

March 16, 1937.

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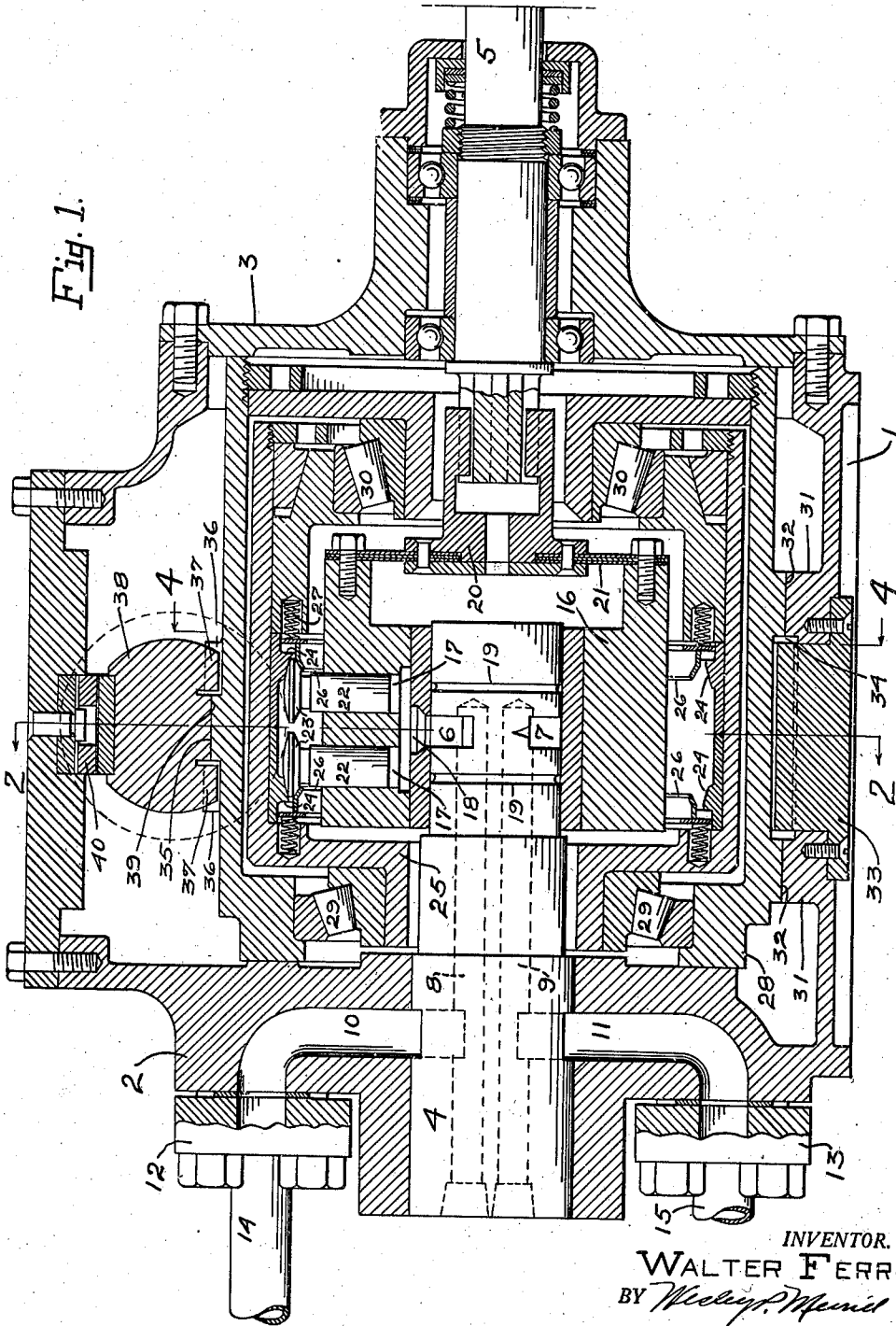
2,074,068

PUMP OR MOTOR

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5 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

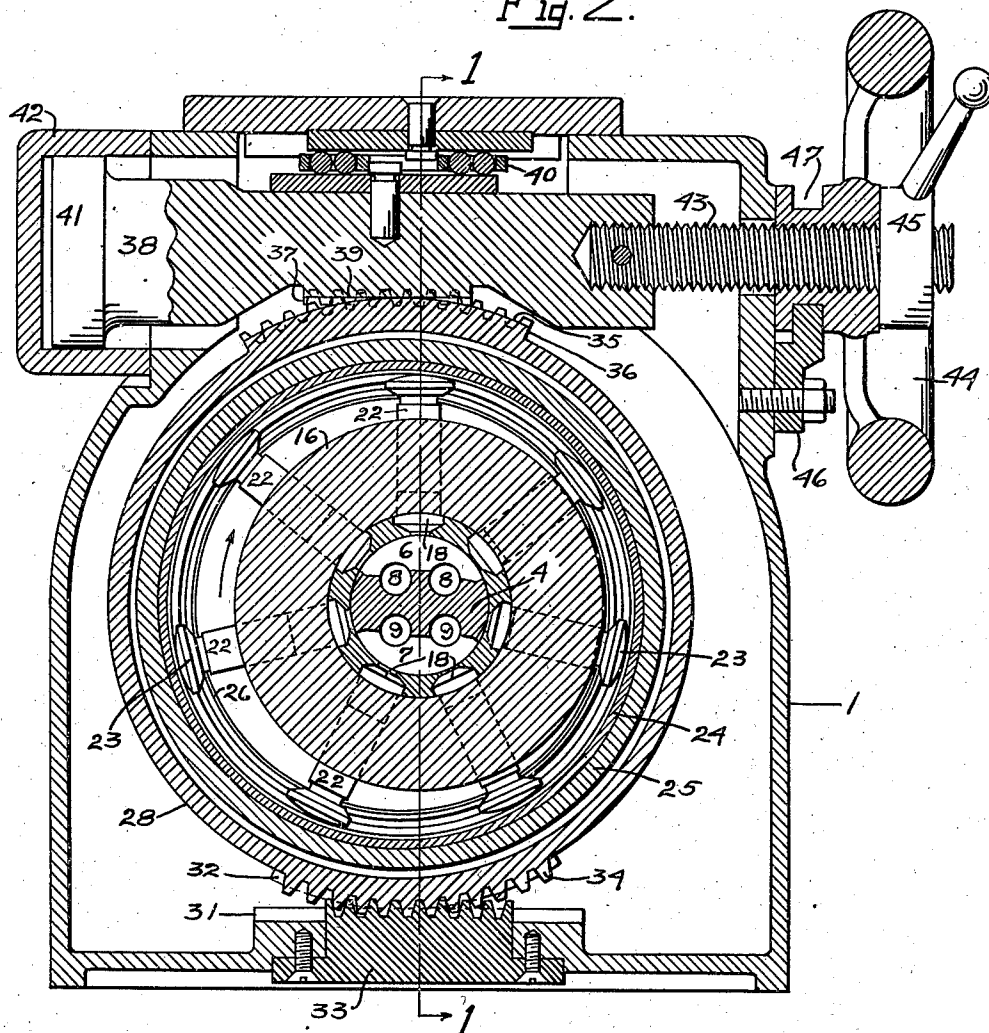
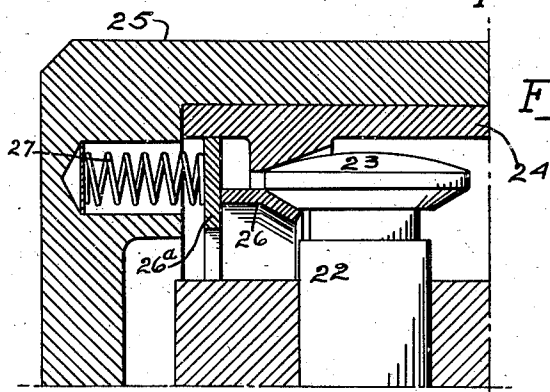


Fig. 3.



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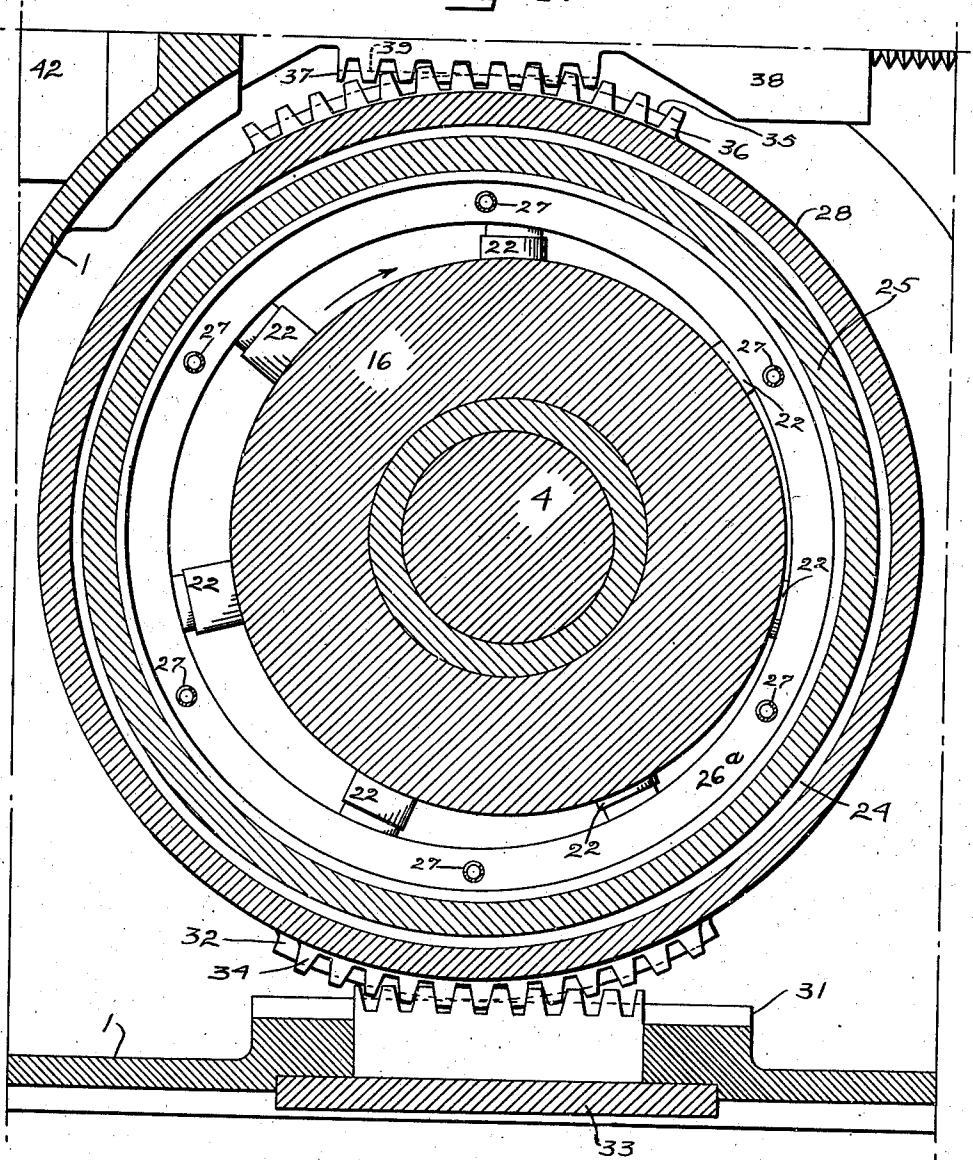
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Fig. 4.



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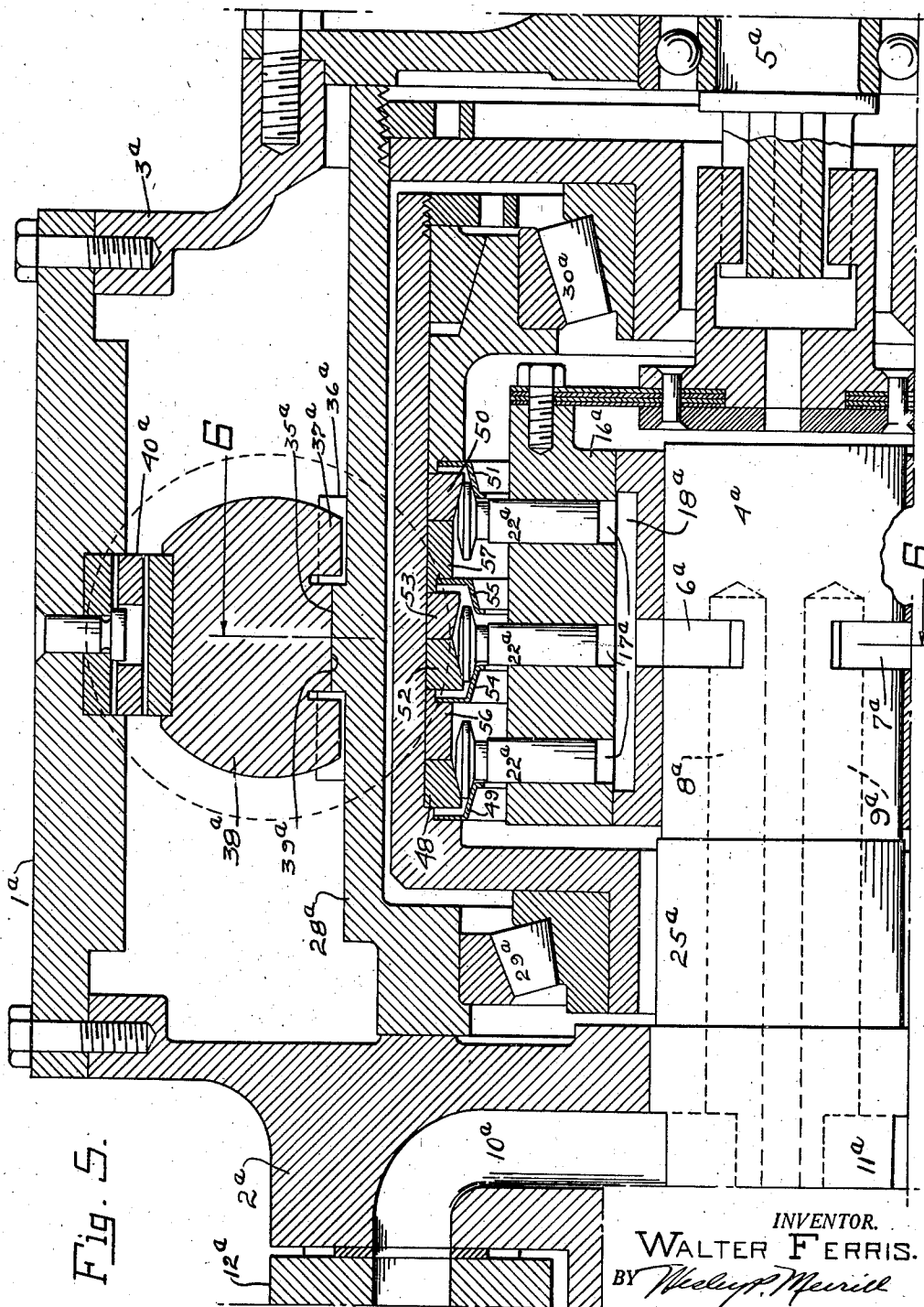
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5 Sheets-Sheet 4



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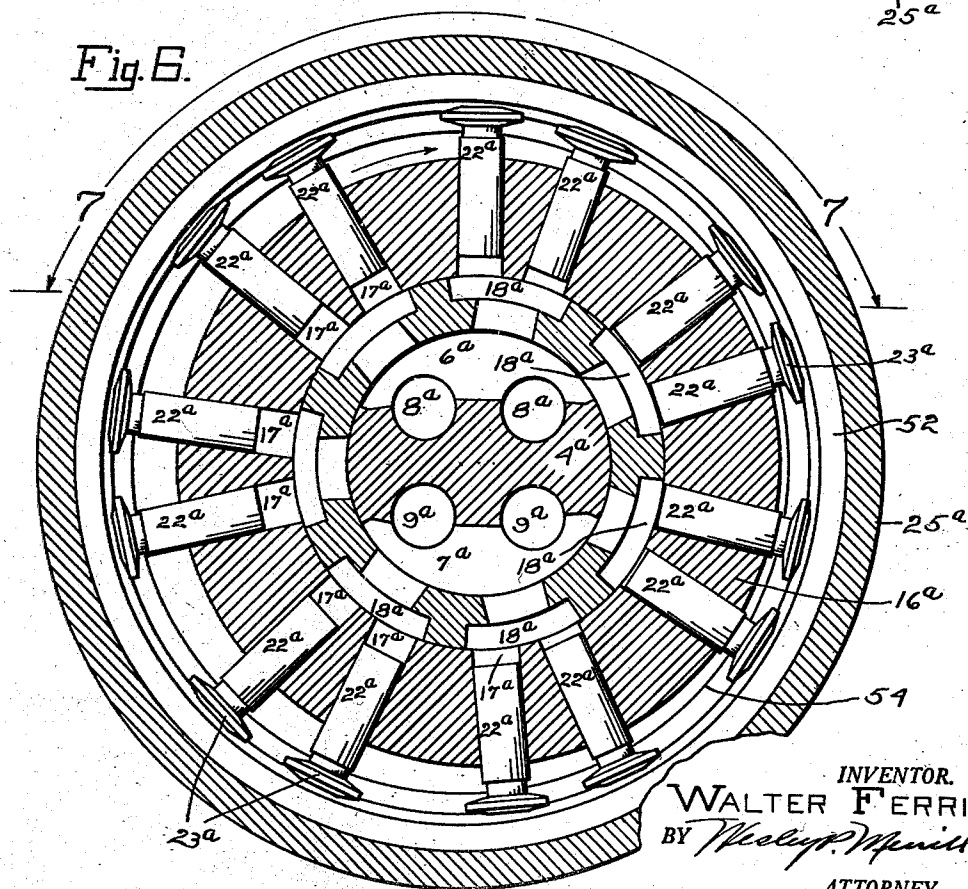
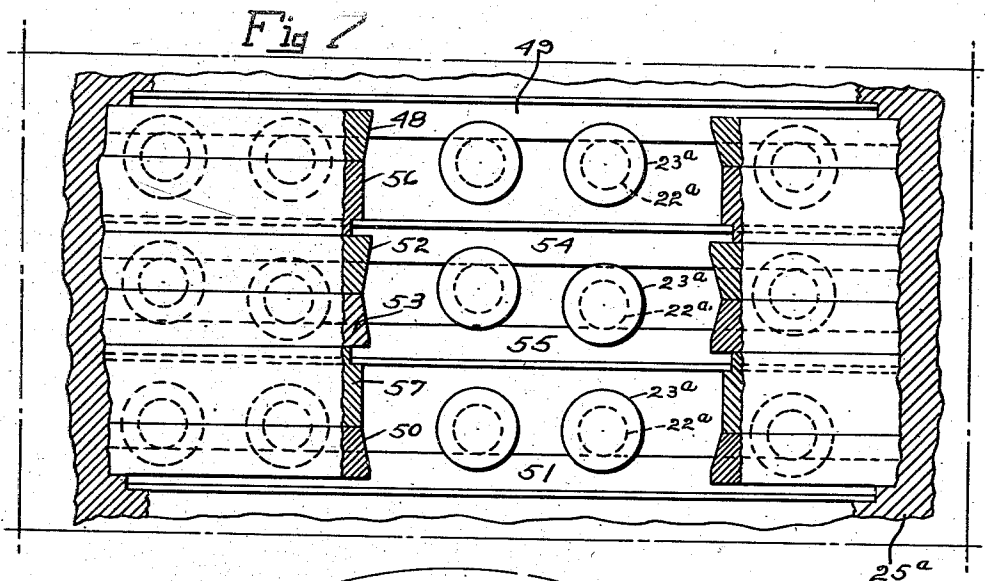
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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,074,068

PUMP OR MOTOR

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Application March 23, 1933, Serial No. 662,219

23 Claims. (Cl. 103—161)

This invention relates to pumps or motors of the type in which a plurality of cylinders are arranged in a rotatable cylinder barrel and provided with pistons which have the outer ends thereof in engagement with a thrust member 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 is supplied to its cylinders. 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 but it is to be understood that the invention is equally applicable to a motor of the same type.

Certain characteristics of the invention are applicable to axial pumps of the type in which the cylinders are arranged in a rotatable cylinder barrel parallel to the axis thereof and are provided with pistons which extend from one end of the cylinder barrel into engagement with an inclined thrust member or swash plate and are reciprocated thereby as the cylinder barrel rotates.

The invention as a whole is applicable to radial pumps and it will be explained in connection with the description hereinafter set forth of a pump of this type.

The radial type of pump to which the invention applies in particular is provided with a rotatable cylinder barrel having cylinders arranged therein radial to the axis of rotation thereof, a piston arranged in each cylinder, and a crosshead arranged upon the outer end of each piston in engagement with a thrust member which ordinarily rotates with the cylinder barrel and forces the pistons inward during one-half of a revolution and permits the pistons to move outward during the other half of the revolution whenever its axis is offset from the axis of rotation of the cylinder barrel.

As each piston moves outward and thereby increases the distance between its crosshead and the axis of the cylinder barrel, the linear speed of its crosshead increases and, as it moves inward, the linear speed of its crosshead decreases so that, if the thrust member rotates with the cylinder barrel, each crosshead moves faster than a given point on the thrust member during a part of a revolution and slower than that point during another part of a revolution.

The forces required to increase and decrease the speed of the crosshead, which are ordinarily designated as crosshead accelerating forces, are primary factors in limiting the volumetric deliv-

ery or output of the pump for the reason that they place a definite limit upon the speed at which the cylinder barrel may be rotated. Further, accelerating forces at outer ends of a piston tend to tilt the piston in its cylinder and cause unequal wear of the piston and cylinder both circumferentially and longitudinally thereof.

The present invention has as an object to provide a pump in which the crosshead accelerating forces are reduced to a minimum and which is capable of being operated at high speeds.

Another object is to provide a pump in which a substantially uniform lubricating film is maintained between each piston and its cylinder and abrasion of the pistons and cylinders is reduced to a minimum.

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

Another object is to provide a pump with a cylinder barrel in which the cylinders are arranged closer to each other than was heretofore possible whereby the pump has a large volumetric capacity relative to its overall dimensions.

Another object is to provide a pump which is susceptible of close adjustment and control.

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

Other objects and advantages will appear from the description and explanation hereinafter set forth.

According to the invention in one of its aspects, a pump is provided with a rotatable cylinder barrel having cylinders arranged therein, a piston arranged in each cylinder and provided at its outer end or head with a sloping or beveled outer face, and a thrust member which engages the sloping outer face of each piston at one side of the piston axis and is so arranged that it forces each piston inward during one part of a revolution of the cylinder barrel and permits it to move outward during another part of a revolution of the cylinder barrel whereby, during reciprocation of the pistons, relative movement between each piston and the thrust member causes the outer end of the piston to roll upon the thrust member and the piston to rotate within its cylinder.

If the pump is of the radial type, the pistons are urged inward by a thrust ring which is arranged around the cylinder barrel eccentric thereto and engages the sloping faces on the outer ends or heads of the pistons, thereby eliminating the heavy crossheads previously employed

and reducing to a minimum the accelerating forces at the outer ends of the pistons.

According to the invention in another aspect, the cylinders are arranged in groups and the cylinders of each group are served by a single cylinder port whereby a large number of cylinders may be arranged around a pintle of a given diameter or employed in a pump of given overall dimensions.

According to the invention in another aspect, the cylinder barrel is arranged within a cradle which carries the thrust member and is adapted to be rolled along a stationary support to change the stroke of the pistons.

According to the invention in another aspect, the cylinder barrel is connected by a flexible and expansible joint to a shaft which rotates the cylinder barrel when the machine is functioning as a pump and is driven by the cylinder barrel when the machine is functioning as a motor, whereby the cylinder barrel may adjust itself upon the pintle independently of this shaft.

The invention is exemplified by the pumps shown in the accompanying drawings in which the views are as follows:

Fig. 1 is a central longitudinal section through a pump in which the invention is embodied, the view being taken on the line 1—1 of Fig. 2.

Fig. 2 is a vertical transverse section taken on the line 2—2 of Fig. 1.

Fig. 3 is a detail view taken on the line 1—1 of Fig. 2.

Fig. 4 is a vertical transverse section taken on the line 4—4 of Fig. 1.

Fig. 5 is a longitudinal sectional view similar to Fig. 1 but showing a modified form of pump.

Fig. 6 is a transverse section taken on the line 6—6 of Fig. 5.

Fig. 7 is a developed plan view of the mechanism shown in Fig. 6, the view being partly in section and taken on the line 7—7 of Fig. 6.

Referring first to Figs. 1 to 4, the pump shown therein has its mechanism arranged within and carried by a casing 1 which is provided at its rear end with a head 2 of substantial thickness and at its front end with a removable head 3.

The rear head 2 has a pintle 4 secured therein at its rear end in axial alinement with a drive shaft 5 which is journaled in the front head 3 in suitable bearings and restrained thereby from axial movement.

The pintle 4 extends into the casing 1 and has two segmental ports 6 and 7 formed therein diametrically opposite each other near the front end thereof. The ports 6 and 7 communicate, respectively, with two upper passages 8 and two lower passages 9 which extend longitudinally of the pintle and communicate, respectively, with a passage 10 and a passage 11 which are formed in the rear head 2 and terminate on the rear face thereof.

The pump may be connected into a hydraulic circuit by means of two pipe fittings 12 and 13 which are attached to the rear head 2 to connect a pipe 14 and a pipe 15 thereto in communication, respectively, with the passages 10 and 11.

The pintle 4 has a cylinder barrel 16 closely fitted upon the front part thereof to rotate thereon and shown as consisting of a body and an inner ring which are rigidly secured to each other and which may be made of dissimilar metals.

The cylinder barrel is provided with a plurality of radial cylinders 17, which are arranged therein around the pintle 4, and with a plurality of

cylinder ports 18 each of which serves a plurality of cylinders 17 and registers with the pintle ports 6 and 7 alternately as the cylinder barrel rotates.

As shown in Figs. 1 and 2, the cylinder barrel 16 is provided with seven ports 18, which are spaced around the pintle, and with fourteen cylinders 17 which are arranged in two series of seven cylinders each with each cylinder in one series arranged parallel to a cylinder in the other series and communicating at the inner end thereof with the other cylinder and with a pintle port whereby the entire supply of liquid delivered to two cylinders and discharged therefrom flows through a single cylinder port. This permits the cylinders of one series to be arranged close to the cylinders of the other series and reduces to a minimum the length of pintle and cylinder barrel required for efficient operation.

When the pump is in operation, a small volume of liquid from the cylinders is forced between the bearing surfaces of the cylinder barrel and the pintle and forms a lubricating film upon which the cylinder barrel rotates. This film is subjected to pump pressure and tends to move the cylinder barrel toward the high pressure or discharge side of the pump and thereby cause it to bear more heavily upon the low pressure or intake side of the pintle.

In order to overcome this tendency, pressure limiting grooves 19 are formed in the pintle to determine the width of the region of high pressure tending to lift the cylinder barrel away from contact with the pintle on the high pressure side. This width is so proportioned that the pressure of the pistons inward upon the inner ends of the cylinders and tending to hold the cylinder barrel against the pintle is equal to or greater than the separating pressure of the film between the surfaces tending to lift the cylinder barrel away from the pintle.

The cylinder barrel 16 is rotated by the shaft 5 through a flexible and expansible joint which has its hub 20 loosely splined upon the shaft 5 and connected by a flexible laminated spider or disk 21 to the front end of the cylinder barrel to allow the cylinder barrel to adjust itself radially and axially upon the pintle.

Each of the cylinders 17 has a piston 22 fitted therein and provided at its outer end with a head 23 to engage the inner face of a thrust ring 24 one of which extends around the cylinder barrel substantially in the plane of each circular series of pistons and may be restrained from rotation but is shown as being fixed in a rotatable drum 25 and rotated therewith substantially in synchronism with the cylinder barrel by rotative forces transmitted through the pistons.

When the pump is in operation, the thrust ring 24 is arranged eccentric to the cylinder barrel to force each piston inward during one half-revolution of the cylinder barrel and to permit it to move outward during the other half-revolution.

The distance between each piston head and the axis of the cylinder barrel thus changes twice during each revolution with a resultant variation in the linear speed of the piston head. Since the thrust ring 24 is rotated by contact with all of the piston heads, it moves at substantially the average speed of all piston heads or rotates at substantially the same speed as the cylinder barrel. Consequently, each piston head moves faster than a given point on the inner face of the thrust ring during one half-revolution of the cylinder barrel

and slower than that point during the other half-revolution.

If the thrust ring engaged the piston upon its axis and transmitted pumping forces to the piston parallel to the piston axis in the same manner that pumping forces were transmitted through the crossheads of the prior pumps, sliding friction would be created between the piston and the thrust ring and this friction would detract from the efficiency of the pump.

In order to prevent creation of this sliding friction, each piston 22 is provided upon its outer end or head 23 with a beveled face, the inner face of the thrust ring 24 is beveled, and the beveled inner face of the thrust ring 24 engages the beveled outer face of the head 23 at one side of the piston axis. Then, whenever the head 23 moves either faster or slower than a corresponding point on the thrust ring, it rolls along the thrust ring and rotates the piston in its cylinder.

If the piston were provided with a conical outer end or head, its end or outer face would make a line contact with the thrust ring and, when the head rotated, would cause abrasion of the thrust ring and piston head and this abrasion would cause undesirable friction and eventually abrade the piston head until it had a slightly curved outer face. Consequently, the outer end or head of the piston is provided with a beveled or sloping outer face which is slightly curved lengthwise of the bevel or slope so that the thrust ring 24 engages the piston upon a single spot which is offset from the piston axis and through which pumping forces are transmitted from the thrust ring to the piston.

In practice, the curvature of the outer face of the piston head is made to correspond to the curvature which would be produced if the outer part of the head were made in the form of a truncated cone and then abraded by contact with the thrust ring so that the pumping force acts at right angles to that point upon the head with which the thrust ring is in contact. When so made, the outer face of the head is non-spherical and its radii do not converge upon the axis of the piston.

The piston head 23 may be of the same diameter as the piston but it is ordinarily of greater diameter in order that it may engage the thrust ring at a point removed a suitable distance from the piston axis and from the periphery of the head, and also in order to provide means for moving the piston outward and for keeping the head in contact with the thrust ring.

The centrifugal force created by rotating the cylinder barrel at an ordinary operating speed, for instance 1000 R. P. M., is sufficient to hold the piston heads in contact with the thrust ring and to move the pistons outward with sufficient force to cause them to fill their cylinders with liquid from a nearby source.

The pistons may be moved outward and the heads thereof positively retained in engagement with the thrust ring by supplying liquid under pressure to the cylinders from an auxiliary pump in the well known manner, as disclosed in Patent No. 1,619,200 issued March 1, 1927, but are shown urged outward and positively retained in engagement with the thrust rings 24 by two resilient inner rings 25 one of which is arranged alongside each series of pistons and provided with a beveled outer face to engage the beveled underface of the piston heads 23 and urge the beveled outer faces thereof into engagement with the thrust ring.

When the thrust ring is eccentric to the cylin-

der barrel and the pump rotor is rotating, each piston head moves faster than a given point on the thrust ring during a half-revolution of the pump rotor and slower than that point during the other half-revolution, as previously explained.

When the piston is at the end of its instroke and when it is at the end of its outstroke, the point of contact between the piston head and the thrust ring is offset from the piston axis in a direction parallel to the axis of the pintle, that is, it is arranged in the radial plane of the piston axis.

As the piston moves inward or outward from its outstroke or instroke position, its head moves either slower or faster than the thrust ring with the result that the point of contact between its head and the thrust ring is displaced from the radial plane of the piston axis and, since the inner face of the thrust ring is substantially conical, this displacement of the point of contact causes the piston head to be forced inward independent of the normal piston stroke which is effected by offsetting the axis of the thrust ring from the axis of the cylinder barrel.

The inward movement of the piston head, caused by the displacement of the point of contact, is ordinarily only a few thousandths of an inch in a medium size pump but it would be sufficient to exert considerable pressure upon the inner ring 26 if the ring were rigid.

Consequently, the inner ring 26 is ordinarily made in two parts, the ring 26 proper and a detached flange or ring 26^a, as shown in Fig. 3.

The ring 26 has one of its edges beveled and arranged in engagement with the sloping underfaces of the piston heads 23, and it is resilient so that it may assume a slightly elliptical form when the pump is in operation.

The detached flange 26^a is urged against the other edge of the ring 26 by several helical compression springs 27 which are arranged in recesses formed in the drum 25.

The springs 27 urge the ring 26 toward the pistons and thereby enable it to keep the piston heads firmly in contact with the thrust ring.

The drum 25 is arranged within a cradle 28 and rotatably supported therein at the rear end thereof by a roller thrust bearing 29 and at the front end thereof by a roller thrust bearing 30.

The cradle 28, which is shown as being circular in cross-section, is supported within the casing 1 upon two tracks or supports 31 which are formed on or carried by the bottom wall of the casing and engaged upon the tops thereof by two arcuate rolling surfaces 32 formed upon the underside of the cradle.

The bottom wall of the casing 1 has a rack 33 inserted therein between the supports 31 and in mesh with gear teeth 34 which are arranged upon the underside of the cradle 28 between the rolling surfaces 32. The rack and gear teeth permit the cradle to roll upon the supports 31 but prevent it from sliding thereon.

The cradle 28 is provided upon its top with an arcuate rolling surface 35 and with a series of gear teeth 36 upon each side of the surface 35. The gear teeth 36 mesh with rack teeth 37 arranged in two rows upon the underside of a movable support 38 which has a bearing surface 39 arranged between the two rows of teeth 37 and engaging the rolling surface 35 to hold the cradle 28 in firm engagement with the stationary support 31. The movable support 38 is restrained from upward movement by a roller bearing 40 ar-

ranged between its upper face and the top of the casing 1.

The stroke of the pump is adjusted by moving the support 38 which is ordinarily operated hydraulically but which, for the purpose of illustration, has been shown as being operated mechanically.

As shown, the movable support 38 is guided by a piston 41, which is fixed upon one end thereof and fitted in a cylinder 42 carried by the casing 1, and it is moved by a screw 43 which is fixed to the other end thereof and extends through the side wall of the casing 1. The screw 43 is moved axially by a handwheel 44 which is threaded upon the outer end thereof and retained in adjusted position by a locknut 45. The handwheel 44 is restrained from axial movement in one direction by abutting the wall of the casing 1 and from axial movement in the opposite direction by a retainer plate 46 which is fastened to the casing 1 and fitted in a groove 47 formed in the hub of the handwheel 44.

When the handwheel 44 is turned, the support 38 is moved transversely of the cradle 28, the gear teeth 36 and the rack 37 roll the cradle along the stationary support 31, and the rack 33 and the gear teeth 34 prevent the cradle from sliding thereon.

Rolling the cradle 28 along the support 31 moves the axis of the thrust ring 24 relatively to the axis of the cylinder barrel and thereby changes the piston stroke which is always equal to twice the distance between the axis of the thrust ring and the axis of the cylinder barrel.

The axis of the thrust ring is moved in a straight line so that a given degree of movement of the cradle at any point in its path of travel varies the piston stroke by exactly the same amount as at any other point and, since the movable support engages the cradle at its periphery, it moves through a much greater distance than the axis of the thrust ring, thereby enabling the pump to be accurately adjusted and closely controlled.

In order that each piston head may roll upon the thrust ring, it may have but a very limited area in contact therewith, and the entire force required to move the piston inward must be transmitted through this limited area. Consequently, if the pump is to develop high pressure, pistons of limited cross-sectional area must be employed and the volumetric capacity of the pump increased by increasing the number of cylinders.

The thrusting force transmitted from the thrust ring through the piston head is applied at an angle to the piston axis while the force required to expel the liquid from the cylinders acts parallel to the piston. However, the lines of these two forces intersect at a point intermediate the ends of the cylinder and the lateral component of the thrusting force acts at right angles to the cylinder wall so that the piston is not tilted in its cylinder but is uniformly supported by the lubricating film between it and the cylinder wall.

In order to prevent this lateral component from tending to move the cylinder barrel axially, one half of the piston heads are ordinarily engaged by one or more thrust rings arranged upon one side of the piston axis and the other half of the piston heads are engaged by one or more thrust rings arranged upon the other side of the piston axis.

In the prior pumps and motors, it was customary to provide each cylinder in a circular

series or radial plane with a separate cylinder port and to arrange as many cylinders in the circular series as possible while maintaining an adequate seal between adjacent cylinder ports and between the intake and exhaust ports of the pintle. A pump of greater capacity was produced by increasing the bore of the cylinders, the limiting factor being the wall thickness between the inner ends of adjacent cylinders.

In a rolling piston type of pump such as described herein, the bore of the cylinders is limited by the carrying capacity of the small areas on the piston heads and on the thrust ring which are in contact with each other and through which pumping forces are transmitted from the thrust ring to the pistons.

Therefore, a rolling piston pump designed to deliver liquid at a given maximum pressure has its displacement determined by the number of cylinders and the length of piston stroke, but it is capable of delivering liquid at a greater volumetric rate than a prior pump of the same displacement due to the fact that it may be operated at considerably higher speeds.

The number of ports which may be formed in the cylinder barrel is limited since adjacent ports must be separated by a bridge of adequate width. After the cylinder barrel has been provided with as many ports as possible, additional pump displacement is provided by adding other cylinders and connecting two or more cylinders to each port.

In the pump shown in Figs. 1 to 4, the cylinders are arranged in two series of seven cylinders each and one cylinder of each series, or a total of two cylinders, is connected to each port.

If a pump of larger volumetric capacity is required, more cylinders may be added to each series and/or more series may be added as shown in Figs. 5 to 7 in which the cylinders are arranged in three series of fourteen cylinders each and two cylinders of each series, or a total of six cylinders, are connected to each port.

The addition of another series of cylinders adds but little to the overall length of the pump, and but little increase is required in the diameters of the pintle and the cylinder barrel to permit the addition of cylinders to each series to thereby utilize the space between adjacent cylinders which was wasted in the prior pumps. Consequently, the volumetric capacity may be increased without a corresponding increase in the size of the pump.

Referring now to Figs. 5 to 7, the pump shown in these figures is substantially the same as that previously described except that it has a greater volumetric capacity which has been obtained by increasing the number of cylinders and providing additional thrust rings to operate the additional pistons. Consequently, like parts have been indicated by like reference numerals with the exponent "a" added.

The pump has a pintle 4^a fixed at its rear end in the read head 2^a of the pump casing 1^a and provided with two diametrically opposed segmental ports 6^a and 7^a which communicate, respectively, through pintle passages 8^a and 9^a with two passageways 10^a and 11^a formed in the head 2^a.

The pintle 4^a has a cylinder barrel 16^a journaled thereon and provided with a plurality of cylinder ports 18^a which register with the pintle ports 6^a and 7^a alternately as the cylinder barrel is rotated by the drive shaft 5^a.

The cylinder barrel 16^a is provided with a plurality of radial cylinders 17^a each of which has a piston 22^a fitted therein. The cylinders are shown arranged in three series of fourteen cylinders each and in fourteen rows of three cylinders each, or a total of 42 cylinders. Each series of cylinders extends around the pintle and each row extends longitudinally of the pintle.

The cylinders in each row communicate with the same cylinder port 18^a and with the three cylinders in an adjacent row whereby each cylinder port 18^a serves six cylinders.

The cylinders in the rear series extend around the cylinder barrel in a straight row, and the heads of the pistons fitted therein are engaged upon their outer faces at the rear of the piston axes by a thrust ring 48 and upon their under faces by a resilient inner ring 49 which holds the piston heads in engagement with the thrust ring 48.

The cylinders in the front series extend around the cylinder barrel in a straight row, and the heads of the pistons fitted therein are engaged upon their outer faces at the front of the piston axes by a thrust ring 50 and upon their under faces by a resilient inner ring 51 which holds the piston heads in engagement with the thrust ring 50.

The cylinders of the center series are staggered alternately into two straight rows which are offset from each other and extend around the cylinder barrel, as shown in Fig. 6. The pistons in the cylinders in one of these rows have the heads thereof engaged upon their outer faces at the rear of the piston axes by a thrust ring 52, and the pistons in the cylinders in the other row have the heads thereof engaged upon their outer faces at the front of the piston axes by a thrust ring 53. The piston heads in one row are held against the thrust ring 52 by a resilient inner ring 54, and the piston heads in the other row are held against the thrust ring 53 by a resilient inner ring 55.

The lateral components of the forces exerted upon the piston heads by the thrust rings 48 and 50 are equal and opposite in direction, and the lateral components of the forces exerted upon the piston heads by the thrust rings 52 and 53 are equal and opposite in direction. Consequently, these forces do not move the cylinder barrel longitudinally of the pintle.

The thrust rings 52 and 53 abut each other and are spaced from the thrust rings 48 and 50, respectively, by spacer rings 56 and 57. The thrust rings and the spacer rings are all rigidly secured within a drum 25^a which is journaled in a cradle 28^a by means of roller thrust bearings 29^a and 30^a.

The cradle 28^a may be moved transversely of the pintle 4^a by means of a movable support 38^a which is provided upon its underside with a bearing surface 39^a, to engage a rolling surface 35^a on the cradle, and with rack teeth 37^a which are arranged upon each side of the surface 39^a in mesh with complementary gear teeth 36^a which are formed upon the top of the cradle at each side of the surface 35^a. The support 38^a is restrained from upward movement by a roller bearing 40^a arranged between it and the top wall of the casing 1^a.

The pump has substantially the same characteristics as the pump shown in Figs. 1 to 3, and it is adjusted and operated in substantially the same manner.

The pumps disclosed herein may be operated

as motors and are susceptible of various modifications without departing from the scope of the invention as hereafter claimed. The invention is defined in the following claims as applied to a pump but it is to be understood that it is equally applicable to a rotary hydraulic motor.

The invention is hereby claimed as follows:

1. A pump, comprising a cylinder member and a thrust member rotatable upon axes which are parallel and offset from each other, means for rotating said cylinder member, a piston independent of any other piston fitted in said cylinder member and having the outer and inner end portions thereof fixed for rotation with each other, an arcuate contact face arranged upon the outer end of said piston, and a reaction surface arranged upon said thrust member and engaging said contact face, said reaction surface being so shaped that it engages said contact face only upon a single spot which remains upon the same side of the piston axis in respect to a given point on the axis of said cylinder member and which is offset far enough from the axis of said piston to cause said contact face to roll along said reaction surface and said piston to rotate in said cylinder member first in one direction and then in the opposite direction during rotation of said cylinder member.

2. A pump, comprising a cylinder member and a thrust member rotatable upon axes which are parallel and offset from each other, means for rotating said cylinder member, a plurality of cylinders arranged in said cylinder member, a piston independent of any other piston fitted in each cylinder and having an enlarged head arranged upon its outer end and fixed for rotation with its inner end, an arcuate contact face arranged upon said head, and a reaction surface arranged upon said thrust member at an angle to the piston axes and engaging the contact face on each piston head upon a single spot which remains upon the same side of the piston axis in respect to a given point on the axis of said cylinder member and which is offset far enough from the piston axis to cause the piston head to roll along said reaction surface and the piston to rotate in its cylinder first in one direction and then in the opposite direction during rotation of said cylinder member.

3. A pump, comprising a cylinder barrel having cylinders arranged therein, means for rotating said cylinder barrel, a cylindrical piston fitted in each cylinder to reciprocate and rotate therein and having the outer and inner end portions thereof fixed for rotation with each other, and a thrust ring surrounding said cylinder barrel eccentric thereto for urging said pistons inward during rotation of said cylinder barrel and engaging each piston at a single point which is offset from the axis of that piston to cause said piston to rotate in its cylinder and which remains upon the same side of the piston axis during a complete revolution of said cylinder barrel.

4. A pump, comprising a cylinder barrel having cylinders arranged therein, means for rotating said cylinder barrel, a cylindrical piston fitted in each cylinder to reciprocate and rotate therein and having the outer and inner end portions thereof fixed for rotation with each other, and a rotatable thrust ring surrounding said cylinder barrel eccentric thereto for urging said pistons inward during rotation of said cylinder barrel and to be rotated with said cylinder barrel by said pistons, said thrust ring engaging each piston only at a single point which is offset

from the axis of that piston to cause said piston to rotate in its cylinder and which remains upon the same side of the piston axis during a complete revolution of said cylinder barrel.

5 5. A pump, comprising a rotatable cylinder barrel having radial cylinders arranged therein in a circular series and in the same radial plane, a piston having the outer and inner end portions thereof fixed for rotation with each other fitted
10 in each cylinder to reciprocate and rotate therein and provided upon its outer end with a contact face inclined to the piston axis, means for rotating said cylinder barrel, a thrust ring arranged around said cylinder barrel eccentric
15 thereto to urge each piston inward during one half-revolution of the cylinder barrel and to permit it to move outward during the other half-revolution, and a reaction surface arranged upon said thrust ring at an angle to the axis thereof
20 and engaging the contact face of each piston only at a point offset from the axis of that piston to transmit thrust to said piston and to rotate the same during reciprocation thereof.

6. A pump, comprising a rotatable cylinder
25 barrel having radial cylinders arranged therein in a circular series and in the same radial plane, a piston having the outer and inner end portions thereof fixed for rotation with each other fitted in each cylinder to reciprocate and rotate therein
30 and provided upon its outer end with a contact face inclined to the piston axis, means for rotating said cylinder barrel, a rotatable thrust ring arranged around said cylinder barrel eccentric thereto to urge each piston inward during
35 one half-revolution of the cylinder barrel and to permit it to move outward during the other half revolution, a reaction surface arranged upon said thrust ring at an angle to the axis thereof and engaging the contact face of each piston only at a
40 point offset from the axis of that piston to transmit thrust to said piston and to rotate the same during reciprocation thereof, and means for rotatably supporting said thrust ring to enable said pistons to rotate it in unison with said cylinder
45 barrel.

7. A pump, comprising a cylinder barrel having cylinders arranged therein, means for rotating said cylinder barrel, a piston having the outer and inner end portions thereof fixed for
50 rotation with each other fitted in each cylinder to reciprocate and rotate therein and provided with a head at its outer end, a thrust ring surrounding said cylinder barrel eccentric thereto and engaging said pistons to urge the same inward during rotation of said cylinder barrel and
55 having a single point of contact with each piston offset from the axis of that piston to cause said piston to rotate in its cylinder, and an inner ring arranged within said thrust ring and engaging each piston head upon the underside thereof to
60 retain it in contact with said thrust ring.

8. A pump, comprising a rotatable cylinder barrel having radial cylinders arranged therein in a circular series and in the same radial plane,
65 a piston having the outer and inner end portions thereof fixed for rotation with each other fitted in each cylinder to reciprocate and rotate therein and provided upon its outer end with a head having an outer contact face inclined to the piston
70 axis, means for rotating said cylinder barrel, a thrust ring arranged around said cylinder barrel eccentric thereto to urge each piston inward during one half-revolution of the cylinder barrel and to permit it to move outward during the other
75 half-revolution, an inner ring arranged within

said thrust ring in contact with said piston heads upon the undersides thereof to retain the same in contact with said thrust ring, and a reaction surface arranged upon said thrust ring at an
5 angle to the axis thereof and engaging the contact face of each piston only at a point offset from the axis of that piston to transmit thrust to said piston and to rotate the same during reciprocation thereof.

9. A pump, comprising a rotatable cylinder
10 barrel having radial cylinders arranged therein in a circular series and in the same radial plane, a piston having the outer and inner end portions thereof fixed for rotation with each other fitted in each cylinder to reciprocate and rotate therein
15 and provided upon its outer end with a head having an outer contact face inclined to the piston axis, means for rotating said cylinder barrel, a rotatable thrust ring arranged around said cylinder barrel eccentric thereto to urge each piston
20 inward during one half-revolution of the cylinder barrel and to permit it to move outward during the other half-revolution, an inner ring arranged within said thrust ring in contact with said piston heads upon the undersides thereof to retain
25 the same in contact with said thrust ring, a reaction surface arranged upon said thrust ring at an angle to the axis thereof and engaging the contact face of each piston only at a point offset from the axis of that piston to transmit thrust to
30 said piston and to rotate the same during reciprocation thereof, and means for rotatably supporting said thrust ring to enable said pistons to rotate it in unison with said cylinder barrel.

10. A pump, comprising a cylinder barrel having
35 cylinders arranged therein, means for rotating said cylinder barrel, a piston having the outer and inner end portions thereof fixed for rotation with each other fitted in each cylinder to reciprocate and rotate therein and provided at
40 its outer end with a head having an inclined under face, a thrust ring surrounding said cylinder barrel eccentric thereto and engaging said pistons to urge the same inward during rotation of said cylinder barrel and having a single point of
45 contact with each piston offset from the axis of that piston to cause said piston to rotate in its cylinder, an inner ring arranged within said thrust ring and engaging the inclined under faces of said piston heads, and springs urging said inner
50 ring against said inclined under faces to thereby retain said piston heads in contact with said thrust ring.

11. In a pump, for converting rotary mechanical motion into a flow of fluid, the combination
55 of two relatively movable members in one of which is formed a cylinder, a cylindrical piston fitted in said cylinder to reciprocate and rotate therein and having the outer end thereof beveled and fixed for rotation with the inner end thereof,
60 and a reaction surface inclined to the axis of said piston arranged upon the other member and engaging the outer end of said piston only at a point which is removed from the piston axis and which remains upon the same side of the piston
65 axis during a complete revolution of said cylinder barrel, the reaction surface being so arranged that a line normal thereto through the point of contact with the piston intersects the axis of said piston at a point intermediate the ends of the
70 piston proper and within the cylinder, whereby the bearing force of said piston is landed directly upon the wall of the cylinder.

12. A pump, comprising a cylinder barrel rotating upon an axis and provided with a plurality
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of radial cylinders, a cylindrical piston fitted in each cylinder to reciprocate and rotate therein, a thrust ring surrounding said cylinder barrel and rotating upon a different axis, and a reaction surface inclined to the axial plane of said pistons formed on said thrust ring to transmit force between said pistons and said thrust ring during rotation of said cylinder barrel and engaging each piston only at a single point which is offset from the axis of that piston and remains upon the same side of said axis during a complete revolution of said cylinder barrel, said point of contact being so located that a line drawn there-through normal to said reaction surface intersects the axis of said piston at a point lying intermediate the ends of the piston proper and within the cylinder bore whereby the bearing force of the piston is landed directly upon the wall of the cylinder.

13. A pump, comprising a cylinder barrel rotating upon an axis and having a plurality of radial cylinders formed therein, a piston having the outer and inner end portions thereof fixed for rotation with each other fitted in each cylinder to reciprocate and rotate therein and having a contact face formed upon its outer end and inclined to the piston axis, a thrust ring surrounding said cylinder barrel and rotating upon a different axis parallel to the first named axis, and a reaction surface arranged upon the inside of said thrust ring in engagement with said contact faces to reciprocate said pistons as said cylinder barrel rotates, said reaction surface being inclined to the axis of rotation of said thrust ring and having a single point of contact with each of said pistons so positioned that a line drawn through said point of contact normal to said surface will intersect the axis of that piston at a point intermediate the ends of the piston proper and within the cylinder bore whereby the bearing force of the piston is landed directly upon the wall of its cylinder.

14. A pump, comprising a rotatable cylinder barrel having a limited number of ports, a larger number of radial cylinders arranged in said cylinder barrel in a circular series and connected to said ports whereby a plurality of cylinders are served by the same port, a cylindrical piston fitted in each cylinder to reciprocate therein, means for rotating said cylinder barrel, a thrust member arranged around said cylinder barrel eccentric thereto to urge each piston inward during one half-revolution of the cylinder barrel and to permit it to move outward during the other half revolution and having its axis parallel to the axis of said cylinder barrel, and a reaction surface arranged upon said thrust member and engaging a limited area of each piston to transmit thrust to said piston.

15. In a pump, the combination of a cylinder barrel having a limited number of ports and a larger number of radial cylinders arranged in radial planes, each of said ports being connected to a plurality of cylinders including at least two cylinders in the same radial plane, a thrust member arranged around said cylinder barrel eccentric thereto and having its axis parallel to the axis of said cylinder barrel, a cylindrical piston fitted in each cylinder to reciprocate therein and having its outer end in contact with said thrust member, and means for rotating said cylinder barrel.

16. In a pump provided with a pintle having intake and exhaust ports and passages and a cylinder barrel journaled upon said pintle and

provided with radial cylinders having ports communicating with said intake and exhaust ports alternately as said cylinder barrel rotates, the combination of a drive shaft rotating upon a stationary axis and connected by a flexible and expansible joint to said cylinder barrel for rotating the same, a cylindrical piston fitted in each cylinder and having an arcuate head fixed upon its outer end, a rotatably supported thrust ring arranged around said cylinder barrel eccentric thereto and having its axis parallel to the axis of said cylinder barrel, and an inclined face arranged upon said thrust ring and engaging the head of each piston at one side only of the piston axis to cause said ring to rotate with said cylinder barrel but about a different axis and said piston heads to roll upon said ring and rotate said pistons as said cylinder barrel rotates.

17. In a pump provided with a pintle having intake and exhaust ports and passages and a cylinder barrel journaled upon said pintle and provided with radial cylinders having ports communicating with said intake and exhaust ports alternately as said cylinder barrel rotates, the combination of a drive shaft rotating upon a stationary axis and connected by a flexible and expansible joint to said cylinder barrel for rotating the same, a piston having the outer and inner end portions thereof fixed for rotation with each other fitted in each cylinder and provided with an arcuate head having a sloping underside, a thrust ring arranged around said cylinder barrel eccentric thereto and engaging the head of each piston at one side only of the piston axis whereby said piston head rolls upon said ring as said cylinder barrel rotates, an inner ring arranged within and rotatable with said thrust ring and having a tapered face for engaging the sloping undersides of said piston heads, and springs for urging said inner ring toward said pistons to keep said piston heads in contact with said thrust ring.

18. In a pump or motor provided with a pintle having intake and discharge ports and passages, the combination of a cylinder barrel fitted upon said pintle to rotate thereon and provided with a plurality of cylinder ports spaced around said pintle to communicate with said pintle ports alternately as said cylinder barrel rotates, a plurality of radial cylinders spaced around said pintle and arranged in said cylinder barrel in groups each of which has its cylinders communicating with a single cylinder port, a cylindrical piston fitted in each cylinder and having an arcuate head fixed upon its outer end, and thrust rings arranged around said cylinder barrel eccentric thereto and engaging the heads of a part of the pistons of each group upon one side only of the piston axes and the remaining piston heads upon the opposite side only of the piston axes.

19. In a pump or motor having a pintle fixed in a stationary position and provided with intake and exhaust ports and passages, a cylinder barrel journaled upon said pintle to rotate thereon and provided with radial cylinders having ports for communicating with said pintle ports alternately as said cylinder barrel rotates, pistons arranged in said cylinders, and means arranged around said cylinder barrel and engaging said pistons for reciprocating the same as said cylinder barrel rotates, the combination of a cradle for supporting said piston reciprocating means, a rolling surface upon the underside of said cradle, a support en-

gaging said surface and supporting said cradle, and adjusting means connected to said cradle at the top thereof for rolling the same along said support and thereby moving the axis of said piston reciprocating means toward and from the pintle axis to vary the stroke of said pistons.

20. A pump or motor, comprising a casing, a cradle supported within said casing, a drum rotatably supported within said cradle and provided upon its inside with a thrust ring, a pintle carried by said casing in a stationary position within said drum and provided with intake and exhaust ports and passages, means for moving said drum transversely of said pintle, a cylinder barrel arranged within said drum and journaled upon said pintle to rotate thereon and provided with radial cylinders having ports for communicating with said pintle ports alternately as said cylinder barrel rotates, a cylindrical piston arranged in each cylinder and having a head fixed upon its outer end in engagement with said thrust ring at one side only of the piston axis whereby said thrust ring will operate said pistons whenever it is eccentric to said cylinder barrel and said piston heads will roll upon said thrust ring.

21. A pump, comprising a cylinder barrel having cylinders arranged therein, means for rotating said cylinder barrel, a piston fitted in each cylinder and provided with a head at its outer end, a thrust member surrounding said cylinder barrel eccentric thereto and engaging each piston only at a point offset from the piston axis to urge the same inward during rotation of said cylinder barrel and to cause said pistons to rotate in said cylinders, and a separate inner ring independent of said thrust member arranged within said

thrust member in engagement with the under sides of said piston heads to retain the same in contact with said thrust ring.

22. A pump, comprising a cylinder barrel having cylinders arranged therein, means for rotating said cylinder barrel, a piston fitted in each cylinder and provided with a head at its outer end, a thrust member surrounding said cylinder barrel eccentric thereto and engaging each piston only at a point offset from the piston axis to urge the same inward during rotation of said cylinder barrel and to cause said pistons to rotate in said cylinders, a separate inner ring arranged within said thrust member in engagement with the under sides of said piston heads to retain the same in contact with said thrust ring, and yielding means for retaining said inner ring in engagement with said piston heads.

23. A pump, comprising a cylinder barrel having cylinders arranged therein, means for rotating said cylinder barrel, a piston fitted in each cylinder and provided with a head at its outer end, a thrust member surrounding said cylinder barrel eccentric thereto and engaging each piston only at a point offset from the piston axis to urge the same inward during rotation of said cylinder barrel and to cause said pistons to rotate in said cylinders, and a separate inner ring arranged within said thrust member in engagement with the under sides of said piston heads to retain the same in contact with said thrust ring, said inner ring being resilient to permit substantially free relative movement between each piston head and said thrust member.

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