

Sept. 17, 1935.

D. MITCHELL, JR

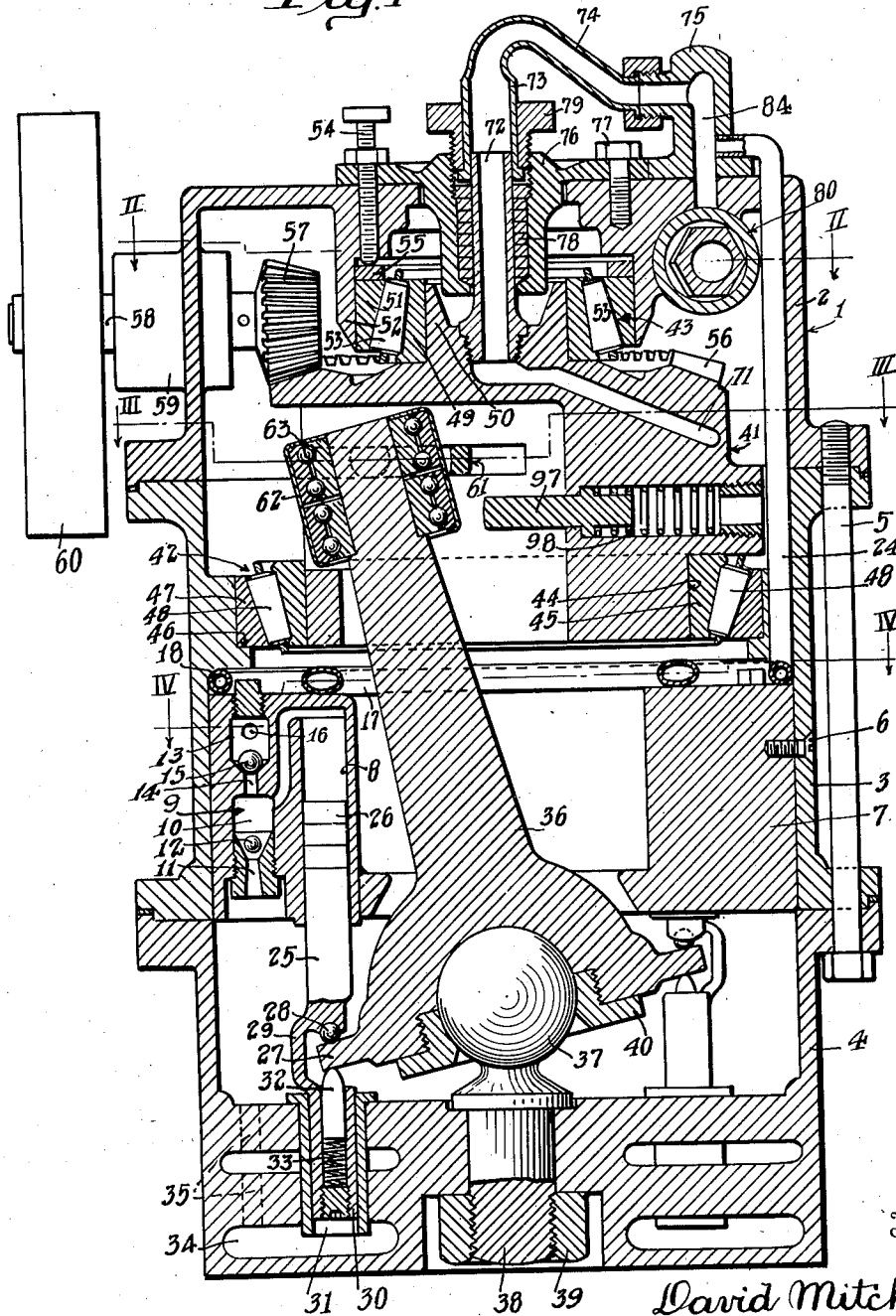
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PUMP

Filed May 22, 1934

5 Sheets-Sheet 1

Fig. 1



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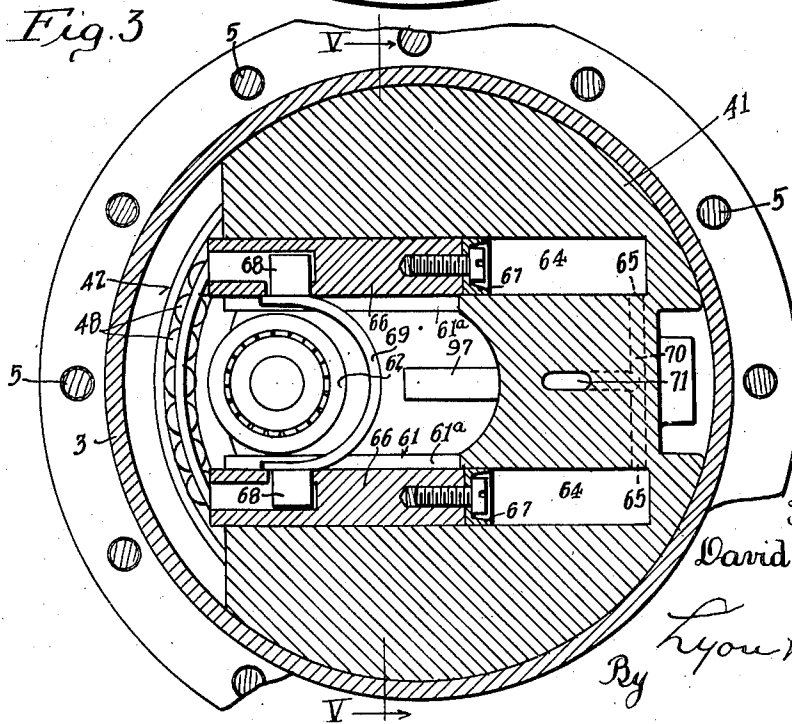
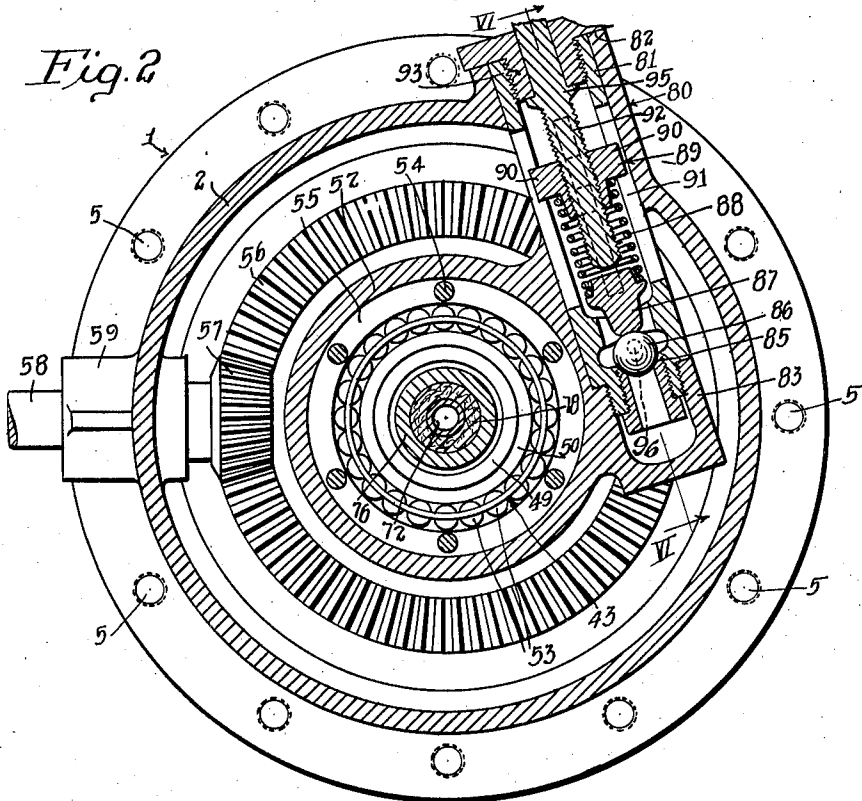
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2,014,860

PUMP

Filed May 22, 1934

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Filed May 22, 1934

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Fig. 4

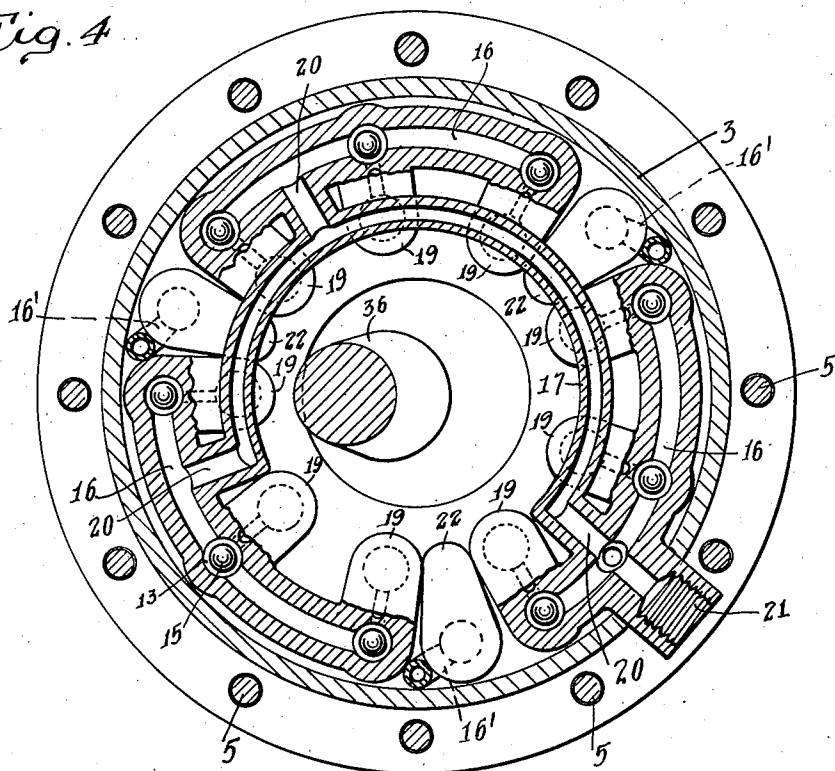
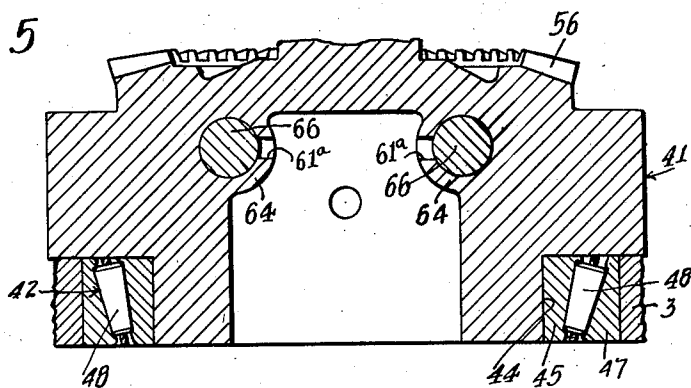


Fig. 5



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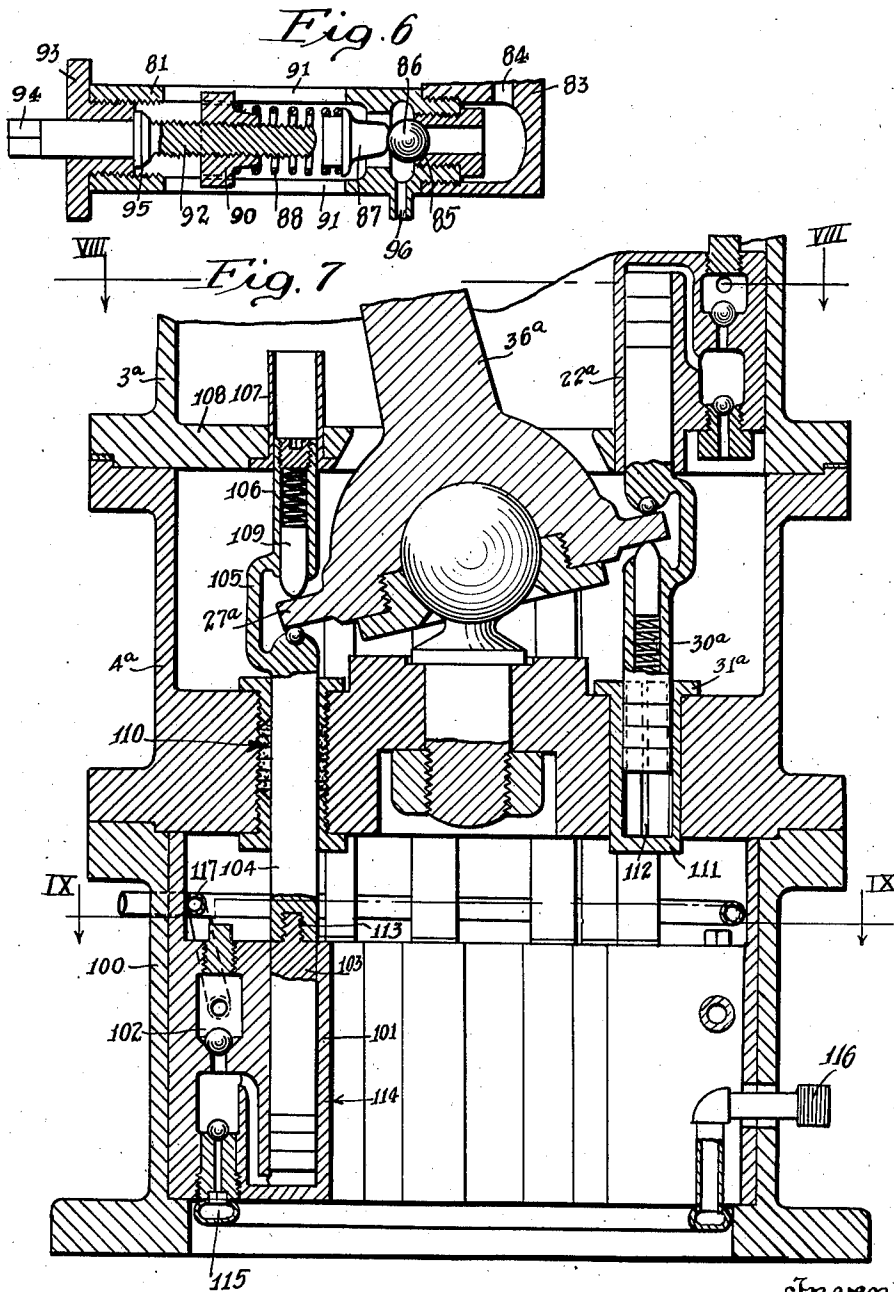
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2,014,860

PUMP

Filed May 22, 1934

5 Sheets-Sheet 4



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2,014,860

PUMP

Filed May 22, 1934

5 Sheets-Sheet 5

Fig. 8

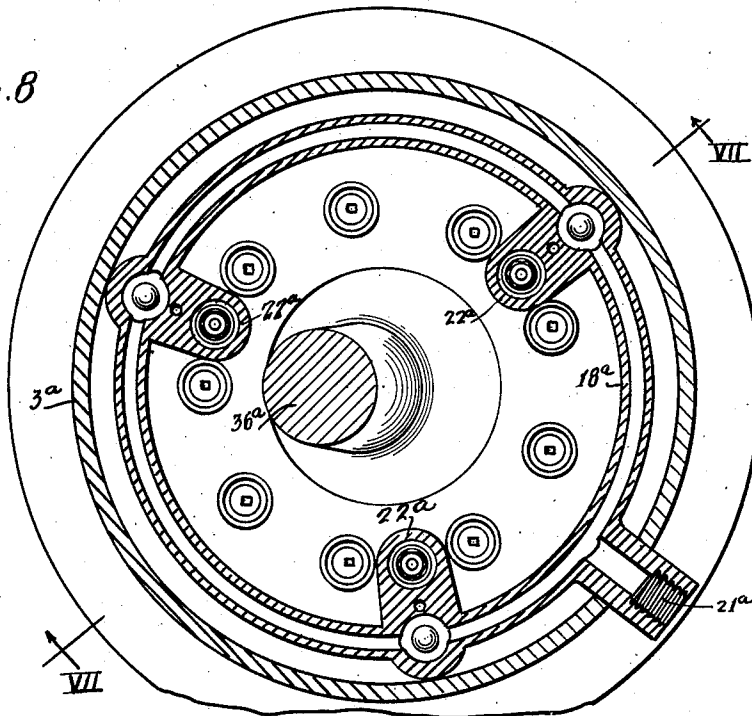
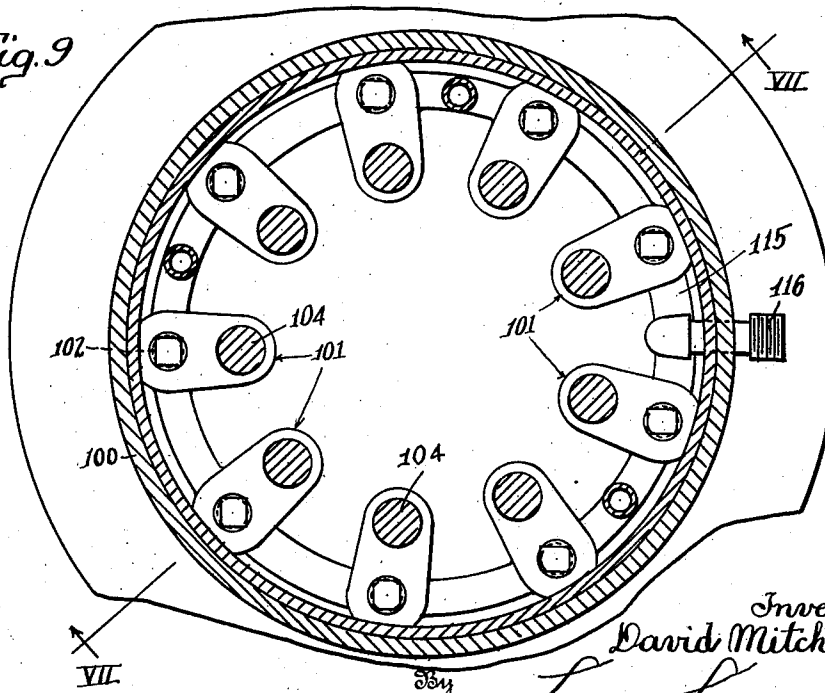


Fig. 9



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UNITED STATES PATENT OFFICE

2,014,860

PUMP

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Application May 22, 1934, Serial No. 726,886

8 Claims. (Cl. 103—162)

This invention relates to pumps and particularly to multicylinder pumps of the type in which the cylinders are positioned parallel to each other and disposed symmetrically about a common central axis, and the plungers reciprocated by a wobble plate pivotally supported at the common axis. A useful characteristic of such pumps is that by varying the arc of movement of the wobble plate the strokes of the pump plungers may be varied to any desired extent between zero and maximum.

An object of the invention is to simplify the construction and improve the efficiency of pumps of the type described.

Another object is to provide a construction for pumps of the general type described in which the pump barrels and plungers are readily removable from the rest of the mechanism and in which barrel and plunger assemblies of different sizes may be interchanged without disturbing the operating mechanism of the pump.

Another object is to provide a pump of the general type referred to that automatically varies its stroke as necessary to maintain a predetermined pressure and in which the predetermined pressure may be varied while the pump is operating.

A further object is to provide a pump for automatically maintaining a predetermined pressure in the discharge line without utilizing the fluid in the discharge line to actuate the pressure-control mechanism, thereby completely segregating the working suction and discharge lines of the pump from the control mechanism.

Other more specific objects and features of the invention will be apparent from the following detailed description which refers to the drawings.

In the drawings:

Fig. 1 is a vertical section of a complete pump in accordance with the invention;

Fig. 2 is a horizontal section in the plane II—II of Fig. 1;

Fig. 3 is a horizontal section in the plane III—III of Fig. 1;

Fig. 4 is a horizontal section in the plane IV—IV of Fig. 1;

Fig. 5 is a vertical detail section through the main rotor member of the pump in the plane V—V of Fig. 3;

Fig. 6 is a detail longitudinal vertical section through the pressure controlled valve taken in the plane VI—VI of Fig. 2;

Fig. 7 is a vertical section of the lower part of a pump which is a modification of that shown

in Fig. 1, the construction of the portion not shown corresponding to the construction shown in Fig. 1 and the section being taken in the plane VII—VII of Figs. 8 and 9;

Fig. 8 is a horizontal section in the plane VIII—VIII of Fig. 7; and

Fig. 9 is a horizontal section in the plane IX—IX of Fig. 7.

Referring first to Figs. 1 to 6 of the drawings, the pump therein disclosed comprises an outer casing 1, within which substantially the entire mechanism is contained. This case 1 is preferably made in three sections, there being an upper section 2, a middle section 3 and a lower section 4. The upper and lower sections constitute closed ends for the casing and are provided with flanges cooperating with flanges on the middle section 3 for securing the sections together. Thus they are preferably united by bolts 5 which pass through the flanges on the lower and middle sections and screw into threaded apertures in the flange on the upper section.

The pump mechanism proper is contained within the middle and lower sections of the case. Thus the middle section 3 has secured therein as by screws 6 a hollow cylindrical block 7 in which openings constituting barrels and valve chambers are formed. The shape of one of the barrels and its associated valve chamber is clearly shown in Fig. 1, the barrel being indicated at 8 and the valve chamber at 9. It will be observed that each valve chamber 9 is divided into two compartments, the lower compartment 10 having an inlet opening 11 extending upwardly therein from the interior of the pump casing with a ball valve 12 for closing the opening during the compression stroke of the pump and the upper portion 13 communicating with the lower portion 10 through a passage 14 adapted to be closed by a ball valve 15 during the suction stroke of the pump. The upper chamber 13 also connects with a discharge passage 16 (Fig. 4) which connects to one or the other of two discharge manifolds 17 and 18, respectively. Two discharge manifolds are employed for the reason that part of the barrel and valve assemblies constitute the working portion of the pump for supplying fluid under pressure to a working line and the remaining pump and barrel assemblies constitute control pumps for automatically regulating the pressure developed by the pump. In the particular pump shown there are nine working barrels and three control barrels.

Referring for the moment to Fig. 4, the nine working barrels identified by the reference num-

meral 19 are symmetrically spaced circumferentially from each other about the center axis of the casing and have their associated discharge passages 16 connected through passages 20 to the main discharge manifold 17, which is connected to a discharge orifice 21 in the exterior of the pump casing. The control barrels 22, three in number, are also symmetrically spaced circumferentially about the axis of the casing, each being located between a pair of working barrels 19. The discharge passages 16' from the valves of the control barrels 22 connect directly to the discharge manifold 18, which in turn is connected to a discharge pipe 24 (Fig. 1) which extends upwardly through the casing and out through the top of the casing, at which point it connects with the pressure control mechanism for automatically controlling the pump. As previously stated, all of the inlet passages 11 on both the working and controlling pump assemblies communicate with the interior of the pump casing which is adapted to be kept partially filled with the fluid to be pumped. The pump is particularly designed for supplying fluid such as oil to a hydraulic press or the like and in this case the oil within the casing serves to lubricate the pump.

Each pump barrel 8 (the reference numeral 8 being generic to both the control and working barrels) is provided with a plunger 25, which is preferably equipped with packing cups 26 at its upper end and the lower end of which extends out of the barrel. Each plunger is reciprocated by a wobble plate 27 which comprises a disc projecting into the axes of the various plungers 25. Thus each plunger is provided in its lower end with a ball 28 which bears against the upper face of the plate 27. Each plunger is also connected by a yoke 29 which extends around the edge of the plate 27 with a guide plunger 30 adapted to reciprocate in a guide bushing 31 mounted in the lower casing member 4. Each guide plunger 30 is drilled to receive a detent 32 which is maintained in engagement with the under side of the plate 27 by a spring 33. The lower end of the plunger guide 31 opens into a cavity 34 provided in the lower casing member 4, which cavity communicates through passages 35 with the interior of the casing to permit free surging of oil into and out of the guides 31 as the plungers 30 reciprocate.

The plate 27 is rigidly secured to and forms a part of a spindle 36 which is pivotally mounted for rocking movement on a ball 37 rigidly secured to the lower case member 4 by a threaded extension 38 and a nut 39. The spindle 36 is provided with a socket in its under side to smoothly engage the ball 37 and the spindle is secured in position upon the ball by a cap 40 threaded into the under side of the spindle. In operation the upper end of the spindle 36 gyrates about a central vertical axis passing through the ball 37, the arc of gyration being variable and determining the strokes of the plungers 25.

To gyrate the spindle 36 a rotor element 41 is provided in the upper end of the pump casing, this rotor element being rotatably supported in the pump casing between a lower tapered roller bearing 42 and an upper tapered roller bearing 43. Thus the lower end of member 41 is provided with a cylindrical shoulder 44, upon which there is mounted a cone 45 and the inner wall of the central casing member 3 is provided with a shoulder 46 upon which rests a bearing cup 47, rollers 48 being positioned between the cup and cone. The upper bearing assembly 43 comprises a cone

49 mounted upon a cylindrical extension 50 on the upper end of the member 41, a cup 51 mounted within a tubular sleeve 52 extending inwardly from the top wall of the casing member 2, and rollers 53 positioned between the cup and cone. Adjustment of the upper cup 51 is obtainable by means of adjusting bolts 54, preferably three in number, which are threaded into the upper case member and contact a ring 55 which bears against the upper end of the cup 51. The member 41 is adapted to be rotated through a beveled gear 56 mounted thereon which meshes with a drive pinion 57 mounted on a shaft 58 journaled in a bearing 59 in the wall of the casing member. A pulley 60 is shown mounted on the outer end 15 of the shaft 58 although it is to be understood that if desired this shaft may be coupled directly to an electric motor or other source of power.

The upper end of the spindle 36 is engaged between a pair of parallel guide faces in the rotating member 41, these guide faces being indicated at 61 in Fig. 3. To permit free rotation of the member 41 without undue friction between the upper end of the spindle and the guide faces 61, a sleeve 62 is mounted upon the upper end 25 of the spindle 36 and separated therefrom by ball bearings 63.

It will be observed from inspection of Figs. 1 and 3 that the sleeve 62 on the upper end of spindle 36 is freely movable in a radial direction with respect to the vertical axis through the ball 37, between the guide faces 61 and, by shifting the upper end of the spindle outwardly from the axis or inwardly toward the axis, the effective stroke of the pump plungers 25 may be varied from zero to maximum value. The reaction of the pump plungers 25 tends to restore the spindle 36 to central position. Therefore in order to reciprocate the plungers the spindle 36 must be maintained in off center position by some force. This force is provided in the present pump by hydraulic means. Thus (referring to Fig. 5) there are provided in the upper part of the rotatable member 41 a pair of cylinders 64 positioned on opposite sides of and parallel to the guideway defined between the guide surfaces 61, the main portions of these cylinders being positioned to the right of the center line of the member 41 as it is shown in Fig. 1. These cylinders 64 are provided with ports 65 (Fig. 3) in their forward ends for the admission of fluid under pressure and contain plungers 66 of substantial length which are preferably provided with packing cups 67 on their forward ends. The plungers 66 are drilled adjacent their rear ends to receive stub shafts 68 on a yoke 69 which is curved to engage the sleeve 62 on the upper end of spindle 36. The rear ends of the walls of the cylinders 64 are provided with longitudinal slots 61a communicating with the guideway in which the sleeve 62 is positioned to permit longitudinal movement of the yoke 69 and plungers 66. It will be observed that with the construction described the spindle 36 may be shifted off center by applying fluid pressure to the cylinders 64 through their ports 65 and that the radial position of the spindle 36 with respect to the neutral axis will be determined by the relative values of the reactive forces acting on the pump plungers 25 and the pressure of the fluid in the control cylinders 64.

Since the member 41 containing the control cylinders 64 is constantly rotating when the pump is in operation, special means must be provided to introduce pressure fluid for control purposes to the cylinder 64. This pressure fluid is

introduced, in the embodiment shown, through a packing joint located in the upper end of the pump casing. Thus the ports 65 (Fig. 3) communicate with a passage 70 which is connected through a passage 71 with an upwardly extending nipple 72, which is concentrically positioned with respect to the center line of the rotary member 41 and projects upwardly through the pump casing. The nipple 72 rotates with the member 41 and extends into a stationary sleeve 73 which communicates through a pipe 74 with a pressure fluid supply fitting 75. The upper end of the casing member 2 is provided with a packing gland fitting 76 secured to the case by cap screws 77 and containing a packing 78 which is adapted to be compressed by a packing nut 79 to form a fluid seal between the nipple 72 and the sleeve 73.

Although pressure fluid from any desired source may be supplied to the control cylinders 64, I prefer to supply this fluid from the three control barrels 22 of the pump and to this end the discharge tube 24, which extends through the upper wall of the pump casing, is connected into the fitting 75 which, as previously described, is connected to the control cylinders 64.

If the output from the control barrels 22 of the pump were connected directly through a closed system to the control cylinders 64, a terrific pressure would be built up and applied to the plungers 66 which would maintain the spindle 36 in maximum off center position regardless of the reaction of the various pump plungers 25. It is therefore necessary to regulate the pressure applied to the control cylinders 64 and I effect this regulation by means of a relief valve which is indicated generally at 80 in Fig. 1 and is shown in detail in Figs. 2 and 3.

The relief valve proper is removable as a unit from the casing and comprises a tubular member 81 adapted to be inserted into a recess extending from the outer wall of the upper casing member 2 into the interior of the casing. Thus the outer orifice of the recess is constituted by a shoulder 82 and the inner end constitutes a closed hollow cap 83 which communicates through a passage 84 (Fig. 1) with the interior of the fitting 75. This passage 84 is also shown in the vertical sectional view of Fig. 6. The inner end of the tubular member 81 and the outer end of the cap 83 are threaded so that the parts screw together to form a fluid tight seal. A valve seat 85 is threaded into the inner end of the tubular member 81 and cooperates with a valve ball 86 which is pressed against the seat 85 by a plunger 87 which in turn is forced against the ball with a predetermined pressure by a coil spring 88 which is interposed between the plunger 87 and a retainer 89. The retainer 89 is provided with outwardly extending ears 90 on opposite sides thereof which slide in longitudinal slots 91 provided in the tubular member 81. The retainer 89 is provided with a threaded aperture in the center which screws onto a threaded adjusting shaft 92 rotatably supported in a plug 93 threaded into the outer end of the tubular member 81. Shaft 92 projects through and beyond the plug 93 and is provided with a squared end 94 so that it can be turned with a wrench. The shaft 92 is provided with a shoulder 95 interior of the plug 93, which shoulder bears against the plug and prevents the shaft 92 moving outwardly in response to the pressure exerted by the spring 88. It will be observed that by turning the shaft 92 the spring retainer 89 may be shifted longitudinally in the tubular member 81, thereby varying the force exerted on

the valve ball 86 between wide limits. The pressure fluid delivered through the passage 84 shifts the valve ball 86 away from its seat whenever the pressure exceeds the predetermined value for which the valve is adjusted, thereby discharging fluid past the valve ball and out through a discharge orifice 96 into the interior of the pump casing where it returns to the fluid supply maintained in the casing.

If the pump as described happened to be on 10 dead center, that is, with the spindle 36 in alignment with the central axis of the casing when started up, it would never move off dead center for the reason that the control cylinders 64 would receive no pressure fluid and therefore the yoke 15 69 would not be actuated by the control plungers 66 to shift the spindle 36 away from its central position. To prevent the spindle 36 remaining on dead center position when the pump is stopped, a spring plunger 97 (Fig. 1) is provided, this 20 plunger being slidably mounted for radial movement in the rotatable member 41 and being constantly urged outwardly into the position shown in Fig. 1 by a spiral spring 98 positioned back thereof. It will be observed that the outer end 25 of the plunger 97 is in the path of the sleeve 62 on the upper end of spindle 36 so that whenever the spindle tends to move into central position it intercepts the plunger 97 and is resiliently urged away from the central position. 30

When the pump is in operation, the plungers 25 in both the working barrels 19 and the control barrels 22 are uniformly sequentially reciprocated to deliver fluid from the interior of the pump casing to the discharge manifolds 17 and 35 18. The fluid discharged to the manifold 17 is discharged to any suitable discharge line through the discharge port 21 (Fig. 4) and all of the fluid from manifold 18 is discharged through the pipe 24 to the control valve 80 and through fitting 75, 40 pipe 74, nipple 72, passage 71 and passages 70 to the control cylinders 64 where it acts against the control plungers 66 tending to shift the latter to the left (with reference to Fig. 3) and thereby move the spindle 36 into maximum off center 45 position (the position of maximum stroke). The spindle will remain in this position so long as the back pressure in the main discharge line remains below a predetermined value, under which conditions the pump operates with maximum volumetric efficiency to deliver a full stream of fluid. 50 In the meantime, the fluid discharged from the control barrels 22 must all be discharged through the control valve 80 so that a constant pressure of magnitude dependent upon the setting of the control valve is maintained in the control cylinders 64. However, should the back pressure in the main discharge line rise above a predetermined value dependent upon the setting of the control valve 80, then the reaction of the plungers 25 in the working barrels 19 upon the wobble plate 27 increases to a value sufficient to overcome the force exerted on the spindle 36 by the yoke 69 connected to the plungers 66 of the control cylinders 64, which shifts the spindle 36 toward its center position, thereby reducing the effective stroke of the pump. 65 If the discharge line is not completely closed off, the reduction in the stroke of the pump will be just sufficient to maintain the predetermined pressure in the discharge line. However, if the discharge line should be completely closed off, then the reaction of the plungers 25 and working cylinders will be sufficient to force the spindle 36 into its central position in which no pumping motion whatever oc- 70 75

4 curs. The spring tension on the plunger 97, which tends to maintain the spindle off its dead center position, is insufficient to maintain the spindle off center when the reaction of the plungers 25 and the working cylinders rises appreciably above the predetermined pressure for which the pump is set. Should at any time the pressure in the discharge line be reduced, the constant force exerted upon the spindle through the yoke 69 by the plungers 66 in the control cylinders 64 shifts the spindle off center to increase the amount of fluid pumped sufficient to restore the pressure in the discharge line to the predetermined value or to permit the spindle to move into position of maximum stroke.

The pump is highly efficient in operation for the reason that friction between the moving parts is reduced to a relatively low value. Thus the rotatable member 41 is completely supported on roller bearings for free rotation and the relative rotation between the spindle 36 and the faces of the guideways 61 is reduced to a low value by the ball bearings 63 interposed therebetween. The ball and socket joint between the spindle 36 and the supporting ball 37 operates in the oil in the casing and therefore little frictional losses occur at this point. Furthermore, the motion between the ball 37 and the socket in the spindle 36 is relatively slight for the reason that the spindle 36 does not necessarily rotate (although it is free to do so) but merely rocks around the ball 37.

Although in the pump illustrated the working barrels 19 and the control barrels 22 are identical in construction and size, it is not essential that they be of the same size. As a matter of fact, since very little fluid need be supplied to the control valve 80, the control barrels 19 and their plungers 25 may be of substantially smaller size than the working barrels 19 and their associated plungers, thereby reducing the reactive force of the control plungers upon the spindle 36 and increasing the efficiency of the pump.

As previously stated, the embodiment of the pump disclosed in Figs. 1 to 6 is designed particularly for supplying fluid such as oil to a hydraulic press or the like. In such a device the fluid from the press would be returned to the pump casing through any suitable connection, thereby maintaining a substantially constant supply of oil in the pump casing. However, there are many applications in which a fluid other than oil is to be pumped and in which the pumped fluid is not necessarily circulated through a closed system. My pump can be readily adapted for such purposes by positioning the working barrels below the plate 27 (Fig. 1) and preferably attachable and removable as a separate unit from the rest of the mechanism. Such a unit is disclosed in Figs. 7, 8 and 9.

Fig. 7 discloses only the lower portion of a complete pump, the upper portion of the pump corresponding exactly to the upper portion of the pump shown in Fig. 1. Thus corresponding parts in the pump shown in Fig. 7 are identified by the same reference numerals employed in Fig. 1 with the suffix "a". It will be observed that the control barrels 22a, which may be three in number the same as in the pump shown in Fig. 1, are positioned above the wobble plate 27a exactly the same as in Fig. 1 and the connections from these control barrels through their associated valves to the control valve (not shown in Fig. 7) are exactly the same as in Fig. 1.

The working barrels, however, are positioned in a separate casing unit 100, which bolts onto the bottom of the casing unit 4a. The working barrels 101 and their associated suction and discharge valves 102 are substantially identical in construction to the corresponding construction shown in Fig. 1 except that they are inverted and the plungers 103 in the working barrels are connected by push rods 104 extending up through the bottom wall of the casing member 4a and contacting with the under side of the wobble plate 27a. The push rods 104 are connected by yokes 105 extending beyond the edge of the wobble plate 27a to guide rods 106 positioned thereabove and reciprocating in guides 107 mounted in the web 108 in the middle casing 3a. Spring controlled detents 109 are provided in the guides 106, which detents bear against the upper end of the wobble plate 27a to positively link the push rods 104 with the wobble plate. Since the control barrels 22a of the pump shown in Fig. 7 pump oil exactly the same as in the model shown in Fig. 1, that portion of the pump casing including the sections 4a and 3a is adapted to be filled with oil. It is therefore necessary to prevent leakage of the oil from the casing section 4a down into the pump casing 100. To this end, the push rods 104 are mounted in packing glands 110 and the lower ends of the bushings 31a in which the push rods 30a of the control barrels reciprocate are closed at their lower ends by solid end walls 111 and longitudinal grooves 112 are provided in the surfaces of the bushings 31a to permit the oil to surge in and out below the guide rods 38 as the latter reciprocate.

The plungers 103 in the working barrels are preferably detachable from the push rods 104 and are therefore shown joined to the push rods by screw thread connections, as shown at 113. This construction permits the complete removal of the block 114 containing the working barrels 101 and their associated valves, together with the plungers 103 and the substitution of a different block containing barrels of different diameter together with plungers to fit.

In the embodiment of Fig. 7, since the fluid connections to the working barrels are entirely separate and distinct from the pump casing containing the oil or other fluid used to actuate the control mechanism, the intake ports of the valves 102 are all connected to a common intake manifold 115 adapted to be connected to any desired source through a terminal connection 116 and the exhaust ports of the valves 102 are all connected to an exhaust manifold 117 adapted to be connected to a discharge line.

The automatic operation of the pump disclosed in Fig. 7 is exactly the same as that of Fig. 1. The maximum pressure delivered by the pump is determined by the setting of the control valve mechanism (which corresponds exactly to the mechanism shown in Fig. 1), which mechanism functions to decrease or increase the deflection of the spindle 36a with respect to the center line to vary the volume output of the pump.

Although the invention has been disclosed and described particularly with reference to two specific embodiments, it is to be understood that various changes and modifications may be made in the structure shown without departing from the invention and the latter is therefore to be limited only as set forth in the appended claims.

I claim:

1. In a multiple barrel pump comprising a series of parallel pump barrels concentrically posi-

tioned about a central axis, plungers operating in said barrels, a spindle, means for pivotally supporting one end of said spindle in alignment with said central axis whereby the other end of the spindle is free to gyrate about said axis, lever means on said spindle extending radially from the pivot point of said spindle into alignment with said barrels, means linking each of said plungers to the juxtaposed portion of said lever means whereby gyration of said spindle reciprocates said plunger; in said barrels, means for gyrating said spindle comprising a member rotatably supported adjacent the other end of said spindle for rotation about said central axis, guide means on said member extending diametrically with respect thereto for slidably engaging said other end of said spindle, means for continuously rotating said member, stroke-varying means on said member for moving said other end of said spindle diametrically in said guide means to vary the inclination of, and arc of gyration of said spindle while said member is rotating, and stationary control means constantly coupled to said stroke-varying means for moving the latter while said member is rotating.

2. A pump as described in claim 1 in which said stroke-varying means comprises hydraulic motor means responsive to fluid pressure to increase the inclination of said spindle from said central axis, and in which said control means includes means for constantly supplying fluid under predetermined pressure to said hydraulic motor means.

3. A pump as described in claim 1 in which said stroke-varying means comprises hydraulic motor means responsive to fluid pressure to increase the inclination of said spindle from said central axis, in which some of said pump barrels and associated plungers constitute working pumps and others constitute control pumps for supplying fluid under pressure to said hydraulic motor means and in which said control means comprises a valve for limiting the pressure of fluid applied to said hydraulic motor means to a predetermined value.

4. A pump as described in claim 1 in which said lever means on said spindle comprises a disc projecting from the spindle into the projected paths of travel of said plungers, and in which each of said linking means comprises a yoke straddling the edge of said disc and connected to its associated plunger on one side of said disc with a guide rod aligned with the plunger and connected to said yoke on the other side of said disc, and a guide for each rod.

5. A pump as described in claim 1 in which said stroke-varying means comprises hydraulic motor means responsive to fluid pressure to increase the inclination of said spindle from said central axis, in which some of said pump barrels and associated plungers constitute working pumps and others constitute control pumps for supplying fluid under pressure to said hydraulic motor means, said control pumps being uniformly circumferentially spaced about said axis and each positioned between a pair of working pumps, and means for limiting the pressure of fluid applied from said control pumps to said hydraulic motor means to a predetermined value.

6. In a pump of the type described, a casing, a spindle within said casing pivotally supported at its lower end from said casing, whereby the upper end is free to gyrate about a vertical axis extending through the pivot point, means for gyrating said spindle, fluid actuating means for radially shifting the upper end of said spindle away from said axis to increase the arc of gyration on said spindle, a wobble disc on said spindle, extending radially therefrom, a plurality of control pumps, each comprising a barrel and a plunger symmetrically positioned about said axis and above said wobble disc, means linking said control pump plungers to said wobble disc, said control pumps having suction ports communicating with the interior of said casing and discharge ports communicating with said fluid-actuated means, means for regulating the pressure of fluid applied to said fluid-actuated means, means for discharging excess fluid from said control pump discharge ports back into said casing, a plurality of working pumps each comprising a barrel and plunger detachably supported exterior of and below said casing, and push rods extending through packing glands in said casing for coupling said working pump plungers to said wobble plate.

7. A pump as described in claim 1 in which said stroke-varying means for moving said other end of said spindle diametrically in said guide means comprises a pair of cylinders positioned parallel to and on opposite sides of said guide means, plungers in said cylinders, a yoke connecting said two plungers adapted to contact said spindle, and means for supplying fluid under predetermined pressure to said cylinders.

8. In a pump of the type described, a casing, a spindle within said casing pivotally supported at one end from said casing, whereby the other end is free to gyrate about a central axis extending through the pivot point, means for gyrating said spindle, fluid-actuated means for radially shifting the upper end of said spindle away from said axis to increase the arc of gyration of said spindle, lever means on said spindle extending radially from the pivot point of said spindle, a plurality of barrels concentrically positioned about said central axis, each barrel having a plunger therein and means linking each plunger to said lever means whereby each plunger is reciprocated in response to gyration of said spindle through a stroke proportional to the radius of gyration of the spindle, some of said pumps constituting control pumps and others constituting working pumps, fluid responsive means supplied with fluid from said control pumps for urging said spindle away from said central axis to increase the stroke of said pump, and spring means for constantly urging said spindle into inclined position out of alignment with said central axis, said spring means being relatively weak, whereby it exerts a force on said spindle substantially negligible in comparison with the reactive force on said spindle exerted by said pump plungers, whereby the arc of gyration of said spindle is controlled substantially entirely by the relative pressures developed by said control pumps and working pumps, respectively.

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