Feb. 28, 1961 J. E. McAULEY 2,973,001

MULTIPLE-PASSAGE PRESSURE-RESPONSIVE VALVE

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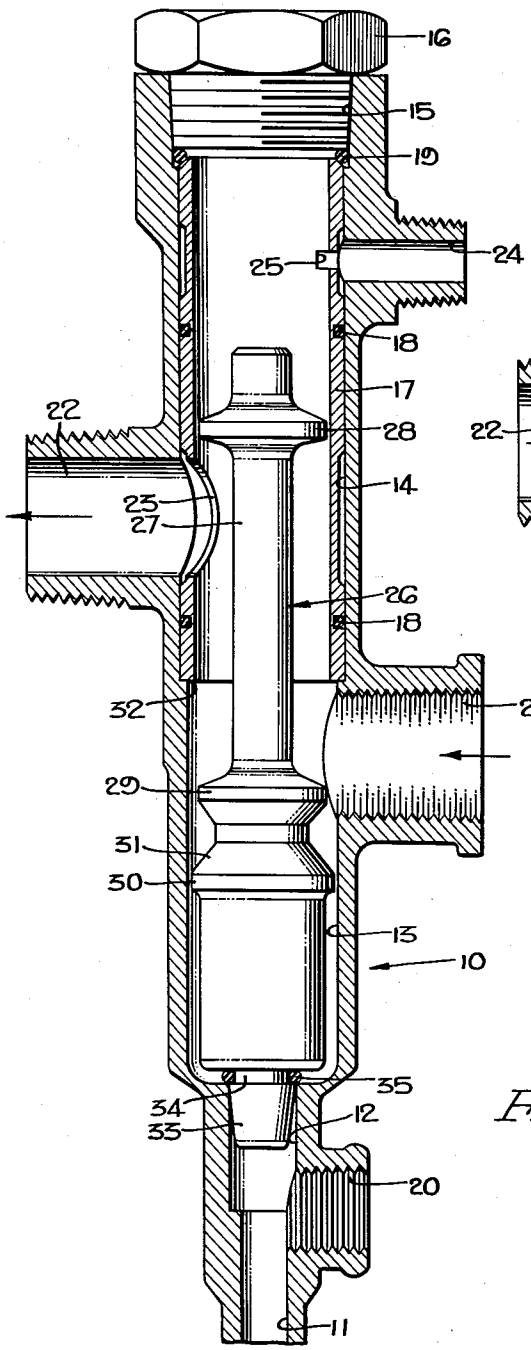


FIG. 1.

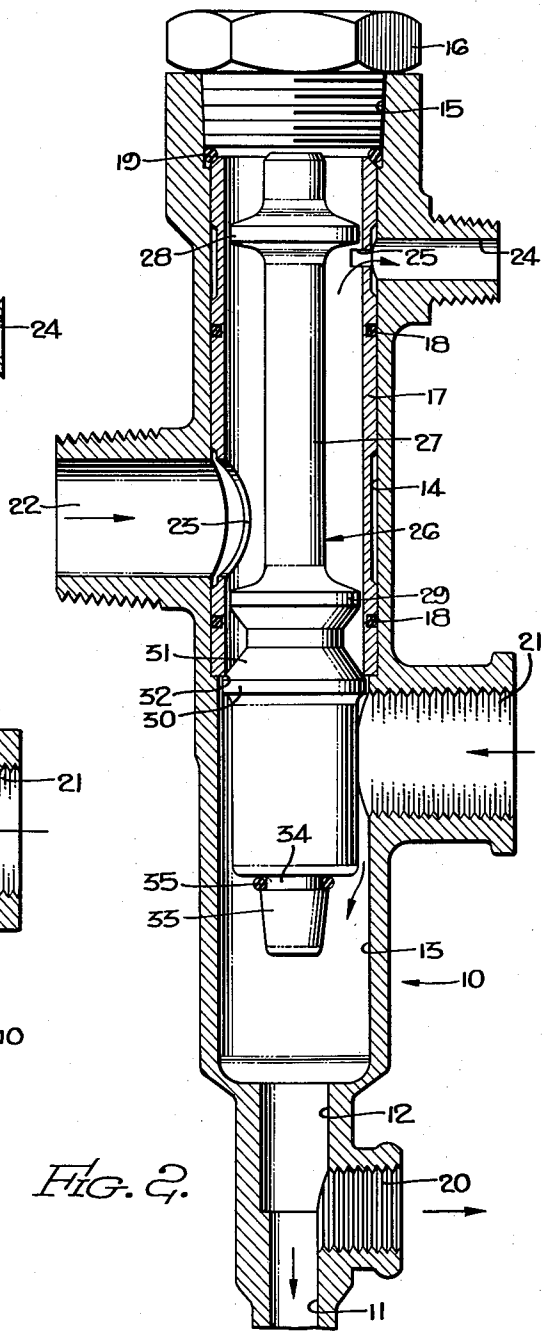


FIG. 2.

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# MULTIPLE-PASSAGE PRESSURE-RESPONSIVE VALVE

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9 Claims. (Cl. 137—118)

This invention relates to fluid valve mechanisms and more particularly to a multiple-passage pressure-responsive valve operable on a change in pressure conditions to modify the flow circuits through the valve and to restore the original operating condition upon resumption of the prior pressure conditions.

There are various fluid circuits where it is desirable to have a valve automatically responsive to pressure changes to modify the flow circuits, which is positive in action and which seats and remains seated in each of its operating positions. The valve of the present invention has been specially proportioned and designed for use in an automatic water-softening system of the type more fully disclosed in my co-pending application for Letters Patent Serial No. 576,424, filed April 5, 1956, now abandoned, and to which reference may be had for a more complete disclosure of the present construction embodied in a typical operating environment. However, it will be appreciated that the valve per se has numerous fluid circuit applications and particularly where it is desirable to provide automatically for a change in flow conditions in response to changing pressure conditions. It goes without saying that the proportions of the parts, passages and outlets may vary widely, depending on the particular application and whether the valve is being used as a relay or pilot control for a larger master control or merely as the actual master valve mechanism itself.

The device to be disclosed here is characterized by extreme simplicity of construction, low cost, ease of manufacture, ruggedness, and the use of but a single moving part so designed as to be moved in one direction between its two operating positions by fluid pressure and in the other direction by gravity. Its operation is marked by the absence of any tendency to flutter or become unseated from either of its operating positions, as well as by the absence of any tendency to hesitate or become stalled between seated positions, both of which have been so characteristic of prior constructions.

Numerous other objects and advantages of the invention will readily suggest themselves from the following detailed specification of an illustrative embodiment of the invention taken in connection with the accompanying drawings, wherein:

Figure 1 is a vertical sectional view through the valve mechanism of the present invention showing the valve in the lower of its two operating positions and with a single flow passage through the mid-portion of the valve; and

Figure 2 is a similar view of the same valve with the movable element held in the second of its operating positions by fluid pressure and with the flow through the valve divided between two separate and distinct passages.

The unitary main body of the valve generally designated 10 may be cast in a single unit having the general configuration shown. Extending longitudinally through the housing is a stepped passages having its maximum diameter at the upper end of the housing and its minimum diameter at the lower end. This construction facilitates



both the molding and the accurate machining of the several bores to size. Thus these bores increase progressively in size from the smallest-diameter outlet bores 11 and 12 beyond the lower end of the housing proper through a lower valve-guide bore 13, an upper sleeve-seating bore 14, and a threaded bore 15 for closure cap 16.

Frictionally seated within bore 14 is an accurately-machined sleeve of bronze, brass or other suitable non-corrosive bearing material 17. This sleeve may be provided with annular grooves in its exterior surface for supporting fluidtight sealing O-rings 18, 18. Another O-ring 19 is also preferably inserted between cap 16 and the upper end of the sleeve to form a seal for the threads and eliminating the need for white lead or the like sealing agents commonly used in plumbing assemblies.

The valve body is provided with a series of nipples extending laterally from its sides to facilitate the connection of fluid circuits to the casing. As here shown, these nipples include a small-bore threaded passage 20 at the lower end of the casing, a large-bore threaded inlet 21 immediately below the lower end of sleeve 17, another large bore outlet 22 opening through a large aperture 23 in the mid-section of sleeve 17, and a smaller-diameter outlet 24 at the upper end of the sleeve and in registry with a rectangular opening 25 in the sleeve.

The single unitary valve element 26 constituting the only moving part in the entire mechanism will now be described. This element comprises an elongated stem 27 having three radially disposed pistons 28, 29 and 30 spaced along the stem, as clearly illustrated in the drawing. Pistons 28 and 29 are of generally similar contour and have an exterior diameter forming a loose sliding fit within the bore of sleeve 17. Piston 30 has a similar fit with bore 13 at the lower end of the housing 10. Since the diameter of bore 13 is somewhat greater than the interior bore of sleeve 17, it will be apparent that the inclined surface 31 of piston 30 is adapted to seat against the lower corner 32 of the sleeve to provide a fluidtight seat therewith when the valve is in the position shown in Figure 2. Preferably, the peripheries of all three pistons have a clearance of about 20 mils with the juxtaposed walls of the valve housing. Even so, it will be quite apparent that pistons 28 and 30 are the two principal supports for the moving valve element and serve to hold the intermediate piston 29 accurately centered with respect to the lower end of sleeve 17 with the result that this intermediate piston enters the sleeve without interference and without the need for a pilot or other guide means therefor.

The final element of the moving part comprises a tapered plug 33 projecting downwardly from the end of element 26 and positioned to seat within bore 12. A groove 34 surrounding its base provides a retainer for a resilient valve sealing member such as O-ring 35. This member is held seated against the rim of bore 12 to seal the outlet therefrom when the valve is in its lower position, since otherwise considerable leakage might occur between the central bore of the valve housing and bore 13.

### *Operation*

Although the valve may be connected in circuits in a multitude of manners and operated to control fluid flow in various ways, the present description of its operation will be based on a particular circuit connection in which the pressurized fluid supply is connected to inlet nipple 21. It will also be assumed that outlets 11, 20 and 22 are connected in a common fluid circuit having numerous other branches all interconnected with one another. It will also be assumed that outlet 24 is connected to a normally closed drain outlet open to the atmosphere or like

source of pressure lower than the fluid pressure within the system. It therefore follows that so long as outlet 24 remains closed, fluid will enter inlet 21 and flow upwardly and outwardly through outlet 22. Valve element 26 will remain seated in the position shown in Figure 1 since the pressure conditions on all sides of pistons 28, 29 and 30 will be substantially equalized and the weight of the element, including its massive lower end, will therefore be controlling. The various fluid circuits and the valves therein connected to outlets 11, 20 and 22 may be opened and closed at will without influencing the position of valve element 26 in any way.

However, if the normally closed valved outlet 24 is opened for some reason, either manually or automatically, the pressure at the upper end of sleeve 17 overlying upper piston 28 will be instantly relieved. In consequence, the pressure of the fluid beneath piston 28 will be effective to elevate element 26 in immediate response to the pressure drop in the chamber above piston 28. Were it not for piston 29 and its particular relationship to piston 28 and outlet port 25 in the sleeve, there would be grave danger that the piston would stop or waiver as soon as it starts to rise above port 25. This would be due, of course, to the lowering of the pressure below piston 28 due to flow through port 25.

The present construction gives positive assurance that this hesitation or waivering cannot occur by virtue of piston 29 which is positioned to enter the lower end of the sleeve 17 prior to the opening of port 25. Immediately that piston 29 enters the sleeve, the previous unrestricted flow of liquid into the sleeve is greatly reduced. In addition, substantially the full supply pressure is effective to complete the elevation of the valve until surface 31 of piston 30 seats against the lower end of the sleeve.

A divided flow thereupon takes place through the valve. One of these passages extends through inlet 21 downwardly through chamber 12 and outwardly through the pair of outlets 11 and 20. The second completely independent passage is inwardly through passage 22 upwardly within the sleeve and out through port 25 and outlet 24. Due to the low pressure existing above piston 29 and the much higher pressure acting on the larger area of lower piston 30, there is no tendency for the valve to open or become unseated in the slightest. However, should the valved outlet 24 be closed, the pressure will quickly equalize in the chambers above piston 29 and below piston 30. As a result of this and the considerable weight of valve element 26, it will fall until gasket 35 at the lower end thereof seats against the upper shoulder on bore 12, thereby restoring the original conditions illustrated in Figure 1.

While I have illustrated but a single embodiment of my invention, it will be readily appreciated by those familiar with the invention that its structure and arrangement of parts with respect to the ported outlets may be varied over a wide range, both as to disposition and relative proportions, without departing from the principles or spirit of the present invention. Accordingly, I do not wish to be limited except as indicated by the scope of the annexed claims.

I claim:

1. A pressure-responsive valve mechanism adapted to control the flow between different interconnected circuits depending on pressure conditions in a certain one thereof, said valve comprising a unitary housing having an elongated bore, a unitary valve assembly reciprocally supported in said bore all made of the same material and including a first piston near one end and a pair of axially-spaced rigid pistons adjacent the other end thereof, said last-mentioned pistons being of smaller diameter than the bore of said housing, said housing having an inlet opening positioned between the ends of the travel path of said pair of pistons, a first outlet opening traversed by the travel path of said first piston, a second outlet opening positioned intermediate the travel paths of said first piston and said pair of pistons, and a third outlet positioned on the remote side of said pair of pistons from said second outlet opening.

2. A pressure-responsive valve as defined in claim 1 including a sleeve supported by and sealed with respect to the inner wall of said bore but terminating short of one end thereof, one of said pair of pistons being slightly larger in diameter than the other, said larger piston being slidably supported by said bore beyond the end of said sleeve and the smaller-diameter piston associated therewith being movable and out of the adjacent end of said sleeve and having a loose sliding fit therewith when supported within said sleeve.

3. A pressure-responsive valve as defined in claim 2 wherein said first piston has a loose sliding fit with the inner surface of said sleeve and is located therewithin in all operating positions of said valve.

4. A pressure-responsive valve mechanism adapted to control the flow in different interconnected circuits depending on pressure conditions therein comprising, an elongated housing having a bore opening through an end thereof, a sleeve in said bore terminating short of one end thereof and having a fluid-tight seal with the bore, a pair of openings extending into said one end with one opening being positioned adjacent the end of said sleeve and adapted to be connected to a pressurized fluid source, a unitary valve assembly movably supported in said housing and including a stem interconnecting a pair of non-flexible pistons of different diameters at one end and a single piston at the other end, said single piston and the adjacent one of said pair of pistons having similar loose fits with the juxtaposed inner surfaces of said sleeve, the larger-diameter one of said pair of pistons having a loose fit with said bore wall and being movable across said pressurized fluid inlet opening into seating engagement with the adjacent end of said sleeve which sleeve is of smaller diameter than said larger piston, said single piston being movable simultaneously with said pair of pistons between operating positions on the opposite sides of an outlet opening adapted to be closed normally, and a fourth opening extending into said housing at a point between the paths of travel of said single piston and said pair of pistons.

5. A pressure-responsive valve mechanism as defined in claim 4 wherein the end of said valve assembly adjacent said pair of pistons carries a fourth valve member projecting axially of said stem and in alignment with an outlet opening in the end of said housing, said fourth valve being adapted to close off flow through said outlet opening in one operating position of said valve assembly and to permit free flow therethrough in the other position of said assembly.

6. A pressure-responsive valve mechanism as defined in claim 4 including means on said fourth valve for supporting a resilient sealing gasket thereabout and position to form a fluidtight seal with said outlet opening when seated thereagainst.

7. A pressure-responsive valve mechanism as defined in claim 4 wherein the radial clearance between said pistons and the side walls of said housing ranges between 10 and 30 mils.

8. A pressure-responsive valve mechanism as defined in claim 4 wherein the radial clearance between said pistons and the juxtaposed housing walls is substantially 20 mils.

9. A valve device adapted to respond to a change in pressure within the valve device, said device comprising a housing having a plurality of fluid passage openings thereinto and adapted to be mounted in an upright position in a pressurized fluid circuit, a movable valve assembly within said housing movable between a lower gravity responsive normal position wherein flow is blocked through one of said passages and an upper pressure-actuated position wherein said one passage is open, said valve housing having a large area inlet opening adapted to be connected to a source of fluid under pressure for flow through said housing without substantial restriction, said valve assembly being provided with an enlarged end hav-

ing a loose fit with the wall of a chamber at the upper end of said valve housing when said housing is normally filled with fluid at or near the fluid pressure at said inlet opening, an opening from the upper portion of said chamber of greater capacity than provided past the enlarged end of said valve whereby the closing and opening of said last mentioned opening is effective to equalize and unbalance the fluid pressures on the opposite sides of said enlargement to effect the movement of said valve assembly between the said two positions thereof, a pair of closely spaced pistons of slightly different diameters at the lower end of said valve assembly normally spaced below said large area inlet opening, said valve housing having a seat closely overlying the upper edge of said



inlet opening which seat is engageable with the lowermost large diameter of said pair of pistons, and the upper one of said pair of pistons being movable upwardly past said seat.

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