

Nov. 18, 1947.

J. F. HOFFER

2,431,175

PUMP STRUCTURE

Filed June 20, 1944

7 Sheets-Sheet 1

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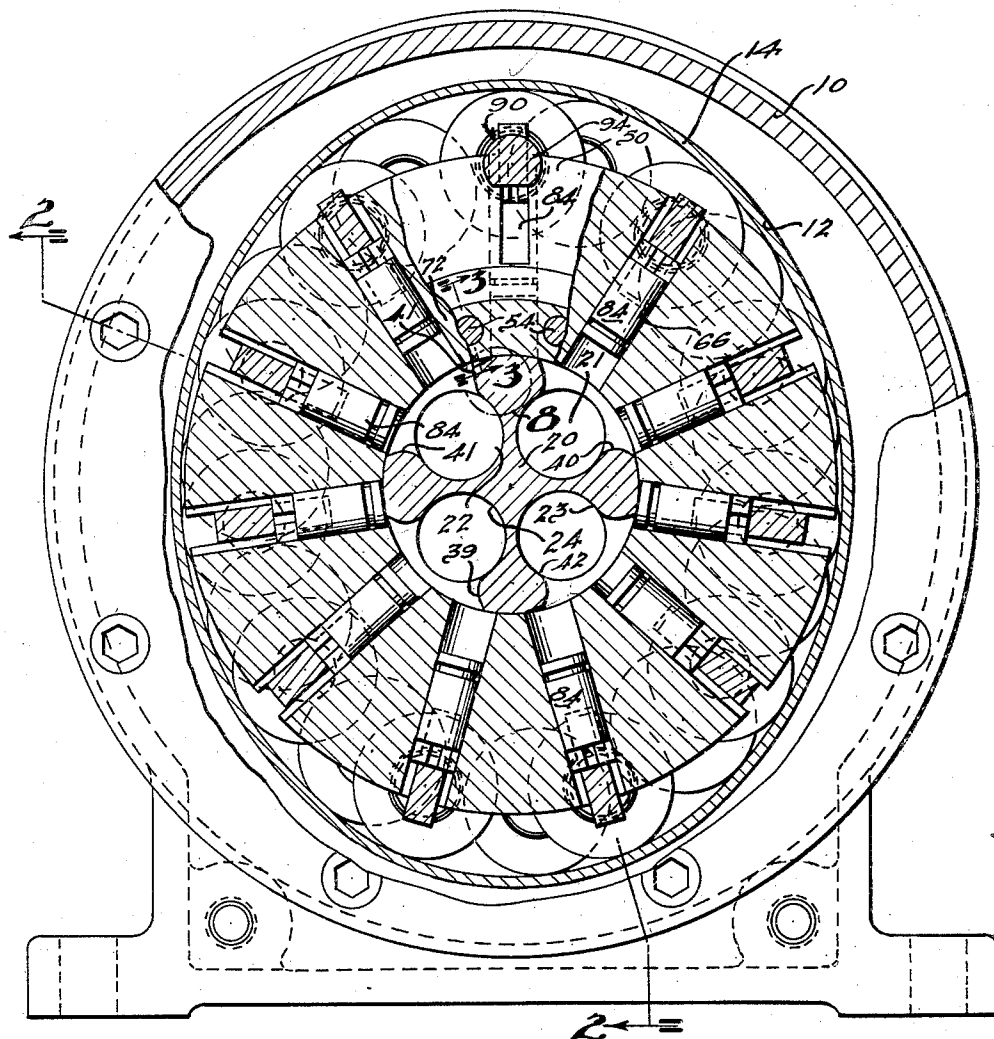


FIG. 1.

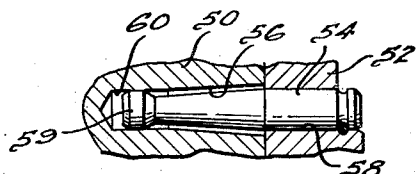


FIG. 3.

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Nov. 18, 1947.

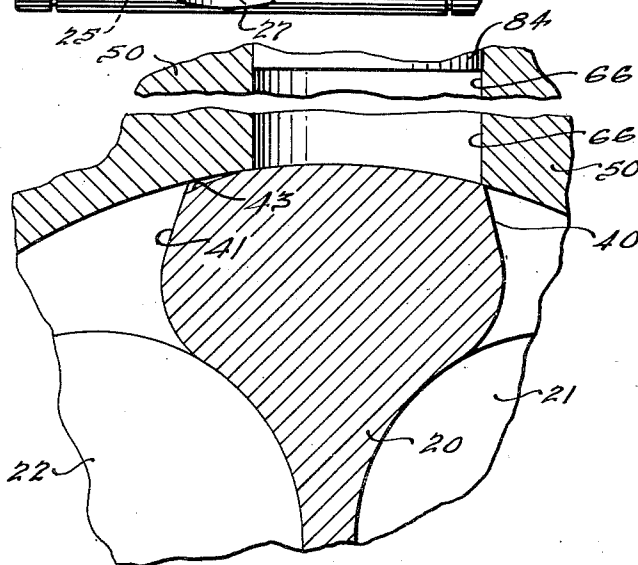
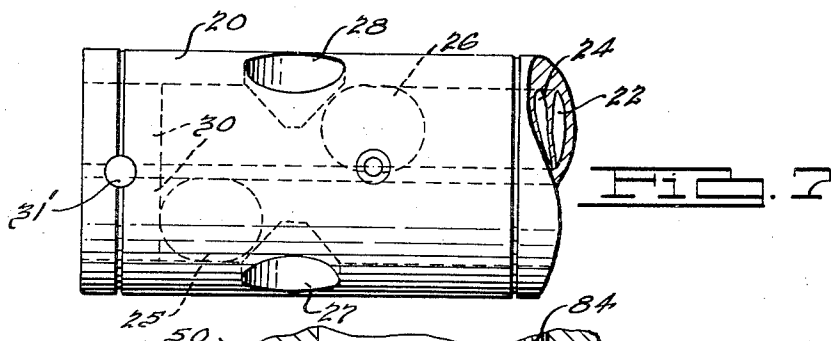
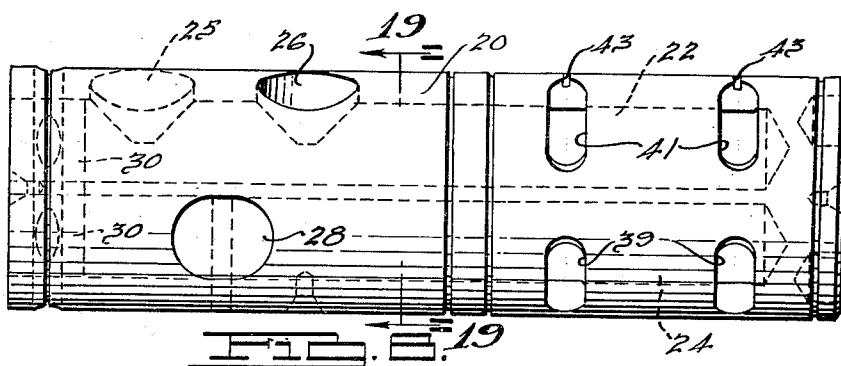
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PUMP STRUCTURE

Filed June 20, 1944

7 Sheets-Sheet 4



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PUMP STRUCTURE

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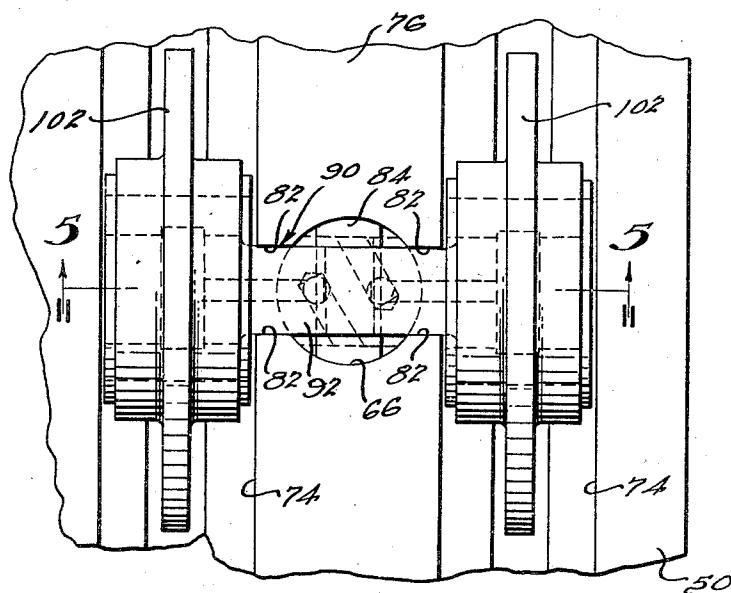


FIG. 4.

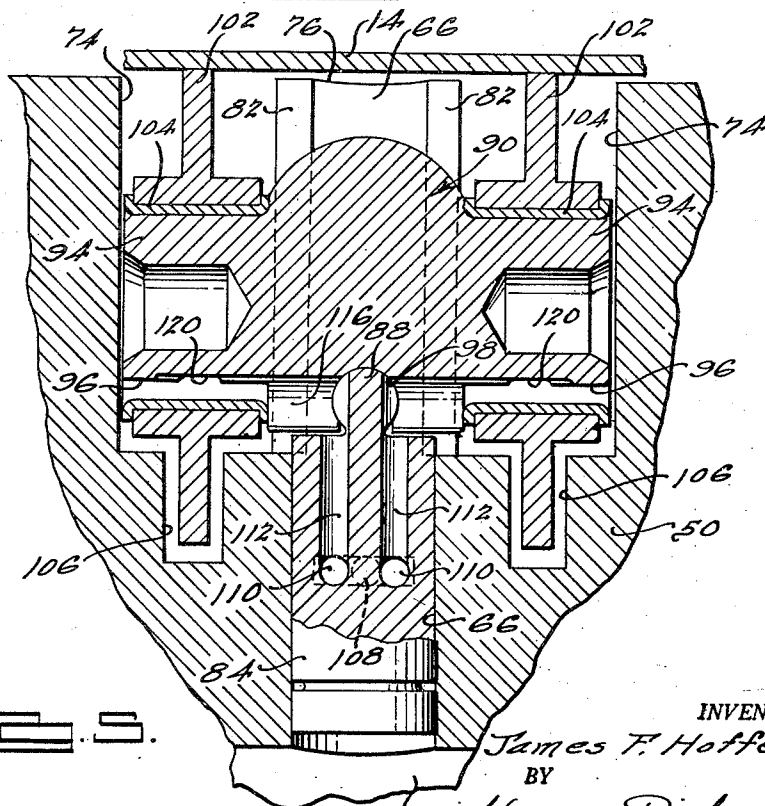


FIG. 5.

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Nov. 18, 1947.

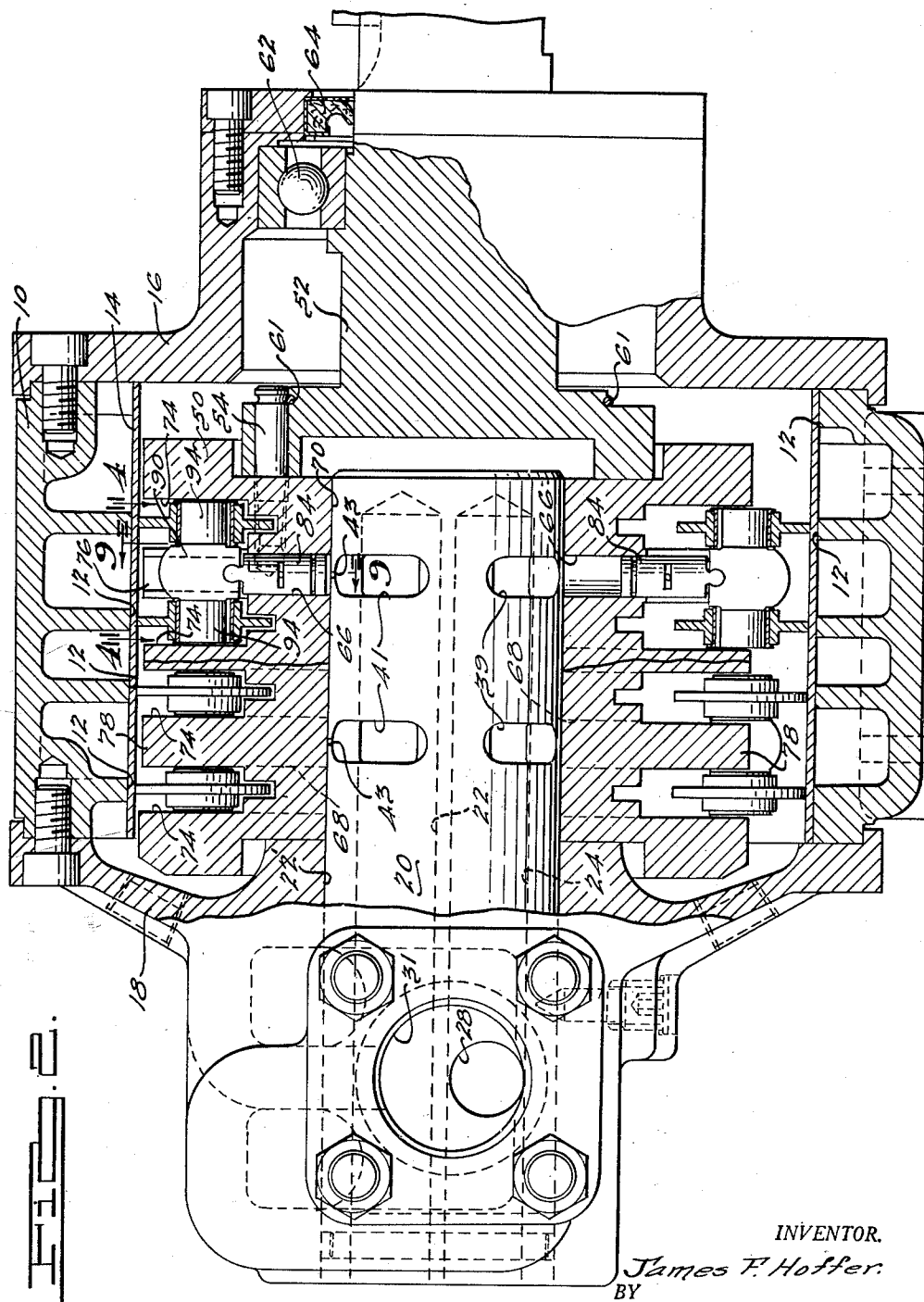
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PUMP STRUCTURE

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7 Sheets-Sheet 2



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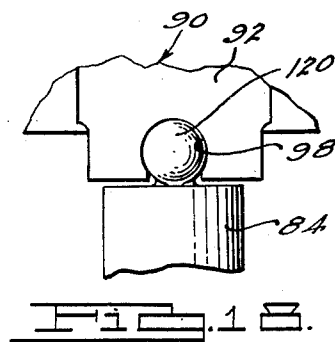
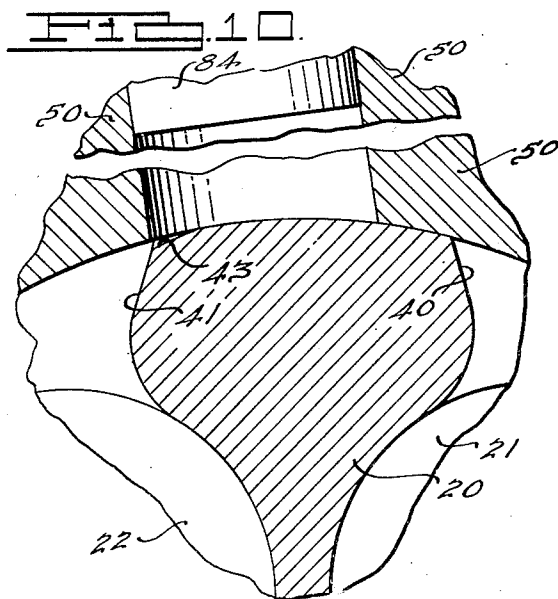
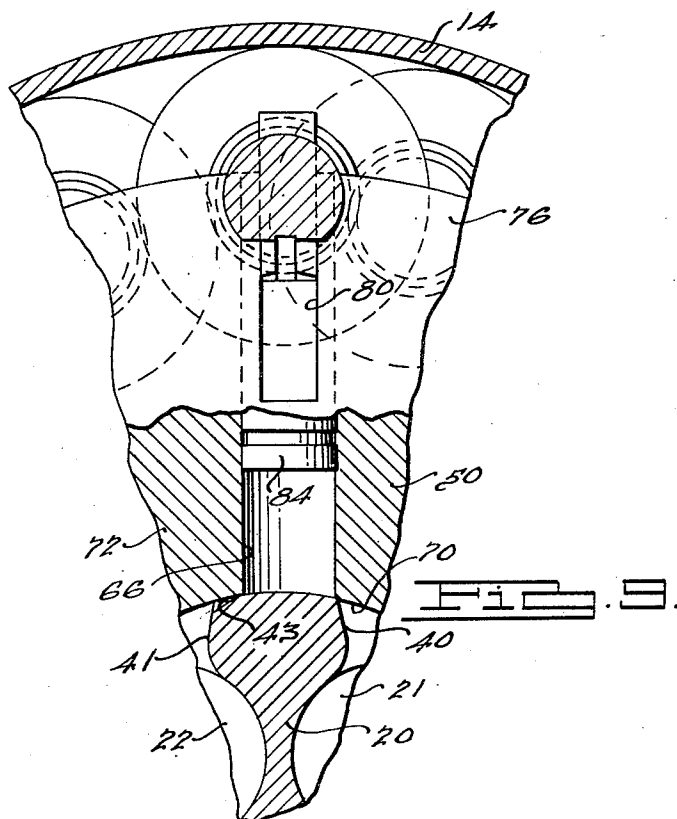
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PUMP STRUCTURE

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7 Sheets-Sheet 5



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PUMP STRUCTURE

Filed June 20, 1944

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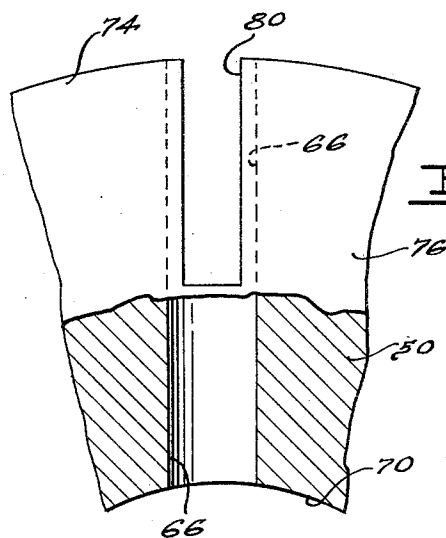


FIG. 11.

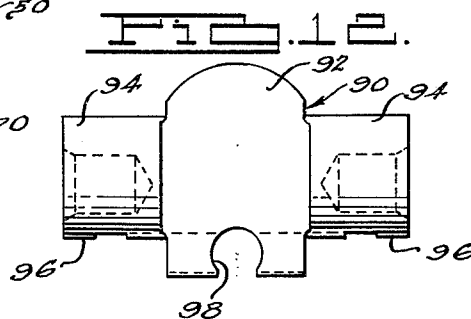


FIG. 12.

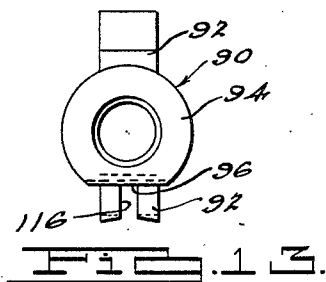


FIG. 13.

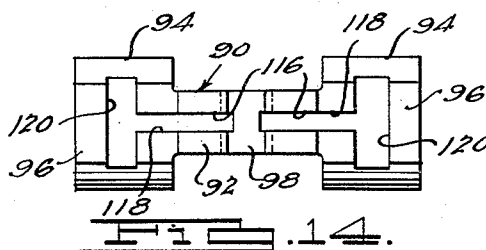


FIG. 14.

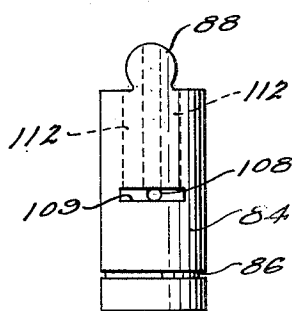


FIG. 15.

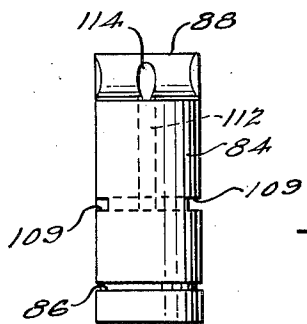


FIG. 16.

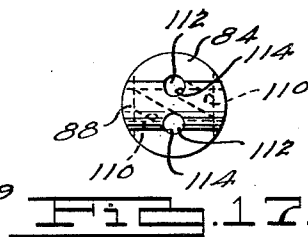


FIG. 17.

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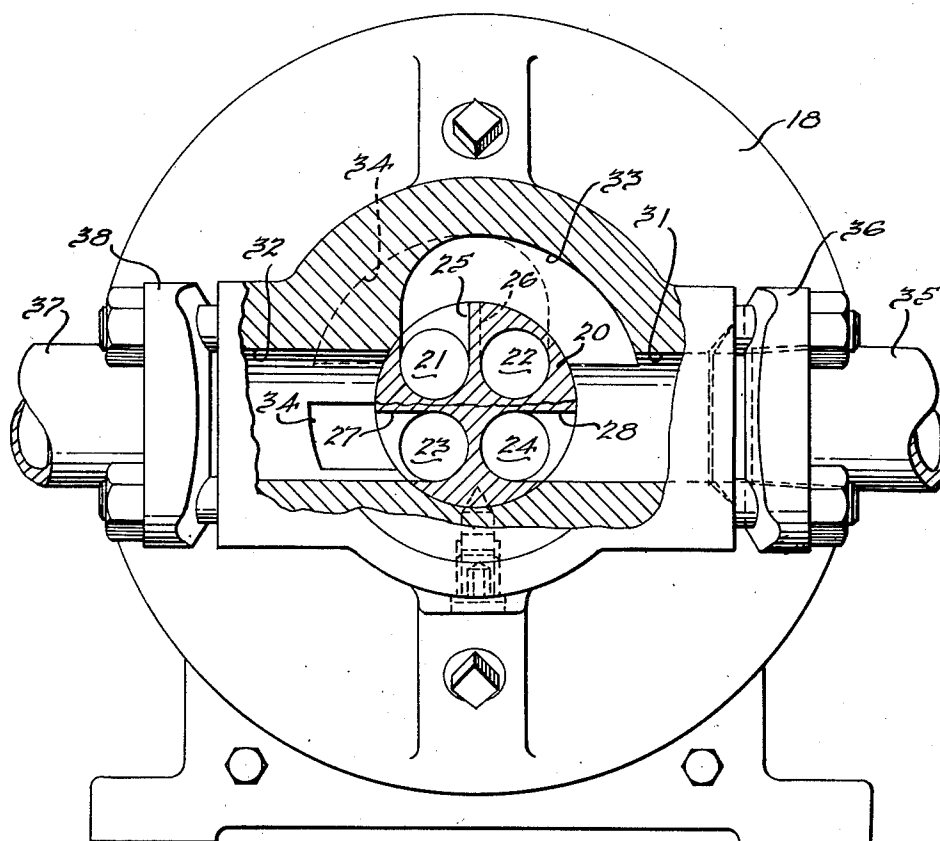
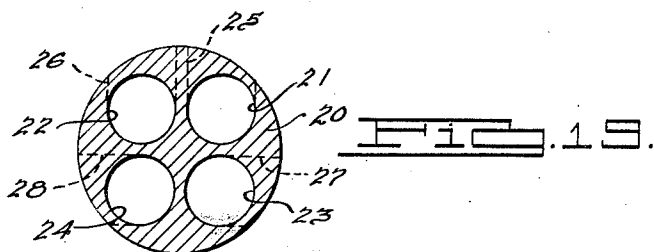
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PUMP STRUCTURE

Filed June 20, 1944

7 Sheets-Sheet 7



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2,431,175

PUMP STRUCTURE

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Application June 20, 1944, Serial No. 541,167

19 Claims. (Cl. 103—161)

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The present invention relates to improvements in pumps and particularly relates to improvements in high pressure, plunger-type pumps.

One of the primary objects of the present invention is to provide improvements in pumps of the type mentioned in which plungers are employed to effect the pumping action and in which a large volume of oil is delivered at high hydraulic pressures up to and in excess of five thousand pounds per square inch.

A further object of the invention is to provide improvements in pumps of the types mentioned for operation at high speeds, for example, in excess of 4500 R. P. M.

Another object of the invention is to provide improvements in pumps of the type mentioned in which the plunger and associated operating elements are of light weight to minimize bearing loads induced by centrifugal force.

Another object is to provide a compact plunger structure by which the plungers may be compactly arranged radially in a plane while at the same time maintaining adequate valve capacity and small housing diameter.

A further object is to provide a structure of the type mentioned having practically no side loading of the plungers under all operating conditions.

A further object is to provide an improved structure of the type mentioned wherein the plunger movement has a high suction capacity at low speeds.

A further object is to provide an improved pump structure whereby the return strokes of the plungers are accomplished by centrifugal force.

A further object of the invention is to provide an improved pump which is in perfect hydraulic balance, in that opposite quadrants go through an identical cycle, and which is in perfect mechanical balance, statically and dynamically.

A further object of the invention is to provide improved lubrication of the plunger actuating means so that the pump may operate at high speeds without developing excessive heat.

A further object is to provide an improved structure of the type mentioned in which the plunger has roller elements connected thereto and in which the roller elements run against an outer bearing ring, or reaction member, and in which the connections between the rollers and plungers are such that the rollers are self-aligning at all times, whereby the plunger load is equally divided on the rollers.

Another object of the invention is to provide

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improvements in pumps of the type mentioned whereby a smooth porting action is accomplished with respect to the plungers passing from suction to pressure ports and from pressure to suction ports.

A further object of the invention is to provide improvements in pumps of the type mentioned in which the elements are interchangeable and readily assembled and disassembled.

Other objects of the invention will become apparent from the following specification, the drawings relating thereto, and from the claims hereinafter set forth.

In the drawings, in which like numerals are used to designate like parts in the several views throughout,

Fig. 1 is an end elevational view of one illustrative embodiment of the present invention having parts broken away in different longitudinal planes and illustrating parts of the internal mechanism in elevation and section;

Fig. 2 is a cross-sectional view taken substantially along the line 2—2 of Fig. 1, with the pintle shown in elevation in its normal fixed position;

Fig. 3 is a cross-sectional view taken substantially along the line 3—3 of Fig. 1;

Fig. 4 is an enlarged plan view of the plunger and roller subassembly, showing such subassembly in position on the rotor, and taken substantially along the line 4—4 of Fig. 2;

Fig. 5 is a cross-sectional view taken substantially along the line 5—5 of Fig. 4;

Fig. 6 is an elevational view of the pintle shown in Figs. 1 and 2 and illustrating more clearly the ports and passageways for the oil;

Fig. 7 is a bottom plan view of the left-hand portion of the structure shown in Fig. 6;

Fig. 8 is an enlarged view of that portion of the structure shown within the circle 8 of Fig. 1;

Fig. 9 is an enlarged cross-sectional view taken substantially along the line 9—9 of Fig. 2;

Fig. 10 is an enlarged view of a portion of the structure shown in Fig. 9 and illustrating the rotor and plunger in a different position;

Fig. 11 is a view of that portion of the rotor shown in Fig. 9 with the plunger and actuating members removed;

Fig. 12 is an elevational view of the axle member disconnected from the piston;

Fig. 13 is an end elevational view of the structure shown in Fig. 12;

Fig. 14 is a bottom plan view of the structure shown in Fig. 12;

Fig. 15 is an elevational view of the plunger

and showing the construction of the portion for connection with the axle;

Fig. 16 is a side elevational view of the structure shown in Fig. 15;

Fig. 17 is a top plan view of the structure shown in Fig. 15;

Fig. 18 is a partial elevational view illustrating a modified construction for connecting the plunger to the axle;

Fig. 19 is a cross-sectional view taken substantially along the line 19—19 of Fig. 6; and

Fig. 20 is an end elevational view of the structure shown in Fig. 2, with parts broken away and showing parts in cross section.

Referring to the drawings, a pump embodying features of the present invention is illustrated, and such a pump includes a housing having a central section 10 having open ends and formed with inwardly directed flanges 12 having the inner surfaces thereof elliptical in shape, as best seen in Fig. 1. A reaction member 14, also elliptical in shape, is disposed within the housing 10 and bears against the inner surfaces of flanges 12. End housing members 16 and 18 are secured to opposite sides of the central section 12 by means of suitable screws or the like and serve to enclose the housing.

The housing 18 serves to provide the inlet and outlet ports for the pump and also serves as the mounting for a stationary or fixed pintle 20 which is fixedly mounted within an axial opening 22' formed in housing 18.

The pintle 20 is formed with longitudinally extending, separate passageways 21, 22, 23 and 24 therealong which terminate adjacent one end to close that end of the passage and which are plugged by means of individual plugs 30 at the other end of the passageway. Such plugs 30 are held against axial displacement by means of a pin 31' which extends through a central aperture through the pintle having a portion of the pin received within cutout portions in the adjacent sides of the plugs 30.

Inlet and outlet ports are formed through the walls of the pintle communicating with their respective passageway. Inlet ports 25 and 28 communicate with inlet passageways 21 and 24, respectively; and outlet ports 26 and 27 communicate with outlet or pressure passageways 22 and 23, respectively. Ports 25 and 28 are offset along and around the axis of the pintle with respect to each other; and ports 26 and 27 are offset along and around the axis of the pintle with respect to each other. Ports 27 and 28 are aligned, with respect to the longitudinal axis of the pintle and with respect to each other.

The member 18 has an axial bore 22 within which one end of the pintle 20 is received; and has a transverse bore forming an inlet passageway 31 and an outlet passageway 32 (Fig. 20). The inlet passageway 31 communicates directly with intake port 28 and communicates through an angled, cored passageway 33 with intake port 25. Pressure port 27 communicates directly with outlet passageway 32, and the passageway 32 communicates with pressure port 26 through an angled, cored passageway 34.

An inlet conduit 35 leads from a supply tank to the inlet 31 and is connected thereto by means of a coupling 36. An outlet or pressure conduit 37 communicates with outlet 32 and is connected to the housing 18 by means of a coupling 38. The conduit 37 then leads to the work mechanism (not shown).

The opposite end of the pintle 20 has a pair

of ports 39 communicating with inlet passageway 24 which are longitudinally spaced with respect to each other, and has another pair of diametrically opposed, longitudinally spaced ports 40 which communicate with passageway 21. The pintle 20 also has a pair of longitudinally spaced pressure ports 41 which communicate with passage 22 and has another pair of diametrically opposed pressure ports 42 which communicate with passageway 23. One of each of the pairs of ports, 39, 40, 41, and 42 lies in the same transverse position and the other of each of the pairs lies in another, same transverse position, there being one of the pairs for one of the banks of plungers and the other of the pairs for another bank. This will be more apparent from the description to follow.

Each of the pressure ports 41 and 42 is formed with a central groove or slot 43 on the leading edge, each groove being of gradually increasing depth therearound, as shown in Fig. 10. The purpose of these slots will be described hereinafter in connection with the operation of the pump.

The pintle 20 projects inwardly of the housing 10 axially thereof and serves to rotatably support a pump rotor 50. The rotor 50 is driven by a drive shaft member 52 which is connected thereto by means of a plurality of drive pins 54 which are uniformly arranged around the axis of the drive shaft and project within apertures 56 formed in the adjacent face of the rotor 50. As best shown in Fig. 3, the drive pins 54 have a cylindrical portion which is received within a complementary opening 58 formed in the drive member 52 and then have a tapered portion terminating in a head 59 having a flat peripheral surface. The apertures 56 in the drive member are formed with enlarged portions around the tapered portion of the drive pins and terminate in cylindrical portions 60 of reduced diameter against which the flat surface 59 of the drive pin bears. Thus the drive pins do not bear against the enlarged portion of the apertures 56, but bear only in the cylindrical portion 60. The drive pins 54 are held against axial displacement by means of a split ring 61 which is received within an annular recess formed in the drive member 52 and is also received within complementary grooves formed in the outer ends of the drive pins.

The drive shaft 52 extends through a central axial opening in the housing member 16 and is rotatably supported therein by means of a ball bearing assembly 62. The shaft projects outwardly beyond the housing member 16 and is connected to a suitable drive means. An oil seal 64 is disposed within the outer opening of the housing member 16 and bears against the drive shaft in the usual way.

The rotor 50 is formed with a plurality of banks of radially disposed bores 66 and 68, the bores 66 of one bank being uniformly disposed about the rotor and the bores 68 of the other bank also being uniformly disposed about the rotor, but the bores 68 of the second bank being spaced to follow the bores 66 of the first bank a distance, for example, of about three-eighths the distance between the bores 66 of the first bank where there are eleven bores in each bank. By having the bores of one bank so offset with respect to the bores of the other bank, separate portings spaced at equal decrements results. The bores 66 overlie and communicate with one of the pairs of ports 39, 40, 41, and 42; and the

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bore 68 overlie and communicate with the other of the pairs of ports. It will, therefore, be understood that separate intake and pressure ports, communicating with separate inlet and outlet passageways in the pintle, are provided for each of the banks.

However, a detailed description of the construction and arrangement of the plungers and means interconnecting the plungers with the reaction member 14 of one of the banks or of one of the plungers will be sufficient for an understanding of the construction and arrangement of the other plungers and their interconnecting means. Such constructions are best shown in Figs. 4, 5, and 9 through 17. The rotor 50 has a central opening 70 therethrough which rotates on the pintle 20 with one end of the rotor running against the adjacent face of housing member 18 and the other end connected to the drive 52. The rotor 50 is formed with axially spaced, annular grooves 74 which form therebetween outwardly directed annular flanges 76 and 78, the flanges 76 having the bores 66 for one of the banks of bores formed therethrough and the flange 78 having the bores 68 for the other bank of bores formed therethrough. The bores 66 extend completely through the rotor 50 from the outer end thereof through openings 70 and are of uniform diameter throughout their length. In the flange portions of the rotor, such as flange 76, transverse slots 80 are cut through the bores 66 in the flange portion, in a direction transverse to the direction of rotation of the rotor, providing parallel faces 82 on opposite sides of each bore. The purpose of the slot 80 and the parallel faces 82 will be more apparent from the latter description.

A cylindrical plunger 84 is disposed within each of the bores 66 (and also each of the bores 68). Such plungers 84 are adapted to reciprocate within their bores as the rotor 50 rotates and are moved outwardly by centrifugal force caused by such rotation. The axial movement or position of the plungers is controlled through a connection between the outer ends of the plungers and the reaction member 14 as the rotor 50 rotates.

The plunger 84, as best seen in Figs. 15 through 17, is formed with an annular, pressure-balancing recess 86 and is flat at its inner end. At the outer end it is formed with an integral projection 88 which is generally circular in cross section and which extends completely across the top of the plunger.

Means are provided for interconnecting each plunger 84 with the reaction member 14 of such a character that there is practically no side loading of the plunger and also of such a character that it is self-aligning at all times whereby the plunger load is equally divided on roller means which engage the reaction member.

Thus interconnecting means include (Figs. 12 through 14) an axle or equalizing member generally indicated at 90. Such axle 90 is ruggedly constructed and includes a central portion 92 having flat parallel sides and having the outer end crowned as shown in Fig. 12. The outer sides of member 90 are formed to provide bearing trunnions 94 with the inner surfaces thereof flattened as indicated at 96. The central portion 92 is formed with a transversely extending recess 98 which is complementary in transverse section to the transverse sectional shape of projection 88 and is adapted to slidably receive the projection 88 therein. The recess 98 is formed in the direction of rotation of the rotor, and when positioned

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in the rotor the projection 88 extends in the same direction. The flat sides of central portion 92 are adapted to bear against the parallel sides 82 of slot 80 in the rotor as the plunger reciprocates.

Rollers or wheels 102 are rotatably mounted on the trunnion portions 94 of the axle 90, through bearing sleeves 104 when assembled, as shown in Figs. 4 and 5. The trunnions and wheels are received within the annular groove 74 with the peripheral portions of the wheels received within annular grooves 106 formed in the bases of groove 74.

Means are provided for lubricating the wheels and such means include diametrically opposed openings 108 formed through the wall of plunger 84 and communicating with the exterior of the plunger through slots 109. The openings 108 communicate through separate passageways 110 with upwardly directed, separate passageways 112. Such passageways 112 open through the top of each plunger on opposite sides of the projection 88 and a portion of such projection is removed on the sides of the projection immediately above the openings as indicated at 114 in Fig. 16. Thus, oil enters through openings 108 and passes upwardly through passageways 112 into the space between the projection 88 and the complementary recess 98 in the axle 90. Slots 116 are formed through the inner portions of central portion 92 of the axle providing communication from the space within recess 98 to the flattened portions 96 of trunnions 94. Continuations of such grooves are formed in the flattened portions of trunnions 94 as shown at 118 in Fig. 14. Other transverse grooves 120 are formed in the flats 96 communicating with grooves 118 so that passages for the oil are provided from openings 108 to the wheel bearing portions on the trunnions.

In assembly, the axle 90 is slidably mounted to the projection 88 on the plunger 84. This slidable connection will permit a slight aligning movement between axle 90 and plunger 84 in the direction of rotation of the rotor. The connection between groove 98 and projection 88 will permit a slight rocking action of the axle so that the wheels 102 are self-aligning in their engagement with the reaction member 14 as the rotor rotates.

Due to the self-alignment of the axle member 90 in its interconnection between the plunger 84 and the reaction member 14, there is practically no side loading on the plunger during rotation of rotor 50. The axle 90 is free, in a limited way, to slide and rock, in planes at right angles to each other, with respect to the plunger 84 and also with respect to the engaging surfaces 82. As the plunger 84 is caused to reciprocate within its cylinder 66 the forces applied to the plunger are directly along its axis. Since the bore 66 is of uniform diameter throughout its length, the piston 84 is completely supported throughout its stroke; that is, the outer portion of bore 66 engages the piston 84 when the piston is at the outer end of its stroke and such piston is supported completely along its length throughout its stroke.

In the operation of the device above described, oil enters through conduit 35 into passageway 31 and into intake passageways 21 and 24. Passageway 21 communicates with bores 66 and 68 through ports 40; and passageway 26 communicates with such bores at a diametrically opposed position. Pressure passageway 22 communicates with the cylinder bores 66 and 68 through pressure ports 41; and pressure passageway 23 communicates with such cylinder bores through pressure ports 42. Pressure ports 41 and 42 are

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diametrically opposed. It will be understood that by the elliptical construction of the reaction member 14 with the axis of rotation of the rotor centrally disposed, there will be two intake strokes and two delivery strokes of each plunger for each rotation of the rotor. With the intake strokes occurring in opposite quadrants and the delivery strokes in opposite quadrants, the pumping forces are therefore balanced.

The ports are so arranged that the plungers are in their innermost positions as they approach suction ports 39 and 40 and move outwardly in passing across such ports to an outermost position prior to reaching the leading edges of pressure ports 41 and 42. In passing across the pressure ports, the plungers are moved inwardly so that the oil collected in the bores inwardly of the plungers is discharged under pressure through such ports into the pressure passageways 22 and 23 and passes out of the pressure ports 26 and 27 through passageway 32 into conduit 37.

It will be appreciated that as the plungers 84 leave the following edges of the pressure ports that there will be a certain amount of trapped oil under pressure between the inner end of the plungers and the peripheral surface of the pintle. The lands, or spaces, on the peripheral portions of the pintle between the following edges of the pressure ports and the leading edges of the intake or suction ports are of such length as to permit enough travel of the rotor to allow the plungers to move outwardly so that the pressure of the trapped oil is reduced to a point that when the bores communicate with the intake passageways there will be an equalizing of pressure which will prevent hydraulic hammer.

The grooves 43 in the leading edges of the pressure ports are such as to provide bleeding communication between the pressure ports and the bore spaces inwardly of the plungers as the plungers move toward and across the pressure ports. These grooves serve to gradually equalize the pressure in the pressure port and that of the trapped oil in the space inwardly of the plunger at this stage to eliminate hydraulic hammer. This position just referred to is illustrated in Fig. 10 where the plunger 84 is approaching pressure port 41. It will be seen that the bore space inwardly of the plunger is in communication with the pressure port through groove 43.

In Fig. 18 a modified connection between plunger 84 and axle 90 is illustrated. The construction of the axle 90 is the same as that above described and instead of the transversely extending projection 88 on the top of plunger 84, a centrally located ball head 120 is integrally formed with the plunger 84. Such ball head 120 is received within the recess 98 in the same manner as the projection above described. The action of the inner connection between the plunger and the reaction member is the same as that above described, except that in the preferred embodiment above described, a more rugged construction is provided. That more rugged construction has advantages in high speed, high pressure pumps.

What is claimed is:

1. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, means on said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the

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axle to the outer end of the plunger, said last-named means being constructed to permit limited relative movement between the axle and the plunger in all directions except axially of the plunger.

2. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, rolling means on each end of said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means being constructed to permit limited relative movement between the axle and the plunger in all directions except axially of the plunger.

3. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, a wheel rotatably mounted on each end of said axle to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means being constructed to permit limited relative movement between the axle and the plunger in all directions except axially of the plunger.

4. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, rolling means on each end of said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a projection on the end of the plunger having a substantially circular cross-sectional configuration in a plane in the direction of rotation of the rotor, and a groove of complementary cross section on the adjacent side of the axle adapted to receive said projection therein, said last-named means being constructed to permit limited rocking movement between the axle and the plunger in a plane transverse to the direction of rotation of the rotor.

5. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, rolling means on each end of said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a projection on the end of the plunger extending across said plunger in the direction of rotation of the rotor and having a substantially circular cross-sectional configuration in a plane in the direction of rotation of the rotor, and a groove of complementary cross section extending across the adjacent side of the axle adapted to slidably receive said projection therein, said last-named means being constructed to permit limited rocking movement between the axle and the plunger in a plane transverse to the direction of rotation of the rotor.

6. In a pump structure, a housing, a reaction member disposed within said housing, a rotor

having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, a wheel rotatably mounted on each end of said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a projection on the end of the plunger extending across said plunger in the direction of rotation of the rotor and having a substantially circular cross-sectional configuration in a plane in the direction of rotation of the rotor, and a groove of complementary cross section extending across the adjacent side of the axle adapted to slidably receive said projection therein, said last-named means being constructed to permit limited rocking movement between the axle and the plunger in a plane transverse to the direction of rotation of the rotor.

7. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, rolling means on each end of said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a ball head on the end of the plunger, and a groove of substantially circular cross section on the adjacent side of the axle adapted to receive said ball head therein, said last-named means being constructed to permit limited rocking movement between the axle and the plunger in a plane transverse to the direction of rotation of the rotor.

8. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, means forming parallel slots through the opposite walls of said bores at the outer portions thereof in a direction transverse to the direction of rotation of the rotor, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger and slidably receivable in said slots, rolling means on each end of said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a projection on the end of the plunger having a substantially circular cross-sectional configuration in a plane in the direction of rotation of the rotor, and a groove of complementary cross section on the adjacent side of the axle adapted to receive said projection therein, said last-named means being constructed to permit limited rocking movement between the axle and the plunger in a plane transverse to the direction of rotation of the rotor.

9. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, means forming parallel slots through the opposite walls of said bores at the outer portions thereof in a direction transverse to the direction of rotation of the rotor, a plunger in each bore, an axle having parallel walls in the central portion thereof extending transverse to the direction of rotation of the rotor for each plunger and slidably receivable in said slots with said axle walls slidably engageable with the adjacent slot walls, rolling means on each end of said axle adapted to engage said reaction member to control the axial

movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a projection on the end of the plunger having a substantially circular cross-sectional configuration in a plane in the direction of rotation of the rotor, and a groove of complementary cross section on the adjacent side of the axle adapted to receive said projection therein, said last-named means being constructed to permit limited rocking movement between the axle and the plunger in a plane transverse to the direction of rotation of the rotor.

10. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, means forming parallel slots through the opposite walls of said bores at the outer portions thereof in a direction transverse to the direction of rotation of the rotor, a plunger in each bore, an axle having parallel walls in the central portion thereof extending transverse to the direction of rotation of the rotor for each plunger and slidably receivable in said slots with said axle walls slidably engageable with the adjacent slot walls, a wheel rotatably mounted on each end of said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a projection on the end of the plunger extending across said plunger in the direction of rotation of the rotor and having a substantially circular cross-sectional configuration in a plane in the direction of rotation of the rotor, and a groove of complementary cross section extending across the adjacent side of the axle adapted to slidably receive said projection therein, said last-named means being constructed to permit limited rocking movement between the axle and the plunger in a plane transverse to the direction of rotation of the rotor.

11. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, means forming parallel slots through the opposite walls of said bores at the outer portions thereof in a direction transverse to the direction of rotation of the rotor, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, said axle having parallel walls in the central portion thereof and terminating at the ends in trunnion portions, said axle being slidably receivable in said slots with said axle walls slidably engageable with their adjacent slot walls, wheels rotatably mounted on said trunnion portions adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means being constructed to permit limited relative movement between the axle of the plunger in all directions except axially of the plunger.

12. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, means forming parallel slots through the opposite walls of said bores at the outer portions thereof in a direction transverse to the direction of rotation of the rotor, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, said axle having parallel walls in the central portion thereof and terminating at the ends in trunnion portions, said axle being slidably receivable in said slots with said axle walls slidably engageable with their adjacent slot walls, a wheel rotatably

mounted on each of said trunnion portions adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a projection on the end of the plunger having a substantially circular cross-sectional configuration in a plane in the direction of rotation of the rotor, and a groove of complementary cross section on the adjacent side of the axle adapted to receive said projection therein, said last-named means being constructed to permit limited rocking movement between the axle and the plunger in a plane transverse to the direction of rotation of the rotor.

13. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores of uniform diameter throughout the length thereof disposed within said housing, means forming parallel slots through the opposite walls of said bores at the outer portions thereof in a direction transverse to the direction of rotation of the rotor, a plunger in each bore, an axle having parallel walls in the central portion thereof extending transverse to the direction of rotation of the rotor for each plunger and slidably receivable in said slots with said axle walls slidably engageable with their adjacent slot walls, rolling means on said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means being constructed to permit limited rocking movement between the axle and the plunger in a direction transverse to the direction of rotation of the rotor.

14. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, rolling means mounted on each end of said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, and lubricating means for said rolling means, said lubricating means including passageways in each plunger extending from openings in the side wall of said plunger intermediate the ends thereof radially outwardly to openings in the outer end of said plunger, and grooves in the inner surface of said axle communicating with said end openings and extending sidewardly adjacent said rolling means.

15. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, rolling means mounted on each end of said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, and lubricating means for said rolling means, said lubricating means including separate passageways in each plunger extending from opposite openings in the side wall of said plunger intermediate the ends thereof radially outwardly to openings in the outer end of said plunger on opposite sides of said connecting means, and grooves in the inner surface of said axle on opposite sides of said connecting means communicating with their adjacent end openings and extending sidewardly adjacent said rolling means.

16. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, rolling means mounted on each end of said axle adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a projection on the end of the plunger having a substantially circular cross-sectional configuration in a plane in the direction of rotation of the rotor, and a groove of complementary cross section on the adjacent side of the axle adapted to slidably receive said projection therein and lubricating means for said rolling means, said lubricating means including separate passageways in each plunger extending from opposite openings in the side wall of said plunger intermediate the ends thereof radially outwardly to openings in the outer end of the plunger on opposite sides of the projection, and grooves in the inner surface of said axle on the opposite sides of said first-named groove communicating with their adjacent end openings and extending sidewardly adjacent said rolling means.

17. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, a wheel rotatably mounted on each of said trunnion portions adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a projection on the end of the plunger having a substantially circular cross-sectional configuration in a plane in the direction of rotation of the rotor, and a groove of complementary cross section on the adjacent side of the axle adapted to slidably receive said projection therein, and lubricating means for said wheels, said lubricating means including separate passageways in each plunger extending from opposite openings in the side wall of said plunger intermediate the ends thereof radially outwardly to openings in the outer end of the plunger on opposite sides of the projection, and grooves in the inner surface of said axle on the opposite sides of said first-named groove communicating with their adjacent top openings and extending sidewardly adjacent said wheels.

18. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, said axle terminating at the ends in trunnion portions, a wheel rotatably mounted on each of said trunnion portions adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a projection on the end of the plunger having a substantially circular cross-sectional configuration in a plane in the direction of rotation of the rotor, and a groove of complementary cross section on the adjacent side of the axle adapted to slidably receive said projection therein, and lubricating means for said wheels, said lubricating means including separate passageways in each plunger extending from opposite openings in the side wall of said plunger

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intermediate the ends thereof radially outwardly to openings in the outer end of the plunger on opposite sides of the projection, and grooves in the under surface of said axle on opposite sides of said first-named groove communicating with their adjacent end openings and extending sidewardly adjacent said trunnion portions to supply lubricant thereto.

19. In a pump structure, a housing, a reaction member disposed within said housing, a rotor having radial bores disposed within said housing, means forming parallel slots through the opposite walls of said bores at the outer portions thereof in a direction transverse to the direction of rotation of the rotor, a plunger in each bore, an axle extending transverse to the direction of rotation of the rotor for each plunger, said axle having parallel walls in the central portion thereof and terminating at the ends in trunnion portions, the inner sides of said trunnion portions being flat, said axle being slidably receivable in said slots with said axle walls slidably engageable with their adjacent slot walls, a wheel rotatably mounted on each of said trunnion portions adapted to engage said reaction member to control the axial movement of said plunger, means connecting the axle to the outer end of the plunger, said last-named means comprising a projection on the end of the plunger having a substantially circular cross-sectional configuration in a plane in the direction of rotation of the rotor, and a groove of complementary

cross section on the adjacent side of the axle adapted to slidably receive said projection therein, said last-named means being constructed to permit limited rocking movement between the axle and the plunger in a plane transverse to the direction of rotation of the rotor, and lubricating means for said wheels, said lubricating means including separate passageways in each plunger extending from opposite openings in the side wall of said plunger intermediate the ends thereof radially outwardly to openings in the outer end of the plunger on opposite sides of the projection, grooves in the under surface of said axle on opposite sides of the first-named groove communicating with their adjacent end openings and extending sidewardly in communication with the flats on said trunnion portions, and grooves extending across said flats.

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