CHAPTER 2 FUEL SYSTEM

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TO STARB'D WING TANKS

TO STARB'D WING TANKS

COLOUR KEY

FUEL
RE-FUELLING / DE-FUELLING
RE-FUELLING
DE-FUELLING
AIR PRESSURE
VENTS
DRAINS

FROM OUTB'D DROP TANK.

TO OUTB'D DROP TANK

NOTE :- FROM THE NON-RETURN VALVE THIS PIPE IS A VENT DURING RE-FUELLING.

FIG. I. FUEL SYSTEM INSTALLATION.

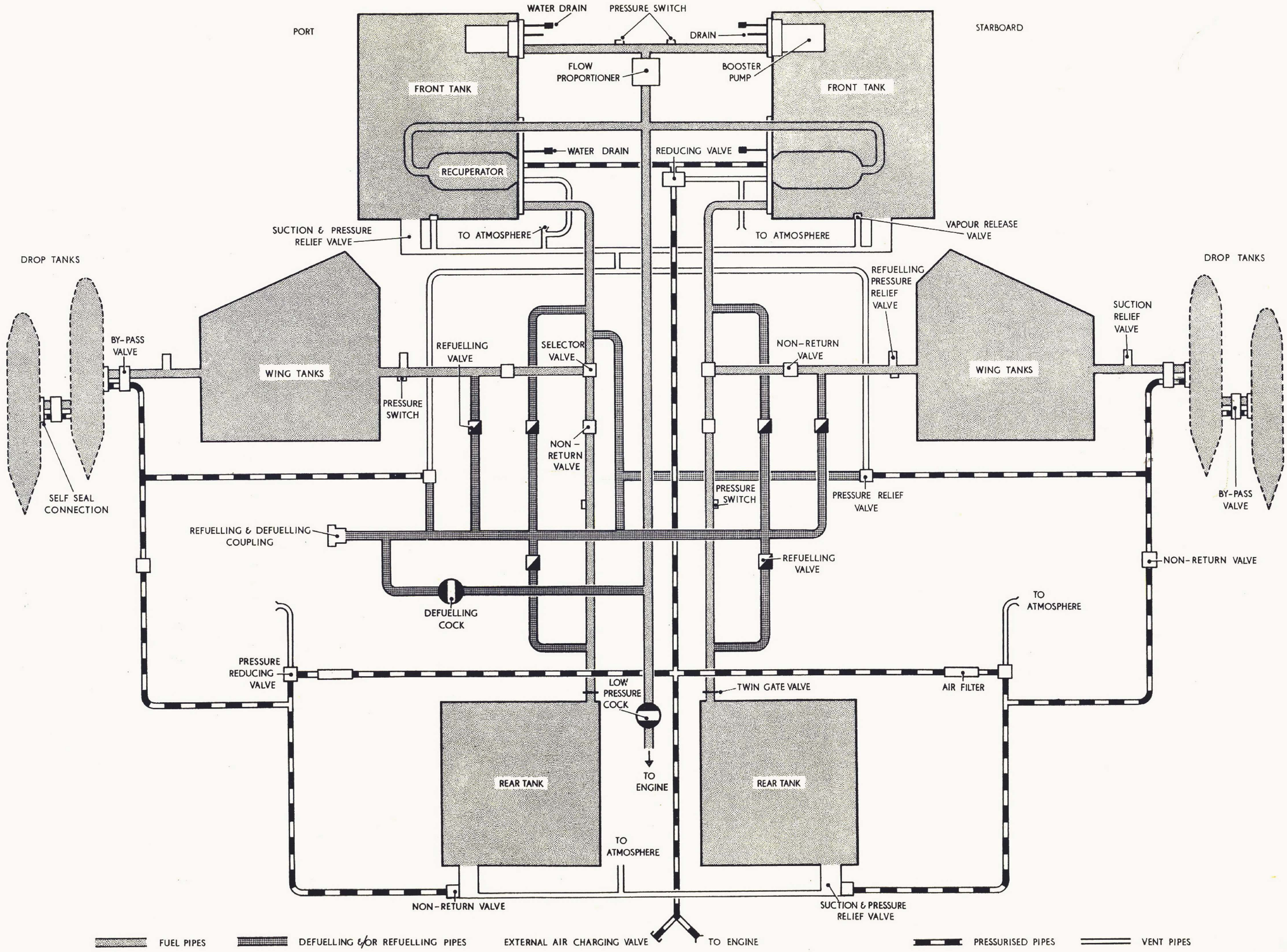


FIG. 2 FUEL SYSTEM DIAGRAM

DESCRIPTION AND OPERATION

Introduction

1. The fuel system consists of four flexible bag-type tanks installed within the fuselage and four in each wing. In addition, and according to operational necessity, two drop tanks may be carried on universal pylons under the wings. The system, including drop tanks, has been designed for pressure refuelling. Delivery of fuel to the engine is from the front pair of fuselage tanks, the supply being supplemented by means of electrically-driven booster pumps, one of which is submerged in each front tank.

2. Transfer of fuel from the remaining tanks to the front tanks is accomplished by air pressure obtained from a restricted tapping on the engine compressor. Provision is made to ensure an adequate supply of fuel when the aircraft is flying under negative 'g' conditions. The capacity of the tanks is given in the Leading Particulars.

Fuselage tanks

3. The four fuselage tanks are flexible rubber bag-type tanks reinforced with madapollan vulcanized on the outside. Over this reinforcement are three layers of glass cloth, the tanks afterwards being finished with fire-proof laquer. Two of these tanks are installed in the centre fuselage forward of the main spar frame and the other two in the rear fuselage where they together encircle the rear of the engine.

4. Each front tank is provided with an S.P.E.2009 electrically-driven and immersed fuel booster pump. These supplement the flow to the engine-driven pump unit which increases the pressure still further before the fuel is passed to the high pressure cock. Also housed in each front tank is a Type R.C.38A, Mk.2 inverted flight recuperator. A description of these and their function is given in para.14.

5. All four tanks are provided with a combined suction and pressure relief valve (para.22). These valve units are similar in construction to each other except that the rear tank units accommodate a third valve that is used as a non-return for fuel tank pressurisation purposes. Non-return valves are fitted in the transfer pipe lines between the rear tanks and the tank selector cocks to prevent back flow during refuelling of the system. Ganged cocks are inserted, one in each transfer pipe, at their breakdown points in the region of the transport joint. These are only accessible when the transport joint butt strap is removed. Known as the 'twin gate valve', these cocks should always be turned off during the process of the removal of the rear fuselage from the remaining structure. The front tanks are fitted with vapour release valves (para.9).

Wing tanks

6. Each wing accommodates four tanks, these being installed in the wing in bays formed between ribs A and 1, 1 and 2, 2 and 3, and between ribs 3 and G. They are flexible rubber bag-type tanks with nylon net reinforcement vulcanized on the outside and finished with fire-proof laquer. The

four tanks are interconnected and, for practical purposes, may be considered as one tank. The fuel from these tanks is transferred to the fuselage system by air pressure (para.10-11), interconnection being by means of transfer pipes, one of which runs from each inboard tank to its respective selector cock in the centre fuselage. These pipes each contain a non-return valve to prevent back flow during refuelling. The tanks are provided with a pressure relief valve (para.23) and a suction relief valve (para.24).

Drop tanks

7. On the underside of each wing, provision is made for the fitting of universal pylons. Situated just outboard of the wing tanks, these pylons are designed to carry various external stores, including drop tanks. The tanks, when fitted, are in connection with the wing tanks, by means of transfer pipes. These pipes and the air pressure pipes which feed engine air into the drop tanks for fuel transfer purposes, are joined to the drop tanks by means of self-sealing connections which interconnect the air and fuel pipes when the drop tanks are jettisoned. A by-pass valve, consisting of a ducted plate which interconnects the air and fuel pipes, is assembled to the wing when a pylon is not fitted. Each drop tank, which is of streamlined plastic construction, has its own float switch. These switches, like their counterparts in the wing tanks with which they are in parallel, come into action automatically during refuelling of the tanks. The construction of the universal pylons to which the drop tanks may be attached, is described in Sect.3, Chap.2 of this volume and the drop tank release mechanism in Sect.5, Chap.1.

Refuelling valves

8. The refuelling valves Mk.17, one of which is fitted into the pipe line to each tank, are servo controlled, the servos being operated by the refuelling pressure. They are in direct connection with the standard $1\frac{1}{2}$ in. refuelling coupling in the port wheel bay.

Vapour release valves (fig.6)

9. The vapour release valves, one of which is fitted to each front tank, are rubber-faced poppet valves controlled by cork floats. The floats have a weighted arm which renders the valve inoperative when the tanks are subjected to negative 'g' conditions. The function of the valves is described in para.12 and 30.

Fuel tanks pressurisation

10. For the transfer of fuel to the front tanks, at all altitudes and rates of flow, a pressure of about 6 lb. per sq.in. is required. The air supply for tank pressurisation is taken from a restricted tapping on the engine compressor. From this tapping, a pipe conveys the air through a non-return valve to a junction from where one pipe continues via a pressure reducing valve to split up and feed air to the recuperators in the front tanks. The other two pipes from the junction turn outwards, each to join an air filter and continue to a reducing valve. From the reducing valves, the pipes branch to feed the rear and wing tanks, (or drop tanks if fitted). Non-return valves are inserted in the pipe lines to the wing tanks; the rear tank feed utilises the non-return valve which is incorporated in the tank suction and pressure relief

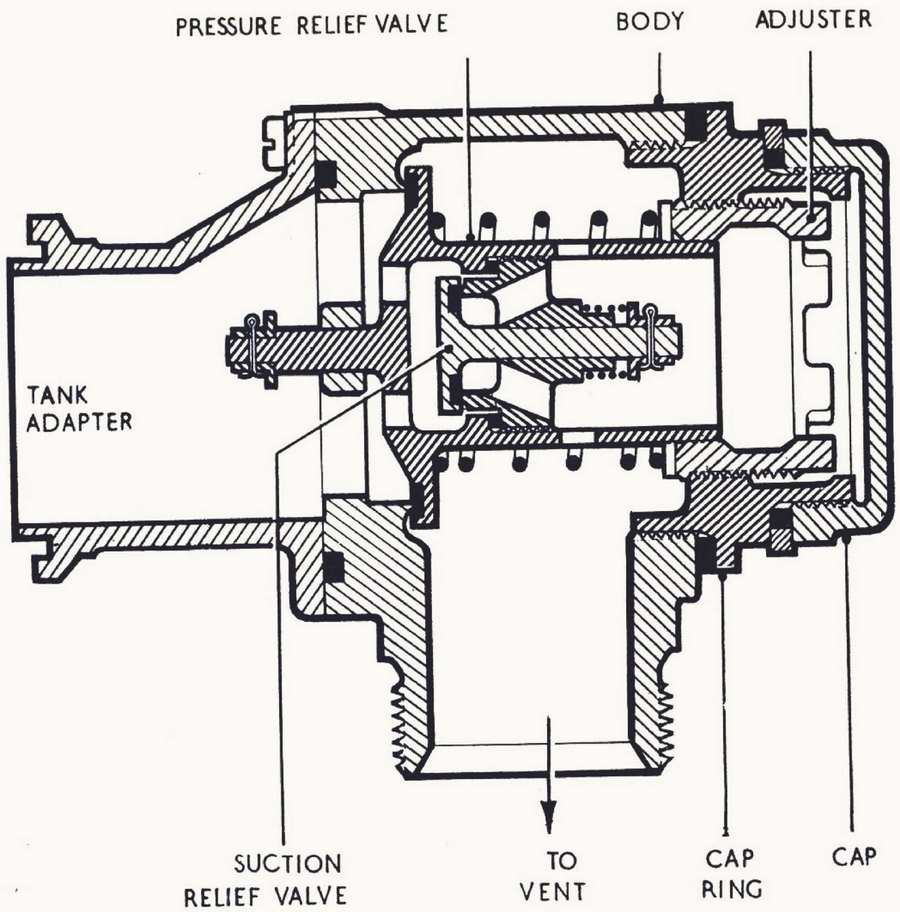
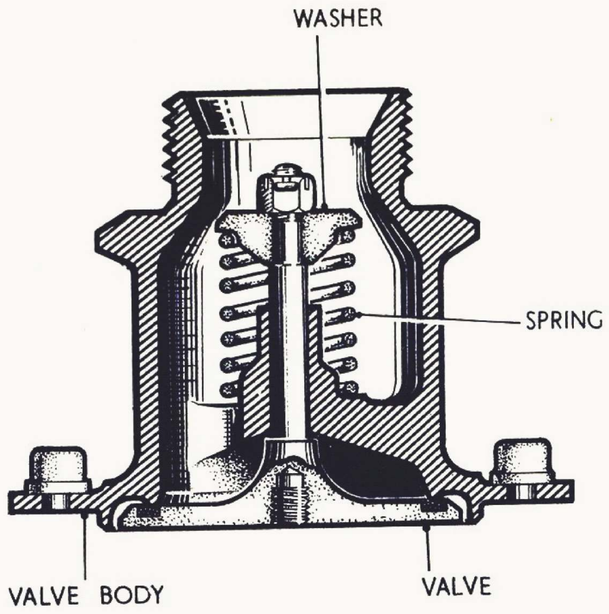


FIG. 3 SUCTION AND PRESSURE RELIEF VALVE



VALVE MUST NOT LEAK AT 6LB SQ. IN. PRESSURE

FIG. 4 REFUELLING PRESSURE RELIEF VALVE

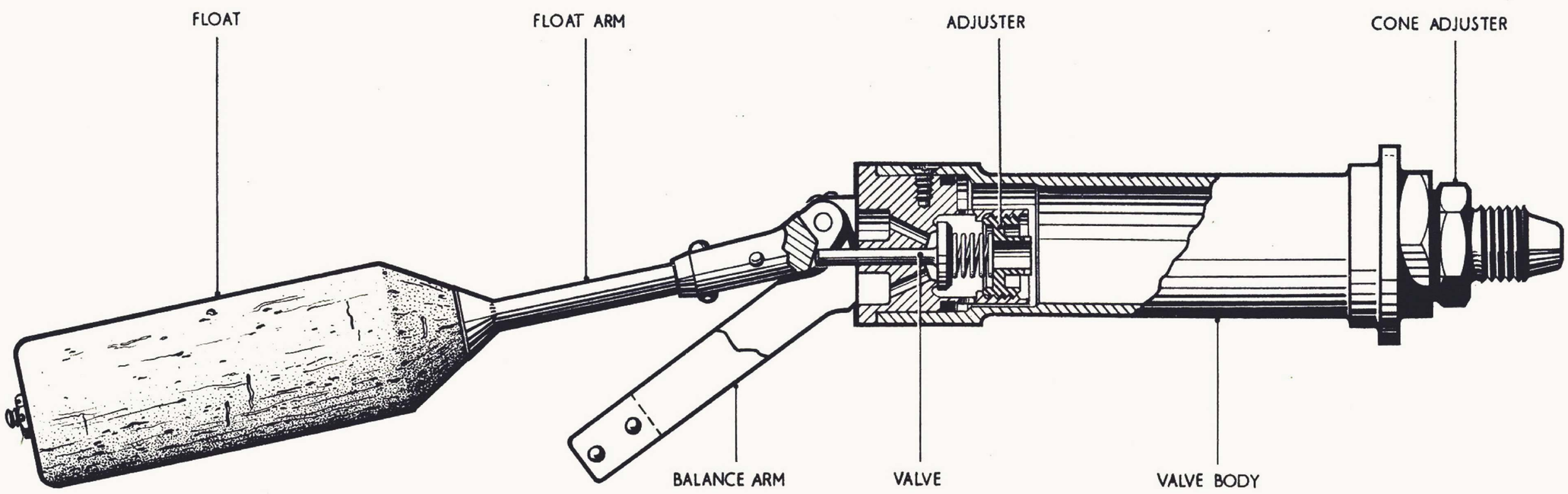


FIG. 6 VAPOUR RELEASE VALVE

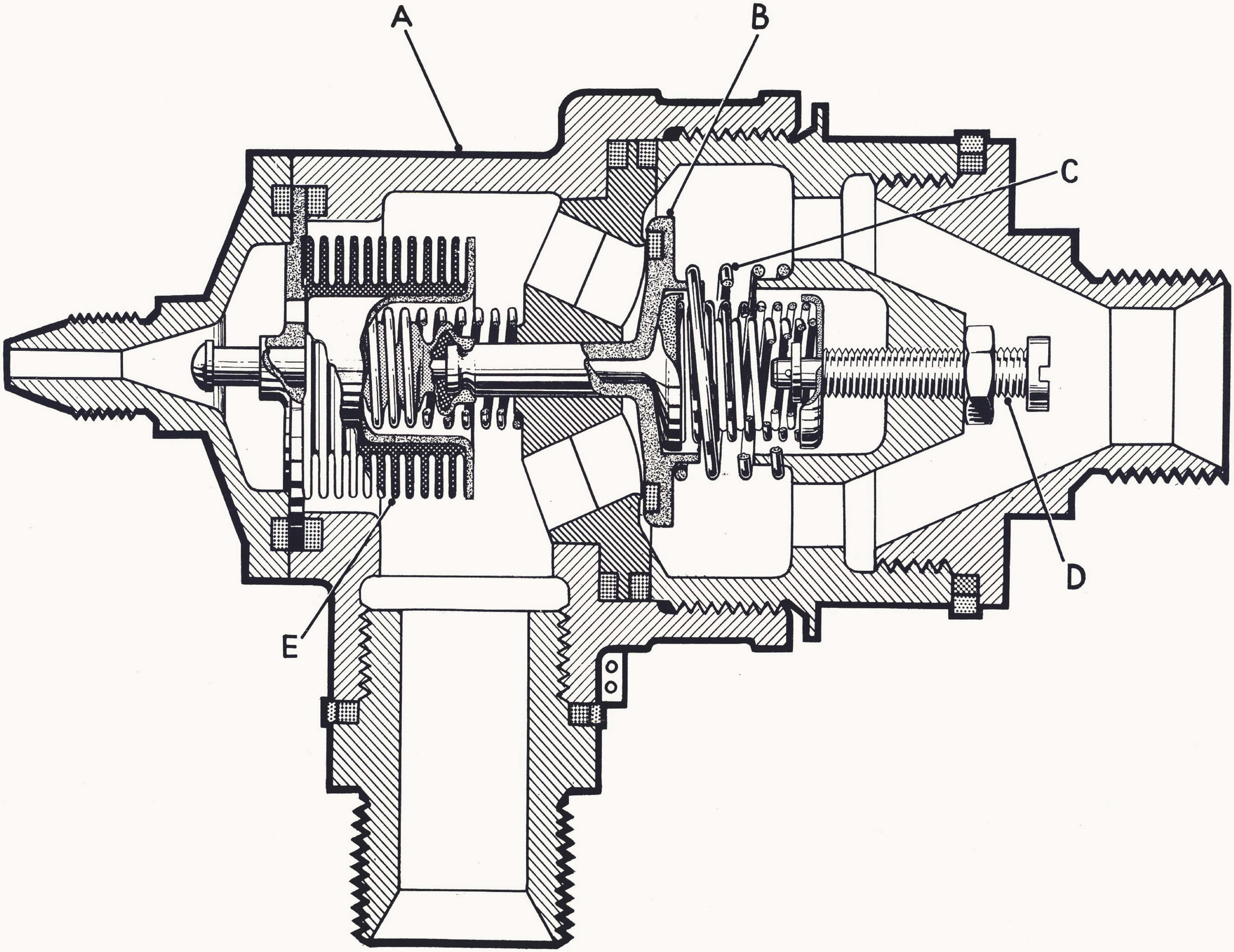


FIG. 5 WING TANK PRESSURE RELIEF VALVE

valve unit (para.22). The pressure reducing valves serving the rear and wing or drop tanks have an outlet pressure of 6 lb. per sq.in. and that for the recuperators 10 lb. per sq.in. A branch pipe from the engine air pressure pipe is in connection with an external air charging connection mounted in the spine of the centre fuselage.

Fuel transfer

11. Air pressure, from the tank pressurisation system (para.10), causes displacement of the fuel from the outboard wing tanks to the inboard wing tanks and thence via a non-return valve and selector cock to the front tanks. When drop tanks are fitted, displacement from these tanks is to the outboard wing tanks. Thus the drop tanks are the first to empty. When the inboard wing tank is empty a low-level float switch in the tank operates the selector cock to close the wing tank transfer pipe and open the pipe from the rear tank. Air pressure in the rear tank then forces the fuel to the front tank. Normally, the selector cock is operated automatically, but switches situated in the cabin enable the pilot to override the control should such action become necessary. A cock position indicator is mounted adjacent to the switches.

12. Under certain conditions of flight, particularly during inverted flying, air may pass into the front tanks. Air also comes out of solution from the fuel at altitudes, or the fuel may boil. The expansion of this air, or vapour, while climbing may prevent fuel transfer, allowing the front tanks to drain while fuel remains in the other tanks. To prevent this, a vapour release valve (para.9) is fitted to each front tank. When the fuel level falls, the valves open, allowing air or vapour to escape to atmosphere and the fuel to transfer. The valve is overridden during negative 'g' conditions to prevent fuel draining out of the vent pipe. Should the air pressure system fail, very little fuel will transfer from the wing or rear tanks and the fuel transfer indicator in the cabin will operate. The transfer switches operating the indicator are also coupled to the fuel contents gauges, giving an EMPTY indication to the rear or wing tanks when pressure fails. Thus, when transfer failure is indicated, the contents of the front tanks only is shown, this being the only fuel available to the engine.

Fuel flow proportioner

13. A Rotol F.F.P.2/2 fuel flow proportioner is fitted in the main delivery line from the booster pumps. It consists of a ganged pair of vane type pumps with a non-return valve in each side and a by-pass valve to permit flow if the pump rotor jams. Providing that the inlet pressures to the unit do not differ by more than 2 lb. per sq.in., the flow proportioner ensures that equal amounts of fuel are taken from both sides of the tank system.

Inverted flight recuperators

14. The two inverted flight recuperators Type R.C.38A, Mk.2 are $3\frac{1}{2}$ gallon rubber bags contained in metal cases and stowed, for convenience, one in each front tank. Fuel is fed to one side of the recuperators by means of branch pipes from the main delivery line to the engine just downstream of the flow proportioner while air pressure from the tank pressurisation system is fed to the other side via a reducing valve which has an outlet

pressure of 10 lb. per sq.in. This air pressure is sufficient to force the stored fuel out of the recuperators to the engine when the pump pressure fails, as for example, during inverted flying. A relief valve, set to 8 lb. per sq.in., allows the air to discharge to atmosphere when the booster pumps again provide sufficient pressure for re-charging the recuperators.

Delivery

15. Fuel is delivered to the engine-driven fuel pumps from the front tanks by means of S.P.E.2009 electrically-driven immersed booster pumps. These pumps are designed for two-speed operation. Normally, they run continuously throughout flight in low speed but either is capable, in high speed, of supplying the maximum fuel demand from the engine. The pumps are controlled by independent switches situated on the cabin starboard shelf. The high or low speed operation is controlled by pressure switches tapped into the pump outlet pipes. These pressure switches are set to operate at 8 lb. per sq.in. with falling pressure and 12 lb. per sq.in. with rising pressure. Failure of pressure from one pump operates, through a relay, an indicator in the cabin and switches the other pump to high speed. Should one pump fail, the other should be switched OFF and the fuel fed by pressure to the engine equally from both sides of the system, unless sufficient fuel remains in the sound side to complete the flight. Under these conditions, the low-pressure warning light may come on and the engine should be throttled back until the light goes out, as otherwise the engine pump may be damaged. Also, the recuperators will discharge and no negative 'g' manoeuvres can be carried out. The sound pump should be switched on for landing.

16. From the booster pumps, the fuel passes to the flow proportioner which ensures a balanced flow from the two sides of the system under normal conditions (para.13) and thence via the low-pressure cock to the engine. Branch pipes from this main delivery line feed the recuperators (para.14). On the pipe carrying fuel from the low-pressure cock to the engine is a tapping carrying a pressure switch which operates the low-pressure warning indicator in the cabin.

Throttle control

17. The throttle control is mounted in a quadrant on the cabin port shelf and moves forward from CLOSED to OPEN. The first part of this movement opens the high-pressure fuel cock.

Low-pressure fuel cock control

18. The low pressure fuel cock control is mounted on the cabin port shelf and moves forward from OFF to ON. The cock is fitted in the main pipe line from the flow porportioner to the engine inlet. It should never be turned OFF before the throttle is closed.

Fuel contents gauges

19. The Smith-Waymouth fuel contents gauges, one each for port and starboard, are mounted together on the cabin starboard shelf. The tank units, which are assembled by the tank manufacturers, consist of small condensers on flexible straps. These are fitted into pockets in the tanks and are secured by press fasteners. The condensers operate the gauges through amplifier units. There are no gauges for the drop tanks.

Fuel pump test switches

20. A selector switch and an ammeter socket, mounted on the cabin starboard shelf, are provided for testing the fuel pumps. The fuel pump circuit breakers are mounted on the same shelf and must be tripped before the pumps are tested.

Engine-driven pump

21. The high-pressure engine-driven fuel pump is of the dual multi-plunger type consisting of two pumps in the same casing interconnected by spur gears which drive a third shaft carrying a hydro-mechanical governor rotor. The pump delivery is controlled by servo pistons which alter the stroke of the pump plungers. For further information on the engine-driven pump and the engine fuel system generally, reference should be made to the engine handbook.

Suction and pressure relief valves (fig.3)

22. The suction and pressure relief valves, one of which is fitted to each fuselage tank, consist of a body which contains a spring-loaded relief valve which is adjusted to open at the required pressure by means of an adjuster which screws into a cap ring. After adjustment, the cap ring is sealed by a cap. The valves of the front tank units are set to lift at a pressure of $10\frac{3}{4}$ - $11\frac{1}{4}$ lb. per sq.in., and those of the rear tanks to $6\frac{3}{4}$ - $7\frac{1}{4}$ lb. per sq.in. This pressure relief valve in each unit incorporates a small suction relief valve set to open at a pressure below $\frac{1}{2}$ lb. per sq.in. The action of these small valves is opposite to that of the main valves in that they admit air into the tanks should the pressurisation system fail, so preventing the formation of a negative pressure and possible collapse of the tanks. The valve units of the rear tanks incorporate an adaptor which contains a third valve. These valves are lightly loaded, being set to open at a pressure below $\frac{1}{2}$ lb. per sq.in. They serve as non-return valves in the fuel tank pressurisation system, the valves being in connection with the reducing valves in the air system. They are also in connection, through the same piping system, with the external air charging connection located in the spine of the centre fuselage. Through this connection, air pressure is delivered to the rear and wing tanks to facilitate defuelling of the system (para.31).

Wing tanks pressure relief valves (fig.5)

23. One of these valve units is incorporated in each wing tank circuit. Each unit consists of a body (a) which contains a spring-loaded rubber-faced poppet valve (b). Opening pressure of the valve is dependent on the force exerted by the three springs (c) which is suitably loaded by the adjusting screw (d) to allow the valve to open at a pressure of 7 lb. per sq.in., for normal venting purposes. During refuelling of the system, the bellows assembly (e), actuated by the refuelling pressure, expands and off-loads the double spring. The small outer spring then controls the opening pressure to 2 lb. per sq.in. A bleed pipe is provided from the refuelling system to the transfer pipe to allow the refuelling pressure to leak away after refuelling so that the reducing valve recovers its 7 lb. per sq.in. setting.

Wing tanks suction relief valve

24. The wing tanks are provided with a lightly

loaded rubber-faced poppet valve, one of which is inserted in the piping system in the region of each outboard wing tank. Designed to open at a pressure below $\frac{1}{2}$ lb. per sq.in., they serve as inward vents to relieve the tanks should they be subjected to negative pressure and possible collapse of the tanks.

Refuelling pressure relief valves (fig.4)

25. A refuelling pressure relief valve is fitted in the underside of each stub wing. These are spring-loaded rubber-faced poppet valves which safeguard the wing tanks in the event of a refuelling valve failure.

Fuel filter de-icing (fig.8)

26. Aircraft fuel normally contains a small quantity of water dissolved from the atmosphere. As the fuel temperature falls, some of this water comes out of solution with the fuel and forms ice crystals if the fuel temperature is below about - 10 deg.C. To eliminate a blockage of the system due to an accumulation of ice crystals on the engine fuel filter element, a fuel filter de-icing system is provided.

27. The fuel filter de-icing tank is of stainless steel, partly for its non-corrodible properties but mainly to increase the fire resistance of the system as it is mounted in the engine bay. The tank is provided with a suction and pressure relief valve (fig.8). The valve opens at less than $\frac{1}{2}$ lb. per sq.in., suction and at 6 lb. per sq.in. pressure, the pressure setting being to prevent excessive alcohol loss due to boiling. A Plessey priming pump Type F.P.3 Mk.3 is used in the installation and to ensure an adequate flow of de-icing fluid against the fuel delivery pressure, its relief valve is set to 60 lb. per sq.in. The system is controlled by a F.A.W/A/325 Teddington control valve.

28. Icing is detected by an increase in the pressure drop through the filter, which operates a differential pressure switch. This switch, through a relay, starts the pump and opens the solenoid valve. When the ice is cleared, and the pressure drop returns to normal, the pressure switch opens. This stops the pump and closes the valve. A filter is inserted in the pipe line from tank to pump and a non-return valve in the line from the pump to the fuel system. The metering jet, where alcohol enters the fuel, is a 1/16" dia. orifice protected by a small filter. Filling of the system is given in Sect.2, Chap.2.

Refuelling

29. The aircraft is refuelled by pressure through a standard $1\frac{1}{2}$ in. coupling in the port wheel bay. The L.P. fuel cock, operated from the cabin, and the defuelling cock, accessible via the engine starter access door, aft of the main spar in the bottom of the fuselage, must be turned OFF and the selector cock switches in the cabin must be in AUTO before operations are commenced. A time switch, adjacent to the coupling must be turned ON. This switch energises the refuelling circuit (Sect.5, Chap.1). Smith float switches in the front and rear tanks and the Flight Refuelling switches in the outboard wing tanks and drop tanks are ON until the switches are immersed. The refuelling valves, fitted in the pipe lines to the tanks, are essentially servo-controlled poppet valves, the servos being operated by the refuelling pressure. A solenoid, when energised, opens the servo exhaust

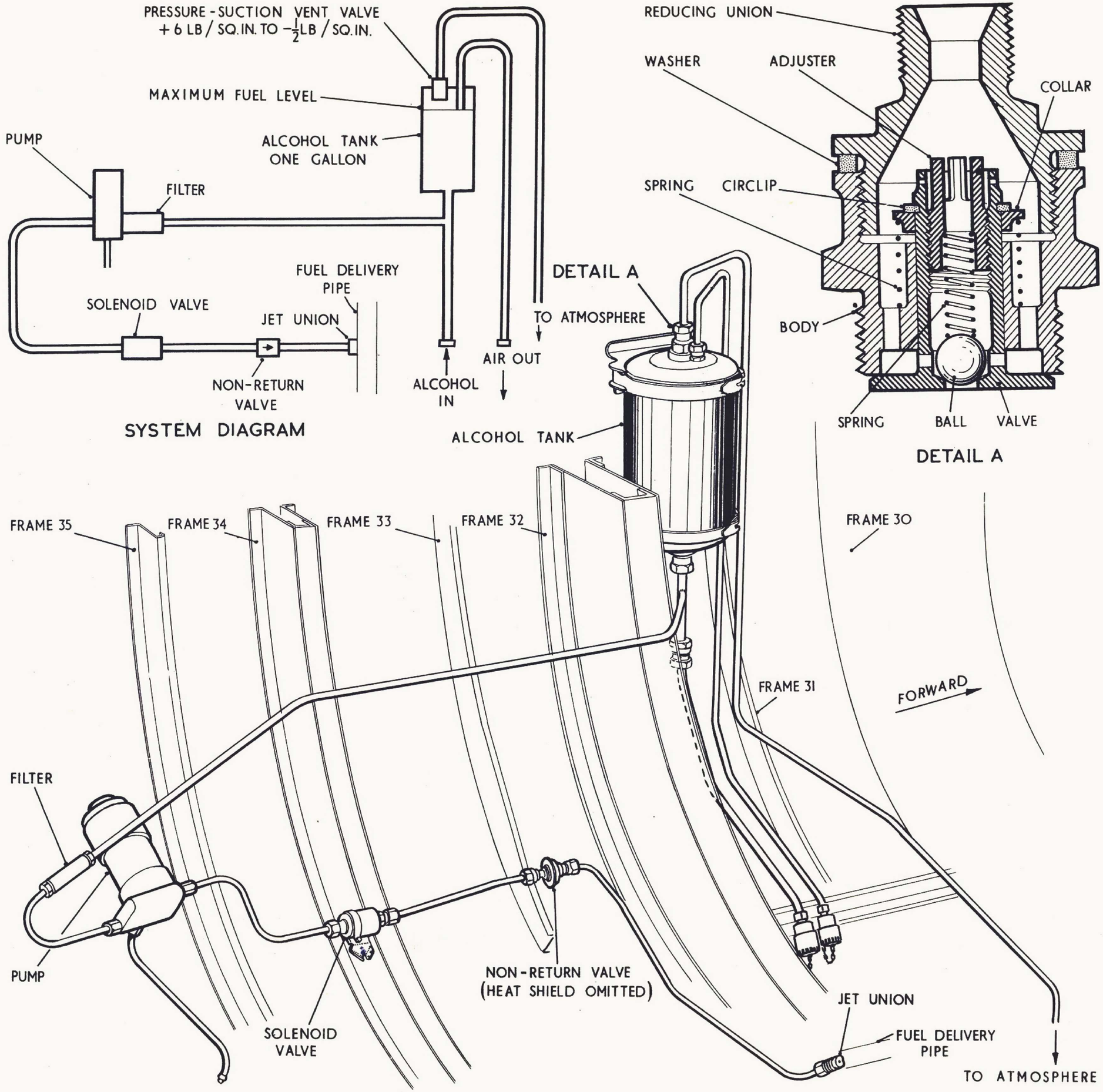


FIG. 8 FUEL FILTER DE-ICING SYSTEM

and allows the valve to open. During refuelling, the fuselage tanks are filled directly from their respective valves. When the tanks are full, the float switches are immersed and go to OFF; this releases the solenoid in the valve. The inboard wing tanks are filled direct from their refuelling valves. When full, they overflow into the second wing tanks, thence to the third tanks and finally to the outboard wing tanks, and drop tanks if fitted. When the outboard tanks are filled, (or drop tanks, if fitted,) the float switches operate to close the refuelling valves.

30. During refuelling, the front tanks are vented to atmosphere via the vapour release valves (para.9), and when these are immersed via the tank relief valves (para.22) which are set at 11 lb. per sq.in., this setting is to prevent transfer pressure plus head of fuel from forcing fuel out of the vents in a steep dive. The rear tanks are vented through the tank relief valves set at 7 lb. per sq.in. The tank pressure relief valves incorporate suction relief valves which are set to open at a pressure below $\frac{1}{2}$ lb. per sq.in. These valves operate in an opposite or inward direction and allow air to enter the tanks should pressure fail, thus avoiding a negative pressure and consequent collapse of the tanks. The wing tanks are vented through a relief valve (para. 23) which normally opens at 7 lb. per sq.in. During refuelling, however, fuel pressure is applied to a bellows incorporated in the valve casing which off-loads the valve and reduces the opening pressure to 2 lb. per sq.in. This is to keep the refuelling pressure in the system at an acceptable value. A refuelling relief valve is fitted to the underside of each wing, set at 8 lb. per sq.in., to safeguard the tanks in the event of a refuelling valve failure. This condition is catered for in the fuselage tanks by large vent pipes. Non-return valves are fitted in the transfer pipes to prevent back flow during refuelling from the front to the rear and wing tanks. The procedure for refuelling the system is described in Sect.2, Chap.2 of this volume.

Defuelling

31. Defuelling is effected from the refuelling coupling in the port wheel bay. The defuelling cock accessible via the engine starter access door, aft of the main spar in the bottom of the fuselage, must be turned ON and the selector cock switches in the cabin put to auto during defuelling. The L.P. cock must be turned OFF. An air pressure of 10 lb. per sq.in. is necessary to transfer the fuel from the wing and drop tanks and the rear tanks to the front tanks from where it is sucked overboard by bowser pump or pumped out by the aircraft booster pumps. The air is fed via the external air supply connection mounted in the spine of the centre fuselage, the air passing through the reducing valves into the wing (or drop tanks) and rear tanks in the same manner as for normal pressurisation.

NOTE...

To completely drain the system, especially the recuperators, pressurisation air must be maintained to the full 10 lb. per sq.in., during defuelling.

General

32. Scrupulous cleanliness is essential during all servicing of the fuel system. The fuel pumps and their accessories are manufactured to a high degree of accuracy and in order to ensure maximum pumping efficiency, tolerances are reduced to a minimum. Consequently, the efficiency of the components will be seriously impaired if foreign matter, however small, is allowed to enter the system. When components are removed for servicing, all orifices exposed as a result of such removal, as well as the pipe ends which connect to them, must be blanked off immediately to prevent the ingress of dirt or moisture. The servicing of certain components of the fuel system is described in the Air Publications appropriate to the component concerned, to which reference should be made when it is found that the servicing of a particular component is not included in this chapter. The procedure for filling, priming and draining of the system is described in Sect.2, Chap.2 of this volume.

Water drains

33. Drain valves are provided in the lowest points of the fuel system from which water can be drawn off during servicing. The procedure for doing so is given in Section 2, Chap.2 of this volume.

Replacement of fuel pipe lines

34. Before attempting to replace fuel pipe lines that have been removed during servicing, or fitting new pipe lines, ensure that they are clean and smooth internally, as sharp edges at joints, nipples etc. can cause aeration of the fuel. When fitted ensure that all connections are effectively locked. The piping of the circuit affected by such replacement should be pressure tested as follows:-

Engine feed lines - 28 lb. per sq.in. This can be satisfactorily approximated by pressurising the tanks to operating pressure and switching on the tank booster pumps.

Refuelling lines (L.P. cock OFF) - 50 lb. per sq. in. This can be carried out with the use of the refuelling bowser.

WARNING

On no account is the test pressure of 50 lb. per sq.in. to be exceeded, as otherwise fuel will flow through the refuelling valve reliefs and out through the vent pipe.

Transfer pipes - 14 lb. per sq.in. (including head of fuel). The tank pressure test described in para.37 will cover this requirement.

Air supply line (engine to tanks)

Apply an air pressure of 120 lb. per sq.in. to the spine air connection, using Mk.1 or Mk.2 Pneumatic Servicing Trolley and adaptor A.208035 and check for leaks. The tank pressure gauges should be observed and should not register more than 7 lb. per sq.in.

NOTE...

During the above test it is essential to ensure that all tank vent lines are clear to guard

against damage to the tanks in the event of a leaking reducing valve.

For general system test, including tanks, reference should be made to para.37.

Refuelling pressure relief valves

35. The refuelling pressure relief valves in the underside of each stub wing should be checked to ensure that they are free to operate by screwing a $\frac{1}{4}$ in. B.S.F. bolt into the valve and pulling the valve down. This is particularly important if the aircraft has not been flown for an appreciable length of time.

Low pressure fuel cock control

36. Adjustment of the low-pressure fuel cock control must be so arranged that with the control lever in the cabin set to the OFF position in its quadrant, the cock is fully closed. (This is important).

Ground pressure testing of fuel tanks

37. The fuel system installation should be pressure tested as follows:-

(1) Fit bung (Part No.A.207899) into the front tanks vent pipe (bottom skin of centre fuselage).

(2) Fit bung (Part No.F.207940) into recuperator vent pipe (bottom skin of centre fuselage, adjacent to front tanks vent pipe).

(3) Fit blanking covers (Part No.A.207818) over the refuelling pressure relief valve in underside of each stub wing (to fit, remove two screws through access door).

(4) Disconnect and plug exhaust from tank pressurisation reducing valves, port and stbd. (Access doors top of centre fuselage on either side of spine, forward of rear transport joint).

(5) Fit pressure gauges (service supply) to tapping points on front tank relief valves (access doors, top centre fuselage, either side of spine in region of main spar).

(6) Remove spine fairing over rear transport joint and connect pressure gauges to pipes leading from rear tanks relief valves.

(7) Fit bung (Part No.A.207563) into rear tanks vent pipe (in region of air brake fairing) and connect bung to Fuel System Ground Pressure Test Control Box (Part No.B.207700) and thence to external air supply trolley.

(8) Fit pressure test connection to fuel pipe tapping in each wheel bay and connect to Fuel System Ground Pressure Test Control Box (Part No.B.207700) and thence to external air supply trolley.

(9) Apply an air pressure of 13 - $13\frac{1}{2}$ lb. per sq.in. with all tanks full. This pressure should be maintained for 10 minutes without any sign of leakage at any point in the system.

NOTE...

It is very important that the test is carried out with all tanks full. Under no circumstances is the test pressure to be allowed to exceed 14 lb. per sq.in.

(10) When the test has been satisfactorily completed, all bungs, blanking covers and other test equipment must be removed immediately. This is particularly important before refuelling or before flight.

WARNING...

On no account is the air brake to be operated while the bung is assembled into the rear vent pipe.

Ground pressure testing of fuel filter de-icing system.

38. A test switch to operate the system on the ground is located adjacent to the solenoid valve in the engine bay. This switch is used in conjunction with special ancillary test equipment which consists of a pressure gauge, a relief valve and associated piping. The procedure for ground pressure testing is as follows:-

(1) The alcohol tank must be full, the fuel system primed, the L.P. cock OFF and the throttle closed (i.e. H.P. cock OFF).

(2) Remove the blanking cap from the King drain valve on the fuel delivery pipe in the engine bay and fit the pipe of the test equipment (C.209813) in its place. (The fitting of the pipe opens the valve).

(3) Place the relief valve of the test equipment into a suitable container.

(4) Connect an external air supply to the alcohol tank vent pipe and apply an air pressure of 10 lb. per sq.in. Inspect for leakage in low pressure system from tank to pump.

(5) If no leakage occurs in the low pressure system, remove external air equipment from tank vent and operate test switch to start the pump and inspect for leakage from pump to fuel delivery line. With pump running, the pressure on the gauge should rise to 45 lb. per sq.in. To avoid unneccessary spillage from the test equipment relief valve, do NOT run the pump any longer than is necessary to conduct the test.

WARNING...

The test switch must NOT be operated unless the test equipment with its relief valve is connected to the King drain valve.

Functioning check of fuel filter de-icing system

39. The functioning check of the fuel filter de-icing system, which MUST be carried out daily, using the same equipment as described in para.38, is as follows:-

(1) Prepare the aircraft as described in para.38, sub-para. (1), (2) and (3).

(2) Operate the test switch to start the pump and note pressure on the test equipment pressure gauge, which should rise to 45 lb. per sq.in. Switch off, without delay, once this pressure

has been attained, in order to avoid unnecessary spillage from the test equipment relief valve.

WARNING...
The test switch must NOT be operated unless the test equipment with its relief valve is connected to the King drain valve.

REMOVAL AND ASSEMBLY

General

40. When handling the tanks, extreme care must be taken to ensure that they are not damaged. Under no circumstances are they to be dragged across the floor as such treatment will cause damage to the outer surface of the tanks. When taken out of the aircraft, they should be laid on a layer of felt. The fact that the tanks are flexible does not mean that they may be folded indiscriminately. During removal or installation they should not be folded any more than is absolutely necessary. It is particularly important to remember that the capacitors for the fuel gauges are built into the structure of the tanks and, consequently, may be damaged if the tanks are subjected to rough handling. Under no circumstances may implements of any nature, or material of any kind be inserted into the tanks to push them into the shape of the tank bays during installation, as to do so will cause serious damage to the tanks and capacitors.

41. To prevent leakage at the tank unit connections, after assembly, it is important that the two countersunk screws at each tank opening are flush with the structure. The following method of assembly must be adopted:-

(1) Check that the inner sealing washer is in place on the tank studs. (As an aid to retain the washers on the studs while fitting the tank, the face of the washer in contact with the tank may be lightly smeared with graphite grease).

(2) Fit the studs into the holes provided in the tank bay skin and screw down nuts on the studs adjacent to the countersunk screw holes (4 nuts for the Marston tank and 2 nuts for the Fireproof tank).

(3) Fit and screw down flush, the countersunk screws (2 B.A. for Marston tank and 4 B.A. for Fireproof tank). Remove the nuts, fit the outer sealing washers, fit the unit and bolt down.

Removal of front tanks (fig.9)

42. Either the port or starboard front tanks may be removed first. The removal of the port tank is described, the removal of the starboard tank being similar unless otherwise stated below. During removal, it is essential that the sequence followed is in the order of the following paragraphs. Notes on assembly are also included.

Preliminaries

43. Preparatory to removal, the following operations should be carried out:-

(1) Render the aircraft electrically safe (Sect.5, Chap.1).

(2) Drain the fuel system (Sect.2, Chap.2).

(3) Remove the gun package (Sect.7, Chap.3).

(4) Remove the wireless access door from under the fuselage between frames 16 and 18.

(5) In the case of the port tank, remove the wireless sets and structure (Sect.6, Chap.1 and 2) and the cable clipping on the tank door. Remove the tank door on frame 19. In the case of the starboard tank, remove the ARM J.B.1 (Sect.5, Chap.1), the starter circuit breaker and the circuit breaker T.B. Disconnect the relay 1254 (Sect.6, Chap.1). Remove the cable clipping on the tank door.

(6) Remove the fuel pump access door (14, fig.9) and the fuel system access door (24). Remove the engine starter access door aft of frame 25.

(7) Remove the fuel level switch access door (4) and the fuel vent connection access door (9).

Removing fuel contents gauge terminal box (fig.9)

44. (1) Remove the eight nuts attaching the fuel gauge terminal box (12) to fuselage (frame 19).

(2) Withdraw the terminal box sufficiently to disconnect the electrical cables, then remove the terminal box, with the sealing ring, making sure that the detached cables do not fall back into the tank. (Whilst working at this location, remove the two countersunk screws attaching the fuel tank to the rear of frame 19).

Removing fuel level switch (fig.9)

45. (1) Remove the terminal box cover from the fuel level switch (3), disconnect the cables and put back the cover.

(2) Take off the twelve nuts and remove the fuel level switch and sealing ring. (While on this location, remove the two countersunk screws attaching the fuel tank to the fuselage inner skin).

Removal of tank retaining cords (fig.9)

46. Remove the tank retaining cords as follows:-

(1) Remove the section of the fuselage spine (1) from frame 18 to frame 23.

(2) Remove the screws from the tank retaining nuts (2).

(3) Working from front to rear, insert one hand between the fuel tank and the inner skin of the fuselage and, while compressing the tank with this hand, use the other to cut the retaining cords with a suitable blade. Alternately, it may be found more convenient to insert a drill of suitable size into the

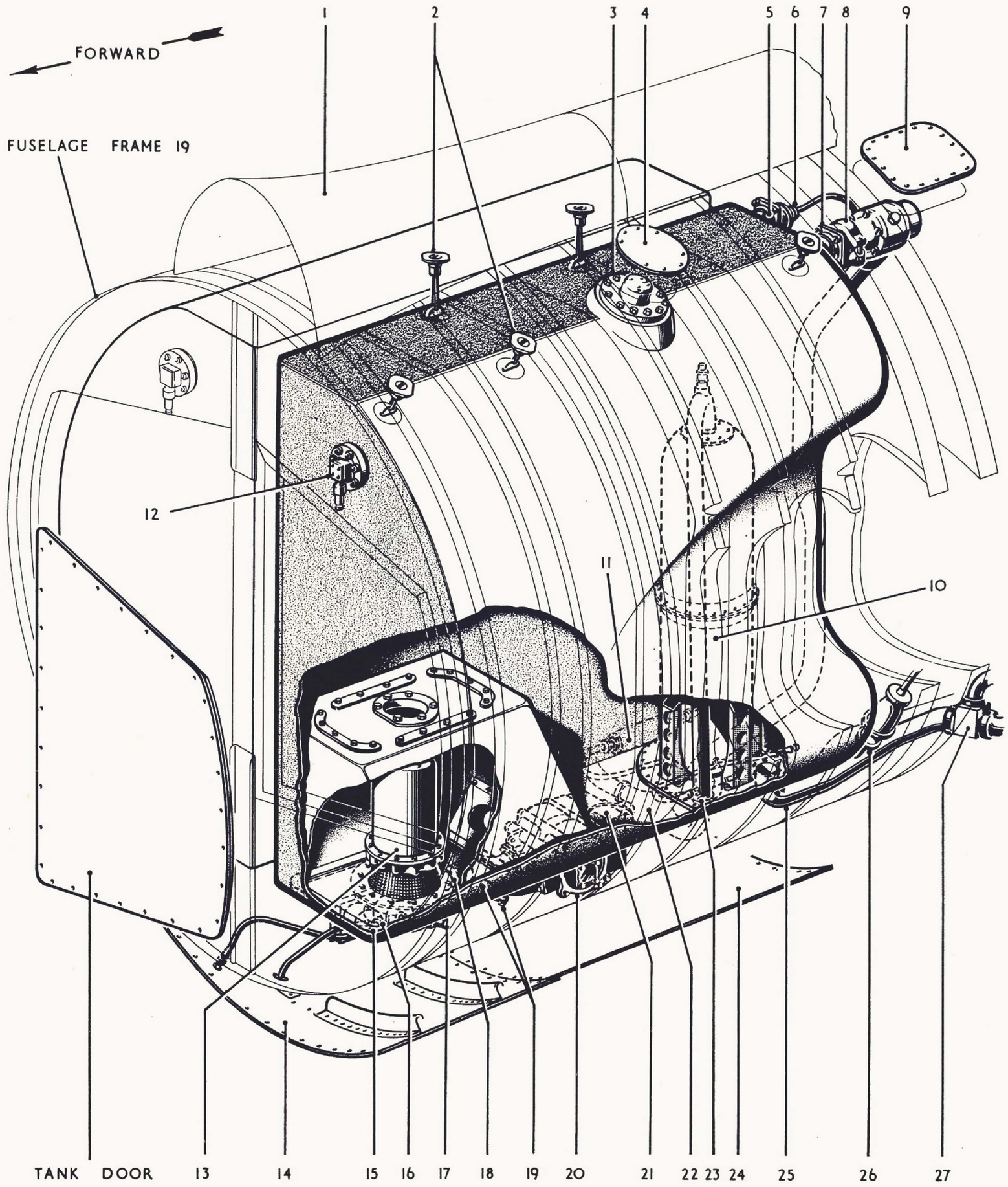


FIG. 9 REMOVAL OF FRONT FUEL TANKS

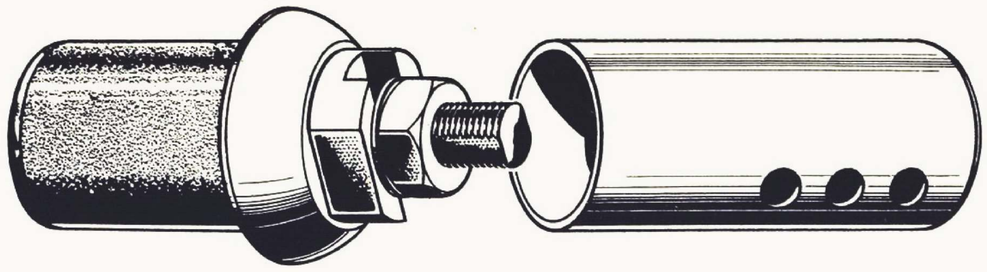


FIG.10 GUIDE FOR SUCTION AND PRESSURE RELIEF VALVE CONNECTION

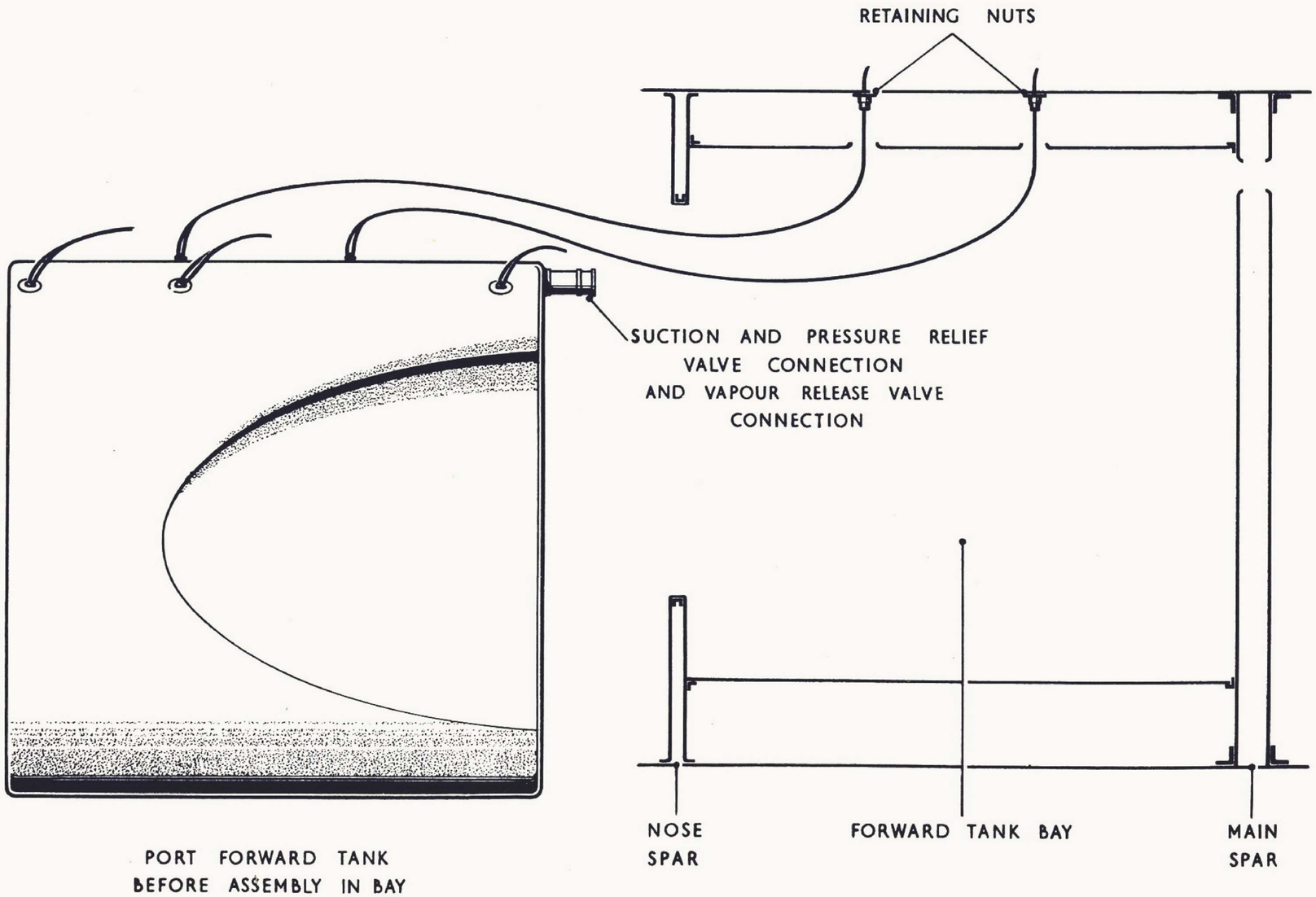


FIG.11 METHOD OF INSTALLING FRONT TANKS

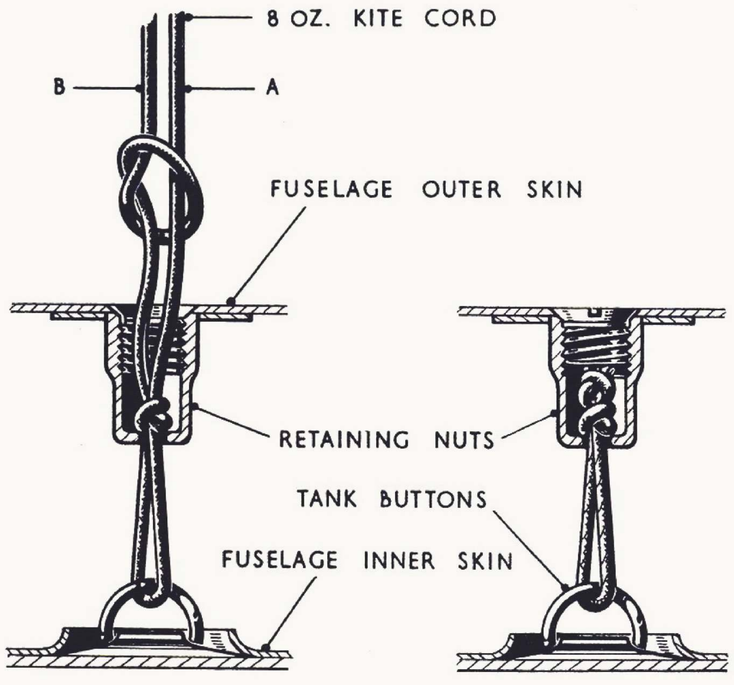


FIG.12 SECURING THE TANK CORDS

tank retaining nuts and chew the cord knots until they are severed, taking care not to penetrate the tank skins or to damage the threads of the tank retaining nuts.

(4) Pull out the severed cords and put back the screws.

Disconnection of suction and pressure relief valve (fig.9)

47. At the connection of the suction and pressure relief valve, disconnection should be effected as follows:-

(1) Unscrew the nut on the clamp eyebolt, swing the clamp (8) open and remove the clamp.

(2) Remove the circlip and the two halves of the collar.

(3) Unscrew the four bolts and remove the two halves of the locking plate (7) on the rear face of the main spar.

Removal of vapour release valve (fig.9)

48. Remove the vapour release valve as follows:-

(1) Disconnect pipe at (6).

(2) Unscrew the vapour release valve retaining nut.

(3) Withdraw the vapour release valve (5).

(4) Unscrew four bolts and remove the two halves of the locking plate on the rear face of the main spar.

Removing blanking plate (fig.9)

49. (1) Take off the twelve nuts and locking lug.

(2) Remove the blanking plate (21) and sealing ring. (While on the same location, remove the four nuts, distance pieces and washers, and the two countersunk screws attaching the support plate to the tank skin and remove the support plate. Remove the gun heating pipe from under the front port tank. Release the strapping on electrical cables under the tank and spread apart or remove as necessary).

Removing booster pump (fig.9)

50. (1) Disconnect the electrical lead (17) on the booster pump (13).

(2) Disconnect the water sediment drain at (15) and the fuel drain at (16).

(3) Disconnect the two pressure pipes at the pressure switch and at (18) on the pipes from the flow proportioner to the booster pump and remove (port only).

(4) Disconnect the fuel delivery pipe (18) on the pump.

(5) Take off the 34 nuts attaching the booster pump to the support plate and tank and remove the pump (13). (While on the same location, remove the four countersunk screws attaching the tank and sealing washer to the support plate).

Removing the inverted flight recuperators (fig.9)

51. (1) Remove the six screws attaching the transfer pipe (25) to the cover plate and disconnect the branch pipes at the refuelling valve (26). Disconnect the pressure balance pipe (port only). Disconnect the transfer pipe at the tank selector valve (27) and remove the transfer pipe with sealing ring.

(2) In the case of the port tank, proceed as follows:-

Remove the clip attaching the four-way branch pipe (22) to the flow proportioner (20). Remove the clip attaching the four-way branch pipe to the recuperator charging pipe. Unscrew the connection of the four-way branch pipe to the recuperator cover plate (23). Unscrew the connection of the four-way branch pipe to the fuel delivery pipe and remove the four-way branch pipe with sealing washers.

(2A) In the case of the starboard tank, observe the following:-

The four-way branch pipe does not have to be removed, but the recuperator charging pipe must be disconnected at the four-way branch pipe and at the recuperator cover plate and removed.

(3) When removing either tank, remove the water sediment drain pipe, the pressurising pipe and the vent pipe attached to the recuperator.

(4) In the case of starboard tank removal, remove the pressurising pipe and pressurising branch pipe from the pressure reducing valve (11), remove nuts and packing from the U bolts attaching the pressure reducing valve to the fuselage structure and remove the pressure reducing valve.

(5) When removing either tank, take off the 32 nuts and remove the inverted flight recuperator cover plate and sealing ring and then remove the recuperator (10). Remove the four countersunk screws attaching the tank to the support plate.

(6) The tank, which is now ready for removal, should be carefully folded and withdrawn through the tank door in frame 19, ensuring that the sealing washers are left on the studs attached to the tank at the fuel contents gauge terminal box (12), at the fuel level switch (3), at the booster pump (13) and at the recuperator cover plate (23). Pipe lines must be blanked off immediately after removal to prevent the ingress of dirt or moisture. Should there be any fuel on the outside of the tank it must be dried off. If the tank is to be stored, blanking plates and caps must be fitted over all apertures.

Assembly of front tanks (fig.10, 11 and 12)

52. The procedure for the assembly of the front fuel tanks is a reversal of the procedure for removal, but the following points should be observed:-

(1) For ease of installation, the inside of the

tank bay and the outer surface of the tank should be greased with M.S.4 silicone release agent.

(2) Ensure that the tank bay is clean and free from all foreign matter, nuts, washers etc.

(3) The suction and pressure relief valve connection and the vapour release valve connection must each be fitted with a guide (Part No. A.194464).

(4) All sealing rings and sealing washers must be examined for serviceability prior to use.

Assembly

53. Proceed with the assembly of the tank as follows:-

(1) Remove the screws from the five tank retaining nuts.

(2) Thread 8 oz. kite cord (Stores Ref.32A/107) through the nuts into the tank bay and out through the tank door in frame 19.

(3) Pass the cords through the buttons on the top of the tank (fig.9, item 2 and fig.12).

Note...

Before assembling the tank, observe the precautions given in para.40 and 41.

(4) Fold the tank and push it into the tank bay. Pull all cords until the tank is held against the tank bay skin by the cords.

(5) Cut the cords and tie one end of the cord round the other in a slip knot (fig.12) and pull down into the retaining nut. Tie another slip knot (around the other end of the cord this time) and work down into the retaining nut as far as possible. Cut both ends of the cord at outer skin level.

(6) Replace the screws in the retaining nuts and lock by peening the skin into the slot.

Miscellaneous precautions.

54. During assembly, the following precautions should be taken:-

(1) All internal fittings, pumps, contents gauge units etc., should be examined for damage and corrosion.

(2) Before tightening up the slip knots, ensure that the tank skin studded plates are positioned correctly and that the holes for the countersunk screws are set squarely against the holes drilled in the fuselage structure. Also ascertain that the suction and pressure relief valve connection and the vapour release valve connection are correctly inserted in the retaining holes in the main spar and that the grooves are engaged correctly with the locking plates on the aft face of the main spar and that the locating lug on the vapour release valve connection is at the top. Unless these precautions are taken, it is possible for the connections to be fractured.

Removal of rear tanks (fig.13 to 20)

55. Either the port or starboard tanks may be removed first. The removal of the port tank is described, and, except where stated otherwise, the removal of the starboard tank is similar. When removing a tank, the sequence to be followed is that given in the following paragraphs.

Preliminaries

56. Before attempting to remove either of the rear tanks, proceed as follows:-

(1) Render the aircraft electrically safe (Sect.5, Chap.1, Group A.1).

(2) Drain the fuel system (Sect.2, Chap.2).

(3) Remove the tail cone (Sect.3, Chap.1) and jet pipe (Sect.4, Chap.1).

(4) Drain any residual fuel from the pipes between the front and rear tanks by means of the two drains (fig.13). (Any fuel remaining below the drains will be released on disconnecting the fuel pipes at the transport joint).

(5) Remove the rear fuselage (Sect.3, Chap.1).

Removing fire protection ring (fig.13 and 14)

57. The fire protection ring should be removed in the following order: Top centre, lower side (port and starboard), side portions (port and starboard) and the bottom centre portion by removing the 18 bolts and washers securing the ring to the detachable support panel and 16 bolts and washers securing it to frame 40B.

Removing twin gate valve (fig.13 and 15)

58. (1) Unscrew and remove the screwed connections from the forward face of the twin gate valve.

(2) Remove the valve control handle.

(3) Disconnect and remove the clamp fittings from the tank connections and the rear face of the valve.

(4) Remove the twin gate valve. (While at this location, remove the connectors and sealing washers from the tanks by unscrewing the nuts from the tank studs. Remove the two countersunk screws (2 B.A. for Marston tanks and 4 B.A. for Fireproof tanks) locating the tanks with the aircraft structure).

Note...

<u>These countersunk screws on all tank unit openings in the structure are for location and alignment purposes of the tank stud rings with the structure during assembly.</u>

Removing fuel gauge terminal box (fig.13 and 16)

59. (1) Remove the access door at the fuel gauge terminal box, adjacent to frame 45.

(2) Remove the cover from the terminal box by removing the six bolts and washers.

(3) Disconnect the electrical lead from the terminal box.

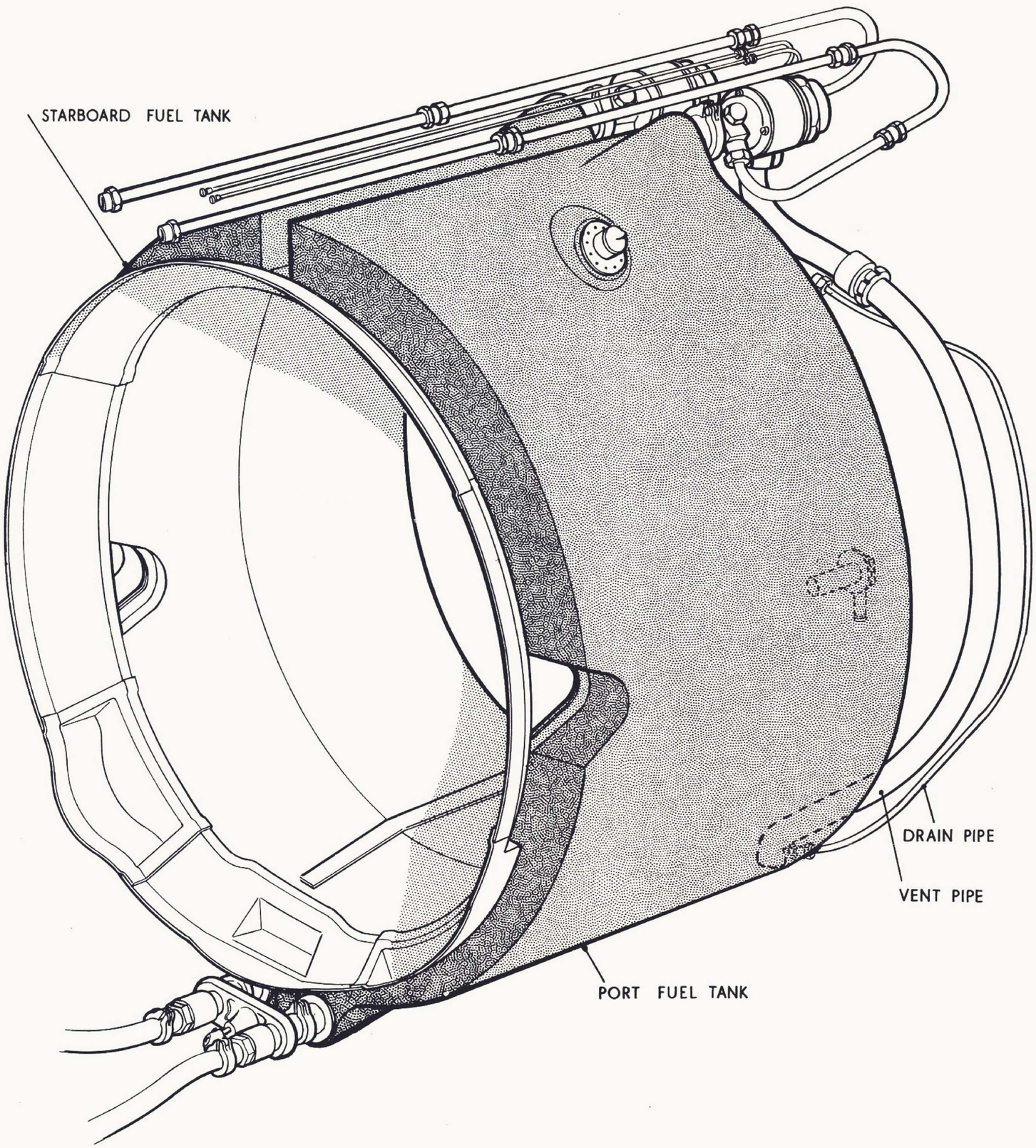


FIG. 13 REMOVING REAR FUEL TANKS

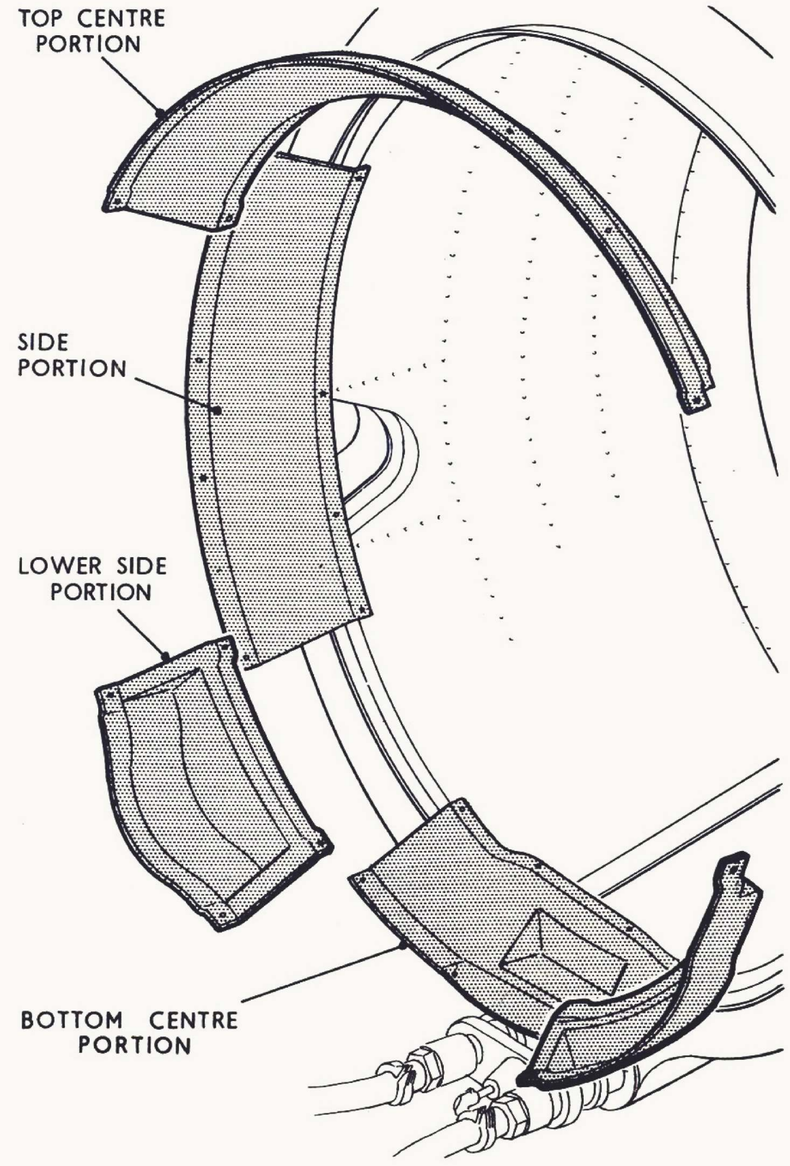


FIG. 14 FIRE PROTECTION RING

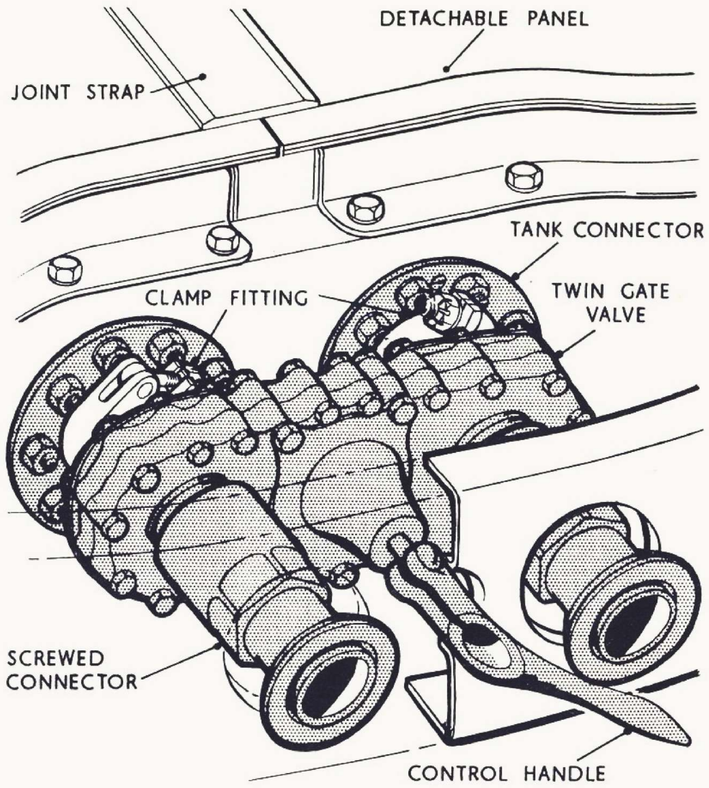


FIG. 15 TWIN GATE VALVE

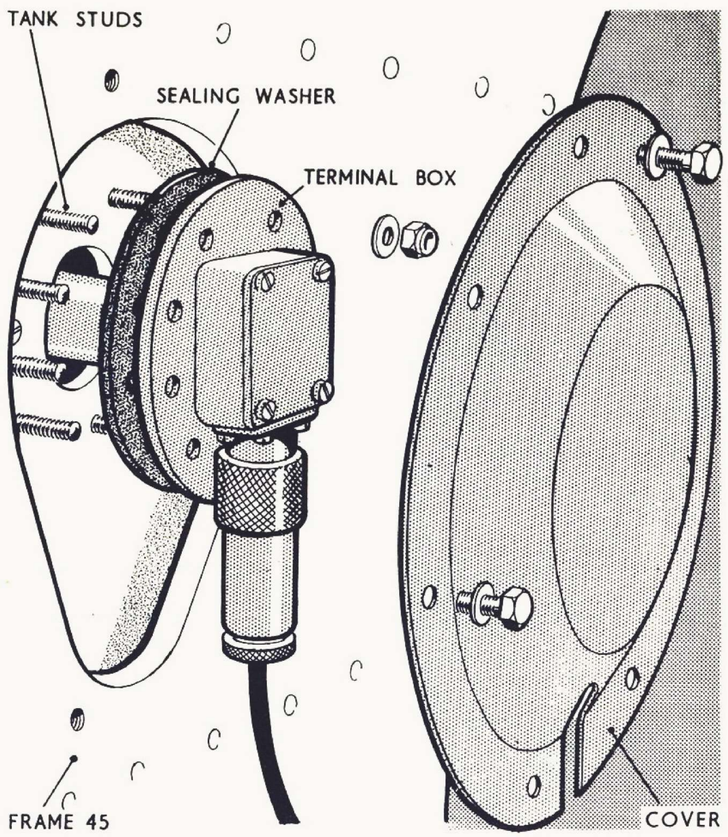


FIG. 16 FUEL GAUGE TERMINAL BLOCK

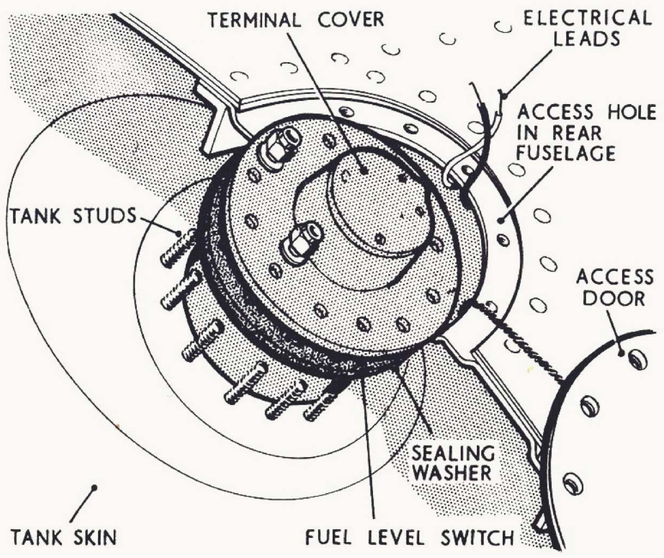


FIG. 17 FUEL LEVEL SWITCH

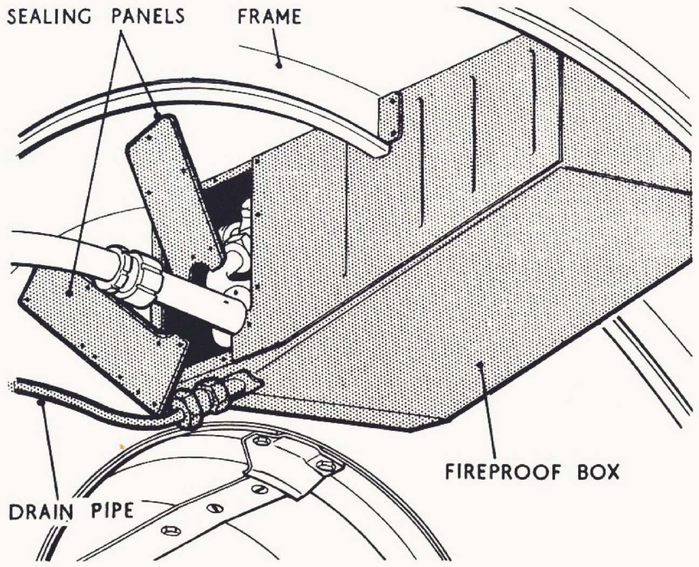


FIG. 18 FIREPROOF BOX

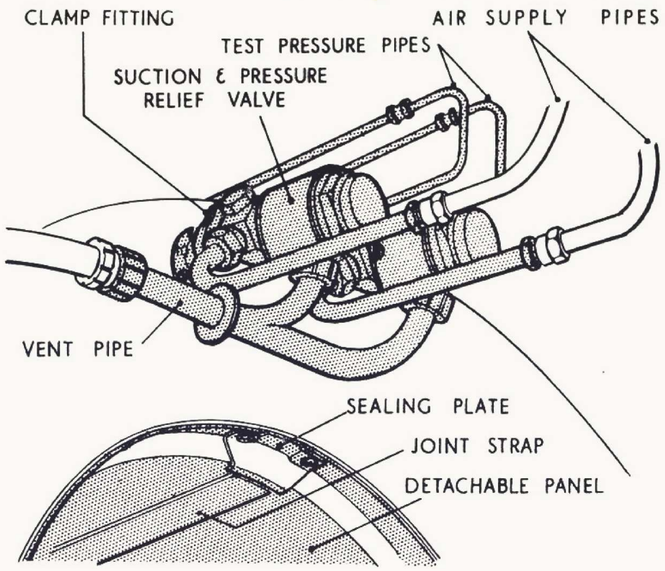


FIG. 19 SUCTION AND PRESSURE RELIEF VALVE

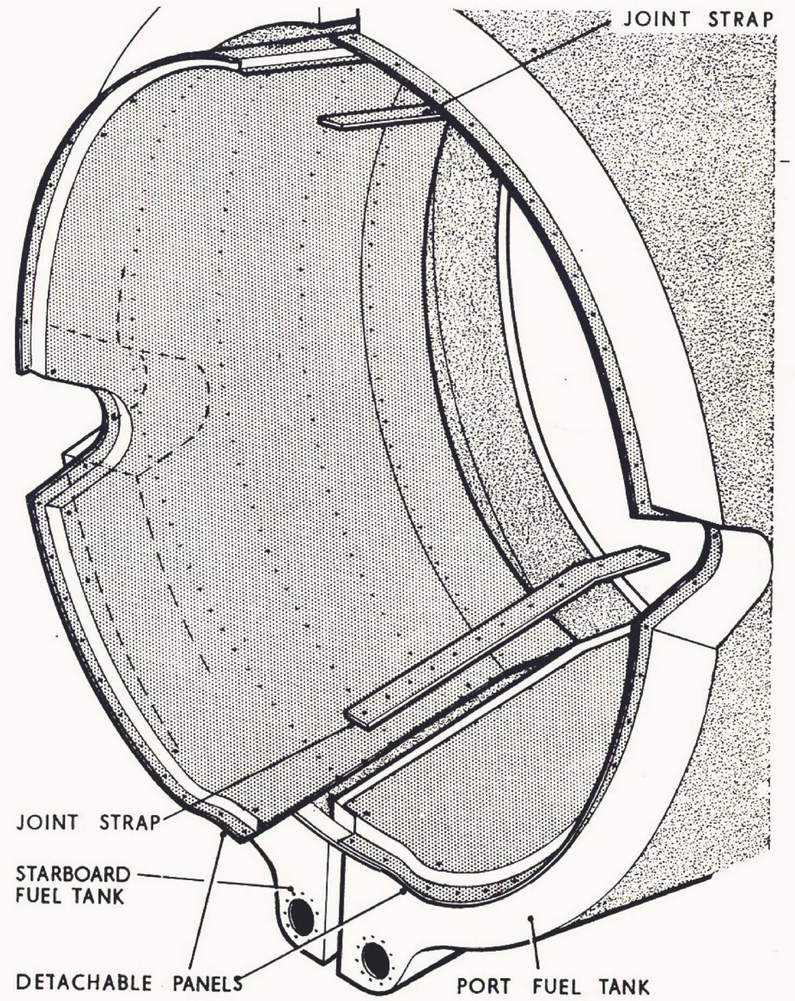


FIG. 20 DETACHABLE PANELS

(4) Unscrew the eight nuts, remove the washers and withdraw the terminal box sufficiently to expose the electrical cable connections and disconnect the cables. Secure the cables so that they do not fall back inside the tank.

(5) Remove the terminal box and sealing washer. (While at this location, unscrew the two countersunk screws locating the stud ring with the structure and free the studs).

Removing fuel level switch (fig.13 and 17)

60. (1) Remove the access door over the fuel level switch between frames 43 and 44.

(2) Remove the terminal cover from the switch and disconnect the two electrical cables. Put back the cover and stow the cables.

(3) Remove the 12 nuts and washers securing the switch and remove the switch. (While at this location, remove the sealing washer and unscrew the two countersunk screws locating the stud ring with the structure. Free the studs from the structure).

Removing fireproof box (fig.13 and 18)

61. (1) Disconnect and remove the drain pipe from the fireproof box.

(2) Remove the two sealing panels from the port side of the fireproof box by unscrewing 14 bolts.

(3) Remove the box by unscrewing the 28 bolts.

Removing suction and pressure relief valve (fig.13 and 19)

62. (1) Disconnect and remove the short length of pipe from the suction and pressure relief valve and the union.

(2) Remove the branched vent pipe from the base of the suction and pressure relief valve.

(3) Disconnect the test pressure pipes from the suction and pressure relief valve.

(4) Release the clamp fitting securing the suction and pressure relief valve to the connector on the tank and remove the valve. (While at this location, remove the connector and sealing washer by unscrewing the eight nuts and removing the washers from the tank studs. Unscrew the two countersunk screws locating the stud ring with the structure and free the studs).

Removing detachable panels and tank (fig.13 and 20)

63. (1) Remove the top and bottom joint straps by unscrewing the 20 bolts (10 top and 10 bottom) from the interior of the fuselage.

(2) Remove the two sealing plates (fig.19) at the top and bottom joints at the rear end of the detachable panels.

(3) Remove one of the tank supporting panels by removing the 19 bolts from the rear end and 27 bolts from the forward end of the tank panel.

(4) Ease the tank out of its bay and remove it from the aircraft.

(5) Check that there are four sealing washers to each tank and that there are none left in the tank bay. As soon as possible, blank off all orifices in the tank to prevent the ingress of dirt or moisture. (If the tank is to be re-installed, put back the sealing washers removed earlier, so that there are two to each orifice. If a new tank is to be fitted, use existing sealing washers provided they are serviceable).

Assembly of rear tanks

64. The assembly of the rear tanks is a reversal of the removal procedure, but the following points should be noted:-

(1) Ensure that the tank bay is clean.

(2) Observe the precautions given in para.40 and 41 before handling the tanks.

(3) Grease the outside of the tanks, the interior of the tank bay and the detachable panels with M.S.4 Silicone release agent before installing the tanks.

(4) The twin gate valve (at the transport joint) must be wire-locked in the open position, i.e. the handle of the valve must be moved to as far to port as it will go.

REMOVAL OF WING FUEL TANKS (fig.21)

General

65. The removal of the port wing tanks is described, the starboard wing tanks being similar. The removal should be carried out in the order described below.

Preliminaries

66. Preparatory to the removal, the following operations should be carried out.

(1) Render the aircraft electrically safe, Sect.5, Chap.1.

(2) Drain the fuel system, Sect.2, Chap.2.

(3) Disconnect the refuelling pressure relief valve (5), the pipe (6) and the branch pipe (7) in the stub wing as described in the wing removal, Sect.3, Chap.2.

Removal of the outlet pipe assembly (2).

67. Remove the twelve tank-stud nuts and washers securing the outlet pipe mounting plate to nose rib A then withdraw the pipe assembly. Remove the two set screws locating the tank to nose rib A (these being omitted when "Fireproof" tanks are fitted) and push the tank studs inwards to free the tank from the structure. Retain the seals for re-assembly.

Removal of the low level switch assembly (3).

68. Remove the electric cable plug (4) from its

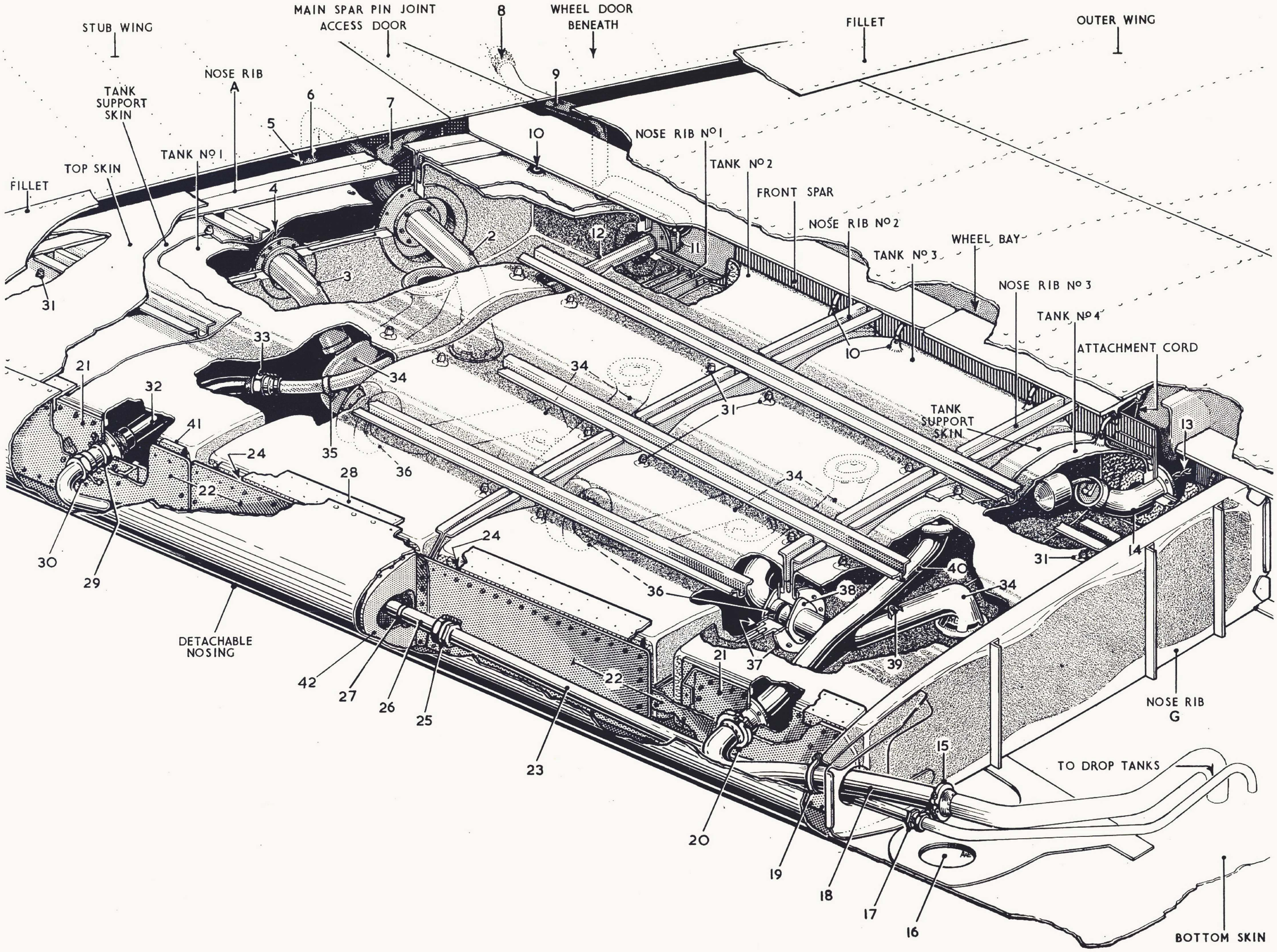


FIG. 21 REMOVAL OF WING FUEL TANKS

socket. Remove the seven 2 B.A. and one $\frac{1}{4}$" B.S.F. tank-stud nuts and washers securing the assembly flange to nose rib **A**, then withdraw the switch assembly. Remove the two screws locating the tank to nose rib **A** (these being omitted when Fireproof tanks are fitted) and push the tank studs inwards to free the tank from the structure. Retain the seals for re-assembly.

Removal of the nosing

69. Remove the fifty screws in the leading edge spar (28), six at nose rib **A**, four at nose rib G and fifteen in the upper surface at nose ribs 1, 2 & 3.

Removal from the leading edge, of the transfer pipe (18) and the air-pressure pipes (23) and (26).

70. Through the general access hole (16) remove the split pin, slacken off the nut and open the clamp coupling (15). Likewise open the clamp coupling (20) also remove clip (19). Remove the locking wires from the unions (17) and (25) and disconnect. Remove the air pressure pipe (23), then the transfer pipe. Dismantle clip (27), remove the locking wire from the union (30) and disconnect. Remove the air-pressure pipe (26).

Removal of the four leading edge spar webs (22).

71. Detach the four wing nosing ribs (42) by removing the bolts and washers securing them to the leading edge spar webs. Remove the sixteen bolts and washers fixing the four mounting plates (21) and (24) to the four leading edge spar webs and the necessary bolts and washers round the web perimeters then remove the webs from the structure.

Removal of the four mounting plates (21) and (24).

72. Remove the locking wire from the adaptor (29) and unscrew and retain the bonded washer for re-assembly. Remove from beneath No.1 tank the six bolts and washers and one locking lug with seal, securing the flexible air-pressure pipe (32) flange, also the twenty four nuts and washers securing the tank and remove the mounting plate (21). Retain the seals for re-assembly.

Remove from the tanks Nos.2 and 3 the twenty four nuts and washers securing each tank then remove the mounting plates (24). Retain the seals for re-assembly.

Remove from tank No.4 the eight nuts and washers securing the inlet transfer pipe (40) flange, also the twenty four nuts and washers securing the tank and remove the mounting plate (21). Retain the seals for re-assembly.

Removal of the inlet pipe (40).

73. Through the access hole in tank No.4 free the lug (39) and withdraw the inlet pipe.

Removal of the flexible air-pressure pipe (32)

74. Through the access hole in tank No.1 remove the locking wire from the union nut (33) and unscrew (using 2 spanners to avoid wrenching the joint) then remove the flexible pipe.

Removal of rigid air-pressure pipe (12).

75. Through the access hole in tank No.1 remove the stiff nut, bolt and clip (35) to free the air

pipe from the interconnection pipe (34). Through the stub wing general access doors, immediately aft of the main spar pin joint, remove the locking wire and loosen the nipple (8) then remove the coupling (11). With the outboard end of the pipe (9) twisted upwards, remove the eight nuts and washers securing the pipe flange to the front spar web and withdraw the pipe. Push the tank studs inwards to free the tank from the structure and retain the seal for re-assembly.

Removal of the refuelling level switch (14).

76. Remove the electric cable plug (13) from its socket in the wheel bay. Remove the seven 2 B.A. and one $\frac{1}{4}$" B.S.F. nuts and washers securing the flange to the front spar web and withdraw the switch. Remove the two set screws from behind the "U" seal flange locating the tank to the front spar and push the tank studs inwards to free the tank from the structure. Retain the seal on the spar web for re-assembly.

Removal of the tank interconnection pipes (34)

77. The six tank interconnection pipes are similar but not interchangeable and care must be taken to ensure their return to the appropriate tank upon re-assembly. Reaching through any two adjoining tanks remove the two $\frac{1}{4}$" bolts and nuts and four sealing washers (38) then withdraw the pair of interconnection pipes and seals, one from each tank. Similarly withdraw the two remaining pairs. To free the tanks from one another remove at each interconnection (36) the six remaining 2 B.A. nuts and twelve sealing washers and extract from each tank the clamp ring (37). In readiness for removal, ease the tank walls inwards from the nose rib webs.

Tank button attachments (31).

78. Adjacent to the stringers, withdraw from the support skins the thirty four integral rubber tank buttons, lubricate with Hellerine if necessary. The buttons are located as follows:-

Seven on the top and seven on the bottom surface of tank No.1.

Six on the top and six on the bottom surface of tanks Nos.2 & 3.

Four on the top and four on the bottom surface of tank No.4.

Tank eyelet Cord Attachments (10).

79. Cut the sixteen attachment cords spaced along the rear face of the front spar, these being located adjacent to the four rear corners of each tank. The tanks may now be withdrawn forwards, with care from the structure. In order to clear the packing pieces (41) at the two front corners it is necessary to concertina tank No.1.

ASSEMBLY OF WING FUEL TANKS (fig.21).

Preliminaries

80. Before commencing assembly, the following precautions should be taken:-

(1) Ensure that the aircraft, is electrically safe, Sect.5, Chap.1.

(2) Reference should be made to the precautions given in para.40 and 41.

(3) Ensure that the tank bays are free from foreign matter.

Assembly

81. Select sixteen 5 yard lengths of kite cord (Stores Ref.32A/107) and wax about 18" of one end and knot the other end of each cord. The wax assists threading and durability. Thread each of the sixteen attachment tubes (10) from the rear side of the front spar, with a waxed end of cord and from the front pull the cords through the tank bays and secure the waxed ends to the appropriate tank eyelet. Grease the outside of each tank and the inside of tank bays with M.S.4 Silicone release agent. Coat the thirty four tank buttons (31) with Hellerine to assist insertion.

Concertina the tank sufficiently and pass them through the apertures in the leading edge spar (28), taking up in the wheel bay, the slack on the cords and from the inside push the tank walls into position against the adjacent structure. Pull each cord tightly through its bracket, to be found on the top or bottom skin and secure with a knot as shown.

Proceed in the reverse order as described in the removal, para.(77) and (78). When assembling the clamp rings (37) and the interconnection pipes (34) pass the bonded washers along the bolts by hand as far as possible and then tighten up by turning the bolt heads to ensure even seating of the washers, otherwise the threads may drag the seals from their bonds, giving rise to leakage.

Proceed in the reverse order as described in the removal para.(76) ensuring that the "U" seal has its large flange forward when fitted to the front spar web and that the tank bolts when engaged pass through both flanges of the "U" seal. The set screws must be tightened as much as possible as the flange bolts when tightened may force the set screws back proud on the outer seal, possibly causing leakage.

Proceed in the reverse order as described in the removal para.(75) ensuring that the "O" seal, is seating evenly while tightening up is taking place.

Proceed in the reverse order as described in the removal para.(73) and (74).

Proceed in the reverse order as described in the removal, para.(72) ensuring that the bonded washer is replaced beneath and not above the wiring lug.

Proceed in the reverse order as described in the removal, para.(69) (70) and (71).

Proceed in the reverse order as described in the removal, para.(67) and (68) and in each case the tightening of the set screws should be aided by pulling up on the adjacent studs otherwise the flange when tightened fully may force the set screws back, proud on the outer seal.

Complete in the reverse order using new locking wire and taking care that all seals are replaced in serviceable condition.