

SECTION I

DESCRIPTION

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SECTION I

DESCRIPTION

LIST OF CHAPTERS

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Chapter I

GENERAL DESCRIPTION

Note.—This chapter applies to Avon Mk. 10801 and 11401 Engine Change Units

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INTRODUCTION

1. The Avon is a turbo-jet aero-engine fitted with reheat and having a twelve-stage axial flow compressor directly coupled to a two-stage turbine.

2. Fuel is injected through a burner into each of the eight separate combustion chambers and the flow is controlled by a fuel control unit in conjunction with an engine-driven dual pump of variable stroke.

3. Drives for the fuel pump, governor pump and the tachometer generator are provided on an externally mounted wheelcase driven from an internal wheelcase surrounding the centre main bearing. A coupling flange is provided on the port side for driving an accessory gearbox.

4. The oil system is entirely self-contained in the engine and incorporates a fuel-cooled oil cooler and a combined oil tank and sump containing immersed oil pumps.

5. The engine has a cartridge-operated turbo-starter mounted in the central fairing in the air-intake.

GAS FLOW

6. The ducts which carry the main gas stream through the engine have smooth internal surfaces to reduce frictional and aerodynamic losses to a minimum.

7. The compressor is designed to operate over a wide range of engine speeds, aircraft speeds and intake air densities, and delivers air to the combustion chambers at a compression ratio of 6:1 at maximum engine speed at normal atmospheric temperature; slightly higher ratios are given at lower temperatures.

8. Air entering the compressor passes through an annular intake duct and is directed on to the compressor rotor blades at the correct angle by a

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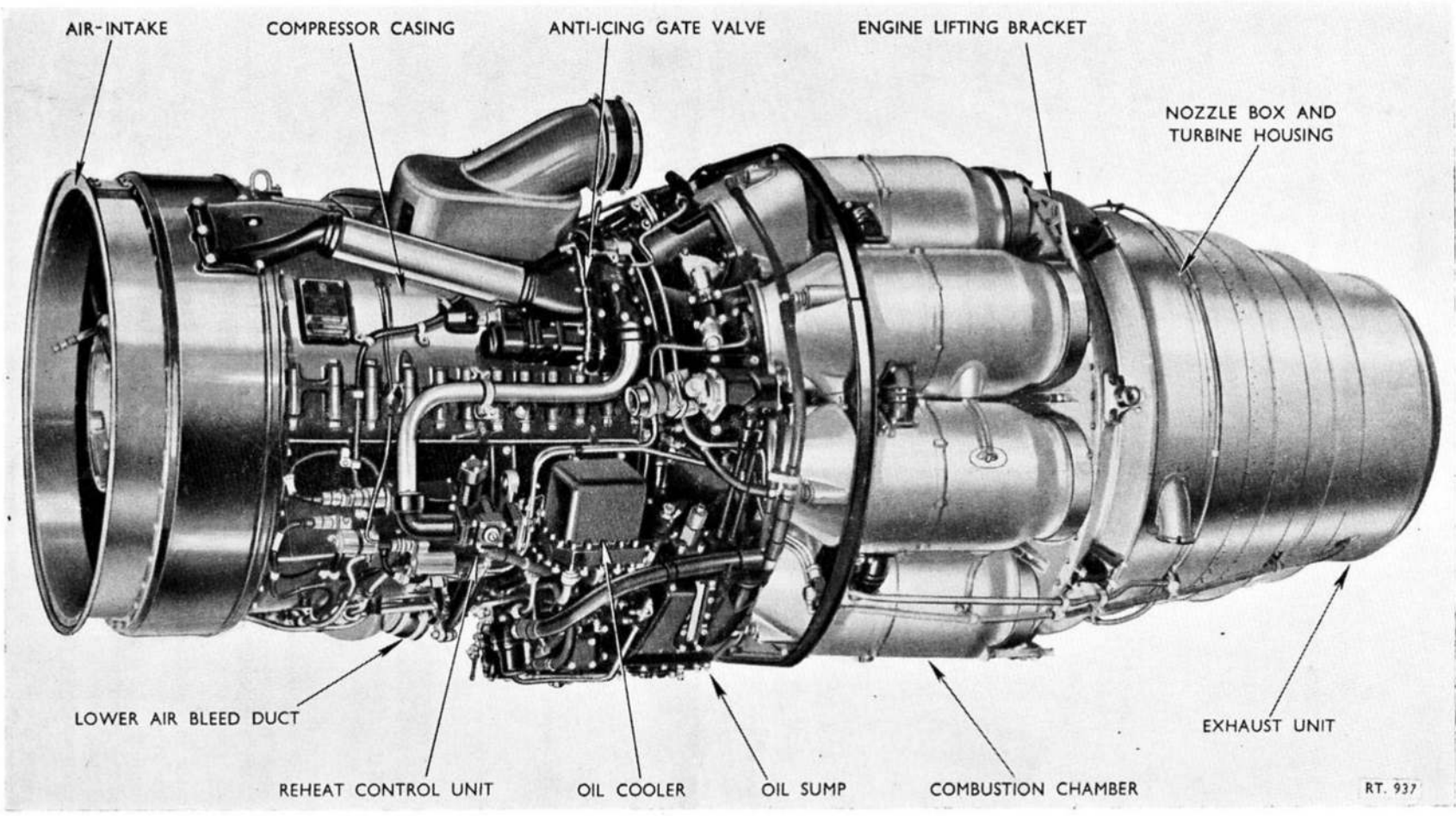
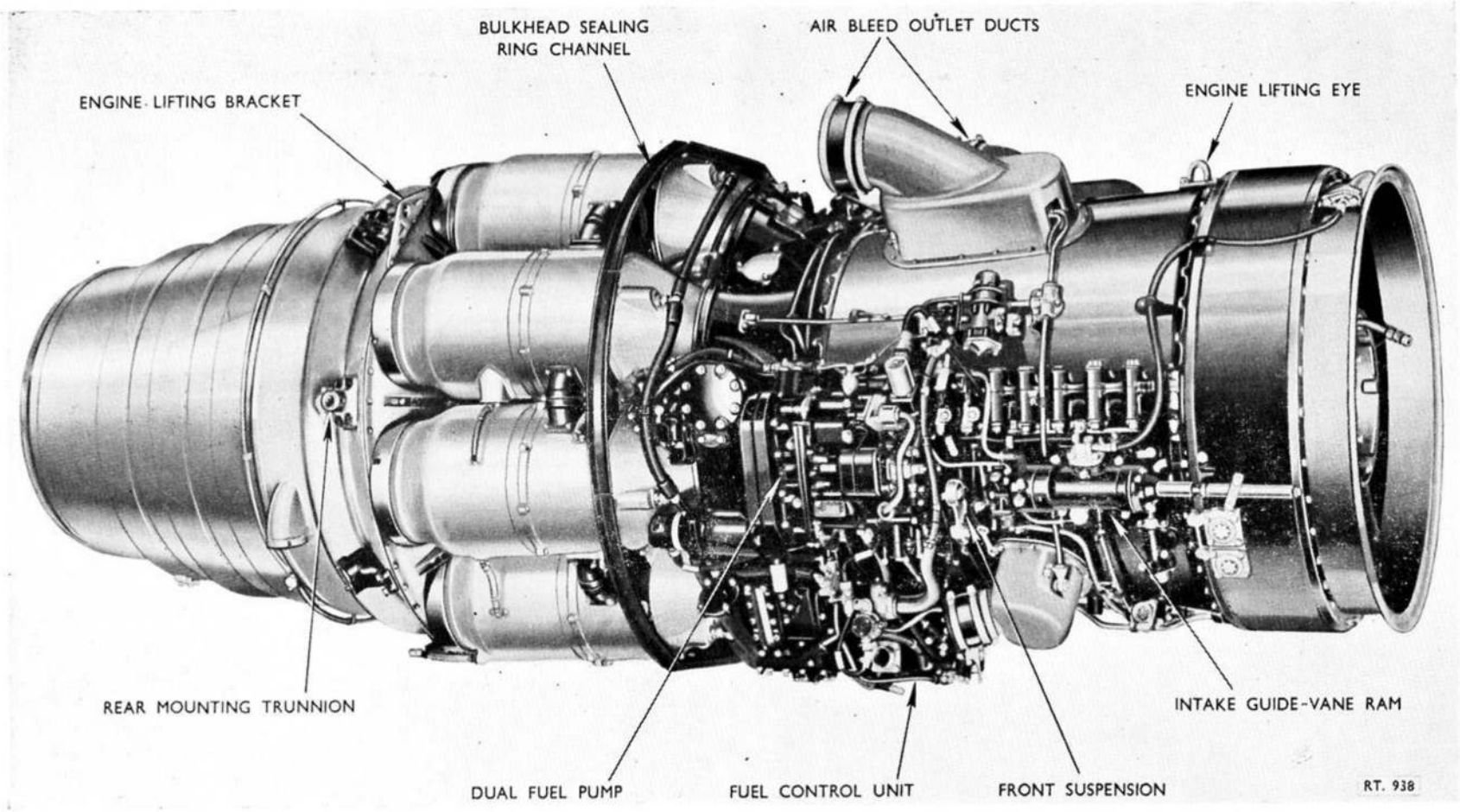


Fig. 1. Location of units (port view)



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Fig. 2. Location of units (starboard view)

ring of intake guide-vanes. The angular setting of the intake guide-vanes is controlled automatically to suit the engine speed. After each row of blades there is a set of stator blades fixed to the casing, which direct the air at a higher pressure and at a suitable angle on to the next row of rotor blades. The cross-sectional area of the compressor air duct is reduced at each stage to maintain the velocity of the air under the rising pressure. From the last stage of the compressor the air passes through a ring of outlet guide-vanes. The annular duct of the compressor outlet casing then divides into eight separate circular ducts, each supplying air to a combustion chamber.

9. The combustion chambers are designed to facilitate complete and stable burning of the fuel and to enable the heat so generated to expand the main gas flow and accelerate it rearwards. The products of combustion are surrounded by and mixed with cooler air to distribute the heat evenly. This reduces the temperature of the gas before it reaches the turbine, so that critical temperatures within the turbine are not exceeded.

10. The gas is fed to the turbine through nozzles which gradually merge from the individual circular section of the combustion chambers to segments which form a complete annulus at the high pressure nozzle guide-vanes.

11. To keep the diameter of the turbine small and yet enable it to extract sufficient power from the gas stream to drive the compressor, two turbine wheels are used and these are coupled together to drive through a single shaft. All the gas passes through both the high pressure (front) and the low pressure (rear) turbines, being directed on to each row of blades at a suitable angle by a ring of nozzle guide-vanes. These guide-vanes produce a considerable increase in the velocity of the gas and a reduction in the pressure and temperature.

12. After leaving the low pressure turbine the gas passes through the exhaust unit and the jet pipe to the propelling nozzle. To avoid frictional losses in the jet pipe the gas velocity is slightly reduced by diffusion between the cone and the walls of the exhaust unit.

13. The reduction to atmospheric pressure and the final acceleration of the gas stream occurs at the propelling nozzle, the exit area of which is variable to suit the maximum gas flow when reheat is either selected or cancelled.

COOLING AIR

14. To counteract the transfer of heat from the gas stream, air is fed under pressure to cool various parts of the engine.

15. Both faces of each turbine disc are cooled by air which is discharged through labyrinth seals into the main gas stream, thus preventing any leakage of hot gases on to the disc faces. To ensure that the pressure of the cooling air exceeds that of the main gas stream at the point of discharge, the front face of the high pressure turbine disc receives air from the twelfth stage of the compressor, the

space between the two discs receives air from the eleventh stage, and the rear face of the low pressure disc receives eleventh stage air through a restrictor hole which maintains an adequate pressure between the turbine discs.

16. The twelfth stage cooling air is collected in an annular space in the compressor outlet casing, and is conveyed through internal pipes to the high pressure turbine.

17. The eleventh stage air passes through a 'vortex reducer' which reduces the swirl energy ultimately dissipated as heat and thus minimizes the rise in temperature. The air then passes through a further vortex reducer and transfer tubes inside the compressor shaft and through the hollow turbine shaft to the turbine discs.

18. Third stage air also passes through a vortex reducer into the compressor shaft, but then flows through the intermediate casing, cooling the turbine shaft, the main bearings and those in the internal wheelcase, and pressurizing the main oil seals. From the intermediate casing, the air flows through the rear bearing housing and then outwards through the arms of the nozzle box frame into a shield where it cools the outer casing of the nozzle box before escaping to atmosphere.

19. To counteract the transfer of heat from the engine and jet pipe to the aircraft structure, the spaces surrounding the engine are ventilated and a circulation of air at atmospheric pressure is assured by the ejector action of the main gas stream at the propelling nozzle and by a similar effect at the outlet for air from the centrifugal breather and the compressor rotor vent.

STRUCTURAL FEATURES

20. The main frame of the engine is formed by a number of basically circular casings secured together by flanged joints to form a rigid structure, inside which the main rotating assembly is supported by three bearings. The concentricity of the structure is assured by a series of spigots, dowels, and close-fitting bolts.

21. Each casing is manufactured from the lightest material which will withstand the stresses and temperatures to which it is subjected in service. For example, magnesium alloy is used for the intake casing, the oil sump and the wheelcases, which are the coolest parts of the engine; steel is used for the nozzle box where the temperature is fairly high and through which the thrust of the engine is transmitted to the airframe; aluminium alloy is used for those casings subject to intermediate temperatures.

Thermal expansion

22. Due to the wide divergence of temperature and the variety of materials used, expansion is not uniform throughout the engine.

23. To allow for this, sliding joints are used on the combustion chambers; the nozzle guide-vanes have clearance when assembled in the cold nozzle box, and the turbine blades have clearance both at

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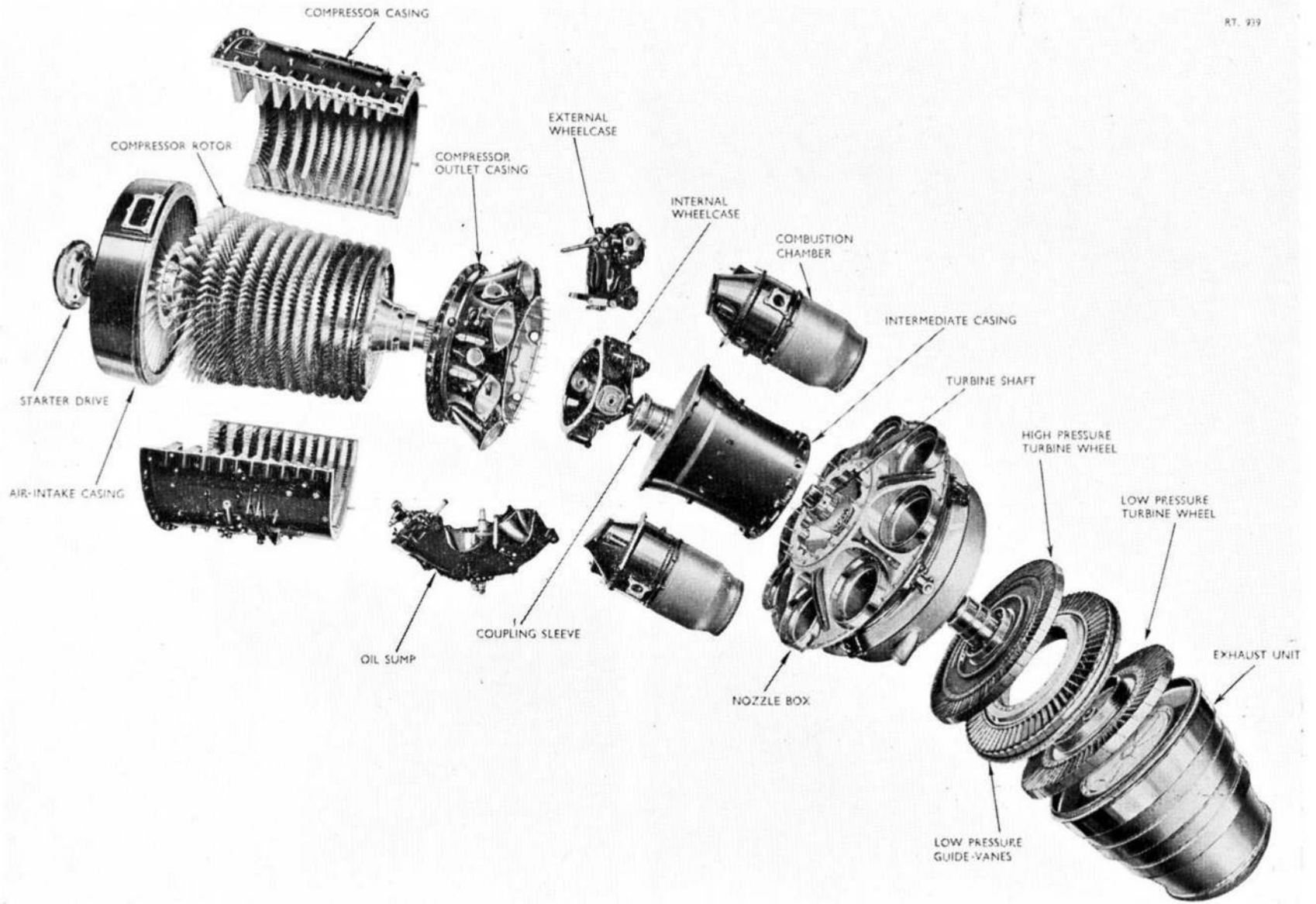


Fig. 3. Main units of engine

the blade root and at the tip to allow for relative movement.

24. To allow for relative movement without losing the alignment of the drive, the external wheelcase is attached to the compressor outlet casing by two pivots and a swinging link, and the oil feed, drain and vent connections are made by transfer tubes with rubber sealing rings.

Internal stresses

25. Most of the joints between the main casings are in a state of tension, and in the more highly stressed positions the nuts are tightened to a specified torque loading during assembly to ensure adequate tightness of the joints under running conditions. Controlled tightening is also applied to nuts retaining gears and bearings on shafts, and to the bolts on the compressor and turbine shaft flanges.

26. The compressor rotor tends to pull itself forward due to the increase in pressure across each stage of blades; the effect of air pressure acting on the rear face of the twelfth stage rotor disc is practically eliminated by venting this space to atmosphere. The turbine wheels tend to move rearwards due to the difference in pressure across the turbine discs and blades. The centre coupling transmits the whole of the turbine thrust to the compressor shaft, and the remaining forward load on the main shafts is carried by one thrust bearing at the rear end of the compressor shaft.

Gas seals

27. Throughout the engine there are several places where gas must be confined at the junction of a stationary and a rotating member. Due to the high peripheral speeds, the seals used are of the labyrinth type, having a number of pockets between areas of close clearance. These seals are not air-tight but merely form a controlled restriction to the passage of air or gas. Leakage of hot gas on to the turbine discs is prevented by supplying air at a pressure exceeding that of the main gas stream.

28. The seals between the turbine discs are self-clearing if there is a rub due to thermal and centrifugal expansion of the discs. This is achieved by making the outer members of high expansion material so that the heat produced by the rub causes them to expand away from the rotors.

Engine mounting

29. Engine thrust is transmitted to the airframe through two trunnions, attached to the nozzle box, which also support the rear of the engine. One trunnion is designed to slide in its housing to allow for lateral expansion of the engine. A ball-jointed framework attached to the compressor casing supports the front of the engine but does not carry any forward thrust. This front suspension permits limited movement to allow for engine expansion, torque reaction and airframe distortion without excessive stress in the compressor casing.

30. For lifting the engine two brackets are attached to the nozzle box and a lifting eye to the top of the compressor casing.

MECHANICAL FEATURES

Main rotating assembly

31. The turbine and compressor rotors are directly coupled and are supported in a roller bearing at each end and a ball thrust bearing at the centre.

32. To accommodate the slight variations in alignment which may occur under running conditions, the centre coupling incorporates a ball and socket joint, and a splined coupling sleeve is used to transmit the torque from the turbine. The coupling is located axially by a collar which is turned to cross the splines after assembly, and the collar itself has a spring-loaded locking plunger. The axial load of the turbine is transmitted to the compressor shaft through the ball and socket; these have three segments cut away to permit assembly, and a system of baulking pegs and three master splines on the coupling sleeve ensures that the remaining spherical segments are correctly aligned to withstand the axial load.

33. The compressor and turbine rotors are built up from components which are individually balanced, but, to allow final balancing of the assemblies, provision is made for the fitting of balancing plugs on both the compressor and the turbine rotors.

Accessory drives

34. The main drive to the compressor passes through the internal wheelcase in which drives are taken from the compressor rear shaft through spur and bevel gears to the centrifugal breather, to the oil pumps, to the external wheelcase, and to the accessory gearbox. The gears in the external wheelcase drive the dual fuel pump, the tachometer generator, and the ram governor pump.

35. The accessory gearbox drive is on the port side and a pair of bevel gears are used to turn the drive through nearly 90 degrees towards the front of the engine.

36. Ball and roller bearings are used throughout the wheelcases, except on the shafts driving the oil pumps and the tachometer generator, which run in plain bearings.

COMPRESSOR

37. The compressor rotor has twelve sets of blades between which are eleven rings of stator blades. The blades in the first eight stages are of aluminium alloy but the later stages are in bronze alloys to withstand the heat due to compression.

Compressor rotor

38. The rotor blades are secured to discs which are splined to the main shaft. Between the discs are spigoted spacing rings which locate the discs axially and also retain the blade securing pins. The clearance between the spacing rings and the tips and shrouds of the stator blades is kept to a minimum to ensure that as little leakage as possible occurs across each stage.

39. The pins securing the rotor blades to the discs are a free rolling fit and allow the blades to rock

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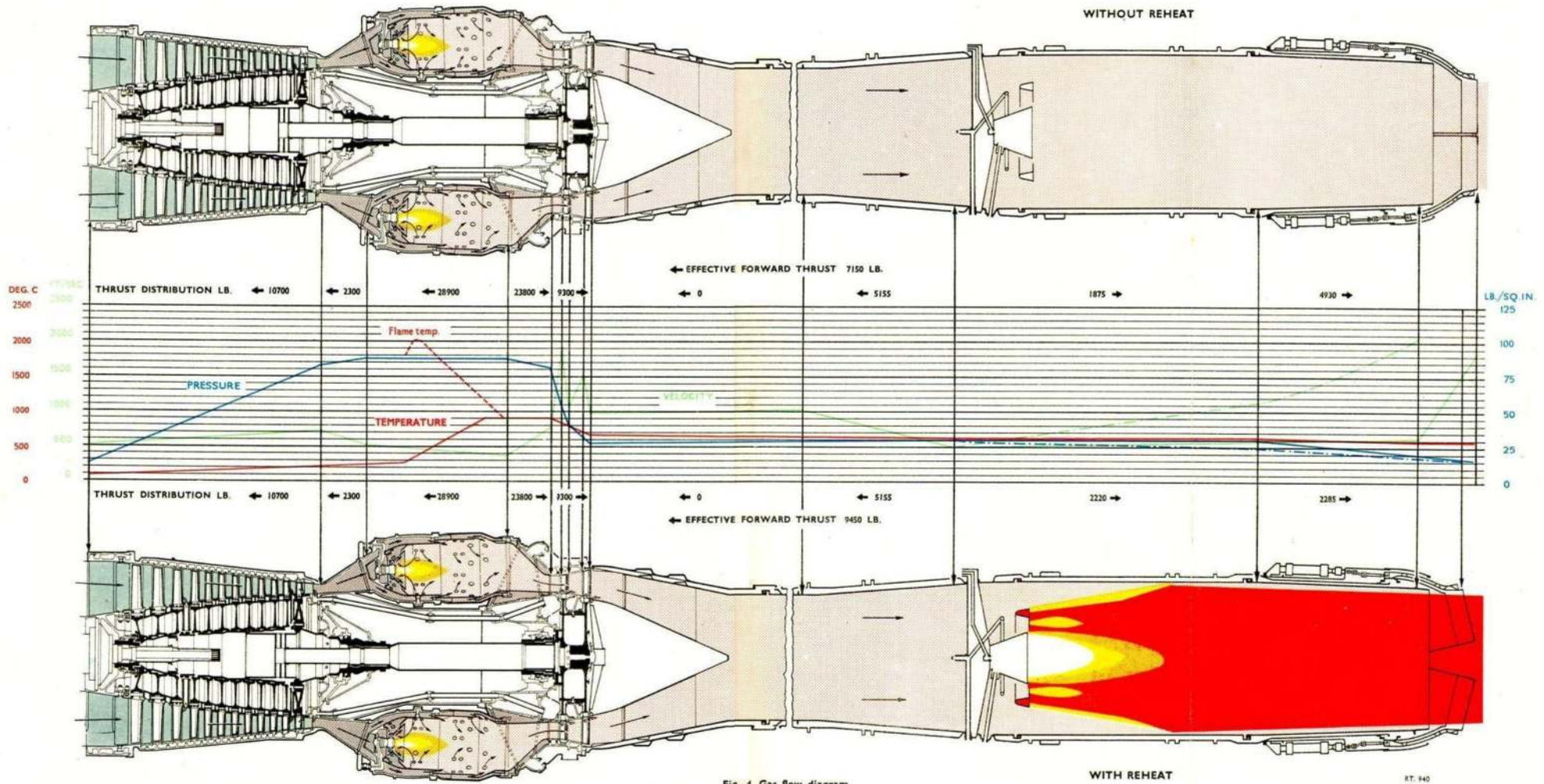


Fig. 4 Gas flow diagram

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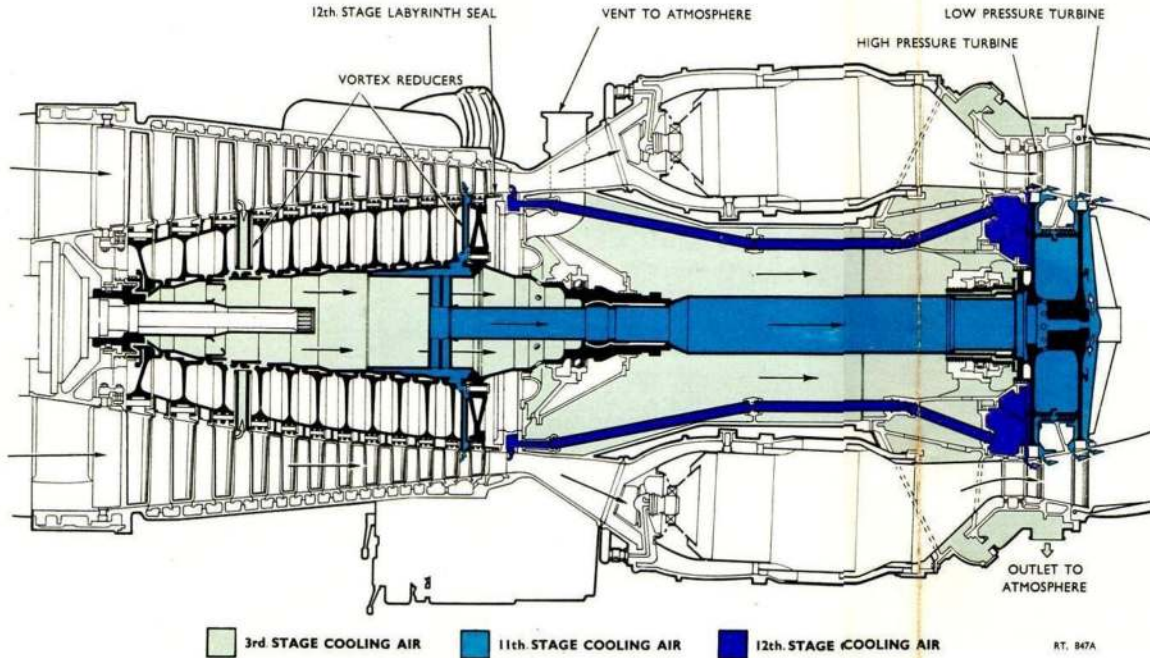


Fig. 5. Cooling air diagram

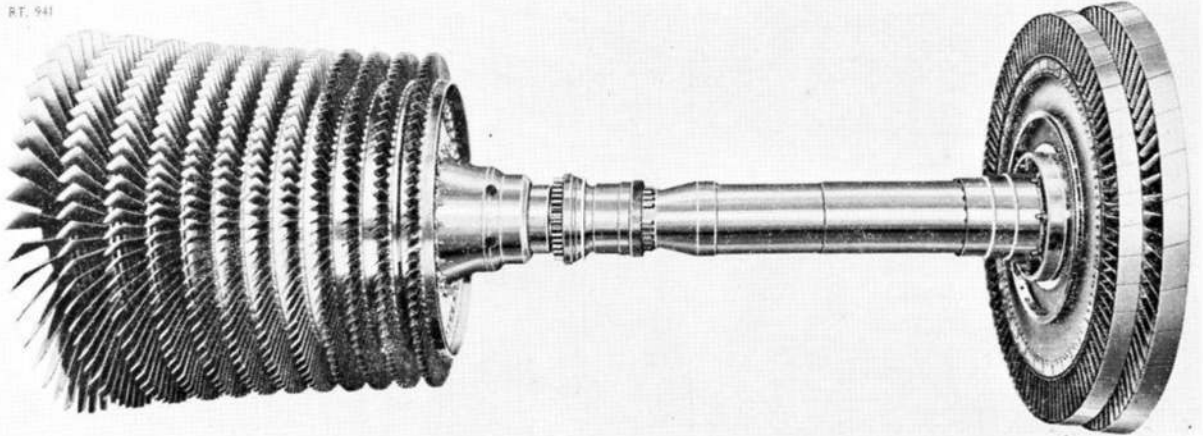


Fig. 6. Main rotating assembly

slightly; blade root vibration stresses are thus considerably reduced.

40. The compressor shaft is in two parts joined together by flanges with taper bolts. The coupling bolts also secure the two discs which carry the the twelfth stage rotor blades. The shorter rear shaft carries the gear from which all the auxiliary drives are taken.

41. To achieve dynamic balance of the rotor assembly the individual discs and the shaft are balanced, and balancing plugs are inserted at both ends of the rotor.

Compressor casings

42. The eleven rows of stator blades are housed in two casings which together form a cylinder. Each casing is grooved to hold the blades, and the land between the grooves is just clear of the rotor blade tips. Stops at the casing joints prevent the stator blades from sliding round the grooves when the engine is running.

43. The blades in the first four stages are joined together in groups. The pieces joining the blade tips form a complete inner shroud ring for each of these stages. This minimizes the vibration in aerodynamic loading, which would otherwise be excessive on the longer blades.

44. The blades in the last two stages are joined together at the root in groups of four and five. These are the smallest and most closely spaced blades, and the grouping maintains correct alignment of the blades.

45. Mounting faces on the main casing carry the oil cooler, the acceleration control unit, the intake guide-vane operating ram, the hot air gate valve and the reheat control unit.

Air-intake casing

46. The air-intake casing has a large hub on which the front main bearing and the starter are

mounted. The hub is supported by six spokes which, to allow for expansion, are tangential rather than radial.

47. These spokes are hollow and are used to convey oil to and from the front main bearing and to carry the electrical cables to the starter. Each spoke also conveys hot air for anti-icing purposes.

48. To the rear of the spokes and between the hub and the outer ring are the intake guide-vanes. Each vane has a lever at the inner end engaging with trunnions in an actuating ring to enable the angle of incidence of all the vanes to be altered together. Two vanes have also a lever at the outer end, and through these master vanes a ram controls the setting of all the vanes. Internal stops are incorporated to limit the movement of the vanes under compressor surge conditions, and the operating ram is provided with internal limiting stops.

Outlet casing

49. The compressor outlet casing is shaped to divide the air stream into eight ducts, each leading to a combustion chamber. In the annular space immediately after the last stage of rotor blades there are the outlet guide-vanes which remove the swirl from the air as it leaves the compressor. These outlet guide-vanes are retained both axially and circumferentially by a toothed ring which engages with the root of every vane.

50. In the compressor outlet casing there is a ring of holes behind the outlet guide-vanes to supply air at final delivery pressure to cool the front face of the high pressure turbine wheel. Compressed air is also taken through external connections to the acceleration control unit, the air bleed control unit, the reheat control unit and for aircraft services, e.g. cabin pressurizing and heating.

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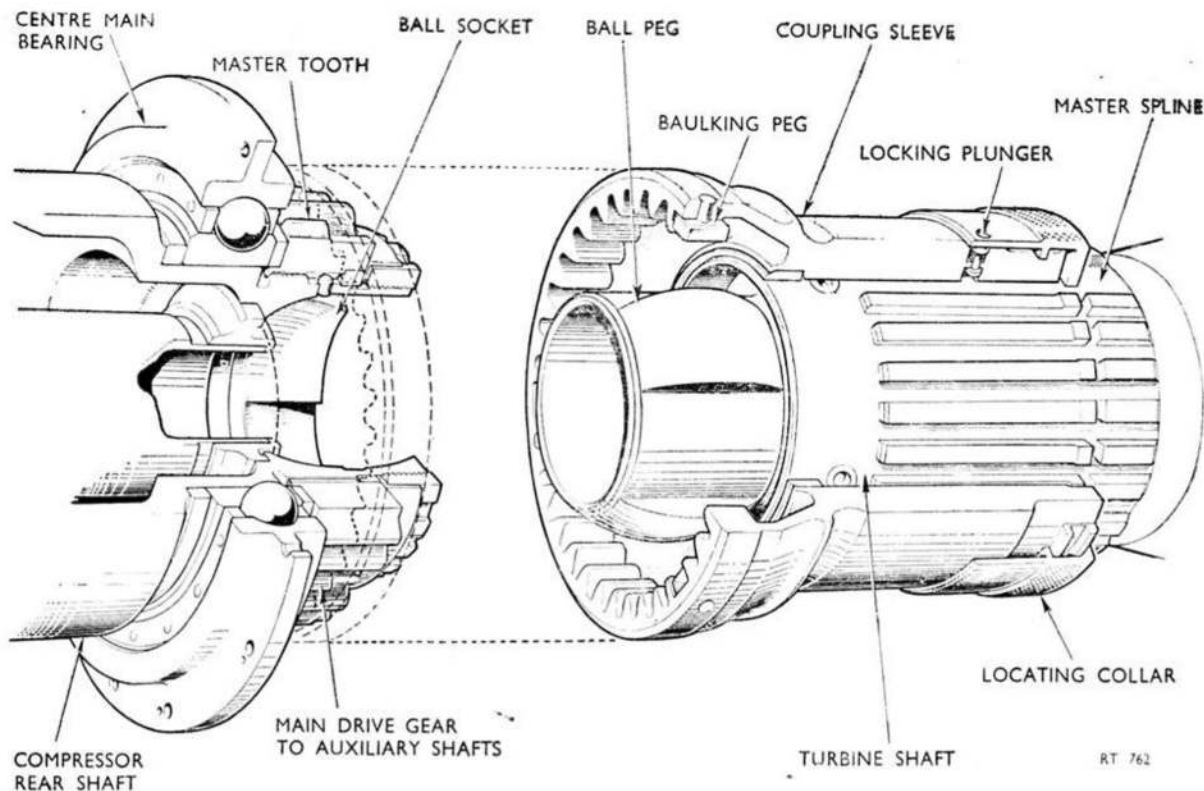


Fig. 7. Centre coupling

51. The compressor outlet casing also carries the centre bearing housing and the internal wheelcase. Mounted on the outside of the casing are the external wheelcase, the accessory gearbox drive, the oil sump and the air bleed valve control unit.

Compressor performance

52. The stages of the compressor are designed for maximum efficiency in the speed range near maximum r.p.m. in which the engine normally operates. However, the engine must run satisfactorily at all speeds and, to achieve this, variations in the angular setting of the intake guide-vanes and a system of bleed valves, operating automatically, are used to ensure stability of the air flow.

53. At low engine speeds the bleed valves are open and the guide vanes are at 40 degrees incidence; at high engine speeds the bleed valves are closed and the guide vanes are at zero incidence, producing a minimum of swirl. The vanes are operated by a progressive hydraulic ram which incorporates its own control mechanism.

54. When the air bleed valves are open, i.e. at the lower engine speeds, they allow some of the air from the middle stages of the compressor to escape to atmosphere so that airflow stability is maintained at the lower velocity without surge.

Air bleed system

55. The air bleed valves are controlled by a unit in which a piston valve directs air at compressor delivery pressure to the top of the bleed valve

pistons to close the valves. When the bleed valves are required to be open, the control unit vents the pistons to atmosphere.

56. The main controlling parts of this unit are a valve operated by a double-acting piston, and a diaphragm-controlled half-ball valve.

57. The piston-operated valve is spring loaded to close the port that supplies compressed air to the bleed valves, the piston being actuated by air admitted through the main half-ball valves.

58. Two diaphragms of unequal area combine to control the main half-ball valve. The space between the two diaphragms is connected to a venturi through which a small flow of twelfth stage air is discharged to atmosphere. As the engine accelerates from idling speed, the air flow in the venturi becomes choked and thereafter the venturi pressure rises rapidly. As the two diaphragms are of unequal area, the venturi pressure exerts a larger force on the larger diaphragm and, at a certain engine speed or compression ratio, opens the main half-ball valve thus directing compressed air to the bleed valves and closing them.

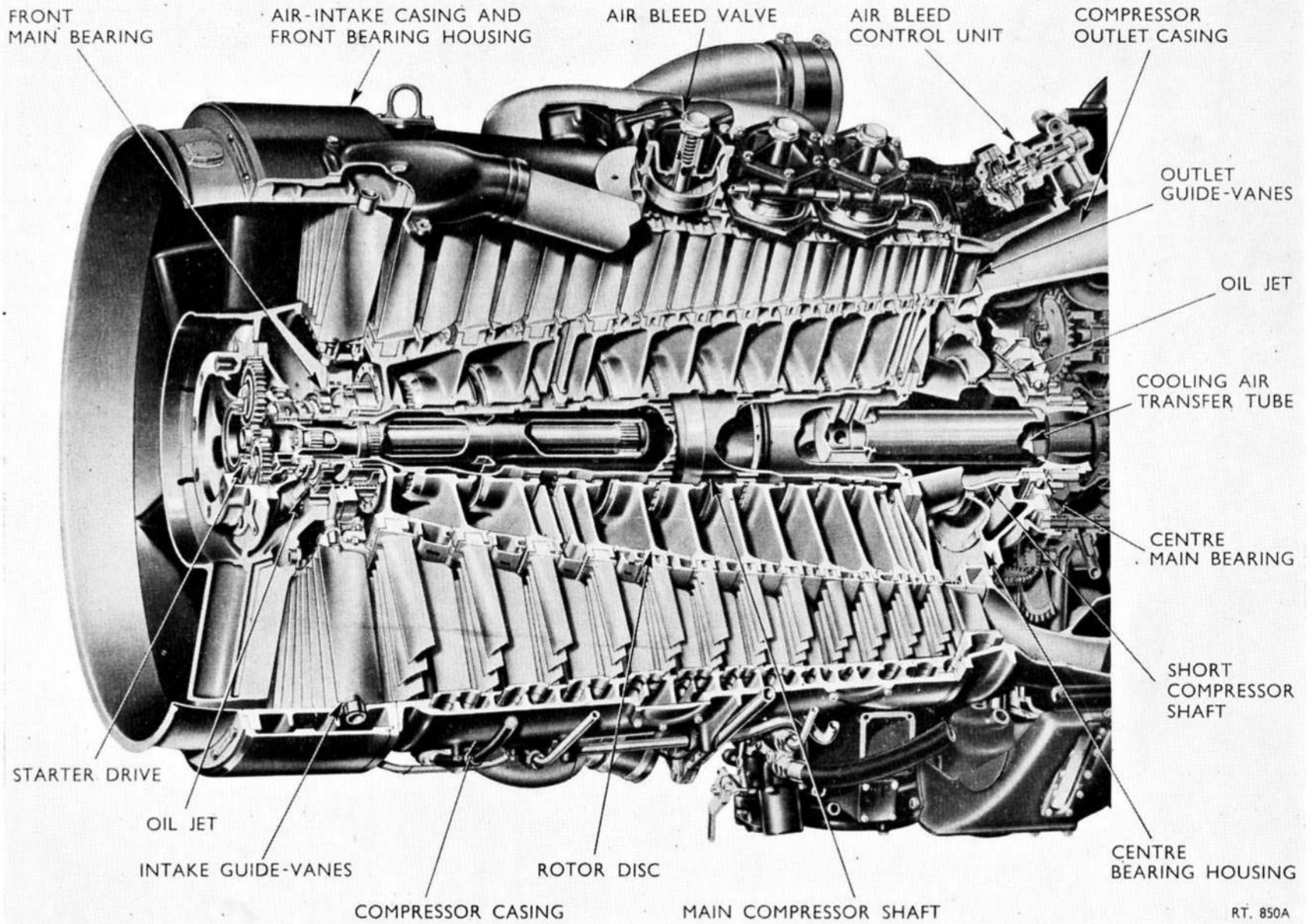
59. The controlling pressure behind the large diaphragm is adjustable and determines the compression ratio or engine speed at which the bleed valves are closed and opened. Air flowing from the twelfth to the seventh stage, through two adjustable restrictors, provides an intermediate pressure which is applied to the diaphragm.

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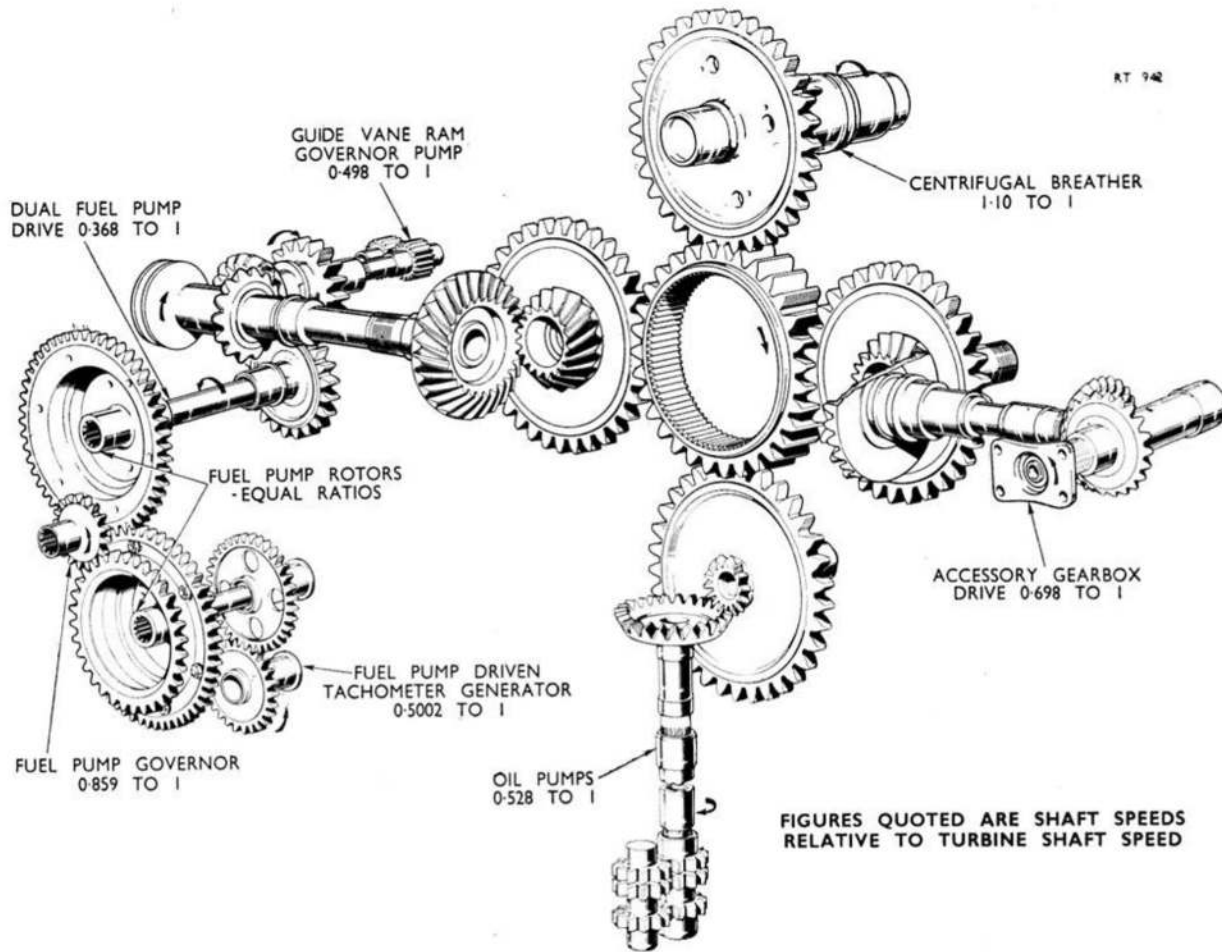
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Fig. 8. Compressor



FIGURES QUOTED ARE SHAFT SPEEDS
RELATIVE TO TURBINE SHAFT SPEED

Fig. 9. Gear train diagram

Intake guide-vane ram

60. The hydraulic ram moves the intake guide-vanes progressively over a range of engine speed. As engine speed increases in this range, the ram piston moves rearward and the angle of incidence of the vanes decreases from 40 degrees to zero.

61. The position of the ram is related to engine speed and a measure of this is obtained in terms of a pressure difference from an engine-driven governor pump circulating fuel through an orifice. A profiled needle in the orifice is mounted on a capsule connected by capillary tubing to a thermometer bulb in the air intake extension ring, so that the pressure difference also depends on the air intake temperature. This temperature compensation makes the ram sensitive to 'corrected r.p.m.' rather than actual engine speed. The needle is adjustable to determine the range of engine speed over which the ram operates.

62. The ram incorporates its own servo system and derives its power from the high pressure pumps in the main fuel system. Both sides of the ram piston are supplied with high pressure fuel, one side direct and the other side via a restrictor. A push-rod attached to the piston operates a half-ball valve through a diaphragm which is subject

to governor pump fuel pressure on one side and to low pressure fuel on the other.

63. With increase in engine r.p.m. and consequent increase in governor speed, the greater pressure difference across the diaphragm deflects the diaphragm in the direction of the ram piston. This movement causes the half-ball valve to open, thus bleeding away fuel from the diaphragm side of the piston and initiating a movement of the piston assembly in the direction of the diaphragm. By this action the inlet guide vanes are moved toward the zero incidence position and the same movement closes the half-ball valve, equalizing piston pressures and, together with a spring, stabilizing the vanes in the new angular position to suit the higher engine speed.

64. Movement is limited in both directions by internal stops in the ram, and the connecting-rod incorporates a spring-loaded coupling to avoid imposing excessive stress on the master vanes.

COMBUSTION CHAMBERS

65. In each combustion chamber there is a burner which emits a finely atomized spray of fuel. A flame tube stabilizes the flame, regulates the flow of the outer layer of cooler air, and protects the outer air casing from the direct heat of the flame.

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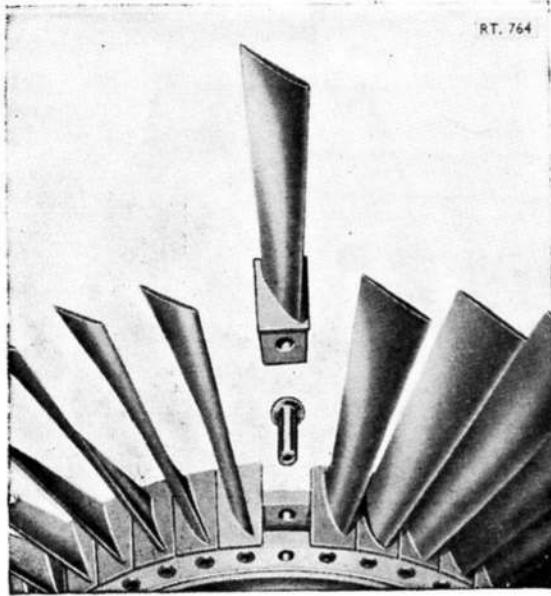


Fig. 10. Compressor blade attachment

66. To ensure stability and completeness of combustion, the fuel spray is in the form of a hollow wide-angle cone burning in the primary zone of the flame tube where the air flow is comparatively slow. To assist atomization of the fuel and to combat the formation of carbon a flow of air is directed across the face of the burner from passages in the burner head.

67. Approximately 15 per cent of the air entering each combustion chamber flows through the primary air scoop and passes through perforated and corrugated baffles which slow down and even-up the air flow, and through swirl vanes which produce a vortex in the primary zone. The depression near the burner head due to the vortex causes a reverse flow in the centre of the chamber, which assists the stabilization of combustion by mixing the fuel and air and helps to reduce the overall length of the flame.

68. The air which passes outside the primary air scoop cools the flame tube and is admitted progressively through corrugations at the welded joints and through the secondary and tertiary holes. Some of the secondary air takes part in combustion, but the fuel needs only approximately 25 per cent of the total air flow for complete combustion. The remain-

ing air is heated by mixing with the products of combustion. Thus the heat energy of the fuel is distributed throughout all the gas, and the temperature falls from a maximum of 2,000 deg. C in the flame itself to approximately 850 deg. C. at the inlet to the high pressure turbine when the engine is running at full speed.

69. Adjacent combustion chambers have their flame tubes and air casings interconnected by tubes to allow the flame to spread when starting.

70. The combustion chambers expand more than the intermediate casing, and, to allow for this, the discharge end is able to slide in the nozzle box, gas leakage being prevented by a piston-ring type seal. The interconnector tubes also have sliding joints or bellows to allow for expansion.

71. To allow for both axial and radial expansion, one end of each flame tube is loosely spigoted on to the burner housing and the discharge end has a number of raised pads which are free to slide in the air casing. The flame tube is positioned axially and further supported by the two interconnectors and by a locating piece.

72. The joint rings between the expansion chambers and the compressor outlet casing have spherical seatings to ensure an air-tight seal while allowing for a wide tolerance on alignment.

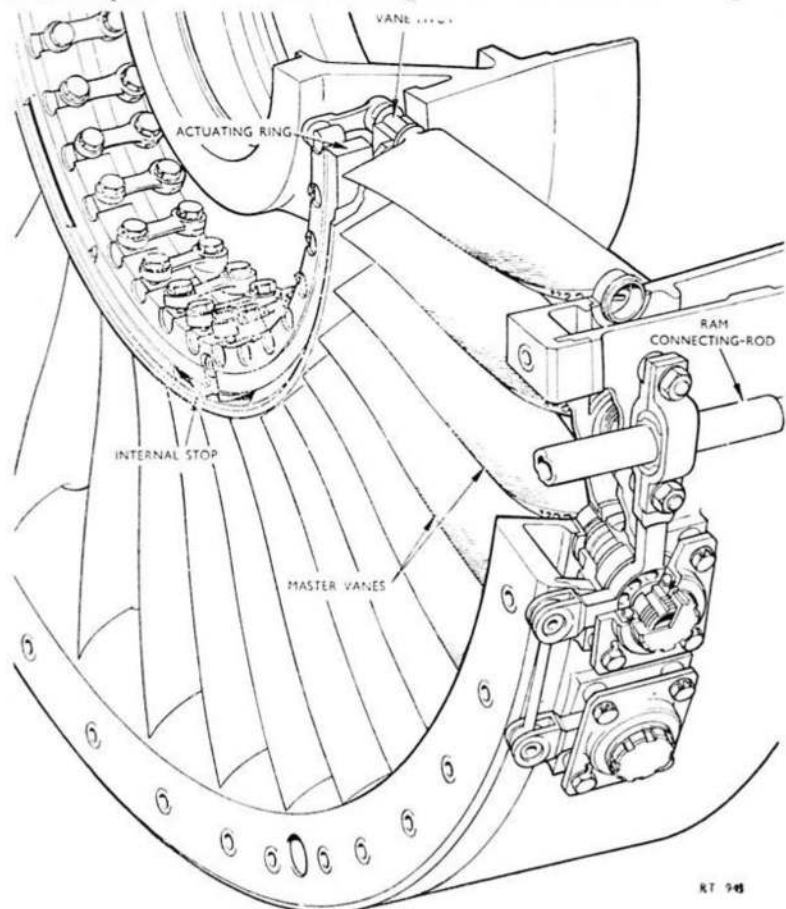


Fig. 11. Intake guide-vanes

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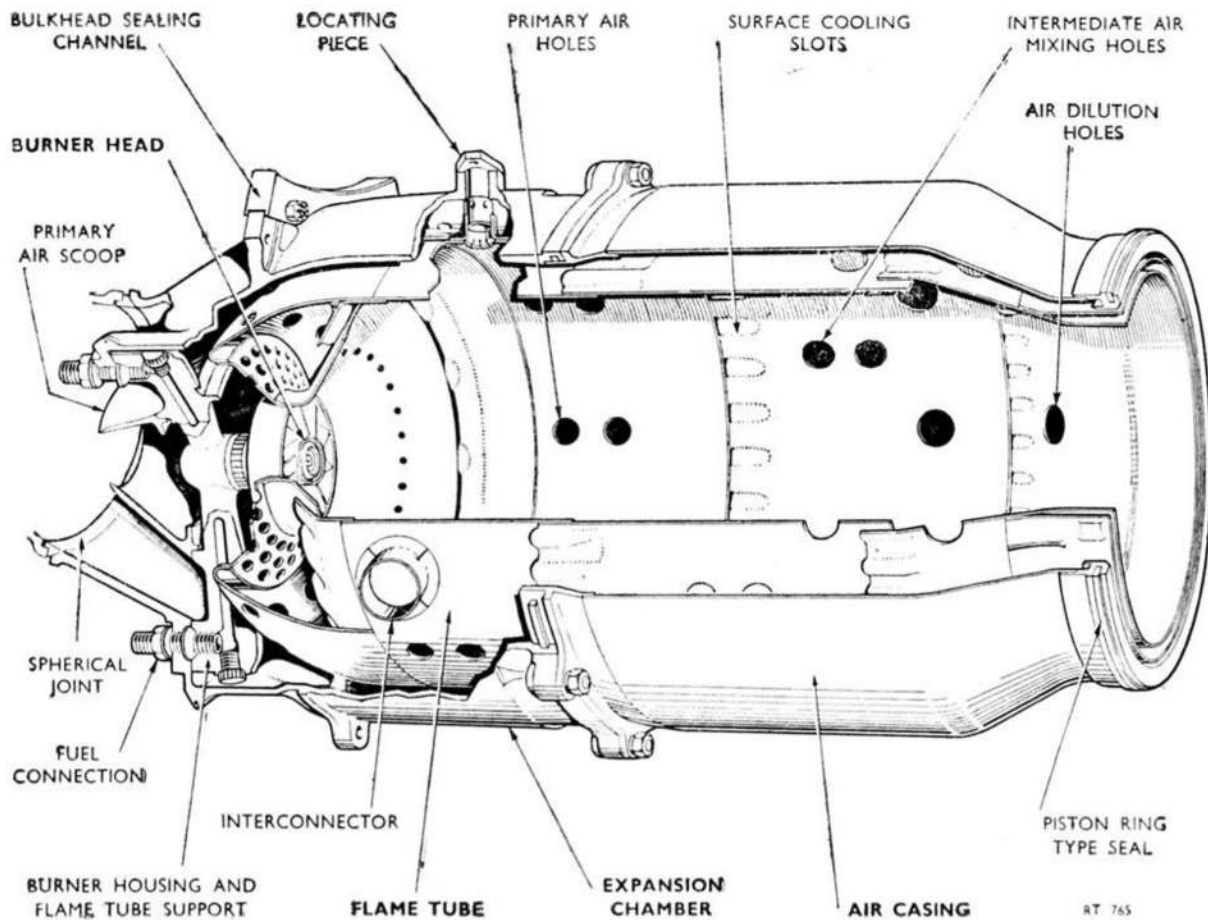


Fig. 12. Combustion chamber

TURBINE AND NOZZLE BOX

73. A two-stage turbine is used to extract sufficient power from the gas stream to drive the compressor and the auxiliaries. Compared with a single stage turbine of similar output, the two-stage turbine is smaller in diameter and more efficient, and under the lower centrifugal forces the discs and the blades are less highly stressed.

74. The two turbine wheels are mounted on one shaft and are housed with the nozzle guide vanes inside the nozzle box.

75. The turbine shaft runs in a roller bearing supported in the nozzle box frame. To allow for uneven expansion, the webs in the bearing are tangential rather than radial. The rear main bearing is cooled both internally and externally by air from the third stage of the compressor, the air being drawn between the bearing sleeve and the turbine shaft by oblique slots and radial passages in the latter.

76. The high pressure turbine disc is secured to the shaft by taper bolts which also retain the bearing sleeve.

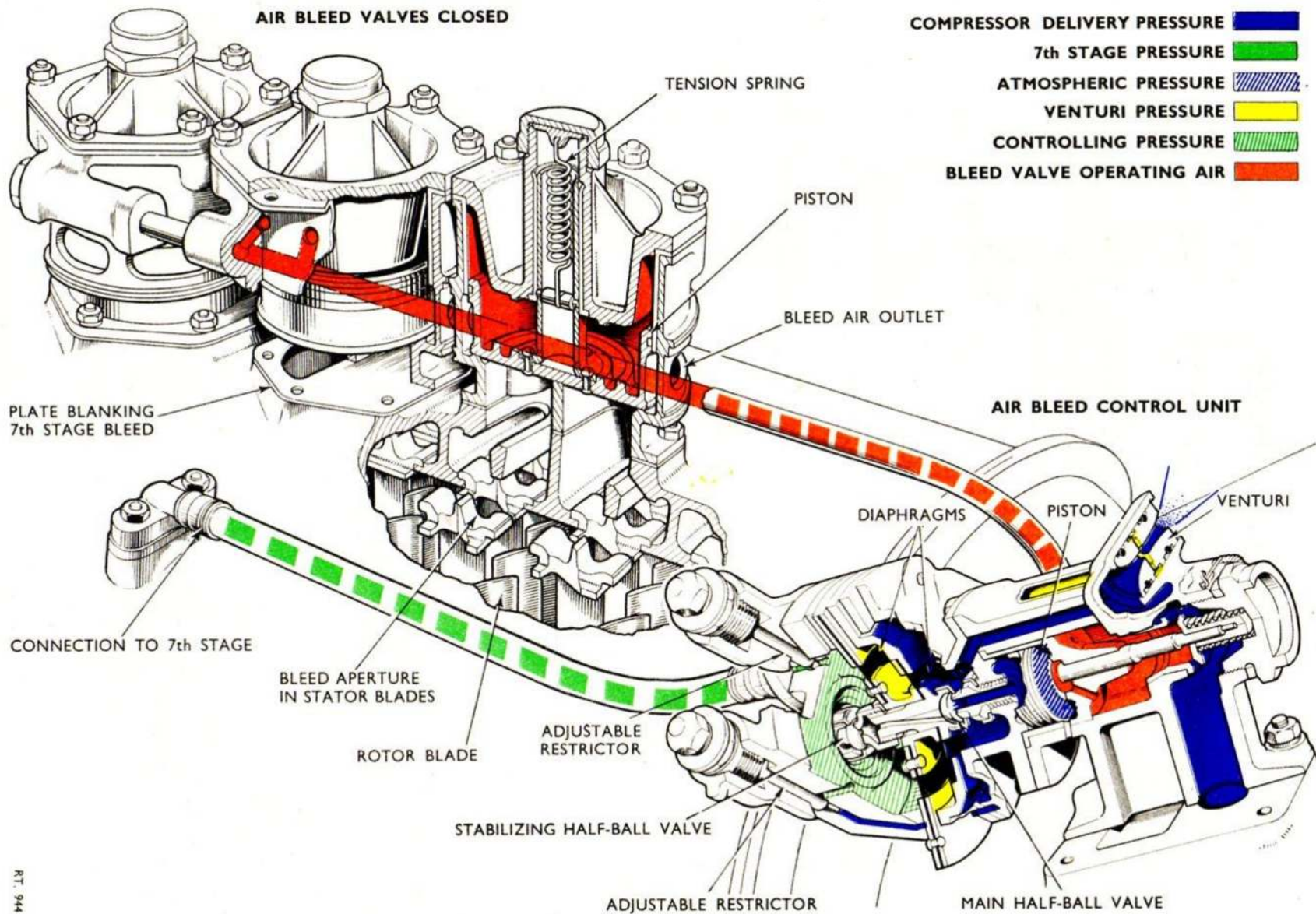
77. The low pressure turbine disc is secured by a hollow bolt and nut, with a locking plate through which a restricted flow of cooling air passes to the rear face. The driving torque is transmitted to the high pressure disc through dogs; these form part of the inter-stage labyrinth gas seals, and spaces between the dogs allow cooling air to flow outwards through the labyrinths to the main gas stream.

78. The inner frame of the nozzle box is a star-shaped casting or spider, the arms of which, together with brackets bolted to the inner cone of the spider, support the outer casing and also convey third stage cooling air to the outlet manifold. Between each pair of arms is a nozzle, mounted on the front panel and seating on the platform of the high pressure nozzle guide-vanes.

79. The high pressure nozzle guide-vanes are mounted between slotted flanges in the outer casing and an inner ring, each vane having tongues which engages with the slots to provide circumferential location. The outer ends are positioned axially by segments which shroud the high pressure turbine wheel, and the inner ends by a ring which

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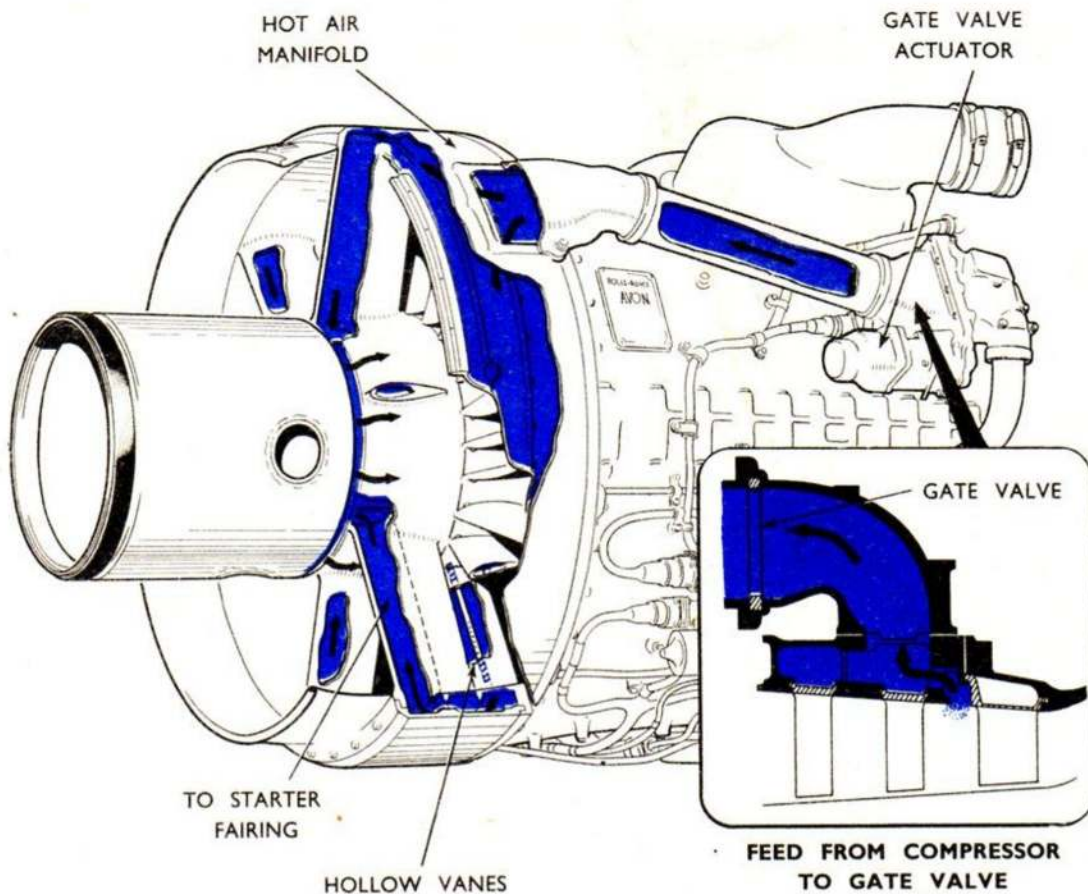
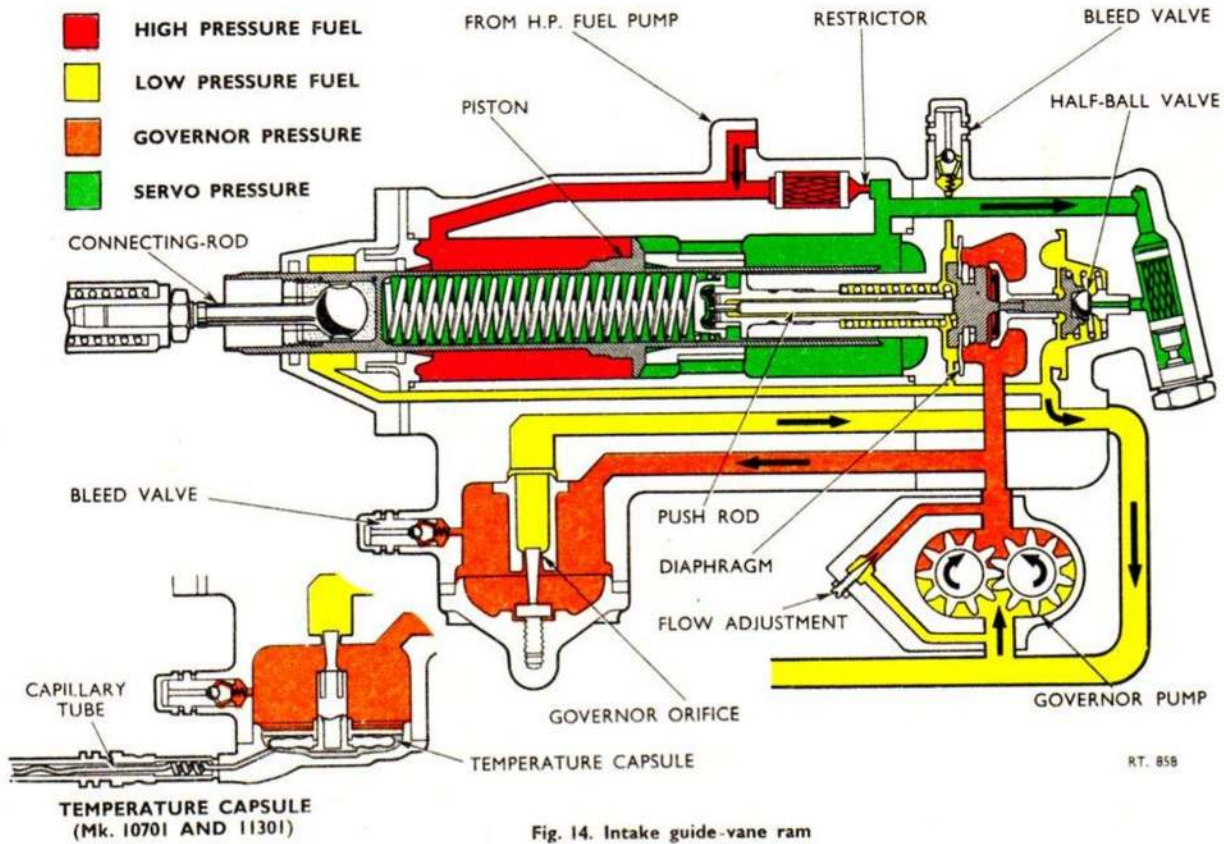


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Fig. 13 Air bleed system

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forms a labyrinth seal with the turbine wheel. The seal ring is bolted to the guide vane support ring together with a baffle plate which directs the high pressure cooling air on to the turbine disc.

80. The low pressure nozzle guide-vanes are supported in a similar manner at the outer ends, and the inner ends are joined by a ring which carries the inter-stage self-clearing labyrinth seals and a ring which forms a labyrinth seal with the low pressure turbine wheel. The support ring also carries baffle plates which ensure that the intermediate cooling air flows close to both turbine discs.

81. The root of each turbine blade is of 'fir tree' shape, and fits into a corresponding 'fir tree' slot broached in the turbine disc. The gaps between the blade roots are covered by blanking plates which also retain the blades in position. Each blade has a platform at the outer end, and these combine to form a complete rotating shroud ring for each wheel. For additional stiffness to resist vibration the platforms are welded together in pairs and threes.

82. The guide-vanes and the turbine blades are free in their slots when cold to allow for expansion at the operating temperatures. The turbine blades also obtain extra rigidity from centrifugal loading when the wheel is rotating.

83. As the main casings of the engine expand more than the turbine shaft, both turbine wheels

move towards their respective nozzle guide-vanes and reduce the labyrinth seal clearances to the optimum value at working temperature. The thermal and centrifugal expansion of the turbine wheels brings the blades into the most efficient position in which a minimum of gas by-passes them.

EXHAUST UNIT

84. The exhaust unit is of welded sheet steel construction, and layers of metal foil provide a degree of thermal insulation, the foil being retained in position by an outer casing.

85. The exhaust unit consists of an outer tube and an inner cone which is supported on bars clamped together in pairs at the centre to ensure concentricity. The bars pass through fairings which are a loose fit between the outer tube and the inner cone to allow for expansion.

86. To prevent buckling due to excessive pressure differences, vent holes are cut in the tie bar fairings, in the apex of the inner cone, and in the plates at the front of the cone.

87. The exhaust unit rear flange is shaped to accommodate the jet pipe keep plate and is fitted with a piston ring type seal.

88. A pressure tapping point, connected to the reheat control unit, is located in the exhaust unit rear section.

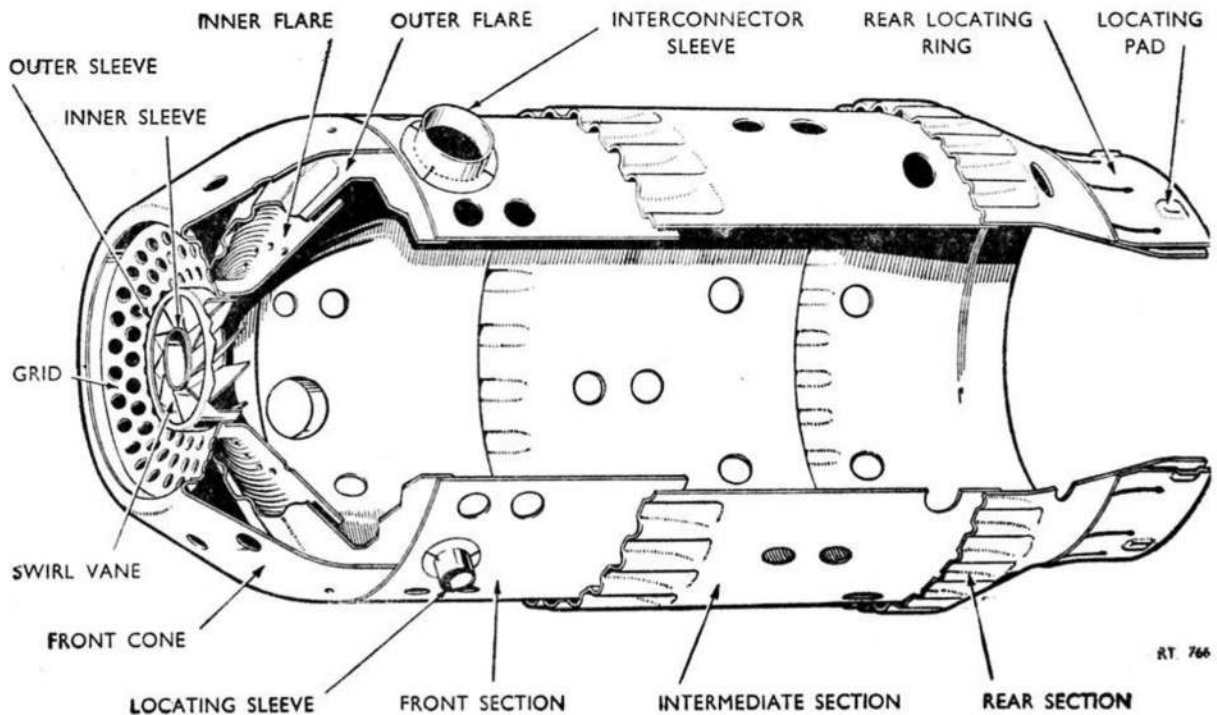


Fig. 16. Flame tube

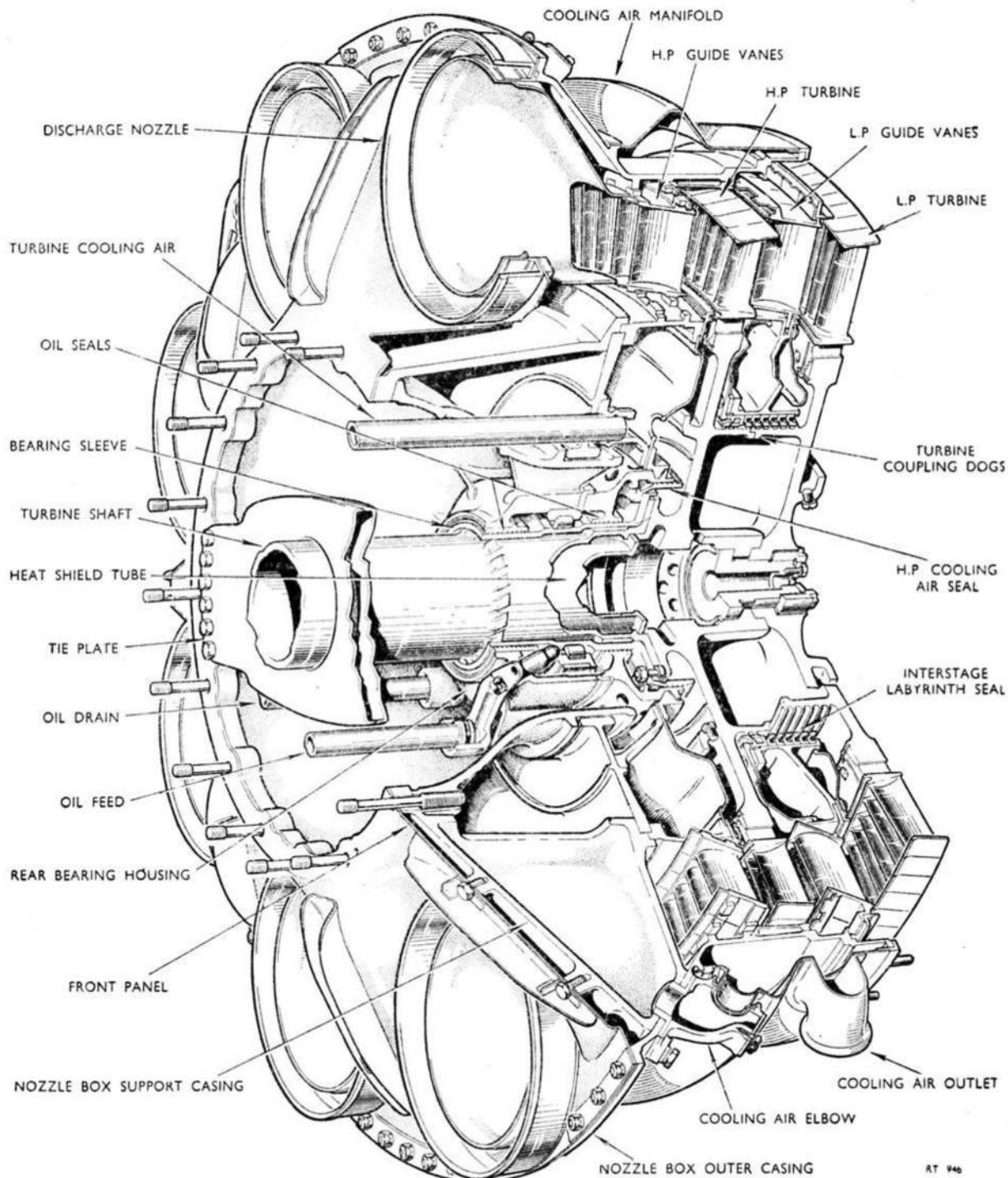


Fig. 17. Turbine and nozzle box

CONTROLS AND INSTRUMENTS

89. There are only two manual controls on the engine; the throttle lever for control of engine speed and thrust, and the high pressure cock lever for stopping the engine.

90. The only instruments needed for control of the engine are those which indicate engine speed and jet pipe temperature. For the former a tachometer generator is mounted on the external wheel-case and driven at half engine speed, and to indicate temperature there are thermocouples mounted in the jet pipe.

91. Engine oil pressure is measured by a transmitter mounted on the oil sump.

92. To provide a warning whenever the high pressure fuel pump is not receiving an adequate

meter generator is mounted on the external wheel-case and driven at half engine speed, and to indicate temperature there are thermocouples mounted in the jet pipe.

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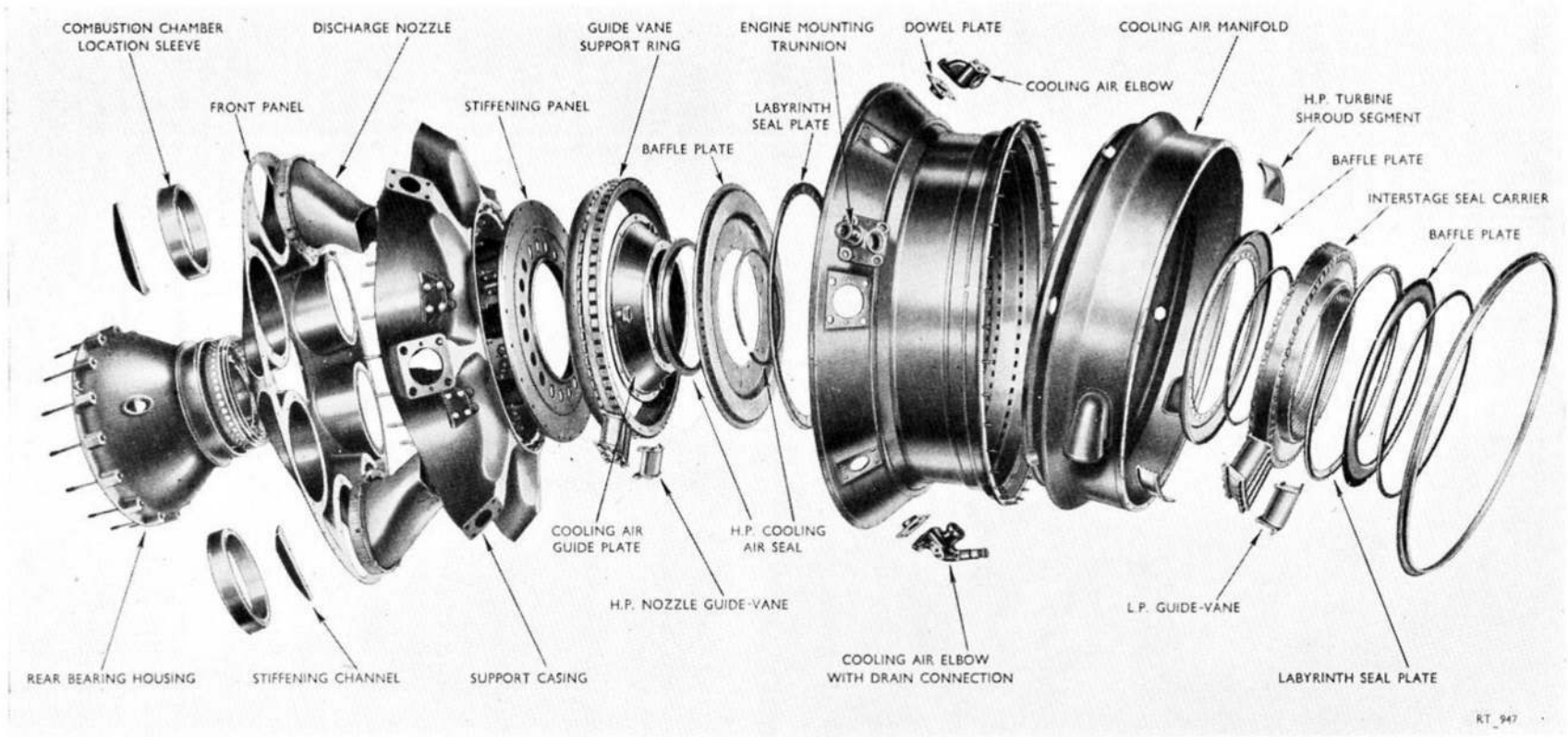


Fig. 18. Nozzle box components

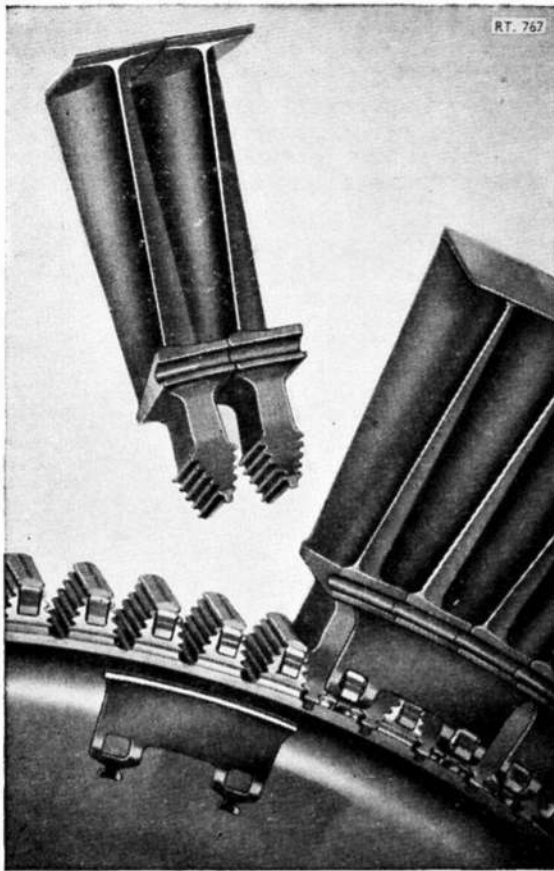


Fig. 19. Turbine blade attachment

fuel supply, a pressure-operated switch is connected to the outlet of the low pressure filter.

93. An instrument to indicate the maximum positions of the reheat eyelids is also provided.

ELECTRICAL SERVICES

94. The normal 24-volt supply is used to fire cartridges in the turbo-starter, to actuate the anti-icing air gate-valve, to operate the fuel pump isolating valve solenoid, and to feed the starter panel and the units which produce the high voltage for the igniter plugs.

95. The electrical harness provides one connection point which serves the turbo-starter, the oil pressure transmitter, the isolating valve solenoid, the tachometer generator and the fuel pressure warning switch, and another connection point which serves the anti-icing system and reheat fuel control unit.

STARTING SYSTEM

96. For ground starting the engine, a turbo-starter is fitted to accelerate the engine to a self-sustaining speed and an ignition system to initiate combustion; these are both controlled by

an automatic starter panel mounted in the airframe and incorporating a time switch and relays to energise the circuits for suitable periods. For relighting in flight, the ignition system is separately energized.

97. The starter motor is housed inside the air-intake fairing and is described in A.P.1181, Vol. I.

98. The turbine in the starter drives the engine through a two-stage reduction gear and a spring drive shaft, but for convenience of assembly the starter as a unit incorporates only the first stage gears and the sun gear of the second stage; the planet gears, the stationary annulus gear and the engagement mechanism are regarded as part of the engine.

99. In the engagement mechanism, the pawls are spring loaded towards the driving position, but above a certain engine speed are disengaged by centrifugal force.

100. Igniter plugs are fitted in No. 3 and 6 combustion chambers, and the flames from these spread rapidly round the engine through the interconnectors between the flame tubes.

ANTI-ICING SYSTEM

101. To combat the formation of ice in the air-intake, the critical surfaces can be heated whenever icing conditions are anticipated. Air is drawn from the delivery end of the compressor, having been heated in its passage through the compressor, and is fed to a jacket surrounding the air-intake casing. The hot air then flows through the intake support struts and the hollow guide vanes, finally escaping to the main air stream passing through the engine.

102. The flow of hot air is controlled by a gate valve actuated by a reversible motor driving through reduction gears. The limit switches can be connected to a gate valve position indicator in the cockpit.

FIRE PRECAUTIONS

Separation into zones

103. A fireproof bulkhead divides the engine bay into a hot zone, which includes the combustion chambers and the rear end of the engine, and a cooler zone at the front in which the main fuel units and external oil pipes are located.

104. All apertures in the bulkhead are sealed, and there is a flow of air through both zones to maintain a safe air temperature around the engine and to carry away any fuel vapour.

Fire detector system

105. Temperature sensitive switches are placed at strategic points around the engine to give warning in the cockpit of any outbreak of fire.

Fire extinguisher system

106. To distribute fire extinguishing fluid, pipes

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drilled to spray forward and rearward are fitted round the nozzle box and round the compressor and the fuel system units.

Disposal of unburnt fuel

107. Unburnt fuel may be present in the combustion chambers and parts of the nozzle box if the engine has failed to light up. In addition, a small quantity of fuel may emerge from the lower burners while the engine is stationary.

108. To dispose of this fuel, the combustion chambers have drain pipes which convey fuel down to the lowest chambers and out through a drain valve mounted on the nozzle box.

109. The drain valve is open when the engine is

at rest, and is closed by the gas pressure from the combustion chambers when the engine is running.

110. Fuel may also become deposited in the nozzle box or may drain down into it from the upper combustion chambers. Fuel draining forward to the lowest point between the outer casing and the front panel is conveyed by drillings to the drain valve. Fuel draining rearwards enters the low pressure cooling air casing and is drained away through the exhaust unit drain or the fuel collector ring surrounding the jet pipe attachment joint. As this fuel from the rear of the turbine is only subject to jet pipe pressure, it is not necessary to seal the passage with a drain valve when the engine is running.

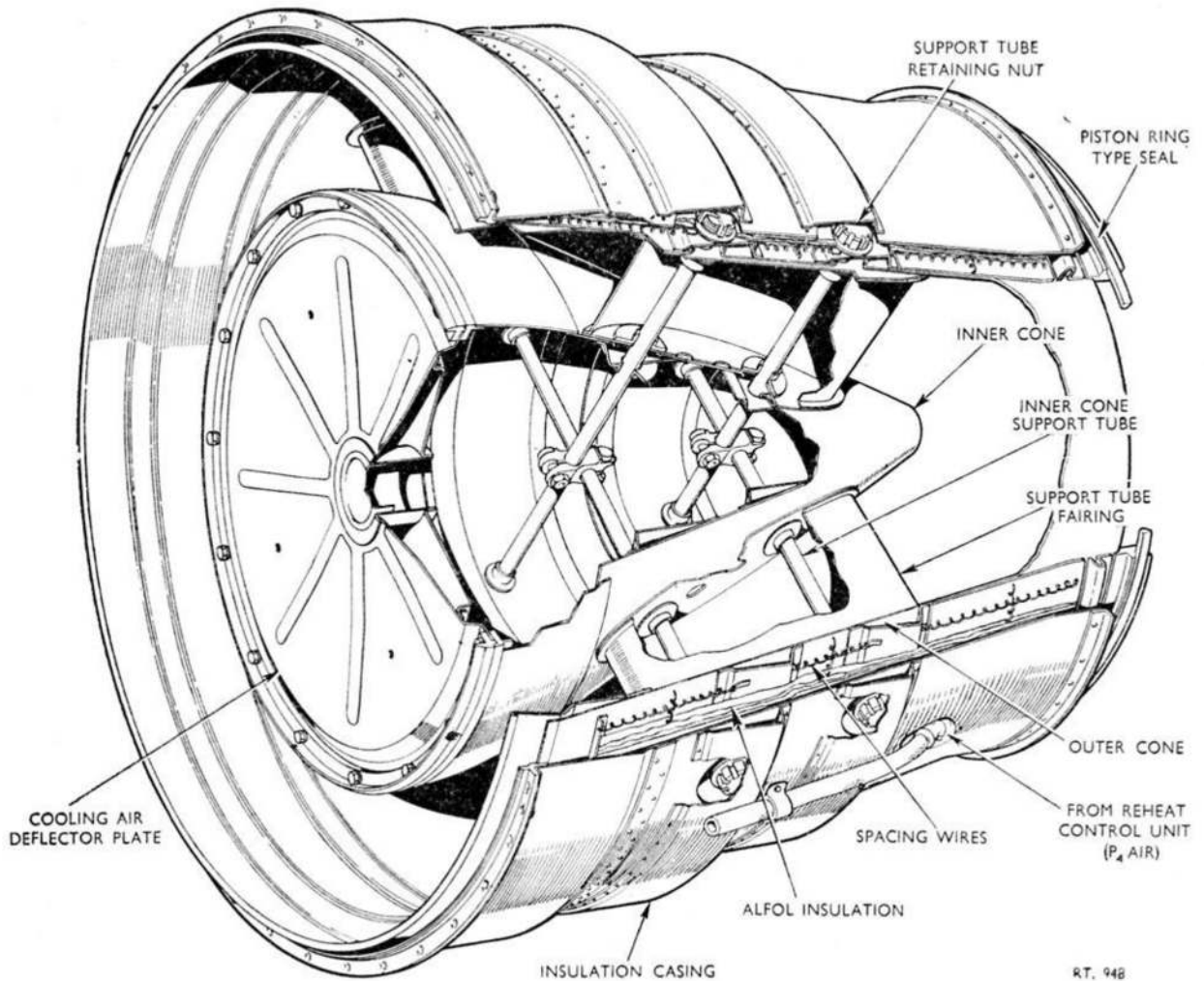
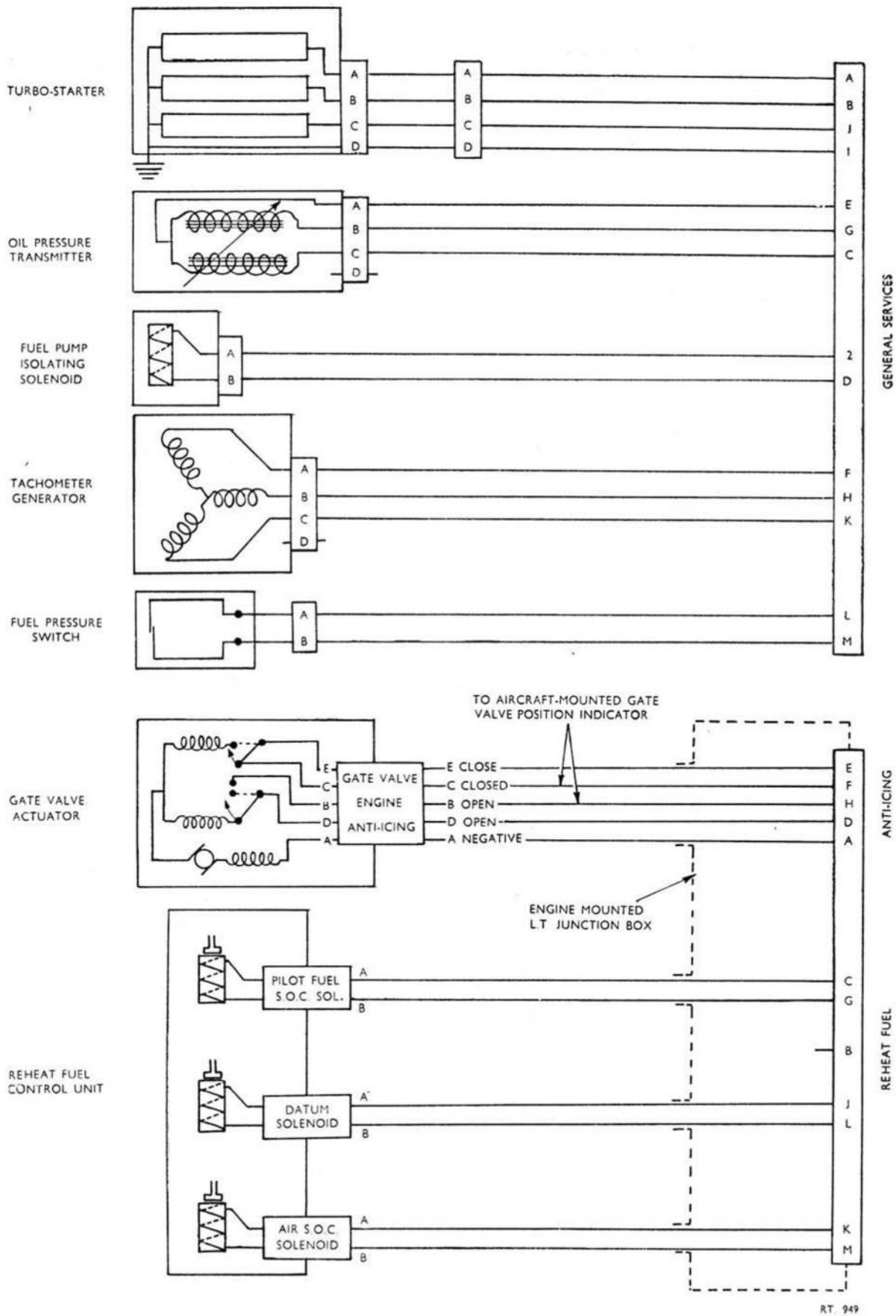


Fig. 20. Exhaust unit



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Fig. 21. L.T. harness diagram

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Chapter 2

FUEL SYSTEM

Note.—This chapter applies to Avon Mk. 10801 and 11401 Engine Change Units

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INTRODUCTION

1. Since the amount of fuel consumed determines the speed and, therefore, the thrust of the engine, the fuel system is required to supply to the burners a metered flow of fuel which will be appropriate under all conditions of altitude and forward speed.
2. Engine control is by a single lever operating the throttle valve, with an additional lever connected to the high pressure cock for stopping the engine.
3. The low pressure fuel supply from the pumps in the aircraft tanks enters a dual high pressure pump through a filter. The pump delivers the fuel to the burners through metering valves, the oil cooler, the throttle valve, the high pressure cock, and a pressurizing valve which apportions the flow between the burner orifices.
4. The fuel delivery of the high pressure pump is varied by a servo system in which the controlling pressure is affected by a barometric pressure control, a maximum speed governor and an acceleration control unit working in conjunction with the metering valve unit.
5. Fuel for the reheat pilot burner and servo system of the reheat control unit is supplied by the engine H.P. pump, the servo fuel being returned to the inlet side of the pump. The reheat fuel system is described in Chapter 5.

BURNERS

6. The burners inject a spray of fuel into the combustion chambers and produce sufficient atomization to ensure stabilization of the flame. The atomized spray is emitted from a swirl chamber

which narrows towards its outlet, causing the swirl of the fuel to speed up rapidly to a maximum in the outlet orifice. The range of fuel flow for which the burner is suitable is limited at the upper end by the pressure required to produce the flow, and at the lower end by the minimum pressure and flow which will ensure sufficient atomization.

7. As the range of fuel flow from low power at high altitudes to full power at ground level is greater than one size of burner orifice can satisfactorily deliver, two orifices with independent swirl chambers are used in each burner. The main orifice is large enough to pass the maximum flow, but is not used when the flow is small. The much smaller primary orifice, emitting a separate spray through the centre of the main orifice, produces atomization at the minimum flow required, but could not pass the maximum flow within the pressure limitations of the other units of the fuel system.

PRESSURIZING VALVE

8. The pressurizing valve is a spring-loaded plunger which controls the flow to the main burner manifold. The flow to the primary burner manifold is uninterrupted, and it is the primary burner pressure which determines the position of the plunger in the metering orifice.
9. When the flow of fuel is small, the primary burner fuel pressure is less than the minimum required to lift the valve off its seat, so that all the fuel passes through the primary burner orifices. As the fuel flow increases, the primary burner pressure rises, and eventually part of the flow is diverted to the main burner orifices which then carry on increasing proportion of the total flow.

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The main pressure is always less than the primary, but when the pressurizing valve is open the primary pressure does not rise so rapidly with increases in total flow as when the valve is closed.

HIGH PRESSURE FUEL PUMP

10. In the dual high pressure pump, each rotor has seven spring-loaded plungers bearing on a cam plate which can be tilted by a servo piston to vary the stroke. The pump has a positive displacement, i.e., for a given stroke each plunger delivers a definite quantity of fuel.

11. Both pump rotors are interconnected by spur gears which also drive a third shaft carrying a hollow rotor. Centrifugal pressure from this rotor operates a maximum speed governor which controls both pumping mechanisms.

THROTTLE VALVE

12. The throttle valve is a rack-operated profiled plunger working in a fixed orifice. For lightness of operation, fuel passes up the centre of the hollow plunger to equalize the pressure acting on the ends.

13. A small adjustable orifice allows fuel to bypass the main metering orifice of the throttle valve. This by-pass adjustment is used during calibration and may be reset in service to alter the idling speed. As the by-pass flow is small, and only significant when the total flow is small, the by-pass adjustment will only affect the throttle calibration at the slow running end.

SERVO CONTROL OF PUMP DELIVERY

14. The total fuel flow from the dual pump is determined by the speed of the pump and the stroke of the plungers. If the outlet of the pump was connected direct to the pressurizing valve, the pump delivery pressure would be equal to the primary burner pressure and would vary with the fuel flow; in practice, the throttle valve is interposed between the pump and the pressurizing valve, and the pressure drop through the throttle valve accounts for the difference between the primary burner pressure and the throttle inlet pressure as stabilized by the servo system. The metering valve unit is also inserted in the pump delivery line, but this is only to transmit to the acceleration control unit a measure of the fuel flow.

15. The throttle valve is a manually operated, variable restriction, in the flow of fuel, and the servo system automatically adjusts the delivery flow of the pump so that the throttle inlet pressure is stabilized at a predetermined value. Thus on opening of the throttle valve, the burner pressures rise and more fuel is allowed to flow to the engine.

16. The servo system, as well as adjusting the pump stroke in response to throttle manipulation, provides overriding control to compensate for changes in altitude and forward speed, to limit the engine speed, and to limit the fuel/air ratio during acceleration.

17. In each pumping mechanism the servo piston is spring-loaded towards the full stroke position. The side of the piston remote from the spring is subject to the full delivery pressure of the pump, while the other side is subject to the controlling servo pressure, thus an increase in servo pressure causes an increase in pump stroke.

18. The two pumping mechanisms are interconnected so that they have a common delivery pressure and, unless the isolating valve is closed, they have a common servo pressure and equal plunger stroke.

19. The servo pressure is obtained by feeding fuel from the pump delivery through fixed restrictors into the servo system, and allowing the fuel to escape through various bleeds by which the servo pressure is controlled. To ensure good cut-off and an accurate and rapid response, each controlled bleed has an orifice sealed by the flat surface of a self-aligning half-ball. There is one half-ball valve in the barometric pressure control, one in the acceleration control unit and two in the maximum speed governor.

20. As the dual fuel pump is of the positive-displacement type, it is possible for the throttle valve to control the flow of fuel only if each adjustment of the throttle is accompanied by a corresponding change in pump stroke. The main control of pump stroke is vested in the barometric pressure control (B.P.C.) which varies the pressure in the servo system to maintain a constant throttle inlet pressure, irrespective of the degree of throttle opening.

BAROMETRIC PRESSURE CONTROL

21. In the barometric pressure control a half-ball valve is normally slightly open when the engine is running at a steady speed. A spring tending to close the valve is opposed by throttle inlet pressure. If the throttle inlet pressure rises for any reason, e.g. excessive pump stroke or closure of the throttle, this causes the half-ball valve to open slightly more, bleeding more fuel from the servo system and reducing the servo pressure. The servo pistons then decrease the stroke of the plungers until the throttle inlet pressure is reduced to the original value and equilibrium is restored in the B.P.C.

22. An evacuated capsule in the B.P.C., sensitive to intake air pressure, also varies the bleed through the half-ball valve, thus, under changes of altitude and forward speed the throttle inlet pressure and, therefore, the fuel flow, is automatically decreased or increased to minimize the need for re-setting the throttle.

ACCELERATION CONTROL

23. Acceleration is achieved by opening the throttle valve, thus supplying more fuel, and the engine speed increases until the air flow again matches the fuel flow. Opening the throttle valve causes the throttle inlet pressure to fall and, to restore this, the pump stroke is increased by the servo system. The resultant increase in the fuel/air ratio produces higher temperatures throughout the turbine and the jet pipe, and stabilization after a

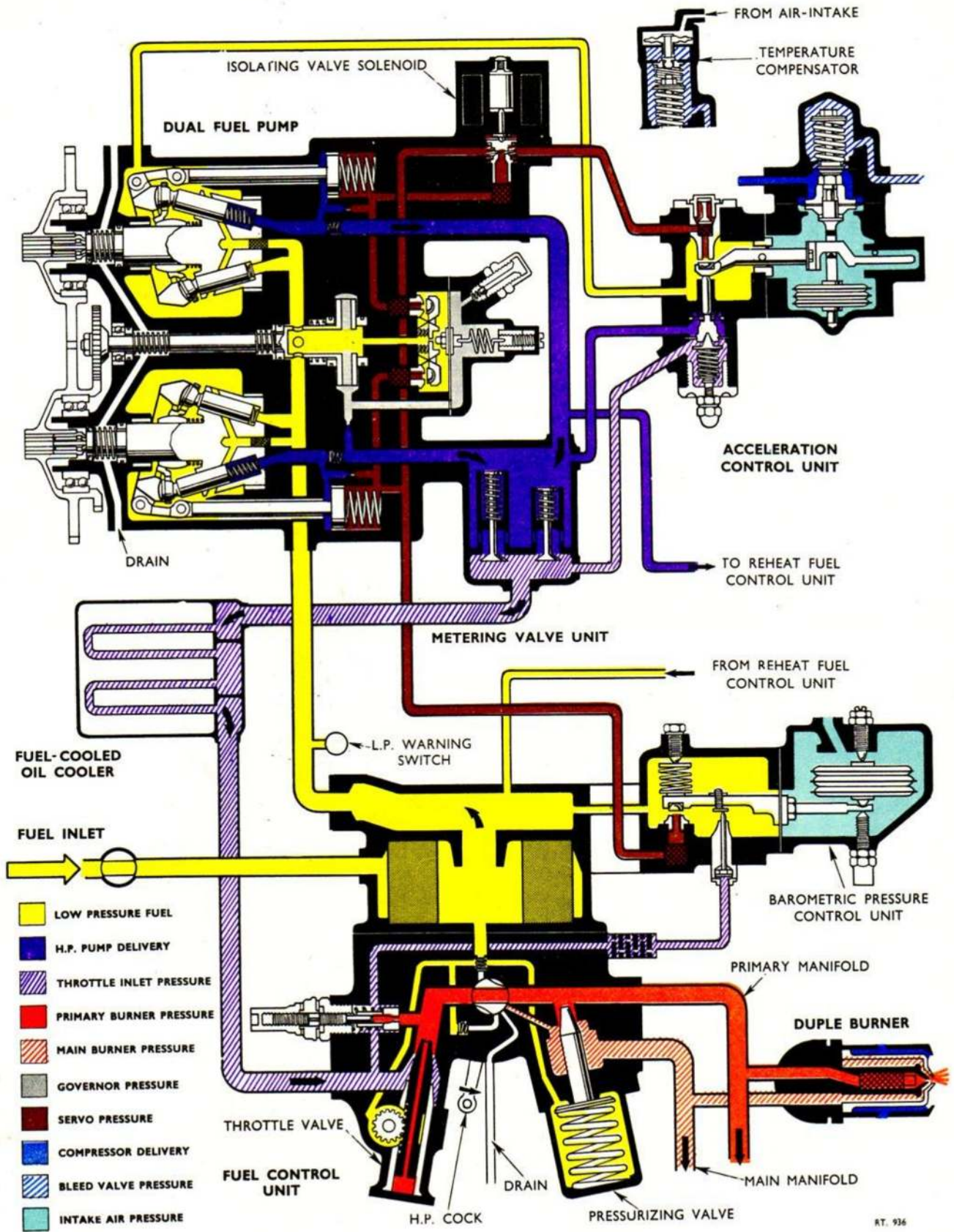
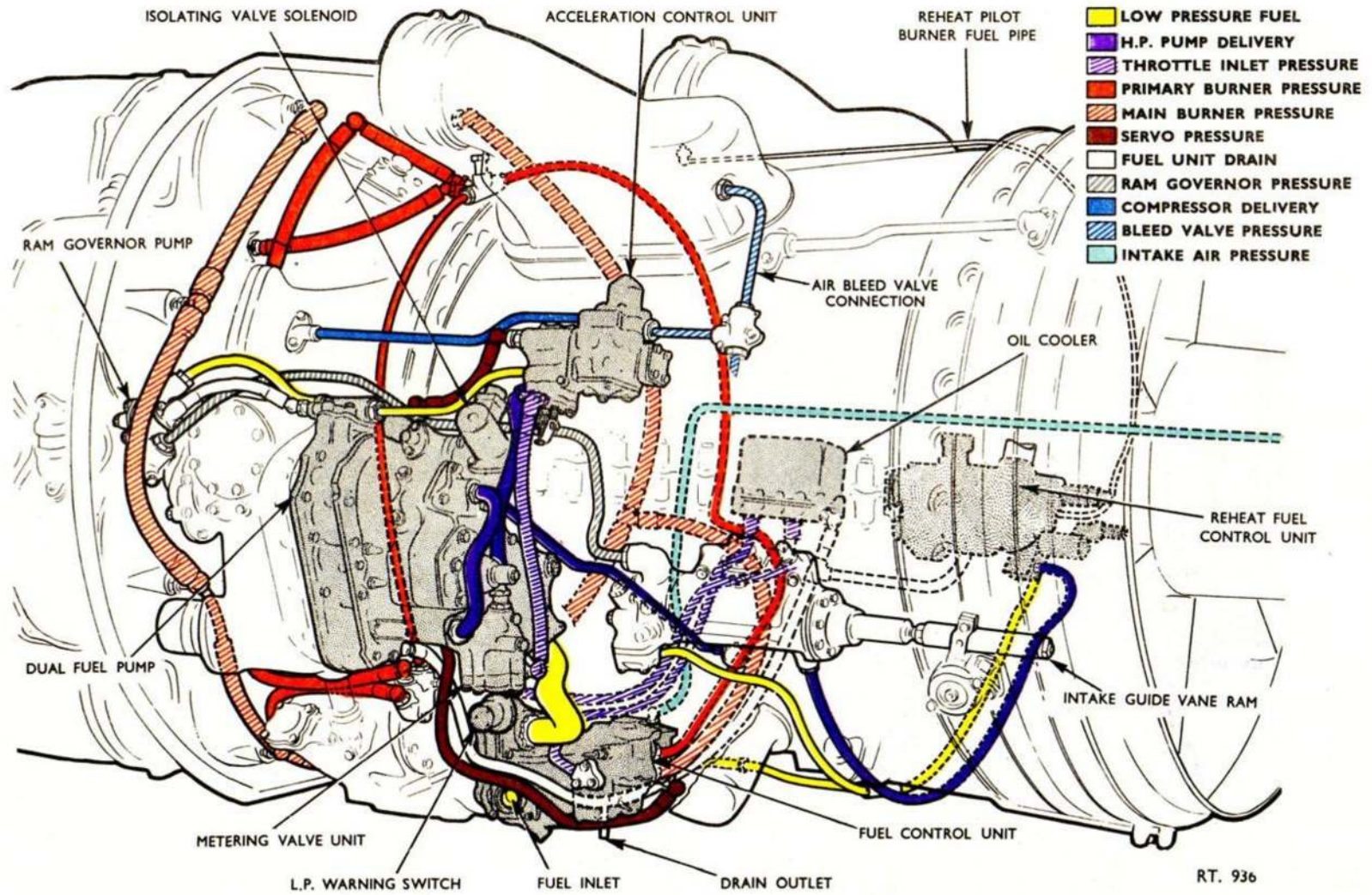


FIG. 1. Fuel system diagram

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FIG. 2. Fuel system pipes and units

rapid acceleration is accompanied by a decrease in pump stroke and a reduction in temperature as the fuel/air ratio assumes the new steady value.

24. A substantial change of engine speed requires an appreciable time, since the main rotating parts have considerable inertia, and it would be possible for the fuel system, without the acceleration control unit, to increase the fuel supply so rapidly as to cause excessive jet pipe temperature and engine surge. The acceleration control unit (A.C.U.) prevents this by limiting the fuel flow in relation to the air flow so that a safe fuel/air ratio is not exceeded. This maximum value of the fuel/air ratio permitted by the A.C.U. varies with the air flow to suit the engine characteristics, and is always greater than the fuel/air ratio for steady running at the corresponding engine running conditions.

25. The acceleration control unit does not affect the flow of fuel while the engine is running steadily or slowly accelerating, but during rapid acceleration the unit bleeds away servo fuel through a half-ball valve to reduce the servo pressure and the pump stroke and limit the fuel/air ratio to the maximum value acceptable.

26. The acceleration control unit is sensitive to compressor delivery pressure as a measure of the air flow through the engine, and to the pressure difference across the metering valve unit as a measure of the fuel flow. These pressures are applied to diaphragms in opposition—the air pressure tending to close the half-ball valve and the fuel pressure tending to open it—and the main spring holds the valve closed unless the fuel flow exceeds the critical value for the air flow.

27. As the calibration of the acceleration control unit must follow the limiting value of the fuel/air ratio as closely as possible, without allowing the engine to surge and without limiting the engine speed below governed r.p.m., the two following additional features are incorporated, one in the acceleration control unit and one in the metering valve unit.

28. When the compressor air bleed valves are closed, the twelfth stage air pressure supplied to close them is also fed to the acceleration control unit so that it acts on a small diaphragm linked to the main air diaphragm. This is equivalent to a change in the effective area over which the compressor delivery pressure operates, so that the balance between air and fuel is modified to correspond more closely to the maximum safe fuel/air ratio.

29. The metering valve unit has two orifices through which the entire pump delivery passes to the throttle valve. The spring-loaded metering valve itself is situated in one orifice and the by-pass valve is in the other so that they are progressively opened by the fuel flow. The only purpose of the unit is to provide for the acceleration control unit a measure of the fuel flow in terms of a

pressure difference. As a greater excess of fuel for acceleration is acceptable when the combustion chamber pressure exceeds a certain value, the second valve known as the by-pass valve is incorporated in the metering valve unit. This valve is closed at lower values of the fuel flow but then opens progressively so that the pressure difference transmitted to the A.C.U. rises more slowly in proportion to further increase in fuel flow.

30. The rate of acceleration as controlled by the A.C.U. is affected as follows:—

(1) *The body temperature of the A.C.U.* To stabilize the acceleration time, a heat insulating plate is fitted between the A.C.U. and the compressor casing, so that the temperature of the compressor casing is not transmitted direct to the A.C.U. The amount of differential expansion is further reduced by the use of materials of similar expansion.

(2) *The temperature of the fuel passing through the metering valve.* When the fuel is hot, the pressure difference across the metering valve is above normal for the same fuel flow. The A.C.U. therefore limits the fuel/air ratio to a lower value, and the engine accelerates more slowly.

(3) *The temperature of the air entering the engine.* When the intake temperature is high, the compressor delivery pressure is below normal for the amount of air (lb. per sec.) passing through the engine. On some engines a temperature sensitive capsule, connected by capillary tubing to a thermometer bulb in the air-intake, provides compensation in the A.C.U. for the change in air pressure. The capsule is arranged to increase the spring loading on the half-ball valve as the temperature increases, but a movement stop prevents any correction at temperature below 5 deg. C.

MAXIMUM SPEED GOVERNOR

31. A hydraulic governor is incorporated in the engine-driven fuel pump to limit the engine speed by opening half-ball valves connected to the servo system. The half-ball valves are operated by a spring-loaded diaphragm exposed to the pressure difference set up by centrifugal force in radial drillings in the governor rotor. As the throttle is opened and the engine speed reaches the maximum permissible, the half-ball valves are opened, causing a reduction in servo pressure and pump delivery pressure, thus preventing acceleration beyond governed speed.

32. The levers carrying the half-balls are spring-loaded to close the valves against servo pressure when the governor is not functioning. Although only a small area of each half-ball valve is exposed to servo pressure, it is possible under some circumstances for this pressure to lift the valve against the spring acting on the lever. This feature determines the 'stall' pressure, the maximum pressure which the pump is allowed to develop, and hence provides a safeguard against overload. The spring loading is adjusted so that the stall pressure is well above the normal maximum delivery pressure.

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ISOLATING VALVE

33. The half-ball valves have a very small lift and, although protected by fine mesh filters, can be seriously upset by small particles of dirt on the valve seat. As a safeguard against complete loss of engine thrust if one half-ball valve is prevented from closing by a particle of dirt, a solenoid-operated isolating valve may be incorporated on the fuel pump to enable the upper servo mechanism to operate independently of all the rest of the servo system. The full output of one pump rotor is thus available and the fuel flow is sufficient for full thrust at take-off.

34. If the isolating valve is closed when the fuel system is serviceable, the servo pressure in the isolated servo cylinder rises towards pump delivery pressure, and the servo piston moves towards the full stroke position. As the increased fuel output must be delivered through the same restrictions and burner orifices, pressures rise throughout the fuel system, and the barometric pressure control attempts to restore the pressures to their former values by reducing the servo pressure and hence the stroke of the lower pump—the only one then controlled by the barometric pressure control.

35. If the fuel demand is less than the output of one rotor at full stroke, the lower one moves to minimum stroke, and the engine accelerates to a speed corresponding to the increased fuel delivery of the upper rotor. The upper rotor operates at full stroke unless governed speed is reached or the pump delivery pressure reaches stall pressure; in either event the governor half-ball valve opens and the reduction in servo pressure within the isolated cylinder causes the rotor to operate at less than full stroke.

36. If, however, there is a defect causing excessive bleed from the servo system, either the upper mechanism will operate under the control of the governor half-ball valve or the lower one will operate under the control of the B.P.C. and the governor half-ball valve, according to the location of the fault. Each pumping mechanism remains under the overriding control of the governor.

HIGH PRESSURE COCK

37. All the fuel delivered to the burners passes through a high pressure cock immediately before reaching the pressurizing valve. The cock must be open to enable the engine to run, and the closing of the cock is the normal means by which the engine is stopped.

38. When closed, the H.P. cock completely stops the flow of fuel to the burners and diverts the pump delivery fuel back to the pump inlet through the low pressure filter casing.

39. As the sudden release of extra fuel into the low pressure filter casing could cause a considerable pressure rise, a 30 lb. per sq. in relief valve is incorporated. The outlet from the valve is controlled by small drillings in the high pressure cock so that the relief valve cannot operate when the cock is fully open.

40. Additional drillings in the high pressure cock allow the fuel in the burner manifolds to drain when the cock is in the closed position, thus preventing the fuel draining into the lower combustion chamber while the engine is stationary.

41. A non-return valve is fitted in the low pressure filter casing adjacent to the high pressure cock so that if the cock is left partly open the valve will prevent fuel draining right through from the fuel tanks.

FUEL CONTROL UNIT

42. For convenience, certain units are grouped together to form a fuel control unit.

43. The central feature of the unit is the low pressure filter casing, through which all fuel passes on entering the engine fuel system. A felt element provides a high degree of filtration to protect the pumps and ensure the reliability of the servo system. For compactness the element is corrugated, and the effective area is sufficiently large to keep the pressure drop across the filter within the acceptable value at maximum fuel flow.

44. A casing incorporating the throttle valve, the high pressure cock and the pressurizing valve is attached to the front of the filter casing. The barometric pressure control is mounted on the port side of the filter casing.

45. To prevent high frequency fluctuation in fuel pressure reaching the barometric pressure control, an attenuator is incorporated in the throttle inlet pressure connection on the low pressure filter casing. The attenuator consists of a succession of plates with a fine hole in each plate, so that steady pressure is transmitted but rapid fluctuations are damped out.

DRAIN FROM FUEL UNITS

46. A drain pipe conveys overboard any leakage from the oil cooler and the fuel and oil seals on the driving shafts of the dual fuel pump and the ram governor pump. The pipe also disposes of any leakage from the high-pressure cock and the fuel which drains from the burner manifolds when the cock is closed.

EFFECT OF LOW TEMPERATURES ON FUEL SYSTEM

47. At low temperatures the engine may not attain governed speed on the ground and at low altitudes. An increase in air density caused by a fall in temperature results in higher power being required to drive the compressor at the same speed; the engine, therefore, requires more fuel to maintain the same speed, or will run at a reduced speed if no increase in fuel flow is available.

48. Considering a gradual fall in temperature from 15 deg. C., the governed speed is maintained down to approximately minus 5 deg. C. as extra fuel is available. The speed obtained at each throttle setting falls slightly with decreases in temperature, and the throttle position for governed speed advances to the end of the quadrant. The increase in the maximum fuel feed involves increased burner pressures (primary and main);

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the throttle inlet pressure is, however, controlled by the barometric pressure control at a value which prevents any further rise of the burner pressures at temperatures below approximately minus 5 deg. C. At lower temperatures, therefore, the maximum fuel supply is practically constant, and the engine speed obtainable falls with decrease in temperature.

49. The thrust obtainable at governed speed varies in proportion to the fuel flow. At temperatures exceeding 15 deg. C. the maximum thrust is less than the rated value, and at lower temperatures the thrust obtained at governed speed at sea level is greater than the rated value. Below minus 5 deg. C the thrust at the maximum obtainable engine speed rises slightly and is always in excess of that at 15 deg. C.

50. At temperatures down to minus 40 deg. C. it is possible to obtain governed speed on the ground by sealing off the servo connection to the barometric pressure control so that the fuel pumps operate at stall pressure.

51. The effect of low temperature in limiting obtainable engine speed is not so marked in flight as on the ground. At low temperatures, therefore, the maximum obtainable engine speed normally rises with altitude until the governor comes into action, and it is always essential that the governor is correctly adjusted, even if governed speed is unobtainable on the ground.

EFFETS OF CHANGE OF FUEL

52. The main effects on the engine of a change from one grade of fuel to another arise from the variation of specific gravity and the number of heat units (B.Th.U's) obtainable from a gallon of fuel. As the number of heat units per pound is practically the same for all fuels approved for gas turbine engines, a comparison of heat value per gallon can be obtained by comparing specific gravities.

53. An increase in specific gravity has the following results:—

- (1) A reduction in the engine speed at which the governor controls.
- (2) A decrease in the number of gallons used per hour for the same thrust, hence an increase in range for the same tankage.

54. Conversely, a decrease in specific gravity results in a decrease in range and the necessity to control the engine speed entirely by manual operation of the throttle to prevent over-speeding until the governor is re-set.

55. When using fuel other than aviation kerosine, additional servicing may be required, operational limitations may be imposed, and the approved engine life may be affected.

Note . . .

Changes in the specific gravity of the fuel will also affect the functioning of the P.V. ram.

Chapter 3

OIL SYSTEM

Note . . . This chapter applies to Avon Mk.10801 and 11401 Engine Change Units

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LUBRICATION REQUIREMENTS

1. The engine has no heavily loaded plain bearings and is thus able to use a thin oil at low pressure to obtain the necessary lubrication and cooling.
2. The oil chosen remains fluid at all temperatures at which the engine may be operated and preliminary heating is unnecessary for starting. The oil will not vaporise or oxidise under high temperature conditions.

OIL CIRCULATION

3. The oil is contained in a combined oil tank and sump beneath the compressor outlet casing; it is circulated by one feed pump and two scavenge pumps, each of which draws its oil through a coarse mesh wire gauze filter which protects the pump from damage. The system is complete within the engine.
4. The feed oil passes through a cooler and a pressure filter to a passage in the port side of the sump from which it is distributed at a pressure controlled by a relief valve.
5. Some oil passes through an external pipe to the front main bearing, and the remainder is conducted by transfer tubes to the internal wheelcase, where it is distributed to a circular oil gallery on the centre bearing housing, to the oil pump drive and, through internal pipes, to the rear main bearing.
6. The oil gallery feeds the centre main bearing and the gears of the internal wheelcase and also supplies oil through transfer tubes to the external wheelcase.

7. Oil from the front and rear main bearings is returned by separate scavenge pumps to the sump. Oil from the centre main bearing, and the internal and external wheelcases, drains back to the sump by gravity.

MAIN BEARINGS

8. The three bearings on the compressor and turbine shafts are each lubricated by a jet of oil directed on to the front face of the bearing. The oil penetrates through the bearing and then drains down on both sides.
9. Each jet orifice is a single hole of small diameter, protected by a slotted thread type filter (*fig. 1*).

Front main bearing

10. The front main bearing receives oil through an external pipe and a drilling in a web of the front bearing housing. Oil drains down both sides of the bearing housing and returns through a similar drilling and pipe to the lower scavenge pump.

Centre main bearing

11. The centre main bearing receives oil from the circular oil gallery on the centre bearing housing. This bearing housing forms the front casing of the internal wheelcase, and surplus oil from the front of the bearing passes through a drilling to join the oil draining from the wheelcase.

Rear main bearing

12. The rear main bearing receives oil through a pipe inside the casing surrounding the turbine shaft. Surplus oil drains through holes drilled at the lowest point of the space on each side of the bearing, and is carried by an internal pipe to the

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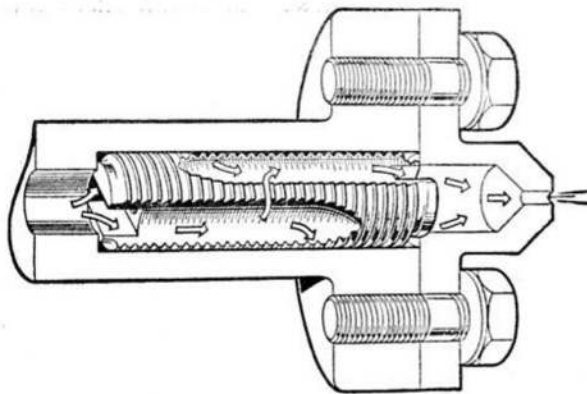


Fig. 1. Main bearing oil jet

compressor outlet casing and thence to the upper scavenge pump.

Oil seals

13. Each main bearing operates in an enclosed space, the main shafts being provided with oil seals of the screw thread type—one seal behind the front bearing and one on each side of the centre and rear bearings. These seals contain a right or left-hand helical groove so arranged in relation to the rotation of the shaft that any oil creeping along the shaft is flung outwards by centrifugal force and is conducted back by the groove towards the bearing housing.

14. Oil clinging to a rapidly rotating tapered shaft will move along the taper towards the larger diameter, from which it will be flung by centrifugal force. From the front main bearing the diameter of the shaft increases towards the oil seals, and a groove is cut to form an oil finger, thus minimizing the amount of oil which reaches the seal. In a similar way the large diameter of the centre coupling assists the rear oil seal of the centre bearing to prevent oil leakage.

15. The efficiency of all these oil seals depends on the air pressure outside the seal being greater than that inside, so that the flow of air through the seal opposes any escape of oil.

16. The effectiveness of the oil seals on the centre and rear bearings is assisted by the pressure of the cooling air passing along the intermediate casing from the third stage of the compressor. To assist in removing the heat which flows along the shaft from the turbine, thus enabling the rear bearing to run without overheating, some of this air is drawn through the bearing sleeve by oblique slots on the turbine shaft and radial passages in the flange of the sleeve.

17. As the front bearing seal is subject to the depression existing behind the intake guide vanes, a double seal is provided and the intervening

space is fed with third stage air from the compressor shaft. The outer seal is a labyrinth type air seal maintaining the third stage pressure between the seals and ensuring the efficiency of the oil seal.

Drain system

18. Although the main bearing oil seals are normally effective and the internal oil feed tubes have rubber sealing rings to prevent loss of oil, a small hole is drilled for the disposal of any oil collecting in the inner space of the compressor outlet casing. This hole connects the inner space with the air duct to No. 4 expansion chamber so that, when the engine is stationary, oil can flow into the air duct and the combustion chamber, finally escaping through the combustion chamber drain valve. When the engine is running, the full air pressure from the compressor prevents the drainage of oil, the small amount of air flowing inwards through the drain hole being added to the cooling air from the third stage of the compressor.

INTERNAL WHEELCASE

19. The spiral bevel gears driving the external wheelcase and the accessory gearbox are lubricated by two jets of oil from the circular oil gallery on the centre bearing housing. The oil splash from these gears and the centre bearing spreads throughout the wheelcase, thus lubricating the other gears. The ball and roller bearings are fed by splash oil entering apertures between the bearing housings and the casing and passing through holes drilled in the housings.

20. The two shafts in the oil pump drive carried in plain bearings whose journal and thrust faces are fed with oil through drillings in the casing from the point where the main oil feed enters the internal wheelcase.

21. Surplus oil from the wheelcase drains to the sump between concentric tubes surrounding the vertical oil pump drive shaft.

Centrifugal breather

22. Pressure in the sump, the external wheelcase and the internal wheelcase is equalised through connecting passages, and is vented to atmosphere through a centrifugal breather, which is incorporated in the internal wheelcase and separates oil mist from the outgoing air. A considerable quantity of air enters the oil system through the pressurized oil seals, and the breather passages are made as large as possible to assist the passage of this air and at the same time allow the particles of oil to be extracted and retained in the engine.

23. Before it enters the hollow drive shaft, the oil-laden air must pass through drilled passages in the breather rotor. The oil particles, being heavier than air, are flung out by centrifugal force, through radial drillings and back into the wheelcase.

24. A seal is fitted to the end of the shaft to

prevent air escaping direct, under the pressure produced by the centrifugal breather, without passing through the rotor. The seal is in two parts and the intervening space is pressurized by air from the space surrounding the internal wheelcase. The rear part is an air seal maintaining a pressure between the seals and ensuring the efficiency of the oil seal.

EXTERNAL WHEELCASE

25. The oil supply to the external wheelcase is obtained from the circular oil gallery through a series of transfer tubes. The oil enters near the bottom of the main casing, and flows up a long drilled passage from which it branches out along various drillings.

26. Jets of oil from the main supply are directed on to each main pair of gears at the point of meshing.

27. The other gears and the ball and roller bearings are lubricated by splash oil and the oil mist generated when the engine is running. The circulation of air carrying the oil mist to certain bearings is assisted by radial drillings in the hollow shafts and drillings in the casing venting the enclosed spaces at the ends of the shafts.

28. The tachometer generator drive runs in plain bearings which are pressure fed from the main oil supply to the wheelcase.

29. Surplus oil from the wheelcase drains by gravity through a short pipe to the oil sump.

ACCESSORY GEARBOX DRIVE

30. A supply of oil from the distribution passage in the oil sump provides a jet which is directed on to the gear teeth at the point of meshing. The ball and roller bearings are lubricated by oil splashing from the gear teeth and surplus oil drains by gravity to the top of the relief valve housing, from which a passage leads direct to the oil in the sump.

31. Loss of oil from the external drive is prevented by a rubber seal, the efficiency of which is maintained by a direct supply of oil tapped from the main feed. Oil trapped in a reservoir in the seal housing when the engine is stationary is sufficient to provide adequate lubrication on starting up.

COMBINED OIL TANK AND SUMP

32. The combined oil tank and sump holds the supply of oil from which the engine is fed and also contains the oil pumps and the oil filters.

33. A window is fitted on the side of the casing for checking the oil level, and a filler orifice is provided.

Oil pump unit

34. The three gear-type oil pumps are in a single unit bolted to the base plate of the oil sump. The pumps have a common vertical shaft driven from the internal wheelcase, and on the delivery side

of each pump a relief slot is milled in the casing to relieve hydraulic pressure between the gear teeth as they come into mesh.

35. To lubricate the pump bearings, oil from the outlet of the feed pump passes down a hollow fixed spindle on which the idler gears rotate and is distributed by radial drillings to the idler gear bushes, and by drillings in the casings to the driving shaft bearings.

Oil circulation in sump

36. Each pump draws oil through a gauze filter, the filter housings being integral with the base plate of the sump and arranged on the starboard side of the pump unit. Each filter element is removable from the bottom of the sump and is retained by a cover and a central setscrew, both the element and the cover being captive on the screw. Partial withdrawal of the central filter setscrew allows the sump to be drained through a hose connection integral with the cover, while a spring on the screw head retains the cover in position to prevent spilling the oil.

37. The upper pump draws oil from the sump through the central gauze filter and feeds it through the oil cooler and the pressure filter to a passage at the port end of the sump casing for distribution throughout the engine. The pressure filter is on the port side of the pump unit and has an edge-filtration element in a housing integral with the base plate of the sump. A pressure transmitter is connected to the distribution passage by a small restrictor orifice which damps out minor pressure fluctuations in the transmitter oil cavity. The delivery pressure is controlled at approximately 25 lb. per sq. in. by a non-adjustable relief valve, surplus oil going direct into the sump.

38. The middle pump scavenges oil from the rear main bearing through the rear gauze filter, and the lower pump receives scavenge oil from the front main bearing through the front gauze filter. The combined delivery from these two pumps passes up a vertical funnel and is de-aerated as it overflows into the reservoir of oil in the sump.

Oil de-aeration

39. Scavenge oil from the front and rear main bearings together with some of the pressurizing air from the oil seals is delivered through the de-aerating funnel where the air and oil separate; the oil flows over the edge of the funnel into the sump and the air passes up an inner shroud surrounding the oil pump drive, through the hollow gearshaft into the internal wheelcase, and out to atmosphere through the centrifugal breather.

40. Oil draining from the centre main bearing and the internal wheelcase is de-aerated as it passes down the outside of the shroud to the reservoir of oil in the sump.

OIL COOLER

41. Excess heat is extracted from the oil by a cooler and is carried away by the fuel supplied to

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the burners. This arrangement ensures that the degree of cooling is adequate for ground running and, being controlled by the rate of fuel flow, is at all times related to engine operating conditions.

42. The cooler is divided into two main sections; the upper section is the main casing and houses the cooling matrix immersed in oil; the lower section is a smaller casing with four shallow recesses, the fuel flowing from one to the other through matrix tubes which pass through the plates of the double partition into the oil chamber and back again.

43. The internal tubes are provided with numerous fins to assist the transfer of heat, and the oil is made to pass along the fins and back again in a zig-zag manner by a series of baffle plates.

44. The tubes are brazed into the partition plates and, when the engine is running, the fuel inside the tubes is always at a much higher pressure than the oil in the cooler, thus minimizing the possibility of leakage between the tubes and the plates. The lower plate is recessed to form cavities between the plates, and these are vented and drained by a pipe so that, if any slight leakage develops during the engine life, it is impossible for fuel to penetrate to the upper chamber to dilute the oil.

45. The oil reaches the cooler direct from the feed pump and subsequently passes through the pressure filter to the point where the main relief valve controls the feed pressure. To limit the oil pressure in the cooler when the oil is cold, a 30 lb. per sq. in. by-pass relief valve is incorporated between the inlet and the outlet oil connections.

STARTER DRIVE

46. The gears and bearings of the starter drive are lubricated by oil splash and mist from the oil jet feeding the front main bearing of the engine. Some oil collects at the bottom of the reduction gear housing, and the planet gears pick up oil from this supply.

47. The starter casing contains a quantity of oil which is picked up by the gears and splashed throughout the drive casing. Each time the engine is started, engine oil pressure depresses a piston in a cylinder on the planet carrier bearing housing, and supplies a small quantity of oil to the starter casing. When the engine stops, the spring returns the piston to the top of the cylinder, and oil flows into the cylinder from the pocket previously mentioned, ready for the next engine start. An overflow port in the cylinder, uncovered when the piston is fully returned by the spring, controls the oil level in the starter casing.

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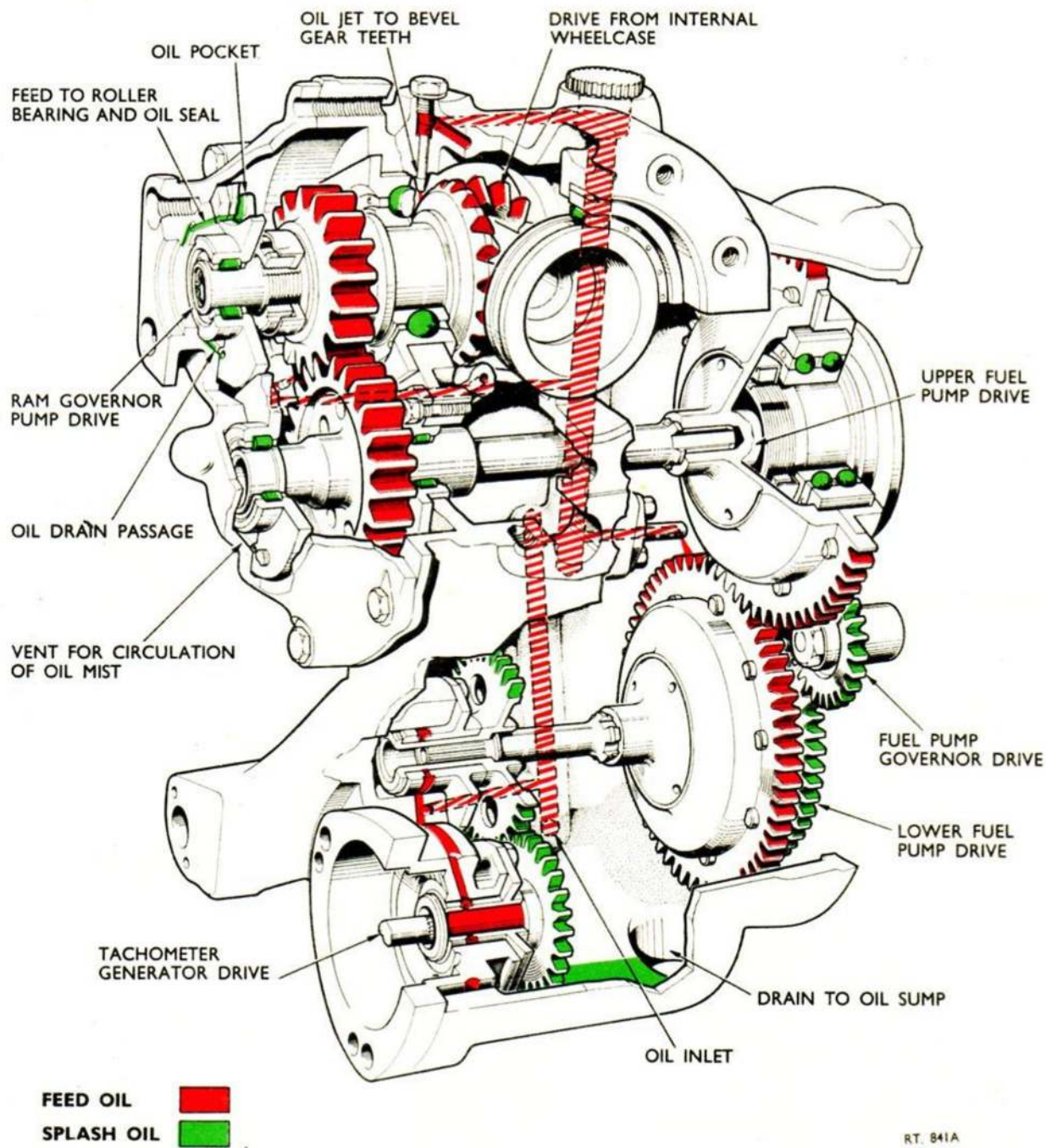


Fig.3 External wheelcase

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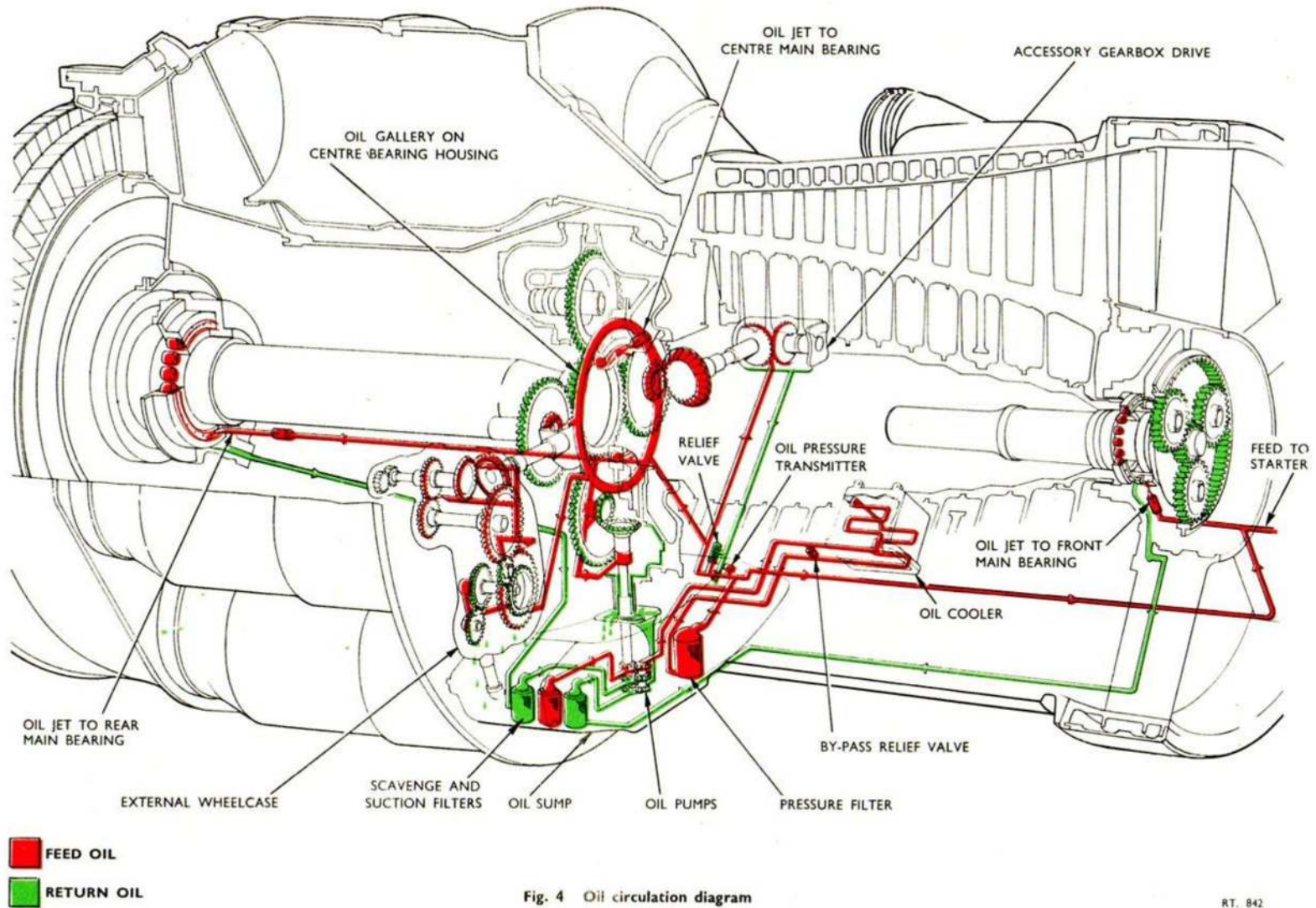
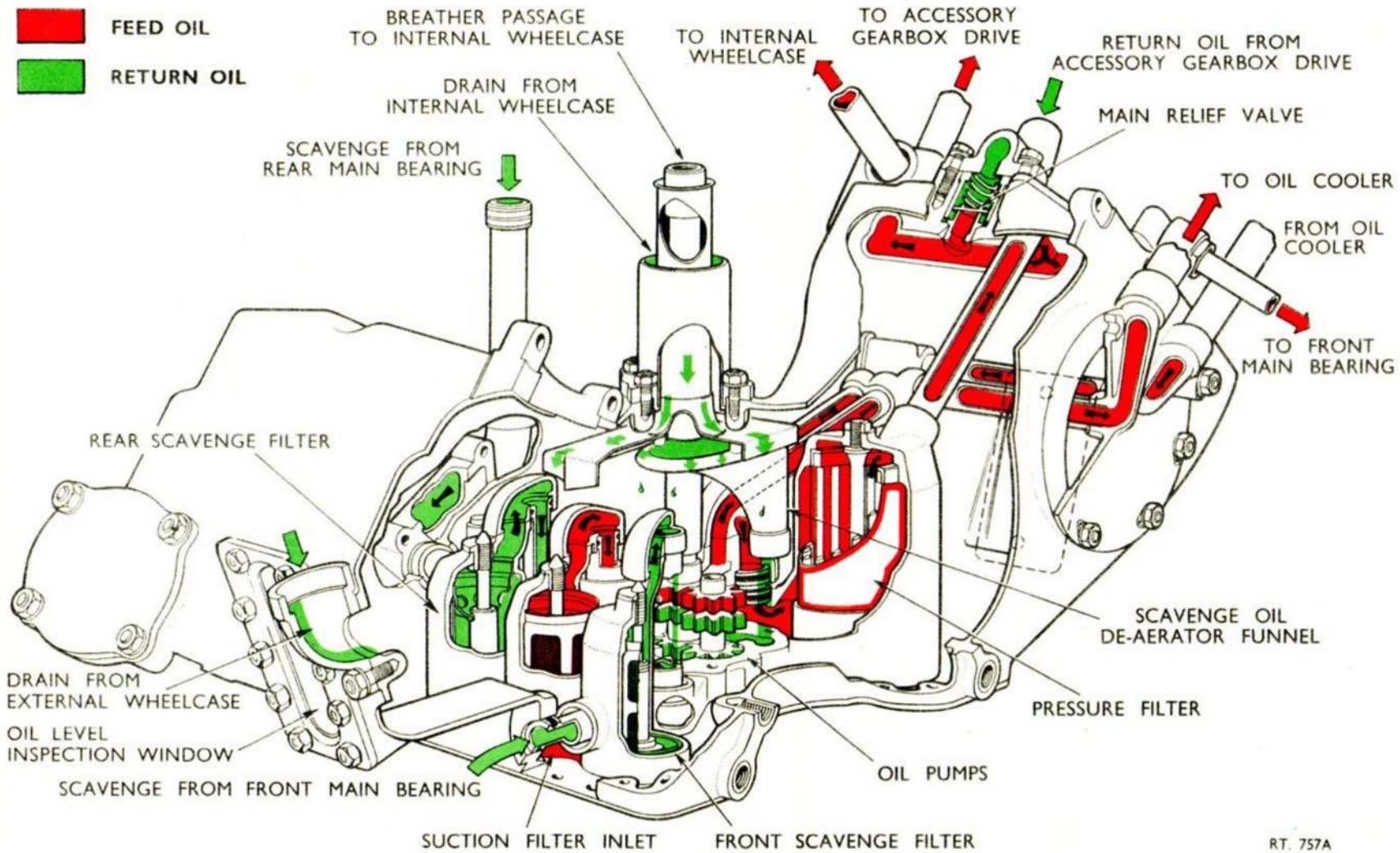


Fig. 4 Oil circulation diagram

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Fig. 5 Oil sump

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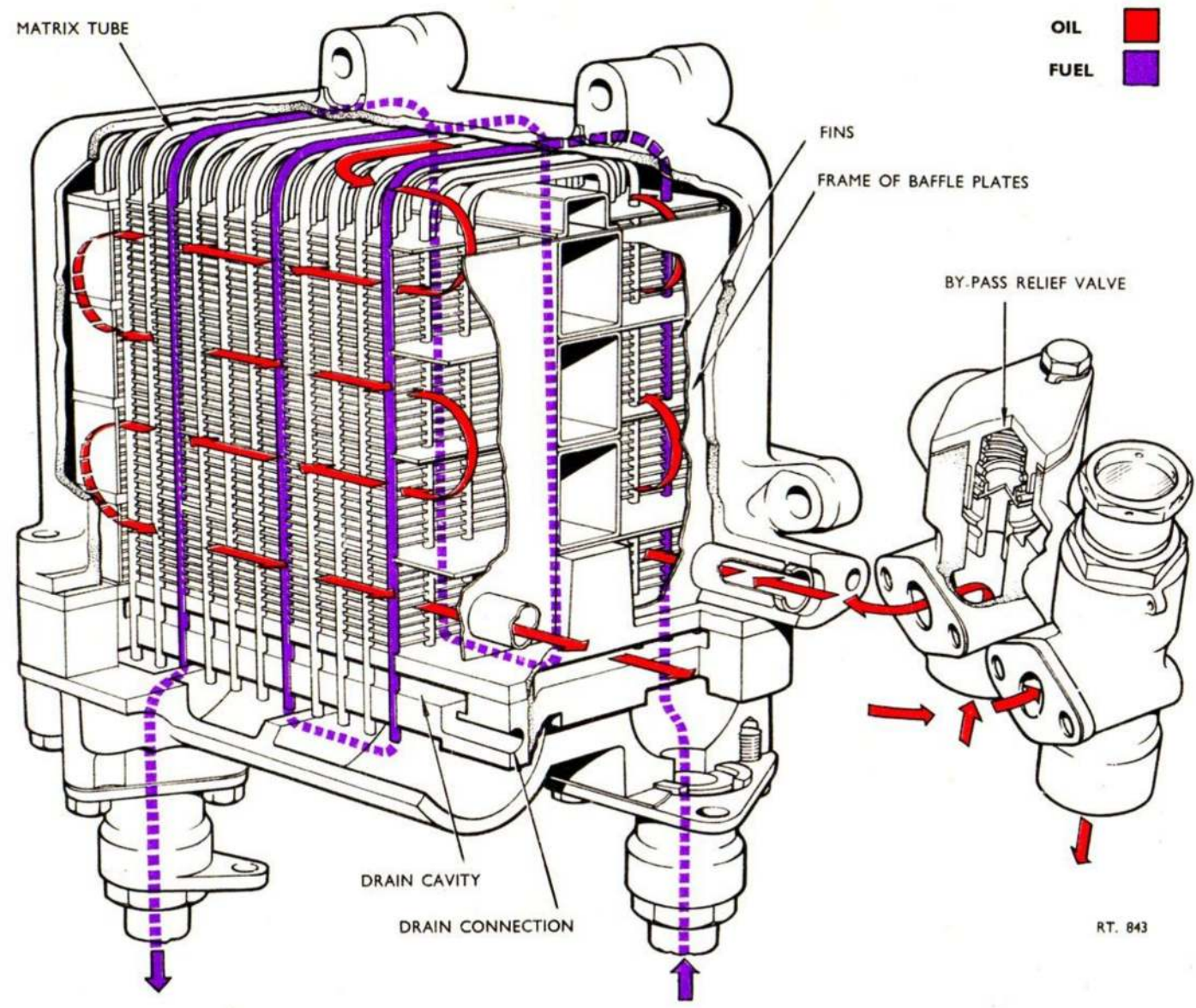
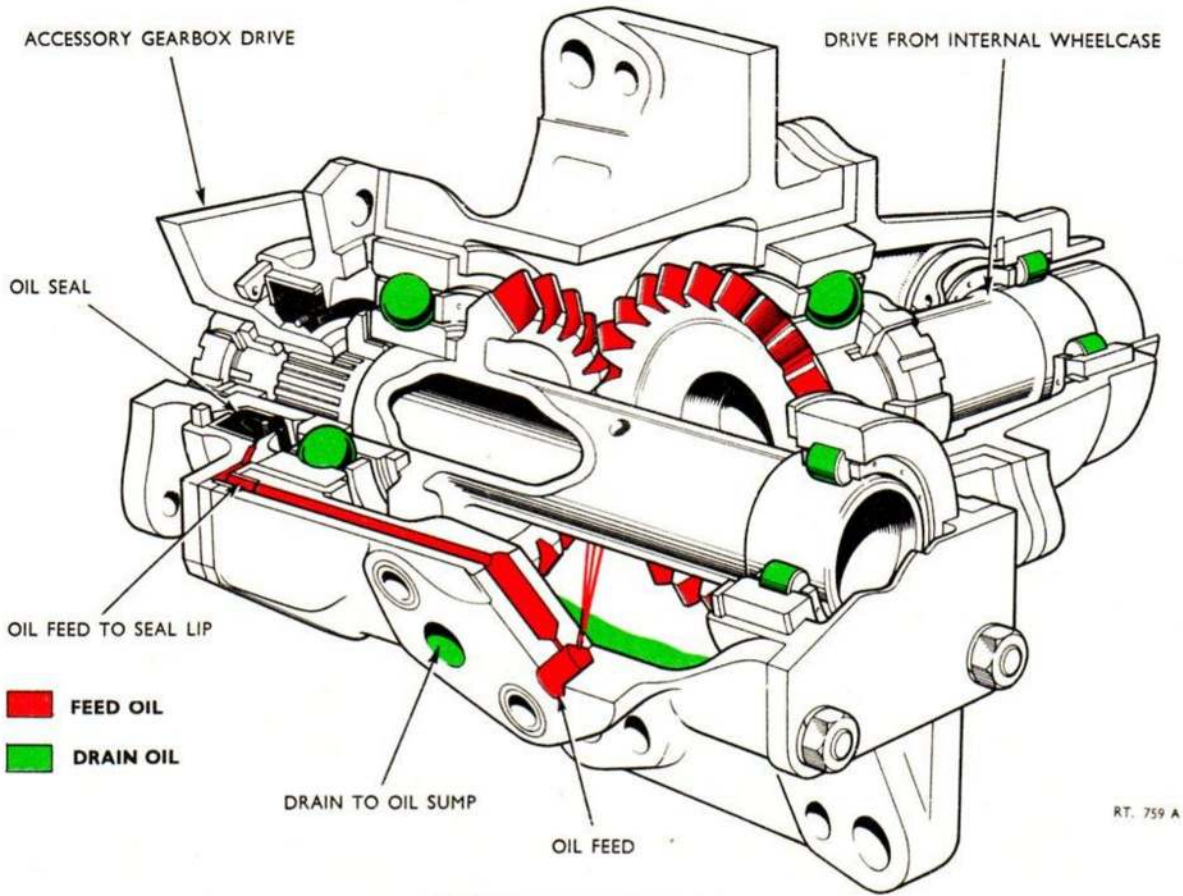


Fig. 6 Oil Cooler

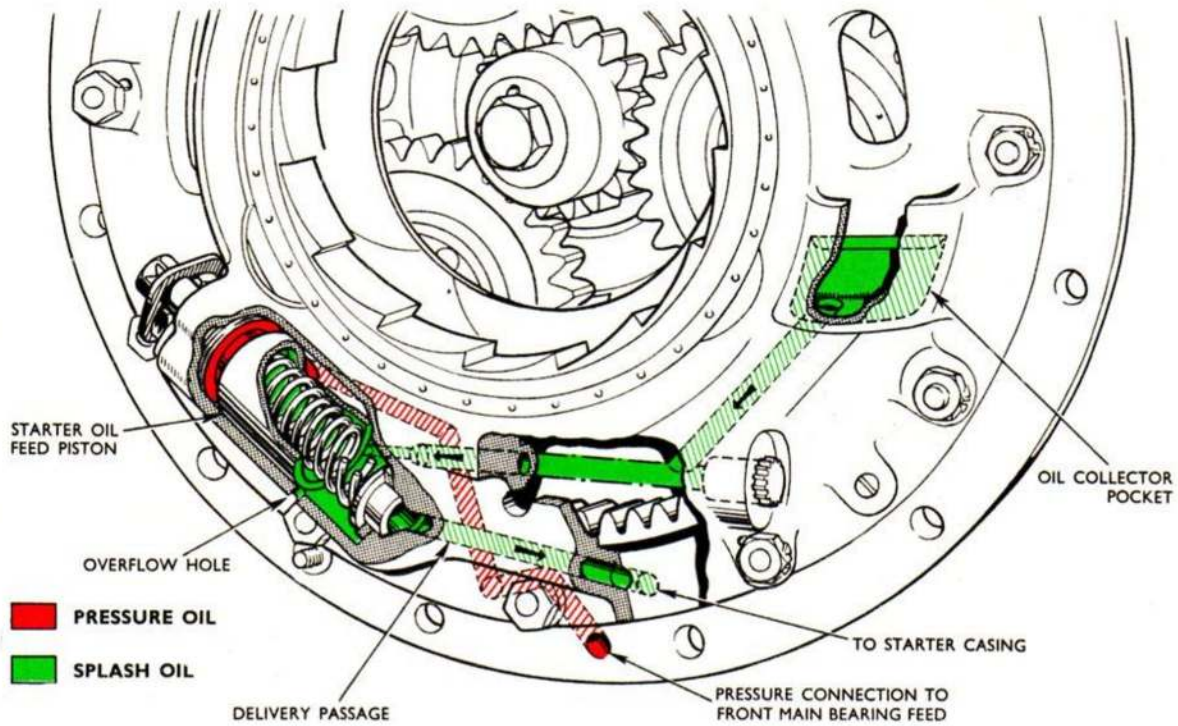
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Fig. 7 Accessory gearbox drive



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Fig. 8 Starter drive oil feed

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Chapter 4

IGNITION SYSTEM

Note.—This chapter applies to Avon Mk. 10801 and 11401 Engine Change units

1. Two surface-discharge igniter plugs are fitted in No. 3 and 6 combustion chambers. The type number of the plugs is given under Leading Particulars, and a description of them will be found in A.P.1374G, Volume 1, Section 2.

2. Each igniter plug is supplied with impulses of current from an ignition unit of the type specified in the aircraft Air Publication and described in A.P.1374E, Volume 1, Section 4.

3. An igniter plug is fitted in the reheat burner assembly to ignite the pilot fuel supply. A booster coil in the aircraft starter panel supplies the H.T. current when reheat is selected.

WARNING.

The energy stored in the igniter unit may under certain circumstances be lethal and, if it is necessary to disturb the system, disconnect the L.T. supply and wait for a period of one minute to elapse, to allow the energy to dissipate before handling the unit or H.T. cable.

Chapter 5

JET PIPE AND REHEAT SYSTEM

Note.—This chapter applies to Avon Mk.10801 and 11401 Engine Change Units

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Cooling	9	Igniter	30
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Fuel control unit	5		

Introduction

1. To increase the maximum thrust available during take-off, climb and combat, these E.C.U. are fitted with a jet-pipe reheat system.

2. Extra thrust is obtained by increasing the temperature of the exhaust and hence its velocity through the propelling nozzle. The increase in temperature is achieved by burning fuel with a portion of the unburnt air passing through the jet pipe.

3. A mechanically operated, two-position, final nozzle is fitted to the jet pipe to increase the nozzle exit area to accommodate the additional mass gas flow when using reheat. When reheat is in operation a control unit restores engine conditions, as indicated by the j.p.t. or the ratio between the compressor outlet pressure (P_2) and the exhaust unit pressure (P_1), to those which obtained before selection of reheat.

4. If an excessive temperature is generated in the jet pipe a temperature limiter cancels the reheat.

5. Fuel is injected into the jet pipe through burners which are supplied by a high pressure pump turbine driven by P_2 air. The supply to the pump is taken from the normal aircraft tanks. The pump output is controlled by the reheat control unit which governs the supply of P_2 air to the pump.

Jet pipe and nozzle

6. The reheat jet pipe is mounted and installed in a similar manner to a normal jet pipe and is connected by a transition piece to the exhaust unit of the engine. It consists of a diffuser section carrying the burner assembly, a parallel section,

and a two-position nozzle. The pipe is of double skin construction, the outer skin forming the main structural member. The sections of the inner skin are supported by suspension straps welded to them at intervals and secured between the flanged joints of the outer skin. The centre parallel section of the inner skin has a sliding ring joint at each end to allow for thermal expansion.

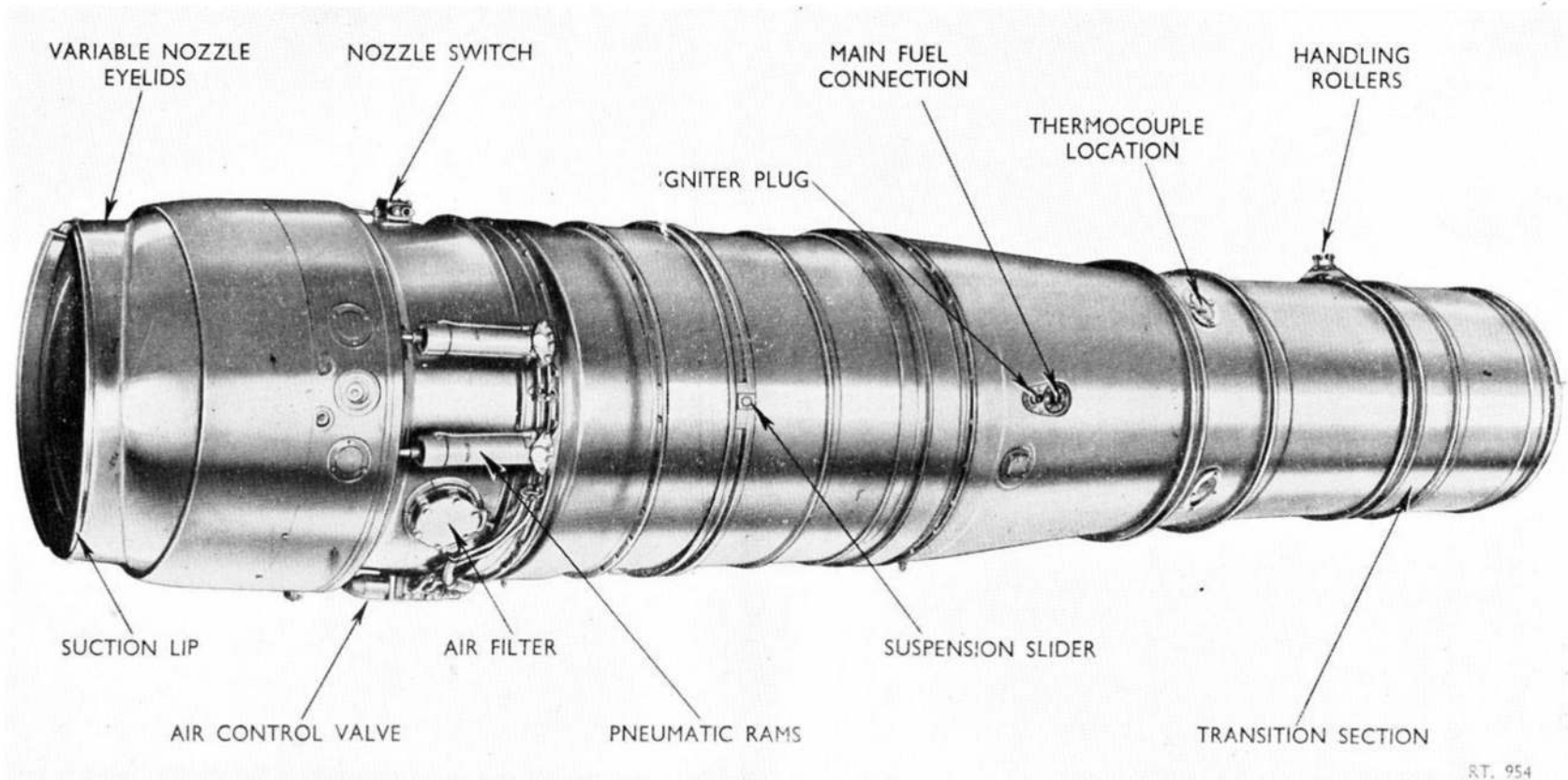
7. The two-position nozzle (*fig. 2*) consists of a fixed area reheat nozzle surmounted by two movable spherically-shaped eyelids. The eyelids, when closed, form an elliptical nozzle of smaller area for normal running and are interconnected by synchronising linkages which, when the nozzle is opening, equalise the loading to ensure that the rate of opening of each eyelid is the same.

8. The eyelids are operated by four pneumatic rams connected in pairs to each eyelid by triangulated levers which are designed to increase the ram loading by 2:1 when the nozzle is closed. The rams are actuated by nozzle box cooling air pressure (P_3). The air passes from the nozzle box through a filter to a solenoid operated shuttle valve which directs the air to either side of the ram pistons and maintains the eyelids in the position selected as illustrated in *fig. 3*.

Cooling

9. To keep both the inner and outer skins cool the double skin of the jet pipe forms an annular gap through which air is drawn by the ejector effect of the jet stream. When the nozzle is closed air is drawn through the space between the inner and outer skins of the eyelids but, when the nozzle is open, the air flows between the inner surface of the eyelids and the fixed area reheat nozzle (*fig. 4*). During the transitional period there is no cooling air flow.

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Fig. 1. Jet pipe and nozzle.

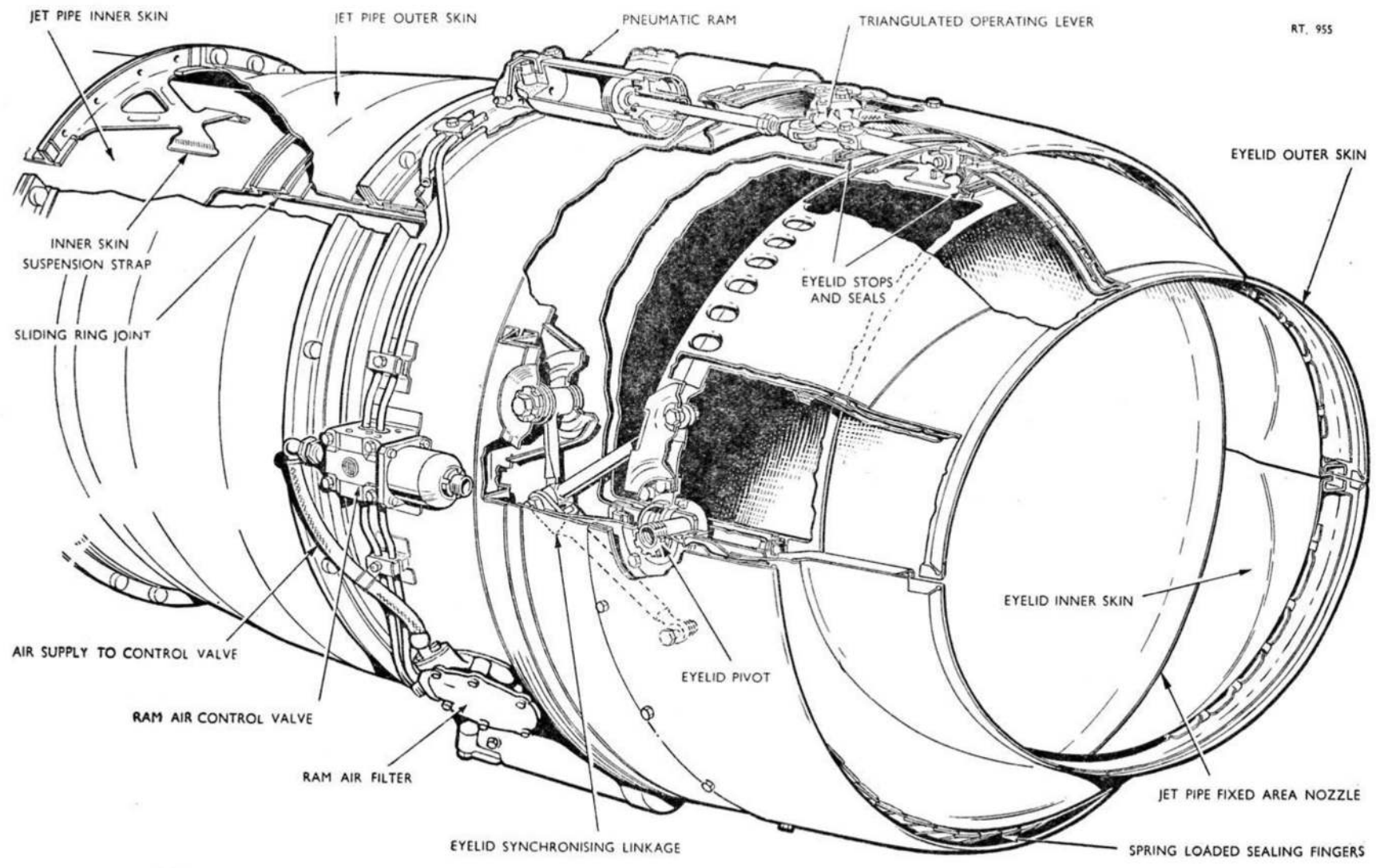


Fig. 2. Two-position nozzle

Seals

10. To prevent a reverse flow of hot gases into the jet pipe cooling annulus and to maintain the ejector effect, braided inconel seals are incorporated at both the forward and rear stops of the eyelids. Spring loaded 'fingers' seal the space between the eyelids and the outer jet pipe skin, thus preventing an inward flow of atmospheric air into the cooling annulus as any entry of air would break down the positive flow of the cooling air.

Safety devices

Nozzle position warning indicator

11. A switch controlling a nozzle position warning indicator is located on the jet pipe, forward of the nozzle, and is connected to the upper operating linkage by an adjustable rod. The indicator shows BLACK if the nozzle is in the correct position for the particular running condition selected, and WHITE during the transitional period of the eyelid movement or if the eyelids are in the wrong position.

Hot gas warning indicator

12. The hot gas warning indicator operates if the temperature inside the cooling air annulus rises due to a breakdown in the cooling air flow or a fractured inner jet pipe skin allowing hot gas leakage.

Fire warning indicator

13. In addition to the usual fire warning indicator provided in the engine bay a further unit is fitted in the space containing the reheat fuel pump and the jet pipe diffuser section.

Air extractor failure indicator

14. In flight the reheat fuel system compartment is ventilated by forward facing louvres but on the ground it is effected by an air extractor operated by compressor delivery air. When the system is operating correctly the air extractor failure indicator should show BLACK with the undercarriage up and WHITE with the undercarriage down.

Reheat control unit

15. The reheat control unit governs the supply of fuel to the main reheat burners in relation to any change in the ratio between P_2 - P_4 . Any change is sensed by the unit which accordingly increases or decreases the amount of P_2 air to the fuel pump thus indirectly controlling the flow of fuel to the burners. The unit is fully described in A.P.4282.

16. The control unit (fig. 5 and 7) contains an air throttle actuated by a servo piston. Servo pressure is regulated by two half-ball valves; one is controlled by diaphragms sensitive to any change in

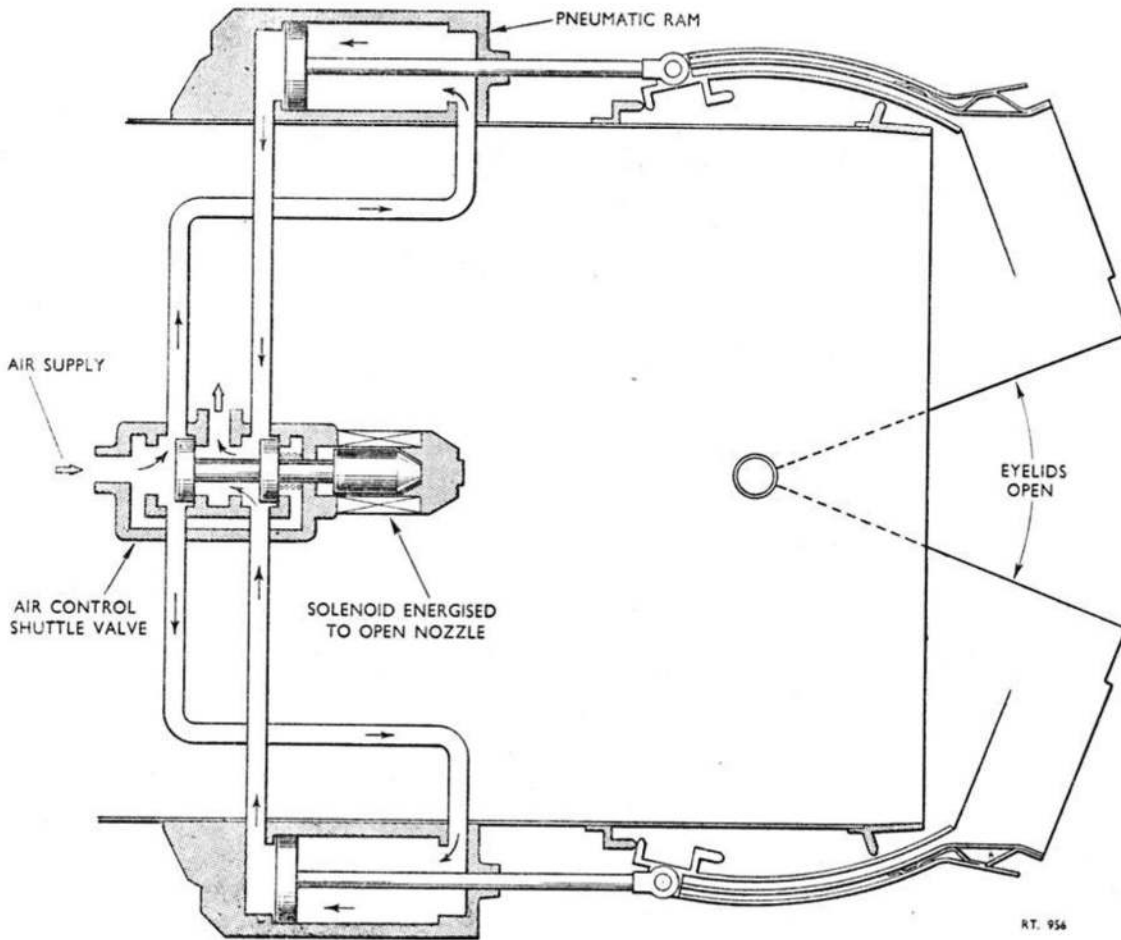


Fig. 3. Nozzle control system

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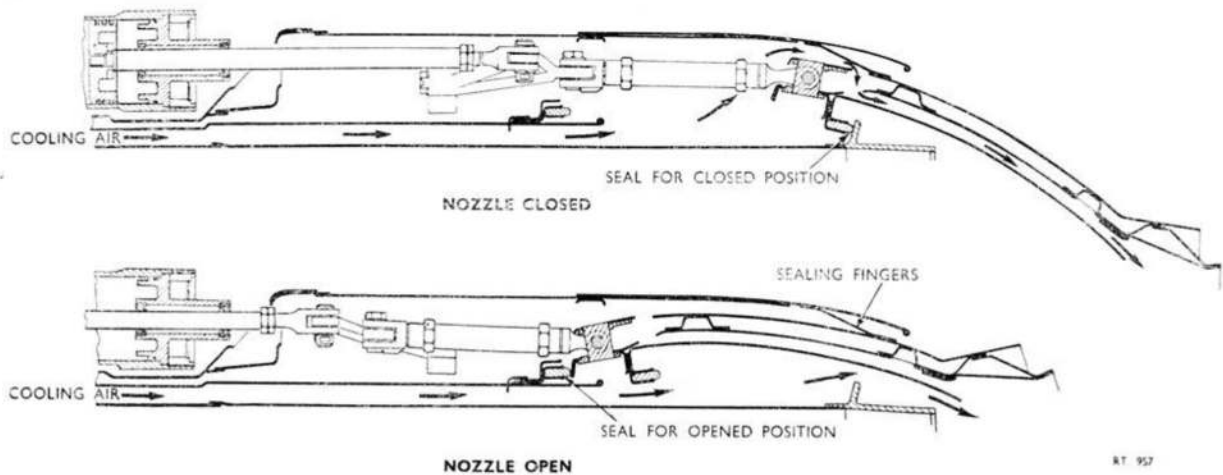


Fig. 4. Diagrammatic view of nozzle showing cooling air flow

the pressure ratio P_2-P_4 , the other is solenoid operated and is open when reheat is off, thus preventing servo-pressure build-up and maintaining the throttle piston in a closed position.

17. When reheat is in operation the solenoid valve is closed and any changes in the P_2-P_4 ratio are sensed by the diaphragm valve which adjusts the bleed from the servo system, thus altering the throttle position and the fuel flow to the main reheat burner.

18. To prevent cancellation of reheat by the high pressure in the exhaust unit during initial reheat light up, a solenoid-operated override valve opens for 30 seconds and bleeds air from the diaphragm in the control unit thus rendering the unit unresponsive to P_2-P_4 variations.

19. The control unit houses a solenoid-operated pilot shut-off cock which controls the flow of fuel from the engine H.P. pump to the pilot atomizer burner.

20. The correct P_2-P_4 ratio is set by a valve which regulates the effective air pressure on the diaphragms.

Reheat fuel pump

21. The air-driven fuel pump (fig. 6 and 7) supplies the main reheat burner with high pressure fuel. The pump consists of a two-stage turbine driving a centrifugal fuel pump; both the turbine and the pump are splined to a common shaft which rotates on ball and roller bearings at speeds between 18,000 and 30,000 r.p.m. The pump is fully described in A.P.4282A.

22. The pump receives its fuel supply from the aircraft low pressure system and delivers it, under sea level static conditions, at a flow of approximately 1,500 gall. per hr. and a pressure of 250 lb. per sq.in.

23. A shut-off cock consisting of a diaphragm-operated plate valve controls the flow of fuel from the pump. When the pump output pressure reaches a pre-set figure a pressure-operated switch passes current to energize a solenoid in the shut-off cock which opens a half-ball valve; this allows fuel to bleed from the rear of the diaphragm-operated plate valve. The unbalanced pressure across the valve causes it to open and pass fuel to the main burner. A non-return valve is fitted between the pump and the burner assembly to ensure that the fuel tank booster pump cannot pass fuel through the pump to the main burner in the event of a failure of the main shut-off cock when reheat is not in use.

Burners

24. The burners are designed to ensure good distribution and mixing of the fuel and air in the reheat jet pipe and to maintain combustion in the high velocity gas stream. The burner assembly, as illustrated in fig. 8, consists of a stabilizer, a main burner, a pilot atomizer burner and an upstream pilot burner. The whole assembly is located in the jet pipe and, with the exception of the stabilizing gutter, is mounted on a horizontal faired crossbar secured at each end to the jet pipe inner skin. The main fuel supply is taken inside through the bar to a central distribution core.

25. The main burner consists of a spray ring with short radial stub pipes welded across it at intervals around its circumference. Fuel is fed to the ring through two pipes radiating from the centre feed core, and is sprayed radially through small orifices at each end of the stub pipes.

26. The pilot atomizer burner, located in the downstream side of the centre core of the assembly, provides the pilot flame used in lighting the main fuel flow and receives its fuel from a pipe passing through the main support bar. A small non-return valve, located in the outer end of the feed pipe, prevents leakage from the burner when the fuel supply has been cut off.

27. On the apex of the centre cone the upstream pilot burner is mounted which sprays fuel upstream of the main spray. Its flow increases proportionally to that of the main burner whose combustion it supports by feeding the pilot atomizer flame with additional fuel as the main fuel flow increases.

28. The stabilizer system consists of an inner cone attached to the burner support arm and an outer ring gutter supported from the jet pipe inner skin. The gutter forms a stabilizer for the main reheat flame, the combustion of which is supported by the pilot flame produced in the inner cone and fed radially outwards along vee-sectioned troughs to the ring gutter.

29. To reduce resonance encountered with the ring type burner and to smooth the boundary air layer and so prevent skin overheating, a short corrugated sleeve is riveted to the inner jet pipe skin around the burner assembly.

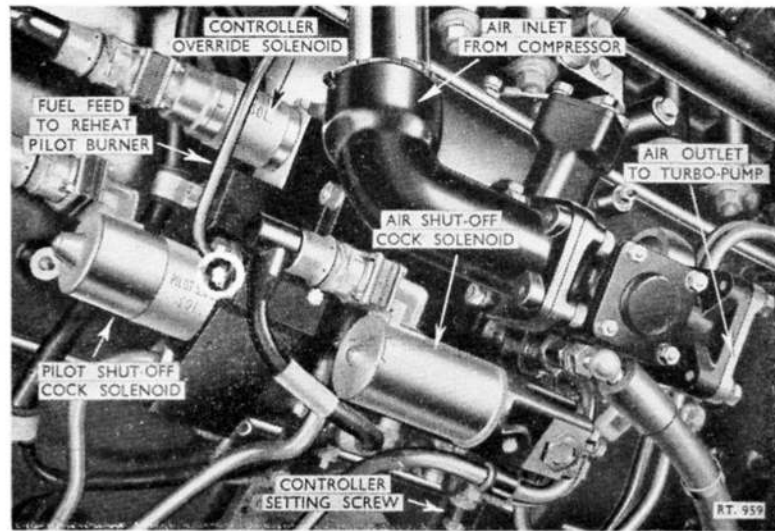


Fig. 5. Fuel control unit

Igniter

30. A high tension igniter plug is used for lighting the pilot atomizer fuel and is located inside the stabilizing cone. It is operated by a booster coil controlled by a 30-second time switch in the reheat circuit.

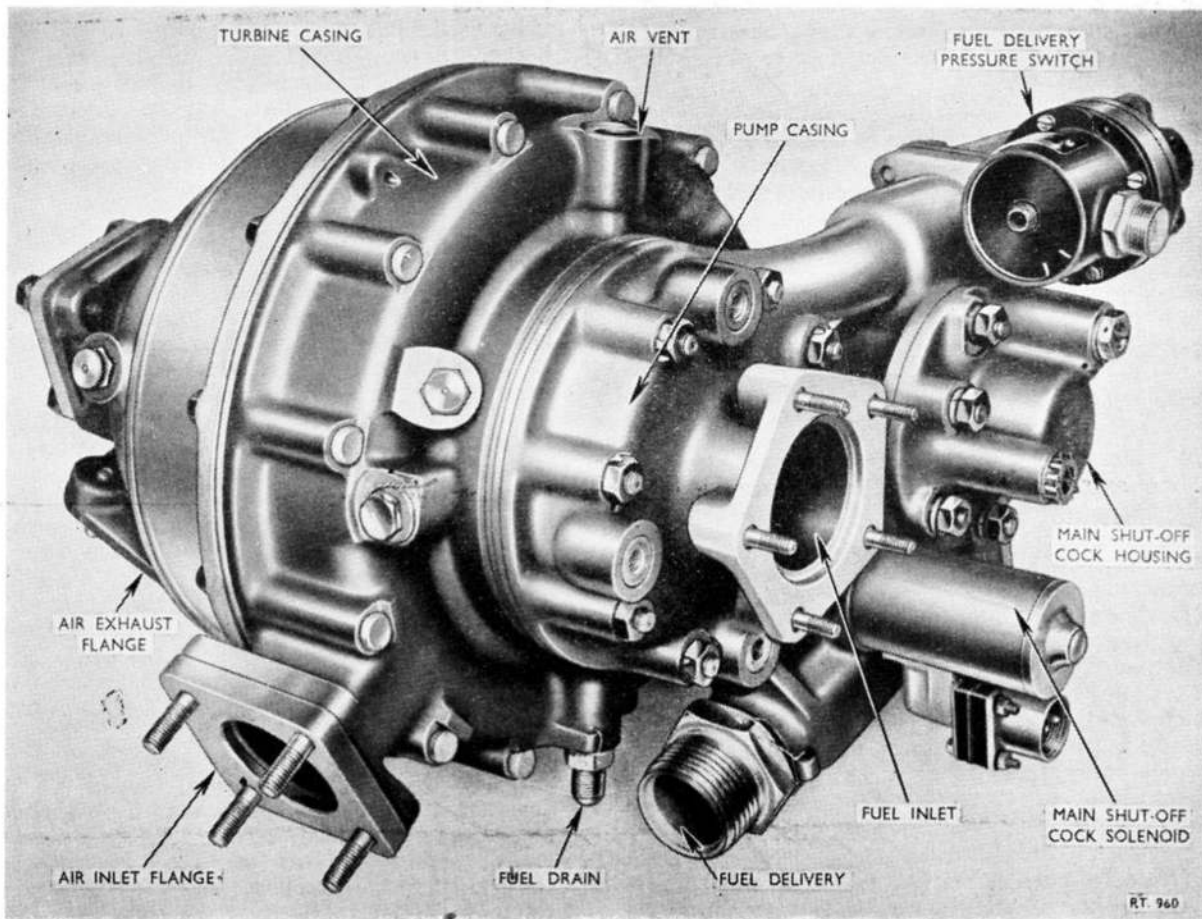


Fig. 6. Reheat fuel pump

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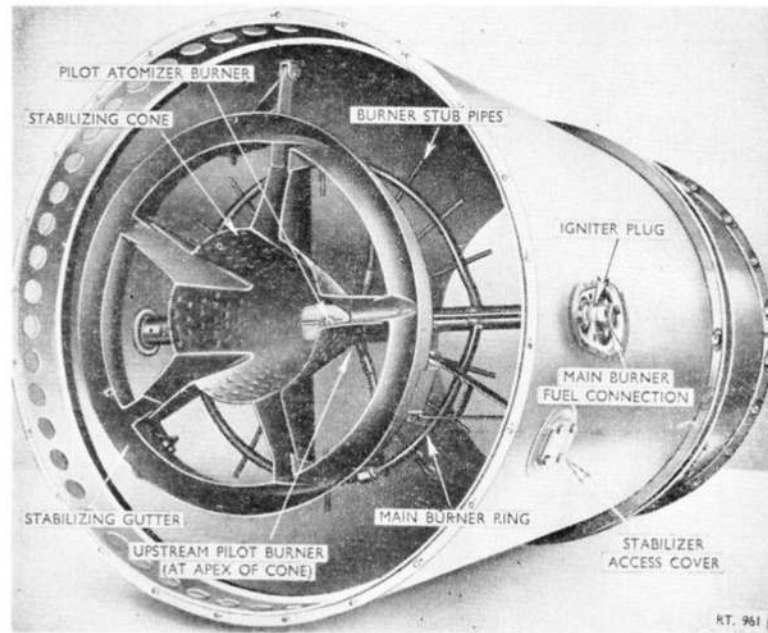


Fig. 8. Burner assembly

Operation of reheat system

31. Under non-reheat conditions the nozzle is closed and the indicator shows BLACK. When reheat is required the engine is accelerated to maximum r.p.m. and the throttle lever then moved into the segment marked REHEAT. The nozzle warning indicator will show WHITE, indicating that the nozzle is still closed; in approximately 2 to 3 seconds the indicator will change to BLACK showing that the nozzle has opened and that reheat is in operation.

32. When the throttle lever is moved into the reheat segment two switches are closed to energize a circuit which operates as follows:—

- (1) The solenoid-operated valve in the pilot shut-off cock opens and permits high pressure fuel from the engine pump to pass to the pilot atomizer burner in the reheat burner cone.
- (2) A booster coil is energized and supplies a high-tension spark at the igniter plug which ignites the fuel and produces a pilot flame.
- (3) In the control unit, two solenoid-operated valves are energized; one opens the override valve and spills air from a diaphragm controlling a half-ball valve in the servo system thus causing the valve to close, and the other solenoid closes the air shut-off cock. The resultant increase in servo pressure moves the servo piston, opens the air throttle and permits P_2 air to flow to the fuel pump. At this stage the control unit is unresponsive to P_2 - P_4 .
- (4) The reheat-pump is started and commences to pass fuel into the main shut-off cock chamber. When the pump outlet pressure reaches a pre-set figure, the contacts of a pressure switch close and pass current to four other circuits; these respond as follows:—

- (i) The solenoid-operated nozzle control valve moves and passes air to the rear side of the nozzle ram pistons and the eyelids commence to open.
- (ii) The solenoid operated valve in the main shut-off cock opens and spills fuel from the rear of the shut-off diaphragm. The unbalance in pressure across the diaphragm lifts a plate valve which permits pump delivery fuel to flow to the main reheat burner.
- (iii) The controller override closes and puts the reheat control unit in control of the reheat fuel flow.
- (iv) The time switch motor is set in operation.
- (5) The nozzle is now fully open with the indicator showing BLACK, and reheat is in operation.
- (6) The time switch operates and in sequence:—
 - (i) After 3 seconds, temperature limiter is operative.
 - (ii) After 30 seconds, igniter is cut off.
 - (iii) After 30 seconds, time switch motor cuts off.

33. If an excessive temperature is generated in the jet pipe the temperature limiter in the reheat system energizes a relay which opens and breaks the circuit to the reheat units thus cancelling reheat and closing the nozzle.

Cancelling reheat

34. When the throttle lever is moved out of the reheat segment on the quadrant, the reheat switch opens and current ceases to flow to the reheat units whereupon all the control solenoids are de-energized, allowing the reheat-pump fuel and air cocks and the jet pipe nozzle to close simultaneously.

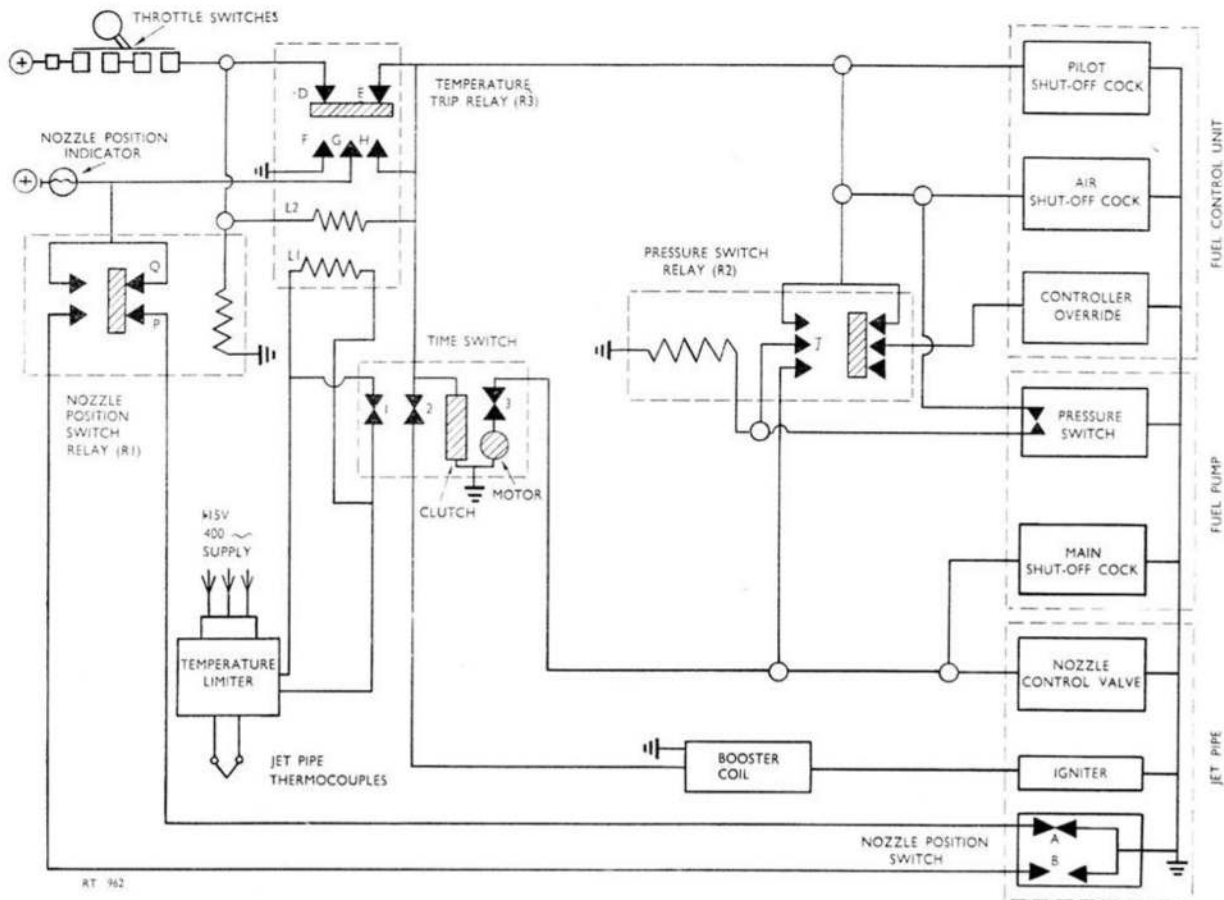


Fig. 9. Electrical system diagram

KEY TO FIG. 9 (ELECTRICAL SYSTEM DIAGRAM)

First sequence

- 1 WHEN THE THROTTLE IS MOVED INTO THE REHEAT POSITION TWO SERIES WIRED SWITCHES CLOSE AND PASS CURRENT INTO THE REHEAT CIRCUIT.
- 2 CURRENT FLOWS THROUGH POINTS A IN THE NOZZLE POSITION SWITCH AND POINTS P AND Q IN RELAY R₁ TO THE NOZZLE POSITION INDICATOR.
- 3 CURRENT FLOWS THROUGH POINTS D & E IN THE TEMPERATURE TRIP RELAY (R₃) TO THE PILOT SHUT-OFF COCK, THE AIR SHUT-OFF COCK AND THE CONTROLLER OVERRIDE. AT THE SAME TIME IT ALSO PASSES FROM RELAY (R₃) THROUGH NO. 2 CONTACTS IN THE TIME SWITCH TO THE BOOSTER COIL AND IGNITER.
- 4 FUEL IS NOW EMITTED FROM THE PILOT BURNER AND THE IGNITER PLUG SPARKS TO PRODUCE A PILOT FLAME, AND THE FUEL PUMP IS RUNNING.

Second sequence

- 1 WHEN THE PRESSURE SWITCH CONTACTS CLOSE, CURRENT PASSES TO ENERGISE RELAY R₂ WHICH ISOLATES THE CONTROLLER OVERRIDE AND, AT THE SAME TIME, PASSES CURRENT TO THE TIME SWITCH MOTOR AND TO THE SOLENOIDS IN THE MAIN SHUT-OFF COCK AND THE NOZZLE CONTROL VALVE. CONTACTS J IN RELAY R₂ KEEP THE RELAY ENERGISED IF THE PRESSURE SWITCH CONTACTS OPEN.

- 2 THE TIME SWITCH MOTOR IS STARTED AND THE NOZZLE OPENS, BREAKING CONTACTS A IN THE NOZZLE POSITION SWITCH AND THUS THE CURRENT SUPPLY TO THE NOZZLE POSITION INDICATOR.
- 3 THE REHEAT SYSTEM IS NOW IN ACTION

Time switch motor

- (a) AFTER 3 SECONDS CONTACTS NO. 1 OPEN AND ALLOW CURRENT TO FLOW THROUGH COIL L₁ IN RELAY R₃ THUS MAKING THE TEMPERATURE LIMITER OPERATIVE.
- (b) AFTER 30 SECONDS CONTACTS NO. 2 OPEN TO BREAK THE IGNITER CIRCUIT AND CONTACTS NO. 3 OPEN TO BREAK THE TIME SWITCH MOTOR CIRCUIT; A FLYBACK CLUTCH MAINTAINS THE CONTACTS IN THESE POSITIONS.

Operation of temperature trip

IF AN EXCESSIVE TEMPERATURE IS EXPERIENCED IN THE JET PIPE THE TEMPERATURE LIMITER ENERGISES COIL L₁ IN RELAY R₃, CONTACTS D AND E OPEN AND BREAK THE CIRCUIT TO THE REHEAT UNITS. CONTACTS F, G, H, CLOSE AND ENERGISE COIL L₂ IN RELAY R₃ WHICH HOLDS THE RELAY IN.

Cancellation of reheat

WHEN THE THROTTLE IS MOVED OUT OF THE REHEAT SEGMENT THE THROTTLE SWITCHES OPEN AND BREAK THE CURRENT SUPPLY TO THE SYSTEM.

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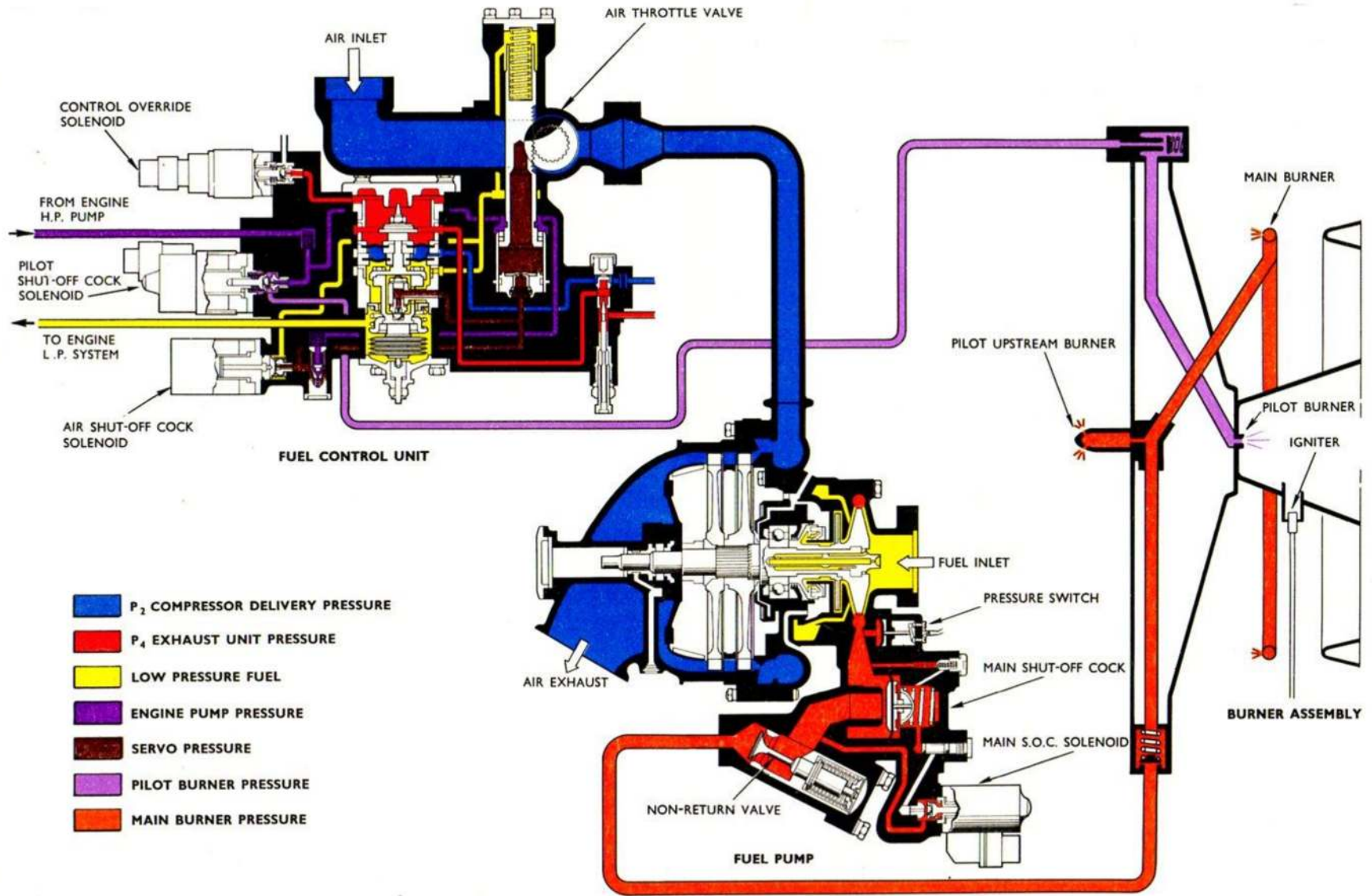


Fig. 7 Fuel system diagram

