United States Patent

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[54] **POWER TRANSMISSION**

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[52] **U.S. Cl.** **137/501**
[51] **Int. Cl.** **F16k 31/12**
[58] **Field of Search** 137/501, 494, 497

[56] **References Cited**

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Primary Examiner—Henry T. Klinksiek
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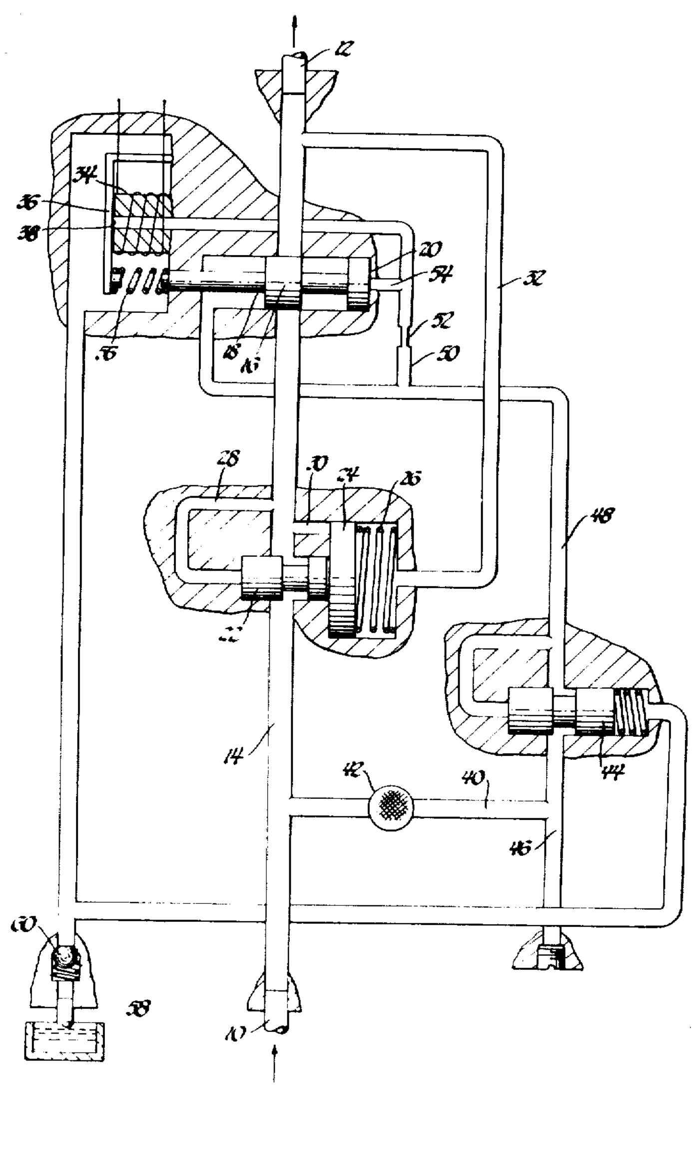
[57] **ABSTRACT**

An electrically controlled hydraulic flow control valve has a nozzle and flapper valve acting as a pilot control for a shiftable main throttle valve. A pressure compensating valve responsive to the pressure drop across the main throttle keeps the flow rate constant, independent of inlet and outlet pressures. Pilot control fluid is supplied by a pressure reducing valve which maintains constant pressure on a small area servomotor, biasing the throttle valve toward closed position. The flapper valve receives control fluid from the reducing valve through a fixed orifice and by means of a feedback connection with the throttle valve, maintains the latter in a position corresponding to the energization of the solenoid.

7 Claims, 7 Drawing Figures



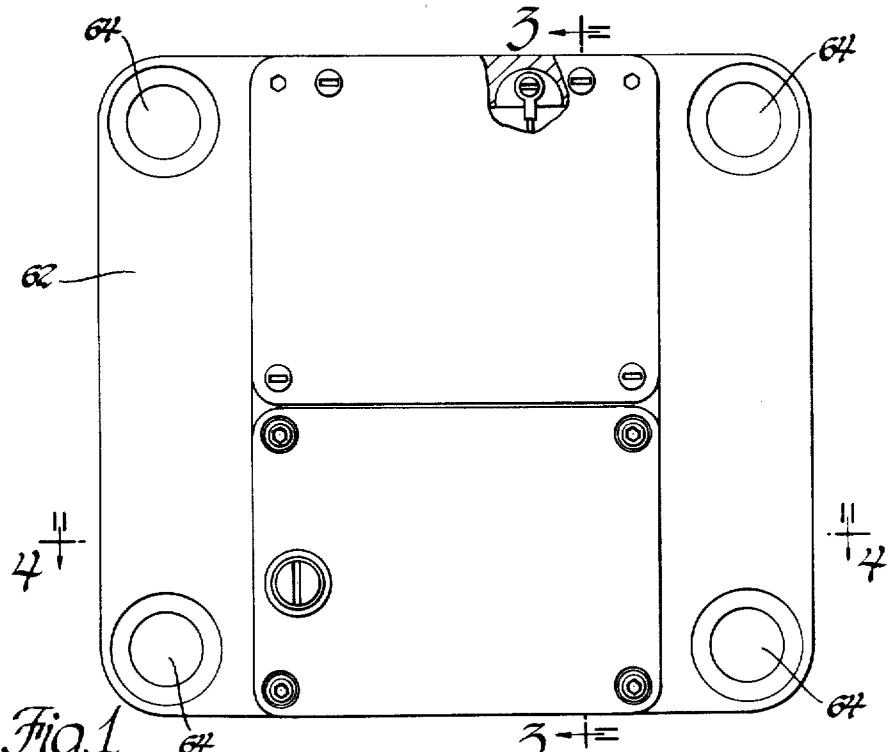


Fig.1

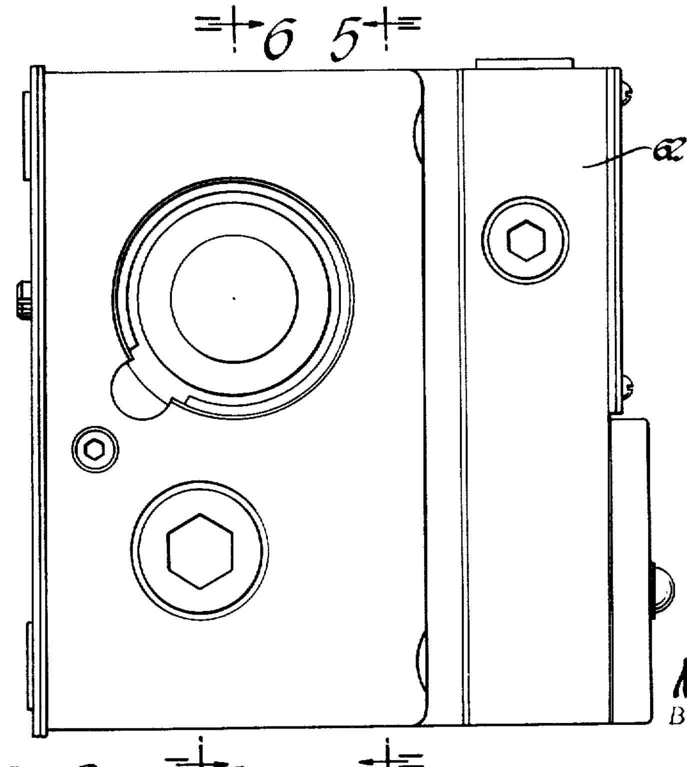


Fig.2

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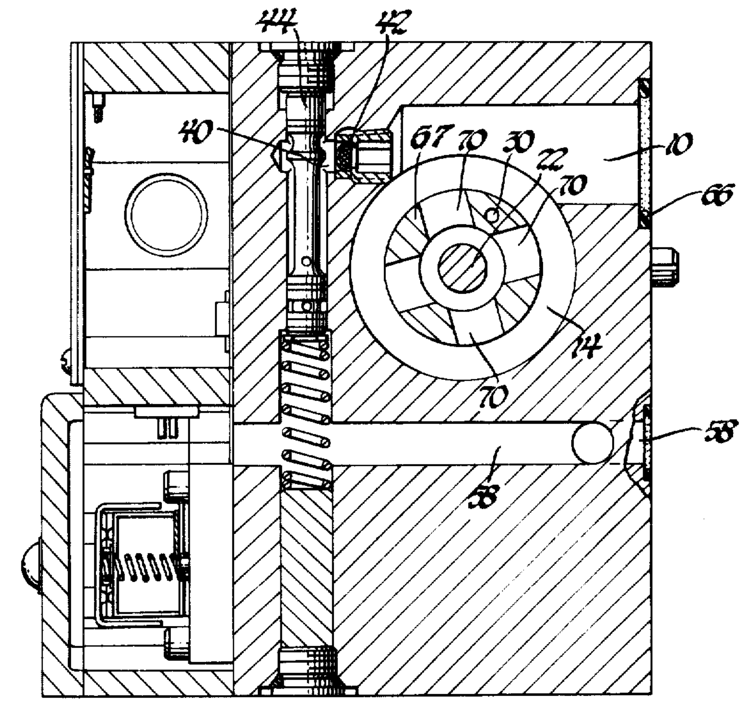

Fig. 3

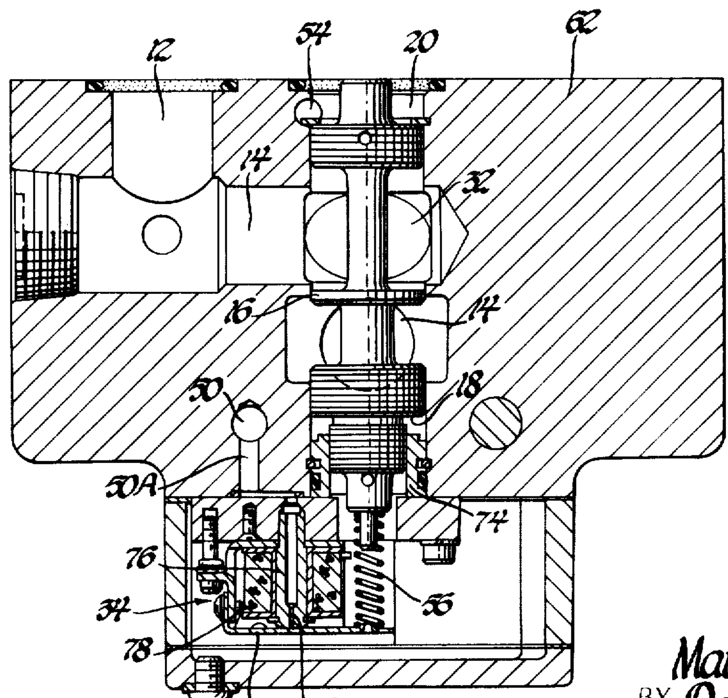

Fig. 4

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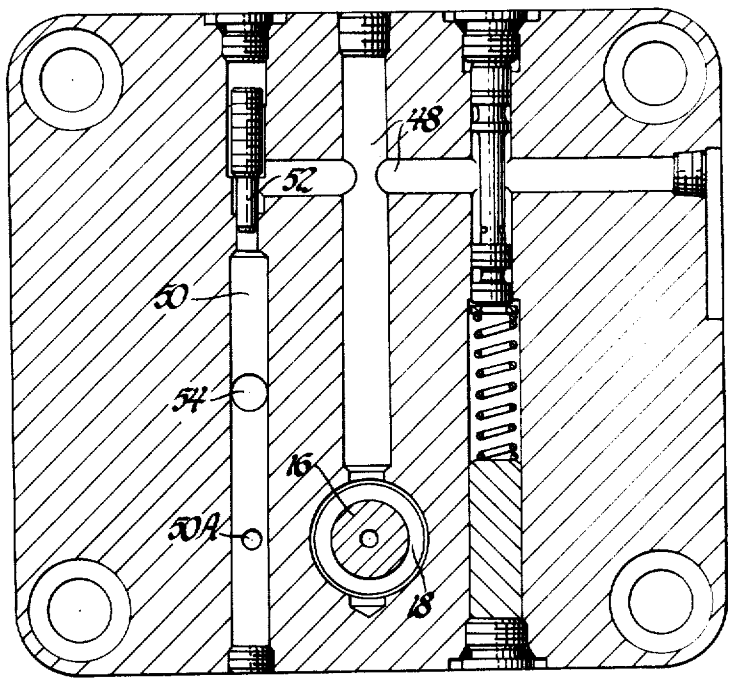

Fig. 5

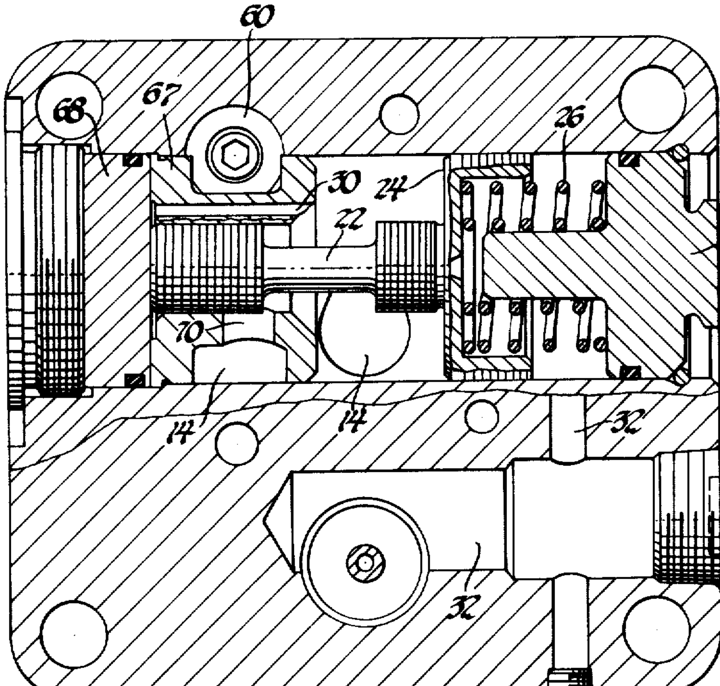

Fig. 6

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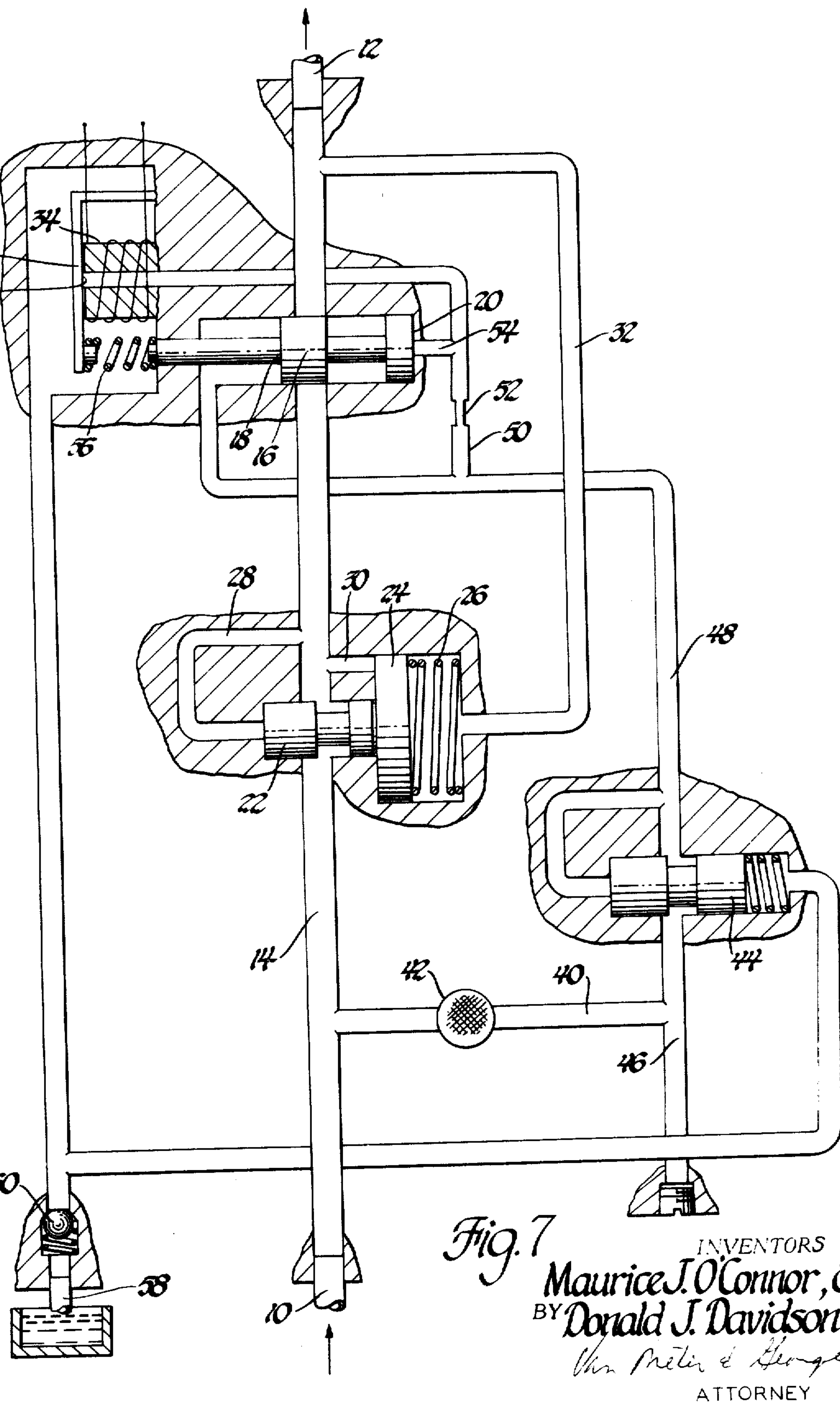

Fig. 7

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POWER TRANSMISSION

Hydraulic power transmission systems frequently require a flow control valve to maintain a constant flow rate through a passageway independently of the inlet and outlet pressures which may vary widely from moment to moment, and these needs have been met by providing an adjustable throttle and a pressure compensating valve which maintain a constant pressure drop across that throttle. It is frequently necessary to provide such a valve with the capability for remote adjustment, as for example, by the provision of an electro-hydraulic transducer for adjusting the variable throttle. Such electro-hydraulic controls as heretofore known have produced undesirable side effects upon the main flow control system, causing hunting and erratic operation, and have been generally unreliable.

The present invention aims to provide a remotely controlled electro-hydraulic flow control valve which will overcome the foregoing difficulties and provide reliable accurate response to changes in the electric signal applied to it and which is durable and economical to construct.

The invention consists in an electro-hydraulic flow control valve comprising a body having an inlet and an outlet for pressure fluid, together with means forming a main flow passageway for fluid flow from the inlet to the outlet, an adjustable orifice valve, and a pressure compensating valve effective to maintain a constant, but adjustable rate of flow through the main passageway, a means forming an auxiliary passageway from the inlet to the outlet, a pressure reducing valve near the upstream end of the auxiliary passageway effective to maintain a constant reduced pressure in the auxiliary passageway, a fixed restriction in the auxiliary passageway, an electrically controlled flapper valve downstream of the fixed restriction, a means responsive to the pressure between the fixed restriction and the flapper valve for urging the orifice valve in one direction, a means biasing the orifice valve in the opposite direction, and a feedback means between the orifice valve and the flapper valve.

FIG. 1 is a front view of a flow control valve incorporating a preferred form of the present invention.

FIG. 2 is a side view of the valve of FIG. 1.

FIG. 3 is a section on line 3—3 of FIG. 1.

FIG. 4 is a section on line 4—4 of FIG. 1.

FIG. 5 is a section on line 5—5 of FIG. 2.

FIG. 6 is a section on line 6—6 of FIG. 2.

FIG. 7 is a hydraulic circuit diagram of the valve.

Referring first to FIG. 7, the valve has a main inlet at 10, an outlet at 12, and a passageway 14 extends therebetween. The main adjustable throttle valve 16 is pilot operated by means of a small area servomotor 18 at its left-hand side and a large area servomotor 20 at its right-hand side. The pressure compensating valve 22 has a large operating piston 24 which is biased by spring 26 toward open position. Pressure in the passageway 14 at a point upstream of the throttle 16 is applied to the left face of the valve 22 and piston 24 through conduits 28 and 30, while pressure downstream of throttle 16 is applied to the right face of piston 24 through conduit 32. Thus, the valve 22 maintains a constant pressure drop across throttle valve 16, the magnitude of which is determined by the force of spring 26 and the area of the piston 24 and consequently, for any given setting of the throttle valve 16, the flow therethrough is maintained constant, regardless of changes in pressure applied at the inlet 10.

An electro-hydraulic transducer is provided for remotely shifting the position of throttle valve 16. It includes a solenoid 34 having an armature 36 which acts as a flapper valve controlling a nozzle 38 extending through the center of solenoid 34. For the purpose of supplying control fluid, a passage 40 having a filter 42 is branched off from passageway 14 near the inlet and leads to a pressure reducing valve 44. An alternative supply of control fluid from an external source is indicated at 46, and when this inlet is used, a plug may be substituted for the filter 42. In either case, the reducing valve 44 forms a source of control pressure fluid at constant pressure in its outlet passageway 48. This leads directly to the small area servomotor 18 and leads through a branch 50 and fixed restrictor 52 to the nozzle 38 and the flapper valve 36. Intermediate these elements, a branch 54 leads to the right-hand or large area servomotor 20. To form a closed loop servo system between the flapper valve and the throttle valve, a spring 56 connects them for feeding back the position of the throttle valve 16 as a variable force upon the armature 36. The valve is also provided with an external drain connection at 58 having a check valve 60, this being connected with the chamber surrounding the flapper valve 36 and with the spring end of the reducing valve 44.

Referring now to FIGS. 1 through 6, a physical embodiment of the flow control valve diagrammed in FIG. 7 is there illustrated. This includes a body 62, shown in front view in FIG. 1 and in side view in FIG. 2. Its configuration from the top resembles the shape of a T, as seen in FIG. 4. The body 62 is adapted for so-called panel mounting against a flat surface having appropriate connecting passages registering with passages in the body. Four bolts may be located in the holes 64 for this purpose. The inlet passage 10, as seen in FIG. 3, is provided with its O-ring seal 66. In this figure there also appears the drain connection 58, similarly sealed.

The pressure compensating valve 22 is mounted in a bore perpendicular to the inlet 10 and constituting part of the main passageway 14. At this point, the body 62 contains a pressed-in valve cage 67, retained by a plug 68, and within which the small diameter portion of compensating valve 22 is shiftable to control flow through the radial passages 70. A plug 72 closes the right end of the bore in which valve 22 and piston 24 reciprocate, as seen in FIG. 6.

Referring now to FIG. 4, a main throttle valve 16 is there shown as mounted in the body 62 and controlling flow upwardly through the passages indicated at 14 to the outlet 12. The large area servomotor 20 is open to the panel mounting surface and sealed thereagainst by the usual sealing ring, its operating connection being indicated at 54. The small area servomotor is indicated at 18 in FIG. 4 and the body 62 contains a sleeve 74 through which the stem of valve 16 extends to contact the feedback spring 56.

Referring again to FIG. 3, from inlet 10, passageway 40 leads through the filter 42 which is mounted in a removable hollow plug and feeds the inlet of the pressure reducing valve 44. The latter has a central passage, not illustrated, through which pressure from its outlet is transmitted to its upper end for the purpose of reacting against the spring at its lower end. The outlet 48 from the reducing valve, as shown in FIG. 5, leads to the small area servomotor 18 and also to the fixed restrictor 52 which is formed as a screwed-in plug having a V-shaped notch along its side. The branch 54 leading to the large area servomotor is indicated in FIG. 5, and the passage 50 extends on downwardly in FIG. 5 and branches as shown at 50A to enter the central core of the electro-hydraulic transducer 34. This includes a central core 76 (FIG. 4), a solenoid winding 78, and a combined armature and flapper valve 36 which controls the nozzle 38.

The operation of the valve as a whole is seen by considering that when connected into a suitable hydraulic circuit and having a suitable variable source of direct current for application to the solenoid coil 78, the degree of energization of the solenoid will determine the force applied to attract the armature 36 toward the nozzle 38. Stable conditions will be reached when the electrical force attracting the armature equals the sum of the hydraulic pressure force exerted by the nozzle on the flapper valve and the mechanical force exerted by the spring 56, which of course, depends upon the position of the main throttle valve 16. Under these stable conditions, a certain pressure is maintained by the flapper valve 36 upon the large area servomotor 20 and this is balanced by the constant pressure from the outlet of the pressure reducing valve 44 applied to the small area servomotor 18. The compensating valve 22 will, of course, maintain a fixed pressure drop across the main throttle valve 16 in the usual manner.

When it is desired to change the rate of flow through the valve, the energization of solenoid 78 is changed, which upsets this pressure and force balance. A new balance is accordingly achieved at a different position of the flapper valve 36, thus setting up a different pressure in the large area servomotor 20 and resulting in the throttle valve taking up a new position which is fed back through the spring 56 to the flapper valve 36. Thus, a new flow rate through the valve as a whole is established. In this way, remote adjustment of the flow rate may be obtained by remotely changing the current flowing through the solenoid coil 78.

We claim:

1. An electro-hydraulic flow control valve comprising a body having an inlet and an outlet for pressure fluid, means forming a main flow passageway for fluid flow from the inlet to the outlet, an adjustable orifice valve and a pressure compensating valve effective to maintain a constant but adjustable rate of flow through the main passageway, means forming an auxiliary passageway from the inlet to the outlet, a pressure reducing valve near the upstream end of the auxiliary passageway effective to maintain a constant reduced pressure in the auxiliary passageway, a fixed restriction in the auxiliary passageway, an electrically controlled flapper valve downstream of the fixed restriction, means responsive to the pressure between the fixed restriction and the flapper valve for urging the orifice valve in one direction, means biasing the orifice valve in the opposite direction, and feedback means between the orifice valve and the flapper valve.

2. A valve as defined in claim 1 wherein the feedback means includes a resilient mechanical force transmitting member between the orifice valve and the flapper.

3. A valve as defined in claim 1 wherein the biasing means for the orifice valve includes an expansible chamber connected to the outlet of the pressure reducing valve.

4. A remotely adjustable flow control valve comprising a pilot operated adjustable throttle valve, a valve responsive to the pressure drop across the throttle valve for maintaining a constant flow rate through the throttle, and a pilot control system for remotely positioning the throttle valve and including an electrohydraulic transducer having a nozzle and a flapper valve opposing the nozzle, means forming a source of control fluid at a constant pressure, a fixed restriction connected between the source and the nozzle, and means for hydraulically shifting the throttle valve including a small area servomotor connected to the source and an opposing large area servomotor connected between the fixed restriction and the nozzle.

5. A valve as defined in claim 4 wherein the source of control fluid includes a pressure reducing valve connected to receive pressure fluid from the stream entering the flow control valve.

6. A valve as defined in claim 4 wherein the transducer includes a solenoid having a central core, and the nozzle is formed on one end of the central core.

7. A valve as defined in claim 4 wherein the flapper valve is biased toward open position by a spring connected with the throttle valve.

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