Feb. 20, 1940. G. A. WAHLMARK 2,190,812

HYDRAULIC MOTOR OR PUMP

Filed May 17, 1937 4 Sheets-Sheet 1

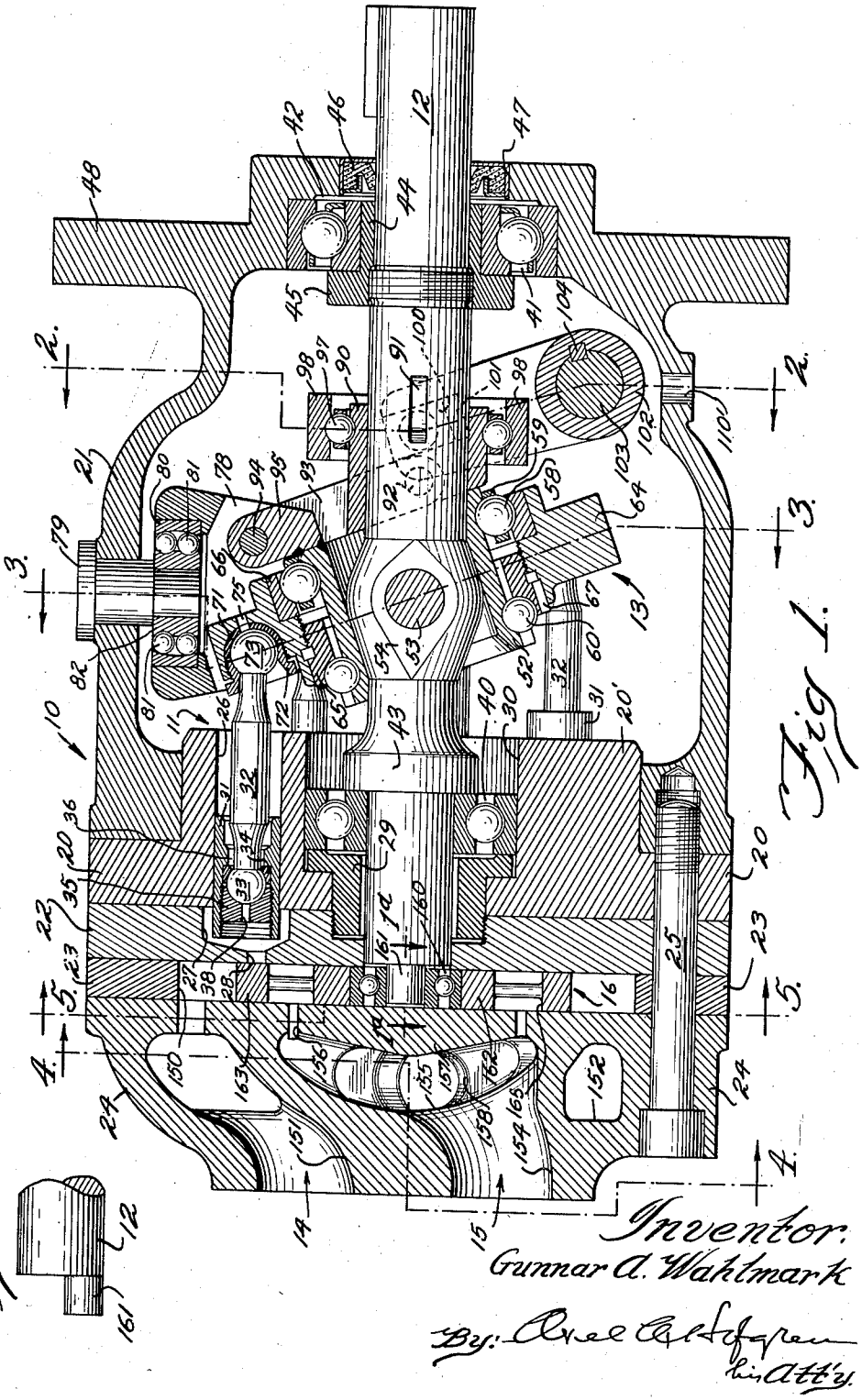


Fig. 1.

Fig. 1a.

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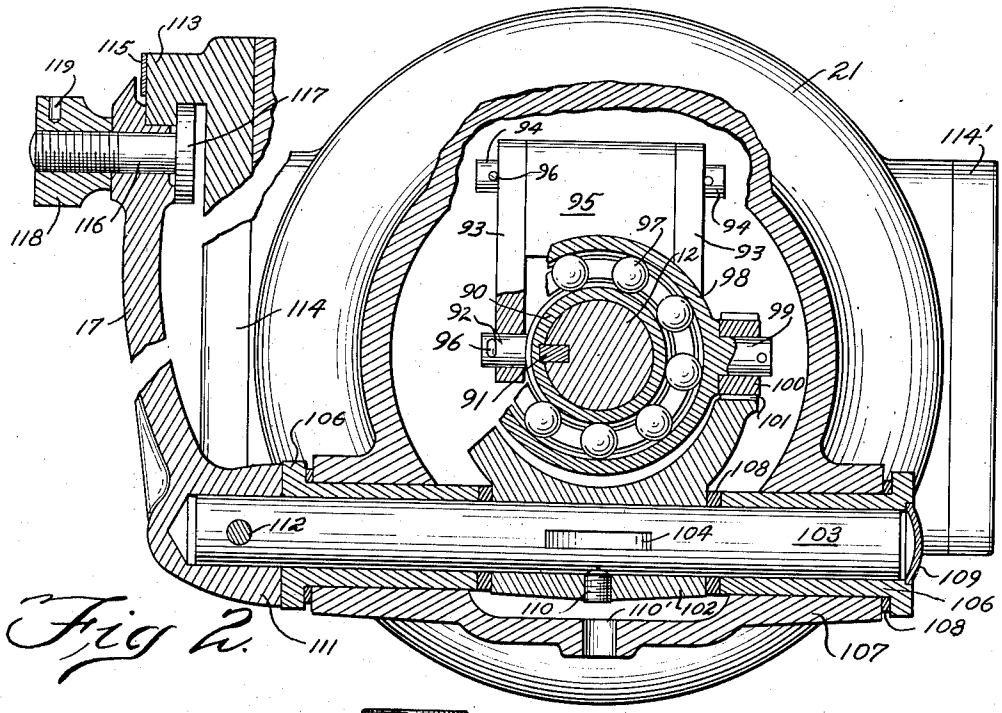


Fig 2.

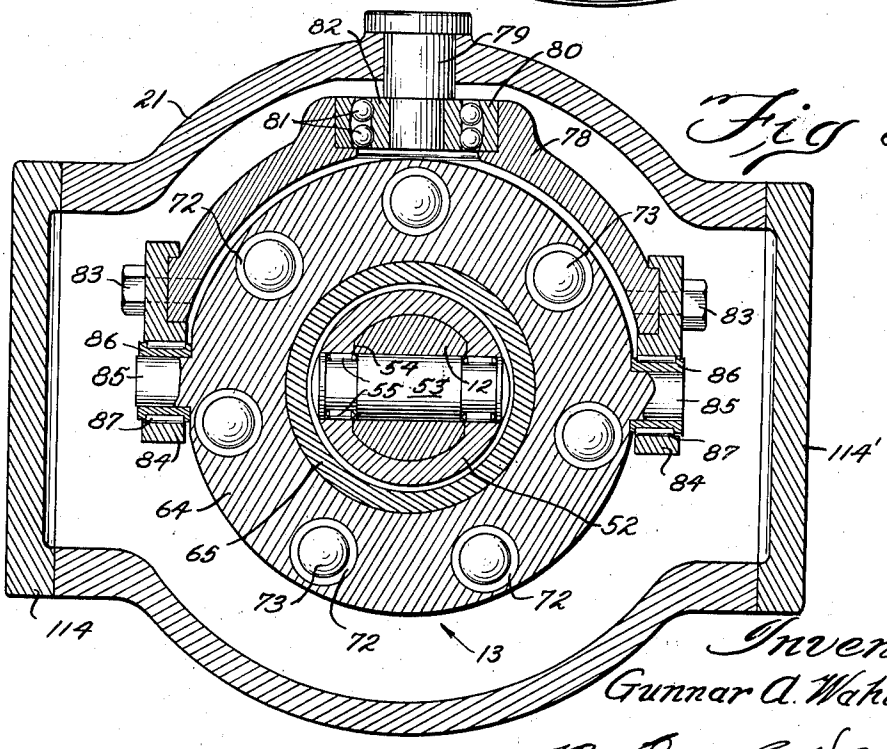


Fig 3.

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HYDRAULIC MOTOR OR PUMP

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Fig 4.

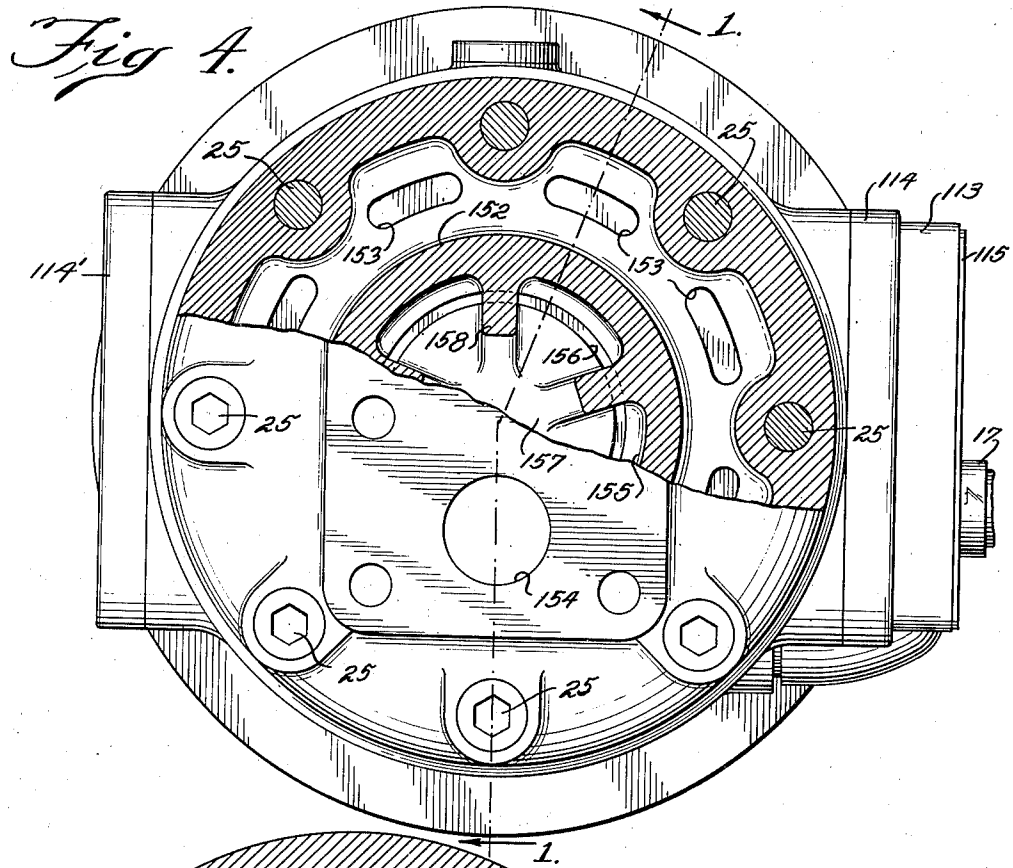
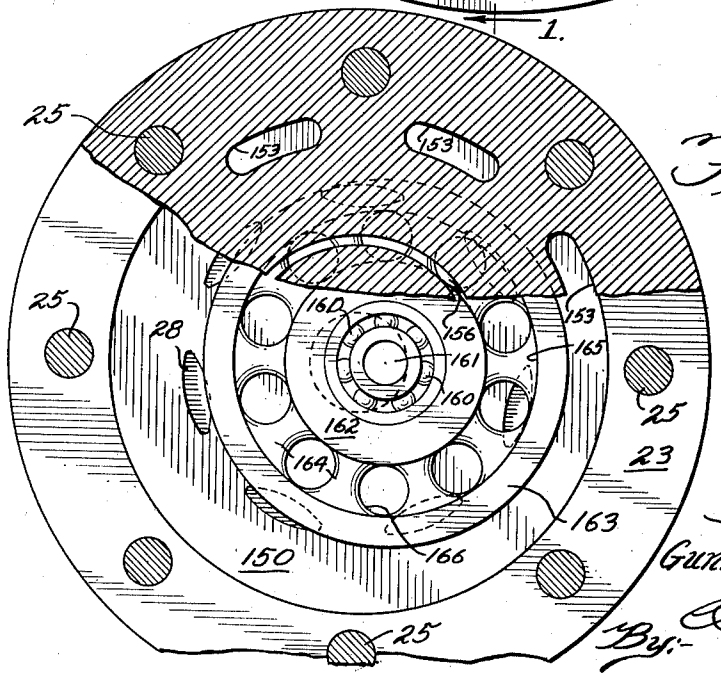


Fig 5.



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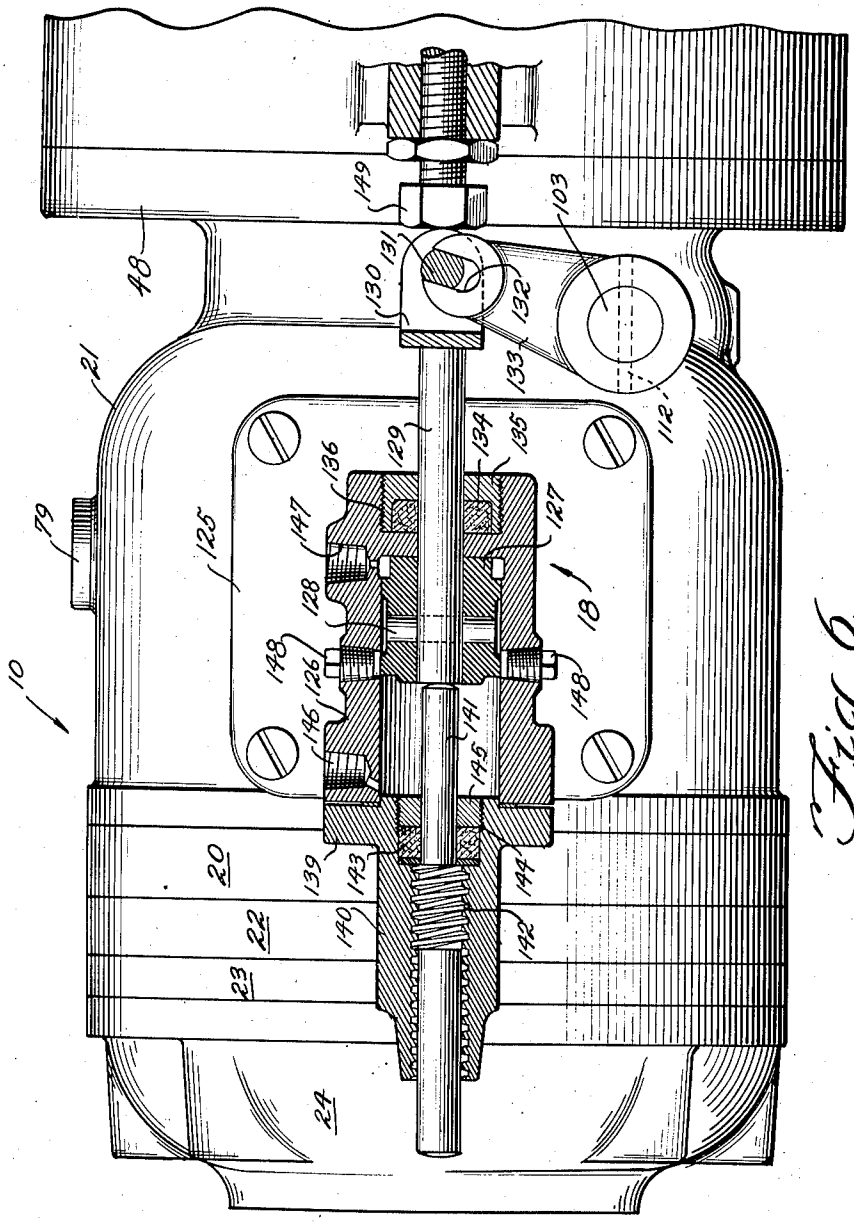


Fig 6.

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Patented Feb. 20, 1940 2,190,812

UNITED STATES PATENT OFFICE

2,190,812

HYDRAULIC MOTOR OR PUMP

Gunnar A. Wahlmark, Rockford, Ill.

Application May 17, 1937, Serial No. 143,069

5 Claims. (Cl. 121—121)

The invention relates to a fluid motor or pump and more particularly to a motor or pump of the piston and cylinder type having means for converting the reciprocatory motion of the pistons into rotary motion of a shaft.

A general object of the invention is to provide a device of that character which is of new and improved construction.

It is a more particular object to provide a device of that character having new and improved valve means for controlling the supply and exhaust of fluid to and from the cylinders of the device.

Another object is to provide in a device of that character a new form of valve means with the valve thereof having a new motion effecting a rapid opening and closing of the ports leading to the cylinders without a high speed of the valve as a whole.

Yet another object is to provide in a device of the character described a plurality of annularly arranged ports opening to the cylinders and a valve in the form of a circular plate mounted to have an eccentric movement with respect to the ports and in timed relation with the reciprocation of the pistons.

A further object is to provide in a device of the character described a new and improved means for converting the reciprocatory motion into rotary motion.

Other objects and advantages will become apparent from the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a longitudinal sectional view taken approximately on line 1—1 of Fig. 4 of a preferred construction embodying the features of the invention.

Fig. 1*a* is a fragmentary detail view taken approximately along the line 1*a*—1*a* of Fig. 1.

Fig. 2 is a transverse sectional view taken approximately along the line 2—2 of Fig. 1, partially broken away to reveal structure behind the plane of the figure.

Fig. 3 is a transverse sectional view taken approximately along the line 3—3 of Fig. 1.

Fig. 4 is a view partially in section and partially in elevation taken approximately along the line 4—4 of Fig. 1.

Fig. 5 is a transverse sectional view taken approximately along the line 5—5 of Fig. 1.

Fig. 6 is a front elevational view having in section a modified form of means for varying the speed of the motor.

Although the invention is susceptible of various modifications and alternative constructions, it is shown herein and will hereinafter be described in a preferred embodiment and one modification, but it is not intended that the invention is to be limited thereby to the specific construction disclosed, but it is intended to cover all modifications and alternative constructions falling within the spirit and scope of the invention as defined by the appended claims.

While the principles of construction and operation of the invention are in large part equally applicable either to a motor or to a pump, these principles, for purposes of disclosure, will hereinafter be described as embodied in a motor. Accordingly, the invention is embodied in a device which comprises generally a casing 10 within which is housed fluid handling mechanism 11, which herein is of the reciprocatory type, a rotatably mounted shaft 12 and conversion means 13 for converting the reciprocatory motion of the fluid handling mechanism into rotary motion of the shaft. Formed in the casing 10 are a passage 14 and a passage 15 alternatively constituting a passage for the supply of operating fluid to the fluid handling mechanism or a passage for the exhaust of fluid after its energy has been spent in imparting reciprocatory movement to the mechanism depending upon the direction the shaft 12 is to be rotated. The supply and exhaust of operating fluid to and from the mechanism is controlled by a valve 16 of unique construction driven by the shaft 12. The speed of the motor, with a constant supply of operating fluid, may be varied by adjustment of the conversion means 13 either manually by a lever 17 or automatically by a hydraulic means 18 (Fig. 6).

In greater particularity, the casing 10 is composed of a plurality of sections 20, 21, 22, 23, and 24 secured together as a unit by bolts 25 extending through the sections 24, 23, 22 and 20 and threaded into the section 21. Of these, the section 20 constitutes a cylinder block and accordingly has a thick portion 20′ formed with a plurality of bores 26, herein 7 in number (see Fig. 5), disposed longitudinally of the casing and annularly arranged. Each of the bores constitutes a part of a cylinder of the fluid handling mechanism. Abutting the flat face of the section 20 is the section 22 which is in the nature of a port plate and which, with the section 20, completes the motor block. The port plate 22 is formed with a plurality of recesses 27 slightly larger in diameter than a bore 26. These recesses are annularly disposed and open through the face of the plate

adjacent the section 20 so that one recess registers with each of the bores 26 to complete the cylinders. Opening to each of the recesses through the other face of the plate is a port 28 which, as best seen in Fig. 5, is elliptical and is disposed with its major axis tangent to the circle passing through the center of each of the ports. The cylinder block 20 and the port plate 22 are secured together by means of a shouldered sleeve 29 inserted through a central aperture, formed in the block 20 by a stepped bore 30, and threaded into the port plate 22.

Reciprocable in each of the bores 26 is a hollow piston 31 connected by means of a piston rod 32 to the motion conversion means 13. To provide the maximum freedom of movement between the piston 31 and the piston rod 32, the piston rod 32 is connected to the piston 31 by means of a ball and socket joint. Accordingly, the piston rod 32 terminates at its end in a ball 33 which is received within a split socket composed of a divided annular ring 34 and a plug 35. The annular ring 34 rests against a shoulder formed by an internal annular flange 36 formed in the piston, while the plug 35 is threaded into the piston to form the head end thereof. The ball and socket joint is well lubricated by means of an oil hole 38 formed in the plug 35, which hole, however, is effectively sealed during the working stroke of the piston by the ball 33 of the piston rod which, during the working stroke, will bear tightly against the plug 35.

Section 21 is cup-shaped to complete one end of the casing 10 and to constitute a housing for the conversion means 13. Extending longitudinally of the casing and projecting at one end through the end of the section 21 is the shaft 12 which derives its rotary motion from the pistons 31 through the conversion means 13. At its inner end, the shaft is journaled in a ball bearing 40 mounted in the bore 30, while at its outer end it is journaled in a ball bearing 41 received in a recess 42 formed in the end of the section 21. Both bearings also serve as thrust bearings and to that end the shaft 12 is formed near its inner end with an annular flange 43 which bears against the inner race of the bearing 40 to prevent inward movement of the shaft, and at the point of projection through the section 21 carries a sleeve 44 which is threaded onto the shaft and which is formed with an annular flange 45 bearing against the inner race of the bearing 41 to prevent outward movement of the shaft. Preferably, a suitable seal 46 is received in an opening 47 through which the shaft 12 projects to prevent leakage outwardly along the shaft. The section 21 is provided with a radially extending flange 48 which may be utilized for mounting the motor.

The conversion means 13 for transforming the reciprocatory motion of the pistons 31 into rotary motion of the shaft 12 herein takes the form of a wobble plate of unique construction. Composing one part of the wobble plate is an inner annular member 52 (see Figs. 1 and 3) encircling the shaft 12 and pivoted at diametrically opposite points on the ends of a pin 53 extending transversely through an enlarged and slightly rounded section of the shaft 12. Preferably, as best seen in Figs. 1 and 3, the shaft is flattened at 54, the points of projection of the pin 53, and the member 52 likewise is flattened in order to aid the pin 53 in retaining the member 52 against rotational movement relative to the shaft 12. Pin bearings 55 are preferably interposed between the ends of the pin 53 and the member 52 in order that pivoting of the member with respect to the shaft 12 may encounter little resistance. Near its outer end the member 52 is formed with an annular groove constituting one race for ball bearings 58 retained in a spacing ring 59, while at its inner end the member is formed with a second annular groove constituting the inner race for ball bearings 60.

Composing another part of the wobble plate is an annular outer member 64 encircling the inner member 52 and rotatably mounted relative thereto but secured to pivot therewith by means of the bearings 58 and 60 and an intermediate annular take-up member 65. The member 64 at its outer end is formed with a recess in which is received an outer race 66 for the bearings 58, while the outer race for the bearings 60 is formed by a groove in the take-up member 65. This member is formed at its inner end with threads for engagement with internal threads on the outer member 64 and is disposed to bear outwardly on the bearings 60 to retain the outer member 64 rotatably on the inner member. It will be apparent that by rotating the member 65 the bearings may initially be adjusted and subsequently any wear in the bearings may be taken up and the member may then be locked in adjusted position by a key 67.

The outer member 64 is operatively associated with the pistons 31 and to that end is formed with a plurality of recesses in its inner face in each of which is received a semi-spherical liner 71 and an annular ring 72 threaded into the recess and forming with the liner a socket for the reception of a ball 73 formed on the end of the piston rod 32. Registering with an aperture in the liner is an opening 75 formed in the member to lubricate the ball and socket connection.

To hold the outer member 64 against rotation while permitting it to wobble freely, a torque arm is provided which here takes the form of a yoke 78, best seen in Fig. 3, which is journaled intermediate its ends on a pin 79 extending downwardly through the top of the section 21. Preferably the yoke carries the outer race 80 of ball bearings 81, the inner race 82 of which is carried by the pin 79. Secured as by a bolt 83 to the outer end of each arm of the yoke 78 is an apertured block 84 in which is received a stud 85 extending radially from the member 64 and at right angles to the pin 79. Encircling each stud 85 is a sleeve 86 formed with flanges for retaining pin bearings 87 interposed between the block and the sleeve.

With a conversion means of the character disclosed, the stroke of the pistons 31 and hence the displacement of the motor varies with the tilt of the wobble plate with respect to the shaft 12. The stroke and the displacement is zero when the wobble plate is perpendicular to the shaft and increases as the angle of the plate with a perpendicular to the shaft increases. Thus, by adjusting the tilt of the wobble plate the speed of the motor may be varied when the supply of fluid to the motor is constant. Herein the means for adjusting the wobble plate, as best seen in Figs. 1 and 2, comprises a sleeve 90 encircling the shaft 12 and secured as by a key 91 against rotation relative to the shaft, while permitting longitudinal movement thereof along the shaft. Projecting from the sleeve on diametrically opposite sides are studs 92 in the same plane as the pin 53 upon which the inner member 52 is journaled. Each stud 92 is connected by a link 93 with a projecting end of a pin 94 extending laterally through a plate 95 welded to the outer face of the inner

member 52. The links are retained on the pin and the studs by cotter pins 96.

To shift the sleeve 90 longitudinally while permitting rotation thereof with the shaft 12, the sleeve is formed with an annular groove forming one race for ball bearing 97, the other race of which is formed by an annular ring 98 having studs 99 projecting radially on diametrically opposite sides. Carried by each of the studs 99 is a block 100 slidably received in a recess 101 formed in the extremities of a yoke 102 fixed on a shaft 103 extending transversely of the casing 10. The yoke is non-rotatably secured on the shaft by means of a key 104 and functions upon rocking of the shaft 103 to shift the sleeve 90 longitudinally of the shaft 12 which through the links 93 tilts the wobble plate to form a greater or a lesser angle with the shaft 12. The shaft 103 is journaled at each end in a sleeve bearing 106 received within a tubular extension 107 projecting laterally from each side of the section 21 near the bottom thereof. Suitable bushings 108 preferably are interposed between the inner end of the sleeve bearing 106 and the yoke 102 and between the tubular extensions 107 and the flanged outer end of the sleeve. At its rear end, the shaft 103 terminates within the sleeve 106 and is concealed by a cap 109, while at the forward end it projects outwardly of the sleeve. A screw plug 110 threaded through the yoke and into engagement with a recess in the shaft 103 serves to retain the shaft against axial movement relative to the yoke 102 and relative to the casing. An aperture 110' is formed in the bottom of the section 21 for giving access to the screw plug 110.

Herein the shaft 103 may be rocked to change the speed of the motor either manually by manipulation of the lever 17 or automatically through the hydraulic means 18 shown in Fig. 6. When the shaft 103 is to be rocked manually, lever 17 is secured to the projecting end of the shaft 103 by means of a recessed hub 111 formed on the end of the lever in which the projecting end of the shaft 103 is received and a pin 112 extending through the hub and the shaft. The free end of the lever 17 extends upwardly and forwardly into sliding engagement with an arcuate flange 113 formed on a plate 114 secured on the front side of the section 21, which flange may carry a scale 115 for indicating the speed of the motor. Extending loosely through an aperture in the free end of the lever 17 is a pin 116 having a large head 117 for engagement with one side of the arcuate flange 113, the other side of which is engaged by the lever proper. The outer end of the pin 116 is threaded for the reception of a nut 118 formed with spanner wrench holes 119 by means of which the nut may be tightened firmly to clamp the lever 17 in an adjusted position of the wobble plate resulting in the speed of the motor which is sought.

When the shaft 103 is to be rocked automatically, the plate 114 is removed from the casing and a plate 125 substituted, which plate carries a cylinder 126 of the hydraulic means 18. Reciprocable in the cylinder is a piston 127 secured by a pin 128 to a piston rod 129 projecting through one end of the cylinder 126. At its outer end, the rod 129 terminates in a yoke 130 carrying a pin 131 which is flattened on opposite sides intermediate its ends and at the flattened portion is received within a slot 132 formed in the free end of an arm 133 secured at its other end as by the pin 112 to the shaft 103. The end of the cylinder through which the rod 129 projects is sealed by a packing 134 retained by a cap 135 threaded into a recess 136 in the end of the cylinder.

The head end of the cylinder 126 is closed by a cap 139 having an internally threaded tubular extension 140. Received within the tubular extension 140 and projecting through the cap 139 into the cylinder is an adjusting rod 141 formed with threads 142 intermediate its ends for cooperation with the internal threads of the extension 140 whereby it may be adjusted inwardly or outwardly of the cylinder by rotation. The inner end of the rod 141 extends through a packing 143 retained in a recess 144 formed in the cap 139 by means of an annular ring 145 to prevent leakage of fluid along the adjusting rod. Opening to the head end of the cylinder 126 is a port 146 and opening to the rod end is a port 147, whereby actuating fluid may be supplied to the cylinder to shift the piston 127 either to the right or to the left, as viewed in Fig. 6. The extent of shift to the right is limited by abutment of the yoke 130 with an adjustable stop 148 mounted on the support to which the motor is bolted, and the extent of shift to the left is limited by abutment of the piston with the rod 141 which has a wide range of adjustment. Such shift of the piston to the left rocks the shaft 103 to tilt the wobble plate in a manner to decrease the speed of the motor. Apertures closed by plugs 148 preferably are provided in the cylinder 126 to permit removal of the pin 128 for disconnecting the piston from the rod 129. While the hydraulic means 18 has been described as an alternative means for adjusting the tilt of the wobble plate, it is believed apparent that instead of replacing the plate 114 and the lever 17 with the hydraulic means 18 the hydraulic means might replace a plate 114' disposed on the opposite side of the section 21 from the plate 114. The hydraulic means might then be connected to the rear end of the shaft 103 in the manner shown in Fig. 6 and thus provide both a manual and an automatic adjustment in the same construction.

The left end of the casing 10, as viewed in Figs. 1 and 6, is completed by the sections 23 and 24 with the section 24 taking the form of a cap housing the supply and exhaust passages 14 and 15 which open through the end thereof, and the section 23 taking the form of an annular ring spacing the section 24 from the port plate 22 so as to form a chamber 150 therebetween. The passage generally designated 14 is composed, as best seen in Figs. 1, 4, and 5, of a port 151 which opens into an annular passage 152, in turn communicating with the chamber 150 by means of a plurality of oblong openings 153 annularly arranged and opening to the chamber 150 at the outermost part thereof. The passage generally designated 15 is composed of a port 154 which opens into a generally circular recess 155 communicating with an annular slot 156 opening through the inner face of the section 24. This annular slot 156 is disposed concentric with the shaft 12 and with the ports 28 and is of a smaller diameter than the circle on which the ports 28 are disposed. The circular portion 157 of the section 24 severed by the annular slot 156 is retained by means of ribs 158, as best seen in Figs. 1 and 4.

Disposed in the space between the port plate 22 and the section 24 to control the supply and exhaust of fluid to and from the cylinders 26 through the passages 14 and 15 is the valve 16.

This valve is adapted to cooperate with the unique arrangement of ports and passages described, and it is of unique construction and has a unique movement whereby opening and closing of the ports 28 in timed relation with the reciprocation of the pistons 31 is effected very rapidly, while obtaining a maximum period of port opening during which the fluid is supplied to or exhausted from the cylinders. This rapid opening and closing of the ports is effected without a high speed of the valve as a whole, which is characteristic of rotary valves and which is objectionable and prevents the motor from attaining high speeds and from operating efficiently at such high speeds. This improved operation is accomplished herein by giving to the valve 16 an eccentric movement with respect to the ports 28 so that opening and closing of the ports is effected by the eccentric movement of the valve as distinguished from a rotary movement thereof. Accordingly, the valve 16 is circular and is mounted by means of ball bearings 160 located centrally thereof on a stud 161 formed eccentrically on the inner end of the shaft 12 and projecting into the space between the port plate 22 and the section 24.

The faces of the valve 16 are ground so as to have a fluid-tight sliding fit with the adjacent faces of the port plate 22 and the section 24. The valve is most easily pictured as a wheel having a hub 162 and a rim 163 retained on the hub by a plurality of spokes 164 of reduced thickness so as to form an annular passage 165 opening through both faces of the valve and freely communicating by means of the openings 166 formed between the spokes. This passage 165, as best seen in Fig. 5, is so disposed that it is always in communication with the slot 156 forming a part of the passage 15 and is of such width that in any position of the valve three of the ports 28 open in whole or in part thereto. The rim 163 has a radial thickness which is slightly greater than the width of a port 28 so that in any position of the valve 16, three of the ports 28 are disposed in whole or in part outwardly of the valve 16 to communicate with the chamber 150, while the seventh port is blocked by the rim 163. It is believed apparent from the foregoing description and Fig. 5 that eccentric movement of the valve 16 as a result of the rotation of shaft 12 will cause the ports successively to be connected alternately with the passage 14 through the chamber 150, and the passage 15 through the annular passage 165 in the valve and the slot 156. It is believed apparent, moreover, that each port 28 will be closed when the piston 31 is at its dead center point, namely, when reversing from a power stroke to an exhaust stroke and from an exhaust to a power stroke, and that the opening or closing of a port will be very rapid because, as clearly seen in Fig. 5, in the position of the valve shown and the position of the stud 161 the valve has a large movement in a vertical direction thereby rapidly closing and opening the ports at the top of the figure and at the bottom of the figure, while it has practically no movement in a horizontal direction, thereby leaving the ports at the side of the figure wide open and in communication with the chamber 150 and the passage 165 respectively.

While the passages 14 and 15 may alternately serve as supply or exhaust passages depending upon the direction which the shaft 12 is to be rotated, if it be assumed that the shaft is to be rotated in a clockwise direction, as viewed in Figs. 4 and 5, the passage 14 will constitute the fluid supply passage whereas the passage 15 will constitute the exhaust passage. The operation of the motor briefly will then be as follows: Assuming that the valve is in the position shown, the operating fluid supplied through the passage 14 will enter the chamber 150 through the openings 153 and will flow through the three ports to the left of the valve 16, as viewed in Fig. 5, and will impart a working stroke to the pistons 31 in the cylinders with which those ports communicate. As a result, the wobble plate will be actuated and the shaft 12 rotated in a clockwise direction, as viewed in Fig. 5. With an actuation of the wobble plate and the shaft, three of the pistons will be moved through an exhaust stroke and the fluid from the cylinders in which those pistons reciprocate will be discharged through the three ports shown in the right half of Fig. 5, which ports are in whole or in part open to the passage 165 of the valve 16. The exhaust fluid will flow through the openings 166 between the spokes of the valve and thence out through the annular slot 156, recess 155 and port 154. The seventh and topmost piston, shown in Fig. 1, is just reversing from an exhaust to a power stroke and correspondingly the port 28 thereof is closed by the rim 163 of the valve as it is moving to change the connection of the port from the passage 165 to the chamber 150. It will be apparent that as the valve is eccentrically driven in a clockwise direction, as viewed in Fig. 5, the uppermost port 28 will be uncovered and connected to the chamber 150 so that operating fluid may be supplied thereto and impart a working stroke to the piston, and that as the valve is further moved each of the ports will successively be connected to the chamber 150 to receive operating fluid, blocked while the respective piston is reversing from movement in one direction to movement in the other, then opened to the passage 165 in the valve to permit discharge of the exhaust fluid, and is then again blocked while the piston again is reversing and is then connected to the chamber 150 to complete the cycle.

It is believed apparent from the foregoing that I have perfected a motor or pump which has many novel and advantageous features, among the most important of which is the novel valve means which I have disclosed, and the novel construction of the wobble plate and the torque arm for retaining a portion of the plate against rotation.

I claim as my invention:

1. In a fluid handling mechanism, in combination, a casing having a plurality of cylinders formed therein and a cylindrical valve chamber having parallel end faces, a port opening to the head end of each cylinder and to one end face of said valve chamber in an annular row, a fluid passage opening to said valve chamber radially outwardly of said ports and a second fluid passage opening to said valve chamber radially inwardly of said ports, valve means operable successively to connect said ports alternately to the passage opening radially outwardly of the ports and to the passage opening radially inwardly of said ports, said valve means comprising a wheel-like member having a hub, a rim, and spokes connecting the rim to the hub to provide a passage from one face of the wheel to the other which is sealed about its inner periphery by the hub and about its outer periphery by the rim, said hub having end faces of substantially equal area in fluid-tight sliding engagement with the end faces of said valve chamber and said rim

having end faces of substantially equal area in fluid-tight sliding engagement with the end faces of said valve chamber, and means engaging the hub for driving said valve means through an eccentric movement with respect to said ports.

2. In a fluid handling mechanism, in combination, a casing comprising a cylinder block having a plurality of cylinders formed therein and having a flat face at one end of the block, a port opening through said end face of the block to each of the cylinders, said ports being annularly arranged, a section having fluid supply and exhaust passages formed therein and having a flat face disposed opposite the flat face of said cylinder block, and an annular spacer interposed between said section and said cylinder block and cooperating with said cylinder block and said section to form a cylindrical valve chamber, one of said passages in said section communicating with the valve chamber inwardly of said ports, and the other of said passages communicating with said valve chamber adjacent the periphery of the valve chamber, and an integral wheel-like valve having a hub and a rim each having a fluid-tight sliding fit with the face of both said cylinder block and said section, and spokes of reduced thickness connecting said hub and said rim to provide an annular passage opening through each face of the valve, said passage always being in communication with the passage in said section opening to the valve chamber inwardly of said ports, and the valve chamber beyond the rim of the valve always being in communication with the other of said fluid passages in said section, and means for imparting to said valve an eccentric motion whereby the valve successively connects said ports alternately to the supply and exhaust passages in said section.

3. In a device of the character described, a casing comprising a motor block having a plurality of annularly arranged parallel cylinders formed therein, and a port opening through one face of the block to each of the cylinders, said ports being annularly arranged, a section having a flat face positioned parallel to and in spaced relation to the face of said block, an annular spacer interposed between said section and said motor block faces, fluid supply and exhaust passages, one of said passages communicating with the space formed between said motor block and said section inwardly of said ports and the other of said passages communicating with said space adjacent the periphery of the space, and a wheel-like valve having a rim and a hub each having end faces in fluid-tight sliding engagement with the adjacent faces of said motor block and said section, and means for imparting to said valve an eccentric motion whereby the valve successively connects the ports alternately to the supply and exhaust passages.

4. In a device of the character described, a casing having a plurality of annularly arranged cylinders formed therein and a cylindrical valve chamber adjacent one end of said cylinders having parallel end faces, a port opening to each of said cylinders and to one end face of said valve chamber, and fluid supply and return passages, one opening to said valve chamber radially outwardly of said ports and the other opening to said valve chamber radially inwardly of said ports, a piston reciprocable in each of said cylinders, a rotatably mounted shaft disposed concentrically of said annularly arranged cylinders, means for converting the reciprocatory motion of said pistons into rotary motion of said shaft, and a wheel-like valve positioned in said valve chamber controlling the supply and exhaust of fluid to and from said cylinders having a rim and a hub each having end faces in fluid-tight sliding engagement with the end faces of said valve chamber, and a stud mounted eccentrically on the inner end of said shaft and engaging said valve centrally thereof to drive the same through an eccentric motion in timed relation with the reciprocation of said pistons.

5. In a device of the character described, a casing comprising a motor block having a plurality of annularly arranged parallel cylinders formed therein and a port opening through one face of the block to each of the cylinders, said ports being annularly arranged, a section having fluid supply and exhaust passages formed therein and an annular spacer interposed between said section and said motor block and cooperating therewith to form a cylindrical valve chamber, one of said passages communicating with said valve chamber inwardly of said ports and radially outwardly of the center of the chamber, and the other of said passages communicating with said chamber adjacent the periphery of the chamber, and a wheel-like valve comprising a rim, a hub and connecting spokes, said rim and hub each having a fluid-tight sliding fit in said valve chamber with both said motor block and said section, said hub and rim providing said valve with a fluid-tight seal at its inner periphery as well as at its outer periphery, and means for imparting to said valve an eccentric motion whereby the valve successively connects the ports alternately to the supply and exhaust passages.

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