Nov. 11, 1947. A. GABRIEL 2,430,764

PUMP

Filed April 7, 1945 2 Sheets-Sheet 1

FIG. 1.

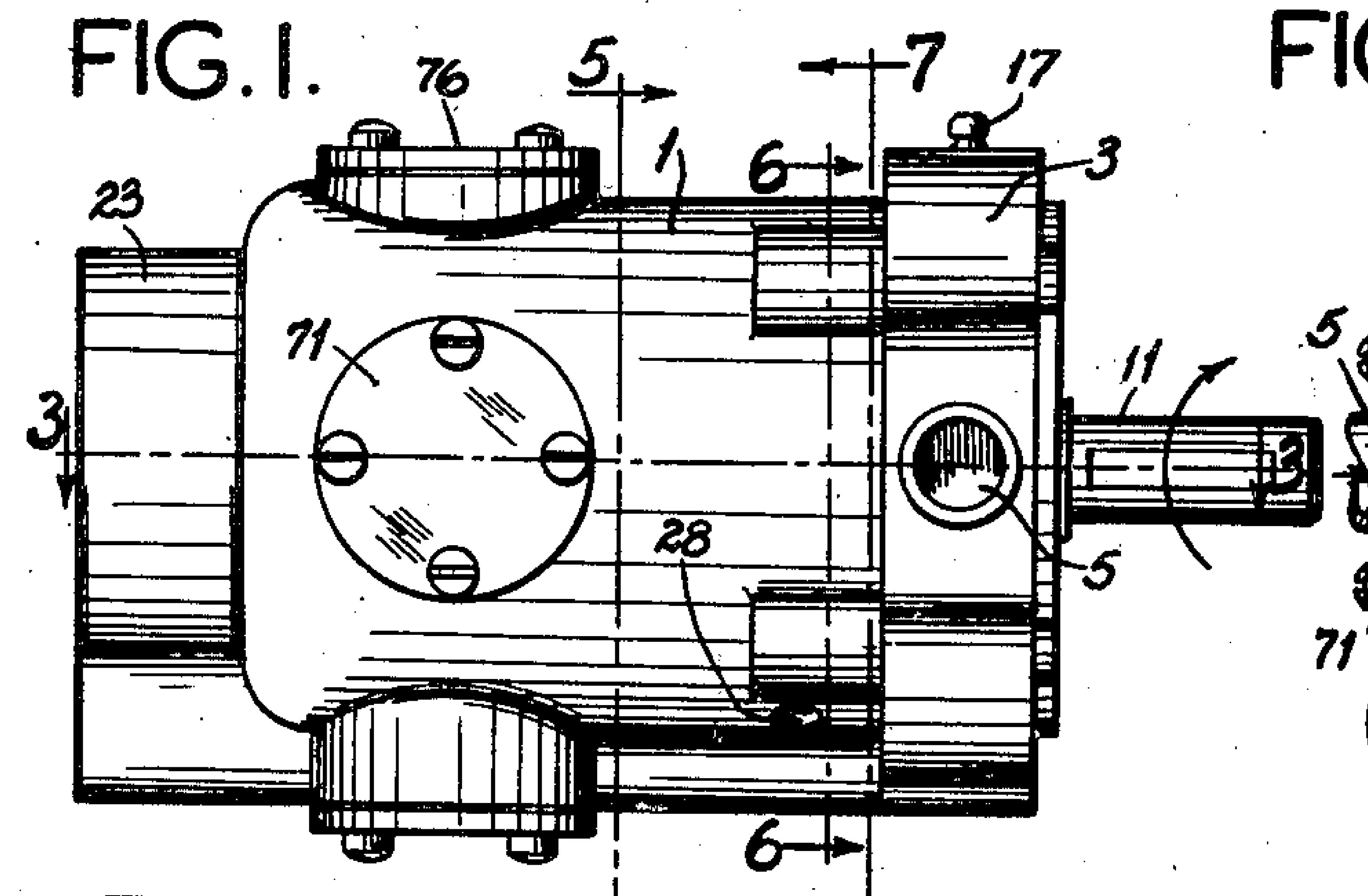

FIG. 2.

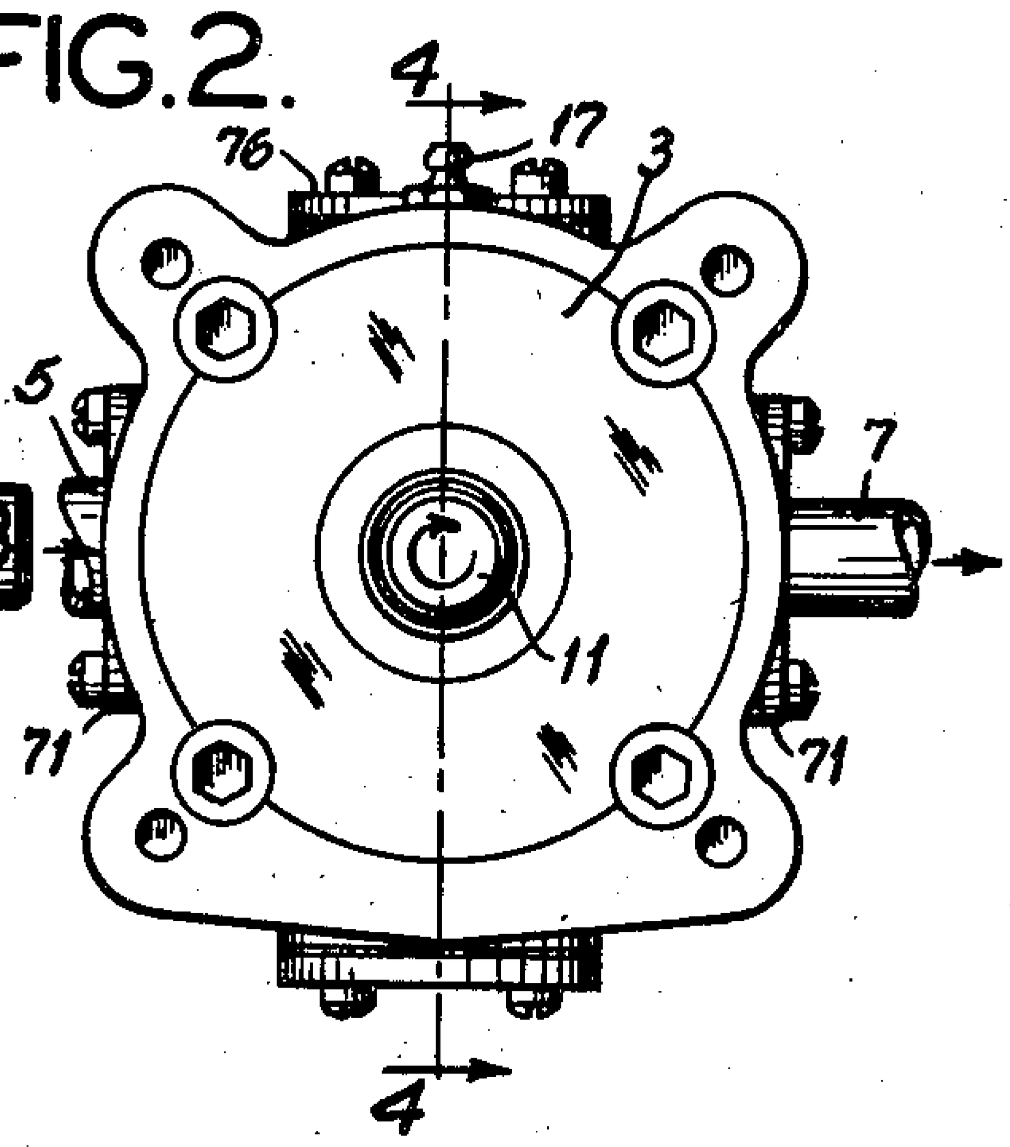

FIG. 5.

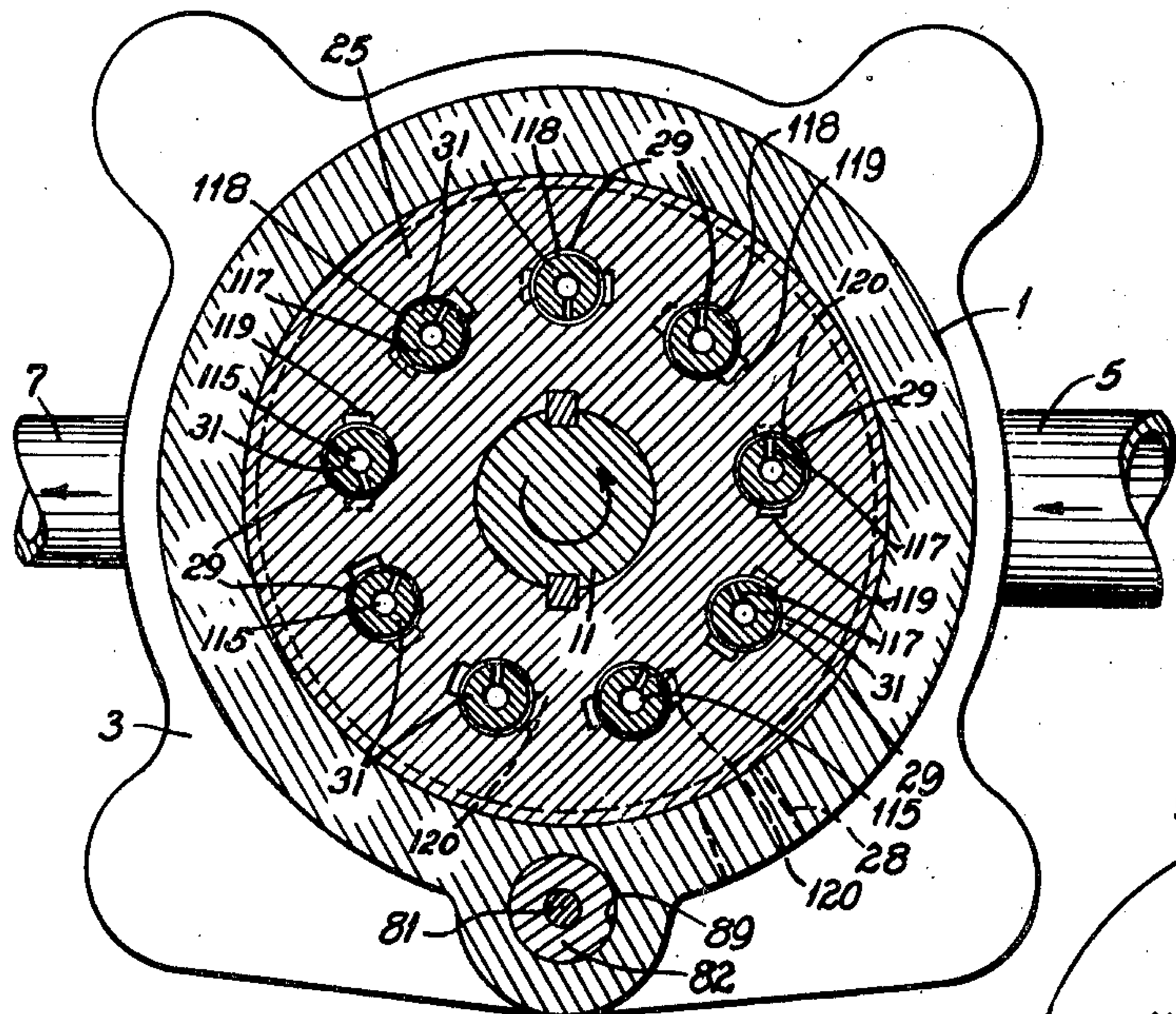

FIG. 7.

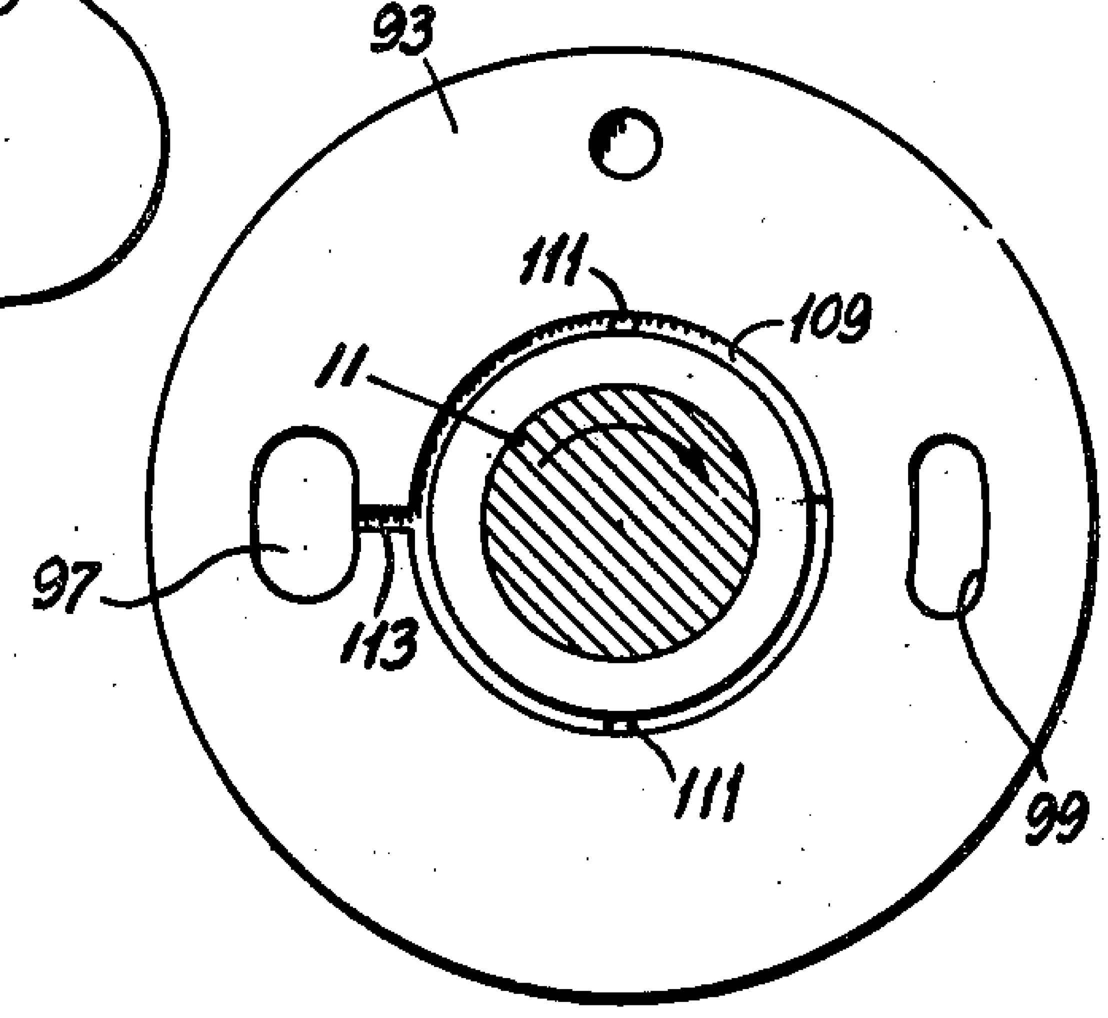

FIG. 6.

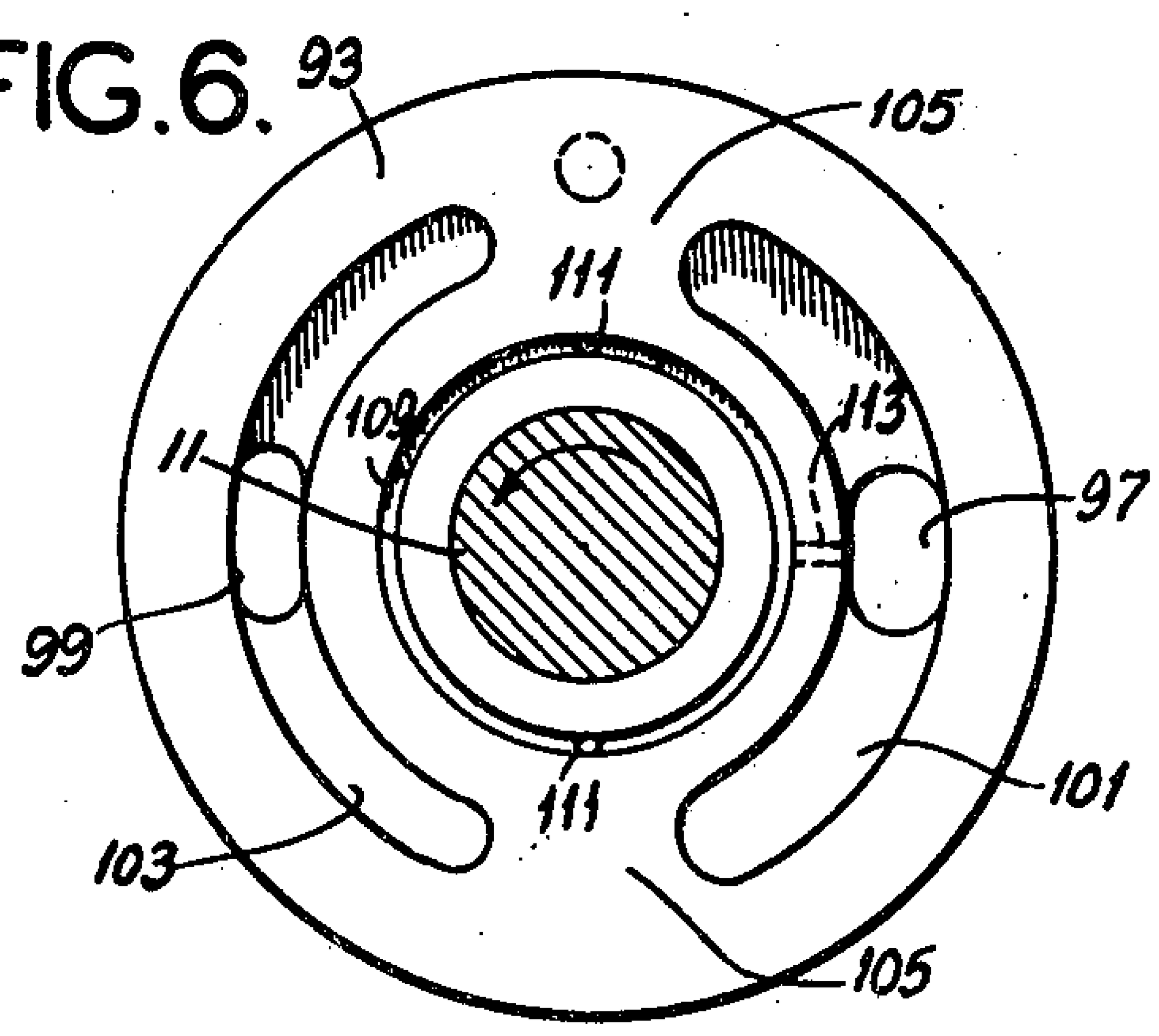

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FIG. 3.

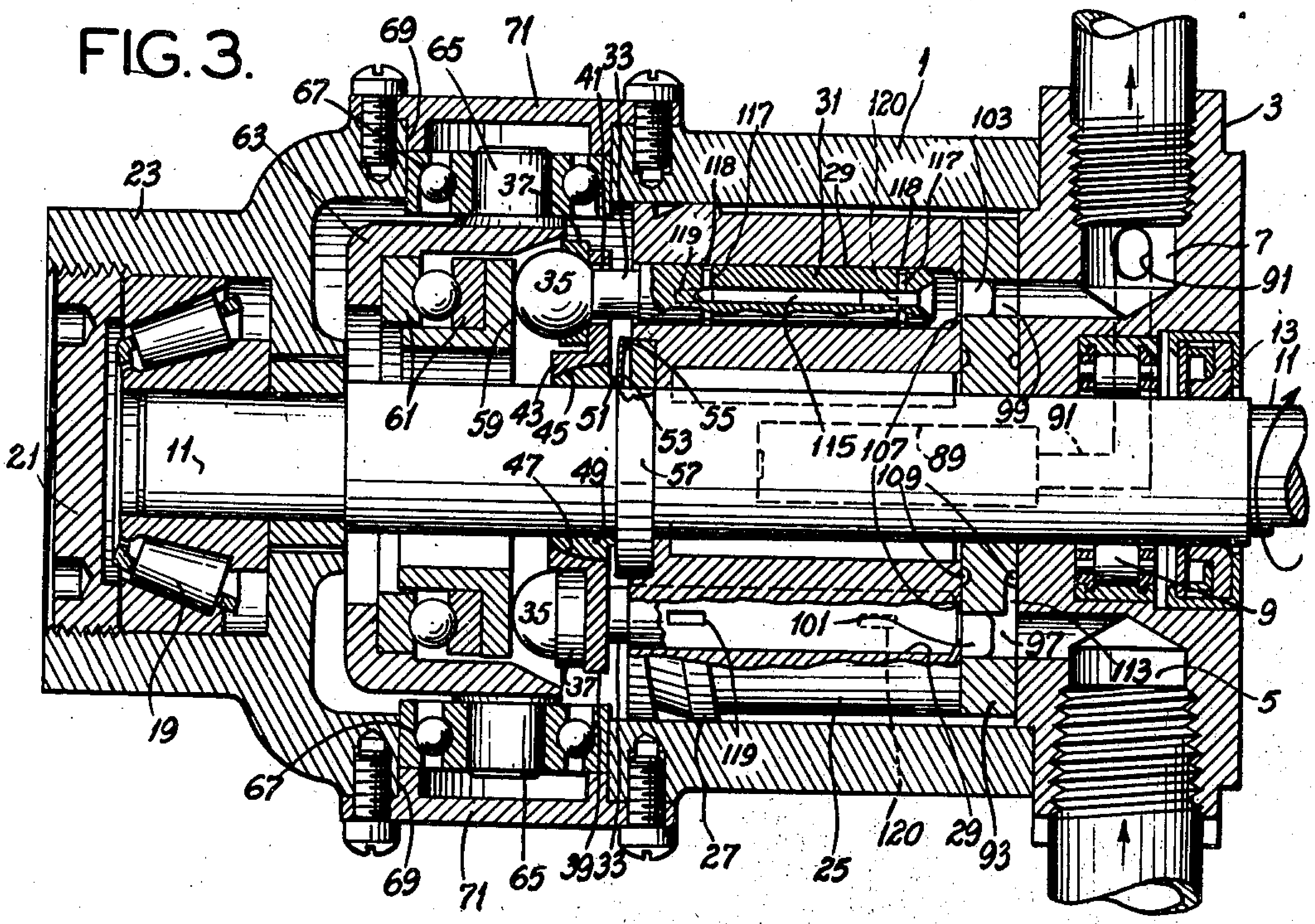
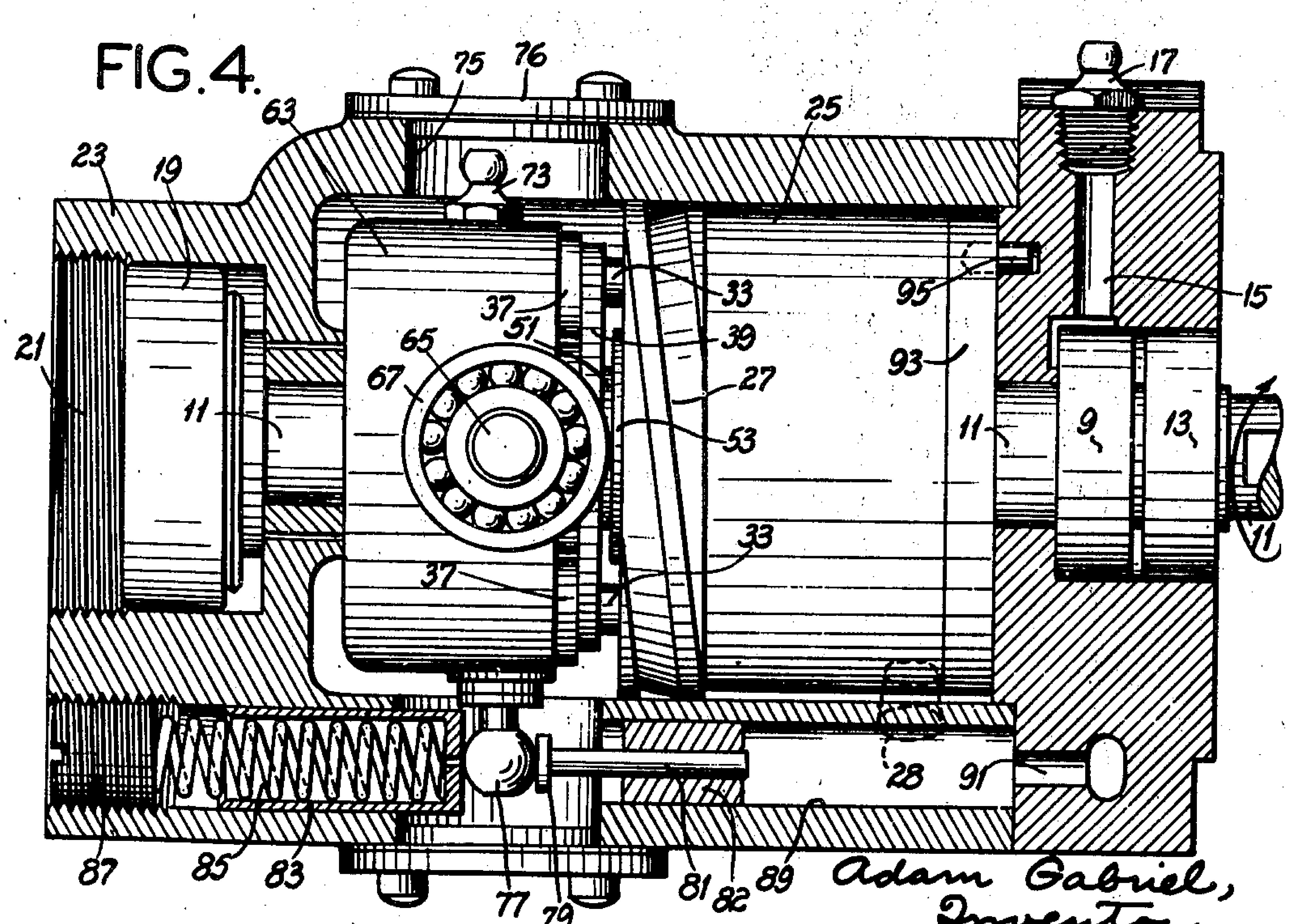


FIG. 4.



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2,430,764

PUMP

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Application April 7, 1945, Serial No. 587,151

6 Claims. (Cl. 103—162)

1

This invention relates to pumps, and with regard to certain more specific features, to variable-delivery, positive-displacement, hydraulic pumps.

Among the several objects of the invention may be noted the provision of a pump of the class described having control means for substantially determining maximum delivery pressure with automatic volume control for maintaining volume as required by a fluid-consuming appliance; the provision of a pump of the class described which maintains control without the use of disadvantageous by-pass pressure relief arrangements which cause heating and thinning of hydraulic fluids; the provision of a pump of the class described which exactly supplies the volume under the desired pressure required by the appliance which is served, thus conserving power; and the provision of a pump of the class described which is simple to construct and maintain and which has an inherently long life. This invention is an improvement upon swash-plate pumps of the class described in United States Patent 2,341,768, dated February 15, 1944. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which is illustrated one of various possible embodiments of the invention,

Fig. 1 is a side elevation of the pump on a reduced scale;

Fig. 2 is a right-end elevation of Fig. 1;

Fig. 3 is an enlarged, horizontal section taken on line 3—3 of Fig. 1, showing parts in a limiting operating position corresponding to a blocked outlet;

Fig. 4 is an enlarged longitudinal section taken on line 4—4 of Fig. 2, certain internal parts being shown in elevation, the positions of parts being as in Fig. 3;

Fig. 5 is a vertical section taken on line 5—5 of Fig. 1 but on an enlarged scale;

Fig. 6 is a vertical section taken on line 6—6 of Fig. 1 but on an enlarged scale; and,

Fig. 7 is a vertical section taken on line 7—7 of Fig. 1 but on an enlarged scale.

As noted above, the scale of Figs. 1 and 2 is smaller than that of Figs. 3–7. Similar reference characters indicate corresponding parts throughout the several views of the drawings.

2

Positive displacement pumps in many applications, particularly for pumping liquids, have certain advantages. Their chief disadvantages are that for variable volume service they are difficult to build, particularly when at predetermined pressures automatic volume regulation is desired. The usual practice has been to design this class of pump for maximum volume under the desired pressures and then to by-pass some of this volume when it is not required by the receiving appliance. This involves a by-pass pressure-release valve or the equivalent. The resulting heating in the hydraulic fluid, as well as the wire-drawing effect on the fluid of the by-pass valve caused undesirable heating and viscosity changes in the fluid, as well as large losses of energy. Where attempts have been made to avoid the by-pass valve difficulties, variable delivery has been obtained by differential action between several pistons, that is, by variably phasing them without changing their individual stroke. This solution to the problem involved rather complex mechanical constructions difficult to operate at high speeds. The present invention provides a simple, quiet, high-speed, variable-stroke, positive-displacement pump in which control of pressure may be maintained under any volume requirements within its range as imposed by the receiving appliance.

Referring now more particularly to the drawings, numeral 1 indicates a hollow cylindric case on which is bolted a head 3. This head has an inlet 5 and an outlet 7. Centrally the head carries a bearing 9 for a power shaft 11. A lubricant retainer is shown at 13. The bearing 9 is greased by means of a grease passage 15 which leads from a lubricant supply fitting 17 (Fig. 4).

At its other end the shaft 11 is supported upon a conical roller bearing 19 which is backed up by a thrust plate 21, the latter being threaded into a cylindric extension 23 of the casing 1.

Keyed to the shaft 11 is a cylinder block 25 having double-helix slinger threads 27. This block is rotary with the shaft 11. Exteriorly it is of cylindric shape, spaced within the case 1 as indicated in Fig. 4, and at the left end is formed with said helical slinger threads 27 which more closely fit within the case. The normal rotation of block 25 is such that the slinger threads 27 tend to pump any leakage fluid toward the right as viewed in Figs. 3 and 4. The fluid here referred to is not the main pumpage of the pump, as will appear. This leakage may escape at port 28.

At spaced intervals around the axis of rotation of the shaft 11 are positioned cylinders 29. These are located parallel to the axis. They carry reciprocating pistons 31. In the present example there are nine cylinders carrying nine pistons. Other numbers may be used. At its left end each piston 31 has a reduced neck 33, beyond which is a spherical ball end or head 35. Under each ball end 35 is a circular washer forming a rocker seat 37 having a female internal spherical shape which forms a bearing for a corresponding head 35. Since the pistons 31 and heads 35 are preferably made of steel, the seats 37 are made of some material forming a suitable bearing for the steel.

The seats 37 themselves rest upon a rocker disc 39, having suitable openings 41 for freely clearing the necks 33. These openings 41 allow for relative rocking between the rocker disc and the pistons.

The rocker disc 39 has an inside boss 43 in which is an internal spherical surface 45 engaging an external spherical surface 47 of a rocker seat 49. Thus the rocker disc 39 may rock in any plane relatively to the rocker seat 49.

The rocker seat 49 is slidable on the shaft 11 and its right-hand end is made as a boss 51 which engages the inner periphery of a dished-disc Belleville spring 53. The outer periphery of this Belleville spring 53 rests upon a peripheral land 55 of a reaction washer 57. The latter is held in a recess at the left end of the cylinder 25. The Belleville spring 53, reacting from the land 55, biases the rocker seat 49, bearing 47 and pistons 31 toward the left. Thus slack is taken up, as will be clear.

All of the piston heads 35 engage a rotary race 59 of a swash plate assembly. The race is carried upon a thrust-bearing assembly 61, annularly surrounding the shaft 11. Bearing assembly 61 is carried in an annular cradle 63 which carries lateral coaxial gudgeons 65. The gudgeons 65 are supported in bearings 67, said bearings being supported in sideward openings 69 of the case 1. The common axis of bearings 67 and gudgeons 65 is perpendicular to the axis of shaft 11. The outer races of the bearings 67 are retained by cover plates 71.

On its top the cradle 63 is provided with a lubricant fitting 73 (Fig. 4) which is accommodated in an opening 75 having an upper cover plate 76 which may be opened for lubrication through the fitting 73. As will appear later, the fitting 73 rocks in the opening 75.

At its lower end (Fig. 4) the cradle 63 carries a ball control stud 77. This stud 77 is caught between the head 79 of a compensating piston 81 and a sliding spring retainer cup 83. Within the cup 83 is a spring 85 which reacts from an adjustable regulating screw 87. The piston 81 slides in a bushing 82 and responds to liquid pressure in a cylinder 89 formed in the case 1. This cylinder 89 communicates with a passage 91 in the head 3 which, as indicated by dotted lines in Fig. 3, communicates with the outlet port 7. Thus it will be clear that the position of the stud 77 is controlled by the pressure in the cylinder 89 and hence by the pressure in the outlet. As the stud 77 moves, the cradle 63 rocks in the bearings 67, thus adjustably angling the rotary race 59. As the angle of this race 59 changes, the strokes of the pistons 31 into cylinders 29 are varied as the shaft 11 is driven from some outside power source. Also, the angle which the cradle will assume in response to a given pressure in the cylinder 89 is determined by the pressure from spring 85. This in turn is determined by the position of the adjusting screw 87. In short, the adjustment of screws 87 determines the pressure at which the pump will operate, as will be clear.

At numeral 93 is shown a phasing disc valve which, angularly considered, is held stationary with respect to the stationary head 3. This is accomplished by means of a dowel pin 95 (Fig. 4). Axially considered, the disc is floating between the block 25 and head 3. This disc 93 is shown in detail in Figs. 3, 4, 6 and 7. It includes an inlet port 97 which is in communication with the inlet 5 (Fig. 3). It also includes an outlet port 99 which is in communication with the outlet 7. On the side of the disc (Fig. 6) which faces the rotary block 25 are partial circular grooves 101 and 103 in communication with the inlet port 97 and the outlet port 99, respectively. These grooves form communications with the cylinders 29 as the latter rotate. This is in order to place the cylinders in communication with the inlet 5 when the pistons 31 therein are axially retracting in suction, and to place them in communication with the outlet 7 when the pistons 31 are axially advancing in compression. The flat portions 105 between the grooves 101 and 103 serve to seal off the inlet 97 from the outlet 99.

As above indicated, the phasing disc 93 is separate from the shaft 11 and the rotary block 25 and also from the stationary head 3. The dowel 95 only prevents rotation. There are circular grooves 109, one on each side of the disc. These are in communication with one another through holes 111. They are also in communication with the inlet as indicated by the radial slot 113 (Figs. 6 and 7). These grooves 109 also serve as suction returns for any leakage that occurs around the disc 93 from the outlet 99. In order to reduce to a minimum pressure on the thrust bearing 19, the ends of the cylinders 29 are restricted as indicated at 107. This provides for some axial pressure from the contents of each cylinder being applied upon the rotary block 25 (toward the right in Fig. 3) so as to offset pressure which is applied on the block 25 (toward the left) over areas between cylinders as they come into the range of the passages 101 and 103.

A side-thrust balancing feature is also employed in connection with the pistons 31, which is as follows:

Each is drilled axially as shown at 115 and crosswise as shown at 117 for conveying the hydraulic fluid which acts as a lubricant. This fluid reaches the walls of cylinders 29 from passages 117 via peripheral grooves 118. Balancing grooves 119 and 120 are used in each cylinder 29 and these are in communication with the grooves 118 throughout a substantial part of the stroke of each piston 31. The members of each pair of grooves 119, 120 are arranged on opposite ends and sides of their respective cylinders 29 to offset side thrusts on the pistons created by an angularity of the race 59. The arrangement is such that the grooves 119 near the outwardly extending parts of the pistons are trailing the pistons in revolving about the axis of shaft 11; whereas the grooves 120 which are farther away from said piston extensions lead the pistons in their rotation about the axis of the shaft 11. This is clear from Figs. 3 and 5. Thus during the compression stroke in any cycle wherein the piston side thrust is a maximum due to any angular position of the race 59 there is some fluid counterbalance against such side thrust. Of course on the suction stroke the side thrust is opposite and the pressure-filled grooves 119 and 120 are then ineffective, but side thrust upon a suction stroke is negligible from the view-point of wear.

Operation is as follows:

Assume that the shaft 11 is power-operated in the direction shown by the arrows in the various figures. Since at the start of rotation there is presumably no pressure in the outlet 7, there will be no pressure in the control cylinder 89. Thus the spring 85 biases and angles the cradle stud 77 to the right of the position shown in Fig. 4. This angles the cradle 63 and the race 59 and, as the cylinder block 25 rotates, each piston makes a suction stroke and a compression stroke during each revolution. In the lowest position of each piston, its cylinder is blocked off from grooves 101 and 103 by the lower flat portion 105 of disc 93. As block 25 rotates counterclockwise (Figs. 5 and 6), each piston moves upward from this lowest position and also moves to the left as viewed in Fig. 3. When its cylinder comes into communication with groove 101, fluid is drawn in from inlet 5 through inlet port 97 and groove 101. This suction stroke continues until the piston has travelled to its uppermost position wherein its cylinder is blocked off from grooves 101 and 103 by the upper flat portion 105. The piston then moves downward and also to the right as viewed in Fig. 3. When its cylinder comes into communication with groove 103, the piston forces fluid out through groove 103, outlet port 99 and outlet 7. This compression stroke continues until the piston has travelled back to its lowest position wherein its cylinder is blocked off from grooves 101 and 103 by the lower flat portion 105. Thus, fluid is transferred from the inlet 5 to the outlet 7 and builds up pressure in the latter and supplies the volume required by the consuming appliance attached to the outlet. As the volume requirement is met, pressure builds up in the control cylinder 89 and the piston 81 is pushed to the left against the reaction of spring 85, thus forcing back the cradle stud 77 and reducing the angle from the perpendicular of the cradle 63. This also reduces the angle of the race 59 and hence the angle of the plane in which the heads 35 operate. The result is to reduce the strokes of the pistons 31. This stroke-reducing action goes on until the pressure in the control cylinder 89 is reduced to such value, due to the resultant decrease in volume delivered through the outlet, as to be counterbalanced by the reaction in spring 85. Under such balanced conditions the exact volume required by the appliance is supplied at a certain pressure determined by previous adjustment of the screw 87. The balance occurs at some given angle of the cradle 63 which is less than its starting angle.

Assume next that the appliance connected with outlet 7 admits a greater volume. This incipiently reduces the pressure in the outlet 7 and in the control cylinder 89 which permits the spring 85 to expand and increase the angle of the cradle 63 and race 59. This increases the strokes of the pistons 31 and thus tends to counteract the incipient loss in pressure caused by the greater volumetric output. Finally a balanced condition is again reached.

Next, assume that the appliance in connection with the outlet 7 restricts the volume received. This incipiently raises the pressure in the outlet 7 and the control cylinder 89 which compresses the spring 85 until a new balance is reached at a smaller angle of the race 59.

Any desired pressure at any given volumetric flow within the range of the device may be obtained by adjusting the screw 87.

In view of the above it will be seen that there is a balanced operating condition for each volumetric and pressure requirement of the appliance which is being served, the same being under manually adjustable automatic pressure control. Thus the pump automatically maintains steady conditions according to the requirements of the appliance.

Several important structural and mechanical features should be noted as follows:

As the heads 35 ride with the race 59 from a low point to a high point, they drive the pistons 31 through a compression stroke in the correct phase relationship with respect to the outlet groove 103. This is a positive motion.

Positive motion during the suction phase of the action of each cylinder is obtained through the rocker disc 39. As one side of this disc rocks in one axial direction, the diametrically opposite side rocks in the opposite axial direction. Thus the disc functions as a simple lever across any diameter. This lever is pivoted on the ball and socket joint 45, 47. Thus a positive mechanical withdrawal is effected for a suction stroke of each of the pistons 31.

Also, the fulcrum for the disc 39 acting as a rocking lever is on the center of the Belleville spring 53 which in turn reacts at its edge on the circular land 55. This spring makes an essentially stationary fulcrum but one which is resilient enough that any looseness is taken up between the disc 39, seats 37, heads 35, race 59, and the various parts of the thrust bearing 61. Looseness is also taken up at the ball and socket joint 45, 47, spring 53 and washer 57. Thus quiet action is assured even at high speeds.

Furthermore, the seats 37 may slide on the surface of the disc 39 as well as rock under the heads 35. This compensates for relative radial motions between the swinging ends of the disc 39 and the reciprocating ball ends 35 of the pistons. Any bias thrust from the angled race 59 against the piston heads 35 which tends to cock the pistons 31 in their cylinders 29 tends to be counteracted by the fluid pressure in the grooves 119.

Any leakage which escapes under pressure from the grooves 103 and port 99 past the valve disc 93 will either pass toward the center and be received by the grooves 109, 111 and be returned to the suction port 97 via groove 113, or some may work out radially in between the cylinder 25 and the case 1. From the latter it will pass out of the drain 28. This latter leakage is prevented from flowing to the cradle operating mechanism by the slinger 27. Any leakage past the pistons 31 moves radially toward the slinger 27 and is pumped thereby back toward the drain 28. Thus the operating linkage to the left of the slinger is kept free of pumpage and may be independently lubricated as already indicated. The drain 28 may, if desired, be connected to the suction inlet 5 for returning leakage to the system. Or in some cases it may be eliminated and the liquid pumped by the slinger be allowed to find its way back to the inlet past the disc 93.

All axial thrust reactions on the pistons 31 are received by the race 59, bearing 61, cradle 63, gudgeon 65 and bearings 67. The bearing 19 receives end thrust from shaft 11 arising from any leakage pressure on the right end of cylinder block 25 which tends to push it and the shaft 11 to the left.

It will be observed that the invention comprises more than the ordinary swash plate pump which is subject to the same disadvantages as ordinary reciprocating pumps, so far as is concerned the matter of pressure and volume control. The swash plate assembly including race 59 is automatically adjusted in response to pressure in the outlet, thereby compensating for differences in the volumetric requirements of the appliance which is being served with hydraulic pressure fluid.

It will be seen from the above that besides providing an automatically-controlled, variable-delivery, positive-pressure displacement pump, that I have produced novel features in the swash plate construction itself. Besides, the swash plate type of pump construction is itself advantageous because of its compactness. Thus in the present example a nine-cylinder pump is confined within the relatively small cylinder composed by the casing 1. This is due to the circular distribution of the pump cylinders and pistons with their axes parallel to the axis of rotation of the shaft 11.

While the present pump will handle any ordinary liquid pumpage, such as water, gasoline, oil and the like, it is preferable that when this pumpage acts simply as a hydraulic pressure link between the pump and a power appliance the pumpage have a lubricating quality. In such instances oil, hydraulic brake fluid and similar substances are preferable.

In view of the above it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A pump comprising a casing, a pump shaft extending through the casing, a head closing one end of the casing having an inlet and an outlet therein, a swash plate assembly in said casing including an annular cradle surrounding said shaft and axially spaced from said head, said cradle being pivoted for rocking movement upon an axis substantially perpendicular to and intersecting the axis of said shaft, a block having axially extending open-ended cylinders therein carried by said shaft for rotation therewith intermediate said swash plate assembly and head, the ends of said cylinders adjacent said head communicating successively with said inlet and outlet, pistons reciprocating in said cylinders having portions extending out of the other ends of the cylinders, single spring means for biasing all of said pistons to maintain their extending portions in engagement with said swash plate assembly, a control stud extending outward from said cradle substantially radially with respect to the pivotal axis of said cradle and in the plane thereof, a spring engaging said stud to rock the cradle in one direction, a control cylinder in communication with said outlet, and a control piston movable in said control cylinder and engaging said stud for biasing said cradle to rock in the other direction.

2. A pump comprising a casing, a pump shaft extending through the casing, a head closing one end of the casing having an inlet and an outlet therein, a swash plate assembly in said casing including an annular cradle surrounding said shaft axially spaced from said head, said cradle being pivoted for rocking movement upon an axis substantially perpendicular to and intersecting the axis of said shaft, a block having axially extending open-ended cylinders therein carried by said shaft for rotation therewith intermediate said swash plate assembly and head, the ends of said cylinders adjacent said head communicating successively with said inlet and outlet, pistons reciprocating in said cylinders having portions extending out of the other ends of the cylinders, means for biasing said pistons to maintain their extending portions in engagement with said swash plate assembly, a control stud extending from said cradle substantially radially with respect to the pivotal axis of said cradle and in the plane thereof, a spring engaging said stud to rock the cradle in one direction, a control cylinder in communication with said outlet, and a control piston movable in said control cylinder and engaging said stud for biasing said cradle to rock in the other direction, said means for biasing said pistons comprising a rocker disc mounted for axial sliding and universal rocking movement on said shaft between said swash plate assembly and block, means for biasing said disc to move axially toward said swash plate assembly, and means on the extending portions of said pistons engaged by said disc for biasing said extending portions into engagement with said swash plate assembly.

3. A pump comprising a casing, a pump shaft extending through the casing, a head closing one end of the casing having an inlet and an outlet therein, a swash plate assembly in said casing including an annular cradle surrounding said shaft axially spaced from said head, said cradle being pivoted for rocking movement upon an axis substantially perpendicular to and intersecting the axis of said shaft, a block having axially extending open-ended cylinders therein carried by said shaft for rotation therewith intermediate said swash plate assembly and head, the ends of said cylinders adjacent said head communicating successively with said inlet and outlet, pistons reciprocating in said cylinders having portions extending out of the other ends of the cylinders, means for biasing said pistons to maintain their extending portions in engagement with said swash plate assembly, a control stud extending from said cradle substantially radially with respect to the pivotal axis of said cradle and in the plane thereof, a spring engaging said stud to rock the cradle in one direction, a control cylinder in communication with said outlet, and a control piston movable in said control cylinder and engaging said stud for biasing said cradle to rock in the other direction, said means for biasing said pistons comprising a rocker disc supported for axial sliding and universal rocking movement on said shaft between said swash plate assembly and block by means of a ball and socket joint slidable on the shaft, said extending portions of said pistons passing through openings in said disc and having heads on their ends, seating means between said heads and the disc adjacent said openings, and a dished-disc type spring reacting between said block and said ball and socket joint for biasing said disc and said pistons toward said race.

4. A swash plate pump comprising a casing having a cylindric chamber adjacent a swash plate compartment, a head closing the end of

said chamber remote from said compartment and having an inlet and an outlet therein, a block journalled for rotation coaxially in said chamber, said block having axially extending open-ended cylinders therein, the ends of said cylinders adjacent said head communicating successively with said inlet and outlet, pistons reciprocating in said cylinders and extending from their other ends into engagement with swash plate means mounted in said compartment, said block being provided on its end adjacent said compartment with a helical fluid slinger rigid with the block and closely fitting within said chamber, said slinger being rotatable with the block and adapted to pump any fluid which has leaked into said compartment from said cylinders away from said compartment toward said head.

5. A swash plate pump comprising a casing having a cylindric chamber adjacent a swash plate compartment, a head closing the end of said chamber remote from said compartment and having an inlet and an outlet therein, a block journalled for rotation coaxially in said chamber, said block having axially extending open-ended cylinders therein, the ends of said cylinders adjacent said head communicating successively with said inlet and outlet, pistons reciprocating in said cylinders and extending from their other ends into engagement with swash plate means mounted in said compartment, said block being peripherally provided on its end adjacent said compartment with a helical fluid slinger closely fitting within said chamber, the remainder of said block being of smaller diameter than the internal diameter of said chamber to form an annular fluid passage, said slinger being adapted to pump any fluid which has leaked into said compartment from said cylinders away from said compartment toward said head in said annular fluid passage.

6. A swash plate pump comprising a rotary block having a plurality of axially extending open-ended cylinders annularly arranged around its axis, one end of each of said cylinders being adapted successively to communicate with a pump inlet and a pump outlet, pistons reciprocable in said cylinders and having extensions from their other ends, angular swash plate means engageable by said extensions for reciprocating said pistons as the block rotates, said swash plate means tending to cause side thrust on said pistons as they rotate with the block, each of said cylinders being provided with a groove adjacent said one end thereof in the side of said cylinder which leads with respect to the direction of rotation of said block, each of said cylinders also being provided with a groove adjacent its other end in the side of said cylinder which trails with respect to the direction of rotation of said block, each of said pistons having fluid passages therein for supplying fluid under pressure from said cylinders to said grooves, the fluid under pressure in said grooves tending to counteract said side thrust.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,135,515	Hull et al.	Nov. 8, 1938
2,284,111	Vickers	May 26, 1942
2,284,169	Robinson	May 26, 1942
2,288,768	Zimmerman	July 7, 1942
2,299,234	Snader et al.	Oct. 20, 1942
2,299,235	Snader et al.	Oct. 20, 1942
2,300,009	Rose	Oct. 27, 1942
1,772,828	Egersdorfer	Aug. 12, 1930
1,912,284	La Brie	May 30, 1933
2,299,233	Hoffer	Oct. 20, 1942
2,303,955	Rose	Dec. 1, 1942
2,313,407	Vickers et al.	Mar. 9, 1943
2,337,821	Huber	Dec. 28, 1943