March 5, 1963 H. M. PURCELL 3,079,869

PUMP OR MOTOR

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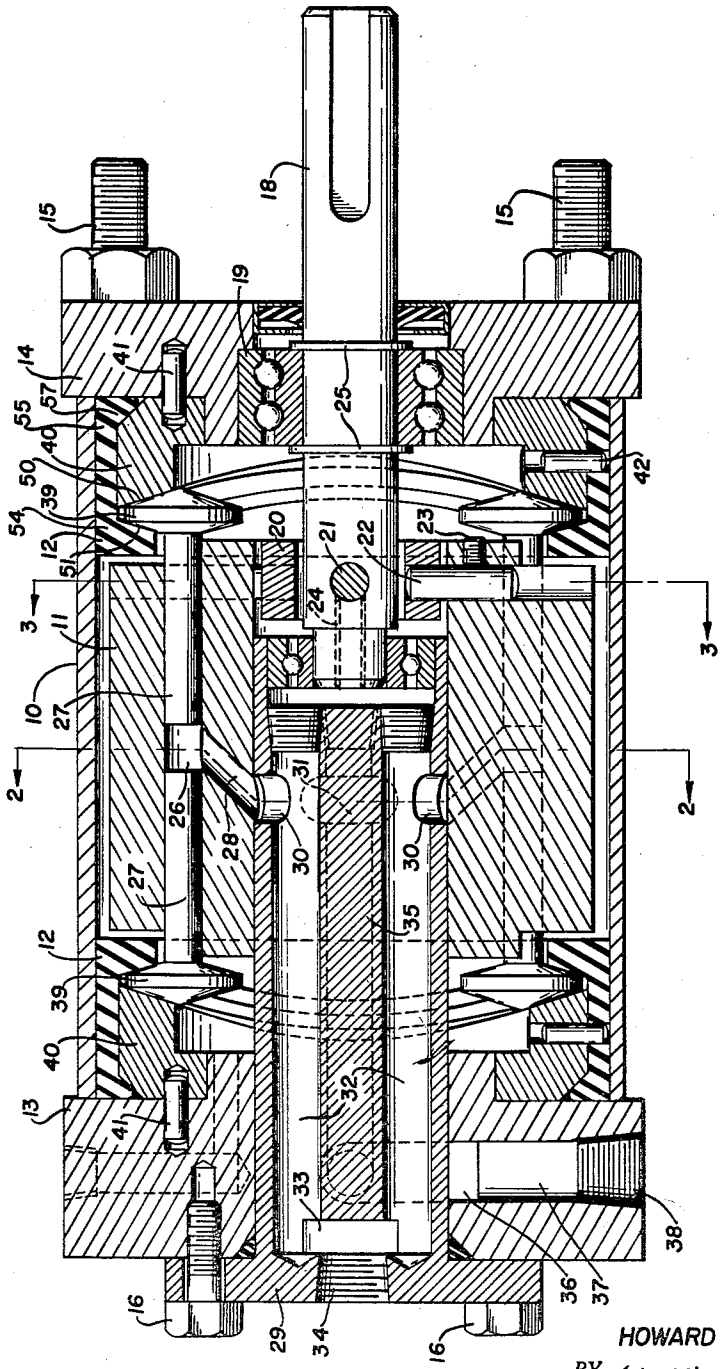


Fig. 1

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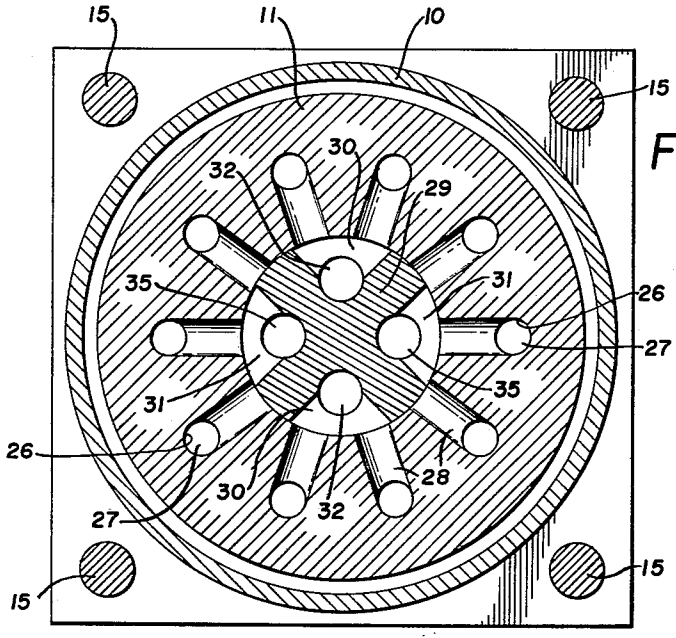


Fig. 2

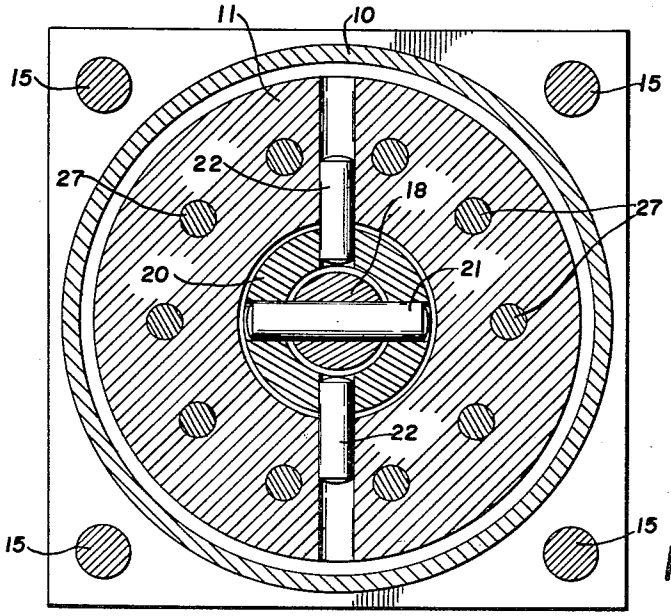


Fig. 3

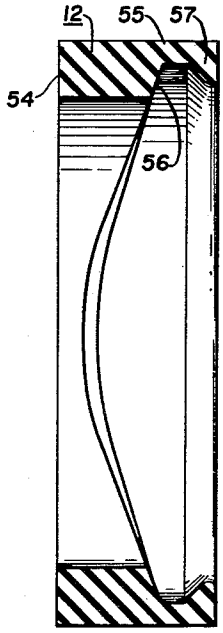


Fig. 4

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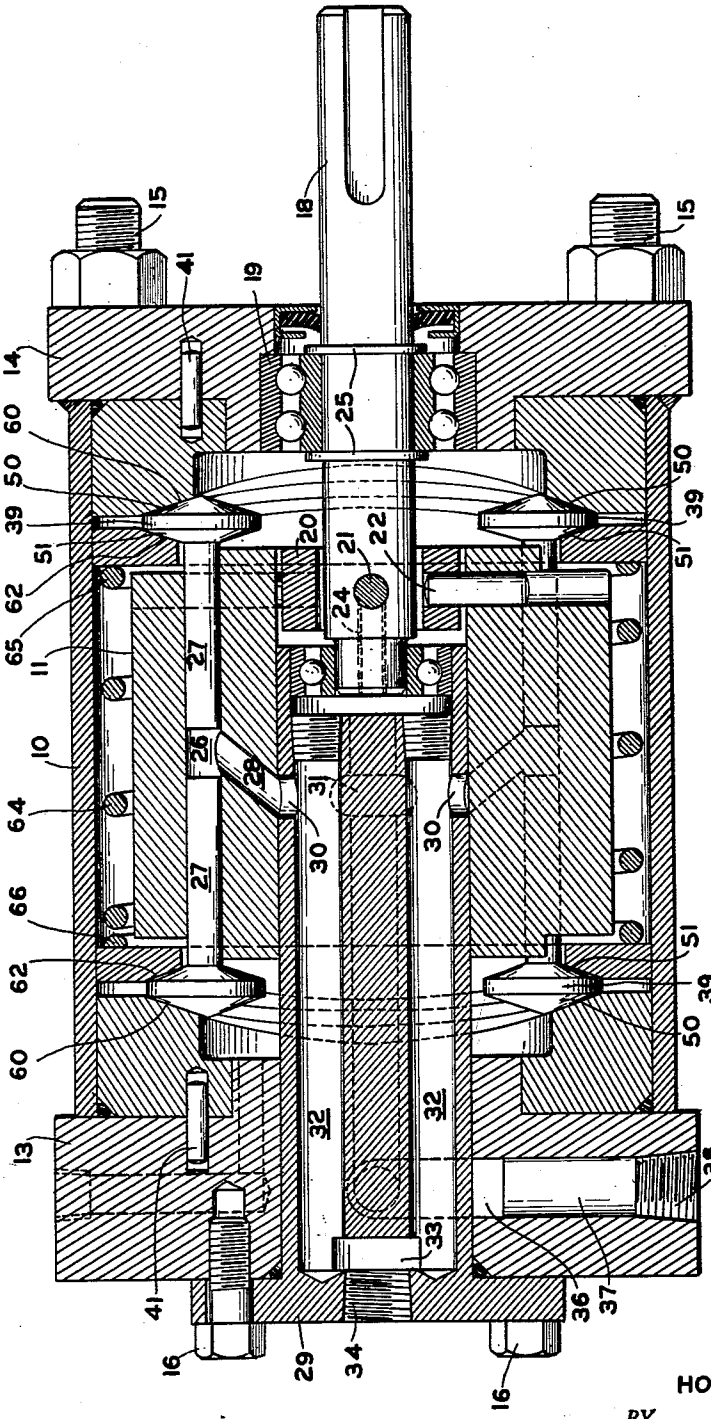


FIG. 5

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Filed April 27, 1959 5 Sheets-Sheet 4

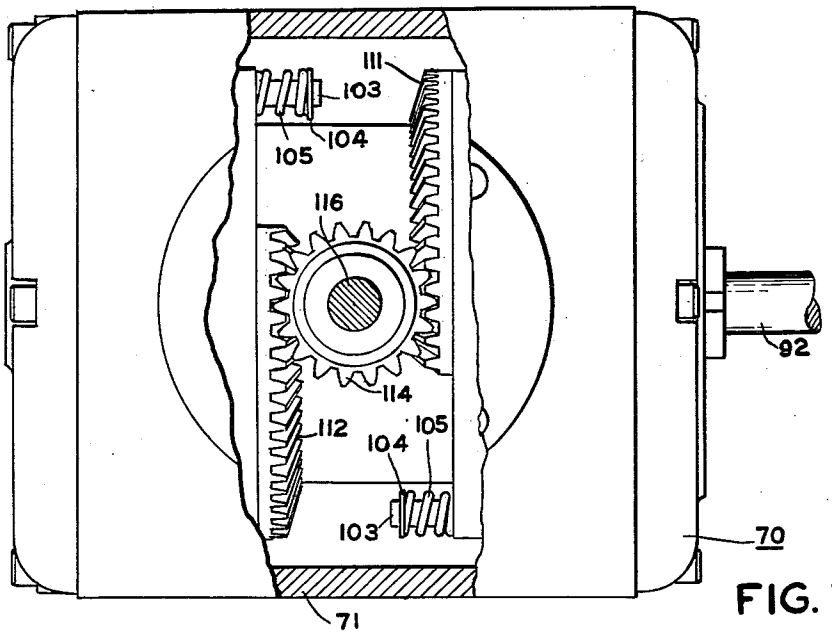


FIG. 7

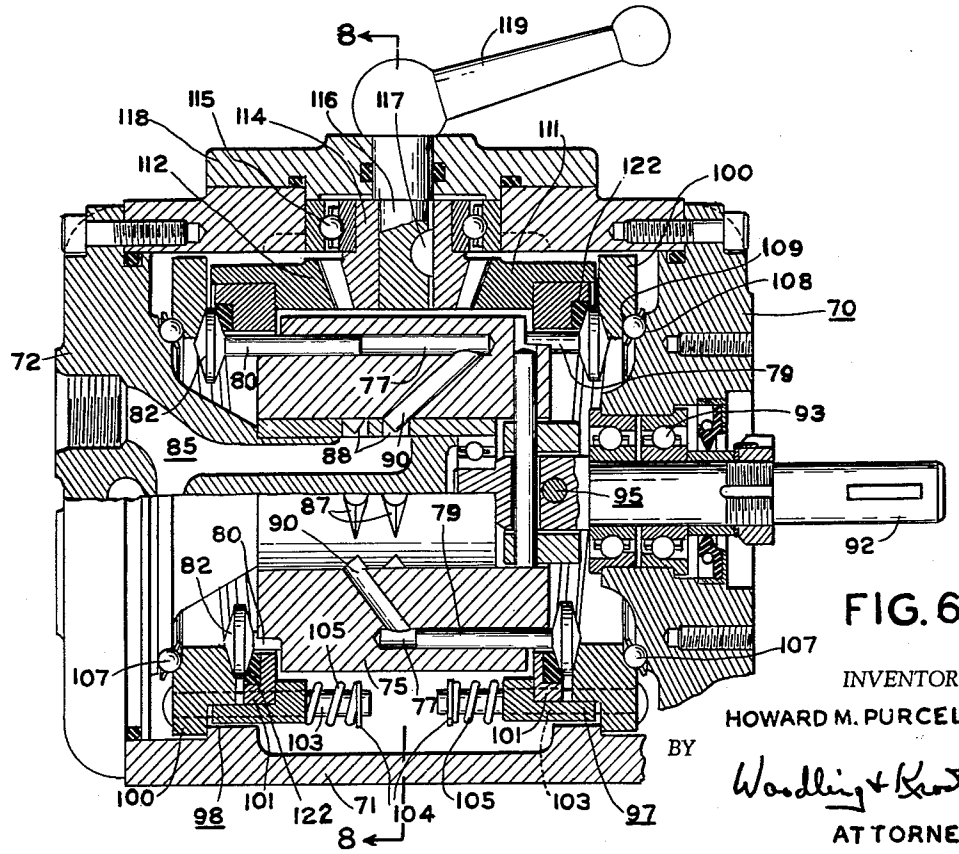


FIG. 6

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PUMP OR MOTOR

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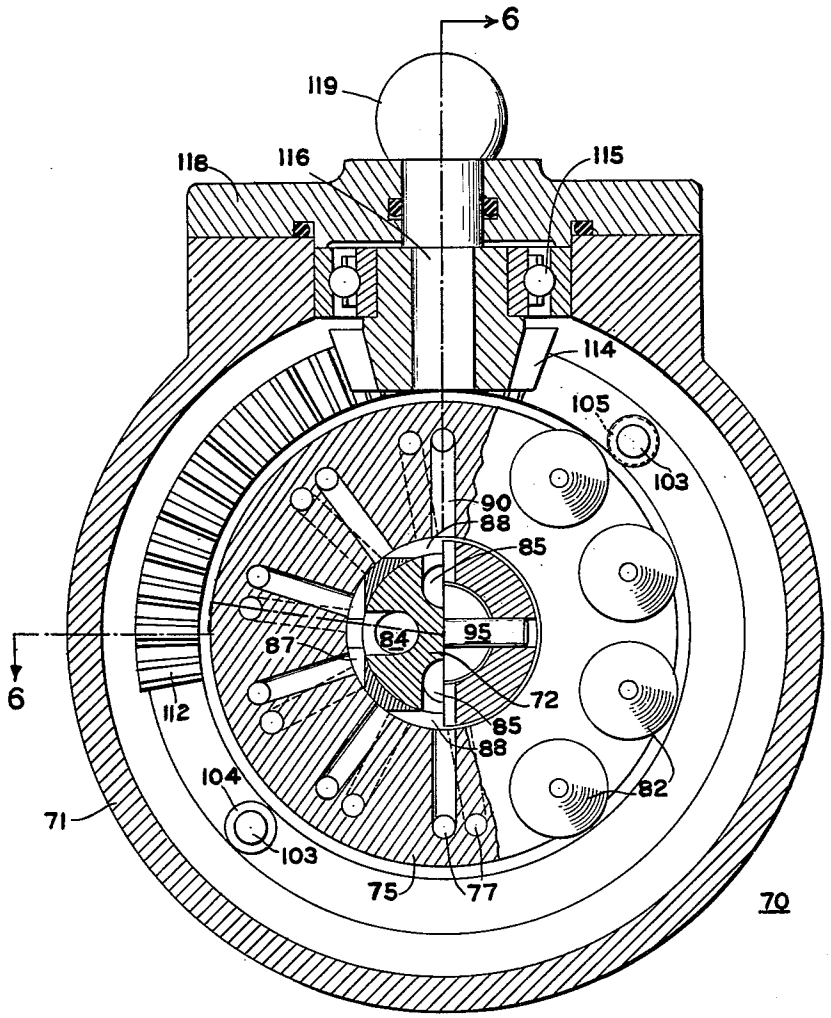


FIG. 8

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PUMP OR MOTOR

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Filed Apr. 27, 1959, Ser. No. 809,306

5 Claims. (Cl. 103—162)

This invention relates to pumps or motors of the type in which a plurality of parallel cylinders are arranged in a rotatable cylinder barrel and provided with pairs of pistons which have the outer ends thereof in engagement with sinuous cam thrust members and are reciprocated thereby as the cylinder barrel rotates. A machine of this type will function as a pump when it is driven mechanically and will function as a motor when driving liquid or gas is supplied between the pairs of pistons. For the purpose of illustration the machine will be referred to herein as a pump and the invention will be explained as applied to a pump for pumping liquid but it is understood that the invention may be used as a fluid motor and with the proper lubrication will pump gas and is equally applicable to a motor of the same type.

An object of the invention is to provide a pump in which the mechanical and pressure noises are substantially eliminated.

Another object of the invention is to provide an improved construction for an axial type piston pump in which the various components are more readily manufactured to the necessary tolerances without the use of special and expensive machinery.

Another object of the invention is to provide a piston pump structure in which the piston return means are resilient thereby compensating for machining tolerances and wear which normally takes place between the heads of the pistons and cam thrust members.

Another object of the invention is to provide a piston pump or motor structure in which the piston return means are spring biased thereby compensating for machining tolerances and wear which normally takes place between the pistons and piston actuating means.

Another object of the invention is to provide a piston pump or motor structure in which the piston return means are spring biased and a portion thereof which engages the pistons is constructed of resiliently yieldable material.

Another object of the present invention is to provide a construction whereby the cam actuating means at opposed ends of the pump or motor may be rotated with respect to each other to a position whereby the net displacement of the pump is substantially zero or to any position between zero and maximum displacement. With this provision the displacement of the pump may also be completely reversed whereby what was originally a pressure stroke is an intake stroke.

Another object of the invention is to provide a pump in which the pistons are rotated during reciprocation thereof.

Another object of the invention is to provide a pump with a cylinder barrel in which identical pistons are assembled in pairs in straight parallel cylinder bores thereby permitting it to rotate with substantially no end thrust.

Another object of the invention is to provide a pump which is compact and efficient.

Other objects and a fuller understanding of this invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a longitudinal section through a pump constructed according to this invention;

FIGURE 2 is a transverse section through the pump and is indicated by the line 2—2 of FIGURE 1;

FIGURE 3 is a transverse section through the pump as indicated by the line 3—3 of FIGURE 1;

FIGURE 4 is a cross-sectional view of the resilient cam return means shown in FIGURE 1 but taken in a direction 90 degrees removed from the view of FIGURE 1 and with the resilient cam return means removed from the body of the pump;

FIGURE 5 is a longitudinal section through a pump illustrating another physical construction of the present invention;

FIGURE 6 is a longitudinal section through a pump illustrating still another physical construction of the present invention and in addition shows a construction whereby the cam means may be shifted or varied relative to each other;

FIGURE 7 is a plan view of FIGURE 6 partially broken away to show the construction for shifting the cam means relative to each other; and

FIGURE 8 is a view taken generally along the line 8—8 of FIGURE 6.

General Arrangement

A pump constructed according to this invention comprises generally, a casing within which is rotatably mounted a cylinder barrel having straight parallel cylinder bores therein for receiving pairs of reciprocating piston members. The piston members have heads which are adapted to rotate between sinuous thrust and resilient return cam members that are secured to the case in identical circumferential positions which actuate the pairs of pistons in opposite directions thereby causing pumping action. This pumping action occurs twice each revolution which makes it possible for the cylinder barrel to be continuously in a state of hydraulic balance. This eliminates the necessity of antifriction bearings.

The entire assembly is rotated by a drive shaft which is attached to the cylinder barrel by means of a flexible coupling. This inhibits wear in the event of misalignment and provides for a more readily rotatable cylinder barrel.

Structural Arrangement

Referring more particularly to the drawings, the pump comprises a casing portion 10 which is hollow to receive a cylinder barrel 11 and which is also large enough to receive resilient cam members 12 at each end. The casing 10 is engaged by cover plates or closure members 13 and 14 which are secured in place by any suitable means such as tie rods 15 and whereby the device as a whole may be mounted to a suitable support. Secured to the member 13 by cap screws 16 is a pivot valve 29 on which the cylinder barrel 11 rotates. The cylinder barrel 11 is rotated by a drive shaft 18 that extends through cover plate 14 which is bored to receive an antifriction bearing 19 on which the drive shaft 18 is supported. The drive shaft 18 is attached to the cylinder barrel 11 by means of a flexible coupling 20.

Referring to FIGURE 3 it will be seen that the coupling ring 20 is adapted to slide vertically on drive pins 22 secured to the cylinder barrel 11 with set screws 23 and horizontally on drive pin 21 secured to the drive shaft 18 by set screw 24. It also can be seen that the drive shaft 18 and the cylinder barrel 11 may be assembled with a substantial eccentricity without causing either member to bind or prevent them from rotating.

Drive pins 21 and 22 also prevent the cylinder barrel 11 from moving horizontally along the pivot shaft 29 by means of retaining rings 25 mounted in grooves not shown in the drive shaft 18 and on each side of the bearing 19.

The barrel 11 is provided with a plurality of straight parallel cylinder bores 26 which retain a piston 27 in each end thereof for reciprocating movement. Midway between pistons 27 and projecting inwardly are bores

28 which connect cylinder 26 with the pivot valve 29 and are adapted to alternately register as seen in FIGURE 2 with pressure ports 30 and suction ports 31. The two pressure ports 30 being on opposite sides of pivot valve 29 makes it possible for the cylinder barrel to be continuously in a state of hydraulic balance eliminating the necessity for antifriction bearings normally used in pumps. Ports 30 connect with passageways 32 which join in area 33 in which is tapped 34 for the discharge of the pump. Ports 31 connect the passageways 35 which are drilled to join in area 36 in which a passage 37 is tapped 38 for the suction of the pump. Tap 34 preferably is used for discharge pressure and tap 38 for suction, however, it will be apparent that if the cylinder barrel is rotated in the opposite direction the pressure and suction ports change without hindering the operation of the pump.

Referring to the pistons 27 which are provided with mushroom heads 39 with similar conical outer and inner surfaces 50 and 51, respectively. The outer face 50 is tapered to correspond to and adapted to fit the taper on the sinuous thrust cam members 40 with a line contact which are respectively mounted on the cover plates 13 and 14. Dowel pins 41 locate the position of the cams and retain them from rotating.

The cam thrust members 40 are formed preferably with a face to provide means for moving the pistons inward with a sinuous movement twice each revolution and they are located in identical relative positions to cause the pistons 27 that are in pairs to move toward and away from each other in succession.

For the purpose of maintaining the mushroom piston heads 39 in contact with the thrust cams 40 during their outward stroke, annular piston return cams 12 are provided. The annular piston return cams 12 have a generally L-shaped cross section including a short or first leg portion 54 and a long or second leg portion 55. The first leg portion 54 has an annular bearing or cam surface 56 formed thereon and the second leg portion has an annular connecting projection 57 integrally formed thereon. The connecting projection 57 fits in behind the thrust cams 40 to help secure the cam 12 in place. The bearing surface 56 is adapted to engage the inner conical surface 51 of the piston mushroom head. This return cam is preferably formed of a resilient synthetic rubber material having a Shore Durometer hardness in the range of from 60 to 100 and is generated to contact the inner conical surfaces 51 at all positions thereof by a line contact. The piston return cam 12 is prevented from rotating by dowel pins 42. The cams 12 being formed of resilient material may be molded so that when assembled will be slightly deformed by each of the mushroom heads 39 whereby lost motion between the piston heads and the thrust cams 40 and the noisy operation which would result therefrom is positively avoided.

FIGURE 5 is another structural illustration of the inventive concept disclosed in the present application. FIGURE 5 is quite similar to FIGURE 1 in most respects and where like structure is found, the same reference numerals have been applied thereto as in the pump shown in FIGURE 1. A different structure is presented in the cam mechanism which is utilized to drive the pistons through the reciprocatory movement. Thrust cam members are provided at either end of the rotatable cylinder barrel and have been identified by the reference numerals 60. The thrust cams 60 are in engagement with the outer face 50 of the mushroom heads on the pistons 27. As described hereinabove in the operation of the pump of FIGURE 1, the thrust cams 60 serve to drive the pistons 27 on their inward movement upon rotation of the cylinder barrel 11. As in the pump of FIGURE 1, the thrust cams 60 drive the pistons inwardly twice during each rotation of the cylinder barrel or rotor.

For the purpose of returning the pistons 27 outwardly on a suction or intake stroke after the thrust cams have driven the same through a pumping or output stroke, rigid sinuous return cams 62 are provided which are separate from the thrust cams 60. A spring member 64 is provided and has first and second end portions 65 and 66. The spring 64 generally surrounds the cylinder barrel or rotor 11 and the first end portion 65 is in engagement with the right sinuous return cam 62 whereas the second end portion 66 of the spring is in engagement with the sinuous return cam 62 on the left. The force of the spring 64 serves to bias the sinuous return cams 62 outwardly at all times which serves to move the pistons on a suction or intake stroke. Since the thrust and return cams are separate from each other, it will be seen that an automatic provision is built in where machine tolerances are compensated for and also a provision is provided whereby wear is compensated for.

The pump illustrated in FIGURES 6, 7, and 8 incorporates the teachings disclosed hereinabove and in addition discloses a construction wherein the delivery of the pump may be varied from a maximum down through a range to substantially zero volume delivery and also through the zero volume delivery to a complete reversal of maximum delivery. In other words by this means the function of a piston with respect to a port may be changed from a discharge function to an intake or suction function. The pistons of the pump disclosed in FIGURES 6–8 are driven in a reciprocatory fashion by means of sinuous cams engaging mushroom heads on the end portions of the pistons. The sinuous cams are provided with at least one high point and one valley on each (in this construction each cam has two high points and two valleys) and when the high points and the valleys on each cam means are substantially oppositely disposed, the pistons which are substantially oppositely disposed are performing substantially identical operations. In the opposite case, when a high point of one cam is located substantially opposite a valley on the other cam, then the opposed pistons are performing substantially opposite functions or operations. In other words, if one piston is going through a pumping stroke, the opposite piston is going through a suction or intake stroke. As a result, substantially all of the fluid pumped by the one piston is taken in to the opposite piston chamber by the opposite piston moving on the intake or suction stroke. It will thus be apparent that positioning the opposite cams in various positions between these two extremes will result in varying the delivery of the pump between a maximum and a substantially zero delivery. If the cams are rotated or shifted further to a position where different high points are opposite each other the pistons will be performing a function opposite to that described hereinabove that is if the above pistons were pumping at the time described they would now be on an intake stroke.

The pump which is disclosed in FIGURES 6–8 has been indicated generally by the reference numeral 70 and includes a housing 71. A stationary pivot valve or pintle 72 is provided and extends axially into the housing 71. A rotatable cylinder barrel or rotor 75 is provided in the housing and is located on the pivot valve for rotation thereabout. Wall means are provided in the cylinder barrel 75 which serves to define a plurality of axially parallel cylinders all of which have been indicated by the reference numeral 77. Pistons are provided in each of the cylinders 77 and the pistons which extend from the right end of the cylinder barrel as viewed in FIGURE 6 have been designated by the reference numeral 79 and the pistons which extend from the left end of the cylinder barrel have been designated by the reference numeral 80. The pistons 79 and 80 are adapted for reciprocatory movement within their cylinders and all of the pistons have been provided with mushroom heads 82 on their outermost end portions. Inlet conduit means 84 are provided in the pivot valve 72 as well as discharge conduit means 85. Inlet and discharge ports 87 and 88 respectively, are also provided in the pivot valve and serve to alternately con-

nect passageway means 90 which extend from each of the cylinders 77 with the inlet and discharge conduit means upon rotation of the cylinder barrel or rotor 75. A shaft 92 is journalled in bearings 93 in the housing 70 and is connected to the cylinder barrel 75 by a connection indicated generally by the reference numeral 95 and which will not be described further in detail.

First and second sinuous cam means 97 and 98, respectively, are provided at either end of the rotatable cylinder barrel 75 and are for the purpose of driving the pistons through their reciprocatory movement. Each of the sinuous cam means 97 and 98 includes a thrust cam member 100 which engages an outer surface on the mushroom heads 82 of the pistons for driving the pistons on a pump or discharge stroke. The cam means also include a return cam member 101. The thrust cam members 100 are connected to associated return cam members by means of connecting members 103 which extend therebetween. Each of the connecting members has a washer 104 in an end thereof and a spring 105 is mounted on the connecting member and exerts a force between the return cam member and the washer which serves to bias the thrust cam members and the return cam members together.

The sinuous cam means 97 and 98 are mounted in such a way that they may be rotated with respect to each other about an axis which is substantially coaxial with the axis of the rotatable cylinder barrel 75. The cam means 97 and 98 are mounted by means of ball bearings 107 with an outer race 108 formed as part of the pump housing and an inner race 109 formed on a thrust cam member 100. A first bevel gear sector 111 is suitably secured to the return cam member 101 of the first sinuous cam means 97 and a second bevel gear sector 112 is suitably secured to the return cam member 101 of the second sinuous cam means 98. This is best seen in FIGURE 7 of the drawings. The physical angular extent of the first and second gear sectors 111 and 112 is substantially on the order of 110 degrees. It will be noted that the gear sectors are oppositely disposed from each other. A bevel gear 114 is mounted on bearings 115 suitably positioned in the housing and the teeth on the bevel gear intermesh with the teeth on each of the bevel gear sectors 111 and 112. A shaft 116 is keyed to the bevel gear 114 as at 117 and extends through a cover plate 118 to the exterior of the housing where it is connected to a control handle 119.

In the pump disclosed in FIGURES 6–8 the first and second sinuous cam means 97 and 98 have been constructed so there are two high points or peaks in each and two low points or valleys. This means that during one complete rotation of the cylinder barrel or rotor 75 that each individual piston will be actuated through two complete cycles with a single cycle being made up of a pumping stroge and a suction stroke. The high points of the cam means 97 and 98 in the FIGURE 6 position are substantially opposite each other. It will be seen that upon rotation of the cylinder barrel 75 by a corresponding rotation of shaft 92 that the pistons which are substantially opposite each other will be actuated through a pumping stroke at substantially the same time and through a suction or intake stroke at substantially the same time and under this condition the delivery of the pump will be maximum. If it is then desired that the delivery of the pump be substantially zero it is necessary to move the control handle 119 which causes a corresponding movement of the bevel gear 114 which causes an angular shifting of the cam means 97 and 98 in opposite directions from each because of the intermeshing of the bevel gear teeth with the bevel gear sectors 111 and 112. When the cam means 97 and 98 have been shifted 90° relative to each other (each being shifted 45°), the delivery of the pump will be substantially zero. This is true because while one piston is on a discharge stroke, the piston substantially opposite is on a suction stroke which cancels

the discharge stroke out. If the cam means are shifted relative to each other substantially 180° (each being shifted 90°), then a complete reversal of the pumping action can be made to take place. In this situation in FIGURE 6 the high points on the cams would each be moved in opposite directions 90° and as a result low points on the cams would be engaging the two upper pistons shown in this position and in this angular position of the rotor the pistons would be starting their suction stroke rather than their discharge stroke. It is possible by shifting the cams through positions intermediate the maximum and zero delivery of the device to correspondingly vary the delivery of the pump. It will be noted that the gear sectors 111 and 112 and the action of the bevel gear cooperating therewith provides a construction wherein the forces exerted thereon during rotation of the bevel gear are substantially balanced out.

Another feature of the construction shown in the pump of FIGURES 6–8 resides in the construction of the return cam members 101. This construction is basically a combination of the return cam structure which is illustrated in the pumps of FIGURE 1 and FIGURE 5. In FIGURE 6, it will be seen that the face of the return cam members 101 has been constructed of a suitable resiliently yieldable material 122 which, in this instance is rubber, and has basically the characteristics of the rubber in the return cams of FIGURE 1. The resiliently yieldable material 122 serves a similar funtion as that disclosed in the description of the pump of FIGURE 1 whereas the construction of the separate cam members 100 and 101 in combination with the spring 105 serves to urge the two separate cam members together as does the spring in the construction of the pump of FIGURE 5. In the devices of FIGURES 5 and 6, the resiliently yieldable spring members urge the thrust and return cams together whereas in the device of FIGURE 1 the resiliently yieldable material of construction of the return cams and their connection enables the thrust and return cams to be urged together.

It will be readily appreciated by those skilled in the art that although a manual control handle 119 has been provided for varying the angular position of the cam means with respect to each other, many other means might be used to accomplish this result. It is entirely possible to provide a remote control which is hydraulically or electrically operated and which, for example, may be responsive in the case of a pump, to the volume of hydraulic fluid required for a particular job. In cases where it is desired, it is possible by many mechanical means to fix the position of the control handle 119. It will also be appreciated by those skilled in the art that the teachings of the invention may be applied to motors as well as to pumps and the term hydromechanical device is meant to generically include both.

It will be apparent that various modifications may be made in the arrangement and construction of this device without in any way departing from the spirit of this invention.

Accordingly it will be understood that I wish to comprehend such modifications and substitution of equivalents as may be considered to come within the scope of the appended claims and the invention.

This application is a continuation-in-part of my application, Serial No. 559,038, filed January 13, 1956 for Pump or Motor, now abandoned.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. In a piston pump the combination of a rotary cylin-

der barrel having a plurality of cylinders formed therein parallel to the axis of barrel rotation, and having port holes extending inwardly between the ends of each said cylinder, a stationary pivot valve within said barrel provided with passages and intake and exhaust ports, flexible means for rotating said barrel, a plurality of pistons extending from and adapted for rotary and reciprocal motion in each end of said cylinders, rigid sinuous thrust cams generated to urge said pistons inwardly during rotation of said cylinder barrel and mounted at opposite ends of said barrel, said pistons having heads each having outer and inner bearing surfaces, said outer bearing surfaces bearing directly against said rigid cams, separate sinuous piston return cams axially moveably mounted at each end of said barrel bearing against said inner bearing surfaces of said piston heads to move the pistons outwardly in the respective cylinders, said return cams being resilient in the region engaged by the heads of the pistons, and resilient means acting on said return cams trusting them toward the respective adjacent thrust cam, said return cams and a respective thrust cam being fixedly connected together and being non-rotative with respect to each other, said return cams and a respective thrust cam forming tracks to receive said piston heads with said return cams being capable of non-compressive deformation to take up for inaccuracies.

2. In a piston pump or motor the combination of a rotatable cylinder barrel having a plurality of cylinders formed therein generally parallel to the axis of barrel rotation and having port holes extending from and communicating with each cylinder, a pivot valve within said barrel provided with intake and exhaust passages and ports, means for rotating said barrel, a piston residing in and having an end portion extending from each of said cylinders, said pistons adapted for reciprocal motion in said cylinders with said end portions thereof extending from either end of said rotatable cylinder barrel, first and second rigid sinuous thrust cams mounted at either end of said rotatable cylinder barrel to urge said pistons inwardly during rotation of said cylinder barrel, said extending end portions of said pistons having inner and outer bearing surfaces, said outer bearing surfaces of said pistons engaging said rigid sinuous thrust cams for causing said inward movement of said pistons, first and second rigid sinuous return cams located at either end of said rotatable cylinder barrel to urge said pistons outwardly during rotation of said cylinder barrel, said return cams being axially movable relative to said thrust cams, said inner bearing surfaces of said pistons engaging said rigid sinuous return cams for causing said outward movement of said pistons, and spring means urging said return cams toward respective thrust cams, one of the surfaces of each return cam engaged by said inner bearing surfaces of the extending end portions of the pistons and the said inner bearing surfaces being resilient to eliminate all lost motion between the said end portions of the pistons and said thrust and return cams.

3. In a piston pump or motor the combination of a rotatable cylinder barrel having a plurality of axially extending cylinders having port holes extending from and communicating with each cylinder, a pivot valve within said barrel provided with intake and exhaust passages and ports, means for rotating said barrel, a piston residing in and having an end portion extending from each of said cylinders, said pistons adapted for reciprocal motion in

said cylinders with said end portions thereof extending from both ends of said rotatable cylinder barrel, first and second rigid sinuous thrust cams; one mounted at each end of said rotatable cylinder barrel to urge said pistons inwardly during rotation of said cylinder barrel, said extending end portions of said pistons having inner and outer bearing surfaces, said outer bearing surfaces of said pistons engaging said rigid sinuous thrust cams for causing said inward movement of said pistons, first and second rigid sinuous return cams located at either end of said rotatable cylinder barrel to urge said pistons outwardly during rotation of said cylinder barrel, said return cams being axially movable relative to said thrust cams, a resiliently yieldable material secured to the rigid sinuous return cams, said inner bearing surfaces of said pistons engaging said resiliently yieldable material of said rigid sinuous return cams for causing said outward movement of said pistons, and spring means urging said return cams toward respective thrust cams.

4. In a piston pump or motor the combination of a rotatable cylinder barrel having a plurality of axially extending cylinders having port holes extending from and communicating with each cylinder, a pivot valve within said barrel provided with intake and exhaust passages and ports, means for rotating said barrel, a piston residing in and having an end portion extending from each of said cylinders, said pistons adapted for reciprocal motion in said cylinders, a rigid sinuous thrust cam mounted to urge said pistons inwardly during rotation of said cylinder barrel, said extending end portions of said pistons having inner and outer bearing surfaces, said outer bearing surfaces of said pistons engaging said rigid sinuous thrust cam for causing said inward movement of said pistons, a rigid sinuous return cam mounted to urge said pistons outwardly during rotation of said cylinder barrel, said return cam being axially movable relative to said thrust cam, resiliently yieldable material secured to said return cam, said inner bearing surfaces of said pistons engaging said resiliently yieldable material of said rigid sinuous return cam for causing said outward movement of said pistons, and spring means urging said return cam toward said thrust cam.

5. A pump according to claim 1 in which studs are provided on said thrust cams extending through said return cams, and said resilient means comprising springs mounted on said studs and bearing between the return cams, and the studs.

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