CHAPTER 3

INTRODUCTION TO GAS TURBINE ENGINE FUEL SYSTEMS

Objectives

1. This Chapter has been written with the aim of helping you to satisfy the objectives in the relevant Skills and Knowledge Specifications (SAKS) for your trade in this subject area. When you have studied this Chapter, you should be able to:

a. Explain the requirements which a fuel system for a gas turbine engine must satisfy.

b. List the components that may be found in a gas turbine engine fuel system and explain their purpose.

c. Explain, in general terms, how the fuel supply to a gas turbine engine is controlled.

d. State the general safety and servicing precautions to be observed when working on gas turbine engine fuel systems.

Introduction

2. A gas turbine engine fuel system must be such that the following requirements are satisfied:

a. The pilot must have complete control of the engine power at all times.

b. The fuel fed into the combustion chambers must be in such a state that it burns readily and completely.

c. Fuel flow control must be such that the engine has good acceleration capabilities.

d. Damage to the engine by overspeeding and excessive temperatures must be prevented by including appropriate automatic safety devices in the system.

e. Engine starting must be both positive and easy — especially at altitude following 'flame-out'.

f. The fuel control system must provide a supply of fuel to the burners in the correct quantity *under all conditions of flight*. The fuel flow must be capable of being controlled *manually* by the pilot (through his manual throttle or power lever). It must also be capable of being controlled *automatically* to take account of variations in:

(1) Aircraft forward speed.

(2) Altitude.

(3) Acceleration.

(4) Air temperature.

(5) Engine rev/min.

(6) Gas temperature.

3. **Propeller-turbine engines.** In discussing fuel systems for propeller-turbine engines, changes in propeller speed and pitch have to be taken into consideration, because of their effect on the power output of the engine. It is usual to interconnect the throttle lever and the propeller control unit (PCU). By doing this, the correct relationship between fuel flow and airflow is maintained at all engine speeds, and the pilot is given single lever control of the engine. Although the maximum speed of the engine is normally determined by the propeller speed controller, overspeeding is prevented by a governor in the fuel system.

4. **Other considerations.** The fuel system can also serve auxiliary functions, such as reheat, oil cooling, and the hydraulic control of various engine systems. For example, the air intake guide vanes (IGV) angle may be altered by fuel pressure through an operating ram.

Control of Fuel Flow

5. **Manual control.** The power or thrust of a gas turbine engine is controlled by regulating the *quantity* of fuel injected into the combustion chambers. When a higher thrust is required, the throttle is opened and this increases the fuel flow. As a result, the pressure to the burner increases, the gas temperature rises, and the acceleration of the gases through the turbine increases. The effect of this is to give a higher engine speed and a correspondingly greater airflow, thus providing an increase in thrust.

6. **Automatic control.** As noted earlier in para 2f, the fuel flow must be capable of being controlled *automatically* to account for variations in altitude, air temperature and so on. To balance the change in airflow from such variations, a similar change must occur in fuel flow. Various devices in the fuel system measure the changes that are taking place in these factors; they then act on the fuel control system to correct the fuel flow.

7. **How the control is effected.** One method of varying the fuel flow to the burners is by adjusting the output of an engine-driven pump (known as the high pressure fuel pump). This is achieved through a servo system in response to some, or all, of the following:

a. Throttle movement (normally controlled by the pilot).

b. Air temperature and pressure variations.

c. Rapid acceleration and deceleration.

d. Monitored inputs representing changes in engine speed, exhaust gas temperature, and compressor delivery pressure.

8. Another method of control is to use a high pressure pump whose output depends solely on its speed of rotation; any fuel in excess of that required under any given condition is then diverted and by-passed back to the input of the pump.

9. Both methods of control are in use and each will be considered in more detail later.

Basic Fuel System

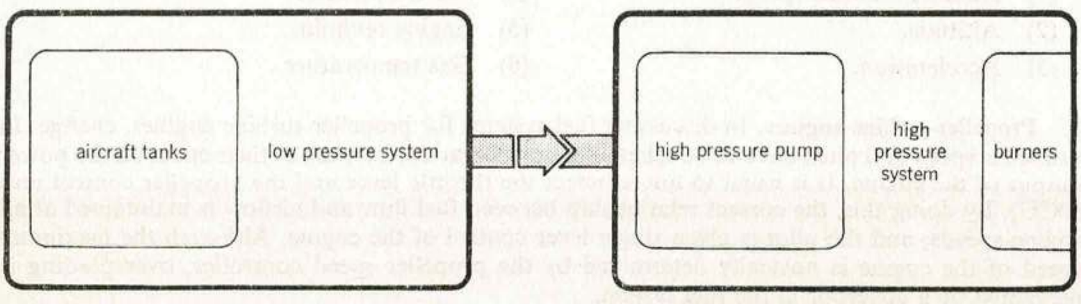

Fig 2.3.1 Basic fuel system

10. The basic fuel system for a gas turbine engine can be considered in two separate parts: the low pressure fuel system and the high pressure fuel system (Fig 2.3.1). The low pressure part of the system extends from the aircraft fuel tanks to the input to the high pressure pump The higher pressure part of the system extends from the high pressure pump to the burners in the combustion chamber.

11. In most installations, the low pressure systems in use have a great deal in common. We can, therefore, consider a typical low pressure system as applying to most situations. However, there are a number of different high pressure systems in use in different aircraft. Since the components and the method of operation of the various high pressure systems vary considerably, we shall consider them separately in the next Chapter.

THE LOW PRESSURE (LP) FUEL SYSTEM

Block Diagram of LP Fuel System

12. Fig 2.3.2 illustrates a block diagram of the low pressure part of the fuel system. This drawing shows the components that can be used in the system and indicates how the fuel is passed from the aircraft tanks to the input to the high pressure pump. Some notes on the various components are given in the following paragraphs. The function of the system is such that it supplies fuel to the high pressure fuel pump:

- At a suitable pressure (*eg* 30psi).
- At a suitable rate of flow (*eg* 200lb/min).
- At a suitable temperature (*eg* 100°C).

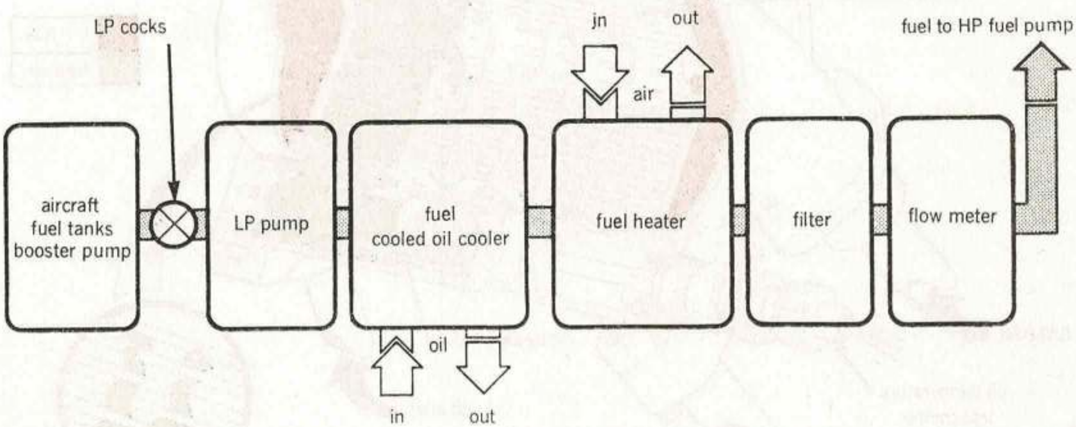

Fig 2.3.2 Diagram of low pressure fuel system

Aircraft Fuel Tanks

13. Aircraft fuel tanks will be considered in more detail elsewhere in this book. So far as the LP fuel system is concerned, the fuel tanks often contain an electrically-operated *booster pump*, operating at a pressure of a few bars (14 to 40 psi). It maintains a positive pressure at the input to the system to prevent aeration and vapour locking.

Low Pressure Cock

14. The LP cock is controlled from the cockpit and enables the engine and fuel system to be isolated from the aircraft fuel tanks. This isolation may be required during servicing (*eg* when replacing components) or in the event of fire. Under normal conditions, the engine should *never be stopped* by this control. This may cause the high pressure pump to run 'dry', with resulting damage.

Low Pressure Pump

15. It is normal to fit a LP pump, in addition to the booster pump in the aircraft tanks. It operates as a back-up to the booster pump and makes the system less dependent on the booster pump. Its purpose is to ensure that the fuel pressure at the input to the high-pressure fuel pump is high enough to prevent cavitation and vapour locking in the system under normal operating conditions. The low pressure pump is usually an impeller type, driven from a gearbox on the engine at some 5000 rev/min. A warning lamp is fitted in the cockpit and is usually incorporated in the LP pump circuit; this will light if the pressure in the system drops below a pre-determined value.

Fuel Cooled Oil Cooler (FCOC)

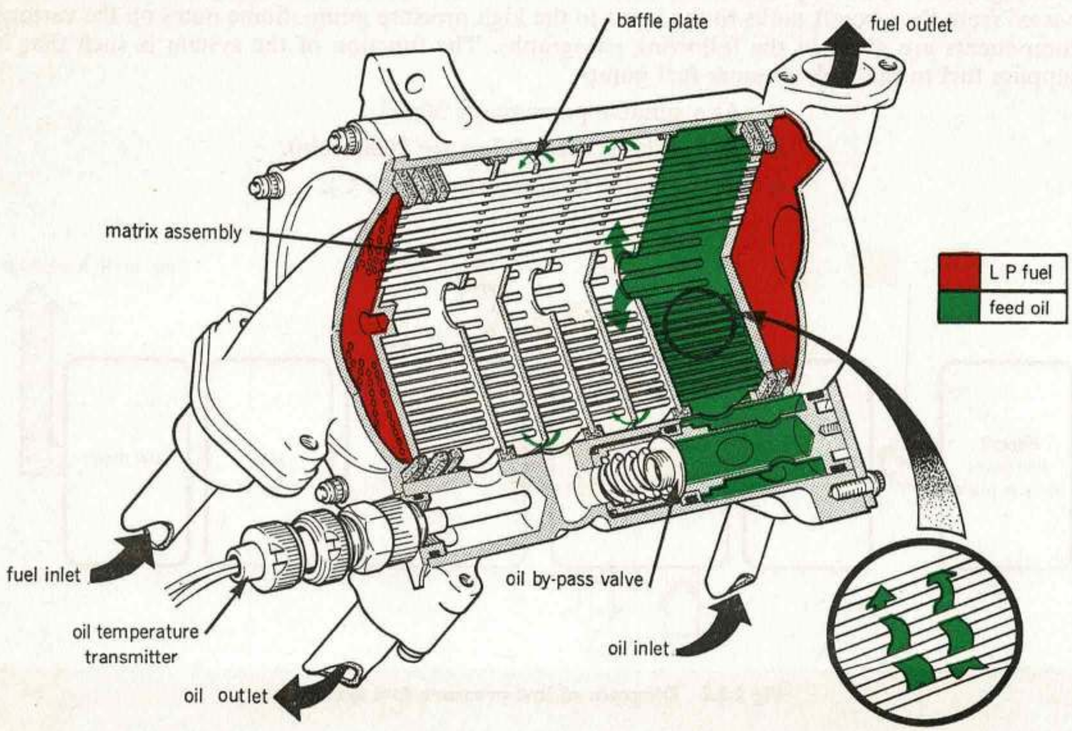

Fig 2.3.3 Fuel cooled oil cooler

16. A typical FCOC is illustrated in Fig 2.3.3. During the passage to the burners, the fuel is used to *cool the oil* in the engine oil system. At this point in its passage through the system, the fuel is relatively cold and considerable heat can be removed from the oil. At the same time, heat is transferred to the fuel, and this leads to higher engine thermal efficiency — *ie* better atomization

of the fuel. Also, with warm fuel, there is less tendency for ice crystals to form in the fuel; such crystals would tend to block the fuel system. Note, however, that the FCOC is effective as a heat exchanger *only when the oil is warm*. When starting up a cold engine, the oil is cold and there can then be no transfer of heat to the fuel. Some other means must then be found for heating the fuel (*see* para 18).

Note. In some installations, the FCOC is found on the HP side of the fuel system.

17. In some systems, a *velocity cleaned filter* is inserted in the FCOC assembly to protect the reheat fuel system. This will be dealt with more fully in the Chapter on 'reheat'.

Fuel Heater

18. A typical fuel heater is illustrated in Fig 2.3.4. As its name suggests, the purpose of this component is to heat the fuel and also to *control its temperature* under normal running conditions. As stated in para 16, the fuel may or may not be already pre-heated by the FCOC. The fuel heater consists of a number of finned control tubes enclosed in an outer case. The fuel passes through the outer case to a limiter in a fuel flow regulator (and also to the reheat system). The air from the compressor is warm and, again, we have an exchange of heat — this time from the air to the fuel. As the fuel warms up, a thermally-controlled valve closes to reduce, and finally shut off, the flow of warm air through the outer casing. If the temperature of the fuel falls, the valve begins to open again to allow air through the outer casing. In this way, the temperature of the fuel is controlled. A temperature transmitter is normally fitted in the fuel heater to signal the fuel temperature to the control part of the high pressure fuel system.

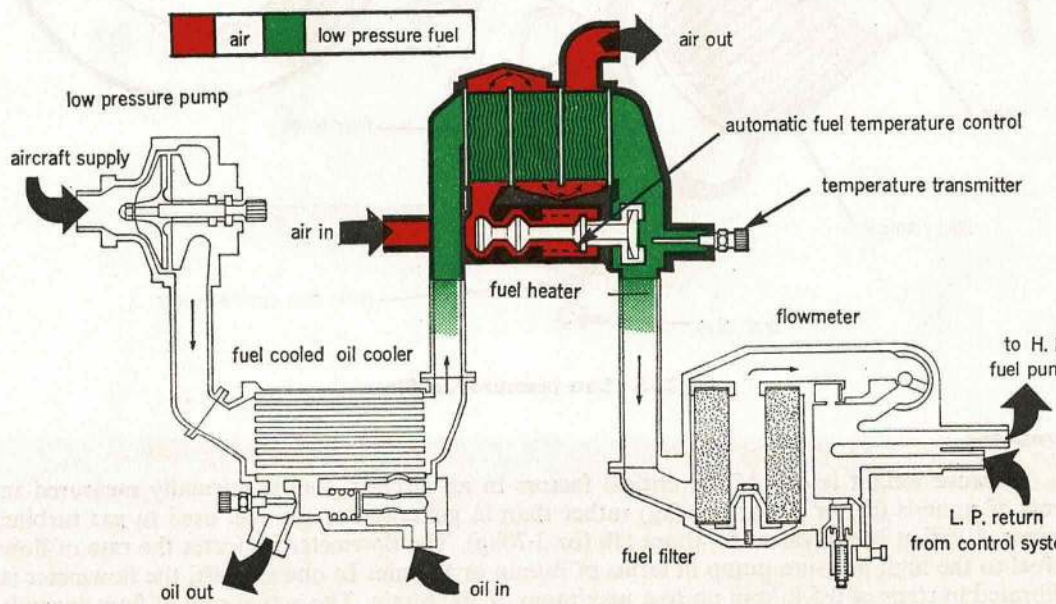

Fig 2.3.4 Fuel heater

Low Pressure Filter

19. A typical low pressure filter is illustrated in Fig 2.3.5. The filter may be a corrugated felt element type or a paper type filter element; both give a high degree of filtration and prevent the entry into the fuel system of particles of dirt or foreign matter. The filter element may or may not be capable of being cleaned, depending upon the installation. In some installations, limited washing and refitting is allowed. In others, it is always necessary to replace the element with a new item. *Always consult the appropriate Servicing Schedule during servicing or maintenance of the filter*. A differential pressure switch may be fitted to the case of the filter; where fitted, this will operate a warning lamp in the cockpit when the *pressure difference* across the filter element exceeds a certain pre-determined value. In addition, a drain valve allows the filter casing to be drained for sampling the fuel; if the fuel is contaminated, the filter must be removed and the source of contamination located and remedied; the filter element is then cleaned or replaced as stated in the Servicing Schedule. In some installations, a collector block is attached to the fuel filter case outlet connection; this collects return fuel from a number of sources within the system (*see later*).

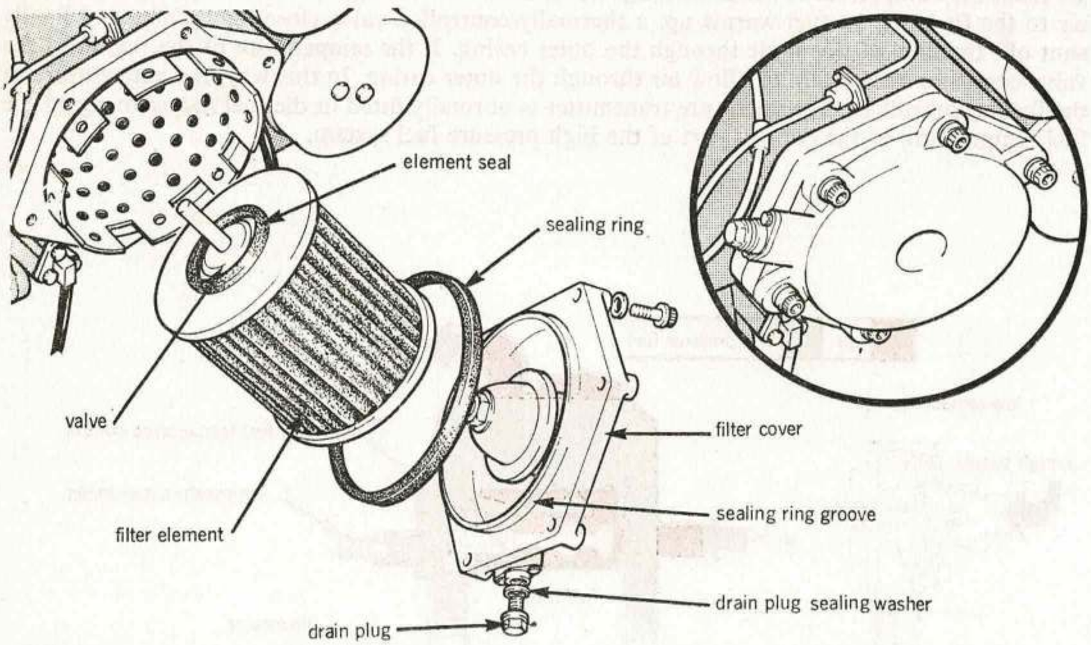

Fig 2.3.5 Low pressure fuel filter

Flowmeter

20. Because weight is one of the critical factors in an aircraft, fuel is normally measured in terms of pounds (lb) or kilograms (kg) rather than in gallons. For the fuel used in gas turbine engines, 1 gallon is equivalent to about 8lb (or 3·70kg). The flowmeter indicates the rate of flow of fuel to the high pressure pump in terms of lb/min or kg/min. In one aircraft, the flowmeter is calibrated in steps of 0·5 lb/min up to a maximum of 300lb/min. The actual rate of flow depends upon the aircraft operating conditions: at high forward speeds at sea level, or during take-off, the rate of flow will be high; at idling speeds at altitude, it will be low.

HIGH PRESSURE FUEL SYSTEM

General Points

21. The purpose of the high pressure part of the fuel system is to supply fuel to the burners in the combustion chamber at the correct pressure and in the correct quantity for all required conditions. So that the fuel may combine with the oxygen from the engine airflow to give a readily combustible mixture, it must be introduced into the combustion chamber as an atomized spray or vapour. It is the burner that produces this spray. A certain minimum pressure is required for atomization. Thus, even at idling speeds at altitude, a pressure of the order of 2 or 3 bars (30 to 40 psi) is required at the burners. The rate of fuel flow required during take-off, or when flying at high speeds at sea level, can be very high and, to give the required rate of flow through the orifices of the burners, a high pressure is then required; this can be as high as about 138 bars (or 2000 psi).

22. To provide the high pressure in the system, a high pressure (HP) pump is required; furthermore, in at least one system, the pressure produced by this pump must be capable of being varied to provide the required control over the rate of flow of fuel. Finally, we need some form of fuel control unit to vary the pump pressure and the rate of flow of fuel in response to various input demands. This basic design is illustrated in outline in Fig 2.3.6.

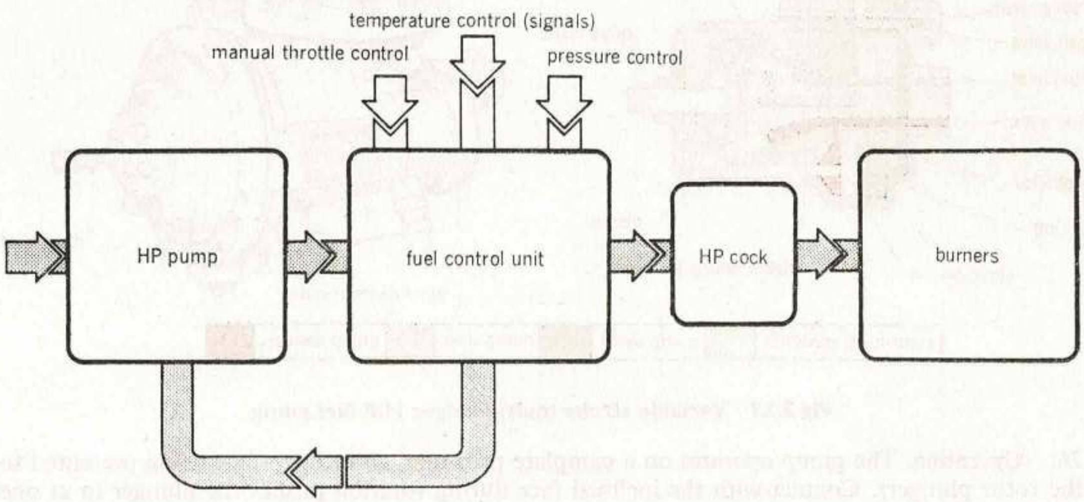

Fig 2.3.6 Outline of one type of basic H.P fuel system

The Fuel Control Unit

23. **The Fuel Control Unit (FCU) must respond to manual (throttle) movement initiated by the** pilot. It must also respond automatically to account for variations in altitude, air temperature, engine speed and so on. There are various ways in which the flow of fuel to the burners can be controlled: a pressure control system may be used; a flow control system may be used; a combined acceleration and speed control system may be used; or a similar system called the pressure ratio control system may be used. These will all be considered in the next Chapter. However, there remain some components that are common to most engine fuel systems — namely, the high pressure pump, the burners, and the associated burner components. These are discussed in the paragraphs that follow.

High Pressure Pumps

24. The purpose of the high pressure fuel pump is to provide a fuel supply to the engine at sufficient pressure to ensure satisfactory atomization of the fuel which passes into the burners in the combustion chamber. We shall consider two types of high pressure pump: the variable stroke multi-plunger type unit, and the gear type pump whose output is directly proportional to its speed.

Variable Stroke Multi-plunger Type Pump

25. The variable stroke multi-plunger type pump is illustrated at Fig 2.3.7. It may be fitted as a single unit or as a double unit to suit the engine fuel flow requirements, *ie* dual pumps are often fitted when a large supply of fuel is needed for higher powered engines (higher delivery rates), or as an added safety factor.

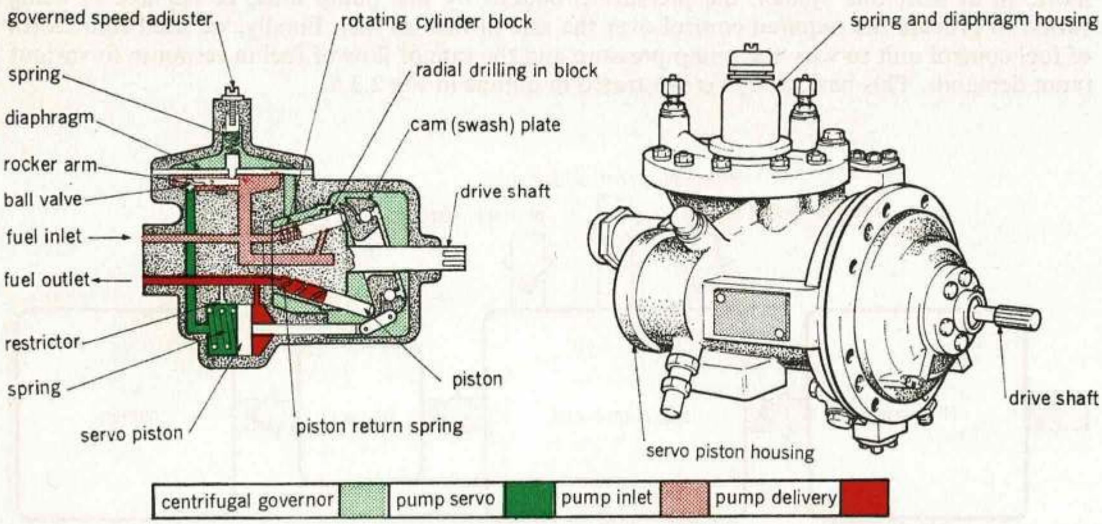

Fig 2.3.7 Variable stroke multi-plunger H.P fuel pump

26. **Operation.** The pump operates on a camplate principle, an inclined face being presented to the rotor plungers. Contact with the inclined face during rotation pushes the plunger in at one point, whilst the spring loading returns them on the opposite stroke. Thus, according to their position on the fixed ported insert, each plunger is alternately on the intake and delivery stroke once per revolution, causing the fuel to be taken in through one port and delivered at high pressure through the second port in the insert. The quantity of fuel delivered depends upon the angle of the camplate relative to the plungers. An increased angle increases the stroke of the plunger which, in turn, increases the fuel delivery; a decreased camplate angle will reduce the fuel flow.

27. The camplate angle is controlled by a servo piston linked to the camplate. The piston head is spring-loaded to the *maximum* angle position. The servo piston operates in a cylinder and is subjected to pump delivery pressure on one side and the combined forces of reduced delivery (servo) pressure and a spring on the other. A calibrated restrictor supplies pump delivery fuel to the spring side of the piston and this is bled off by the control system to adjust the servo piston position and, hence, the angle of the camplate. This, as we have seen, controls the fuel delivery.

28. An engine speed governor is also fitted (Fig 2.3.7). As its name implies, it prevents the engine from exceeding its maximun speed limitations. Radial drillings in the fuel pump rotor direct fuel under centrifugal force to one side of a spring-loaded diaphragm in the governor unit. When centrifugal force reaches a pre-determined value, the diaphragm flexes sufficiently to open its spill valve and reduce servo pressure. The reduction in servo pressure adjusts the HP fuel pump camplate angle to limit the amount of fuel delivered to the engine, so controlling speed.

Gear Type Fuel Pump

29. The gear type HP fuel pump is driven from the engine compressor shaft and, as stated earlier, the output is directly proportional to its speed. The fuel flow to the spray nozzles is controlled by recirculating fuel in excess of that required *back to the inlet side of the pump*. The pumping action is produced by two spur gears which are meshed to rotate in opposite directions and housed in a close tolerance casing. The gears are mounted on pressure-loaded bushes to attain a high volumetric efficiency. When the gears are rotated, fuel in the space between each gear tooth is carried around the outer edge of the casing to the delivery side of the pump. A pressure relief valve in the pump delivery line by-passes pump delivery flow to the low pressure side of the pump in the event of excessive pump delivery pressure. The pump drive shaft may incorporate integral gears; one may drive a pressure drop regulator (described later in the flow control system); another may be used to drive the LP pump described in para 15.

Fuel Burners/Spray Nozzles

30. The purpose of the fuel burners is to atomize or vaporize the fuel to ensure rapid burning. The usual method of atomizing the fuel is to pass it through a swirl chamber where tangentially disposed holes or slots impart swirl to the fuel by converting its pressure energy to kinetic energy. In this state, the fuel passes through the discharge orifice where the swirl motion is removed as the fuel atomizes to form a cone shaped spray. The shape of the spray is an important indication of the degree of atomization; thus the rate of swirl and, therefore, the pressure of the fuel at the burner are important factors in good atomization. An illustration of the various stages of atomization is at Fig 2.3.8.

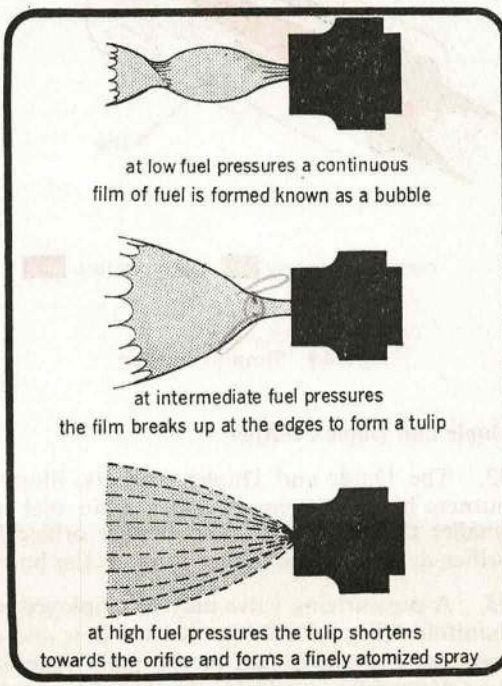

Fig 2.3.8 Stages of fuel atomization

Simplex Burner

31. The Simplex burner, illustrated at Fig 2.3.9, consists of a chamber which induces a swirl into the fuel and a fixed-area atomizing orifice. A Simplex burner is adequate for those engines where the *range* of fuel flow requirement is *small*. However, large, modern gas-turbine engines normally have a very wide range of fuel flow requirements, varying from a low rate of flow at cruising speed at altitude to a very high rate of flow at take-off. This is difficult to achieve with a single spray nozzle, such as in the Simplex burner. If the orifice were of a size suitable for atomizing fuel at low rates of flow, the pressure required at take-off would be very high (because the flow through an orifice is proportional to the *square* of the pressure drop across it). This means that if the minimum pressure for effective atomization was 30 psi (2·068 bars), the pressure needed to give maximum flow would be about 3000 psi (207 bars). Rather than design HP fuel pumps to produce this very high pressure, dual spray burners (Duple and Duplex) were introduced to give similar results at lower pressures.

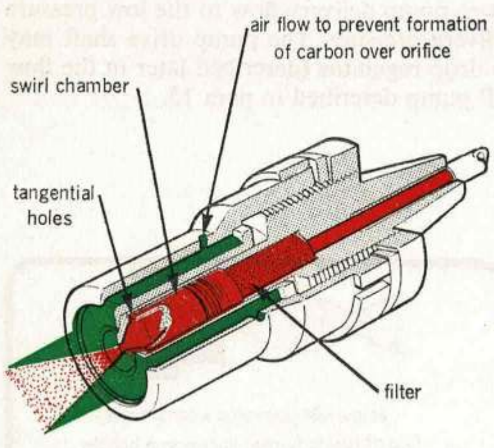

Fig 2.3.9 Simplex burner

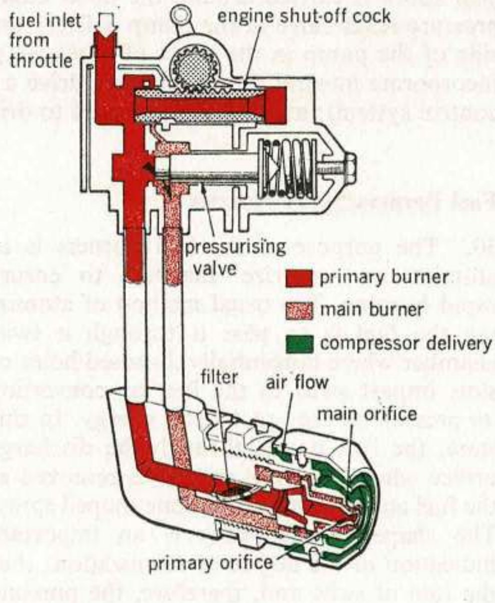

Fig 2.3.10 Duplex burner

Duple and Duplex Burner

32. The Duple and Duplex burners, illustrated at Fig 2.3.10, are, by definition, dual spray burners having a primary and a main fuel mainfold and two independent orifices, one much smaller than the other. The smaller orifice handles the low rates of fuel flow, and the larger orifice deals with the higher flows as the burner pressure increases.

33. A pressurizing valve may be employed with this type of burner to apportion the fuel to the manifolds (Fig 2.3.10). As the fuel flow and pressure increase, the pressurizing valve moves to progressively admit fuel to the main manifold and the main orifices. This gives a combined flow down both manifolds. In this way, the Duple and Duplex burner are able to give effective atomization over a wider range than the Simplex burner for the same maximum burner pressure. Efficient atomization is also obtained at the low flows that may be required at high altitude.

Spray Nozzle

34. The spray nozzle, illustrated at Fig 2.3.11, carries a proportion of the primary combustion air with the injected fuel. By aerating the spray, the fuel-rich concentrations produced by other types of burner are avoided, thus giving a reduction in both carbon formation and exhaust smoke. An additional advantage of the spray nozzle is that the low pressures required for atomization of the fuel permits the use of the comparatively lighter type gear pump.

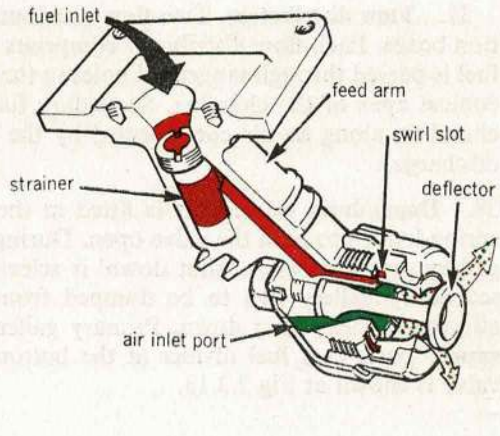

Fig 2.3.11 Spray nozzle

Fuel Gallery or Burner Manifold

35. Fuel is passed from the Fuel Control Unit (FCU) to the burners or spray nozzles via a fuel gallery (sometimes known as a burner manifold). As an example, we shall describe the fuel distribution fitted to a Pegasus Engine in a Harrier aircraft.

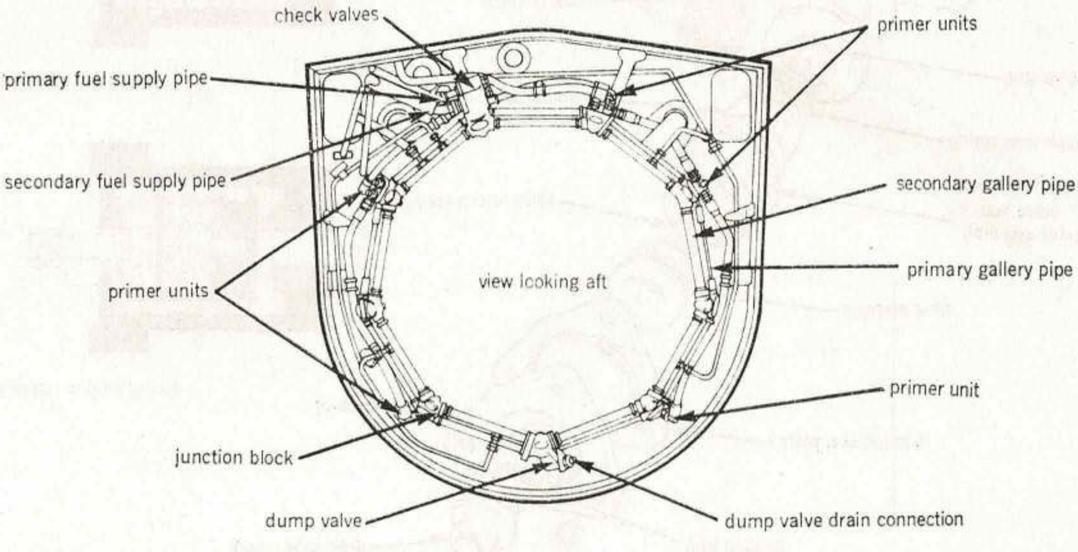

Fig 2.3.12 Fuel gallery and primer jet system

36. The fuel gallery pipelines are made from stainless steel and encircle the engine; they interconnect junction boxes serving the combustion system. Check valves are also fitted in the system. The check valves act as pressurizing valves to ensure that pump delivery pressure does not fall below a predetermined figure (approx 200 psi at low flow conditions). The valves also control the flow of fuel to the galleries. At pressures below a predetermined figure (300 psi), all fuel is passed into the primary gallery; at pressures above this, fuel is passed into both the primary and the secondary galleries. An illustration of the fuel gallery, together with the primer jet system (which is described in a later paragraph) is shown at Fig 2.3.12.

37. **Flow distributors.** Two flow distributors are incorporated in each of the nine gallery junction boxes. Each flow distributor comprises a swirl chamber with two fuel entry ports. Primary fuel is passed through tangential holes in the side of the swirl chamber and discharges through a conical apex of the chamber. Secondary fuel is passed through a port in the base of the swirl chamber, along an air core formed by the swirling primary flow and unites with the primary discharge.

38. **Dump/drain valve.** This is fitted at the 6 o'clock position. It is diaphragm operated and spring-loaded to hold the valve open. During engine running, the valve is held closed by primary gallery pressure; when 'shut down' is selected, the spring loading opens the valve and permits secondary gallery fuel to be dumped from the system into the aircraft drain tank, thereby effecting a clean shut down. Primary gallery fuel is also dumped through the secondary flow supply ports in a fuel divider at the bottom of the gallery system. An illustration of a dump valve is shown at Fig 2.3.13.

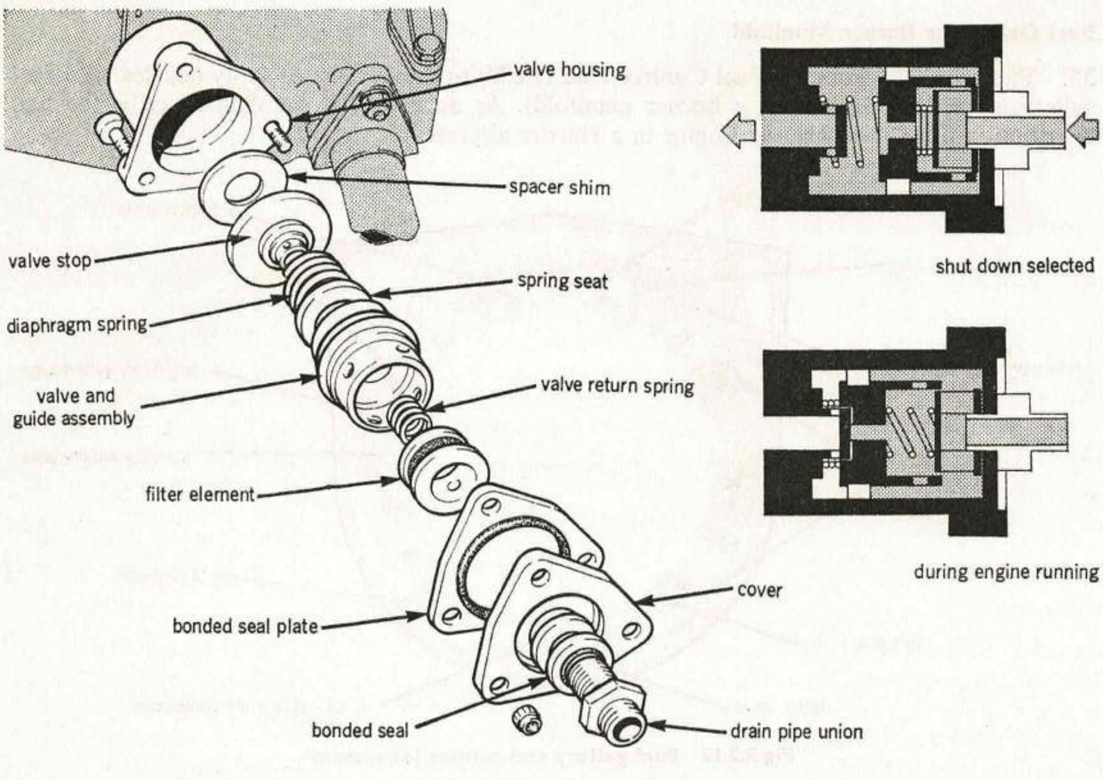

Fig 2.3.13 Dump valve

39. **Torch igniter and primer jet system (Fig 2.3.12).** Fuel tapped from the metered supply is injected into the vaporizing chamber through five primer jets, two of which are positioned adjacent to the igniters. This fuel assists light-up on starting and is controlled by a solenoid valve on the igniter circuit. A check valve permits a small flow of fuel to the primer jets *at all engine speeds*; this prevents the jets becoming blocked by carbon deposits and stabilizes the flame during deceleration.

SAFETY AND SERVICING PRECAUTIONS

General

40. *Before any servicing is carried out, Safety and Servicing Notes should be read and understood.* During adjustment or replacement of components, reference should always be made to the appropriate AP. Particular attention should be given to any torque loading figures which are given, and they should never be exceeded. If leaks persist after making a connection and the correct torque values have been applied, then the connection should be dismantled, the joint faces examined for cleanliness, and the connection remade, using new gaskets, washers or 'O' rings as appropriate. Generally, an examination is made of the complete system for security, bonding, freedom from leaks and correct positioning and functioning of the drain system. Lubrication of gaskets, washers and 'O' rings is usually required during assembly of components unless stated otherwise. *Rubber seals and sealing rings must not be wetted with fuel as this induces swelling of the rubber*.

41. If you are removing any fuel system component, make sure that the HP and LP fuel cocks are 'OFF', and after removal of components make sure that all apertures are blanked off to avoid ingress of foreign matter. Before replacing any component, all expendable items such as sealing rings, gaskets, lockwire, lockwashers and split pins must be renewed. The fuel system must be bled after replacing or disturbing any fuel system component so that all air is expelled from the system.

42. **Cleanliness.** Scrupulous cleanliness is absolutely essential, and this cleanliness must start at the source, during the refuelling stage. Particular care must be taken to prevent the introduction of extraneous material, such as water, dust or grit, into the fuel tanks when refuelling the aircraft. Refuelling nozzles should be kept scrupulously clean. Cleanliness in the use of tools and equipment is also important. If, for instance, you are renewing a filter, do not unwrap the new element until just prior to fitting, and make sure you clean the filter housing and fit a new seal. Except where renewable elements are used, filters should be thoroughly washed in kerosene and dried with compressed air — never use rag for cleaning a filter. The low pressure fuel filter is normally provided with a drain valve for sampling purposes. A word of warning here about the use of cleaning solvents: most of these have a deleterious effect on rubber components; they may also have an adverse effect on your health if inhaled or absorbed through your skin — so make sure you wear protective clothing to protect your eyes, face and hands. If you become contaminated, wash your skin with soap and water and report the facts to your NCO i/c.

Adjustments

43. Adjustments to the fuel system may be necessary when a new engine is installed, when a component is replaced, or when incorrect operation of the system in flight is reported. Each component is bench tested before final approval; it is usual for the manufacturer to limit the extent to which adjustments can be made in service. If it becomes apparent that the permitted adjustment would be exceeded in order to achieve correct engine operation, then the appropriate air and fuel pipes must be checked for leaks. If the required adjustment is still excessive, it must be assumed that the component concerned is unserviceable and it should be replaced. The recording of any adjustment or replacement must be made in the appropriate MOD F720 job card.

44. As air temperature, pressure and humidity all affect engine operation, any adjustments to the system must take account of ambient conditions and, where applicable, specific gravity of the fuel. Graphs or Tables are provided in the appropriate engine Air Publication, showing the correction to be applied to a basic setting under different operating conditions. For example,

when setting an idling speed, which may be 40% at standard atmospheric pressure of 1013 millibars, it may be necessary to reset the actual engine speed to 43·5% when the atmospheric pressure is only 950 millibars. On some engine installations, it may also be necessary to disconnect or override other controls in order to make an adjustment where pressure sensing capsules, by their influence on the system, would restrict fuel flow.

45. Mechanical adjustments to the idling speed, maximum governed speed and acceleration rate are usually by means of a screw and, to avoid unnecessary engine running, the effect of a set amount of rotation of the screw is usually quoted in the relevant AP. Before making an adjustment, the engine should be run for a sufficient length of time to stabilize engine temperatures and, when altering power settings, the controls should be operated carefully and instruments kept under observation to prevent exceeding operating limitations. This is particularly important after the installation of a new engine or a component change. Adjusting screws must always be relocked.

Pipes

46. When changing fuel system components or pipes, care is necessary to ensure that the pipes are not strained, as this could result in the development of leaks due to the high fuel pressure in the system. Short rigid pipes are often used between components, and special fitting instructions may be quoted in the AP. It may, for instance, be necessary to loosen or remove an adjacent component in order to fit a pipe. When installing a *flexible* pipe, care must be taken to prevent the pipe from twisting when the connections are tightened. Before pipes are re-connected, they should always be examined for cleanliness and damage, especially at flared ends and nipples. Seals should be lubricated if necessary, and union nuts must be correctly locked. *Whenever pipes have been reconnected, the system should be bled to expel air from the system.*

Return of Components to Supply Squadron

47. When you return a component of the fuel system, make sure it is filled with storage oil, blanked off and properly labelled. Sometimes the components are placed in a polythene bag or in a special container. The bleeding and inhibition of the fuel system components for the appropriate engine is contained in the AP102C series, Part 16A.

CONCLUSION

48. In this Chapter, we have discussed the requirements which must be satisfied in a fuel system for a gas turbine engine. We have also described the low pressure part of the system and have indicated, in general terms, how the fuel supply to the engine is controlled. As stated earlier, the actual method of control can vary from one aircraft to another. Several different methods of control are in use and these are described in some detail in the next Chapter. Whatever method of control is employed, the objective has been to make sure that the correct quantity of fuel is introduced into the combustion chamber in the form of a freely atomized spray so that it may readily combine with the oxygen from the engine air flow to provide instant combustion. The type of burners or spray nozzles used is entirely a matter of design and varies from one aircraft to another.

49. Again it must be stressed that no adjustments or repairs are to be carried out to an engine fuel system without reference to the appropriate AP. Absolute cleanliness is essential. Remember, too, the words 'Foreign Object Damage (FOD)'; make sure that, when you have completed any work on the fuel system, all items used on the job have been accounted for. Check to be absolutely certain.