March 22, 1966 P. E. DIEDRICH ET AL 3,241,495

CONSTRUCTION FOR AXIAL PISTON PUMP OR MOTOR

Filed Aug. 12, 1963 2 Sheets-Sheet 1

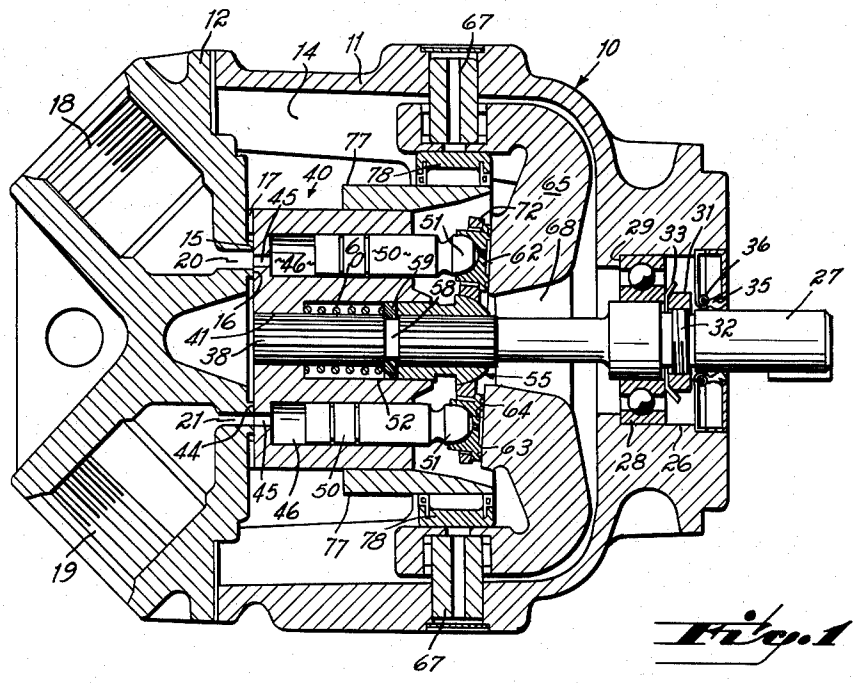

Fig. 1

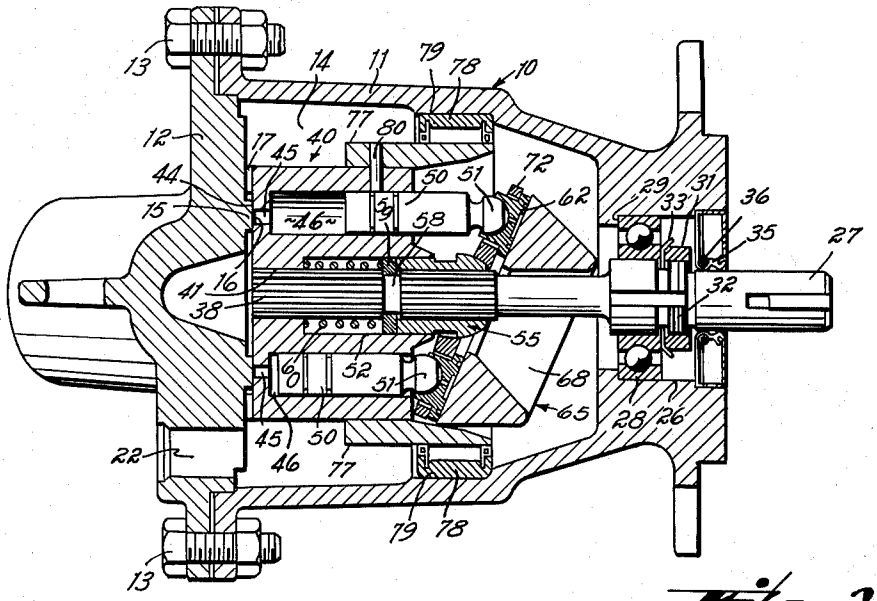

Fig. 2

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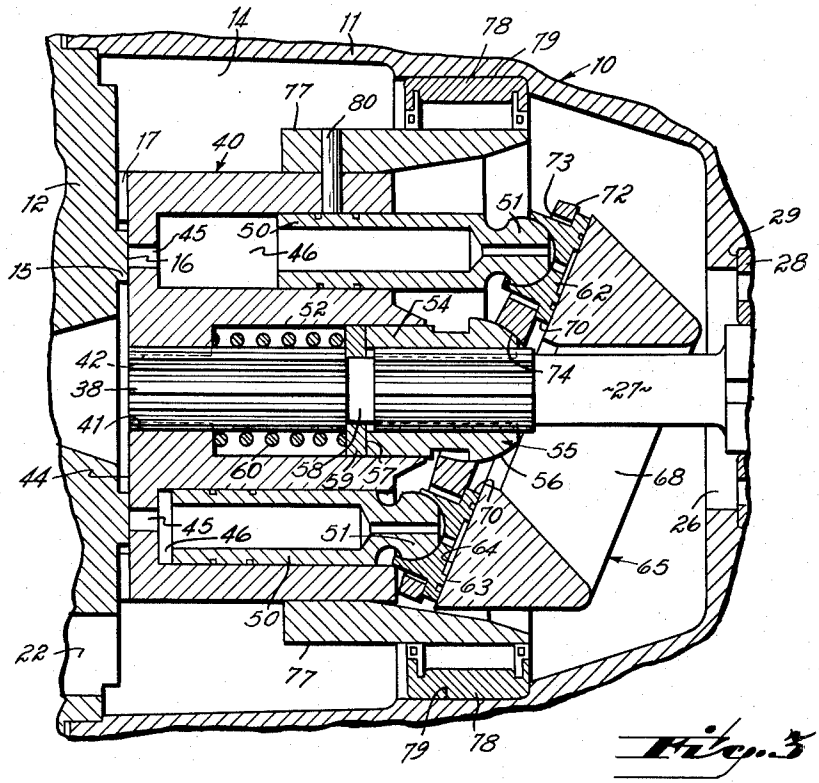

Fig. 3

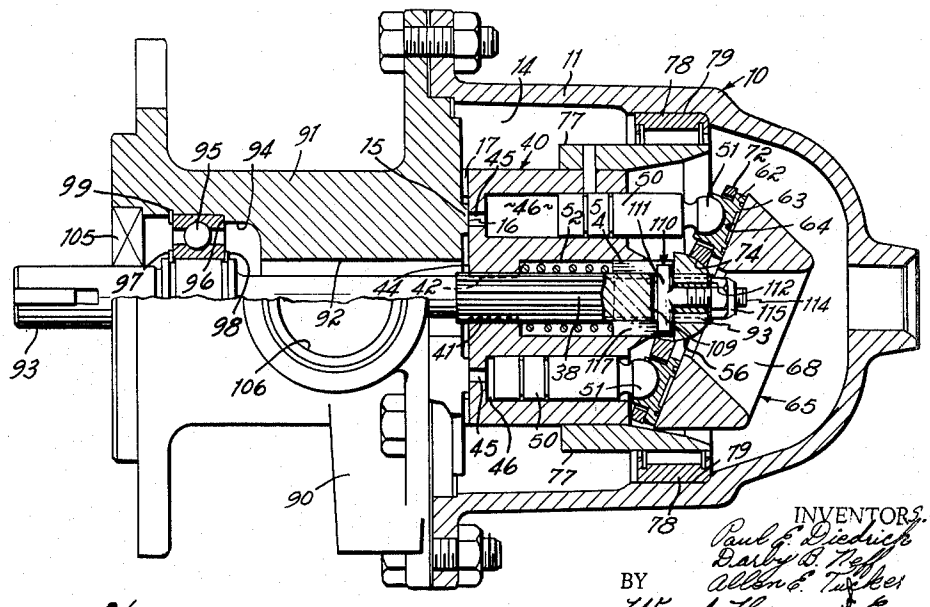

Fig. 4

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CONSTRUCTION FOR AXIAL PISTON PUMP OR MOTOR

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5 Claims. (Cl. 103—162)

This invention relates to an improved construction for fluid pumps or motors of the axial piston type.

Fluid pressure energy translating devices of the axial piston type are characterized by a rotatable cylinder barrel which contains a plurality of reciprocable pistons. The pistons are received in chambers formed in the cylinder, and have shoes which are universally connected to their outer ends. The shoes engage a cam plate or swash plate which is tilted about an axis transverse to the axis of rotation of the cylinder barrel, so that as the barrel is rotated the pistons reciprocate in their respective chambers. Means are provided to hold the shoes in contact with the cam plate as the cylinder barrel revolves. The barrel is connected to a shaft for rotation. Ports formed in the cylinder barrel connect the piston chambers and the end face of the barrel, and these ports communicate sequentially with inlet and outlet ports formed in a fixed valve surface or port plate in the casing.

This invention is directed to a new construction for fluid pressure energy translating devices of the axial piston type, which will display pumping efficiency generally commensurate with that of prior constructions, but which is simpler and more economical to manufacture.

The invention is predicated in part upon the determination that a high degree of operating efficiency can be obtained in an axial piston type pump or motor if rotation or drive power is transferred between the operating shaft and the cylinder barrel through a coupling or spline connection which is adjacent the port end surface of the cylinder barrel, and if one end only of the shaft is journalled in the housing at a position remote from the valve surface and the cylinder barrel is journalled in the body or casing of the pump in a bearing which is in line with or generally symmetrical in the plane of the tilting forces acting on the pistons.

The invention is also predicated in part upon improved means for holding the cylinder barrel in sealing engagement with the fixed valve or bearing surface of the casing, and for holding the piston shoes in close engagement with the swash plate.

In a related aspect, the invention is also directed to means for positively limiting the extent to which the piston shoes can move away from or off of the swash plate.

The construction which we have invented is applicable to axial piston type pumps or motors wherein the drive shaft is at either the port end of the casing or at the swash plate end of the casing.

A preferred axial piston type pressure energy translating device incorporating the principles of this invention includes a hollow casing defining an internal chamber at one end of which a planar porting and bearing surface is presented. Fluid ports communicate through the casing with the porting and bearing surface. An operating shaft extends into the chamber in the direction perpendicular to the porting and bearing surface, and is journalled in the casing at one end only, at a position remote from the porting and bearing surface. A cylinder barrel having a plurality of axially reciprocable pistons is disposed in the casing, and the barrel has an end surface which engages the porting and bearing surface of the casing. The shaft extends axially to the barrel and is splined to

the barrel for rotary movement at a position adjacent the end thereof which engages the fixed porting and bearing surface. Piston shoes are universally connected to the ends of the pistons in the barrel, and a cam plate is angulated with respect to the axis of the barrel about an axis transverse to the barrel axis. A shoe hold-down plate engages the shoes. The barrel has an internal bore about the shaft at the end opposite to the porting and bearing surface, and a plunger is slidably received in this bore. The plunger has a spherical head portion which is socketed in a cooperating spherical recess in the center of the hold-down plate. A coil spring is compressed in the bore of the cylinder barrel between the barrel and the inner end of the plunger, such that the plunger is urged toward the hold-down plate. The barrel has a cylindrical flange portion or skirt which extends around the plunger, and this flange portion is journalled in the casing in a bearing which is disposed symmetrically about the midpoint of the hold-down plate.

For purposes of illustration, the invention is described herein primarily in relation to a device which is to be operated as a pump, but it will be understood that the invention is equally applicable to axial piston type devices which are to be operated as motors.

FIGURE 1 is a horizontal cross-section through an axial piston pump including the features of this invention, wherein the drive shaft extends from the cam plate end of the pump;

FIGURE 2 is a vertical cross-section through the pump of FIGURE 1;

FIGURE 3 is an enlarged cross-sectional view of a portion of the pump shown in FIGURES 1 and 2; and

FIGURE 4 is a vertical cross-section through a modified embodiment of a pump in accordance with this invention, wherein the drive shaft extends from the port end of the pump.

The axial piston pump shown in FIGURES 1 and 2 has an outer casing 10 comprising a hollow, generally cylindrical body 11 and an end cap 12. The end cap 12 is secured at one end of the body 11 by suitable means such as the bolts 13, 13 shown in FIGURE 2. The pump casing 10 presents an internal chamber 14 within which the operating mechanism is disposed.

The inner face of the cap 12 is provided with a raised annular boss 15 which presents a flat porting and bearing surface 16. A plurality of wear pads 17 are also formed on the inner face of cap 12, and these are finished so that their faces are co-planar with the porting and bearing surface 16.

As illustrated in FIGURE 1, the cap 12 is provided with two ports 18 and 19, one of which constitutes the fluid inlet while the other constitutes the fluid outlet. These ports 18 and 19 communicate at their inner ends with passageways or ports 20 and 21 respectively, which extend through the porting and bearing surface 16. A drain port 22 in the cap 12 communicates with the chamber 14.

A central opening 26 is formed in body 11 at the end thereof which is opposite to cap 12. The operating shaft 27 of the pump extends through this opening 26 into chamber 14 toward cap 12. The outer face of an antifriction ball bearing assembly 28 is push-fitted in opening 26 and is seated against a shoulder 29 formed therein. A lock nut 31 is threaded on shaft 27 at 32 and bears against a lock washer 33, which engages the inner race of bearing 28, thereby preventing axial movement of shaft 27 in the direction toward cap 12.

An oil seal 35 is secured around shaft 27 at the outer end of opening 26, and is held in constant engagement with shaft 27 by a coil or garter spring 36 to prevent the escape of fluid along the shaft.

The inner end of shaft 37 is splined as at 38. The shaft is coupled thraugh the splines 38 to a cylinder barrel 40. The barrel 40 has a central bore 41 splined only at the inner end of the bore 41, i.e. only at the end adjacent to the cap 12, as indicated at 42 in FIGURE 3. This spline connection between the shaft 27 and barrel 40 is relatively loose, and functions in the nature of a universal joint; that is, its function is not to precisely align or position the cylinder barrel with respect to the fixed porting and bearing surface 16 and the passageways or ports 20 and 21, but rather is solely to transmit power to the barrel, which is precisely positioned by other means to be described.

The inner end face of the cylinder barrel 40 is provided with a flat porting and bearing surface 44 which is facially engaged with the porting and bearing surface 16 of the end cap 12 and the wear pads 17. Ports 45 extend from piston chambers 46 formed in the cylinder barrel to this porting and bearing surface 44. As the cylinder barrel revolves, these ports 45 therein alternately register with the ports 20 and 21 in the cap 12 to establish communication between the chambers 46 in the barrel and the inlet and outlet ports 18 and 19 in the cap. The several piston chambers 46 are disposed in parallel circular relation around the axis of the cylinder barrel, and contain reciprocable piston elements 50, the outer ends of which are formed with generally spherical heads 51.

The axial bore 41 in cylinder barrel 40 has an enlarged portion 52 outwardly of the splined portion 42. In this enlarged portion 52 is received the cylindrical shank 54 (best seen in FIGURE 3) of a plunger 55 the outer end 56 of which is generally spherical. The shaft 27 passes through an axial bore in the plunger 55. The plunger may be splined to the shaft in order to prevent relative rotation between them, and for convenience in mounting the plunger on the shaft. It is pointed out, however, that no rotation is transmitted from the shaft to the barrel 40 through the plunger 55, the outer surface of the plunger shank 54 being slip-fitted in the bore 52 of the barrel.

The shaft 27 is provided with an annular groove or neck 58 the diameter of which is smaller than the diameter of the spline 38, and this groove 58 extends in both axial directions from the inner end 57 of the plunger 55. A split washer 59 is loosely seated or engaged in this groove 58, and is held therein by the bore 52. The axial dimension of split washer 59 is less than the axial dimension of groove 58, so that the washer can slide axially in the groove. As will be explained, this washer 59 limits movement of the plunger 55 in the direction toward the end cap 12.

A coil spring 60 is disposed in the enlarged part 52 of bore 41, encircling shaft 27, and is compressed between the cylinder barrel and the split washer 59, whereby the latter is urged toward the plunger 55 and whereby the cylinder barrel is urged toward the end cap 12. The function of this spring 60, as will be described, is to urge the piston shoes against the swash plate of the pump, and to urge the barrel porting and bearing surface 44 against the surface 16.

Piston shoes 62 are connected with the spherical heads 51 of the several pistons 50 in a ball and socket type connection which provides universal movement between these elements whereby the bearing surfaces 63 of the shoes can constantly engage the planar bearing surface 64 of a cam plate or swash plate 65. The swash plate 65 is mounted for rotation about an axis transverse to the axis of shaft 27, on trunnions 67, 67 (shown in FIGURE 1), which are secured in the body 11. The swash plate 65 has an open center area 68, through which the shaft 27 passes in the embodiment shown in FIGURES 1, 2 and 3. The bearing surface 64 and the swash plate 65 can be inclined with respect to the axis of rotation of the cylinder barrel 40 so that as the latter member revolves, the pistons 50 will be reciprocated in the barrel to draw in and expel fluid through the ports 45.

To maintain the shoes 62 in sliding engagement with cam plate surface 64, the shoes are formed with shoulders 70 (FIGURE 3) for engagement by a retaining disk or shoe hold-down plate 72. The hold-down plate 72 has openings 73 through which portions of the shoes 62 project for connection with the piston heads 51. The openings 73 are larger in diameter than the portions of the shoes which pass through them, to permit relative lateral movemena between these elements, as caused by the angular relation of the axes about which the pistons 50 and the plate 72 revolve.

In its central portion the plate 72 is provided with a spherically shaped socket or opening 74 in which the spherical end 56 of the plunger 55 is seated. The spring 60 urges the plunger 55 into engagement with the socket 74 in the hold-down plate, and thereby urges the hold-down plate toward the swash plate 65, normally insuring constant engagement of the shoes 62 with the bearing surface 64. Movement of the shoes off the surface 62 is limited by the point at which the inner face of the split washer 59 (i.e., the left face in the drawings) abuts the left face of groove 58 in shaft 27; preferably this movement is no more than about .001.

A particular bearing construction has been provided to support the cylinder barrel. As previously mentioned, the spline connection at the inner end of the cylinder barrel functions in the nature of a universal drive connection. A radial bearing surface for the cylinder barrel is provided by a skirt-like flange 77 which projects from the outer end of the cylinder barrel, around the plunger 55. The flange 77 is preferably pinned to the barrel as at 80. The outer surface of this flange is accurately finished to cylindrical contour and serves as the inner race for a roller bearing assembly 78, the outer race of which is press-fiitted into a cylindrical surface 79 formed on the interior of the body 11. This bearing 78 supports the cylinder barrel for rotation in the body 11.

In the operation of the device as a pump, fluid is drawn into the chambers 46 in the cylinder barrel 40 from one of the ports 18 or 19, and as the barrel is rotated the angulation of the swash plate 65 forces the pistons 50 sequentially to the left in the barrel, thereby reducing the volume of the chambers 46, so that the fluid is expelled under pressure from the chambers to the other port 19 or 18. The angulation or inclination of the swash plate determines the stroke of the pistons, and therefore determines the fluid displacement in each revolution of the barrel.

As the barrel is rotated, the left end of spring 60 bears against the shoulder at the end of enlarged bore portion 52, and thereby urges the cylinder barrel into engagement with the porting and bearing surface 16 on the end cap. At its right end spring 60 engages split washer 59, which in turn bears against the plunger 55, thereby urging the hold-down plate 72 toward the swash plate 65, so that the shoes 62 are normally held in constant engagement with the bearing surface 64 during the suction portion of the piston stroke. The right face of groove 58 is so positioned that the split washer does not bear against it.

Tests have demonstrated this construction to be very efficient in operation, yet the construction is such that the pump or motor can be manufactured economically in comparison to other pumps of similar operating performance.

In assembling the pump, with the plunger head 56 engaged in its socket 74 in the hold-down plate 72, the lock nut 31 is drawn up tightly, so as to pull the shaft 27 to the right and thereby bring the left face of groove 58 into abutment with the split washer 59 and force the shoes 62 tightly against the swash plate bearing surface 64. The lock nut 31 is then loosened sufficiently to permit the shaft 27 to move back preferably about .001" from

the tight initial position; in operation, this clearance will be reduced as pump temperature increases. This clearance positively limits the extent to which the shoes can move off the bearing surface **64**, since the split washer will abut the left face of groove **58** and prevent further movement of the plunger and hold-down plate in the direction away from the swash plate.

It should be noted, however, that while the provision of these movement limiting means is a desirable safety factor, they are not necessary for successful operation of the device. Axial movement of shaft **27** may alternatively be limited, for example, by the provision of any means which secure the shaft to the bearing **28** and the bearing **28** to the pump housing.

The pump shown in FIGURE 4 of the drawings is similar to that shown in FIGURES 1, 2, and 3, except that the drive shaft, rather than passing through the center of the swash plate, passes through the end plate of the pump.

With reference to FIGURE 4, the body **11** of the pump is secured to an end cap **90** which has an elongated portion **91** having a central bore **92** through which the operating shaft **93** extends. Adjacent the outer end of shaft **93**, the bore **92** is enlarged, as at **94**, and receives a ball bearing assembly **95** which journals the shaft **93**. Thus, in this construction as in that previously described, the shaft is journalled at a point remote from the porting and bearing surface **16**. The outer race of this bearing **95** is press fitted against a shoulder **96** in bore portion **94**, and the inner race of the bearing **95** is fitted on shaft **93**. Spring clips **97** and **98** are seated in shaft grooves on each side of the inner race of bearing **95**, and a spring clip **99** holds the outer race of bearing **95** against shoulder **96**, so that the shaft **93** is fixed axially with respect to the pump casing. An oil seal **105**, which may be of the type shown in FIGURES 1 and 2, encircles the shaft **93** at the end of bore portion **94** and prevents fluid from escaping along the shaft.

The inner end of the cap **90** is provided with a raised annular boss or porting surface **16**, around which are formed co-planar wear pads **17**, similar to the corresponding elements previously described in relation to FIGURES 1–3. The cap is provided with two ports, only one of which **106** is shown in FIGURE 4, and these ports communicate with ports corresponding to ports **20** and **21** shown in FIGURE 1. The cylinder barrel **40**, pistons **50**, shoes **62**, hold-down plate **72**, cylinder barrel bearing **78**, and swash plate **65** of this pump are all identical to those previously described.

The drive shaft **93** is splined to the cylinder barrel through the barrel splines **42**, adjacent the cap porting surface **16**. The drive shaft **93** is also preferably splined to the plunger **55** to prevent relative rotation between them.

In place of the split washer motion-limiting means described in connection with the embodiment of FIGURES 1–3, the construction illustrated in FIGURE 4 utilizes a T-bar motion limiting device between the shaft **93** and plunger **55**.

The end of shaft **93** is slotted radially, the inner end of the slot being shown at **109** in FIGURE 4. A T-shaped bar **110** is received loosely in this slot. The bar **110** has a head section **111** the dimension of which is greater than the inside diameter of plunger shank **54**. The shank **114** of T-bar **110** is threaded and carries a nut **115**. The nut **115** bears against a washer **112** which abuts the end of shaft **93**, thereby limiting movement of the T-bar **110** in the direction toward the end cap **90**.

The cylindrical shank **54** of the plunger is radially slotted as at **117** toward its head **56**, and the head section **111** of the T-bar is slidably engaged in this slot **117**. The right side of the T-bar head section **111** is positioned, by adjusting nut **115**, to limit the movement of the plunger **55** to the left, preferably to about .001" or less. This adjustment is achieved by initially tightening nut **115** to hold the shoes **62** tightly against surface **64**, and then backing off the nut to the desired adjustment. By the provision of these means, movement of the shoes off the swash plate is positively limited to a small amount. The spring **60** urges the plunger against its socket **74**, and holds the cylinder barrel against the head bearing surface **16**.

It will be seen that in both embodiments the operating shaft is journalled at its outer end in the housing of the pump, at a position remote from the porting and bearing surface **16**, and that the cylinder barrel is journalled for rotation in a bearing which is disposed symmetrically about a plane passing through the center of the thrust forces applied to the ball heads **51** of the pistons **50**. This arrangement preserves the thrust balancing features which are described by Ellis H. Born in his U.S. Patent No. 2,608,159. It will also be apparent that in both instances the drive power is taken off the shaft through a coupling adjacent the porting and bearing surface, substantially closer to the bearing surface than the journal for the outer end of the shaft, but that this coupling does no function in the nature of a journal for the shaft or barrel. It is preferred that the center of the spherical end **56** of the plunger **55** lie in a plane passing through the centers of the piston balls **51**, and that the pivot axis of the hanger **65**, which axis passes through the centers of the trunnions **67** (through the roller bearing **78**), passes through the center of the end **56** of the plunger at a point which lies on the axis of the shaft **27** or **93** in said plane. In addition to the foregoing, it is also highly desirable that the mentioned pivot axis of the hanger pass substantially through the center of the cylinder barrel bearing **78**.

With the arrangement above described, the shaft **27** or **93** is supported by two spaced bearings, one at **28** or **95** and the other being the bearing **78** which supports the cylinder barrel **40** and the shaft **27** or **93** through the plunger **55**.

Having described our invention, what is claimed is:

1. A fluid pressure energy translating device comprising, a hollow casing defining an internal chamber, means defining a planar bearing surface at one end of said chamber, fluid ports communicating with said bearing surface through said casing, an operating shaft extending into said chamber normally to said surface and having one end only journalled in said casing at a position spaced from said surface, a cylinder barrel having a plurality of reciprocable pistons received therein, said barrel having an end surface engaging said bearing surface of said casing, said shaft extending axially through said barrel, drive coupling means for transferring rotary movement directly between said shaft and said barrel, said coupling means being located at the end of said barrel which is adjacent to said bearing surface, piston shoes universally connected to the ends of said pistons, a cam plate angulated with respect to the axis of said barrel about an axis transverse thereto, a shoe hold-down plate engaging said shoes and holding said shoes constantly in engagement with said cam plate, a plunger received axially in said barrel, said plunger having a spherical head portion which is centrally socketed in said hold-down plate, said plunger being slidable axially with respect to said barrel, there being no drive connection between said plunger and said barrel, stressed spring means between said barrel and said plunger urging the latter toward said hold-down plate, said barrel having a flange portion extending around said plunger and pistons, and bearing means journalling said flange portion in said casing, said bearing means being disposed symmetrically about the midpoint of said hold-down plate.

2. In a fluid pressure energy translating device including a casing, an operating shaft, a cylinder barrel containing pistons, shoes on said pistons, a cam plate, a hold-down plate engaging said shoes, and a valve surface engaged by an end surface of said barrel; means journalling said shaft in said casing only at a single bearing remote

from said valve surface, bearing means journalling said barrel in said casing, said bearing means being aligned axially with the mid-point of said hold-down plate, and a loose spline connection between said shaft and said barrel at the end surface of said barrel which is adjacent said valve surface.

3. In an axial piston type fluid pressure energy translating device including a casing, a rotatable cylinder barrel in said casing, an inclined cam plate at one end of said cylinder barrel, a plurality of pistons disposed for movement in said cylinder barrel, a bearing shoe universally connected to each piston and having a surface in engagement with said cam plate, hold-down means for holding said shoe surfaces in engagement with said cam plate, a fixed valve surface, one end of said cylinder barrel abutting said valve surface, and an operating shaft, the improvement comprising, a spline directly interconnecting said shaft and said cylinder barrel at the end of said barrel which abuts said valve surface, there being no other rotational interconnection between said shaft and said barrel, means journalling said shaft in said casing only at a position therealong which is remote from said valve surface, a sleeve-like plunger slidably received on said shaft, said plunger having a spherical end portion, a bore in said barrel in which said plunger is slidably received, a spherical socket formed in the center of said hold-down means, the spherical end portion of said plunger being seated in the socket of said hold-down means, spring means in said bore between said barrel and said plunger urging the latter into engagement with said hold-down means, stop means limiting movement of said plunger along said shaft in the direction toward said valve surface, and bearing means journalling said barrel in said casing, said bearing means being disposed in alignment with and symmetrically about the mid-point of said hold-down means.

4. In a fluid pressure energy translating device, a casing, a rotatable cylinder barrel in said casing, a cam plate at one end of said cylinder barrel, a plurality of pistons disposed for movement in said cylinder barrel, a bearing shoe universally connected to each piston and having a surface in engagement with said cam plate, hold-down means for holding said shoe surfaces in engagement with said cam plate, a fixed valve surface, one end of said cylinder barrel abutting said valve surface, an operating shaft, a spline interconnecting said shaft and said cylinder barrel at the end of said barrel which abuts said valve surface, there being no other rotational interconnection between said shaft and said barrel, means journalling said shaft in said casing only at the end thereof which is opposite to said valve surface, adjustment means for adjusting the axial position of said shaft with respect to said casing, a plunger slidably received on said shaft, said plunger having a rounded end, a bore in said barrel in

which plunger is slidably received, the rounded end of said plunger being engaged with said hold-down means, spring means in said bore between said barrel and said plunger urging the latter into engagement with said hold-down means, a groove in said shaft axially aligned therein with the inner end of said plunger in said bore, a washer slidable axially in said groove and engageable with the inner end of said plunger, said groove limiting movement of said washer and plunger along said shaft in the direction toward said valve surface, and bearing means journalling said barrel in said casing, said bearing means being disposed in alignment with and symmetrically about the mid-point of said hold-down means.

5. In a fluid pressure energy translating device, a casing, a rotatable cylinder barrel in said casing, a cam plate at one end of said cylinder barrel, a plurality of pistons disposed for movement in said cylinder barrel, a bearing shoe universally connected to each piston and having a surface in engagement with said cam plate, hold-down means for holding said shoe surfaces in engagement with said cam plate, a fixed valve surface, one end of said cylinder barrel abutting said valve surface, an operating shaft, a spline interconecting said shaft and said cylinder barrel at the end of said barrel which abuts said valve surface, there being no other rotational interconnection between said shaft and said barrel, means journalling said shaft in said casing at the end thereof which is adjacent to said valve surface, said journalling means being spaced axially outwardly of said valve surface, a plunger slidably received on said shaft, said plunger having a rounded end, a bore in said barrel in which plunger is slidably received, the rounded end of said plunger being facially engaged with said hold-down means, spring means in said bore between said barrel and said plunger urging the latter into engagement with said hold-down means, a slot in the end of said shaft, a T-bar in said slot, a stop on the shank of said T-bar and abutting the end of said shaft, the head of said T-bar limiting axial movement of said plunger on said shaft in the direction toward said valve surface, and bearing means journalling said barrel in said casing, said bearing means being disposed in alignment with and symmetrically about the mid-point of said hold-down means.

References Cited by the Examiner

UNITED STATES PATENTS

2,525,498	10/1950	Naylor et al.	103—162
2,633,104	3/1953	Lauck et al.	103—162
2,743,674	5/1956	Shaw	103—162
2,776,628	1/1957	Keel	103—162
3,139,038	6/1964	Stewart	103—162

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