

Sept. 15, 1959

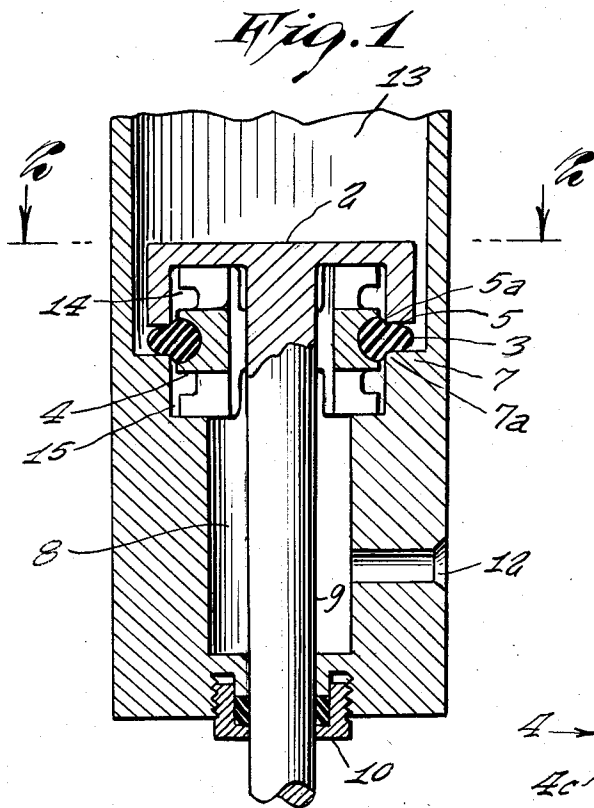
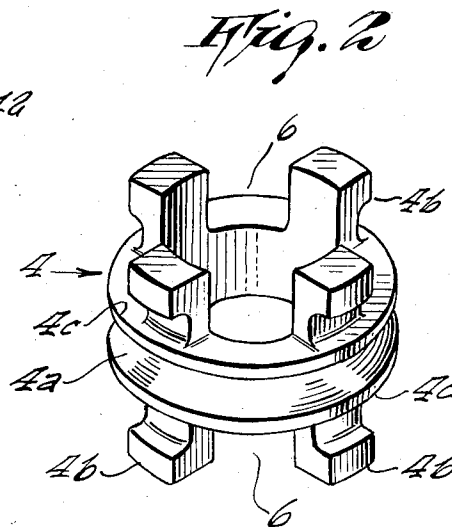
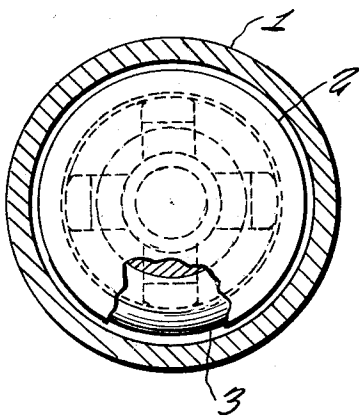
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2,904,072

VALVES HAVING RESILIENT SEALS

Filed Dec. 14, 1956

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

Fig. 3

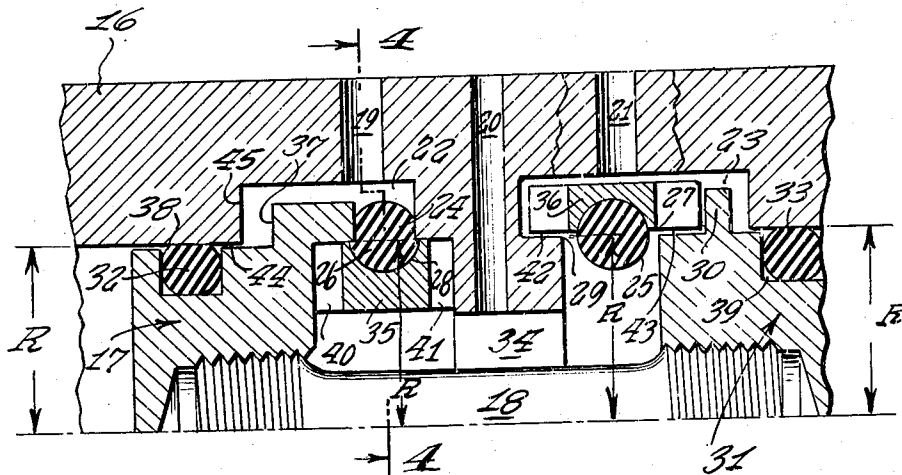
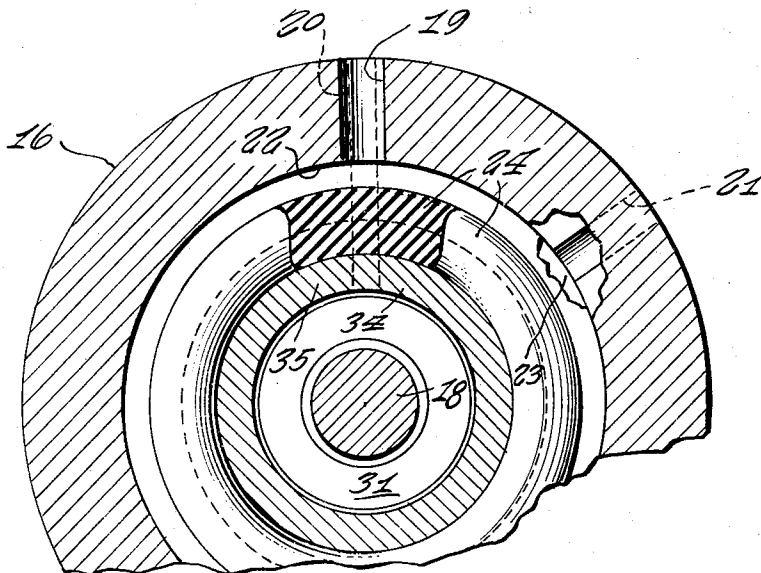


Fig. 4

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4 Sheets-Sheet 3

Fig. 5A

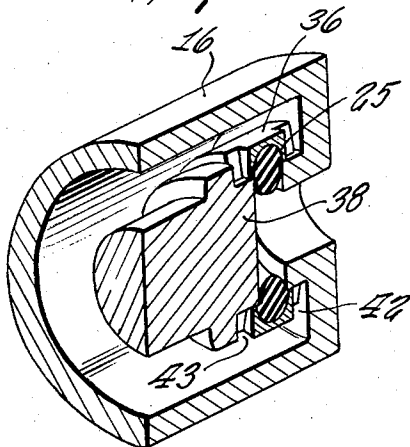


Fig. 5B

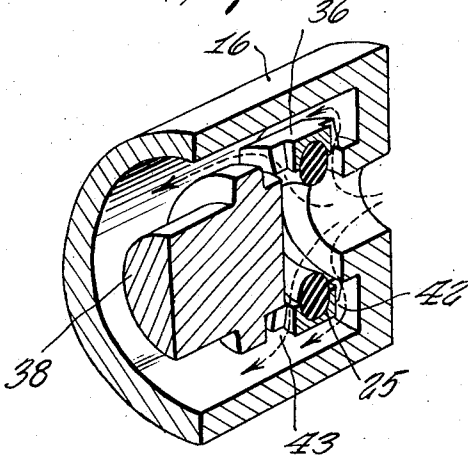


Fig. 5C

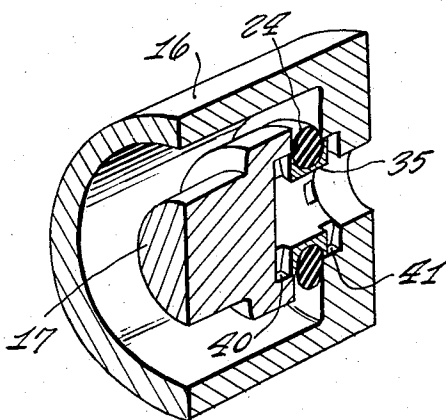
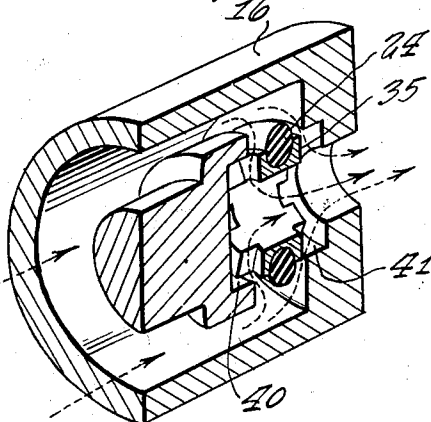


Fig. 5D



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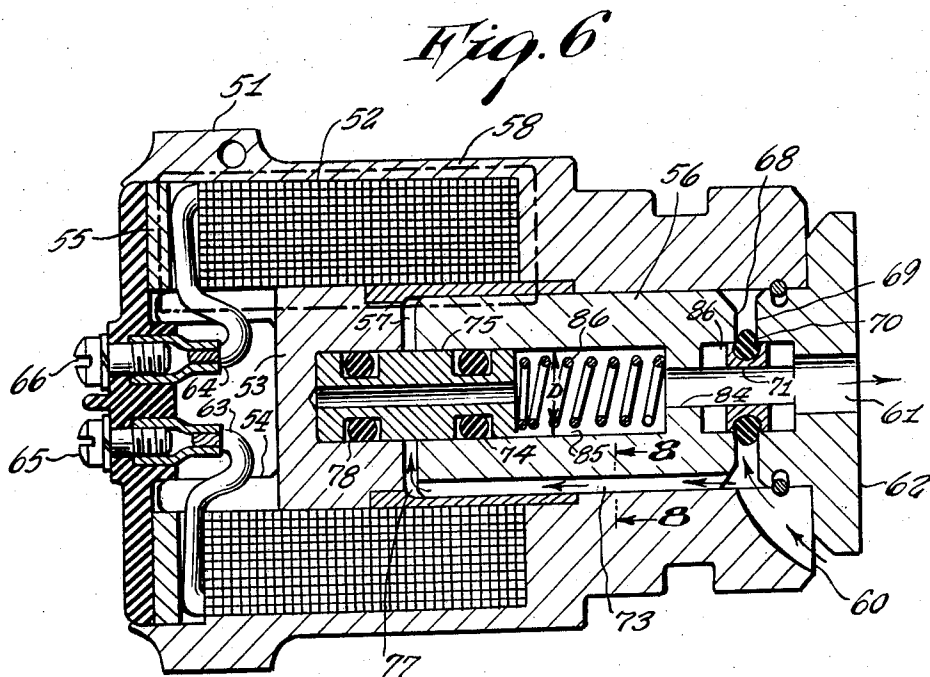
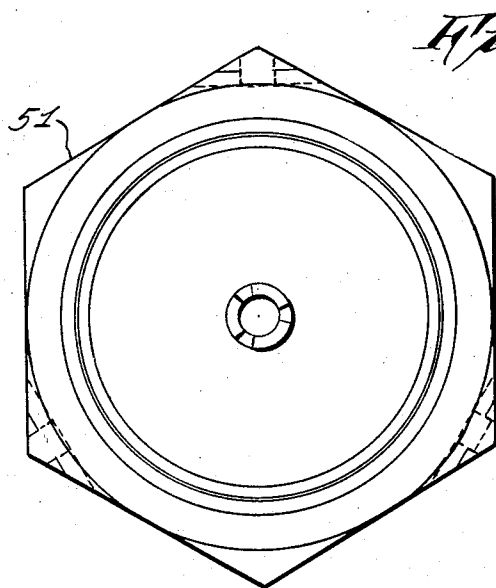
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4 Sheets-Sheet 4



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VALVES HAVING RESILIENT SEALS

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Application December 14, 1956, Serial No. 628,327

19 Claims. (Cl. 137—620)

This application is a continuation-in-part of my application Serial No. 472,724, filed December 2, 1954.

This invention relates to valve sealing means and more particularly as applied to poppet configurations in which closure is effected through axial translation of a plug type member.

In the prior art, valves with movable poppet type closures have usually employed semi-hard or hard materials in the construction of the valve seats and seating bodies, especially where high fluid pressures were present. The selection of such materials, as opposed to the more resilient types such as elastomers, has been required to achieve the following objectives:

(a) The sealing member or seat must not "blow-out" during seating and unseating operations, even when very high pressure differentials develop.

(b) The sealing members, including the body seat and poppet, must withstand eroding fluid flow without damage in order to preserve the effectiveness of the seal over what may be considered a reasonable service life, and must be capable of withstanding considerable mechanical loading during the closing cycle of the valve without suffering severe deformation or plastic yielding.

The typical poppet configurations which in the prior art have met these requirements, were fundamentally based on concentrating a loading force upon a narrow annular band of contact between the opposing fixed and movable members of the valve proper in such a manner as to develop sufficient contact pressure to prevent the escape of fluid. Practical considerations have prohibited a knife-edge sharpness for this narrow band. The appreciable width of the contact band has caused the loading force required to prevent leakage, to become considerable and generally increasing in proportion to the pressure being sealed off. Furthermore, the exact diameter at which sealing was effective, somewhere between the inner and outer circles of the seat band, was indefinite. Thus, in spite of efforts to pressure-balance the movable poppet, there was always present a resultant pressure induced force, of varying magnitude, tending to seat or to unseat the poppet and the force varied according to pressure, according to the amount of seal deformation under load, and according to the extent to which the seats were machined or re-ground after service.

The use of resilient materials in high pressure valves has not heretofore been practical for the reason that valve seals made of such materials tend to blow-out during the seating and unseating operation under high pressures. Furthermore, very resilient materials have aggravated the problem of the shifting in sealing diameter due to an even larger amount of deformation experienced by such resilient material. Even in low to medium pressure applications where mechanical means can be devised to prevent blow-out, the resultant unbalance in the pressure induced forces requires large spring loads and/or actuating loads and, accordingly, valve weight, size power consumption and cost are adversely affected.

The present invention discloses a means for balancing

2

the pressure induced axial forces on the poppet, regardless of the pressure and a means for using a resilient or flexible seal element which cannot blow out during seating and unseating operations.

5 A further object of this invention is to provide a poppet valve arrangement requiring only a small nominal force for opening or closing, which is independent of fluid pressure. This feature renders the invention particularly suitable for high pressure systems, especially those in
10 airborne installations where weight and actuating power are desired to be minimum.

A further object of this invention is to provide a safe, reliable and durable seal which is not susceptible to malfunctions because of minute scratches, surface im-
15 perfections, or wear incurred in service such as has been generally the case in prior valves.

A further object is to assure a tight seal with a poppet valve arrangement using a much coarser degree of alignment, concentricity, and squareness within and between
20 the various components of the assembly than has been generally possible in the prior art, thus permitting more economical fabrication and eliminating malfunctions resulting from incidental distortions caused by temperature or other changes.

25 A further object of the invention is to provide a high pressure face sealing valve which requires no adjustment in use and no reseating at overhaul periods.

A further object of the invention is to provide a balanced poppet valve arrangement which is self-sealing and
30 in which the balance will not be destroyed by wear.

A further object of the invention is to provide a poppet design which will give reliability of control without the use of excessive force to operate the valve.

35 A final object of the invention is to provide a simple economical and safe type of valve for use in high pressure systems.

A complete understanding of the invention may be had by reference to the drawings in which:

40 Figure 1 is a sectional view of an elemental poppet and valve-body embodying the subject valve seal.

Figure 1A is a top view of Figure 1 taken along line 2—2 of Figure 1.

Figure 2 is a an isometric view of an O-ring retainer.

45 Figure 3 is a half section of a typical valve assembly employing the poppet seal in several forms and including a pressure balancing arrangement.

Figure 4 is a sectional view taken along line 4—4 of Figure 3.

50 Figures 5A through 5D are isometric renditions of the typical seal elements employed in the valve assembly of Figure 3. Figures 5A and 5B show the seated and unseated positions respectively of the outflow seal, which is used to block fluid tending to flow outwardly from within the seal cavity. Figures 5C and 5D show the seated and unseated positions respectively of the inflow
55 seal, which is used to block fluid tending to flow inwardly into the seal cavity.

Figure 6 is a sectional view of another embodiment of the invention;

60 Figure 7 is an end view of the valve shown in Figure 6;

Figure 8 is a partial sectional view taken along line 8—8 of Figure 6.

Referring now to Figure 1, the poppet valve arrangement comprises a body member 1 containing fluid pressure in its upper cavity 13. The poppet element 2 is shown
65 seated and there is no flow past seal ring 3. This ring may be in the form of a torus or O-ring as in the case shown, and made of a resilient material such as rubber or "Teflon." However, the exact cross section and material of construction may be varied to suit special conditions without in any way departing from the principle
70 of operation. A rigid supporting retainer 4 is provided to

back up this resilient ring on its inner diameter and thus prevent its collapse under the effect of fluid pressure along its outer circumference. The retainer groove 4a is so proportioned that it exactly matches the torus contour of ring 3 and extends preferably as far out as an imaginary cylinder passing through the center of the torus cross section. On either side of this groove, retainer 4 has a plurality of guides 4b which extend along this cylinder a sufficient distance to prevent tilting in the counterbores 14 and 15 which are provided for that purpose in both the poppet member 2 and body 1. Between guides 4b slots 6 are provided on either end of retainer 4 to serve as flow passages in the open position of the poppet and will be described more fully in succeeding paragraphs. In the closed position of the poppet, as shown, the resilient ring 3 is lightly squeezed axially between the poppet nose piece 5 and the body nose piece 7. The exact amount of this squeeze is controlled by the dimensional combinations of the two counterbore depths and the length of the supporting retainer, while the force required to pinch the ring is provided by a suitable compression spring (not shown in Fig. 1) adapted to act on poppet stem 9.

This spring load assures sealing at all pressures while allowing a considerable degree of out-of-parallelism between the opposing poppet and body nose pieces 5 and 7 and a considerable degree of surface irregularities or roughness in these same pieces, the degree of which non-parallelism and surface irregularities would be considered far beyond the usually acceptable limits for more conventional cone poppet designs. Once intimate and continuous contact between the O-ring and opposing nose pieces is thus established, fluid pressure in body cavity 13 bearing upon seal ring 3, develops through its resiliency the additional and proportional contact pressure of seal ring 3 with the nose pieces, which as we have noted above, is necessary to assure a leak tight seal.

A close examination of this mechanism of sealing is necessary to completely define its characteristics. The positioning of seal ring 3 such that the center of its cross section is substantially at the same diameter as the inner edge of nose pieces 5 and 7 assures that intimate contact will exist down to this diameter under all conditions of spring load and of fluid pressure. The corner 5a, 7a joining the counterbore and the flat face of each nose piece has a small radius to prevent damaging the seal ring even under the maximum pressure condition of squeeze when the nose piece dents the ring by the greatest amount. At the opposite extreme of minimum squeezing of the seal ring 3, a penetration as low as 2% of the ring cross section is sufficient to embed the rounded corners of the nose pieces, since these are in line with the longest axial dimension of the seal ring, namely, the diameter of the cross section parallel to axis of the valve. It will be apparent now that the pressure induced forces on either nose piece, whether applied directly by the fluid medium on the exposed portions of faces 5 and 7 or transmitted by the resilient ring to the remaining embedded portions of these faces, is at all times exactly defined by (a) the dimension of the counterbores or effective sealing diameter and, (b) the magnitude of the pressure. Because these pressure induced forces are predictable in any one given installation and proportional only to pressure, without regard to the fluid medium, the nature of the seal material, or the amount of spring loading, it is possible to exactly balance these forces by suitably dimensioning the cross-sectional area of piston 2.

Referring again to Figure 1, the elemental poppet member 2 is axially movable from outside the valve body 1 by means of stem 9 which protrudes from its base and is sealed therethrough by means of gland nut and packing 10. A connection port 12 is provided through the side wall of body 1 to conduct the fluid from cavity 8 which is the discharge side of the valve.

To open the valve and connect inlet cavity 13 to dis-

charge cavity 8, poppet 2 is raised from its seated position a distance slightly less than the depth of the counterbore of nose piece 5. Slots 6 in the retainer will then be exposed to provide the flow passage through the seal.

It will now be explained why the resilient sealing ring 3 is at no time urged to blow out of its retainer 4 in spite of the pressure differential which exists in the region of the sealing ring 3 during the valve opening sequence.

Consider the position of the poppet, during its initial travel, till the time when seal ring 3 has regained its free diameter. Pressure on the circumference of ring 3 during this time causes the latter to maintain contact with opposing nose pieces 5 and 7 and therefore the seal is not broken. Some further motion of the poppet may even cause the ring cross section to stretch axially into the shape of an ellipse under the effect of fluid pressure in an effort to follow the receding nose piece and span the widening gap. The point of incipient breakaway or separation will vary according to the elasticity of the resilient ring, the magnitude of the fluid pressure and the speed with which the poppet is lifted. But so long as sealing contact is maintained and a high pressure differential exists, the seal ring is completely supported on the low pressure side by retainer 4, except in the clearance spaces 14 and 15 between the nose piece counterbore and the retainer. This clearance space is of the order commonly allowable in the application of O rings in pistons and rod seals and as such represents what may be classed as a wide clearance fit. Experience has shown that the materials commonly used in O-rings will not extrude through such clearances. However, to insure that there shall not be any large unsupported areas through which extrusion of the ring could occur under pressure, the retainer slots 6 provided for flow are machined some distance away from the edge of the O-ring groove in order to leave unbroken that portion of the outside diameter surface on the retainer first uncovered by the receding nose piece. Up until the slots are unmasked in the retainer, the poppet therefore travels through a dead-band during which there is virtually no flow.

Breakaway may occur between the seal ring and either of the two nose pieces, immediately followed by a high speed flow of fluid through the widening gap thus exposed. At the same time, the pressure differential which existed until then across the ring is transferred to the throttle defined by the radial clearance between the retainer outside diameter and the nose piece counterbore, so that the axial forces on seal ring remain in balance and the ring is at no time urged to blow out of its retainer groove.

As the opening sequence continues, flow slots 6 in retainer 4 are uncovered and the flow area increases to its maximum. This flow area is defined by two relatively sharp concentric metallic edges facing one another, namely, the inner or counterbore edge 5a or 7a of the nose piece and the outer edge 4c at the bottom of the retainer slots.

These relatively sharp edges form a diverging throttle in the direction of flow through which fluid velocities increase while the pressure drops. Now it is a well known law in fluid mechanics that a drop in pressure in a flowing stream does not occur instantaneously but rather develops through a gradient within a definite distance downstream of the throttle edges. In the present invention, this effect is sought to provide a small but positive force upon the bottom surface of each slot in the retainer urging the latter to remain seated upon the opposite nose piece with which it stayed in contact at the time of separation. Thus, although the said retainer and ring constitute a mechanically free member in the path of fluid flow, there is no tendency for it to flutter or chatter, regardless of the fluid medium or speed with which it traverses the valve seal.

A further benefit which derives from this general arrangement is that the seal ring is not exposed to the

high velocities occurring at the throttle, since it is located at some distance back from the edge of the slots. Thus, the ring is protected from erosion, which is a common trouble source in the more conventional designs, and will show good service life in spite of being relatively soft and having low abrasion resistance.

In certain valve applications handling contaminated fluids, bearing significant traces of grit, sand, or chips, it is possible to select low durometer hardness elastomers for the seal ring against which these solid particles, even if highly abrasive, will bounce off rather than become embedded or produce severe scoring. This is an important consideration for a basic seal design not only in extending its usefulness to a wider field of applications but also in lessening significantly the dangers of malfunction in supposedly clean hydraulic or pneumatic systems where occasional chips or scales are likely to become dislodged and flow through the system.

The poppet seal just described is designed to handle flow converging from the annular space surrounding the poppet to the central efflux passage which is obturated by the poppet in its closed position. By placing the supporting retainer on the outside of the seal ring to prevent the latter expanding under pressure, a companion design to that just described can be made to handle flow in the opposite direction, that is from a center feed hole outwardly and into the annular space surrounding the poppet. To distinguish between these two basic configurations in the following text, the terms "inflow" and "outflow" will be applied respectively. Referring to Figures 5A through 5D, the closed and open positions of both configurations are shown. Figure 5A shows an outflow seal arrangement in the closed position in which 25 is the resilient seal ring, which is squeezed between the nose pieces of poppet 38 and body 16. In this case, the seal retainer 36 is outside the ring 25 and provides support against the outward thrust of fluid pressure contained by ring 25 in the central annular passage which is at the left end of the body. In Figure 5B, the poppet 38 has been withdrawn to the left and flow is shown passing through slots 42 and 43. In actual practice and for the reasons described above in the case of the inflow seal, the seal ring and retainer combination will remain seated against one or the other of the two nose pieces with flow occurring through slots 42 or 43 exposed on the opposite side of the retainer. Figures 5C and 5D are similar isometric views of an elemental inflow seal application in which pressure is contained in left cavity of the body and flow is toward the right.

Figure 5C shows the valve in closed position and Figure 5D shows the valve in the open position. The fluid flows to the right along stem 17 and then over the nose piece thereof past the seal ring 24 through the slots of retainer 35 and then out through the central opening in the end wall of the valve. While for the purpose of illustration flow is shown through the slots 40 and 41 of retainer 35, actually this flow will be through one or the other set of slots 40, 41.

Referring now to Figure 3, a typical application of both inflow and outflow seals is shown representing a three port valve, in which 19 is the fluid supply passage, 20 is the delivery passage, and 21 is the exhaust or vent passage. In the closed position of the valve, as shown in this figure, pressure from passage 19 is banked in cavity 22 outside of the inflow seal ring 24 which is pinched between poppet member 17 and stationary body 16. A sliding O-ring 32 in piston groove 38 on poppet 17 provides a second seal to isolate fluid pressure in the annular cavity 22. In this arrangement, advantage is taken of the fact that the inflow seal has an effective diameter which is fixed and predictable and equal to the diameter $D=2R$ of the nose piece counterbores. By making the bore 44 in which O-ring 32 slides equal to "D," all fluid pressure induced forces acting upon poppet 17 are neutralized and said poppet is neither urged to

move to the right nor to the left. This is so because seal ring 24 is elastic enough to transmit the fluid pressure undiminished to the adjacent nose pieces and because wall 37 and nose piece 47 have the same area and walls 48 and 49 of cavity 34 have the same area.

Attached to poppet 17 by means of central stud 18 and axially movable with it, is poppet 31 at the opposite end of the valve mechanism. Poppet 31 is machined to accommodate an outflow seal whose ring 25 is supported by retainer 36. Poppets 17 and 31 are adjustably positioned axially relative to one another so that when one is seated in the manner shown for poppet 17, the other is unseated so as to allow flow past its seal. Examining the figure closely, it will be seen that the delivery passage 20 is fluidly connected to vent passage 21; through central cavity 34 surrounding stud 18, thence through slots 42 or 43 of retainer 36 and into annular cavity 23 from which radial passage 21 emanates. In a typical application of such a three port valve to a hydraulic system, fluid initially delivered through passage 20 is required to discharge via port 21 in the closed position shown of the valve and in so doing causes a pressure to exist within the system of cavities 34 through 23. These cavities together are sealed off by inflow seal 24 and by piston seal 33 respectively on the left and right ends. Once again, by matching these seals to a common diameter $D=2R$, all pressure induced forces that might otherwise urge the poppet assemblage 17, 18, 31 to move axially are neutralized.

To open the valve, poppet assembly 17, 18 and 31 is shifted to the left, opening inflow seal 24 and closing outflow seal 25. In that position, pressure passage 19 is fluidly connected to delivery passage 20 and flow is through cavity 22 through slots 40 or 41, into central cavity 34 thence to passage 20.

Retainers 35 and 36 have dimensions in the axial direction of the valve such that they form mechanical stops limiting the movement of the poppet 18 in both directions. The limitation of the poppet movement prevents possible damage to O-rings 24, 25 and improves the uniformity of operation of the valve. Pressure balancing in this instance is achieved between outflow seal 25 and piston seal 32 which are respectively on the right and left ends of the system of pressurized cavities 22 through 34.

In any intermediate position, while the poppet assembly 17, 18 and 31 is being shifted and both inflow and outflow seals are partially open, pressure balancing is achieved between piston seals 32 and 33 on the left and right hand ends of the assembly respectively.

This continuous state of equilibrium regardless of the position of the poppets enables use of the valve system disclosed for either positive "open-shut" operation or for metering operation as in a flow or pressure responsive regulator. The effect of this equalization is to enable free and ready shifting of the poppet assembly regardless of the fluid pressure within the system.

Referring to Fig. 6 there is shown another example of a valve in which the fluid pressure induced forces on the poppet are balanced. The valve includes a body 51 formed principally of a magnetic material. Within the body there is a solenoid winding 52 and pole-piece 53 magnetically connected to casing 51 by bars or a ring 54 and an end plate 55. In the de-energized condition of the valve, poppet 56 is separated from pole-piece 53 by gap 57. There is consequently a magnetic circuit indicated by dotted line 58, round winding 52. In the de-energized condition, the valve is closed and no fluid flows from inlet port 60 through the valve to outlet port 61 in the end plate 62. The valve is energized by supplying current to solenoid 52 over wires 63 and 64 connected to a pair of screw terminals 65 and 66. Energization of the valve causes poppet or armature 56 to move toward pole-piece 53 so as to at least partially close gap 57 and open the valve. Between the pairs of nose pieces 68

and 69 there is a flexible or resilient captive seal 70, of the type previously described, held in a retainer 71. Seal 70 may be an O-ring of resilient material such as "neoprene," rubber, or "Teflon." The median diameter of the O-ring is substantially equal to the inner diameter D of nose pieces 68 and 69.

Fluid from inlet port 60 flows through one or more slots 73 to a cavity 77 provided by gap 57 at the rear of armature 56. The fluid admitted to cavity 77 bathes a piston 75 having a pair of O-rings 74 and 78. The effective sealing diameter of O-ring 74 is made equal to the diameter D, which is the effective sealing diameter of the valve. The inner corners of nose pieces 68 and 69 are preferably rounded, with a very small radius of curvature. When the valve is in its closed position, the rounded corners of the nose pieces indent the seal ring 70 and deform it. The material of seal 70 is capable of communicating the inlet fluid pressure to the faces of nose pieces 68 and 69 so that fluid induced pressure is applied over the entire transverse face of the nose pieces. The force applied by the fluid to nose piece 68 is balanced by the fluid pressure in cavity 77 applied to the other side of armature 56, since the effective sealing diameter D of the valve is equal to the effective sealing diameter of O-ring 74.

Armature 56 is provided with a window 84 providing access to a cavity 85 in which a spring 86 is mounted. Spring 86 holds the valve closed when it is de-energized. Since the fluid pressure on armature 56 is balanced when the valve is de-energized, spring 86 is required to apply only a minimum force. The fluid pressure itself is sufficient to deform seal member 70 and provide secure sealing. When the valve is energized, armature 56 is attracted to pole-piece 53 and the valve seats or nose pieces 68, 69 begin to separate. Resilient ring 70 thereupon begins to assume its circular cross-sectional shape. As the nose pieces separate further, O-ring 70 may be flattened by the fluid pressure into an ellipse which is longitudinal to the axis. As the separation of the valve seats proceeds, a break-away occurs between O-ring 70 and one of the valve seats. The fluid then proceeds through the gap that is provided and forces the O-ring against the other valve seat, and as a result of this, chattering is prevented. As the fluid proceeds, inwardly, its pressure is reduced, due to the increase in velocity. The fluid flows through slots 72, corresponding to slot 6, Fig. 2, to the outlet port 61 and also through the window 84 into the cavity 85. Pressure balance is obtained in the open position of the valve because inlet fluid pressure is applied to both sides of armature 56 with an effective sealing diameter of D, and outlet fluid pressure is applied over the same diameter in cavity 85 and the counterbore 86 of nose piece 68.

Still another important application of the floating O-ring and face sealing valve seats is in multiple units where two or more seals on a common poppet assemblage are required to close simultaneously in what may be termed a series configuration. Only through the use of relatively soft materials for the seal ring, is it possible to do this. Indeed, a sufficient tolerance always exists in the amount of O-ring squeeze between the lowest value which will guarantee a leak tight seal and the largest value which will prevent damage to the ring, in order to absorb the incidental deformations due to service conditions. In the more common types of poppet valves, having relatively hard seat members, this multiple seal configuration is generally impossible to achieve.

From the foregoing, it is apparent that the poppet seal of the present invention may be applied to many types of valve mechanisms. It will also be obvious to those skilled in the art that both the seal ring and retainer as described may be interchanged with various equivalent elements without departing from the present invention. For example, a ring having a cross section which is in the form

of an ellipse, a regular polygon, a C, a D or a U may be substituted for the O-ring.

The retainer ring or support member (Fig. 2) need not be slotted nor is it necessary for it to span the gap between the poppet and body nose pieces in the fully opened position of the valve. In the latter case, retention means may be provided to prevent disengagement of the floating retainer with the nose piece upon which it pilots without restricting the limited axial play required to prevent seal ring blow-out. In addition, a second retainer or support may be added on the opposite side of the sealing ring in valve systems which fluid flow in the direction reverse to normal is contemplated. This additional support may float with the seal ring or may be attached to one or the other of the two nose pieces, provided, in this instance, that venting means are included to simulate the condition of a free floating retainer, which, as we have seen, must accommodate flow from either side of the seal ring, regardless of which side first breaks away to assure a continuous pressure balance of said seal ring and prevent blow-out. Balancing of the pressure induced forces on the poppet assemblage of a valve, having dual support rings may be affected with supplementary pistons whose functions is to offset the change in seal diameter from the inner to the outer edge of the nose pieces according to the direction of flow through the valve. In this case, as before, the exact equilibrium of forces is fundamentally achieved by a relationship of areas and is not dependent on materials of construction, or pressures.

I have described what I believe to be the best embodiments of my invention. I do not wish, however, to be confined to the embodiments shown, but what I desire to cover by Letters Patent is set forth in the appended claims.

I claim:

1. A valve comprising a pair of nose pieces having two opposing valve seats spaced apart in the axial direction of the valve and movable axially with respect to each other, said valve seats having seating surfaces substantially transverse to the axis of the valve, each nose piece having a longitudinal surface in the direction of the axis, the seating surfaces and the longitudinal surfaces forming at their line of intersection peripheral corners of similar size and shape, and a member of resilient material between said nose pieces, said resilient member extending into the region between the peripheral corners of the nose pieces and capable of being deformed by engagement of said corners therewith to form a seal.

2. A valve according to claim 1, including means for limiting the axial movement of said valve seats toward each other to a fixed distance.

3. A valve according to claim 2, wherein the means for limiting the movement of the valve seats includes a rigid retainer on which said resilient member is fixedly mounted.

4. A valve comprising a body and a poppet mounted in the body for axial movement with respect thereto, the body and the poppet including a pair of nose pieces having two opposing valve seats, the seating surfaces of which are transverse to the axis of the valve and spaced apart in an axial direction, the nose pieces on said body and poppet having a longitudinal surface extending in the direction of the axis, the nose piece seating surfaces and longitudinal surfaces forming at their line of intersection peripheral corners of similar size and shape and a member of resilient material located between said nose pieces, said resilient member extending into the region between the nose pieces and beyond the corner and capable of being deformed by engagement of said corner therewith to form a seal.

5. A valve according to claim 4, including means responsive to the fluid pressure at the inlet of the valve for producing an axially directed balancing force on the poppet which is equal and opposite to the axial force exerted on the poppet nose piece by the fluid.

6. A valve comprising two opposing circular valve seats spaced apart in an axial direction and movable axially with respect to each other, each of said seats having an annular surface transverse to said axis and a longitudinal cylindrical surface on the outlet side of the valve seats concentric with the axis, the annular surfaces and the longitudinal surfaces forming peripheral corners of essentially identical size and shape, and an O-ring of resilient material between said valve seats and capable of axial movement in either direction between said peripheral corners, said member extending into the region between the corners of the valve seats and capable of being deformed by engagement of said corners therewith to form a seal.

7. A valve having two opposing valve seats spaced apart in an axial direction, a resilient member located between said valve seats, means for mounting the resilient member for free axial movement with respect to both valve seats, said valve seats being adapted to contact opposite sides of said resilient member when the valve is closed, one of said valve seats being movable axially, and means for causing the effective area of said movable valve seat to which fluid induced pressure is applied in an axial direction to remain substantially constant during the operation of the valve irrespective of the amount of deformation of said resilient material.

8. A cylindrical valve having two opposing valve seats spaced apart in an axial direction, a seal ring of resilient material located between said valve seats, a retainer ring mounted for free axial movement with respect to both valve seats and on which said seal ring is held captive, means for moving one of said valve seats with respect to the other, means for supplying fluid to the region between said valve seats, said one valve seat being proportioned with respect to said seal ring so that a predetermined force corresponding to the fluid pressure is exerted on the movable valve seat, and means responsive to the fluid pressure for producing an equal and opposite force on said movable valve seat.

9. A valve according to claim 8, wherein the valve seats have counterbores concentric with the seal ring, the peripheral surfaces of the counterbores intersecting the seal ring throughout its entire length.

10. A valve according to claim 9, wherein the retainer ring is mounted in said counterbores and has a width in the axial direction related to the length of the counterbores in the axial direction so that the retainer ring forms a mechanical stop limiting the axial movement of the valve seats toward each other to a fixed distance.

11. A valve comprising a housing having a cylindrical chamber and a fluid inlet to said chamber, means on said housing for providing an annular valve seat, a poppet in said chamber having at one end a second annular valve seat opposed to said first mentioned valve seat, said valve seats having substantially equal inner diameters, a resilient seal ring or circular cross-section concentric with said valve seats and having a mean diameter equal to said inner diameters, means for providing a fluid cavity at the other end of said poppet, means for placing said cavity in fluid communication with the inlet and with the space between said valve seats, said cavity having an inner diameter equal to the first mentioned inner diameters, said poppet having an axial cylindrical cavity extending therethrough and of substantially the same diameter as said inner diameters, means providing an outlet port in communication with said cavity.

12. A valve according to claim 11, including a retainer ring located internally of said valve seats and mounted for movement in the axial direction, said seal ring being fixedly mounted on said retainer ring.

13. A valve comprising a housing having a cylindrical chamber and a fluid inlet to said chamber, means on said housing for providing an annular valve seat, a poppet slidably mounted in said chamber and having at one end

a second valve seat opposed to said first mentioned valve seat, said poppet having a counterbore of a given diameter, a resilient seal ring of circular cross section concentric with said counterbore and having a mean diameter equal to the diameter of the counterbore, means for providing a fluid cavity at the other end of said poppet means for placing said cavity in fluid communication with the inlet and with the space between said valve seats, said cavity having an inner diameter equal to the diameter of the counterbore, means providing an outlet port in communication with said counterbore, said poppet having a cylindrical cavity of substantially the same diameter as said counterbore and in communication with the outlet port, means for urging the poppet toward the first mentioned valve seat and means for retracting said poppet from the first mentioned valve seat.

14. A valve comprising a housing having a cylindrical chamber and a fluid inlet to said chamber, means on said housing for providing an annular valve seat, a poppet slidably mounted in said chamber and having at one end a second valve seat opposed to said first mentioned valve seat, said poppet having a counterbore of a given diameter, a resilient seal ring of circular cross section concentric with said counterbore and having a mean diameter equal to the diameter of the counterbore, means for providing a fluid cavity at the other end of said poppet, means for placing said cavity in fluid communication with the inlet and with the space between said valve seats, said cavity having an inner diameter equal to the diameter of the counterbore, means for providing an outlet port in communication with said counterbore, said poppet having a cylindrical cavity extending to the other end thereof, of substantially the same diameter as said counterbore and in communication with the outlet port, spring means for urging the poppet toward the first mentioned valve seat and means for retracting said poppet from the first mentioned valve seat, and a retainer ring mounted within said counterbore for free axial movement, said resilient seal ring being mounted on said retainer ring.

15. A valve comprising a housing having a cylindrical chamber and a fluid inlet to said chamber, means on said housing for providing an annular valve seat, an armature in said chamber having at one end a second valve seat opposed to said first mentioned valve seat, said armature having a counterbore of a given diameter, a resilient seal ring of circular cross section concentric with said counterbore and having a mean diameter equal to the diameter of the counterbore, means for providing an annular fluid cavity at the other end of said armature, means for placing said cavity in fluid communication with the inlet and with the space between said valve seats, said cavity having an inner diameter equal to the diameter of the counterbore, means for providing an outlet in communication with said counterbore, said armature having a cylindrical cavity extending to the other end thereof, of substantially the same diameter as said counterbore and in communication with the outlet, spring means mounted in the cylindrical cavity for urging the armature toward the first mentioned valve seat, a solenoid for retracting said armature from the first mentioned valve seat, a retainer ring mounted within said counterbore for free axial movement, said resilient seal ring being mounted on said retainer ring, the width of said retainer ring in an axial direction being related to the length of the counterbore in the axial direction so that retainer ring forms a mechanical stop which limits the movement of the armature toward the first mentioned valve seat.

16. A valve system comprising a valve body having a cylindrical bore, a poppet concentric with said bore and mounted for slidable axial movement therealong, sealing rings between the poppet and the wall of said bore near each end of the poppet, a pair of valves each having one valve seat formed by said body and a cooperating valve

11

seat on said poppet, said valve seats being annular, a resilient sealing ring positioned between each pair of cooperating valve seats, said resilient rings being mounted for free axial movement with respect to said valve seats, the valve seats being located on said poppet and said valve body so that movement of the poppet in one direction closes one of the valves and opens the other and movement in the opposite direction closes said other valve and opens the first valve, said valve seats having peripheral corners defining downstream circular perimeters thereof having the same diameter, said resilient rings extending into the region between the peripheral corners of adjacent valve seats and being capable of being deformed by engagement of said corners therewith to form a seal, and fluid pressure responsive means for balancing the fluid induced axially directed forces on said poppet.

17. A valve system comprising a valve body having a cylindrical bore, a poppet concentric with said bore and mounted for slidable axial movement therealong, sealing rings between the poppet and the wall of said bore near each end of the poppet, a pair of valves each having one valve seat formed by said body and a cooperating valve seat on said poppet, said valve seats being annular, a resilient sealing ring positioned between each pair of cooperating valve seats, a retainer ring fixed to each resilient ring and mounting said resilient ring for free axial movement with respect to the valve seats adjacent thereto, the valve seats being located on said poppet and said valve body so that movement of the poppet in one direction closes one of the valves and opens the other and movement in the opposite direction closes said other valve and opens the first valve, said valve seats having peripheral corners defining downstream circular perimeters thereof having the same diameter, said resilient rings extending into the region between the peripheral corners of adjacent valve seats and being capable of being deformed by engagement of said corners therewith to form a seal, and means for balancing the fluid induced, axially directed forces on said poppet.

18. A valve system comprising a valve body having a cylindrical bore, a poppet concentric with said bore and mounted for slidable axial movement therealong, sealing rings between the poppet and the wall of said bore near each end of the poppet, a pair of valves each having one valve seat formed by said body and a cooperating valve

12

seat on said poppet, said valve seats being annular, a resilient sealing ring positioned between each pair of cooperating valve seats, said resilient rings being located along the downstream perimeter of the said annular valve seats, a retainer ring fixed to each resilient ring and mounted for axial movement with respect to the valve seats adjacent thereto, the valve seats being located on said poppet and said valve body so that movement of the poppet in one direction closes one of the valves and opens the other and movement in the opposite direction closes said other valve and opens the first valve, means providing for one valve an inlet port which is external and an outlet which is internal of the valve seats thereof, means providing for the other valve an inlet which is internal and an outlet port which is external of the valve seats of said other valve, and means responsive to fluid pressure for balancing the axially directed fluid induced forces on said poppet.

19. A valve system comprising a valve body having a cylindrical bore, a poppet concentric with said bore and mounted for slidable axial movement therealong, sealing rings between the poppet and the wall of said bore near each end of the poppet, a pair of valves each having one valve seat formed by said body and a cooperating valve seat on said poppet so that both valves are operated by said poppet upon axial movement thereof, said valve seats being annular, a resilient sealing ring positioned between each pair of cooperating valve seats, said resilient rings being mounted for free axial movement with respect to said valve seats, said valve seats having peripheral corners defining downstream circular perimeters thereof having the same diameter, said resilient rings extending into the region between the peripheral corners of adjacent valve seats and being capable of being deformed by engagement of said corners therewith to form a seal, and fluid pressure responsive means for balancing the fluid induced axially directed forces on said poppet.

References Cited in the file of this patent

UNITED STATES PATENTS

2,484,102	Le Volley	Oct. 11, 1949
2,599,622	Folmsbee	June 10, 1952

FOREIGN PATENTS

445,704	Great Britain	Apr. 15, 1936
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