Oct. 12, 1943. R. K. JEFFREY 2,331,694

HYDRAULIC PUMP OR MOTOR

Filed July 31, 1940 2 Sheets-Sheet 1

Fig. 1

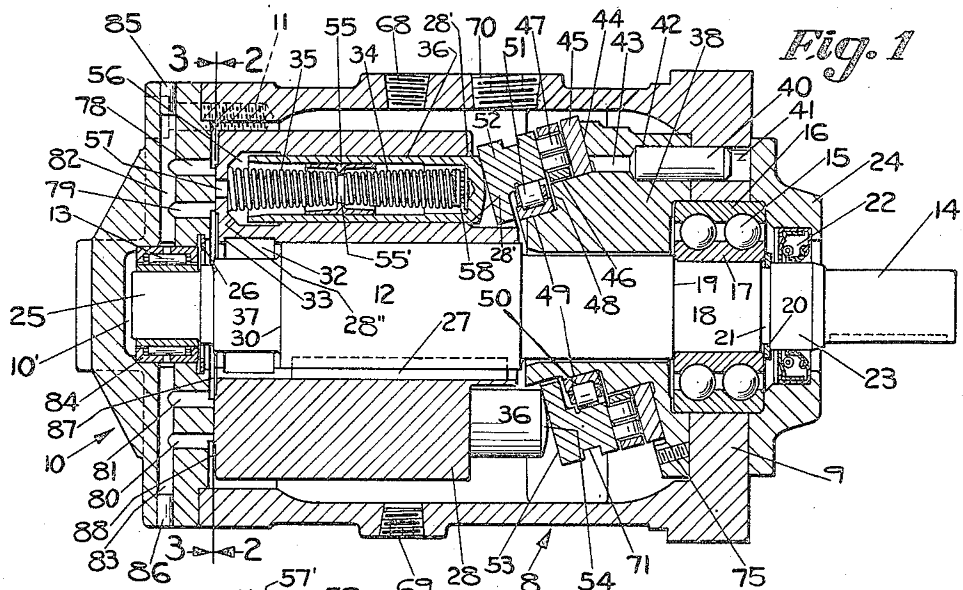
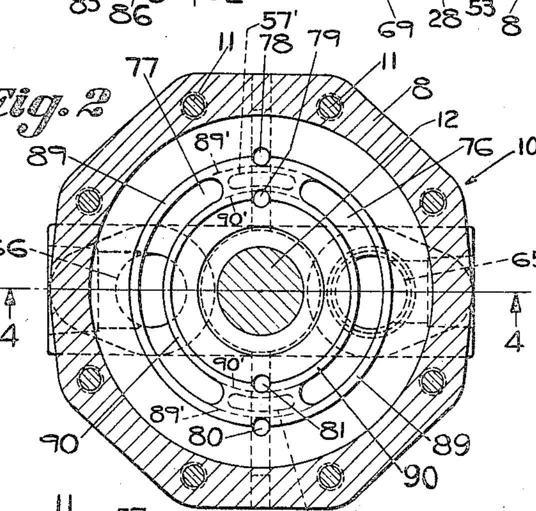


Fig. 2



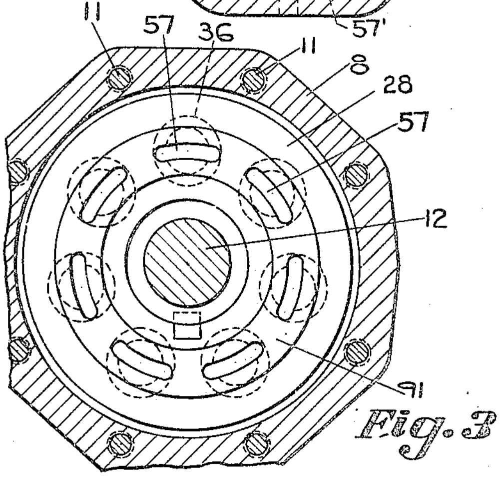


Fig. 3

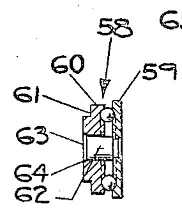


Fig. 1a

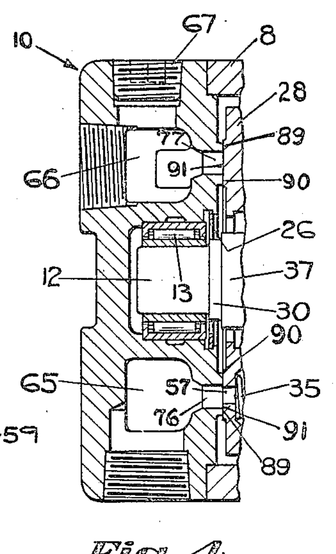


Fig. 4

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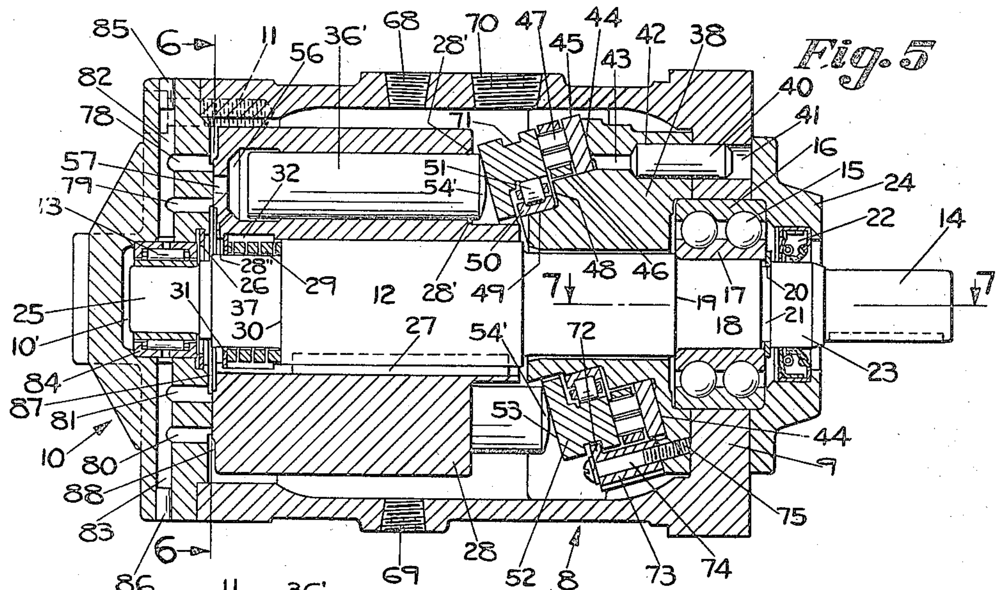

Fig. 5

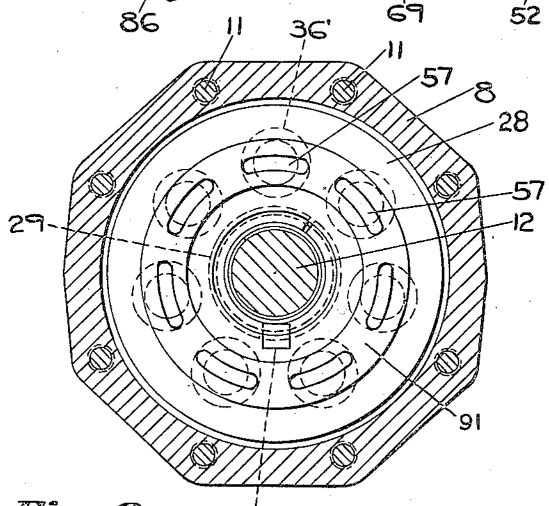

Fig. 6

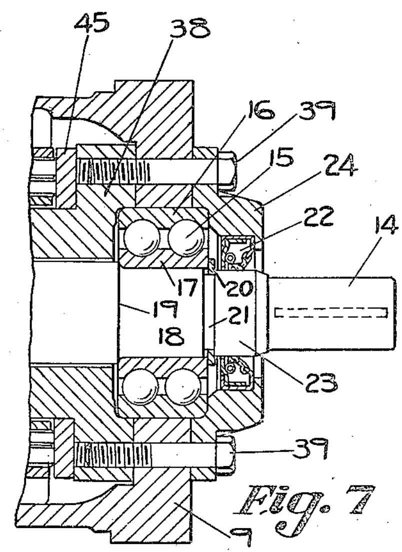

Fig. 7

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2,331,694

UNITED STATES PATENT OFFICE

2,331,694

HYDRAULIC PUMP OR MOTOR

Robert K. Jeffrey, Columbus, Ohio, assignor to The Jeffrey Manufacturing Company, a corporation of Ohio

Application July 31, 1940, Serial No. 348,765

27 Claims. (Cl. 103—162)

My invention relates to rotating-cylinder pumps or motors for hydraulic transmission of power, and is adapted for use in hydraulically operated mining machines although it may have a general application.

One of the objects of my invention is the provision of improved and efficient structure which may be used either as a hydraulic motor or as a hydraulic pump with a minimum number of parts added or substituted.

Another object of the invention is the provision in a rotating-cylinder type of pump or motor, of the balancing of the hydraulic pressures tending to separate the rotating cylinder from the valve port plate and tending to hold them in contact by predesigning the area of contact to be equal to the combined active pressure on the pistons.

A further object of the invention is the reduction to a minimum of the wear between the rotating piston cylinder and the valve port plate by predesigning the pressure areas to secure such balance as will maintain maximum efficiency.

A still further object of the invention is the provision of resilient means for holding the rotating-cylinder block in contact with the port plate in cooperation with the balancing of the pressures tending to separate the cylinder block from the valve port plate, and hold the cylinder block against the port plate and thereby reducing the wear between the cylinder block and the port plate to a minimum and thus prolong the life of the motor pump at relatively high pressures.

Another object of the invention is the provision of an anti-friction bearing between the bottom of a hollow piston and a spring within the piston to enable the piston to oscillate on its own axis relatively to the rotating-cylinder block while the outer end of the piston engages a rotatable ring plate mounted on a thrust block.

Still another object of the invention is the provision of tapered springs in the pistons combined with means including seats in a cylindrical cross-head to keep the springs out of contact with the inner walls of the pistons.

Another object of the invention is the provision of pockets located for the automatic release of dirt or abrasive material from the valve plate seats.

A further object of the invention is the provision of a retainer for a rotating face plate mounted in an inclined position on a thrust block in a structure adapted to be used as a hydraulic motor.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the accompanying drawings,

Fig. 1 is a sectional elevation of a rotating-cylinder hydraulic device embodying my invention for use as a hydraulic pump;

Fig. 1ª is an enlarged view of the ball bearing structure located at the bottom of the piston shown in Fig. 1;

Fig. 2 is a sectional elevation taken on the line 2—2 of Fig. 1, looking in the direction of the arrows;

Fig. 3 is a sectional elevation taken on the line 3—3 of Fig. 1, looking in the direction of the arrows;

Fig. 4 is a sectional bottom plan view taken on the line 4—4 of Fig. 2, looking upwardly in the direction of the arrows;

Fig. 5 is a sectional elevation similar to Fig. 1 but showing the arrangement of the parts when the structure is adapted to be used as a hydraulic motor;

Fig. 6 is a sectional elevation taken on the line 6—6 of Fig. 5, looking in the direction of the arrows; and

Fig. 7 is a sectional plan view taken on the line 7—7 of Fig. 5.

Referring to Figs. 1 and 5 illustrating respectively the hydraulic pump and the hydraulic motor, it will be seen that nearly all of the parts are in common in the two structures. The same reference numbers are used on the parts which are duplicates in the pump and in the motor.

The casing 8 is provided with end plates 9 and 10, the end plate 9 being integral with the body portion 8 of the casing while the end plate 10 is detachable. By means of the machine screws 11, 11, circumferentially spaced as shown in Fig. 2, the end plate 10 may be securely fastened with a liquid-tight fit to the body portion of the casing 8. The end plate 10 serves as a valve, feed or port plate, as hereinafter more fully explained.

A shaft 12 is journaled at its inner end to the end plate 10 by means of the roller bearing 13. The outer end 14 of the shaft 12 may be connected to a motor or to apparatus to be driven. That is to say, a motor may be connected to the shaft 12 in Fig. 1 to drive the structure as a pump, whereas the shaft 12 may be connected to apparatus to be driven by means of the structure shown in Fig. 5 which operates as a motor.

The shaft 12 is journaled in the end plate 9 by means of the ball bearing structure 15 which comprises concentric races 16, 17, the former fitting in an opening in the end plate 9 and the latter fitting on the reduced portion 18 of the shaft 12. The inner end of the race 17 engages the shoulder 19 on the shaft 12. The outer end of the race 17 engages a retaining ring 20 fitting in a groove 21 in the shaft 12. Inasmuch as the casing 8 both in Fig. 1 and in Fig. 5 may be filled with oil during operation, an oil seal 22 is provided between the reduced portion 23 of the shaft 12 and the cap plate 24 which may be secured to the end plate 9 by means of circumferentially spaced machine screws 39 (Fig. 7). At the inner end of the shaft 12 the roller bearing 13 is mounted on the reduced inner end 25 with the outer race of the roller bearing having its inner end engaging an annular shoulder, the other end of the outer race being retained in place by the ring 26.

A key 27 fits in a keyway in the shaft 12 so as to be immovable endwise relatively thereto. The key 27 also projects into a keyway which extends the entire length of the cylinder block 28 so that the latter will rotate with the shaft 12. While the shaft 12 may be restricted against axial movements by means of the journal bearing mountings, it is desirable that the cylinder block keyway shall permit free movement of the cylinder block 28 relatively to the shaft 12 toward and from the port plate 10. The cylinder block 28 may be held against the port plate by means of the spiral spring 29 which surrounds a reduced portion of the shaft 12 and which at one end rests against the shoulder 30 on the shaft 12 and at its other end engages the retaining ring 31 which rests against an annular shoulder at the inner end of the cylindrical recess 32. The spring 29 is therefore located entirely within the confines of the cylinder block 28. Such annular shoulder is clearly shown at 33 in Fig. 1, in which view the spring 29 has been omitted because the structure in this view is a hydraulic pump in which the springs 34, 35 in the hollow pistons 36 are relied on to hold the cylinder block 28 against the port plate, as more fully explained hereinafter.

In Fig. 5 the pistons 36′ are solid or integral throughout, whereas in Fig. 1 the pistons 36 are hollow to receive the springs 34 and 35. In Fig. 5 showing the hydraulic motor, the spring 29 is mounted on the reduced portion 37 of the shaft 12 and acts between the shoulder 30 on the shaft and the retaining plate 31 to push the cylinder block toward the left as viewed in Fig. 5. In Fig. 1 showing the hydraulic pump, the spring 29 is omitted, and the springs 34, 35 push the cylinder block 28 toward the left against the port plate.

Secured to the inner face of the end plate 9 is a thrust block 38. Machine screws 39, 39 as shown in Fig. 7 may be used to secure the cap plate 24 to the end plate 9 and at the same time to secure the thrust block 38 to the inner face of the end plate 9. Such assembly may be more readily obtained by first inserting the connecting pin 40 in registering opening 41, 42 in the end plate 9 and the thrust block 38, as shown in Figs. 1 and 5. Such pin 40 makes a fairly tight fit in the registering openings 41 and 42 and may be removed by inserting a tool in the bore 43 and driving the pin 40 toward the right after the cap plate 24 has been removed.

The thrust block 38 is provided with an annular face 44 in an inclined transverse plane for receiving the thrust ring plate 45 which fits over the cylindrical face 46. Also surrounding the cylindrical face 46 is a ring roller thrust bearing 47, the rollers of which engage the thrust ring plate 45. Another annular face 48 in an inclined plane parallel to the annular face 44 but of smaller diameter, is located at right angles to the cylindrical surface 49, the latter being concentric with the cylindrical surface 46 but of smaller diameter. The ball bearing race 50 fits the cylindrical surface 49 and serves to co-operate with the rollers 51 to journal the rotary thrust plate 52 to the thrust block 38. The face 53 of the rotary thrust plate 52 is engaged by the outer ends of the pistons in the cylinder block 28. It is highly desirable that the face 53 be ground smooth and be free from identification marks or imperfections. Each of the pistons 36, 36′ has the same diameter throughout its length. The outer ends 54 of the pistons 36 and the outer ends 54′ of the pistons 36′ each has the shape of a segment of a sphere, different portions of which are in contact with the face 53 of the rotary thrust plate in different positions of the cylinder block 28. While the point of contact between the spherical end 54 or 54′ and the face 53 is always at the same distance from the axis of the piston 36 or 36′ for any given angle of the plate 52, the distance of such point of contact from the periphery of the plate 52 varies, as shown in Fig. 1 or Fig. 5. This variation in such point of contact results in oscillations of each piston on its own axis relatively to the block 28 during a complete rotation of the shaft 12.

In the hydraulic pump shown in Fig. 1, however, it is desirable to reduce friction to a minimum so that the hollow pistons 36 will be free to oscillate on their axes or reciprocate when their spherical surfaces 54 engage certain portions of the face 53 of the rotary thrust ring 52. The springs 34 and 35 may taper toward each other and be seated at their adjacent ends on the annular seats within the sleeve or cross-head 55 which is free to slide or rotate within the hollow piston 36. As shown in Fig. 1, the left-hand end of the spring 35 extends into the recess 56 and engages the inside of the cylinder block 28 where the port 57 is located. As shown in Fig. 3, there are seven (7) elongated arcuate ports 57, one for each of the cylinders in which the hollow pistons 36 are located. The ports 57 are formed in a plane circular bearing and hydraulic fluid sealing surface provided on a projecting end 91 of rotor or cylinder block 28.

As shown at 28′ in Figs. 1 and 5 the right hand ends of the cylinders are each beveled to facilitate lubrication of the exterior surfaces of the pistons as they move toward the left. Right angle edges of the cylinders tend to wipe off the oil whereas the beveled edges 28′ serve to lead the oil into the cylinders as the pistons move toward the left as viewed in Fig. 1.

Reverting to the provisions for freedom of rotary oscillation of the pistons, it should be understood that the springs 34, 35 are tapered to keep them out of contact with the inner walls of the piston 36 and also out of contact with the inner walls of the cylindrical cross-head 55.

The left-hand end of the spring 35 is centered over the port 57 by the beveled seat 28″. The adjacent ends of the springs 34, 35 rest against annular seats inside of the cross-head 55 and an opening 55′ is provided so that when the piston 36 moves axially relatively to the cross-head 55 the oil within the piston will not be locked. In other words, the opening 55′ permits freedom of expansion and contraction of the springs while friction is reduced to a minimum by keeping the springs out of contact with any other parts intermediate their ends. Two springs are preferred to one because a single spring tends to buckle causing contact with the piston walls and consequent undue friction. By the use of two springs buckling is avoided and lack of frictional contacts co-operates with the anti-friction bearing 58 to prevent rotary oscillation of the pistons from twisting the springs.

Between the right-hand end of the spring 34 and the bottom of the piston 36 is located an anti-friction or ball bearing device 58. Such a ball bearing device is preferably constructed as shown in Fig. 1[a]. One race 59 frictionally engages the bottom of the piston 36 at the right-hand side thereof. The race 60 is provided with an annular seat 61 for the right-hand end of the spring 34. A pin 62 is provided with a head 63 which engages the annular seat 64 on the ball race 60. The pin 62 passes through ball races 60 and 59 and is rigidly secured to the race 59 by peening the pin 62 thereto. The race 59 and pin 62 therefore move with the piston 36 when the latter oscillates, while the race 60 remains frictionally connected to the right-hand end of the spring 34. The diameter of the hole at the center of the race 60 may be made larger than the diameter of the pin 62 so that the race 60 fits loosely on the pin thereby permitting better seating of the balls. The balls cannot escape because of the rigid connection of the pin 62 to the race 59. An anti-friction bearing without balls may be used by modifying the part 60 to fit against a hardened shoulder on pin 62 at 59.

Fig. 4, being a bottom plan view on the line 4—4 of Fig. 2, shows the ports 65 and 66. Either of these ports may be the supply port and the other the exhaust port, depending upon which direction the shaft 12 is rotated either by means of a motor connected to the shaft for the hydraulic pump of Fig. 1, or by means of the hydraulic pressure for the hydraulic motor shown in Fig. 5. As shown in Fig. 4, piping may be screw-threaded to the ports 65 and 66. A screw-threaded plug 67 may be provided for an opening leading to the port 65. Filling and draining plugs 68, 69 may be provided for the casing 8. An additional screw-threaded plug 70 may be provided for an opening permitting observation of or access to the thrust ring 52.

The thrust ring 52 is provided with an annular groove 71 into which is adapted to extend a retaining element 72, as shown in Fig. 5. This retaining element may be carried by a semi-circular bracket 73 through which extends a plurality of spaced-apart cap screws 74 each threaded into an opening such as that shown at 75 at the lower end of the thrust block 38, as shown in Fig. 5.

Such retaining element 72 is not necessary in the hydraulic pump shown in Fig. 1 because of the presence of the springs 34, 35 which urge the pistons 36 toward the plate 52 to hold the latter in the position illustrated in Fig. 1. In the hydraulic motor shown in Fig. 5, however, the pistons are solid, and the spring 29 surrounds the shaft 12. When hydraulic pressure on the pistons 36' is lacking, the pistons will be unable to hold the plate 52 in the position shown in Fig. 5 and consequently it is desirable to include in the structure the retaining element 72 extending into the annular groove 71 so as to cooperate with the right-hand end of the cylinder block to hold the parts in their proper inter-related positions shown in Fig. 5.

As shown in Fig. 2, the valve plate 10 is provided with arcuate ports 76 and 77 which respectively communicate with the ports 65 and 66. Between the ends of the ports 76 and 77 are the ports 78, 79, 80 and 81. These ports are all in communication with the radial passageways 82 and 83, each having their inner ends extending to the outer race 84 of the roller bearing 13. The outer end of the passageway 82 is closed by the plug 85, and the outer end of the passageway 83 is closed by the plug 86. Annular recesses at 87 and 88 are provided to establish free communication of the oil in the casing through the ports 78, 79, 80, 81 and the passageways 82 and 83 to the annular space 32 surrounding that portion of the shaft 12 which is designated 37.

While the foregoing ports and passageways provide ample lubrication for the roller bearing 13, the principal function of the annular recesses 87 and 88 is to provide zero hydraulic pressure at both the outer edges and the inner edges of the arcuate seats 89 and 90.

Where the circular bearing surface on left-hand end 91 (Fig. 3) of the cylinder block 28 engages the seats 89 and 90, the ports 57 are adapted to communicate with the ports 77 and 76 of Fig. 2 but not with the ports 78, 79, 80 and 81. The ports 57 are narrower than the ports 76, 77 and the length of each port 57 is less than the spaces in the form of bearing and hydraulic fluid sealing surfaces between the adjacent ends of the ports 76, 77. The ports 78 and 80 each has a diameter about twice the width of the seat 89 and the ports 79 and 81 each has a diameter about twice the width of the seat 90. In other words, the ports 78 and 80 are in alinement with the arcuate seats 89, 89 and span the width thereof whereas the ports 79 and 81 are in alinement with the arcuate seats 90, 90 and span the width thereof.

The ports 78, 79, 80 and 81 are therefore in the most efficient positions for eliminating grit or other particles of foreign material between the seating faces of the cylinder block 28 and the valve plate 10. Such particles of material tend to travel circularly around the seats 89 and 90 but the ports 78, 79, 80, 81 being in such circular paths act as ejection ports for such particles of material into the zero pressure compartments or chambers. In Fig. 2 the dotted lines 89', 90' merely represent prolongations of the arcuate edges of the seats 89 and 90 in relation to the ports 78, 79, 80, 81, and the dotted lines 57', 57' represent the positions of the ports 57, 57 between the adjacent ends of the ports 76, 77. While the differential pressure across the valve seats from the supply to the zero pressure chambers, may assist by leakage to remove such particles, there is no assurance that such particles will be removed without the presence of the ports 78, 79, 80, 81.

If the port 66 is a supply port, the hydraulic pressure through the port 77 extends through the port 57 into three of the piston cylinders. The tendency is for such pressure to cause leakage across the annular seats 89 and 90. It is highly desirable to predesign the areas across which such leakage tends to occur. In other words, the structure shown in either Fig. 1 or Fig. 5 is predesigned with respect to the balancing of the pressures on the port plate and cylinder block, which pressures tend to separate the cylinder block from the port plate. Assuming for example that the hydraulic pressure in the piston cylinder or in the chamber 56 is 1250 pounds per square inch, the total pressure tending to move the piston toward the right, would be obtained by multiplying 1250 by the cross-sectional area of the piston in square inches.

The port plate 10 has two ports 76 and 77, one being a suction port and the other a pressure port. The port plate is stationary and does not rotate. On the other hand, the cylinder block 28 rotates with the shaft 12 on the axis of the latter. This rotation is effected by means of the pistons engaging the inclined thrust plate 52, the direction of rotation being dependent upon which of the ports 65 and 66 is a supply port and which the exhaust port.

As the cylinder block 28 rotates, its left-hand end 91 (Fig. 3) is in contact with the port plate at the seating surfaces 89 and 90. The engaging surfaces 91 and 89, 90 are very accurately finished. The port plate is preferably made of high lead bronze and very accurately turned and machined. The cylinder block 28 is preferably made of nickel cast iron and is carefully machined and then lapped in on a lapping block.

As the cylinder block 28 rotates, the oil or other liquid pressure medium at the ports 57 which are in communication with the pressure supply line, tends to leak along the seating surfaces into the annular recesses 87 and 88 due to the pressure differential, the pressure in the ports 57 being substantially 1250 pounds per square inch while the pressure in the annular recesses 87, 88 is substantially zero. That is to say, since the annular recesses 87 and 88 are connected to the exhaust line, the fluid pressure within the casing 8 is substantially zero.

The leakage as it flows along the seating surfaces 89 and 90 presents a separating force that tends to move the cylinder block 28 away from the port plate 10 but the structure is predesigned so that the back pressure or reactionary pressure in the cylinder block balances or cancels the forces which tend to move the cylinder block away from the port plate 10.

As shown in Fig. 3, seven (7) pistons may be used, three being presented to the supply port, three to the exhaust port, and one being in neutral position. There would be a minimum of three pistons under pressure that would produce the aforesaid reactionary or back pressure force. This reactionary force is due to the piston pressing against the thrust ring 52 and tends to hold the cylinder block 28 against the port plate. This back pressure or reactionary force is equal to the pressure per square inch times the cross-sectional area of the piston in square inches. This reactionary force is subject to calculation and if three cylinders are receiving pressure, the total pressure would be 1250 multiplied by 3 and then by the cross-sectional area of each piston in square inches.

On the other hand, the separating force or leakage force may be calculated by multiplying the seating areas 89 and 90 by the average pressure which varies from 1250 to zero. That is to say, the areas of the seating surfaces 89, 90 in square inches should be such that when multiplied by one-half of 1250 the product will be equal to the reactionary pressure which is found by multiplying the number of active pistons by the cross-sectional area in square inches of each, and then multiplying this product by the pressure in square inches which was assumed to be 1250 pounds.

The pressure of the spring 29 in Fig. 5 or the pressure of the spring mechanism 34, 35 of Fig. 1 may be taken into consideration in the predesigning of the apparatus to reduce the leakage to a minimum and thereby reduce the wear at the valve seats to a minimum. That is to say, the pressures of the springs may be added to the back pressure or reactionary pressure, and the areas of the seats 89 and 90 calculated accordingly so that assurance may be had that the seating surfaces will always remain in contact. However, over-balancing by means of the spring mechanism is highly desirable because at times the structures may be operating at no load and at such times maintenance of contact between the cylinder block and the port plate is obtained by the pressure from the springs inside the pistons of Fig. 1. In the hydraulic motor shown in Fig. 5, the spring 29 on the shaft performs this function under similar circumstances.

While I have described the part designated 38 as a thrust block, it may be regarded as a tilted swash box, and the thrust ring 52 termed a swash plate accordingly.

The outer ends of the pistons 36 and 36′ preferably each has the shape of a segment of a sphere so that the thrust plate 52 may be mounted in a pre-designed pump or motor at any one of various angles relative to the axis of rotation of the cylinder block. However, the rotary oscillations of the pistons individually will nevertheless persist although reduced to a minimum in this arrangement.

While Fig. 1 has hereinbefore been referred to as particularly adapted for use as a pump it should be understood that this structure shown in Fig. 1 may also be used as a motor without change. When a motor is desired, however, the cost of construction may be materially reduced by omitting the relatively expensive construction of the hollow pistons, tapering springs and cylindrical cross-head and substituting solid pistons therefor and adding the spring 29 and the bracket 73. In other words, when a motor is desired, the structure in Fig. 5 is preferred by reason of its lower cost of construction.

Furthermore, while the structure shown in Fig. 1 may be used as a pump or a motor but is designed particularly for use as a pump, the structure shown in Fig. 5 is designed particularly for use as a motor but can be used as a pump if provided with a well-known supercharging arrangement.

It should also be noted that the pump and motor structures are well adapted for high pressures such as 1250 pounds per square inch because capable of withstanding such high pressures without any appreciable leakage. Such pump and motor structures are therefore well adapted for use in connection with hydraulically operated machines such for example as mining machines.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claims hereto appended, and I therefore wish not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of my invention, what I desire to secure by Letters Patent of the United States is:

1. In a device of the class described, the combination with a casing, of a shaft journaled therein, a cylinder block secured to said shaft to rotate therewith, pistons in said cylinder block, a tilted thrust block secured to one end of said casing, a thrust plate mounted on said thrust block to rotate relatively thereto, a valve plate fixed

to the other end of said casing, ports and passageways in said valve plate to control the flow of pressure medium to the cylinders in said cylinder block to act on the pistons therein to force the same against said thrust plate, and resilient means surrounding said shaft within said cylinder block to press the latter against said valve plate, said resilient means being in position within the cylinder block to act on the latter at that end thereof adjacent to said valve plate.

2. In a device of the class described, the combination with a casing, of a shaft journaled therein, a cylinder block connected thereto to rotate therewith, a tilted plate mounted in said casing, a plurality of circumferentially spaced pistons in said cylinder block in position to engage said tilted plate, resilient mechanism within the pistons, anti-friction bearings between said resilient means and the interior ends of said pistons to facilitate oscillation of said pistons relatively to said cylinder block during rotation of the latter, and mechanism affording ports and passageways to control the flow of pressure medium to the cylinders of said cylinder block to act on the pistons therein to force the same against said tilted plate.

3. In a device of the class described, the combination with a casing, of a shaft journaled therein, a cylinder block connected thereto to rotate therewith, a tilted plate mounted in said casing, a plurality of circumferentially spaced pistons in said cylinder block in position to engage said tilted plate, spring mechanisms in said pistons, anti-friction devices between the interior bottoms of said pistons and the adjacent ends of the spring mechanisms, the other ends of said spring mechanisms being in engagement with said cylinder block, and mechanism affording ports and passageways to control the flow of pressure medium to the cylinders of said cylinder block to act on the pistons therein to force the same against said tilted plate, said anti-friction devices facilitating oscillation of said pistons as the cylinder block rotates with said shaft and said spring mechanisms serving to hold the cylinder block against said port mechanism.

4. In a device of the class described, the combination with a casing, of a shaft journaled therein, a cylinder block connected to said shaft to rotate therewith, a plurality of reciprocating pistons in the cylinders of said block, mechanism engaged by said pistons to secure rotation of said block and shaft, and mechanism affording supply and exhaust ports to control the flow of fluid pressure medium to and from said cylinders, said mechanism comprising valve seats engaged by a predetermined area of said block to effect an approximate balance between the back pressure on the block and the average leakage pressure between the supply port and the exhaust.

5. In a device of the class described, the combination with a casing, of a shaft journaled therein, a cylinder block connected to said shaft to rotate therewith, a plurality of pistons reciprocably mounted in the cylinders of said block, mechanism engaged by said pistons to secure rotation of said block and shaft, mechanism affording supply and exhaust ports and passageways to control the flow of liquid to and from said cylinders, said mechanism comprising valve seats engaged by a predetermined area of said block to effect a balance between the average leakage pressure across the valve seats and the fluid pressure exerted to move the block against said seats, and resilient means for exerting an overbalancing pressure on the block to hold the same against the valve seats.

6. In a device of the class described, the combination with a casing, of a shaft, a cylinder block connected to said shaft to rotate therewith, a valve plate having an arcuate pressure port and an arcuate exhaust port adapted to communicate with ports in said block leading to said cylinders, concentric annular seats at the inner and outer edges of said arcuate ports, and foreign material ejector ports in said seats in position to effect ejection of solid particles moved arcuately along such seats by the cylinder block.

7. In a device of the class described, the combination with a casing, of a shaft, a cylinder block connected to said shaft to rotate therewith, a valve plate having pressure and exhaust ports in a valve seat, said ports being adapted to communicate with ports in said block leading to said cylinders, and a foreign material ejector port in said valve seat in position to effect ejection of solid particles moved arcuately along the valve seat between the cylinder block and valve plate and by the relative rotation of the cylinder block and the valve plate.

8. In a device of the class described, the combination with a casing, of a shaft, a cylinder block connected to said shaft to rotate therewith, a valve plate having arcuate supply and exhaust ports in a circular valve seat, said ports being adapted to communicate with a plurality of ports in said cylinder block, and two pairs of foreign material ejection ports in said seats each pair being spaced from the ends of the supply and exhaust ports.

9. In a device of the class described, the combination with a casing, of a shaft journaled in said casing, a cylinder block secured to said shaft to rotate therewith, pistons in said cylinder block, a valve plate, ports and passageways to control the flow of the pressure medium to the cylinders in said block to act on the pistons therein, mechanism engaged by said pistons to secure rotation of said shaft, two springs in each piston, a cylindrical cross-head slidably mounted in each piston, and two seats in each cylindrical cross-head for the adjacent ends of the springs extending into the opposite ends of said crosshead.

10. In a hydraulic motor, the combination with a casing, of a drive shaft journaled therein, a cylinder block connected to said shaft to rotate therewith, pistons in the cylinders of said block, a valve plate, ports and passageways in said block and said valve plate to control the flow of liquid pressure medium to said cylinders, a tilted box secured to said casing, a swash plate mounted on said box for rotation relatively thereto in position to be engaged by the outer ends of said pistons, and a supporting bracket secured to said box and having an arcuate tongue and groove connection with the periphery of said rotary swash plate.

11. In a hydraulic pump, the combination with a casing, of a driven shaft journalled therein, a cylinder block connected to said shaft to rotate therewith, pistons in the cylinders in said block, a tilted thrust block secured to said casing, a thrust plate, springs urging the pistons against said thrust plate, thrust roller bearing mechanism between the peripheral portion of said thrust plate and said tilted thrust block, and journal bearing mechanism between said thrust plate and said thrust block, said thrust plate

remaining in operative position during operation of the pump without additional support.

12. In a device of the class described, the combination with a casing, of a shaft journaled therein, a cylinder block secured to said shaft to rotate therewith, pistons in said cylinder block, mechanism mounted in position to be engaged by said pistons to effect rotation of said cylinder block and said shaft, mechanism affording ports and passageways to control the flow of pressure medium to the cylinders in said cylinder block to act on the pistons therein, a plurality of cylindrical cross-heads one in each piston and each slidable in its piston, a plurality of pairs of springs one pair in each piston, and seats in each slidable cross-head for adjacent ends of the springs, the springs in each cross-head acting in series and serving to press the cylinder block against the port mechanism.

13. In a device of the class described, the combination with a casing having a perforation in one end thereof, of a thrust block mounted at the inner side of said end of the casing and having a perforation registering with the perforation in the casing end, mechanism comprising a pin insertable into said registering perforations to hold said thrust block against turning relatively to said casing, a ring seat mounted on said thrust block, a ring roller bearing mounted on said ring seat, a thrust plate contacting with said ring roller bearing, and a ring roller bearing for journaling said thrust plate to said thrust block.

14. In a device of the class described, the combination with a casing, of a shaft, a journal bearing between said shaft and said casing, a cylinder block connected to said shaft to rotate therewith, a valve plate having pressure and exhaust ports adapted to communicate with ports leading into the cylinders in said block, pistons in such cylinders, means engaged by said pistons to effect rotation of said shaft, a radial passageway in said valve plate, and a pair of spaced-apart passageways in said plate, one in direct communication with the casing outside of said cylinder block and the other in direct communication with said journal bearing adjacent the shaft journal.

15. A hydraulic motor comprising the combination with a casing, of a thrust block secured thereto, a thrust plate mounted on said thrust block to rotate relatively thereto, and a detachable bracket having an extension into an annular groove in the periphery of said thrust plate.

16. A hydraulic pump comprising a hollow piston, a pair of tapering springs within said piston, a cylindrical cross-head having therein an opening through seats for adjacents ends of said springs, and a seat at the inner bottom end for the inner end of the innermost spring, said cross-head being movable along said hollow piston while said seats are engaged by the adjacent ends of said springs.

17. In a device of the class described, the combination with a casing, of a shaft journaled in said casing, a cylinder block secured to said shaft to rotate therewith, pistons in said cylinder block, a tilted swash plate thrust block secured to one end of said casing and occupying a position in close proximity to said cylinder block, a thrust plast mounted on said thrust block to rotate relatively thereto, a valve plate fixed to the other end of said casing, ports and passageways in said valve plate to control the flow of pressure medium to the cylinders in said cylinder block to act on the pistons therein, and resilient means within the cylinder block at that end thereof adjacent said valve plate in position to press the cylinder block against the latter.

18. In a device of the class described, the combination with a casing, of a shaft journaled therein and having a portion of reduced diameter, a cylinder block secured to said shaft to rotate therewith, pistons in said cylinder block, a tilted support secured to one end of said casing in close proximity to said cylinder block, a tilted plate on said support in position to be engaged by the outer ends of said pistons, mechanism affording ports and passageways to control the flow of pressure medium to the cylinders in said cylinder block to act on the pistons therein to force the same against said tilted plate, a spring spiraled about that portion of said shaft having the reduced diameter at that end of said cylinder block remote from said tilted support, an annular shoulder on said shaft serving as a seat for one end of said spring, and a ring seat on said cylinder block for the other end of said spring, said spring being entirely within the confines of said cylinder block closely adjacent said ports and passagesways and adapted to press the cylinder block against said mechanism.

19. In a device of the class described, the combination with a casing, of a shaft journaled therein, a cylinder block secured to said shaft to rotate therewith, pistons in said cylinder block, a tilted plate mounted in said casing in position to be engaged by the outer ends of said pistons, means affording ports and passageways to control the flow of pressure medium to the cylinders in said cylinder block to act on the pistons therein to force the same against said tilted plate, a spring surrounding said shaft within said cylinder block adjacent said ports and passageways, an annular shoulder on said shaft serving as a seat for one end of said spring, and mechanism providing an annular seat on the interior of said cylinder block for the other end of said spring, the construction and arrangement being such that the entirely enclosed spring acts between the shaft and the cylinder block to press the latter in a direction away from said tilted plate to maintain said ports and passageways.

20. In a device of the class described, the combination with a casing, of a shaft, a cylinder block having cylinders therein and connected to said shaft to rotate therewith, pistons in said cylinders, a valve plate associated with said cylinder block and having arcuate supply and exhaust ports in a circular valve seat, said ports being adapted to communicate with a plurality of ports in said cylinder block, two pairs of foreign material ejection ports in said seat each ejection port having a diameter at least equal to the width of the seat at the side of the supply and exhaust ports, and means engaged by said pistons to receive pressure from said pistons and rotate said shaft.

21. As an article of manufacture, a valve plate having arcuate supply and exhaust ports bounded by circular concentric valve seats, and a plurality of ejection ports in said seats and located intermediate the ends of said supply and exhaust ports and spaced therefrom.

22. As an article of manufacture, a valve plate having arcuate supply and exhaust ports in a circular valve seat, and two pairs of ejection ports in said seat each pair being intermediate

adjacent ends of the supply and exhaust ports and spaced therefrom.

23. As an article of manufacture, a valve plate having arcuate supply and exhaust ports bounded by circular concentric valve seats, and two pairs of ejection ports each having a diameter twice the width of a valve seat at the lateral edges of the supply and exhaust ports, each ejector port being in arcuate alinement with concentric circles defining the edges of a seat and each pair of ejector ports being located between adjacent ends of the supply and exhaust ports and spaced therefrom.

24. In a device of the class described, the combination with a casing, of a rotor in said casing having cylinders therein and ports leading thereto, said ports being formed in a circular bearing surface carried by and rotating with said rotor, a feed plate having feed and discharge ports formed as extended arcs and bounded by concentric circular seats which bear upon said bearing surface on opposite sides of said rotor ports, ends of said feed and discharge ports being separated by a bearing surface in contact with the first named bearing surface, said first named bearing surface being in hydraulic sealing contact with said seats and with said second named bearing surface, and means formed in the circular path of each of said circular seats and between said feed and discharge ports to eject any foreign material caught between the contacting surfaces during rotation of said rotor.

25. In a device of the class described, the combination with a casing, of a rotor in said casing having cylinders therein and ports leading thereto, said ports being formed in a circular bearing surface carried by and rotating with said rotor, a feed plate having feed and discharge ports formed as extended arcs and bounded by concentric circular seats which bear upon said bearing surface on opposite sides of said rotor ports, ends of said feed and discharge ports being separated by a bearing surface in contact with the first named bearing surface, said first named bearing surface being in hydraulic sealing contact with said seats and with said second named bearing surface, and means formed in the circular path of at least one of said circular seats and between said feed and discharge ports to eject any foreign material caught between the contacting surfaces during rotation of said rotor.

26. In a device of the class described, the combination with a casing, of a rotor in said casing having cylinders therein and ports leading thereto, said ports being formed in a circular bearing surface carried by and rotating with said rotor, a feed plate having feed and discharge ports formed as extended arcs and bounded by concentric circular seats which bear upon said bearing surface on opposite sides of said rotor ports, ends of said feed and discharge ports being separated by a bearing surface in contact with the first named bearing surface, said first named bearing surface being in hydraulic sealing contact with said seats and with said second named bearing surface, and means formed in the circular path of at least one of said circular seats to eject any foreign material caught between the contacting surfaces during rotation of said rotor.

27. In a device of the class described, the combination with a casing, of a rotor in said casing having cylinders therein and ports leading thereto, said ports being formed in a circular bearing surface carried by and rotating with said rotor, a feed plate having feed and discharge ports formed as extended arcs and bounded by concentric circular seats which bear upon said bearing surface on opposite sides of said rotor ports, ends of said feed and discharge ports being separated by a bearing surface in contact with the first named bearing surface, said first named bearing surface being in hydraulic sealing contact with said seats and with said second named bearing surface, and means formed in the circular path of each of said circular seats to eject any foreign material caught between the contacting surfaces during rotation of said rotor.

ROBERT K. JEFFREY.

DISCLAIMER

2,331,694.—*Robert K. Jeffrey*, Columbus, Ohio. HYDRAULIC PUMP OR MOTOR. Patent dated October 12, 1943. Disclaimer filed February 5, 1944, by the assignee, *The Jeffrey Manufacturing Company.*

Hereby enters this disclaimer to claims 1, 17, 18, and 19 of said patent.

[*Official Gazette March 7, 1944.*]