bracket on the starboard side of the rear end cover.

4. All the A.A.P.P. electrical connections are grouped on a single panel on the starboard side member of the central beam. These connections comprise: the generator terminal block, the generator field connection plug, the main harness connection plug E.23, the igniter plug connector, and the two fire detector heads.

5. The connection plug E.23 forms the input connection for the burner H.P. cock actuator, the sump heater, the motorised air pump, and the oil pressure warning switch; all of these are linked by a single harness. The E.23 plug also provides an output connection for the jet pipe thermocouples.

D.C. generator

6. One of the principal functions of the A.A.P.P. is to provide electrical power for starting the aircraft main engines, and for this purpose a 9kW Rotax generator, type No. B3503 is employed.

7. The generator, which is secured to the starboard side of the auxiliaries gearbox cover, is driven in an anti-clockwise direction at 4512 rev/min through an internally splined coupling bolted to the hub of the driving gear.

8. The continuous rated output of the generator is 30 volts at 300 amps with a 30 minute overload rate of 30 volts at 400 amps. A facility to 'motor' the generator is provided so that it can be utilised as the engine starter.

Igniter plug

9. During the initial starting cycle, the air/fuel mixture is ignited by a K.L.G. surface discharge igniter plug, type No. R.H.231/6 (Pre Mod. M101). The igniter plug is positioned in the combustion chamber by a suspension plug and retained by an insulated gland nut. Later engines are fitted with a one piece igniter K.L.G. type No. R.H.231/14 (Post Mod. M101).

10. The igniter is connected, via an insulated connector plug mounted on the port side of the central beam, with a Rotax high energy ignition unit mounted in the aircraft.

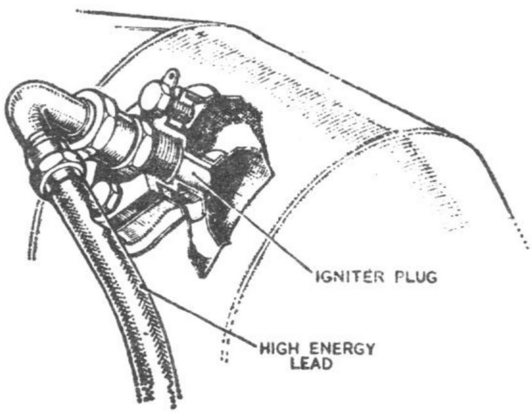


Fig. 1. Igniter plug

WARNING . . .

The energy stored in the capacitors incorporated in the high energy igniter can in certain circumstances be of a lethal nature. No servicing should be attempted until at least one minute has elapsed after disconnection of the L.T. supply to the input plug.

Operation of the starter and ignition system

11. When the master switch on the A.A.P.P. services panel is selected to START, the open field windings of the air intake scoop actuator are energised, and the 'close' field windings of the burner H.P. cock actuator are isolated.

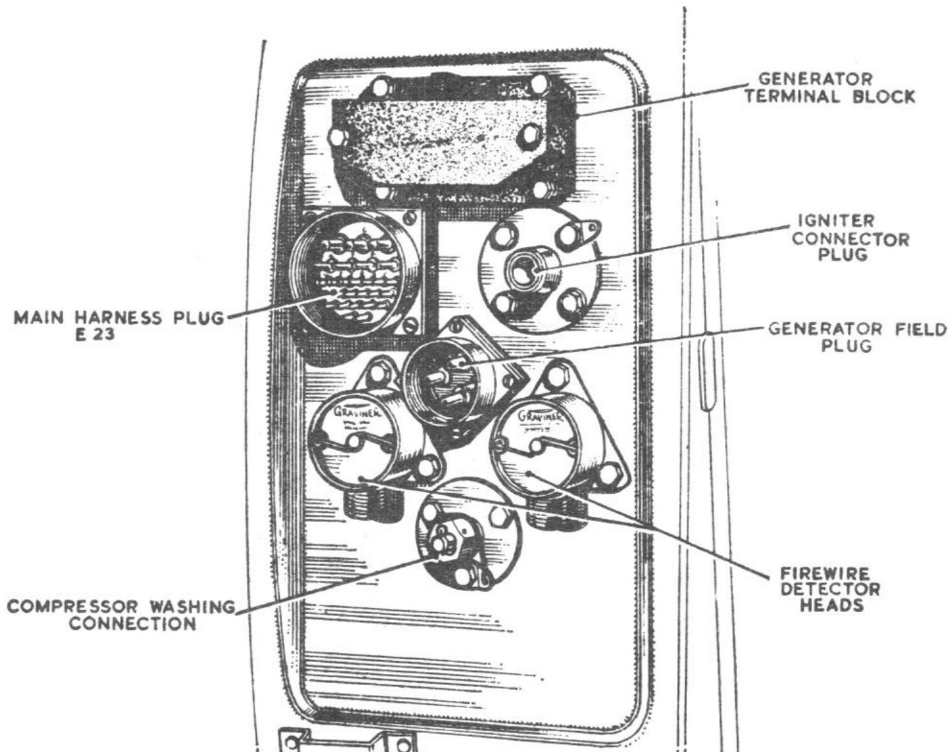


Fig. 2. Electrical connections panel

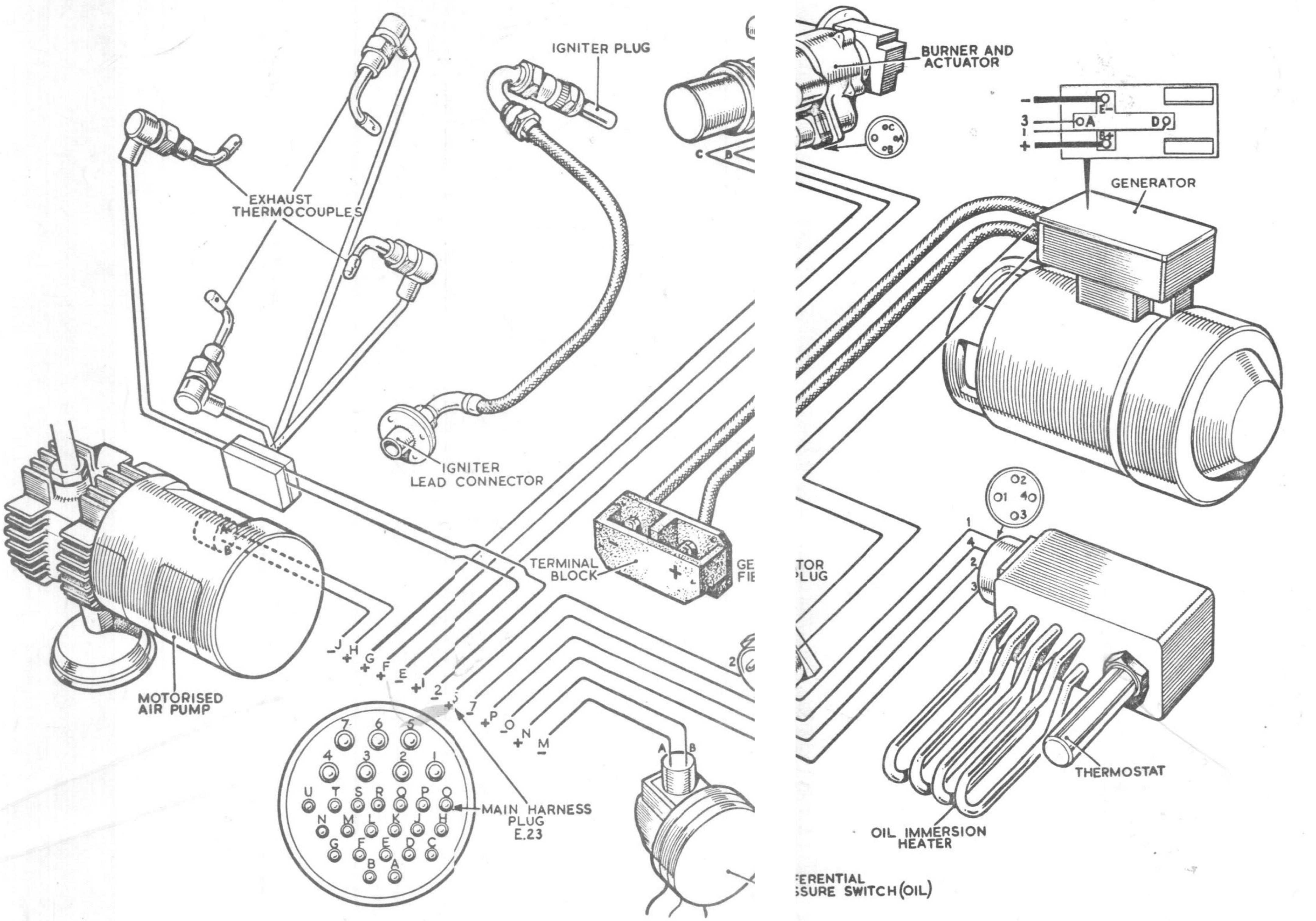


Fig.3 Wiring diagram

12. Selection of the starter push switch, on the A.A.P.P. services panel in the aircraft, energises the burner H.P. cock actuator open field windings, the high energy iginition unit, the motorised air pump and at the same time permits current to flow from battery positive to the positive terminal of the generator, causing the generator to'motor' and drive the engine.

13. The generator will continue to 'motor' until the engine reaches a self sustaining speed of approximately 25000 rev/min. when an overspeed relay will disconnect the circuit to the generator. After a period of thirty seconds, a time delay switch will de-energise the burner actuator open field windings, the ignition system and the motorised air pump.

Burner h.p. cock actuator

14. The burner H.P. cock is operated by a Rotax actuator, type No. C5536/1, which is secured to the body of the burner by two studs, spring washers and nuts. The actuator, which is capable of exerting a torque loading of 15 lb in. is supplied from the aircraft 28 volt D.C. system through the bulkhead plug on the port side of the central beam.

15. At the commencement of the starting cycle, the actuator open field windings are energised and the burner H.P. cock is rotated through 90 deg. to allow fuel to pass to the combustion chamber.

16. When the A.A.P.P. is shut down, the actuator's direction of rotation is reversed thus closing the burner H.P. cock and cutting off the supply of fuel to the combustion chamber. The actuator will automatically operate to close the H.P. cock in the event of the fire extinguishing system being operated.

Sump heater

17. For operation in low temperature conditions, the engine oil sump is equipped with a 600 volt immersion heater, G.E.C. type No. H.E.50572 M.1. The heater, which is fed from the aircraft 28 volt D.C. supply, incorporates a thermostat that will maintain the engine oil temperature at ◀50 ± 5°C▶ when the heater is selected.

18. An amber warning light, which is mounted on the A.A.P.P. services panel, is connected in parallel with the sump heater and will continue to glow as long as the sump heater is selected.

Jet pipe thermocouples

19. Four bosses equally spaced around the exhaust cone provide mounting points for the jet pipe thermocouples. Earlier units are fitted with a single chromel-alumel thermocouple, Smiths Aircraft Instrument type No. F.1223; later engines are fitted with four thermocouples wired in parallel.

20. The thermocouples which project into the exhaust gas stream just downstream of the turbine rotor, are connected to an instrument calibrated from 0 to 1000° C and a compensating resistor. Both these units are mounted in the A.A.P.P. services panel in the aircraft.

Oil pressure warning switch

21. The oil pressure warning switch, Smiths type No. 1001/2 PG, is incorporated in the pressure side of the lubrication system on the outlet side of the oil cooler.

22. The pressure switch, which operates on decreasing pressure, contains a diaphragm operated contact arm that will complete a circuit to a red warning light on the A.A.P.P. services panel in the aircraft if the engine oil pressure falls below 2 lb/in^2. The warning light is effective only when the A.A.P.P. is running.

Hours counter and start counter

23. The hours counter and starts counter together with their connection socket are both mounted on a single bracket which in turn is supported by three anti-vibration mountings on the starboard side of the rear end cover.

23. The starter counter, Counting Instruments type No. 52/4/B29, is energised each time the starter push switch on the A.A.P.P. services panel is depressed. The counter consists of a series of moulded number wheels and pinions, giving a display reading from 0000 to 9999, which are energised by electro-magnets spaced around a common armature.

25. The hours counter, Smiths type No. A.T.F.C. 268/2/R, registers during the time the master switch, on the A.A.P.P. services panel, is selected to START. The counter gives a total count of 9999 hours, then automatically returns to zero and re-starts. The reading cannot be reset by hand. A small indicator is provided on the dial to show when the counter is functioning.

SCHEDULE OF COMPONENTS

26. The following electrical components are fitted to the A.A.P.P.

Component	*Type and Ref No.*	*A.P. reference*
9 kW D.C. generator	Rotax type No. B3503 Ref. No. 5UA/6928	A.P.4343A, Vol. 1, Sect. 3
Igniter plug	K.L.G. type No. R.H.231/6 Ref. No. 36AF/3 or K.L.G. type No. R.H.231/14 Ref. No. 36AF/1212	A.P.1374G, Vol. 1, Sect. 4
Burner H.P. cock actuator	Rotax type No. C5536/1 Ref. No. 5W/4694	A.P.4343D, Vol. 1, Book 5, Sect. 16
Sump heater	G.E.C. type No. HE50572.M.1. Ref. No. 36AF/849	A.P.4343F, Vol. 1, Book 2
Jet pipe thermocouples	K.L.G. type No. F1223 Ref. No. 36AF/1232 F1225 Ref. No. 36AF1230 F1226 Ref. No. 36AF/1229 F1227 Ref. No. 36AF/1231	A.P.1275A, Vol. 1, Sect. 24
Oil pressure warning switch	Smiths type No. 1001/2P.G. Ref. No. 36AF/1186	A.P.1275A, Vol. 1, Sect. 27
Hours counter	Smiths type No. A.T.F.C.268/2/R Ref. No. 36AF/1226	A.P.1275A, Vol. 1, Sect. 27
Starts counter	Counting instruments Type No. 52/4/B29 Ref. No. 36AF/1018	A.P.1275A, Vol. 1, Sect. 27
E.23 connection plug	Plessey, type No. 508/1/00455 Ref. No. 36AF/981	A.P.4343C, Vol. 1, Book 3

Chapter 5

HYDRAULIC SYSTEM

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. The A.A.P.P. hydraulic system consists of an Integral type 180 Mk. 42 hydraulic pump that is connected via the inlet, delivery and by-pass hoses with three self-sealing Lockheed-Avery couplings on the top face of the central beam.

2. The hydraulic pump is described in A.P. 1803J, Vol. 1, Sect. 2; the aircraft system is described in A.P.4745A, Vol. 1.

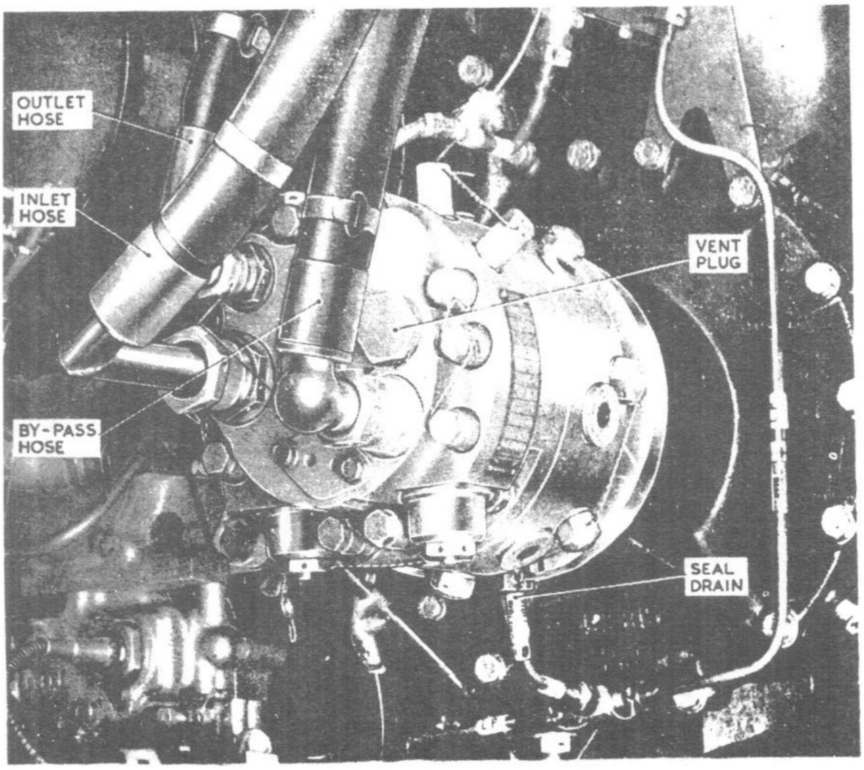


Fig. 1. Hydraulic pump installation

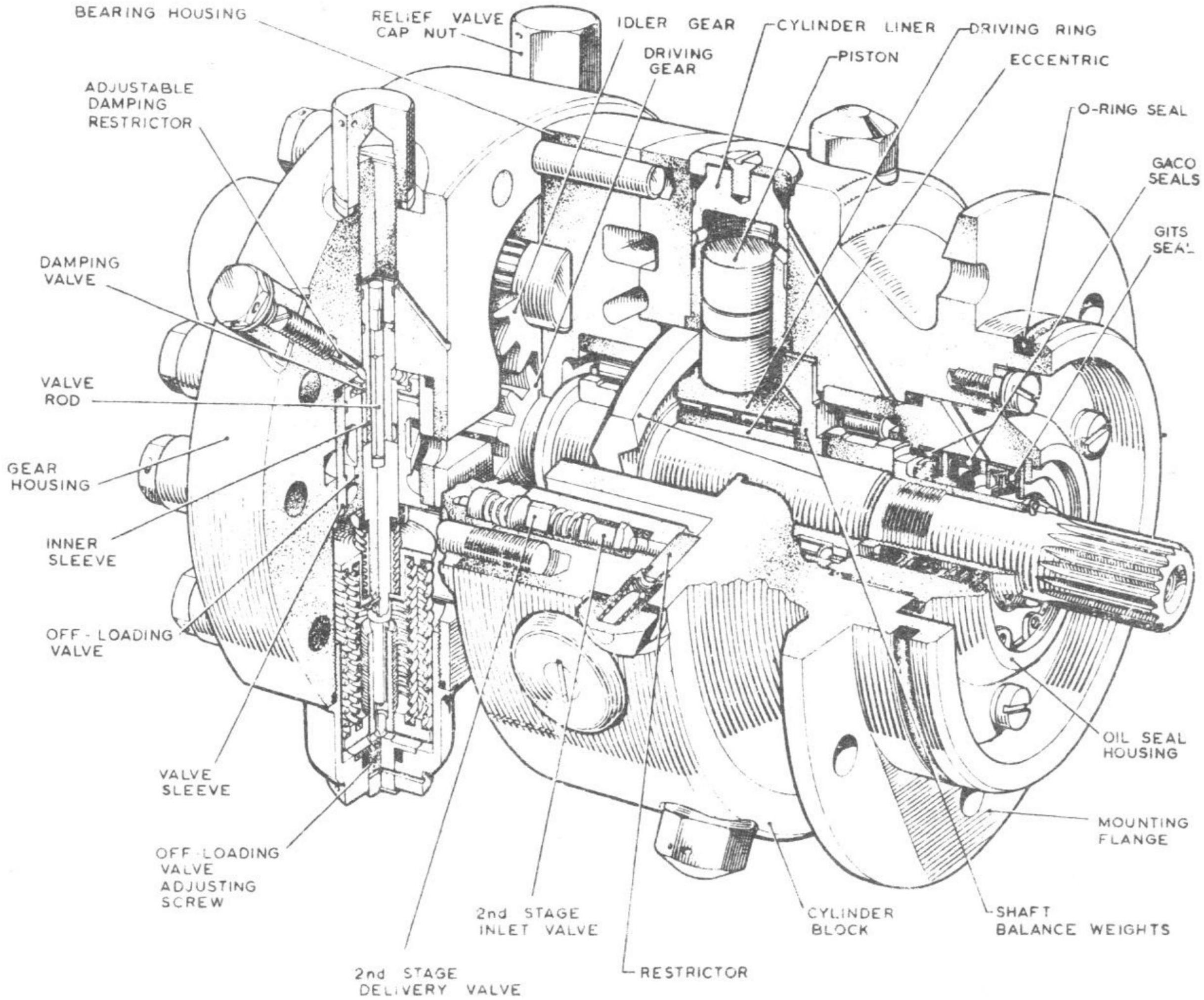


Fig. 2. Cut-away view of pump

Hydraulic pump

3. The hydraulic pump, which is secured to lower starboard side of the auxiliary gearbox cover by six studs, nuts, plain and spring washers, is driven through an internally splined muff coupling from the hub of the appropriate gear wheel in the gearbox.

4. The pump is of the two stage type. The first stage comprises a pair of meshing gears, and the second stage comprises seven pistons working in radially disposed cylinders.

5. The first stage feeds the second stage at a medium pressure and has a delivery in excess of the maximum requirements of the second stage which delivers at high pressure. An off-loading valve relieves the first stage, when its full delivery is not required, and a relief valve limits the pressure delivered by its second stage.

6. Fluid drawn in through the inlet port by the first stage gears is carried around the periphery of the gear chambers between the gear teeth, and is delivered into an inner annular duct. This duct feeds the inlet valves for the second stage cylinders via spring-loaded restrictors. The annular duct also communicates with the off-loading valve. While the full output of the first stage gears in being delivered to the system, the off-loading valve remains closed, and the restrictors and second stage inlet and delivery valves are held open by the first stage pressure; fluid then flows into the annular second stage delivery duct and out to the system. As the pressure builds up in the system, the off-loading valve is lifted from its seat, by-passing surplus fluid to the inlet side of the pump.

7. Fluid beyond the capacity of the cylinders having been by-passed, the remainder acts on the pistons and charges each cylinder in turn. As each piston is forced up by the eccentric, the fluid is discharged through the delivery valve at second stage pressure into the delivery duct and then into the system.

8. As the line pressure approaches the normal full pressure, the off-loading valve is opened

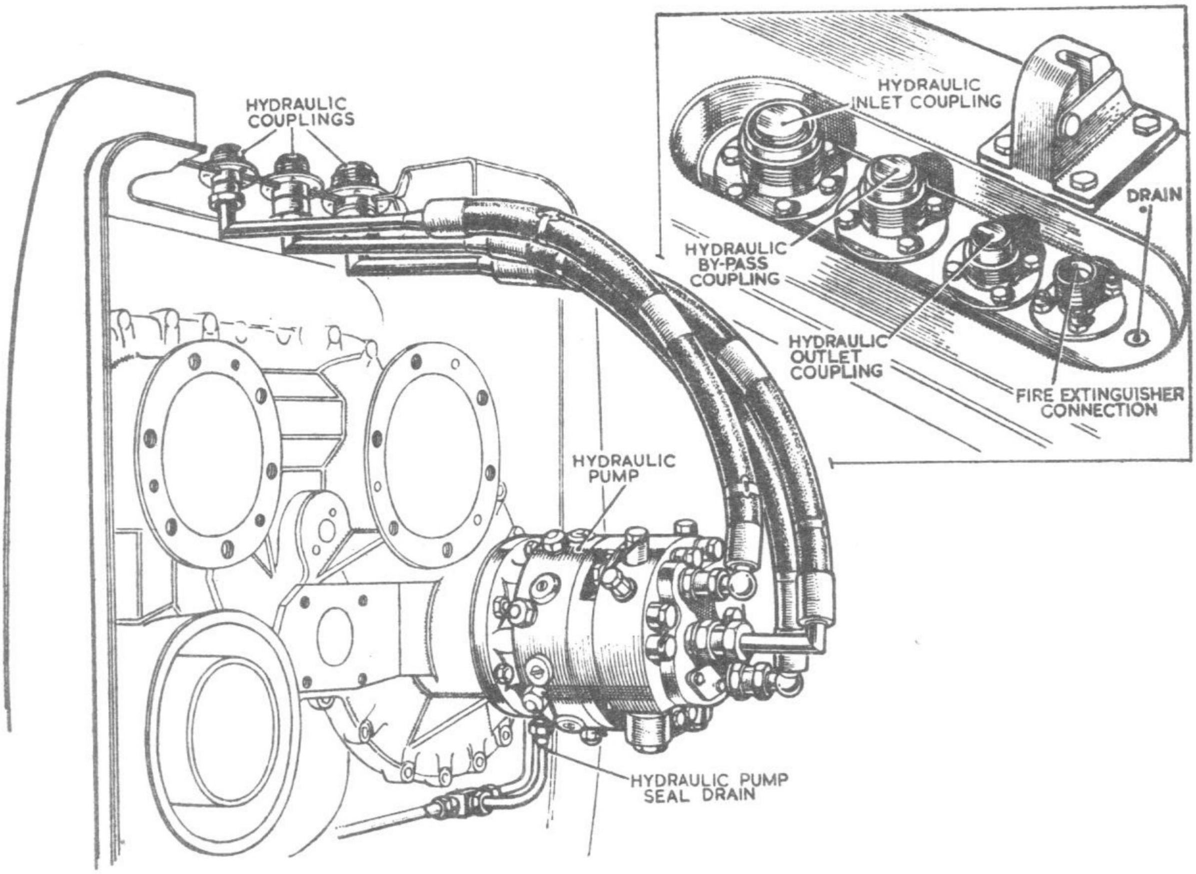


Fig. 3. Hydraulic system

further, reducing the first stage pressure. As the first stage pressure drops, the restrictors will close under the influence of their springs, cutting down the supply of fluid to the inlet valves until the flow is insufficient to fully charge the cylinders. The fluid supplied to the cylinders will thus progressively decrease until the maximum line pressure is reached. The pistons will then continue to deliver sufficient fluid to make up any line losses caused by seepage, etc. In these circumstances the off-loading valve will be fully open and the first stage pressure will have dropped to between 15 and 45 lb/in^2.

9. The restrictors prevent excessive supply of fluid to the cylinders during off-load running and prevent sudden fluctuation in the second stage delivery at around the maximum pressure. The cylinders will not be fully charged under these conditions and the pistons will therefore operate over only a small distance at the top of their stroke. Any excess delivery at the maximum line pressure will be relieved by the relief valve and returned into the by-pass recess. The operation of the relief valve is damped, preventing rapid pressure fluctuations.

10. A small plate valve on the rear face of the off-loading valve prevents rapid oscillation of the valve by restricting the flow of fluid behind the valve. An externally adjustable damping restrictor allows the degree of damping to be adjusted.

11. The by-pass connection permits a proportion of the by-pass fluid to return to the system reservoir, maintaining a constant circulation to assist in cooling the pump while running off-load. The remainder of the by-pass flow returns direct to the first stage gears, passing around the magnetic element which extracts any steel particles that may be present.

Hydraulic connections

12. The inlet, outlet and by-pass ports are connected by three flexible hoses to Lockheed-Avery self-sealing couplings mounted in a dished tray on the top face of the central beam. To prevent any accidental accummulation of hydraulic fluid, a drain boss and pipe connect the mounting tray with the power plant drain system.

13. Fluid draining from the hydraulic pump seals is fed into the power plant drain system via a union on the underside of the pump.

Chapter 6

FIRE PREVENTION SYSTEM

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. This chapter describes the location and function of those components that protect the A.A.P.P. from fire or overheat conditions. For a complete description of the Graviner equipment, refer to A.P.4343E.

2. The fire protection consists of three phases; first, the power plant is completely enclosed by a stainless steel nacelle designed to contain any possible outbreak of fire; second, the nacelle itself contains a heat sensing Firewire element that will automatically signal an outbreak of fire; third, the aircraft carries a methyl bromide extinguisher bottle which will, in the event of a signal from the Firewire control unit, discharge into the interior of the nacelle through twin nozzles built into the central beam assembly.

Nacelle

3. A complete description of the power plant nacelle is given in Chapter 7 of this publication.

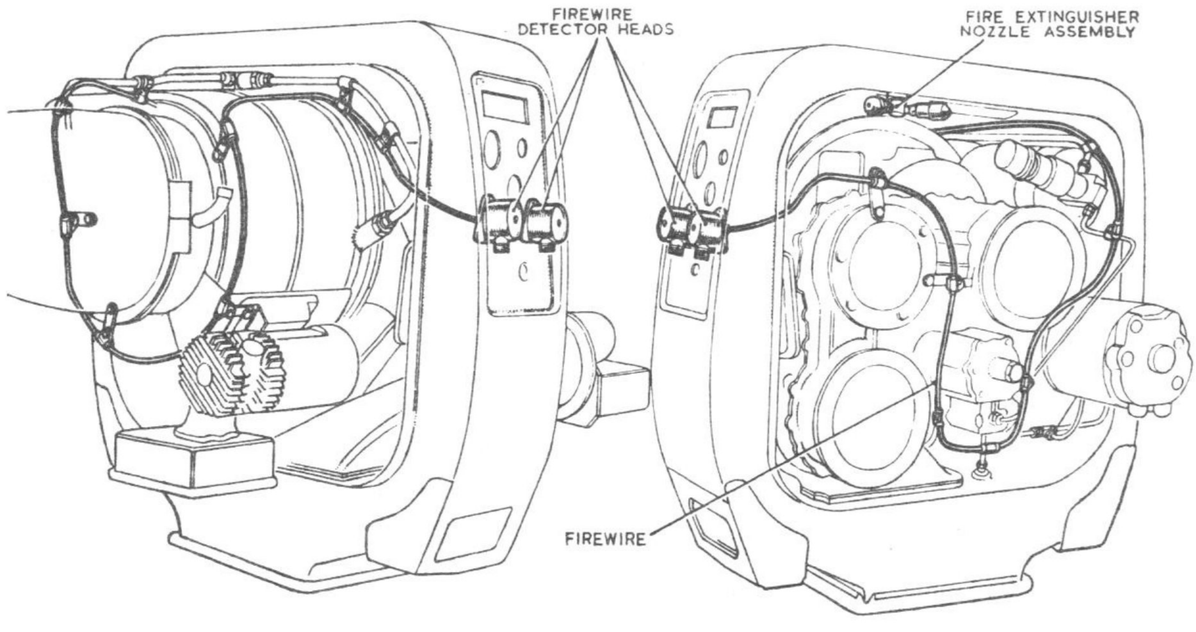


Fig. 1. Firewire system

Fire detectors

4. The fire detector system within the nacelle consists of a pliable sensing element, and two bulkhead connectors that are connected to a control unit in the aircraft.

5. The flexible sensing element consists of a stainless steel capillary provided with an integral means of interconnection and a co-axial centre conductor. The central electrode is separated from the walls of the capillary by a filling material; the electrical resistance of the material falls with increase in temperature, and conversely rises as the temperature decreases. Each end fitting contains a ceramic insulating bush and co-axial centre pin assembly.

6. The bulkhead connectors are flange mounted adapter units which on one side of the bulkhead accept the element co-axial fitting; on the other side, they accept an electrical cable connection. The cable terminal and an earthing terminal are enclosed by a cylindrical metal cover that has an A.G.S. cable entry.

7. When any part of the Firewire sensing element is heated to a certain level, the resistance of the capillary filling material decreases and allows the small stand-by current flow through the control unit relay coil to increase, and to close its warning circuit contacts.

8. When subsequently the source of overheat or the fire is removed, the resistance of the element rises, causing the detector relay current flow to decrease to a level which allows the control unit relay contacts to open and the warning light to cancel.

9. Operation of the circuit test switch simulates a lowering of the sensing element resistance, thereby functionally testing the internal circuit of the control unit and continuity of the sensing element central electrode. This allows the control unit relay contacts and the fire warning indicating circuit to operate. As the Firewire system has a power supply to each end, it will still continue to function as a fire and overheat detector even if the Firewire element is severed at any point.

10. Upon receipt of a fire warning, the system will illuminate the fire warning light, will automatically operate the extinguisher bottle, close the A.A.P.P. air intake scoop, isolate the sump heater, and close both the L.P. and the H.P. fuel cocks. For a more detailed description of the fire warning system, refer to A.P.4745A, Vol. 1, Book 2.

Fire extinguisher

11. The fire extinguisher mounted in the aircraft consists of a seamless copper cylinder containing methyl bromide pressurised to 250 lb/in^2.

12. The operating head at the lower end of the cylinder contains a diaphragm and an electrically fired cartridge unit. On receipt of a signal from the fire detector system, the cartridge unit is detonated, and the gas pressure ruptures the diapraghm and forces the charge plug into the end cap, thereby leaving a clear passage through which the extinguishant can flow to the outlet.

13. When the charge plug enters the end cap, it strikes an indicator pin, and causes it to protrude through the cap to give a visible indication that the extinguisher bottle has been operated.

Extinguisher nozzles

14. The extinguishant enters the nacelle via a ½ in. B.S.P. union mounted in the hydraulic tray on the top face of the central beam. The union is connected with two forward facing stainless steel nozzles joined at an angle of 90 deg. on the inside face of the central beam assembly.

15. The spray pattern developed by the two nozzles is designed to completely envelope the forward end of the nacelle, from whence it is carried aft by the air blast issuing from the blower unit.

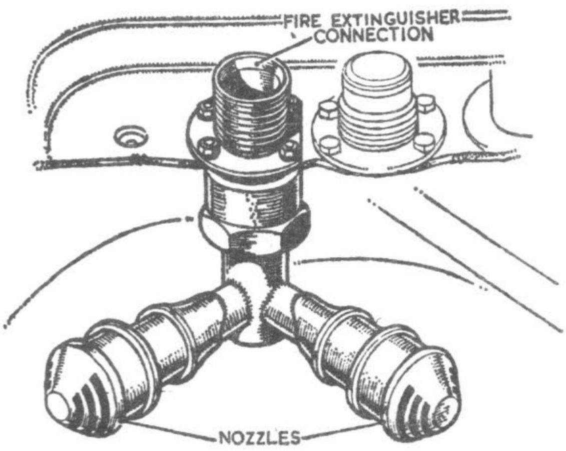


Fig. 2. Fire extinguisher nozzle assembly

Chapter 7

NACELLE

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

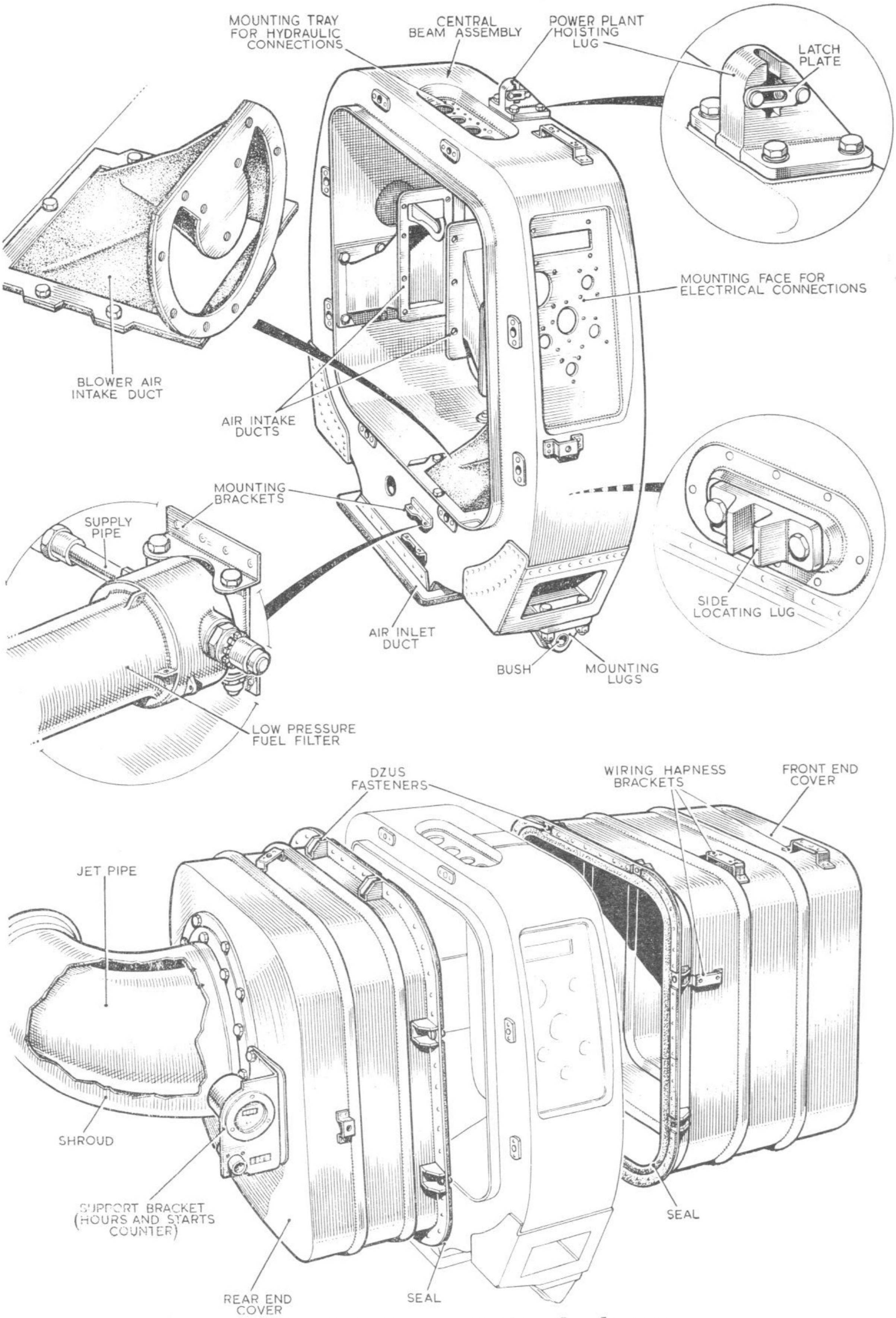


Fig. 1. Central beam assembly and end covers

General arrangement

1. The power plant nacelle consists basically of a fabricated stainless steel central beam assembly and two stainless steel end covers. The central beam, in addition to being the main structural member of the power plant, also serves as the engine and blower air intake ducting.

2. The two end covers, which are secured to the central beam by locking peg fasteners, completely enclose the engine unit to form a fireproof box. A circular opening in the lower side of the rear end cover provides access to the re-oil valve tray which, in addition to the re-oiling connection, also contains the external drain unions for the power plant drain system.

Central beam

3. The central beam assembly consists of 28 shaped stainless steel panels, spot-welded together to form a rectangular hoop. The bottom members of the beam and the lower half of the two side members together form a bifurcated air intake for the engine unit, suspended centrally within the beam by two rectangular section air intake ducts bolted to the inner faces of the beam side members.

4. The blower air intake is formed within the main intake by two fairings that direct the air flow upward via a rubber duct to the rear face of the auxiliaries gearbox, where after passing through the gearbox inner shroud, it enters the first compressor stage of the blower.

5. The two main mounting lugs for the power plant are located on brackets spot-welded to the lower corners of the beam. Each lug, which is forged from aluminium alloy, contains two stainless steel bushes and is secured to the mounting bracket by four bolts, plain washers, castellated nuts and split pins. A third aluminium alloy lug, which is secured to the forward face of the beam by two bolts, plain washers and captive nuts, serves to absorb any side thrust.

6. The top face of the beam is dished to provide a mounting tray for three Lockheed-Avery self sealing couplings which are the inlet, outlet and by-pass connections for the hydraulic pump. To prevent any accidental accumulation of hydraulic fluid, a drain boss and pipe connect the tray with the power plant drain system. The tray also contains a $\frac{1}{2}$ in. B.S.P. union connecting a fire extinguisher bottle in the aircraft with two extinguisher nozzles mounted on the underside of the top member of the beam.

7. The power plant hoisting lug on the top face of the beam contains a slotted recess that is designed to receive a ball ended cable hoist; the slot is protected by a latch plate. The lug is forged from aluminium alloy and is secured to the central beam by four bolts, castellated nuts and split pins.

8. A dished mounting face on the starboard side member of the beam provides a location for all the power plant electrical connections. These connections comprise the generator terminal block, the main harness connection plug, the igniter plug connector, the generator field connection plug, and the two fire detector leads. Also located on the mounting face is the connection for the engine compressor washing nozzle.

9. The low pressure fuel filter is supported in a horizontal position by two bolts and self-locking nuts between parallel brackets that are spot-welded to the lower rear face of the central beam.

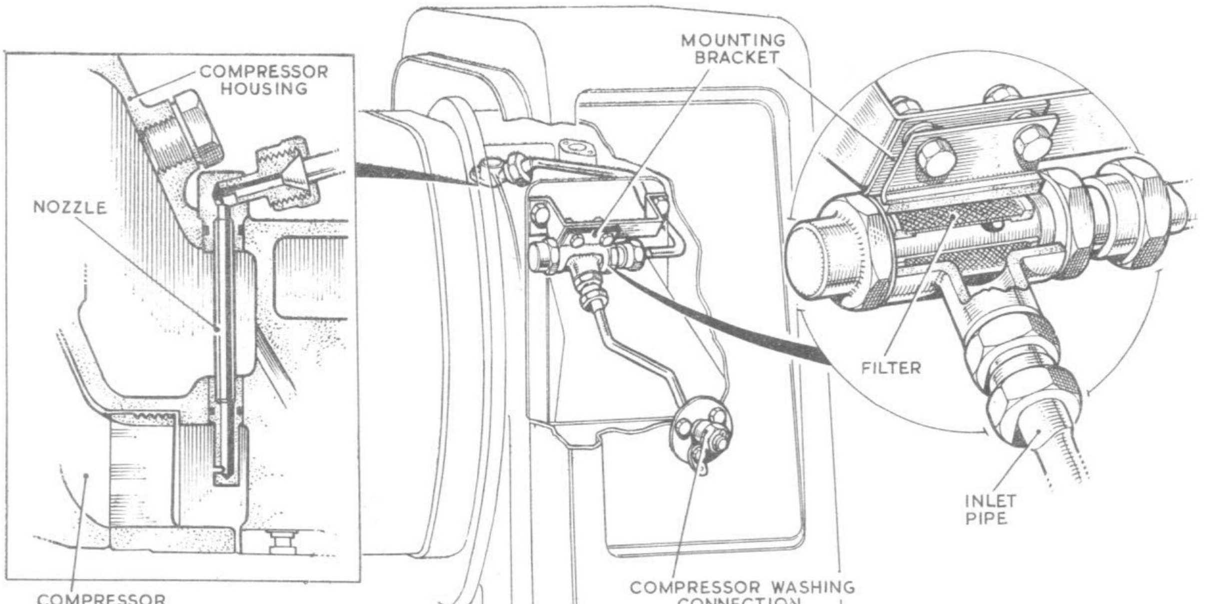


Fig. 2. Compressor washing

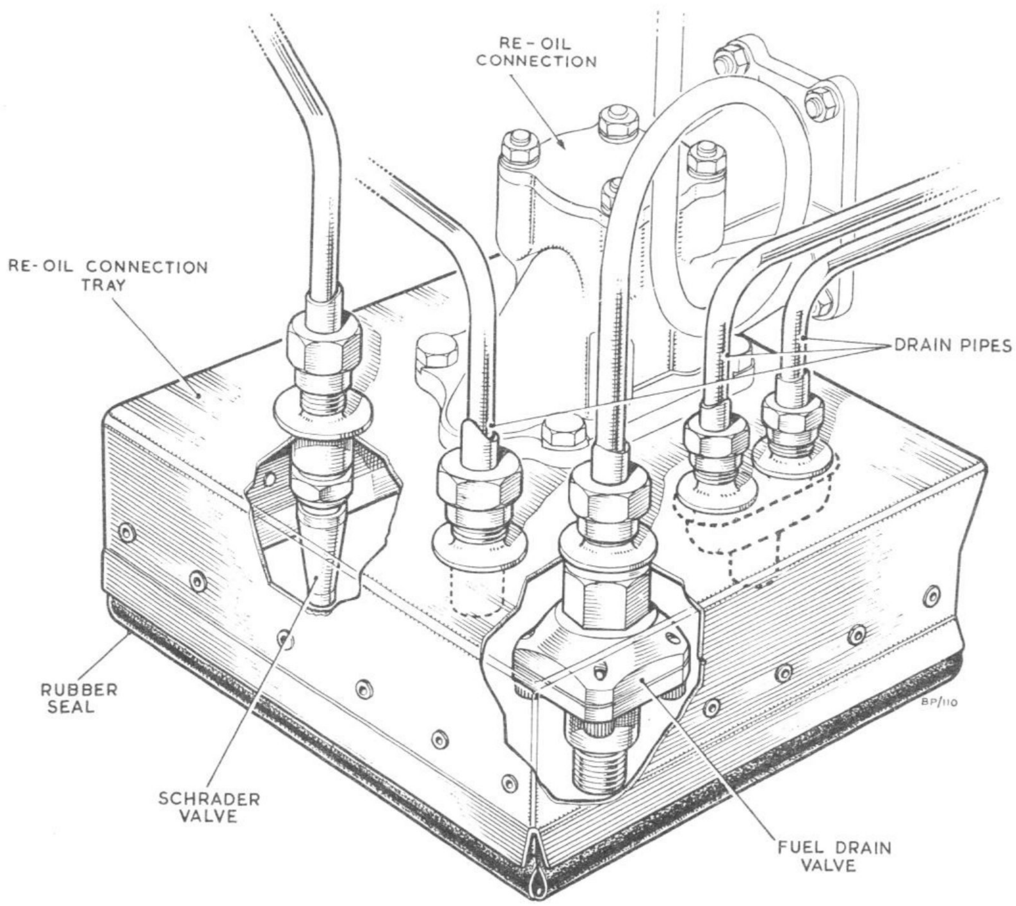


Fig. 3. Re-oil connection tray

The supply pipe from the filter to the fuel pump passes through the air intake wall and emerges within the central portion of the beam immediately beneath the fuel pump.

10. The compressor washing injector consists of a nozzle in the compressor housing, positioned to face directly into the eye of the compressor. The nozzle is connected, via an external pipe, with a T-shaped gauze filter unit mounted on the starboard air intake duct; from the filter, a second pipe leads directly to the injector union on the starboard side-member of the central beam. The injector union is protected by a nipple, union nut and split pin.

Re-oil connection tray

11. The re-oil connection, secured to the rear wall of the engine oil sump, carries on its lower face an inverted stainless steel tray that provides a convenient exit for the power plant drain system.

12. The tray, which is fabricated from 22 s.w.g. stainless steel sheet, is secured to the re-oil valve by four bolts, plain washers and locknuts. The interior of the tray is accessible through a circular aperture in the bottom of the rear end cover. The aperture is sealed from the interior of the nacelle by asbestos covered rubber bedding tape riveted to the bottom edge of the tray.

13. Within the tray, four unions connect the power plant drain system with the drain pipes running to the outer skin of the aircraft. A fifth union carries a Schrader valve which provides a test point for the motorised air pump.

Fuel drain valve

14. To prevent any loss of compressed air from the engine main air casing, the appropriate drain union in the re-oil valve tray carries a fuel drain valve. The valve consists of two aluminium alloy housings containing a spring-loaded stainless steel diaphragm.

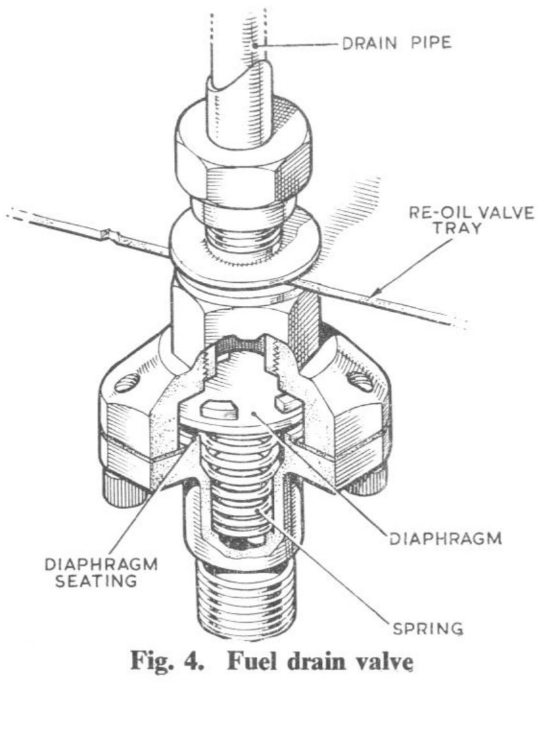


Fig. 4. Fuel drain valve

15. When the engine is stationary, spring pressure prevents the diaphragm from seating and allows any fuel that may have accumulated to escape through a central passage in the housings and around the edge of the diaphragm disc. Once the engine has started, an air pressure of approximately 2 lb/in^2 in the main air casing is sufficient to force the diaphragm on to its seat, thus sealing the valve and preventing any loss of compressed air.

Front end cover

16. The front end cover, closing the forward end of the nacelle, consists of a radiused box section unit fabricated from two spot welded stainless steel panels.

17. The cover is secured to the central beam by eight Dzus fasteners located in pockets on the flanged leading edge of the cover. A continuous strip of asbestos-covered rubber bedding tape, pop-riveted to the flanged edge of the cover, serves to seal the interior of the nacelle. Three brackets riveted to the exterior of the cover provide support for the aircraft wiring harness leading to the power plant.

Rear end cover

18. Formed in a similar manner to the front end cover from two spot welded stainless steel panels, the rear end cover is also secured to the central beam by eight Dzus fasteners. As in the case of the front end cover, bedding tape riveted to the flanged edge of the cover is utilised to seal the interior of the nacelle.

19. A circular aperture in the rear of the cover locates the jet pipe and shroud assembly which conducts the turbine exhaust gases from the nacelle to atmosphere. The stainless steel jet pipe is fastened to the turbine exhaust cylinder by a two piece clamping ring held by two bolts, nuts and tab-washers.

20. The stainless steel jet pipe shroud is secured to an adapter ring by 12 bolts, plain washers and captive nuts, whilst the ring itself is secured to the rear end cover by a further 12 bolts, plain washers and captive nuts. The shroud, which completely encloses the jet pipe, also serves as an exit point for the cooling air ducted into the nacelle by the blower unit.

21. The exterior of the rear end cover also carries a support bracket for the hours and starts counters. The bracket, supported by two of the jet pipe shroud adapter ring bolts, carries the housing for the two counters and their connection socket on three anti-vibration mountings.

Third point mounting

22. The power plant third point mounting consists of an adjustable rod, secured at one end to the engine exhaust cone with a spherical bearing whilst the other end, which has a fork ending, is secured to a second spherical bearing in the aircraft.

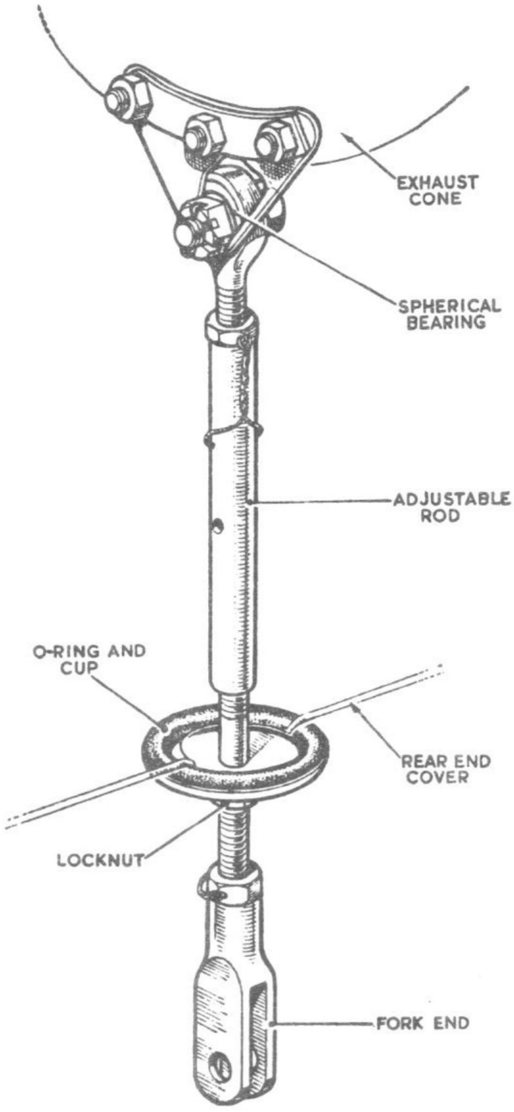


Fig. 5. Third point mounting

23. The main purpose of the mounting is to permit the engine exhaust cone to be adjusted vertically in relation to the exhaust aperture in the aircraft skin, whilst the two spherical bearings provide a working tolerance in the event of any misalignment of the main mountings.

24. The point at which the mounting rod passes through the rear end cover is sealed by a rubber O-ring in a shallow cup that is retained against the exterior of the cover by a locknut.