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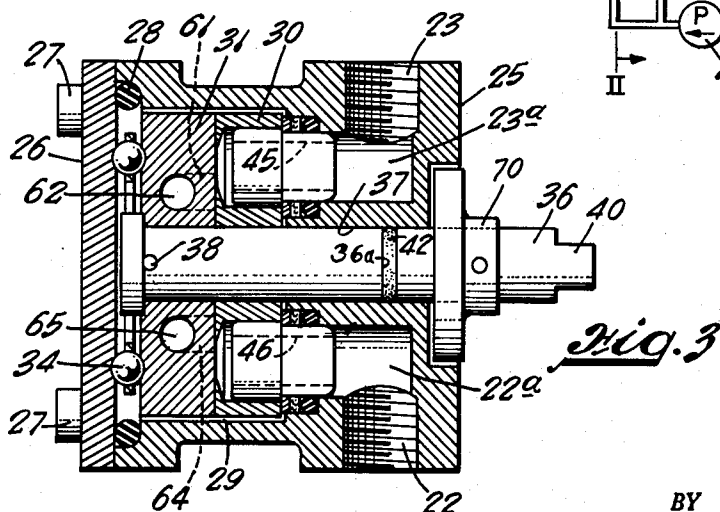
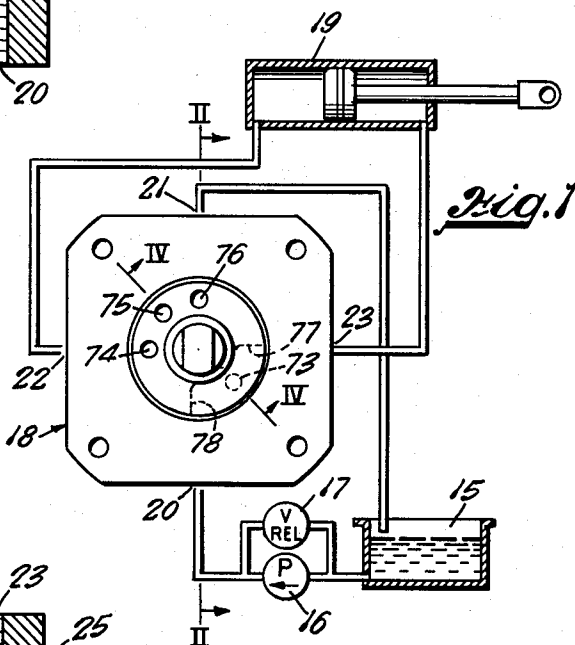
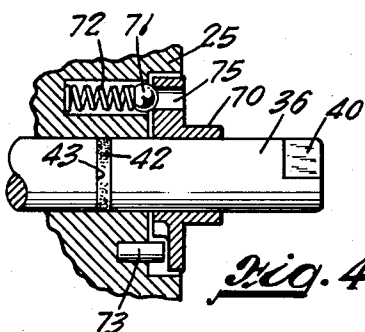
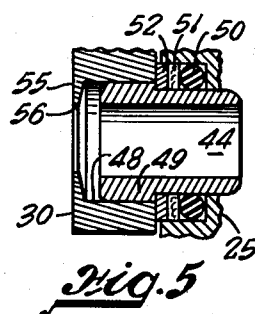
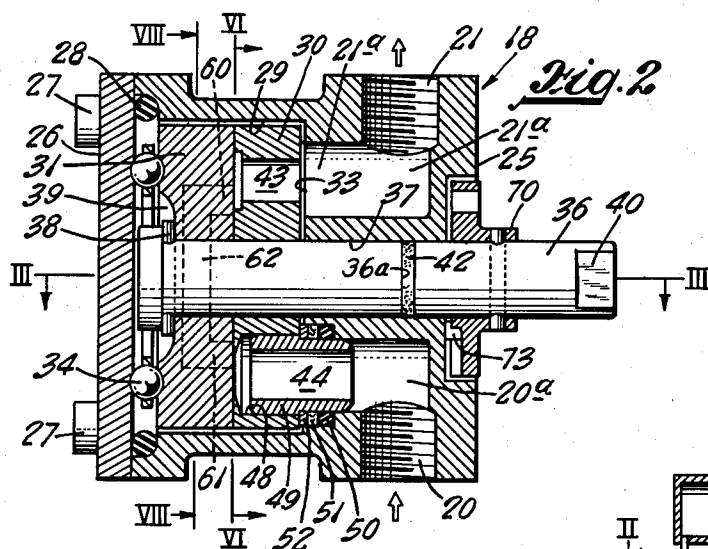
D. Z. ERLE

2,744,540

PLATE TYPE HYDRAULIC VALVE

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2 Sheets-Sheet 1



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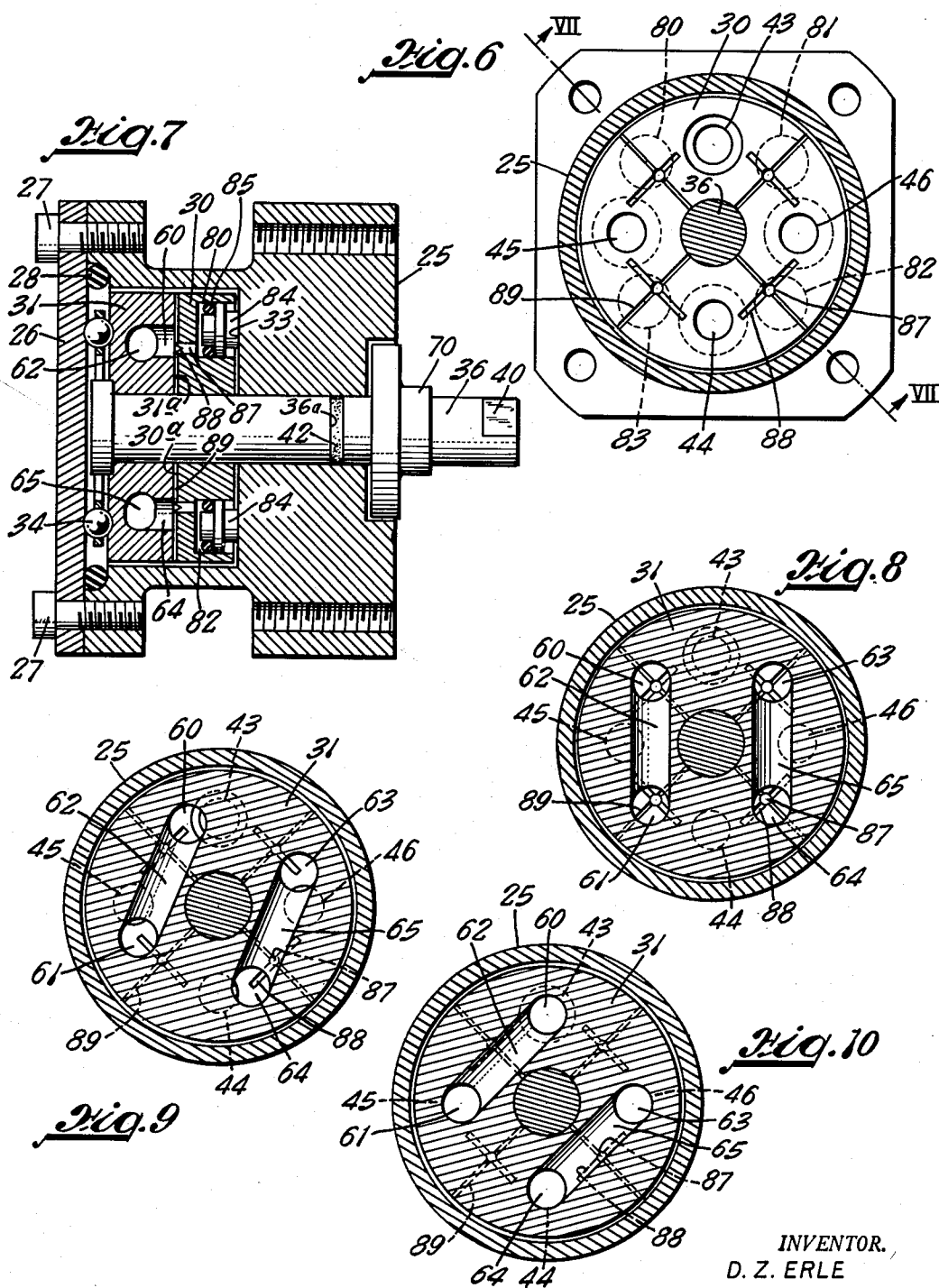
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2,744,540

PLATE TYPE HYDRAULIC VALVE

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11 Claims. (Cl. 137—624)

This invention relates to hydraulic valves of the plate type involving ported, flat sliding sealing surfaces, as distinct from poppet valves and from shuttle valves having cylindrical sealing surfaces.

An object of the invention is to provide a plate type valve capable of handling relatively high pressures with low leakage.

A more specific object is to minimize the resistance to operating movement of a pressure-sealed plate type valve.

Other more specific objects and features of the invention will appear from the description to follow.

In its simplest and most commonly used form a plate valve consists of a fixed and a rotatable disk having ground and lapped flat surfaces sealing against each other, the surfaces containing cooperating ports movable into and out of registration with each other in response to rotation of the movable disk. To reduce or prevent leakage the rubbing surfaces of the disks must not only fit, i. e. be flat, but must be pressed together with a force greater than the separating force of the pressure fluid in the ports. Excessive force is undesirable because it increases the frictional resistance to rotation. It has been found desirable in practice to develop the sealing force by applying the fluid pressure in the ports to a portion of the rear face of the movable disk so that the sealing force is proportional to the separating force regardless of variations of pressure in the fluid. Unfortunately, however, even though the fluid pressure remains constant the separating force varies in different positions of the valve due to the fact that when cooperating ports are in partial registration the opposed areas between the disks to which the pressure is applied are greater than when the ports are in registration. The result is that much greater force is required to turn the valve in the positions of port registration than in the positions of port overlap.

This defect is reduced in accordance with the present invention by providing means for applying sealing pressure to properly located areas of one of the disks during port overlap and removing this pressure in positions of port registration.

Another defect of prior known plate type valves is that even relatively heavy thick disks are capable of sufficient distortion under high pressures to permit excessive leakage between the disks.

This defect is corrected in accordance with the invention by making the port edges thin and reentrant so that they are capable of distorting (bending) in response to pressure in the ports to seal with the opening disk even though the disks do not seal with each other at all other areas.

A full understanding of the invention may be had from the following detailed description when read in connection with the drawing, in which:

Fig. 1 is a schematic diagram of a hydraulic system incorporating a selector valve constructed in accordance with the invention, the valve being shown in elevation;

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Fig. 2 is a longitudinal vertical sectional view through the valve taken in the plane II—II of Fig. 1;

Fig. 3 is a longitudinal horizontal sectional view through the valve the section being taken in the plane III—III of Fig. 2;

Fig. 4 is a detail section taken in the plane IV—IV of Fig. 1;

Fig. 5 is an enlarged detail sectional view taken through one of the ports in the valve;

Fig. 6 is a cross sectional view taken in the plane VI—VI of Fig. 2;

Fig. 7 is a longitudinal sectional view taken in the plane VII—VII of Fig. 6; and

Figs. 8, 9, and 10 are cross sectional views taken in the plane VIII—VIII of Fig. 2 and showing the valve in three different positions of operation.

Referring first to Fig. 1 there is disclosed a conventional hydraulic system consisting of a reservoir 15, a pump 16, a pressure relief valve 17, a selector valve 18 in accordance with the invention, and a motor 19 to be selectively actuated in one direction or the other by manipulation of the selector valve 18. Thus the valve 18 is provided with a pressure passage 20 which is connected to the output of the pump 16, a return passage 21 which is connected to the reservoir 15, a motor passage 22 connected to one end of the motor cylinder 19, and a second motor passage 23 connected to the other end of the motor cylinder 19. The valve 18 has a neutral and two active positions. In the neutral position the valve isolates the motor passages from the pressure passage and the return passage. In this position of the valve the blocking of the motor passages 22 and 23 locks the motor 19 in whatever position it happens to be in. In a first active position, the valve 18 has its pressure passage 20 connected to the motor passage 22 and has the other motor passage 23 connected to the return passage 21, so that pressure fluid from the pump 16 is delivered to the left end of the motor cylinder 19, and fluid is exhausted from the right end of the motor cylinder back to the reservoir. In the second active position of the valve the pressure passage 20 is connected to the motor passage 23, and the motor passage 22 is connected to the return passage 21, so that fluid from the pump is delivered to the right end and fluid is exhausted from the left end.

Referring to Fig. 2, the valve 18 comprises a cup shaped casing 25 closed at its rear end by a cover plate 26 which may be secured in place by screws 27 and sealed with respect to the case 25 by a sealing ring 28. The casing 25 and the cover plate 26 define a cylindrical chamber 29 containing a fixed valve plate in the form of a disk 30 and a rotatable plate in the form of a disk 31. The disk 30 is fixed only in the sense that it is not free to rotate within the chamber 29. However it is free to move to a limited extent longitudinally within this chamber toward and away from a backing face 33 in the casing 25 which constitutes the front wall of the cylindrical chamber 29. On the other hand the rotatable disk 31 is not free to move longitudinally between the disk 30 and the cover plate 26 because it is supported with respect to the cover plate 26 by a ball thrust bearing 34.

To rotate the disk 31, there is provided an actuating shaft 36 which extends through a bore 37 provided therefor in the casing 25 and through corresponding central bores in the disk 30 and the disk 31. Adjacent its inner end the shaft 36 is provided with a cross pin 38 which projects beyond the surface of the shaft into a slot or keyway 39 in the disk 31 whereby the latter disk can be rotated by rotating the shaft 36. At its right end, exterior of the casing, the shaft 36 is provided with flats 40 for the attachment of a suitable actuating handle. To seal against fluid leakage between the bore 37 of the casing

25 and the shaft 36 a sealing ring 42 may be provided in an annular groove 36a in the shaft.

The pressure, return, and motor passages of the valve 18 previously referred to in connection with Fig. 1 communicate respectively with four longitudinal passages 20a, 21a, 22a, and 23a in the casing body, which latter passages are symmetrically disposed about the center bore 37 and register with corresponding ports extending through the fixed plate 30.

Thus the return passage 21a communicates with a return port 43, the pressure passage 20a communicates with a pressure port 44, the motor passage 23a communicates with a motor port 45 and the motor passage 22a communicates with a motor port 46. The expression "pressure port" as used herein means the port in which the pressure is always as high or higher than in any other port.

No effort is made to provide a seal between the return passage 21a and the return port 43 in the disk 30 because minimum pressure exists in these passages. However all of the other three passages in the casing 25 are sealingly connected to their associated ports in the disk 30. The sealing construction is the same in each instance and will be described with reference to that associated with the port 44 and passage 20a in Fig. 2. Thus the disk 30 is provided with a bore 48 which has welded therein a sleeve 49, the outer end of which projects into the passage 20a in slide fitting relation therewith. The left end of the passage 20a is counterbored to receive a sealing ring 50 and a pair of backing members 51 and 52, so that pressure fluid tending to leak from the passage 20a around the outside of the sleeve 49 is blocked by the ring 50. The structure described provides for a seal between the ports 44, 45 and 46 in the disk 30 and the corresponding passages 20a, 22a and 23a in the casing 25, while permitting limited longitudinal or axial movement of the disk 30 with respect to the casing.

As best shown in Fig. 5 the left ends of the ports 44, 45 and 46 in the disk 30 terminate in thin reentrant edges 56 at the contact surface 55 of the disk 30 which bears against the rotatable disk 31. Pressure fluid in any one of the ports 44, 45 or 46 urges the thin edges 56 against the disk 31 to improve the seal therebetween.

The rotatable disk 31 has in its sealing face 31a (Fig. 7), two ports 60 and 61 (Fig. 8) interconnected by a passage 62 in the disk, and two ports 63 and 64 interconnected by a passage 65 in the disk. In the neutral position of the valve shown in Fig. 8 the ports 60, 61, 63 and 64 are positioned midway between the ports 43, 44, 45 and 46 in the fixed plate, so that the latter ports are isolated from each other. When the rotatable plate is rotated clockwise 45° from the position shown in Fig. 8 into the position shown in Fig. 10, the ports in the rotatable plate register with ports in the fixed plate so that passage 62 connects the return port 43 in the fixed plate to the motor port 45, and the passage 65 in the rotatable plate connects the pressure passage 44 in the fixed plate to the motor port 46, to deliver pressure fluid to the left end of the motor 19 (Fig. 1) and exhaust fluid from the right end thereof.

If the rotatable plate is rotated 45° counterclockwise from the position shown in Fig. 8 the passage 65 connects the return port 43 in the fixed plate to the motor port 46, and the passage 62 connects the pressure port 44 to the motor port 45, to actuate the motor 19 in the opposite direction.

To limit motion of the rotatable shaft 36 and the rotatable disk 31, a collar 70 is secured to the shaft 36 at the front end of the case 25, and the case is provided with a detent ball 71 (Fig. 4) urged outwardly by a spring 72, and with a stop pin 73. The collar 70 is provided with three holes 74, 75 and 76 which register with the detent 71 in the three positions of the rotatable valve to yieldably retain the rotatable disk in the desired positions. The pin 73 is adapted to cooperate with a pair of shoulders 77

and 78 on the collar 70 for preventing rotation of the rotatable disk beyond the open positions.

In the neutral position of the valve as shown in Fig. 8 all the ports in the fixed plate 30 are closed by the rotatable plate 31. Pressure fluid in any of these ports will leak away from the ports between the two plates to an extent dependent upon the accuracy of the fit between the two plates, and a separating force will be produced between the two plates by the leakage fluid. By carefully lapping the surfaces of the plates the leakage can be held down to such value that the separating force resulting therefrom can be made less than the sealing force of the pressure fluid in the ports acting against the flange 56 and the seals 50, so that an effective seal is obtained in neutral position. The pressure forces tending to separate and oppose separation of the plates in either of the fully opened positions of the valve are the same as in the neutral position.

However the separating forces increase in positions intermediate the fully opened and fully closed positions, in which the ports in one plate partially overlap the ports of the other plate. Thus in Fig. 9 the overlap of the pressure port 44 with the port 64 and of the port 63 with the port 46 produces pressure in all of these ports, and the separating force resulting from the pressure in the ports 44 and 46 in the fixed plate is supplemented by the separating force of the same pressure in the ports 64 and 63 in the rotatable plate. Hence more sealing force is required to overcome the separating force in positions of partial overlap of the ports than in positions of full overlap (registration) and of no overlap.

Heretofore, separation of the plates by the increased pressure forces during partial overlap has been prevented by permanently applying pressure to a rear face or faces on one of the plates of sufficient area to develop a sealing force exceeding the maximum separating force in intermediate positions. This is objectionable because it unduly increases the resistance to rotation in the fully opened and fully closed positions of the valve.

In accordance with the present invention there is applied a pressure to the rear faces of the fixed plate through ducts in the face of the fixed plate that are connected to ports in the rotatable plate only in intermediate positions of the latter.

Thus referring to Figs. 6 and 7 the fixed plate 30 has four cylindrical recesses 80, 81, 82 and 83 extending into the plate from the rear face thereof, and each contains a piston 84 sealed by a sealing ring 85. Each piston abuts against the face 33 of the casing 25 so that pressure in the associated recess acts against the inner end of the recess to urge the plate 30 away from the casing face 33 and toward the plate 31 with a force proportional to the pressure and the area of the inner end of the recess. Each recess 80 is connected by a small duct 87 to a groove 88 in the sealing surface 30a. The four grooves 88 are positioned between but end short of the ports in the fixed plate and lie in the paths of the ports in the rotatable plate. The grooves 88 are shown straight and normal to radii drawn from the ducts 87 for ease of manufacture but they would function as well or better if they were arcuate in shape about the axis of rotation.

There are also formed in the face 30a of the fixed plate 30 four fine radial grooves 89 extending from the inner to the outer edges of the fixed plate and intersecting the grooves 88 at the ducts 87. The grooves 89 are much smaller than the grooves 88 so that they offer substantial resistance to fluid flow therethrough and serve to provide paths for the drainage of pressure fluid from the grooves 88 and the ducts 87 when the grooves 88 are not in lapping relation with a pressure port. Fluid draining through the grooves 89 can escape to the return port or passage 21a in the casing (Fig. 2) since this passage is not sealed with respect to the port 43 in the fixed plate as are the other ports in the fixed plate.

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It will be observed from inspection of Fig. 8 that all of the grooves 88 are spaced from the ports in the fixed plate and are in registration with the ports in the rotatable plate. By virtue of the leakage paths through the fine grooves 89, pressure is dissipated from all of the ports in the rotatable plate.

Referring now to Fig. 9, the rotatable plate is shown rotated in clockwise direction into a position where the ports therein just begin to lap the ports in the fixed plate, thereby admitting any pressure fluid that may be in the ports in the fixed plate into the ports in the movable plate. In this position the ports in the movable plate also register with the grooves 88. Pressure fluid therefore flows from the ports in the rotatable plate into the grooves 88 faster than it can be dissipated therefrom through the fine return grooves 89, so that pressure is applied through the ducts 87 to the recesses 80 to develop pressure against the inner ends of those recesses tending to urge the fixed plate more strongly against the movable plate and overcome the additional separating force developed between the plates because of the additional port area that is exposed to pressure.

This condition prevails until the ports in the rotatable plate closely approach full overlap or registration with the ports in the fixed plate, at which time the ports in the rotatable plate leave the grooves 88. This permits the pressure in the recesses 80 to be dissipated by leakage through the ducts 87 and the radial grooves 89 into the casing, thereby dissipating the pressure urging the fixed plate against the rotatable plate so that the resistance to rotation of the valve is reduced in the fully opened position.

When the valve is next returned to neutral by counter-clockwise rotation of the rotatable plate 31 from the position shown in Fig. 10 toward the position shown in Fig. 8 the ports 60, 61, 63 and 64 approach the ends of the grooves 88 so that the leakage paths between the lapped surfaces of the plates from the ports 64 and 63 to the grooves 88 are shortened prior to the time when the ports actually begin to lap the grooves. This gradually increasing leakage flow into the grooves gradually raises the pressure in the recesses 80 to compensate for the increased separating force between the plates due to the departure from full registration of the ports in the rotatable and fixed plates respectively. The result is that when the ports in the rotatable plate do begin to lap the grooves 88 there is not a violent sudden increase in pressure in the recesses 80 to 83.

It will be noted from inspection of Fig. 2 that the return port 43 in the fixed plate 30 is counterbored at its left end so that the effective diameter of this port in the surface 30a is greater than that of the other ports. This is often desirable because it causes connection of one motor port to the return line slightly before the other motor port is connected to the pressure line. This enlargement of the return port necessitates the shortening of the two grooves 88 adjacent thereto as best shown in Fig. 6.

Although for the purpose of explaining the invention, a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and I do not desire to be limited to the exact details shown and described.

I claim:

1. A valve comprising: casing means containing first and second relative slidable members having cooperating contact faces adapted to substantially seal with each other when pressed together, and means for relatively sliding said members between a neutral and an active position with respect to each other; means supporting said first member against movement with respect to said casing in direction away from the second member, the second member having a rear side opposite its contact face, and said casing having a backing face juxtaposed to said rear side and spaced therefrom; said first member having a

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fluid flow passage therein terminating in a port in its contact face and said second member having a pressure passage therein terminating in a pressure port in its contact face, the said ports being so positioned as to register with each other in said active position of said members and be displaced from each other in said neutral position; means defining a pressure chamber responsive to pressure therein for developing thrust between said second member and said backing face of said casing for urging said second member against said first member; and said second member having a duct therein connecting said pressure chamber to a portion of the contact face of the second member in the path of the port in said first member and adjacent to but spaced from the said pressure port in the second member whereby: fluid can flow from the pressure port in said second member to said pressure chamber only through a leakage path between said faces from said pressure port in said second member to said duct in said neutral position of said members, the leakage path is shortened by overlap of the port in said first member with said duct during approach of the ports in said two members toward each other, said pressure chamber is directly connected to both said ports while said port in said first member is overlapping both said duct and the pressure port in said second member, and fluid can flow from the pressure port in said second member to said pressure chamber only through a leakage path of increasing length between said surfaces from the port in said first member to said duct as the port in the first member moves from overlapping relation with said duct into full registration with the pressure port in said second member.

2. A valve according to claim 1 in which said portion of the contact face of said second member is defined by a groove in said contact face connected to said duct and extending in the direction of relative movement between said members.

3. A valve according to claim 1 in which said contact face of said second member contains a fine groove extending from said duct to a margin of said contact face and defining a bleed path for controlled flow of fluid from said pressure chamber.

4. A valve according to claim 1 including means defining a bleed path for dissipating pressure in said chamber.

5. A valve according to claim 1 in which said pressure port in said second member has an inwardly extending thin flange the outer face of which defines the portion of said contact face immediately surrounding said port and the opposite face of which is exposed to pressure in said port.

6. A valve according to claim 1 in which said means defining said pressure chamber comprises a recess in the rear side of said second member and piston means closing the outer end of said recess and abutting against said backing face of said casing.

7. A valve according to claim 1 in which said first member has a second port in its contact face connected to the other end of said fluid passage therein; said second member has a second port, and means for connecting said first mentioned and second ports in said second member to an external fluid line; said duct connecting to that portion of the contact face of said second member intermediate the said ports therein.

8. A valve according to claim 1 in which: said members are relatively rotatable about an axis normal to their contact surfaces; said first member has, in addition to said first mentioned port, second, third and fourth ports all symmetrically located about said axis, and a second passage, the first and second ports being adjacent each other and interconnected by said first mentioned fluid passage in said first member, and the third and fourth ports being interconnected by said second passage; said second member has in addition to said first mentioned port second, third and fourth ports so located as to register respectively with the four ports of the first member in said active

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position of said member and be isolated therefrom by the contact face of the first member in said neutral position; means defining second, third and fourth pressure chambers responsive to pressure therein for developing thrust between said second member and said backing face of said casing; and second, third and fourth ducts in said second member connecting said second, third and fourth pressure chambers respectively to different portions of the contact face of the second member in the paths of said second, third and fourth ports in said first member, said pressure chambers and ducts be circumferentially disposed between said ports in said second member in juxtaposed relation to the respective ports of said first member in said neutral position of said members.

9. A valve according to claim 8 in which said casing defines fluid passages registering with said ports in said second member; means connecting three of said ports in said second member in sealing relation with their associated registering passages in said casing, the fourth port and registering passage being in communication with the space between said casing and said members.

10. A valve according to claim 1 in which said casing defines a fluid passage extending thereinto from said backing face; said second member comprises a sleeve extending therefrom into said casing passage in telescoping relation therewith and communicating said pressure fluid passage in said second member with said casing passage, and means effecting a fluid seal between said sleeve and said casing passage, said casing passage being of larger cross-sectional area than said pressure port, whereby pressure in said passage urges said second member toward said first member.

11. A valve comprising casing means containing a rotatable member and a non-rotatable member, said members having cooperating contact faces adapted to substantially seal with each other when pressed together; means for

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rotating said rotatable member between a neutral and an active position; means supporting said rotatable member against movement with respect to said casing in direction away from said non-rotatable member, the latter having a rear side opposite its contact face and having an integral sleeve projecting from said rear side, and said casing having a backing face juxtaposed to said rear side and spaced therefrom, and a fluid passage extending through said casing from said backing face and receiving said sleeve in telescoping relation; said rotatable member having a fluid flow passage therein terminating in a port in its contact face, and said non-rotatable member having a pressure fluid passage therein communicating with said sleeve and terminating in a pressure port of reduced diameter in its contact face, the said ports being so positioned as to register with each other in said active position of said rotatable member and to be displaced from each other in said neutral position; and means effecting a fluid seal between said sleeve and said casing passage, said casing passage being of larger area than said pressure port, whereby pressure in said casing passage and said sleeve urges said non-rotatable member toward said rotatable member; said sleeve telescoping part way into said pressure fluid passage in said non-rotatable member and being rigidly joined thereto for movement therewith; and said pressure fluid passage having an inwardly extending, pressure-deflectable, thin flange at the contact face end thereof, said flange defining said pressure port of reduced diameter in said contact face.

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