Nov. 11, 1947.  A. ZISKA  2,430,753

PUMP

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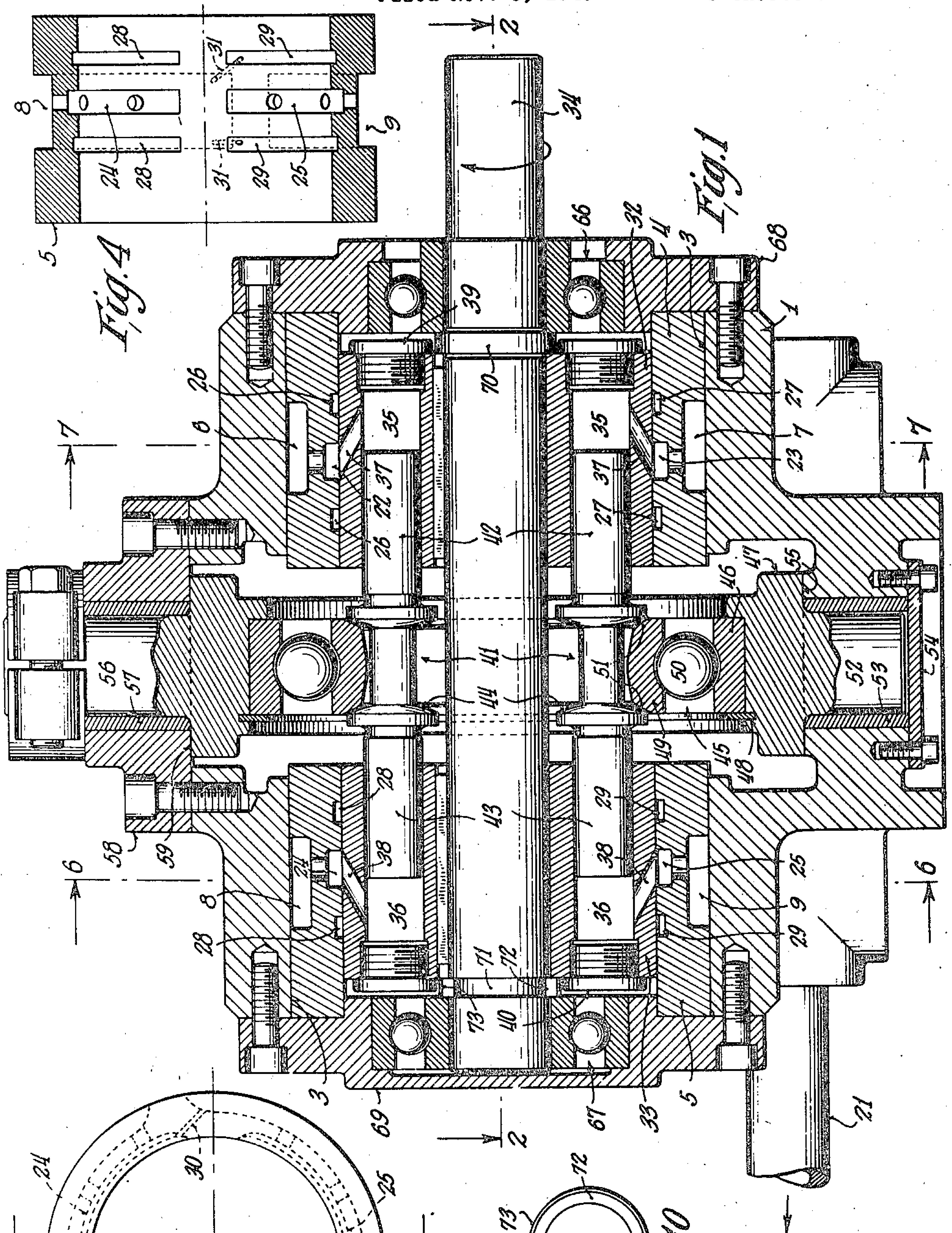


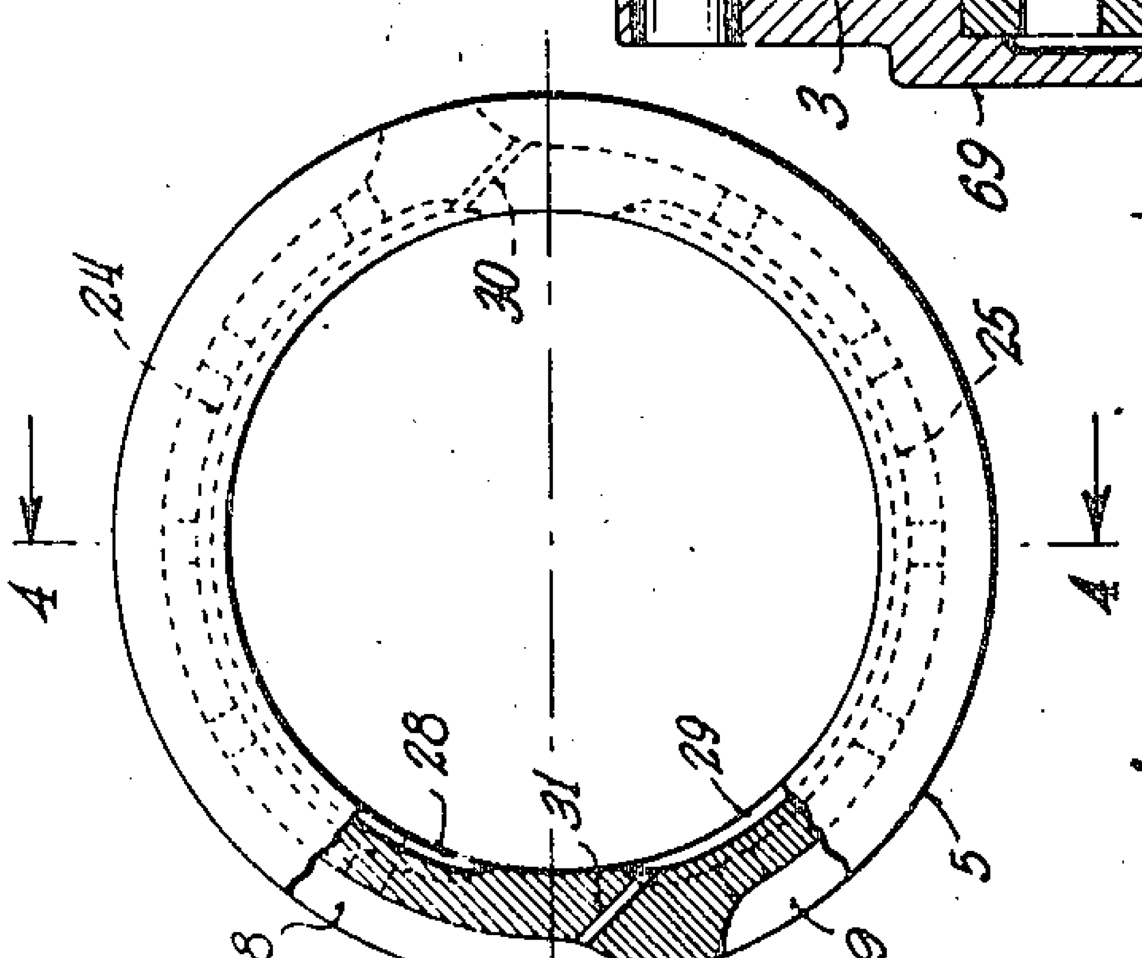


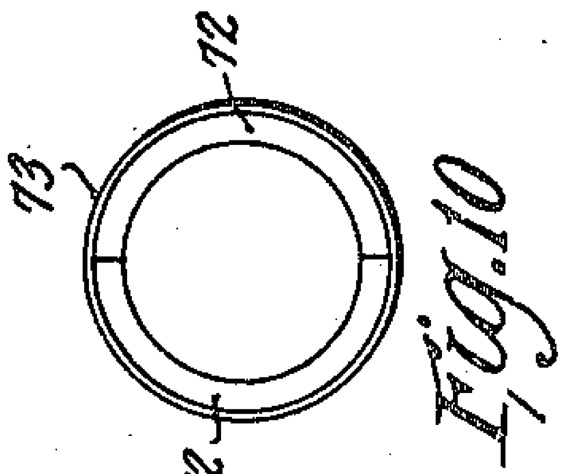


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Fig. 2

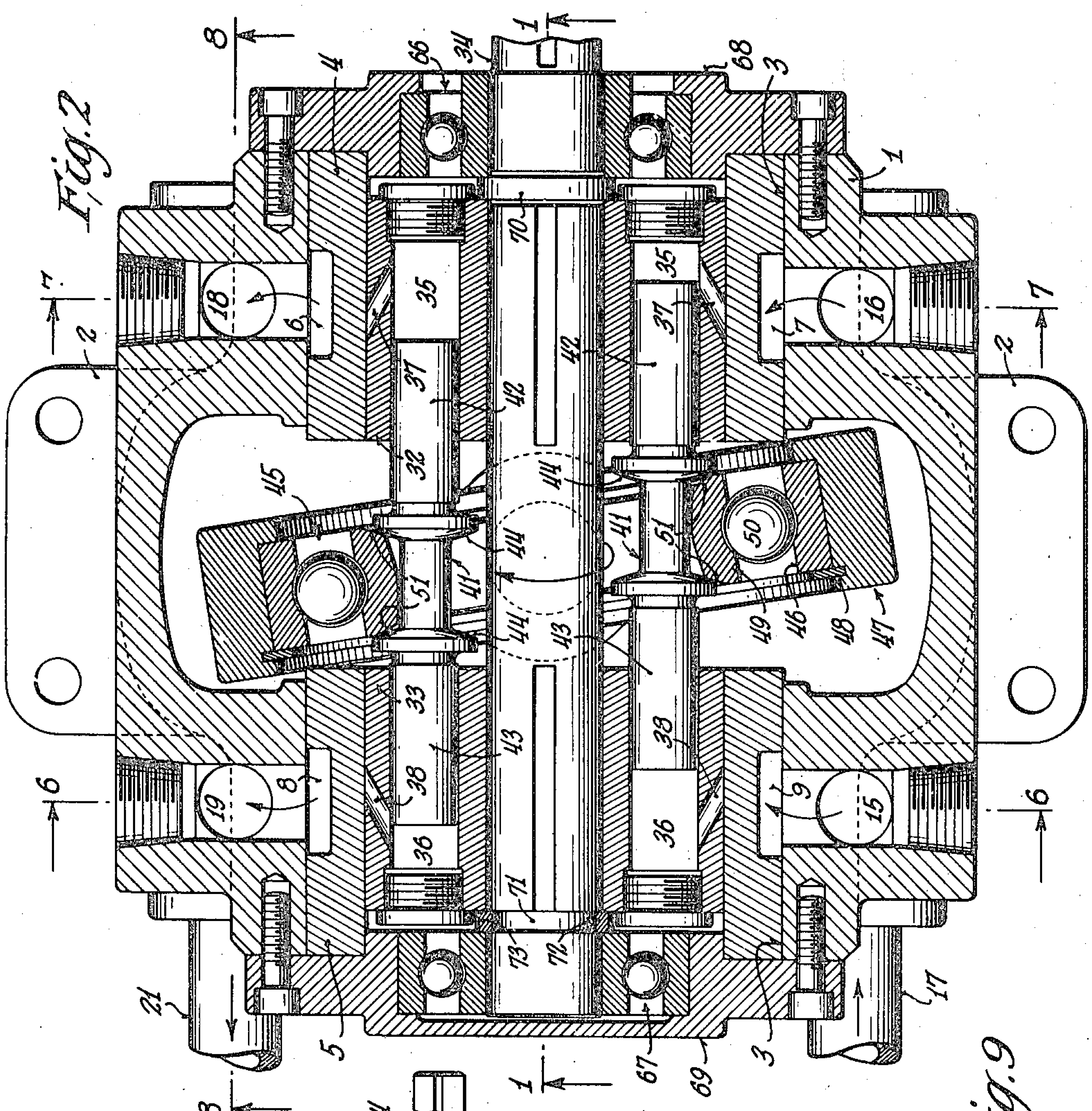


Fig. 5

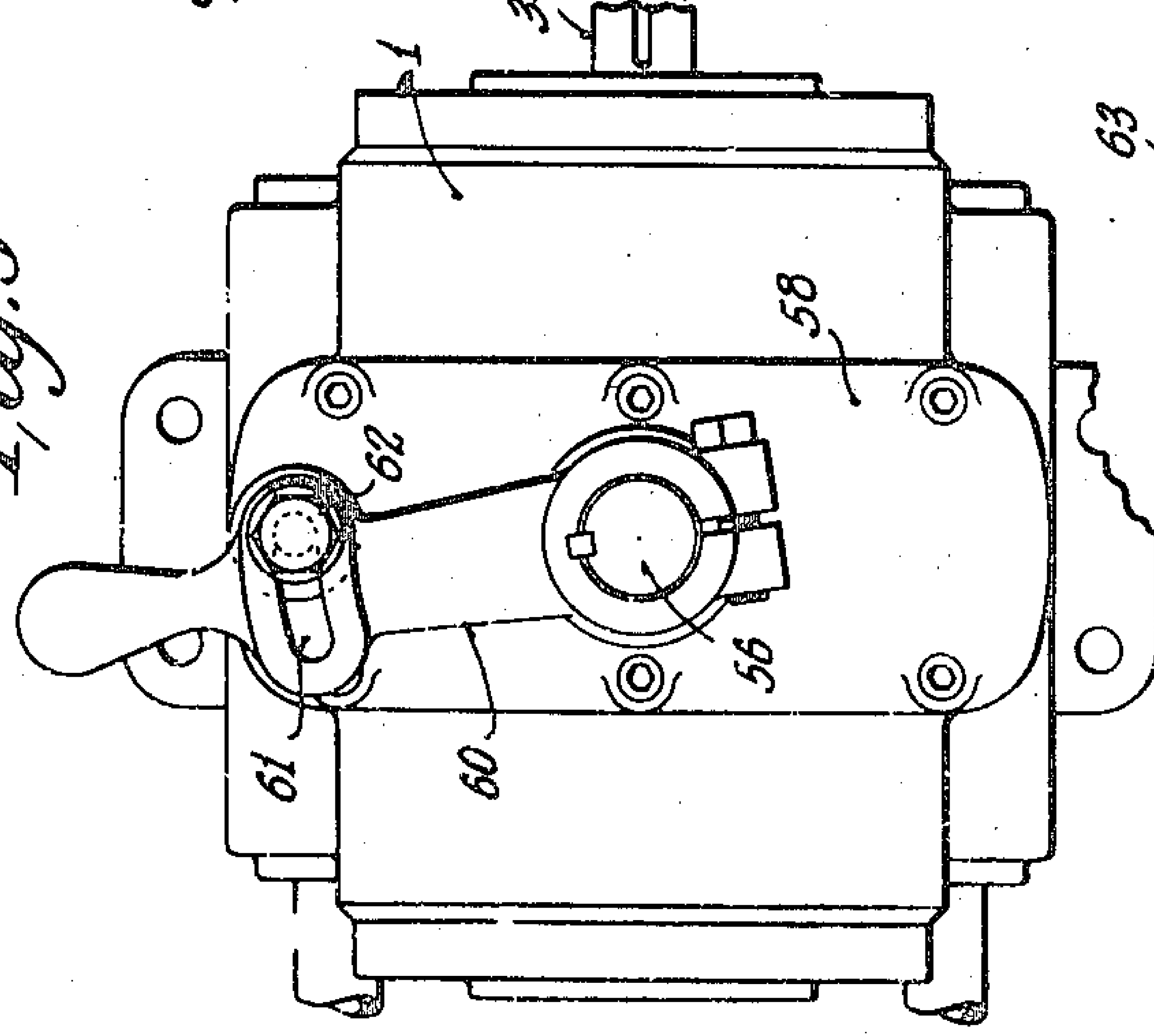
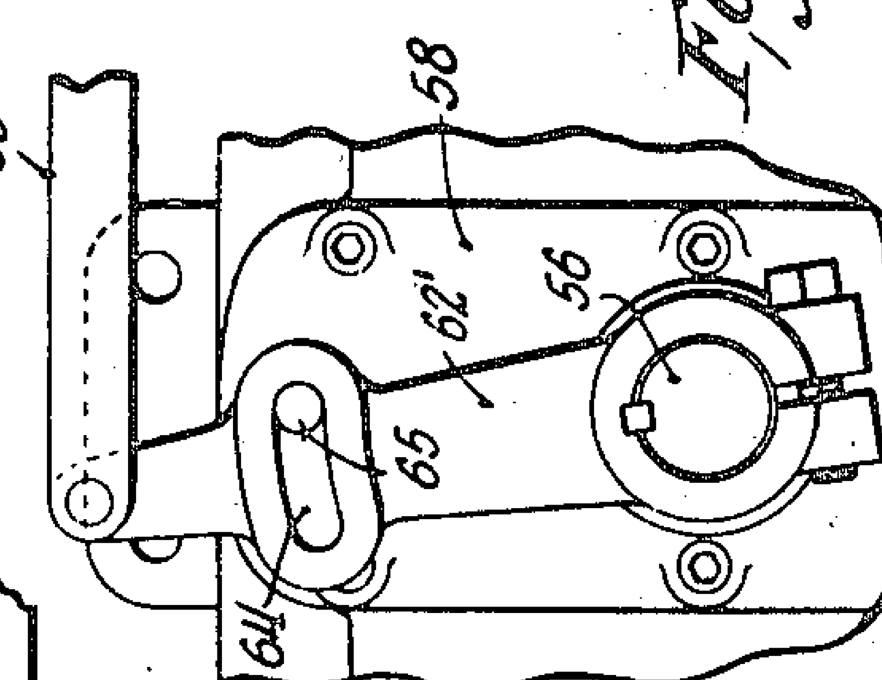


Fig. 9



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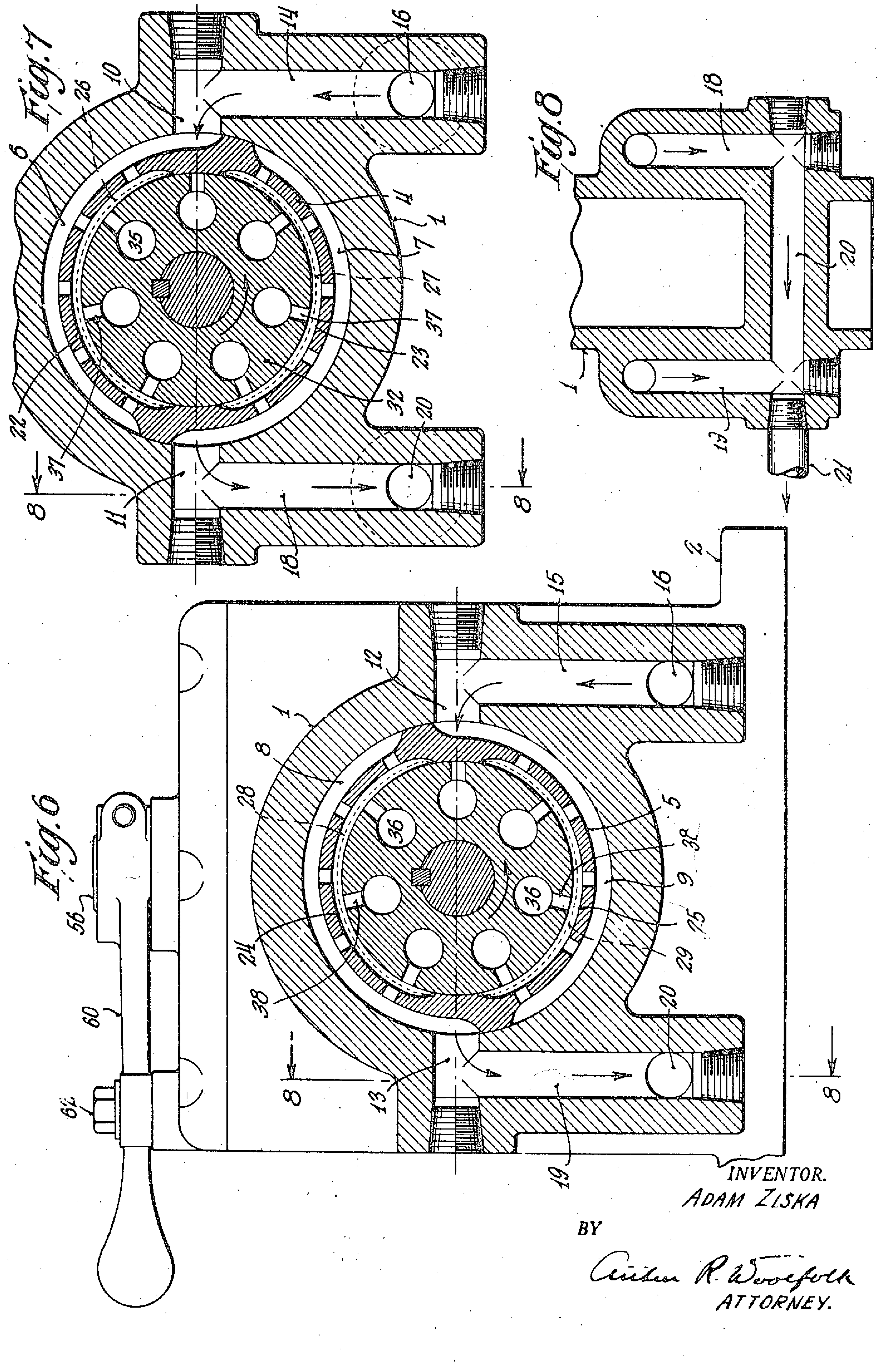


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Patented Nov. 11, 1947

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# UNITED STATES PATENT OFFICE

2,430,753

## PUMP

Adam Ziska, Wauwatosa, Wis.

Application November 8, 1943, Serial No. 509,343

13 Claims. (Cl. 103—162)

1

This invention relates to pumps.

Objects of this invention are to provide a pump in which the cylinders are arranged in a revolving rotor and the pistons reciprocate back and forth in the cylinders parallel to the axis of rotation of the rotor, and to so arrange the parts that mechanically the entire rotating assembly is accurately balanced about the center of rotation.

Further objects are to provide a pump having the cylinders formed in a revolving rotor and the pistons located within the cylinders, which is so arranged that the hydraulic pressures on diametrically opposed sides at each end of the rotor are balanced so that there is no pressure due to the hydraulic pressure transmitted to the main bearings of the shaft of the rotor, and to so arrange the cylinders that the reaction due to hydraulic pressure axially of the shaft is balanced so that there will, therefore, be no end thrust at either end of the shaft due to hydraulic pressure, thus minimizing friction and wear at the bearings and on the revolving rotor.

Further objects are to provide a pump adapted to pump fluid and primarily designed to pump a liquid such as oil, which is so made that the pump may be made in a very small physical size and yet will have a relatively large capacity, and to so design the pump that it can be used to produce any desired pressure up to a very high pressure if so desired.

Further objects are to provide a pump having rotating cylinders with pistons therein, in which a piston controlling member in the form of a ball bearing is carried by a pivotally mounted yoke and is arranged to engage the pistons between the active ends thereof and to cause the pistons to oscillate back and forth to any desired extent to thereby control the volume of liquid displaced by the pump, and to so arrange the apparatus that the pump is reversible by merely rocking the yoke about its pivotal axis, the yoke when in neutral position causing cessation of pumping.

Further objects are to provide a pump having rotating cylinders with pistons therein which is so arranged that no charging mechanism is required but instead in which the pistons while executing pumping action at one end are executing a positive suction action at the other end.

In greater detail, objects of this invention are to provide a pump having a series of rotating cylinders with pistons therein which is so made that there are two sections of the rotor with the two series of pistons, a section being located at each end of the rotor with the pistons actuated intermediate their ends, and to so construct the parts of the pump that they may be produced by simple turning and boring operations without requiring elaborate coring.

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Further objects are to provide a pump of the above defined character which is very simple to make and which, as has been indicated, may be produced by simple machine shop methods without requiring any special apparatus whatsoever.

Embodiments of the invention are shown in the accompanying drawings, in which:

Figure 1 is a vertical sectional view through the pump, such view corresponding to a section on the line 1—1 of Figure 2 with the parts, however, arranged in their neutral position.

Figure 2 is a horizontal sectional view on the line 2—2 of Figure 1 with the parts, however, arranged in one of their pumping positions.

Figure 3 is a view of the left-hand ring, such view being partly in section.

Figure 4 is a sectional view on the line 4—4 of Figure 3.

Figure 5 is a top plan view of the pump, such view being drawn to a smaller scale and showing the means for controlling the pump.

Figure 6 is a sectional view on the line 6—6 of Figures 1 and 2, the direction of flow of the liquid being in accordance with the position of the parts shown in Figure 2.

Figure 7 is a sectional view on the line 7—7 of Figures 1 and 2, the direction of flow of the liquid being in accordance with the position of the parts shown in Figure 2.

Figure 8 is a sectional view on the line 8—8 of Figures 2, 6 and 7, the direction of flow of the liquid being in accordance with the setting of the parts shown in Figure 2.

Figure 9 is a fragmentary top plan view of a modified form of control means for the pump.

Figure 10 is a view drawn to a reduced scale showing the semicircular keys for locking the left-hand end of the shaft against displacement to the left as viewed in Figure 1.

Referring to the drawings, it will be seen that the pump comprises a body portion 1 which may be provided with oppositely projecting apertured feet 2 whereby it may be secured to any suitable support. The body portion is bored straight through from end to end to provide the cylindrical bore 3. Within this bore a right-hand ring 4 and a left-hand ring 5 are located and have a pressed fit and form a unitary portion of the body portion of the device. These right and left-hand rings are provided respectively with arcuate channels 6, 7, 8 and 9 respectively. The channels 6, 7, 8 and 9 extend approximately half way around each of the rings, as shown most clearly in the sectional views of Figures 6 and 7. Ports are formed in the body portion communicating with the channels by drilling straight across the body portion, as shown in Figures 7 and 8. The holes are subsequently plugged by the threaded plugs shown in Figures 6 and 7. The ports are indicated by the reference characters 10, 11, 12 and 13. The ports 10 and 12 communicate by means of passageways 14 and 15 with a transverse passageway 16 which in turn communicates with a pipe 17. These ports may be drilled and the openings not used may be closed by means of screw threaded plugs as shown. The ports 11 and 13 communicate by means of passageways 18 and 19 with a transverse passageway 20 which in turn communicates with the pipe 21, see Figure 2. These passageways may be drilled if desired and the ends not used may be closed by means of screw threaded plugs as indicated.

The rings 4 and 5 are provided with inner channels on opposite sides thereof. These inner channels are indicated respectively by the reference characters 22, 23 and 24, 25. The inner channels 22, 23 and 24, 25 communicate respectively, by means of a plurality of openings as shown, with the outer channels 6, 7, 8 and 9. The rings 4 and 5 are also respectively provided with pairs of channels 26, 27 and 28, 29. These inner pairs of channels are pressure or thrust balance channels as will appear hereinafter. It is to be distinctly understood, however, that in place of having the channels arranged in pairs, a single channel may replace each of the pairs of channels 26, 26, 27, 27, 28, 28 or 29, 29, provided such channel is twice as wide as and coextensive with a single one of the channels. It is preferable, however, to have these channels arranged in pairs and located symmetrically on opposite sides of the main channels 22, 23 and 24, 25. It is to be noted that the channels 26, 27 and 28, 29 appear in Figures 6 and 7 in dotted lines and are almost complete semicircles.

In the ring 4 the pressure balancing channels 26 are located on opposite sides of the channel 22 and the pressure balancing channels 27 are located on opposite sides of the channel 23. In the ring 5 the pressure balancing channels 28 are located on opposite sides of the channel 24 and the pressure balancing channels 29 are located on opposite sides of the channel 25. The channels 26 communicate with the channel 7 and the channels 27 communicate with the channel 6 in the ring 4. In the ring 5 the channels 28 communicate with the channel 9 and the channels 29 communicate with the channel 8.

The manner in which this communication is obtained is shown for the left-hand ring in Figures 3 and 4. It will be seen in reference to Figure 3, for instance, that the channel 9 communicates with the channels 28 by means of the slanting passageways 30 and that the channel 8 communicates with the channels 29 by means of the slanting passageways 31. The right-hand ring has the same channels, not shown, which, as stated, place the channel 7 in communication with the channels 26 and the channel 6 in communication with the channels 27.

The sum of the widths of the channels 26 is equal to the width of the channel 23 and the sum of the widths of the channels 27 is equal to the width of the channel 22 for the ring 4, and similarly for the ring 5 the sum of the widths of the channels 28 is equal to the width of the channel 25 and the sum of the widths of the channels 29 is equal to the width of the channel 24 and they are all co-extensive in length.



The purpose for the above described construction is apparent when it is considered that the pressure in the balancing channels 26 is the same as the pressure in the channel 23 and the pressure in the balancing channels 27 is the same as the pressure in the channel 22 for the right-hand ring 4, and for the left-hand ring the pressure in the balancing channels 29 is the same as the pressure in the channel 24 and the pressure in the balancing channels 28 is the same as the pressure in the channel 25. From this it will be seen that the thrust applied at diametrically opposite portions on the two main sections of the rotor hereinafter described is identically the same and consequently no transverse thrust or pressure due to the liquid pressure is transmitted to the ball bearings supporting the rotor and the ball bearings supporting the rotor are, therefore, called upon only to sustain the weight of the rotor and are not called upon to sustain any unbalanced pressure due to the hydraulic pressure generated by the pump. Thus it will be seen further that the channels 26, 27 and 28, 29 are in reality thrust balancing channels.

The rotor comprises a right and a left-hand portion 32 and 33 respectively. These rotor sections are rigidly keyed as shown to the shaft 34 which may be driven in any suitable manner. The right-hand section 32 of the rotor is provided with a plurality of cylinders 35, and the left-hand section 33 of the rotor is provided with a plurality of cylinders 36. A slanting passageway or port 37 extends outwardly from each of the cylinders 35 and opens outwardly through the external periphery of the right-hand section 32 of the rotor. Similarly the cylinders 36 are each provided with slanting passageways 38 which open outwardly through the outer periphery of the left-hand section 33 of the rotor. The outer ends of the cylinders 35 are closed by means of threaded plugs 39 and the outer ends of the cylinders 36 are closed by means of the threaded plugs 40.

A plurality of double-ended pistons are provided and are indicated generally by the reference character 41. These pistons are provided with piston portions 42 at their right-hand ends and piston portions 43 at their left-hand ends which respectively fit within the cylinders 35 and 36. The intermediate portions of the pistons 41 are reduced and each piston carries a pair of flange members 44 located on opposite sides of the reduced portion.

A piston controlling or reciprocating member in the form of a ball bearing indicated generally by the reference character 45 is positioned centrally of the pump. This piston controlling member consists of an outer race 46 which has a pressed fit with a yoke 47. It is held in place by means of the ring 48 which may, if desired, be a split ring. The inner race of the piston controlling member 45 is indicated by the reference character 49 and between the two races a plurality of balls 50 are positioned. The inner race 49 clears the central reduced portion of the piston 41 and the inner race is provided on opposite sides with inwardly slanting faces 51 which engage the curved faces of the flanges 44 of the pistons. During operation of the pump the inner race 49 travels around with the pistons.

It is to be noted that the yoke 47 is provided with a lower trunnion 52 which is mounted within a bushing 53 in the body portion 1 and the hole in which the sleeve 53 is mounted is closed by means of a bottom plate 54. The yoke is provided with a bottom collar portion 55 which rests on a shoulder formed on the body portion 1, as shown in Figure 1. The upper end of the yoke is provided with an upper trunnion 56 which is carried within a bushing 57 which in turn is carried by a cap 58 secured to the upper side of the body portion 1, as shown in Figure 1. The upper portion of the yoke is provided with an upper collar portion 59 which bears against a suitable shoulder formed on the cap 58. The bushings 53 and 57 are pressed into place in accordance with the usual practice. The trunnion 56 extends outwardly beyond the collar 58 and may be provided, as shown in Figure 5, with an operating handle or member 60 rigidly secured thereto as shown and provided with an arcuate slot 61 through which a locking bolt 62 passes. This hand lever is adapted to be shifted to either side of center to thus rock the yoke into the extreme position shown in Figure 2 on one side of center or to rock the yoke into the extreme position on the other side of center or to any intermediate positions, or to hold the yoke in a neutral position as shown in Figure 1.

Any other suitable means may be provided for rocking the yoke. For instance, the operating member 62′ shown in Figure 9 may be actuated by means of a link 63 connected to any automatic control means or to a manual control means as desired. The member 62′ is provided with an arcuate slot 64 and the cap 58 carries a limit pin 65 to limit the extreme rocking motion of the member 62 on opposite sides of center.

The shaft 34 is carried at opposite ends by ball bearings indicated generally at 66 and 67. The ball bearing 66 is carried in the right-hand end plate 68 and the ball bearing 67 is carried in the left-hand end plate 69. The shaft is prevented from moving to the right as viewed in Figure 1 by means of the integral collar 70 which is adapted to coact with the inner race of the ball bearing 66 to prevent right-hand shifting of the shaft. The left-hand end of the shaft is provided with a groove 71 within which an annular split key 72 is seated. This split key is surrounded by means of a ring 73 which is pressed on to the key and holds the two halves of the key 72 in place as shown most clearly in Figure 10. The annular key 72 is adapted to coact with the inner race of the ball bearing 67 to prevent left-hand shifting of the shaft 34.

It is to be understood that the coacting parts of the pump are accurately ground and are accurately fitted. The pump is adapted to pump any fluid but is primarily designed to pump a liquid and is adapted to produce any desired pressure even up to a very high hydraulic pressure.

The operation of the apparatus is as follows: Assume that the pump is being driven in the direction indicated by the arrows in Figures 1, 2, 6 and 7, and that the piston controlling member indicated generally at 45 has been rocked to the position shown in Figure 2. It will be seen that during the rotation of the rotor, the upper half of the rotor is pumping on the left-hand end of the pump and the lower half of the rotor is pumping on the right-hand end of the pump. The pistons 41 are traveling to the left as viewed in Figure 2 for the upper half portion of the rotor and consequently are pumping liquid out of the cylinders 36 of the rotor section 33. The liquid is discharged from the cylinders 36 through the



passageways 38 into the channel 24 and from this channel it is discharged into the channel 8. The channel 8 communicates with the channel 19 and the channel 20 and finally with the discharge pipe 21. On the lower half of the left-hand end of the pump the pistons 41 are traveling to the right as viewed in Figure 2 and are sucking liquid from the inlet pipe 17 through the channels 16 and 15 and the arcuate channels 9 and 25. On the right-hand end of the pump on the lower half thereof the pistons 41 are traveling to the right as viewed in Figure 2 and consequently are pumping liquid from the cylinders 35 through the apertures 37 into the channel 23 and from there into the channel 7. The liquid is discharged through the channels 18 and 20 to the discharge pipe 21. On the upper half of the right-hand portion of the pump the pistons are traveling to the left as viewed in Figure 2 and consequently are drawing liquid into the cylinders 35 through the inlet pipe 17 and through the channels 16 and 14 through the annular channels 6 and 22.

The pressure downwardly on the left-hand portion of the rotor, see Figure 6, due to the fluid under pressure in the channel 24 is transmitted to the balancing channels 29 diametrically opposed the channels 24 and and coextensive both in length and in total width with the channel 24. Consequently these two pressures are balanced and consequently the thrust due to the pressure of the liquid is not transmitted to the shaft 34. Similarly on the right-hand portion of the pump the force acting on the rotor due to the pressure in the channel 23 is exactly balanced by the pressure on the rotor due to the pressure of the liquid in the channels 26 and consequently no thrust is imparted to the shaft due to the hydraulic pressure as the channels 26 are coextensive in total width and length with the channel 23. If the piston controlling member is moved to the other side of center from that shown in Figure 2, the pressure of the liquid in the channels 25 and 28 for the left-hand portion of the rotor and the pressure in the channels 22 and 27 for the right-hand end of the rotor will exactly balance in exactly the same manner and for the same reasons as that previously described, and consequently no thrust will be imparted to the shaft.

The balancing is complete for each section of the rotor and there is no lateral thrust tending to rock the shaft laterally about a point intermediate its ends. In addition to this the shaft has no longitudinal thrust imparted thereto due to the pressure of the liquid. The right and left-hand rotor sections 32 and 33 bear respectively against the collar 70 and the annular key 72 and the thrusts in opposite directions imparted to the members 32 and 33 of the rotor are exactly equal and consequently are balanced and there is, therefore, no tendency to drive the shaft in either direction axially of the shaft.

The supporting ball bearings indicated generally at 66 and 67 are therefore not called upon to carry any thrust in any direction due to the pressure of the liquid.

In addition to this it is to be noted particularly that the right-hand ring 4 does not withstand any thrust from the rotor 32 due to fluid pressure and similarly the left-hand ring 5 does not withstand any thrust from the rotor due to fluid pressure as is apparent from the above description.

The result of this accurate balancing of hydraulic pressure is that there is the minimum wear between the right and left-hand sections of the rotors 32 and 33 and the right and left-hand rings 4 and 5 respectively, and there is also the minimum wear on the bearings supporting the shaft 34.

It is to be noted further that the pistons 41 are guided and supported at opposite ends and consequently at widely spaced points. Therefore there is no tendency of the pistons to tilt.

It is apparent that there is a slight oscillatory or back and forth rotary motion imparted to the piston causing the pistons to oscillate about their axes when the piston controlling member 45 is moved to either side of the neutral position shown in Figure 1 as the flange members 44 ride either further out or further in on the inner race 49 of the piston controlling member 45. This imparts, as stated, a slight oscillatory or rotary motion to the pistons back and forth about their longitudinal axes and consequently insures uniform wear between the pistons and the walls of their cylinders.

Another important feature of the pump forming the subject matter of this invention is that there is no tendency due to hydraulic pressure to rock the yoke about its vertical axis out of position. It is to be noted that the yoke 47 is pivoted about a vertical axis and when it is rocked to one side or the other of neutral position, the pistons executing pumping motion are symmetrically positioned on opposite sides of this vertical axis for each end of the rotor. Thus it is possible to shift the piston controlling member to either side of neutral with a minimum effort. There is a tendency to rock the yoke about a horizontal axis but in view of the fact that the trunnions 56 and 52 are widely spaced and are relatively large, it is apparent that this tendency is readily resisted.

It is to be noted also that there are no unbalanced masses which would tend to cause vibration about the longitudinal axis of the shaft even when the pump is run at a high speed.

Another point of considerable importance in the actual manufacture of the pump is that practically all of the main surfaces are easily machined. For instance the main body portion of the pump is bored straight through from end to end and the rings 4 and 5 are readily turned on a lathe and are bored out from end to end. Also it is to be noted that the cylinders are formed by drilling straight through each section of the rotor.

It is to be noted also that though the pump is rotated in one direction, nevertheless the flow of fluid through the pump may be reversed or may be stopped entirely by respectively shifting the yoke to one or the other side of neutral or moving the yoke back to neutral. It is to be noted also that the yoke may be shifted from neutral to maximum on either side of center to thus cause the pump to pump the liquid at any desired rate from zero up to its maximum capacity.

It will be seen that the pump forming the subject matter of this invention can be used to produce any desired pressure even up to a very high pressure.

It will be seen that the pump forming the subject matter of this invention is so organized that the forces are balanced and consequently minimum wear results. It will also be seen that the pump may be very readily produced by simple machine shop operations.

It is to be noted that the pistons are positively driven in both directions and consequently the



pistons execute a positive suction action at one end while they compress the liquid at the other end and thus there is no necessity for a charging mechanism to charge the cylinders with oil.

It is to be understood that although a ball bearing has been shown, any suitable type of anti-friction bearing could be employed for the piston controlling member. Obviously, other changes could be made where they do not affect the spirit of the invention and, therefore, although this invention has been described in considerable detail, it is to be understood that such description is intended as illustrative rather than limiting, as the invention may be variously embodied and is to be interpreted as claimed.

I claim:

1. A pump comprising a cylindrical rotor having a plurality of cylinders therein, pistons mounted within the cylinders, means for reciprocating the pistons as the rotor rotates, a body portion surrounding the rotor and having arcuate suction and delivery channels on opposite sides of the rotor arranged for successive communication with the cylinders as the rotor rotates and having open sides closed by the cylindrical surface of the rotor, said body portion having at least one thrust balancing channel diametrically opposite the delivery channel and directly communicating with the delivery channel and having an open side closed by the cylindrical surface of the rotor, whereby the pressure produced in the delivery channel is transmitted directly to the thrust balancing channel diametrically opposite the delivery channel.

2. A pump comprising a cylindrical rotor having a plurality of cylinders therein, pistons mounted within the cylinders, said pistons and said cylinders having their axes paralleling the axis of rotation of the rotor, means for reciprocating the pistons as the rotor rotates, a body portion surrounding the rotor and having arcuate suction and delivery channels on opposite sides of the rotor arranged for successive communication with the cylinders as the rotor rotates and having open sides closed by the cylindrical surface of the rotor, said body portion having at least one thrust balancing channel diametrically opposite the delivery channel and directly communicating with the delivery channel and having an open side closed by the cylindrical surface of the rotor, whereby the pressure produced in the delivery channel is transmitted directly to the thrust balancing channel diametrically opposite the delivery channel.

3. A pump comprising a cylindrical rotor having a plurality of cylinders therein, pistons mounted within said cylinders, means for reciprocating said pistons as said rotor rotates, a body portion surrounding said rotor and having arcuate delivery and suction channels on opposite sides of said rotor arranged to successively communicate with said cylinders as the rotor rotates and having open sides closed by the cylindrical surface of said rotor, said body portion having at least one thrust balancing channel diametrically opposite the delivery channel and axially spaced from the suction channel and communicating with the delivery channel and having an open side closed by the cylindrical surface of the rotor.

4. A pump comprising a cylindrical rotor having a plurality of cylinders therein, pistons mounted within said cylinders, means for reciprocating said pistons as said rotor rotates, a body portion surrounding said rotor and hav-

ing arcuate delivery and suction channels on opposite sides of said rotor arranged to successively communicate with said cylinders as the rotor rotates and having open sides closed by the cylindrical surface of said rotor, said body portion having a pair of thrust balancing channels diametrically opposite the delivery channel and communicating therewith and located on opposite sides of said suction channel and having open sides closed by the cylindrical surface of said rotor.

5. A pump comprising a rotor formed in two sections spaced apart axially and provided with cylinders with their axes parallel to the axis of rotation of the rotor and with the cylinders of one section in alignment with the cylinders in the other section, a plurality of pistons each having rigidly related piston portions at opposite ends positioned in the cylinders of the two sections of said rotor, a body portion surrounding the two sections of said rotor and having suction and delivery channels successively communicating with said cylinders as said rotor rotates, an anti-friction bearing having races located between the sections of said rotor and pivoted about an axis transverse to the axis of said rotor and adapted to rock in either direction with reference to a neutral plane, said pistons having portions intermediate their ends coacting with one of the races of said anti-friction bearing to cause said pistons to reciprocate axially of said rotor as said rotor rotates when said anti-friction bearing occupies a position at an angle to said neutral plane.

6. A pump comprising a rotor formed in two sections spaced apart axially and provided with cylinders with their axes parallel to the axis of rotation of the rotor and with the cylinders of one section in alignment with the cylinders in the other section, a plurality of pistons each having rigidly related piston portions at opposite ends positioned in the cylinders of the two sections of said rotor, a body portion surrounding the two sections of said rotor and having suction and delivery channels successively communicating with said cylinders as said rotor rotates, an anti-friction bearing having inner and outer races surrounding said pistons and located between the two sections of said rotor, said pistons having spaced flanges intermediate the ends of said pistons engaging the inner race of said anti-friction bearing, and a member holding the outer race of said anti-friction bearing and pivoted about an axis transverse to the axis of said rotor.

7. A pump comprising a rotor formed in two sections spaced apart axially and provided with cylinders with their axes parallel to the axis of rotation of the rotor and with the cylinders of one section in alignment with the cylinders in the other section, a plurality of pistons each having rigidly related piston portions at opposite ends positioned in the cylinders of the two sections of said rotor, a body portion surrounding the two sections of said rotor and having suction and delivery channels successively communicating with said cylinders as said rotor rotates, an anti-friction bearing having inner and outer races surrounding said pistons and located between the two sections of said rotor, said pistons having spaced flanges intermediate the ends of said pistons engaging the inner race of said anti-friction bearing, a yoke holding the outer race of said anti-friction bearing and pivoted about an axis transverse to the axis of said rotor, and



means for rocking said yoke in either direction with reference to a neutral plane.

8. A pump comprising a rotor formed in two sections spaced apart axially and provided with cylinders with their axes parallel to the axis of rotation of the rotor and with the cylinders of one section in alignment with the cylinders in the other section, a plurality of pistons each having rigidly related piston portions at opposite ends positioned in the cylinders of the two sections of said rotor, a body portion surrounding the two sections of said rotor and having suction and delivery channels successively communicating with said cylinders as said rotor rotates, an anti-friction bearing having inner and outer races surrounding said pistons and located between the two sections of said rotor, said pistons having spaced flanges intermediate the ends of said pistons engaging the inner race of said anti-friction bearing, a yoke holding the outer race of said anti-friction bearing and pivoted about an axis transverse to the axis of said rotor, means for rocking said yoke to either direction with reference to a neutral plane, and means for locking said yoke in its adjusted position.

9. A pump comprising a cylindrical rotor formed in two sections spaced apart and mechanically tied together and having a plurality of cylinders with the cylinders of one section aligning with the cylinders in the other section, a plurality of pistons each having piston portions at opposite ends positioned in the cylinders of the two sections of said rotor, a body portion surrounding the two sections of said rotor and having arcuate suction and delivery channels for each section of said rotor on opposite sides of the corresponding sections of said rotor and arranged to successively communicate with the cylinders of said rotor and having open sides closed by the cylindrical surface of said rotor, said body portion having at least one thrust balancing channel diametrically opposite each delivery channel and communicating with the corresponding delivery channel and having open sides closed by the cylindrical surface of said rotor, and means coacting with an intermediate portion of said pistons to cause said pistons to reciprocate as said rotor rotates.

10. A pump comprising a cylindrical rotor formed in two sections spaced apart and mechanically tied together and having a plurality of cylinders with the cylinders of one section aligning with the cylinders in the other section, a plurality of pistons each having piston portions at opposite ends positioned in the cylinders of the two sections of said rotor, a body portion surrounding the two sections of said rotor and having arcuate suction and delivery channels for each section of said rotor on opposite sides of the corresponding sections of said rotor and arranged to successively communicate with the cylinders of said rotor and having open sides closed by the cylindrical surface of said rotor, said body portion having a pair of thrust balancing channels diametrically opposite each delivery channel and communicating with the corresponding delivery channel and located on opposite sides of the corresponding suction channel and having open sides closed by the cylindrical surface of said rotor, and means coacting with an intermediate portion of said pistons to cause said pistons to reciprocate as said rotor rotates.

11. A pump comprising a cylindrical rotor having a plurality of cylinders therein, pistons mounted within the cylinders, said pistons and

said cylinders having their axes paralleling the axis of rotation of the rotor, means for reciprocating the pistons as the rotor rotates, a sleeve surrounding the rotor and having arcuate suction and delivery channels on opposite sides of the rotor arranged for successive communication with the cylinders as the rotor rotates and having open sides closed by the cylindrical surface of the rotor, a body portion suurounding said sleeve, said sleeve having at least one thrust balancing channel diametrically opposite the delivery channel and directly communicating with the delivery channel and having an open side closed by the cylindrical surface of the rotor, whereby the pressure produced in the delivery channel is transmitted directly to the thrust balancing channel diametrically opposite the delivery channel.

12. A pump comprising a rotor having a plurality of cylinders therein, pistons mounted within the cylinders, said pistons and said cylinders having their axes paralleling the axis of rotation of the rotor, means for reciprocating the pistons as the rotor rotates, a sleeve surrounding the rotor and having arcuate inner suction and delivery channels on opposite sides of the rotor and having discharge and entrance channels on the outer side of said sleeve communicating respectively with said delivery and suction channels, and a body portion surrounding said sleeve and having inlet and outlet openings communicating with said entrance and discharge channels respectively, said sleeve and body portion having a pressed fit.

13. A pump comprising a cylindrical rotor having a plurality of cylinders therein, pistons mounted within the cylinders, means for reciprocating the pistons as the rotor rotates, a body portion cooperating with the rotor and having diametrically opposed arcuate suction and delivery channels arranged for successive communication with the cylinders as the rotor rotates and having open sides closed by the cylindrical surface of the rotor, said body portion having at least one thrust balancing channel diametrically opposite the delivery channel and communicating with the delivery channel and having an open side closed by the cylindrical surface of the rotor, whereby the pressure produced in the delivery channel is transmitted to the thrust balancing channel diametrically opposite the delivery channel.

ADAM ZISKA.

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| 1,427,740 | Johnson | Aug. 29, 1922 |
| 1,506,892 | Egersdorfer | Sept. 2, 1924 |