Dec. 20, 1966 M. M. HANN 3,292,553

PISTON RETURN MECHANISM

Filed Dec. 30, 1963 2 Sheets-Sheet 1

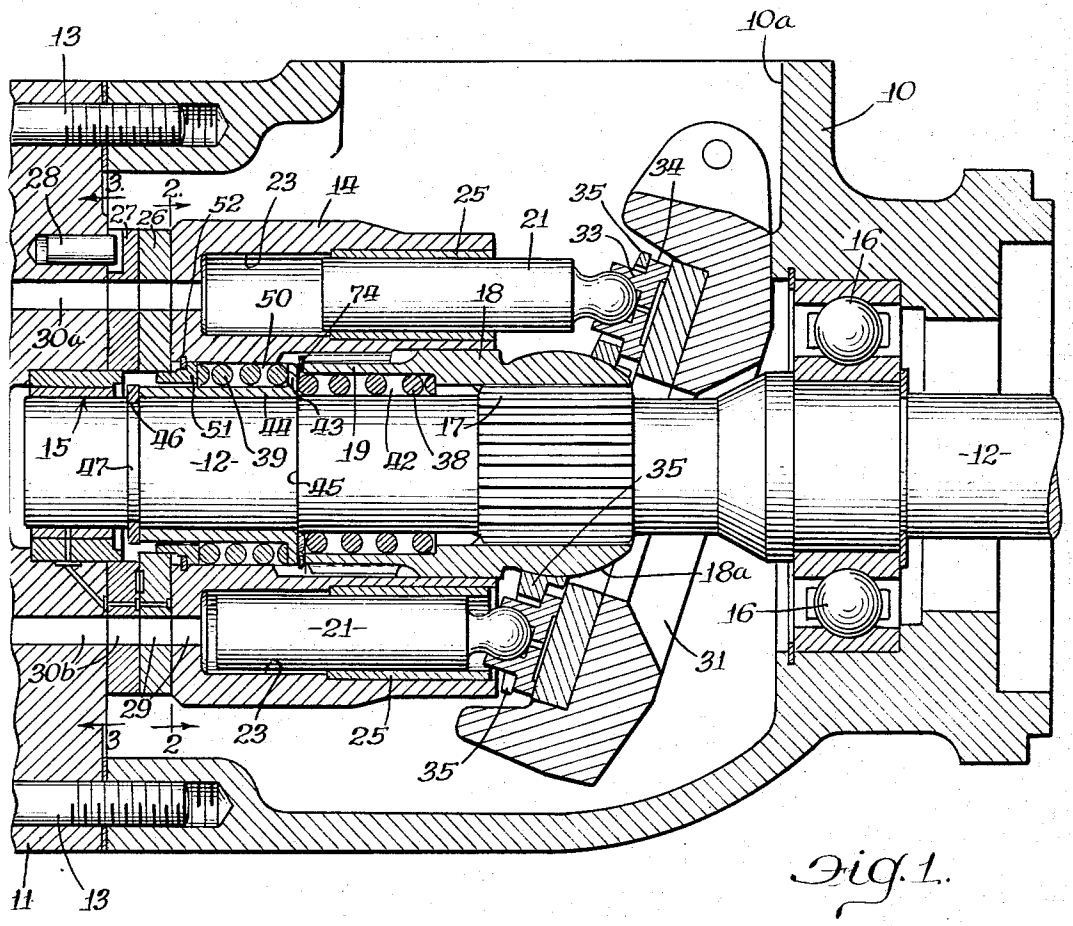


Fig. 1.

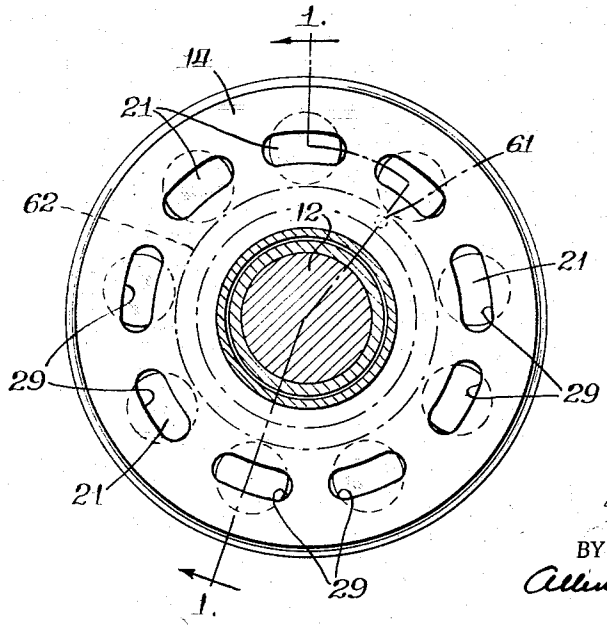


Fig. 2.

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Dec. 20, 1966 M. M. HANN 3,292,553

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Filed Dec. 30, 1963 2 Sheets-Sheet 2

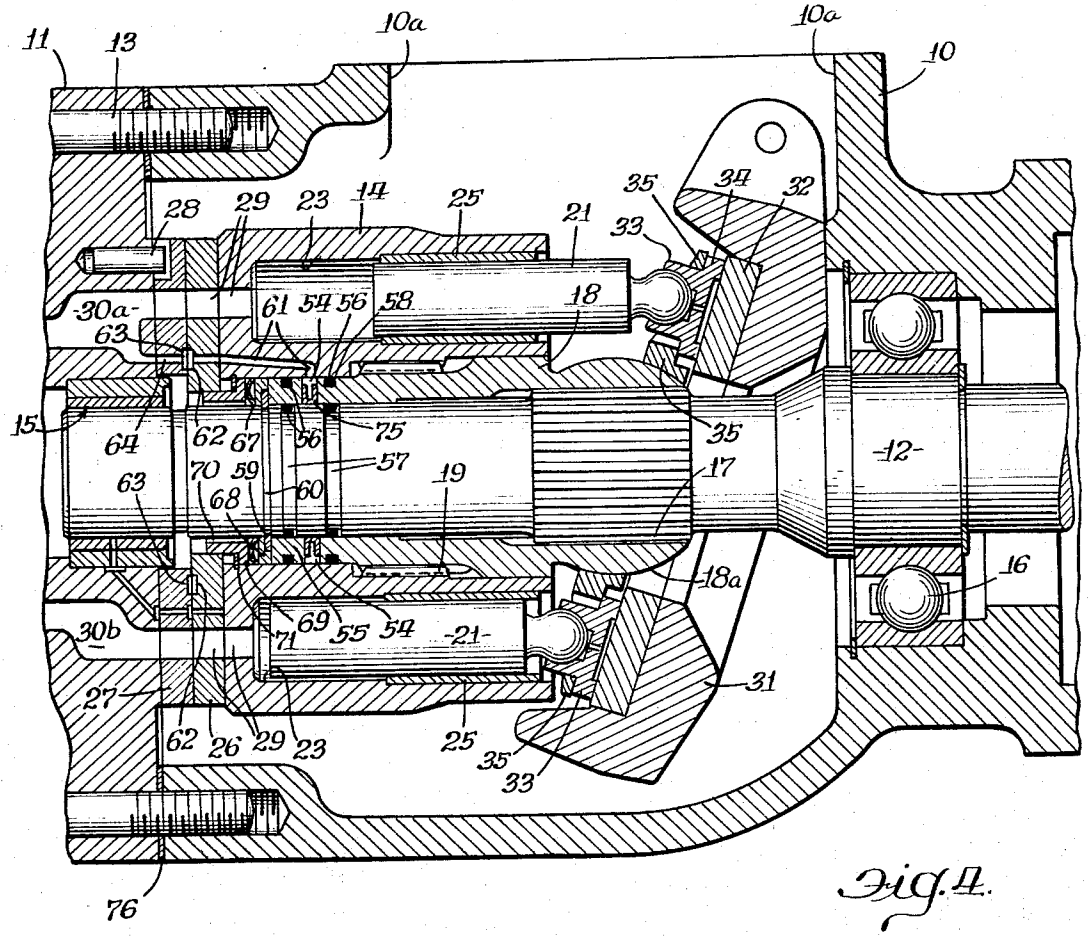


Fig. 4.

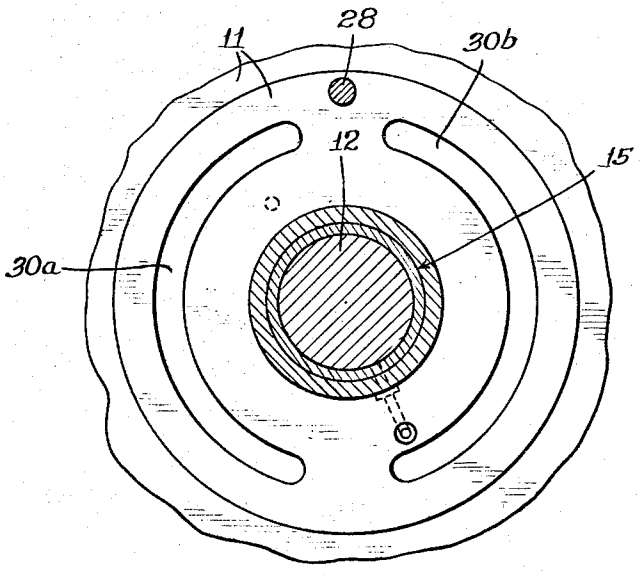


Fig. 3.

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PISTON RETURN MECHANISM

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5 Claims. (Cl. 103—162)

This invention relates to axial piston hydraulic pumps and motors, and particularly to means in such devices for biasing the cylinder barrel against the port plate and for biasing the pistons toward the cam plate.

It is a general object of this invention to provide a new and useful system employing separate means for biasing the cylinder block and the pistons in opposite directions, which separate means are both grounded to a drive shaft in a hydraulic fluid translating device.

Another object of this invention is to provide a system in accordance with the foregoing objects in which an adjustable member is provided for maintaining a predetermined clearance between the cam and piston elements under conditions in the device sufficient to otherwise force such elements away from proper association with the cam.

It is another object to provide a new and useful hydraulic piston return mechanism in a pump or motor of the type described.

Still other objects will become readily apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a longitudinal section, taken along line 1—1 with respect to FIG. 2 of a hydraulic fluid translating device incorporating an embodiment of the present invention;

FIG. 2 is a partial section taken along line 2—2 of FIG. 1;

FIG. 3 is a partial section taken along line 3—3 of FIG. 1; and

FIG. 4 is a longitudinal section through another embodiment or form of the invention, taken along the same general section line as the section of FIG. 1.

FIG. 2 also shows, in phantom, fluid distribution canals and ports which are present in the device of FIG. 4, the locations of such canals and ports being specifically described hereinbelow.

While this invention is susceptible of embodiment in many different forms, there are shown in the drawings and will herein be described in detail embodiments of the invention, with the understanding 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 embodiments illustrated.

Turing first to both illustrated embodiments of the invention as shown in FIGS. 1–4, certain elements are similar in the two forms and are described at once as incorporated in a pump or motor of the axial piston type, including a housing indicated generally at **10**, having an end plate **11** removably secured thereto by bolt means **13**. Drive shaft **12** is rotatably supported at one end of housing **10** by bearings **16** and extends through cylinder block **14** to end plate **11** where the drive shaft is rotatably mounted in bushing **15** within a recess in end plate **11**.

Drive shaft **12** is drivingly connected as by splines **17** to a torque tube **18** in turn drivingly connected by splines **19** to cylinder block **14** for rotation of cylinder block **14**, torque tube **18**, and drive shaft **12** together. Splines **17** and **19** permit relative axial movement between shaft **12**, torque tube **18** and cylinder block **14**, and a midportion of the torque tube provides a pilot for the end of the cylinder block.

Cylinder block **14** includes pistons **21**, two of which are shown in FIG. 1, having inner ends reciprocating within bores or cylinders **23** in cylinder block **14**. Cylinders **23** are provided with bearing inserts or bushings **25** within which the pistons reciprocate. Although only two pistons are shown in any one view of the figures, it is to be understood that cylinder block **14** includes an annular plurality of axially disposed cylinders within the cylinder block, each cylinder having an inner end of a piston reciprocating therein. It will be apparent from the discussions below that there are nine pistons in the annular series in the illustrated embodiment; however, any number of pistons and cylinders may be used, as will be recognized by those in the art.

One end of cylinder block **14** has a bearing plate **26** pinned thereto for rotation therewith. Facing the other face of bearing plate **26** is a port plate **27** which is pinned by pin **28** to end plate **11**. Bearing plate **26** is rotatably slidable in facial contact with port plate **27**. Urging of cylinder block **14** axially to the left relative to shaft **12**, as viewed in FIGS. 1 or 4, will tend to hold bearing plate **26** against separation from port plate **27**.

Cam plate **31** is mounted within housing **10** facing the other end of cylinder block **14** for pivotal movement about an axis transverse to and intersecting the axis of drive shaft **12**. The pivotal mounting of cam plate **31** is provided by trunnions (not shown) secured to housing **10** with the pivotal axis of the cam plate generally horizontal with respect to FIG. 2. 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 **23**. For this purpose an opening **10***a* in the wall of housing **10** is provided for access to cam plate **31** as for linking cam plate **31** to suitable actuating means to control the inclination of cam plate **31** as is well known.

Cylinders **23** are provided with arcuate end ports **29** (FIG. 2) and bearing plate **26** includes complementary extensions of ports **29** therethrough. The passage configuration, as viewed from either side of plate **26** is the same as the passage configuration on the end of cylinder **14** as illustrated in FIG. 2. Plate **26** may include wear-resistant materials on its opposing surfaces and particularly on the surface facing port plate **27** or may be entirely of suitable bearing material such as bronze.

Port plate **27** includes arcuate inlet and outlet passages **30** passing therethrough for conducting fluid to and from passages **29** as cylinder block **14**, including plate **26**, rotates. The general configuration of passages on both sides of port plate **27** 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. 3. The high pressure passage is designated **30***a* and the low pressure passage is designated **30***b*, assuming cylinder block **14** to be rotated clockwise, as viewed in FIG. 2, during pumping operation. During pumping operation of the device, displacement is increased by pivoting cam plate **31** to the incline shown in FIGS. 1 and 4, and high pressure passage **30***a* serves as the outlet for fluid being pumped. Port plate **27** may also have wear-resistant surfaces, such as hardened steel, especially facing cylinder block end plate **26**.

Inlet and outlet passages **30** extend through housing end plate **11** to an inlet and an outlet (not shown) in the usual manner. The inlet and outlet are connectable to conduits (not shown) for operation of the device as a pump as will be readily apparent to those skilled in the art.

The outer ends of pistons **21** are of spherical configuration and are universally connected to bearing members, such as bearing shoes, **33** which are adapted to slide upon an annular surface of a thrust or bearing member **32** which is backed by and annularly slidable on cam plate **31**. Of course, other pistons within the motor are equipped with similar bearing shoes and wherever pistons **21** are described in association with other members, it is to be understood that each of the pistons is associated with similar or the same members, as will be obvious to those in the art from the description herein.

A hold-down member, such as ring **35**, engages flanges **34** of bearing shoes **33** and carries the bearing shoes in slidable contact with bearing surface **32**. Hold-down ring **35** is provided with a central bore having a concave inner surface which is slidably engaged by and receives a spherical outer surface **18***a* of an end portion of torque tube **18**. Torque tube **18**, axially slidable on shaft **12** and with respect to cylinder block **14**, when urged to the right in FIGS. 1 or 4, will carry hold-down ring **35** toward the bearing surface of cam plate **31**, thereby urging bearing shoes **33** against bearing surface of plate **32**.

The center of spherical surface **18***a* in the embodiments illustrated falls on the plane containing the centers of the universal joints of pistons **21** and shoes **33**, i.e., the centers of the ball ends of pistons **21**, at approximately the axis of shaft **12**, the axial center of spline **17**, and the pivot axis of the swash plate.

In each form of the invention as illustrated in FIGS. 1 and 4, separate means are provided, each grounded on the drive shaft, for biasing the piston ends against the cam plate and for biasing the cylinder block against the port plate.

Turning first to the embodiment of FIG. 1, biasing means in the form of springs **38** and **39** provide the biasing forces. In order to maintain the bearing shoes **33** against bearing member **32**, one of the biasing means, i.e., coiled compression spring **38**, is disposed in an annular chamber **42** between drive shaft **12** and torque tube **18**. Spring **38** bears at one end against a shoulder on torque tube **18** for urging torque tube **18** to the right and is grounded at the other end against an outward annular projection **43** of a sleeve **44**. Sleeve **44** is grounded against axial movement on shaft **12** between a circumferential shoulder **45** on shaft **12** and a snap ring **46** contained in groove **47** in shaft **12**. Abutment of sleeve **44** against snap ring **46** grounds spring **38** against shaft **12**.

The other biasing means, i.e., compression spring **39**, is provided for biasing cylinder block **14**, including bearing plate **26**, against port plate **27**. Spring **39** is contained in chamber **50** between sleeve **44** and cylinder block **14** and is grounded at one end against projection **43** of sleeve **44**. The other end of spring **39** bears against a ring member **51** which abuts a snap ring **52** secured in a groove in cylinder block **14**. An extension of member **51** provides a pilot for bearing plate **26**.

As the device is operated as a pump, rotation of block **14** clockwise, as viewed in FIG. 2, causes fluid to be drawn in through inlet or intake **30***b* and to be forced from the device via outlet **30***a*. Rotation of shaft **12** causes rotation of torque tube **18** and cylinder block **14** relative to cam plate **31**. Springs **38** and **39**, respectively, maintain proper running or sliding association of shoes **33** with bearing member **32** and bearing plate **26** with port plate **27**.

Turning now to FIG. 4, other separate biasing means are provided for maintaining contact of the pistons with the cam plate and the cylinder block with the port member. First, for urging the piston ends and slippers toward the cam plate, there is provided a hydraulic system which includes an annular hydraulic chamber **54** having its inner and outer diameters respectively defined by shaft **12** and cylinder block **14**, respectively, and having its axial limits respectively defined by torque tube **18** and ring **55**, or more specifically by O-rings **56** in grooves **57** on shaft **12** and in grooves **58** on torque tube **18** or ring **55**. Ring **55** is grounded against axial sliding to the left, as viewed in FIG. 4, by snap ring **59** in groove **60** around shaft **12**. It will be apparent that torque tube **18** is urgeable to the right by pressure within chamber **54**.

In order to supply fluid pressure to chamber **54**, a fluid supply passage **61** is provided extending from chamber **54** through block **14** and bearing plate **26** to an annular groove **62** in the surface of bearing plate **26** facing port plate **27**. It will be seen in FIG. 2 that annular groove **62** has been illustrated in phantom on the butt end of cylinder block **14**, which butt end has the same general configuration as the face of bearing plate **26** disposed against port plate **227** except that annular groove **62** is absent on cylinder block **14**.

A similar annular groove **63** is provided in the face of port plate **27** facing annular groove **62** and the two annular grooves cooperate to define an annular passageway in communication with passage **61** and with a passage **64**. Passage **64** extends through port plate **27** and end plate **11** to the high pressure outlet passage **30***a*. Passage **64** is an elongate passage which is narrower than and generally parallel to the portion of passage **30***a* extending through port plate **27**. Passage **64** maintains constant communication between high pressure passage **30***a* and the conduit formed by grooves **62** and **63**, thereby maintaining pressure in hydraulic chamber **54** during operation of the device for urging torque tube **18** to the right forcing slippers **34** toward bearing member **32**.

For urging cylinder block **14** to the left and for maintaining facial contact between bearing plate **26** and port plate **27**, a second biasing means in the form of a spring washer such as a Belleville spring **67**, is provided between an anchor ring **68**, abutting snap ring **59**, and an outward annular projection **69** of a bearing plate guide sleeve **70** which in turn abuts a snap ring **71** secured in a groove in cylinder block **14**. An extension of sleeve **70** pilots bearing plate **26**. The Belleville spring **67** illustrated in FIG. 4 is an annular member having an open C cross-section configuration in its noncompressed form with the C configuration opening more as the spring is compressed, e.g., to the very wide open C configuration illustrated in FIG. 4. The C configuration of the compressed spring tends to close under tension of the spring metal to expand the spring to a thicker, more closed C configuration. Spring **67**, therefore, defines a compression spring between ring **68** and sleeve **70**, urging block **14** to the left in FIG. 4.

In each form of the invention illustrated, an auxiliary piston return is provided in the form of an annular shim **74** (FIG. 1) or **75** (FIG. 4) which functions as a spacer blocking return of shoes **33** away from bearing member **32** and thereby retaining shoes **33** in close association or contact with the bearing surface of cam plate **31**. The spacer **74** in FIG. 1 is a washer member between an end of torque tube **18** and the outwardly projecting flange **43** of sleeve **44** and prevents return of torque tube **18** to the left greater than a predetermined distance, thereby establishing a running clearance between shoes **33** and bearing member **32** and also determining the maximum opening between shoe flanges **34** and hold down ring **35** carrying the shoes **33**. The running clearance is maintained by spacer **74**, especially during periods of abnormal operation when the force necessary to return pistons **21** and slippers **35** might exceed the force provided by spring **38**.

In FIG. 4, the spacer member is in the form of a compressible or crushable washer **75**, located within hydraulic chamber **54** between an end of torque tube **18** and the grounded ring **55**. Ring **55** grounds the crushed washer

75 to drive shaft 12. Washer 75 is illustrated as having been compressed to a thickness determining the maximum opening that can be obtained between slippers 33 and retaining ring 35 and establishing the running clearance for slippers 33 against the bearing surface of the cam plate. The crushed washer functions as an adjusted shim so that during periods of operation when the piston return pressure in chamber 54 may be too low to return the pistons against the cam plate, the fixed clearance established by crushed washer 75 assures that slippers 33 are maintained in close association or contact with cam plate bearing member 32.

Washer 75 is capable of compensating for tolerance build-up within the device. During manufacture or assembly of such a device as shown in FIG. 4, the elements are loaded from the open end of housing 10 with end plate 11 removed. A gasket 76 and end plate 11 are then positioned for closure of housing 10 and bolts 13 are used to pull end plate 11 against the end of housing 10 with gasket 76 therebetween. Where a plurality of similar units are to be made, it will be seen that tolerances of any of the individual pieces slightly off of specified precise dimensions could build up and create too little or too much running room between the shoes 33 and the bearing member 32, creating undue wear in either instances. The crushed washer 75 establishes the desired precise clearances.

The crushed washer 75 may readily be adjusted to proper thickness, for example, by employing a gasket 76 of a thickness conforming with the desired clearance between elements within the device, e.g., a few thousandths of an inch. In such instance, the device is first assembled without gasket 76 and with end plate 11 pulled tight against the end of housing 10, thereby compressing or crushing the compressible washer 75 to a thickness eliminating all clearances between sliding members. End plate 11 is then removed and gasket 76 is inserted. End plate 11 is replaced and tightened against gasket 76 by bolts 13. Thus, a predetermined running clearance equal to the thickness of gasket 76 is established within the device. The washer does not resiliently return to its original thickness.

The adjusted spacer shown in the form of crushed washer 75 is preferably an adjustable member which is adjustable by compression through a range of thicknesses. The force necessary for compressing the adjustable member is readily obtainable by tightening end plate 11 in its closing position on housing 10 but is substantially greater than any axial force which will be placed upon the member after its adjustment during operation of the device. The adjustable member, after being adjusted to the desired thickness, will not further be compressed during operation. It may be used in either embodiment.

Although the invention has been exemplified with particular reference to a hydraulic pump, the principles can also be applied to a motor. The principles are further applicable to a variety of fluid energy translating devices of fixed or variable displacement, e.g., variable on both sides of a neutral position. In such use, suitable arrangement should be made to maintain chamber 54 in communication with the high pressure line.

I claim:

1. An axial piston hydraulic pump or motor device comprising a housing, 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 extending through said cylinder block, a torque tube in said housing between said shaft and cylinder block, a first spline connection between the cylinder block and torque tube, a second spline connection between said shaft and torque tube, 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 and having a bearing face inclined to one 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 surface on said torque tube engaging the hold-down ring, an axially expandable chamber grounded on said shaft at one end and biasing said torque tube at the other end, means for supplying fluid for expanding said chamber, and resilient means grounded on said shaft at one end and bearing against said cylinder block at the other end to urge the block toward the port plate.

2. The combination of claim 1, wherein the spherical center of the spherical surface being located at the approximate midpoint of said second spline and falling upon the axis of said shaft at the point where the shaft axis pierces the plane containing the centers of the spherical piston ends.

3. An axial piston hydraulic pump or motor device comprising: a housing, a port plate in said housing having inlet and outlet passages therein, a rotatable cylinder block mounted in said housing slidably engaging said port plate, an annular series of axially disposed cylinders within said block, a series of pistons having inner ends reciprocable within said cylinders, a drive shaft rotatably mounted in said housing and extending through said cylinder block, a torque tube in said housing between said shaft and said cylinder block, first spline means interconnecting the shaft and said torque tube, second spline means interconnecting said torque tube and said cylinder block, said torque tube having a generally spherical portion extending from one end of said cylinder block, a pilot member on said torque tube separate from said splines for radially supporting said cylinder block, a cam plate mounted in said housing at one end of said cylinder block and having an inclined bearing face, said pistons having generally spherical outer ends, bearing shoes universally mounted on the spherical piston ends, each having a bearing face slidably engaging said cam face, a hold-down ring engaging said bearing shoes, and means biasing the spherical surface on said torque tube in engagement with said hold-down ring.

4. A hydraulic fluid translation device including a housing, a drive shaft mounted for rotation in said housing, a cylinder block mounted for rotation with said drive 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, bearing means on the outer ends of said pistons adapted to slidably follow said bearing surface, inlet and outlet port means communicating successively with ports from said cylinders upon rotation of the cylinder block, hold-down means axially movable relative to said cylinder block and engaging said bearing means, said hold-down means being movable toward and away from a position retaining said bearing means in engagement with said bearing surface, means on the shaft defining between the shaft and said cylinder block an expandable chamber means grounded on said shaft and adapted to receive fluid acting against said hold-down means to move said hold-down means to said position upon expansion of said chamber, a portion of said hold-down means being slidable in said chamber, and means interconnecting said chamber means with the high pressure one of said inlet and outlet.

5. The device of claim 4, including adjusted means limiting the extent of collapse of said chamber in the

absence of sufficient hydraulic pressure to expand said chamber.

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