

Feb. 10, 1942.

J. B. HAWLEY, JR

2,272,771

HYDRAULIC PUMP

Filed March 16, 1938

6 Sheets-Sheet 1

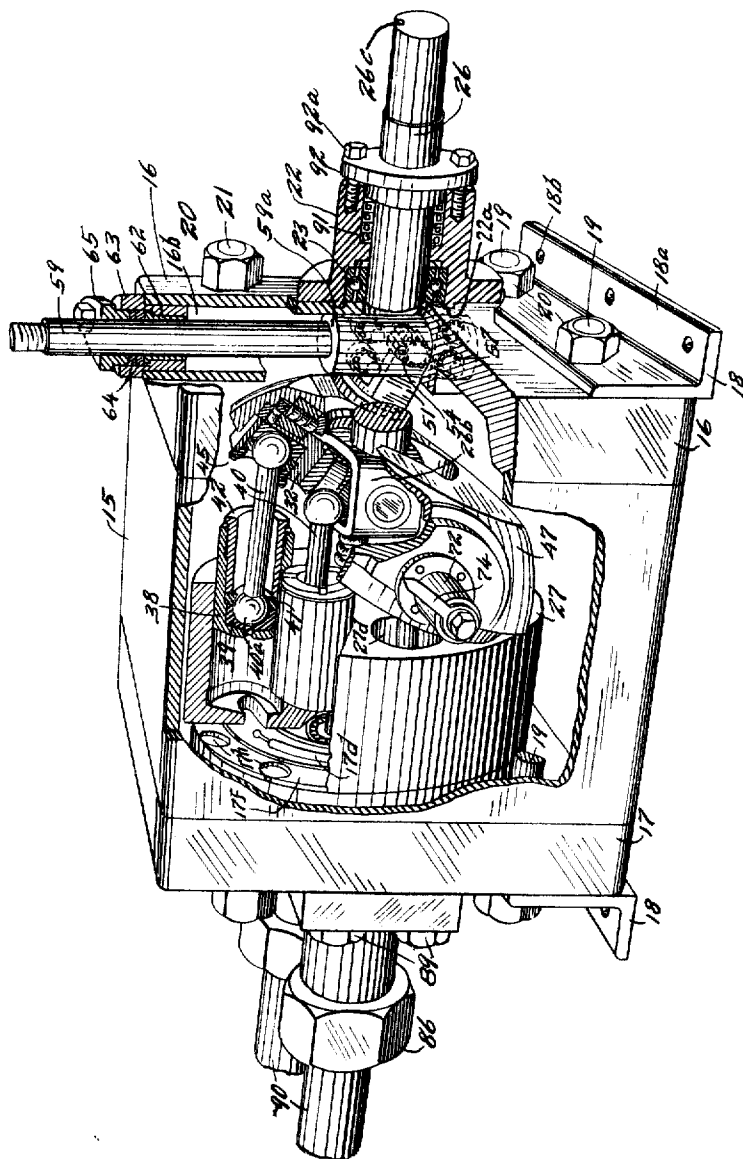


Fig. 1.

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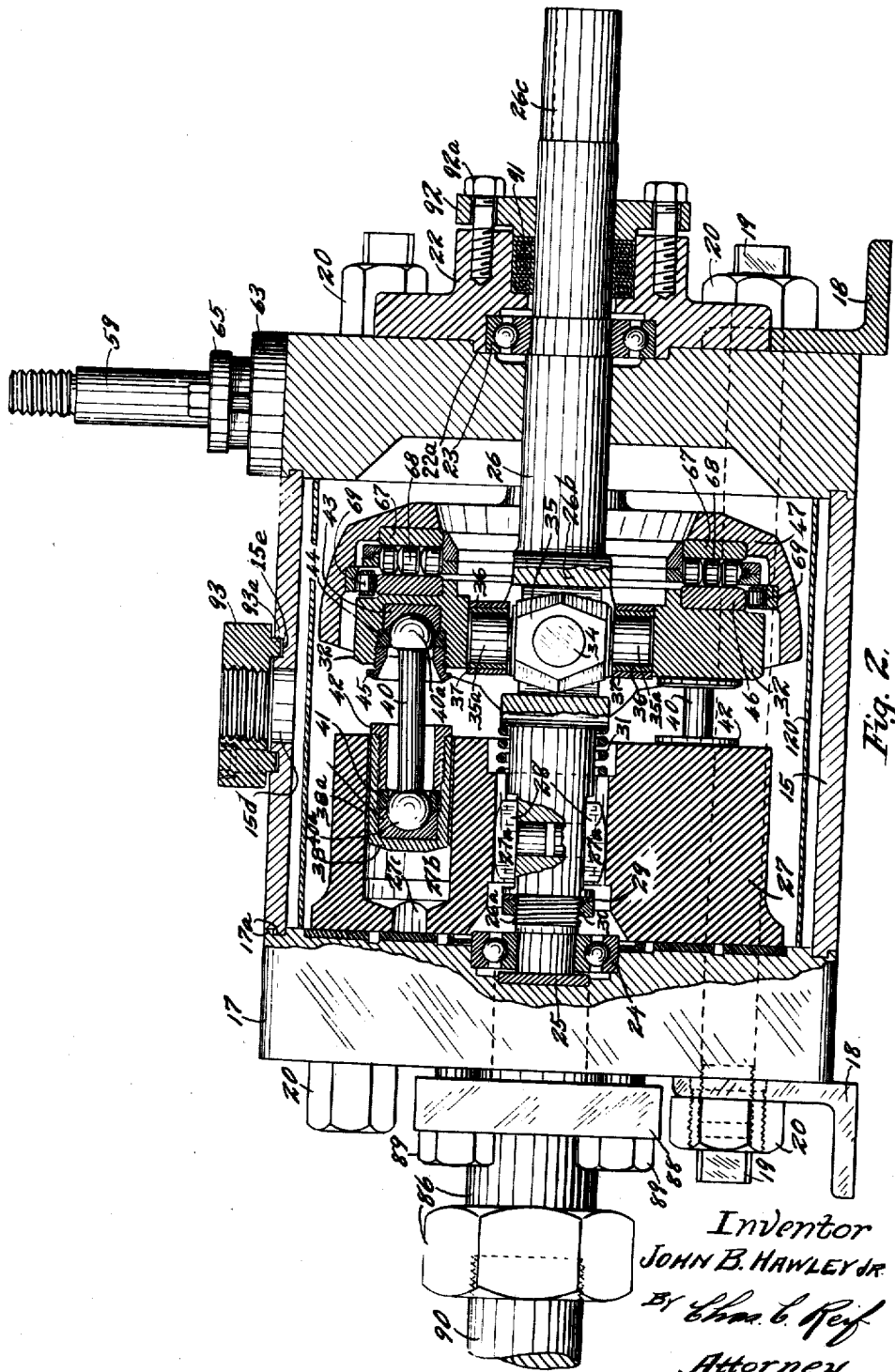
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HYDRAULIC PUMP

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6 Sheets-Sheet 2



Feb. 10, 1942.

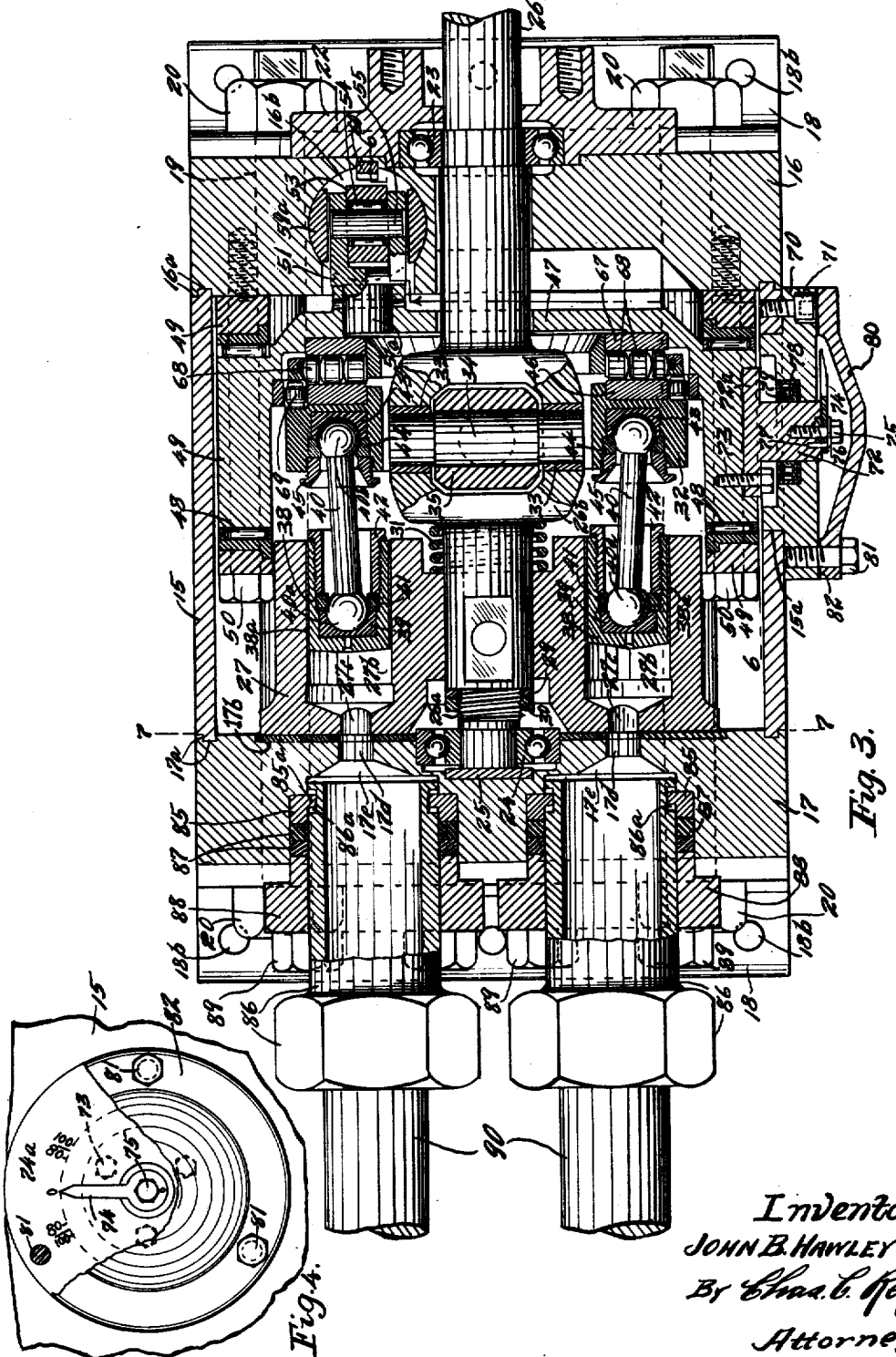
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6 Sheets-Sheet 3



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HYDRAULIC PUMP

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6 Sheets-Sheet 4

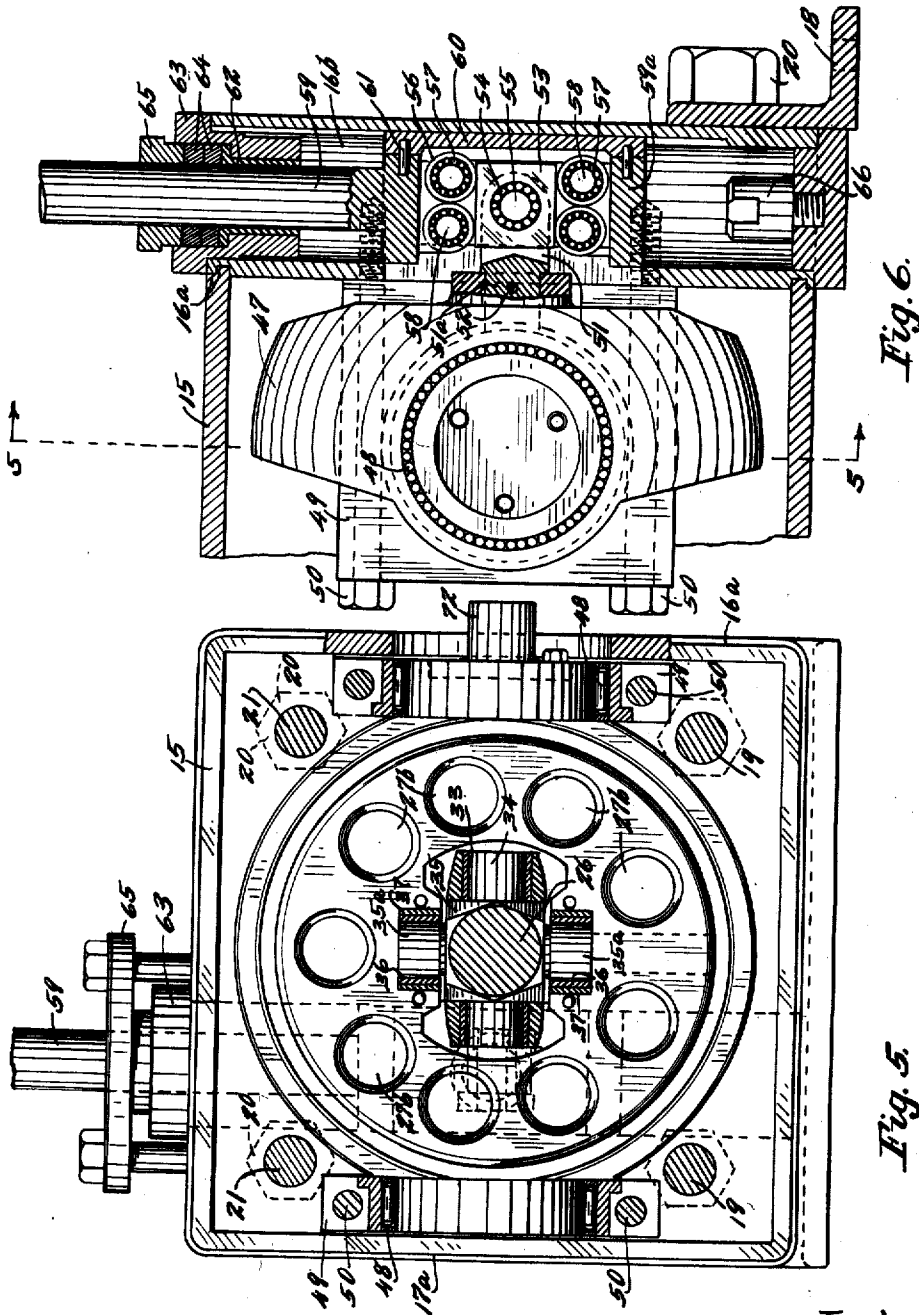


Fig. 5.

Fig. 6.

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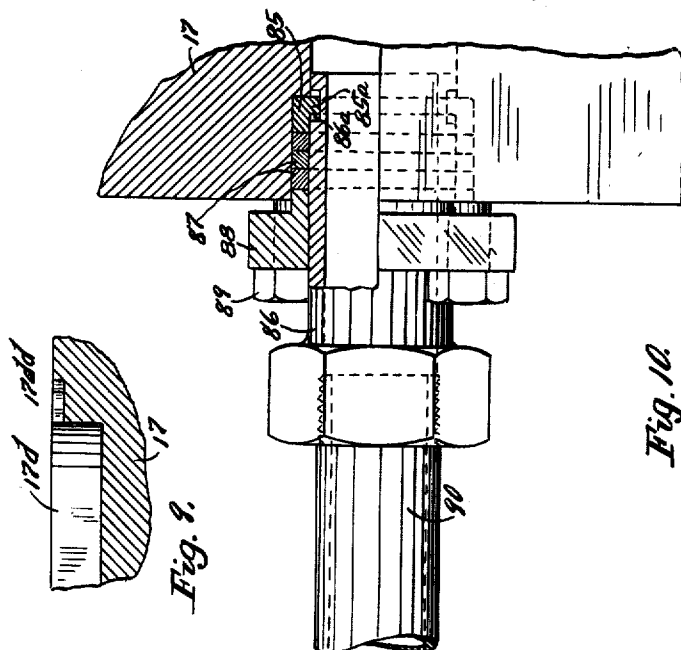


Fig. 10.

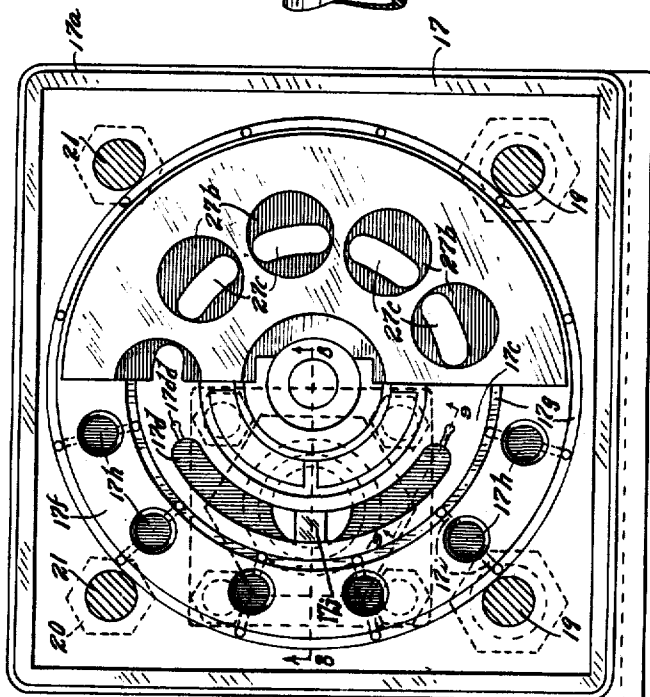


Fig. 7.

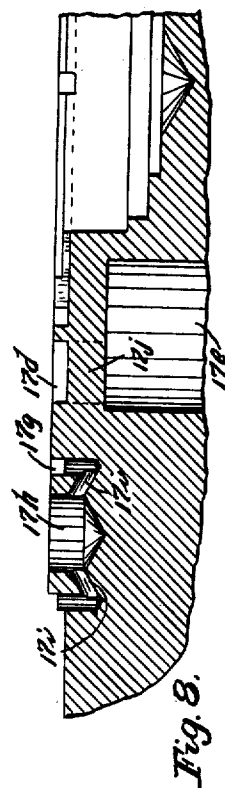


Fig. 8.

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6 Sheets-Sheet 6

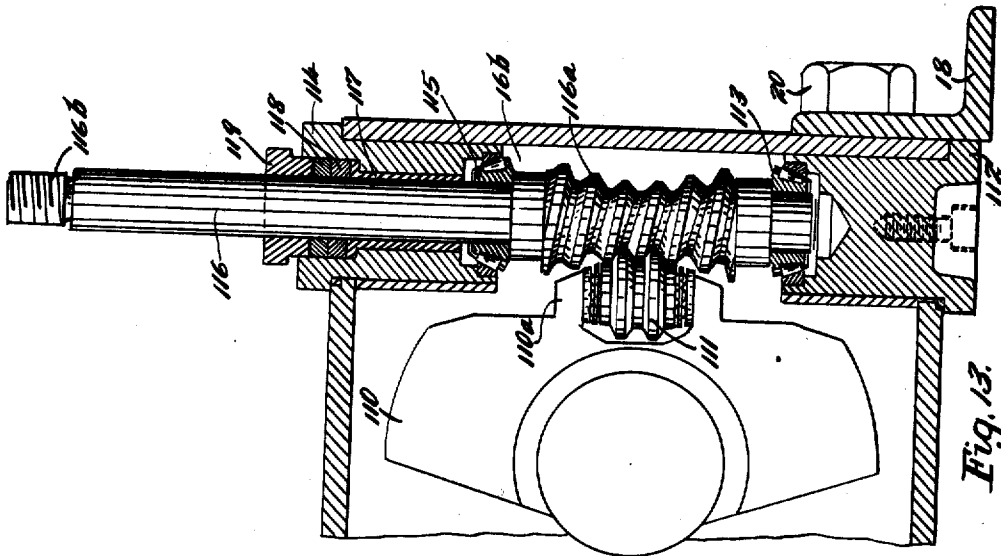


Fig. 13.

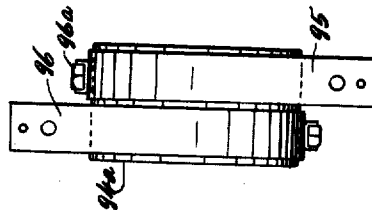


Fig. 12.

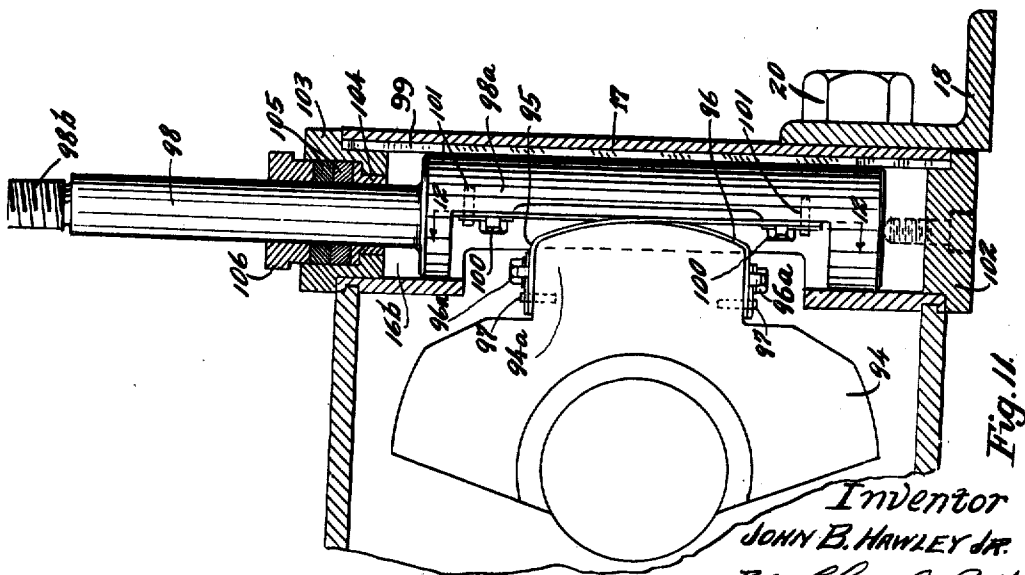


Fig. 11.

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UNITED STATES PATENT OFFICE

2,272,771

HYDRAULIC PUMP

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Application March 16, 1938, Serial No. 196,225

4 Claims. (Cl. 103-162)

This invention relates to a fluid pump, motor or hydraulic transmission device and particularly to such a device of the kind known as the swash plate type. Such a device comprises a rotating cylinder barrel in which pistons reciprocate, these pistons being movable by a rotating swash plate rotating about the axis of the cylinder barrel but being given a wobble motion by a tilting plate which can be tilted at various angles to the axis of said cylinder barrel.

It is an object of this invention to provide such a device comprising a novel form of piston and specifically a piston having an outer surface of hard bronze welded onto steel.

It is a further object of the invention to provide such a device having a tilting plate together with simple, novel and efficient means for varying the inclination of said tilting plate.

It is another object of the invention to provide a novel form of indicator showing the inclination of the tilting plate and one which will be normally covered and sealed.

It is still another object of the invention to provide a novel structure of lubricating the valve plate engaged by the cylinder barrel.

It is still further an object of the invention to provide a novel construction of discharge and inlet pipe in combination with the pump parts.

It is also an object of the invention to provide a novel structure of valve plate and particularly to provide a novel surface for the valve plate engaged by the cylinder barrel.

It is further an object of the invention to provide a novel construction of frame or casing for the pump and a novel form of supporting means for said casing.

These and other objects and advantages of the invention will be fully set forth in the following description made in connection with the accompanying drawings in which like reference characters refer to similar parts throughout the several views and in which:

Fig. 1 is a perspective view of the device, some parts being broken away and others shown in vertical section;

Fig. 2 is a view partly in side elevation of the device and partly in central vertical longitudinal section;

Fig. 3 is a horizontal section taken substantially on the plane of the axis of the inlet and discharge conduits and of the central driving shaft;

Fig. 4 is a partial view in side elevation showing the indicator cover with a portion of the cover being broken away to show the indicator;

Fig. 5 is a view in vertical section taken substantially on line 5-5 of Fig. 6 as indicated by the arrows;

Fig. 6 is a partial vertical section taken substantially on line 6-6 of Fig. 3 as indicated by the arrow;

Fig. 7 is a vertical section taken substantially on line 7-7 of Fig. 3, half of said view looking in one direction and half thereof looking in the other direction;

Fig. 8 is a partial horizontal section taken on line 8-8 of Fig. 7 as indicated by the arrows; and shown on an enlarged scale;

Fig. 9 is a partial section taken on line 9-9 of Fig. 7 as indicated by the arrows;

Fig. 10 is a view partly in side elevation and partly in vertical section showing the structure of the inlet and discharge conduits;

Fig. 11 is a view similar to Fig. 6 showing a modification;

Fig. 12 is a view as seen from line 12-12 of Fig. 11 looking in the direction of the arrows; and

Fig. 13 is a view similar to Fig. 6 showing a modification.

Referring to the drawings a device such as referred to above is shown comprising a casing section 15. As illustrated, this section is made of box-like form rectangular in vertical cross section. A front end plate 16 is secured to one end of casing 15, the same fitting tightly thereagainst and having therewith a rabbeted joint comprising a ledge and shoulder indicated at 16a. A rear end plate or valve plate 17 is provided fitting against the other end of casing 15 and also having therewith a rabbeted or offset joint as indicated at 17a. Angle members or brackets 18 have vertical flanges disposed against the outer sides of plates 16 and 17 and have horizontal flanges 18a constituting feet or supports for the casing, the same having holes 18b there-through which may receive securing bolts. Long screws 19 extend through section 15 and the plates 16 and 17 as well as brackets 18, the same being disposed adjacent the corners of the casing and being threaded at their ends to receive the securing nuts 20. Bolts 19 therefore secure said parts together. Similar bolts 21 extend through members 15, 16 and 17 adjacent the upper corners of the casing and are also equipped with nuts 20. Bolts 21 also act to secure the sections of the casing together. A bearing bracket 22 has an inner short flange 22a set into the outer end of plate 16 and is recessed to carry a ball bearing 23. Plate 17 is recessed at its inner

side to receive a ball bearing casing 24 and said plate also has a thrust plate 25 set thereinto. A driving shaft 26 is journaled in the bearings 23 and 24, the same having its inner end engaging plate 25 and having a shoulder engaging the inner side of bearing 23. A cylinder barrel 27 surrounds shaft 26 adjacent its inner end and is secured thereto by the oppositely disposed keys 28, said keys being shown as having cylindrical shanks or projections fitting in similarly shaped holes in shaft 26. Said keys extend into keyways 27a in cylinder barrel 27. Shaft 26 has a threaded portion 26a adjacent its inner end receiving a collar 29 and a nut 30 engaging said collar. Collar 29 engages a shoulder on said shaft adjacent said threaded portion. Shaft 26 has a yoke 26b formed thereon at the inner side of barrel 27 and a coiled compression spring 31 surrounds shaft 26 bearing at one end against yoke 26b and at its other end against barrel 27, said spring being partly disposed in the recess in barrel 27. Spring 31 acts to press cylinder barrel 27 against the flat face of the valve plate 17. Barrel 27 has a flat face engaging said valve plate and has formed therein a plurality of cylinders 27b, the same being shown as nine in number and said cylinders having openings 27c at their inner ends forming inlet and discharge openings which openings are of the form and disposition shown in Fig. 7. A swash plate 32 surrounds shaft 26 at yoke portion 26b. Said yoke portion has bores at opposite sides receiving bushings 33 in which are journaled the ends of a main shaft pin 34. The central part of shaft pin 34 extends through a trunnion block 35 disposed within yoke 26b and having trunnions 35a at opposite ends projecting at right angles to pin 34. Trunnions 35a are received in bushings 36, said bushings or bearings 36 in turn received in trunnion bearing blocks 37 which are received in swash plate 32 and locked therein. Swash plate 32 is thus rotated by shaft 26. Cylinder barrel 27 has a piston 38 in each of its cylinders, said piston having a bore in the inner end of which is disposed a ring socket 39 having a semi-spherical recess therein adapted to receive the end of a ball as formed on one end of a connecting rod 40. A connecting rod end bushing engages the outer end of a socket 39 also having a surface fitting part of the other half of the ball 40a and held in place by a flanged hollow nut 42 threaded into the bore of piston 38, the flange thereof engaging the end of said piston. While pistons 38 might be variously made, in practice it has been found highly efficient to have them made of steel, the cylindrical bearing portions of the pistons being coated with a coating 38a of hard bronze welded thereon. Connecting rod 40 has a ball 40b at its other end and swash plate 32 is provided with a plurality of sockets equal in number to and aligned with the cylinders in barrel 27. Each of said sockets has disposed therein a ring socket 43 receiving the outer end of ball 40b. A bushing 44 engages the member 43 and also has a partly spherical surface engaging ball 40b. A nut 45 is threaded into swash plate 32 and engages member 44, the same being hollow to accommodate connecting rod 40. Some locking means, not shown, will be provided for locking nuts 42 and 45 in place. Swash plate 32 is recessed at its outer side to receive a hard bearing plate 46. A tilting plate 47 of ball-like form surrounds shaft 26 and has a large central opening through which said shaft passes. Plate 47 has rather

large trunnions at either side thereof which are journaled in roller bearings 48. The bearings 48 are carried in bearing brackets 49 which are secured to end plates 16 by the headed bolts 50 which pass through said brackets at the sides of bearings 48. It will be seen that tilting plate 47 may be tilted about the axis of its trunnions which axis extends perpendicularly to the axis of shaft 26. Tilting plate 47 also carries and forms a support for the swash plate 32. For the purpose of tilting plate 47 a fork 51 is provided having a cylindrical shank 51a fitted into a boss on plate 47 and secured therein by a tapered pin 52. Fork 51 has flat surfaces at the inner sides of its arms between which is disposed a block 53. Block 53 is centrally bored to receive the roller bearings 54 and a pin 55 extends centrally through bearings 54 and has its ends disposed in the arms of fork 51. Block 53 has flat top and bottom sides and these are engaged by bearing sleeves 56 mounted on roller bearings 57 into which bearings extend the bearing shafts 58. Shafts 58 are secured in the sides of a yoke 59a formed on the lower end of a vertically extending control shaft 59. The yoke 59a has secured thereto a key member 60 fitting in a keyway in the end plate 16 and extending from the bore 16b formed in said end plate and in which the yoke or cage 59a slides, the latter having outer cylindrical surfaces as shown in Fig. 3. Key 60 is secured to portion 59a adjacent its top and bottom by the pins 61. Shaft 59 and the portion 59a are thus guided for vertical non-rotative movement. Shaft 59 passes through the flanged bushing 62 fitted into a cover member 63 closing the outer end of bore 16b and being bored to accommodate the packing material 64 pressed therein and about shaft 59 by the gland 65. A stop block 66 has a reduced threaded stem secured in plate 16 at the bottom of bore 16b and limits the downward movement of shaft 59. It will be seen that by raising and lowering shaft 59 that block 53 will be raised and lowered and this in turn will move plate 47 about the axis of its trunnions. Block 53 can move parallel to the axis of shaft 26 but can have no rotative movement. Plate 47 is recessed to receive a bearing plate 67 and roller bearings 68 are disposed between plate 67 and plate 46. Plate 46 at its outer edge also engages roller bearings 69 so that swash plate 32 rotates against both bearings 68 and 69.

Casing section 15 is provided with a cylindrical opening 15a and a reduced cylindrical portion of a bracket 70 fits into said opening, bracket 70 being secured to the side of section 15 by a plurality of circumferentially spaced screws 71 having their heads countersunk into member 70. The adjacent trunnion of tilting plate 47 is recessed to receive the flange 72a of a member 72, said flange being secured to said trunnion by the circumferentially spaced bolts 73. Member 72 has a cylindrical portion projecting outwardly from flange 72a and this extends through a cylindrical central opening in bracket 70, the same projecting a short distance beyond the outer surface of bracket 70. An indicator pointer 74 is provided with a hub set into the outer end of member 72 and said hub and pointer are secured to member 72 by the headed bolt 75 engaging a washer 76. A pin 77 also extends through pointer 74 into member 72. Pointer 74 cooperates with graduations 74a formed on the face of member 70. Packing 78 surrounds member 72 within member 70 and is carried in a casing 79.

The pointer 74 is covered and enclosed by cover plate 80 secured to member 70 by the circumferentially spaced headed screws 81, a gasket 82 being placed between said members to insure a tight seal.

As stated, end plate 17 forms a valve plate and is provided with a bronze surface 17b welded onto said plate which is made of Invar steel. This steel used contains about 57 percent nickel and has one-twentyfifth the coefficient of expansion of regular steel. Outside of bearing 24 the face of the valve plate is tightly engaged by the outer flat face of barrel 27. Valve plate 17 has an annular bearing surface 17c and this is provided with diametrically opposite arcuate slots 17d, one of which forms an inlet port and the other of which forms an outlet port. These slots extend through plate 17 and communicate with the discharge openings 17e. Small grooves 17dd extend from each end of slots 17d for a short distance. Said valve plate has another annular bearing surface 17f outward of ports 17d and this bearing surface has the grooves 17g at either side thereof. A series of holes 17h are formed in bearing surface 17f located substantially centrally thereof and in circumferentially spaced relation. A passage 17i extends from each side of and substantially at the bottom of each opening 17h into the grooves 17g. Oil can thus pass or be forced through the passages 17i and into the holes 17h so that a film of oil will always be provided on the bearing surface 17f. A bridge of metal 17j extends across each slot 17d substantially at the center thereof, said bridge being of comparatively narrow width and of comparatively small depth, the same having its top surface disposed below bearing surface 17c. The outer side of plate 17 is provided with a pair of parallel bores in alignment with the discharge openings 17e and rings 85 are disposed in the bottom of said bores against the shoulder formed therein, said rings having inwardly extending flanges 85a. Coupling members 86 have cylindrical pipe portions extending into reduced extensions of the bores in plate 17, said portions each having an annular groove 86a formed therein in which the flanges 85a of the rings 85 extend. Rings 85 must of course, be in two parts. Packing 87 is disposed in said bores engaging the rings 85 at its inner ends and being engaged at its outer end by the glands 88, said packing thus being tightly pressed about the pipe portions of members 86. Glands 88 as usual have flanges through which extend the headed bolts 89 threaded into the end of plate 17. The inlet and discharge conduits 90 are suitably connected to members 86. As shown in Fig. 1 packing material 91 is disposed in member 22 about shaft 26, said material being engaged by the cylindrical portion of a packing gland 92 extending into the bore of member 22. Gland 92 has a flange through which pass the bolts 92a threaded into member 22 and material 91 is thus compressed about shaft 26. The outer end of shaft 26 is shown as having a reduced portion threaded with a keyway 26c adapted to receive a suitable driving member. Casing 15 is shown as having an opening 15d in its top about which is secured a member 93 having an annular flange 93a entering an annular groove 15e in casing 15. A gasket may be placed beneath flange 93a. Member 93 is shown as interiorly threaded and is provided to receive a connection to an expansion tank which may be disposed above casing 15.

In Fig. 11 a modified form of an adjusting

means for tilting plate 94 is shown similar to plate 47. In this form said plate is provided with a reduced portion 94a having flat surfaces and flexible metal bands or ribbons 95 and 96 are secured respectively to said surfaces by the bolts 96a and pins 97. A plunger 98a formed on an adjusting shaft 98 is of cylindrical form at its top and bottom and fits in bore 100 being slidable therein. Said plunger is kept from rotation by having a keyway in its outer side in which is disposed the key 99 secured to plate 17. Plunger 98a is cut away at its inner side to have a flat surface substantially in the plane of its axis and the other ends of bands 95 and 96 are secured respectively to the upper and lower portions of this surface by the bolts 100 and pins 101. The lower end of bore 100 is closed by a flanged plug 102 and the upper end of said bore is closed by a flanged plug 103. Plug 103 is bored to have a flanged bushing 104 at its inner portion surrounding shaft 98 and packing 105 surrounds said shaft in the bore of member 103 and engages bushing 104. A gland 106 surrounds shaft 98 and extends into the bore in member 103 to engage and compress the packing 105 about shaft 98. Shaft 98 is shown as having a reduced threaded portion 98b at its upper end which will receive some suitable means for moving said shaft. It will be seen that when shaft 98 is moved vertically that plate 94 will be rotated about its trunnions in a counter-clockwise direction. The bands 95 and 96 move over the convex or semi-cylindrical outer portion of projection 94a. When shaft 98 is moved downwardly plate 94 will be tilted in a clockwise direction about its trunnions.

In Fig. 13 a further modification is shown in which the tilting plate 110 similar to plate 47 is provided with a lateral projection 110a in the form of a fork between the arms of which is secured a member 111 having spaced annular ribs or projections 111a thereon. A plug 112 closes the lower end of bore 100 and at its inner end is provided with a thrust tapered roller bearing 113. A flange plug 114 closes the upper end of bore 100 and also carries at its inner end a thrust tapered roller bearing 115. An adjusting shaft 116 extends through bearings 113 and 115 and is provided with shoulders engaging the adjacent sides of said bearings. Shaft 116 is provided adjacent member 111 with a worm or helical gear formation 116a. Member 114 is bored to receive a flange bushing 117 surrounding shaft 116. Packing material 118 is disposed in the upper and enlarged end of the bore in member 114 and is engaged by a gland 119 having a portion extending into said bore. Packing material 118 is thus compressed about the shaft 116. Shaft 116 is provided at its upper end with a reduced threaded portion 116b adapted to receive some means by which said shaft will be rotated.

It will be seen that when shaft 116 is rotated that the member 111 will be traversed along the gear or worm portion 116a and member or plate 110 will be rotated in a clockwise or counter-clockwise direction depending upon the direction of rotation of shaft 116. The parts are held firmly and securely in position and no play is permitted in said parts due to the arrangement of the bearings 113 and 115.

In operation, shaft 26 will be driven and if the device is being used as a pump the conduit 90 which is opposite the port 17d aligned with openings 27c when the pistons 38 move away from plate 17 will be connected to the inlet sup-

ply of oil or fluid to be pumped. The other conduit 90 will then form the discharge conduit. Plate 47 will be tilted to the desired angle by upward movement of shaft 59. Such upward movement as already stated, moves block 53 and this swings plate 47. The stroke of the pistons 38 is determined by the degree of inclination of plate 47. With plate 47 so inclined swash plate 32 is rotated by shaft 26 through the trunnion block 35 and when the roller bearings 68 approach the side of plate 47 nearest the cylinder barrel, said bearings and plate will be moved toward the barrel and through the connecting rods 40 pistons 38 will likewise be moved. As the bearings 68 approach the side of plate 47 farthest from the barrel 27 the pistons will be moved outwardly of the cylinders and barrel 27. The liquid entering the inlet pipe 90 will pass through members 86, inlet members 17e, the port 17d and through the opening 27c into the cylinders in barrel 27. Liquid is thus drawn into the cylinders as the pistons move away from barrel 27. As the barrel 27 and swash plate 32 rotate, the cylinder with the liquid therein will move into registry with the discharge port 17d and the pistons are then moved into the cylinder and the liquid is discharged through the openings 27c and discharge openings 17e into the other member 86 and the discharge conduit 90. Barrel 27 has its flat face tightly engaging the bearing surfaces on valve plate 17 and by the construction of the holes 17h and passages 17i a film of oil is maintained on these surfaces giving perfect lubrication. Bridge 17j strengthens the valve plate and the port 17d. It will be seen that some motion of the inlet and discharge conduits 90 longitudinally thereof is possible without placing much strain or twisting stress upon valve 17. This is very important as the surface of the valve plate must be kept in close contact with the end of the cylinder barrel. The elimination of the stresses placed on the valve plate by the inlet and discharge pipes is thus a great improvement. There is a considerable difference in temperature of the incoming and outgoing oil due to the high pressures developed in the pump and it is necessary to have a valve plate which has a very low coefficient of expansion. This problem has been solved in the present case by using a high nickel Invar steel as above described. The pistons 38 being coated with a coating of hard bronze welded onto the steel are also very strong and durable and there is low friction between the pistons and the cylinder wall. The construction of applicant's casing also results in a great improvement. Not only are the parts comparatively simple and easily made but it will be seen that when the plate 17 is removed that the bolts 50 holding the tilting plate trunnion bearings can then be removed. The indicator member 72 can be removed and the whole pump mechanism including the shaft 26, swash plate 32 and the cylinder barrel can be removed through one end of casing section 15. It will be seen that block 53 can be removed from between the bearing sleeves 56. The casing section 15 is of exceedingly simple construction. A simple and efficient connecting means for the casing is also provided by the long bolts 19 which also hold the feet brackets 18. By providing roller bearings for the trunnions of tilting plate 47 this plate may be quite easily adjusted. There is a considerably impending motion or gyroscopic effect on this part and this is practically eliminated by the

provision of the roller bearings. The mechanism provided for adjusting the tilting plate is very simple and highly efficient. No play can take place between the parts 53, 59a and the fork 51.

The structure of the indicator comprising the pointer 74 is also novel. It is not desired to observe this with great frequency. It is sometimes desired to know when the pump is in neutral position that is when there is no inclination of plate 47. At such times the cover 80 may be removed and the setting of the plate observed. Member 70 and packing means 78 and 79 are provided to prevent leakage of appreciable fluid while cover plate 80 is removed. At other times the indicator is entirely closed and sealed and is thus not subject to any injury.

The cylinder casing 120 indicated only in Fig. 2, may be used disposed about the rotating parts between plates 16 and 17 and within the bolts 19 and 21 to prevent friction of the fluid in the casing with said bolts. Said casing will be made of light metal of comparatively small thickness.

From the above description it will be seen that I have provided a simple, novel and greatly improved structure of a pump or fluid transmission device of the swash plate type. The device is a great improvement over the devices of the prior art. The same has been amply demonstrated in actual practice, has been found to be very successful and efficient and is being commercially made.

It will be understood, of course, that various changes may be made in the form, details, arrangement and proportions of the parts, without departing from the scope of applicant's invention, which generally stated, consists in a device capable of carrying out the objects above set forth, in the parts and combinations of parts disclosed and defined in the appended claims.

What is claimed is:

1. In a pump of the swash plate type including a casing, a rotating cylinder barrel having a rigid flat end face provided with cylinders having ports in said flat end face of said barrel, a valve plate provided with arcuate ports cooperating with the ports of said cylinders to control the flow of the operating fluid, an annular bearing surface disposed outward radially from said ports and an annular depression at each side of said bearing surface, a series of circumferentially spaced holes formed in said bearing surface for an appreciable depth therein and small passages extending from the sides of said holes to said depressions whereby pressure fluid or oil from said casing is supplied to said annular bearing surface to form a fluid film between said cylinder barrel and valve plate.

2. In a pump of the swash plate type, a valve plate provided with arcuate ports adapted to cooperate with the ports of a cylinder barrel to control the flow of the operating fluid, an annular bearing surface disposed outward radially from said ports and an annular groove extending about the inner side of said bearing surface, a series of circumferentially spaced holes formed in said bearing surface for an appreciable depth therein and small passages extending from the sides of said holes to said groove whereby pressure fluid is supplied to said annular bearing surface to form a fluid film between said cylinder barrel and valve plate.

3. A pump or hydraulic speed transmission device of the swash plate type having in combination, a valve plate provided with arcuate ports

adapted to cooperate with the ports of a cylinder barrel to control the flow of fluid, said arcuate ports cooperating with inlet and discharge passages respectively, inlet and discharge conduits extending into said passages and arranged for longitudinal movement and packing means about said inlet and discharge conduits in said valve plate whereby when great pressure is developed between said barrel and valve plate relative movement between said conduits and valve plate is permitted without placing stress on said conduits.

4. In a pump of the swash plate type, a valve

5 plate arranged to cooperate with a cylinder barrel and provided with arcuate ports, said plate having an annular bearing surface engaged by said barrel and disposed outwardly radially from said ports and means for maintaining a film of fluid upon said bearing surface including circumferentially spaced holes within the sides of said surface and passages leading thereto from the side of said surface and disposed beneath the same so that said surface is uninterrupted by said passages.

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