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Harrison

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[54] **PUMP FOR HYDRAULIC STEERING UNIT**

[75] Inventor: **Robert R. Harrison,** Elyria, Ohio

[73] Assignee: **Nemo Corporation,** Cleveland, Ohio

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[52] **U.S. Cl.** **91/499,** 91/486, 417/291

[51] **Int. Cl.** **F01b 3/00,** F04b 49/00

[58] **Field of Search** ..... 91/6.5, 499; 417/291; 60/54.5 R

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Primary Examiner—William L. Freeh

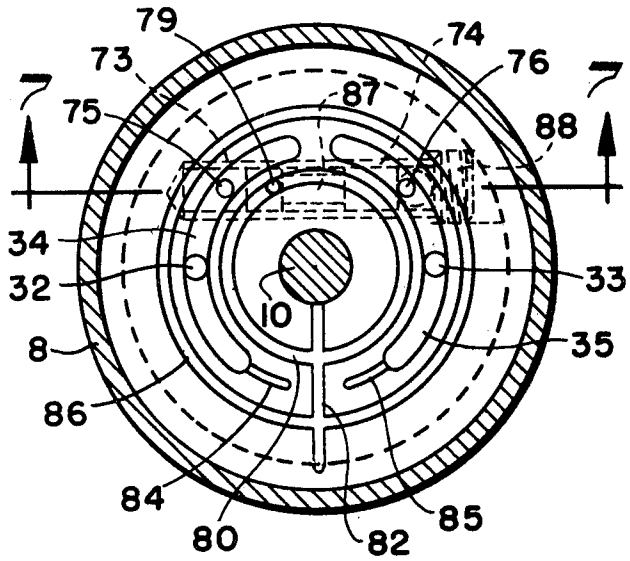
Assistant Examiner—G. P. LaPointe

Attorney—Donald L. Otto

[57] **ABSTRACT**

A pump of the fixed displacement type having a valve assembly which automatically dumps any excess return fluid from the higher volume side of an unbalanced slave cylinder during pressurizing of the lower volume side to prevent a build up of back pressure which might interfere with the operation of the pump.

9 Claims, 9 Drawing Figures



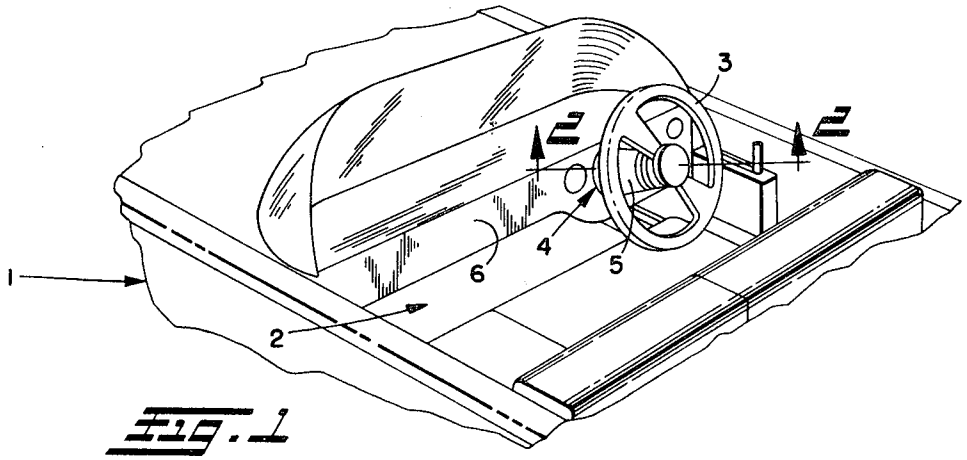


Fig. 1

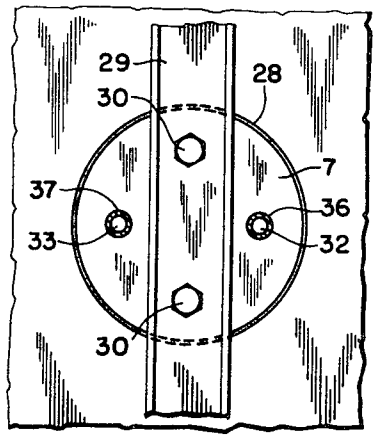


Fig. 3

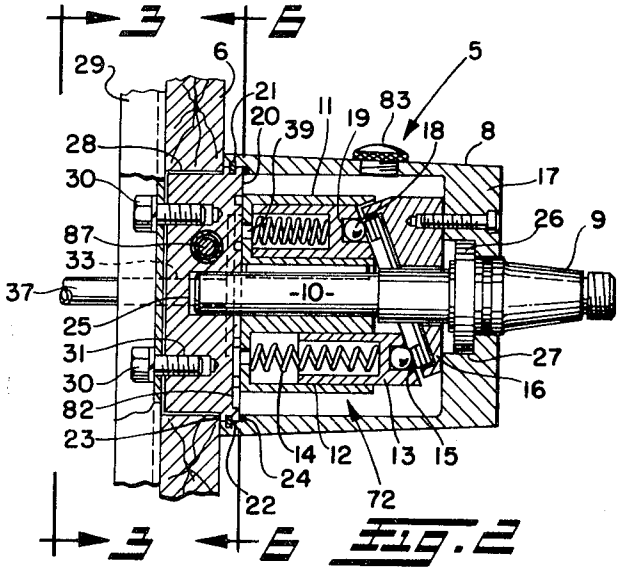


Fig. 2

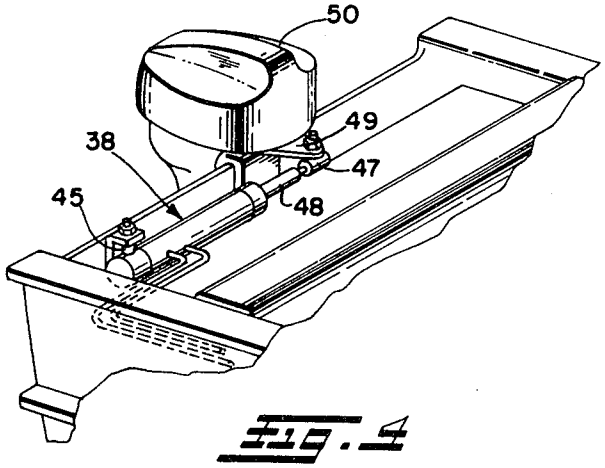


Fig. 4

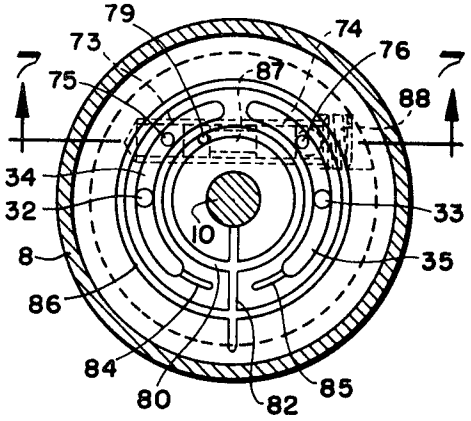


Fig. 6

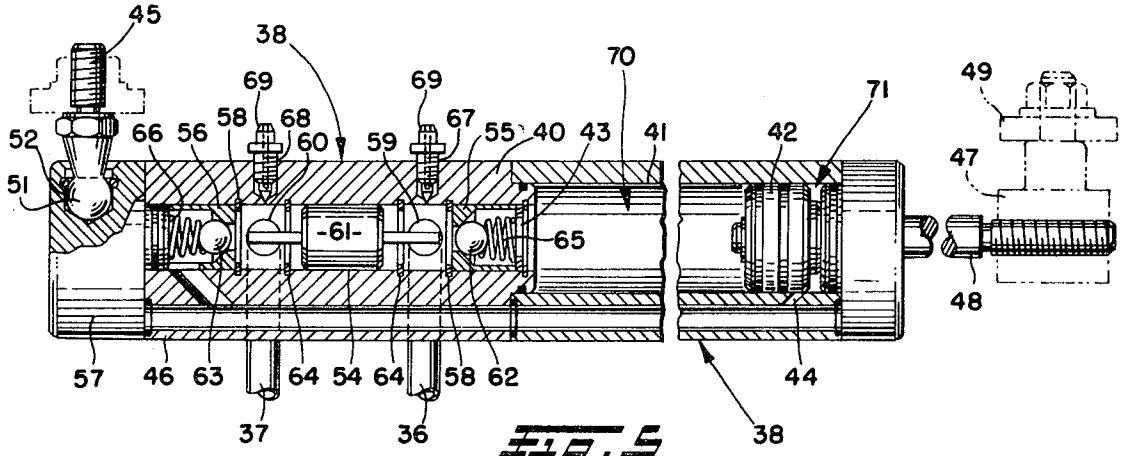


Fig. 5

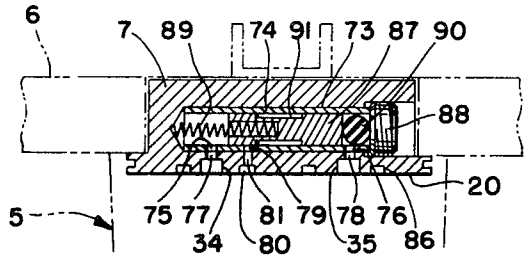


Fig. 7

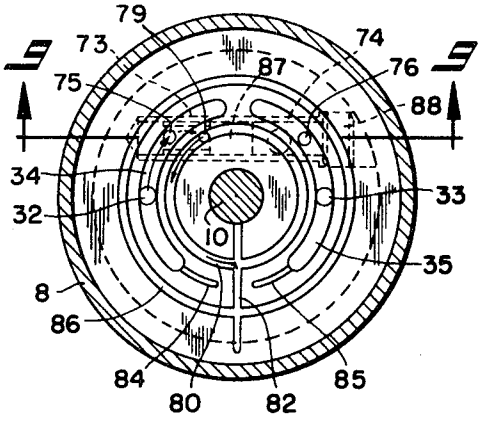


Fig. 8

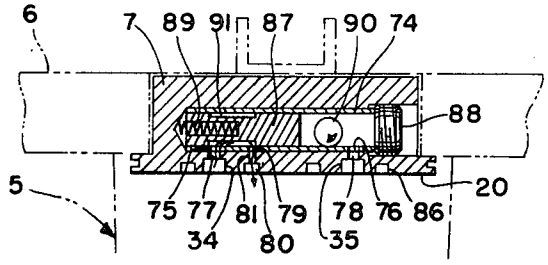


Fig. 9

PUMP FOR HYDRAULIC STEERING UNIT

BACKGROUND OF THE INVENTION

This invention relates generally as indicated to a pump, particularly for use in a hydraulic steering unit to control the movements of an outboard motor or rudder of a boat, which provides for automatic dumping of any excess return fluid from the higher volume side of an unbalanced slave cylinder to a reservoir during pressurizing of the smaller volume side without sacrifice in efficiency.

In a pump of the fixed displacement type, the pump fluid passes directly through the pump, and there is usually no provision for the return of excess fluid to the reservoir. Accordingly, such a fixed displacement pump can ordinarily only be used to operate a cylinder of unequal volumes if the manufacturing tolerances of the pump are such that the excess fluid which is returned to the pump during retraction of the piston is free to escape to the reservoir.

When the cylinder operated by the pump is used to control the movements of a device such as an outboard motor, the torque of the motor provides an additional force on the cylinder aiding in forcing the excess return fluid past the pump pistons. However, such pumps are not very efficient when such leakage occurs, making them especially unsuitable for certain steering systems where space limitations or other factors prevent use of a pump large enough to develop the required pressures.

Merely improving the efficiency of the pump is not enough since with improved efficiency, the amount of fluid leakage is usually greatly reduced and not adequate to dispose of the excess return fluid from the high volume side of the slave cylinder, causing a build up of back pressure which tends to lock the pump up and thus interfere with operation of the cylinder.

SUMMARY OF THE INVENTION

With the foregoing in mind, it is a principal object of this invention to provide a fixed displacement pump for use in operating an unbalanced slave cylinder which is highly efficient and yet will readily dispose of the excess return fluid from the high volume side of the slave cylinder during pressurizing of the small volume side.

These and other objects of the present invention may be achieved by providing a bore in the porting plate for the pump having axially spaced passages therein communicating with a pair of arcuate pressure grooves and an annular make-up groove in the inner end face of the porting plate. The axially spaced passages are isolated from each other during pressurizing of the arcuate groove which is normally connected to the high volume side of the slave cylinder by a spool valve axially slidably received in the bore. However, when fluid pressure is supplied to the arcuate groove which is normally connected to the low volume side of the slave cylinder, the valve spool automatically moves to a position establishing fluid communication between the passage leading to the arcuate groove connected to the high volume side of the cylinder and passage leading to the annular make-up groove for bypassing the excess return fluid.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail a certain illustrative embodiment of the invention, this being indicative, however, of but one of the various ways in which the principles of the invention may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the annexed drawings:

FIG. 1 is a fragmentary perspective view of a portion of a motor boat having mounted on the dashboard thereof the master unit of a steering system embodying a preferred form of pump constructed in accordance with this invention;

FIG. 2 is an enlarged partial longitudinal section through the master unit of FIG. 1 taken along the plane of the line 2—2 of FIG. 1;

FIG. 3 is an end elevation view of the master unit and mount therefor as seen from the plane of the line 3—3 of FIG. 2;

FIG. 4 is a fragmentary perspective view showing the slave unit of the steering system mounted in the stern of a boat;

FIG. 5 is an enlarged partial longitudinal section through the slave unit of FIG. 4;

FIG. 6 is a fragmentary transverse section through the master unit of FIG. 2, taken along the front face of the porting plate as seen from the plane of the line 6—6;

FIG. 7 is a fragmentary longitudinal section through the porting plate of FIG. 6, taken on the plane of the line 7—7 thereof;

FIG. 8 is a fragmentary transverse section similar to FIG. 6 but showing the spool valve moved to a different position which occurs during application of high pressure to the arcuate groove connected to the low volume side of the slave cylinder; and

FIG. 9 is a fragmentary longitudinal section through the porting plate of FIG. 8, taken on the plane of the line 9—9.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in detail to the drawings and initially to FIG. 1 thereof, there is illustrated by way of example a power boat 1 which may be of conventional design including a seating compartment 2 having a steering wheel 3 operatively connected to the master helm unit 4 of a steering system embodying a pump 5 constructed in accordance with the present invention. The master helm unit 4 may be suitably mounted on the dash panel or other suitable mounting support 6 within the boat, in a manner to be more fully described hereafter.

As clearly shown in FIG. 2, the pump mechanism 5 includes a porting plate 7 through which hydraulic fluid flows to and from the pump mechanism 5 as explained below. The pump mechanism 5 is desirably wholly contained within a cylindrical housing 8 which may be a die-casting or stamping projecting outwardly from the front side of the mounting support 6 to provide a mount for a drive shaft 9 and shaft extension 10 enclosed by the cylindrical housing.

The pump mechanism 5 is of the fixed displacement type and desirably consists of a cylinder body 11 keyed to the shaft extension 10 for rotation therewith. Contained within the cylinder body 11 are a plurality of circumferentially spaced axially extending cylinder bores 12 in which there are pistons 13 that are urged axially outwardly by springs 14 against the inclined face 15 of a cam or swash plate 16 bolted to the end wall 17 of the cylindrical housing 8. Ball bearings 18 contained in re-

cesses 19 in the outer ends of the pistons 13 provide rolling engagement with the swash plate.

The inner end of the cylinder body 11 may be maintained in sliding sealed engagement with the inner end face 20 of the porting plate 7 by a snap ring 21 which secures the cylindrical housing 8 and porting plate 7 together. A counterbore 22 in the inner end of the cylindrical housing 8 receives a radial flange 23 on the porting plate for accurately locating the porting plate therein and limiting the extent of inward movement of the porting plate into the cylindrical housing by engagement of the flange with the end wall 24 of the counterbore. A central recess 25 in the inner end face 20 of the porting plate 7 closely slidably receives the inner end of the shaft extension 10 to provide a bearing support therefor, and the shaft extension is also journaled in a roller bearing 26 contained in an opening 27 in the housing end wall 17 through which the shaft extension projects.

The porting plate 7 is adapted to be received in an opening 28 in the mounting support 6 and secured in place as by attachment of a narrow channel member 29 to the porting plate using suitable fasteners 30 extending through openings in the channel member into tapped holes 31 in the porting plate. The channel member 29 is placed behind the dashboard panel 6 and is of a length greater than the diameter of the opening 28 in the dash panel which receives the porting plate, whereby tightening of the fasteners 30 draws the pump 5 into tight engagement with the dash panel.

Spaced apart ports 32, 33 in the porting plate 7 communicate with arcuate pressure grooves 34, 35, respectively, in the inner end face 20 of the porting plate as shown in FIGS. 2, 3 and 6 and the width of the channel member 29 is desirably less than the spacing between such ports 32, 33 as shown in FIG. 3 so as not to interfere with the connections between such ports and the fluid lines 36 and 37 which are used to connect the master unit 4 to the slave unit 38 as described hereafter. Attached to the drive shaft 9 is a steering wheel 3 (see FIG. 1) which when rotated causes the cylinder body 11 to rotate. During rotation of the cylinder body, the cylinder bores 12 alternately communicate with the arcuate grooves 34, 35 through openings 39 in the inner end of the cylinder body (see FIG. 2) for circulation of hydraulic fluid through the system.

The slave unit 38 is shown in FIGS. 4 and 5 and comprises a cylinder 40 including a chamber 41 containing a piston 42 axially movable therewithin upon venting and pressurizing opposite ends of the chamber through the associated ports 43 and 44. A mounting shaft 45 may be secured to the head end 46 of the cylinder to facilitate attachment of the slave unit to the stern of a boat, and a suitable coupling 47 may be provided on the projecting end of the piston rod 48 for connection to the tiller handle 49 of the motor 50 or rudder of the boat as shown in FIG. 4. The inner end of the mounting shaft 45 may be provided with a ball joint 51 for receipt in a socket 52 in the head end of the cylinder and retained in place by a snap ring 53 to permit pivotal movement of the slave unit during actuation of the tiller handle 49 by the slave cylinder 40.

In the head end 46 of the slave cylinder 40 there is desirably provided a bore 54 for receipt of a pair of axially spaced check valve bodies 55, 56. Preferably, the bore 54 extends longitudinally through the head end of the cylinder, communicating with the port 43 and closed at its outer end by an end plate 57 suitably attached to the cylinder. The check valve bodies 55, 56 may be retained in spaced apart relation within the bore 54 by snap rings 58 or the like, and one end of the check valve body 55 may abut against the end plate 57 as shown in FIG. 5. The external ports 59, 60 in the slave unit 38 to which the fluid lines 36, 37 from the master unit 4 are connected communicate with the bore 54 between the check valve bodies 55, 56 and adjacent ends of a shuttle valve 61 disposed therebetween.

During normal operation, turning of the steering wheel 3 in one direction causes fluid pressure to be pumped through the fluid line 36 to the associated external port 59 in the slave unit 38, which opens the associated check valve 62 for flow of high fluid pressure through the port 43 in the left end of the chamber 41. At the same time, such high fluid pressure acting on the right end of the shuttle valve 61 causes the shuttle valve to move to the left unseating the other check valve 63 for return flow of hydraulic fluid from the right end of the chamber. Turning of the steering wheel 3 in the reverse direction causes a reversal in the flow of fluid between the master unit 4 and slave unit 38 as previously described. Snap rings 64 contained within the bore 54 between the external ports 59, 60 and shuttle valve 61 act as stops limiting the movement of the shuttle valve toward the respective check valves 62, 63 to avoid blocking communication between the check valves and external ports by the shuttle valve during opening of the check valves by the projections on the shuttle valve.

Should there ever be a complete loss of fluid pressure within the fluid lines 36, 37, the check valves 62, 63 will remain closed by the associated springs 65, 66 thus locking the slave piston 41 against movement even when a high external force is applied to the piston rod 48. This eliminates any chance of unexpected or wild movements of the steering mechanism for the boat which could endanger the safety or lives of the occupants. The piston 42 is retained in the same position until fluid pressure is restored to the system and the operator turns the steering wheel in the desired direction.

To assure rapid assembly and bleeding of the hydraulic steering system, a pair of bleed ports 67, 68 may be provided in the slave cylinder 40 communicating with the bore 54 between the check valve bodies 55, 56 and adjacent ends of the shuttle valve 61. Contained within the ports 67, 68 are needle valves 69 which may readily be backed off to bleed the hydraulic system and tightened upon completion of the bleeding operation.

Heretofore, the excess fluid which was returned to the pump mechanism 5 during venting of the higher volume side 70 of the slave unit 38 and pressurizing of the smaller volume side 71 was free to escape to the reservoir 72 surrounding the pump mechanism because of manufacturing tolerances which permitted fluid leakage between pump parts. However, such fluid leakage greatly reduces the efficiency of the pump, and there are instances when, due to space limitations and other factors, a more efficient pump is necessary to obtain the required maximum pressures during operation.

A pump can readily be made more efficient with improved tolerances, but in that event provision must be made for disposing of the excess return fluid from the high volume side of the slave cylinder during pressurizing of the small volume side or otherwise the pump will have a tendency to lock up thereby preventing proper

control of the slave cylinder. Such excess return fluid is disposed of by the pump mechanism 5 of the present invention by providing a transverse bore 73 in the porting plate 7 in which is pressed a steel liner 74 having a pair of holes 75, 76 therein adjacent opposite ends of the liner communicating with the arcuate grooves 34, 35, respectively, in the inner end face 20 of the porting plate through passages 77, 78 therein and an intermediate hole 79 in the liner 7 communicating with an annular make-up groove 80 in the inner end face of the porting plate radially inwardly of the arcuate grooves 34, 35 through a further passage 81 in the porting plate. See FIGS. 2, 6 and 7 in this respect.

The annular make-up groove 80 is intersected by a radial groove 82 in the inner end face of the porting plate which extends radially outwardly from the center of the porting plate between the arcuate grooves 34, 35 on the suction side of the pump beyond the cylinder body 11 to provide communication with the interior of the cylinder housing 8 which is used as the reservoir 72 for make-up fluid. A removable cap 83 may be provided on the top of the housing 8 for filling the reservoir with hydraulic fluid, and narrow extensions 84, 85 may also be provided on the arcuate grooves 34, 35 in the inner end face of the porting plate adjacent the region where the pistons 13 are fully extended to prevent cavitation.

A further annular groove 86 may also be provided in the inner end face of the porting plate completely surrounding the arcuate grooves 34, 35 and intersecting the radial groove 82 for filling by low pressure fluid which provides additional make-up fluid to the low pressure groove by passage between the mating faces of the porting plate and cylinder body and also retards leakage from the high pressure groove between such mating faces.

Axially slidably received in the bore liner 74 is a spool valve 87 which is retained within the bore 73 by a pipe plug 88 threaded into the open end of the bore and biased toward such open end by a return spring 89 interposed between the spool valve 87 and blind end of the bore.

When high fluid pressure is supplied to the arcuate groove 34 connected to the high volume side 70 of the slave cylinder 40, such high fluid pressure enters the blind end of the spool valve bore 73 to aid the spring 89 in urging the spool valve 87 toward the right as seen in FIGS. 6 and 7 for blocking fluid communication between the arcuate groove 34 and annular make-up groove 80 via the holes 75, 79 in the bore liner 74. A rubber bumper 90 interposed between the pipe plug 88 in the open end of the bore 73 and the adjacent end of the spool valve 87 prevents the spool valve from covering the hole 76 communicating with the arcuate groove 35 connected to the low volume side 71 of the slave cylinder 40. Accordingly, the low pressure return fluid from the low volume side of the slave cylinder is free to act on the right end of the valve spool but the valve spool will still remain in its rightmost position shown in FIGS. 6 and 7 so long as the combined force of the fluid pressure and spring 89 acting on the left end of the valve spool is greater than the pressure acting on the opposite end thereof.

However, when the direction of rotation of the pump 5 is reversed to provide high fluid pressure to the arcuate groove 35 connected to the low volume side 71 of the slave cylinder 40, the higher fluid pressure acting on the right end of the valve spool 87 causes the valve spool to move to the left against the bias of the return spring 89. When the valve spool 87 has moved to its leftmost position shown in FIGS. 8 and 9, the necked or grooved portion 91 of the valve spool 87 uncovers both of the holes 75, 79 communicating with the arcuate groove 34 connected to the high volume side 70 of the slave cylinder and annular make-up groove 80, respectively, for bypassing the excess return fluid from the high volume side of the slave cylinder to the reservoir 72 through the holes 75, 79, annular make-up groove 80, and radial groove 82 in the inner end face of the porting plate communicating with the reservoir. When the pumping is stopped, the spring 89 again returns the valve spool 87 to the closed position shown in FIG. 5 blocking the hole 79 communicating with the annular make-up groove 80 thus blocking flow to the reservoir.

Since the unbalance of fluid pressure only occurs during the application of high fluid pressure to the low volume side 71 of the slave cylinder 40 and the return of fluid pressure to the pump from the high volume side 70, only one such bypass valve 87 need be provided so long as the appropriate ports in the pump 5 and slave cylinder 40 are connected together. However, two such valves 87 and associated porting may be provided if desired for bypassing any excess return fluid entering either or the arcuate grooves 34, 35 so that either of the ports 32, 33 on the pump may be connected to the ports 59, 60 on the slave cylinder 40 without danger of creating any undesired back pressures.

From the foregoing, it will now be apparent that the fluid pump of the present invention provides a very simple and effective means for preventing any build up of back pressure which might adversely affect the operability of the device when used to control movements of an unbalanced fluid cylinder.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A pump mechanism for operating an unbalanced cylinder comprising a housing, a pump body contained within said housing, said pump body having a plurality of circumferentially spaced axially extending cylinder bores, cylinder ports in the inner end of said pump body communicating with said cylinder bores, means for rotating said pump body to cause reciprocation of said pistons within said cylinder bores, a porting plate secured to said housing having an end face in sliding sealed engagement with the inner end of said pump body, a pair of arcuate grooves in said end face of said porting plate which alternately communicate with said cylinder bores during each revolution of said cylinder body, an annular make-up groove in said end face radially inwardly of said arcuate grooves, a radial groove in said end face between said arcuate grooves on the suction side of said pump mechanism, said radial groove intersecting said annular make-up groove and extending radially outwardly beyond said cylinder body to provide communication with the interior of said housing, said housing comprising a reservoir containing make-up fluid which is supplied to said cylinder bores during rotation past said radial groove, a transverse bore in said porting plate, first and second passages in said porting plate communicating said arcuate grooves with said transverse bore in axially spaced relation along the length of said transverse bore, a third passage

in said porting plate communicating said annular make-up groove with said transverse bore intermediate said first and second passages, and a spool valve axially movable within said transverse bore between a first position blocking fluid communication between said passages and a second position establishing fluid communication between said first and third passages while still blocking communication with said second passage for bypassing excess fluid entering said arcuate groove communicating with said first passage to said reservoir.

2. The pump mechanism of claim 1 further comprising spring means acting on one end of said spool valve for biasing said spool valve to said first position.

3. The pump mechanism of claim 2 wherein the fluid pressure entering said transverse bore from said arcuate groove communicating with said first passage acts on said one end of said spool valve to aid said spring means in maintaining said spool valve in said first position.

4. The pump mechanism of claim 3 further comprising means for preventing said spool valve from blocking communication between said second passage and transverse bore when said spool valve is urged to said first position and permitting the fluid pressure entering said transverse bore through said second passage to act on the other end of said spool valve in opposition to the force of said spring means and fluid acting on said one end of said spool valve.

5. The pump mechanism of claim 4 wherein said means for preventing said spool valve from blocking communication between said second passage and transverse bore comprises a rubber-like bumper interposed between said other end of said spool valve and adjacent end of said transverse bore.

6. The pump mechanism of claim 1 wherein said spool valve has a necked portion for establishing fluid communication between said first and third passages when said spool valve is in said second position.

7. The pump mechanism of claim 1 further comprising a liner in said transverse bore, said spool valve being axially slidable within said liner, and said liner having axially spaced holes therein communicating with said first, second, and third passages in said porting plate.

8. The pump mechanism of claim 1 further comprising means for connecting said first passage to the high volume side of an unbalanced cylinder and connecting said second passage to the low volume side of an unbalanced cylinder.

9. The pump mechanism of claim 1 wherein said means for rotating said pump body to cause reciprocation of said pistons within said cylinder bores comprises a drive shaft for said cylinder body, an inclined swash plate fixed to said housing adjacent the other end of said cylinder body, and spring means urging said pistons into engagement with said swash plate.

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