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(58) Field of search
UK CL (Edition J) **F1W WCM WDA WDD WEJA**
INT CL[4] **F04B**

(54) An hydraulic reciprocating piston pump

(57) An hydraulically driven reciprocating piston pump has a spool valve (12) which controls the direction of fluid through the pump's driving motor (14) and therefore the operation of the pump (16). The spool valve (12) is designed to commute between two positions relatively slowly so that at the end of each pump stroke ball valves (68) of the pump (16) may return under the force of gravity to their seats while the spool valve changes from one position to another. This natural gravity return produces greatly decreased noise levels and increased seat life. The spool 34 of the valve is viscously damped and of a closed-when-centred construction to allow the relatively slow commutation to take place.

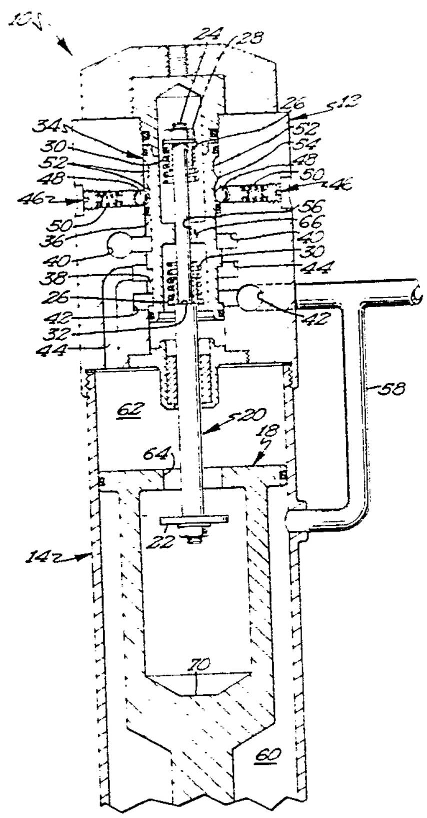

Fig 1

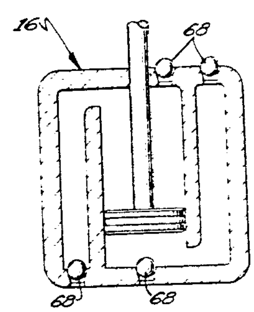

Fig 2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy

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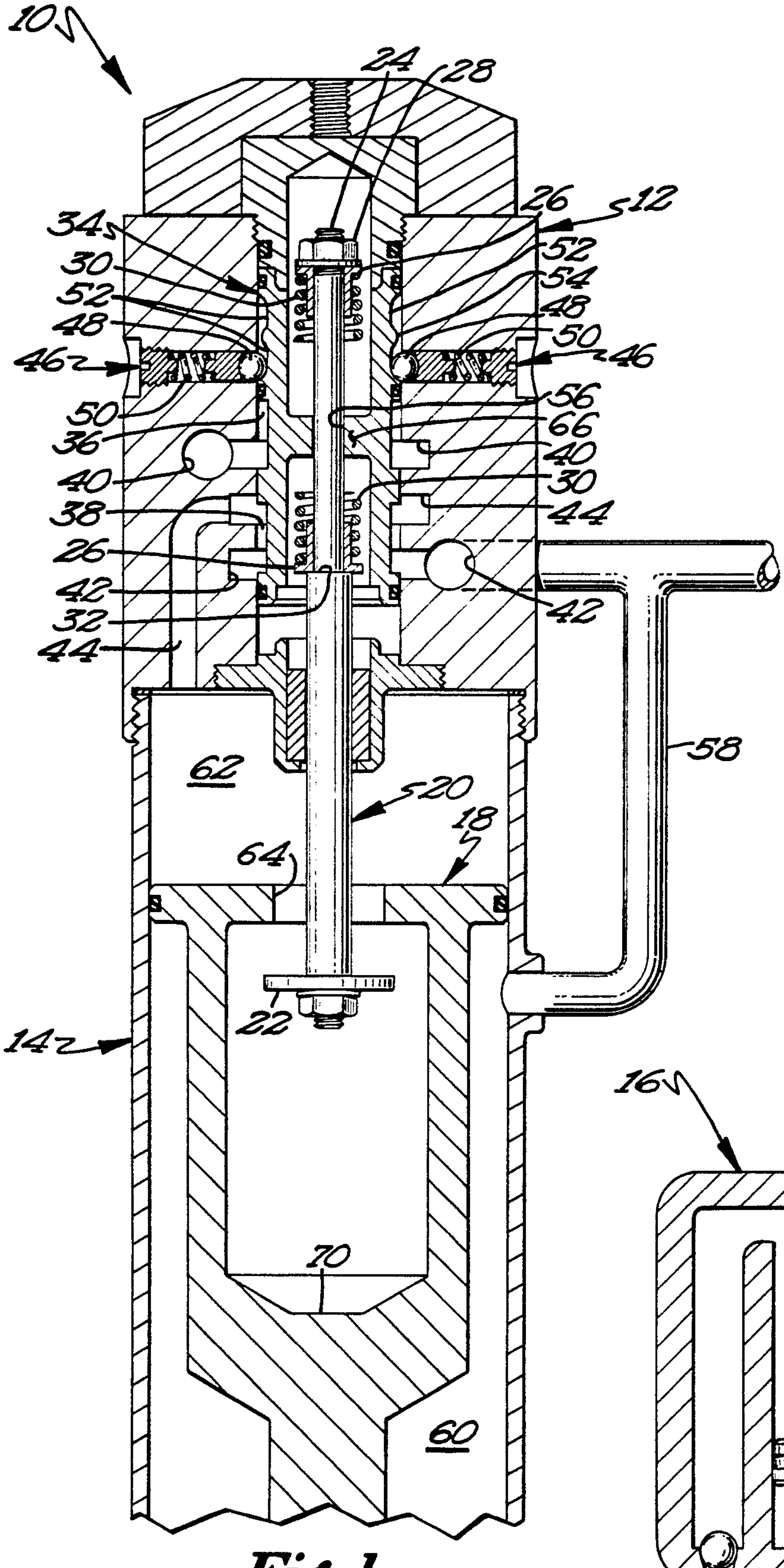
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Fig 1

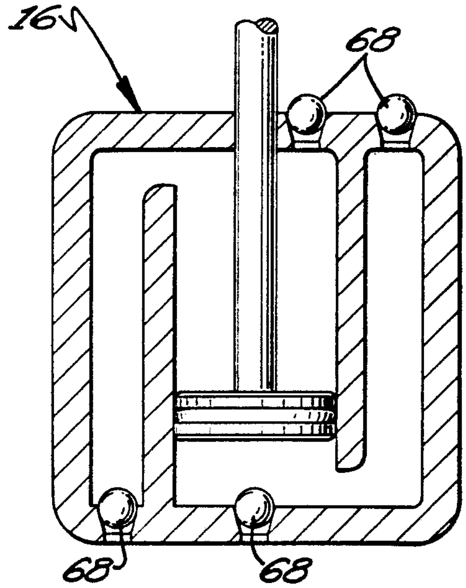
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Fig 2

AN HYDRAULIC RECIPROCATING PISTON PUMP

The present invention relates generally to an hydraulic reciprocating piston pump and particularly to a pump having a viscous damped commutation valve.

Hydraulically powered fluid pumps are becoming increasingly popular, but have the disadvantage that in operation they are very noisy. A high noise level is often unacceptable, and with the increasingly strict noise standards which are coming into force attempts are being made to produce machinery which operates more quietly in order to make it less obtrusive. It has been found that the noise generated by a reciprocating piston hydraulic pump is in large part caused by the impact of the ball valves onto their seats.

This invention seeks therefore to provide a fluid pump which is substantially quieter in operation than prior art pumps and which will be reliable in operation and have decreased maintenance requirements.

According to the present invention there is provided, an hydraulic reciprocating piston pump having gravity-biased ball valves to control the flow of fluid into and out from the pump, a reciprocating piston hydraulic motor to drive the pump piston, and a spool valve for commutation of the flow of hydraulic fluid to the pump motor, in which there are provided means for delaying the commutation of the spool valve after initiation thereof, whereby to allow the ball valves of the pump to close under the action of gravity before experiencing a reversal in the direction of fluid flow urged by the pump piston.

In a preferred embodiment the delay in commutation of the spool valve is introduced by viscous damping of the spool motion.

By allowing the ball valves in the pump to close naturally under the influence of gravity, rather than be slammed shut by a quick fluid changeover onto their seats, noise is greatly reduced and the life of the ball valves is extended along with a reduction of pressure spikes in the outlet pressure.

This is also enhanced by designing the spool valve as a closed-when-centred valve, that is one in which closure of a previous communication pattern is effected before a new communication pattern is opened upon commutation of the valve.

Preferably the said spool valve comprises a spool slidable within a bore in a valve body and separating the bore into two chambers, a trip rod slidable through an aperture in the spool, and at least one spring between the trip rod and the spool. The said aperture in the spool allows communication between the said two chambers separated by the spool, the dimensions of the aperture being such as to allow transfer of fluid upon shifting of the spool at a rate sufficient to allow the said ball valves to close under the influence of gravity before commutation of the spool valve is completed.

There are also preferably provided detent means operating to determine the commuted positions of the spool.

Springs are preferably provided on both sides of the spool over the trip rod so as to allow force to build up as the trip rod is moved and a spring is compressed, until that force exceeds the force required to push the spool past the detent. Because the spool valve is a closed-when-centred design, flow is stopped during the passage from one position to another, thereby allowing the ball valves to settle onto their seats. In addition, the aperture in the spool, through which the trip rod passes, is sized so as to allow the spool to move at the desired rate; that is, the aperture is restricted enough to provide a viscous damping action on the spool during changeover.

One embodiment of the present invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view through a part of a reciprocating piston hydraulic pump, showing the fluid commutation spool valve thereof; and

Figure 2 is a cross-section through a reciprocating hydraulic piston pump having gravity biased ball valves.

Referring now to the drawings, it will be seen that Figure 2 shows a reciprocating piston pump, generally indicated 16, having gravity biased unidirectional ball valves 68 on the inlets and outlets thereof. It had been thought in the art that a rapid changeover, that is closure of one set of the valve balls 68 onto their seats and opening of the other set was absolutely necessary for reliable operation of the pump and to guard against stalling. It has been found, however, that such rapid changeover greatly increases the noise generated by the pump in operation, and that, surprisingly, reliable operation can be maintained, and at the same time the noise reduced, by slowing down the changeover of the ball valves.

In Figure 1 an hydraulic reciprocating piston pump, only part of which is illustrated in Figure 1, is generally indicated with the reference 10. The pump 10 has a commutation valve unit 12 associated with an hydraulically driven fluid motor 14 which drives a pump unit 16, which latter is shown in Figure 2. The motor 14 has located therein a piston 18 which drives the pump plunger by a linkage (not shown). In the crown of the piston 18 is an aperture 64 through which passes a trip rod 20 which has at its lower end thereof a trip plate 22. The trip rod 20 is slidably guided in a spool member 34 of the commutation valve unit 12, which has a central web 66 with a central aperture 56 through which the trip rod is slidable. This general construction is well known in the art and will not be described in more detail except where appropriate.

At its upper end 24 the trip rod 20 has a collar 26 retained by retaining nut 28. Over the collar 26 is fixed one end of an upper shift spring 30. A shoulder 32 on an intermediate portion of the trip rod 20 locates a retainer 26' on which is fixed one end of a lower shift spring 30'. In operation of the pump 10 the trip rod 20 is caused to move axially in alternate directions so that the shift springs 30 and 30' alternately contact the central web 66 of the spool member 34 to cause the spool to commute between an upper and a lower position; it is shown in the upper position in Figure 1. The spool member 34 has an upper circumferential groove 36 formed in its outer surface and a lower circmferential groove 38 similarly formed in its outer surface and spaced axially from the upper groove 36. An oil outlet port 40 from the motor 14, leading to an oil reservoir or the like (not shown), communicates with the groove 36 via corresponding groove 40' in the bore in the body of the valve 12; correspondingly an inlet port 42 from a source of pressurised oil communicates with the lower groove 38 via a corresponding groove 42' in the bore in the valve body. An oil transfer passage 44 alternatively communicates with grooves 36 and 38 depending on the position of the spool 34. As shown in Figure 1, the oil transfer passage 44 is connected by groove 38 to the pressurised fluid inlet 42. The axial positions of the grooves 36, 38 in the spool 34 and the axial positions of the grooves 40' and 42' in the bore of the valve body are such that in the middle of its commutation movement the spool 34 closes off communication between the transfer passage 44 and the inlet or outlet ports 42, 40 as appropriate. This is termed a "closed-when-centred" configuration.

The movement of the spool 34 is also influenced by detent assemblies 46 which comprise two balls 48 which are urged against detent grooves 52 in the spool 34 by respective springs 50 held in place by plugs 46. The two detent grooves 52 in the spool 34 are separated by a detent ridge 54.

As shown in Figure 1, the piston 18 is performing a downward stroke and the spool 34 is in its upper position. Oil from the region 60 beneath the piston 18 passes outwardly through a passage 58 and, together with other oil supplied from the pressurised oil source 42 enters groove 38 of spool 34 and from there to the oil transfer passage 44 which leads to the region 62 above piston 18. There is a larger area on the upper side of piston 18 exposed to the oil pressure than on the lower side of piston 18, and consequently the differential piston effect results in a net downward force on the piston 18. As the piston 18 moves downwardly, the underside of the crown of the piston strikes the trip plate 22 on the trip rod 20, thereby starting the movement of the trip rod 20 downwardly. This continues until the bottom end of the upper spring 30 contacts the central web 66 of the spool 34. Initially, spool 34 will not move due to the force exerted by the detent balls 48. Once the piston 19 has moved downwardly sufficiently far the upper shift spring 30 becomes compressed until the force built up in the spring 30 is sufficient to urge the spool 34 across the detents. This commutation of the spool 34 is slowed by a damping action caused by the relatively slow transfer of the oil across the spool since the only route for this oil is through the aperture 56 in the central web 66, between this latter and the trip rod 20. Because of the viscous damping of the spool 34 and because of the "closed-when-centred" design of the spool 34, the piston 18 remains stationary for a moment at the end of its downward stroke before commencing its upward travel, thereby allowing the ball valves 68 to close naturally, under the action of gravity, rather than being forced shut rapidly due to a sudden reversal of flow of fluid through the pump.

After commutation of the spool 34 groove 36 connects the fluid transfer passage 44 to the outlet port 40, and groove 42' is isolated from the transfer passage 44 so that pressurised oil is fed through passage 58 into the region 60 beneath the piston 18, which thus moves upwardly. Oil from the region 62 above the piston 18 is forced out through transfer passage 44, groove 36 and port 40 to the oil reservoir or the like. This continues until a lower face 70 of the interior of piston 18 strikes the lower end 22 of the trip rod 20, causing this latter to move upwardly and commute the spool through the same process, in reverse, as that described above, to return to the position shown in Figure 1.

CLAIMS

1. An hydraulic reciprocating piston pump having gravity-biased ball valves to control the flow of fluid into and out from the pump, a reciprocating piston hydraulic motor to drive the pump piston, and a spool valve for commutation of the flow of hydraulic fluid to the pump motor, in which there are provided means for delaying the commutation of the spool valve after initiation thereof, whereby to allow the ball valves of the pump to close under the action of gravity before experiencing a reversal in the direction of fluid flow urged by the pump piston.

2. A pump as claimed in Claim 1, wherein the delay in commutation of the spool valve is introduced by viscous damping of the spool motion.

3. A pump as claimed in Claim 1 or Claim 2, wherein the spool valve is a closed-when-centred valve.

4. A pump as claimed in any of Claims 1 to 3, wherein the said spool valve comprises a spool slidable within a bore in a valve body and separating the bore into two chambers, a trip rod slidable through an aperture in the spool, and at least one spring between the trip rod and

the spool.

5. A pump as claimed in Claim 4, wherein the aperture in the spool allows communication between the said two chambers separated by the spool, the dimensions of the aperture being such as to allow transfer of fluid, upon shifting of the spool, at a rate sufficient to allow the said ball valves to close under the influence of gravity before commutation of the spool valve is completed.

6. A pump as claimed in any preceding Claim, further comprising detent means operating to determine the commuted positions of the spool.

7. An hydraulic reciprocating piston pump substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

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