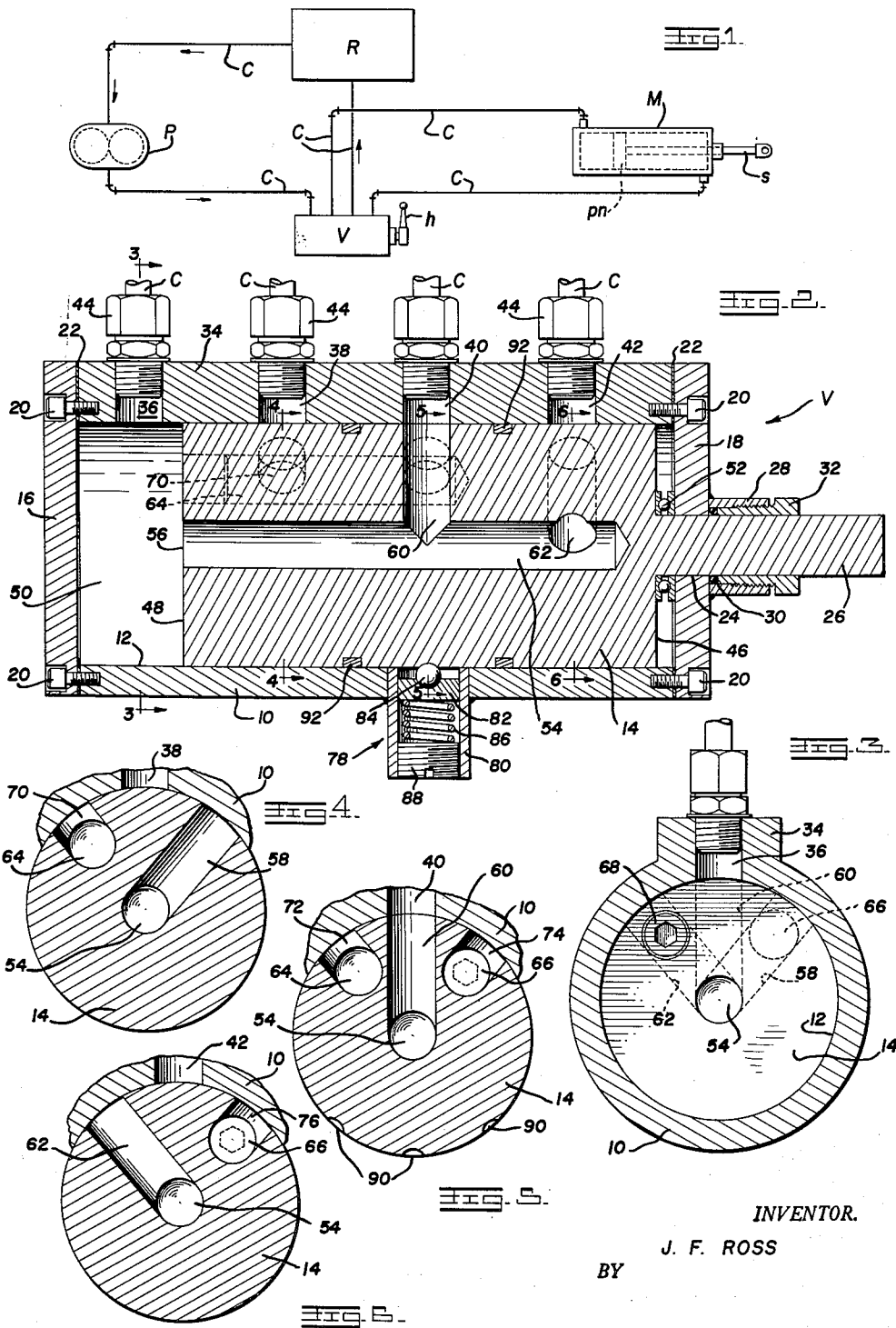


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J. F. ROSS

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ROTARY TYPE HYDRAULIC VALVE

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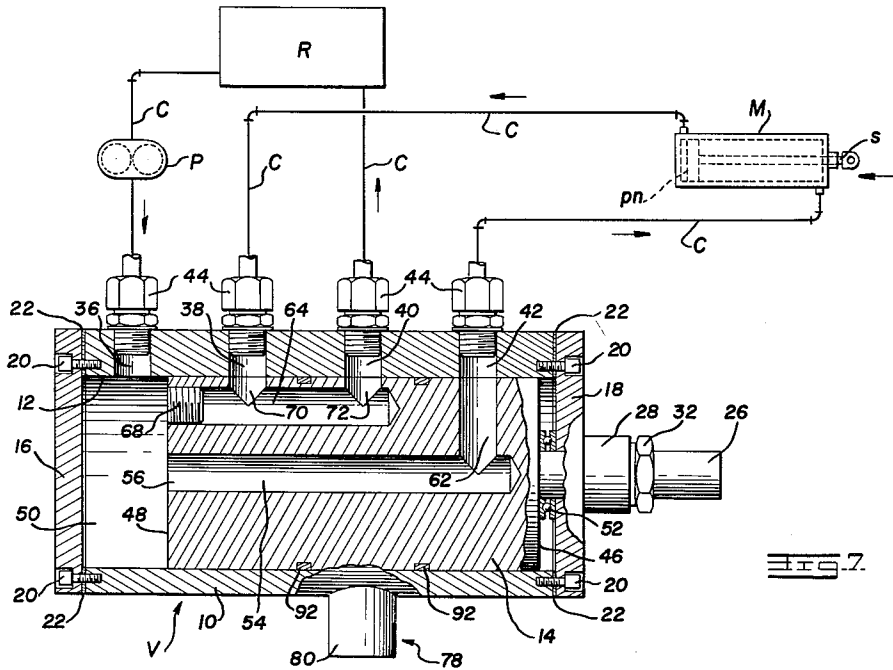


FIG. 7.

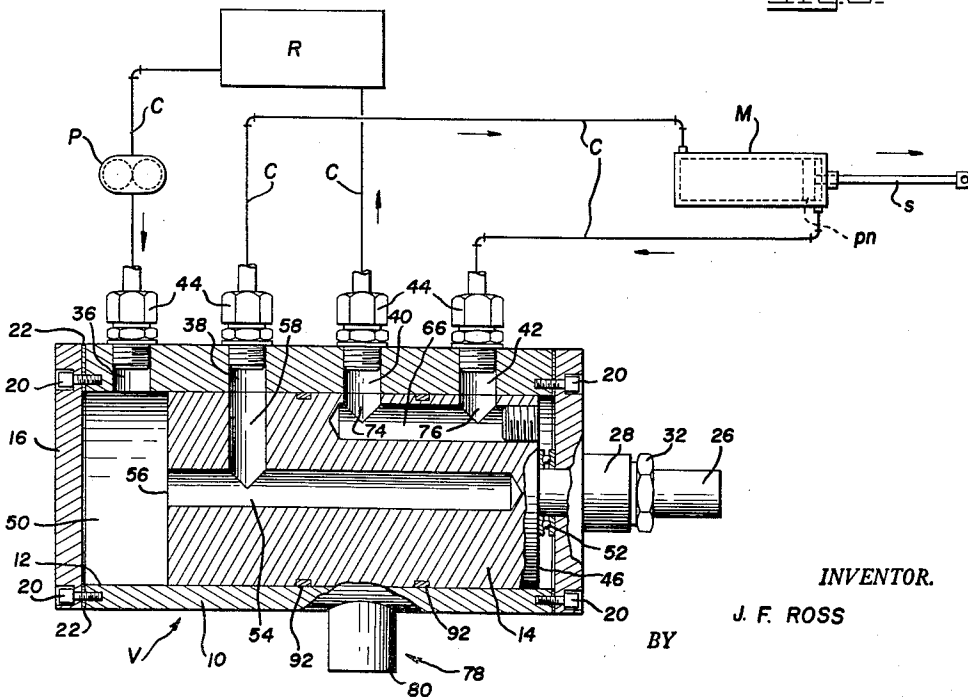


FIG. 8.

INVENTOR.

J. F. ROSS

BY

ATTORNEY

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ROTARY TYPE HYDRAULIC VALVE

James F. Ross, 1308 33rd St., Columbus, Ga.

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12 Claims. (Cl. 137-621)

This invention relates to a rotary type hydraulic valve, and more particularly to an improved valve for use in controlling hydraulic motors or the like.

In hydraulic motors or actuators such as the type comprising a cylinder with a reciprocating piston it is necessary to supply hydraulic fluid to the cylinder at one side of the piston and to exhaust hydraulic fluid from the cylinder at the opposite side of the piston in order to move the piston in one direction or the other. Moreover, to maintain the piston in a given position it is necessary to keep the pressure on opposite sides of the piston balanced.

Various types of control valves have been employed heretofore for controlling the passage of hydraulic fluid to and from the cylinder of the motor. In general, the control valve is connected to a source of hydraulic fluid under pressure and to a fluid reservoir as well as to the motor load. Various schemes have been proposed to permit movement of the valve between its respective operating positions without unduly increasing the back pressure upon the fluid supply and without leakage of fluid in the valve structure.

One form of prior art control valve comprises a valve casing having a cylindrical bore which houses a rotary cylindrical valve plug. In order to prevent an increase in back pressure when the valve is operated as mentioned above, many valves of this type have fluid by-pass passages formed as grooves on the surface of the valve plug. Among the disadvantages of this type of construction are structural complexity and difficulty in preventing leakage around the valve plug.

Another type of control valve construction requires an auxiliary relief valve to prevent a build-up in back pressure. With some of the prior control valves it is necessary to use auxiliary check valves. Other prior art control valves require stationary partitions between valve ports to prevent leakage. Others are not adaptable for use with high or low fluid pressures or for use in different orientations. Moreover, with some control valves the pump cannot be operated at all times.

It is accordingly a principal object of the invention to provide an improved hydraulic valve which overcomes the foregoing disadvantages of prior valves.

Another object of the invention is to provide a valve of the foregoing type which is simple in its construction and which is easy to use and operate.

More specifically, it is an object of the invention to provide a control valve which permits continuous operation of the supply pump, which is positively locked in any of its operating positions, which eliminates an undue increase of back pressure during a change in operating position, which permits the fluid pressure applied to the load to be increased or decreased or balanced at will, which is substantially leak-proof, which can be operated in different orientations, which can accommodate high or low pressures, and which can be made in any size desired.

The foregoing and other objects, advantages, and features of the invention will become more readily apparent upon consideration of the following detailed description of the invention taken in conjunction with the accompanying drawings, which illustrate a preferred and exemplary embodiment, and wherein:

FIGURE 1 is an explanatory flow diagram;

FIGURE 2 is a longitudinal sectional view illustrating the valve of the invention in an operating position for producing the flow indicated in FIGURE 1;

FIGURES 3, 4, 5, and 6 are transverse sectional views

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taken along lines 3-3, 4-4, 5-5, and 6-6, respectively, of FIGURE 2;

FIGURE 7 is a flow diagram showing a longitudinal section of the valve of the invention in another of its operating positions; and

FIGURE 8 is a flow diagram showing a longitudinal section of the valve of the invention in still another of its operating positions.

Briefly stated, the valve of the invention comprises a valve casing having a cylindrical bore in which a smooth cylindrical valve plug is mounted for rotation. The casing has a plurality of ports, at least some of which are selectively alignable with ports in the plug. The arrangement of the ports is such that a supply port always communicates with a reservoir port or with one of a pair of load ports, and such that the load ports communicate with the supply port or the reservoir port, or are blocked. The valve plug is arranged to be locked in any of its operating positions.

Referring to the drawings, a typical environment in which the valve of the invention may be employed is shown in FIGURE 1. In the flow diagram of this figure the valve is designated by reference character V. The diagram also illustrates a pump P, a reservoir R, and a motor load M. These elements are interconnected by suitable conduits C. In the illustrative form, the control valve V has an actuating handle h, and with the handle in the position illustrated (the neutral position), hydraulic fluid is drawn from the reservoir R by the pump P and is forced through the valve V and back to the reservoir R, as indicated by the arrows. The motor M is typically a hydraulic cylinder, and with the actuating handle h of the control valve in the position shown, the pressure on opposite sides of the piston pn of the motor is balanced, so that the output shaft s is stationary.

The internal construction of the valve of the invention is shown in FIGURE 2 as the valve appears in its neutral position. The valve comprises a hollow casing 10 having a cylindrical bore 12. The casing houses a smooth cylindrical valve plug 14, the surface of which closely fits the wall of the casing bore with just enough working clearance to permit rotation of the plug about its longitudinal axis. In the form shown, the open ends of the casing are closed off by end plates 16 and 18, which may be secured to the casing cylinder by a plurality of hollow-headed cap screws 20 threaded into the cylinder and recessed in the end plates as shown. Suitable gaskets 22 are interposed between the adjacent surfaces of the casing cylinder and the end plates. End plate 18 is provided with a circular opening 24 to permit the passage of an axial shaft 26, which may be formed integrally with the valve plug 14, the plug and casing being preferably formed of a suitable metal. Leakage around opening 24 is prevented by providing a sleeve 28, which may be welded to the end plate 18 around the opening, and which receives a sealing or packing ring 30 surrounding the shaft 26 and held in position by a collar 32, which may be threaded into the sleeve 28 as shown. Shaft 26 may have an actuating handle as shown in FIG. 1 or may be actuated in any suitable manner, as by solenoids.

One portion of the valve casing may be thickened as indicated at 34 (see FIG. 3) for reinforcement and is provided with radial casing ports, including, in the form shown, a supply port 36, a load port 38, a reservoir port 40, and another load port 42. These ports are spaced in alignment along the length of the cylinder, and through the provision of suitable fittings 44 and the conduits C are adapted for connection to the corresponding parts of the system illustrated in FIGURE 1, namely, a supply of hydraulic fluid under pressure, a fluid reservoir, and a load such as a motor.

In the form shown, the valve plug is shorter than the

casing and has an end 46 adjacent the end plate 18 of the casing such that the other end 48 of the plug is spaced from the end plate 16 to provide a chamber 50. Supply port 36 communicates with this chamber through the wall of the cylindrical bore of the casing. Fluid pressure on the end wall 48 of the valve plug forces the plug toward the end plate 18 of the casing, and a thrust bearing 52 is provided between the end wall 46 of the valve plug and the opposing wall of the end plate 18 to permit the plug to rotate without binding. This bearing may take the form of a simple ball bearing assembly mounted freely on the shaft 26.

The valve plug of the invention has a longitudinal internal supply passage 54 with an inlet 56 communicating with the chamber 50. The supply passage 54 has three ports which extend radially to the wall of the casing bore 12 and which are selectively alignable with the corresponding ports 38, 40, and 42 in respectively different angular positions of the valve plug 14. One of the ports leading from the supply passage 54 is shown at 58 in FIG. 4. This port is adapted to communicate with load port 38. A second port from the supply passage 54 is shown at 60 in FIGS. 2 and 5. This port is adapted to communicate with the reservoir port 40 and does so in the neutral valve position illustrated in FIG. 2. The third port leading from the supply passage 54 is shown at 62 in FIGS. 2 and 6. This port is adapted to communicate with the load port 42.

The valve plug 14 is provided with additional longitudinal internal passages 64 and 66 best seen in FIGURES 7 and 8, respectively. These passages may be bored from opposite ends of the plug and then closed off at their open ends as by threaded caps 68. The passages are spaced circumferentially on opposite sides of passage 54, as shown in FIGS. 3-6. Passage 64 has radial ports 70 and 72 which are aligned with load port 38 and reservoir port 40, respectively, in the operating position of the valve shown in FIG. 7. In this position, port 62 is also aligned with load port 42. Passage 66 has radial ports 74 and 76 which are aligned with reservoir port 40 and load port 42, respectively, in the operating position of the valve shown in FIG. 8. In this position, port 58 is also aligned with load port 38.

By reference to FIGURES 4, 5, and 6, it will be seen that the ports of the valve plug 14 are located in three groups adjacent the reservoir and load ports, respectively. The ports in the group adjacent reservoir port 40 include the supply passage port 60 disposed between ports 72 and 74 to passages 64 and 66, respectively. The ports in the group adjacent load port 38 include supply passage port 58 and port 70 from passage 64. The ports in the group adjacent load port 42 include the supply passage port 62 and port 76 from passage 66. It will be observed from FIGS. 4 and 6 that corresponding ports in the groups adjacent load ports 38 and 42 are disposed on opposite sides of the supply passage port 60 associated with reservoir port 40 of FIGURE 5.

The valve plug 14 is provided with means for locking it in any one of its operating positions. The locking means is generally designated by the reference numeral 78 and includes a sleeve 80 which may be welded or threaded in a corresponding opening in the cylindrical wall of the casing 10 as indicated in FIGURE 2. Slidably mounted in the sleeve 80 is a disk 82 having a depression at one side thereof for supporting a ball detent 84. The ball is urged toward the valve plug 14 by a spring 86 compressed between the disk 82 and a cap 88 threaded into the sleeve 80. The valve plug is provided with circumferentially spaced recesses 90 as shown in FIGURE 5. The recesses are placed to receive the ball 84, which protrudes beyond the bore wall 12 of the casing 10. The positions of the recesses 90 are selected so that the ball 84 will enter a recess when the valve plug 14 is in one of its operating positions. Between such positions the ball engages the cylindrical surface of the valve plug,

providing a rolling contact, and with the disk 82 is urged farther into the sleeve 80.

To aid in preventing leakage of fluid along the interface of the valve plug and casing, metal sealing rings 92 are employed. Rings 92 may be conveniently mounted in corresponding circumferential grooves in the surface of the valve plug 14 on opposite sides of the reservoir port 40.

For illustrative purposes the use of the valve will be described in conjunction with a hydraulic system of the type shown in FIGURE 1. In the position of the valve illustrated in FIGURES 1-6, load ports 38 and 42 are blocked by the surface of the valve plug, as shown in FIGURES 4 and 6, and the supply passage 54 communicates with the reservoir port 40 through port 60, as shown in FIGURES 2 and 5. From FIGURES 1 and 2 it can be seen that the pump P simply withdraws fluid from the reservoir R and pumps it through the valve back to the reservoir, the fluid entering the supply port 36 and moving through the supply passage 54, port 60, and reservoir port 40. Since load ports 38 and 42 connected to the motor M are blocked, the hydraulic pressure on opposite sides of the piston *pn* is balanced, and the shaft *s* is stationary. Under these conditions, the valve is in its neutral position, and is held in such position by the locking means 78.

To cause the shaft *s* of the motor M to move in one direction or the other, the valve plug is rotated to one of the positions illustrated in FIGURES 7 and 8. From FIGURE 5, it will be seen that if the valve plug is rotated from its neutral position, the port 60 will move away from alignment with the reservoir port 40. The circumferential spacing of the ports illustrated in FIGURES 4, 5, and 6 is chosen so that one of ports 58 and 62 (depending upon the direction of valve plug movement) communicates with its corresponding load port 38 or 42 before the port 60 loses communication with reservoir port 40. Moreover, before this occurs, the ports to one of passages 64 and 66 will communicate with the reservoir port 40 and a corresponding load port 38 or 42. It will thus be seen that in the movement of the valve plug between its operating positions there is always a port in the valve casing through which fluid from the pump P may flow. This arrangement prevents an undue increase in back pressure on the pump when the valve plug is moved.

When the valve plug assumes one of the positions illustrated in FIGURES 7 and 8, it will be held in position by the locking means 78. In the position illustrated in FIGURE 7, fluid is pumped from reservoir R through the supply port 36, the supply passage 54, port 62, and load port 42 to one side of the piston *pn* of the motor M, and from the other side of the piston through load port 38, port 70, passage 64, port 72, and reservoir port 40, back to the reservoir R. The shaft *s* of the motor M thus moves in the direction indicated.

In the position of the valve illustrated in FIGURE 8, fluid is pumped from the reservoir R through the supply port 36, the passage 54, port 58, and load port 38, to one side of the piston *pn* of the motor M, and from the other side of the piston through the load port 42, port 76, passage 66, port 74, and reservoir port 40, back to the reservoir R. The shaft *s* of the motor M thus moves in the opposite direction as shown.

In controlling the operation of the motor M by the control valve V, the control valve is moved to one of the positions illustrated in FIGURES 7 and 8 until the desired extent of movement of the motor M is obtained. Then the control valve is moved back to its neutral position illustrated in FIGURE 2. As pointed out above, in such position the load ports 38 and 42 are blocked, and the motor shaft *s* remains stationary. Operation of the control valve is facilitated by the thrust bearing 52 and by the smooth working contact between the valve plug and the casing. The latter feature together with the rings 92 prevents leakage between plug and casing.

It should be apparent from the foregoing description, that the invention provides a simple yet highly effective control valve. While a preferred embodiment of the invention has been shown and described, it will be appreciated by those skilled in the art that modifications can be made without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims. For example, intermediate control positions may be obtained by providing additional locking recesses 90 between those illustrated so as to permit partial communication of the supply passage 54 with either load port and at the same time maintain partial communication with the reservoir. Accordingly, the foregoing embodiment of the invention is to be considered illustrative, rather than restrictive, and those embodiments which come within the meaning and range of equivalency of the claims are to be included therein.

The invention claimed is:

1. A valve comprising a casing having a valve bore therein, a valve plug rotatably mounted in said casing and having an outer surface in close proximity to the surface of said valve bore, said plug having an internal supply passage with an inlet, said casing having a supply port communicating with said inlet and adapted to be connected to a source of fluid, said casing having additional ports extending through the wall of said bore, said additional ports including a reservoir port adapted to be connected to a fluid reservoir, and a pair of load ports adapted to be connected to a load, said supply passage having three ports extending to the wall of said casing bore and being aligned with said reservoir port and said load ports, respectively, for three corresponding operating positions of said plug, said valve plug having two additional internal passages, one of said additional passages having ports extending to said bore wall and aligned with one of said load ports and said reservoir port, respectively, when said plug is in a first of said positions and in which the remaining load port is aligned with its associated supply passage port, the other of said additional passages having ports extending to said bore wall and aligned with said reservoir port and said remaining load port, respectively, when said valve plug is in a second of said positions and in which said one load port is aligned with its associated supply passage port, said load ports being blocked by said plug when said plug is in a third of said positions and in which said reservoir port is aligned with its associated supply passage port.

2. The valve of claim 1, the supply passage ports in said plug being spaced such that said supply passage always communicates with said reservoir port or one of said load ports regardless of which operating position said plug assumes.

3. The valve of claim 1, said reservoir port and said load ports being spaced along the length of said casing, the ports in said valve plug being located in three groups adjacent said reservoir and load ports, respectively, the ports in the group adjacent said reservoir port including a supply passage port disposed between ports to said additional passages, respectively, the ports in the groups adjacent said load ports, respectively, comprising a supply passage port and a port to a respective additional passage, with corresponding ports in the groups adjacent said load ports being disposed on opposite sides of the supply passage port associated with said reservoir port.

4. The valve of claim 1, said valve plug being shorter than said casing and having one end adjacent an end wall of said casing, a chamber being provided between the other end of said plug and another end wall of casing, said inlet to the supply passage and said supply port communicating with said chamber.

5. The valve of claim 4, further comprising a thrust bearing between the adjacent plug end and casing end wall.

6. The valve of claim 1, further comprising at least one circumferential sealing ring at the interface of said plug and bore surfaces.

7. The valve of claim 6, said sealing ring being mounted in a groove in the surface of said valve plug.

8. The valve of claim 1, said plug having an axial shaft extending through an opening in an end wall of said casing, said opening being provided with a fluid seal whereby said plug may be rotated from the outside of said casing without fluid leakage through said opening.

9. The valve of claim 1, further comprising means for locking said plug in each of said operating positions.

10. The valve of claim 9, said locking means comprising a spring biased detent protruding from one of said plug and bore surfaces and cooperating circumferentially spaced recesses in the other of said surfaces.

11. A valve comprising a hollow casing containing a valve plug movable therein with the outer surface of the plug fitting the inner surface of the casing, a first port in said casing, a first passage in said plug communicating with said first port, a second passage in said plug, second and third ports in said casing communicating with said second passage in a first operating position of the valve plug, a third passage in said plug, a fourth port in said casing, said third and fourth ports communicating with said third passage in a second operating position of said valve plug, said fourth port communicating with said first passage in said first plug position and said second port communicating with said first passage in said second position, said plug having a third operating position in which said third port communicates with said first passage.

12. The valve of claim 11, said casing and said plug being cylindrical, said plug being rotatable about its axis, said second, third, and fourth ports being spaced in succession along a generatrix of the cylindrical casing, all of said passages being internal axial passages in said plug, said second and third passages being located adjacent opposite ends of said first passage and being displaced circumferentially on opposite sides of said first passage.

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