March 16, 1937. E. BENEDEK 2,074,204

HYDRAULIC APPARATUS

Filed April 27, 1933 4 Sheets-Sheet 1

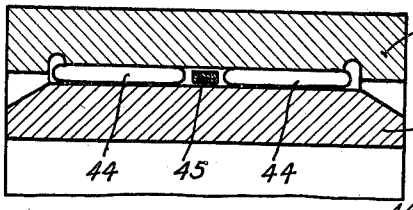


FIG. 2.

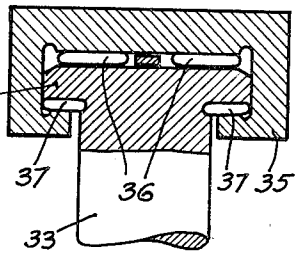


FIG. 3.

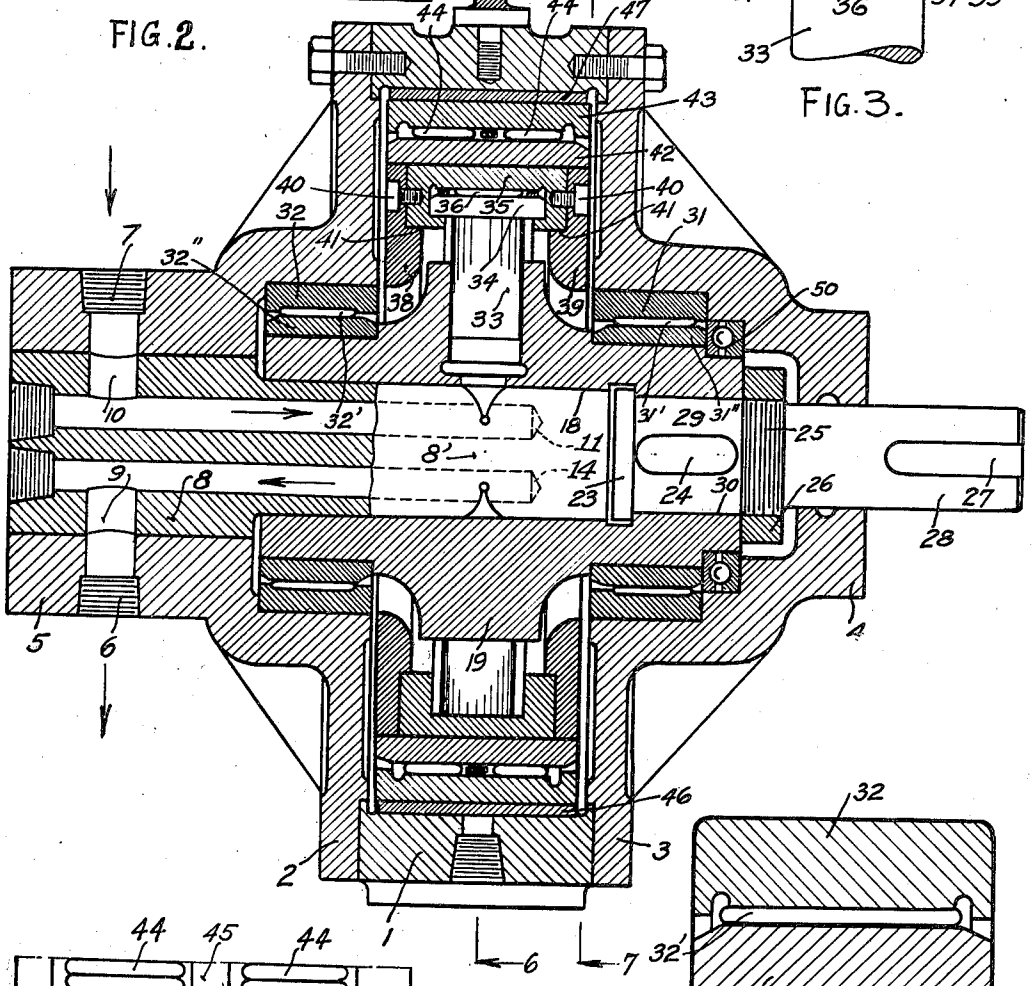


FIG. 1.

FIG. 4.

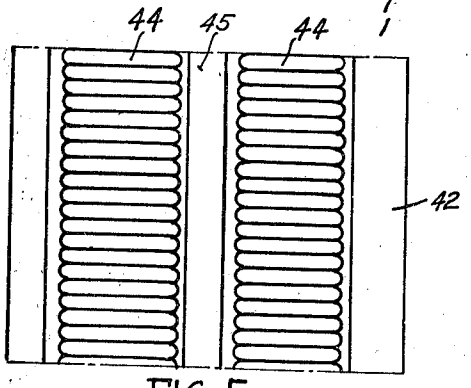


FIG. 5.

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March 16, 1937. E. BENEDEK 2,074,204

HYDRAULIC APPARATUS

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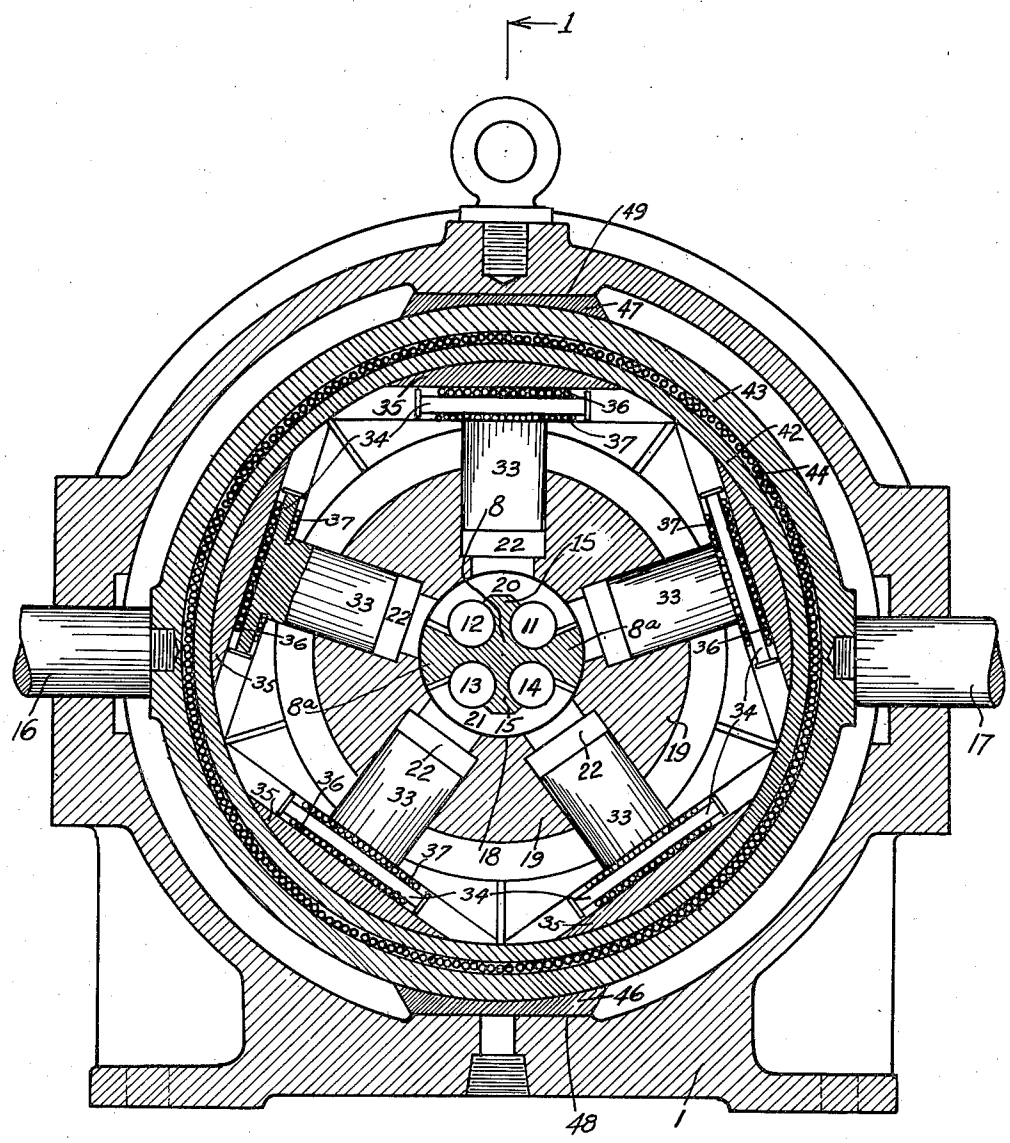


FIG. 6.

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March 16, 1937. E. BENEDEK 2,074,204

HYDRAULIC APPARATUS

Filed April 27, 1933 4 Sheets-Sheet 3

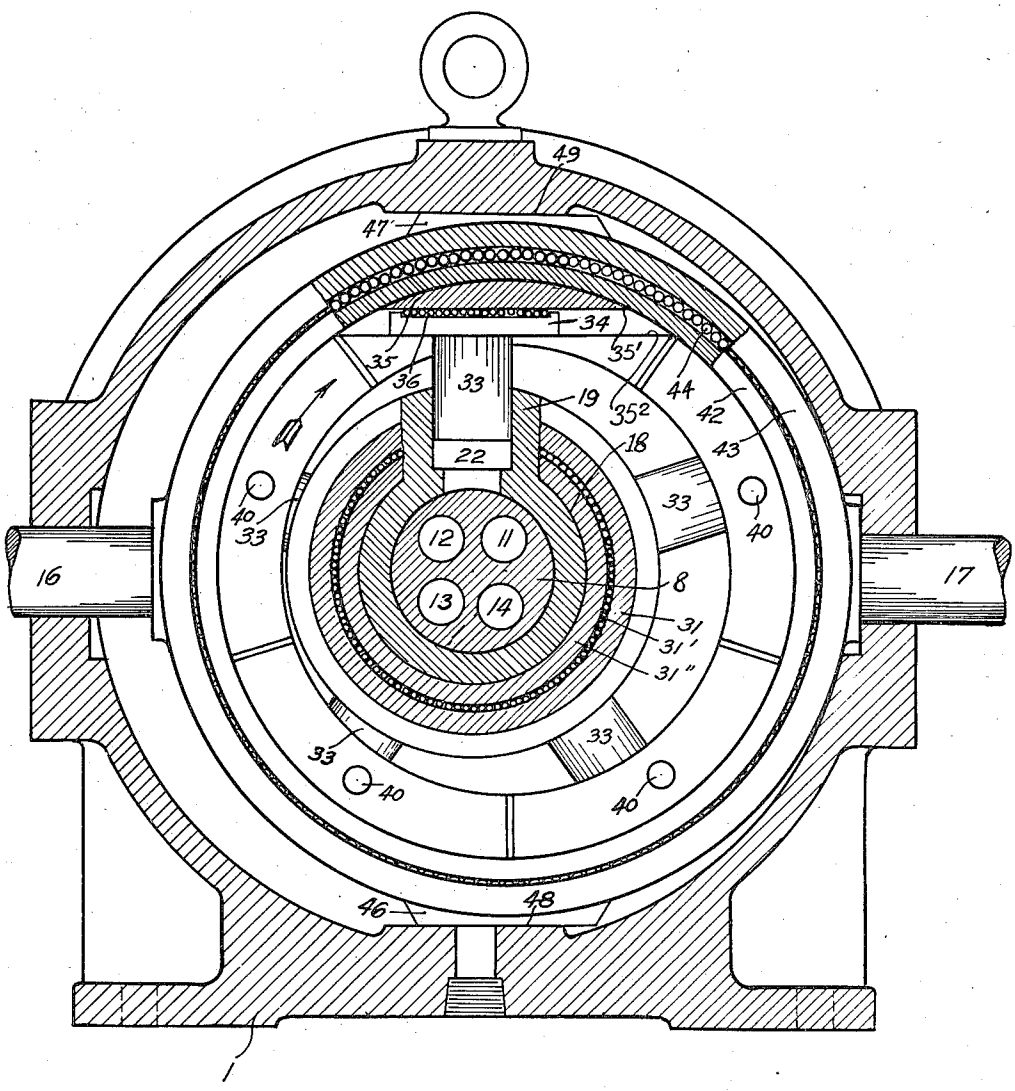


FIG. 7.

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March 16, 1937. E. BENEDEK 2,074,204

HYDRAULIC APPARATUS

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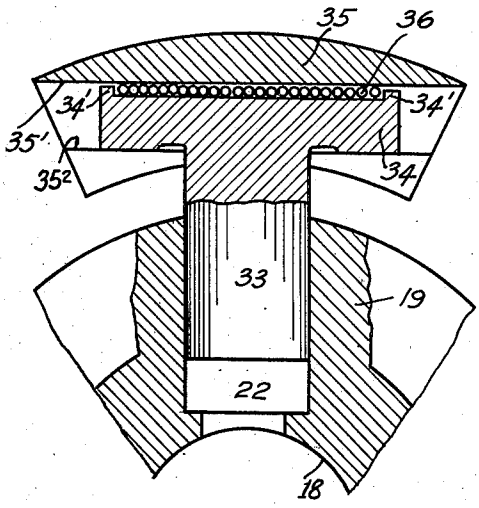


FIG. 8.

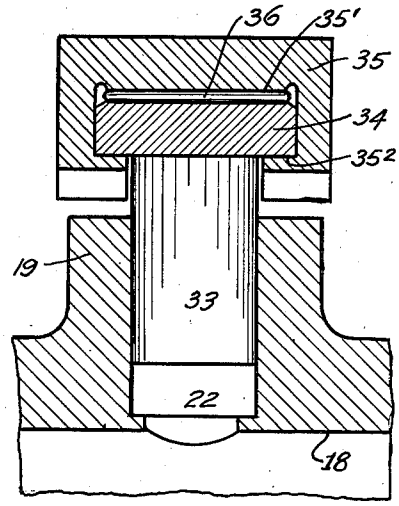


FIG. 9.

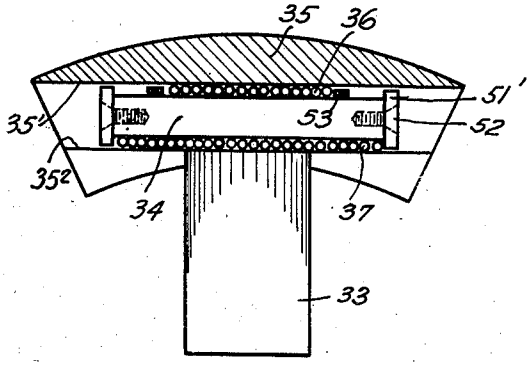


FIG. 10.

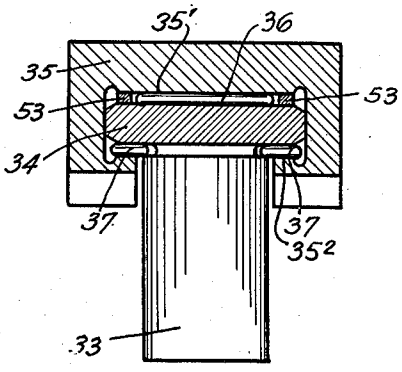


FIG. 11.

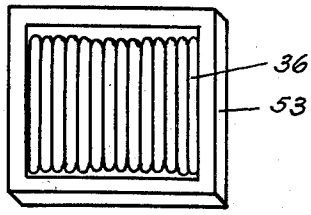


FIG. 12.

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2,074,204

UNITED STATES PATENT OFFICE

2,074,204

HYDRAULIC APPARATUS

Elek Benedek, Mount Gilead, Ohio

Application April 27, 1933, Serial No. 668,254

13 Claims. (Cl. 103—161)

This invention relates to improvements in pumps and motors of the rotary piston type and has for one particular object to provide a novel structure which is capable of operating more efficiently which is easier to manufacture and maintain in operation than pumps heretofore known in the art referred to. Another object is to provide a high pressure fluid pressure pump which, for a given capacity, will occupy a smaller space and comprise fewer working parts than pumps of present commercial design. Another object of the invention is to provide for such a pump a novel piston actuating or reactance rotor member which is positively coupled or driven by the pistons with a cylinder barrel in synchronous speed therewith.

A further object of my invention is to provide reciprocating cageless anti-friction thrust bearing elements for the outer ends of the pistons to provide anti-friction load transmission therefor during both the pressure and the suction cycles.

A further object is to provide a plurality of axially spaced cageless anti-friction supports of the capillary self-lubricating type in radially surrounding relation for the aforesaid piston actuating or reactance member and providing for high speed and high pressure operation.

A further object is to eliminate flexibility in the driving connections between a cylinder barrel and the reaction piston actuating member in a pump of this kind, and provide positive drive and proper timing between the cylinders of said barrel and the valve pintle of the pump.

A further object lies in the provision of a centrifugal pressure lubricating drum, formed with and in my novel piston actuating reactance member and a pair of axially spaced cheek or mounting plates. I attain these objects with a mechanism illustrated in the accompanying drawings forming part of this specification, in which:

Fig. 1 is a vertical sectional view of a pump constructed in accordance with the present invention, taken on the line 1—1 in Fig. 6.

Fig. 2 is a partial radial sectional view of a complete anti-friction needle bearing of the kind described in my co-pending application Serial No. 641,186 filed November 4, 1932, which alone carries the hydraulic load of all the pistons.

Fig. 3 is a detail sectional view of a piston crosshead showing the crosshead mounted in the reaction member mounted by thrust needle bearings disposed on both sides of the crosshead surface to transmit the load of the suction cycle as well as the pressure cycle.

Fig. 4 is a partial radial sectional view of a complete needle bearing provided to support the rotary cylinder barrel.

Fig. 5 is a developed plan view of a section of the eccentric needle bearing shown in Fig. 2.

Fig. 6 is a transverse cross-section of the pump taken through the center line of all the pistons in Fig. 1 on the line 6—6.

Fig. 7 is a combined sectional and side view of the pump showing the eccentric needle bearing in its one off-center position, taken on the line 7—7 in Fig. 1.

Fig. 8 shows a typical mounting of the piston crossheads in their reaction members on needle bearings for transmitting load during the pressure cycle only.

Fig. 9 is a sectional view of a piston and its coacting members shown in Fig. 8.

Fig. 10 shows a complete needle thrust bearing mounting for the piston with provision for maintaining the pressure needles in working relation during the reciprocation of the crosshead independently from the crosshead.

Fig. 11 is a sectional view of Fig. 10 taken along the axis of the piston and transversely to the crosshead.

Fig. 12 is a plan of the pressure needles shown in Fig. 10.

The pump shown for the purposes of illustration is enclosed in a liquid-tight casing comprising a ring portion 1 and side covers 2 and 3 provided with aligned hub portions 5 and 4 respectively. In the hub portion 5 there are two passages 6 and 7 respectively constituting suction and delivery connections.

A tapered central valve or pintle 8 is rigidly mounted in the hub portion 5 of the end plate 2 and is formed with opposed radial passages 9 and 10 which register with the hub passages 6 and 7 and which also communicate respectively with pairs of passages 11—12 and 13—14 extending longitudinally within valve 8. As shown in Figure 6, the passage pairs 11—12 and 13—14 are separated by means of diametrically opposite bridge portions 8^a—8^a. Web portions 15—15 intervening between the passages 11 and 12 and between the passages 13 and 14 serve to stiffen the valve 8. The arrangement is such that the solid bridge formed conjointly by the bridge portions 8^a—8^a lies in the line of shifting movement of the stroke adjusting rods 16 and 17. The cavities defined by the bridge 8^a—8^a and the bore 18 of the cylinder barrel 19 constitute the pump

valve ports 20 and 21 for conducting fluid to and from the radially disposed cylinders in the barrel 19. The cooperating of the bridges 8a of the valve member with the cylinders for controlling the flow of fluid to and from the cylinders will be readily apparent to those skilled in the art.

In accordance with the present invention, novel and improved means are provided for mounting the cylinder barrel 19 to revolve about the central valve 8 in such manner that the entire hydraulic pressure load on the cylinder barrel 19 is carried by assemblies 31—31'—31'' and 32—32' and 32'' of individually rotating needle bearings supported in the casing, whereby the cylinder barrel will not be forced into frictional contact with the valve 8. The valve 8, having a long rigid mounting in the hub 5, can not be forced laterally by direct fluid pressure to an extent sufficient to cause it to frictionally engage with the cylinder barrel. Accordingly, there is provided a space between the barrel bore 18 and valve pintle 8 in which is maintained a high pressure oil film which both effectively seals the cylinders 22 and prevents metal-to-metal contact of the barrel 19 and valve 8.

The needle bearing assemblies located and arranged in the manner illustrated serves to maintain the cylinder barrel 19 and valve 8 in perfectly centered relation with a predetermined definite intervening capillary clearance space for accommodating a high pressure oil film of substantially uniform thickness. In pumps heretofore known in the art it has not been possible effectively to maintain this oil film clearance because of the deforming of the conventional ball or roller bearings usually provided. In my improved arrangement, the relatively long axial span of each of the needle bearing elements as compared to its individual diameter, and the large number of bearing surfaces provided prevents the heavy loading of individual bearing elements and thus eliminates their deformation and results in the maintaining of the desired oil film clearance between the barrel bore 19 and the tapered valve element 8—a clearance sufficiently small to seal the cylinders and yet not small enough to cause metal-to-metal contact of the barrel and tapered valve.

Each cylinder is provided with a piston 33 forged integrally with a rectangular cross head 34 which is mounted for reciprocation in a thrust block 35, there being a plurality of such thrust blocks, one for each piston and cylinder assembly. The integral formation of the piston and cross head provides positive coupling and driving connection between the cylinder barrel and thrust blocks, thus eliminating noise and vibration and resulting in sustained high load capacity. In the embodiment shown in Figures 1, 7, 8, and 9, the inner faces of the cross heads 34 have sliding contact with underlying flange portions 35a on the thrust blocks 35 producing the outward or suction strokes of the pistons, but for transmitting the greater force required to produce the inward or forcing strokes I have provided sets of individually rolling needle bearing assemblies between the outer planar tangential faces of the cross heads and the planar tangential faces 35' of thrust blocks 35. In the forms shown in Figures 1, 8, and 9, a single set 36 of needles is provided for each cross head, and in Figure 3 there is shown a cross head and thrust block assembly including two sets 36 of needle elements, an arrangement more especially adapted for large pumps. In the forms shown in Figures 3, 6, 10, and 11, needle bearing assemblies 37 are shown provided between the inner faces of the cross heads and the thrust blocks.

In order to limit movement of the needle bearing elements relative to the cross heads without connecting the elements to the cross heads or to each other individually, I may form the faces of the cross heads with wells for freely receiving the needles. As shown in Figure 8, the well may be formed by recessing the cross head outer surface in a manner to leave needle-confining portions 34' upstanding at each end. In the form shown in Figure 10, the well is provided by attaching end plates or stop bars 51' to the ends of the cross head by means of screws 52. Cages, such as that shown at 53 in Figures 8, 9, and 12, may also be employed for maintaining the needles in assembled cooperative relation, yet permitting individual rolling.

The thrust blocks 35 are mounted in circumferentially spaced relation by means of check or mounting plates 38 and 39 to which the thrust blocks are rigidly secured by means of screws 40, the mounting plates being formed with shoulders 41 for spacing the thrust blocks at proper radial distances. In assembling the pump, the cylinder barrel, pistons, cross heads, and thrust blocks are assembled and the mounting plates then put in place with the shoulders 41 engaging the bottom edge portions of the thrust blocks, thus resulting in accurate alignment, after which the mounting plates and thrust blocks are secured together in rigid relation by means of the screws 40. This provides a strong, rigid assembly of thrust blocks and mounting plates. The outside surface of the thrust block and mounting plate assembly is machined, thus forming a continuous outside surface which is pressed relatively into the inner race or ring member 42 of an annular reaction bearing assembly including an outer ring or race 43 and an interposed plurality of needle bearing members 44 of the type hereinbefore described. Preferably a plurality of sets of needle bearing members 43 is employed, the sets being maintained in axially spaced relation by means of a separator 45. The press fit between the inner race member 42 and the mounting plate and thrust block assembly is liquid tight, thus providing a pressure reservoir for maintaining the lubricant under centrifugally created pressure around the cross heads 34 and associated bearing elements and surfaces and resulting in the formation of wedge-shaped capillary oil film bearings between the needle elements.

The outer race or ring 43 is guided for shifting stroke-adjusting movements by means of pads 46 and 47 having sliding engagement with fixed pads 48 and 49 formed integrally with the pump casing. In accordance with my invention the pads 46 and 47 are mounted for movements relative to the ring member 43, and in the form shown such movement is provided for by forming the inner faces of the pads 46 and 47 as segments of a circle and conforming to the curvature of the ring member 43 and having sliding contact therewith. By means of this arrangement the pads 46 and 47 will align themselves so as to provide accurate guiding movement of the shiftable parts even though there may be some slight inaccuracies in machining the casing or inaccuracies due to warping of the casing.

The needles 36 may be arranged differently under the cross heads 34 according to the size

and speed of the pump. In a fast pump the crosshead **34** reciprocates more per unit time and therefore the needles are arranged to roll individually between crosshead **34** and reaction face **35¹**. The clearance space between **34** and **35¹** is therefore substantially equal to the diameter of the needles, say to $\frac{1}{16}$ inch as in Fig. 10. The needles are packed in cage **53** in such a manner that the total clearance in the cage across the needles amounts to the diameter of one needle. This arrangement allows the needles to roll individually between the respective working faces whereas the clearance between the individual needles allows the formation of a wedge-shaped high pressure oil film which acts as separator and lubricant between the individual needles. Stop bars **51'** at each end of the cross head prevent the disengagement of the needles between the reaction faces.

In Fig. 8 there is shown a slightly different arrangement of the needles, viz., they are packed closely in the recessed surface of the crosshead **34**. It will be noted that in this arrangement the needles are forced to slide as an entirety and therefore this arrangement is not so efficient as the one shown in Fig. 10 wherein the needles roll freely as anti-friction thrust needle roller elements and therefore the sliding friction is eliminated. The application of the various solutions is enforced and dictated by commercial necessity.

The drawings show the bearing roller needles slightly exaggerated for the purpose of clear illustration.

The pump performs in the following way:

When the eccentric piston actuating reactance member, comprising needle bearing **42**, **43**, **44** is in its on-center position as shown in Fig. 6, the piston and cylinder assemblies **22** and **23** and the eccentric piston actuating reactance member, comprising needle bearing **42**, **43** and **44** forms a single piece rotary assembly and the whole unit rotates as an entirety. In this case, the pistons will have no reciprocation in their cylinders and the pump will deliver no fluid. As soon as said eccentric piston actuating reactance member is adjusted to one of its off-center positions as shown in Fig. 7, and assuming a rotation in the direction as shown by the arrow the pistons, in the upper 180 degrees of their rotation, travel outwardly and consequently draw in fluid from main port **7** and through bores **11** and **12** respectively as indicated by arrows in Fig. 1, and during the lower 180 degree rotation travel inwardly and therefore displace the working fluid as shown again in Fig. 1 by the arrows.

It is evident that by setting the piston actuating reactance assembly into left hand off-center position in Fig. 7 and maintaining a clockwise rotation, the upper pistons will displace whereas the lower ones will suck. Thus, the pump and the connected oil circuit will be reversed without reversing the driving power and the rotation of the pump.

It will be noted that the pump will operate equally well as a hydraulic motor by allowing the pressure fluid to go through port **7** into the motor which in the shown adjustment of the eccentric in Fig. 7 will cause a rotation of the motor in the direction of the arrow. It is therefore evident that the term pump and a motor substantially designate the same apparatus and a series combination of two apparatus will form a hydraulic transmission.

It will be observed that each piston thrust load will be distributed over a substantially continuous area constituted conjointly by a plurality of needle bearing elements and a plurality of intervening capillary oil bodies. This arrangement provides for power transmission with low frictional loss, and moreover provides for rapid transfer of heat from the piston and cross head outwardly to the reactance block. Consequently, machines embodying this construction will run cool even when operating under high pressure.

Various changes may be made in the embodiment of the present invention hereinabove specifically described without departing from the invention as defined in the appended claims.

I claim:

1. In a pump or motor of the character described, in combination with a casing, of a pintle secured therein, a cylinder barrel mounted for rotation around said pintle and supported in the casing, a radial series of piston and cylinder assemblies carried by said cylinder barrel, a reactance member surrounding said assemblies and operatively engaging the same, said reactance member including capillary thrust rolling means and centrifugal pressure lubricating means simultaneously to support the working reaction of said assemblies between said reactance means and said pintle respectively, said piston and cylinder assemblies comprising reciprocating piston cross-heads having parallel anti-friction rolling surfaces, a plurality of capillary rolling elements disposed in rolling engagement with each of said rolling surfaces to support the working reaction of the pistons during pressure and suction stroke respectively, and means surrounding said rolling elements collectively and carried by said elements only to maintain said elements collectively in parallel rolling relation and being free from individual connection with each, thereby eliminating sliding friction between said means and said individual elements and increasing the efficiency and thrust capacity of the rolling elements in their entirety.

2. In a fluid pressure pump, in combination, a casing, a fixed cylindrical valve in said casing, a radial series of piston and cylinder assemblies rotatably mounted about said valve, a cross head block at the outer end of one element of each assembly, a thrust block for each cross head to operatively engage the same, a pair of axially spaced parallel mounting plates operatively connected to said thrust blocks to actuate said thrust blocks radially and outwardly, fastening means to rigidly secure said mounting plates to the ends of said thrust blocks, and reactance means having thrust-transmitting connection with said thrust blocks including an element surrounding and engaging the thrust blocks and the outer peripheries of said mounting plates in rigid relation thereto.

3. In a fluid pressure pump, in combination, a casing, a fixed cylindrical valve in said casing, a radial series of piston and cylinder assemblies rotatably mounted about said valve, a cross head block at the outer end of one element of each assembly, a thrust block for each cross head to operatively engage the same, a pair of axially spaced parallel mounting plates operatively connected to said thrust blocks to actuate said thrust blocks radially and outwardly, fastening means to rigidly secure said mounting plates to the ends of said thrust blocks, and reactance means having thrust-transmitting connection with said thrust blocks including a ring member surround-

ing and engaging the thrust blocks and having a press fit on the outer peripheries of said mounting plates and thrust blocks.

4. In a fluid pressure pump, in combination, a casing, a fixed cylindrical valve in said casing, a radial series of piston and cylinder assemblies rotatably mounted about said valve, a cross head block at the outer end of one element of each assembly, a thrust block for each cross head to operatively engage the same, a pair of axially spaced parallel mounting plates operatively connected to said thrust blocks to actuate said thrust blocks radially and outwardly, fastening means to rigidly secure said mounting plates to the ends of said thrust blocks, reactance means having thrust-transmitting connection with said thrust blocks including an element surrounding and engaging the thrust blocks and the outer peripheries of said mounting plates in rigid relation thereto, a ring member surrounding said element in spaced relation thereto, and a plurality of axially spaced bearing means interposed between said element and said ring member and having a total axial span greater than the individual diameter of said pistons and cylinders.

5. In a fluid pressure pump, in combination, a casing, a fixed cylindrical valve in said casing, a radial series of piston and cylinder assemblies rotatably mounted about said valve, a cross head block at the outer end of one element of each assembly, a thrust block for each cross head to operatively engage the same, a pair of axially spaced parallel mounting plates operatively connected to said thrust blocks to actuate said thrust blocks radially and outwardly, fastening means to rigidly secure said mounting plates to the ends of said thrust blocks, reactance means including an element surrounding and engaging the thrust blocks and the outer peripheries of said mounting plates in rigid relation thereto, a ring member surrounding said element in spaced relation thereto, and a plurality of sets of axially spaced capillary roller bearing means interposed between said element and said ring member and having a total axial span greater than the diameter of said pistons and cylinders.

6. In a fluid pressure pump, a casing having a pair of parallel sliding surfaces therein, a plurality of radial piston and cylinder assemblies, a shiftable cylindrical piston actuating reactance member inside of said casing, means connecting said assemblies to said reactance member, a pair of interposed segmental bearing blocks having surfaces mating with and slidably engaging the internal surfaces of the casing and the outside cylindrical surface of the piston actuating reactance member, respectively, to thereby freely and adjustably support said bearing in said casing for shifting movements.

7. In a hydraulic machine of the class described, the combination of a plurality of rotatable radially disposed piston and cylinder assemblies each of which includes a piston element and a cylinder element, one of said elements of each assembly being reciprocable relative to the associated other element; a plurality of cross-heads connected respectively to said reciprocable elements and each having a planar tangential thrust bearing surface; a rotary reactance member surrounding said assemblies and being provided with a plurality of planar tangential thrust bearing surfaces associated respectively with said cross-heads and each being spaced radially from the associated cross head thrust bearing surface; and a plurality of lubricated closely contiguous roller bearing elements interposed between and engaging the bearing surfaces of each of said cross-heads and the associated reactance member bearing surfaces, said roller bearing elements being of such size and so closely positioned relatively to each other as to provide, conjointly with said surfaces, a plurality of capillary oil spaces containing bodies of oil, whereby the load on each of said pistons is distributed over a substantially continuous area constituted by the roller bearing elements and the capillary oil bodies, the continuous load-transmitting area providing also for rapid transfer of heat by conduction from the pistons and cross-heads to said reactance member.

8. In a hydraulic machine of the class described, the combination of a plurality of rotatable radially disposed piston and cylinder assemblies each of which includes a piston element and a cylinder element, one of said elements of each assembly being reciprocable relative to the associated other element; a plurality of cross-heads connected respectively to said reciprocable elements and each having a planar tangential thrust bearing surface; a rotary reactance member surrounding said assemblies and being provided with a plurality of planar tangential thrust bearing surfaces associated respectively with said cross heads and each being spaced radially from the associated cross head thrust bearing surface; and a plurality of lubricated needle bearing elements interposed between and engaging the bearing surfaces of each of said cross-heads and the associated reactance member bearing surface, said needle bearing elements being of such size and so closely positioned relatively to each other as to provide, conjointly with said surfaces, a plurality of capillary oil spaces containing bodies of oil, whereby the load on each of said pistons is distributed over a substantially continuous area constituted by the needle bearing elements and the capillary oil bodies, the continuous load-transmitting area providing also for rapid transfer of heat by conduction from the pistons and cross-heads to said reactance member.

9. The combination defined in claim 8 and in which one of the two following elements therein—namely, the cross-head and the reactance block—is formed with a shallow well in which the needle bearing elements are positioned.

10. In a hydraulic machine of the class described, the combination of a plurality of rotatable, radially disposed piston and cylinder assemblies, each piston being provided with a cross-head having inner and outer bearing surfaces; a piston reactance member provided with a plurality of pairs of radially spaced bearing surfaces associated respectively with the inner and outer bearing surfaces of the cross-heads; and a plurality of anti-friction bearing elements interposed between and engaging the inner bearing surface of each cross head and the associated reactance member bearing surface, there being a plurality of said bearing elements on each side of each piston axis, said bearing elements collectively overlying a substantial area of said inner cross-head bearing surface whereby the thrust load on said inner cross-head bearing surface is distributed.

11. In a hydraulic machine of the class described, the combination of a plurality of rotatable, radially disposed piston and cylinder assemblies, each piston being provided with a cross-head having inner and outer bearing surfaces;

a piston reactance member provided with a plurality of pairs of radially spaced bearing surfaces associated respectively with the inner and outer bearing surfaces of the cross-heads; a plurality of outer anti-friction bearing elements interposed between and engaging the outer bearing surface of each cross-head and the associated reactance member bearing surface, said elements collectively overlying a substantial area of said outer cross-head bearing surface whereby to distribute the thrust load on said outer cross-head bearing surface; and a plurality of inner anti-friction bearing elements interposed between and engaging the inner bearing surface of each cross-head and the associated reactance member bearing surface, there being a plurality of said inner bearing elements on each side of each piston axis, said inner bearing elements collectively overlying a substantial area of said inner cross-head bearing surface whereby the thrust load on said inner cross-head bearing surface is distributed.

12. In a hydraulic machine of the class described, the combination of a plurality of rotatable, radially disposed piston and cylinder assemblies, each piston being provided with a cross-head having inner and outer bearing surfaces; a piston reactance member provided with a plurality of pairs of radially spaced bearing surfaces associated respectively with the inner and outer bearing surfaces of the cross-heads; a plurality of outer capillary needle bearing elements interposed between and engaging the outer bearing surface of each cross-head and the associated reactance member bearing surface, said elements and the intervening capillary spaces collectively overlying a substantial area of said outer cross-head bearing surface whereby to distribute the thrust load on said outer cross-head bearing surface; and a plurality of inner capillary needle bearing elements interposed between and engaging the inner bearing surface of each cross-head and the associated reactance member bearing surface, there being a plurality of said inner bearing elements on each side of each piston axis, said inner bearing elements and the intervening capillary spaces collectively overlying a substantial area of said inner cross-head bearing surface whereby the thrust load on said inner cross-head bearing surface is distributed.

13. In a hydraulic machine of the class described, the combination of a plurality of rotatable, radially disposed piston and cylinder assemblies, each piston being provided with a cross-head having inner and outer bearing surfaces; a piston reactance member provided with a plurality of pairs of radially spaced bearing surfaces associated respectively with the inner and outer bearing surfaces of the cross-heads; and a plurality of capillary needle bearing elements interposed between and engaging the inner bearing surface of each cross-head and the associated reactance member bearing surface, there being a plurality of said bearing elements on each side of each piston axis, said bearing elements and the intervening capillary spaces collectively overlying a substantial area of said inner cross-head bearing surface whereby the thrust load on said inner cross-head bearing surface is distributed.

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