

Aug. 12, 1952

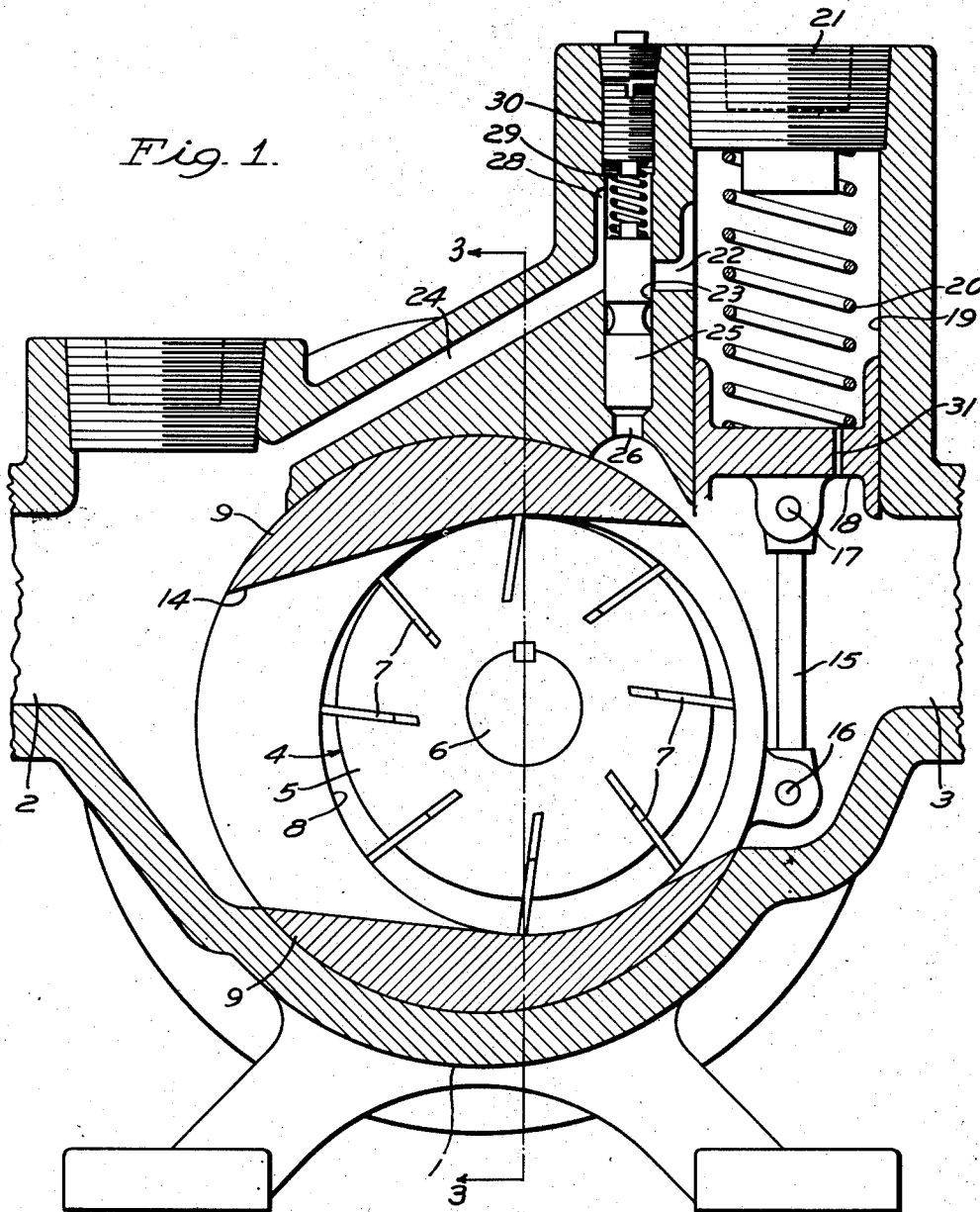
A. M. SHAW

2,606,503

VARIABLE CAPACITY ROTARY PUMP

Filed Jan. 11, 1946

7 Sheets-Sheet 1



ALBERT M. SHAW
INVENTOR.

BY *Robert M. Shaw*
attorney

Aug. 12, 1952

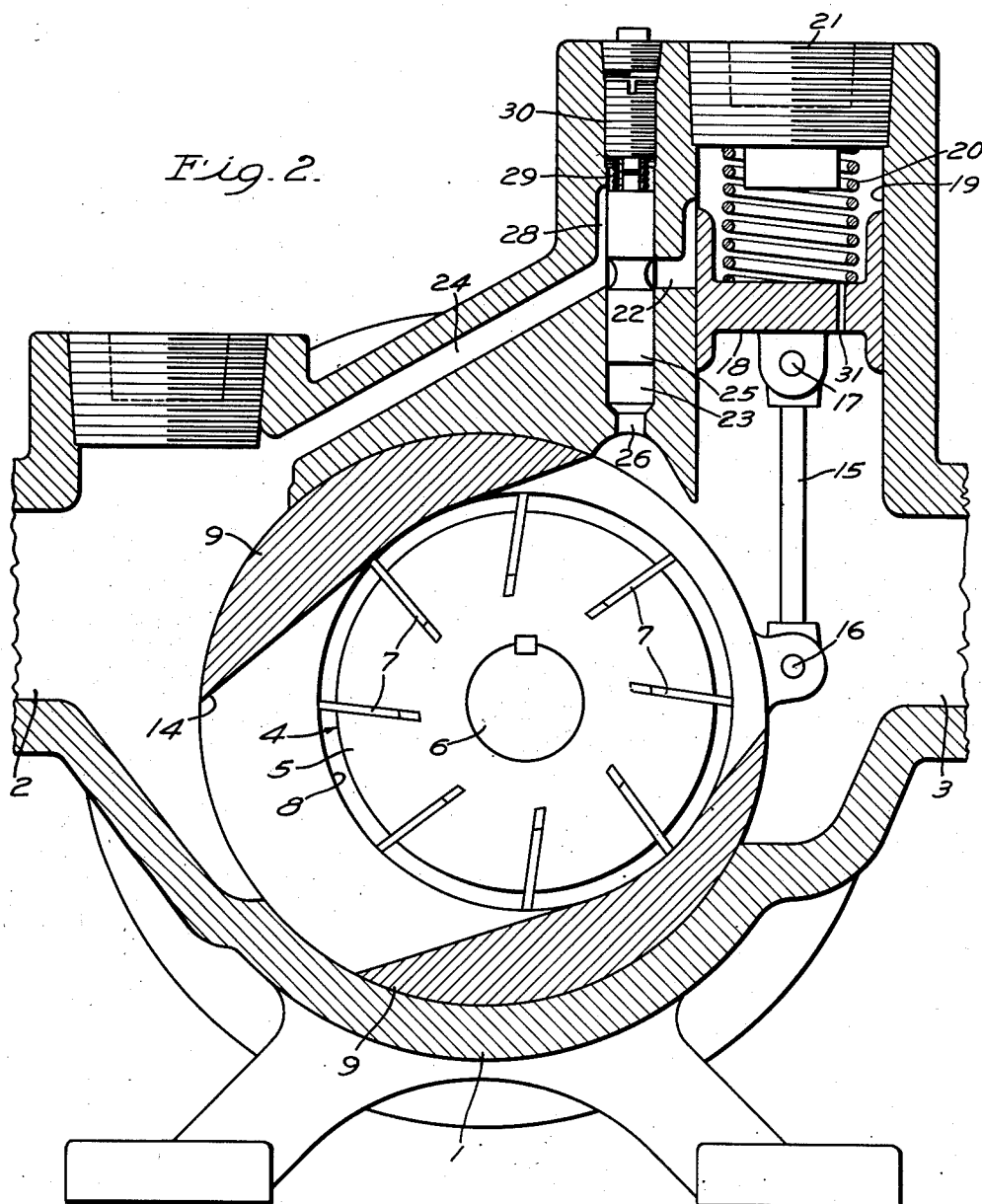
A. M. SHAW

2,606,503

VARIABLE CAPACITY ROTARY PUMP

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ALBERT M. SHAW
INVENTOR.

BY *Robert Meyer*
attorney

Aug. 12, 1952

A. M. SHAW

2,606,503

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7 Sheets-Sheet 3

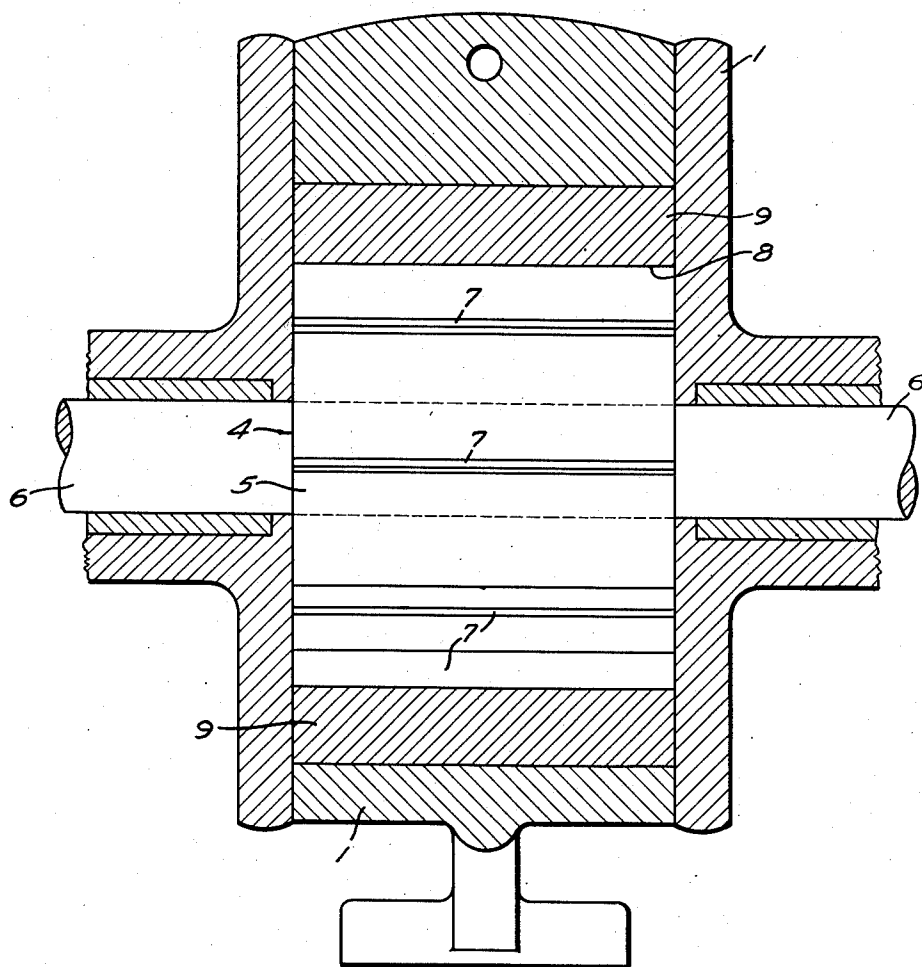


Fig. 3.

ALBERT M. SHAW
INVENTOR.

BY *Robert Meyer*
attorney

Aug. 12, 1952

A. M. SHAW

2,606,503

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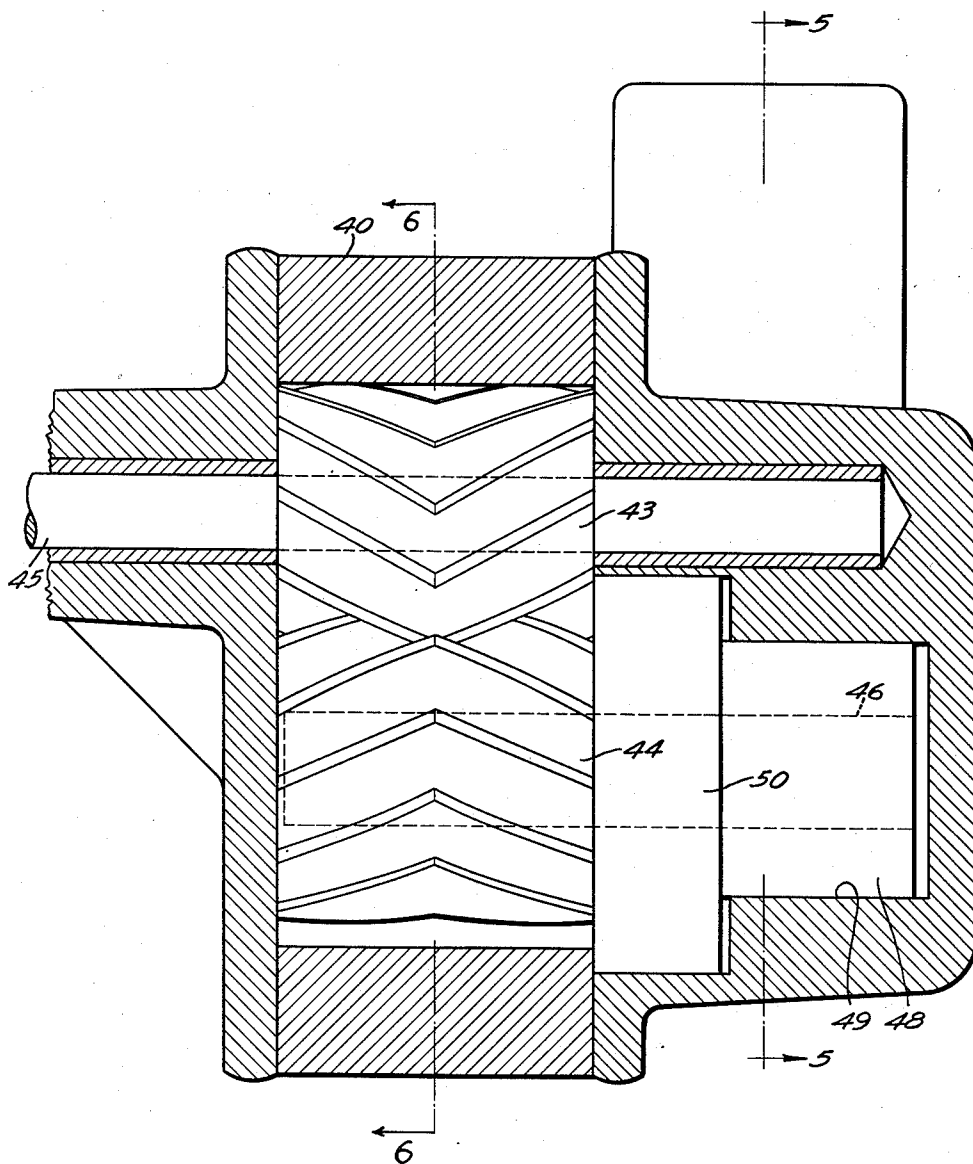


Fig. 4.

ALBERT M. SHAW
INVENTOR.

BY *Robert Meyer*
attorney

Aug. 12, 1952

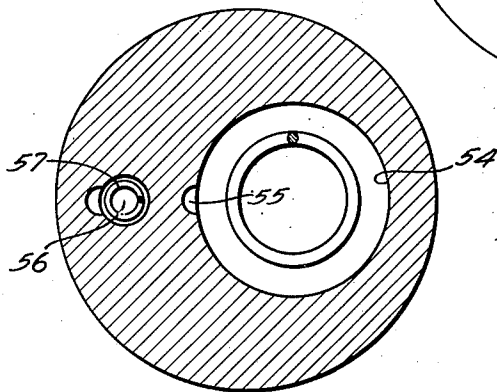
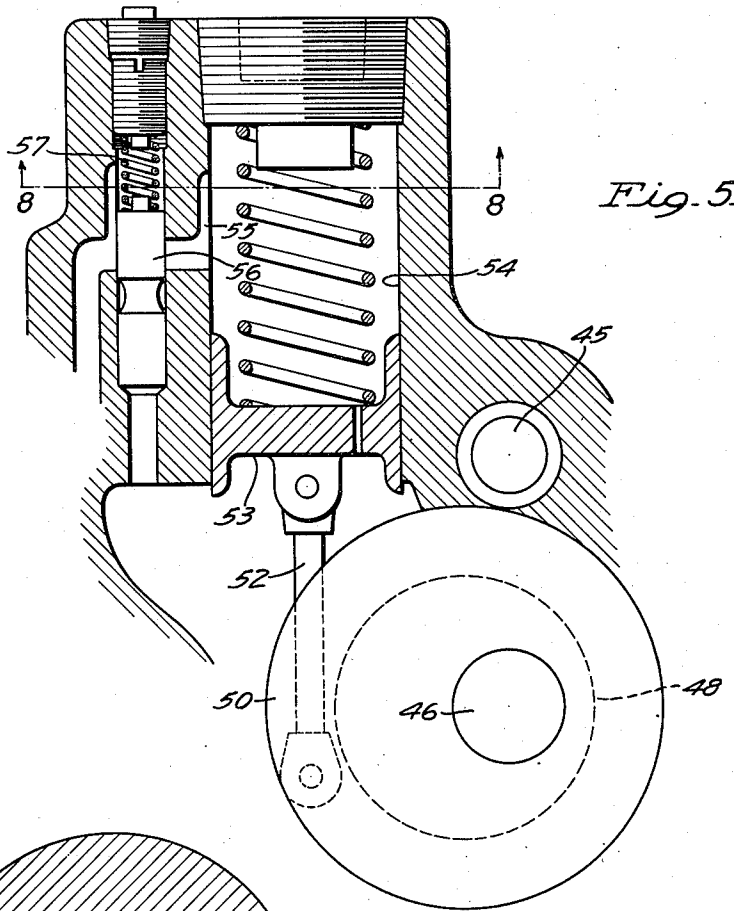
A. M. SHAW

2,606,503

VARIABLE CAPACITY ROTARY PUMP

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ALBERT M. SHAW
INVENTOR.

BY *Robert Meyer*
attorney

Aug. 12, 1952

A. M. SHAW

2,606,503

VARIABLE CAPACITY ROTARY PUMP

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Fig. 6.

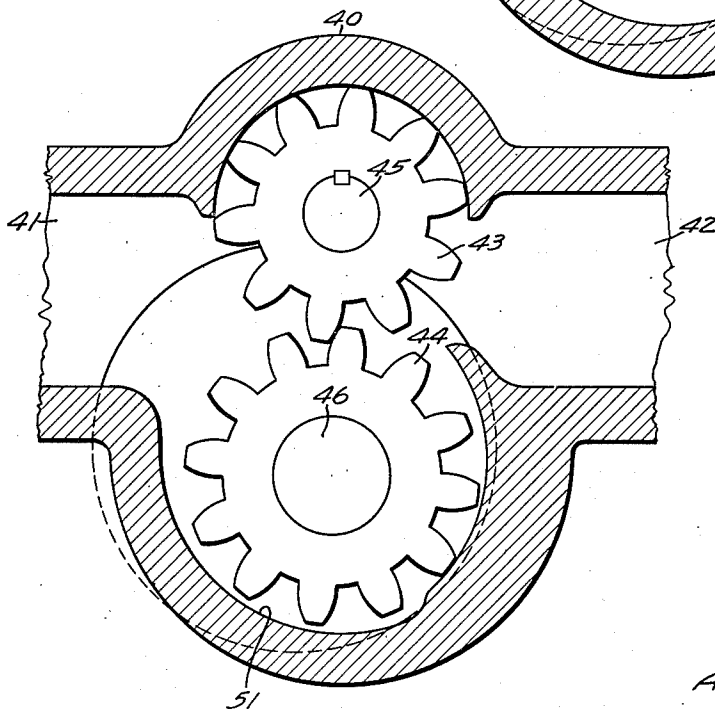
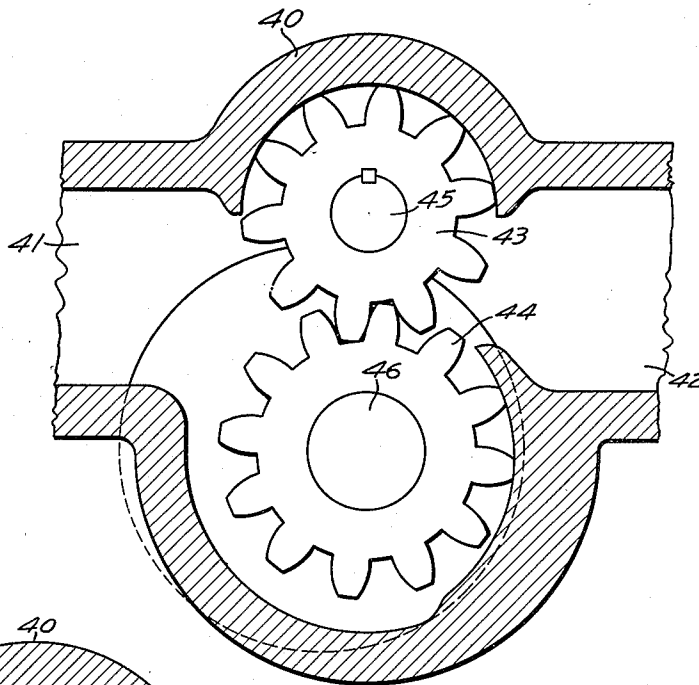


Fig. 7.

ALBERT M. SHAW
INVENTOR.

BY *Robert Meyer*
attorney

Aug. 12, 1952

A. M. SHAW

2,606,503

VARIABLE CAPACITY ROTARY PUMP

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Fig. 9.

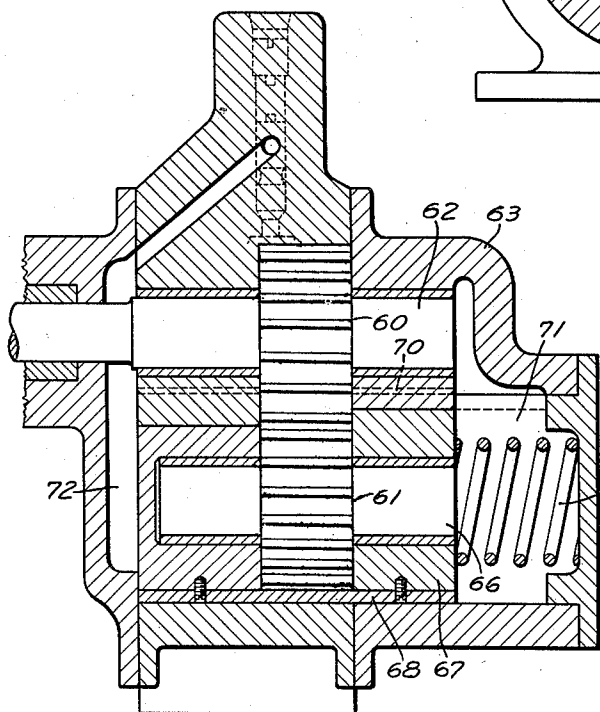
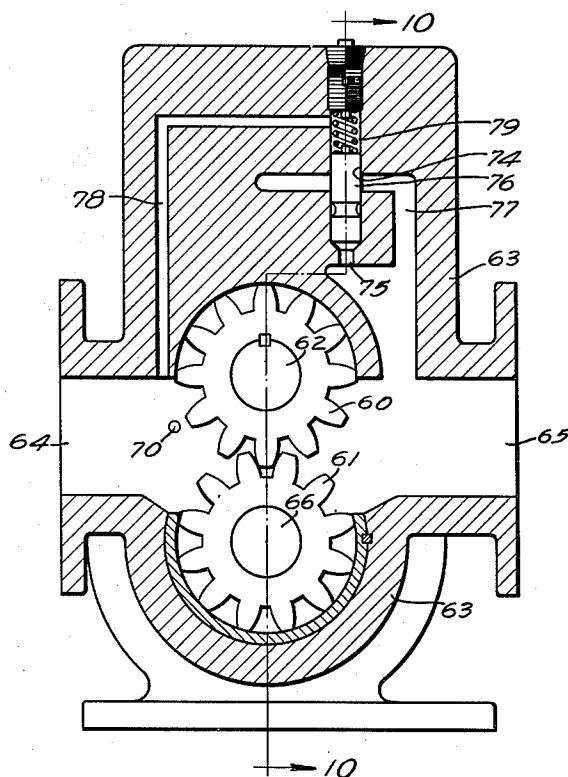


Fig. 10.

ALBERT M. SHAW
INVENTOR.

BY *Robert Meyer*
attorney

UNITED STATES PATENT OFFICE

2,606,503

VARIABLE CAPACITY ROTARY PUMP

Albert M. Shaw, Nutley, N. J., assignor to Worthington Corporation, Harrison, N. J., a corporation of Delaware

Application January 11, 1946, Serial No. 640,555

6 Claims. (Cl. 103—120)

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This invention relates to rotary pumps, that is, positive displacement pumps embodying rotary pistons, and the primary object of the present invention is to provide means for unloading pumps of this type when conditions of operation or work performed require or render advisable the reduction of discharge capacity of such pumps.

More specifically, the present invention embodies the rotary positive displacement pump, and means actuated by pressure differences between the suction pressure and the discharge pressure for varying the discharge capacity of the pump or completely unloading it to zero capacity.

Other objects of the present invention are to provide in a rotary positive displacement pump embodying means for automatically controlling its operation by varying its discharge capacity in accordance with predetermined conditions, various improvements and advantages over prior analogous pumps such as:

The providing of constant capacity of the pump as the pressure increases from atmospheric pressure to the desired predetermined working pressure;

Variable capacity of the pump if and when the discharge pressure rises above the predetermined desired working pressure;

Unloading of the pump to zero capacity with a minimum pressure increase over the predetermined desired discharge pressure;

Return of the pump to full capacity immediately after the discharge pressure drops to the predetermined desired degree;

Readily and easily accomplished adjustment of the parts of the control mechanism to provide for proper automatic control at different desired working pressures;

Minimum heating and/or agitation of the liquid being pumped during the unloaded operation of the pump;

A reduction in operating power consumed while the pump is operating in unloaded or reduced discharge capacity conditions;

Momentary unloading of the pump to zero capacity during starting of operation of the pump or when the pump is subjected to shock loads, together with prompt loading of the pump to capacity upon correction of such conditions, and the provision of partial adjustment of parts of the pump to compensate for wear.

With these and other objects in view, as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying drawings, showing a variable capacity rotary

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pump of a preferred form embodying the invention, and the features forming the invention will be specifically pointed out in the claims.

In the drawings:

Figure 1 is a vertical section through the rotary positive displacement pump showing the pump parts in loaded full discharge capacity operating positions;

Figure 2 is a vertical section through the pump showing the pump parts in unloaded zero capacity operating positions;

Figure 3 is a vertical cross-section through the pump taken at right angles to the section shown in Figure 1 and taken on the line 3—3 of Figure 1;

Figure 4 is a vertical longitudinal section through a modified form of the pump;

Figure 5 is a vertical section through the modified form of the pump and taken on the line 5—5 of Figure 4;

Figure 6 is a fragmentary cross-section through the modified form of the pump taken on the line 6—6 of Figure 4 and showing the pump parts in loaded full capacity operating positions;

Figure 7 is a fragmentary vertical section through the modified form of the pump taken on the line 6—6 of Figure 4 and showing the pump parts in unloaded zero capacity operating positions;

Figure 8 is a horizontal section taken on the line 8—8 of Figure 5;

Figure 9 is a vertical cross-section through a further modified form of the pump;

Figure 10 is a vertical longitudinal section through the modified form of pump shown in Figure 9 and taken on the line 10—10 of Figure 9.

In Figures 1 to 3 of the drawings, a positive displacement rotary pump of the type employing what is known as a sliding vane piston type is illustrated, and this form includes the casing 1 having a suction inlet 2 and a discharge outlet 3 with the rotor or rotating piston 4 positioned in the casing between the suction and discharge.

The rotating piston 4 comprises the carrying body 5 which is keyed upon and rotates with the drive shaft 6. A plurality of vanes 7 are slidably carried by the rotor 5 and project radially from the perimeter of the rotor contacting the inner surface of the bore 8 of the stator 9. During normal operation of a pump of this type, the rotor perimeter is eccentric of the bore 8 of the stator so that the vanes 7 are forced inwardly from the perimeter of the rotor during its rotating operation to provide the pumping action of the fluid being pumped.

To vary the discharge capacity of the pump

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shown in these figures, the relationship between the perimeter of the rotor and the inner surface of the bore 8 of the stator are varied so as to vary the degree of eccentricity between the rotor perimeter and the stator bore, thus decreasing the discharge capacity of the pump as these two elements of the pump are brought into concentric relationship so that when they are truly concentric the pump will operate at zero discharge capacity, the water being merely twirled around in the circular space between the perimeter of the rotor and the bore of the stator.

To accomplish the adjustment or variation of the eccentric relationship of the rotor to the stator so as to vary the discharge capacity of the pump, if required, the structure shown in Figures 1 to 3 inclusive has the stator 9 rotatably carried by the casing 1 of the pump.

The stator 9 has a transversely extending passageway 14 extending therethrough to provide communication between the suction and discharge passages 2 and 3 through the stator 9 and rotor 5. A piston rod 15 is pivotally connected to the perimeter of the stator 9, as shown at 16, and is also pivotally connected, as shown at 17, to a piston 18. The piston 18 is mounted for reciprocatory movement in a cylinder 19, one end of which is open to the discharge passage 3. A predetermined tensioned pressure is applied to the end of the piston opposite that end which faces and is open to the discharge passage 3 of the pump by a spring 20. The tension of the spring 20 may be regulated by adjustment of the nut 21.

A passage 22 opens into the cylinder 19 at the outer end of the piston 18, that is, on the side of the piston opposite to that side which is subjected or open to discharge pressure from the discharge passage 3. The passage 22 has communication through a valve chamber 23 and a passage 24 with the suction passage 2 of the pump. A piston valve 25 is mounted for reciprocatory movement in the valve chamber 23 and to control the flow of liquid pumped through the passage 22 from the cylinder 19. One end of the valve chamber 23 is open to discharge pressure of the pump as shown at 26 so that one end of the valve 25 is subjected to discharge pressure, while the other end of the valve is subjected to suction pressure by means of the passage 24 and a passage 28 formed in the housing of the valve chamber 23. The end of the valve 25 which is subjected to suction pressure is also subjected to regulated tension pressure by means of a spring 29 which engages the end of the valve 25 opposite to that subjected to discharge pressure. The tension of the spring 29 is regulated by an adjusting tension nut 30.

The piston 18 has a pressure equalizing port 31 extending therethrough, the purpose of which will be brought out in the following description of the operation of the pump capacity varying or regulating means.

During normal operation of the pump, when the discharge pressure of the pump is at or below a predetermined desired discharge pressure for the work to be performed, the combined pressure of the suction pressure fluid and the spring 29 will be sufficient to hold the piston valve 25 in closed position (as shown in Figure 1 of the drawings) against the action of the discharge pressure of the pump; and at such time, the piston 18 will be in its lowermost position, being held therein by the pressure of the spring 20 and the pressure of liquid or fluid which leaks into the

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cylinder 19 through the pressure equalizing port 31. At this time, the stator 9 will be held in the position shown in Figure 1 of the drawings, that is, with a maximum degree of eccentric relationship between the bore 8 of the stator and the perimeter of the rotor 4. At this time the pump will operate at full discharge capacity.

In the event the discharge pressure builds up beyond the desired discharge pressure for the work to be performed, such increased discharge pressure will act upon the valve 25 and move the valve upward against the combined pressure of the spring 29 and of the suction fluid acting upon the valve. This opening movement of the piston valve 25 will permit fluid to flow through the port 22 from the cylinder 19 to the pump suction at a greater rate than the discharge pressure fluid can flow through the equalizing opening or port 31, and thus the pressure on opposite sides of the piston 18 will become unbalanced, causing the discharge fluid or liquid at the higher pressure to force the piston 18 upwardly and rotate the stator 9. It will be appreciated that any degree of pressure rise less than the pressure difference required to cause maximum movement of the piston 18 will result in partial movement of the piston 18 with partial rotation of the stator 9 between the amount of rotation required to move the stator so that the perimeter of its bore 8 and the perimeter of the rotor 4 will be in true concentric relation, but when these members are in true concentric relation the pump will be operating at zero capacity. Thus it will be seen that through the effects of the pressure difference between the suction pressure of fluid entering the pump and the discharge pressure of fluid leaving the pump, above a predetermined degree controlled by the adjustment of the tensions of the springs 20 and 29, the discharge capacity of the pump will be regulated in increments corresponding to this pressure difference and thus the pump will automatically be adjusted to operate at various percentages of its full discharge capacity from full load or capacity to zero capacity or unloaded condition.

As the discharge pressure of the pump reduces, due to reduced discharge capacity and load conditions, the spring 29 will move the valve 25 to cut off communication between the passage 24 and the cylinder 19 and the pressure above the piston 18 will quickly become equal to the discharge pressure of the pump through the bleeding of discharge pressure fluid through the pressure equalizer port or opening 31. When the fluid pressure on the opposite sides of the piston 18 is equalized, the spring 29 will force the piston 18 downwardly, and, consequently, move the connecting arm or rod 15 and the stator back to the normal position shown in Figure 1 of the drawings, and the pump will discharge at its full discharge capacity. The degree of speed of return of the stator to its normal full capacity operating position may be regulated by regulating the size of the bleeder port or opening 31. Thus by reducing the size of this port to a certain capacity flow, a delayed action in the return of the stator to its normal full capacity operating position may be provided, and consequently the speed of movement of the parts may be regulated by regulating the speed of flow of the discharge fluid through this bleeder port 31.

In Figures 4 to 8 of the drawings, the improved pressure difference actuated pump capacity varying means is shown as applied to what is com-

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mercially known as a rotary gear pump embodying herringbone gears which form the rotative positive displacement piston of the pump.

This form of pump includes a casing 40 having a suction inlet 41 and a discharge outlet 42 between which are positioned a pair of normally intermeshing herringbone gears 43 and 44. The driving gear 43 is mounted on a shaft 45 which is rotated by any suitable type of prime mover (not shown) and during full capacity operation of the pump it meshes with the driven gear 44 to provide the pumping action of the pump.

In the form shown in the drawings, the driven gear 44 is mounted upon a stub shaft 46 which is in turn supported by a suitable bearing collar 48 rotatable in a recess 49 in the housing 40. The bearing collar 48 has a crank thereon in the form of an eccentrically mounted disc 50 (see Figures 4 and 5 of the drawings) so that rotation of the eccentric 50 will vary the distance between the axes of the driving shaft 45 and the driven stub shaft 46, and, consequently, vary the distance between the axes of the driving herringbone gear 43 and the driven herringbone gear 44, resulting in a variation of the degree of surface meshing of the teeth of the two gears, and, consequently, vary the discharge capacity of the pump. Figure 6 shows the gears in full tooth surface meshing arrangement at which time the pump will operate at full discharge capacity, while Figure 7 of the drawings shows them in partial surface meshing engagement, namely, of such a degree as to result in zero discharge capacity operation of the pump. The portion of the casing 40 in which the driven gear 44 rotates has its bore 51 shaped so as to accommodate the movement of the driven gear 44 relative to the driving gear 43 for the varying of the capacity of the pump.

The crank or eccentric 50 is connected by a connecting rod 52 to a piston 53. The piston 53 is mounted for reciprocatory movement in a cylinder 54, one end of which is open to discharge pressure in the pump, while the other end is open to suction pressure of the pump through a passage 55 when the valve 56 is open. The valve 56 and the piston 53 are identical, both in structure and operation, with the piston 18 and valve 25 described in connection with the form of the invention shown in Figures 1 to 3 of the drawings, so that when the pressure difference between the suction pressure of the pump and the discharge pressure of the pump rises above a predetermined degree regulated by the tension of the spring 57 which corresponds to the spring 29, the valve 56 will be opened by the action of discharge fluid pressure of the pump, thus causing a pressure difference on opposite sides of the piston 53 so that the piston 53 will be moved by discharge pressure to rotate the crank or eccentric 50 and move the driven gear 44 to vary the relationship between the driving and driven gears of the pump to vary the discharge capacity of the pump from full load capacity to zero load capacity in accordance with the pressure difference between the suction pressure and the discharge pressure of the pump.

Figures 9 and 10 of the drawings show a still further modification of a positive displacement rotary pump of variable capacity. The pump shown in Figures 9 and 10 is of the spur or single helical gear rotary pump in contradistinction to the herringbone or double helical gear type shown in Figures 4 to 8 inclusive.

In the pump structure shown in Figures 9 and 10 of the drawings, a pair of spur or single helical gears 60 and 61 comprise the rotary piston of the

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pump. The spur gear 60 is mounted upon the driving shaft 62 which is driven by any suitable type of prime mover (not shown) and it meshes with and drives the driven spur or single helical gear 61. The gears 60 and 61 are mounted in a casing 63 having a suction inlet passage 64 and a discharge outlet passage 65.

The driven spur gear 61 is mounted on a stub shaft 66 which is rotatably carried by a bearing block 67. The bearing block 67 is mounted for longitudinal sliding movement in the casing 63 of the pump, as clearly shown in Figure 10 of the drawings, and it has a liner 68 attached thereto which is contacted by the periphery of the teeth of the driven spur gear 61. The bearing block 67 is movable longitudinally of the axis of the spur gear 61 so as to move the spur gear 61 longitudinally relative to the driving spur gear 60 to vary the degree of surface meshing contact between the driving and driven spur gear to vary the discharge capacity of the pump. A spring 69 engages the casing 63 and the slidable bearing block 67 and is tensioned so that it, together with the pressure of discharge fluid which leaks through the pressure equalizing ports 70 into the chamber 71, will counterbalance the normal desired discharge pressure of the pump in the chamber 72 at the opposite end of the slidable bearing block 67.

A valve chamber 74 is formed in the casing 63, and it has one end open to the discharge passage 65 of the pump as shown at 75. A sliding piston valve 76 is mounted in the valve chamber 64 and it controls the flow of discharge pressure from the discharge outlet 65 of the pump through the passage 77 into the chamber 72, that is, against the end of the bearing block 67 opposite to that against which the spring 69 engages. A passage 78 admits suction pressure fluid to the valve chamber 74 against the end of the valve opposite to the end which is subjected to discharge pressure of the pump, and this suction pressure together with the tensioned pressure applied against the sliding valve 76 by the spring 79 holds the valve 76 in closed position until such time as the discharge pressure in the pump exceeds the combined suction pressure and the tensioned pressure of the spring 79; that is, until the discharge pressure exceeds the desired operating pressure. When this occurs, the valve 76 is moved to open the passageway 77 and permit discharge fluid to flow into the chamber 72 and move the sliding block 67 in proportion to the pressure difference between the pressures on the opposite ends of the bearing block so as to shift the driven spur gear 61 and vary the discharge capacity of the pump. The movement of the spur gear 61 against the action of the pressure fluid in the chamber 71 causes a reduction in the length of tooth contact of the spur gear 60 and 61, with a resultant reduction of liquid displacement. As soon as the discharge pressure drops to the desired point, or below the combined suction pressure and tension pressure of the spring 79, the spring 79 will close the pilot or distributing valve 76, and the pressure on each end of the slidable bearing block 67 will equalize or balance through the pressure equalizing holes 70, and the spring 69 will return the bearing block and the spur gear 61 to their original normal positions, as shown in Figure 10 of the drawings, and full discharge capacity of the pump will be re-established.

It will be understood that the invention is not to be limited to the specific construction or ar-

rangement of parts shown, but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. In a positive displacement rotary pump, means for varying the discharge capacity of the pump including a cylinder, a piston in said cylinder, tensioned pressure applying means in said cylinder and applying tensioned pressure against one end of said piston, the other end of said piston being subjected to discharge pressure of the pump, said piston provided with a pressure equalizing port extending therethrough to allow bleeding of discharge pressure fluid into the cylinder against the end of the piston subjected to the tensioned pressure, and means operated upon a rise in the pressure difference between the suction and discharge pressures beyond a predetermined degree to overcome the pressure equalization on opposite ends of the piston to allow movement of the piston by discharge pressure fluid, and means operated by movement of the piston to vary the discharge capacity of the pump.

2. In a positive displacement rotary pump, means for varying the discharge capacity of the pump including a cylinder, a piston in said cylinder, tensioned pressure applying means in said cylinder and applying tension pressure against one end of the piston, the other end of the piston being subjected to discharge pressure of the pump, said piston provided with a pressure equalizing port extending therethrough to allow bleeding of discharge pressure fluid into the cylinder against the end of the piston subjected to said tensioned pressure, a distributing valve, means whereby said distributing valve will be operated upon a rise in the pressure difference between the suction and discharge pressures of the pump beyond a predetermined degree to permit flow of fluid from said cylinder to overcome the pressure equalization on the opposite ends of the piston to allow movement of the piston, and means operated by movement of the piston to vary the discharge capacity of the pump.

3. In a positive displacement rotary pump including a casing, a driving rotary piston and a driven rotary piston cooperating therewith, of means for varying the discharge capacity of the pump including a cylinder, a piston in said cylinder, tensioned pressure applying means in said cylinder and applying tensioned pressure against one end of said piston, the other end of said piston being subjected to discharge pressure of the pump, said piston provided with a pressure equalizing port extending therethrough to allow bleeding of discharge pressure fluid into the cylinder against the end of the piston subjected to said tensioned pressure, means operated upon a rise in the pressure difference between the suction and discharge pressures of the pump beyond a predetermined degree to overcome the pressure equalization on the opposite ends of the piston for allowing movement of the piston by discharge pressure fluid, and means operated by movement of the piston to vary the discharge capacity of the pump.

4. A positive displacement pump as claimed in claim 1 wherein said piston operated means for varying the discharge capacity of the pump comprises, an eccentric, a piston rod pivotally connected to said eccentric and to said piston for rotating the eccentric by movement of the piston to vary the discharge capacity of the pump, and adjustable means acting upon said pressure difference actuated means whereby said pressure

difference actuated means may be regulated to be operated by various predetermined pressure differences between the suction and discharge pressures of the pump.

5. In a positive displacement rotary pump embodying a casing provided with an inlet and outlet passage, a stator mounted for limited rotary movement in said casing, said stator provided with a cylindrical bore arranged eccentrically of the axis of rotation of the stator, a rotary piston in said eccentric cylindrical bore, sliding vanes carried by said rotary piston and engaging the wall of said eccentric cylindrical bore, means for varying the discharge capacity of the pump by varying the degree of eccentricity between the perimeter of the rotary piston and the eccentric cylindrical bore of the stator, a cylinder carried by said pump casing and having communication with the inlet and outlet of the pump, a reciprocating piston in said cylinder and subject to discharge pressure on its outer end, means for equalizing the pressure against both ends of said piston, a valve controlling communication of said cylinder with the inlet of said pump, means holding said valve closed during normal operation of the pump and to allow opening of the valve when the pressure difference between the suction and discharge pressures of the pump rise above a predetermined amount, the opening of said valve acting to open the cylinder to the pump suction to break down the equalized pressure on the opposite ends of said piston whereby said piston will be moved by discharge pressure of the pump when said valve is opened, and means connecting said piston and said stator to rotate the stator relative to the rotor upon movement of the piston to vary the discharge capacity of the pump.

6. In a positive displacement rotary pump embodying a casing provided with an inlet and outlet passage, a stator mounted for limited rotary movement in said casing, said stator provided with a cylindrical bore arranged eccentrically of the axis of rotation of the stator, a rotary piston in said eccentric cylindrical bore, sliding vanes carried by said rotary piston and engaging the wall of said eccentric cylindrical bore, means for varying the discharge capacity of the pump by varying the degree of eccentricity between the perimeter of the rotary piston and the eccentric cylindrical bore of the stator, a cylinder carried by said pump casing and having communication with the inlet and outlet of the pump, a reciprocating piston in said cylinder and subject to discharge pressure on its outer end, means for equalizing the pressure against both ends of said piston, a valve controlling communication of said cylinder with the inlet of said pump, means holding said valve closed during normal operation of the pump and to allow opening of the valve when the pressure difference between the suction and discharge pressures of the pump rise above a predetermined amount, the opening of said valve acting to open the cylinder to the pump suction to break down the equalized pressure on the opposite ends of said piston whereby said piston will be moved by discharge pressure of the pump when said valve is opened, and means connecting said piston and said stator to rotate the stator relative to the rotor upon movement of the piston to vary the discharge capacity of the pump, said pressure equalizing means embodying adjustable means whereby the pressure equalizing means may be regulated to be operated by various predetermined degrees of pressure difference between the suction and discharge pressures of the

pump, tensioned means for applying tensioned pressure against said valve, and adjustable means for regulating the tension of said tensioned applying means.

ALBERT M. SHAW.

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