

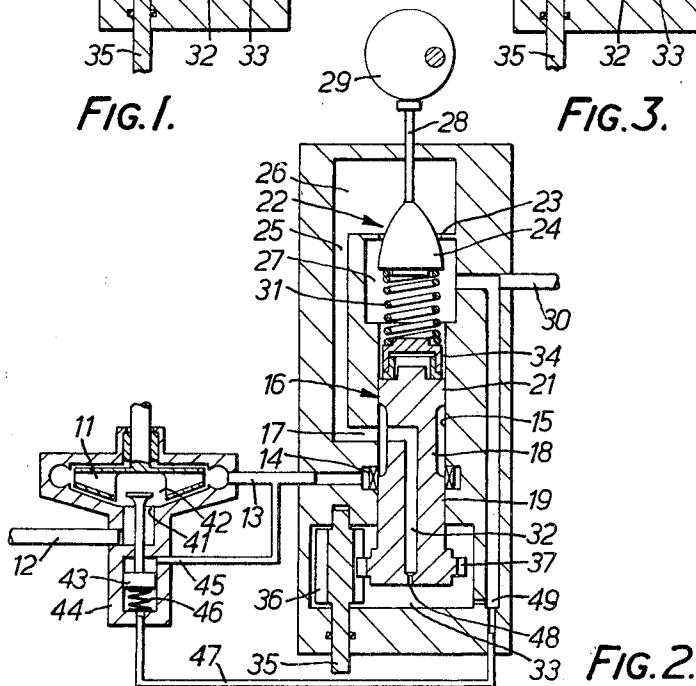
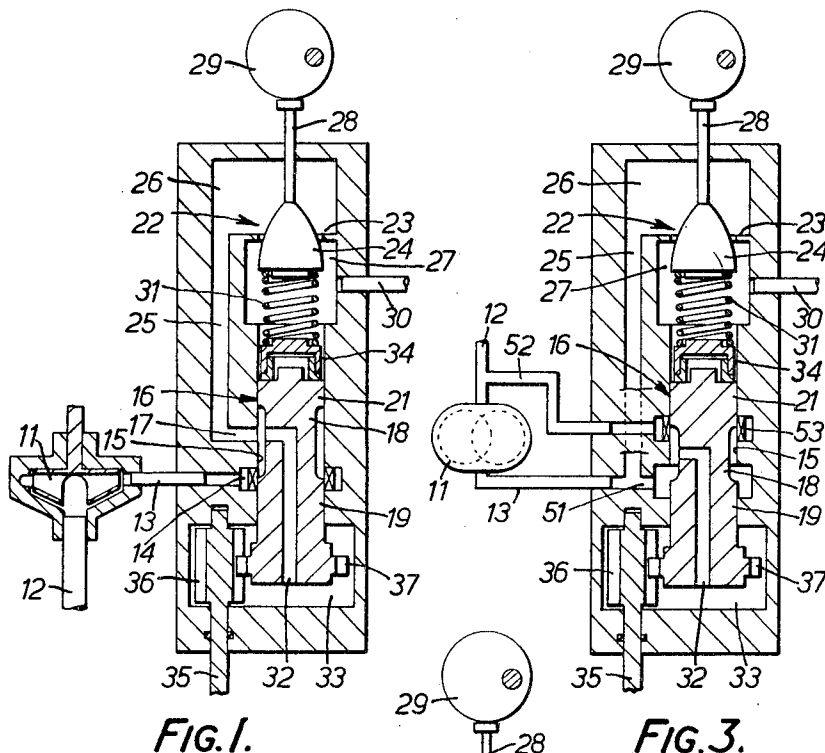
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LIQUID SUPPLY APPARATUS

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LIQUID SUPPLY APPARATUS

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8 Claims

ABSTRACT OF THE DISCLOSURE

Liquid supply apparatus comprises a pump supplying liquid through a throttling or metering valve which has a movable member controlled to vary the throttle valve opening, while a flow-regulating valve, which regulates the flow of liquid from the pump through the throttle valve, has a movable member responsive both to pressure difference across the throttle valve, and to the load of a spring which is interposed between the movable member of the throttle valve and the movable member of the flow-regulating valve.

BACKGROUND OF THE INVENTION

Field of the invention

Flow-metering devices, particularly for the control of fuel flow to aircraft gas turbine engines.

Description of the prior art

In United States specification Ser. No. 3,323,463 liquid supply apparatus is described having a variable delivery pump with a throttle valve in its delivery, the opening of which is varied in response to the magnitude of a control signal, and a servomotor which varies the delivery of the pump under the control of spring means, and in response to a change in pressure difference across the throttle valve so as to maintain said pressure difference substantially constant for a given load of the spring means, wherein the load of the spring means is varied by the movable member of the throttle valve so as to vary the pressure difference across the throttle valve in accordance with the extent of opening of said valve.

In the apparatus described, the throttle is operated by servomechanism under the control of an input signal. Further servo-mechanism controls the delivery from the pump through the throttle valve.

One object of the present invention is to provide liquid supply apparatus in which the pressure across the throttle is increased as the throttle opening increases, but by means of a simpler construction without servo-mechanism.

SUMMARY

According to the present invention, liquid supply apparatus comprises a pump having its inlet connected to a source of liquid and its outlet connected to a throttle valve, the throttle valve having a member movable to vary the extent of opening in accordance with a controlling signal, a flow-regulating valve arranged to vary the flow of liquid from the pump to the throttle valve, the flow-regulating valve having a valve member movable in one direction by a proportion at least of the pressure difference across the throttle valve, and movable in the opposite direction by a spring, the load in which is varied by movement of the throttle valve, hereby the valve member regulates the flow through the throttle valve, so that the pressure difference across the throttle valve varies in accordance with the extent of opening.

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The throttle valve may have a movable member formed as a plug which is movable axially in a circular orifice, while the flow-regulating valve is co-axial therewith, the valve member being formed as a pressure-responsive spool between which and the movable member of the throttle valve the spring is interposed.

If the pump is of a dynamic type, e.g. a centrifugal pump, the flow-regulating valve is interposed in the delivery to the throttle valve. If the pump is of a positive displacement type, the flow-regulating valve by-passes part of the liquid delivery back to the pump inlet.

BRIEF DESCRIPTION OF THE DRAWING

FIGURE 1 shows liquid supply apparatus, including a centrifugal pump, suitable for the supply of fuel to the burners of an aircraft gas turbine engine,

FIGURE 2 shows apparatus similar to FIGURE 1 but having a centrifugal pump with a controllable inlet valve, and

FIGURE 3 shows liquid supply apparatus which includes a positive displacement pump.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGURE 1 a centrifugal pump 11 designed for running full of liquid has an inlet 12 connected to a source of liquid and an outlet 13 connected to a control port 14 which is formed in the bore 15 of a flow-regulating valve 16. An outlet port 17 is axially spaced from the control port 14. A valve spool 18 slidable in the bore 15 has a land 19 co-operating with the control port 14 and a land 21 which separates the outlet port 17 from the discharge side of a throttle valve 22. This throttle valve comprises an orifice 23 which is co-axial with the bore 15, and a shaped plug 24 which is axially movable to vary the effective area of the orifice 23. The outlet port 17 is connected by a passage 25 to an inlet chamber 26 of the throttle valve 22. A chamber 27 on the discharge side of the throttle valve opens into a delivery passage 30 which leads to a service to which liquid is to be delivered at a controlled rate.

One end of the plug 24 has a stem 28 engaged by a cam 29 which transmits a controlling input causing correlated axial movement of the plug 24. The total movement is considerably greater than the axial length of the control port 14. A spring 31 is interposed between the plug 24 and a thrust bearing 34 which engages the end of the land 21 of the valve spool 18. The lower end of the land 19 is exposed to the liquid pressure of the outlet 17 by way of a passage 32 in the spool 18 which opens into a chamber 33 at the end of the spool.

The spool 18 is rotated when in use by a continuously driven shaft 35 which is formed with an elongated pinion 36 engaged by a pinion 37 on the lower end of the spool 18, whereby the effect of friction on the axial position of the spool 18 in the bore 15 is minimised. The spring 31 may be of the kind which is machined from a tubular blank with its respective ends keyed to the plug 24 and the thrust bearing 34 to prevent relative rotation.

In operation, fluid from the pump outlet 13 flows through the control port 14, through the recess in the spool 18 formed between the lands 19, 21 and the passage 25 to the chamber 26, between the orifice 23 and the plug 24 to the chamber 27, and through the delivery passage 30. The pressure upstream of the orifice acts through the passages 25 and 32, in the chamber 33 upon the lower end of the spool 18. The pressure downstream of the orifice 23 acts in the chamber 27 upon the upper end of the spool 18. Thus, the pressure difference across the throttle valves 23, 24 urges the valve spool 18 upwardly with a force which is balanced by the load of the spring 31.

If, when the plug 24 is in a given position, the delivery pressure of the pump 11 tends to increase, the resulting

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increased pressure difference across the throttle valve 23, 24 causes the valve spool 18 to move upwardly whereby the land 19 decreases the opening of the control port 14. Similarly, with a fall in delivery pressure of the pump 11, the resulting reduced pressure difference across the throttle valve 23, 24 causes the valve spool 18 to move downwardly whereby the land 19 increases the opening of the control port 14. The valve spool 18 therefore varies the restriction of the control port 14 whereby the fluid flow across the throttle valve 23, 24 produces a pressure difference which is substantially constant for a given position of the plug 24.

If the cam 29 is turned anti-clockwise to depress the plug 24 and increase the opening of the throttle valve, the spring 31 is compressed whereby the spool 18 moves to increase the flow through the control port 14 and the throttle valve 22 to a value at which the fluid pressure forces on the spool 18 again balance the spring load. Since the movement of the plug 24 is large compared with the corresponding flow-regulating movement of the valve spool 18, the compression in the spring 31 will increase the pressure difference across the throttle valve 23, 24 as the latter is opened by the cam 29.

At the minimum flow-end of the range of opening of the throttle valve 23, 24, the compression of the spring 31 is at a minimum and therefore the pressure drop across the throttle valve is low. At the maximum flow end of the range of opening of the throttle valve, the compression of the spring 31 is at a maximum and therefore the pressure drop across the throttle valve is high.

In previously known flow-controlling devices having an adjustable throttle or metering valve across which the pressure is maintained substantially constant, the proportional change in flow occurring for a given movement of the valve is much greater at the lower end of the flow range than at the higher end.

This requires extreme accuracy in the dimensioning of the throttle valve parts at the low end of the flow range, and in the control, whether direct or servo-operated, which operates on the movable member of the throttle valve.

By increasing the pressure drop across the throttle valve as the latter is opened, in accordance with the present invention, the proportional change in flow occurring for a given movement of the valve can be made more uniform over the entire flow range of the valve.

The present arrangement provides greater travel of the movable member of the throttle valve at the low end of the flow range, so that the dimensions and the control become less critical.

This arrangement is of particular advantage in controlling the fuel flow in an aircraft gas turbine engine, as the sensitivity of the throttle valve in controlling engine speed becomes more uniform at widely spaced positions in the flow range, e.g. during high flow when maximum power is demanded at low altitude, and during low flow for cruising at high altitude.

In the embodiment of FIGURE 2, elements which correspond to elements in FIGURE 1 have the same reference numerals. The centrifugal pump 11 is of the kind having an inlet valve adjacent the centre of the impeller. This valve comprises a seat 41 and a valve member 42 which is operable by servo piston 43 in a cylinder valve member 42 which is operable by servo piston 43 in a cylinder 44. The piston 43 is urged in the valve-closing direction by pump outlet pressure which is led to one end of the cylinder 44 by a passage 45 from the outlet 13. The piston 43, is urged in the valve-opening direction by a spring 46 and by delivery pressure which is led to the other end of the cylinder 44 by a passage 47 from the delivery passage 30.

This embodiment also differs in that valve spool 18 is subjected to only a proportion of the pressure difference across the throttle valve 23, 24. To this end, the passage 32 connecting the chamber 33 at the lower end of the

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spool 18 to the chamber 26 upstream of the throttle valve has a restrictor 48 therein. The chamber 33 is also connected to the passage 30 downstream of the throttle valve by way of a restrictor 49. The pressure restrictors 48 and 49 may be adjustable for pre-setting the proportion of the said pressure difference between the chamber 33 and the delivery passage 30.

The operation of the flow-regulating valve is nevertheless similar to that of the previous embodiment.

The provision of the inlet valve 41, 42 does not substantially affect the operation of the flow-regulating valve and the throttle valve as its purpose is mainly to reduce the power absorbed by the pump 11 and thus the heat generated under low flow demand. With the inlet throttled, the pump is adapted to operate in known manner with an outer annulus of liquid in the impeller and an inner core of vapour.

At low flow rates the total flow-resistance across both valves, 16 and 22 is high, so that the pressure drop across the passage 13 and 30 is also high. This pressure difference acting on the piston 43 against the load of the spring 46 tends to close the inlet valve 41, 42, thereby reducing the radial depth of the liquid annulus in the impeller of the pump 11, and thus the pressure in the passage 13.

At high flow rates, the total flow resistance across both valves is low, and the pressure drop is lower. The spring 46 therefore tends to open the inlet valve 41, 42, thereby increasing the pressure in the passage 13.

The control of outlet pressure exerted by the inlet valve has the effect of reducing the movement of the valve spool 18 over the controlled flow range as compared with the embodiment of FIGURE 1, whereby the influence of the position of the valve spool 18 on the load of the spring 31 is further reduced compared with the influence of the position of the plug 24.

The embodiment of FIGURE 3 shows a positive displacement pump 11 having an outlet 13 which supplies both an inlet port 51 to the flow-regulating valve 16, and also the chamber 26 by way of the passage 25. A control port 53 is variably throttled by the land 21 of the valve spool 18 to regulate return flow through a by-pass 52 to the inlet 12 of the pump 11, and thus to regulate the pressure across the throttle valve 22. The embodiment is similar in other respects to the embodiment of FIGURE 1 and corresponding reference numerals are used.

The valve spool 18 is balanced by the spring 31 and by the pressure drop across the throttle valve 22 so as to vary the flow in the by-pass 52 and thus to maintain a pressure drop across the throttle valve which is correlated with the position of the plug 24.

I claim as my invention:

1. Liquid supply apparatus comprising:

- (A) a pump having
 - (1) an inlet arranged to be connected to a source of liquid and
 - (2) an outlet connected to a delivery conduit,
- (B) a throttle valve interposed between the pump outlet and the delivery conduit, and having a movable member,
- (C) spring means,
- (D) control means operable on the movable member of the throttle valve and on the spring means, to vary the extent of opening of the throttle valve and simultaneously to vary the load of the spring means, and
- (E) a flow-regulating valve arranged to regulate the flow of liquid from the pump through the throttle valve, the flow-regulating valve including a movable member responsive to
 - (1) pressure difference across the throttle valve, and to
 - (2) the load of the spring means, the load of the spring means being varied by movement of the control means and the movable member of the throttle valve whereby the movable member of

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the flow-regulating valve causes the pressure difference across the throttle valve to vary in accordance with the extent of opening of the throttle valve.

2. Liquid supply apparatus comprising

- (A) a pump having
 - (1) an inlet arranged to be connected to a source of liquid and
 - (2) an outlet connected to a delivery conduit,
- (B) a throttle valve interposed between the pump outlet and the delivery conduit, and having a movable member
- (C) control means operable on a movable member of the throttle valve to vary the extent of opening of the throttle valve,
- (D) a flow-regulating valve arranged to regulate the flow of liquid from the pump through the throttle valve, the flow-regulating valve including a movable member responsive to
 - (1) pressure difference across the throttle valve, and to
 - (2) a spring interposed between the movable member of the throttle valve and the movable member of the flow-regulating valve, the load of the spring being varied by movement of the movable member of the throttle valve whereby the movable member of the flow-regulating valve causes the pressure difference across the throttle valve to vary in accordance with the extent of opening of the throttle valve.

3. Liquid supply apparatus according to claim 2, wherein the movable member of the throttle valve is a plug which is movable within, and along the central axis of, a fixed orifice to vary the effective area of the opening between the plug and the orifice.

4. Liquid supply apparatus according to claim 3, wherein the flow-regulating valve comprises a valve bore which is co-axial with the fixed orifice, and in which the movable member is axially slidable.

5. Liquid supply apparatus according to claim 4, including drive means operable to rotate the movable member of the flow-regulating valve in the valve bore, and a thrust bearing interposed between one end of the spring and the valve member which is relatively rotatable with respect to the spring.

6. Liquid supply apparatus according to claim 4, including a means defining a chamber wherein one end of the movable member of the flow-regulating valve adjacent to the throttle valve, is subject to the pressure on the downstream side of the throttle valve, while the other end of said movable member is disposed in the chamber so as to be connected to the upstream side of the throttle valve.

7. Liquid supply apparatus according to claim 5, wherein the chamber is connected to the upstream side

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of the throttle valve through a restrictor, and is connected to the delivery conduit through another restrictor whereby the pressure difference between the chamber and the delivery conduit is a proportion of the pressure difference across the throttle valve.

8. Liquid supply apparatus comprising:

- (A) a centrifugal pump having
 - (1) an inlet arranged to be connected to a source of liquid,
 - (2) a control valve interposed between the inlet and the source, and
 - (3) an outlet connected to a delivery conduit,
- (B) a throttle valve interposed between the pump outlet and the delivery conduit, and having a movable member,
- (C) spring means,
- (D) control means operable on the movable member of the throttle valve and on the spring means, to vary the extent of opening of the throttle valve and simultaneously to vary the load of the spring means,
- (E) a flow-regulating valve arranged to regulate the flow of liquid from the pump through the throttle valve, the flow-regulating valve including a movable member responsive to
 - (1) pressure difference across the throttle valve, and to
 - (2) the load of the spring means, the load of the spring means being varied by movement of the control means and the movable member of the throttle valve whereby the movable member of the flow-regulating valve causes the pressure difference across the throttle valve to vary in accordance with the extent of opening of the throttle valve, and
- (F) a piston and cylinder motor operable on the control valve to vary the flow from the source to the pump inlet, the piston and cylinder motor being responsive to the total pressure difference across the regulating valve, whereby the control valve tends to close at high pressure differences and to open at low pressure differences.

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HENRY F. RADUAZO, Primary Examiner

U.S. Cl. X.R.

103—40, 37; 137—565, 613