April 9, 1940. J. M. LARSON ET AL 2,196,926

REVERSE ACTING RELAY

Filed Aug. 12, 1937 2 Sheets-Sheet 1

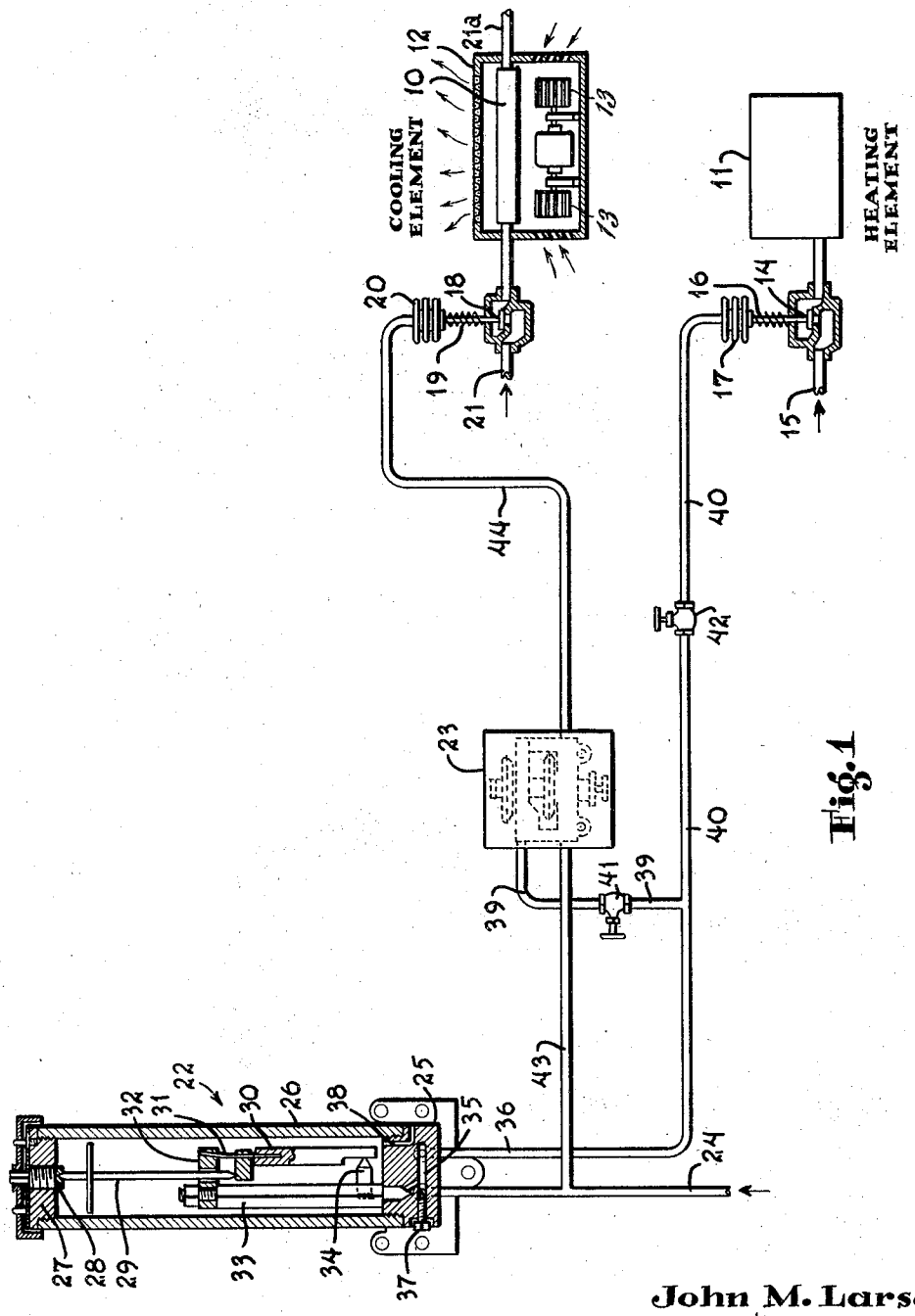


Fig. 1

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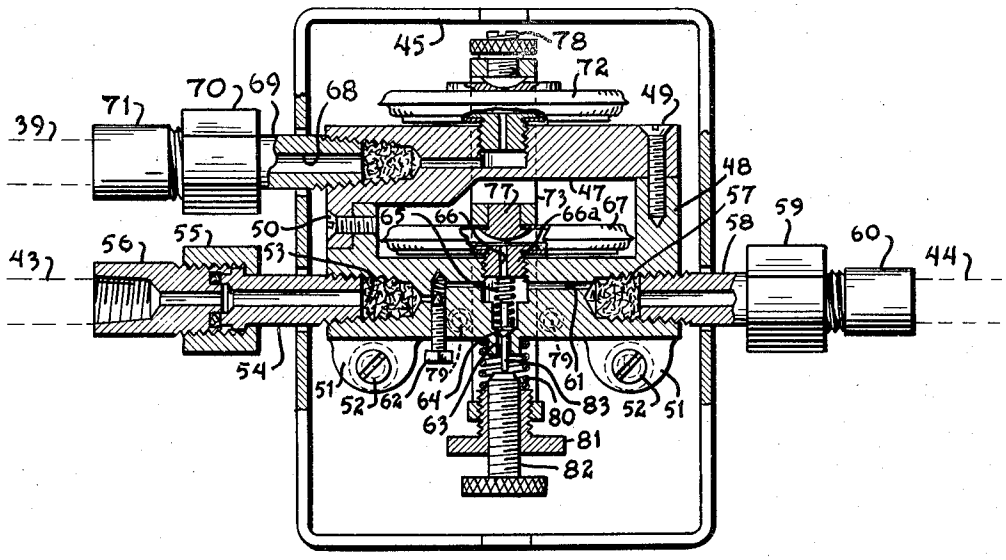


Fig. 3

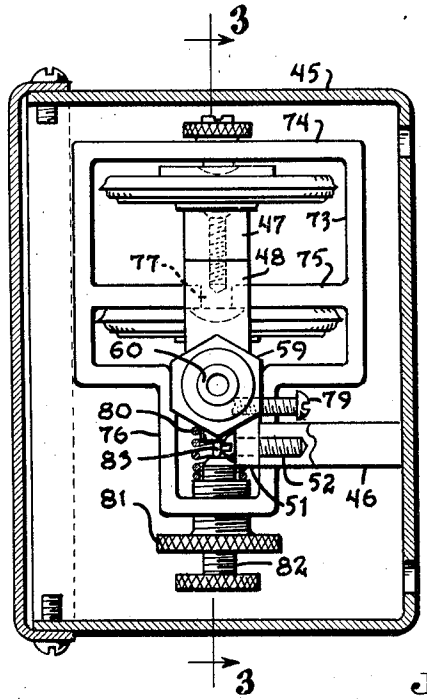


Fig. 2

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REVERSE ACTING RELAY

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6 Claims. (Cl. 236—1)

Our invention relates in general to automatic controls and is more particularly concerned with fluid pressure relay means for supplying to pressure responsive devices a pressure which varies gradually and reversely to a variable control pressure applied to the relay. It is an object of our invention to provide a simple, reliable, and inexpensive device of this character.

A further object of our invention is the provision of a novel summer-winter control system utilizing a relay of the type above mentioned for obtaining control of both a heating system and a cooling system from a single thermostat.

Other objects of our invention lie in the various features of construction of our improved reverse acting relay and will become apparent from the following description and the appended claims.

For a complete understanding of our invention, reference should now be had to the drawings, in which:

Fig. 1 is a somewhat diagrammatic illustration of a fluid pressure control system illustrating one embodiment of our invention;

Fig. 2 is an elevational view partly in section of the improved pressure control device or relay shown somewhat diagrammatically in Fig. 1; and

Fig. 3 is a sectional view taken on a line substantially corresponding to line 3—3 of Fig. 2, certain parts being shown in elevation and other parts being broken away to illustrate more clearly the constructional details.

Referring to Fig. 1 of the drawings, we have shown our invention as applied to a fluid pressure control system for a plurality of temperature changing elements 10 and 11 which may be of any desirable type well known in the art, the element 11 being a heating element and the element 10 being a cooling element and enclosed in a perforated casing 12 along with a pair of motor driven fans 13. The fans may be arranged as shown to draw air inwardly through the sides of the casing and to expel it outwardly from the top of the casing.

As shown, the heating element 11 is provided with suitable inlet valve means 14 for controlling the supply of heating fluid thereto, and it will be understood that the supply conduit 15 may be connected to any suitable source of heating medium. The movable stem of the valve 14 is normally biased to its fully open position by a spring 16 and is adapted to be operated to the closed position shown by a fluid pressure motor means 17, here shown as comprising an expansible bellows or diaphragm. Valve means of this type are well known in the art as direct acting valve means. Similarly, the supply of cooling medium to the cooling element 10 is controlled by means of a direct acting valve 18 normally biased to its open position by a spring 19 and adapted to be operated to the closed position shown, by fluid pressure motor means 20, and it will be understood that the supply and exhaust conduits 21 and 21*a*, respectively, may be connected to any suitable source of cooling medium. It will, of course, be understood that any suitable type of motor operated inlet valves may be used and they may be either direct acting or reverse acting.

In order to provide for automatic operation of the valve means 14 and 18 in response to changing temperature conditions, we provide means including suitable temperature responsive means such as a thermostat 22 and a pressure control device or relay 23 for varying, in accordance with the temperature conditions, the pressure supplied to the motor means 17 and 20 from a source of constant pressure represented by a supply conduit 24.

The temperature responsive means 22, as shown, may be of a type well known in the art and in the present embodiment, comprises a base 25 on which is supported a temperature responsive element or tube 26. The outer end of the tube is provided with a closure member 27 for supporting an adjustable bearing member 28, the inner face of which is engaged by one end of a push rod 29, the other end of the push rod 29 being supported on one arm of a bell-crank member 30. As shown, this bell-crank member 30 is supported on a leaf spring 31 secured to an outstanding arm 32 on a post 33, and the downwardly extending end of the bell-crank member 30 cooperates with a leak-port or vent 34, the spring 31 being arranged normally to close the vent.

The temperature responsive device 22 is provided with a passageway 35 having a restriction therein, one end of the passageway being connected to the supply conduit 24 and the other end of the passageway being connected to an exhaust or outlet conduit 36. As shown, an adjustable member 37 is provided for varying the degree of restriction of the passageway 35 and the vent or leak-port 34 communicates with the passageway 35 on the opposite side of the restriction from the supply conduit 24. When the bell-crank lever 30 of the temperature responsive device 22 occupies the position shown, which position corresponds to relatively high temperatures, the

leak-port 34 is closed and accordingly the full supply pressure is available in the outlet conduit 36. Upon a decrease in temperature, however, the temperature responsive element 26 contracts, and the push rod 29 thereupon pivots the bell-crank lever 30 so as to open slightly the leak-port 34. Thus, a portion of the fluid pressure medium is allowed to exhaust through the leak-port 34 into the interior of the device 22 from which point it exhausts to atmosphere through a suitable exhaust passageway 38. Accordingly, the pressure available in the outlet conduit 36 is substantially reduced, and, when the leak-port 34 is completely open, this outlet pressure will be approximately zero.

The outlet conduit 36 is connected to suitable branch conduits 39 and 40 which are respectively connected through valve means 41 and 42 to the pressure control device or relay 23 and to the valve motor means 17 associated with the heating element 11. Furthermore, the pressure control device 23 is connected by means of a conduit 43 to the supply conduit 24 and by means of a conduit 44 to the motor means 20 associated with the cooling element 10.

In Figs. 2 and 3, the pressure control relay 23, shown diagrammatically in Fig. 1, is shown in detail. This pressure control device 23 comprises a housing 45, the rear wall of which supports a pair of inwardly extending posts 46, the inner ends of which support a stationary frame comprising upper and lower frame members 47 and 48, respectively (Fig. 3). These upper and lower frame members may be secured together by suitable screws 49 and 50, and the lower frame member 48 is provided with a pair of depending ears 51 through which extend suitable screws 52 threadedly engaging the supporting posts 46. It will, of course, be understood that the stationary frame may comprise a single unitary member, if desired, the two-part construction here shown being preferred for assembly purposes.

As shown best in Fig. 3, the left-hand end of the lower frame member 48 is provided with an inlet passageway 53 which is internally threaded for cooperation with the connecting members 54, 55 and 56 which serve to connect the inlet passageway 53 to the conduit 43 of Fig. 1. Likewise, the lower frame member 48 is provided with an outlet passageway 57 adjacent its right-hand end, which passageway is provided with suitable connecting members 58, 59, and 60 for connecting the passageway 57 to the conduit 44 of Fig. 1. Extending through the lower frame member 48, between the inlet and outlet passageways, is a connecting passageway 61 which is provided with a restricted portion adjacent the inlet passageway 53, an adjustable member 62 being provided for varying the degree of restriction. This passageway 61 is provided intermediate its ends with a vent or leak-port 63 which is controlled by a valve 64 normally biased by a spring 65 to the closed position shown. Likewise, the passageway 61 communicates through a conduit or passageway 66 with the interior of an expansible bellows or fluid pressure motor means 67, the passage 66 being formed in a nipple 66a which secures the lower wall of bellows 67 to the lower frame member 48.

In addition to the inlet and outlet passageways 53 and 57, the stationary frame member is provided with an auxiliary passageway 68, formed in the upper frame member 47 and provided with suitable connecting members 69, 70, and 71 for connecting the passageway 68 to the conduit 39 of Fig. 1. As shown in Fig. 3, this passageway 68 communicates with the interior of an expansible bellows or fluid pressure motor means 72 secured to the upper face of the frame member 47.

Associated with the expansible bellows 67 and 72, we provide a movable frame member 73 for operating the valve 64 to control the leak-port 63, in a manner to be hereinafter described. This frame member 73, as shown best in Fig. 2, comprises a top cross member 74, an intermediate cross member 75, and a reduced bottom portion 76, and is arranged substantially at right angles to the stationary frame with the intermediate cross member 75 extending through the space between the upper and lower stationary frame members 47 and 48, the upper wall of the expansible bellows 67 being secured to the cross member 75 in any suitable manner, for example, by means of a rivet 77 (Fig. 3).

Likewise, the top cross member 74 is cooperatively associated with the bellows 72, an adjustable bearing member 78 being provided which threadedly engages the top cross member 74 and abuttingly engages the upper wall of the expansible bellows 72. Thus, the movable frame 73 is supported on the bellows 67 and 72 for vertical reciprocal movement in accordance with the expansion and contraction of the bellows. A pair of spaced guide bolts 79 is provided which threadedly engages the stationary frame member 48 and extends outwardly therefrom on opposite sides of the movable frame to prevent tilting or twisting of the movable frame during its vertical movement.

In order to control in the desired manner, as will be more fully explained hereinafter, the movements of the frame 73, we provide a balancing spring 80, one end of which engages the lower stationary frame member 48 and the other end of which engages an adjustable seat 81, which spring seat threadedly engages the reduced lower portion 76 of the movable frame 73. This spring seat 81 is threaded internally so as to support an adjustable abutment member 82, the upper end of which is arranged to engage a depending stem 83 extending downwardly from the leak-port valve 64. It will thus be apparent that whenever the frame 73 moves upwardly from the position shown in the drawings, the abutment member 82 forces the valve 64 upwardly so as to open the leak-port 63. Also, the spring 80 may be adjusted to balance any desired pressure in the bellows 67 and 72 by adjusting spring seat 81, and the screw 82 may be adjusted to control the leak-port valve in accordance with requirements.

With the above description of the principal elements in mind, it is believed that a complete understanding of my invention may best be had from a description of the operation of the system as a whole.

In Fig. 1 the various elements are shown in the respective positions occupied during relatively high temperature conditions, and it will be assumed that the system is set for winter or cold weather conditions, in which case the valve 41 will be closed and the valve 42 will be open. It will further be assumed that the temperature of the room or space being controlled, to which temperature the device 22 is responsive, begins to decrease, under which conditions it is, of course, desirable that heating medium be supplied to the heating element 11. In response to this decrease in temperature, the temperature responsive element 26 of the thermostat 22 con-

tracts, whereupon the push rod 29 operates the bell-crank lever 30 to open the vent or leak-port 34 and thereby reduces the pressure in the outlet conduit 36 and the branch conduit 40 so as to permit the spring 16 partially to open the valve 14, whereupon heating medium is supplied to the heating element 11. It will, of course, be understood that the amount which the leak-port 34 is opened and, accordingly, the amount which the valve 14 opens is proportional to the decrease in the room temperature. Correspondingly, whenever the room temperature rises, the leak-port 34 will tend to close and effect an increase in the pressure supplied to the branch conduit 40 and to effect partial or complete closure of the valve 14 so as to decrease or shut off the supply of heating medium.

In order to convert the system from winter to summer operation, it is necessary only to close the valve 42 and to open the valve 41 so that the temperature responsive device 22 controls the pressure supplied to the pressure control relay 23 through the branch conduit 39. In describing the operation of the relay 23, with particular reference to Figs. 2 and 3, it will be assumed that the normal pressure available in the supply conduit 24 is, for example, fifteen pounds per square inch, although of course it will be understood that any other suitable pressure may be employed.

In Figs. 2 and 3, the control device 23 is shown in the position occupied when zero pressure is being supplied through the conduit 39 to the bellows 72. The valve 64 is closed, and accordingly the pressure in the bellows 67 and available in the outlet passageway 57 is equal to fifteen pounds. It will, of course, be apparent that the bellows 67 which communicates with the exhaust passageway exerts, on the frame 73, a force tending to open the valve 64, but movement of the valve 64 is prevented by the springs 65 and 80, the spring 80 being so adjusted that the total force exerted on the frame 73 by the two springs is equal and opposite to the force exerted by the bellows 67 with fifteen pounds pressure therein.

It will now be assumed that such a change in temperature occurs as to cause the thermostat 22 to supply, through the conduits 36 and 39 leading to the auxiliary passageway 68, a fluid pressure of two pounds. Since the passageway 68 communicates with the bellows 72, the bellows 72 exerts a force corresponding to two pounds pressure on the movable frame 73. The total force now exerted on the frame 73 by the bellows 67 and 72 is, therefore, greater than the force of the springs 65 and 80 and, accordingly, the frame 73 moves upwardly to open the leak-port 63. As soon as the frame 73 begins to move, however, the fluid pressure medium in the passageway 61 which extends between the inlet and outlet ports 53 and 57 is vented through the leak-port and accordingly the pressure in the outlet passageway 57 is reduced. This reduction in the outlet pressure causes a corresponding reduction in the force exerted by the bellows 67 and as soon as the total force exerted by the bellows 67 and 72 is reduced to a value equal to the force exerted by the springs 65 and 80, the frame 73 and valve 64 come to rest in a position of equilibrium, which position depends upon the pressure in the auxiliary passageway 68.

Thus, any tendency of the valve 64 to open wider produces a decrease in the outlet pressure and a corresponding reduction in the force tending to open the valve, while any tendency of the valve to close causes an increase in the outlet pressure which increase tends to open the valve. We have found that by properly proportioning the springs 65 and 80, the operation of the valve 64 is so controlled that the pressure supplied to the outlet passageway 57 is complemental to the pressure supplied to the auxiliary passageway 68, taking the normal supply pressure as a base. Thus, if two pounds of pressure are available in the auxiliary passageway 68, the outlet pressure will be substantially equal to thirteen pounds; if the pressure in the auxiliary exhaust passageway 68 is equal to six pounds, the pressure in the outlet passageway will be substantially equal to nine pounds; and if the pressure in the auxiliary passageway 58 equals fifteen pounds the outlet pressure will be substantially zero.

There may, of course, be some slight variation in these values due to the characteristics of the springs under compression. The total movement of the valve 64 between its closed and its fully open position may be relatively small, however, and any variation which may occur is substantially negligible.

Referring again to Fig. 1, it will now be apparent that when the thermostat 22 is in the position shown so as to supply maximum pressure to the control relay 23 through the conduit 39, the relay port valve 64 will occupy its extreme open position and accordingly substantially zero pressure will be supplied to the outlet passage 57, the conduit 44, and the motor means 20, and the spring 19 will cause the valve 18 to open so that cooling medium is supplied to the cooling unit 10. Likewise, upon a reduction in the room temperature, the thermostat 22 effects a decrease in the pressure supplied through the conduit 39 to the control device 23, and this decrease in the pressure supply will be effective partially or wholly to close the leak-port 63 depending upon the magnitude of the decrease so as correspondingly to increase the pressure supplied to the motor means 20, whereupon the valve 18 is correspondingly partially or wholly closed to reduce or cut off the supply of cooling medium.

It will be understood, of course, that the motor means 20 may also be arranged to control the energizing circuit of the motor which drives the fans 13 or, if desired, separate pressure responsive means connected to the conduit 44 may be provided for this purpose.

While we have shown the valves 41 and 42 as being independently operable manual valves, it will, of course, be understood that any suitable valve means may be provided for transferring from summer to winter operation in response to predetermined outdoor temperature conditions. Furthermore, it may in some cases be desirable to employ both the heating element 11 and the cooling element 10 during all temperature conditions, in which case the valves 41 and 42 may be omitted entirely. Under this condition, it will be apparent that whenever the thermostat effects an increase in the variable fluid pressure supplied through the outlet conduit 36, this increase of pressure will effect partial or complete closure of the valve 14 associated with the heating element 11 and will likewise effect through the control device 23 an inverse variation of the pressure in the pipe 44, which inverse variation in the pressure will effect partial or complete opening of the valve 18 associated with the cooling element 10. Similarly, a decrease in the pressure in the exhaust conduit 36 will effect

opening of the valve 14 and closure of the valve 18.

It will now be apparent that we have provided an improved fluid pressure control system comprising a fluid pressure control device which is effective when supplied with a gradually varying fluid pressure to provide a corresponding gradually varying pressure which may vary inversely with respect to the pressure supplied.

While we have shown a particular embodiment of our invention, it will be understood, of course, that we do not wish to be limited thereto since many modifications may be made and we, therefore, contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of our invention.

We claim:

1. In a system of the class described, in combination, a first condition changer, a second condition changer, said first and second condition changers being arranged to have different effects upon a medium to be controlled, pressure actuated control means for each of said condition changers for controlling the action thereof, a condition responsive device responsive to the demand for conditioning of the medium being controlled, said condition responsive device being connected to a source of actuating medium and arranged to provide different control pressures for different values of the condition to which the condition responsive device responds, a reversing pressure control means having a pressure responsive device and arranged for providing a control pressure which varies inversely with pressure applied to said pressure responsive device, means for connecting said reversing pressure control means to the pressure actuated control means of one of said condition changers, and means for selectively connecting said condition responsive device in operative relationship with the pressure actuated control device of the other of said condition changers, or in operative relationship with said reversing pressure control means.

2. In a system of the class described, in combination, condition changing means for either increasing or decreasing the value of the condition of a medium to be controlled, pressure actuated control means for controlling the action of said condition changing means, a condition responsive device responsive to the demand for conditioning of the medium being controlled, said condition responsive device being connected to a source of actuating medium and arranged to provide different control pressures for different values of the condition to which the condition responsive device responds, a reversing pressure control means having a pressure responsive device and arranged for providing a control pressure which varies inversely with pressure applied to said pressure responsive device, and selective connecting means between said pressure actuated control means, said reversing pressure control means, and said condition responsive means, said selective connecting means being arranged to selectively place said reversing pressure control means into or out of operation, to thereby reverse the operation of said condition responsive device.

3. In a system of the class described, in combination, a first condition changer, a second condition changer, said first and second condition changers being arranged to have different effects upon a medium to be controlled, pressure actuated control means for each of said condition changers for controlling the action thereof, a condition responsive device responsive to the demand for conditioning of the medium being controlled, said condition responsive device being connected to a source of actuating medium and arranged to provide different control pressures for different values of the condition to which the condition responsive device responds, a reversing pressure control means having a pressure responsive device and arranged for providing a control pressure which varies inversely with pressure applied to said pressure responsive device, means for connecting said reversing pressure control means to the pressure actuated control means of one of said condition changers, means for connecting the condition responsive device in operative relationship with the pressure responsive device of said reversing pressure control means for causing said condition responsive device to control the pressure actuated control means of said one condition changer through said reversing pressure control means, and means for connecting said condition responsive device to the pressure actuated control means of said other condition changer, whereby said pressure actuated control means are controlled in opposite manners by said condition responsive device.

4. In a fluid pressure relay of the character described, in combination, an inlet passage adapted for connection to a source of fluid under pressure, an outlet passage adapted for connection to a device to be controlled, a fixed restriction for restricting the flow of fluid from said inlet passage to said outlet passage, a leak port communicating with said outlet passage in a manner to permit pressure fluid entering said outlet passage past said restriction to leak from said outlet passage, a leak port valve cooperating with said leak port for controlling the flow of fluid from said outlet passage, said leak port having a greater flow capacity than said restriction whereby the pressure in said outlet passage is reduced to zero when said leak port valve is positioned to maximum flow position, said leak port valve and said restriction cooperating to maintain different pressures in said outlet passage corresponding to different positions of said leak port valve, and pressure actuated means responsive jointly to a variable controlling pressure and to said outlet pressure, said pressure actuated means being arranged to actuate said leak port valve in a manner to cause said outlet pressure to vary oppositely to said variable controlling pressure.

5. In a fluid pressure relay of the character described, in combination, an inlet passage adapted for connection to a source of fluid under pressure, an outlet passage adapted for connection to a device to be controlled, a fixed restriction for restricting the flow of fluid from said inlet passage to said outlet passage, a leak port communicating with said outlet passage in a manner to permit pressure fluid entering said outlet passage past said restriction to leak from said outlet passage, a leak port valve cooperating with said leak port for controlling the flow of fluid from said outlet passage, said leak port having a greater flow capacity than said restriction whereby the pressure in said outlet passage is reduced to zero when said leak port valve is positioned to maximum flow position, said leak port valve and said restriction cooperating to maintain different pressures in said outlet passage corresponding to different positions of said leak port valve, pressure actuated means for actuating said leak port valve in a manner to cause the pressure in said outlet passage to vary

oppositely to changes in pressure applied to said pressure actuated means, said pressure actuated means comprising a first device arranged to be responsive to a variable controlling pressure, a second device arranged to be responsive to said outlet pressure, and a means actuated by the joint action of said pressure responsive devices for actuating said leak port valve.

6. In a fluid pressure relay of the character described, in combination, an inlet passage adapted for connection to a source of fluid under pressure, an outlet passage adapted for connection to a device to be controlled, a fixed restriction for restricting the flow of fluid from said inlet passage to said outlet passage, a leak port communicating with said outlet passage in a manner to permit pressure fluid entering said outlet passage past said restriction to leak from said outlet passage, a leak port valve cooperating with said leak port for controlling the flow of fluid from said outlet passage, said leak port having a greater flow capacity than said restriction whereby the pressure in said outlet passage is reduced to zero when said leak port valve is positioned to maximum flow position, said leak port valve and said restriction cooperating to maintain different pressures in said outlet passage corresponding to different positions of said leak port valve, a first pressure responsive device adapted for response to a variable controlling pressure, a second pressure responsive device arranged to be responsive to the pressure of the fluid in said outlet passage, a member actuated by the joint action of said pressure responsive devices, said pressure responsive devices being arranged to act upon said member in the same direction for causing the total force applied to said member to vary with the sum of the variable controlling pressure and the outlet pressure, means for causing said member to actuate said leak port valve, and means for biasing said member against the action of said pressure responsive devices.

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