

Chapter I

BAROMETRIC FLOW CONTROL UNIT

(Python Mk. 2 and 3 aero-engines)

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Introduction

1. The flow control unit described in this chapter is fitted to the Python Mk. 2 and 3 aero-engines. The unit is fitted between the high-pressure fuel pump and the burners and its function is to regulate the fuel flow to the engine according to the throttle setting and changes in barometric pressure. The throttle control system is operated from the pilot's throttle lever which is linked to a diaphragm and servo valve assembly in the flow control unit through an engine control unit. Operation of the throttle lever reacts, through ports in the servo control valve-diaphragm assembly, on the servo system embodied in the fuel pump, and the resultant operation of this system regulates the pump delivery in accordance with the throttle setting. The barometric control system is controlled by a sealed capsule stack, subjected to compressor air-intake pressure, which operates a servo piston within the unit; movement of the piston governs the opening of a control orifice, thereby regulating the fuel flow to the engine. The operation of the unit is described in paragraph 25.

DESCRIPTION

General (fig. 1)

2. The barometric flow control unit incorporates an orifice member assembly (4) and an orifice piston assembly (17). The function of these assemblies is to meter the fuel

under altitude conditions, and both assemblies are housed in the vertical central bore of the main body casting. At the lower end of this bore, the casting is enlarged to form the capsule chamber which houses an evacuated capsule stack (22). A detachable cover (23), fitted to the lower end face of this chamber, carries the capsule adjusting screw (25) and a drain plug (24).

3. A facing on the side of the unit contains the servo control valve body (7), and also provides for the attachment of the throttle control assembly. The fuel inlet union (*item* 49, *fig. 2*) is situated in the side of the body and the fuel outlet connection (1) to the high-pressure shut-off cock in the top of the orifice member (4). Arranged around the body are the pipe connections to the pump servo system (27), the bleed to pump inlet (28), and a union connection (16) for the air pipe from the engine air-intake. Dismantled views of the unit are given in *fig. 1* and *2*, and should be referred to during the following detailed description of the component parts.

Main body (fig. 1 and 2)

4. The main body (15) is an aluminium-alloy casting having an enlarged chamber formed at the lower end for the capsule stack (22), and a central bore forms the operating cylinder for the servo-piston of the orifice piston assembly (17). At the upper end of this

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FUEL SYSTEM COMPONENTS (GENERAL) FOR
GAS TURBINE AERO-ENGINES

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ENGINEER

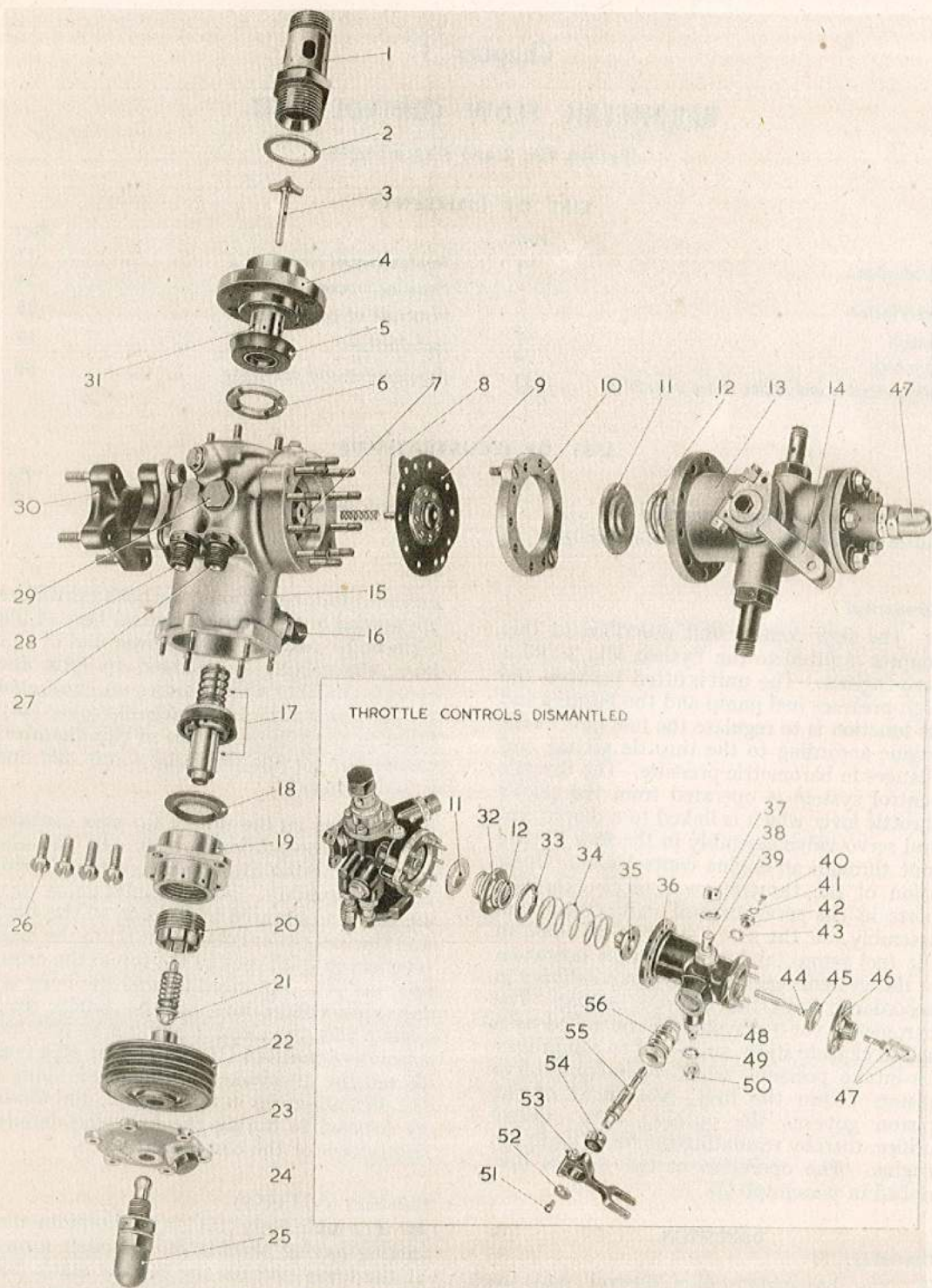


Fig. 1. Barometric flow control unit dismantled

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KEY TO FIG. 1

- 1 FUEL OUTLET CONNECTION TO H.P. SHUT-OFF COCK
- 2 SEALING WASHER FOR ITEM 1
- 3 LEAK ROD
- 4 ORIFICE MEMBER
- 5 ORIFICE MEMBER SEAL, GACO
- 6 WASHER FOR ORIFICE MEMBER GACO SEAL
- 7 SERVO CONTROL VALVE BODY
- 8 SERVO CONTROL VALVE
- 9 SERVO CONTROL VALVE DIAPHRAGM ASSEMBLY
- 10 DIAPHRAGM RING AND RETAINING SCREWS
- 11 SPRING CARRIER
- 12 THROTTLE CONTROL SPRING
- 13 THROTTLE CONTROL BODY
- 14 THROTTLE CONTROL OPERATING LEVER
- 15 FLOW CONTROL BODY
- 16 CONNECTION TO ENGINE AIR-INTAKE
- 17 ORIFICE PISTON ASSEMBLY
- 18 WASHER FOR CAPSULE CHAMBER GACO SEAL
- 19 RETAINING RING FOR CAPSULE CHAMBER GACO SEAL
- 20 STOP SCREW FOR ORIFICE PISTON ASSEMBLY
- 21 NEEDLE VALVE AND SPRING FOR ITEM 17
- 22 CAPSULE STACK
- 23 CAPSULE CHAMBER COVER
- 24 DRAIN PLUG
- 25 CAPSULE ADJUSTING SCREW
- 26 SET-SCREWS FOR RETAINING RING (ITEM 19)
- 27 CONNECTION TO FUEL PUMP SERVO SYSTEM
- 28 BLEED TO FUEL PUMP INLET
- 29 FILTER FOR ITEM 27
- 30 MOUNTING BRACKET
- 31 METERING HOLES IN ORIFICE MEMBER
- 32 SPIGOT RING FOR THROTTLE CONTROL ASSEMBLY
- 33 RETAINING RING FOR RETURN SPRING
- 34 RETURN SPRING FOR SERVO-PISTON
- 35 SPRING CARRIER
- 36 THROTTLE CONTROL ASSEMBLY ATTACHMENT FLANGE
- 37 CAP-NUT, SECURING RETURN FUEL PIPE
- 38 SEALING WASHER FOR ITEM 37
- 39 PIVOT CONNECTION FOR FUEL OUTLET PIPE (RETURN TO PUMP INLET)
- 40 RETAINING SCREW FOR THROTTLE VALVE
- 41 TAB-WASHER FOR ITEM 40
- 42 VALVE RETAINER
- 43 PLAIN WASHER FOR ITEM 42
- 44 THROTTLE SERVO PISTON
- 45 RING TYPE SEAL, GACO (SHOWN IN POSITION)
- 46 THROTTLE CONTROL ASSEMBLY END COVER
- 47 SLOW-RUNNING ADJUSTING SCREW, LOCKNUT AND CAP-NUT
- 48 THROTTLE SERVO INLET PIPE PIVOT CONNECTION (FROM PUMP DELIVERY)
- 49 SEALING WASHER FOR ITEM 50
- 50 CAP-NUT SECURING THROTTLE SERVO INLET PIPE
- 51 RETAINING SCREW FOR SPLIT BUSH (ITEM 54)
- 52 WASHER, RETAINING SPLIT BUSH ON THROTTLE VALVE SLEEVE (ITEM 56)
- 53 ADJUSTING BOLT AND LOCKNUT FOR THROTTLE CONTROL OPERATING LEVER
- 54 SPLIT BUSH FOR THROTTLE CONTROL OPERATING LEVER
- 55 THROTTLE SERVO VALVE
- 56 THROTTLE VALVE SLEEVE

bore, the phosphor-bronze orifice member (4) spigots into a long counterbore and is retained by four studs, nuts and spring washers. At the inner end of this counterbore is a Gaco seal (5) attached to the inner end of the stem of the orifice member (4). At the capsule end of the main central bore is a second counterbore, within which the retaining ring (19) for the capsule chamber Gaco seal is spigoted and secured by four set-screws (26) and spring washers.

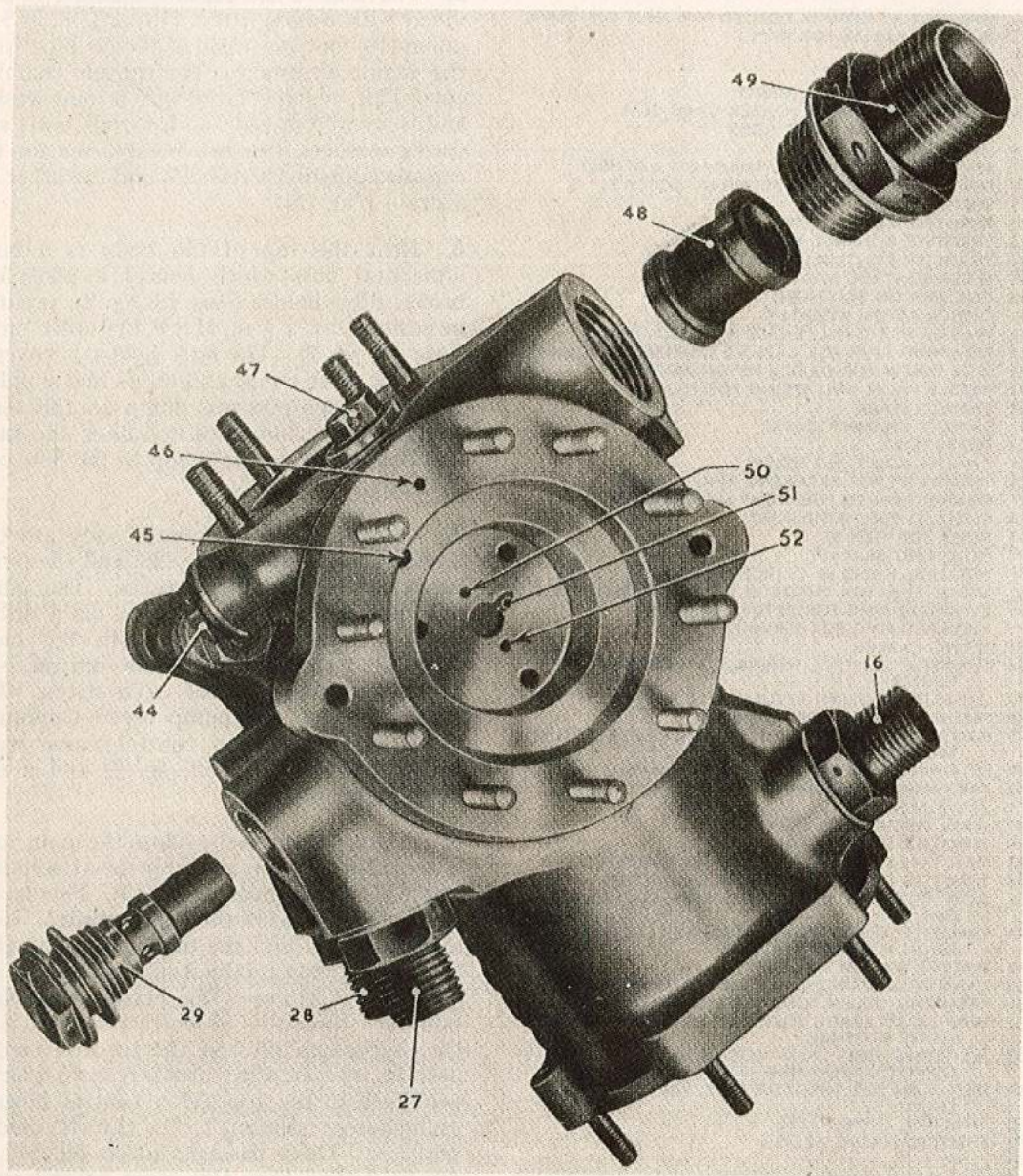
5. The wall of the capsule chamber is provided with a boss fitted with a $\frac{1}{4}$ in. B.S.P. union (16) for connection of the air pipe from the engine air-intake. The capsule chamber cover (23), which is fitted with a joint washer and is secured in position by studs, nuts and spring washers, has two bosses, one for the capsule adjusting screw (25) and the other for a drain plug (24).

6. Near the top of the body is a large horizontal boss which houses a phosphor-bronze filter holder (item 48, fig. 2), retained in position by a $\frac{1}{2}$ in. B.S.P. fuel inlet union (item 49, fig. 2). The filter holder is covered with fine mesh gauze and filters fuel supplied from the high-pressure pump to the servo control valve, but does not filter the main fuel delivery from the pump to the flow control unit.

7. On the side of the main body are two unions for the pump inlet (28) and the pump servo system (27) connections. The pump inlet connection communicates, via a drilled passage (item 50, fig. 2), with the bleed chamber formed in the main central bore above the orifice control servo piston. The connection for the pump servo communicates with the servo control valve by a drilled passage (item 52, fig. 2) and a fine mesh gauze filter.

8. A large facing on the side of the main body is provided with ten studs for the attachment of the throttle control body (13). This facing also accommodates the servo control valve diaphragm (9) and the diaphragm ring (10), the latter being retained in position by two countersunk screws. The servo control valve body (7), the valve of which is operated by the diaphragm (9) and the throttle control system, is secured by three screws to a facing provided at the base of a central housing immediately adjacent to the throttle control position. Three passages (items 50, 51, 52, fig. 2), drilled from this servo control valve facing connect with the bleed chamber in the unit main body, the pump servo connection (27) and the fuel inlet passage (item 51, fig. 2).

9. An annulus formed in a counterbore in the throttle assembly facing contains a drilled passage (item 45, fig. 2), which allows fuel at pump delivery pressure to reach the servo control valve side of the diaphragm. Another passage (46 fig. 2) in the diaphragm facing of the body transmits fuel at metered fuel pressure through small holes in the dia-



- 16 CONNECTION TO ENGINE AIR-INTAKE
- 27 CONNECTION TO FUEL PUMP SERVO
- 28 BLEED TO FUEL PUMP INLET
- 29 FILTER FOR ITEM 27
- 44 BLANKING PLUG
- 45 PASSAGE, DELIVERY FUEL TO INNER SIDE OF DIAPHRAGM
- 46 PASSAGE, ORIFICE MEMBER TO THROTTLE SIDE OF DIAPHRAGM

- 47 BALL RELIEF VALVE FOR DIAPHRAGM
- 48 FILTER, PUMP DELIVERY PASSAGE (51) TO SERVO VALVE
- 49 FUEL INLET UNION FROM PUMP
- 50 PASSAGE, BLEED CHAMBER TO SERVO VALVE
- 51 PASSAGE, FUEL PUMP DELIVERY PRESSURE TO SERVO VALVE
- 52 PASSAGE TO FUEL PUMP SERVO CONNECTION ITEM 27

Fig. 2. Flow control body, showing filters and fuel passages

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phragm and the diaphragm ring (10) to the throttle control side of the diaphragm. These passages are inter-connected and sealed by a ball relief valve (47 *fig. 2*), and in the event of the normal pressure difference between pump delivery and metered fuel pressure being exceeded, the ball will lift and allow fuel to pass, thus protecting the diaphragm from excessive pressure.

10. The diaphragm assembly (9), which is retained against the main body facing by the diaphragm ring (10), is of flexible material. Two ring plates, one on each side of the diaphragm centre, are secured together by eight countersunk screws. The outer ring plate locates against the throttle spring carrier (11) whilst the inner one locates on the end of the servo control valve.

11. The servo control valve unit comprises a phosphor-bronze cylindrical body (7), with an external attachment flange formed at the inner end. This flange contains three equally spaced holes to receive the countersunk attachment screws. The central bore through the body houses the landed piston-type servo control valve (8), and ports within the bore are connected by suitable passages to the bleed, servo, and pump delivery pressure passages in the main body of the unit. The servo control valve is a cylindrical steel rod having a mushroom head formed at its outer end, which contacts the outer diaphragm ring plate. A small spring, interposed between the head of the valve and the inner diaphragm ring plate, serves to maintain contact between the valve and diaphragm assembly (9).

Orifice member and orifice piston assemblies

12. The orifice member (4) consists of a cylindrical phosphor-bronze body having a thick external flange. The flange is drilled to fit over the securing studs and the outer end of the body is internally threaded to accommodate the fuel outlet union (1). This union retains the leak rod (3), which has a three-legged support of slightly larger dimensions than the bore of the union. The leak rod (3) extends from this support piece into the bore of the orifice piston assembly. A double spiral of radial holes (31) is provided in the stem of the orifice member to control the fuel flow to the H.P. cock. Under altitude conditions these holes are progressively closed by the upward movement of the orifice piston (17).

13. The flange on the orifice member contains a drilled passage which permits fuel to pass from the central bore of the member, through a passage in the flow control body, to the outer face of the servo control valve diaphragm. A Gaco seal (5) is fitted at the base of the orifice member stem and is secured in position by a circlip. A steel washer (6) prevents the Gaco seal (5) from being moved out of position into the bleed chamber immediately below the orifice member body. The washer is bevelled on the lower face and has shallow radial slots, which permit the flow of fuel from the bleed passage in the main body to the bleed chamber, and via the bleed connection (28) to the fuel pump inlet.

14. The orifice piston assembly (17) consists of a steel piston, a Gaco seal which acts as a servo piston, and a phosphor-bronze tail-piece, the three items being assembled to form a single unit. The steel piston operates in the bore of the orifice member; the tail-piece, which accommodates the capsule stack needle-valve (21), operates in the capsule chamber seal which is housed in the retaining ring (19). A small spring is interposed between the flange on the orifice piston and the lower face of the orifice member. The orifice piston has a central bore which communicates with a radial hole drilled through the walls of the piston and tail-piece, thus permitting fuel to enter a servo chamber formed below the Gaco seal which constitutes the servo piston. A cone seating for the capsule needle valve (21) is formed at the lower end of the piston bore, and immediately below this is a second radial hole which passes bleed fuel through a slot to the bleed chamber. The needle-valve (21) is partially slotted on the cone face and is held off its seating by a small spiral spring.

15. An aluminium retaining ring (19), attached to the unit main body by four set-screws (26), contains the capsule chamber Gaco seal and, in its lower face, an adjustable stop ring (20). This stop ring (20) limits the downwards travel of the orifice piston assembly (17) and is adjusted at the manufacturers during assembly to control the maximum fuel flow of the unit.

16. The aneroid capsule stack (22) consists of five capsule wafers, which are inter-connected and evacuated. The lower end of the stack locates on the ball of the capsule adjusting screw (25) and the upper end on the

outer ball of the needle valve (21). The adjusting screw (25) is secured in the capsule chamber cover (23) by a lock-nut and sealed by a cap-nut and washer; this screw is adjusted during the rig testing of the flow control unit and *must not* be disturbed.

Throttle control assembly (fig. 1)

17. The throttle control assembly is mounted on the large facing provided on the side of the flow control unit body. The assembly comprises the throttle control body, two large helical springs with carriers and stop ring, the throttle control operating lever, the throttle servo piston and valve mechanism, and the end cap complete with the slow running adjusting screw with its locknuts and cap-nut.

18. The throttle control body is an aluminium casting, cylindrical in form, with an external flange at each end. The inner flange is drilled to pass over the attachment studs in the flow control body facing; these studs also locate the throttle diaphragm and diaphragm ring. The throttle control body outer flange contains studs for the attachment of the end cap and slow running adjustment assembly. Two bosses, one on each side of the body, accommodate the throttle servo operating valve and sleeve. Two bosses, one formed below and the other above the body, are internally threaded and accommodate the connections for the throttle servo fuel feed and return pipes. Internally the body is divided by a transverse diaphragm containing a central housing for the inner end of the throttle servo piston. A Gaco ring type seal is fitted within an annular groove provided in this housing. The inner portion of the throttle body contains two helical springs. The inner spring transmits the throttle servo piston loading to the throttle diaphragm and fuel servo control valve in the flow control body. A portion of bore at the outer end of the throttle body forms the cylinder in which the throttle servo piston operates. Passages formed in the body casting connect the servo piston with the throttle servo valve and sleeve and also with the fuel inlet and outlet connections.

19. The end cap for the throttle control body has an internally threaded boss formed in the centre for the slow running adjusting screw. The adjusting screw, threaded along the greater part of its length, has a square head. After adjustment, the screw is secured by a locknut and cap-nut. The plain inner portion of the screw strikes the throttle servo piston to form the slow running stop.

20. The servo piston is sealed by a ring type Gaco seal which is retained in a groove. The piston rod is integral with the piston and has a rack formed along a portion of its length. This rack, in the form of a series of annular grooves, operates in conjunction with a gear segment formed on the throttle servo valve sleeve. The inner end of the piston rod passes through the diaphragm formed in the throttle control body and operates against the outer spring carrier.

21. The throttle lever is carried on a shaft which for the greater part of its length contains both circumferential and longitudinal grooves, the combination of which form the throttle servo-valve. This valve assembly is completed by a sleeve which is free to rotate independently around the grooved shaft and which is directly actuated from the rack on the servo piston rod. The combination of the valve, sleeve and servo piston form an immediate follow-up mechanism which transmits all alterations in throttle lever position to the servo piston and thence to the flow control system within the main unit.

22. The outer end of the throttle lever shaft is hexagonal to receive a split bush which is retained by a set bolt and washer. The serrated periphery of this bush engages the thread of the throttle control lever adjusting bolt. Rotation of this bolt provides fine adjustment for the throttle lever. Ring type Gaco Seals prevent fuel leaking from the throttle shaft valve and sleeve. The throttle lever shaft is retained within the throttle control body by an adapter, and a set bolt locked by a tab-washer.

23. The movement of the throttle servo piston is transmitted through a heavy spring to the fuel servo control valve and diaphragm in the main body. A second and lighter spring surrounds the first spring and, acting between the spring carrier and a steel ring screwed into the bore of the throttle body, always tends to return the throttle servo piston to the slow running position. The inner spring is carried between two carriers; the inner carrier has a pivot recess on its inner face which locates on the diaphragm outer centre plate whilst the outer carrier has a deep recess which houses the inner end of the servo piston rod. The flange of the latter carrier receives the thrust of both the throttle springs.

Mounting bracket

24. The mounting bracket (30) for the barometric flow control unit is attached to the mounting flange at the rear of the main

body (15) by four studs, nuts and spring washers. The bracket itself is an aluminium casting with four attachment feet, each containing a securing stud, which pass through holes provided in the engine accessory drive box and bulkhead. The unit is mounted forward of this bulkhead, as shown in Section 1, Chapter 1, fig. 2 and 3.

PRINCIPLE OF OPERATION

25. The barometric flow control unit operates in conjunction with the fuel pump and the throttle control lever, and it would be advantageous if the following description is read in conjunction with the description of the complete fuel system (Sect. 1, Chap. 1).

26. The principle of operation is illustrated in fig. 3, and figs. 1 and 3 should be referred to during the following description. Movement of the cockpit throttle lever reacts, through the throttle control assembly in the flow control unit, and thence to the diaphragm and servo control valve, in the manner described in the following para.

27. The throttle control assembly provides servo operation of the throttle in the throttle opening direction only; the return movement being actuated by the throttle control spring and the return spring, the latter finally assisting to overcome seal ring friction at small throttle opening.

28. Movement of the throttle lever and valve toward the open position causes fuel at pump outlet pressure to move the piston toward the maximum flow position. The resultant movement of the piston, in addition to compressing the throttle control spring and operating the fuel control system, auto-rotates the throttle valve sleeve about the throttle valve by means of the rack and pinion segment. When the throttle movement ceases, the rotation of the sleeve cuts off further supply of fuel to the piston head.

29. Conversely, movement of the throttle lever and valve toward the slow running position, causes the pressure side of the piston to be connected to the fuel pump inlet until movement of the throttle lever ceases.

30. It follows therefore that any movement of the throttle lever on the unit servo head is transmitted through the throttle control spring to the flow control mechanism, by means of the diaphragm and the servo control valve.

31. The diaphragm is subjected to pump delivery pressure on the servo control valve side, and to the metered fuel pressure plus the throttle spring (12) pressure on the opposite side. Because the metered fuel pressure plus the spring pressure equals the pump delivery pressure the servo control valve (8) is normally maintained in a neutral position. When the throttle is opened, however, the spring pressure is increased, the balance of the diaphragm becomes disturbed, and the servo control valve (8) is moved inwards thus allowing fuel at pump delivery pressure to flow to the fuel pump servo system. The resultant operation of this servo system causes the pump delivery pressure to increase until pressure equilibrium at the diaphragm is restored. If the throttle is moved towards the closed position, the diaphragm moves the servo control valve outward, thus allowing fuel at pump inlet pressure to communicate with the pump servo. This results in a reverse flow through the servo control valve unit, and fuel bleeds via a spill passage and external pipe to the pump inlet. The consequent change in pressure, acting on the pump servo piston, will cause the pump delivery to decrease until the diaphragm pressure balance is again restored; thus any movement of the throttle lever will finally result in a corresponding adjustment of pump delivery.

32. The control of the fuel supply at altitude conditions is governed by the capsule system. The evacuated capsule stack (22) is subjected to engine air-intake pressure and the consequent variation in length of the stack acts directly on the needle-valve (21) which in turn controls the orifice piston servo. The capsule stack is mounted on an adjustable datum screw (25) by which the basic fuel setting and range of the control is determined. This adjustment is locked after the flow control unit has been flow rig checked and *must not* be disturbed.

33. When the engine is running at a constant speed and altitude, fuel from the pump flows through the series of holes (31) in the orifice member (4) and through the outlet union (1), to the fuel distributor and burners via the H.P. shut-off cock (fig. 3). A pressure drop which occurs when the fuel passes through the orifice member (4), is transmitted to the throttle diaphragm (9) through the passage (46) shown in fig. 2.

34. Fuel at metered pressure passes down the bore of the orifice piston assembly (17), where the clearance between the leak rod (3) and the bore of the piston forms an annular jet. This fuel then enters the servo-chamber through a radial hole in the piston assembly. The resultant increase in servo-pressure will cause the orifice piston assembly (17) to rise slightly. This will open the needle-valve (21) until the servo chamber pressure is sufficient to stabilize the position of the orifice piston assembly (17) against the combined downward force of the return spring and the metered fuel pressure, acting on the orifice piston head. It follows therefore that after its initial movement, the orifice piston assembly (17) will remain stationary, thus maintaining a constant metered pressure and, through the throttle assembly, a constant fuel pump delivery.

35. For a given throttle setting, an increase in aircraft altitude and speed will cause the capsule system to adjust the fuel flow to engine requirements in the following manner. Expansion of the capsule stack (22), due to a reduction of air-intake pressure, will cause the needle valve (21) to close. This will increase the servo-chamber pressure and will disturb the balance of pressure of the orifice piston assembly (17), causing the orifice piston to rise and so decrease the metered fuel pressure. The reduction in metered fuel pressure, by acting on the throttle assembly, will cause the fuel pump servo system to decrease the fuel pump delivery. At a stabilized altitude the needle valve (21) will re-open and the conditions of operation obtaining in para. 27 will apply.

36. A reduction in altitude will reverse both the sequence of operations and the movement of the orifice piston assembly (17), and result in an increased fuel delivery. Changes in altitude, therefore, directly affect the flow through the orifice member (4) which in turn affects the fuel pump delivery.

INSTALLATION

37. The flow control unit is attached to the engine accessory drive box and bulkhead by four studs, nuts and spring washers. When connecting the fuel pipes to the unit, care must be taken that foreign matter is excluded from all pipe unions and banjo connections. Attention must be paid to the correct fitting of pipes, special care being taken that the connections to pump servo (27), and the bleed to pump inlet (28) are not interchanged. After final tightening, all unions and cap-nuts are to be secured by locking wire.

38. The throttle control, which is provided with a micro-adjustment, is pre-set to obtain maximum and minimum fuel flows; the slow running r.p.m. and fuel adjustment being also pre-set on a test rig for a flow of between 80-85 gallons per hour. The capsule (25) and the slow running adjusting screws (47 fig. 1), together with their cap-nuts and lock-nuts, must not be disturbed.

Note . . .

Modification No. P.122 introduces a new type throttle control operating lever and fork-end which is adjustable in length. By adjusting the fork-end the fuel flow at the full-throttle position can be trimmed without materially affecting the slow-running.

ADJUSTMENT AND SERVICING

39. Should the unit prove defective, it must be removed and replaced by a serviceable unit in accordance with the procedure detailed in A.P.4293A, Vol. 6, Part 1, Section 2, Chapter 1.

40. Servicing of the flow control filters (items 29 and 48, fig. 2) should be carried out to the instructions detailed in A.P.4293A, Vol. 1, Section 2, Chapter 1.

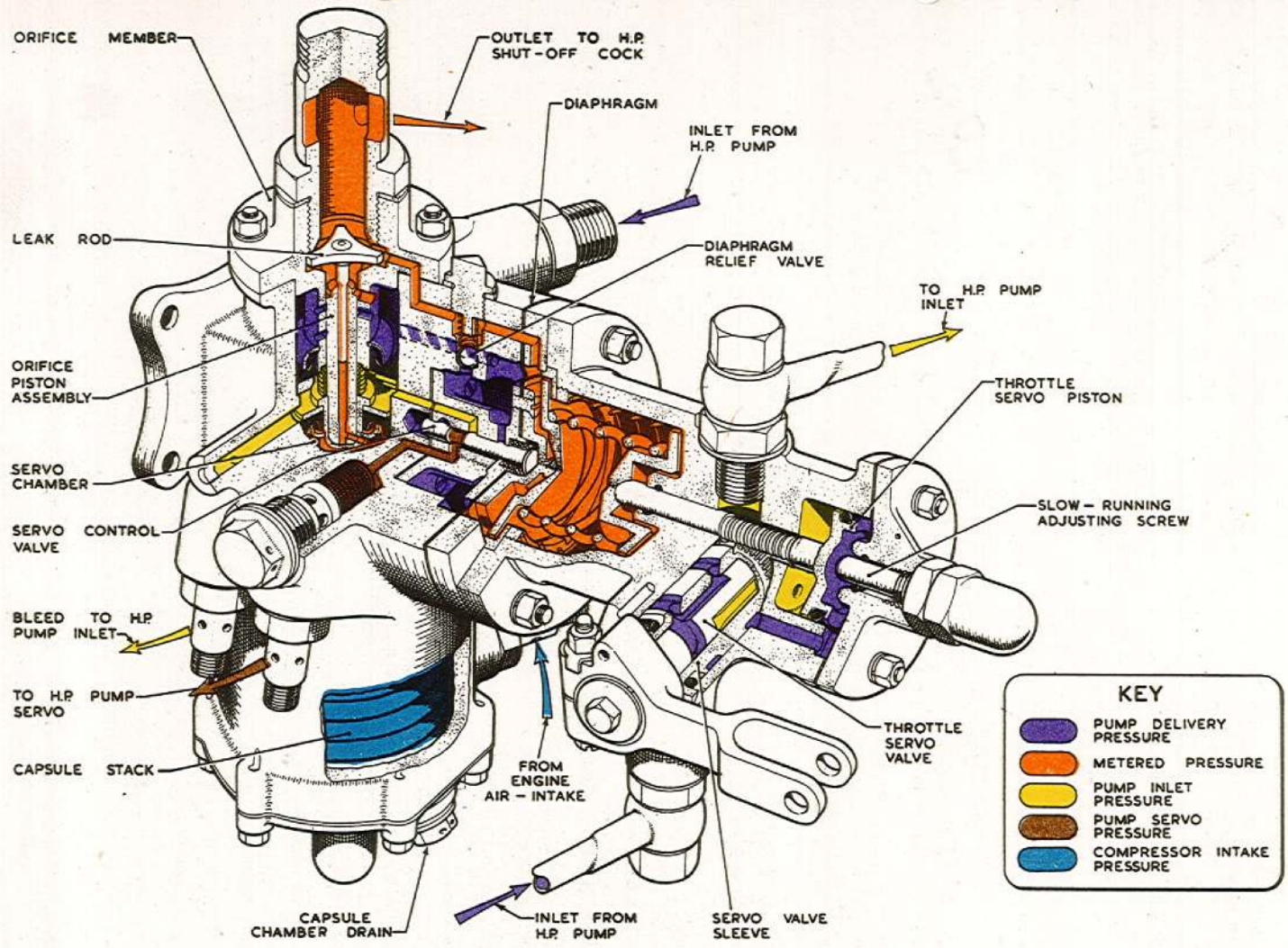


FIG. 3. BAROMETRIC FLOW CONTROL UNIT.

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