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HYDRAULIC ACTUATING SYSTEM

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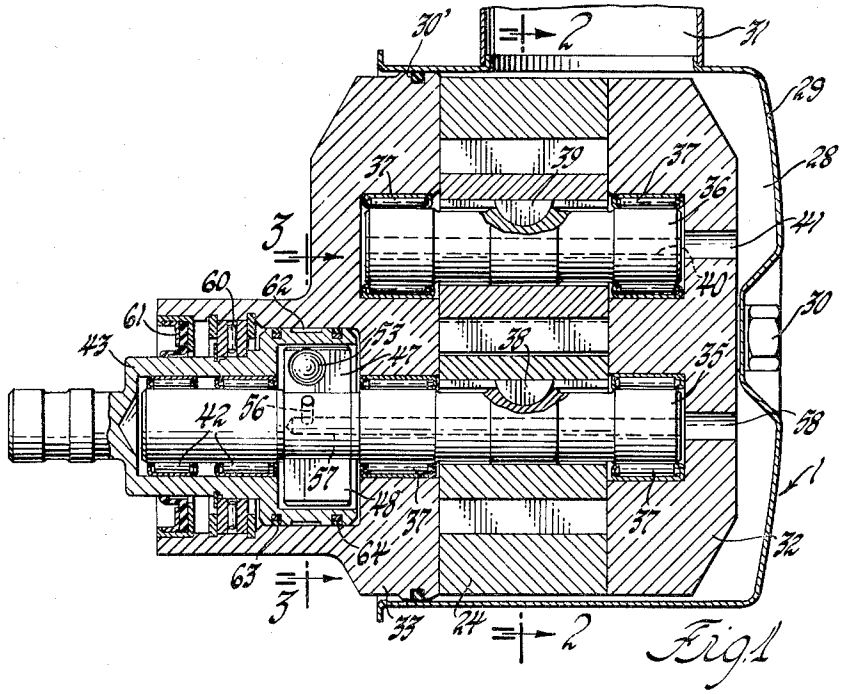


Fig. 1

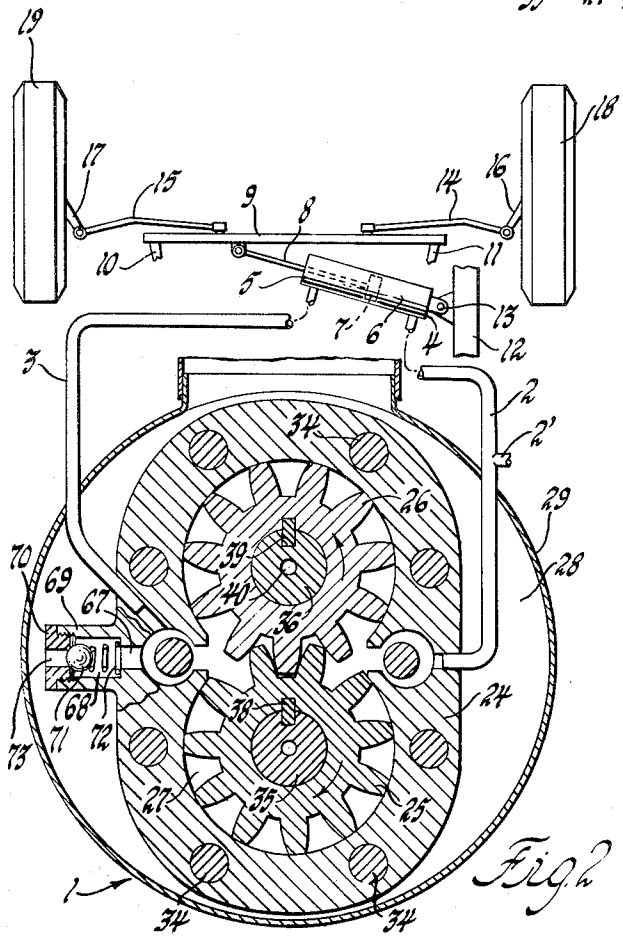


Fig. 2

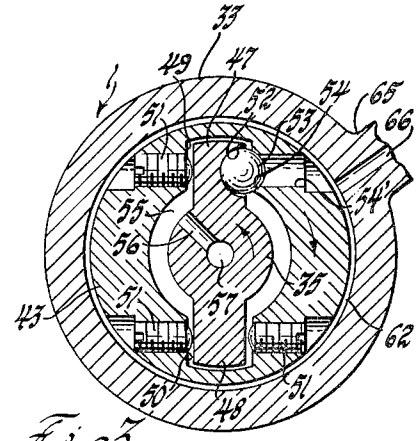


Fig. 3

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# HYDRAULIC ACTUATING SYSTEM

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This invention relates to hydraulic actuating systems wherein a hydraulic motor is fluid driven in either of two directions by a reversely drivable pump, and wherein one of the motor and pump has a greater difference in fluid displacement in one direction of operation than does the other.

Since the volume of fluid delivered to the motor by the pump must equal the fluid returned to the pump by the motor such directional difference in displacement presents a problem in handling the excess fluid returned to the pump when driven in one direction, and in making up for the deficiency of fluid returned thereto when the direction of operation is reversed. Although such difference in fluid displacement can be compensated for by employing a sump and a pump pressure operated shuttle valve which will open the sump to alternate sides of the pump with change in pump operating direction, these valves are subject to faulty operation, and the large fluid displacement they require to insure sensitivity of their operation detracts from the sensitivity and efficiency sought in the actuation of the motor. Also, while it is possible to mechanically link such a shuttle valve to the pump, such an arrangement has disadvantages in cost of construction and avoidance of excessive leakage if it is not to have an objectionable amount of lost motion.

It is the object of my invention to compensate for the aforementioned difference in fluid displacement by means which is relatively simple and inexpensive and which does not have any of the disadvantages of either the pump pressure operated or the mechanically operated shuttle valve. I obtain the desired result by arranging the sump with both an inlet and an outlet and providing valves controlling each so that fluid returned from the motor in excess of fluid delivered thereto by the pump may enter the sump, and fluid necessary to supplement that being returned from the motor during operation in the opposite direction may be drawn from the sump. The valve controlling the sump inlet flow is mechanically responsive to direction of pump operation, while the valve controlling sump outlet flow may be merely pressure responsive in operation.

The invention will be more clearly understood from the following description of one preferred embodiment thereof which I have selected for purposes of illustration, having reference to the drawing, wherein:

FIGURE 1 is a longitudinal sectional view through a gear type pump having a sump associated therewith and showing a valve controlled inlet to the sump in accordance with the invention.

FIGURE 2 is a transverse sectional view taken substantially along the line 2—2 of FIGURE 1, together with a hydraulic motor and associated elements shown schematically arranged therewith and illustrating application of the invention to a hydraulic steering system of a motor vehicle.

FIGURE 3 is a fragmentary sectional view of the pump taken substantially along the line 3—3 of FIGURE 1.

Referring now in detail to the drawing, and first to FIGURE 2, a gear type pump is shown designated generally by the numeral 1. Connected in closed series fluid circuit with the pump, as represented by fluid lines 2 and 3, are the respective ends 4 and 5 of a reversible hydraulic motor 6. The motor is shown in the form of a power cylinder having a piston 7 therein with a connecting rod 8 extending outwardly of the end 5 for reciprocal actuation of a vehicle steering system relay rod 9 whose opposite ends are suitably hinged by links 10 and 11 to the vehicle frame 12 by means not shown. The end 4 of the power cylinder is pivotally anchored at 13 to this frame, and tie rods 14 and 15 pivotally link the relay rod to steering arms 16 and 17 which dirigibly control the vehicle wheels 18 and 19.



The pump 1 comprises a housing 24 with meshing driving and driven gears 25 and 26 which cooperate in conventional manner when rotated in the housing chamber 27 to positively displace hydraulic fluid into either the line 2 or the line 3, depending on the direction of rotation of the gears. It is to be understood, however, that the invention is not limited to the use of this particular type pump, but may employ any other known form of positive displacement pump which is reversely drivable in accordance with the desired direction of actuation of the motor 5. Likewise, while the motor 5 illustrated is of the cylinder and piston type, any other form of positive displacement motor may be employed which is reversely drivable by the pump 1, it being only necessary in utilizing the principles of my invention that either the motor or the pump have a greater difference in fluid displacement than the other in one direction of operation than in the opposite direction.

A sump 28 is also provided, being shown in the form of an enclosure shell 29 surrounding the pump housing and secured and sealed thereto, respectively, as by the bolt 30 and gasket 30' seen in FIGURE 1. At the upper end of the shell 29 is an opening 31 through which hydraulic fluid such as oil may be introduced in filling the sump. Embracing the opposite ends of the pump housing 24 are housing end members 32 and 33, being held thereagainst by suitable studs 34 (FIGURE 2). The shafts 35 and 36 of the respective pump gears are suitably journaled in bearings 37 in each of these housing end members, and are suitably keyed as at 38 and 39 to the pump gears. The oil level in the sump 38 will normally be maintained above the level of the shaft 36, and this shaft is axially drilled to provide a lubricating passage 40 so that the hydraulic fluid in the sump is available at all times for lubrication of the bearings 37, the oil entering this passage 40 through a connecting hole 41 in the housing end member 32.

Means for driving the pump includes the shaft 35 which extends beyond its bearings 37 in the housing end member 33, and is suitably journaled in additional bearings 42 at its extended end. Journaled on these same bearings 42 within the housing end member 33 is a pump driving member 43 which has a lost motion driving connection with the shaft 35. This lost motion driving connection, as best seen in FIGURE 3, comprises radially opposite tongue portions 47 and 48 on the shaft 35 extending into recesses 49 and 50 provided in the driving member 43. These recesses are of sufficient circumferential extent about the axis of the shaft 35 that relative rotation between the shaft 35 and the member 43 may occur. The extent of this lost motion is adjustable by set screws 51 extending oppositely toward the tongue 48 in the member 43 and a like set screw 51 is disposed opposite one side of tongue 47. This tongue 47 is formed with a pocket 52 for retaining a ball valve 53, and opposite the pocket 52 is a ball seat 54 and a passage 54' extending therefrom through the member 43. Sufficient clearance is provided between the pocket 52 and the ball seat 54 to accommodate fluid flow around the ball when the tongue 47 is in abutment with its set screw 51. Clearance 55 also is provided within the member 43, inwardly of the recesses 49, 50, for the oil to circulate when the ball valve 53 is open, and a radial passage 56 and a connecting axial passage 57 are provided in the

shaft 35 to connect this clearance space 55 with a sump through an opening 58 in the housing end member 32.

FIGURE 1 shows a two-way thrust-bearing 60 suitably secured in the housing end member 33 to maintain the driving member 43 in proper position axially of the pump shaft 35, and spaced outwardly of this thrust bearing is a suitable oil seal 61. Adjacent its inner end, the outer circumference of the driving member 43 is provided with an annular groove 62, and on opposite sides of this groove are provided seals 63, 64. An enlargement or boss 65, shown in FIGURE 3, is located on the exterior of the housing end member 33, and a passage 66 extends therethrough to connect with this groove 62. A branch line 2' connects line 2 with this passage 66. It will thus be seen that an inlet to the sump in the form of a one-way flow connection with the motor-pump line 2 is provided via the branch line 2', boss passage 66, groove 62, passage 54', clearance space 55, pump shaft passages 56 and 57 and housing end passage 58.

An outlet from the sump is provided in the form of a one-way flow connection with the opposite motor-pump line 3, as shown in FIGURE 2. This comprises a passage 67 extending through the pump housing 24 from the pump chamber 27 adjacent the connection to the latter by the fluid line 3. At its outer end, this passage communicates with a spring chamber 68 within a projecting boss 69. At the outer end of this boss is a valve seat 70 against which a ball valve 71 is normally biased by a coil spring 72. A passage 73 in this valve seat, normally closed by the ball valve 71, completes this second flow connection.

During operation, by reason of the motor 6 having a greater fluid displacement during movement of its piston 7 toward the cylinder end 4 than during movement of the piston toward the end 5, a greater volume of fluid is returned by the motor to the line 2 than is delivered by the pump to line 3. Likewise, by reason of this same difference in fluid displacement of the motor, during movement of the piston 7 toward the cylinder end 5 a smaller volume of fluid is returned by the motor to line 3 than is delivered by the pump to line 2. In the former case (during movement of the piston to the right as shown in FIGURE 2) the pump operation is in the direction of the arrows shown in FIGURES 2 and 3, with the result that the pump driving member 43 tends to lead its driven member, i.e. shaft 35, and the ball valve 53 is thus enabled to uncover the passage 54. During such operation, the one-way flow connection of branch line 2', passages 66, 54', 56, 57 and 58 is open for returning to the sump such excess fluid displaced by the motor. No loss of pump fluid pressure to the motor from the other side of the pump can occur, because such pressure maintains the check valve 71 closed.

On the other hand, during movement of the motor piston to the left as viewed in FIGURE 2, the pump is operating in the opposite direction from that shown by the arrows in FIGURES 2 and 3, and the rotary lost motion between the pump driving member 43 and pump shaft 35 is taken up with the result that the ball valve 53 is held tightly on its seat 54 so as to maintain the passage 54' closed. No loss of fluid pressure from line 2 can thus occur via the branch line 2'. The deficiency in fluid volume being returned via line 3 to the pump, relative to the pump fluid volume delivered to the motor via line 2, tends to create a vacuum in the passage 67 and spring chamber 68. As a result, the check valve 71 opens, admitting the necessary additional volume of fluid to that side of the pump from the sump 28.

It will thus be seen that my invention provides a very simple and low cost arrangment for compensating for the difference in directional fluid displacement of the motor relative to that of the pump. The operation is automatic yet requires no substantial amount of fluid displacement to operate the one-way valves, and the valve members of both one-way flow connections are self-sealing. It will be



appreciated that various minor changes in the construction and arrangement of the parts will readily suggest themselves to persons skilled in the art without departing from the spirit and scope of the invention as defined by the following claims.

I claim:

1. In combination with a reversely drivable hydraulic motor having greater fluid displacement in one direction of operation than in the opposite direction, a reversely drivable positive displacement pump in fluid driving relation with said motor, said pump having equal fluid displacement in both directions of operation, a sump having a first one-way flow connection with the motor accommodating flow to the sump of the volume of motor displaced fluid exceeding the volume of pump delivered fluid during operation in said one direction and having a second one-way flow connection with the pump accommodating flow of fluid to the pump to compensate for the volume of pump delivered fluid exceeding the volume of motor returned fluid during operation in said opposite direction, and pump driving and driven members having a lost motion connection therebetween, said first one-way flow connection including a passage in one of said members and a valve operable by the other of said members to close said passage when said lost motion is taken up in response to operation of the pump in said opposite direction.

2. In combination with a reversely drivable hydraulic motor and a reversely drivable hydraulic pump in closed circuit fluid driving relation with said motor, one of said motor and pump having a substantially greater fluid displacement in one direction than in the opposite direction and the other of said motor and pump having more equal fluid displacement in both directions of operation, a sump having an inlet for fluid displaced from said one of said motor and pump in excess of fluid returned thereto from the other thereof during operation in said one direction and on outlet for fluid to supplement the fluid returned to said other thereof during operation in said opposite direction, a valve controlling sump inlet fluid flow and a check valve controlling sump outlet fluid flow, and means for driving said pump, said inlet flow controlling valve being closable by said driving means in response to operation of said pump in said opposite direction.

3. In combination with a reversible hydraulic motor having greater fluid displacement in one direction of operation than in the opposite direction, a reversibly drivable positive displacement pump connected in closed fluid circuit relation with said motor and having substantially equal fluid displacement in both directions of operation, a sump for receiving fluid displaced by the motor in excess of fluid delivered thereto by the pump during operation in said one direction and for supplementing fluid return to the pump from the motor during operation in said opposite direction, pump driving means including driving and driven members having limited lost motion therebetween, said driving member having a passage for said excess fluid flow to the sump, and a valve operable by said driven member to close said passage, said lost motion accommodating opening said passage with operation of the pump in said one direction.

4. In a hydraulic actuating system including a power cylinder closed at each end, a piston operable therein and having a connecting rod extending outwardly of one end of the cylinder, a reversely drivable rotary pump connected in closed fluid circuit relation with the respective ends of the cylinder, a sump having an inlet and an outlet, said outlet being in fluid communication with said one end of the cylinder and having a check valve blocking flow into the sump via said outlet, driving means for the pump including a pump shaft and a member having a rotary lost motion driving connection with said shaft, said inlet comprising a passage in said member communicating at one end with the sump and at its opposite end with the end of the cylinder remote from said con-

necting rod, a valve seat on said member at said sump communicating end of said passage, a valve engageable with said seat to close said passage and movable away from said seat to open said passage, said shaft having a portion engageable by said member upon taking up said lost motion in one direction and engageable with said valve to move it against said seat upon taking up said lost motion in the opposite direction.



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