United States Patent [19]

Bobier

[11] **3,739,691**

[45] **June 19, 1973**

[54] **FLUID DEVICE**

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

[22] Filed: **Aug. 3, 1970**

[21] Appl. No.: **60,333**

[52] **U.S. Cl.** **91/506**

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

[58] **Field of Search** ..... 308/DIG. 5, DIG. 7; 91/6.5, 485, 499–506; 417/252, 218, 222; 74/60; 92/12.2

[56] **References Cited**

UNITED STATES PATENTS

2,667,862	2/1954	Muller	91/506
3,405,646	10/1968	Thoma	91/488
2,298,850	10/1942	Vickers	91/487
2,699,123	1/1955	Bonnette et al.	91/505
2,975,720	3/1961	Schoellhammer	91/499
3,009,422	11/1961	Davis	417/222
3,092,034	6/1963	Bartholomaus	91/499
3,256,782	6/1966	Ebert	92/12.2
3,384,028	5/1968	Thoma	91/501
3,504,492	4/1970	Neukirch	60/53 A
2,704,232	3/1955	Johnston et al.	308/1 PM
2,709,339	5/1955	Edelmann et al.	417/252
2,885,248	5/1959	White	308/1 N
2,972,962	2/1961	Douglas	91/507
3,124,008	3/1964	Firth et al.	74/60
3,241,495	3/1966	Diedrich et al.	91/507
3,255,673	6/1966	Thoma	91/485
3,396,670	8/1968	Baits	91/506
3,457,873	7/1969	Fischer et al.	91/6.5
3,512,178	5/1970	Russell	417/218

FOREIGN PATENTS OR APPLICATIONS

662,105	6/1949	Great Britain	415/219
1,812,743	7/1969	Germany	91/506
1,161,762	1/1964	Germany	91/507

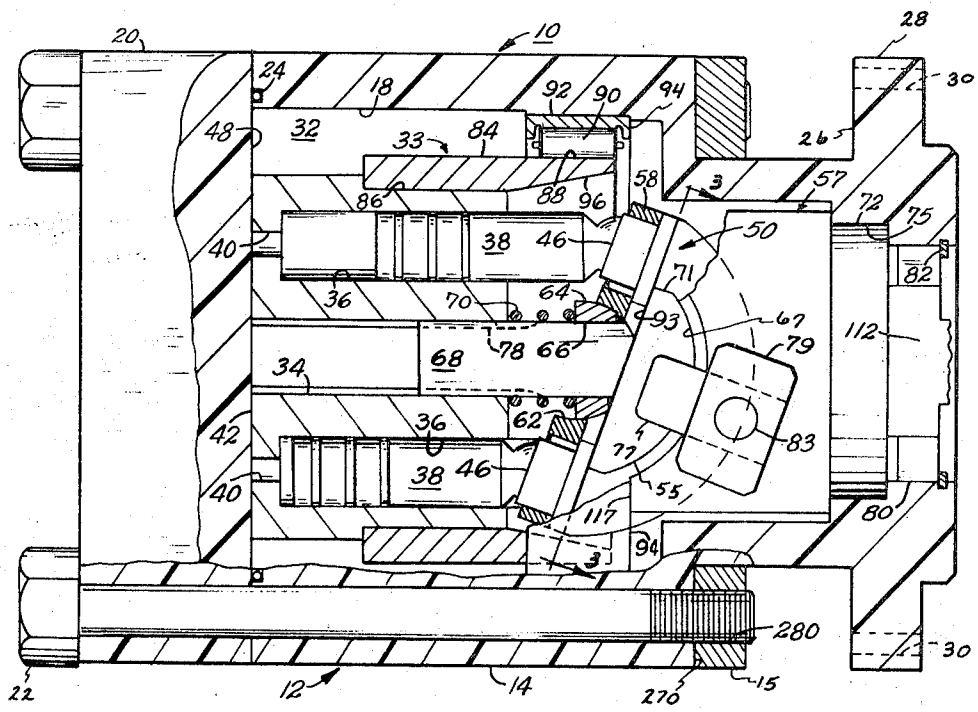
Primary Examiner—William L. Freeh
Attorney—Andrew R. Basile

[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 cylinder barrel with each end 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. In one example of the invention, the thrust plate assembly, the cylinder barrel and other rotating components of the fluid device are constructed of a sintered material enclosed in 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.

In a second example of the invention, a variable displacement fluid device is disclosed as having several means for varying the inclination of the thrust plate assembly with respect to the longitudinal axis of the shaft on which the rotating cylinder barrel is carried.

23 Claims, 11 Drawing Figures



Patented June 19, 1973 3,739,691

4 Sheets-Sheet 1

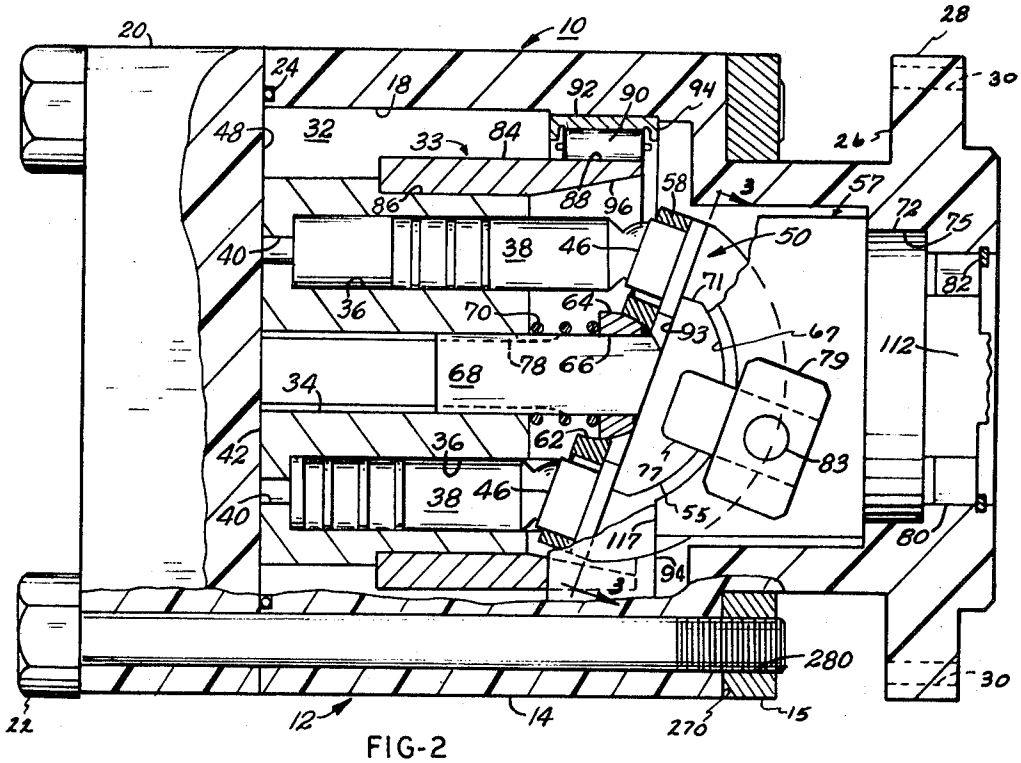


FIG-2

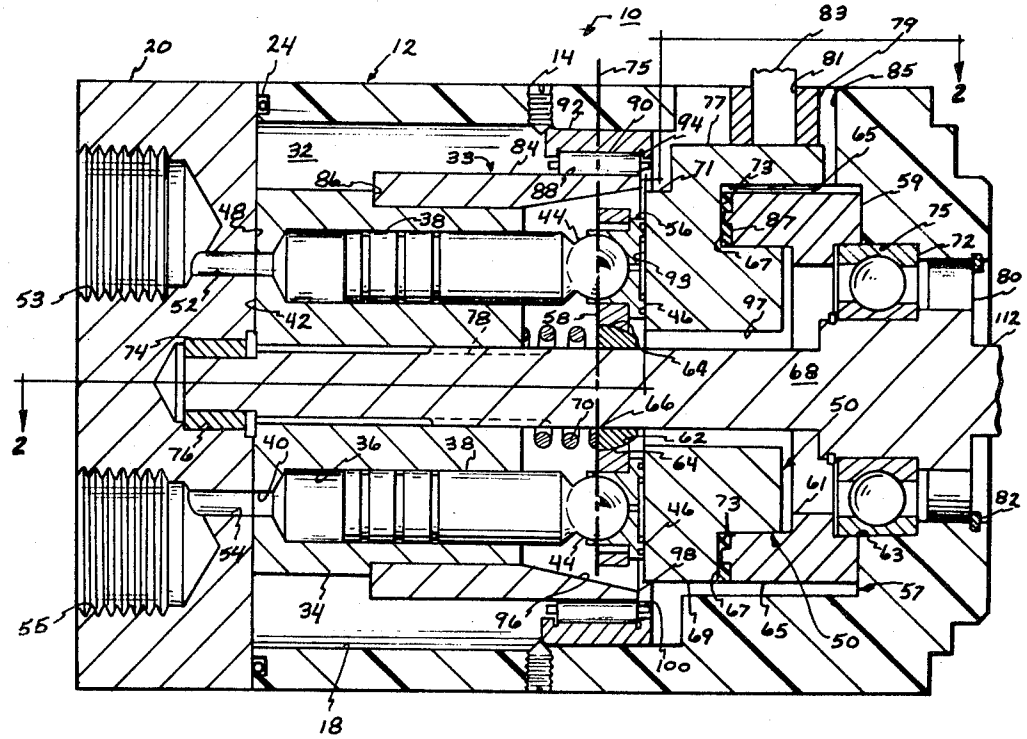


FIG-1

INVENTOR
WILFRED S. BOBIER
BY
Hauke, Gifford & Patalidis
Attorneys

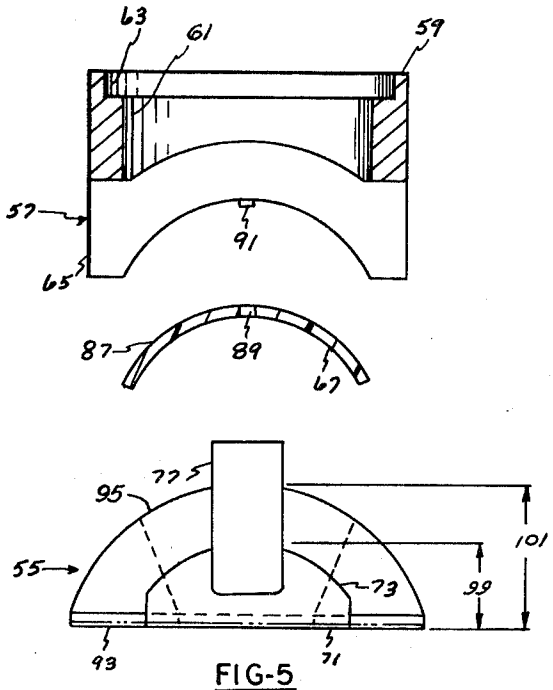


FIG-5

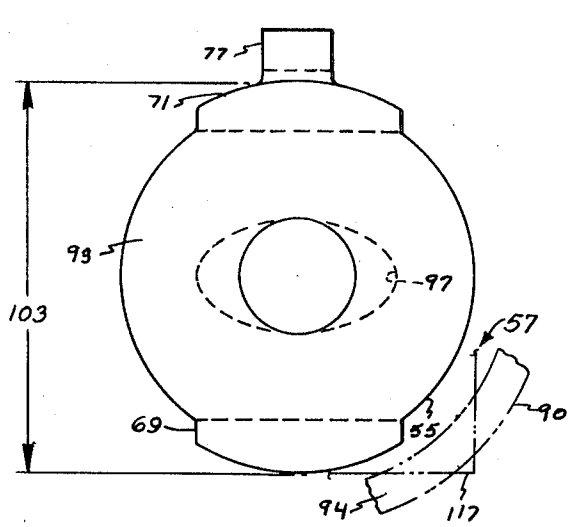


FIG-3

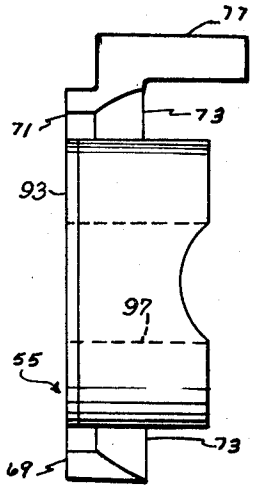


FIG-4

INVENTOR
WILFRED S. BOBIER
BY
Hauke, Gifford & Patalidis
Attorneys

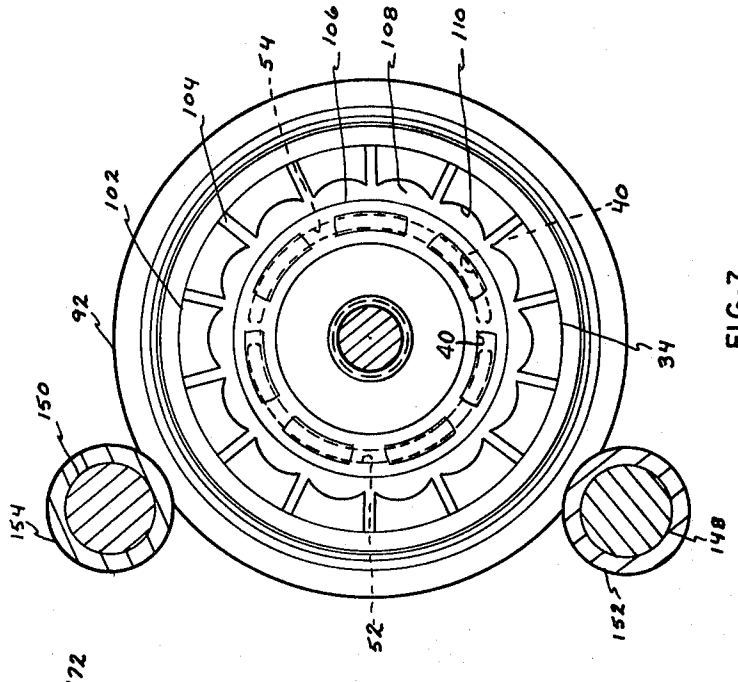


FIG-7

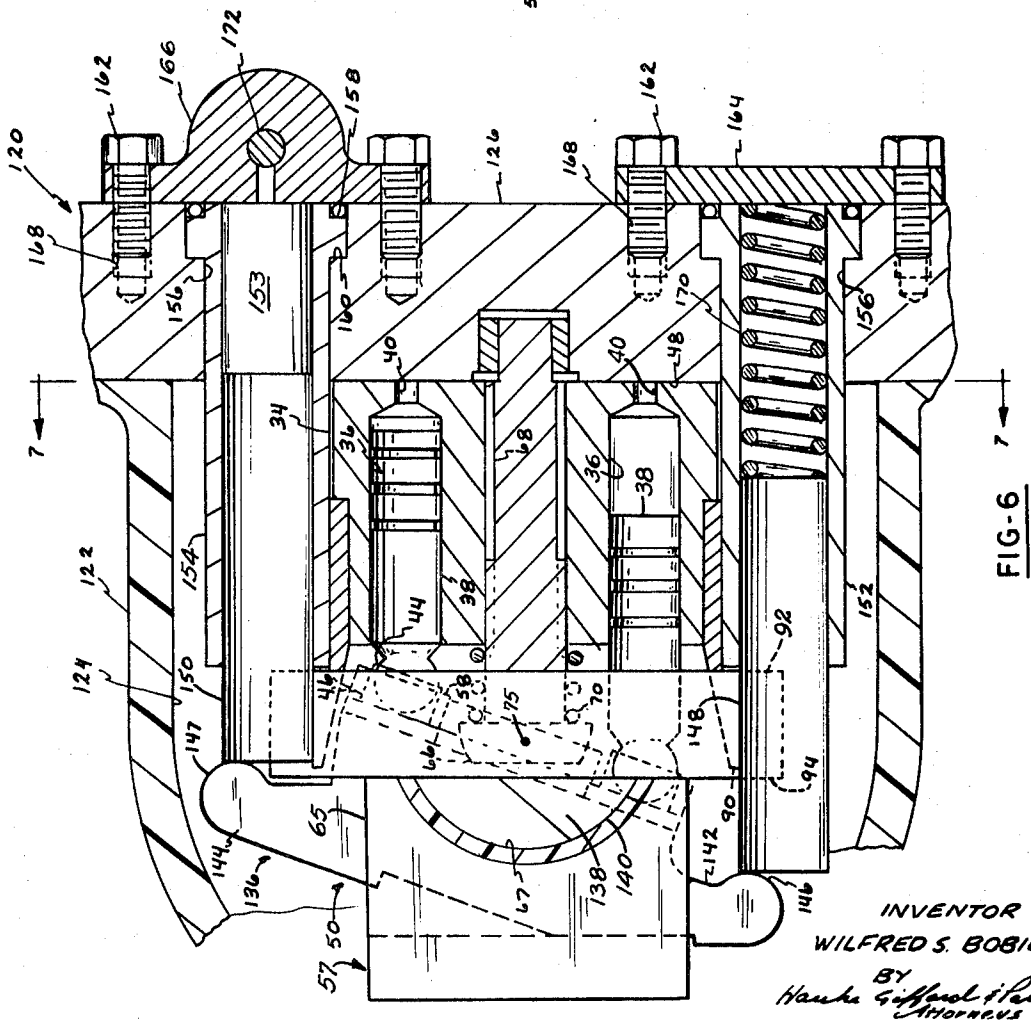


FIG-6

INVENTOR
WILFRED S. BOBIER
BY
Hauke Gilfillan & Patalidis
Attorneys

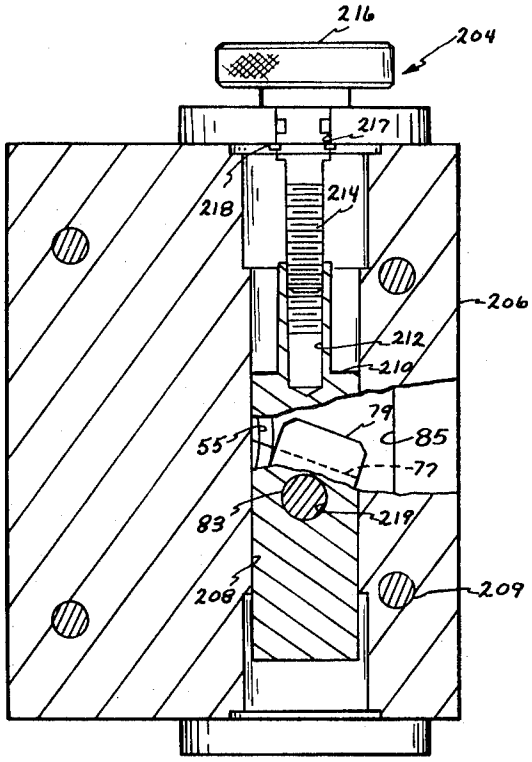


FIG-10

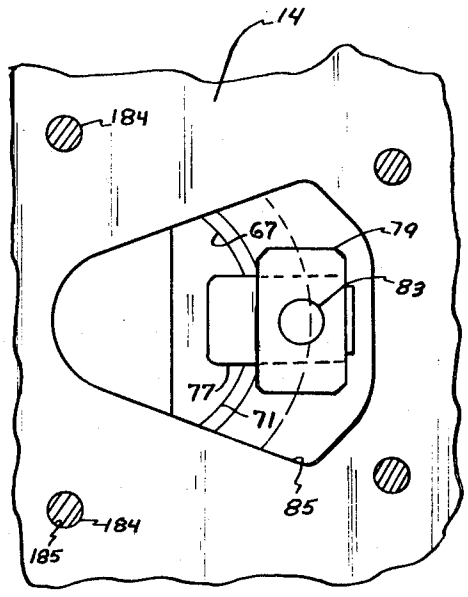


FIG-8

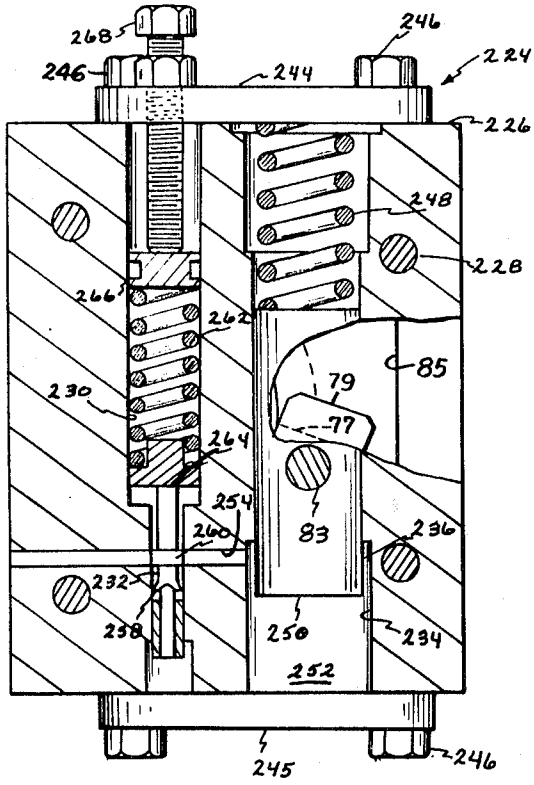


FIG-11

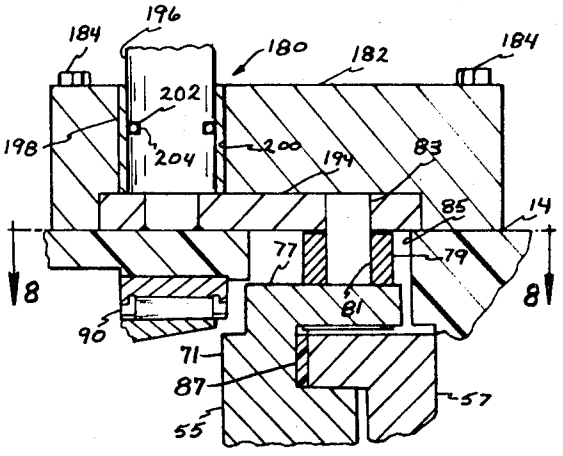


FIG-9

INVENTOR
WILFRED J. BOBIER
BY
Hauke, Gifford & Patalidis
Attorneys

FLUID DEVICE

BACKGROUND OF THE INVENTION

1. 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.

2. Description of the Prior Art

Heretofore, fluid pumping or motoring devices of the axial piston type have been constructed of a metallic housing having a revolving cylinder barrel with a plurality of parallel cylinder bores therein, within which pistons are reciprocated by means of a thrust plate assembly or the like. A rotary valve mechanism in the form of cylinder ports at one end of the cylinder barrel alternately connects each cylinder bore with an inlet and an outlet passage of the device as the cylinder barrel is rotated.

The thrust plate assembly in fluid devices of the variable displacement type normally takes 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 piston within the cylinder barrel bores is taken by the housing, thus necessitating a strong metal housing. Such metal housings are expensive in that they must be cast molded and subsequently require a machining operation to provide the necessary precision that is needed in such constructions. It would be desirable to provide a housing for such axial piston fluid devices, constructed of a plastic material which would eliminate the subsequent machining operations and the resulting expenses normally incurred in using such metal housings. For example, housings constructed for fluid devices having the same displacement capacity would cost approximately $2.00 for a metal housing as compared to $0.60 for a housing constructed of a plastic material. The equipment needed to manufacture a metal housing costs approximately $750,000.00 as compared to $3,500.00 for an injection mold which would be used in constructing a housing of a plastic material.

Further, heretofore fluid devices of the variable displacement type have used a thrust plate assembly which is normally of a metal construction such as cast iron or steel which, in addition to requiring substantial machining, adds to the overall weight of the device. It would be desirable to replace such cast iron and/or steel thrust plate assemblies with one constructed of a sintered material which, heretofore, has not been possible because of the high loads and complicated shape that such thrust plate assemblies require.

In addition to the high loads transmitted to the thrust plate assembly, suitable means must be provided which permit an easy movement of the thrust plate assembly with respect to the longitudinal axis of the drive shaft on which the cylinder barrel is rotated so as to vary the amount of reciprocal stroking movement imparted to the pistons within the cylinder bores to thereby permit a selected variation in the displacement of such axial piston fluid devices.

In such previously constructed axial piston fluid devices, the displacement control mechanism used to control the inclination of the thrust plate assembly with respect to the longitudinal axis of the drive shaft has necessitated a different design for both the fixed displacement device and the variable displacement pump as the displacement control mechanism is normally constructed as part of the housing in such variable displacement devices, thus requiring a larger housing for the variable displacement device. Heretofore, if the same housing were used for both variable and fixed displacement units, a larger housing would have been required since portions thereof would be used to mount the displacement control mechanism. The use of such a variable displacement housing in a fixed displacement unit results in an unduly large unit in proportion to its displacement. It would therefore be desirable to provide a housing which is constructed for both variable displacement and fixed displacement devices without requiring a larger housing for the variable displacement design.

It is also a conventional practice that such previously used devices have been normally constructed to use only one type of displacement varying control mechanism, whereas it may be desirable to have a fluid device having a housing construction which is adaptable for use with manual controls, pressure compensated controls and the like, thus eliminating the necessity of having several different housing designs for the same capacity unit so as to accommodate different displacement control applications.

Fluid devices of the axial piston type normally are characterized by having a valving face formed by a flat surface on which the cylinder barrel normally runs in abutment and in a fluid sealing relationship. The abutting face of the cylinder barrel on which the cylinder ports are disposed normally has been provided with arcuately spaced elevated pressure pads disposed radially outwardly from the cylinder ports providing a bearing surface on which the cylinder barrel rides in a manner which avoids excessive wear. Such bearing pads are more commonly referred to as "Kingsbury Pads" and have functioned in an acceptable manner in the past to compensate for wear and variations in oil viscosity due to changing temperatures and different fluids. In devices of this type operating at high speeds and high pressures, considerable difficulty may be experienced in providing a satisfactory running surface between the cylinder barrel and the valving face due to a lack of oil flow across the face of the cylinder barrel from the cylinder ports to the Kingsbury pads.

It would therefore be desirable to provide a new and improved Kingsbury pad for such axial piston fluid devices.

As speed and pressure is increased in such previously used fluid devices, there is always an accompanying increase in noise. This general increase in noise with increased speed and pressure may be attributed to a number of factors in devices of the axial piston type. First, the sound frequencies generated by the device increase with speed as the components of the device are subjected to increased alternating impact forces; second, the intensity of speed related sounds increases as the impact forces between components of the device increase; and third, the excitation spectrum of the significant piston harmonics also broadens, thus increasing the number of resonant responses.

It would therefore be desirable to provide a fluid device wherein the attendant noise and vibration levels are significantly reduced.

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 construction which permits the adaptation of an outer plastic housing with a substantially large percentage of the rotating parts thereof constructed of a sintered material, providing an axial piston fluid device adapted for use over a wide range of applications.

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 construction resulting in a reduction in surface wear and galling between the cylinder barrel and the valving face.

It is also an object of the present invention to provide a rotary fluid device of the axial piston type having an improved thrust plate assembly resulting in greater reliability and long life while operating at high pressures and temperatures, proportioned and simplified so that it can be made inexpensively from sintered materials.

It is also an object of the present invention to provide a rotary fluid device of the axial piston type having a construction which contributes to the reduction in the general noise radiated by such a device.

It is also an object of the present invention to provide a rotary fluid device of the axial piston type having means for varying the displacement thereof, and a housing construction adaptable to accommodate a variety of displacement varying mechanisms.

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 drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and in which:

FIG. 1 is a longitudinal cross sectional view of a fluid device incorporating a feature 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 and illustrating a component thereof and taken generally on line 3—3 of FIG. 2;

FIG. 4 is a side view of the component illustrated in FIG. 3;

FIG. 5 is a fragmentary, exploded view of the fluid device illustrated in FIG. 1;

FIG. 6 is a fragmentary cross sectional view of a fluid device incorporating another feature of the present invention;

FIG. 7 is a transverse fragmentary cross sectional view of the fluid device illustrated in FIG. 6 taken on line 7—7 thereof; and

FIGS. 8–11 are fragmentary views of several modifications of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, and particularly FIGS. 1 and 2, there is illustrated a fluid device in the form of an axial piston pump 10 comprising 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 threadedly 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 (shown only in FIG. 1) 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 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 in a manner which will be described in

greater detail hereinafter. 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. Heretofore, fluid devices have been constructed with the inner race of the bearing extending beyond the roller bearings the same distance as the outer race. By having the end 98 of the inner race 88 flush with the end 100 of the roller bearings 90, a greater diameter of thrust plate assembly 50 with respect to the longitudinal axis is provided which may increase the displacement capacity of the pump 10 by as much as 15 percent as compared to fluid devices heretofore constructed by allowing the pistons to operate on a larger piston bore circle. The piston bore circle is a circle defined by the longitudinal axes of the pistons 38 as the same rotate about the longitudinal axis of the shaft 68. As the diameter of the piston bore circle is increased, the diameter of each piston bore 36 may likewise be increased, thus the displacement of the pump 10 may be increased without increasing the overall size thereof.

The face 42 of the cylinder barrel 34 which is substantially identical to the configuration illustrated in FIG. 7, comprises a plurality of bearing pads 102, separated from one another by radial grooves 104 and separated from the balancing lands 106 of the cylinder ports 40 by an annular groove 108. The bearing pads 102 are generally referred to as "Kingsbury pads" and function in a manner well known in the art. The bearing pads 102 are further provided with a concave contour on the inner wall 110 facing the cylinder ports 40 to provide a larger oil pool to aid in lubricating the bearing pads 102 as the cylinder barrel 34 rotates. The oil pools decrease excessive wear during high temperature and high speed operations, thereby increasing the life of the face 42 of the cylinder block 34.

As can best be seen in FIG. 7, the cylinder ports 40 are arranged in a circle, having a radius equal to the radius of the arcuate ports 52 and 54 (shown in phantom lines in FIG. 7) so that communication will be maintained throughout the full length of the arcuate ports 52 and 54. This communication will be interrupted whenever a cylinder port 40 moves across a cut-off portion or space separating the arcuate ports 52 and 54.

With reference to FIGS. 1 and 2, 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.

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.

Referring to FIGS. 1–5 for an understanding of the accompanying description of the thrust plate assembly 50 which 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 as can best be seen in FIG. 1 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 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 a axis 75 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 a 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 (FIGS. 1 and 2) 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 which will be described in greater detail hereinafter. As can best be seen in FIG. 8, the opening 85 is so sized as to permit the member 79 to be positioned therethrough onto the arm 77 during assembly with the connecting pin 83 extending through the housing body section 14 and adapted to pivot about the axis 75 defined by the radius of the support pins 69 and 71 without interference with the sidewall of the housing bore 85. As can best be seen in FIG. 2, the preferred axis of rotation for the connecting pin 83 and for purposes of description the longitudinal axis of the support pins 69 and 71, is the axis 75 passing through the center point about which each of the arcuate bearing surfaces 73 is formed. The axis 75 should intersect the plane at which the centers of the spherical piston ends 44 lie and may also intersect the longitudinal axis of the drive shaft 68. However, the axis 75 may be vertically offset from the drive shaft axis, in a well known manner, depending upon the desired results.

The arcuately shaped bearing surfaces 67 formed on the sidewalls of the yoke support 57 are in the form of a plastic bearing 87, such as teflon-lead bearing or the like, which provides the necessary support to withstand the load transmitted through the pistons 38 and the movable yoke 55, while at the same time offering the least amount of frictional resistance to the pivotal movement of the yoke 55 therewithin. The plastic bearings 87 have a central aperture 89 (FIG. 5) adapted to receive a boss 91 formed in each sidewall 65 to securely retain the bearing 87 on its associated sidewall 65.

The yoke 55 has a circular thrust bearing face 93 with which the shoes 46 cooperate and a hemispherical cross section 95 (FIG. 5) with 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 interfer-

ence therewith. Since the yoke **55** and the yoke support **57** are both constructed of a sintered material, the radial thickness **99** (FIG. **5**) of support pins **69** and **71**, as measured from the bearing face **93** to the bottom of the support pin bearing surface **73** must be at least 40 percent of the total thickness or longitudinal length **101** of the yoke **55** as measured from the bearing face **93** to the bottom thereof to assure that the yoke **55** will withstand the loads to which it is subjected, while the L-shaped arm **77** extending from the support pin **71** should have a length which is at least equal to the yoke thickness **101** in order to provide good fill characteristics when the same is manufactured.

The amount of friction between the bearing surfaces of the yoke **55** and the yoke support **57** will be directly proportional to the load exerted thereon, while the frictional torque is in direct proportion to the radius of the arcuate bearing surfaces **67** or **73.** In the present design the radius of the bearing surfaces is kept to a minimum, and thus the frictional torque minimized. It should also be noted that present construction of the yoke **55** and the yoke support **57** results in the length **103** and the thickness **101** of the yoke **55** being respectively shorter and greater than comparable components of presently used devices. The shorter length and increased thickness of the yoke **55** reduces unit vibrations and results in an extremely quiet pump compared to such presently used designs.

Since the periphery of the yoke support **57** is rectangular and the periphery of the yoke **55** is circular, each corner **117** of the yoke support **57** will project radially outwardly beyond the yoke **55** as illustrated in FIG. **3** in phantom lines. As can best be seen in FIG. **2**, the bearing **90** is axially positioned with respect to the center of each piston ball **44** by the abutment of the thrust plate facing side **94** of outer race **92** against the corners **117** of the yoke support **57.** This arrangement provides a simple construction which insures proper axial alignment, which is essential for a smooth, efficient and accurate operation of the pump **10.**

Referring now to FIGS. **6** and **7** wherein there is illustrated a modification of the present invention in the form of a variable displacement axial piston pump **120** comprising a housing **122** having an internal bore **124** enclosed by a cap **126** by means of screws (not shown) extending through the cap **126** and into threaded bores within the housing **122,** the pump **120** is similar to the pump **10** disclosed in FIGS. **1** and **2** in that it is provided with a drive shaft **68** on which a cylinder barrel **34** is rotatably mounted and having a plurality of parallel cylinder bores **36** and cylinder ports **40** through which fluid communication to arcuate passageways **52** and **54** (FIG. **7**) in the valving face **48** formed on the inner face of the cap **126** for directing fluid from an inlet port to an outlet port. Radial support for the cylinder barrel **34** is provided by roller bearings **90** in the same manner as describe hereinbefore. Each of the cylinder bores **36** has a piston **38** reciprocably mounted therein with the pistons **38,** in turn, having rounded ends **44** on which piston shoes **46** are positioned against a thrust plate assembly **50** by means of the contact cage **58,** the collar **66** and spring **70** in a manner substantially identical as hereinbefore described.

The thrust plate assembly **50** comprises the fixed yoke support **57** carried on the inner wall of the housing **122** by bearing **75** and includes a pair of axially projecting sidewalls **65,** each of which has an arcuately shaped bearing surface **67** supporting a movable yoke **136** 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 **136** has a pair of transversely extending, aligned support pins **138,** each having arcuately shaped bearing surfaces **140** contoured to mate with the arcuately shaped bearing surfaces **67** of the projecting sidewalls **65,** such that the yoke **136** is adapted to pivot within the sidewall bearing surfaces **67** about the axes **75** of the transversely extending support pins **138** (only one of which is shown in FIG. **6**). The yoke **136** includes a pair of transverse arms **142** and **144** which project in a plane perpendicular to the support pins **138** and have rounded bearing surfaces **146** and **147** at their projecting ends which respectively cooperate with a pair of pistons **148** and **150** to rotate the yoke **136** within the bearing surface **67** in a manner which will be described in greater detail hereinafter.

The pistons **148** and **150** are slidably mounted for reciprocal movement, respectively, within sleeve members **152** and **154** which, in turn, are carried within stepped bores **156** in the cap **126.** Each sleeve member **152** and **154** has an enlarged end portion **158** which abuts a step **160** within bores **156,** and is secured to the cap **126** by screws **162** extending through cover plates **164** and **166** into threaded bores **168** within the cap **126.** The inner ends of each sleeve member **152** and **154** abuts one side of the outer race **92** of the roller bearings **90** to maintain the opposite side **94** of the outer race **92** in abutment with the corner **117** formed on the yoke support **57** in the same manner hereinbefore described with respect to the pump **10.** As can best be seen in FIGS. **6** and **7,** the sleeve members **152** and **154** have a sufficient radial thickness such that the pistons **148** and **150** will traverse the outer surface of the outer race **92** without interference therewith.

The sleeve member **152** has a spring **170** in compression between the cover plate **164** and the piston **148** biasing the piston **148** to engage the round bearing surface **146** of the arm **142** and rotate the yoke **136** so as to stroke the yoke **136** to a full displacement position, that is, the yoke is at an angle with respect to the longitudinal axis of the drive shaft **68** that permits the greatest degree of relative reciprocal stroking movement between the pistons **38** and the cylinder bores **36.**

The interior **153** of the sleeve member **154** is adapted to be communicated to a source of pressure through a pressure compensated valve **172** or the like, which selectively controls the pressure admitted to the interior of the sleeve member **154** to move the piston **150** against the bearing surface **147** of the arm **144** to selectively position the yoke for controlling the inclination of the thrust plate with respect to the longitudinal axis of the drive shaft **68.** Thus, the displacement of the pump **10** may be varied to provide any desired output from a minimum output to a maximum output.

The cylinder barrel **34,** the piston shoes **46,** the yoke **136** and the yoke support **57** are all constructed of a sintered metal which, in addition to reducing the weight of the pump **120,** increases the lubricating characteristics of the rotating components and results in a fluid device which is substantially less expensive to manufacture than fluid devices previously used.

Referring now to FIGS. **8–11** wherein there is illustrated several modifications of the present invention for varying the inclination of the thrust plate assembly

50 with respect to longitudinal axis of the drive shaft 68 to control the displacement of the fluid pump 10. FIGS. 8 and 9 there is illustrated a fragmentary cross sectional view of manually operated displacement control mechanism 180 with FIG. 8 being a fragmentary cross-sectional view taken on line 8—8 of FIG. 9. The control mechanism 180 comprises an outer plastic housing 182 fastened to the plastic body section 14 by screws 184 extending therethrough into threaded bores 185 in the plastic body section 14. The outer housing 182 is carried by the body section 14 adjacent to the support pin 71 of the movable yoke 55. The manually operated displacement control mechanism 180 includes a manually operated handle 196 rotatably mounted within a bushing 198 extending through a bore 200 in the outer housing 182. An O-ring 202 disposed in a recess 204 around the periphery of the handle 196 provides a fluid tight seal preventing leakage from the interior of the fluid pump 10. The handle 196 is coupled to the connecting pin 83 by a pivot arm 194. When it is desired to vary this displacement of the pump 10, the handle 196 is manually rotated so as to pivot the pivot arm 194, which, in turn, pivots the yoke 55 to any desired position.

FIG. 10 discloses a second displacement control mechanism 204 for varying the displacement of the fluid pump 10 and comprises an outer plastic housing 206 having a cylindrical bore 208 in which a sleeve member 210 is slidably mounted. The outer housing 206 is mounted to the side of the plastic body section 14 adjacent the opening 85 and is secured to the pump 10 by a plurality of screws 209 extending through the outer housing 206 into the threaded bores 185 in the body section 14.

One end of the sleeve member 210 has a threaded bore 212 in which a threaded stem 214 projecting from a knob 216 engages. The knob 216 is rotatably mounted in an aperture 217 extending through the housing 206 and is secured in place by a retainer ring 218 such that the knob 216 may be rotated about the longitudinal axis of the housing bore 208 while being restrained against longitudinal movement by the retainer ring 218. Thus, as the knob 216 is selectively rotated in opposite directions, the sleeve member 210 will be reciprocated within the bore of the housing under the driving action of the threaded stem 214. The inner end of the sleeve member 210 has a bore 219 mounting the connecting pin 83 which joins the sleeve member 210 to an arm 77 of the support pin 71 such that reciprocal movement of the sleeve member 210 causes pivotable movement of the yoke 55, thereby permitting a selected variation in the displacement of the pump 10.

FIG. 11 illustrates a displacement control mechanism 224 of the pressure compensated type as having an outer plastic housing 226 fastened to the plastic body section 14 adjacent the opening 85 by screws 228 extending through the outer housing 226 into the threaded bores 185 in the plastic body section 14. The outer housing 226 includes two parallel bores, one bore 230 having a pressure compensator valve 232 carried therein, while the other bore 234 has a pressure responsive piston member 236 slidably mounted therein which, in turn, is attached to the yoke 55 by the connecting pin 83 extending through the opening 85 in the wall of the housing 12. Each of the bores 230 and 234 are enclosed at their open ends by closure plates 244 and 245 secured to the outer housing 226 by crews 246 or the like. The piston carrying bore 234 has a spring 248 disposed between the closure plate 244 and the one side of the pressure responsive piston 236 to bias the piston 236 toward the other end of the bore 234. The pressure responsive piston 236 is so attached to the yoke 55 that the yoke 55 is normally pivoted toward a maximum flow position when piston 236 is positioned toward the closure plate 245 as illustrated in FIG. 10. The inner end 250 of the piston 236 and the associated end of the bore 234 form a pressure chamber 252 adapted to be selectively communicated to a source of fluid pressure generating a force acting on the piston 236 to move the piston 236 against the bias of the spring 248 and stroke the yoke 55 toward a minimum displacement position. The pressure chamber 252 is supplied with fluid pressure through a passageway 254 in communication with the high pressure port of the device. The bore 234 is enlarged at the pressure chamber end to provide a path between the passageway 254 and the pressure chamber 252 which permits a construction having a minimum amount of passageways while at the same time allowing for a compact construction of the mechanism 224.

The pressure compensator valve 232 comprises a piston member 258 having the sealing land 260 adapted to control the amount of fluid through the passageway 254 to the pressure chamber 252. The piston member 258 is normally biased to a closed position by a spring 262 disposed between one end 264 of the piston member 258 and a second movable wall member 266 which, in turn, is axially adjustable within the bore 230 by a threaded member 268 extending through the wall of the housing 226 and externally thereof. By adjusting the position of wall member 266 with respect to the piston end wall 264, the compression force of the spring 262 may be varied to thereby vary the amount of force necessary to move the piston 258. The piston end of the valve 232 is connected directly to high pressure passageway generating a force against the piston 258 urging it against the bias of the spring 262. When the pressure of the pump 10 exceeds a predetermined value, the sealing land 260 is moved toward an opened position permitting fluid pressure to pass thereby and into the pressure chamber 252, generating the aforementioned force for urging the piston member 236 to move against the bias of the spring 248. A pressure between 200 psi and 300 psi acting against the piston member 236 will move the same at sufficient distance to stroke the yoke 55 from a full flow or maximum displacement to a near zero flow or minimum displacement.

The plastic housing illustrated in FIG. 2 has an outer annular recessed portion 270 at the drive shaft end thereof on which the elongated metal clamps 15 are carried. By tightening the bolts 22 within threaded bore 280 in 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. 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. These forces tend to exert a load on the plastic body section 14 of the housing 12 which tends to longi-

tudinally expand the same. By precompressing the plastic body section 14 by a predetermined amount, the effect of the expansion loads exerted on the plastic body section 14 by internal forces of the rotating group 33 will be cancelled.

Thus, it can be seen that the present invention has provided 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 and for varying the displacement thereof.

While the forms of the embodiments of the invention as disclosed herewithin constitute a preferred form, it is to be understood 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;

a cylinder barrel rotatably mounted about its longitudinal axis within said housing, said cylinder barrel having a plurality of arcuately spaced cylinder bores communicating with both longitudinal ends of said cylinder barrel;

a valve face having arcuate passages, said valve face and one end of said cylinder barrel being disposed for relative rotary movement, with said cylinder barrel bores communicating successively with said arcuate passages as said cylinder barrel rotates;

a plurality of pistons with inner ends disposed for reciprocal movement within said cylinder bores at the other end of said cylinder barrel;

a support member carried within said housing, said support member having a pair of transversely spaced arcuately shaped bearing surfaces facing toward said other end of said cylinder barrel;

a movable yoke constructed of a sintered metal material and having a piston engaging bearing surface on the side thereof facing the other ends of said pistons and cooperating therewith for imparting said reciprocal movement to said pistons within said cylinder barrel bores as said cylinder barrel rotates relative to said valve face, said movable yoke having laterally extending integral support pins with arcuately shaped bearing surfaces pivotably supported in said support member arcuately shaped bearing surfaces, each of said yoke support pins having a radial thickness as measured from said piston engaging bearing surface to the periphery of the support pin arcuate bearing surface which is approximately 40 percent of the longitudinal thickness of said movable yoke as measured from said piston engaging bearing surface;

means for varying the inclination of said piston engaging bearing surface, said last mentioned means cooperating with said movable yoke to pivot said movable yoke about an axis defined by said arcuately shaped bearing surfaces of said support pins, said means for varying the inclination of said piston engaging bearing surface comprising an arm member carried by and radially extending from one of said support pins and pivotable therewith about the axes of said support pins, and a displacement varying mechanism carried externally of said housing and operatively coupled to said arm member to pivot said arm and said movable member about the longitudinal axes of said support pins, said displacing varying mechanism comprising a second housing carried by said first housing, said second housing having a longitudinal bore with a sleeve member adapted to be selectively reciprocated therein, said sleeve member having an internal threaded surface, a threaded member rotatably mounted about an axis concentric with the longitudinal axis of said second housing bore and restrained against movement along said last mentioned longitudinal axis, said threaded member having a threaded portion engaging said sleeve threaded surface such that rotation of said threaded member in opposite directions causes relative reciprocal movement between said sleeve member and said second housing bore, said sleeve member being operatively coupled through an aperture in said housing arm member to pivot said arm member and said movable yoke about the axes of said support pins.

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

a housing having a longitudinal bore;

a cylinder barrel rotatably mounted about its longitudinal axis within said housing bore, said cylinder barrel having a plurality of arcuately spaced cylinder bores communicating with both longitudinal ends of said cylinder barrel;

a valve face having arcuate passages, said valve face and one end of said cylinder barrel being disposed for relative rotary movement, with said cylinder barrel bores communicating successively with said arcuate passages as said cylinder barrel rotates;

a plurality of pistons with inner ends disposed for reciprocal movement within said cylinder bores at the other end of said cylinder barrel;

thrust plate means having a piston engaging bearing surface on the side thereof facing the other ends of said pistons and cooperating therewith for imparting said reciprocal movement to said pistons within said cylinder barrel bores as said cylinder barrel rotates relative to said valve face, said piston engaging bearing surface being constructed of a sintered metal;

a shaft rotatably mounted in said housing along the longitudinal axis of said bore, said cylinder barrel being drivingly connected to and rotatable with said shaft;

bearing means carried at one end of said housing bore, said bearing means mounting said shaft for rotational movement, said thrust plate means being mounted in said housing bore and having a portion thereof in abutment with said last-mentioned bearing means to provide both proper radial alignment of said thrust plate means with said shaft and proper alignment of said thrust plate means with said cylinder barrel when said thrust plate means is mounted on said bearing means, and

wherein said one end of said cylinder barrel has a plurality of elevated arcuately spaced bearing pads, said bearing pads being radially outwardly spaced from said cylinder ports, the inner cylinder port facing wall of each of said bearing pads having a concave contour.

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

a housing having a longitudinal bore;

a cylinder barrel rotatably mounted about its longitudinal axis within said housing bore, said cylinder barrel having a plurality of arcuately spaced cylinder bores communicating with both longitudinal ends of said cylinder barrel;

a valve face having arcuate passages, said valve face and one end of said cylinder barrel being disposed for relative rotary movement, with said cylinder barrel bores communicating successively with said arcuate passages as said cylinder barrel rotates;

a plurality of pistons with inner ends disposed for reciprocal movement within said cylinder bores at the other end of said cylinder barrel;

thrust plate means having a piston engaging bearing surface on the side thereof facing the other ends of said pistons and cooperating therewith for imparting said reciprocal movement to said pistons within said cylinder barrel bores as said cylinder barrel rotates relative to said valve face, said piston engaging bearing surface being constructed of a sintered metal;

a shaft rotatably mounted in said housing along the longitudinal axis of said bore, said cylinder barrel being drivingly connected to and rotatable with said shaft;

bearing means carried at one end of said housing bore, said bearing means mounting said shaft for rotational movement, said thrust plate means being mounted in said housing bore and having a portion thereof in abutment with said last-mentioned bearing means to provide both proper radial alignment of said thrust plate means with said shaft and proper alignment of said thrust plate means with said cylinder barrel when said thrust plate means is mounted on said bearing means, said thrust plate means comprises a support member carried in said housing bore and having a portion thereof in abutment with said bearing means to provide a proper radial alignment of said support member with said shaft, said support member having a pair of transversely spaced arcuately shaped bearing surfaces facing toward said other end of said cylinder barrel; a movable yoke constructed of a sintered metal material and having said piston engaging bearing surface formed on the said thereof facing said other ends of said pistons, said movable yoke having laterally extending integral support pins with arcuately shaped bearing surfaces pivotably supported in said support member arcuately shaped bearing surfaces;

means for varying the inclination of said piston engaging surface;

bearing means having an outer race carried by said housing concentric with said housing bore, said outer race having a portion of one side supported by each said support member;

an inner race carried around a portion of the peripheral surface of said cylinder barrel;

a plurality of roller bearings disposed between said inner and outer races; and

said means for varying the inclination of said movable yoke comprising a pair of spaced sleeve members each disposed along axes paralleling the axis of said shaft and radially spaced from the peripheral surface of said cylinder barrel, each of said sleeve members having one end of a piston member reciprocably mounted therein, the other ends of said piston members adapted to abut a portion of said movable yoke to pivot said movable yoke about the longitudinal axes of said support pins, said sleeves being radially spaced a distance from the centerline of said shaft axis to abut the outer race of said bearing means to maintain said outer race in a supporting abutment with said support member, said piston members being carried within said sleeves and so spaced from said longitudinal axis of said shaft as to freely reciprocate in a spaced relationship with respect to the outer periphery of said outer race.

4. The fluid pressure energy translating device defined in claim 3 wherein the yoke facing ends of said roller bearings and said inner race are substantially flush; a portion of said inner race extending beyond said other end of said cylinder barrel and having an annular inclined inner surface flared upwardly from said other cylinder barrel end and toward said yoke facing end of said inner race.

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

a housing constructed of a plastic material;

a cylinder barrel rotatably mounted about its longitudinal axis within said plastic housing, said cylinder barrel having a plurality of arcuately spaced cylinder bores communicating with both longitudinal ends of said cylinder barrel;

a valve face having arcuate passages, said valve face and one end of said cylinder barrel being disposed for relative rotary movement, with said cylinder barrel bores communicating successively with said arcuate passages as said cylinder barrel rotates;

a plurality of pistons with inner ends disposed for reciprocal movement within said cylinder bores at the other end of said cylinder barrel;

a support member carried within said housing, said support member having a pair of transversely spaced arcuately shaped bearing surfaces facing toward said other end of said cylinder barrel;

a movable yoke constructed of a sintered metal material and having a piston engaging bearing surface on the side thereof facing the other ends of said pistons and cooperating therewith for imparting said reciprocal movement to said pistons within said cylinder barrel bores as said cylinder barrel rotates relative to said valve face, said movable yoke having laterally extending integral support pins with arcuately shaped bearing surfaces pivotably supported in said support member arcuately shaped bearing surfaces, each of said yoke support pins having a radial thickness as measured from said piston engaging bearing surface to the periphery of the support pin arcuate bearing surface which is approximately 40 percent of the longitudinal thickness of said movable yoke as measured from said piston engaging bearing surface;

means for varying the inclination of said piston engaging bearing surface, said last mentioned means cooperating with said movable yoke to pivot said movable yoke about an axis defined by said arcuately shaped bearing surfaces of said support pins, said means for varying the inclination of said piston engaging bearing surface comprising an arm member carried by and radially extending from one of said support pins, and a displacement varying mechanism carried externally of said plastic hous-

ing and operatively coupled to said arm member to pivot said arm member about the axes of said support pins, said displacement varying mechanism comprising a second housing carried by said plastic housing, said second housing having a longitudinal bore with a sleeve member adapted to be reciprocated therein, said sleeve member having an internal threaded surface, a threaded member rotatably mounted in a fixed position in said housing and adapted to rotate about a longitudinal axis of said second housing bore, said threaded member having a portion thereof engaging said sleeve member such that rotation of said threaded member in opposite directions produces reciprocal moving between such sleeve member and said second housing bore, said sleeve member being operatively coupled through an aperture in said plastic housing to said arm member to pivot said arm member and said movable yoke about the axes of said support pins.

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

a housing;

a cylinder barrel rotatably mounted about its longitudinal axis within said housing, said cylinder barrel having a plurality of arcuately spaced cylinder bores communicating with both longitudinal ends of said cylinder barrel;

a valve face having arcuate passages, said valve face and one end of said cylinder barrel being disposed for relative rotary movement, with said cylinder barrel bores communicating successively with said arcuate passages as said cylinder barrel rotates;

a plurality of pistons with inner ends disposed for reciprocal movement within said cylinder bores at the other end of said cylinder barrel;

a support member carried within said housing, said support member having a pair of transversely spaced arcuately shaped bearing surfaces facing toward said other end of said cylinder barrel;

a movable yoke constructed of a sintered metal material and having a piston engaging bearing surface on the side thereof facing the other ends of said pistons and cooperating therewith for imparting said reciprocal movement to said pistons within said cylinder barrel bores as said cylinder barrel rotates relative to said valve face, said movable yoke having laterally extending integral support pins with arcuately shaped bearing surfaces pivotably supported in said support member arcuately shaped bearing surfaces, each of said yoke support pins having a radial thickness as measured from said piston engaging bearing surface to the periphery of the support pin arcuate bearing surface which is approximately 40 percent of the longitudinal thickness of said movable yoke as measured from said piston engaging bearing surface;

means for varying the inclination of said piston engaging bearing surface, said last mentioned means cooperating with said movable yoke to pivot said movable yoke about an axis defined by said arcuately shaped bearing surfaces of said support pins, said housing having a longitudinal bore; a shaft rotatably mounted in said housing along the longitudinal axis of said bore, said cylinder barrel being drivingly connected to and rotatable with said shaft, and bearing means carried at one end of said housing mounting said shaft for rotational movement, said support member being mounted in said housing bore and having a portion thereof in abutment with said last mentioned bearing means to provide proper radial alignment of said support member with said shaft, said movable yoke being carried by said support member such that said movable yoke is properly aligned with said cylinder barrel when said yoke support is mounted on said bearing means.

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

a housing having a longitudinal bore;

a cylinder barrel rotatably mounted about its longitudinal axis within said housing, said cylinder barrel having a plurality of arcuately spaced cylinder bores communicating with both longitudinal ends of said cylinder barrel;

a valve face having arcuate passages, said valve face and one end of said cylinder barrel being disposed for relative rotary movement, with said cylinder barrel bores communicating successively with said arcuate passages as said cylinder barrel rotates;

a plurality of pistons with inner ends disposed for reciprocal movement within said cylinder bores at the other end of said cylinder barrel;

a support member carried within said housing, said support member having shaped bearing surfaces facing toward said other end of said cylinder barrel;

a movable yoke having a piston engaging bearing surface on the side thereof facing the other ends of said pistons and cooperating therewith for imparting said reciprocal movement to said pistons within said cylinder barrel bores as said cylinder barrel rotates relative to said valve face, said movable yoke having complementary shaped bearing surfaces cooperating with said support member shaped bearing surfaces;

means for varying the inclination of said piston engaging bearing surface, said last-mentioned means cooperating with said movable yoke to pivot said movable yoke with respect to said support member shaped bearing surfaces; a shaft rotatably mounted in said housing along the longitudinal axis of said bore, said cylinder barrel being drivingly connected to and rotatable with said shaft, and bearing means carried at one end of said housing mounting said shaft for rotational movement, said support member being mounted in said housing bore and having a portion thereof in abutment with said last-mentioned bearing means to provide proper radial alignment of said support member with said shaft, said movable yoke being carried by said support member such that said movable yoke is properly aligned with said cylinder barrel when said yoke support is mounted on said bearing means.

8. The fluid pressure energy translating device defined in claim 7 wherein said housing is constructed of a plastic material.

9. The fluid pressure energy translating device defined in claim 8 wherein said plastic housing is longitudinally precompressed a predetermined amount which is a function of the force generated by the pressure of the fluid acting against the inner ends of said pistons, said force tending to longitudinally expand said plastic housing.

10. The fluid pressure energy translating device defined in claim 7 wherein said shaped bearing surfaces on said support member are constructed of a plastic material.

11. The fluid pressure energy translating device defined in claim 7, further comprising: a bearing means having an outer race carried by said housing concentrically with said housing bore, an inner race carried around the peripheral surface of said cylinder barrel, and a plurality of roller bearings disposed between said inner and outer races, the yoke facing end of each of said roller bearings and said inner race being substantially flush, a portion of said inner race extending beyond the other end of said cylinder barrel and having an annular inclined inner surface flared upwardly from said other cylinder barrel end toward said yoke facing end of said inner race.

12. The fluid device defined in claim 7 wherein said support member is constructed from a sintered metal material.

13. The device defined in claim 7 further comprising an arcuately shaped member carried by said support member and defining said support member shaped bearing surface, said arcuately shaped bearing surfaces of said movable yoke support pins being received and supported by said bearing members, said bearing members being fabricated from a plastic material.

14. The device defined in claim 7 further comprising bearing means having an outer race carried within said housing; an inner race carried around a portion of the peripheral surface of said cylinder barrel; and a plurality of roller bearings disposed between said inner and outer races, said bearing means providing radial support for said cylinder barrel as said cylinder barrel rotates, said bearing means being properly axially positioned within said housing by the abutment of one side of one of said bearing races with a portion of said support member.

15. The fluid pressure energy translating device defined in claim 45, wherein said support member has a pair of transversely spaced arcuately shaped bearing surfaces facing toward said other end of said cylinder barrel; a said movable yoke having said piston engaging bearing surface formed on the side thereof facing said other ends of said pistons, said movable yoke having laterally extending integral support pins with said complementary shaped bearing surfaces being pivotably supported in said support member arcuately shaped bearing surfaces; and means for varying the inclination of said piston engaging surface.

16. The fluid pressure energy translating device defined in claim 15, wherein said means for varying the inclination of said piston engaging surface cooperates with said movable yoke to pivot said movable yoke about an axis defined by said arcuately shaped bearing surfaces of said support pins.

17. The fluid pressure energy translating device in claim 15 wherein said means for varying the inclination of said movable yoke comprises: an arm member carried at the end of one of said support pins and pivotable therewith about the axes of said support pins, and a displacement varying mechanism carried externally of said housing and operatively coupled to said arm member to pivot said arm member and said movable yoke about the axes of said support pins.

18. The fluid pressure energy translating device defined in claim 17 wherein said displacement varying mechanism comprises: a second housing carried by said first housing and having a bore disposed along an axis extending transversely of said longitudinal axis, a manually operated shaft rotatably mounted in said second housing bore, a second arm member radially extending from said manually operated shaft and operatively coupled through an aperture in said device housing to said first mentioned arm member to pivot said first mentioned arm and said movable yoke about the axes of said support pins as said manually operated shaft is rotated in said second housing bore.

19. The fluid pressure energy translating device defined in claim 17 wherein said displacement varying mechanism carried comprises: a second housing attached to said housing, said second housing having a bore with a pressure responsive member slidably mounted therein and biased to a predetermined position, valve means responsive to a predetermined operating pressure of said fluid device to supply a second pressure of predetermined value to said pressure responsive member to move said pressure responsive member from said predetermined position, said pressure responsive member being operatively coupled to said arm member through an aperture in said device housing to pivot said arm member and said movable yoke about the axes of said support pins as said pressure responsive piston moves from said predetermined position.

20. The fluid pressure energy translating device defined in claim 15, wherein said housing is constructed of a plastic material.

21. The fluid pressure energy translating device defined in claim 20 wherein said means for varying the inclination of said movable yoke comprises: an arm member carried by and radially extending from one of said support pins and pivotable therewith about the axes of said support pins, and a displacement varying mechanism carried externally of said housing and operably coupled to said arm member to pivot said arm member about said axes of said support pins, said displacement varying mechanism comprising: a second housing having a bore disposed along on axis extending transversely of said shaft axis; a manually operated shaft rotatably mounted in said second housing bore, a second arm member radially extending from said second manually operated shaft and operatively coupled through an aperture in said plastic housing to said first mentioned arm member to pivot said first mentioned arm and said movable yoke about the axes of said support pins as said manually operated shaft is rotated in said second housing bore.

22. The fluid pressure energy translating device defined in claim 20 wherein said means for varying the inclination of said thrust plate movable yoke comprises: an arm member carried by and radially extending from one of said support pins and pivotable therewith along the axes of said support pins; and a displacement varying mechanism carried externally of said plastic housing and operatively coupled to through an aperture in said plastic housing said arm member to pivot said arm member about the longitudinal axes of said support pins, said displacement varying mechanism comprising: the second housing attached to said plastic housing and having a bore with the pressure responsive member slidably mounted therein and biased to a predetermined position; valve means responsive to a predetermined operating pressure of said fluid device to supply

a second pressure of a predetermined value to said pressure response member to move said pressure responsive member from said predetermined position, said pressure responsive member being operatively coupled to said arm member to pivot said arm member and said movable yoke about the axes of said support pins as said pressure responsive member moves from said predetermined position.

23. The fluid pressure energy translating device defined in claim **20** wherein said plastic housing is longitudinally precompressed a predetermined amount which is a function of the longitudinal expansion forces exerted on said plastic housing by the pressure of the fluid acting against the inner ends of said pistons within said cylinder barrel bores.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,739,691 Dated June 19, 1973

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:

In the claims, Column 17, Claim 15 line 40 following "Claim" delete "45" and insert --7--.

Signed and sealed this 17th day of December 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
U.S. GOVERNMENT PRINTING OFFICE: 869-930

Disclaimer

3,739,691.—*Wilfred S. Bobier*, Bloomfield Hills, Mich. FLUID DEVICE. Patent dated June 19, 1973. Disclaimer filed Nov. 20, 1980, by the inventor.

Hereby enters this disclaimer to claim 7 of said patent.

[*Official Gazette February 10, 1981.*]