

[54] FLUSH VALVE

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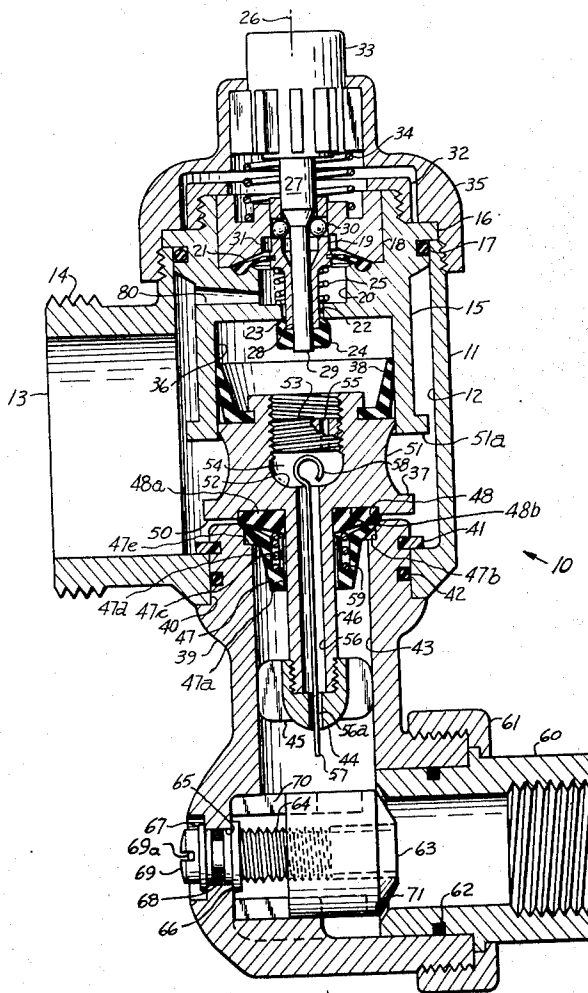
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[57] ABSTRACT

A differential pressure valve for operation over a wide range of system pressures, including relatively low domestic water supply pressures. A probe extends upstream to pick up relatively higher pressure to actuate the valve workings. A yieldable restrictor regulates the pressure drop across the workings of the valve to maintain a suitable pressure differential, and a ball-detent type mechanism provides a snap action from open to closed condition so that the valve does not dither. A shoulder laterally deflects the water passed by the valve in a folded pattern known as the "Coanda" effect, which lessens the forces needed to close the valve and protects the actuating member from sand and other deleterious solid material.

18 Claims, 3 Drawing Figures



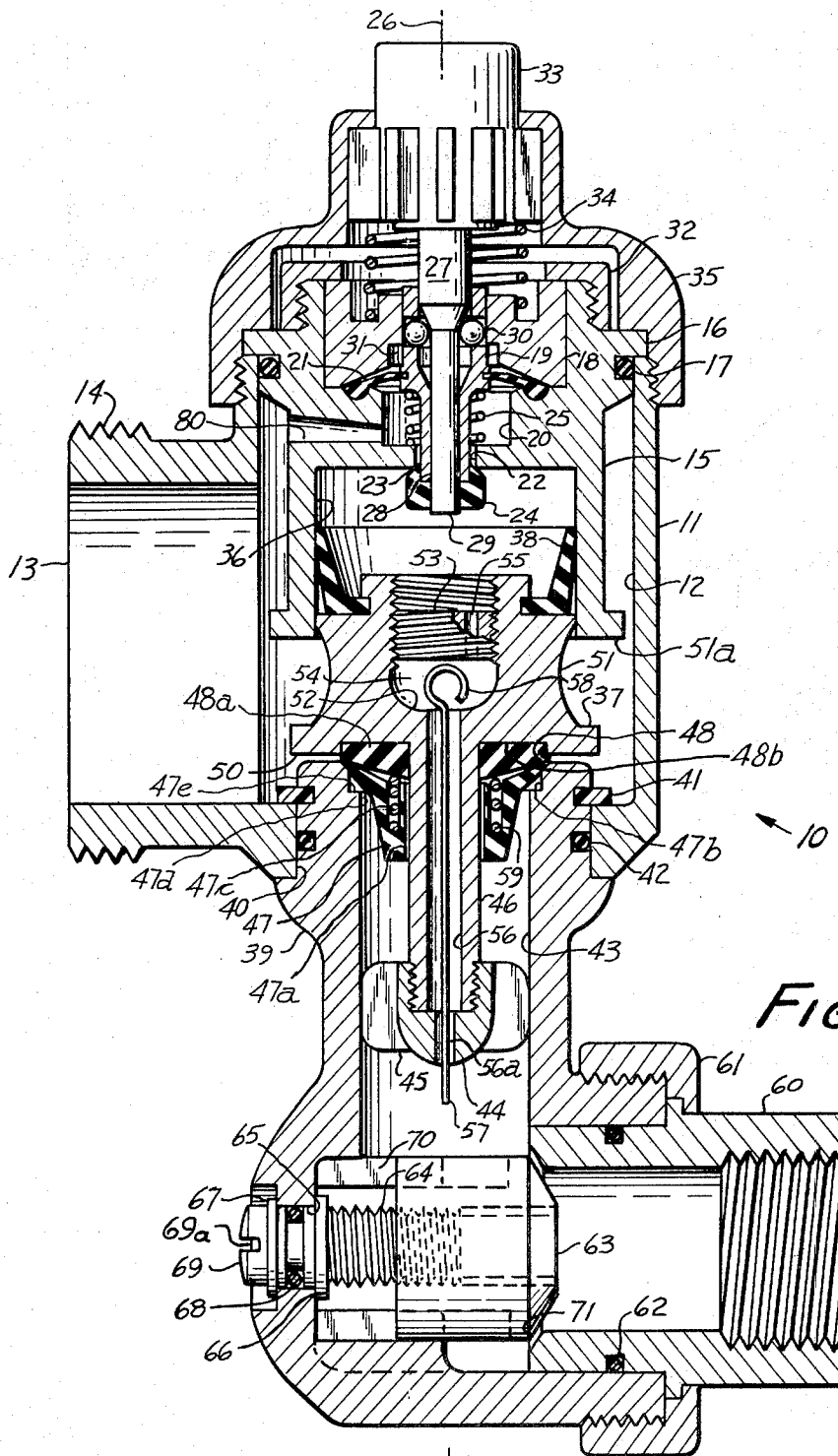
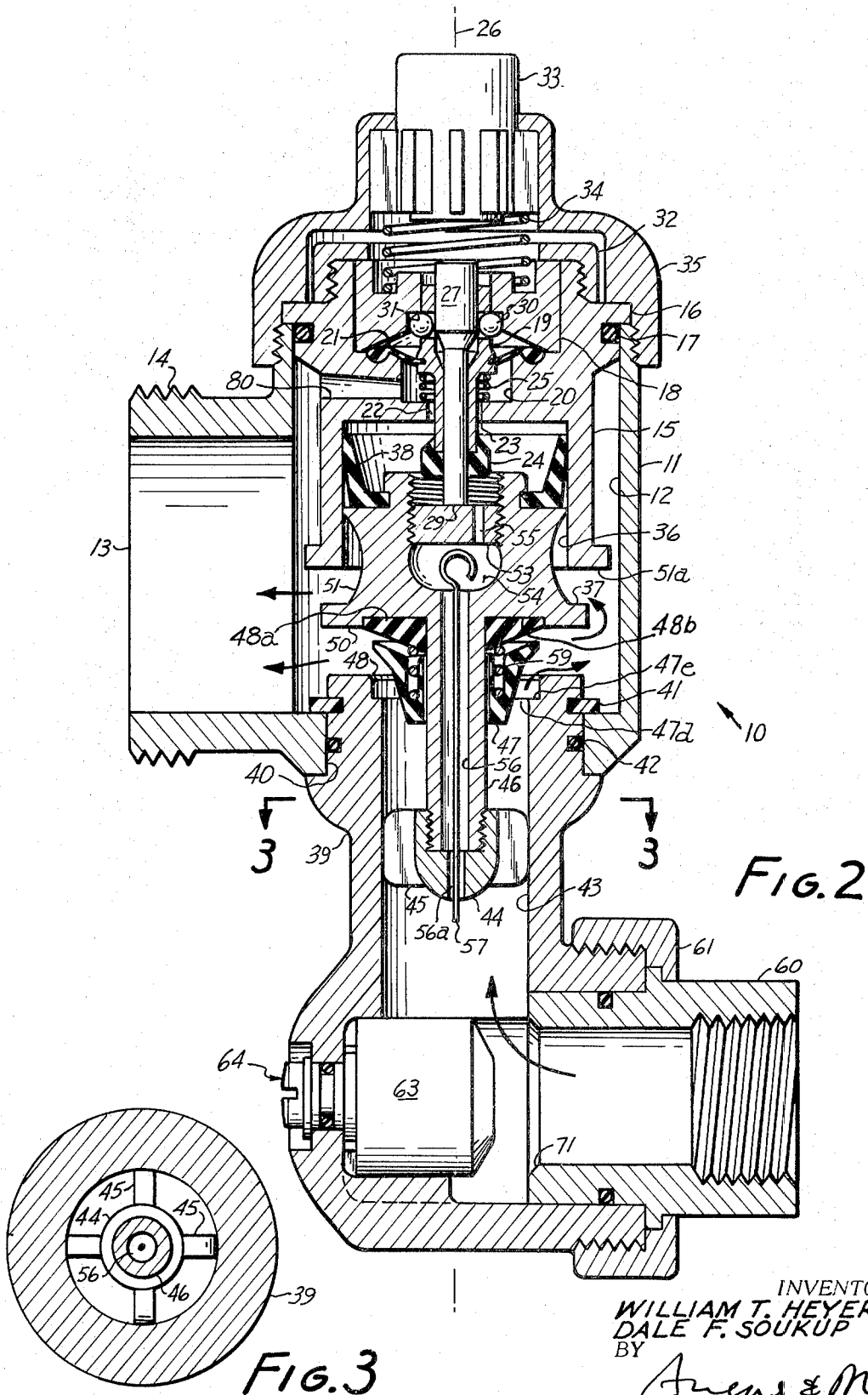


Fig. 1

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FLUSH VALVE

This invention relates to valves which control the flow of fluid from a pipe to a point of usage, determining by their action the volume which is passed.

The prior art is replete with examples of flush valves which are intended to remain open for such a length of time as to pass a pre-determined volume of liquid, and then close. Numerous time-delayed valves are known for this purpose, one class of which is actuated by differential pressure between the inlet water supply pressure and a lesser pressure, usually that of the atmosphere. This is a preferred class of valve, and it is not surprising to find a large number of valves in this category.

Such valves involve several serious design criteria in order that one design can be used in a large number of installations over a wide pressure range. Heretofore this type of valve was not practically useful in systems with large pressure fluctuations, low system pressure, or very dirty water. The valve of this invention is useful in such installations.

It is an object of this invention to prove a flush valve actuated by differential pressure which has a reliable cycle that is appropriately related to volume passed, which has a sharp cut-off without dithering, which can work over a fluctuating range, and at low pressures, and which requires only a minimum force for its actuation.

It is a further object of this invention to provide a valve which includes yieldable means which seeks to maintain a suitable actuating differential pressure when the valve is open, and which also provides a valuable siphon-breaking function.

A flush valve according to this invention includes a piston-cylinder actuator responsive to the differential pressure between the system supply pressure and atmosphere. This actuator moves within the inlet system not only a positive seal to open and to close the system, but also a yieldable restrictor which not only tends to pass liquid, but also to maintain a suitable pressure differential. It can also act as a suitable siphon-breaker. In addition, the valve includes a pilot member which is inserted into a region of system pressure. As a result, the valve can operate over a wide range of system pressures.

A still further feature of the invention resides in means for lowering the forces required to close the valve, and to shield the actuating mechanisms from grit, said means comprising a lateral shoulder that creates a "Coanda" effect at the downstream portion of the valve.

The above and other features of this invention will be more fully understood from the following detailed description and the accompanying drawings, in which:

FIG. 1 is a side view elevation in cutaway cross-section of a flush valve showing the presently preferred embodiment of the present invention;

FIG. 2 is a side view elevation in cutaway cross-section as in FIG. 1, but with the valve in a different operational position; and

FIG. 3 is a section view taken at line 3—3 in FIG. 2.

Referring to the drawings, there is illustrated a flush valve 10 in accordance with the presently preferred embodiment of the present invention. Flush valve 10 includes a main housing 11 having an internal cavity 12 which in turn is in fluid communication with outlet 13. Threads 14 are provided for connecting outlet 13 to a pipe. Body 15 is positioned within a cavity 12 and includes an annular flange 16 adapted to bear against a surface of housing 11. O-ring seal 17 provides a fluid seal between the wall of cavity 12 and body 15.

Pilot guide 18 is received within a recess in the upper portion of body 15 and includes an internal bore adapted to receive pilot 19. Cavity 20 is formed by a recess in housing 15 and is closed at its upper end by flexible seal 21 fastened to pilot 19 and body 15. The lower portion of cavity 20 is in fluid communication through passage 22 to valve seat 23. Pilot 19 includes a portion of reduced cross-section extending through cavity 20 and passage 22, and pilot valve element 24 fastened to pilot 19 in cylinder 36 is adapted to close against seat 23. Compression spring 25 is disposed within cavity 20 and urges pilot 19 to its uppermost position (as shown in the drawings) along axis 26. Passage 80 is provided in body 15 and provides

fluid communication between outlet 13 and cavity 20, thereby establishing cavity 20 as a region of reduced pressure, because it is always connected to exhaust.

Pilot pin 27 includes a portion 28 of reduced diameter which passes through pilot 19 and element 24 to expose a lower surface 29 thereof into cylinder 36. Detent balls 30 carried by pilot 19 are adapted to engage portion 28 of pilot pin 27, and recess 31 on guide 18 is adapted to receive balls 30 when they are moved laterally outward. The arrangement forms a ball-detent mechanism to lock pilot 19 so that it tends to assume only two individual positions.

Push button 33 has a lower surface adapted to engage pilot pin 27. The button is biased upwardly along axis 26 by compression spring 34. Bonnet 35 is threaded to housing 11 to hold the push button 33 to the body, and to grip flange 16 between the upper surface of housing 11 and a shoulder in bonnet 35.

Body 15 includes an internal cylinder 36 which is in fluid communication with seat 23. Piston 37 is reciprocally mounted in cylinder 36. Cup seal 38 is part of the piston, and forms the requisite fluid-sealing, sliding fit with the wall of cylinder 36.

Lower housing 39 is rotatably mounted to housing 11 and is fastened to it by means of lock ring 41. An O-ring seal 42 makes a fluid seal between housing 11 and housing 39. Housing 39 can therefore be turned in port 40 to provide alignment facility during installation.

Housing 39 includes an internal bore 43 which is adapted to receive a probe 44. Probe 44, as shown particularly in FIG. 3, includes guide means such as fins 45 which fit loosely inside the wall of bore 43 so that the probe 44 is retained generally coaxial within the bore. It offers no resistance to sliding motion relative to the wall of bore 43. Probe 44 is threaded to a neck 46 on piston 37 and forms an extension of the piston. It will be understood that the purpose of fins 45 is to align probe 44 as the piston reciprocates along axis 26. The free end of probe 44 is in constant fluid communication with the supply pressure, upstream from the main valve seat.

A restrictor element 47 is loosely fitted over neck 46, leaving a close but definite clearance 47a between them. This element is frusto-conical, and is proportioned to enter bore 43 and a counter bore 47b. There is no effort made to make a seal with this element 47. Instead, it is intended to be freely slidable, being biased toward bore 43 by a compression spring 47c. This element does not make contact with primary seat 48, but passes beyond it in some positions. It does, however, form a variable orifice 47d between its tapered outer surface and a restrictor seat 47e at the lower end of the counter bore. It can, in fact, seat on this seat 47e, but this will not close the passage because of leakage along the neck. The variable orifice is smallest when there is no fluid pressure opposing spring 47c, and largest when there is a relatively large pressure. Thus, the restrictor element tends to maintain a given pressure drop across seat 47e, and maintains a large enough upstream pressure at the free end of the probe to enable the valve to operate. Its primary effect is to keep the upstream pressure from dropping too low when the valve is open.

Primary seat 48 is formed at the top of housing 39, and is adapted to be contacted by primary seal 48a. The primary seal is carried in a recess 48b in the lower face of piston 37. It is shown closing the valve to flow in FIG. 1, and opening it to flow in FIG. 2.

A deflector surface 50 is formed on piston 37 just above the primary seal. It lies in a plane normal to axis 26, and is intended to give a "folding" pattern to the flow through the valve. The effect is known as the Coanda effect, and substantially reduces the axial force necessary to operate the piston.

Attention is called to an elliptical circumferential deflector surface 51 in the wall of the piston, and also to a deflector shoulder 51a on the bottom end of body 15. Their functions will be more fully described below.

Piston 37 includes a recess portion 52 into which a bleed plug 53 is threadably fitted to form a partially closed cavity 54.

Metered passage 55 through plug 53 provides fluid communication between cavity 54 and the internal portion of cylinder 36. Also bore 56 through neck 46 and metered passage 56a through probe 44 provides fluid communication between the inlet and cavity 54. A pin 57, having its head 58 in cavity 54 is received in bore 56 and passage 56a to keep the bore and passage clear of debris. The axial position of plug 53 can be adjusted by turning it.

Inlet fitting 60 is fastened to the lower portion of housing 39 by retainer nut 61. An O-ring 62 forms a fluid seal between inlet fitting 60 and housing 39. A restrictor valve includes a plug 63 which is threadably assembled to threaded fastener 64 which in turn is journaled to housing 39 through passage 65 and held in position by flange 66 and lock ring 67. Fastener 64 is sealed to housing 39 by means of O-ring seal 68. Head 69 of fastener 64 carries a tool engaging surface, such as slot 69a, so that fastener 64 can be rotated. Plug 63 is guided by means of key 70 which is engaged to a key slot so as to travel along the axis of fastener 64. Plug 63 adapted to close against seat 71 of inlet fitting 60 to provide a shut-off valve and, if desired, also a flow-limiting valve.

In operation of the flush valve in accordance with the present invention, plug 63 is moved to a position spaced from seat 71 so that the plug regulates the volume of fluid flowing from the inlet into bore 43. Hence, plug 63 and seat 71 operate as a flow-limiting valve. A source of pressurized fluid is connected to the flush valve via inlet fitting 60 so as to admit pressurized fluid into bore 43 and to impinge upon the lower part of valve element 47. Pressurized fluid also passes through metered aperture 56a and bore 56 into cavity 54 within piston 37. Also, fluid under pressure passes through metered passage 55 into cylinder 36 above piston 37.

Since the pilot valve associated with valve seat 23 and seal 24 is initially closed (FIG. 1), the pressure within cylinder 36 is the same as that in cavity 54, bore 56, and bore 43 below valve element 47. However, cavity 12, being in fluid communication with outlet 13, is at exhaust pressure. Since the cross-section area of piston 37 in cylinder 36 is greater than that of the primary seat, and the remaining region of the lower face of the piston is exposed to exhaust, the net axial force on the piston is such as to close the valve and hold it closed.

When the valve is to be opened button 33 is pressed down. It bears against pin 27, and the conical surface on the pin forces the poppet along by virtue of the engagement between this surface and the balls, and of the balls with the walls of the recesses. Finally, the poppet reaches the position shown in FIG. 2, and the balls are displaced laterally to hold the poppet locked open.

Cylinder 36 is now bled to exhaust, and a differential force appears to force the piston upwardly. It is aided by dynamic forces on the lower side of the piston, but primarily results from the action of spring 47c, which is derived from forces applied against restrictor element 47. Element 47 and the piston are in a state of opposition, and, with cylinder 36 vented to exhaust, the net force is upward.

The rate of upward motion is limited by the size of the venting orifices, and the motion continues until plug 53 strikes the end of pin 27 to release the detent lock. Then spring 25 forces the pin upwardly and seals the vent. The length of the cycle can be adjusted by adjustably positioning plug 53 along the axis so that it closes the vent sooner or later. Then next the cycle continues with the refilling of cylinder 36 from the pressurized supply. This rate is governed by the size of orifice 55. Finally, the refilling is completed, and at this time the primary seal is closed and the valve awaits its next actuation.

A feature of the invention resides in the fact that restrictor element 47 "rides" on a balance of forces provided by bias spring 59 and the pressure at seat 48. When the valve is operated, if the supply pressure is low, the restrictor element will not move as far off the primary seat 48 as would occur had the pressure been higher. This occurs because bias spring 59 urges the poppet element against the seat. Also, the bias force provided by spring 59 is dependent upon the axial position of

piston 37 and is greatest when the piston is in its retracted, or most downwardly position, and is least when the piston is in its uppermost position. Thus, if the supply pressure is low, piston 37 will move upwardly when the pilot valve is operated thereby reducing the bias force provided by spring 59. But instead of merely opening the main valve (which could result in substantially diminishing the pressure at the inlet so the pressure would be insufficient to operate on the piston in the cylinder—thereby resulting in the valve's remaining open indefinitely), restrictor element 47 opens only a small distance from the valve seat so that a greater pressure drop is formed at orifice 47d, and the pressure at that point remains high enough to be passed on to cylinder 36 to operate on piston 37 to close the valve.

Since the area of cylinder 36 is substantially greater than the area of the bore 43, the resultant force, which is dependent upon the relative reaction surface areas, forces piston 37 toward seat 48, and spring 59 holds element 47 seated against seat 48.

Another feature of the invention resides in the fact that the pilot valve snaps between its open and closed positions. Hence, when the valve cycle is initiated and push button 33 is depressed, pilot pin 27 urges pilot 19 open by virtue of the locking action of balls 30 carried by guide 19. Hence, pilot 19 opens the pilot valve by directed action of push button 33. When timing plug 53 contacts surface 29 of pin 27 during the closure of the pilot valve, the pin is moved to a position to permit balls to release pilot 19 so that the pilot snaps back to its original position. This feature prevents dithering of the valve due to incomplete closure of the pilot valve, because there is no condition at which the forces on the pilot valve are balanced while it remains open and unlocked.

Still another feature of the invention resides in the fact that probe 44 extends into bore 43 so as to be in constant fluid communication with the supply pressure, and not be substantially affected by any decrease in pressure near valve seat 48. This enables the valve to be used in a wide range of supply pressures and flow rates. The metered aperture 47d further assures that the upstream pressure is maintained.

Further attention is called to the recessed surface 51. The flow past the primary seal is directed sidewardly by surface 50, and this flow then folds inwardly toward the central axis, except in the region bounded by port 13. The recessed surface channels sand, debris, and the like, toward the center of the recess and thereby away from cylinder 36. This protects the cylinder from damage by this debris. Furthermore, the folded-back flow impinges more heavily on the lower portion of the recessed surface than on the upper while the valve is open and the upper part is partially shielded. The result is an augmented downward force which assists in the shutting of the valve that is especially useful when low system pressures are involved.

With further regard to this folded pattern, attention is called to surface 51. For reasons not completely understood, the folded pattern appeared to give some troubles near the moment of valve closure. This shoulder limits the scope of this pattern, and has eliminated that problem.

A further feature of the invention resides in the fact that the upper housing 11 is journaled to lower housing 39 so that the inlet and outlet portion of the valve may be rotated to any desirable relative position, and not necessarily in the same plane. This takes advantage of the fact that, unlike prior art valves which require substantially vertical installation, this valve will run in any position.

The valve according to the present invention may be adjusted for various time/volume combinations. For example, if a customer desires a large flow in a short period of time, plug 53 is adjusted to a relatively "high" position near the upper surface of piston 37 so that it will operate pin 27 before the piston has accomplished its full travel into the cylinder. Also, the metering valve at the inlet is adjusted so that element 63 is unseated from seat 71 as far as possible. Hence, a maximum flow past element 63 is permitted and the plug 53 permits the valve to operate for a minimum period of time. On the other

hand, if the customer desires a relatively long period of time for the flow but a small quantity, as in the case of most urinals, the metering valve may be adjusted so that the flow of fluid past seat 71 is maintained at a minimum and plug 53 is adjusted deep into piston 37 so that the timing screw will not contact pin 27 until the piston has made almost its full travel into cylinder 36. The fluid passed by the valve may be regulated for any desirable quantity, ordinarily between one-half pint and 5 gallons, and the flow may be adjusted for various periods of time in accordance with the particular use of the valve.

This valve, because of its many features, can be made principally of a hard molded plastic material such as "Delrin". This results in a large saving over those which are made entirely of metal. However, it is not practicable to make plastic parts as large as metal parts for valves of this class, and therefore the reduction in size permitted by the detailed construction is of considerable importance.

This invention is not to be limited by the embodiment shown in the drawings and described in the description, which is given by way of example and not of limitation, but only in accordance with the scope of the appended claims.

WHAT IS CLAIMED IS:

1. In a valve of the class having a housing with an internal flow passage having an inlet and an outlet thereto with a primary seat therein, a piston carrying a primary seal to engage said primary seat, a cylinder in which said piston is reciprocable, and valve means controlling the venting of said cylinder to move the piston toward and away from the primary seal so as to close or to open the valve, respectively, the improvement comprising: a probe carried by said piston and extending through the primary seat into the flow passage and terminating upstream of the primary seat, there being a passage through the probe from the region of termination to the cylinder, an restrictor element slidably fitted to said probe upstream of said primary seal, and a spring biasing the restrictor element toward the upstream direction, the restrictor element comprising an annular body adapted to make a variable area orifice in said flow passage downstream from the free end of the probe.

2. Apparatus according to claim 1 in which fins are disposed on the probe to maintain it in alignment.

3. Apparatus according to claim 1 in which a counterbore is formed in the flow passage upstream from the primary seat with which the restrictor element cooperates to form said variable area orifice.

4. Apparatus according to claim 1 in which a deflector surface is formed adjacent to and surrounding said primary seal to direct fluid laterally from said primary seal.

5. Apparatus according to claim 4 in which a concave peripheral groove is formed in the outer wall of the piston, the deflector surface being upstream therefrom and of greater diameter.

6. A valve operable by differential fluid pressure, comprising: a housing with an internal flow passage having an inlet and an outlet; a primary seat in said flow passage; a cylinder having a central axis; a piston making a sliding, fluid sealed fit in said cylinder, and axially shiftable therein; a primary seal carried by said piston adapted to engage the primary seat and close the flow passage in one axial position of the piston, and to leave it open in another axial position thereof; a probe mounted to said piston and passing through the primary seat, and having a bore extending from the downstream end of the piston to a portion of the probe upstream from the primary seat in all axial positions of the piston; a vent passage extend-

ing from the cylinder on the downstream side of the piston to a region of lesser pressure than the pressure supplied to the valve; a poppet valve adapted to open or to close said vent passage, whereby to connect said cylinder to said lesser pressure, or to leave it closed so that the bore conducts supply pressure to said cylinder, thereby shifting said piston to open and to close the flow passage at the primary seat, respectively; a position lock to restrain the poppet valve in its open position until contacted by the piston; a restrictor element slidably fitted to said probe upstream of said primary seal; a spring biasing the restrictor element toward the upstream direction, the restrictor element comprising an annular body adapted to make a variable area orifice in said flow passage downstream from the free end of the probe; an annular deflector surface on said piston surrounding and adjacent to said primary seal to direct fluid laterally from said primary seal; and a concave peripheral groove in the outer wall of the piston of lesser lateral extent than the deflector surface.

7. A valve according to claim 6 in which the position lock is a ball-detent mechanism.

8. A valve according to claim 6 in which an axially adjustable element is threaded to the piston to adjustably determine the position occupied by the piston when it contacts the position lock.

9. A valve according to claim 6 in which a counterbore is formed in the flow passage upstream from the primary seat with which the restrictor element cooperates to form said variable orifice.

10. A valve according to claim 9 in which said restrictor element has a tapered outer surface which narrows as it extends in an upstream direction.

11. A valve according to claim 10 in which an axially adjustable element is threaded to the piston to adjustably determine the position occupied by the piston when it contacts the position lock.

12. A valve according to claim 11 in which the position lock is a ball-detent mechanism.

13. A valve according to claim 12 in which a push button is provided adjacent to the poppet valve to abut and open the same when pressed.

14. A valve according to claim 13 in which the housing is formed of two parts which are rotationally joined to each other, the outlet being formed in one of said parts and opening into the housing laterally relative to the axis of the cylinder.

15. A valve according to claim 14 in which the cylinder is formed within a neck in said housing, said neck extending axially into a cavity into which the outlet opens, there being a second deflector surface at the upstream end of said neck.

16. A valve according to claim 15 in which a restrictor valve is disposed upstream of the probe to limit flow through the valve.

17. A valve according to claim 15 in which fins are disposed on the probe to maintain it in alignment.

18. In a valve of the class having a housing with an internal flow passage having an inlet and an outlet thereto, with a primary seat therein, a piston carrying a primary seal to engage said primary seat, a cylinder in which said piston is reciprocable, the piston being movable toward and away from the primary seat to close or to open the valve, respectively, the improvement comprising: an axially shiftable poppet valve so disposed and arranged as to open or to close thereby to vent the cylinder or to close it, and a position lock having a ball-detent mechanism adapted to restrain the poppet valve in its open position until contacted by the piston.

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