CHAPTER 2

FUEL SYSTEM COMPONENTS

Introduction

1. In Chapter 1, we considered some of the problems encountered in supplying fuel to an aero-engine in flight. In this Chapter, we shall move on and make a more detailed study of some major components that are fitted in a pressurized pressure refuelled aircraft fuel system.

Components in a Pressurized Fuel System

2. To fully understand how a pressure refuelled system works, it is necessary to become familiar with the purpose and operation of the components fitted to control the pressure and fuel flow throughout the system. In pursuing such a study it is convenient to start at the fuel inlet and to consider first the aircraft pressure refuelling coupling unit.

The Aircraft Pressure Refuelling Unit

3. The aircraft coupling unit is the connection between the aircraft fuel system and the refuelling hose extended from a bowser or a ground refuelling installation. The inner end of the coupling is designed for connecting into the aircraft fuel system and the outer end is manufactured to accept the standard bayonet connector of the fuel supply hose. Three equally spaced slots on the forward face of the flange locate the refuelling hose when it is connected to the aircraft coupling and three lugs on the periphery of the bayonet flange accept and secure a sealing cap which is fitted when the refuelling hose is disconnected.

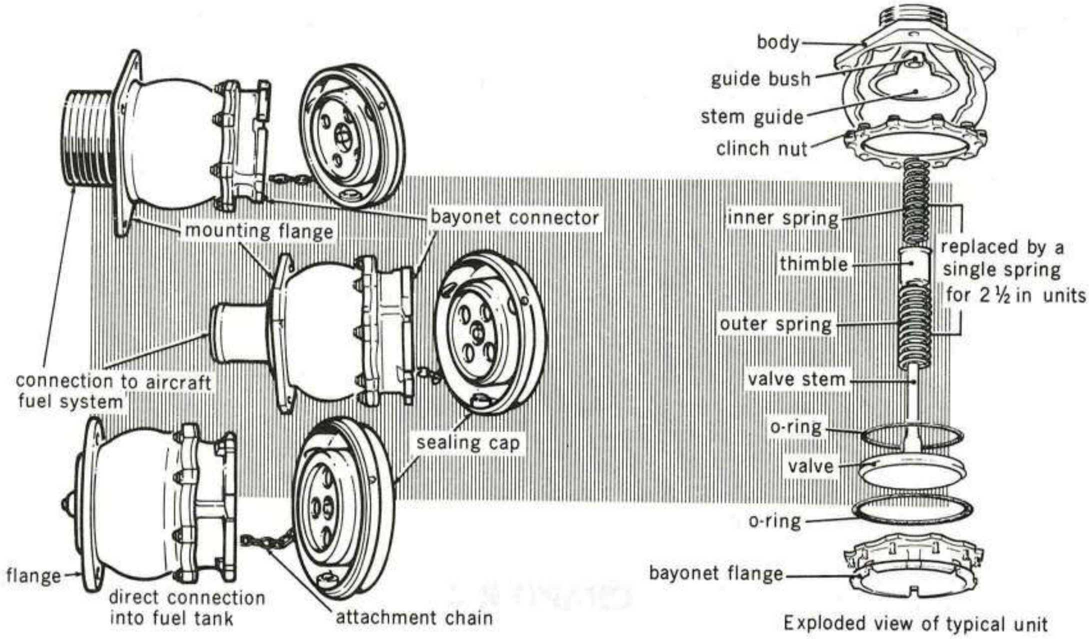

Fig 6.2.1. Examples of aircraft pressure coupling units

4. There are a number of different coupling units which are identified in the conventional manner by supply codes, reference numbers, part numbers and by mark. The couplings are designated 1½ in, 2½ in *etc,* to indicate the size of the union or pipe fitting which connects into the aircraft fuel system (Fig 6.2.1). The size information is not related to the bayonet end fitting which makes the connection with the pressure refuelling hose; these bayonet fittings are a standard size.

5. In addition to the bayonet coupling and the adapter for connecting into the aircraft fuel system, the aircraft pressure refuelling coupling contains the mechanism necessary to provide a self-sealing, non-return valve. The non-return valve is opened mechanically when the pressure hose is connected and automatically closes to prevent leaks when the delivery hose is removed. As a further precaution against leaks, and to prevent ingress of dirt, a sealing cap is fitted manually immediately after the pressure hose is disconnected. The engage, press, and turn to lock type sealing cap is attached to the coupling body by a suitable length of chain or wire (Fig 6.2.1).

Refuelling and Defuelling Valves

6. The filling of a pressure refuelled system is controlled by automatic valves which shut off the fuel flow when the tanks are full. Such valves may be mechanically operated by a float in the fuel tank, or by an electrical solenoid (Fig 6.2..2). The valves, fitted to control refuelling and defuelling, are not all the same. They may be:

- Selective refuelling valves only.
- Selective refuelling/non-selective defuelling valves.
- Selective defuelling valves.
- Selective refuelling/selective defuelling valves.

Whatever valve type or combination of valve types is used, the fuel system is filled or drained through a standard aircraft pressure coupling unit.

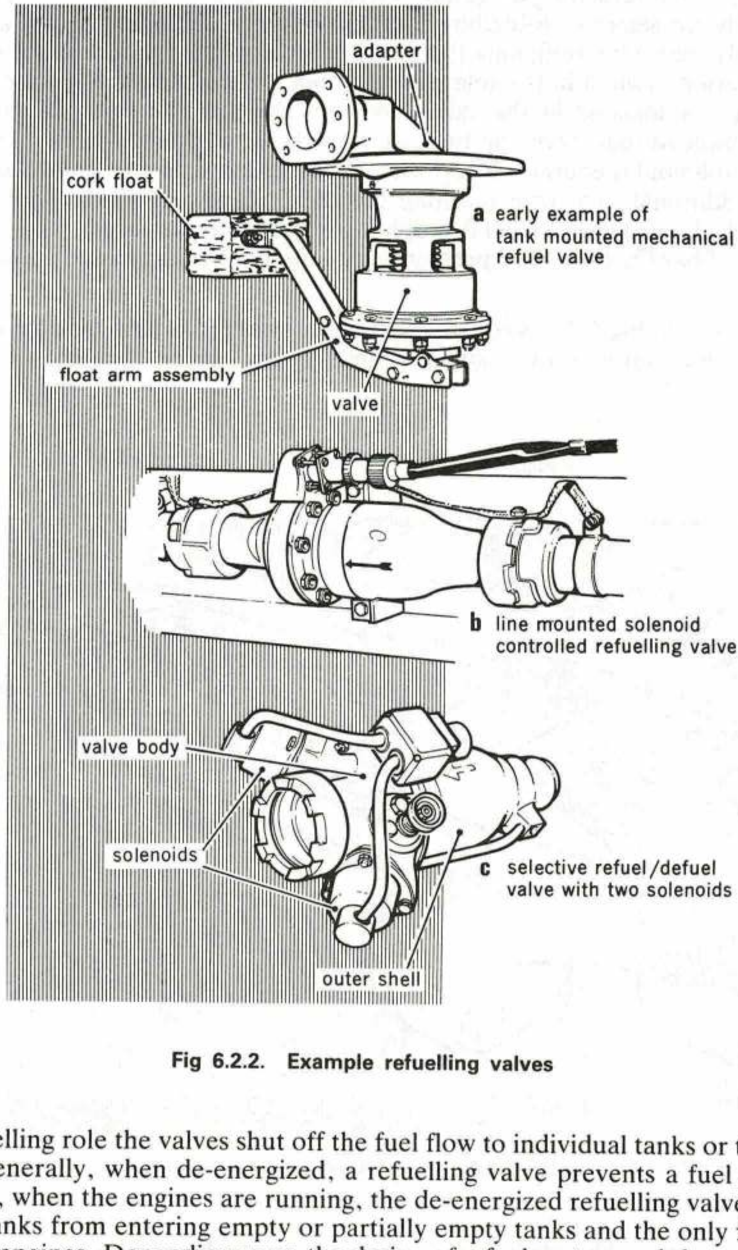

Fig 6.2.2. Example refuelling valves

7. In the refuelling role the valves shut off the fuel flow to individual tanks or tank groups as they fill and, generally, when de-energized, a refuelling valve prevents a fuel flow in either direction. Thus, when the engines are running, the de-energized refuelling valves will prevent fuel from full tanks from entering empty or partially empty tanks and the only fuel flow must be towards the engines. Depending upon the design of a fuel system and the space available, refuelling valves may be tank mounted, fitted in the refuelling line or, for special applications, a refuelling valve may be incorporated into the pressure refuelling unit. When energized, some line-mounted valves may be selected to permit any one of the following functions:

• Refuelling • Defuelling • Fuel transfer

Although refuelling/defuelling valves all serve the same basic purpose, they are not all constructed alike nor is the operation of one type identical to that of another type. Some examples of refuelling valves are shown in Fig 6.2.2.

8. The example of a refuelling/defuelling valve shown in Fig 6.2.3, is a valve which needs an electrical supply for selective refuelling, but *non-selective* defuelling is available without the electrical supply. Selective refuelling is controlled by a switch on the refuelling control panel and a float-operated switch in the relevant fuel tank. When 'refuel' is selected, the electrical current energizes a solenoid in the valve, and movement of the solenoid sets the valve into the refuel position so that incoming fuel can flow to the aircraft tank. Refuelling is possible only when the solenoid is energized, and when the solenoid is de-energized the valve will close and prevent additional fuel from reaching the tank. However, a relief valve mechanism is included, which allows a limited fuel flow if line pressure becomes excessive — *ie* flick pressure in the region of 5 bar (72 psi). Flick pressures are caused by quick closure of other valves in the system.

The valve shown in Fig 6.2.3 is constructed so that when a vacuum (suction) is applied to its inlet side, *defuel* conditions exist and the fuel system can be drained without the use of electricity.

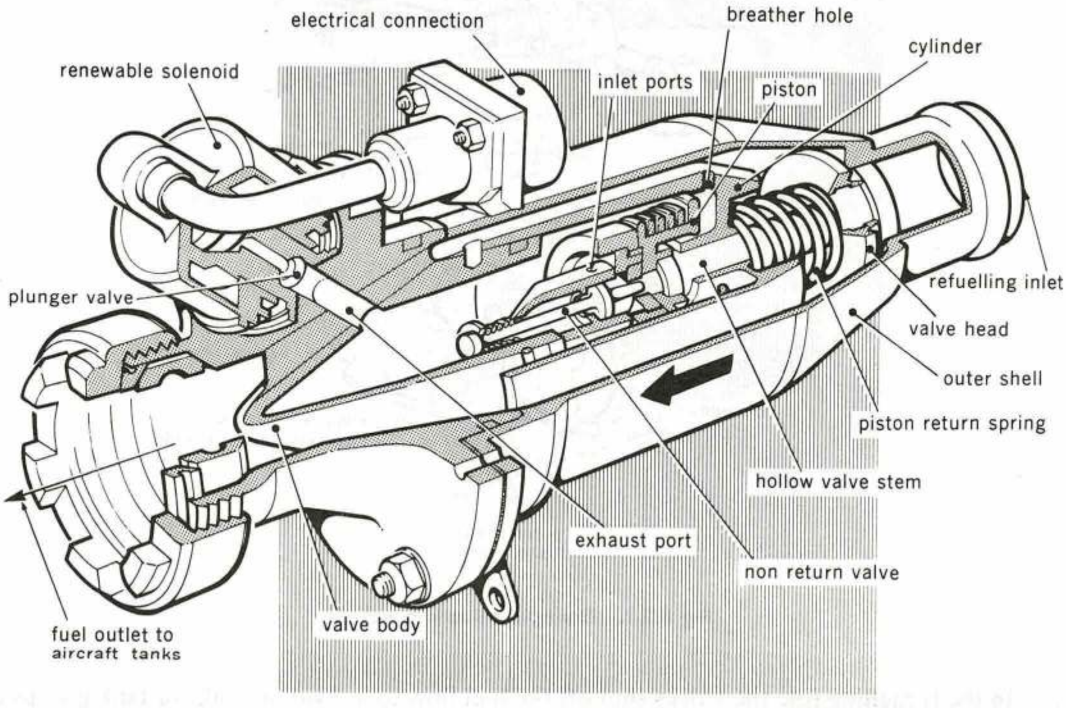

Fig 6.2.3. Example refuel/defuel valve

9. **Electrical supply.** The electrical supply for the refuelling valve is connected through a manually-operated switch on the refuelling control panel and then through the contacts of a series-mounted float-operated switch which has a float positioned inside the fuel tank. As the fuel level in the tank drops, the float is lowered and this causes the contacts of the switch to

close. When the contacts of the float switch are closed and the relevant refuelling selector switch is set to the ground refuel position, an associated green light illuminates to indicate that the solenoid in the refuelling valve is energized and the fuel system will accept fuel. As a tank or tank group fills, the relevant float is lifted by the fuel until, when the tank is full, the contacts of the float switch open and disconnect the electrical supply from the solenoid of the associated refuelling valve. The appropriate warning light is extinguished to give an external indication that the solenoid is de-energized.

10. Wiring for the electrical system is individual to aircraft type and the system, as a whole, is serviced by the electrical/electronics trades. However, circuit wiring diagrams applicable to refuelling are available to the propulsion trades and these diagrams are found in the fuel systems part of the relevant Air Publication — *eg* AP101B-3101-1FB for the Jaguar and AP101B-0603-1D2 for the Harrier Mk 3 aircraft. Similarly, information for each type of aircraft will be found in the relevant aircraft Air Publication.

11. **Valve operation (refuelling).** The principle of refuelling valve operation is shown in Fig 6.2.4 which shows the different conditions encountered in normal use. These conditions are:

- **The valve static condition.** In the static condition, the solenoid of the refuelling/defuelling valve is de-energized, the plunger valve is closed to blank off the exhaust port and there is no fuel flow (Fig 6.2.4a). In the static condition, the piston is at the front end of the cylinder and the valve head is closed against the valve seat on the outer shell. The construction is such that both piston and valve head are seated by the piston return spring to provide a leak proof seal which prevents a fuel flow. The fuel trapped inside the cylinder forms a hydraulic lock which makes it impossible to open the main valve whilst the plunger valve is seated.

- **Refuelling condition.** For refuelling, the solenoid in the refuelling valve is energized to withdraw the plunger valve off its seat in the exhaust port (Fig 6.2.4b). With the exhaust port open, fuel can escape freely from the inside of the cylinder, and this allows the piston to move into the cylinder when a refuelling pressure is applied to the front face of the valve. The pressure applied by the incoming fuel can now move the valve head and piston against the return spring until the valve is open. The subsequent main refuelling flow is between the outer shell and the cylinder, but a secondary fuel flow passes through the hollow valve stem to the inside of the cylinder and joins the main flow through the exhaust port. Fuel also enters the front part of the cylinder through holes in the cylinder wall.

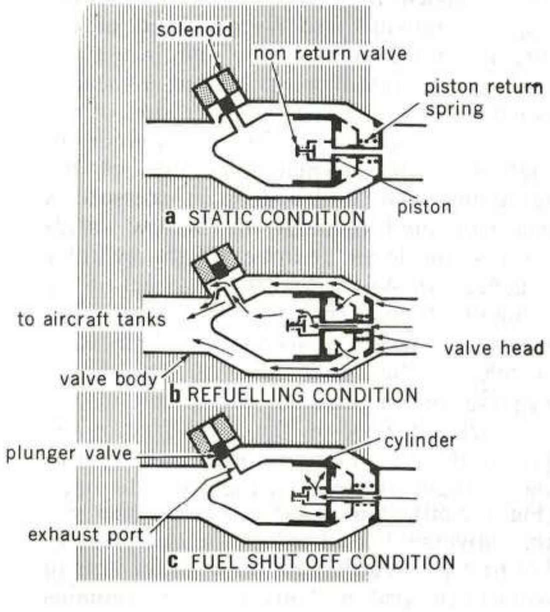

Fig 6.2.4. Valve operation refuelling

- **Flow shut-off condition.** Fuel flow through the refuelling valve is interrupted when the solenoid becomes de-energized (Fig 6.2.4c). When the solenoid is de-energized the plunger valve closes the exhaust port and the pressure inside the cylinder rises until it equals the inlet fuel pressure. With an equal fuel pressure surrounding both piston and valve head, their different surface areas generate a closing force which combines with the piston return spring to produce progressive closing of the valve. The fuel flow through the refuelling valve is quickly, but progressively, reduced until the valve is closed. Progressive closing valves are less likely to generate high flick pressures than valves which snap closed and, for this reason, progressive closing valves are favoured. To reduce or eliminate flick pressures, some modern refuelling valves have the valve head movement deliberatly slowed as it nears the closed position.

12. Normally the solenoid of a refuelling valve is de-energized by the action of a float-operated switch which automatically cuts off the electrical supply when a tank, or tank group, is full. However, if necessary, the solenoid of a refuelling valve can be de-energized manually by operation of the appropriate selector switch on the control panel.

13. **Pressure relief.** Because of the pressure increase caused by thermal expansion of the fuel, and the possibility of flick pressures being caused by closing valves, most refuelling valves are designed to act as relief valves and to open if the system pressure reaches 75 psi (5.25 bar).

14. **Valve operation (defuelling).** Defuelling may be selective through the operation of a second solenoid, or it may be automatic as in the example valve shown in Fig 6.2.3. This latter type of valve provides for non-selective defuelling without the need for an electrical supply. In fact, it is important that the solenoid remains de-energized and that the exhaust port is closed.

15. **Non-selective defuelling.** For defuelling, the tanker hose is connected to the aircraft in the normal way and, when the tanker is operated as a defueller, a vacuum (suction) is created at the inlet side of the aircraft coupling unit. The suction draws fuel from the normal inlet side of the refuelling valve and a drop in pressure is communicated through the hollow valve-stem to the inner chamber of the cylinder (Fig 6.2.5a). As the fuel is drawn out of the cylinder the internal pressure drops, the non-return valve opens and the depression is felt on the inner face of the piston. Because the depression is not felt in the outer chamber or on the front face of the piston, the piston moves towards the rear of the cylinder and causes the valve to open (Fig 6.2.5b). Simultaneously with the piston movement, fuel enters the outer chamber to prevent a depression from forming in front of the piston. Thus, the valve remains open, and the suction created by the tanker generates a fuel flow from the aircraft tanks, through the passage between the outer shell and the cylinder wall into an empty compartment of the tanker.

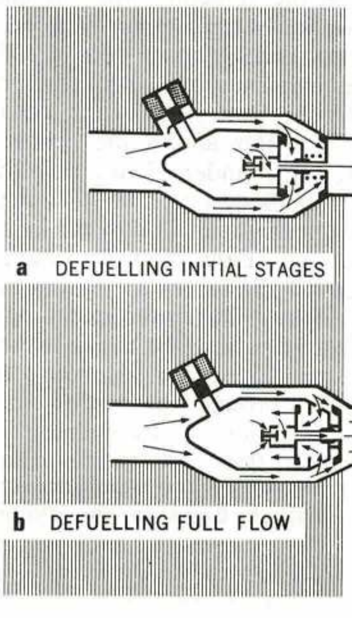

Fig 6.2.5. Non-selective defuelling

16. **Defuelling shut-off.** If, for any reason, the pressures in the inner and outer chambers equalize, the piston return spring will move the piston and valve head into the closed position and defuelling will cease. The outer chamber will fill with fuel, which enters through the holes in the cylinder wall, whilst the inner chamber fills through the hollow valve stem; the non-return valve closes and the refuel/defuel valve returns to the static condition.

Fuel Tank Pressure Relief Valves

17. Pressure relief valves are fitted as an additional precaution to protect the fuel tanks from the harmful effects of high pressures and to ensure that the pressure inside a fuel tank is insufficient to cause damage. The risk of generating excessive pressure is greatest during refuelling when the inlet pressure is 3.5 bar (50 psi) and flick pressure may be generated in excess of this amount. Should a refuelling valve fail to close, the pressure relief valve will open and allow a fuel flow out of the fuel tank into the vent system so that the pressure inside the tank remains below danger level.

18. The example pressure relief valve of Fig 6.2.6 consists of a two-part cylindrical body with the two parts screwed together and sealed by an 'O' section ring. The main body of the cylinder carries the inlet valve seat and the smaller outlet side of the body has an integral flange for attaching the assembled valve to the fuel tank skin. The mechanism of the relief valve is fitted inside the cylindrical body where the valve guide flange is gripped between a shoulder on the main body shell and a spacer tube which is pressed down and clamped as the two parts of the body shell are screwed together. An external arrow on the cylinder shows the direction of flow (Fig 6.2.6).

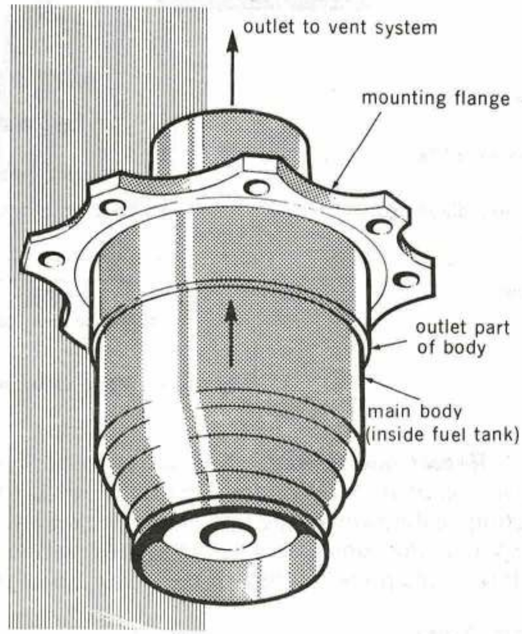

Fig 6.2.6 Fuel tank pressure relief valve

19. **Operation.** In the closed position, the main and pilot valves are held on their respective seats by the valve springs (Fig 6.2.7). The fuel tank pressure enters the neck of the valve body and applies an opening force to the relief valve; simultaneously, fuel pressure is transmitted through the hollow valve stem into chamber 'C' where it exerts a closing force on the valve diaphragm. In practice, the area of the valve head is greater than that of the diaphragm, but the pressure in chamber 'C' combines with the valve spring in producing a force which keeps the main valve closed. However, the pressure in chamber 'C' applies an opening force to the pilot valve and at a pre-determined pressure the pilot valve will open and release the pressure

from the chamber. Immediately the pressure in chamber 'C' drops, the main valve will open to relieve the fuel tank pressure. The main vent valve will be completely open when the tank pressure is 800 m bar (11½ psi approx). As the tank pressure reduces, the pilot valve will close and the pressure in chamber 'C' will increase until, with the aid of the valve spring, the main relief valve is closed.

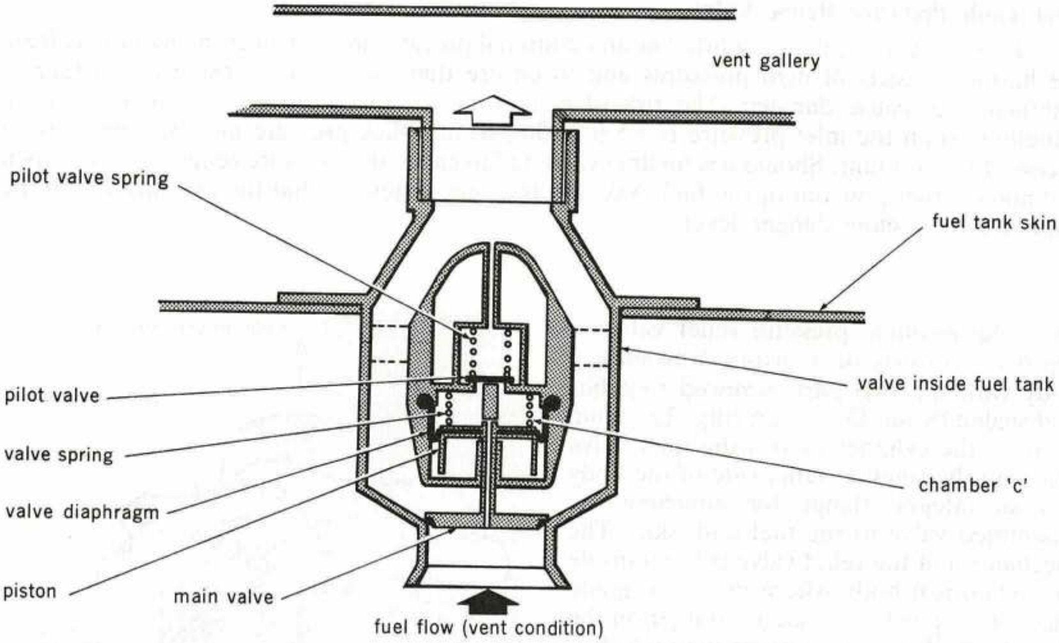

Fig 6.2.7. Vent valve operation (diagramatic)

20. **Repair and testing.** Subject to local facilities, the Bronzavia fuel tank pressure relief valve can be dismantled for repair. Repair is by replacement of certain parts, such as the 'O' section sealing rings, the pilot valve, relief valve diaphragm and relief valve. Details of such work and the subsequent testing is not within the scope of these training notes. Therefore, before attempting to repair the valve, you should read Air Publication AP106C-0414-1.

Float Valves

21. In many fuel systems a centrally-positioned main fuel tank acts as a supply reservoir for the *collector* tank(s) which feed the engines. The main tank is automatically topped up by fuel which is transferred from other tanks in the system and overfilling is prevented by the action of a float-operated valve (Fig 6.2.8).

The action of a float valve is similar to that of a float and needle in a carburettor. When the engine uses fuel, the fuel level in the main feed tank drops, the float is lowered and the float valve opens the inlet port to the tank so that fuel can be transferred to replace the fuel already used by the engine. Normally, fuel is transferred at a rate greater than the engine can use it and the fuel level inside the tank rises. The float is lifted by the fuel until the float valve closes the fuel inlet port when the tank is full. Therefore, whilst there is fuel in the system to be transferred, the main tank will be topped up because the float valve will open the inlet port whenever the fuel level drops and the inlet port closes only when the main tank is full.

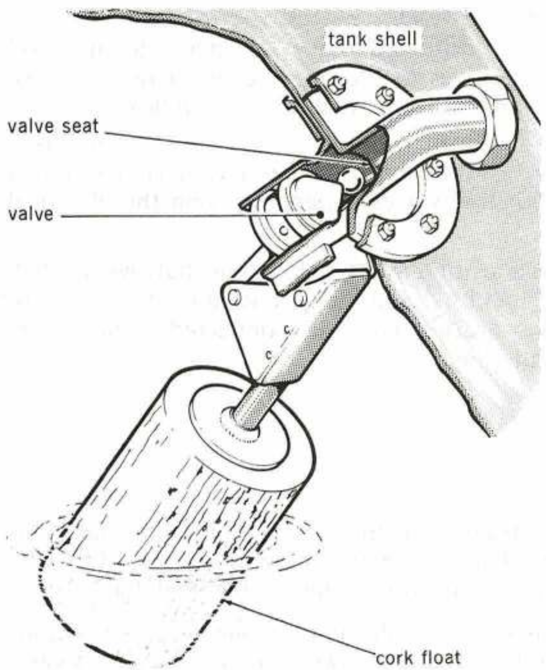

Fig 6.2.8. Typical float valve

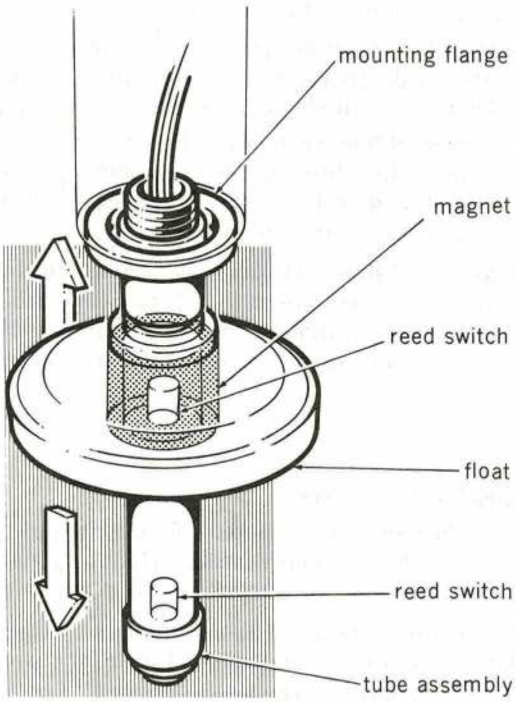

Fig 6.2.9 Example float switch

Float Switches

22. Float switches are fitted in the fuel tanks of most pressurized fuel systems. The floats are positioned to allow their switches to operate at specific fuel levels and they are known as *high level* or *low level* switches, depending upon their position in the fuel tank. A third similar float switch is used in some fuel systems; this switch has a float which is positioned in the fuel tank so that the switch is operated somewhere between high level and low level. This latter type of float switch is fitted only when proper management of a fuel system dictates the need for switch operation at an intermediate fuel level and, although the switch may not be set to operate when the tank is exactly half empty, it is called a *mid-level* float switch. Each switch mechanism consists of a float which is moved by changes in fuel level and a switch that is wired into the main electrical services. In our example, the float switch consists of a steel tube enclosing two magnetically-operated reed switches and an annular float with attached magnet that surrounds the steel tube (Fig 6.2.9). Changes in fuel level cause the float assembly to slide up or down the steel tube and move the permanent magnet. Movement of the magnet causes the magnetic impulses to operate the reed switches which make or break the appropriate electrical circuits. The assembly is positioned in a fuel tank so that switching takes place at a pre-determined fuel level. The circuits affected by the operation of the float switches can be used to energize fuel pumps, tank full, or tank empty indicators, fuel transfer indicators or any system control function necessary for the proper management of the fuel system.

23. In a typical fuel system, float switches are used as:

- **High level float switches.** These switches can be positioned to operate on a rising fuel level and to de-energize the solenoids of refuelling valves to prevent overfilling of the tanks. High level float switches can also operate tank full and fuel transfer indicators.
- **Low level float switches.** These switches work only on a falling fuel level and they are used to move indicators to the tank empty position, but they can also be used to start or stop fuel pumps and to energize the solenoids of air/no fuel valves depending upon the electrical circuits they are linked with.
- **Mid-level float switches.** These switches are not fitted in all fuel systems but, where they are fitted, they normally operate on a falling fuel level and they are used for low pressure fuel pump switching. Mid-level float switches are not normally connected to indicators which show fuel levels or fuel transfer conditions.

Fuel/No Air Valves

24. **Position and purpose.** A fuel/no air valve is normally fitted at the outlet of a fuel tank from which the fuel is transferred by air pressure. The valve unit is fitted to the base of the fuel tank sump and its purpose is to prevent transfer air from entering the fuel feed lines.

25. **Construction.** The fuel/no air valve consists of a light alloy casing with a mounting flange and a fuel outlet pipe. Inside, the casing is divided into two compartments by a valve guide support which is an integral part of the casing. The upper (fuel) compartment accommodates the head of the fuel transfer valve and the valve seat. The valve head is in the upper compartment and the stem passes through the valve guide into the lower compartment. A flexible seal is fitted into a recess in the valve guide to make rubbing contact with the valve stem and prevent air or fuel from escaping between valve and guide. The lower compartment of the casing is a cylinder which contains a piston, piston diaphragm and a valve spring (Fig 6.2.10). The piston is attached to the bottom end of the valve stem and sealed in the cylinder by the diaphragm which divides the cylinder into two separate chambers, one above and one below the piston. The upper (inner) chamber is vented to atmosphere and contains the spring which acts upon the piston to move the fuel transfer valve into the open position. The lower (outer) chamber can be filled with pressure air. The air is applied via a solenoid-operated valve which is energized when the fuel level is such that the outlet from the tank must be closed. The solenoid is linked electrically to a float so that movement of the float will operate a switch and energize the solenoid just before the fuel tank is empty.

26. **Operation (fuel transfer).** When the fuel tank is full, or partially full, the low level float is in the position so that the solenoid in the air supply valve is de-energized and the solenoid valve is closed. The fuel transfer valve is held open by the valve spring so that when air pressure is applied to the fuel in the tank, the fuel is transferred to another tank on its way to the engine (Fig 6.2.11a).

27. **Operation (flow shut-off).** Before the fuel tank is completely empty, the float of the low level switch is lowered by the falling fuel level until the switch operates and energizes the air supply valve solenoid. The energized solenoid opens the air valve, and pressure air is fed into the outer chamber of the cylinder in the fuel/no air valve (Fig 6.2.11b). The pressure air acts upon the piston head and the diaphragm to overcome the resistance of the spring and close the fuel transfer valve. Closing the fuel transfer valve whilst the tank contains a small amount of fuel, prevents air from entering the fuel feed lines.

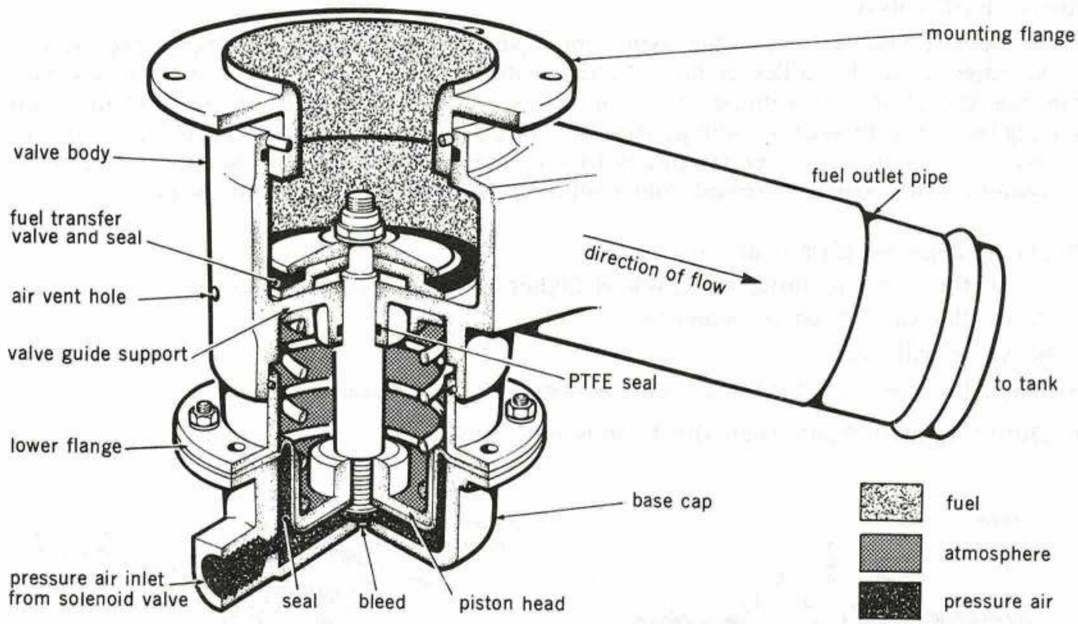

Fig 6.2.10 Example fuel/no air valve

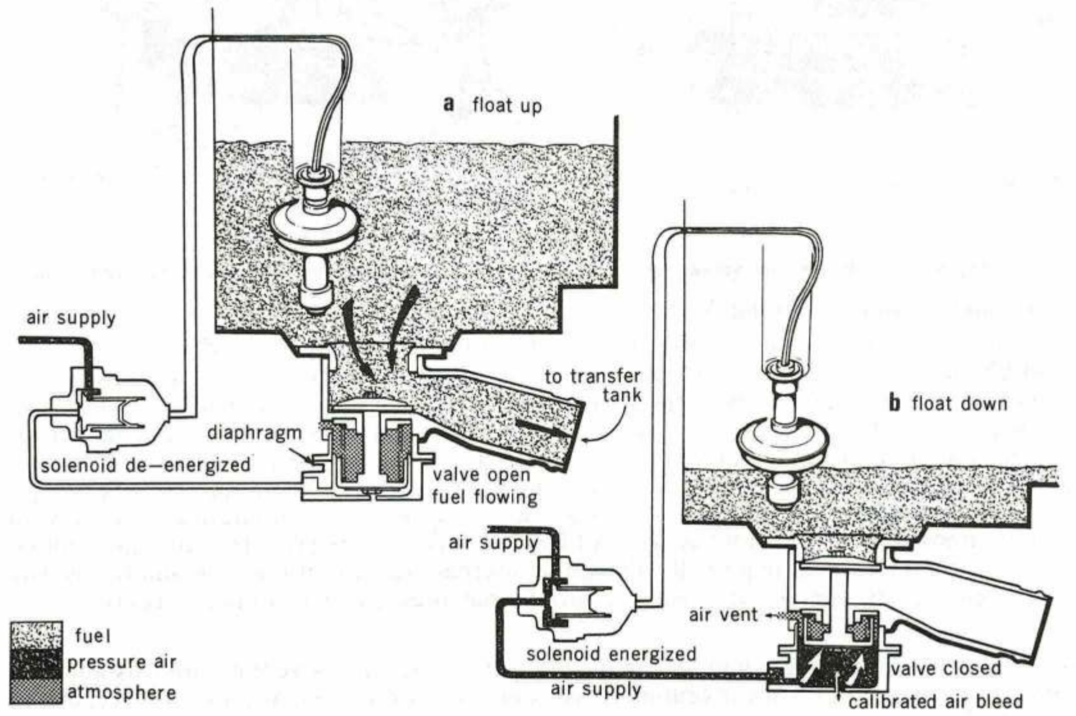

Fig 6.2.11 Operation of the fuel/no air valve

Air/No Fuel Valves

28. The air/no fuel valve is a float-type vent valve fitted to some collector tanks and fuselage tanks adjacent to the collector tanks. These valves connect the tanks directly to the vent galleries and allow free venting of air, but the valve will always close to prevent fuel from leaving the tanks through the vent gallery. The air/no fuel valve, shown in Fig 6.2.12, will close if refuelling or fuel transfer continues to fill a tank above the normal level. The valve mechanism will close to prevent fuel venting in the following circumstances:

- During negative 'g' or inverted flight.
- When the pressure inside the tank is higher than the pressure outside.
- When the valve float is immersed.

The valve will open:

- When the pressure inside the tank is less than the pressure outside.
- During normal flight when the float is not immersed.

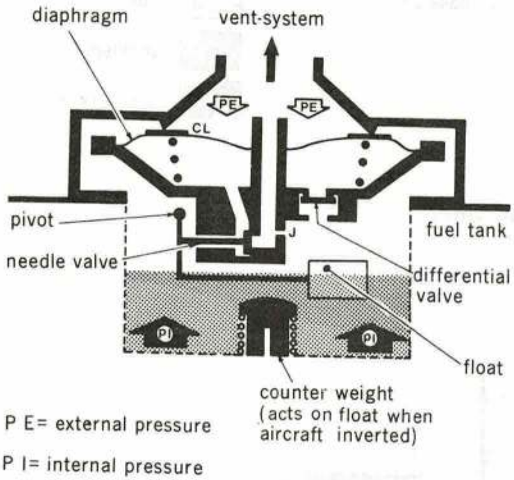

Fig 6.2.12. Air/no fuel valve

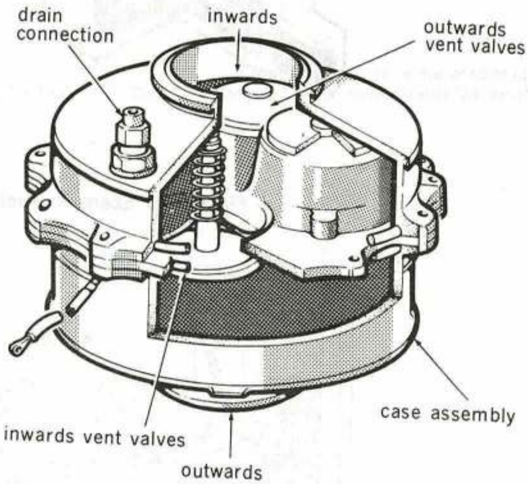

Fig 6.2.13. Example inward/outward vent unit

Inward and Outward Venting Valves

29. When an aircraft engages in high rate climbs or high speed dives, the change in external (atmospheric) pressure is so abrupt that it causes a differential pressure problem between the internal and external pressures of the fuel tanks. This problem is overcome by fitting valve units which compare the tank internal pressure with external pressure and allow inward or outward venting to prevent a large pressure differential from developing and causing damage to the fuel tanks. The inward and outward vent unit shown in Fig 6.2.13 is the type of vent unit fitted to Jaguar aircraft and it is capable of quickly balancing the tank internal pressure with ambient atmosphere. To prevent collapse of flexible tanks, the external pressure must not be allowed to rise more than marginally above the internal pressure of the tank and this is why inward vent valves operate at a smaller differential pressure than outward vents.

30. The vent unit contains four spring-loaded valves, two valves venting inwards and two venting outwards. The outward venting valves open when the internal pressure exceeds the external pressure by 455 m bar (6.6 psi), and the inward venting valves open when the external pressure exceeds the internal pressure by 17 m bar (0.25 psi).

Pressure Reducing Valves

31. When air is taken from the compressor of a gas-turbine engine to be used for pressurizing fuel tanks, the initial pressure of the air is too great to be used in the fuel tanks. To obtain a suitable pressure, air taken from the aero-engine is passed through a pressure reducing valve before it enters the fuel tank pressurizing system (Fig 6.2.14). All aircraft types do not use the same valves, and the reduced pressure may vary (by a small amount) from one aircraft to another. The pressure of the air taken from the engine compressor will be about 2 bar (30 psi), and the pressure reducing valve used for a Jaguar aircraft reduces this pressure to 350 m bar (5 psi) before the air enters the fuel tank pressurization system. The lower pressure is adequate for fuel transfer and tank pressurizing, but insufficient to cause damage to the fuel tanks.

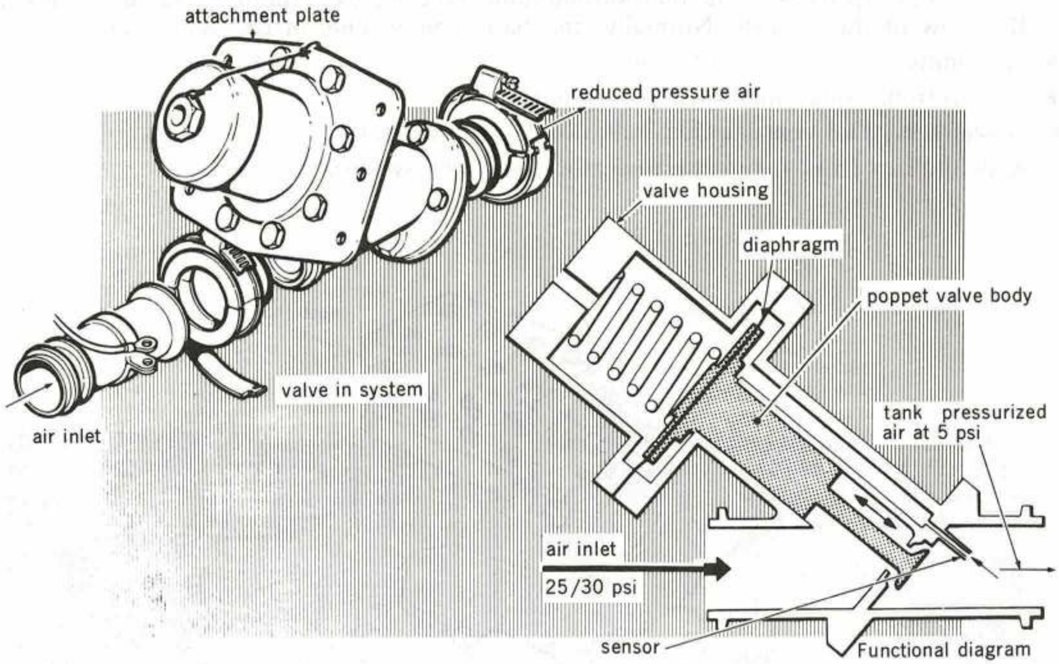

Fig 6.2.14 An example pressure reducing valve

32. **Operation.** The pressure reducing valve, shown in Fig 6.2.14, consists of a valve housing which contains a spring-loaded poppet valve with a cylindrical body, short stem and valve head. A diaphragm, attached to the valve body, separates the valve housing into a valve spring chamber and a cylindrical valve guide with housing for the air inlet port, air outlet port and valve seat. The valve is spring-loaded to the open position and when there is no pressure air the valve remains open. When the engine is running and pressure air enters the inlet, it can flow freely through the valve aperture into the pressurization system and through a sensor to act upon the diaphragm. As the system fills, the air pressure at the valve outlet increases and is felt by the diaphragm as a valve closing force. When the outlet pressure reaches 350 m bar (5 psi), the force acting on the diaphragm is sufficient to overcome the spring and to close the valve. The valve remains closed until the outlet pressure (fuel tank pressure) falls below 350 m bar (5 psi). Therefore, the pressure air at the reducing valve outlet cannot exceed 350 m bar (5 psi) regardless of variations of the inlet pressure.

Fuel Flow Metering Systems

33. **Purpose.** A fuel flow metering system is fitted to an aircraft to make certain vital fuel consumption information available to the aircraft crew at all times. Therefore, the system must include indicators, which are fitted in the cockpit, to display the following information:

- The rate at which each engine is using fuel.
- The total weight of fuel remaining in the aircraft tanks.

From this information the crew calculate the length of time that the aircraft can safely stay in the air.

34. **System parts.** Fuel flow metering equipments differ slightly from one aircraft type to another. However, it is necessary to fit certain basic components in every system (Fig 6.2.15). These components measure the fuel consumption and display constantly updated information to the crew of the aircraft. Normally, the basic components in the system are:

- Transmitters (one for each engine).
- An electronic relay unit (one per system).
- Flowmeters (fuel consumption indicators) (as necessary).
- A detotalizer (fuel remaining indicator) (one per system).

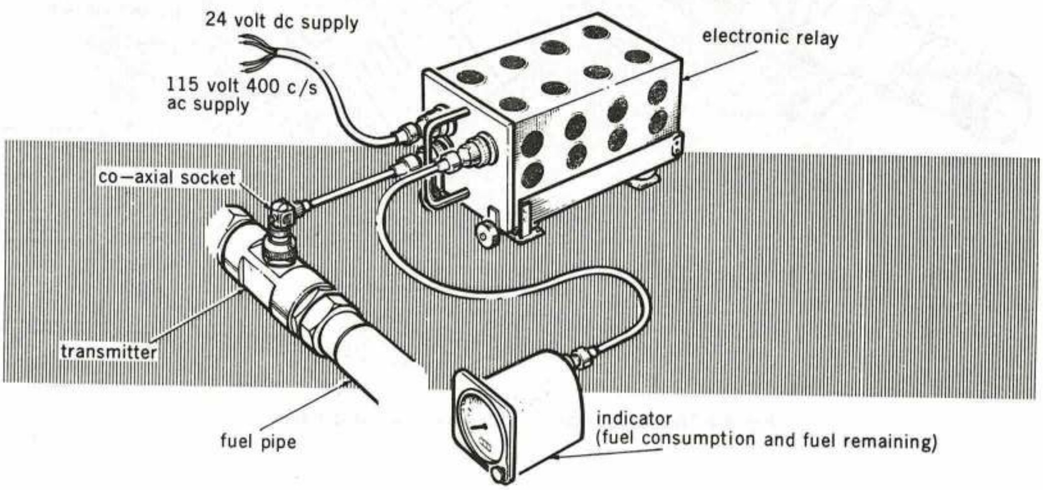

Fig 6.2.15. The basic fuel flow metering system

35. **Flow rate transmitter.** The transmitter is fitted in the fuel feed line and an arrow on the casing shows the correct direction of fuel flow through the unit. The transmitter is fitted as near to the engine as convenient. All the fuel going to the engine passes through the transmitter where a calibrated flow tube is used to measure the mass fuel flow. Although there are different types, the principle of operation is similar for all transmitters in that they all measure mass fuel flow and forward the information to the counting and indicating parts of the system. In the transmitter, the fuel first flows through a straightener which smooths the flow, and then the mass fuel flow is measured by a rotor which is fitted in the flow tube.

36. In some transmitters, the rotor is freely mounted on near frictionless (jewelled) bearings and it is driven by the fuel flow. A magnet is fitted into one rotor blade and, as the rotor spins, magnetic impulses are generated and used to transmit measurements of the fuel flow. In some designs, the transmitter rotor is driven electrically to revolve at a constant speed. The rotor is permitted a limited axial movement and the fuel flow signal is proportionate to the axial displacement of the rotor that is caused by the rate of fuel flow.

37. The transmitter shown in Fig 6.2.16 has a magnet inserted into one blade of the rotor (with balancing carried out on the opposite blade). An inductor coil is attached to the housing so that each time the magnet passes the coil, electrical impulses are generated and they pass fuel flow signals to the relay unit. The relay and the display units in the system convert these signals into *rate* of fuel used and fuel remaining values, for display on the faces of the indicators in the cockpit.

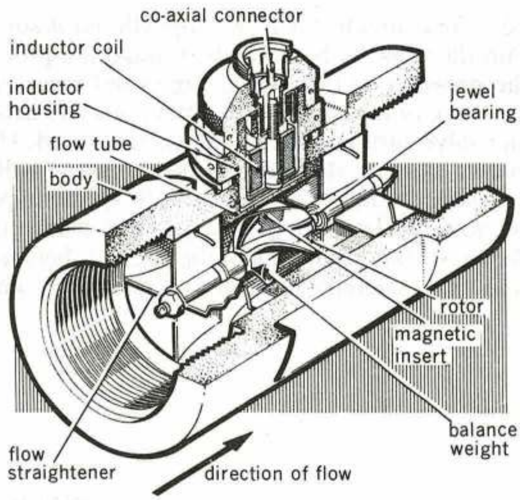

Fig 6.2.16. A fuel flow transmitter

Fuel Flow Proportioner

38. **Purpose.** A fuel flow proportioner is fitted into an aircraft fuel system to provide an equal flow of fuel from each side of the fuel system. This maintains a balance across the aircraft so that the centre of gravity remains within limits and the stability of the aircraft is not disturbed as the fuel is consumed. The fuel flow proportioner is fitted downstream in the fuel flow just before the low pressure (LP) cocks, and all the fuel must flow through the proportioner before it reaches the engines.

39. **Description.** The proportioner consists of two identical capacity vane-type pumps which are mounted side by side, but in independent cells. The pumps are driven by a common shaft, and the power is provided by a hydraulic motor that is mounted on the side of the unit case. The two identical pumps consist of an eccentrically-mounted rotor with four spring-loaded carbon vanes (Fig 6.2.17). Each pump has its own inlet port which is connected into the fuel system so that one pump cell draws fuel from the port side of the aircraft and the other pump draws fuel from the starboard tanks. Both pumps feed through non-return valves into a common outlet manifold which feeds the metered fuel to the engine(s). To cater for emergency failure of the pumps or drive, each inlet port is connected to the outlet manifold through a bypass valve which opens to allow a direct fuel flow if, for any reason, the proportioner is not running. A pulse generator is mounted at the end of the drive shaft remote from the motor and it sends signals to an indicator, in the cockpit, which gives visual indications for proportioner running or proportioner stopped conditions.

40. **Flow trimmer.** Each pump cell has a trimmer valve which is used to balance the output of the pumps. When the proportioner is on test, the makers use the trimmers to adjust the fuel flow until both pumps pass identical amounts of fuel. When the fuel flow is correct, the trimmers are locked and they must not be disturbed again.

41. **Operation.** Each side of the aircraft fuel system feeds fuel into its own pumping cell in the flow proportioner. The two rotors are driven by a common shaft to revolve at the same speed and, because the pumping rotors pass an exactly equal amount of fuel for each revolution, fuel is drawn *in equal quantity* from each side of the aircraft.

42. The inlet to the flow proportioner is supplied with fuel from the low pressure fuel pumps and then, as the fuel passes through the proportioner pumps, its pressure is increased so that the pressure of the fuel in the outlet manifold is much greater than the inlet pressure. The pressure of the fuel in the outlet manifold acts on the heads of the two bypass valves and helps the valve springs to keep the valves closed. However, if for any reason, the flow proportioner rotors slow or stop, the outlet pressure will fall or cease to exist. With little or no outlet pressure the inlet fuel is able to force the bypass valves open and feed fuel to the engines, but without the benefits of flow proportioning. If the pump rotors slow or stop, a 'proportioner failed' warning is shown in the cockpit, because the pulse generator has also slowed or stopped and the magnetic indicator is no longer energized.

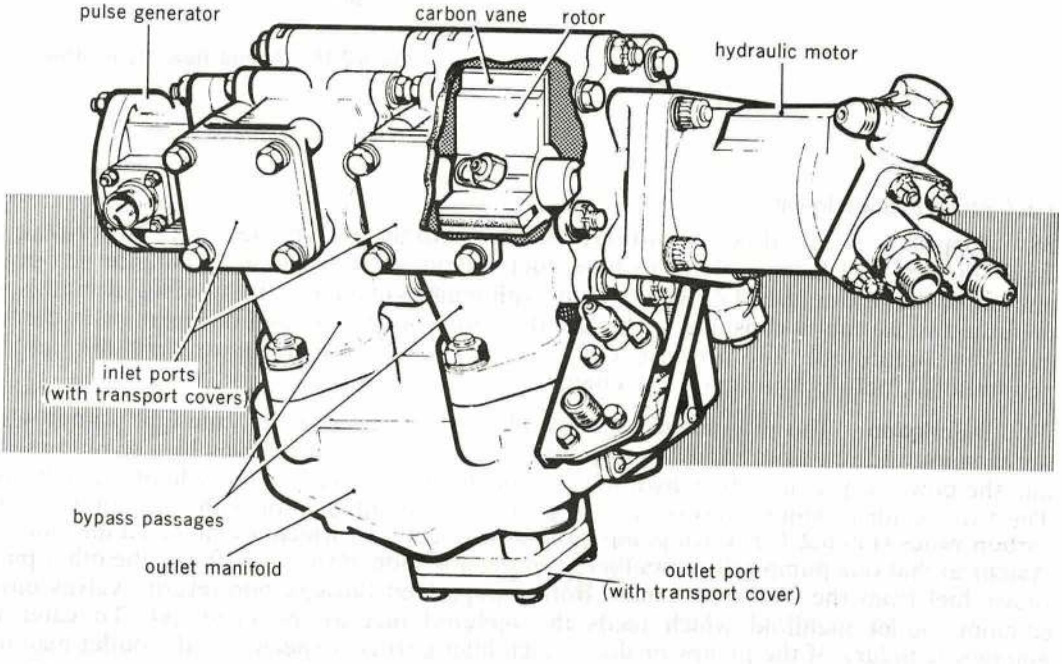

Fig 6.2.17. **Fuel flow proportioner**

43. **Servicing.** A fuel flow proportioner requires routine inspection for fuel leaks, hydraulic leaks, correct assembly of pipe unions, electrical connections and security of attachment. Defects must be recorded and rectification carried out.

44. **Repair.** Depending upon local instructions and the facilities available, a fuel flow proportioner can be removed from the aircraft for local repairs. Repairs are limited to exchanging external defective parts and, using standard engineering practices, the following units may be removed from the proportioner and new or reconditioned parts fitted:

- The hydraulic motor.
- The pulse generator.
- The quill drive.
- External unions and fittings.

The flow proportioner must not be dismantled.

Low Pressure Fuel Pumps

45. **Purpose.** Low pressure fuel pumps (also called fuel booster pumps) are fitted in a fuel system for the following reasons:

- To feed fuel under pressure to the inlet of the engine-driven pumps (EDP).
- To transfer fuel from one tank to another.

The low pressure fuel pump is an electrically-driven pump which is immersed in the fuel and fitted at the base of a tank. The pumps feeding the engine are usually fitted in a collector tank which has anti 'g' devices fitted so that the pump continues to feed fuel to the engines in negative 'g' conditions.

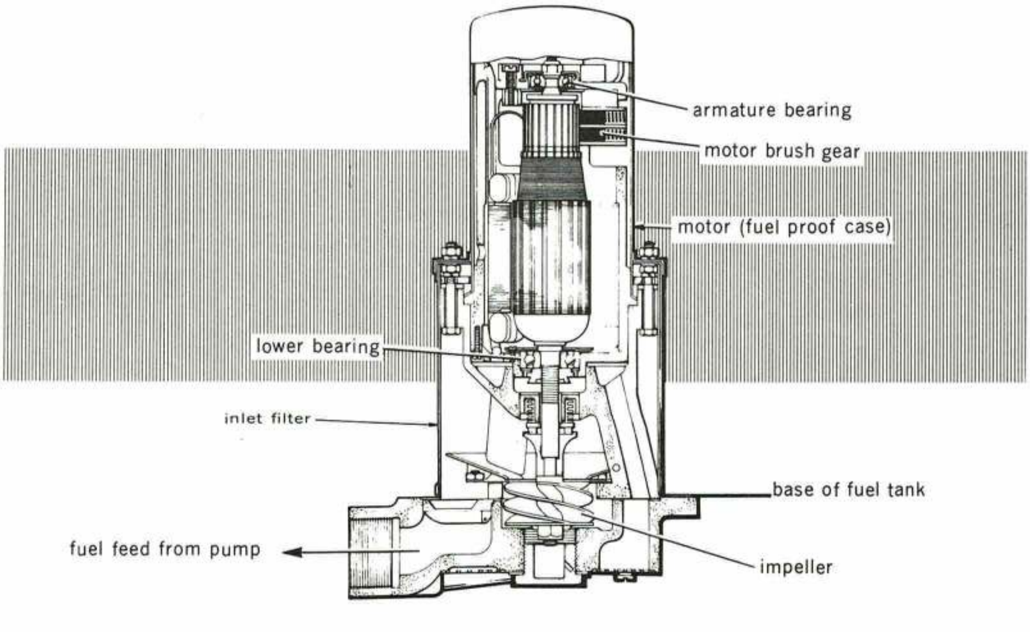

Fig 6.2.18. Example low pressure fuel pump

46. The pump consists of a single stage impeller pumping element which is driven by a 24 volt dc motor (Fig 6.2.18). The impeller is designed to de-aerate the fuel before pressurizing the inlet of the engine-driven pump, and any air removed from the fuel is vented into the air space above the fuel where it can do no harm. For protection against foreign matter the inlet to the impeller is guarded by a gauze mesh filter which surrounds the pump inlet and is attached to the pump casing. A bypass valve is fitted to allow a fuel flow when the pump is not running.

Conclusion

47. The fuel system components described in this Chapter are representative of the components found in most turbine engined aircraft fuel systems. Some systems may include additional items and other systems may not include all these items. This is because each fuel system is designed for a particular aircraft and space may govern the type and number of components used in the system. In the next chapter we shall consider the types of fuel tanks available, the repair and servicing of fuel tanks and the safety precautions observed when working with fuel tanks.


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