Chapter 1

BAROMETRIC FLOW CONTROL FUEL SYSTEM

(As applied to the Python Mk. 2 & 3 aero-engines)

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

GENERAL

1. This chapter deals with the general functsystem as applied to the Python Mk. 2 and 3 aero-engines and provides an introduction to the various units and their working principles. The units are described in detail in Section 5.

BASIC PRINCIPLES

2. The fuel system of the Python Mk. 2 and 3 aero-engines is designed to supply a continuous flow of fuel under all operating conditions of the engine. This fuel is sprayed into the mixing chamber of each of the eleven combustion chambers where it is vaporised and mixed with the correct weight of air for efficient combustion at all normal conditions of engine operation. Fuel for starting purposes is sprayed into the combustion heads of nine of the chambers through Kigass starting atomizers fitted to each chamber, whilst fuel is sprayed into the remaining two chambers through torch igniters. The starting fuel delivery is controlled by a solenoid valve which is opened by the actuation of the cockpit ignition switch and closed by the automatic action of the engine ignition switch governor.

3. The burners and combustion chambers are so arranged that, after initial ignition by the torch igniters, the fuel spray is ignited and burns continuously. Approximately a quarter of the total mass of air flow is used for combustion. The air/fuel ratio for the engine is approximately 55 : 1 by weight. The heat generated raises the temperature of the mass of air flowing through the engine, causing rapid expansion and an increased velocity of the gases which, applied to the turbine, provide the motive force for both engine compressor and propellers. The engine thrust and engine and propeller r.p.m. are controlled by variation of fuel delivery which is maintained relative to the propeller pitch. The operating conditions of both engine and propeller are controlled respectively by the flow control and propeller controller units. These units are linked mechanically and hydraulically to a cockpit single lever control

KEY TO FIG. 2

1 FUEL PUMP OUTLET
2 FUEL PUMP INLET FROM L.P. FILTER
3 H.P. FUEL PUMP
4 BLEED FROM FLOW CONTROL TO H.P. PUMP INLET
5 FUEL PUMP DRAIN CONNECTION
6 PROPELLER CONTROLLER UNIT ATTACHMENT FACING (SHOWN BLANKED-OFF)
7 ENGINE CONTROL UNIT
8 OIL INLET CONNECTION TO ENGINE CONTROL UNIT
9 TELEFLEX CONTROL TO COMPRESSOR BLOW-OFF VALVE
10 COCKPIT THROTTLE LEVER CONNECTION
11 CONTROL ROD LINKING FLOW CONTROL UNIT (16) TO ENGINE CONTROL UNIT (7)
12 SERVO CONNECTION BETWEEN H.P. PUMP AND FLOW CONTROL UNIT
13 BLEED FROM FLOW CONTROL TO H.P. PUMP INLET (SEE 4)
14 ALTITUDE CONNECTION, PIPE FROM ENGINE AIR INTAKE PITOT TO FLOW CONTROL UNIT CAPSULE CHAMBER
15 THROTTLE SERVO H.P. FUEL CONNECTION BETWEEN FUEL PUMP AND THROTTLE ASSEMBLY
16 BAROMETRIC FLOW CONTROL UNIT
17 THROTTLE SERVO L.P. FUEL CONNECTION, RETURN TO H.P. PUMP INLET
18 FUEL OUTLET FROM FLOW CONTROL UNIT
19 STARTING MANIFOLD FUEL CONNECTION FROM H.P. SHUT-OFF COCK
20 FUEL DISTRIBUTOR PRESSURE GAUGE CONNECTION
21 CONTROL ROD LINKING H.P. SHUT-OFF COCK UNIT TO COCKPIT LEVER
22 H.P. SHUT-OFF COCK, BURNER PRESSURE VALVE AND DISTRIBUTOR
23 H.P. SHUT-OFF COCK OPERATING LEVER
24 FUEL INLET TO H.P. SHUT-OFF COCK UNIT
25 STARTING EXCESS FUEL BLEED FROM H.P. SHUT-OFF COCK
26 H.P. FUEL FEED FROM PUMP TO THROTTLE SERVO (SEE ALSO 15)
27 STARTING SOLENOID VALVE (FEED TO STARTING MANIFOLD)
28 EXCESS FUEL BLEED SOLENOID VALVE (RETURN TO PUMP INLET)
29 FUEL PUMP INLET PRESSURE GAUGE CONNECTION
30 L.P. FUEL FILTER

through the engine control unit. To stop the engine, the H.P. shut-off cock is operated from a control lever in the cockpit which simultaneously operates the manual feathering control on the propeller controller unit. The various units are fitted to the engine bulkhead as shown in Fig. 2, 3 and 4.

4. Fuel for both starting and running conditions is supplied from the immersed tank pump through a low-pressure filter to the high-pressure pump. From this pump, fuel is delivered at high pressure to the barometric flow control unit, which incorporates both throttle and altitude control systems. The fuel is then fed through a H.P. shut-off cock (22), through the burner pressure valve to the distributor in which are embodied the slow-running and main jets. Fuel for starting purposes is obtained through a union in the H.P. shut-off cock body, situated immediately upstream of the burner pressure valve; from this union the fuel passes through a solenoid valve (26) to the starting manifold (41), to the torch igniters (31) and to the starting atomizers (38). A second solenoid valve is fitted and permits all fuel in excess of that for starting purposes to bleed back to the pump inlet; these two solenoid valves are operated simultaneously from the cockpit ignition switch. Other than for starting, fuel passes from the distributor through individual pipes to the burners in each of the eleven combustion chambers where it is vaporised and ignited.

COMPONENTS

High-pressure pump

5. The Lucas, type G.C.219/14M, high-pressure pump (3) is a multi-piston rotary type, which at 2,500 pump r.p.m. is capable of delivering 560/570 gall. per hour at 500 lb. per sq. in. and is fully described in A.P.4282A, Volume 1, Section 2. The pump is mounted on the starboard side of the engine accessory drive box cover and is driven from the engine accessory drive gearing through a splined drive rotating at 0·3575 engine speed. Integral with the pump is a servo control system and an overspeed governor control which is coupled to the servo system. Part of the governor control also acts as a maximum pressure relief valve which prevents excess pressures within the fuel system.

6. The pumping element consists of a rotor in which are machined seven cylinders each of which accommodates a spring-loaded piston. The ends of the pistons projecting from the outer face of the rotor contact a trunnion-mounted camplate. The angle of inclination of this plate is controlled by the servo piston to which it is connected by a piston rod. This angle of inclination can be varied from 90 deg. to the rotor axis, at which point there is a zero piston stroke, to 75 deg. to the rotor axis, at which point the maximum stroke is obtained. Consequently with the camplate set at an angle and with the pistons spring loaded against it, the rotation of the rotor imparts a reciprocating motion to all the pistons.

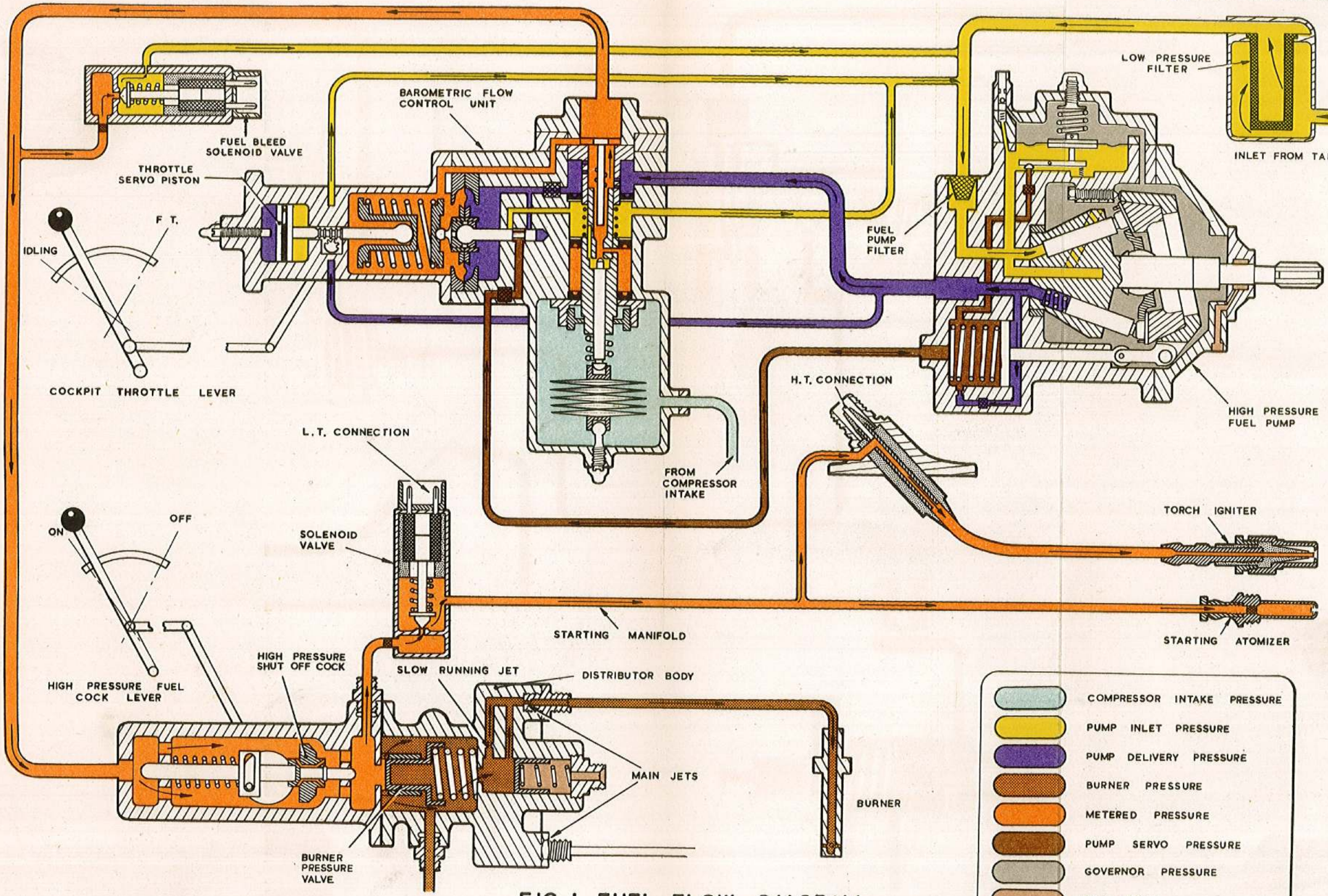

FIG. 1 FUEL FLOW DIAGRAM

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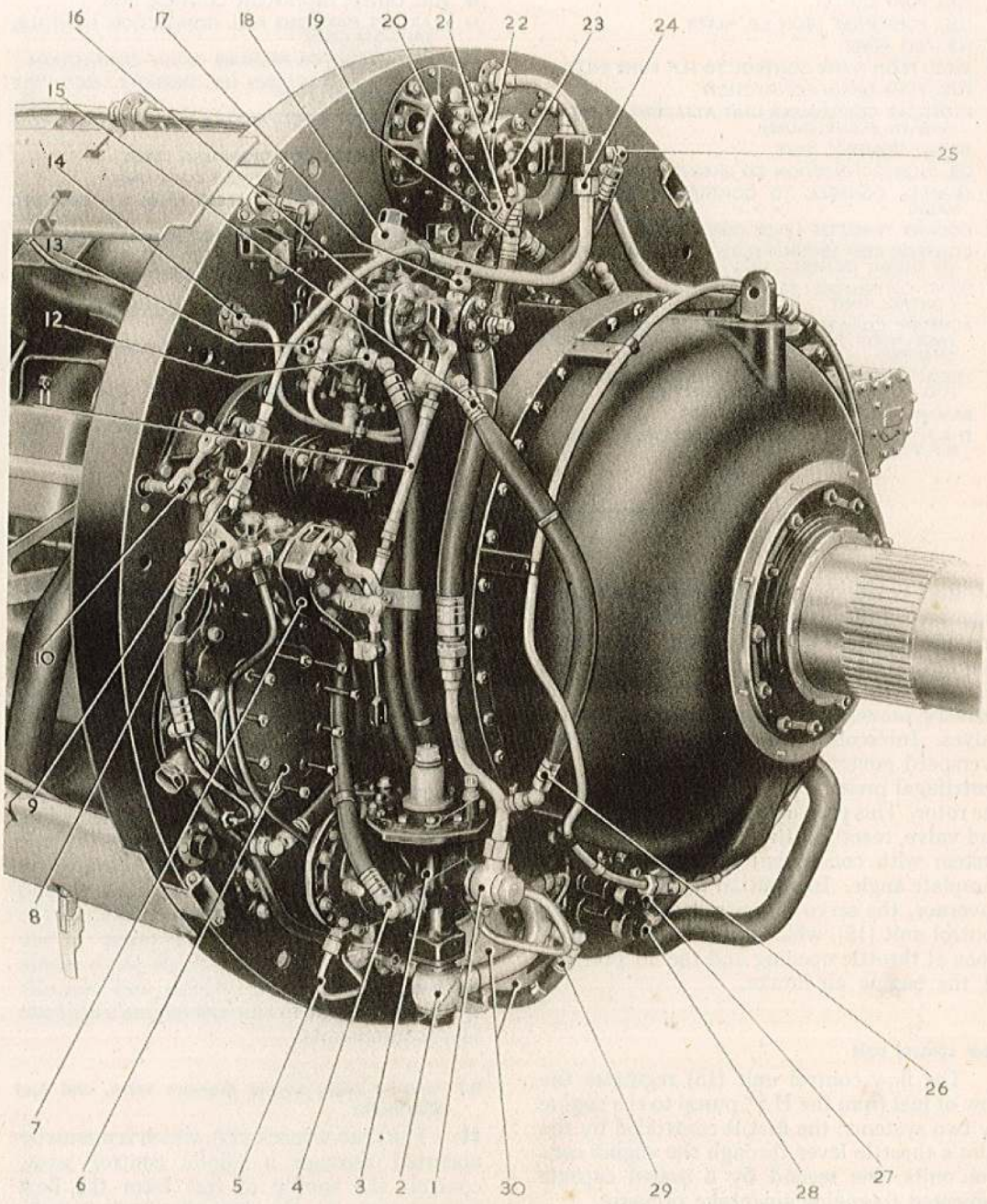

Fig. 2. Arrangement of fuel unit, front view, starboard

KEY TO FIG. 3

1 FUEL PUMP OUTLET
2 FUEL PUMP INLET FROM L.P. FILTER
3 H.P. FUEL PUMP
4 BLEED FROM FLOW CONTROL TO H.P. PUMP INLET
5 FUEL PUMP DRAIN CONNECTION
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24 FUEL INLET TO H.P. SHUT-OFF COCK UNIT
25 STARTING EXCESS FUEL BLEED FROM H.P. SHUT-OFF COCK
26 H.P. FUEL FEED FROM PUMP TO THROTTLE SERVO (SEE ALSO 15)
27 STARTING SOLENOID VALVE (FEED TO STARTING MANIFOLD)
28 EXCESS FUEL BLEED SOLENOID VALVE (RETURN TO PUMP INLET)
29 FUEL PUMP INLET PRESSURE GAUGE CONNECTION
30 L.P. FUEL FILTER
31 FUEL FEED FROM SOLENOID VALVE TO STARTING MANIFOLD
32 EXCESS FUEL BLEED VALVE CONNECTION TO H.P. PUMP INLET

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7. Fuel is fed through a ported plate to the inner face of the pistons and is delivered under pressure by the inward piston movement. The output of the pump is controlled by the servo system, which is operated by the delivery pressure through a series of control valves. Interconnected with this servo is the overspeed governor control actuated by the centrifugal pressure set up by the rotation of the rotor. This pressure, through a diaphragm and valve, reacts on the pressure to the servo system with consequent adjustment to the camplate angle. In addition to the overspeed governor, the servo is controlled by the flow control unit (15), which is actuated by variations of throttle opening and the air pressure at the engine air-intake.

Flow control unit

8. The flow control unit (15) regulates the flow of fuel from the H.P. pump to the engine by two systems; the first is controlled by the pilot's throttle lever through the engine control units, the second by a sealed capsule subjected to engine air-intake pressure.

9. The unit is mounted by a bracket to the engine accessory box and bulkhead and is connected to the engine control unit by suitable levers and control rods. Flexible pipes from the unit connect to the delivery, inlet and servo connections of the H.P. pump, whilst a solid-drawn delivery pipe connects the outlet of the unit to the shut-off cock (22). These pipe connections are shown on the flow control unit diagram of Section 5, Chapter 1.

10. Variation of throttle position caused by the movement of the pilot's lever, operates through a diaphragm on to a valve which reacts on the pump servo-system with consequent adjustment of the pump output to satisfy the engine requirements. Connected to, and working in conjunction with the throttle system, is a second servo-system actuated by the capsule stack of the unit. This second system, through a ported sleeve, controls the flow of fuel delivered by the pump to the engine, furthermore the capsule servo reacts on the throttle servo-systems and controls the pump output to suit the engine's altitude fuel requirements.

H.P. shut-off cock, burner pressure valve, and fuel distributor

11. The shut-off cock (22), which is manually operated through a pilot's control lever, controls the supply of fuel from the flow control unit to the burners, and is only operated during starting and stopping. Under all engine running conditions the cock remains in the open position.

12. The shut-off cock, burner pressure valve and fuel distributor, are incorporated in a single unit which is fitted to the upper part of the engine accessory box and bulkhead, starboard

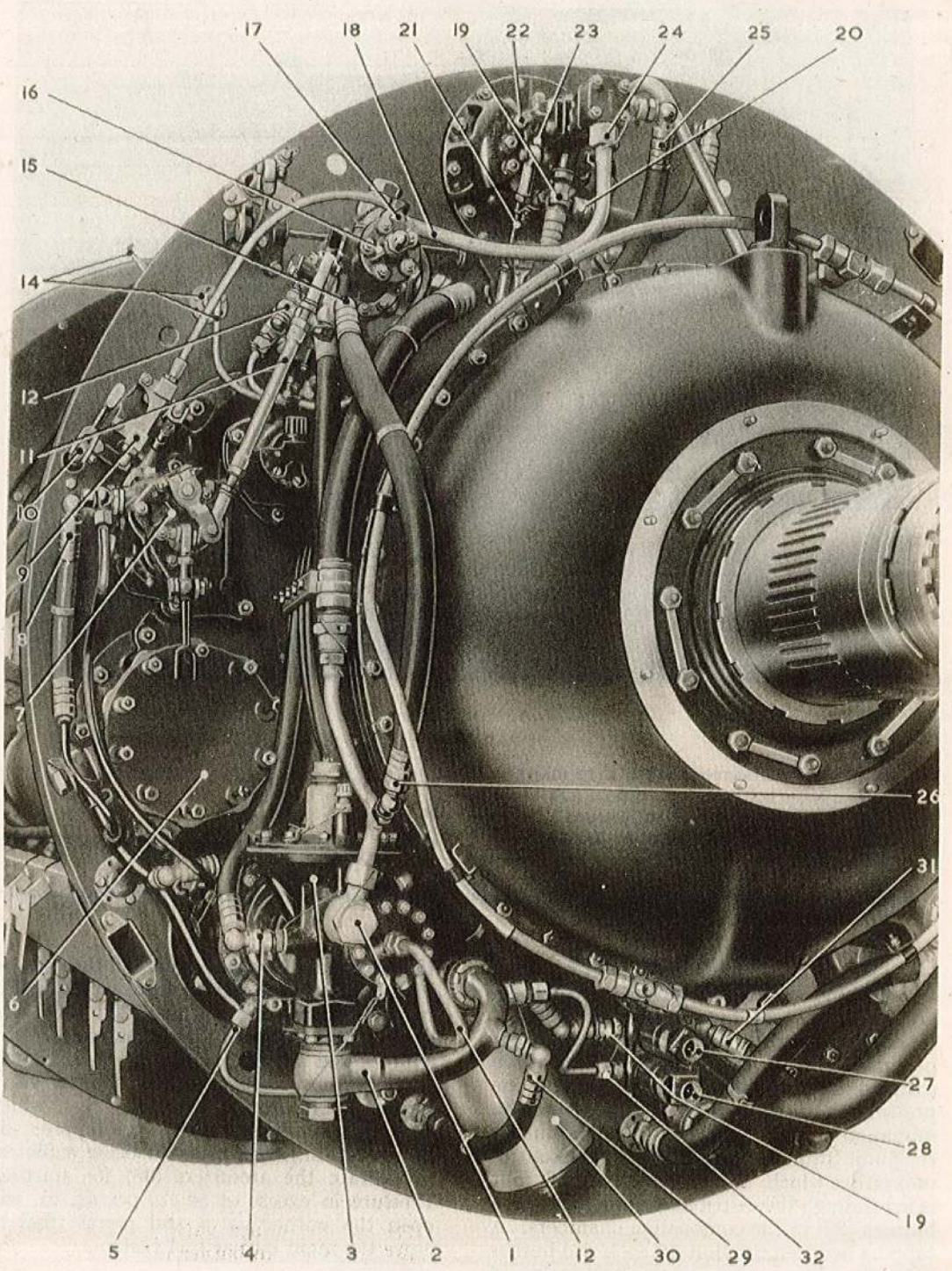
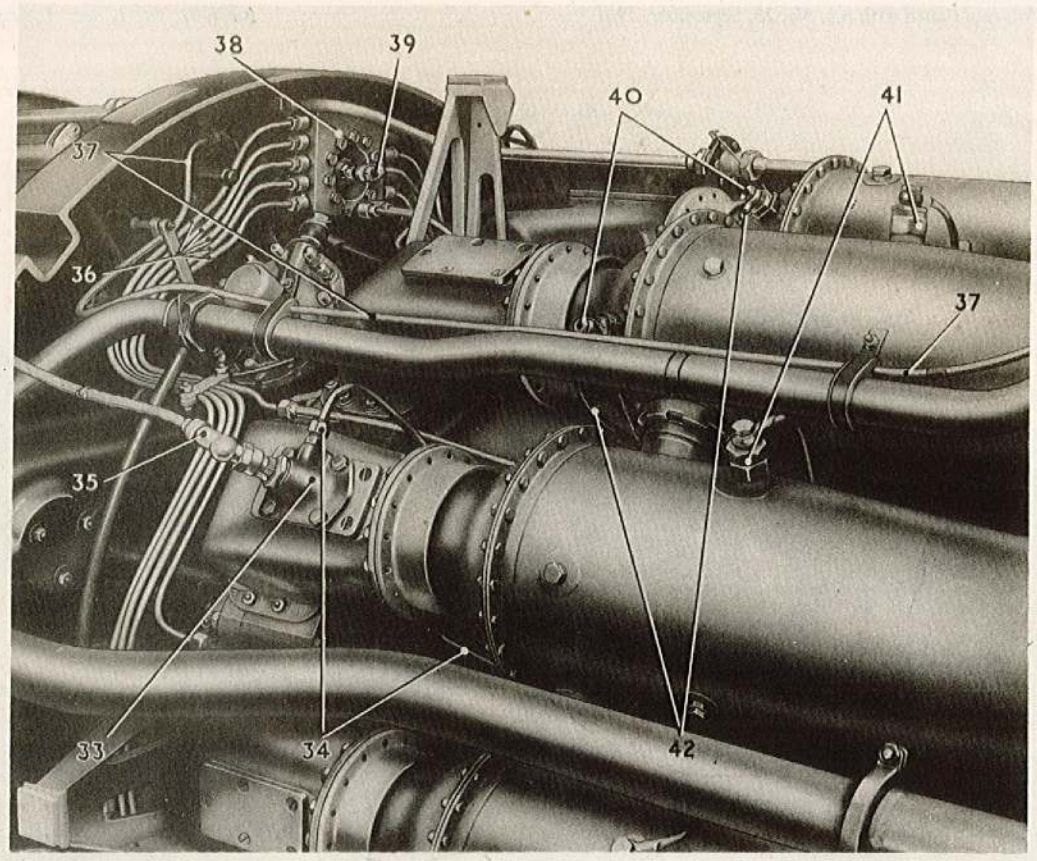


Fig. 3. Arrangement of fuel units, front view, starboard



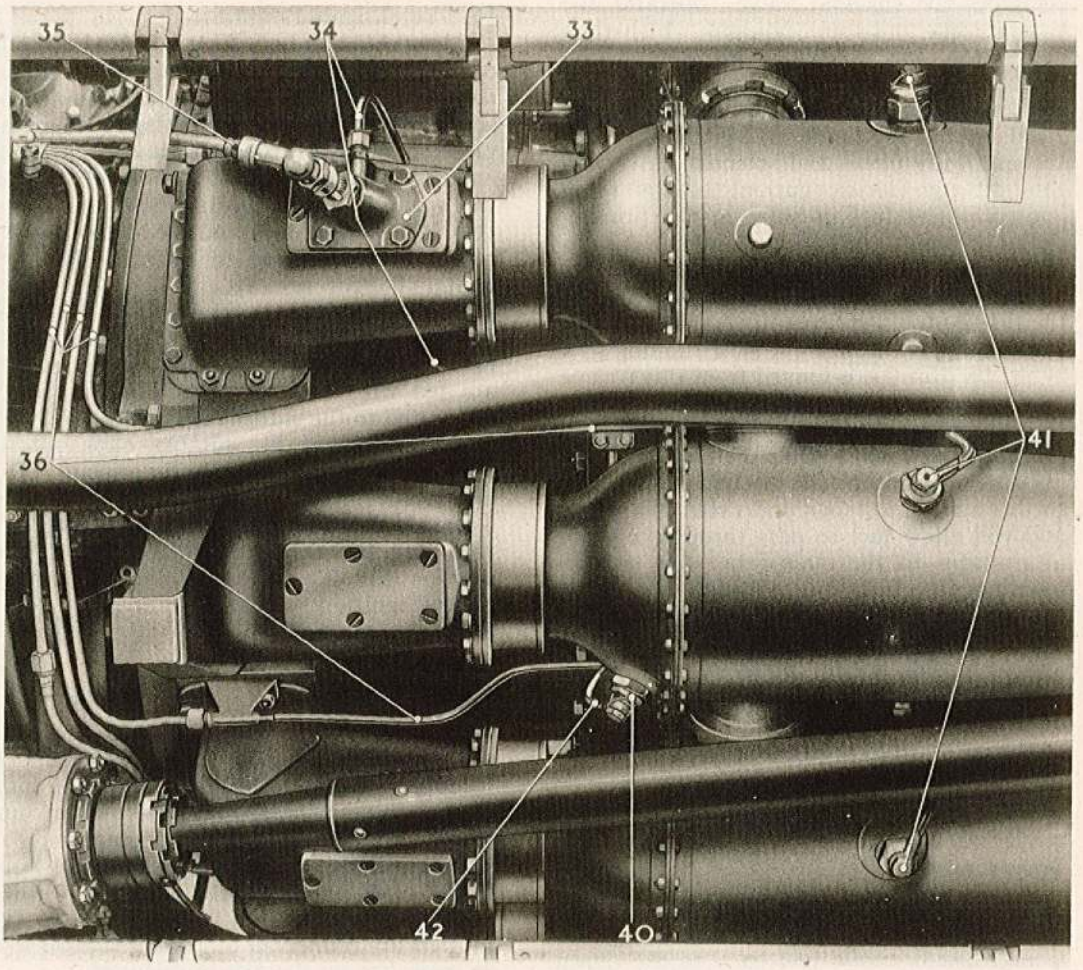
33 TORCH IGNITER
34 FUEL FEED FROM STARTING MANIFOLD TO IGNITER
35 H.T. LEAD FROM BOOSTER COIL TO No. 2 IGNITER
36 FUEL PIPES FROM DISTRIBUTOR TO BURNERS
37 PIPE TO DISTRIBUTOR FUEL PRESSURE GAUGE
38 DISTRIBUTOR BLOCK
39 DISTRIBUTOR DRAIN
40 STARTING ATOMIZERS
41 BURNERS
42 FUEL PIPE FROM STARTING MANIFOLD TO STARTING ATOMIZER

Fig. 4. Arrangement of piping to torch igniters, burners, starting atomizers and distributors

side. The cock is coupled to the pilot's control lever through suitable levers and control rods, and movement of the control lever simultaneously operates the propeller controller unit manual feathering control. A pilot valve situated in the valve head, balances the pressure to enable it to be operated with the minimum of effort. Fuel passes to the shut-off cock unit through a pipe from the flow control unit outlet which, after passing the cock unit is fed through the distributor and pipes to the burners (39) in the combustion chambers. A tapping between the shut-off cock and burner pressure valve supplies fuel through a solenoid valve (26) to the torch igniters and starting atomizers via the starting manifold.

13. Immediately downstream of the shut-off cock is a pipe connection from which fuel is supplied to the starting manifold (41) The flow of fuel to the starting manifold, torch igniters and starting atomizers, is indirectly controlled by a spring-loaded piston valve known as the burner pressure valve, which opens after a pressure build-up (approx. 50 lb. per sq. in.), this pressure being sufficient to operate the atomizers (38) for starting. Pressure in excess of 50 lb. per sq. in. will open the burner valve and permit fuel to enter the main burner fuel system.

14. When the engine is motored, fuel is delivered from the H.P. pump to the H.P.



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38 DISTRIBUTOR BLOCK
39 DISTRIBUTOR DRAIN
40 STARTING ATOMIZERS
41 BURNERS
42 FUEL PIPE FROM STARTING MANIFOLD TO STARTING ATOMIZER

Fig. 5. View of combustion chambers, piping, torch igniters, burners and starting atomizers

shut-off cock via the flow control unit. When the cock is manually opened, fuel flows into the priming chamber and a pressure build up occurs due to the restricting action of the starting atomizers and torch igniters. Operation of the ignition switch prior to starting energizes the solenoid valve, operates the booster coils and torch igniters, which then ignite the fuel. When all combustion chambers are alight, the engine speed increases to idling r.p.m. and at approximately 2,700 r.p.m. the ignition switch governor automatically closes the solenoid valve and cuts off the electric current to the torch igniters. The fuel pressure in the priming chamber (approx. 58 lb. per sq. in.) is sufficient at this stage to open the burner valve and a second spring-loaded piston valve in the distributor body, permitting fuel to flow to the burners through the slow-running jets. When the throttle is moved from this IDLING ON GROUND position (approx. 3,500 r.p.m.) to the minimum running position i.e., IDLING IN FLIGHT at 7,800 r.p.m., the increased fuel pressure will open the second valve still further against a second and a stronger spring and will allow fuel to pass through a series of passages to the main jets, thus supplementing the fuel flow through the slow-running jets. The fuel then leaves the distributor unit by individual pipes to the burners (39). A pipe union, fitted to the casing between the burner pressure valve and the distributor valve, is used for a connection (21) to the cockpit fuel distributor pressure gauge via the pipe (35).

Solenoid valve

15. Two solenoid valves are fitted, the first to regulate the flow of fuel for starting, the second bleeds excess fuel back to the pump inlet to prevent engine stall conditions. Both valves are mounted on a bracket attached to the lower part of the accessory drive box cover. The first or starting valve (26) is connected to the H.P. shut-off cock and distributor unit by a long flexible pipe (20). The outlet from this valve is connected to the starting manifold. The second solenoid valve, which is also connected to the H.P. shut-off cock by a flexible pipe, delivers bleed fuel to the pump inlet pipe by means of a short solid drawn pipe and a restrictor jet calibrated to give a flow of approximately 15 gall. per hr. The solenoids of both valves, to which are connected co. ically-shaped shut-off valves are wired to the cockpit ignition switch and the two booster coils. When the solenoid of the first valve is operated, fuel is allowed to flow to the starting atomizers and to the torch igniters.

Torch igniter

16. Torch igniters are fitted in No. 2 and 8 combustion chambers for the initial ignition of the fuel used during starting. Each igniter consists of an igniter head, containing the spark gap, which seats in the flame tube nose piece. Fuel flows through the central electrode and leaves by an atomizer jet hole adjacent to the spark position, the fuel being fed from the H.P. shut-off cock and the solenoid valve through the starting manifold. The two igniter flanges are attached to the outer surface of No. 2 and 8 diffuser elbows through which the igniter heads pass and protrude into the combustion chambers. The igniters are fed with fuel by pipes (32) which are connected to the starting manifold, the latter being supported in suitable clips spaced around the engine compressor casing. The electrical connection is made from the igniter electrode through suitably insulated adapters to a plug lead connection and thence by an ignition lead (33) to the booster coil and the cockpit ignition switch.

Burners

17. The eleven burners (39), which are fitted one in each of the eleven combustion chambers, discharge fuel direct into the combustion mixing chambers. Each burner comprises a central stem having an adapter at the outer end for a banjo pipe connection. Four radial holes connect with a central drilled passage through which the fuel flows. The burners are connected by rigid fuel pipes (34) to main jets on the distributor unit.

Starting atomizers

18. The nine starting atomizers (38) spray fuel into nine of the flame tube nose pieces, where the fuel is ignited through the interconnectors fitted between the chambers. After ignition occurs in No. 2 and 8 combustion chambers, each of which are fitted with a torch igniter, the flame spreads through the interconnectors to the remaining atomizers. Each atomizer comprises a single stem with a screwed adapter at the outer end for attachment to the combustion chamber boss and also has a banjo pivot for the fuel pipe. A central drilled passage in the body

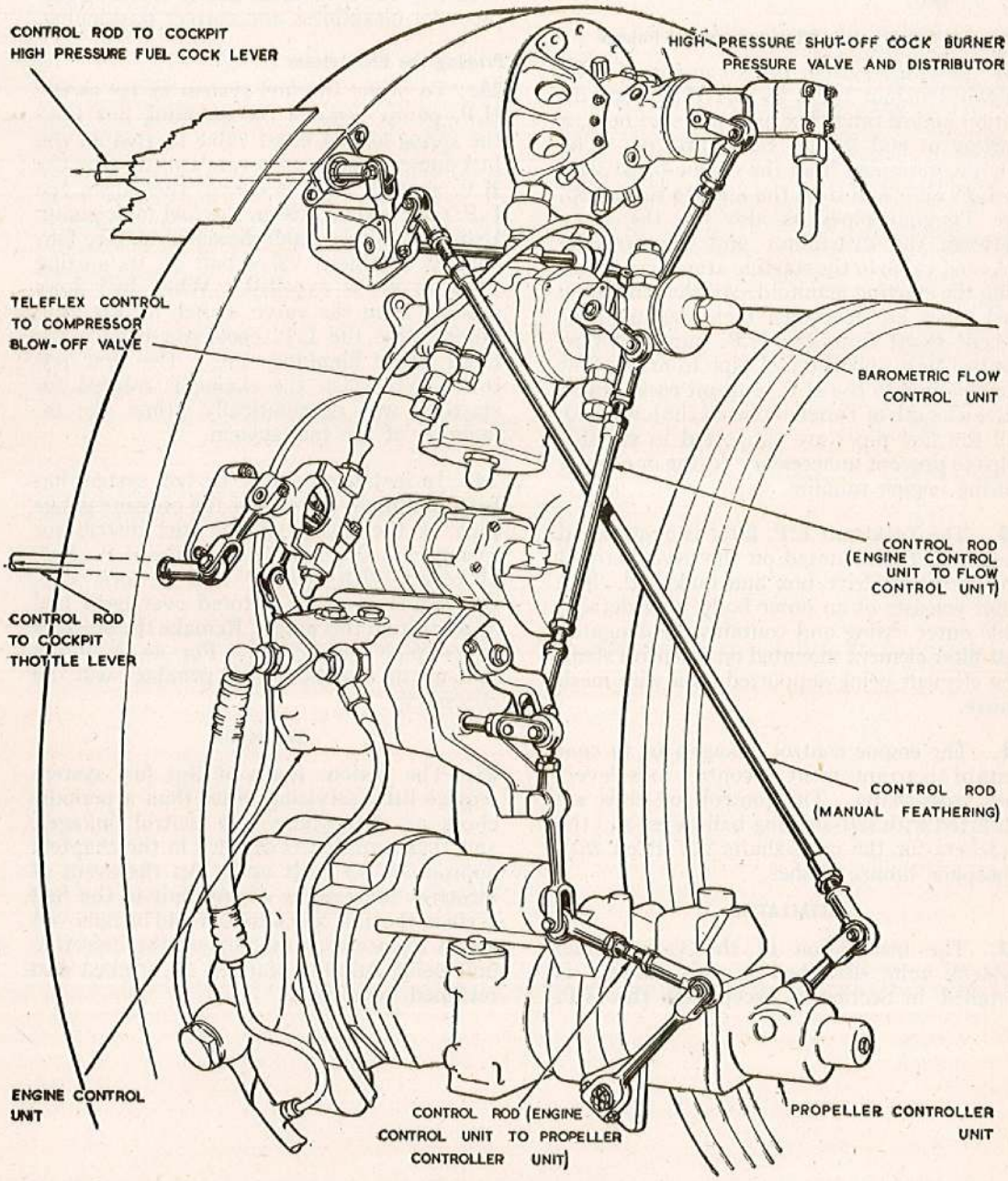

Fig. 6. Control rod layout (Python Mk. 2)

of the atomizer contains a small gauze filter and the atomizer jet. A shroud covers the stem and directs an air stream over the jet to assist mixing and complete atomization of the fuel.

Pipes and fittings, L.P. filter and control linkage

19. The fuel system pipes consists of solid drawn Tungum tubes to D.T.D.323 specification and of Silvo-flex high-pressure hose, a variety of end fittings being utilized. The low-pressure pipe from the engine back plate to L.P. filter and from the filter to the pump, are Tungum pipes as also are the pipes between the distributor and burners, the solenoid valve to the starting atomizers, including the starting manifold. All the remaining fuel pipes are Silvo-flex high-pressure hose except those from the H.P. pump to flow control unit and the fuel pipe from the flow control unit to the H.P. shut-off cock, which have a length of Tungum pipe at the lower end. All the fuel pipes are supported in suitable clips to prevent unnecessary flexing or chafing during engine running.

20. The Tecalemit L.P. filter is of standard design and is mounted on the lower part of the accessory drive box and bulkhead. The filter consists of an outer body with detachable outer casing and contains a corrugated felt filter element mounted on a central stem, the element being supported on a wire mesh gauze.

21. The engine control linkage (*fig. 6*) consists of an arrangement of control rods, levers and cross-shafts. The control rod ends are all fitted with self-aligning ball-races, and the brackets for the cross-shafts are fitted with phosphor bronze bushes.

INSTALLATION

22. The installation of the various fuel system units described in this chapter is detailed in Section 5, except for the H.P. pump, details of which will be found in A.P.4282A, Vol. 1, Section 2 (Lucas fuel pump, Type G.C.219/14M). Care must be exercised in the checking of engine controls for correct assembly and movement and in checking fuel pipes for cleanliness and correct positioning.

Priming the fuel system

23. To prime the fuel system as far as the H.P. pump, remove the blanking nut from the spring-loaded bleed valve located on the fuel pump diaphragm cover. Ensure that the H.P. shut-off cock is closed, then open the L.P. cock and switch on the fuel tank pump. Using a suitable small diameter tommy bar, depress the bleed valve ball off its seating until all air is expelled. When fuel flows steadily from the valve, switch off the tank pump, close the L.P. cock and replace the bleed valve blanking nut. The first few revolutions, when the engine is rotated for starting, will automatically prime the remainder of the fuel system.

24. In instances where the fuel system has been inhibited, disconnect the pressure gauge pipe at the union on the fuel distributor casing immediately in rear of the H.P. shut-off cock. With the H.P. shut-off cock open, the engine must be motored over until fuel appears from this union. Remake the pressure gauge pipe connection. For an inhibited system no further fuel priming will be necessary.

SERVICING

25. The various items of this fuel system require little servicing other than a periodic check on connections and control linkages, and that required is detailed in the chapters appropriate to each unit. In the event of incorrect functioning of any unit in the fuel system, the unit concerned should be removed and a replacement unit fitted, the defective unit being suitably blanked off, packed and returned for repair.