Chapter 5

COMBINED CONTROL UNITS, TYPE FRFC 16, 17, 19 and 20 SERIES

LIST OF CONTENTS

	Para.		Para.
Introduction...	1	Throttle plungers	19
Principle of operation	4	Shut-off cock	21
Construction and operation		Installation	25
General	12	Inhibiting	26
Servo system	15	Servicing	27

LIST OF ILLUSTRATIONS

	Fig		Fig.
Combined control unit, type FRFC 16 and 17 series	1	Throttle valve and shut-off cock assembly... ...	4
Combined control unit, type FRFC 19 and 20 series	2	Functional diagram of unit	5
Altitude control assembly	3		

Introduction

1. The full range flow control units 16 and 17 series are identical except that the 17 series units have a modified operating linkage. The FRFC units 19 and 20 differ from the 16 and 17 in the following respects:—

(1) A self-aligning linkage is fitted.
(2) External adjustment for the altitude control is provided.
(3) The potentiometer has a three-point adjustment.
(4) In some instances, sealing rings are fitted in place of gaskets.

2. The only other variations within the series are in the installation fittings and calibration requirements. For example, on a unit designated FRFC 16/15H, 16 is the basic type number, 15 the type of installation, and H the calibration code.

3. Single lever control is embodied, the unit comprising a throttle valve, shut-off cock and altitude compensation with provision for any desired altitude idling requirement which is capable of being trimmed by a speed and/or temperature signal.

Principle of operation

4. The operating principle is that a constant pressure drop is maintained across the control unit at any given throttle position, but one value of this pressure drop is increased when the throttle is opened.

5. Fuel passes through the unit through two major circuits the larger of which consists of the throttle valve and a barometrically-positioned altitude metering plunger, this in turn controlling the flow through the smaller idling circuit consisting of the altitude idling valve.

6. With the throttle valve closed except for a small idling trim by-pass flow, the desired altitude idling characteristic is obtained with the minimum set pressure-drop across the unit.

7. At a throttle position corresponding to another desired condition, (such as climbing at maximum r.p.m. for ICAN conditions at say 0·8 Mach. No), with an intermediate pressure-drop the conditions are obtained by a suitably shaped altitude plunger, giving the correct flow area at any barometric pressure when taken in conjunction with the throttle valve area in series.

8. Such an arrangement, of two plungers in series, means that movement of either plunger when the other is presenting a relatively small flow area would normally have very little effect on the flow through the unit. This means that movement of the throttle at high altitude would give virtually no flow response until the throttle was nearly closed. To overcome this effect the top range of throttle operation is arranged to control the overall pressure drop of the unit so that a satisfactory, though limited, range of fuel flow is available even at the highest altitudes whilst a range of control covering the widest foreseeable range of requirements is obtained at low altitudes. The fact that most engines require a rising idling speed with increase in altitude offsets to a great extent the reduced control range at high altitude.

9. The control of the overall pressure drop

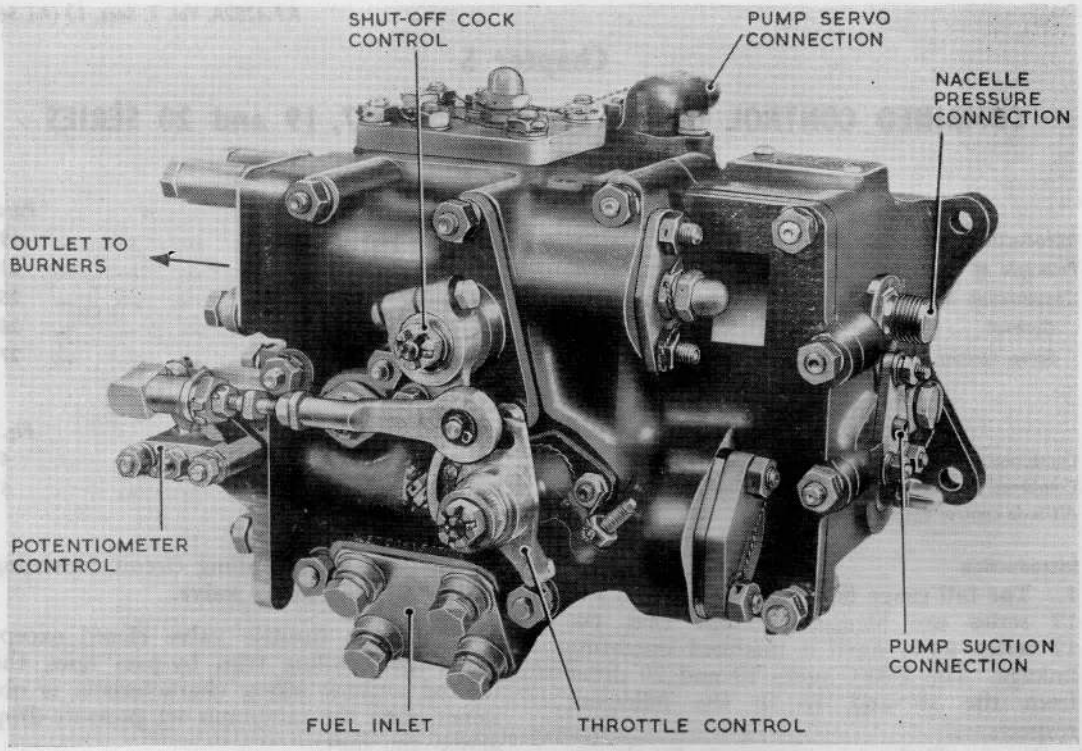

Fig. 1. Combined control unit, type FRFC 16 and 17 series

is achieved by the use of a throttle-controlled potentiometer circuit operating on the control unit pressure drop control, the potentiometer throttle valve being linked mechanically with the main throttle valve.

10. Trimming for the application of range speed or temperature control is applied by opening a parallel circuit across the potentiometer throttle valve to reduce the overall pressure drop. Such a trim is most effective over the higher throttle range, where range speed governing is most effective and desirable, but the trim becomes ineffective at low part-throttle conditions where scheduling control is more desirable. The trim available is of a limited extent, which assists in the stability of the governing system; tappings are provided on the unit for the application of such trimming controls.

11. A hydraulically-operated shut-off cock is incorporated in which the cock movement is controlled by a valve interconnected mechanically with the throttle lever; this, together with the interconnection of the potentiometer throttle, provides unilever control.

Construction and operation

General

12. Referring to fig. 5, it will be seen that fuel at pump delivery pressure (14) passes to the main throttle valve (12), to the idling trimming screw (16) and to the potentiometer throttle valve (18); pump delivery pressure also passes from the throttle valve chamber to the underside of the metering plunger (17) servo piston and an axial drilling in this plunger carries the same pressure to the altitude idling needle (23).

13. After passing through the throttle valve, the main flow and the by-pass bleed through the idling trimmer join together and pass to the altitude metering plunger; thence the flow passes through the metering orifice (24) to the shut-off cock (25) and through its orifice (26) to the outlet to the burners (27).

14. This main flow is controlled initially by the throttle valve, to a datum set manually by the pilot according to his requirements and modified by the metering plunger in response to ambient pressure, or altitude conditions, presented to the control as nacelle pressure P1 (3). Regulation of flow

through the metering orifice (24) is achieved in the following manner.

Servo system

15. The piston attached to the metering plunger (17) forms part of a servo system, the hydraulic pressure for which is supplied through an orifice (13) in the piston.

16. A servo chamber above the piston is in communication, through a drilling (9), with an orifice (5) and servo valve (6); the degree of valve opening and therefore the balance of servo pressure on the piston is controlled by the balance between two forces acting on a control cantilever (1). These forces are (a) the combined force of a range setting spring (7) and the nacelle pressure capsule (4) opposing a force (b) which represents, through a spring (10) and push rod (11) the position of the metering plunger. In equilibrium therefore, a balance is achieved between plunger position and nacelle pressure. Any alteration in nacelle pressure is sensed by the bellows (4) and this, through the striker pin (2), deflects the cantilever and modifies the spill through the servo valve which, in turn, causes an alteration in servo pressure. This destroys the pressure balance across the servo piston which moves until the balance is restored between the piston spring loading (10) and the bellows loading. As the piston moves so also will the plunger move, thus modifying the fuel flow area through the control, both for the main circuit and the idling flow circuit in accordance with the altered conditions.

17. Control of pump delivery is achieved by a pressure drop control piston (31) in a sleeve (29) and loaded by a spring (30); the piston is connected mechanically through a push rod (32) and rocker lever (34) to a servo valve (35) which controls an orifice in communication (33) with the pump servo system. The control spring side of the piston senses the metered fuel pressure downstream of the metering plunger whilst the other side of the piston senses a higher pressure (28) downstream of the potentiometer throttle (18). The difference between the pressures

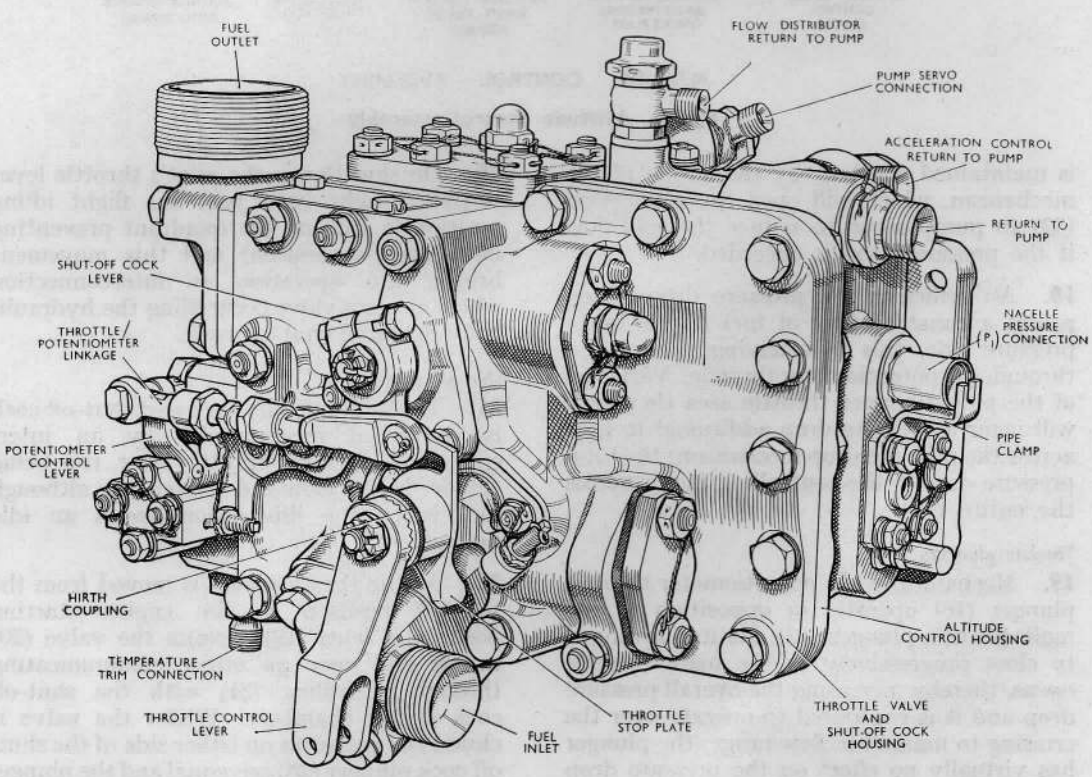

Fig. 2. Combined control unit, Type FRFC 19 and 20 series

(A.L.56, Apr. 58)

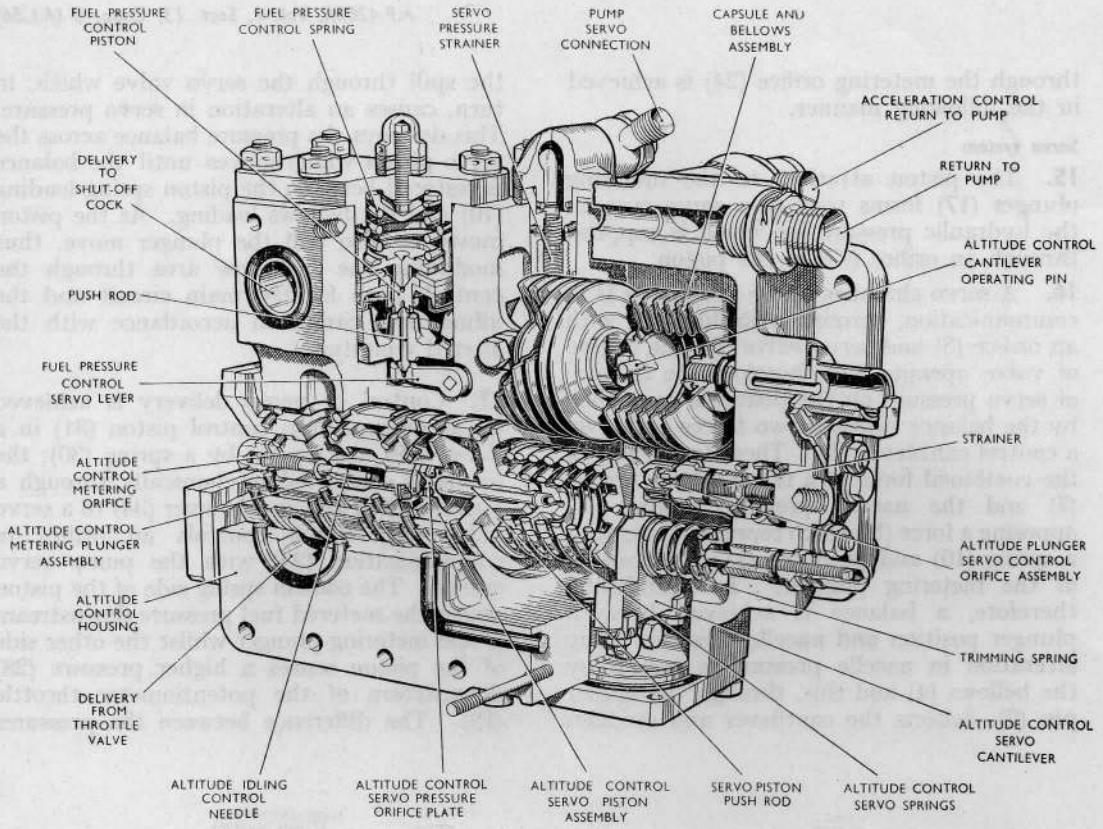

Fig. 3. Altitude control assembly

is maintained constant by the action of the mechanism, which will open the connection (33) to pump servo to reduce the fuel flow if the pressure drop is exceeded.

18. An orifice in the pressure drop piston passes a constant flow of fuel to the lower pressure side, this flow having passed also through the potentiometer throttle. Variation of the potentiometer throttle area therefore, will incur a pressure drop additional to that across the pressure drop mechanism; the total pressure drop is the controlling factor across the entire unit.

Throttle plungers

19. Mechanically the potentiometer throttle plunger (18) operates in opposition to the main throttle plunger (12), i.e. it is arranged to close progressively as the main throttle opens, thereby increasing the overall pressure drop and it is contoured to operate over the cruising to maximum flow range; the plunger has virtually no effect on the pressure drop at low throttle openings.

20. On shut down, the pilot's throttle lever is pulled right back past the flight idling position (a gate on the quadrant preventing inadvertent operation) and this movement brings into operation an interconnection which closes a valve controlling the hydraulically-operated shut-off cock.

Shut-off cock

21. The hydraulically-operated shut-off cock is controlled mechanically by an interconnection with the throttle lever, this being achieved by a cam and striker pin, although for clarity the illustration shows an idle linkage.

22. As the throttle lever is moved from the shut-off position to the engine starting position, a lever (19) permits the valve (20) to lift and open an orifice communicating through a drilling (21) with the shut-off cock spring chamber. Whilst the valve is closed the pressures on either side of the shut-off cock plunger (25) are equal and the plunger is held on its orifice face (26) by the spring.

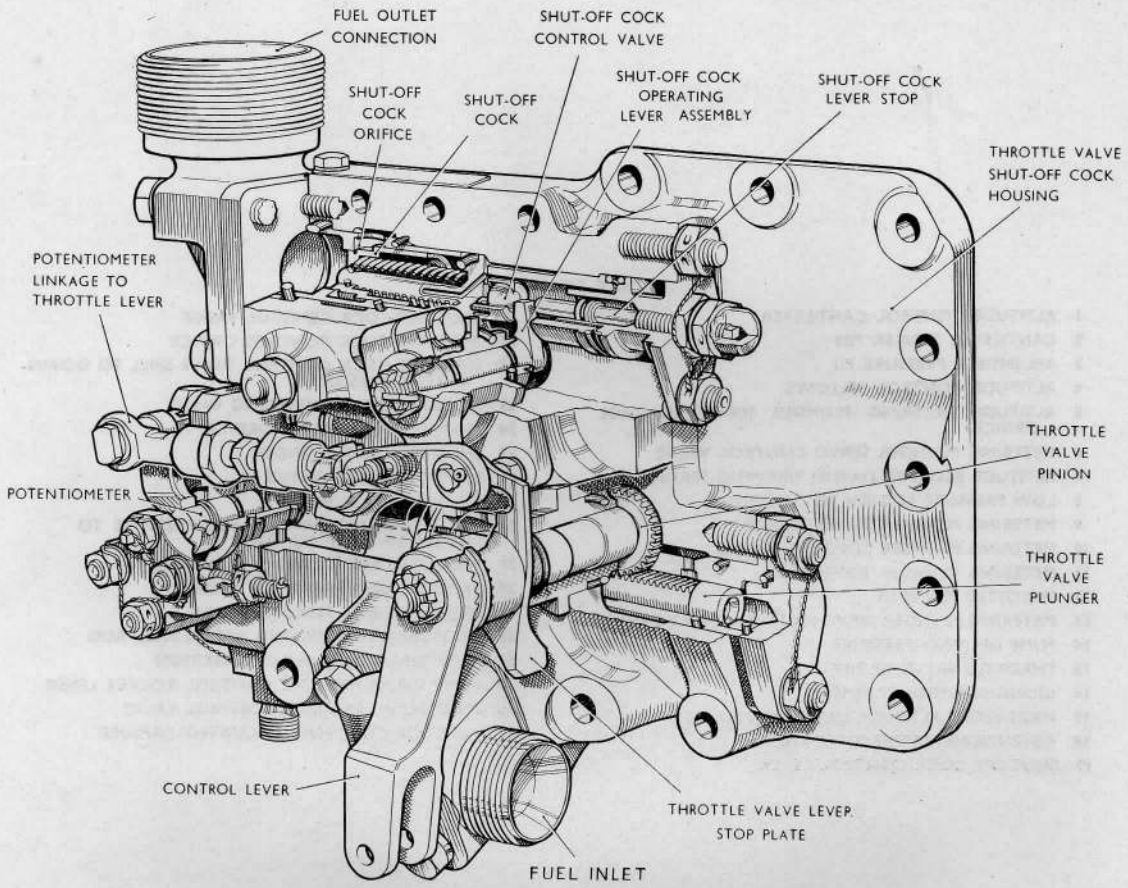

Fig. 4. Throttle valve and shut-off cock assembly

23. When the valve is opened however, it puts the spring chamber into communication with downstream pressure (27) through the tube (22), thereby creating a pressure difference across the plunger which forces it back against the spring and opening the flow passage to the burners.

24. On shutting down, the valve (20) is closed and the pressures are equalized by leakage past the plunger, which then closes under the influence of the spring and the out-of-balance pressure areas. Slightly in advance of this, as the throttle valve (12) closes, the inner end of the throttle plunger exposes a passage which creates a pressure drop across the throttle valve by allowing a flow through the axial drilling in the throttle valve. This is sensed by the pressure drop control piston (31) which then opens the pump servo connection (33) to pump inlet pressure and reduces the pump delivery flow to zero, thus preventing the generation of very high pump pressure due to the sudden obstruction of the main flow by the shut-off cock.

Installation

25. The unit is attached to the engine at the four stud holes in the back plate. For complete installation details reference must be made to the relevant engine Air Publication.

Inhibiting

26. The unit should be flushed through and inhibited in accordance with the detailed information contained in AP.4471A. Dust caps should be fitted to all connections and the unit packed in a suitable container.

Servicing

27. Once the unit is installed on an engine, no servicing is normally necessary except for regular inspection of the pipes and connections for signs of leakage. No leakage is permissible.

(A.L.56, Apr. 58)

KEY TO FIG. 5

1 ALTITUDE CONTROL CANTILEVER
2 CANTILEVER STRIKER PIN
3 AIR INTAKE PRESSURE P.I
4 ALTITUDE CONTROL BELLOWS
5 ALTITUDE METERING PLUNGER SERVO CONTROL ORIFICE
6 METERING PLUNGER SERVO CONTROL VALVE
7 ALTITUDE BELLOWS DATUM TRIMMING SPRING
8 LOW PRESSURE RETURN TO PUMP INLET
9 METERING PLUNGER SERVO PRESSURE
10 METERING PLUNGER CONTROL SPRING
11 METERING PLUNGER PUSH ROD
12 THROTTLE PLUNGER
13 METERING PLUNGER SERVO PRESSURE SUPPLY ORIFICE
14 PUMP DELIVERY PRESSURE
15 THROTTLE VALVE ORIFICE
16 IDLING CONTROL TRIMMER
17 MAIN FLOW ALTITUDE METERING PLUNGER
18 POTENTIOMETER THROTTLE VALVE
19 SHUT-OFF COCK CONTROL LEVER
20 SHUT-OFF COCK CONTROL VALVE
21 SHUT-OFF COCK CONTROL ORIFICE
22 SHUT-OFF COCK CONTROL VALVE SPILL TO DOWN-STREAM PRESSURE
23 ALTITUDE IDLING METERING VALVE
24 MAIN FLOW METERING ORIFICE
25 SHUT-OFF COCK PLUNGER
26 SHUT-OFF COCK ORIFICE
27 DELIVERY TO BURNERS
28 POTENTIOMETER CONTROLLED PRESSURE TO PRESSURE-DROP CONTROL
29 PRESSURE-DROP CONTROL CYLINDER
30 PRESSURE-DROP CONTROL SPRING
31 PRESSURE-DROP SENSING PISTON
32 PRESSURE-DROP SENSING PISTON PUSH ROD
33 PUMP SERVO PRESSURE CONNECTION
34 PUMP SERVO PRESSURE CONTROL ROCKER LEVER
35 PUMP SERVO PRESSURE CONTROL VALVE
36 ALTITUDE CONTROL EVACUATED CAPSULE

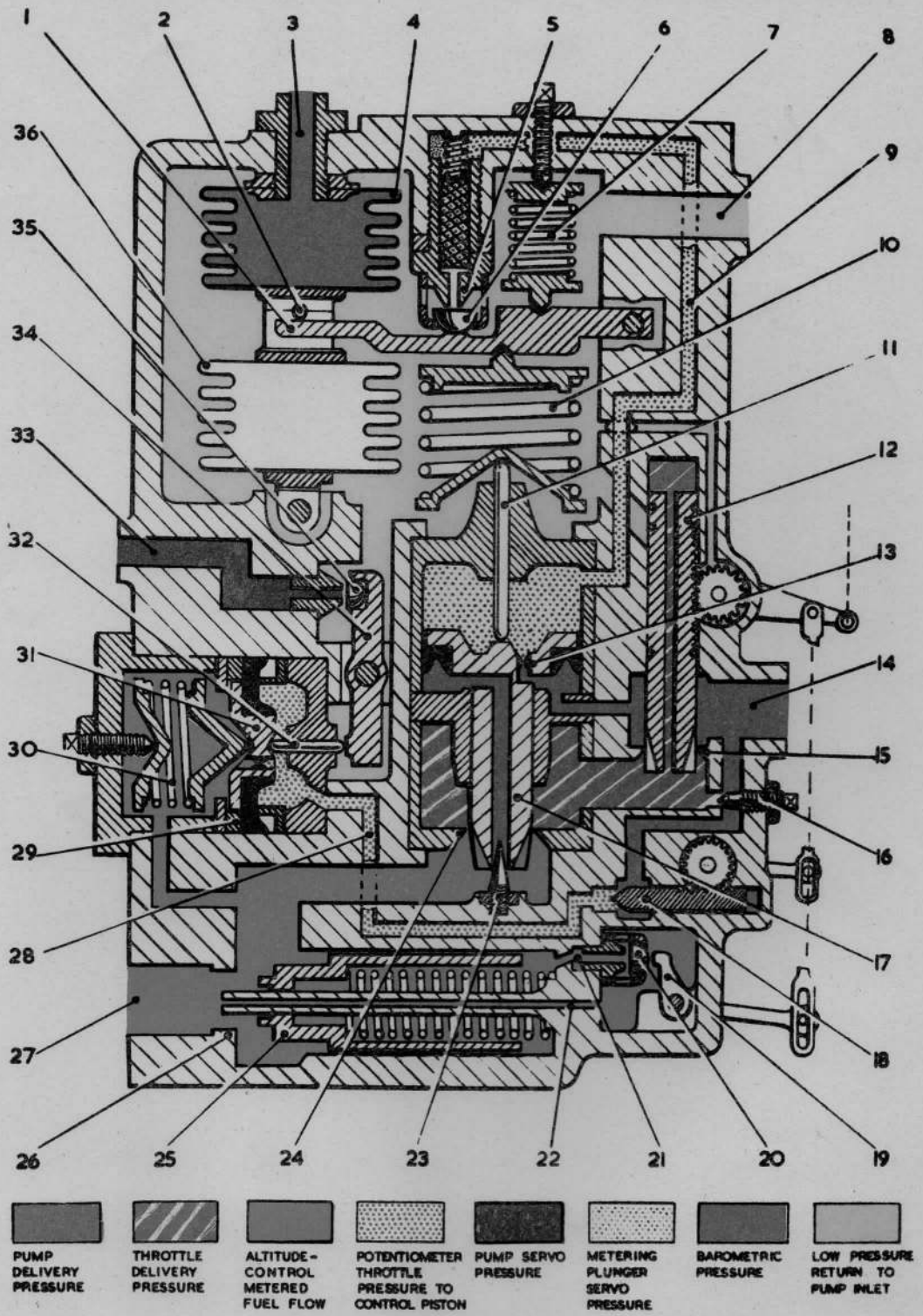

Fig. 5 Functional diagram of unit