Chapter 10

FUEL PUMP AND FLOW CONTROL UNIT, TYPE I.F.S. SERIES

(*Completely revised*)

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Introduction

1. The fuel pump and flow control unit is designed to supply the correct quantity of fuel to the engine at any given fixed throttle setting, thus ensuring that any pre-selected engine condition is maintained irrespective of variations in flight conditions. The necessity for constant throttle adjustment is therefore eliminated, the pilot however still retaining over-riding manual throttle control for use when desired.

2. The unit is mounted on the engine accessory drive casing where the pump quill drive shaft engages with a mating drive; the pump direction of rotation is anti-clockwise when viewed on the mounting flange.

3. The overall fuel system also includes "Simplex" fuel burners, a centrifugal-type filter and an emergency overspeed trip governor. These items are fitted at points suitable to installation requirements; the latter two (filter and governor) are driven through gear trains from the engine. These supplementary units are covered in the following sections and chapters of this publication:—

Simplex burner	Sect. 7, Chap. 8
Centrifugal filter	Sect. 8, Chap. 4
Overspeed trip governor	Sect. 14, Chap. 8

4. The type number of the unit, i.e. I.F.S. 100 indicates the installation standard, and also the calibration code to which the unit must be tested. Differences in the units of this series are listed in Table 1 of this chapter.

Description and operation

5. The fuel pump and control unit comprise four major sub-assemblies bolted together to form the one interconnected and fully-automatic combined unit. These sub-assemblies are:—

(1) Fuel pump unit (f.p.)

(2) Hydro-mechanical governor unit (h.m.g.)

(3) Simple flow control unit (s.f.c.)

(4) Throttle valve and shut-off cock unit (t.v. and s.o.c.).

Fuel pump unit

6. This unit is of the positive-displacement, variable-stroke, multi-piston type, and incorporates both a servo control mechanism and an overspeed control; this overspeed control also functioning as a maximum pressure relief valve.

7. The quill driven rotor is supported in carbon bearings and incorporates five parallel bores which house the operating pistons; the spherical head of each piston is fitted with a socketed slipper that contacts an appropriately shaped camplate.

8. An auxiliary camplate (pivoted at its centre on a spring-loaded thrust ball) is fitted under the slipper heads and serves to retain the slippers in contact with the main non-rotating camplate. This camplate is mounted in two trunnions thus enabling its angle to be varied by the servo control piston with which it is connected. The rotor, the piston assemblies, and the auxiliary camplate together form the rotating assembly; lubrication and cooling of the piston slippers is effected by passing a graduated leakage of fuel through each piston crown.

9. Each rotor bore terminates as a port in the rotor end face which runs in contact with a fixed port insert incorporating two kidney-shaped ports (one inlet and one delivery) over which each rotor passes in turn during a complete piston stroke.

Servo control

10. The servo control piston is spring-loaded on the servo pressure side and is moved by

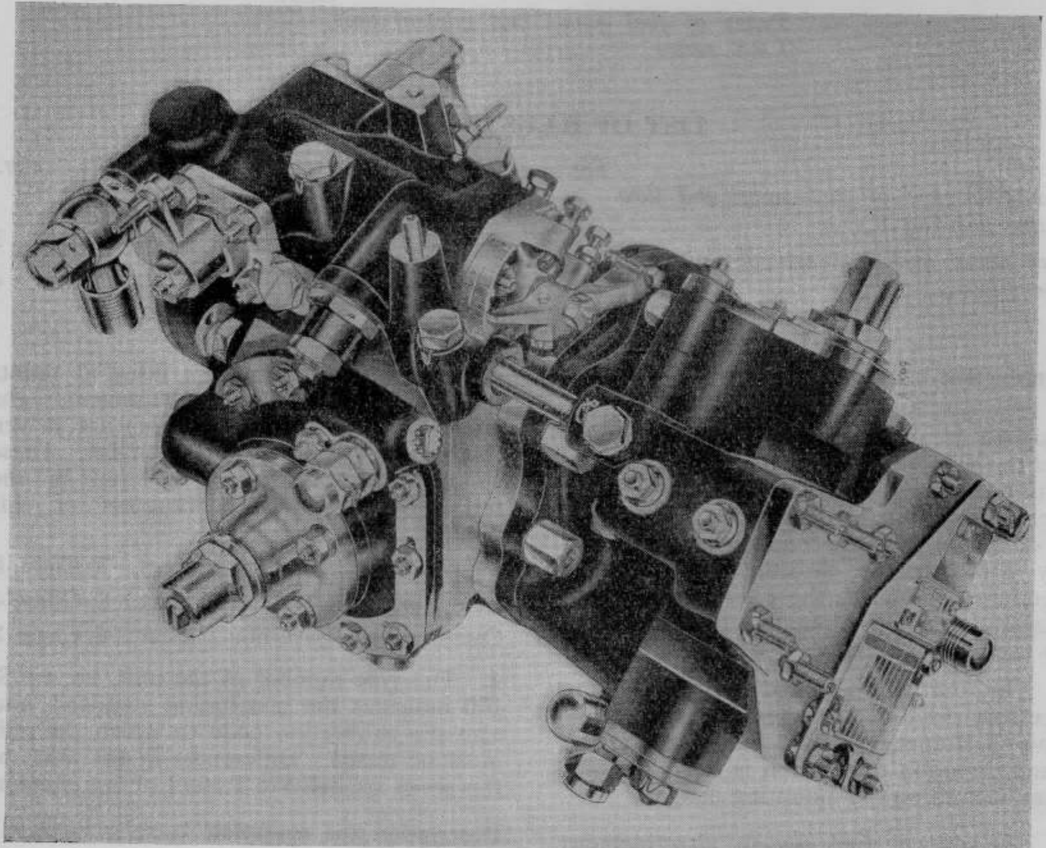

Fig. 1. Complete view of fuel pump and flow control unit (I.F.S.)

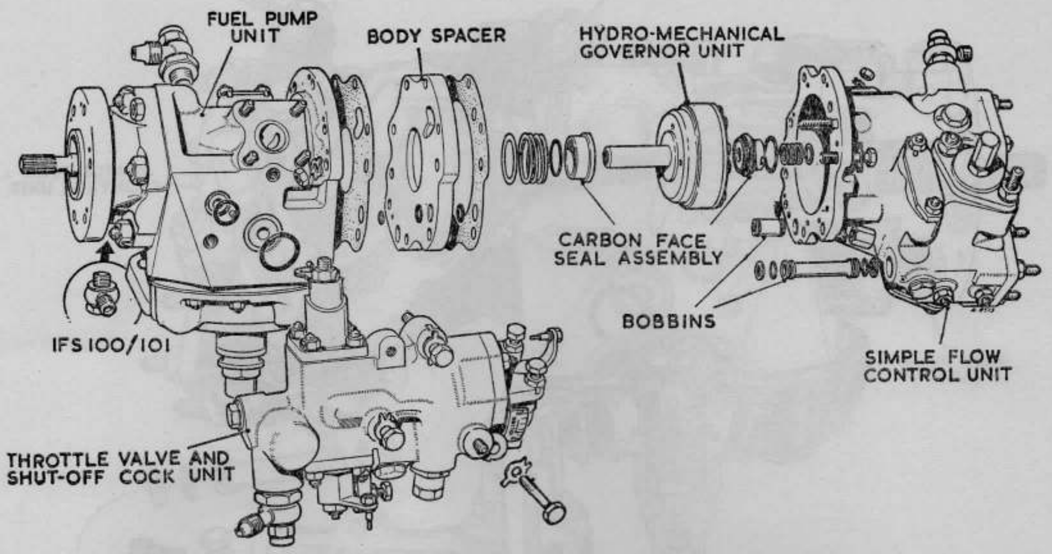

Fig. 2. Fuel pump and flow control unit sub-assemblies

the pressure drop across itself; the pressure drop is provided by pump delivery pressure acting on one side of the piston being opposed by the combined force of spring plus servo pressure acting on the other. The servo pressure is supplied by passing fuel from the pump pressure side of the piston through the strainer and orifice in the piston and into the spring-loaded side of the servo cylinder.

11. Movement of the servo control piston that varies the camplate angle and consequently pump delivery is regulated by modifying the control piston pressure drop; this is achieved by connecting the servo cylinder to two half-ball type control valves, one of which (located in the overspeed control) is held closed at all conditions except governing or stall as described later.

12. The second control valve is located in the simple flow control unit where, under steady running conditions, it remains slightly open to allow a steady spill of fuel from the pump servo chamber. In this state, the system is in equilibrium and the servo control piston remains almost stationary thus maintaining a constant delivery from the pump.

13. As the control valve in the simple flow control unit is responsive to both throttle valve pressure drop *and* compressor intake pressure (P1), any alteration in either throttle angle or ram pressure will increase or decrease the flow rate through the valve, which, in turn, will modify the servo control piston pressure drop to effect a change in pump stroke until equilibrium is again restored.

Relief valve

14. As previously stated, the control valve situated in the overspeed control opens only if the engine exceeds the maximum permissible rev/min, or if the fuel pressure exceeds a permissible maximum (stall pressure). In the overspeed condition, the control valve will open to reduce servo pressure in the manner described under 'Overspeed control valve'.

15. In the stall pressure condition, the pressure rise in the pump servo cylinder, which is tending to maintain the pump at full stroke (stalled), overcomes the force of the stall pressure spring in the overspeed control and forces the control valve to lift thereby reducing servo pressure and, therefore, pump delivery.

Hydro-mechanical governor

Speed signal generator

16. Fuel at pump delivery pressure is fed through a fixed make-up orifice to the speed signal generator rotor chamber whence it

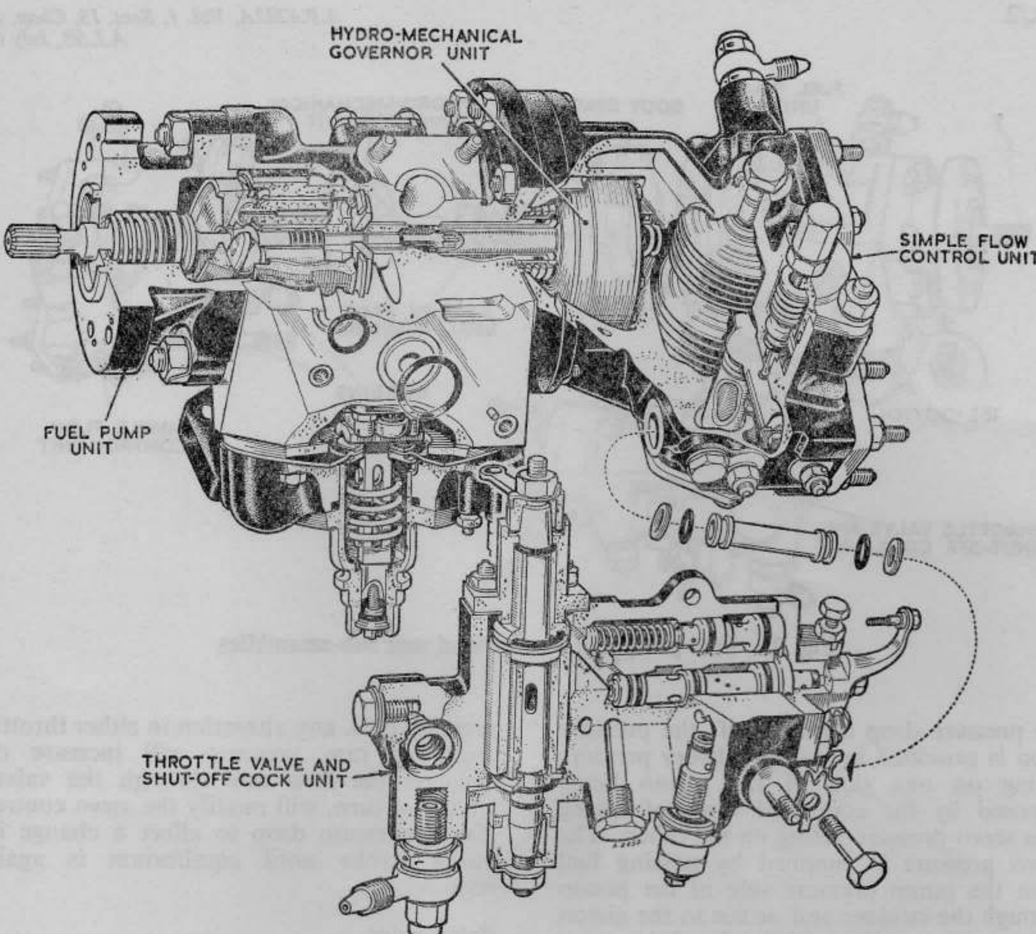

Fig. 3. Fuel pump and flow control unit (cutaway view)

passes through a variable control orifice in the rotor and returns to pump inlet through the rotor end plate.

17. The flow through the variable control orifice is controlled by a weighted lever which forms a plate valve over the orifice and is retained in the rotor by a hinge. The lever lies across the diameter of the rotor and (as the weight is above the plane of the hinge) any increase in rotor speed moves the lever tip towards the orifice thus providing a speed-sensitive force. At its centre, the lever is connected to a small diaphragm which senses the pressure drop across the control orifice and so opposes the lever weight force. This combination of forces produces a state of equilibrium at any one rotor speed and an increasing pressure drop characteristic with increase in rotor speed; this pressure drop is sensed as a speed signal pressure by the overspeed control diaphragm as described in para. 18 to 20.

Overspeed control

18. The overspeed control comprises a spring-loaded diaphragm assembly that operates the half-ball type control valve which is in communication with the pump servo cylinder. The overspeed valve is operated by the speed signal pressure from the H.M.G.; this speed signal pressure is opposed by a tension spring, the loading of which is adjustable in order that the governed speed may be accurately set.

19. As soon as the pre-determined maximum engine speed (and consequently governor signal pressure) is obtained, the diaphragm is deflected against a rocker lever which actuates, and thus causes the half-ball control valve to open. This action allows fuel at pump servo pressure to spill from the chamber above the pump servo control piston, with the result that the increased pressure drop across the piston moves it against its spring-loading thus reducing pump delivery and therefore reducing the engine rev/min.

20. Should a blockage occur on the pressure delivery side of the pump, the consequent rapid rise in pressure is immediately relieved by a stall valve (see para. 37), situated downstream of the pump. At the same time, the rise in pressure in the servo cylinder will lift the half-ball control valve from the orifice and thereby reduce pump output.

Simple flow control

21. The simple flow control is essentially a barometric pressure-sensing device which automatically controls the flow rate to the burners at varying altitudes; this control is achieved by relating P1 pressure (the pressure existing at the engine intake) to the pressure drop across the throttle valve and shut-off cock.

22. The operating mechanism consists of a capsule assembly, an operating lever and a pressure drop control; the bellows portion of the capsule assembly is open to P1 pressure on the inside. The lever (which carries a half-ball valve controlling a pump servo control orifice) is so arranged as to be sensitive to any expansion or contraction of the capsule assembly, therefore any movement of the lever will have a direct effect upon pump output.

23. High pressure fuel is fed to both sides of the pressure drop piston which is balanced on one side with a spring capable of external adjustment to allow calibration setting. The supply to the underside of the piston is taken from pump outlet, whereas that to the upper (or spring) side is tapped from a point *downstream* of the final restricting factor, i.e. the shut-off cock. In this way, the overall pressure drop across the system is constantly communicated to the pressure drop control assembly. Each of the two sensing flows is passed through a strainer and attenuator; this attenuator modifies any shock waves which may otherwise cause the piston to oscillate.

24. During steady-running conditions, both the intake pressure (P1) and the system pressure-drop are reasonably constant. The capsule assembly and the pressure drop valve assembly are therefore in balance (through the lever), the half-ball control valve is very slightly open and the system is in equilibrium.

25. As the aircraft deviates from level flight conditions, the P1 pressure will correspondingly increase or decrease owing to the change in atmospheric conditions. Should the aircraft climb, for example, the reduction in P1 pressure will cause the capsule assembly to contract; this movement has the effect of raising the lever and consequently the half-ball control valve. This action allows an increased spill of servo fuel from the pump servo control orifice with the result that pump output is reduced to suit the decreased air mass flow through the engine.

26. This change in rate of flow modifies the pressure drop across the control unit, and this is immediately sensed by the pressure drop piston which, in turn, moves in contact with the lever to modify the flow through the servo valve and so vary the pump delivery until a state of balance is restored.

27. Conversely, a decrease in altitude causes the capsule assembly to expand; this results in a reduced rate of spill through the pump servo control orifice and a corresponding increase in pump stroke and output.

Throttle valve and shut-off cock

28. Before reaching the burners, the main fuel flow passes through the throttle valve, the shut-off cock and a pressure raising valve.

29. The function of the pressure raising valve is to ensure that, under 'start-up' conditions, the pressure of fuel at the burners is sufficiently high to eliminate 'dribble'. The valve remains closed until the pump delivery pressure exceeds the pre-determined spring loading, the valve then opening to allow fuel to pass to the burners.

30. The throttle valve, which has a total nominal movement of 60 degrees, consists of a profiled vane-type rotary valve in a fixed ported sleeve; the position of the valve relative to the sleeve metering ports determines the maximum flow rate possible at any given fixed lever setting.

31. Under idling conditions (whether at altitude or during ground running), much of the flow passes through an idling by-pass situated adjacent to the throttle valve. This by-pass, which is adjustable to allow accurate ground setting, ensures that even with the manual throttle control in the closed position the rate of flow to the burner never falls to a level at which flame extinction can occur.

32. The shut-off cock assembly comprises an outer fixed sleeve, an inner rotary sleeve, an emergency trip rotary cock and a manually-operated spindle. The spindle is connected with the cockpit control lever, and the normally-inoperative trip cock is connected, via linkage, with the overspeed trip governor.

33. During running conditions, the cockpit control lever is in the OPEN position and the ports in the rotary cock and the two sleeves are aligned with the body passages, the fuel flow thus being free to pass to the engine.

34. On 'shut-down' from idling, the cockpit control lever is moved to the CLOSED position; this movement has the effect of rotating the manual shut-off cock spindle and also the inner rotary sleeve with which this spindle is engaged.

35. This movement of the inner sleeve blanks-off the ports in the outer fixed sleeve and thereby cuts off the fuel flow to the engine; the resultant immediate drop in pressure downstream of the shut-off cock allows the pressure raising valve to close under the action of the spring.

36. The state of unbalance created across the system by closing the shut-off cock is immediately sensed by the pressure drop piston (as previously described) which moves under the influence of the large increase in pressure drop across the t.v. and s.o.c. This movement opens the half-ball control valve to spill servo fuel back to pump inlet and so reduce pump stroke to zero while the engine runs down. When the engine is stopped, the pump servo piston is moved to full stroke by the piston spring force.

Stall valve

37. Under normal flight conditions, the output from the pump is such that any sudden shut-off of fuel flow (whether caused by operation of the emergency trip governor or inadvertent closing of the manual control lever) may impart a considerable shock to the system with a consequent risk of damage.

38. This risk is eliminated by the provision of a simple spring-loaded stall valve situated upstream of the shut-off cock assembly. Any sudden rise in pressure will result in the spring-loading being overcome at a predetermined point, the valve then opening to relieve the pressure by passing fuel back to the inlet side of the pump.

39. When installed in the aircraft, the fuel pump and control unit is connected to the inlet guide vane (i.g.v.) control system; three external connection points are provided for this purpose and they perform the following functions:—

(1) Main inlet guide vane connection (situated in the pump body) carries high pressure fuel from the delivery side of the pump.

(2) The h.m.g. connection (situated in the side of the s.f.c. body) carries speed signal pressure.

(3) The suction connection (situated at rear of s.f.c. body) passes the low pressure flow from the i.g.v. control system back to the inlet side of the fuel pump.

40. The banjo pillar of the h.m.g. feed connection incorporates a machined restrictor orifice. This orifice provides a safeguard against complete loss of governor signal pressure (and hence overspeed control) in the event of breakage or excessive leakage in the i.g.v. control system or its associated piping.

Installing and servicing

41. Instructions for installing the unit and adjusting the throttle valve, and the manual and emergency shut-off cock linkages are given in the relevant engine Air Publication.

42. No servicing is necessary in the field other than adjusting the maximum speed governor and the idling by-pass, checking for leakage, and checking the security of connections and locking devices.

43. For inhibiting instructions refer to A.P.4471A.

Caution . . .

Fluids of any description must not be allowed to contact the interior of the capsule assembly; the P1 connection must therefore be kept blanked.

TABLE 1

Types of fuel pump and control unit, type I.F.S. series

Type	Remarks
I.F.S.100	Basic unit as described.
I.F.S.101	As I.F.S.100, with 10 holes incorporated in t.v. sleeve (as opposed to 11). Revised calibration.

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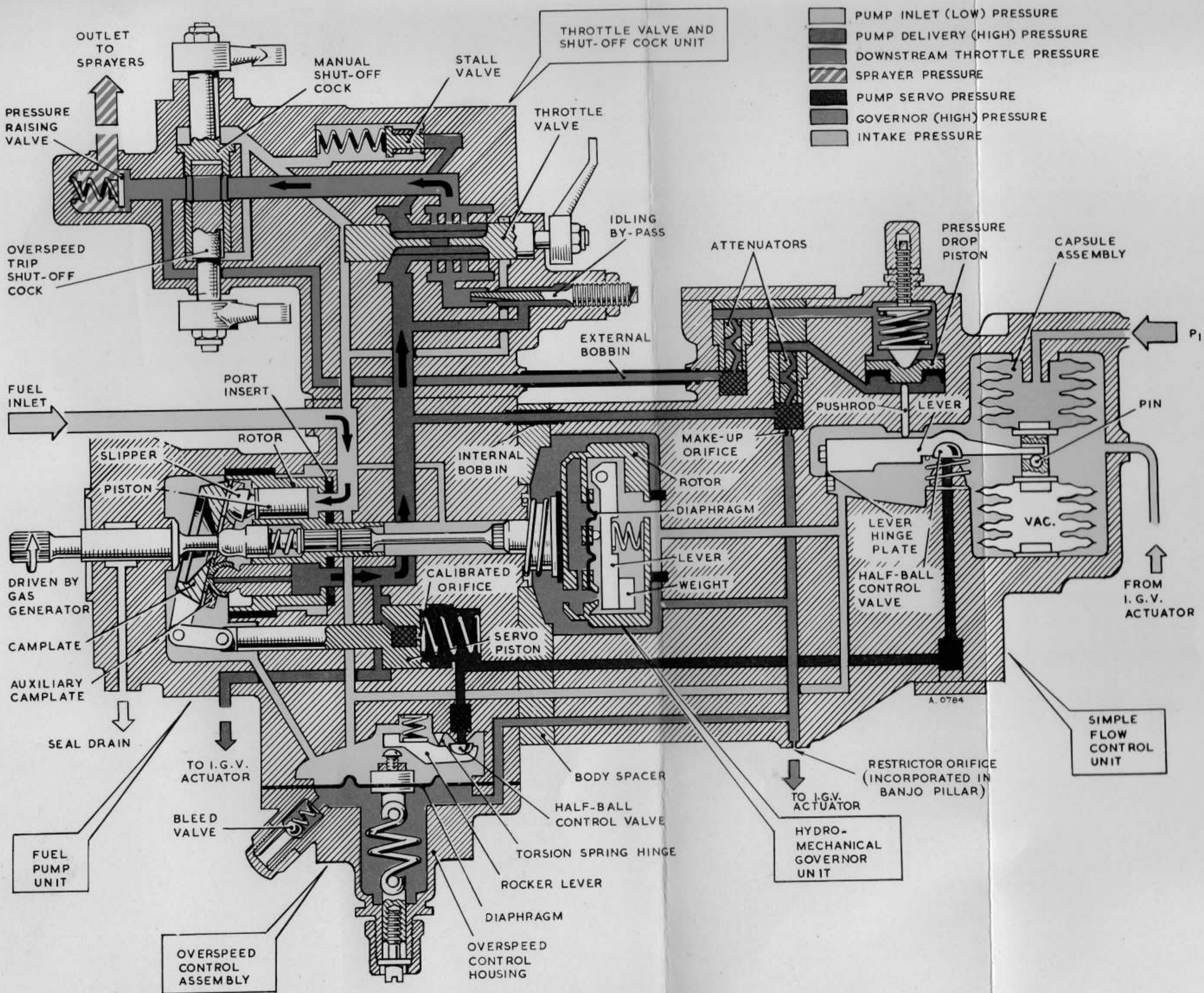

Fig.4 Functional diagram