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PISTON RETURN MECHANISM

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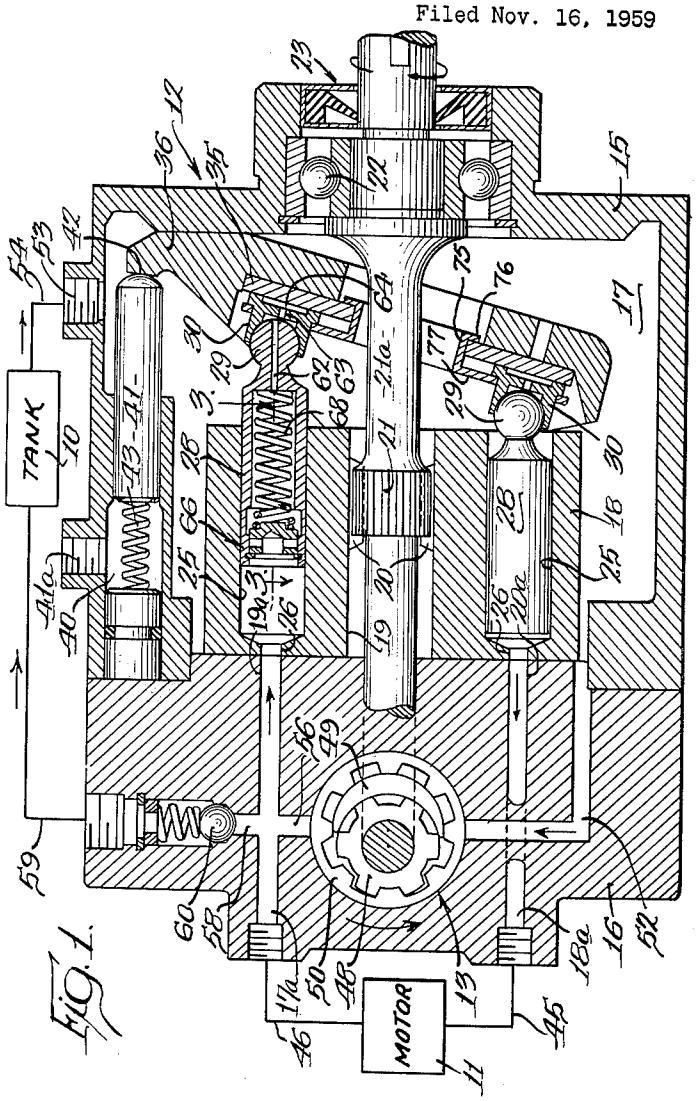


FIG. 1.

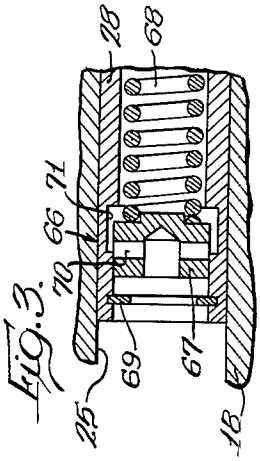


FIG. 3.

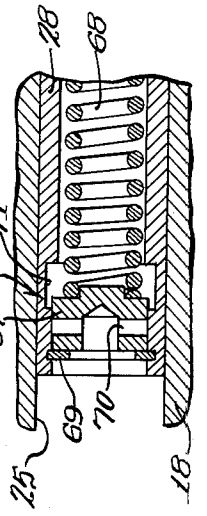


FIG. 2.

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PISTON RETURN MECHANISM

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This invention relates to hydraulic fluid translating devices such as pumps and motors for handling hydraulic fluid.

It is a general object of the invention to provide a new and improved device of the type described.

Another object is to provide a new and improved fluid translating device including cam controlled reciprocable pistons each having a passage therethrough controlled by a spring closed valve so that the full area of the piston is exposed to fluid pressure on the low pressure side of the device and so that the head of the piston is hydrostatically balanced when on the high pressure side of the device.

In devices of the type described, particularly axial piston pumps wherein the pistons are moved through pumping strokes by engagement with a swashplate or wobble, it has been common practice to provide for movement of the pistons through return strokes by means of spring mechanisms, including either individual springs (mounted inside the cylinder or outside the cylinder) with each piston or a single spring acting against a plate outside the cylinder block, the plate in turn bearing against each of the piston heads. However, spring mechanisms of this type have a limited life cycle as the springs deteriorate after rather short periods of operation due to repeated compression and expansion. Further in a spring return mechanism utilizing a single spring and a plate engaging the piston heads, the plate does not effectively maintain the pistons in contact with the swashplate or other cam surface due to manufacturing tolerances in the plate and in the pistons. Additionally, the plate type return adds a frictional drag to the unit by reason of its contact with the revolving pistons or with bearing shoes on the pistons.

With the above and other considerations in mind, it is a more specific object of the present invention to provide a new and improved axial piston pump wherein the pistons are moved through pumping strokes by a swashplate, and wherein a charge pressure is maintained on the intake side of the pump to return the pistons through the suction strokes. The pistons preferably carry bearing shoes engaging the swashplate and a passage is provided through each piston and the bearing shoe thereon with a valve in the passage closable toward the cylinder by a spring having sufficient force to maintain the valve closed while exposed to inlet pressure, but having insufficient force to maintain the valve closed while exposed to high pressure on the discharge side of the pump so that the pistons are thereby hydrostatically balanced during the pumping stroke.

Another object is to provide a new and improved circuit embodying a main pump of the type described above, a charge pump for supercharging the main pump inlet, and a motor having an inlet connected with the main pump outlet and an outlet connected with the main pump inlet.

Other objects and advantages will become readily apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a diagrammatic view of a circuit embodying, as illustrated somewhat diagramamtically in longitudinal section, a pump constructed with pistons according to the principles of the present invention;

FIG. 2 is an enlarged fragmentary view illustrating a

valved piston, with the valve in closed position as when exposed to low pressure; and

FIG. 3 is an enlarged fragmentary sectional view illustrating the valved piston with the valve open as when exposed to high pressure.

While an illustrative embodiment of the invention is shown in the drawings and will be described in detail herein, the invention is susceptible of embodiment in many different forms, and it should be understood that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated. The scope of the invention will be pointed out in the appended claims.

Referring now to the drawings in more detail, FIG. 1 illustrates diagrammatically a closed circuit hydraulic pumping system including a tank or reservoir 10 for holding a supply of hydraulic fluid, a hydraulic motor 11 to be driven by fluid pumped thereto under pressure, a main pump 12, and a charge pump 13.

The main pump 12 preferably comprises a housing 15 having an open end adapted to be closed by an end block or cover 16 suitably secured to the housing. The housing 15 is provided with an internal cavity 17 adapted to rotatably receive a cylinder block 18 preferably formed centrally with an axial bore as at 19. The bore 19 is formed at least partially with splines or keys as illustrated at 20 for receiving a shaft portion 21 formed in a complementary fashion and comprising a part of a drive shaft 21*a*. The drive shaft 20 may be rotatably mounted in the housing 15 as by means of bearings 22. Preferably, a shaft seal 23 prevents a leakage of fluid along the shaft 20. Obviously, the shaft may be connected at the right end as illustrated with a suitable prime mover for driving the pump.

The block 16 is formed with a suitable inlet passage as at 17*a* and a suitable outlet passage as at 18*a*, both of which lead to the cavity 17 and preferably terminate in arcuately shaped inlet and outlet kidneys, respectively, as at 19*a* and 20*a*. Such kidneys may conform generally to the type illustrated, for example, in the copending application of Donald Reinke et al., filed September 19, 1955, as Serial No. 535,164 and now abandoned. The cylinder block 18 is formed with a series of angularly spaced axially extending cylinders as at 25, and also includes at the left end of the cylinders (as viewed in FIG. 1) a plurality of ports as at 26 through the end wall of the cylinder block leading respectively to the cylinders 25 and communicable successively with the inlet kidney 19*a* and outlet kidney 20*a* as the cylinder block rotates.

Within each of the cylidners 25, a piston 28 is reciprocably mounted and each piston terminates in a spherically shaped or ball shaped head portion 29. On each of the head portions 29 a bearing shoe 30 is mounted, and such bearing shoes are formed with a spherically shaped recess for receiving the head portions of the pistons so that the shoes are universally pivotable on the ends of the pistons. The bearing shoes contact a face plate 35 seated on a swashplate 36 suitably mounted in the housing 15 to effect movement of the pistons through the pumping strokes as the cylinder block rotates.

If desired, the pump construction may be such that it facilitates a variable displacement or variable stroking of the pistons, and this may be accomplished by mounting the swashplate 36 for adjustment of its angle relative to the end face of the cylinder block. To this end, a control cylinder 40 may be provided in the housing 15, with a piston 41 reciprocable therein and engageable with the swash plate as at 42. A weak spring 43 maintains the piston in contact with the swashplate. As is now conventional, the swashplate may be mounted in a manner

to normally assume a minimum angle relative to the end face of the cylinder block to thereby provide a minimum displacemnt, and it will be understood that control fluid under pressure may be admitted to the cylinder 40 as through a port 41*a* to cause movement of the control piston 41 outwardly to thereby increase the angle of the swashplate relative to the end face of the cylinder block and thereby increase the piston stroking and the pump displacement.

With the construction thus far described, it will be understood that upon the connection of a prime mover to the input shaft 21*a*, the cylinder block 18 may be rotated to cause movement of pistons 28 through pumping strokes by reason of their engagement with the swashplate and through intake strokes if the intake pressure in the cylinders 25 is sufficient to cause return of the pistons. In this manner, fluid will be drawn into the cylinders 25 through the inlet passage 17*a* and pumped out of the cylinders 25 through the outlet passage 18*a*. As illustrated in FIG. 1, the outlet passage 18*a* is connected by a conduit as at 45 to the inlet of motor 11, and the motor outlet is connected by conduit 46 with the pump intake passage 17*a*.

In order to provide an intake pressure in the inlet pasasge 17*a*, the charge pump 13 is provided and this may take the conventional form of a crescent gear pump including an inner gear member as at 48 mounted on drive shaft 21*a* for rotation therewith, a crescent shaped segment as at 49, and an internal gear member as at 50. Pumps of this type are now well known and may conventionally be mounted in the pump housing 15 or the end block 16 in order to provide a compact construction. The inlet to the gear pump 13 is preferably connected by a passage as at 52 leading to the cavity 17 in housing 15 which in turn may be connected with the tank or reservoir 10 through a port 53 and a conduit 54. The outlet from gear pump 13 is connected by a passage as at 56 leading to the inlet passage 17*a*.

By virtue of the construction described, on rotation of the input shaft 21*a* the charge pump 13 will be driven, taking in fluid through the passage 52 and discharging fluid through the passage 56 to provide an intake pressure in the passage 17*a* sufficient to cause return movement of the pistons 28 outwardly from the position illustrated at the lower portion of the figure to the position illustrated at the upper portion of the figure. In order to maintain the desired charge pressure, a relief passage 58 leads from the inlet passage 17*a* and is connected as by a conduit 59 to the tank or reservoir 10, and in this passage a spring pressed ball check relief valve 60 is provided to maintain the desired pressure and to relieve the pressure in excess of that required for return movement of the pistons 28.

According to the present invention, each of the pistons is of hollow tubular form throughout a major portion of its length, and a passage as at 62 is provided through the piston head 29. The passage 62 connects with a passage 63 through the bearing shoe 30, and the latter is provided in the face thereof engaging the swashplate insert 35 with a pressure chamber as at 64 which may be connected by the passages 62 and 63 with the interior of cylinders 25. The flow of fluid to the pressure chamber 64 is controlled by a valve mechanism in the piston 28 indicated in general by the reference number 66 and illustrated in detail in FIGS. 2 and 3.

The valve mechanism comprises a hollow piston-like valve member 67 slidably mounted in the hollow portion of piston 28 and urged outwardly of the piston by a compression spring 68 toward the end of the piston opposite the head 29. Movement of the valve member under the urge of spring 68 is limited by a snap ring as at 69 which defines the closed position for the valve. In order to provide for communication between the cylinder 25 and the interior of hollow piston 28, the valve member 67 is slidable toward the right as viewed in the drawings, to

place its radial ports 70 in communication with an annular groove 71 formed on the interior of the piston 28. Fluid passing through the valve while open flows to the pressure chamber 64 to provide for hydrostatic balance of the piston shoe while exposed to the high pressure side of the pump. It will be understood that this pressure is less than the pressure in the cylinder 25 at the time by an amount equal to the pressure drop through the piston passage.

The spring 68 urges the valve member 67 toward a closed position with a force sufficient to maintain the valve closed while exposed to inlet pressure provided by charge pump 13 during the time the associated cylinder 25 and port 26 are in communication with the inlet kidney 19*a*. The force of spring 68 is insufficient to keep the valve closed during the time it is exposed to high pressure fluid while the associated cylinder 25 and port 26 are in communication with outlet kidney 20*a* during the pumping stroke.

A hold-down ring 75 having an annular flange 76 beneath the swashplate insert 35 and an annular flange 77 through which bearing shoes 30 project functions to maintain the bearing shoes in position until supercharge pressure is developed by the charge pump. The hold-down ring also maintains the pistons in position during shipment, but it should be understood that a ring such as this is not effective to maintain proper engagement between bearing shoes and swashplate at all times due to wear and manufacturing tolerances in the ring, the shoes and the swashplate.

In operation, it will be understood that the valved pistons provide for exposure of the entire cross sectional area of the piston to inlet pressure during the intake stroke to thereby insure piston return and continuous contact of the bearing shoe with swashplate portion 35. On the other hand, the valve opens during the pumping stroke to admit pressure fluid chamber 64 to provide for hydrostatic balance of the bearing shoe on plate 35, thereby reducing friction and wear of the shoe and plate. It will be understood that the pressure controlling operation of the valves 66 is that in the cylinders 25 and that this pressure may or may not be the same as that in the inlet passage 17*a* at the charge pump 13. There may be a substantial pressure drop between the charge pump and the main pump, the higher pressure of the charge pump being provided to insure filling of cylinders 25 when operating at maximum displacement and high speeds. For example, in one pump constructed according to the invention the relief valve 60 is set at 120 p.s.i. and the valve 66 are set at 70 p.s.i., and in some constructions such as this the pressure drop may be insufficient to permit closing of valves 66 while operating at minimum displacement and low speeds.

While the invention has been described in connection with a pump having a rotatable cylinder block and a relatively stationary swashplate it will be understood that it is also applicable to pumps using a rotatable wobbler and relatively stationary cylinder block.

Also, it will be understood that the principles of the invention are applicable when the device is operated as a hydraulic motor. In this case, the inlet is the high pressure side and the pressure therefore present causes the pistons to follow the cam from the high portion to the low portion thereof, but while the pistons are returned inwardly of the cylinder block by the rising cam surface they develop a certain momentum which causes them to tend to leave the cam before exposure to high pressure at reversal of the stroke. This is prevented by a back pressure valve in the motor outlet to maintain sufficient pressure to keep the pistons or bearing shoes thereon in contact with the cam. In the motor, of course, filling is no problem, and the valves as at 66 may close on the low pressure side under all conditions of operation.

I claim:

1. A hydraulic fluid translating device, comprising, a

housing having a fluid inlet passage and a fluid outlet passage, a cylinder block rotatable in the housing and having a series of cylinders formed therein, a series of ports in the cylinder block opening respectively to the cylinders and communicable successively with the inlet passage and the outlet passage as the block rotates, a piston reciprocable in each cylinder, a bearing on the outer end of each piston, a cam engageable with the bearings as the cylinder block rotates to move the pistons in one direction, a pressure chamber in the face of each bearing engaging said cam, a control passage through each piston and the associated bearing connecting the associated cylinder and pressure chamber, a valve in each control passage exposed to fluid pressure in the associated cylinders, a spring urging each valve closed with a force greater than the valve opening force exerted by the fluid pressure in the cylinder when the cylinder is in communication with the low pressure side of the device and with a force less than the valve opening force exerted by the fluid pressure in the cylinder when the cylinder is in communication with the high pressure side of the device whereby the entire cross-section of the piston is exposed to fluid pressure in the low pressure side, and the fluid pressure in the high pressure side is transmitted to the pressure chambers, and means for maintaining a pressure in the low pressure passage of the inlet and outlet passages sufficient to maintain the bearings in contact with the cam.

2. A hydraulic fluid translating device, comprising, a housing having a fluid inlet and a fluid outlet, a cylinder block in the housing and having a series of axial cylinders formed therein, a series of ports in the block opening respectively to the cylinders and communicable successively with the inlet and outlet, a piston reciprocable in each cylinder, a bearing surface associated with the outer end of each piston, a cam plate engageable with the bearing surfaces, means for relatively rotating the cylinder block and cam plate, a pressure chamber in each bearing surface engaging said cam plate, an axial passage through each piston connecting the associated cylinder and pressure chamber, a valve in each passage exposed to fluid pressure in the associated cylinder, a spring urging each valve closed with a force greater than the valve opening force exerted by the fluid pressure in said cylinder when the cylinder is in communication with the low pressure side of the device and with a force less than the valve opening force exerted by the fluid pressure in said cylinder when the cylinder is in communication with the high pressure side of the device whereby the entire cross-section of the piston is exposed to fluid pressure in the low pressure side, and the fluid pressure in the high pressure side is transmitted to the pressure chambers, and means for maintaining pressure in the low pressure side of the device sufficient to maintain the bearing surfaces in contact with the cam plate.

3. A hydraulic pumping device, comprising, a housing having an inlet passage adapted for connection with a motor outlet and an outlet passage adapted for connection with a motor inlet, a cylinder block rotatable in the housing and having a series of axial cylinders formed therein, a series of ports in the cylinder block opening respectively to the cylinders and communicable successively with the inlet passage and the outlet passage as the block rotates, a piston reciprocable in each cylinder on pumping and suction strokes, a bearing shoe on the end of each piston, a swashplate engageable with the bearing shoes, a charge pump having an outlet connected with said inlet passage, a pressure chamber in the face of each bearing shoe engaging said swashplate, an axial passage through each piston and the associated bearing shoe connecting the associated cylinder and pressure chamber, a valve in each of said last recited passages exposed to fluid pressure in the associated cylinders, and a spring urging each valve closed with sufficient force to maintain the valve closed while exposed to the supercharged inlet pressure and with insufficient force to maintain the valve closed while exposed to the pressure in said outlet passage, whereby the entire cross-section of the pistons are exposed to inlet pressure to maintain the bearing shoes in engagement with the swash plate on the suction stroke of the pistons, and said pressure chambers are in communication with outlet pressure during pumping strokes of the piston to hydrostatically balance the pistons on their pumping strokes.

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