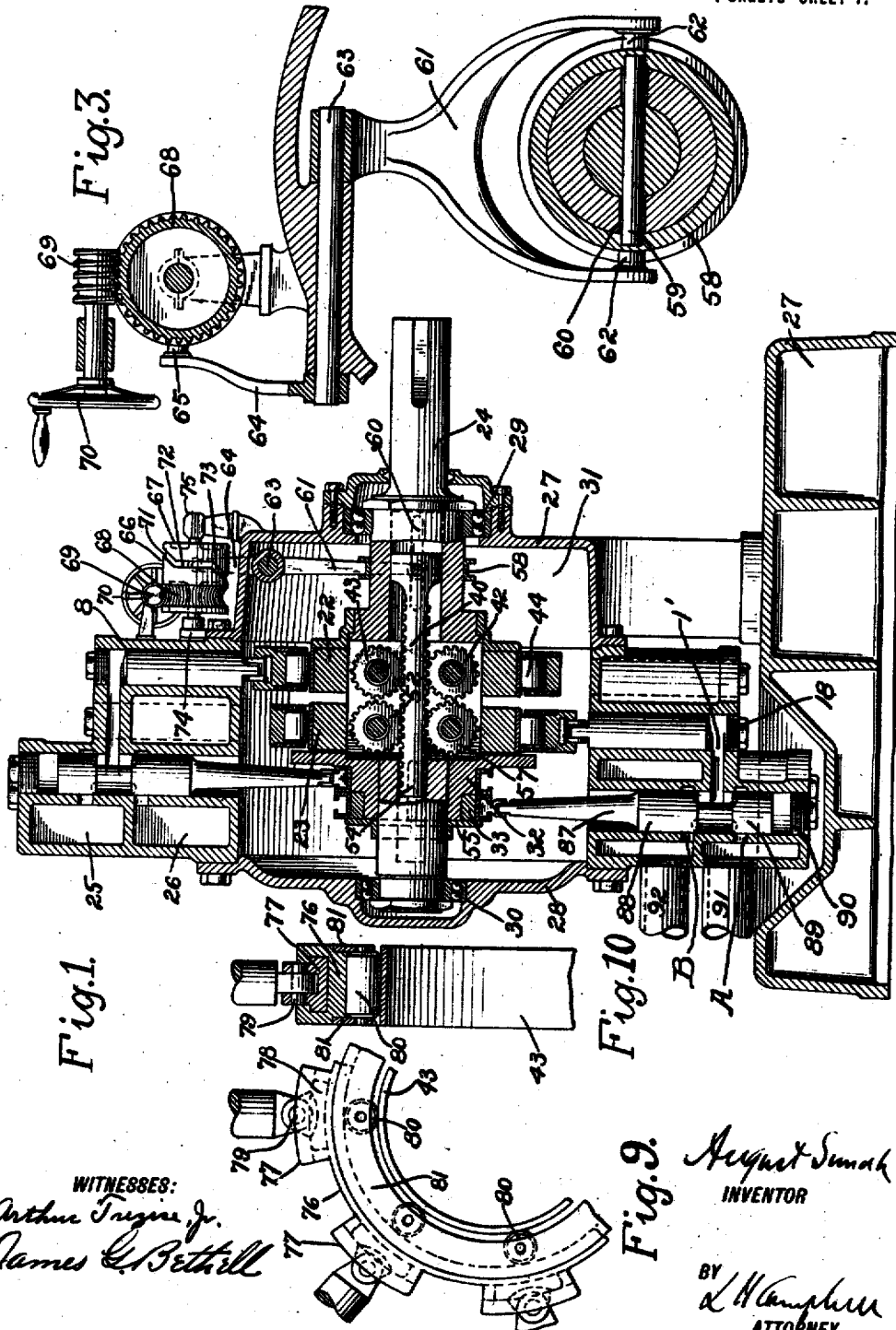


1,239,059.

Patented Sept. 4, 1917.
4 SHEETS—SHEET 1.



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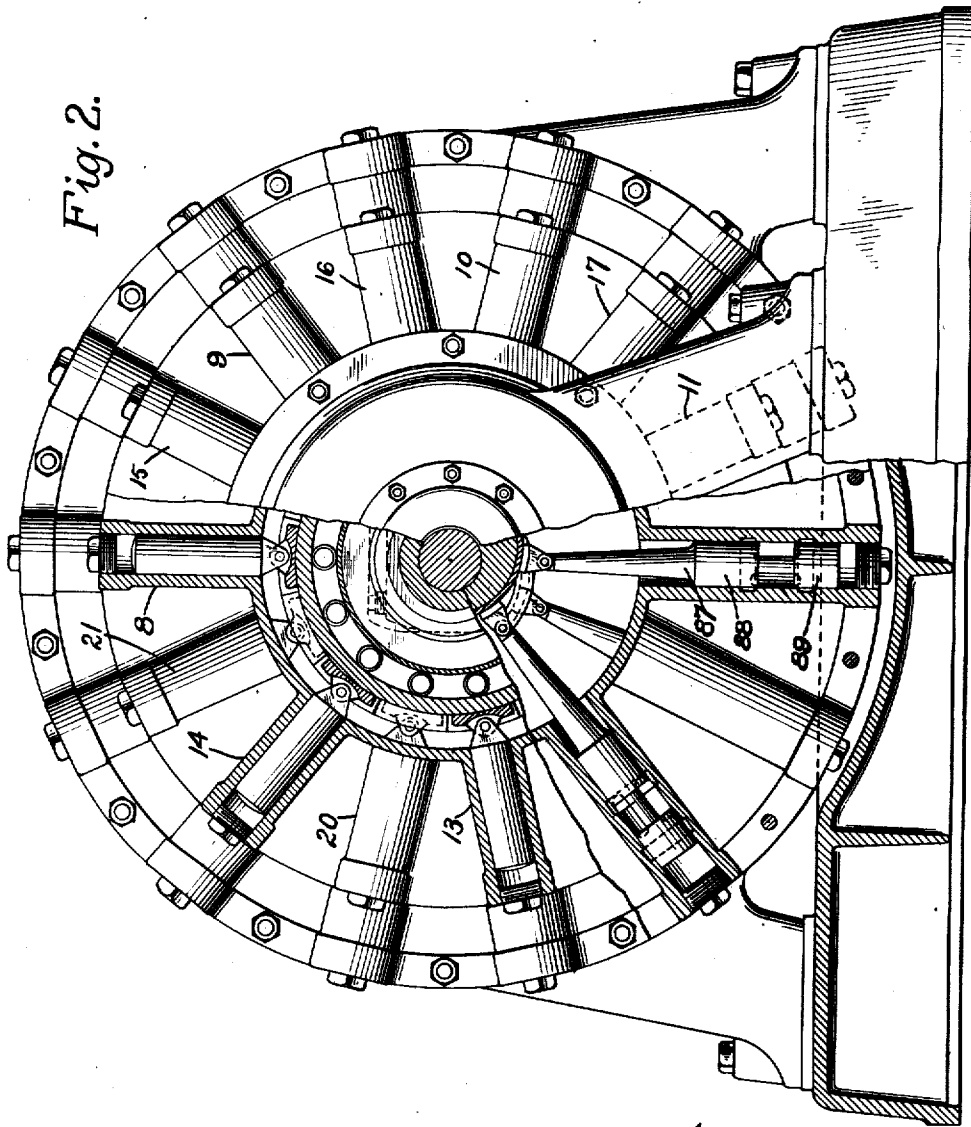
Fig. 9. August Sundh
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4 SHEETS—SHEET 2.



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4 SHEETS—SHEET 3.

Fig. 5.

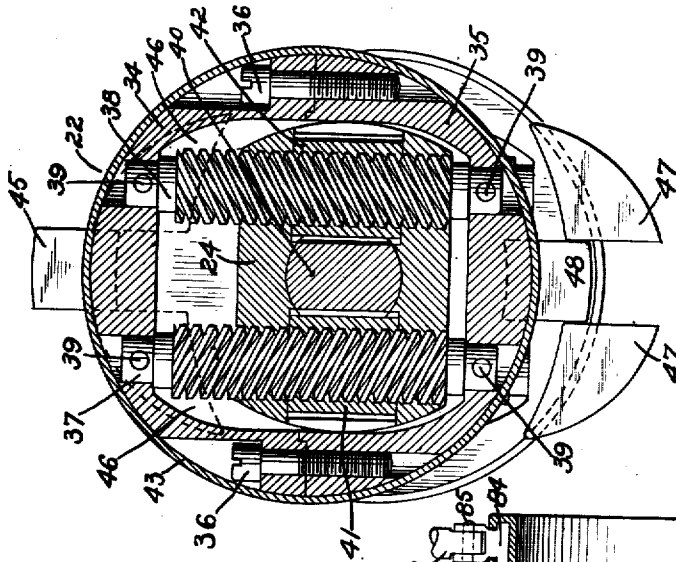


Fig. 4.

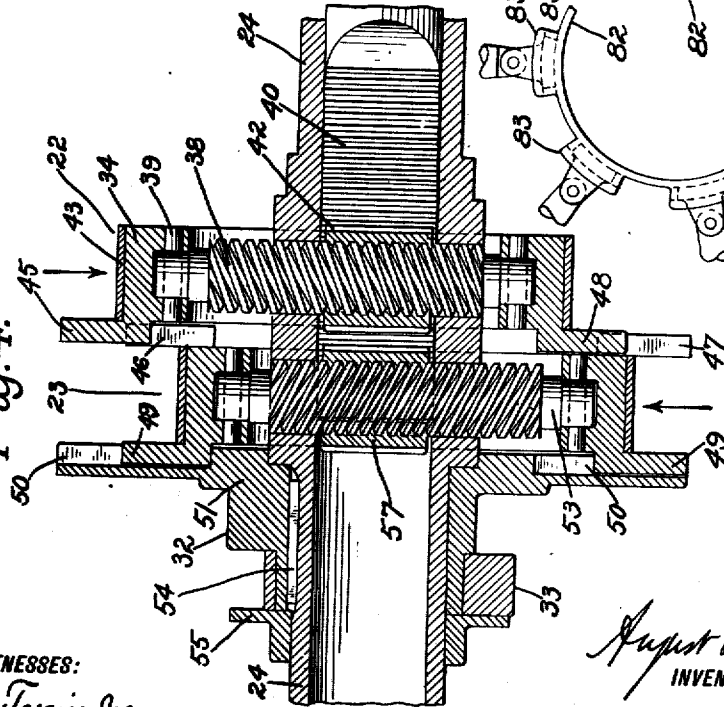
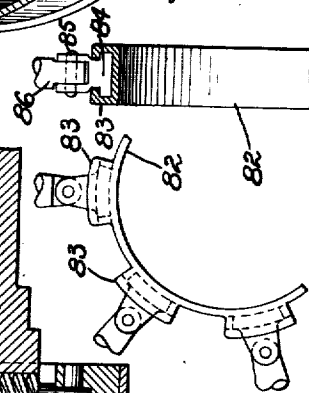


Fig. 11. Fig. 12.



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4 SHEETS—SHEET 4.

Fig. 7.

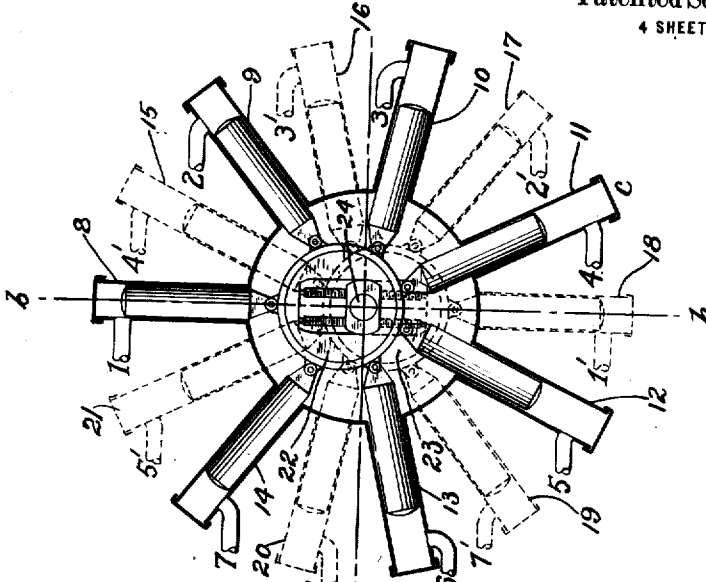


Fig. 6.

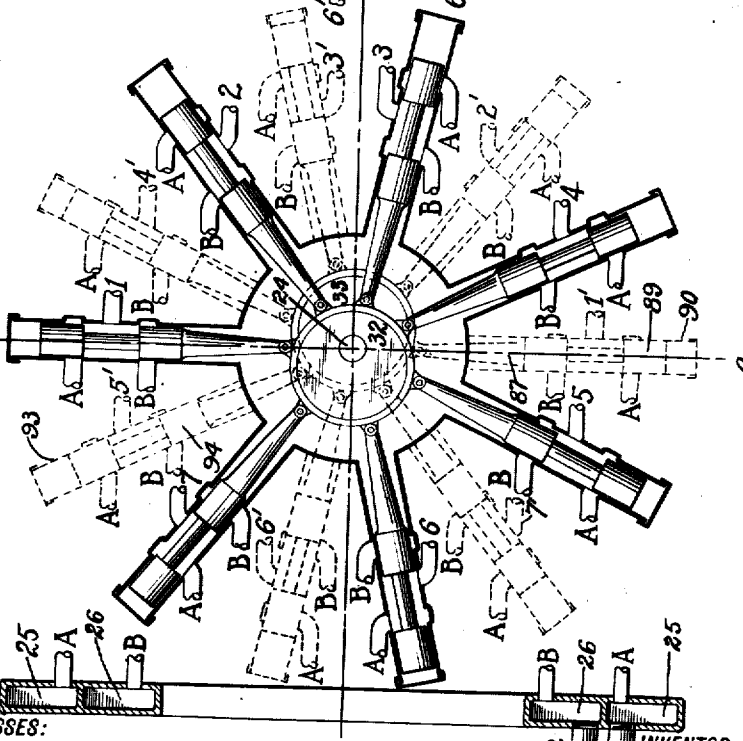
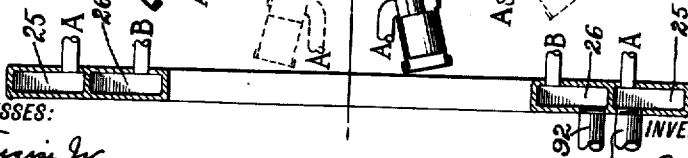


Fig. 8.



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UNITED STATES PATENT OFFICE.

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PUMP.

1,239,059.

Specification of Letters Patent.

Patented Sept. 4, 1917.

Application filed October 13, 1913. Serial No. 794,829.

To all whom it may concern:

Be it known that I, AUGUST SUNDH, a citizen of the United States, residing in Hastings-upon-Hudson, in the county of Westchester and State of New York, have invented a new and useful Improvement in Pumps, of which the following is a specification.

My invention relates to fluid pumps or motors, and more particularly to a reciprocating pump in which the stroke of the pistons or plungers may be varied at will.

One object of the invention is the provision of a multi-cylinder pump in which the thrust of the plungers on a crank shaft is automatically equalized.

Another object is the provision of improved valve mechanism which will avoid churning of the fluid handled by the pump.

Another object is the provision of two sets of pump plungers, the stroke of each set of plungers being capable of equal and simultaneous variation.

Another object of the invention is the provision of a multiple plunger pump, and a center shifting device adapted to vary the stroke of the plungers from zero to a maximum in both directions, and means whereby the center shifting device will positively be held in zero position for an appreciable period of time while the stroke of the plungers is being reversed or moved through a zero or no stroke position.

A further object of the invention is the provision of a reciprocating plunger pump having a center shifting device for variable pump stroke, said center shifting device comprising a pair of eccentrics which may bodily be shifted through zero by a single device, the act of shifting being substantially balanced against fluid pressure.

Other objects of the invention will appear hereinafter the novel combinations of elements being pointed out in the appended claims.

In the accompanying drawings, Figure 1 is a side sectional view of a pump containing an embodiment of my invention; Fig. 2 is a right hand front elevation view of the same in part section; Fig. 3 is a detail view in section of a manual means for effecting the operation of the center shifting device; Figs. 4 and 5 are sectional detail views of the center shifting device taken at right angles to each other; Figs. 6 and

7 are diagrammatic views of the valves and plungers, illustrating the operation of the pump; Fig. 8 is a sectional view of the inlet and exhaust chambers shown in Fig. 1; Figs. 9 and 10 are fragmentary views, taken at right angles to each other, and showing in detail one of the shifting eccentrics and the method of driving the pump plungers thereby; Figs. 11 and 12 are fragmentary views, taken at right angles to each other, and showing one of the fixed eccentrics and the cooperating valve mechanism.

Like reference characters denote similar parts in all of the figures.

Referring to Figs. 1 and 2, it will be seen that the pump therein shown comprises two sets of seven cylinders each and corresponding valves also arranged in two sets, there being seven valves in each set, each cylinder having its own valve. The cylinders of one set are designated by the reference numbers 8, 9, 10, 11, 12, 13 and 14; while the cylinders of the other set are represented by the numerals 15, 16, 17, 18, 19, 20 and 21. Each set of cylinders is operatively connected to a different adjustable eccentric such as 22 and 23, arranged closely side by side on a common crank shaft 24, and each and every cylinder is radially disposed about the axis of the said shaft. The valves for each cylinder are also radially disposed about the crank shaft, and each set of valves is operated by a corresponding eccentric fixed on the shaft 24. The working and valve cylinders, together with the fluid chambers 25 and 26, are preferably cast integral as shown, and this casting is supported upon a substantial bed 27.

The shaft 24 is made in one piece and is supported toward either end in ball bearings 29 and 30, which in turn are supported by the end covers 27 and 28, respectively, secured to opposite ends of the cylinder casting and forming therewith a crank case 31. The plungers of each cylinder together with the corresponding valves are all operated from the shaft 24 by means of the eccentrics 22, 23, 32 and 33. The eccentrics 22 and 23, which are associated with the plungers, are arranged and constructed so as to be shifted in planes perpendicular to the axis of the shaft, so as to reverse the stroke of the plungers and also effect any desired length of stroke from zero to a maximum. These eccentrics are clearly

shown in Figs. 4 and 5, and since their construction is substantially the same, a description of one will answer for both.

The cam 22 is composed of two halves 34 and 35, which are bolted together by the bolts or cap screws 36, 36. A pair of reversely threaded screws 37 and 38 pass through parallel holes in the shaft and each screw is secured at either end to the eccentric by means of pins 39. Threaded upon each of the screws 37 and 38 is a pinion 41 and 42, respectively, each of which snugly fits a recess provided therefor in the shaft 24. The center of the shaft is hollow, and contains a rack 40 which meshes with both of the pinions 41 and 42. Upon the outer periphery of the eccentric 22 is shrunk or otherwise secured a hardened steel ring 43, which assists the bolts 36 in holding the two halves of the eccentric together, and acts as a wearing surface for the anti-friction rollers 44, through which the working plungers are operated. The eccentric 22 is provided at diametrically opposite points with two projections 45 and 48, which have a snug sliding fit with other projections 46 and 47 formed integral with the other cam 23. This construction permits the eccentrics 22 and 23 to slide with respect to each other each in its own plane perpendicular to the axis of the shaft 24, while at the same time prevents a relative displacement of the eccentrics 22 and 23, about the shaft and forms a driving connection between the said eccentrics. The eccentric 23 is provided with projections 49, 49, arranged diametrically opposite each other and slidable in grooves 50, 50, formed in a member 51. The eccentric 23 is provided with a pair of oppositely threaded screws such as the screws 37, and 38, of the eccentric 22, one of which, the screws 56, is shown in Fig. 4, but the screws of the eccentric 23 are reversely threaded with respect to the corresponding screws of the eccentric 22, and each of the screws of the eccentric 23 carry pinions 52 and 57 (see Fig. 1) which mesh with the rack 40. The member 51 is provided with an eccentric 32 and an eccentric 33 arranged side by side and spaced or set at an angle of 180°, or one half revolution, from each other, as clearly shown in Fig. 6. The member 51 is securely keyed to the shaft 24 by a key 54, and kept in proper position against sliding longitudinally of the shaft, by a flanged collar 55. Since the member 51 is keyed to the shaft, and is in driving engagement with each of the eccentrics 22 and 23, through the sliding projections 45, 48, and 49, 49, it follows that the shaft 24 and all four eccentrics must rotate as a unit.

As before pointed out, the eccentrics 22 and 23, are arranged to be varied so as to control the stroke of the plungers, and such variation is effected by means of the rack

40 in the following manner: Referring to Fig. 1, it will be observed that a movement of the rack 40 in a left hand direction causes the pinions 43 and 52 to rotate in a clockwise direction, while the pinions 42 and 57 will rotate in a reverse or anti-clockwise direction. Since the screws upon which these pinions are threaded are fixed against rotation by the pins 39, and since the pinions themselves cannot move within the shaft other than to rotate, it follows that the screws are moved bodily in the direction of their length, carrying with them the corresponding eccentrics. Furthermore, since the screw 53 of the eccentric 23 is reversely threaded with respect to the screw 38 of the eccentric 22, and since the corresponding pinions 42 and 57 are both rotated in the same direction by the rack 40, it follows that the movement or shifting of the eccentrics 22 and 23 is always in a reverse direction, that is to say the throw of one eccentric is always one half revolution, or 180° from the throw of the other eccentric, and the respective throws of each eccentric is always equal.

While various ways could be devised for operating the rack 40 so as to vary the eccentricity of the eccentrics 22 and 23, I prefer the arrangement herein disclosed and illustrated in Figs. 1 and 3. This arrangement comprises a grooved collar 58 which is slidable upon the shaft 24 and is connected to the rack 40 by a pin 59, the latter passing through a slot 60 in the shaft. A yoked lever 61 is provided with pins 62, 62, which rest within the groove of the collar 58, and this lever is secured to a shaft 63 pivoted to the pump casing 27. The shaft 63 also has affixed to it a lever 64, which carries a pin 65 at its upper end adapted to ride in a cam slot 66 formed in a cam cylinder 67. The latter is supported in bearings 74, and 75, and is provided with worm gear teeth 68 which mesh with a worm 69 adapted to be rotated by a hand wheel 70. The cam slot 66 has three distinct parts or portions designated by the reference numbers 71, 72 and 73. The part 72 is circumferential and of considerable length, while the slots 71 and 73 branch out from the slot 72 in opposite directions.

The operation of the center or eccentric shifting device comprising the rack 40 and hand wheel 70, is as follows: Upon turning the hand wheel 70, the cylinder 67 is rotated, but, owing to the length of the circumferential cam slot 72, the pin 65 therein is not at first moved. As the hand wheel continues to turn, one of the cam slots 71 or 73 engages the pin 65 and the latter is moved so as to rock the levers 64 and 61 to the right or left as the case may be. The movement of the lever 61 is transmitted through the pins 62, 62, to the sliding collar 58, and the latter is

caused to slide along the shaft 24, carrying with it the rack 40. In this manner it is possible to move the rack 40 to the right or left as far as it will go, to an intermediate position, and thus vary the eccentricity of both of the eccentrics simultaneously to any desired degree. Owing to the length of the cam slot 72, it will be impossible quickly to reverse the eccentrics 22 and 23, since an appreciable time must elapse before the pin 66 leaves the cam slot 72, when an attempt is made to reverse the pump. In this manner a quick reversal of the pump is not possible and all danger of shock and jar is avoided.

The worm 69 is preferably of very moderate pitch, so as to be irreversible. That is to say, the cam cylinder 67 cannot be moved by the rack no matter what pressure may be brought to bear, but can only be moved when the wheel 70 is turned by hand. Hence it follows that any adjustment to the eccentrics made from the hand wheel remains absolutely fixed just so long as the hand wheel is not disturbed or intentionally rotated.

As before pointed out, each of the eccentrics 22, 23, is operatively connected to a separate set of pump plungers, and this operative connection will now be described. Surrounding each eccentric, such as the eccentric 22, is a ring 76, (see Figs. 9 and 10) which is preferably made of hardened steel and contains a series of radial projections 77, each having a dove-tail peripheral slot. A block 78 is dovetailed in each of these radial projections, and is adapted to have a limited sliding movement therein. The ring 76 has seven equally spaced projections 77, and each of the blocks therein is connected by a pin 79 to a pump plunger. The ring 76 is concentric to the eccentric 22, and a series of anti-friction rollers 80, 80, are interposed therebetween, said rollers being in radial alinement with the various pump plungers and held in this position by means of two rings 81, 81, which embrace either side of the ring 76 and constitute cages for the rollers 80. The eccentric 23 is operatively connected to the seven pump plungers of the other set in precisely the same manner as that just described.

The operative connection between the eccentrics 32 and 33 and the various valves is very much the same as the connections between the eccentrics 22 and 23, and the pump plungers, excepting in the former case, owing to the relatively small thrust between the valves and the valve eccentrics, the anti-friction rollers are left out. This construction is very clearly seen from Figs. 11 and 12, and comprises a ring 82 containing seven equally spaced projections, such as 83, 83, each of which is dovetailed and contains a correspondingly dovetailed block as 84, which is secured by a pin 85 to one end 86 of the valve. The ring 82 surrounds the

eccentric 32 and is in close sliding contact therewith. The pump plungers are all alike in construction and closely fit their respective cylinders, which latter are open ended toward the crank case and closed at the opposite ends by means of screw plugs or other appropriate means. The valves are also similar to each other, and each one, such as the valve 87 (see Figs. 1 and 2), is comprised of two parts or piston valves 88 and 89, which are connected together and thereby form a two-part valve balanced against pressure and requiring a minimum amount of power to operate. The closed end of each plunger cylinder is connected by a passage or port to the center of a corresponding valve. For instance, in Figs. 1, 6 and 7, the lowermost plunger cylinder 18 is connected by a port 1' to the valve 87, said port opening into the valve between the two valve pistons 88 and 89. Other ports such as the ports A and B of each valve are all connected to the fluid chambers 25 and 26, respectively. That is to say, the ports A of all of the valves are in communication through the chamber 25, while the ports B of every valve are in like manner interconnected through the chamber 26. The chambers 25 and 26 are connected through the pipes 91 and 92, to a source of fluid supply and discharge, respectively, or vice versa.

Referring to Figs. 6, 7 and 8, the arrangement of the valves and plunger cylinders is clearly shown in diagrammatic form. The full lines of Figs. 7 and 6, represent one set of seven plungers and the corresponding valves, respectively, while the broken lines represent the other set of plungers, and their corresponding valves. In these figures the mode of operation of the pump may very clearly be seen. Take for example the cylinder 8 shown at the top in Fig. 7. The plunger in this cylinder is shown at the top of its stroke, while the corresponding valve shown at the top of Fig. 6 occupies an intermediate position, with the ports A and B closed and all communication between the plunger cylinder 8 and the chambers 25 and 26, through the port 1 cut off. The same conditions exist with respect to the plunger cylinder 18 of the other set, and its corresponding valve 87. Both of these plungers are in a position of no stroke, or, in other words, on their dead centers. Suppose for example, that the shaft 24 is rotated in a clockwise direction. The piston or plunger of cylinder 18 is moved upwardly by the eccentric 23, while the valve 87 is carried downwardly by the eccentric 33, and the downward movement of the valve causes the valve piston 87 to uncover the port A and thereby place the cylinder 18 in communication with the chamber 25, through the cylinder port 1' and valve port A. The chamber 25 is therefore a suction chamber, and fluid will be sucked

therefrom into the cylinder 18 as the plunger of said cylinder rises. While the cylinder 18 is acting under suction, other cylinders of the same set such as the cylinder 21, is undergoing compression. For instance, as the eccentric 23 rotates in a clockwise direction the plunger of cylinder 21 is moved outwardly and forces the fluid in the cylinder through the port 5' to the valve 93, and through the valve port B into the compression chamber 26, the valve piston 94 having uncovered the valve port B.

The operation of all of the plungers and their respective valves is precisely similar to that just described, with respect to the cylinders 18 and 21. At no time will more than two plungers ever be passing through a dead center at the same time, and the cylinders under suction and compression are so grouped about the shaft that their reaction thereon is distributed uniformly about a circle, which practically eliminates all bending strain on the shaft and reduces the friction at the shaft bearings to a minimum. If the rack 40 of Figs. 1, 4 and 5, be moved so that eccentrics 22 and 23 are concentric with the shaft 24, and the latter be revolved, the pump plungers obviously will remain stationary, and no fluid will be pumped. If the rack 40 be further moved in the same direction, the throw of the eccentrics 22 and 23 will be reversed, and the pump as a whole will work in a reverse direction. That is to say, the chamber 25 which was formerly a suction chamber, now becomes a pressure chamber, while the chamber 26 becomes a suction chamber, and the direction of fluid flow is reversed. The quantity of fluid pumped depends upon the stroke of the pump plungers, which in turn depends upon the amount of eccentricity given the eccentrics 22 and 23. Since the amount of eccentricity of these eccentrics may be varied to any desired amount and the throw of the eccentrics be reversed if desired, it follows that the operator has complete control of the pump through the medium of the hand wheel 70 of Figs. 1 and 3. It never becomes necessary to reverse the direction of rotation of the shaft 24, nor to vary its speed, but it is obvious that the pump could be controlled in that manner if so desired.

It will be observed from Figs. 6 and 7, that the throw or setting of the valve eccentrics is spaced 90° or a quarter revolution from that of the plunger eccentrics, and with this setting the valves will always be in position properly to control the fluid directed to or from the plungers regardless of the adjustment of the plunger eccentrics.

The shifting eccentrics 22 and 23 require very little power to shift them into any desired position during the operation of the pump since the movement of the plungers due to the act of shifting the eccentrics is

not opposed by fluid pressure. The reason why this is so, may be seen by an inspection of Figs. 6, 7 and 8. In Fig. 6, it will be seen that the valves shown in full lines on the right hand side of the center line *a, a*, are all open to the discharge chamber B, so also are the corresponding cylinders 9, 10 and 11, of Fig. 7, whereas the cylinders 12, 13 and 14, are in communication with the suction chamber A. If the line of eccentricity of the eccentrics 22 and 23 which coincides with the line of shifting the eccentrics were at right angles to that shown in Fig. 7, it will be seen that in order to shift the eccentric, the fluid in the cylinders 9, 10 and 11 would have to be forced through the valves and into the discharge chamber B, and if the pump were working against a pressure, this pressure would tend to resist the shifting of the eccentric. In order to permit the stroke to be varied by shifting the eccentrics 22 and 23, I have displaced the line of shifting 90° from the line of eccentricity of the valve eccentrics 32 and 33, or along the line *b, b*, of Fig. 7, and by so doing, I am enabled to shift the eccentrics and consequently the pistons or plungers connected therewith in a direction between the forces set up by fluid pressure acting on the pistons, and in this manner the act of shifting is effected with very little effort and the force required is substantially that required to overcome the mechanical friction of the pistons and other parts.

It is true that were the shaft 24 at rest, it would be possible to have one of the pistons in such position that the corresponding cylinder is cut off from the chambers A and B, by its valve. Under this condition there would be a fluid lock in that particular cylinder and the shifting eccentrics could not be moved. But it is proposed not to attempt to shift the eccentrics at such time, but only when the shaft 24 is rotating, and, in such case the eccentrics may easily be shifted throughout their entire range of movement to either side of center or position of zero stroke.

The pressure of the pump plungers of each set on their respective eccentrics may be resolved into two forces acting at different points on the shaft in opposite directions, and hence these two forces constitute "a couple" tending to rotate the shaft end for end. Since, however, the eccentrics are located very closely together, the tendency of this couple to bend or distort the shaft is for all practical purposes negligible.

In general, a pump constructed according to my invention is particularly adapted for power transmission purposes, wherein it is desirable to effect a variable speed in both directions and where it is desired to have a turning movement or torque inversely proportional to the speed. An example of this

is found in elevator practice where the maximum torque is required in starting the load. In the case of elevators, a constant speed non-reversing alternating current motor could advantageously be connected to drive the pump shaft, and the pump could be connected to a fluid motor such as shown in Patent No. 980,449, issued to me on January 3, 1911, for hydraulic engine. The entire control of the elevator would be effected by means of the hand wheel 70 or other suitable operating mechanism associated with the cam 67, such as an electric or hydraulic motor.

The pump may handle any desired fluid such as oil or water, but in general I prefer to use a good grade of oil which is not appreciably affected by changes in temperature. When oil is used, the entire pump mechanism will be amply lubricated without resorting to oil or grease cups.

By the arrangement of ports and valves herein disclosed, the pump will operate without churning the fluid, which feature is most desirable, and particularly so when oil is used. The fluid is directed between the valves and plunger cylinders through ports or passages which are as short and straight as possible so as not to agitate the fluid any more than possible and to reduce the friction losses in said ports and passages.

While I have disclosed a pump containing an embodiment of my invention in which I use two sets of plungers having seven in a set, it is to be understood that I may use any number of sets and of plungers in a set. However, I prefer to use but two sets, and to use an odd number of plungers in a set, since by such use there are never more than two plungers passing through the dead center at the same time, and the torque is more uniform than where an even number of plungers are employed in a single set.

The pump as shown and described is very compact and occupies but small space, while at the same time it has great capacity. The pump is balanced mechanically and also against fluid pressure, and may therefore be operated at comparatively high speeds without vibration.

The pump may be used as such, or it may be used as a variable speed reversible fluid motor, no changes in the apparatus being necessary to convert it into a motor or engine.

Without limiting myself to the precise arrangement and construction of parts herein set forth, what I desire to have protected by Letters Patent of the United States is:—

1. A variable stroke pump, a plurality of cylinders arranged in two sets, ports for directing the fluid to and from the cylinders, a shaft, pistons in the cylinders, adjustable means operatively connecting the pistons of each set of cylinders with said shaft,

valves for the cylinders, driving means for the valves, and means for varying said adjustable means in both directions from a center so as to vary the direction of flow and amount of fluid pumped by the pistons, and for obtaining an equal and opposite stress on the shaft during the operation of the pump.

2. In a pump of the variable stroke type, two independent groups of cylinders, pistons in the cylinders, a drive shaft, independent means for connecting the pistons of each group with the said shaft, means for varying said connecting means in opposite directions relatively to each other so as to obtain a variable stroke of all of the pistons, said varying means being arranged always to effect equal and opposite stresses on said drive shaft for all positions of the said stroke varying means.

3. A pump comprising a plurality of cylinders each having a piston therein, a shaft, a center shifting device on the shaft connected with said pistons and operable to vary the length of piston stroke from zero to a maximum in both directions, and means to prevent a too sudden reversal of said center shifting mechanism.

4. A pump comprising a plurality of cylinders each having a piston therein, a shaft, a center shifting device on the shaft connected with said pistons and operable to vary the length of piston stroke from zero to a maximum in both directions, and means for maintaining said center shifting device in zero or no stroke position for an appreciable period of time to prevent a too sudden reversal in the flow of the fluid pumped.

5. In a pump, the combination of a plurality of cylinders arranged in two groups, pistons in the cylinders, a drive shaft mechanism connecting said pistons with the drive shaft and consisting of a center shifting device having two independent and conjunctively operated parts, one for the pistons of each group of cylinders, means for controlling said center shifting device and arranged to maintain the same in a position of no stroke of the pistons for an appreciable time during the operation of reversing the stroke of the piston by the center shifting device.

6. In a variable stroke pump, the combination of a shaft, a plurality of cylinders radially disposed about said shaft, a piston in each cylinder, a center shifting device connecting said pistons and the drive shaft, a manually operated device for operating the said center shifting device to vary and reverse the stroke of the pistons, and means associated with said manually operated device for preventing a too sudden reversal of the stroke of the pistons by the center shifting device.

7. A pump comprising a drive shaft, a plurality of cylinders radially disposed about said shaft, pistons for the cylinders, a device connecting said pistons and shaft arranged to effect a variable length of stroke of the pistons and to reverse the stroke of the pistons, and means for preventing a too sudden movement of said device when operated to effect a reversal of stroke of the pistons.

8. A pump comprising a drive shaft, a plurality of cylinders radially disposed about said shaft, pistons for the cylinders, an eccentric on said shaft connected to reciprocate said pistons, means for varying the eccentricity of said eccentric and thereby vary the length of stroke of the pistons and reverse the stroke of the latter, and means for preventing a too sudden movement of said eccentric varying means.

9. A pump having a plurality of cylinders radially disposed about a shaft and arranged in two groups, a piston for each cylinder, a separate eccentric on the shaft connected to the pistons of each group of pistons, screws for varying the eccentricity of each eccentric and thereby vary the length of stroke of the pistons, pinions for operating the screws, and a rack for rotating said pinions.

10. A pump having a plurality of cylinders radially disposed about a shaft and arranged in two groups, a piston for each cylinder, a separate eccentric on the shaft connected to the pistons of each group of pistons, screws for varying the eccentricity of each eccentric and thereby vary the length of stroke of the pistons, pinions for operating the screws, and a single means for simultaneously rotating said pinions.

11. A pump having a plurality of cylinders radially disposed about a shaft and arranged in two groups, a piston for each cylinder, a separate eccentric on the shaft connected to the pistons of each group of pistons, screws for varying the eccentricity of each eccentric, and thereby vary the length of stroke of the pistons, pinions for operating the screws, a rack for rotating said pinions, and a manual controlled device for operating said rack.

12. A pump having a plurality of cylinders radially disposed about a shaft and arranged in two groups, a piston for each cylinder, a separate eccentric on the shaft connected to the pistons of each group of pistons, screws for varying the eccentricity of each eccentric and thereby vary the length of stroke of the pistons, pinions for operating the screws, a rack for rotating said pinions, and a hand operated worm of low pitch for operating said rack.

13. A pump having a plurality of cylinders radially disposed about a hollow shaft, and arranged in two groups, a piston for each cylinder, a separate eccentric on the shaft connected to reciprocate the pistons of each group of cylinders, screws for varying the eccentricity of said eccentrics and thereby vary the length of stroke of the pistons, pinions for operating said screws, and a rack in said hollow shaft adapted to rotate said pinions.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses.

AUGUST SUNDH.

Witnesses:

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WALTER C. STRANG.