April 30, 1963 W. A. RAY 3,087,471

PROPORTIONAL POSITIONING USING HYDRAULIC JET

Filed Oct. 31, 1960

3 Sheets-Sheet 1

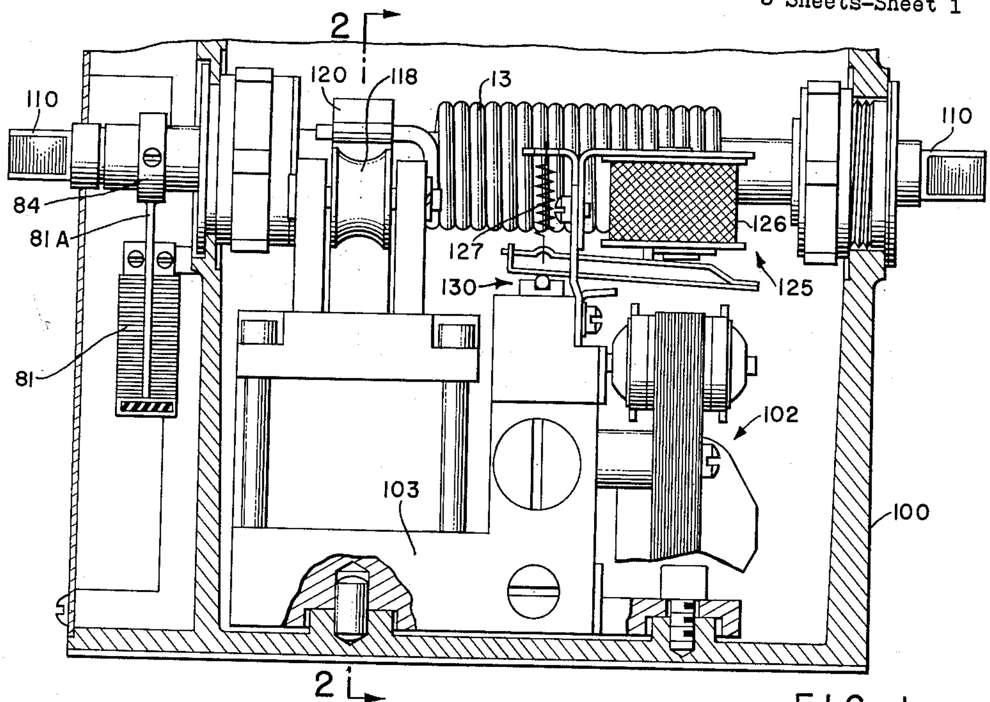

FIG. 1.

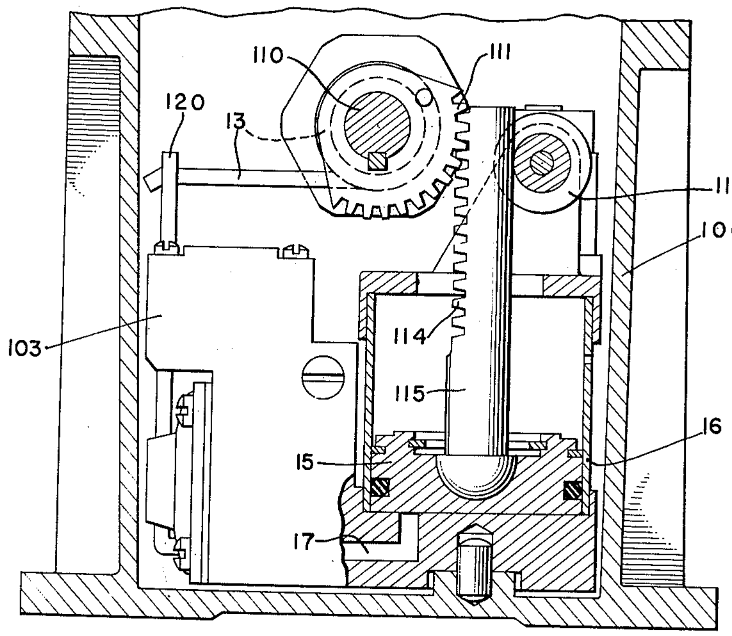

FIG. 2.

INVENTOR.
WILLIAM A. RAY

BY Lyon & Lyon

ATTORNEYS

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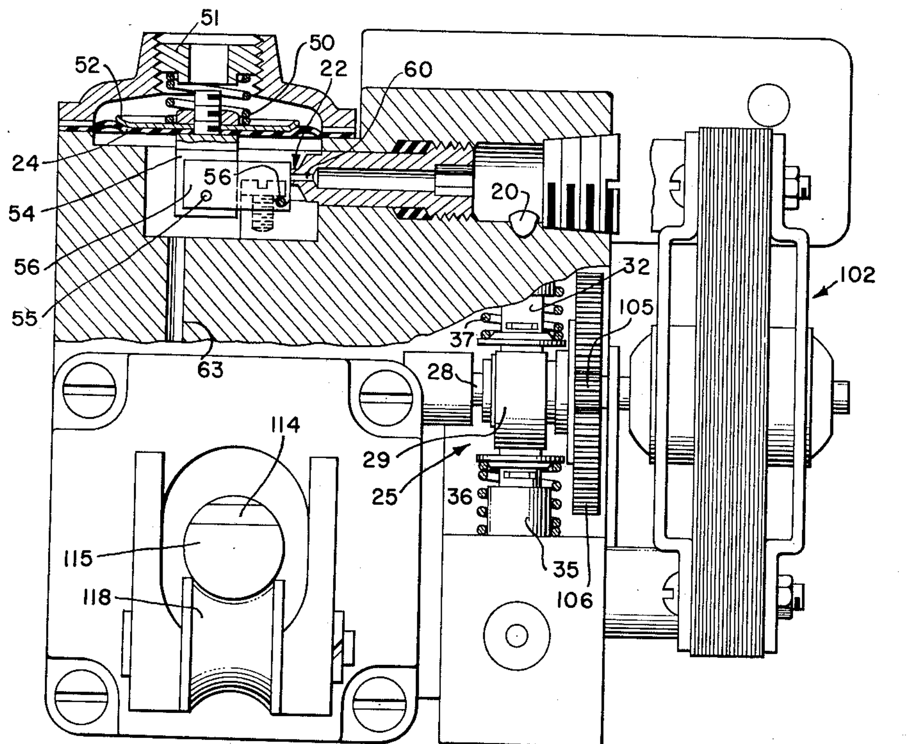

FIG. 3.

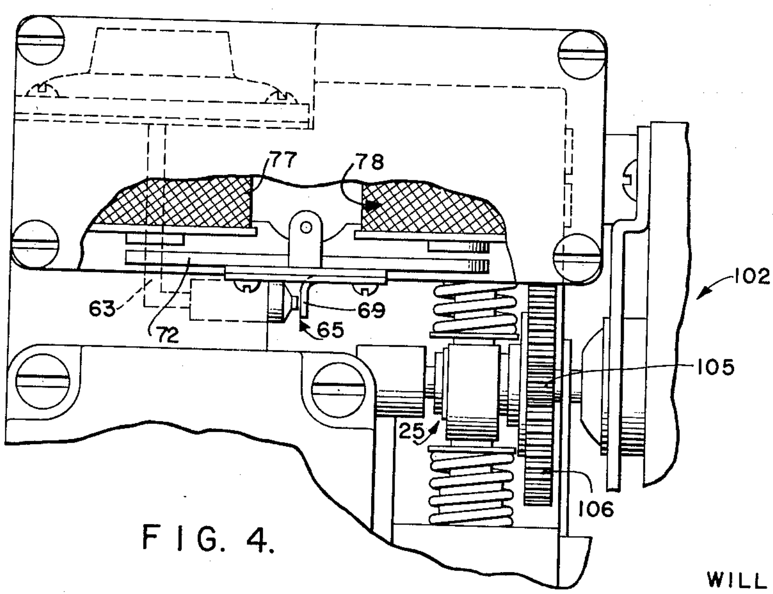

FIG. 4.

INVENTOR.
WILLIAM A. RAY

BY Lyon & Lyon

ATTORNEYS

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PROPORTIONAL POSITIONING USING HYDRAULIC JET

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FIG. 5.

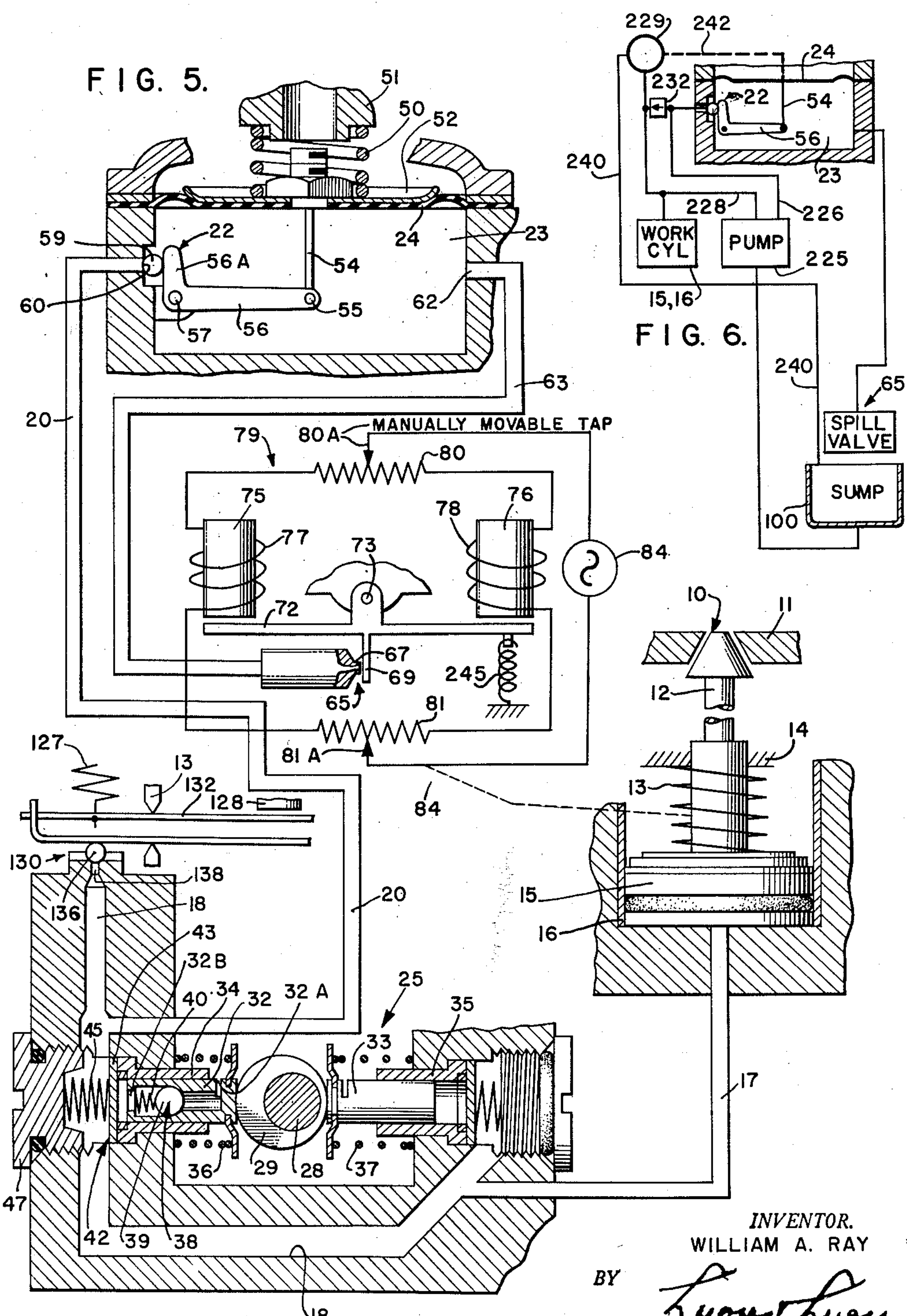

FIG. 6.

INVENTOR.
WILLIAM A. RAY

BY Lyon & Lyon

ATTORNEYS

United States Patent Office 3,087,471

Patented Apr. 30, 1963

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3,087,471 PROPORTIONAL POSITIONING USING HYDRAULIC JET

William A. Ray, North Hollywood, Calif., assignor to General Controls Co., Glendale, Calif., a corporation of California

Filed Oct. 31, 1960, Ser. No. 66,005
31 Claims. (Cl. 121—41)

The present invention relates to hydraulic control systems wherein it is desired to accurately position or adjust a control element such as for example a valve, damper, gate and the like.

Briefly the system disclosed herein involves a hydraulic actuator in communication with a pressure source, the pressure of which is controlled, adjusted or regulated in a unique manner. For this purpose the pressure source is bled through conduit means in which there is interposed what may be termed an amplifier or throttle valve and a control valve in the form of a jet valve, in that order such that fluid from the pressure source flows first through the throttle valve and then through the control valve. Also, interposed in the conduit means is a chamber defined by a diaphragm, the diaphragm being preferably mechanically interconnected to control the throttle valve in accordance with the pressure in the chamber through a motion multiplying system such that small movements of the diaphragm result in large movements in the throttle valve. In turn, the control valve controls the pressure in the chamber. Using this arrangement very large pressures may be controlled, adjusted or regulated by relatively small forces or torques applied to the control valve due to the relatively large magnification in the system. The control valve may thus be controlled by very small sensitive forces developed in, for example, a D'Arsonval type meter movement in which the control valve comprises a jet type valve having a flap moved with respect to the jet by an arm connected to the D'Arsonval movement. Using this latter means a small variation in current results in a relatively large control of pressure. Indeed because of the relatively small forces required to effect the coil for moving the flap of the jet valve may, as described herein, be incorporated in a servo system with the current flow through such coil being automatically regulated in accordance with the position of an actuator operated by the pressure which is regulated by the control valve.

It is therefore a general object of the present invention to provide a system and components thereof functioning as indicated above.

A specific object of the present invention is to provide an arrangement of this character which is extremely simple yet highly effective, accurate both as to operating pressure differential, freedom from hysteresis effects, and freedom from drift.

Another specific object of the present invention is to provide an arrangement of this character in which an electrohydraulic actuator requiring only very small forces or torques may be used to control accurately relatively large pressures and torques.

Another aspect of the present invention is to provide an improved pressure regulating system.

Another specific object of the present invention is to provide an improved servo system for these general purposes.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may be best understood by reference to the following description

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taken in connection with the accompanying drawings in which:

FIGURES 1–4 illustrate a practical embodiment of the present invention, FIGURE 1 being generally a view in side elevation of a mechanism inside the casing shown hatched, FIGURE 2 being a section taken substantially along the line 2—2 in FIGURE 1 and FIGURES 3 and 4 being generally a top plan view of the mechanism with certain parts thereof shown in section.

FIGURE 5 illustrates in somewhat schematic form and in somewhat diagrammatic form a system embodying features of the present invention which incorporates the mechanism illustrated in FIGURES 1–4.

FIGURE 6 illustrates a modified system also embodying features of the present invention.

Referring to the drawings and particularly FIGURE 5 showing the system partly in structural and partly in schematic form, the element which is controlled is represented as the valve **10** having a stationary part **11** and an accurately positioned cooperating valve member **12** which tends to be maintained open by the coil compression spring **13** having one of its ends bearing against the fixed support **14** and the other one of its ends bearing against the valve actuating piston **15** in cylinder **16**, the piston **15** being attached to valve member **12**.

The cylinder **16** is supplied with an actuating fluid such as oil through pipe line **17**, the pressure of such fluid in line **17** being regulated in accordance with important features of the present invention to accurately position or regulate the movable valve member **12**.

This pressure line **17** is in communication with the unrestricted pump outlet channel **18** and the pipe line **20** extending from channel **18** to a diaphragm controlled valve **22**. Valve **22** controls the flow of fluid from pump outlet channel **18** to chamber **23** defined in part by a movable wall comprising the spring biased diaphragm **24**.

Pressure is supplied to the system by a pressure pump **25** having its outlet side in communication with channel **18**. As illustrated such pump **25** is driven by a continuously rotating motor shaft **28** having a single lobe cam **29** thereon engaging spring biased pistons **32** and **33** slidably mounted in stationary cylinders **34** and **35**, the pistons **32** and **33** being pressed against cam **29** by coil compression springs **36** and **37**.

The pistons **32**, **33** are of identical construction and each is in the form of a hollow open ended cylinder having an inlet port represented at **32A** and outlet port **32B** with a spring biased ball check valve **38** therebetween. Such ball check valve **38** comprises a ball **39** pressed by coil compression spring **40** into engagement with a shouldered portion of the piston bore.

The piston outlet **32B** is in communication with the high pressure channel through a check valve **42** comprising a plate **43** biased by coil compression spring **45** which has one of its ends bearing against the removable access plug **47** and the other end bearing against plate **42**.

While the previously described pump construction is preferred other pumps may be used to develop fluid pressure in the high pressure fluid channel **18** which is in free communication with the pipe lines **17** and **20**.

This it will be understood that fluid under pressure is applied to both one side of piston **15** and to the line **20** leading to chamber **23**; and this pressure applied to the piston **15** is regulated in a unique manner embodying important features of the invention.

Fluid under pressure in line **20** is allowed to flow past the valve **22** and into chamber **23**, the valve **22** serving to automatically throttle the pressure by action of the diaphragm **24**. For this purpose the diaphragm **24** biased by coil compression spring **50** having one of its ends bearing against the adjustable support **51** and the other one of its ends bearing against the diaphragm backing plate 52, has connected thereto a centrally extending rod 54 which is pin connected at 55 to one of bell crank or lever 56, the lever 56 being pivoted at 57 with the lever end 56A serving to maintain the ball valve member 59 spaced variable distances from the valve port 60 to regulate the flow of fluid through valve 22 in accordance with the pressure in chamber 23, i.e., the pressure acting on diaphragm 24.

The chamber 23 has an outlet opening 62 in communication, through pipe line with a controlled spill valve 65, this valve 65 comprising a stationary apertured port 67 and a flap 69 extending centrally from the pivoted magnetizable armature member 72 which is pivoted at 73 and which cooperates magnetically with core members 75 and 76 inside of spaced coils 77 and 78 respectively.

These coils 77, 78 are connected electrically in a bridge type circuit 79 with potentiometer type resistances 80 and 81, the tap 80A on resistance 80 being manually adjustable while the tap 81A on resistance 81 is mechanically coupled by mechanical connection 84 (indicated in dotted lines) to the valve member 12. The coil 78 has one of its terminals connected to one terminal of resistance 80 and the other one of its terminals connected to one terminal of resistance 81, the other terminals of resistances 80 and 81 being connected to corresponding opposite terminals of coil 77. The taps 80A and 81A are connected respectively to opposite terminals of A.C. energizing source 84.

In operation of the system shown in FIGURE 5, the tap 80A is manually adjusted to a particular position, which may be calibrated to correspond with a corresponding position of valve member 12. Should the valve member 12 tend to move from this position, the position of the mechanically coupled tap 81A tends to change also. However, this tendency to move is counteracted by an automatic change in pressure in line 17, i.e., line 20 and interconnecting channel 18.

Thus assuming for purposes of explanation that there is a slight downward increment movement of valve member 12 from its adjusted position by the spring 13, the tap 81A moves to the left in FIGURE 5 corresponding incremental amount to produce a changed condition in the bridge type circuit 79 such that a greater current flows through coil 77 and a lesser current flows through coil 78 so that the pivoted valve flap 69 moves closer to the stationary port 67 to allow a lesser fluid flow through the spill valve 65 thereby increasing the pressure in chamber 23, i.e., increasing the pressure on diaphragm 24. This increase in diaphragm pressure causes the rod 54 to move upwardly against the action of spring 50 to cause the throttle valve 22 to close further thereby producing an increase pressure in pipe line 20, channel 18, and pipe line 17. This increase in pressure in line 17 causes the piston 15 and connected valve member 12 and tap 81A to be returned to its normal position established by manual adjustment of tap 80A. Conversely it can be demonstrated that when valve 12 tends to move upwardly a correction is automatically made in the pressure in line 17 to lower the pressure in line 17 to maintain the valve 12 in its adjusted position.

It will thus be seen that the tap 81A is always returned to a mean or balanced position about which it may move to counteract changes in position of valve member 12.

This mean or balanced position of tap 81A and connected valve member 12 is established by adjustment of tap 80A.

Thus, for example, should the tap 80A be moved to the right in FIGURE 5, increased current flows through coil 78 and a lesser current flows at that time through coil 77 to cause the valve flap 69 to pivot counterclockwise thereby further opening valve 65 and decreasing the pressure on diaphragm 24. This decrease in diaphragm pressure causes valve 22 to open further to reduce further the pressure in line 20, channel 18 and line 17 so that the piston 15 descends under the influence of spring 13. This movement of piston 15 causes the tap 81A to move to the left in FIGURE 5 in a direction to effect a partial rebalancing of the bridge circuit 79, i.e., the abovementioned increased current in coil 78 is ultimately reduced somewhat. In other words on initial movement of tap 80A the valve 65 is opened a relatively large amount to obtain relatively quick movement of piston 15 but when and as such piston moves the valve 65 is gradually returned towards closing position and establishes a new mean position corresponding to the new setting of tap 80A and valve 12 which is maintained in such adjusted position by adjustment of the pressure in line 17.

An important feature of the invention involves the series connection of valves 22 and 65 and the motion multiplication of valve 22 effected by diaphragm 25 and the linkage system between the diaphragm and the valve 22. For these purposes the flow capacity of valve 65 is greater than the flow capacity of valve 22 so that continuous flow of pressure bleeding fluid is assured through valve 65.

This arrangement involving force multiplication allows the use of a small amount of force applied to valve 65 to control large pressures precisely. Stated in other words low pressures are controlled at valve 65 to effect control of high pressures at valve 22 by pressure amplication. This pressure amplification is determined essentially by the ratio of diaphragm area multiplied by the mechanical advantages of the linkage system to the area of the nozzle comprising the valve port 67.

In a typical system the diameter of port 67 may be forty-seven thousandths of an inch, the diameter of port 60 may be thirty-one thousands of an inch, the spring rate of spring 50 may be one and one-half pounds per square inch and the pressure in line 17 may have a nominal value of 100 lbs. per square inch. By providing the linkage system 54, 56 the diaphragm may be made of relatively small area for compactness in a small structure as illustrated in FIGURES 1–4.

In FIGURES 1–4 elements corresponding to those in FIGURE 5 have identical reference numerals.

In FIGURES 1–4 elements are mounted in an oil sealed casing 100 such that the oil exiting from valve 65 graviates into a sump into the casing from where it is recirculated by the pump 25. The pump shaft 28 is driven through gears 105 and 106 by the electric motor 102 mounted on pump housing 103, the housing 103 being secured in casing 100 and the smaller gear 105 being on the motor shaft and the larger gear 106 being on the pump shaft 28.

In this instance it is noted that a rotary output shaft 110 is provided for adjusting and positioning rotary elements such as valves, flaps or any other device having a rotary control element which may be secured to the output shaft 110.

The output shaft 110 as shown in FIGURE 2 has keyed thereto a pinion gear 111 meshing with the rack 114 on piston rod 115, the rod 115 being secured to piston 16 and is guided by guide roller 118.

In this case the piston 16 is biased by the coil torsion spring 13 on output shaft 110, the spring 13 having one end fixed to the output shaft and the other one of its ends held by the stationary arm 120. The potentiometer type resistance 81 has its wiper arm 81A attached to output shaft 110 at 84.

Mounted on the pump housing 103 is a current failure device 125 consisting of a solenoid coil 126 for closing the valve 130 (FIGURES 1 and 5). This valve 125 may be opened by coil tension spring 127. This valve 130, as shown in FIGURE 5, is normally closed by the magnetized core member 128 and when the same is opened upon current failure to coil 126, the valve-actuating member 132 pivots about the support 134 under the influence of spring 127 to allow the ball 136 to uncover the port 138 in communication with high pressure channel 18, in which case the high pressure is unloaded and the valve 10 automatically closes.

It will be appreciated that in its broader aspects the jet valve 65 may be controlled by other means and may not necessarily be a part of a servo system as described in FIGURE 5. For example, the valve flap 69 may be positioned manually or electrically by attaching the flap to a movable element of a D'Arsonval-type device and manually controlling the current flowing through the coil of the D'Arsonval-type device.

Also, pressure-sensitive or temperature-responsive devices such as small expansion rod units or liquid-charged bellows assemblies or small pressure elements are used to control the position of flap 69 to easily control substantially greater forces as described above using a variable force applied to the flap having, for example, a mean value of five grams.

In those arrangements wherein the actuating force or power to this type of electrohydraulic proportional controlling actuator is very considerably higher, the form or type of ball valve 22 shown in FIGURE 5 is replaced, for example, by a piston-type valve operable by a relatively small amount of energy with little or no unbalanced pressure head effects on the valve 22 resulting from larger fluid flow, although some pressure head effect at valve 22, as indicated above, is desirable as it tends to produce a feedback effect. To maintain this feedback effect the fluid controlled by valve 22 should also be discharged through the spill valve 65. Using this feature wherein the same fluid controlled by valve 22 also flows through spill valve 65, a system, much improved over the prior art, results, particularly since a sense of "feel" is carried through to the movable control flap 69 which reacts on the sensitive device controlling the flap 69 so that the device receives a portion of the forces applied to the actuating piston 15, not all of such forces.

As to this sense of feel in the system, an analogy may be drawn to the same problem of developing "feel" in the steering system of an automobile where it is desired to transmit some percentage of road shock or pull on the front wheels back to the operator so that he may have a "feel" of the automobile's reaction to the road or vice versa. Likewise, the same sense of feel is desirably developed in the control of aircraft where power-actuated devices are used to operate controlling air surfaces of the aircraft.

The same sense of feel is exemplified and incorporated in the modified system shown in FIGURE 6, also embodying features of the present invention.

In FIGURE 6 there is again provided the same diaphragm 23 defining one wall of chamber 23 into which the flow of fluid is controlled by the diaphragm-operated valve 22 through linkage 54, 56 and the outlet of chamber 23 is again connected to the same control spill valve 65 which may be controlled by the means described above; and the discharge from valve 65 flows into the pump sump or casing 100 in communication with the inlet side of a multi-cylinder motor driven pump 225. In this particular instance the pump 225 comprises a plurality of pump cylinders, one or more of which may be in communication with the inlet side of valve 22 through conduit 226. One or more of other pump cylinders of pump 225 discharges into the work piston-cylinder 15, 16 through conduit 228, the pressure in line 228, however, being controlled by bleeder valve 229 having its inlet side connected to line 228 and its outlet side returned through line 240 to sump 100. This valve 229 is controlled by movement of diaphragm 24 through a mechanical connection indicated by the dotted line 242 such that increased pressure in chamber 23, i.e., upward movement of diaphragm 24 results in further closing of valve 229 to raise the pressure in line 228, i.e., to increase the pressure in work cylinder 15, 16. A check valve 232 is preferably interconnected between lines 226 and 228 to normally allow fluid flow from line 226 to line 228 but to prevent reverse flow under conditions which may be considered abnormal.

It is observed that the amplifier valve diaphragm 24 develops enough energy to operate the valve 22 and 229 simultaneously but the control valve 65 handles only a limited flow without seriously overloading the sensitive relay armature 72 (FIGURE 5). For this reason and sensitivity considerations, the flow rate through spill valve 65 should be limited; but, at the same time, it is important that the amplifier discharge from chamber 23 go to the control valve 65 to preserve the aforementioned sense of feel. Thus, it is desirable that the check valve 232 be provided to prevent flow from line 228 into the chamber 23 through valve 22 but at the same time to allow the pressure developed in line 226 to be utilized in the work cylinder 15, 16.

Preferably the check valve 232 is spring-loaded such that it opens to allow flow between lines 226 and 228 only when the pressure in chamber 23 exceeds normal operation pressure so that it will be possible at all times to build up pressure in chamber 23 high enough for the diaphragm 24 to move the valves 22 and 229 to closed position.

The valve 229, a two-way valve, may be of the balanced piston type functioning to close off flow to the sump line 240 to thereby raise the pressure in line 228, i.e. in the work cylinder 15, 16; and the check valve 232 prevents excessive pressures developed in line 228 from causing excessive fluid flow through spill valve 65.

Referring again to FIGURE 5, it is considered desirable to add the tension spring 245, particularly when large oil flows produced by a pump driven by a 5 or 10-watt input motor are involved. It will be observed that the tension spring 245 biases the armature in a direction tending to close the spill valve 65. In general, this spring 245 should result in the building up of pressure in the amplifier valve chamber 23 to just allow the system to operate. It may be said that the spring develops a hydraulic pressure in proportion to its strength and adjustment of its strength is determinative of that pressure in chamber 23 necessary to balance the force exerted by diaphragm spring 50. Using such spring 245 or adjusting the tension produced by the same effects balancing of the normal or working pressure head in chamber 23 and thus contributes to the accuracy and sensitivity of the system, considering the fact that operation may thereby be selected and effected over a relatively short range of operation where the so-called regulation curve is substantially flat.

While the particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. A control system comprising a fluid pressure source, means bleeding said source to control the pressure of said source, said means comprising conduit means having one end thereof in communication with said source, a pair of valve means spaced in said conduit means through which fluid from said source flows through said first and second valve means in that order, said conduit means comprising a pressure operated diaphragm being interposed between said first and second valve means, means connected between said diaphragm and said first valve means for controlling the same in accordance with the pressure on said diaphragm, and means controlling said second valve means for controlling the pressure on said diaphragm.

2. A system as set forth in claim 1 in which said means connected between said diaphragm and said first valve means comprises a motion multiplying system in which relatively small movements of said diaphragm produce relatively large movements of said first valve means.

3. A system as set forth in claim 2 in which said means

controlling said second valve means comprises means responsive to the pressure of said pressure source.

4. A system as set forth in claim 1 including a device operated by fluid pressure developed by said pressure source, conduit means connecting said source to said device, and means connected to said diaphragm and controlling the pressure in said conduit means to control the pressure developed in said device.

5. A system as set forth in claim 4 including check valve means between said conduit means and said fluid pressure source.

6. A system as set forth in claim 4 in which the last-mentioned means comprises a bleed valve for bleeding the pressure in said conduit means.

7. A control system as set forth in claim 1 including means biasing said second valve means to effect the pressure developed on said diaphragm.

8. A pressure regulating system comprising a source of pressure, conduit means connected to said source, a throttle valve means and a control valve means connected in that order in said conduit means such that fluid from said source first flows through said throttle valve and then said control valve means and means controlling said throttle valve means, said controlling means including an expansible chamber connected between said throttle valve means and said control valve means, and means responsive to pressure in said chamber for adjusting said throttle valve means.

9. A system as set forth in claim 8 including a device operated by fluid pressure, second conduit means interconnecting said source of pressure with said device, and means responsive to pressure in said expansible chamber for controlling the pressure in said second conduit means.

10. A system as set forth in claim 9 including check valve means interconnected between said second conduit means and the upstream side of said throttle valve means with said check valve means being opened by fluid pressure in the first mentioned conduit means to allow fluid flow from the first mentioned conduit means to said second conduit means.

11. A pressure regulating system comprising a source of pressure, conduit means connected to said source, a throttle valve means and a control valve means connected in that order in said conduit means such that fluid from said source first flows through said throttle valve and then said control valve means, means controlling said throttle valve means, said controlling means comprising a fluid chamber in said conduit means between said throttle valve means and said control means, said fluid chamber being defined in part by a movable wall defined by a pressure-responsive element and motion multiplying means interconnecting said pressure-responsive element with said throttle valve means.

12. A system as set forth in claim 11 including a device operated by fluid pressure, second conduit means interconnecting said source of pressure to said device, and means responsive to the position of said pressure-responsive element for controlling the pressure in said second conduit means.

13. A system as set forth in claim 12 including check valve means interconnected between said second conduit means and the upstream side of said throttle valve means with said check valve means being opened by fluid pressure in the first mentioned conduit means to allow fluid flow from the first mentioned conduit means to said second conduit means.

14. A system as set forth in claim 11 including a servo system, said servo system including a means responsive to the pressure of said source for controlling said control valve means.

15. A control system comprising, a source of fluid pressure, a chamber having an inlet and an outlet, a diaphragm defining a wall of said chamber, valve means including a movable control element, means including said valve means communicating said pressure source with said inlet, a motion multiplying lever system interconnecting said diaphragm to said control element for producing relatively large movements of said control element in accordance with small movements of said diaphragm, second valve means having a control element means intercommunicating said outlet with said second valve means, and control means controlling said control element of said second valve means.

16. A system as set forth in claim 15 in which said control means includes a control member, means intercommunicating said pressure source with said control member for positioning the same in accordance with the pressure of said source, current responsive means controlling said control element of said second valve means, and means coupled to said control member for controlling the current flow in said current responsive means.

17. A system as set forth in claim 15 in which said second valve means comprises a jet valve having a movable flap, and means controlling the position of said flap.

18. In a system of the character described, a source of pressure, an element actuated by said pressure source, a first potentiometer resistance having its tap coupled to said element, a pair of coils, a second potentiometer type resistance having its terminals connected in series with said coils and said first resistance, a voltage source, the taps on said resistance being connected to corresponding terminals of said voltage source, each of said coils being connected to different terminals of said resistance to form a bridge type circuit, a pivoted armature having opposite ends magnetically cooperating with a corresponding coil, a valve flap attached to said pivoted armature, a jet valve spaced from said flap and controlling fluid flow through said jet valve, conduit means extending from said pressure source to said jet valve, an amplifier valve in said conduit means between said pressure source and said jet valve, an expansible chamber in said conduit means between said amplifier valve and said jet valve, and means responsive to pressure in said expansible chamber and controlling said amplifier valve.

19. In a system of the character described, a source of pressure, an element actuated by said pressure source, a first potentiometer resistance having its tap coupled to said element, a pair of coils, a second potentiometer type resistance having its terminals connected in series with said coils and said first resistance, a voltage source, the taps on said resistance being connected to corresponding terminals of said voltage source, each of said coils being connected to different terminals of said resistance to form a bridge type circuit, a pivoted armature having opposite ends magnetically cooperating with a corresponding coil, a valve flap attached to said pivoted armature, a jet valve spaced from said flap and controlling fluid flow through said jet valve, conduit means extending from said pressure source to said jet valve, an amplifier valve in said conduit means between said pressure source and said jet valve, said amplifier valve comprising a chamber defining a part of said conduit means, a diaphragm forming a wall of said chamber, a movable valve element controlling the flow of fluid to said chamber, and means connecting said diaphragm to said valve element.

20. A system as set forth in claim 19 in which the last mentioned means comprises a motion multiplying lever system.

21. In a pressure regulating system of the character described, a source of pressure to be regulated, bleed means extending from said source comprising conduit means, said conduit means comprising a fluid chamber having a wall thereof defined by a diaphragm, first valve means controlling the flow of fluid to said chamber, second valve means controlling the flow of fluid from the outlet of said chamber, means controlling said second valve means, and a mechanical connection between said diaphragm and said first valve means for controlling the same.

22. In a system of the character described a fluid cham-

ber having one wall thereof defined by a diaphragm, first valve means controlling the flow of fluid into said chamber, means interconnecting said diaphragm to first valve means to control the same in accordance with movement of said diaphragm, and second valve means controlling the flow of fluid from said chamber.

23. A system as set forth in claim 22 including a pressure source connected to said chamber through said first valve means, a fluid actuator connected to said pressure source, and means controlling said second valve means in accordance with movement of said actuator.

24. A system as set forth in claim 23 in which said actuator is a linear actuator.

25. A system as set forth in claim 23 in which said actuator is a rotary actuator.

26. A control system comprising a fluid pressure source, means bleeding said source to control the pressure of said source, said means comprising conduit means having one end thereof in communication with said source, a pair of valve means spaced in said conduit means through which fluid from said source flows through said first and second valve means in that order, said conduit means comprising pressure-operated means being interposed between said first and second valve means, means connected between said pressure-operated means and said first valve means for controlling the same in accordance with the pressure on said pressure-operated means, and means controlling said second valve means for controlling the pressure on said pressure-operated means.

27. A system as set forth in claim 26 in which said means connected between said pressure-operated means and said first valve means comprises a motion multiplying system in which relatively small movements of said pressure-operated means produce relatively large movements of said first valve means.

28. A control system comprising, a source of fluid pressure, a chamber having an inlet and an outlet, pressure-operated means defining a wall of said chamber,

valve means including a movable control element, means including said valve means communicating said pressure source with said inlet, a motion multiplying lever system interconnecting said pressure-operated means to said control element for producing relatively large movements of said control element in accordance with small movements of said pressure-operated means, second valve means having a control element means intercommunicating said outlet with said second valve means, and control means controlling said control element of said second valve means.

29. A system as set forth in claim 28 in which said second valve means comprises a jet valve having a movable flap, and means controlling the position of said flap.

30. In a pressure regulating system of the character described, a source of pressure to be regulated, bleed means extending from said source comprising conduit means, said conduit means comprising a fluid chamber having a wall thereof defined by a pressure-responsive element, first valve means controlling the flow of fluid to said chamber, second valve means controlling the flow of fluid from the outlet of said chamber, means controlling said second valve means, and a mechanical connection between said element and said first valve means for controlling the same.

31. In a system of the character described a fluid chamber having one wall thereof defined by a pressure-responsive element, first valve means controlling the flow of fluid into said chamber, means interconnecting said element to first valve means to control the same in accordance with movement of said element, and second valve means controlling the flow of fluid from said chamber.

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