United States Patent [19]

Bobier

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[45] **June 24, 1975**

[54] **FLUID DEVICE HAVING PLASTIC HOUSING AND MEANS FOR MOUNTING A CYLINDER BARREL**

[76] Inventor: **Wilfred S. Bobier,** 4518 Brightmore, Bloomfield Hills, Mich. 48013

[22] Filed: **Jan. 22, 1973**

[21] Appl. No.: **325,128**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 60,333, Aug. 30, 1970, Pat. No. 3,739,691.

[52] **U.S. Cl.** **91/487**

[51] **Int. Cl.** **F01b 13/04**

[58] **Field of Search** 91/499, 506, 487; 64/9

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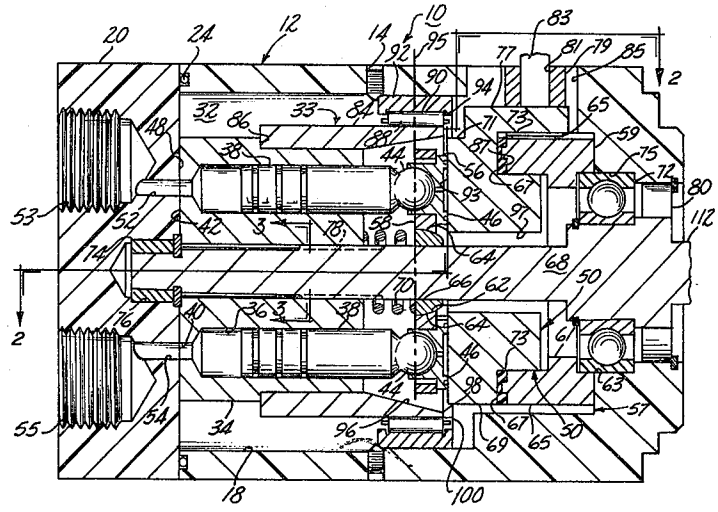
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Primary Examiner—William L. Freeh
Attorney, Agent, or Firm—Basile and Weintraub

[57] **ABSTRACT**

A fluid device of the axial piston type having high and low pressure operating passages, one of which may be an inlet and the other an outlet depending upon the pumping or motoring function of the device. The fluid device which may be of the fixed or variable displacement type has a rotatable shaft driven cylinder barrel with one end of each of a plurality of pistons disposed for reciprocation within cylinder bores in the cylinder barrel, and cylinder ports successively communicating each of the cylinder bores with arcuate inlet and outlet passages formed in a valving face disposed at one end of the cylinder barrel. The other ends of the pistons are drivingly engaged by an inclined thrust plate assembly disposed to impart a reciprocal stroking movement to the pistons within the cylinder bores as the cylinder barrel is rotated. The cylinder barrel has an internal splined portion drivingly connected to a mating splined portion of the drive shaft. An enlarged clearance space between the splined portions permits the cylinder barrel to properly align itself with respect to the drive shaft. The device has a plastic housing which is preloaded by a predetermined amount that is a function of the expansion forces exerted on the housing by the fluid pressure acting against the pistons within the cylinder bores.

5 Claims, 4 Drawing Figures



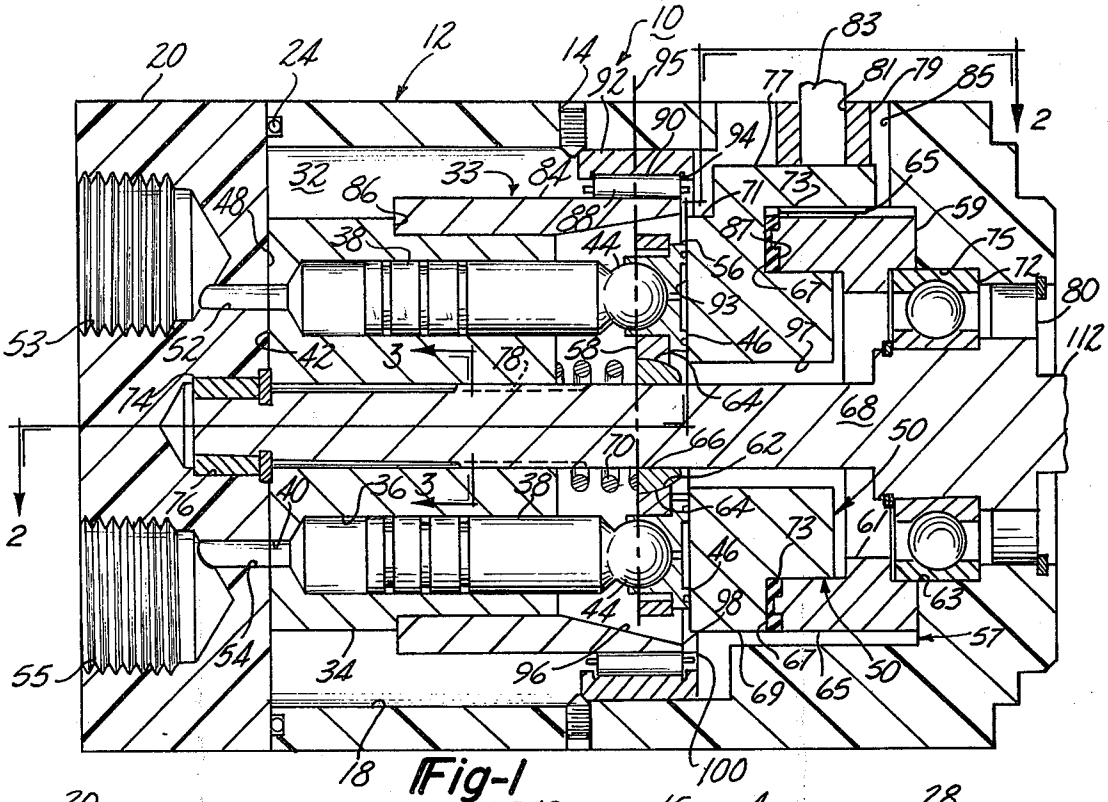


Fig-1

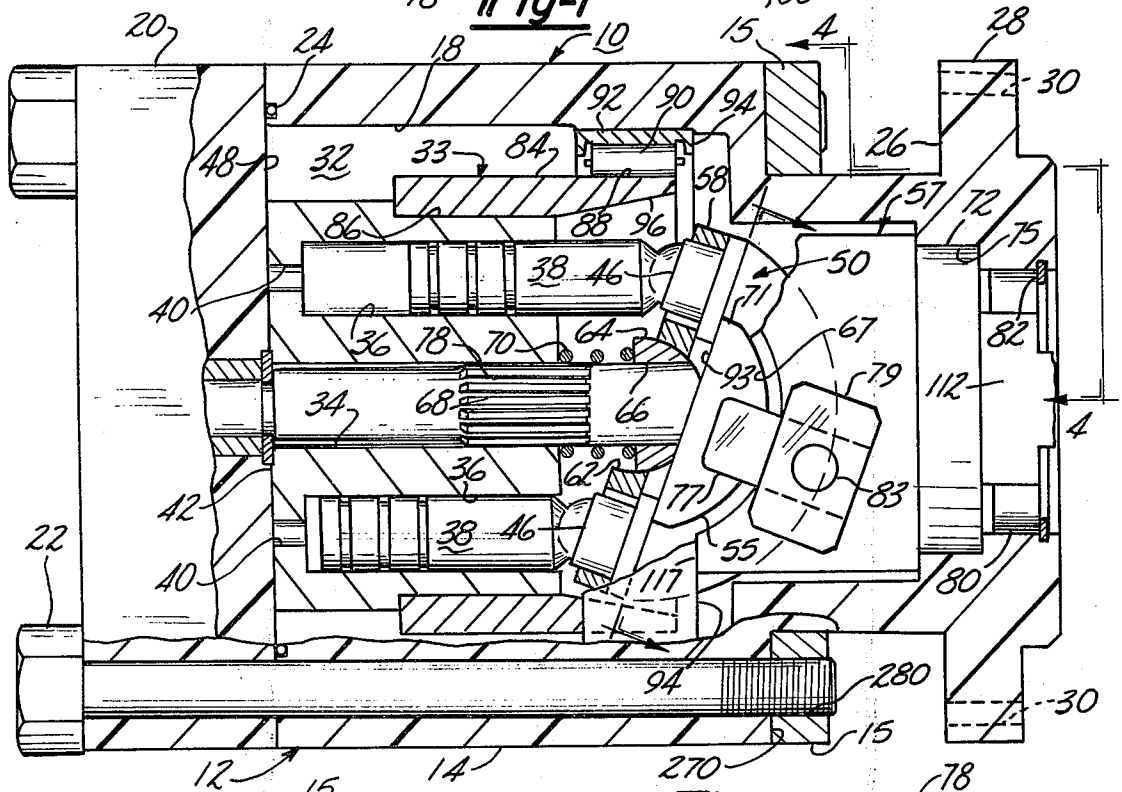


Fig-2

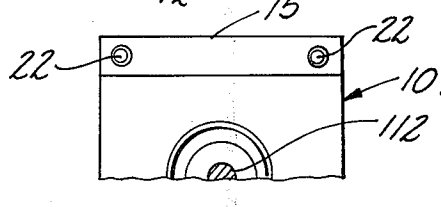


Fig-4

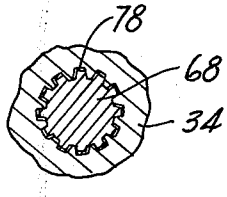


Fig-3

FLUID DEVICE HAVING PLASTIC HOUSING AND MEANS FOR MOUNTING A CYLINDER BARREL

Cross Reference to Related Patent Applications

The present invention is a continuation-in-part of copending U.S. Pat. application Ser. No. 60,333 U.S. Pat. No. 3,739,691 filed 8/30/70 in the name of Wilfred S. Bobier for "Fluid Device."

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates to fluid devices and particularly to those of the axial piston type which may function either as a fluid pump or as a fluid motor.

II. Description of the Prior Art

The present invention is more particularly concerned with a fluid pump or motor construction of the type having a rotary cylinder barrel abutting a stationary valve plate and provided with axial cylinders and pistons reciprocal therein and which abut against a thrust plate, the axis of which is inclined with respect to the axis of rotation of the cylinder barrel. When a unit of this type is operating under pressure, certain related areas are so proportioned that the cylinder barrel is positively biased toward the valve plate by that pressure in a manner which is well known to those skilled in the art. For purposes of starting, however, it is necessary that the barrel be mechanically biased against the valve plate, and this is normally accomplished by means of a spring disposed between the cylinder barrel and the thrust plate. In such devices, the normal thrust component or side thrust of the pistons not only creates the driving torque but also results in a substantial lateral force on the cylinder barrel tending to displace it from its normal position. In counteracting this lateral force, it is important that the cylinder barrel be maintained flatly against the valve plate or it will lift off completely due to fluid flow conditions between the valve plate and cylinder barrel interface and this, of course, renders the device inoperative, or may result in scoring of the valve plate and/or cylinder barrel faces.

In prior art devices of this type support for the cylinder barrel against lateral displacement has been provided by two general schemes. The first of these is to provide a radial bearing encircling the cylinder barrel directly interposed between the cylinder barrel and the housing. The second scheme of construction has been to support the cylinder barrel directly on the shaft at the driving connection therewith and transmit the lateral thrust thereon to the housing throughout the shaft and shaft support. The second of these schemes has advantages in that the size and weight of the units can be reduced. However, in the past when the cylinder barrel was shaft supported, the means utilized for biasing the cylinder barrel into engagement with the valve plate and for biasing the pistons outwardly against the thrust plate were generally unsatisfactory. It has thus been found that the first of the schemes employing the aforementioned radial bearing encircling the cylinder barrel is the most satisfactory method for mounting the cylinder barrel. In such constructions the cylinder barrel which runs in an abutting and fluid sealing relationship with the stationary valve plate, the cylinder barrel is constantly pressed toward engagement with the valve plate, and the fluids flowing across the face of the valve plate between the cylinder barrel and valve plate face provide a hydrostatic fluid film which supports the cylinder barrel. In order to prevent excessive wear or galling of the valve plate face and cylinder barrel face, it is necessary to provide a means which permits a limited and controlled amount of movement of the cylinder barrel with respect to the drive shaft so that the cylinder barrel may find its own natural center and freely float on the hydrostatic balanced fluid film and hydrokinetic lubricating film formed between the faces of the cylinder barrel and the valve plate.

In axial piston pumps and motors of the variable displacement type, the thrust plate assemblies normally take the form of a yoke having transversely extending pintles rotatably carried in bearings suitably mounted to the wall of the housing such that the entire force exerted against the thrust plate assembly due to the fluid pressure acting against the pistons within the cylinder barrel bores is taken completely by the housing. Such a construction necessitates a strong metal housing such as a steel or cast iron housing. Such metal housings are expensive in that they must first be cast molded and subsequently require a secondary machining operation to provide the necessary precision that is essential in fluid pumps and motors of the axial piston type. It would therefore be desirable to provide an axial piston pump or motor having a plastic housing construction which eliminates the necessity for a metal housing, thus eliminating the required secondary machining operations and the accompanying expense normally incurred in using metal housings. For example, housings constructed for fluid devices having the same displacement capacity cost approximately $2.00 for a housing constructed of metal as compared to 60 cents for a housing constructed from a suitable plastic material. In addition, the equipment needed to manufacture a metal housing costs approximately $750,000.00 as compared to $5,000.00 for an injection mold which would be utilized in construction of a housing fabricated from a plastic material.

SUMMARY OF THE INVENTION

The present invention, which will be described subsequently in greater detail, comprises a fluid pumping or motoring device of the axial piston type having a construction which permits the adaptation of an outer plastic housing and which includes means for mounting a rotating cylinder barrel to a drive shaft in such a manner that the cylinder barrel is automatically aligned with respect to the drive shaft and a valve plate face slidably engaged by one end of the cylinder barrel.

It is therefore an object of the present invention to provide a rotary fluid device of the axial piston type having an improved construction which is readily adapted to low cost manufacturing.

It is also an object of the present invention to provide a rotary fluid device of the axial piston type having an improved cylinder barrel and drive shaft construction resulting in a reduction in surface wear and galling between the cylinder barrel and the valving face.

Other objects, advantages, and applications of the present invention will become apparent to those skilled in the art of such fluid devices when the accompanying description is read in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The description herein makes reference to the accompanying drawing wherein like reference numerals

refer to like parts throughout the several views, and in which:

FIG. 1 is a longitudinal cross-sectional view of an example of a fluid device constructed in accordance with the principles of the present invention;

FIG. 2 is a longitudinal cross-sectional view of the fluid device illustrated in FIG. 1 and taken generally on line 2—2 thereof;

FIG. 3 is a fragmentary transverse cross-sectional view of the fluid device of FIG. 1 taken generally on line 3—3 of FIG. 2 illustrating the splined connection between the cylinder barrel and the drive shaft with the clearance space therein between being exaggerated for purposes of clarity; and

FIG. 4 is a reduced fragmentary cross-sectional view of the fluid device taken along line 4—4 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing, and particularly FIGS. 1 and 2, there is illustrated a fluid device in the form of an axial piston pump 10. Although the description herein makes reference to an axial piston pump, it is to be understood by those skilled in the art that the inventive principles to be described hereinafter have equal application to axial piston motors and similar fluid devices.

The axial piston pump 10 comprises a housing 12 having a body section 14 constructed of a plastic material and a longitudinally disposed bore 18 enclosed by a cap 20 secured to the body section 14 by bolts 22 extending axially through the cap 20 and the body section 14 and threadably engaging clamps 15. An O-ring 24 insures a fluid tight seal between the juncture of the body section 14 and the cap 20. The body section 14 includes a pilot portion 26 forming a mounting flange 28 having mounting holes 30 extending therethrough to permit the mounting of the pump 10 at a desired location. The housing bore 18 provides a chamber 32 in which a rotating group 33 is positioned. The rotating group 33 includes a cylinder barrel 34 which is provided with a plurality of arcuately spaced cylinder bores 36, each having one end of a piston 38 axially slidable therein. A plurality of cylinder ports 40 axially aligned with each cylinder bore 36 communicate each of the cylinder bores 36 with a front face 42 of the cylinder barrel 34. Each of the pistons 38 have spherical ends 44 on which are swaged socketed shoes 46. The cylinder barrel 34 is positioned axially between a valving face 48 formed on the inner face of the cap 20 and an inclined thrust plate assembly 50. The valving face 48 serves in a well known manner to provide a properly phased connection between the cylinder ports 40 and a pair of arcuate ports 52 and 54 such that the cylinder ports 40 communicate successively with the arcuate ports 52 and 54 as the cylinder barrel 34 rotates. The arcuate ports 52 and 54 are respectively connected to the external inlet and outlet connection ports 53 and 55 of the pump 10.

The piston shoes 46 have outwardly extending flanges 56 which are contacted by an annular cage 58 with holes corresponding to each piston 38. The annular cage 58 has a centrally disposed conical bore 62 adapted to contact a spherical outer surface 64 of a collar 66 which is, in turn, carried on a drive shaft 68 that extends longitudinally through the housing bore 18. A spring 70 disposed between the piston end of the cylinder barrel 34 and the collar 66 exerts a force urging the face 42 of the cylinder barrel 34 into engagement with the valving face 48, while at the same time biases the shoes 46 by means of the collar 66 and the annular cage 58 into engagement with the thrust plate assembly 50. The drive shaft 68 is supported between bearings 72 and 74. The bearing 72 is carried in a bore 75 of a decreased diameter at the thrust plate assembly end of the housing 12 while the bearing 74 is carried in a centrally disposed bore 76 within the cap 20. The drive shaft 68 is effective to transmit torque from a prime mover (not shown) to the cylinder barrel 34 through a splined driving connection 78 in a conventional manner, a manner which will be described in greater detail. A conventional shaft seal 80 is provided in the decreased diameter bore 75 and retained in position by a snap ring 82.

The cylinder barrel 34 is provided with a skirt portion 84 snuggly fitted in a recessed portion 86 at the piston end of the cylinder barrel 34 to form an inner race 88 for roller bearings 90; the outer race 92 of which is carried by the body section 14 in abutment with the thrust plate assembly. The skirted portion 84 has an annular inclined inner surface 96 extending upwardly from the cylinder barrel 34 and terminating in such a manner that the thrust plate assembly end 98 of the inner race 88 is flush with the thrust plate assembly end 100 of the roller bearings 90.

The face 42 of the cylinder barrel 34 comprises a plurality of bearing pads separated from one another by radial grooves and separated from balancing lands of the cylinder ports 40 by an annular groove. The bearing pads are generally referred to as "Kingsbury pads" and function in a manner well known in the art.

As the cylinder barrel 34 rotates, a reciprocating stroking motion is imparted to the pistons 38 due to the inclination of the thrust plate assembly 50, thus a relative reciprocating motion between the cylinder barrel 34 and the pistons 38 results as the cylinder barrel 34 rotates wherein the cylinder bores 36 are alternately compressed and expanded, resulting in fluid being drawn into and expelled from the cylinder bores 36 through the cylinder ports 40. By changing the inclination of the thrust plate assembly 50 with respect to the axis of rotation of the cylinder barrel the displacement of the pump 10 may be selectively varied as described in greater detail in the aforementioned patent application.

From the foregoing it can be seen that when a rotary movement is imparted to the outer end 112 of the drive shaft 68, the cylinder barrel 34 will be revolved to alternately register the cylinder bores 36 with the arcuate ports 52 and 54 of the valving face 48 by means of the cylinder ports 40.

The thrust plate assembly 50 comprises a movable yoke 55 and a fixed yoke support 57. The fixed yoke support 57 has a U-shaped configuration, the bottom wall 59 of which has a bore 61 through which the drive shaft 68 extends. The bore 61 has an end enlarged portion 63 having an inner diameter closely fitting the outer diameter of the drive shaft support bearing 72, and thus the yoke support 57 is axially aligned with respect to the drive shaft 68 when positioned on the outer periphery of the bearing 72.

The yoke support 57 includes a pair of axially projecting sidewalls 65, each of which has an arcuately shaped bearing surface 67 supporting the movable yoke 55 on which the piston shoes 46 slidably engage

as the cylinder barrel **34** is rotated so as to impart a reciprocal stroking movement to the pistons **38.** The yoke **55** has a pair of transversely extending aligned support pins **69** and **71** each of which has arcuately shaped bearing surfaces **73** contoured to meet with the arcuately shaped bearing surfaces **67** of the projecting sidewalls **65** such that the yoke **55** is adapted to pivot within the side wall bearing surfaces **67** about an axis **95** defined by the radius of the transversely extending support pins **69** and **71** in a manner which will be described in greater detail hereinafter.

The yoke support pin **71** includes an L-shaped arm **77** integrally formed therewith and projecting rearwardly away from the support pin **71.** The projecting leg of the arm **77** carries a member **79** having a slot **81** in which a connecting pin **83** is disposed. The connecting pin **83** extends through an opening **85** formed in a sidewall of the body section **14** and is adapted to be coupled to any one of several displacement varying mechanisms disclosed in the aforementioned patent application.

The yoke **55** has a circular thrust bearing face **93** with which the shoes **46** cooperate and an elliptical, centrally disposed bore **97** through which the drive shaft **68** extends. The elliptical shape of the bore **97** permits the yoke **55** to rotate about the shaft **68** without interference therewith.

Since the periphery of the yoke support **57** is rectangular and the periphery of the yoke **55** is circular, each corner **117** (FIG. **1**) of the yoke support **57** will project radially outwardly beyond the yoke **55** so as to axially support the yoke **55** phantom lines. Thus the forces generated against the pistons **38** are axially directed to the thrust plate assembly **50** and the shaft bearing **72** and ultimately to the housing **12.**

The body section **14** of the housing **12** is fabricated from a plastic material and as illustrated in FIG. **2,** the body section **14** has an outer annular recessed portion **270** at the drive shaft end on which the metal clamps **15** are carried. By tightening the bolts **22** within threaded bore **280** of the clamps **15,** the plastic body section **14** may be precompressed to a predetermined amount, which is a function of the pressure at which the pump **10** will operate and the axial forces generated thereby. During operation of the pump **10,** the pressure within each cylinder bore **36** generates a force against each piston **38** which acts in a direction normal to the face of the cylinder barrel **34.** This force can be resolved in an axial component force and a radial component force acting at the center of the spherical piston ends **44.** As aforementioned, these forces exert an axial or tension load on the plastic body section **14** of the housing **12** which tends to longitudinally expand the same. By precompressing the plastic body section **14** a predetermined amount, the effect of the expansion loads exerted on the plastic body section **14** by the internal axial forces of the rotating group **33** will be canceled, or minimized to such an extent that the use of a metal housing is not required. As can best be seen in FIG. **4,** the clamps **15** each comprise an elongated bar member which extends across the outer recessed portion **270** between two adjacent bolts **22.** Thus the clamps **15,** in addition to providing a means for bolting the pump housing together, function to distribute the precompression load across the face of the housing body section **14.** The clamps can be designed to interconnect two or more bolt ends, as desired. The body section **14** of the housing **12** may be fabricated from any suitable plastic material snythetic capable of carrying a preload of compressive forces. Suitable plastic materials for this purpose may comprise synthetic resins such as polycarbonates, ABS resins and polyamides such as nylon and the like.

As hereinbefore indicated, the face **42** of the cylinder barrel **34** rides on a film of oil disposed between the face **42** and the valve plate face **48.** This film of oil is well known to those well skilled in the art and a further detailed description of the same is not necessary. The normal thrust component for side thrust on the pistons creates the driving torque necessary to drive the pump and results in substantial lateral forces on the cylinder barrel tending to displace it from its normal position. The cylinder barrel is restrained from lateral displacements by the provision of the radial bearing **90** encircling the cylinder barrel **34** and directly interposed between the cylinder barrel and the housing. Although the bearing **90** is effective to restrain the cylinder barrel from moving under the influence of the laterally directed forces as a result of the pressure within the cylinder bores **36,** it is necessary for some relative movement of cylinder barrel **34** and the shaft **68** in order for the cylinder barrel to properly align itself with respect to the shaft and properly float on the hydrostatic film between the valve plate and cylinder barrel interface. Heretofore, the relative tilting of the cylinder barrel with respect to the shaft has been accomplished by providing a standard female spline on the cylinder barrel **34** while a crown spline is formed on the shaft spline. That is, the spline surfaces slope upwardly from each end to a point near the center of the spline or a weakened shaft capable of flexing. The cylinder barrel may then rock on this highpoint in order to obtain the aforementioned proper alignment. Although this method is effective and results in a proper positioning of the cylinder barrel with respect to the shaft and valve plate face, it requires weakening the shaft or expensive manufacturing techniques in order to achieve the crown effect on the drive shaft spline.

It is conventional in the manufacture of splines to control the spline fit by any of three conventionally accepted methods. The first is known as the Major Diameter fit whereby the fit is controlled by varying the major diameter of the external spline. The second type of control is the Minor Diameter fit whereby the fit is controlled by varying the minor diameter of the internal spline and this type of fit is further divided into three subclasses known as the sliding, closed and press, or interference fits. The third type of fit is known as the Size of Teeth fit whereby the fit is controlled by varying the tooth thickness and is customarily used for fillet-root splines. All of these various types of techniques are well known to those skilled in the art and a further detailed description thereof is not necessary except that in all three methods, the pitch diameter of both the male and female splines is equal. In the preferred embodiment the desired relationship between the cylinder barrel and the drive shaft is obtained by providing an enlarged clearance space between the male and female splined portions of the cylinder barrel and drive shaft. This may be accomplished in two ways. As aforementioned, the pitch diameter of the male and female spline are equal with the proportions, dimensions, fits and tolerances being governed by the ASA standards (see Darle W. Dudley, Involute Splines, Production En-

gineering, Volume 28, page 75, October 1957). In the present invention the desired clearance is obtained by decreasing from five- to ten-thousandths per inch of pitch diameter of the drive shaft under the standard ASA pitch diameter for the male spline while maintaining the pitch diameter of the female splined portion at the standard ASA design parameter. Alternately, the male spline pitch diameter may remain at the standard ASA designation and the female spline pitch diameter may be enlarged from five- to ten-thousandths per inch of pitch diameter. Both methods result in an enlarged radial clearance between the female and male splines respectively of the cylinder barrel and drive shaft providing the necessary increased clearance to permit a slight rocking or tilting of the cylinder barrel with respect to the drive shaft to facilitate obtaining the proper interface relationship between the cylinder barrel face **42** and the valve plate face **48.** In addition, this increased clearance between the female and male splines of the cylinder barrel and drive shaft further facilitates proper operational use of the spring **70** which as aforementioned functions to axially bias the cylinder barrel toward the valve plate face **48.** Thus the complementary configurations of the male and female splines of the cylinder barrel **34** and drive shaft **68** provide a selfcentering alignment between the two elements by means of the differing pitch diameters of the male and female splines, all of which results in an extremely less expensive manufacturing operation than the aforementioned crown type spline construction.

Thus, it can be seen that the present invention provides a rugged, compact and low cost fluid device of the axial piston type that can function as a motor or a pump and which has an improved means for mounting the cylinder barrel in an inexpensive manner.

While the form of the embodiment of the invention as disclosed herewithin constitutes a preferred form, it is to be understood by those skilled in the art of fluid pumps and motors that other forms might be adopted, all coming within the spirit of the invention and the scope of the appended claims.

What is claimed is as follows.

1. A fluid pressure energy translating device of the axial piston type comprising:

a housing having a longitudinal bore with a stationary valve plate at one end thereof;

a drive shaft rotatably carried within said housing bore, said drive shaft having a male spline;

a rotatable cylinder barrel mounted on said drive shaft and having one end in abutment with said valve plate, said cylinder barrel having a plurality of arcuately spaced cylinder bores, said cylinder barrel having a female spline mating with said drive shaft male spline to form a driving connection thereinbetween;

a bearing means having an inner race carried by the outer peripheral surface of said cylinder barrel, said bearing means having an outer race carried by the wall of said housing longitudinal bore such that said bearing means providing radial support for said cylinder barrel;

said male and female splines having complementary configurations for permitting self-centering alignment between said cylinder barrel and said drive shaft such that said cylinder barrel will float on said valve plate and said cylinder barrel will be centered with respect to said bearing means, said female spline having a pitch diameter which is greater than the pitch diameter of said male spline such that there is an enlarged radial clearance space between said splines;

a plurality of pistons with inner ends disposed for reciprocal stroking movement within said cylinder bores; and

an inclined thrust plate mounted in said housing in a driving relation with the other ends of said pistons for imparting a reciprocal stroking movement to said pistons within said cylinder barrel bores as said cylinder barrel rotates whereby the radially directed forces exerted on said cylinder barrel are not transferred to said drive shaft.

2. The fluid pressure energy translating device defined in claim **1** wherein the pitch diameter of the male spline of said drive shaft is at a predetermined standard size and the pitch diameter of said female spline of said cylinder barrel is increased with respect to said male spline pitch diameter by a predetermined amount.

3. The fluid pressure energy translating device defined in claim **1** wherein the pitch diameter of the male spline of said drive shaft is a predetermined standard size and the pitch diameter of said female spline of said cylinder barrel is increased with respect to said male spline pitch diameter by a predetermined amount.

4. The fluid pressure energy translating device defined in claim **2** wherein the pitch diameter of said female spline is increased from five- to ten-thousandths per inch of pitch diameter of said male spline of said drive shaft.

5. The fluid pressure energy translating device defined in claim **2** wherein the pitch diameter of said female spline is increased from five- to ten-thousandths per inch of pitch diameter of said male spline of said drive shaft.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,890,882
DATED : June 24, 1975
INVENTOR(S) : Wilfred S. Bobier

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, line 2, following "connection" delete "the-";

Column 8, line 3, delete "reinbetween" and insert --thereinbetween--; and

Column 8, line 8, following "means" delete "providing" and insert --provides--.

Signed and Sealed this

sixth Day of *January* 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks