Sept. 27, 1966 D. B. REINKE 3,274,897

PISTON RETURN MECHANISM

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Fig. 1.

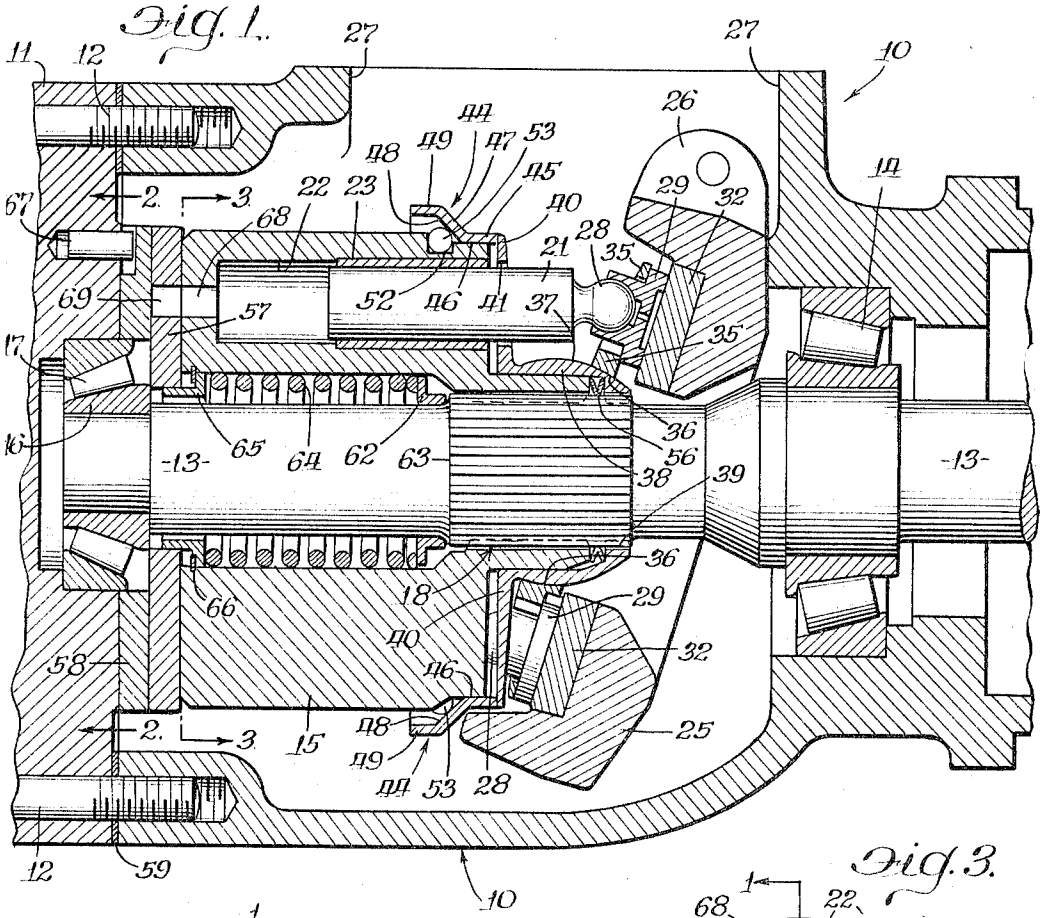



Fig. 2.

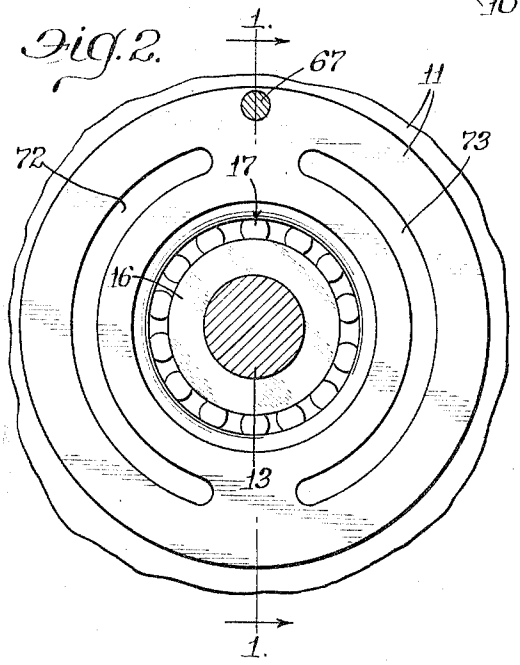
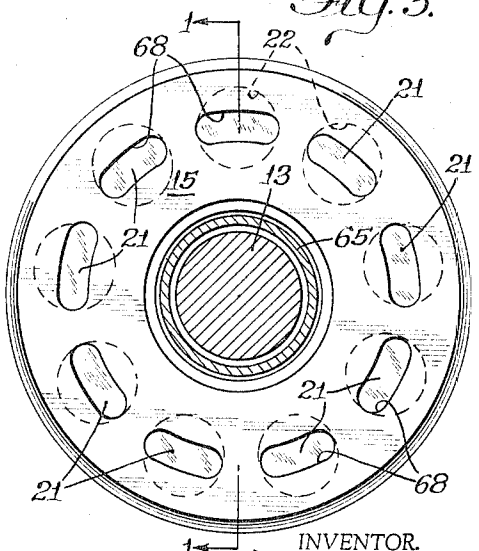



Fig. 3.




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# PISTON RETURN MECHANISM

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This invention relates to fluid pressure translating devices and especially relates to hydraulic pumps or motors of the reciprocating piston design. More particularly, this invention relates to piston return, to piston and cam plate clearances, and to systems for piston return.

Fluid pressure translating devices of the reciprocating piston type are well known to the art to be often usable as either pumps or motors. Among such devices are axial piston pumps or motors which usually include a cylinder block and a cam plate, inclined or inclinable with respect thereto. Relative rotational movement between the cylinder block and a cam plate produces pumping or motor output from the device. The cylinder block includes a plurality of reciprocating pistons in cylinders in circular array about the axis of the cylinder block. The pistons have inner ends disposed for reciprocation within the cylinders and outer ends adapted to bear through a slipper or shoe assembly against and transmit force to or receive force from the inclined cam plate. Where the cylinder block is rotatable it includes passages from each cylinder to an end of the block for association with inlet and outlet passages in a port member or port plate. The inlet and outlet passages of the port member communicate successively with the passages from the cylinders upon relative rotation of the cylinder block with respect to the port member. The cylinder block is positively biased toward the port plate by pressure under operation of the device and is often also biased by mechanical means for supplementing the operating pressure.

In operation of a fluid translating device of the type described, forces tend to inhibit piston return or retention of pistons against the cam plate bearing surface, especially during pumping, necessitating the employment of a positive piston return mechanism. These forces include the inertia or momentum forces of the reciprocating piston-slipper assembly which increase as the square of the rotational speed, the frictional side load forces of the pistons in the bores due to centrifugal force which increase as the square of the speed where the cylinder block is rotated, and the forces from filling and vacuum conditions that retard piston return which increase with the speed of piston reciprocation. Other forces may also inhibit piston return during operation of the device. It is seen that as the speed of operation increases, the forces acting against proper return of the pistons may increase at a much greater than linear rate. For high speeds, a far greater piston return force is needed than at lower operating speeds.

With the above in mind, it is a general object of this invention to provide a new and useful piston return mechanism for fluid pressure translating devices of the reciprocating piston type.

A further object of this invention is to provide a new and useful piston return mechanism for such devices which is responsive to rotational speed and is adapted to apply a greater piston return force at greater rotational speeds.

A more particular object of this invention is to provide a piston return mechanism for such devices which is centrifugally acting and/or responsive and wherein the applied piston return force increases generally as the square of the speed of relative rotation between the cylinder block and cam plate.

An additional object is to provide a new and useful piston return system which is effective during start-up of the device; a more particular object is to provide such a piston return system for start-up conditions which is capable of establishing a maximum clearance between the piston ends and the cam plate bearing surface and which assures piston return under such conditions wherein the rotary return mechanism may not be operating effectively, e.g., before relative rotational speed is attained for proper action of the rotary mechanism.



Other objects of this invention will be apparent to those skilled in the art from the following detailed description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a longitudinal section, taken along line 1—1 with respect to FIGURE 2 or 3, of a hydraulic fluid translating device incorporating a form of the present invention;

FIGURE 2 is a partial section through the device taken along line 2—2 of FIGURE 1; and

FIGURE 3 is a partial section through the device taken along line 3—3 of FIGURE 1.

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail, a specific embodiment of the invention with the understanding that the present disclosure is considered to be an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated.

Turning now to the figures, and especially FIG. 1, the embodiment illustrated is incorporated in a pump or motor of an axial piston type, which includes a housing indicated generally at **10**, having an end plate **11** removably secured thereto by suitable means such as bolts **12**. Drive shaft **13** is rotatably supported at one end of housing **10** by mounting bearings **14** and extends through cylinder block **15** to end plate **11** where it is secured by press fit within inner race **16** of mounting bearing **17**, bearing **17** being fitted in a recess in end plate **11**. Bearings **14** and **17** secure the shaft against axial movement.

Shaft **13** is drivingly connected as by splines **18** to cylinder block **15** for rotation of cylinder block **15** and drive shaft **13** together. The splined connection **18** includes cooperating splines on the drive shaft and cylinder block through which the drive shaft passes, and the splines may be slightly crowned longitudinally to permit tilting of the cylinder block at the splined connection, which allows for irregularities in the rotation of the cylinder block.

Cylinder block **15** includes a plurality of axially disposed pistons **21** in circular or annular array, each reciprocating within a bore or cylinder **22** in cylinder block **14**. Nine similar pistons **21** (FIG. 3) and cylinders **22** are included in the device, although only one piston and cylinder are drawn in detail in FIG. 1. Each cylinder **22** is provided with a bearing insert or bushing **23** within which a piston reciprocates. Although in the form shown there are nine pistons in the annular series, any number of pistons and cylinders may be used, as is known to the art.

Cam plate **25** is mounted within housing **10** at one end of cylinder block **15** for pivotal movement about an axis transverse to and intersecting the axis of the drive shaft. The pivotal mounting of cam plate **25** is provided by a pair of aligned trunnions (not shown) secured to opposite walls of housing **10** and normal to the plane of FIG. 1. The cam plate is adapted to be pivoted about its axis at an incline in either direction with respect to a neutral central position for adjustment of displacement of the pistons **21** within the cylinder block cylinders **22**. For this purpose projection **26** on cam plate **25** is provided to pivot the cam plate on its axis. The projection is accessible through opening **27** in the wall of housing **10** and may be linked to suitable actuating means

connectible by means of a bore in projection 26 to control the inclination of cam plate 25 as is well known.

The outer ends 28 of pistons 21 are of spherical configuration and are universally connected to bearing members such as bearing shoes or slippers 29 which are adapted to slide upon an annular thrust or bearing member 32 which is of annular plate configuration and annularly slidable on cam plate 31. Of course, other pistons within the pump are equipped with similar bearing shoes and wherever the illustrated piston 21 is described in association with other members, it is to be understood that the remainder of the pistons 21 are in association with similar or the same members, as will be obvious to those in the art from the descriptions herein.

A holddown member, such as ring 35, engages the flanged bearing slippers 29 and carries the bearing slippers in slidable contact with bearing member 32. Holddown ring 35 is provided with a spherical bore 36 which is engaged by and receives the spherical outer surface 37 of a spherical collar 38. Spherical collar 38 is splined at 39 for rotation with and axial movement relative to shaft 13. The collar is slidable on and piloted by a cylindrical projection of cylinder block 15 for axial movement of collar 38 with respect to the block 15 and shaft 13. Collar 38, when urged to the right in FIG. 1, urges holddown ring 35 toward the bearing surface 32 of cam plate 25, thereby urging the bearing slippers against the bearing surface. Spherical collar 38 and the inner surface of holddown ring 35 each has its spherical center located at the approximate midpoint of the driving connection 18 between drive shaft 13 and cylinder block 15 and falling upon the axis of drive shaft 13 at the point where the drive shaft axis pierces the plane containing the pivot points of the universal link between pistons 21 and bearing members 32. In the form shown, the pivot points are the centers of balls 28. The pivot axis for swashplate 25 preferably passes through the center of the spherical surface.

A lateral annular extension or flange 40 of collar 38 is provided for engagement of a piston return system therewith for urging collar 38 to the right as viewed in FIG. 1. Extension 40 includes an annular series of bores 41 through which pistons 21 are freely reciprocal.

In the piston return mechanism acting on flange 40 of collar 38, there is provided a skirt-like cam member 44 which abuts extension 40 near the periphery thereof. Cam member 44 includes a tubular sleeve portion 45 axially slidable at 46 on cylinder block 15, a flared portion 47 having an inner camming surface 48, and another tubular or sleeve portion 49 which may act as a stop portion as will be described hereinbelow. The end of sleeve portion 45 abuts extension 40.

Cylinder block 15 includes a plurality of outwardly opening cubicles or recesses 52 angularly spaced from each other about the periphery of cylinder block 15 and approximately equidistant from the axis of rotation of the block. Each of receivers 52 functions in combination with the stop portion 49 or cam portion 47 of the skirt member 44 as a holder for a weighted ball 53 of steel or the like.

Upon rotation of cylinder block 15, e.g., by driving shaft 13 for pumping action, balls 53 are urged outward by centrifugal force against camming surface 48, thereby camming member 44 to the right as viewed in FIG. 1. Balls 53 do not escape from receivers 52 because the inner surface of annular stop portion 49 is not sufficiently outwardly disposed radially from the outer lips of receivers 53 to permit escape of balls 53. Camming of member 44 to the right urges collar 38 axially on shaft 13 via the sliding spline connection 39. Collar 38, in turn, urges the piston holddown ring 35 to the right, pressing slippers 29 against thrust or bearing member 32, thereby holding the ball ends 28 of pistons 21, which are retained in sockets of slippers 29, against forces tending to pull pistons 21 away from bearing member 32.

Thus, the piston return system acts with centrifugal force from balls 53 to return or urge the piston ends into bearing association with the inclined cam plate. This form of the invention is most advantageous in that the centrifugal force exerted increases generally with the square of the speed so that the effectiveness of the holddown system will be assured even at high rotational speeds of cylinder block 15 where at least some of the forces tending to act against piston return may also vary with the square of the speed.

Also provided in the illustrated embodiment is an adjustable member which is capable of establishing and setting clearances and compensating for and accommodating tolerances within the device. This member is illustrated in the form of a deformable "crush" washer 56 of V-shaped cross section. During manufacture or assembly of a device such as shown in FIG. 1, slippers 29, return ring 35, cylinder block 15 including pistons 21, bearing plate 57 and port plate 58 are loaded from the open end of housing 10 with end plate 11 removed. Gasket 59 and end plate 11 are then positioned for closure of housing 10 and bolts 12 are threaded into their receptacles in housing 10 to seal plate 11 against the housing with gasket 59 therebetween. Where a multiplicity of similar units are to be made, it will be seen that buildup of tolerances of any of the individual pieces slightly off from the precise dimensions could easily create too little or too much running room between the slippers 29 and bearing member 32, creating undue wear in either instance. For this reason, the adjustable member in the form of crush washer 56 is provided to establish the desired precise clearances.

For example, usually it is desired to have a few thousandths of an inch clearance between slippers 29 and bearing plate 32, e.g., 0.005 inch. In such instance, the gasket 59 may have a thickness equal the desired clearance, e.g., 0.005 inch. Accordingly, the device is first assembled with crush washer 56 in position as shown but in the absence of gasket 59, and end plate 11 is driven flush against housing 10 to compress washer 56 to a tight-fit configuration. End plate 11 is then removed and gasket 59 is inserted. End plate 11 is replaced and the desired running clearance corresponding to the thickness of gasket 59 is established. Alternatively, as another example, instead of omitting gasket 59 while compressing washer 56, a second gasket thinner than gasket 59 may be used between end plate 11 and housing 10 during the crushing operation; in such case, the difference between thickness of the other gasket and gasket 59 is equal to the desired clearance between slippers 29 and bearing member 32, e.g., 0.005 inch.

Crush washer 56 is a compressible member, compressible to a predetermined thickness within its compressible range, and having no resilient properties of restoration. Adjustment of washer 57 to a precise thickness by compression establishes an adjusted tolerance, especially with reference to the clearance between slippers 29 and bearing member 32. In this manner, the crush washer 56 is capable of compensating for or accommodating tolerances which may be critical to optimum operation and which may vary from unit to unit. The thickness of washer 56 can be varied in each unit while the unit is being assembled and is thereby adapted to whatever tolerances are built into the mechanism or parts of the unit, within the adjustable thickness range of the washer. The pressure necessary for compressing crush washer 56 for adjustment of the tolerances is greater than any pressure of compression on crush washer 56 during operation of the device.

The adjustable member 56 not only accommodates tolerances in the device but functions as a portion of the total piston holddown mechanism of the device. As has been seen, piston holddown can be accomplished during rotation of the cylinder block by the centrifugal means. However, until the rotational speed is established sufficient to obtain good positive action from the

balls 53, e.g., during start-up conditions, there may be little or no piston holddown force. During such conditions, the adjusted crush washer 56 functions as a supplementary return system and establishes a maximum clearance between slippers 29 and bearing member 32 by stopping movement of sleeve 38 to the left as viewed in FIG. 1 relative to cylinder block 15. Thus, crush washer 56 constitutes an adjusted stop member between the block 15 and sleeve member 38 which stops withdrawal of sleeve member 38, the abutting piston holddown ring 35 and slippers 29 from bearing member 32 a distance greater than the desired maximum running clearance during start-up procedures, and functions similarly in the event of a piston sticking and overpowering the centrifugal mechanism.

Turning now to the system for urging cylinder block 15 and bearing plate 57 in abutment with port plate 58, an annular collar 62 abuts an annular shoulder 63 on drive shaft 13. A spring means such as coil spring 64 acts against annular collar 62 and against an annular collar 65, which is axially slidable on shaft 13 toward port plate 58. Annular collar 65 abuts snap ring 66, which is secured to cylinder block 15, and thereby carries the snap ring and cylinder block toward port plate 58 under the urging of spring 64. A hardened bearing plate 57 is pinned to the cylinder block for rotation therewith and is carried by the cylinder block under the urging of spring 64 into slidable contact with port plate 58 which is pinned at 67 to end plate 11. Collar 65 also functions as a guide for bearing plate 57.

Cylinders 22 are provided with arcuate end ports 68 (FIG. 3) and bearing plate 57 includes complementary extensions 69 of ports 68 therethrough. The passage configuration, as viewed from either side of plate 57 is the same as the passage configuration on the end of cylinder 22 as illustrated in FIG. 3. Plate 57 may include wear-resistant materials on its opposing surfaces and particularly on the surface facing port plate 58 or may be entirely of suitable bearing material such as bronze.

Port plate 58 includes arcuate inlet and outlet passages 72 and 73 passing therethrough for conducting fluid to and from passages 69 as cylinder block 15, including plate 57, rotates. The general configuration of passages on both sides of port plate 58 is generally the same and is also generally the same as the configuration of passages to the inner face of housing end plate 11 as illustrated in FIG. 2. Port plate 58 may also have wear-resistant surfaces, such as hardened steel, especially facing cylinder block end plate 57.

Inlet and outlet passages 72 and 73 extend through housing end plate 11 to inlet and outlet openings (not shown) in the usual manner. The inlet and outlet openings are connectible to fluid lines (not shown) for operation of the device as a pump or motor as will be readily apparent to those skilled in the art.

In operation of the device as a pump, shaft 13 is rotated to rotate cylinder block 15. Fluid valved through port plate 58 enters the piston cylinders on the low pressure side or inlet side of the port plate. The pistons 21 are urged to the left in FIG. 1 by bearing shoes or slippers 29 riding on bearing member 32 backed by cam plate 25. The annular series of cylinder block passages are successively brought into association with the low pressure or inlet passage and then with the high pressure or outlet passage in conventional manner as block 15 rotates.

As the cylinder block rotates, bearing plate 57 slides against port plate 58 and is biased thereagainst by the force of pistons on the cam plate and by coil spring 64 which is grounded on the drive shaft. Additionally, slippers 29 slide around cam plate 25 on or with the cam plate bearing member 32 and are urged or held against the bearing surface not only by the action of pistons 21 but also by balls 53 and cam member 44 acting through spherical collar 36 and holddown ring 35.



The adjusted shim or crush washer 56 prevents withdrawal of slippers 29 from surface 32 a greater distance than the minimum operating clearance between the shoes and cam plate surface, thereby keeping the shoes in close association with the cam plate during start-up. Even severe stress during the operation of the pump cannot remove the shoes more than the minimum operating clearance.

It will be apparent to those in the art that the device, although its pump operation has been described, is also operable as a motor.

I claim:

1. A hydraulic fluid translation device including a cylinder block, a plurality of pistons with inner ends disposed for reciprocation within cylinders in the block and protruding therefrom at one end of the block, an inclined cam plate facing said one end of said block, a bearing surface on said cam plate, the outer ends of said pistons having bearing means being adapted to slidably follow said bearing surface, means mounting said cylinder block and cam plate for relative rotation, inlet and outlet means communicating successively with ports from said cylinders upon relative rotation of the cylinder block and cam plate, hold-down means engaging said bearing means and movable toward and away from a position retaining said bearing means in engagement with said bearing surface, means urging said hold-down means toward said position responsive to relative rotation of said cylinder block and cam plate and means blocking said hold-down means from movement greater than a predetermined distance away from said position during start-up of said device.

2. A fluid energy translation device including a cylinder block, a plurality of pistons with inner ends disposed for reciprocation within cylinders in the block and outer ends protruding from the block, an inclined cam plate facing said piston outer ends, a bearing surface on said cam plate, the outer ends of said pistons having bearing means being adapted to slidably follow said bearing surface, means mounting said cylinder block and cam plate for relative rotation, inlet and outlet means communicating successively with ports from said cylinders upon relative rotation of the cylinder block and cam plate, hold-down means engaging said bearing means and movable toward and away from a position retaining said bearing means in engagement with said bearing surface and means urging said hold-down means toward said position responsive to relative rotation of said cylinder block and cam plate.

3. A hydraulic fluid translation device comprising a housing, a rotatable cylinder block, a plurality of pistons with inner ends disposed for reciprocation within cylinders in the block and protruding therefrom at one end of the block, an inclined cam plate facing said one end of said block, a bearing surface on said plate, the outer ends of said pistons having bearing means being adapted to slidably follow said bearing surface, a valve member having inlet and outlet passages communicating successively with ports from said cylinders upon rotation of the cylinder block, means biasing the other end of said cylinder block into facial engagement with said valve member for communication of said passages with said ports from said cylinders, hold-down means engaging said bearing means and movable relative to said cylinder block for retaining said bearing means in engagement with said bearing surface, centrifugally responsive means acting on said hold-down means for urging said bearing means against said bearing surface with a force approximately proportional to the square of the speed of rotation of said cylinder block.

4. The device of claim 3 including means adjusted to conform with the tolerances of said device for establishing a maximum running clearance between said bearing means and said bearing surface.

5. The device of claim 3 wherein said centrifugally responsive means comprises an annular array of spaced weight means mounted for orbital and radial movement responsive to rotation of said cylinder block, and cam

means for limiting the radial outward movement of said weight means, and for directing the centrifugal force of said weight means to said hold-down means.

6. A hydraulic fluid translation device including a housing, a cylinder block, a plurality of pistons with inner ends disposed for reciprocation within cylinders in the block and protruding therefrom at one end of the block, an inclinable cam plate facing said one end of said block, means mounting said cam plate and cylinder block for relative rotation, a bearing surface on said plate, the outer ends of said pistons having bearing means being adapted to slidably follow said bearing surface, valve means defining inlet and outlet passages communicating suucessively with ports from said cylinders upon relative rotation of the cylinder block and cam plate, means biasing the other end of said cylinder block in facial engagement with said valve means for communication of said passages with said ports from said cylinders, means for inclining said cam plate relative to said cylinder block for varying the displacement of the device, and hold-down means engaging said bearing means and adapted to urge said bearing means in engagement with said bearing approximately proportional to the square of the speed of relative rotation between said cylinder block and cam plate.

7. In an axial piston pump, a housing having an end closure, a drive shaft rotatable in the housing, a cylinder block rotatable with the shaft and having an annular series of axial cylinders with piston means reciprocable therein, a swash plate engaging outer ends of the piston means, hold-down means engaging outer ends of the piston means to maintain the latter adjacent the swash plate, and a permanently deformable crushable washer between the hold-down means and cylinder block compressible to a predetermined thickness during assembly of the pump for establishing a predetermined stop so that the piston means cannot be lifted off the swash plate.

8. In an axial piston pump, a housing, a drive shaft rotatable in the housing, an axially slidable cylinder block rotatable with the shaft and having an annular series of axial cylinders with pistons reciprocable therein, a housing end closure opposing axial movement of said cylinder block, bearing shoes universally mounted on the piston outer ends, an inclined swash plate engageable with the bearing shoes, a hold-down ring engaging the bearing shoes for holding the latter adjacent the swash plate, an axially slidable collar having a spherical outer surface engaging the hold-down ring, and a crush washer of V-shaped cross section between the collar and cylinder block permanently compressible during assembly of the pump to a predetermined permanently retained thickness limiting to a predetermined maximum clearance the distance by which the bearing shoes may move off the swash plate.

9. An axial piston hydraulic pump or motor device comprising a housing and a closure end therefor, a rotatable cylinder block mounted in said housing, an annular series of axially disposed cylinders within said block, a series of pistons having inner ends reciprocating within said cylinders, a drive shaft rotatably mounted in said housing and closure end extending through said cylinder block, a spline connection between the cylinder block and drive shaft, bearing means in said housing restricting said drive shaft against axial movement, a cam plate mounted in said housing at one end of said cylinder block having a bearing face inclined to the end of the cylinder block, said pistons having spherical outer ends, a series of shoes universally mounted on the spherical outer ends of the pistons and having a bearing face engaging the bearing face on said cam plate, ports communicating the cylinders with the opposite end of said cylinder block, a port plate in the housing having inlet and outlet passages adjacent the opposite end of the cylinder block communicating successively with said cylinder ports upon rotation of the cylinder block, a hold-down ring carrying said bearing shoes, a spherical collar axially slidable on said shaft and engaging the hold-down ring, an axially slidable annular cam member on the cylinder block abutting said spherical collar for carrying said collar to a position urging said shoes against said cam plate bearing face, a centrifugal weight on the cylinder block acting to move said cam member for movement of said collar to said position responsive to rotation of said cylinder block, and a coiled compression spring acting against said shaft and against said cylinder block to urge said cylinder block against the port plate.

10. A combination as defined in claim 9, wherein the center of the spherical collar is located at the approximate midpoint of said spline and falls upon the axis of said shaft approximately at the point where the shaft axis pierces the plane containing the centers of the spherical piston ends.

11. A combination as defined in claim 9, including a gasket between said housing and closure end, and adjusted shim means between said collar and cylinder block, said gasket and shim means establishing a maximum on the running clearance between said shoes and bearing face.

12. In a hydraulic fluid translation device including a housing with a closing end plate, a cylinder block rotatably mounted in said housing, a drive shaft grounded against axial movement relative to said housing adapted to drive or be driven by said rotatable cylinder block, said cylinder block being axially movable relative to said shaft, a plurality of pistons with inner ends disposed for reciprocation within cylinders in the block and protruding therefrom at one end of the block, an inclined cam plate facing said one end of said block, a bearing surface on said cam plate, the outer ends of said pistons being adapted to slidably follow said bearing surface, a valve member having inlet and outlet passages communicating successively with ports from said cylinders upon rotation of the cylinder block, and means grounded on said shaft for biasing the other end of said cylinder block in facial engagement with said port member for communication of said passages with said ports from said cylinders, the improvement which comprises hold-down means engaging said piston outer ends and axially slidably mounted on said cylinder block for retaining said piston outer ends in engagement with said bearing surface, a plurality of weighted balls, a plurality of radially opening receivers in said cylinder block each receiving one of the weighted balls, an annular skirt axially slidably mounted on said cylinder block and defining a cam surface on the interior of said skirt disposed radially of said receivers and configurated to cam said skirt axially on said block for abutting and urging said piston hold-down means axially on said block to hold said piston ends in sliding association with said cam plate upon rotation of said cylinder block as a result of centrifugal radial force of said balls against said skirt cam surface, adjustable crush washer means and sealing gasket means establishing a maximum clearance between said piston ends and bearing surface during a rotational condition of said cylinder block of less severity than the amount of rotation required to hold said piston ends against said bearing surface by way of centrifugal action of said balls through said skirt cam, said adjustable crush washer means having a range of adjustable thickness, said sealing gasket means comprising a sealing gasket in sealing position between said housing end and said end plate of preselected thickness relative to the adjustment of said crush washer means in said range of adjustable thickness, and said adjustable crush washer means being disposed between said block and said piston hold-down means and being adjustable to desired thickness within said range by closing said housing with said end plate with no gasket or a thinner gasket than said sealing gasket means therebetween, said end plate thereafter being removable for placing said sealing gasket means in its sealing position.

13. A fluid energy translation device, comprising: a shaft, a cylinder block rotatable with said shaft, a plurality of pistons with inner ends disposed in reciprocation within cylinders in the block and outer ends protruding

from the block, an inclined cam plate facing said piston outer ends, a bearing surface on said cam plate, the outer ends of said pistons having bearing means being adapted to slidably follow said bearing surface, means mounting said cylinder block and said cam plate for relative rotation, inlet and outlet means communicating successively with ports from said cylinders upon relative rotation of the cylinder block and cam plate, hold-down means engaging said bearing means and movable toward and away from a position retaining said bearing means in engagement with said bearing surface, and a permnently deformble member substantially stationary with respect to said cylinder block and said shaft and positioned to maintain a desired predetermined maximum clearance between the bearing surface and the bearing means on the outer ends of the pistons.

14. A fluid energy translation device, comprising: a shaft, a cylinder block rotatable with said shaft, a plurality of pistons with inner ends disposed in reciprocation within cylinders in the block and outer ends protruding from the block, an inclined cam plate facing said piston outer ends, a bearing surface on said cam plate, the outer ends of said pistons having bearing means being adapted to slidably follow said bearing surface, means mounting said cylinder block and said cam plate for relative rotation, inlet and outlet means communicating successively with ports from said cylinders upon relative rotation of the cylinder block and cam plate, hold-down means engaging said bearing means and movable toward and away from a position retaining said bearing means in engagement with said bearing surface, and a permanently deformable member positioned between said cylinder block and said hold-down means; said cylinder block, cam plate, and bearng means being positioned so that the permanently deformable member maintains a desired predetermined maximum clearance between the bearing surface and the bearing means on the outer ends of the pistons.

15. The device of claim 14, and further including means for selectively varying the spacing between the cylinder block and the cam plate to thereby vary the maximum clearance between the bearing means and the bearing surface as desired.

16. The device of claim 14, wherein the permanently deformable member has sufficient axial compressive strength to withstand the operating forces from the cylinder block and the hold-down means without permanent deformation.

17. In a hydraulic fluid translation device including a housing with a closing end plate, a cylinder block rotatably mounted in said housing, a drive shaft grounded against axial movement relative to said housing, an axially slidable connection between said shaft and said rotatable cylinder block whereby said shaft is adapted to drive or be driven by said rotatable cylinder block, a plurality of pistons with inner ends disposed for reciprocation within cylinders in the block and protruding therefrom at one end of the block, an inclined cam plate facing said one end of said block, a bearing surface on said plate, the outer ends of said pistons having bearing means being adapted to slidably follow said bearing surface, a port member adjacent the other end of said cylinder block and having inlet and outlet passages communicating successively with ports from said cylinders upon rotation of the cylinder block, and means grounded on said shaft for biasing said cylinder block toward said port member for communication of said passages with said ports from said cylinders, the improvement which comprises hold-down means engaging said bearing means and axially slidable relative to said cylinder block to a position retaining said bearing means in engagement with said bearing surface, means between said hold-down means and cylinder block adjustable during assembly of the device for limiting the axial sliding of said hold-down means away from said position to a predetermined clearance under start-up conditions of said device, means for adjusting said clearance, said adjustable means being a pressure responsive adjustable spacer and said adjusting means comprises a gasket removable from between said housing and end plate and means for tightening said end plate on said housing with said gasket removed, said gasket being of a selected thickness and being replaceable between said end plate and housing after adjustment of said spacer means.

18. In a hydraulic fluid translation device including a housing with a closing end plate, a cylinder block rotatably mounted in said housing, a drive shaft grounded against axial movement relative to said housing, an axially slidable connection between said shaft and said rotatable cylinder block whereby said shaft is adapted to drive or be driven by said rotatable cylinder block, a plurality of pistons with inner ends disposed for reciprocation within cylinders in the block and protruding therefrom at one end of the block, an inclined cam plate facing said one end of said block, a bearing surface on said plate, the outer ends of said pistons having bearing means being adapted to slidably follow said bearing surface, a port member adjacent the other end of said cylinder block and having inlet and outlet passages communicating successively with ports from said cylinders upon rotation of the cylinder block, and means grounded on said shaft for biasing said cylinder block toward said port member for communication of said passages with said ports from said cylinders, the improvement which comprises hold-down means engaging said bearing means and axially slidable relative to said cylinder block to a position retaining said bearing means in engagement with said bearing surface, means between said hold-down means and cylinder block adjustable during assembly of the device for limiting the axial sliding of said hold-down means away from said position to a predetermined clearance under start-up conditions of said device, said adjustable means being a compressible member having a resistance to compression sufficient to withstand compression under axial pressures present in said device between said cylinder block and hold-down means during operation of said device.

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