Oct. 2, 1945. M. W. HUBER 2,385,990

PUMP

Filed Oct. 13, 1943 2 Sheets-Sheet 1

Fig. 1

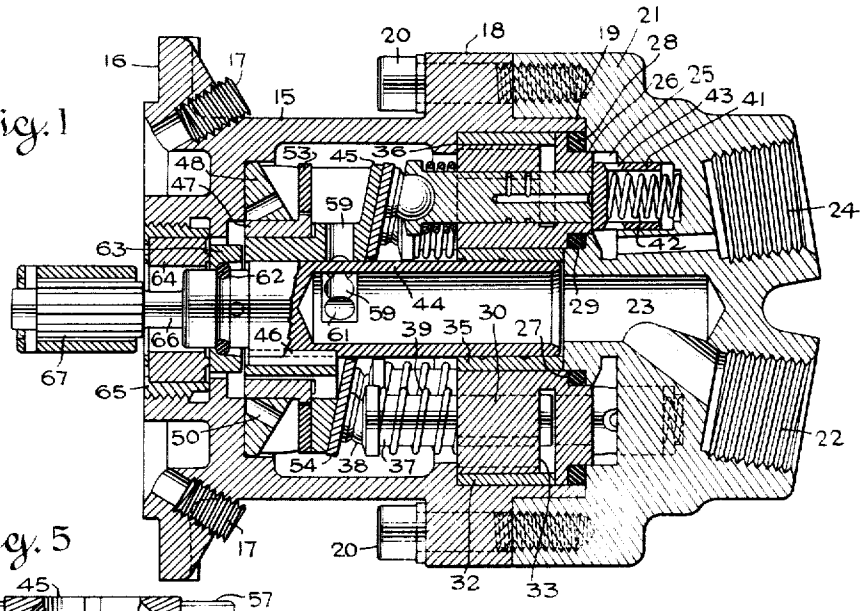


Fig. 5

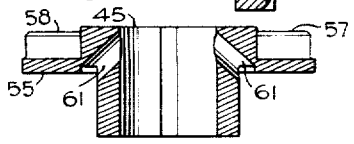


Fig. 2

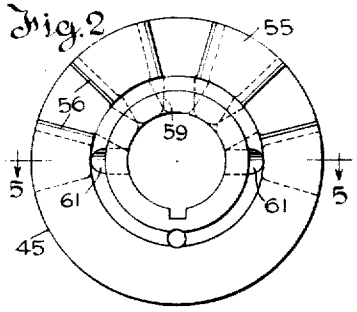


Fig. 3

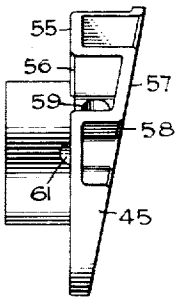
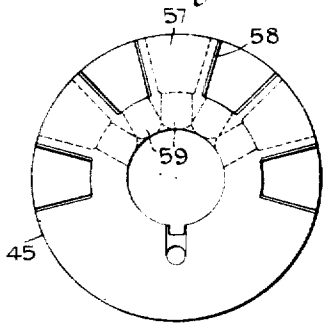


Fig. 4



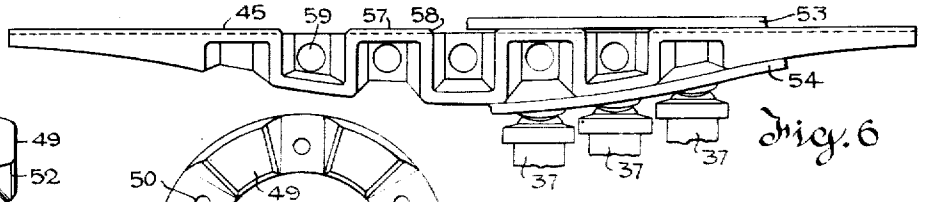


Fig. 6

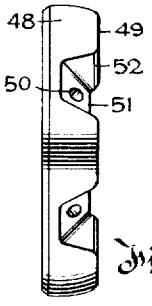


Fig. 7

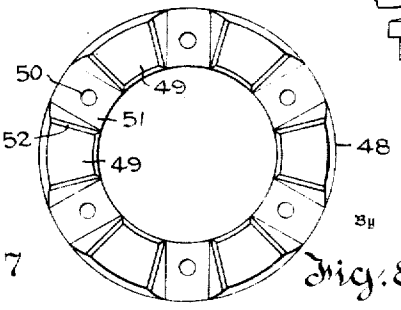


Fig. 8

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Fig. 9

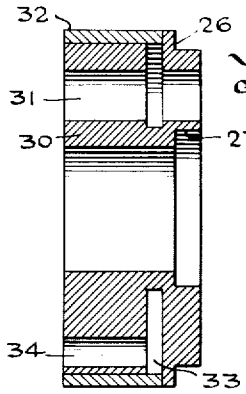


Fig. 11

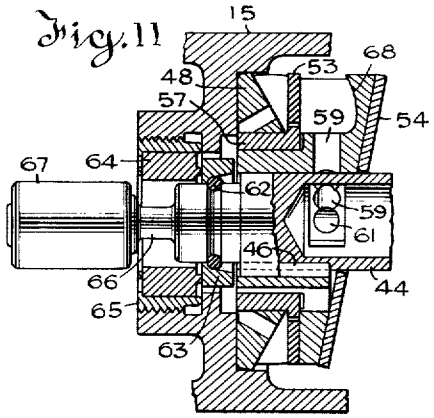


Fig. 10

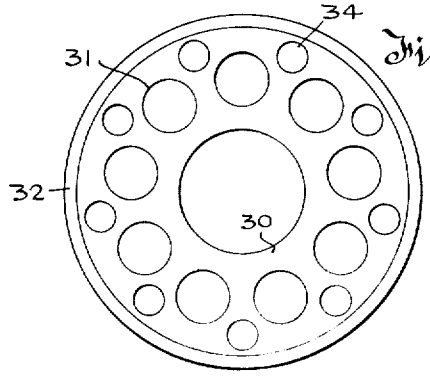


Fig. 12

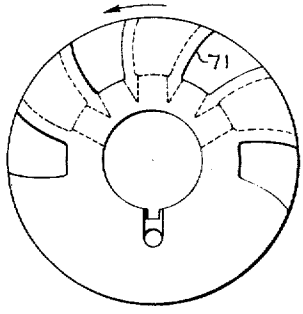
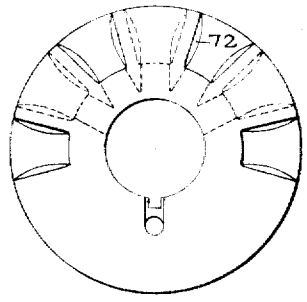


Fig. 13



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Patented Oct. 2, 1945 2,385,990

UNITED STATES PATENT OFFICE

2,385,990

PUMP

Matthew W. Huber, Watertown, N. Y., assignor to The New York Air Brake Company, a corporation of New Jersey

Application October 13, 1943, Serial No. 506,091

6 Claims. (Cl. 103—5)

This invention is directed to high pressure, high speed pumps of the type using single acting plungers working in parallel cylinders arranged in a circular series around a drive shaft. The plungers are actuated by a swash plate.

Pumps of this general description are known and an advanced type thereof is described and claimed in a prior application Ser. No. 462,563, filed October 19, 1942. The pump of the prior application is a small unit designed for use in feathering propellers for airplanes and some of its details are affected by its small size and its intended environment, the latter controlling particularly the feed and discharge connections. In most respects, however, it is capable of use in larger units and for general purposes.

The present application is directed to features which have been found necessary or desirable in pumps of larger capacity and for use in situations where the pump body is not submerged in oil, but requires piped connections for intake and discharge.

The utility of such features involves ease of manufacture inspection and maintenance, improved lubrication, better bearings, and similar features, all intimately related to features characteristic of the pump. The thrust bearing used to sustain the swash plate is a special form of the bearing described and claimed in a prior application Ser. No. 498,479, filed August 13, 1943.

The preferred form of the pump with certain modifications of components thereof will now be described by reference to the accompanying drawings, in which

Figure 1 is an axial section of the complete pump taken on a plane through the inlet and discharge connections.

Figures 2, 3, 4 and 5 are views of the swash plate and are respectively rear elevation, side elevation, face view and section on line 5—5 of Figure 2.

Figure 6 is a development of the periphery of the swash plate and creep plates, and indicating the circular spacing of the plungers.

Figures 7 and 8 are respectively side and face elevations of the fixed element of the thrust bearing.

Figures 9 and 10 are respectively an axial section and end elevation of the cylinder block.

Figure 11 is a view similar to a portion of Figure 1, showing a modification of the swash plate to throw oil toward the thrust bearing.

Figures 12 and 13 are views similar to Figure 4 showing possible modifications of the channels in the swash plate, to afford a better oil impelling effect.

The housing for the pump comprises a body portion 15 and has a mounting flange 16 which can be given any desired form, that shown being intended for use with a particular engine.

The threaded plugs indicated at 17 are drain plugs and have nothing to do with the operation of the pump.

The body 15 has a heavy circumferential flange 18 beyond which is a cylindrical sleeve-like projection 19. This mates with the cap generally indicated by the numeral 21. The cap has a peripheral flange portion which encircles the sleeve 19 and enters into metal to metal engagement with the face of the flange 18.

The body and cap are connected by a series of socket headed cap screws indicated at 20. Since the internal hydraulic pressure is high, a considerable number of screws are required. Eight are used.

The pump is shown full size in the drawings filed with the application.

The cap 21 has a threaded inlet connection 22 which leads to an axial bore 23 communicating with a hollow shaft hereinafter described. The cap also has a discharge connection 24 which communicates directly with the discharge chamber 25, which encircles the passage 23 within the cap, and thus receives oil from all of the discharge valves of the pump.

The connections 22 and 24 can be variously arranged, and it is a simple matter to furnish caps of special design suited to particular installations.

The cylinder block of the pump is of special form and involves a number of novel features. This cylinder block is shown in detail in Figures 9 and 10.

The block proper comprises an annulus 30 bounded by two plane surfaces except that on the right-hand face, as viewed in Figure 9, there are rabbets 26 and 27 designed to receive annular sealing gaskets 28 and 29.

These gaskets are made of any suitable oil resisting rubber-like composition, certain of the synthetic rubber substitutes being suitable. The gaskets are circular in cross-section but when placed under compression fill the rectangular grooves as indicated.

The cylinder block 30 has nine cylinder bores 31 which are arranged in a uniformly spaced circular series parallel with the axis of the block. To afford inlet ports the following construction is adopted. The periphery of the cylinder block

30 is cut away to receive the ring 32 which is pressed to place. Before the ring 32 is mounted, a peripheral slot 33 is cut so that it intersects all of the bores 31 and extends inward slightly beyond the inner margin of each cylinder bore. A series of inlet ports 34 lead from the space to the left of the block 30 to the slot 33.

Nine bores 34 are indicated in Figure 10 so that the groove 33 is supplied with oil close to each piston and very free flow to the inlet port is afforded. Except for the use of the ring 32 pressed to place, the provision of the slot 33 and the ports 34 would weaken the cylinder block materially.

The construction provides a block which can be easily manufactured, which has ample inlet port area, and which nevertheless has adequate strength.

Pressed into the central bore of the cylinder block 30 is a bearing bushing 35. This bushing is flush with the left-hand face of the block 30 but terminates short of the rabbet 27, and the central portion of the cap 21 is so dimensioned that it extends past the rabbet 27 and virtually into contact with the end of the bearing bushing. Thus the gasket 29 is positively confined in all directions. The same is true of the gasket 28 since the confining portion of the cap enters the rabbet 26 and seats on the outer end of the sleeve 19. It may be observed that the cap is not in metal to metal contact with the cylinder block 30, and it might be assumed that the block could move to the right, compressing the gaskets 28 and 29.

In operation the cylinder block is under discharge pressure in the chamber 25 and consequently is held to the left against the seat 36 formed in the housing 15.

In each of the cylinder bores 31 is a plunger 37, essentially similar to the plunger used in the prior application above identified. Each plunger has a flanged head in which is mounted a thrust ball 38 having a projecting boss formed with the flat bearing surface. These balls are snapped or pressed into spherical sockets which are slightly deeper than the radius of the ball so that the balls are captive after being pressed to place. Each plunger is urged outward by a coil compression spring 39, which encircles the plunger and reacts between the cylinder block and the flanged head of the plunger.

In its outermost position indicated as to the lowermost plunger in Figure 1 the end of the plunger overtravels the right face of the slot 33 in the cylinder block and consequently admits oil to the bore 31 to the right of that slot. This is the provision for the admission of oil to the pump working spaces.

It will be observed that the flow path for oil is very large as compared to the port opening.

As indicated with reference to the uppermost plunger in Figure 1 each plunger has an axial bore leading from its end to branch passages which lead to encircling lubricating grooves. In this way the plungers are lubricated by the oil being pumped. Since no novelty is here claimed for this arrangement, the lubricating ports are not numbered on the drawings, but they are adequately illustrated.

As in the structure of my prior application above identified, the discharge valves are larger than the bores 31 and there is one valve for each bore. The valves are cup-shaped members 41 guided in bores formed in the cap 21 and axially aligned with bores 31 in the cylinder block. Each valve seats on the right-hand face of the cylinder block and is urged to its seat by a coil compression spring 42. The space within the cup-shaped valve is vented by ports 43, four such ports being used in each valve. Obviously the discharge from each of the bores 31 occurs past the valve directly into the discharge chamber 25.

In the preferred construction the plunger does not strike the discharge valve, but the minimum practicable clearance is used. It is known practice so to dimension plungers in pumps that they positively unseat their discharge valves. There is nothing in the present invention which precludes the use of this arrangement in any instance where it is desired. The construction is not deemed to have any particular advantage. It is believed, however, that the best action is secured by providing practically no clearance between the end of the plunger and the valve, but since the fluid pumped is substantially inelastic, the use of small clearance has not the importance that it has where a very elastic fluid is pumped.

The drive shaft for the pump is indicated at 44 and is counterbored from its right-hand end so that the bore communicates with the inlet passage 23. The swash plate which actuates the plunger is indicated generally by the numeral 45 and is keyed at 46 to the solid left-hand portion of the shaft 44. The swash plate has a hub which turns in a radial bearing sleeve bushing 47.

This sleeve bushing is pressed into the fixed thrust bearing element 48 which in turn is fixed in a circular seat formed in the housing 15 to receive it.

The arrangement of the thrust bearing and the oil ports is a special feature of the present invention. Reference should now be made to Figures 2 to 8 which show details of these parts.

The fixed thrust bearing element 48 which is best shown in Figures 7 and 8, has a discontinuous thrust surface 49. That is to say, the thrust surface is interrupted by a series of grooves 51 whose form is well illustrated in Figures 7 and 8, the slots being generally radial. The edges of the bearing surface 49 adjacent the slots are relieved or bevelled as indicated at 52. The small ports 50 which lead from the slots are intended to deliver oil to the shaft seal. Resting on the thrust bearing surface 49 and centered by a flange on the radial bearing bushing 47 is a creep ring 53.

A second creep ring 54 is engaged by the flat thrust surfaces on the balls 38 on the various pump peripheries, and this creep ring 54 is centered by the hollow shaft 44.

The swash plate 45 is interposed between the two creep rings 53 and 54.

While the swash plate could be solid except for radial oil ports hereinafter described, it has been found desirable to form it as best shown in Figures 2 to 6 inclusive. Thus its margin has a zigzag configuration so that the left side, which forms the thrust bearing side, has a series of interrupted bearing areas 55 each with a chamfered margin 56. The inclined side of the swash plate 45, which engages the creep ring 54 also has an interrupted series of bearing areas 57 with chamfered margins 58.

As clearly shown in Figure 2 this interrupted area of each bearing area subtends approximately 180° of arc, and the angular spacing of the disconnected areas is such that it coincides with the circumferential spacing of the plungers 37. See Figure 6.

It is necessary that the oil entering through the

connection 22 reach the space within the housing 15 so that it can flow to the passages 34. The invention provides for this by delivering the oil through radial ports 59.

As indicated in Figure 2 there are five ports which deliver oil from the bore of the shaft 44 to the intervals formed by the fluted construction of the swash plate 45. There are also two diagonal ports 61 (see particularly Figure 5) which deliver oil to the radial bearing bushing 47 so that the radial bearing and the bearing surface between the swash plate and the creep plate are adequately lubricated.

It may be remarked in passing that Figure 6 seems to show the periphery of the creep plate 54 as sinuous. It is probably unnecessary to say that this follows from the fact that Figure 6 is a development, so that the intersection of the cylinder with an oblique plane surface appears as a sine curve.

To prevent leakage of oil from the housing 15 it is necessary to provide an oil seal around the left end of the shaft 44. Immediately to the left of the hub of swash plate 45 the shaft is reduced somewhat in diameter and provided with a groove in which is snapped an elastic sealing ring 62 of oil resisting material, such as a synthetic rubber substitute.

This ring sustains a sealing annulus 63 whose left surface is a lapped plane surface. This plane surface coacts with a bead on a sealing ring 64. The sealing ring 64 is held in the housing 15 by the flange of an encircling nut 65 threaded into a recess in the housing 15. The ring 62 seals the ring 63 to the shaft and furnishes the necessary elastic support to cause the ring 63 to run in oil-tight contact with the fixed ring 64.

Further to the left the shaft is reduced in diameter as indicated at 66, and beyond this point of reduction, is formed with a dental clutch arrangement generally indicated at 67. This dental clutch is of a known type in which the two engaging members are loosely fitted to assure a positive driving connection without imposing any lateral flexure on the driven shaft in the event that it should be slightly misaligned.

Since the oil enters at 22 and flows through the passage 23 and the bore of the shaft 44 and is thence thrown radially through the passages 59, there is an impelling action which maintains the interior of the housing 15 under a positive oil pressure. This is highly desirable because it gives a supercharging effect. It puts the port slot 33 in the cylinder block under pressure and thus improves the volumetric efficiency of the plunger pump. It also assures lubrication of the bearing surfaces. Certain expedients may be adopted to enhance these effects.

Figure 11 is identical with a portion of Figure 1 except for the curved configuration indicated at 68. This is designed to throw the discharging oil to the left and thus improve the lubrication of the thrust bearing. Aside from this detail there is not difference between the structure of Figure 1 and Figure 11.

The construction shown in Figures 12 and 13 can be combined with the configuration of Figure 11 or with that shown in Figure 1. In Figure 12 it is assumed that the pump will be driven in one rotary direction only, and in that case the ribs 71 of the flutes in the swash plate, which are shown as radial in Figures 2, 3 and 4 are curved rearwardly for the purpose of enhancing their operation as impellers. The swash plate is assumed to turn in the direction of the arrow on Figure 12.

The plunger part of the pump is, however, indifferent to the direction of rotation of the swash plate, and as a rule it is desirable for the pumps to be capable of operation equally well when driven in either direction. In any case where it is desired to enhance the impelling action, and still preserve indifference to the direction of rotation, the flutes may be given the double convex configuration indicated at 72 in Figure 13. This is believed to give better impelling action than is had with the plane radial flutes of Figures 2, 3 and 4 but not quite so good as that had with the arrangement shown in Figure 12.

Because of its markedly greater simplicity in manufacture the form shown in Figures 2 to 5 is expected to be the commercial form, and the modified forms are likely to be used only in cases where exceptional performance is necessary.

What is claimed is:

1. The combination of a pump housing having inlet and discharge connections; a rotary drive shaft, mounted in said housing, projecting at one end therefrom, and having a counterbore at its inner end, in communication with said inlet connection; means forming a plurality of cylinders arranged in circular series around said shaft within the housing; plungers reciprocable in said cylinders; valves controlling flow from the cylinders to the discharge connection; means including a swash plate turning with said shaft within the housing and arranged to reciprocate said plungers; means controlling flow from the interior of said housing around said swash plate to said cylinders; and impelling means formed as a part of the swash plate and adapted to draw liquid through said inlet and shaft and discharge it into the space around the swash plate within the housing.

2. The combination of a pump housing having inlet and discharge connections; a rotary drive shaft, mounted in said housing, projecting at one end therefrom, and having a counterbore at its inner end, in communication with said inlet connection; means forming a plurality of cylinders arranged in circular series around said shaft within the housing; plungers reciprocable in said cylinders; valves controlling flow from the cylinders to the discharge connection; a fixed bearing member mounted in the housing and having an interrupted thrust bearing surface; a swash plate mounted to rotate with said shaft and fluted to afford an interrupted thrust bearing surface and an interrupted inclined swash bearing surface; creep plates interposed respectively between said thrust bearing surfaces and between the swash bearing surface and said plungers; means urging the plungers toward the swash plate; impelling means including portions of said flutes for drawing liquid through the inlet connection and shaft and delivering it into the space within the housing around the swash plate; and means for admitting liquid from the last named space to the cylinders.

3. The combination defined in claim 2 in which the flutes having inclined deflecting surfaces serving to direct liquid discharging therefrom toward said fixed bearing member.

4. In a pump, the combination of a rotary swash plate having opposite bearing surfaces, one of which is normal to the axis of rotation to serve as a thrust bearing and the other is inclined relatively to the first, each of said surfaces being recessed to form a circumferential series of spaced plain bearing areas; creep plates

one seated against each of said thrust surfaces and rotatable relatively thereto; a fixed bearing member having a thrust bearing surface which is interrupted to afford a circumferential series of spaced plain bearing areas which engage the first creep plate; a plurality of plungers arranged with their axes spaced in a circular series around and substantially parallel with the axis of rotation of the shaft; universally tiltable thrust heads mounted at the ends of said plungers and engaging the second creep plate; and means serving to maintain engagement between the thrust heads and the second creep plate.

5. In a pump, the combination of a rotary swash plate having opposite bearing surfaces, one of which is normal to the axis of rotation to serve as a thrust bearing and the other is inclined relatively to the first, each of said surfaces being recessed to form a circumferential series of spaced bearing areas; creep plates one seated against each of said thrust surfaces and rotatable relatively thereto; a fixed bearing member having a thrust bearing surface which is interrupted to afford a circumferential series of spaced bearing areas which engage the first creep plate; a plurality of plungers arranged with their axes spaced in a circular series around and substantially parallel with the axis of rotation of the shaft; universally tiltable thrust heads mounted at the ends of said plungers and engaging the second creep plate; means serving to maintain engagement between the thrust heads and the second creep plate; a hollow rotatable shaft upon which said swash plate is mounted; and means for passing liquid flowing to the pump through said shaft and thence through the recesses in the swash plate.

6. In a pump, the combination of a rotary swash plate having opposite bearing surfaces, one of which is normal to the axis of rotation to serve as a thrust bearing and the other is inclined relatively to the first, each of said surfaces being recessed to form a circumferential series of spaced bearing areas; creep plates one seated against each of said thrust surfaces and rotatable relatively thereto; a fixed bearing member having a thrust bearing surface which is interrupted to afford a circumferential series of spaced bearing areas which engage the first creep plate; a plurality of plungers arranged with their axes spaced in a circular series around and substantially parallel with the axis of rotation of the shaft; universally tiltable thrust heads mounted at the ends of said plungers and engaging the second creep plate; means serving to maintain engagement between the thrust heads and the second creep plate; and means for causing liquid flowing to the pump to pass through the recesses in the swash plate and in contact with the creep plates.

MATTHEW W. HUBER.

CERTIFICATE OF CORRECTION.

Patent No. 2,385,990. October 2, 1945.

MATTHEW W. HUBER.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 61, claim 3, for the word "having" read --have--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of January, A. D. 1946.

Leslie Frazer

(Seal) First Assistant Commissioner of Patents.

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5. In a pump, the combination of a rotary swash plate having opposite bearing surfaces, one of which is normal to the axis of rotation to serve as a thrust bearing and the other is inclined relatively to the first, each of said surfaces being recessed to form a circumferential series of spaced bearing areas; creep plates one seated against each of said thrust surfaces and rotatable relatively thereto; a fixed bearing member having a thrust bearing surface which is interrupted to afford a circumferential series of spaced bearing areas which engage the first creep plate; a plurality of plungers arranged with their axes spaced in a circular series around and substantially parallel with the axis of rotation of the shaft; universally tiltable thrust heads mounted at the ends of said plungers and engaging the second creep plate; means serving to maintain engagement between the thrust heads and the second creep plate; a hollow rotatable shaft upon which said swash plate is mounted; and means for passing liquid flowing to the pump through said shaft and thence through the recesses in the swash plate.

6. In a pump, the combination of a rotary swash plate having opposite bearing surfaces, one of which is normal to the axis of rotation to serve as a thrust bearing and the other is inclined relatively to the first, each of said surfaces being recessed to form a circumferential series of spaced bearing areas; creep plates one seated against each of said thrust surfaces and rotatable relatively thereto; a fixed bearing member having a thrust bearing surface which is interrupted to afford a circumferential series of spaced bearing areas which engage the first creep plate; a plurality of plungers arranged with their axes spaced in a circular series around and substantially parallel with the axis of rotation of the shaft; universally tiltable thrust heads mounted at the ends of said plungers and engaging the second creep plate; means serving to maintain engagement between the thrust heads and the second creep plate; and means for causing liquid flowing to the pump to pass through the recesses in the swash plate and in contact with the creep plates.

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