

March 23, 1965

W. F. WANNER

3,174,436

RADIAL PUMP

Filed Nov. 23, 1962

4 Sheets-Sheet 1

Fig. 1

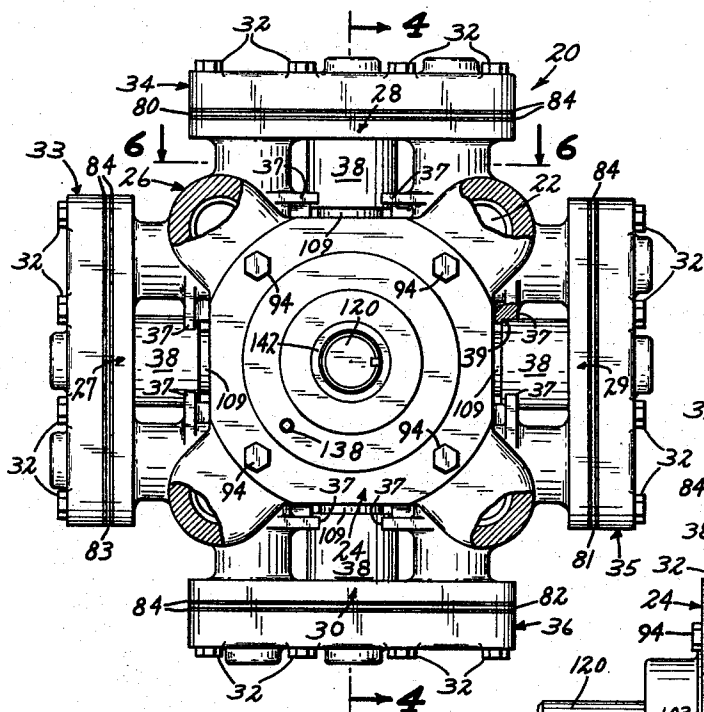


Fig. 2

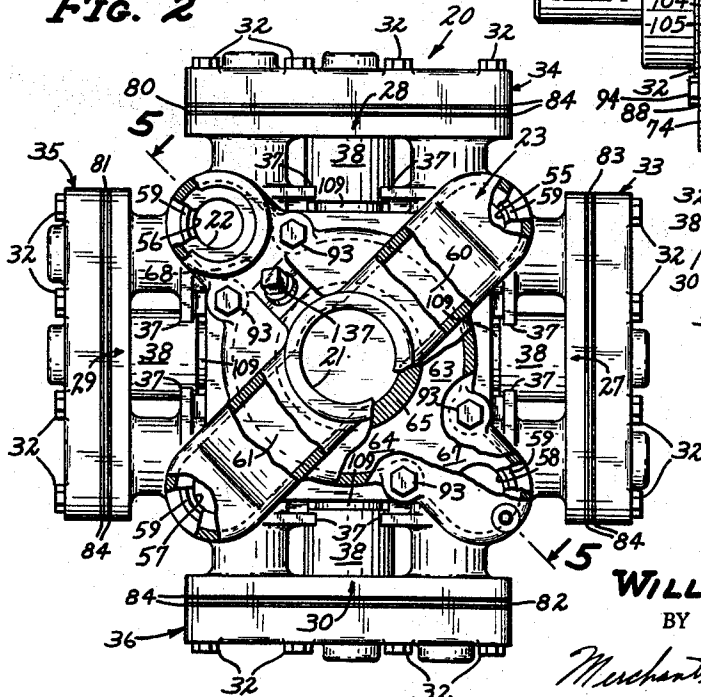
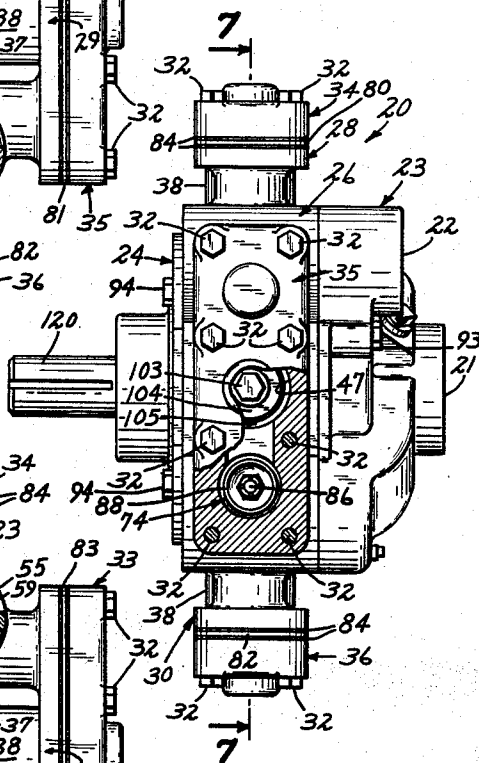


Fig. 3



INVENTOR

WILLIAM F. WANNER

BY

Merchant, Merchant & Gould

ATTORNEYS

March 23, 1965

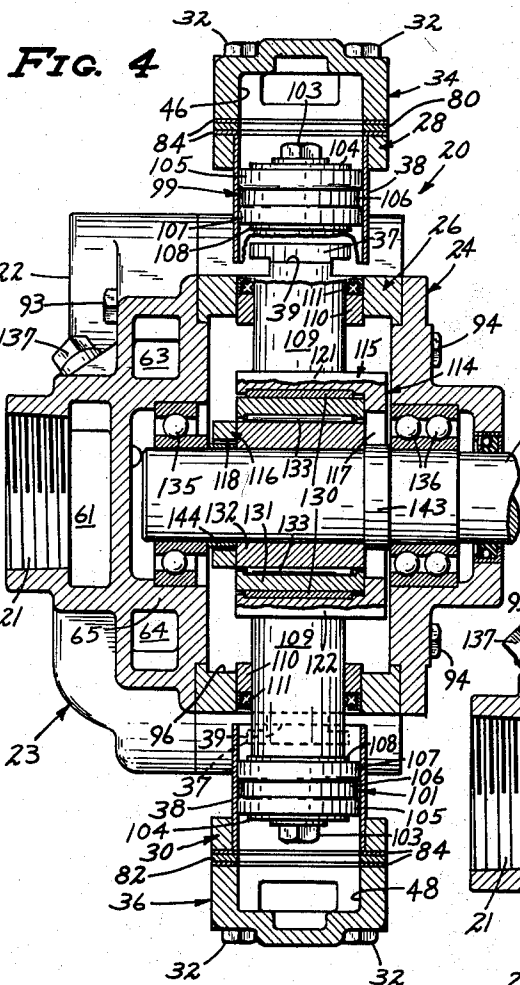
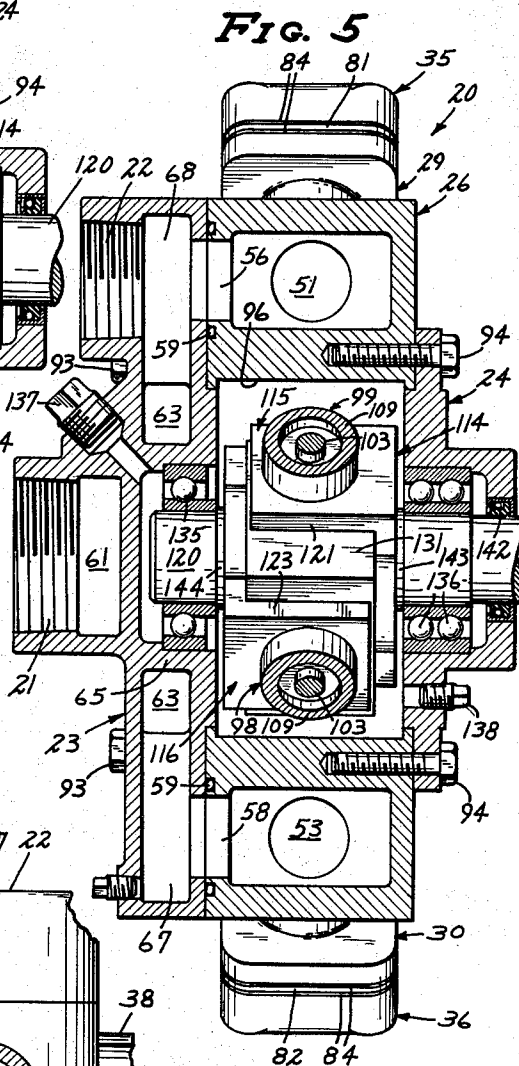
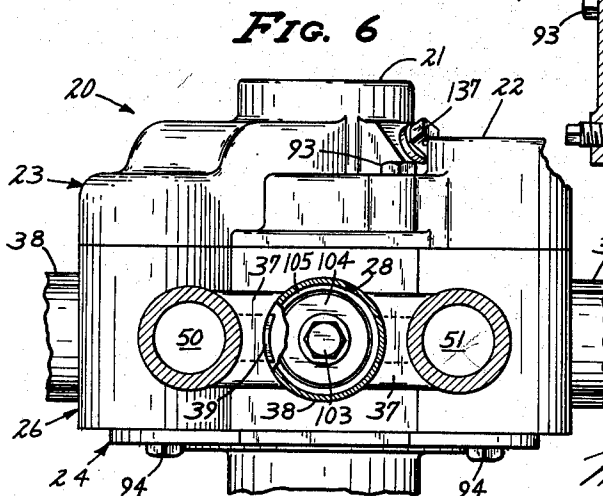
W. F. WANNER

3,174,436

RADIAL PUMP

Filed Nov. 23, 1962

4 Sheets-Sheet 2



INVENTOR.
WILLIAM F. WANNER
BY
Merchant, Merchant & Gould
ATTORNEYS

March 23, 1965

W. F. WANNER

3,174,436

RADIAL PUMP

Filed Nov. 23, 1962

4 Sheets-Sheet 3

FIG. 7

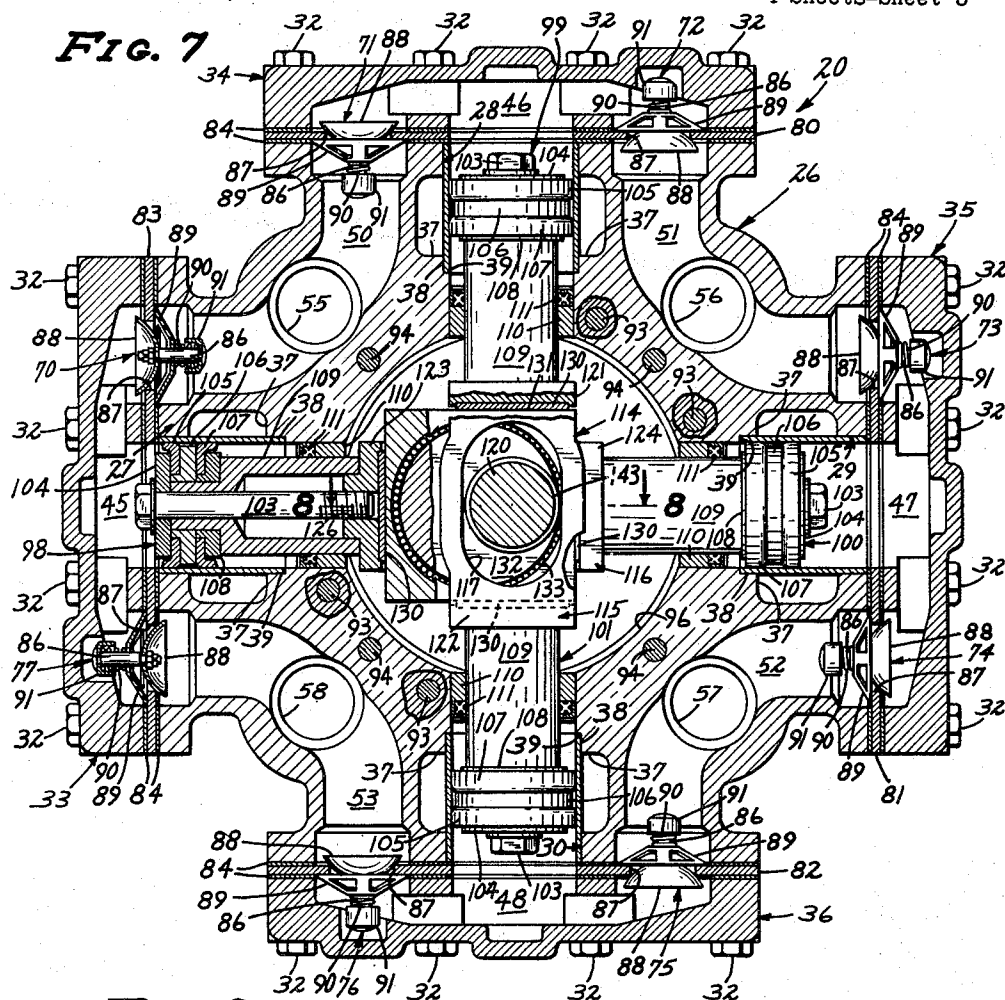
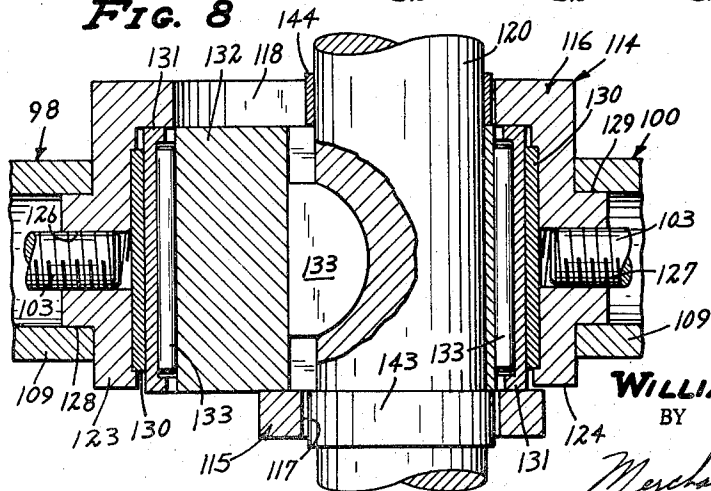


FIG. 8



INVENTOR.

WILLIAM F. WANNER

BY

Merchant, Merchant & Loebl
ATTORNEYS

March 23, 1965

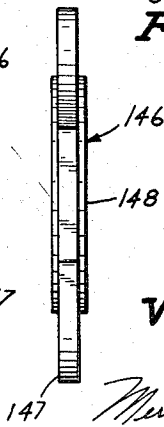
W. F. WANNER

3,174,436

RADIAL PUMP

Filed Nov. 23, 1962

4 Sheets-Sheet 4



1

3,174,436 RADIAL PUMP

William F. Wanner, Minneapolis, Minn., assignor to
Seeger-Wanner Corporation, Minneapolis, Minn.,
a corporation of Minnesota

Filed Nov. 23, 1962, Ser. No. 239,606

6 Claims. (Cl. 103-174)

This invention relates to multiple cylinder radial pumps. More particularly, this invention relates to a new and very useful four-cylinder, positive displacement type radial pump and to integrally connected four-cylinder multiples thereof.

The pumps of this invention are very useful for pumping solutions containing suspended materials, such as those generally used in weed, livestock, insecticide, and other types of sprays, and for pumping extremely heavy, slurry-type mixtures. The pumps have a characteristically smooth high pressure discharge and require little power to operate.

It is an object of this invention to provide a compact, efficient, high pressure, positive displacement, multiple cylinder radial pump.

It is another object of this invention to provide a multiple cylinder radial pump in which the ratio of size and weight to capacity is small and which can be directly connected to a power source without intervening belts, pulleys, or gears to wear out or reduce pump efficiency.

It is another object of this invention to provide a rugged, high pressure, light weight pump capable of pumping solutions containing suspended materials including heavy, slurry-type mixtures.

It is another object of this invention to provide a readily maintainable, four-cylinder radial pump having replaceable cylinder sleeves and self-cleaning, self-sealing, low inertia valves and in which the orientation of parts is such that pump valves and packings can be serviced without disturbing the plumbing or drive arrangement.

It is another object of this invention to provide a radial pump using a compact reciprocating mechanism having a double Scotch yoke with a single bearing block.

It is another object of this invention to provide in a radial pump utilizing a double Scotch yoke in its reciprocating mechanism a center loading seeking needle bearing to direct plunger motion in a straight line, thus requiring yokes having strength substantially in a single direction only.

It is an other object of this invention to provide in a radial pump a single central crank case for the reciprocating mechanism which is separated from cylinders and fluid channels so that such reciprocating mechanism is not contaminated by fluids being pumped.

It is another object of this invention to provide a multiple cylinder radial pump body which can be stacked with similar bodies to provide a number of different pump capacity sizes, each grouping of stacked pump bodies being driven by a single rotary drive shaft.

Other and further objects of this invention will become apparent to those skilled in the art upon the reading of the present specification taken in conjunction with the attached drawings in which:

FIG. 1 is an end elevational view of a pump of this invention, some parts thereof broken away and some parts shown in section;

FIG. 2 is an elevational view of the opposite end of the embodiment shown in FIG. 1, some parts thereof broken away and some parts shown in section;

FIG. 3 is a view in side elevation of the embodiment shown in FIG. 1, some parts thereof broken away and some parts shown in section;

FIG. 4 is an enlarged view in vertical section taken

2

along the line 4-4 of FIG. 1, some parts thereof shown in elevation and some parts broken away;

FIG. 5 is an enlarged diagonal sectional view taken along the line 5-5 of FIG. 2, some parts thereof shown in elevation;

FIG. 6 is an enlarged view in horizontal section taken along the line 6-6 of FIG. 1, some parts thereof broken away;

FIG. 7 is an enlarged view in vertical section taken along the line 7-7 of FIG. 3, some parts thereof shown in elevation and some parts broken away;

FIG. 8 is a further enlarged view in horizontal section taken along the line 8-8 of FIG. 7, some parts thereof broken away;

FIG. 9 is a view in diagonal section similar to FIG. 5 showing two units of FIG. 1 in tandem arrangement;

FIG. 10 is an elevational view of the plate insert utilized in the tandem assembly shown in FIG. 9; and

FIG. 11 is a side elevational view of the structure shown in FIG. 10.

Turning to the drawings, there is seen an embodiment of a radial pump of this invention, herein designated in its entirety by the numeral 20. Liquid to be pumped is drawn into pump port 22.

The body or casing of pump 20 is conveniently formed of a metal such as aluminum or the like and is fabricated by conventional casting and machining operations. Thus, the body of pump 20 is seen to consist of a manifold 23, a hub 24, and a block 26, the latter positioned between the manifold 23 and the hub 24. In block 26 is formed the head and base region for each of four cylinder portions, a first cylinder portion 27, a second cylinder portion 28, a third cylinder portion 29 and a fourth cylinder portion 30. The axes of these cylinder portions 27, 28, 29 and 30 are spaced one from the other at 90° intervals in a common radial plane normal to the pump axis. Secured on block 26, one over the head of each cylinder portion 27, 28, 29 and 30 by means of suitable bolts 32, are respective first cylinder head 33, second cylinder head 34, third cylinder head 35, and fourth cylinder head 36, respectively. Cylinder heads 33, 34, 35 and 36 are conveniently of metal construction formed by suitable casting and machining operations.

The cylinder portions 27, 28, 29 and 30 are each formed to receive metal tubing such as sleeve inserts 38. These sleeve inserts 38 (four in all) are held round and stopped by simple casting projections 37 integrally formed on the block 26. Each replaceable cylinder sleeve insert 38 is pressed into the block 26 through an appropriately formed opening in the radially outer ends (four in all) of cylinder portions 27, 28, 29 and 30 and stops against a shoulder 39 formed in the base region of each respective cylinder portion 27, 28, 29 and 30. The sleeve inserts 38 are each exposed so that each can be removed by merely removing the appropriate adjacent respective heads 33, 34, 35 and 36 and withdrawing sleeves 38 as with suitable sleeve insert puller (not shown).

The sleeve inserts 38 taken together with the adjoining portions 27, 28, 29 and 30 of the block 26 can be considered to form cylinder block portions disposed in radially outwardly spaced relation to the axis of the block 26, which axis is generally normally positioned with respect to the pump axis. Thus, each pair of opposed cylinder portions 28 and 30 is angularly spaced about the pump axis from another pair of opposed cylinder portions 27 and 29.

Formed in each head 33, 34, 35 and 36 and communicating with, respectively, each cylinder portion 27, 28, 29 and 30 is a valve chamber 45, 46, 47 and 48, respectively. Each such valve chamber 45, 46, 47 and 48 extends laterally outwardly (along the common radial plane) in either direction from the head region of each cylinder

portion 27, 28, 29 and 30 (see FIG. 7). Integrally formed within block 26 and communicating with an opposite end region of each valve chamber 45, 46, 47 and 48 are four channels or passages 50, 51, 52 and 53, respectively. Each such channel 50, 51, 52 and 53 communicates with that face of block 26 which abuts against the face of manifold 23 in the assembled pump 20 through respective ports 55, 56, 57 and 58. Placed circumferentially around each port 55, 56, 57 and 58 is an annular groove for O-ring seals 59 so as to provide liquid-tight engagement of manifold 23 with block 26.

It will be observed that the ends of each passage 50, 51, 52 and 53 are spaced apart from the block portions comprising the cylinder portions 27, 28, 29 and 30 and that the ends of these passages 50, 51, 52 and 53 are connected with the head region of each cylinder portion 27, 28, 29 and 30 when the heads 33, 34, 35 and 36, respectively, are mounted in place over the head regions of each cylinder portion 27, 28, 29 and 30, respectively.

Ports 55 and 57, respectively, which are in a side face of block 26, communicate with input port 21 through channels 60 and 61, respectively, which are integrally formed in the manifold 23. Ports 56 and 58 communicate with outlet port 22; the connection between port 55 and outlet port 22 being direct (see FIG. 2) while port 57 communicates with outlet port 22 via channels 63 and 64 which extend within manifold 23 circumferentially around rotary drive shaft bearing mount 65 (the latter being integrally formed in manifold 23), being positioned under channels 60 and 61 in manifold 23. The channels 63 and 64 join in their end regions to form common channels 67 and 68, respectively, with channel 67 connecting port 58 and channel 68 connecting outlet port 22.

Spaced between the ends of channels 50, 51, 52 and 53 and valve chambers 45, 46, 47, and 48, respectively, is a series of check valves (eight in all). The check valves at each end of channel 50 are numbered 70 and 71, respectively; those at the end of channel 51 are numbered 72 and 73; those at the end of channel 52 are numbered 74 and 75 and those at either end of channel 53 are numbered 76 and 77. Check valves 71 and 72 are mounted in a valve plate 80 which is positioned and mounted between block 26 and second cylinder head 34. Check valves 73 and 74 are mounted in a valve plate 81 which is positioned and mounted between block 26 and third cylinder head 35. Check valves 75 and 76 are mounted in a valve plate 82 which is positioned and mounted between block 26 and fourth cylinder head 36. Check valves 77 and 70 are mounted in a valve plate 83 which is positioned and mounted between block 26 and first cylinder head 33. Positioned on either side of each valve plate 80, 81, 82 and 83 is an appropriately shaped gasket 84.

The operation of each check valve 70, 71, 72, 73, 74, 75, 76 and 77 is the same and will now be briefly described by reference to valve 71. Valve 71 has a stem 86 which extends loosely through a circular aperture 87 in valve plate 80. A cup-shaped valve element 88 is mounted on one end of stem 86 so that its convex wall normally seats in the aperture 87 on one side of the valve plate 80. A spider support element 89 loosely journals the stem 86 and is so positioned that its rim portion slidably engages the opposite side of valve plate 80 adjacent the circular aperture 87. The spokes of spider 89 connect the hub and rim portions thereof and define ports for fluid passage therethrough. A coiled spring 90 circumscribes stem 86 and is compressed between the hub portion of spider 89 and the concave walls of a cup 91 which is secured over the end hub portion of stem 86 (the end opposite that to which valve element 88 is mounted). The spring 90 yieldingly urges the stem 86 in a direction to seat the valve element 88 in aperture 87.

The check valves 70 and 71 are each mounted so as to normally close channel 50 against the flow of fluid into such channel 50 from the ends but to pass liquid flow out

of the ends of channel 50 into, respectively, valve chambers 45 and 46. Thus, fluid entering channel 50 through ports 55 passes to either end of channel 50 and past the respective check valve 70 and 71. A similar situation prevails with respect to channel 52 and the respective check valves 74 and 75 mounted at either end thereof. Thus, when fluid enters channel 52 through port 57, it can flow into respective valve chambers 47 and 48 past check valves 74 and 75.

However, as respects channel 51, the check valves 72 and 73 at either end thereof prevent liquid from passing out of either end of channel 51; instead, check valves 72 and 73 are here mounted to admit fluid into channel 51 from, respectively, valve chambers 46 and 47. Thus, fluid enters either end of channel 51 and passes to the mid-region thereof to exit therefrom through port 56. Similarly, check valves 77 and 78 at either end of channel 53 are so mounted as to admit fluid into channel 53 from respective valve chambers 45 and 48 (and not vice versa); fluid entering channel 53 being permitted to exit therefrom through port 58. Manifold 23 is secured to block 26 by means of four bolts 93 which screw into the face of block 26. Hub 24 is secured to the opposite face of block 26 by means of four bolts 94. It will be observed that when manifold 23 and hub 24 are mounted upon block 26, as described, the central portion or crankcase 96 of block 26 is physically isolated from the various channels and ports just described. Even the insert sleeves 38 are isolated from crankcase 96 as will be appreciated from the following description.

Reciprocally moveable in each insert sleeve 38 are, respectively, first piston assembly 98, second piston assembly 99, third piston assembly 100, and fourth piston assembly 101. The construction of each piston assembly 98, 99, 100 and 101 is the same and will now be briefly described by reference to first piston assembly 98. A bolt 103, whose end region is threaded, has slipped (in this order) over its shank a circular follower 104, a first packing cup 105, a top spacer 106, a second packing cup 107, a bottom spacer 108, and finally a plunger 109. The neck region of plunger 109 slidably engages the shank of bolt 103 and its top end butts up against the bottom of circular follower 104. The out-turned, oppositely extending outer faces of each packing cup 105 and 107 slidably engage the inside wall of each sleeve insert 38. The side of plunger 109 slidably engages a plunger guide or bushing 110 (such as a bronze Oilite bearing). On that side of bushing 110 facing towards the head end of the piston assembly 98 is positioned a packing 111 (such as a quading seal and backing washer). Each packing 111 encloses the reciprocating mechanism, herein generally designated by the numeral 114, and seals it in crankcase 96 from the atmosphere and the fluid being pumped.

Plunger 109 taken together with the shank of bolt 103 can be considered to form a piston rod which is rigidly connected to a piston which can be considered as being formed by circular follower 104, first packing cup 105, top spacer 106, and second packing cup 107.

The reciprocating mechanism 114 produces the desired to and fro movement of each piston assembly 98, 99, 100 and 101 slidably within each respective insert sleeve 38. The reciprocating mechanism 114 uses a pair of Scotch yokes 115 and 116. Each of these yokes 115 and 116 consists in a crosshead portion having an elongated slotted region 117 and 118, respectively, extending lengthwise therethrough. The width of each such region is such as to accommodate a rotary drive shaft 120 and the length is such as to correspond to the distance which each piston moves in its cylinder. The legs 121 and 122 of Scotch yoke 115 and the legs 123 and 124 of Scotch yoke 116 each depend normally from opposite end regions of the slotted crosshead portion of each such Scotch yoke 115 and 116, respectively. The Scotch yokes 115 and 116 are positioned in crankcase 96 so that their respective legs oppose one another but are positioned nor-

mally with respect one to the other. Shaft 120 extends therethrough respective slots 117 and 118.

The exposed side face or outside wall of each leg 121, 122, 123 and 124 has a threaded aperture (two of which are shown) centrally positioned therein and each leg pair has these apertures axially aligned. Adjacent each such aperture 126, 127 on the outside face of each leg 121, 122, 123 and 124, respectively, it is a concentrically positioned shoulder 128 and 129 (two of which are also shown) whose diameter generally permits sliding engagement with the inside end wall region of each plunger 109. The threaded apertures 126 and 127 have respective diameters and associated threading which permits each bolt 103 of respective piston assemblies 98, 99, 100 and 101 to be screwed thereto, in the manner shown, for example, in FIGS. 7 and 8.

On the inside face of each leg 121, 122, 123 and 124, in an appropriate slot, is mounted a shoe bearing plate 130 (such as a bronze Oilite bearing or the like). Mounted between the inside faces of each leg 121, 122, 123 and 124, against the shoe bearing plate 130 and between the space between the slotted cross-head portions of the Scotch yokes 115 and 116, is a square-sided bearing block 131 having a cylindrical aperture cut therethrough from face to face. Rigidly mounted on rotary drive shaft 120 is an eccentric cam element 132 whose outer circular surface engages needle roller bearings 133 within bearing block 131. To secure the eccentric cam element 132 to the drive shaft 120, a keyway is provided in the eccentric cam 132 with a matching seat in the drive shaft 120 for a Woodruff key 133. (See FIG. 8.)

When the webs or slotted regions 117 and 118, respectively, or Scotch yokes 115 and 116 are installed at 90° to each other in the axial plane, as described, the square outer race of the needle bearing block 131 floats between the webs or slotted regions 117 and 118 of the respective yokes 115 and 116. The outer race or bearing block 131 provided with needle bearings 133 rides on the eccentric cam 132, located on the drive shaft 120, as described. The loads impressed on the faces of the outer race 131 of the needle bearings are always centered on the bearings since the outer race 131 floats, and a characteristic of a floating needle bearing is to seek a position where the load is centered. Thus, the combination of the two Scotch yokes 115 and 116 together with the needle bearing block 131 and shoes 130 mounted on the eccentric cam element 132 are so operatively connected to each of the piston rods of the piston assemblies 98, 99, 100 and 101, respectively, as to impart radial reciprocatory pumping movements thereto, thereby making the pistons responsive to the rotary movement of the shaft 120.

In the embodiment shown, the reciprocating mechanism 114 is lubricated by running it in oil (not shown). In this case open ball bearings 135 and 136, respectively (see FIG. 4), are used. Oil enters crankcase 96 through the aperture for fill plug 137 in manifold 23. The oil level in the crankcase 96 is conveniently controlled by level plug 138 which is located in hub 24. In this method of lubrication, the outer and inner races for respective ball bearings 135 and 136, respectively, are lubricated by splash action. Observe that shaft 120 is circumferentially sealed at the point where it passes through hub 24 by a conventional sealing assembly 142.

Observe that the arrangement of the Scotch yokes 115 and 116 and respective plungers 109 is such that the plungers 109 can be guided either by a guide sleeve 110 placed on the mechanism side of the packing 111 or simply by the packing washers 105 and 107. The method of guiding the plungers 109 is usually determined by the method of lubrication employed. Instead of being oil lubricated, as in the present embodiment, the mechanism 114 can be lubricated by grease injected into the crankcase 96 behind the manifold bearing 135 and thence conducted through a suitable channel in the shaft 120 to the needle roller bearing assembly. In this case the plungers 109

are guided by the packing washers 105 and 107 on their respective packing assemblies. The crankcase 96 then runs dry and the seals merely keep foreign material from entering crankcase 96.

Observe that the respective sleeve inserts 38 stop away from the body of block 26 against shoulders 42 and 39 so that in the event of a leak past the packing cups 105 and 107 the liquid runs away and does not enter the crankcase 96.

Owing to the construction of a manifold 23, when the reciprocating mechanism 114 operates in oil, that portion of the manifold 23 which would normally serve as the grease cavity is surrounded by water flowing through respective channels 63 and 64. In this case, the water serves as a condenser, thereby preventing oil vapor from escaping out of a vent (not shown) provided in fill plug 137, the vent being of conventional design and not a part of this invention. Since the vent is thus located in the manifold 23, this arrangement also prevents oil from being splashed out of the vent opening. Also, if the pump 20 should become inverted in use, the oil cannot run out of the vent.

To position the drive shaft 120 in the desired fixed relationship to the double Scotch yoke and to the respective ball bearings 135 and 136, a shoulder 143 is formed on the drive shaft 120 at such a distance from the end thereof as to place the shoulder between eccentric cam 132 and the inner race of ball bearings 136.

A sleeve 144 slidably engages the forward end of drive shaft 120 and serves as a spacer positioning the eccentric cam 132 the desired distance from the inner race of the ball bearings 135.

The operation of the reciprocating mechanism 114 is as follows. As the shaft 120 rotates, the eccentric cam 132 causes the bearing block 131 to orbit in crankcase 96 about the axis of drive shaft 120. The axis of the bearing block 131 is eccentric to the axis of drive shaft 120 but is concentric with the axis of eccentric cam 132. As the bearing block 131 orbits, it slidably moves against the respective surfaces of the individual bearing surface plates 130 of the respective Scotch yokes 115 and 116. Since the yokes are fixed 90° to each other in the axial plane upon the drive shaft 120, reciprocatory motion is produced of opposed piston pairs; that is, the first and third piston assemblies 98 and 100, respectively, move in common direction, and the second piston assembly 99 and the fourth piston assembly 101 similarly move in common direction whereby pumping action (i.e., suction and pumping) is simultaneously produced on each stroke of piston pairs 98, 100 and 99, 101.

To assemble radial pump 20 the following procedure can be employed. Hub 24 is suitably positioned on shaft 120, the sealing assembly 142 and the bearing 141 being in the desired sliding engagement with the shaft 120. Next, a pump body having a block 26 is positioned over shaft 120, such pump body having the pistons duly assembled. The next step is to assemble the reciprocating mechanism 114 about the shaft 143, and then bearing 140 is positioned about the end of shaft 120. Finally, the manifold 23 is mounted on the block 26.

The operation of the pump 20 is as follows: Fluid enters the pump 20 through input port 21 in manifold 23, and flows through passages 60 and 61 past ports 55 and 57 into channels 50 and 52, respectively, being drawn through these respective channels past valves 70, 71, 74 and 75 by the suction produced by the reciprocatory motion of the pistons 98, 99, 100 and 101. After passing the valves 70, 71, 74 and 75, the flow of fluid is through the respective valve chambers 45, 46, 47 and 48, and into the respective channels 56 and 58, respectively, past the valves 72, 73, 76 and 77, respectively. Fluid is forced through these valves 72, 73, 76 and 77, as explained, by the reciprocatory motion of the piston assemblies 98, 99, 100 and 101. After entering opposite ends of the respective channels 51 and 53, the fluid passes out

ports 56 and 58 into channels 63 and 64 (from port 58) and directly from port 56 to port 22, and finally exits from outlet port 22 into a delivery line.

In FIGS. 9, 10 and 11 are shown the appearance of a stack arrangement wherein two pump sections of the type shown in FIGS. 1-8 are axially aligned in face to face engagement so as to provide a single pump having approximately a little less than twice the output volume at about the same output pressure as associated with a single pump body. The product assembly involves extending entirely through one block 26' the holes for bolts 94' (four in all) so as to produce a modified block 145. It should be noted that the alternative embodiment of my invention shown in FIGS. 9-11 and hereinafter described corresponds in all respects not specifically hereinafter mentioned to the above described embodiment of my invention shown in FIGS. 9-11, and the parts or elements of said alternative embodiment which correspond to like parts or elements in FIGS. 9-11 are denoted by the use of the same reference characters with prime marks added thereto.

The product assembly also involves modifying a second pump block 26'' by extending through block 26'' four ports, two of which are shown and identified by the numerals 56'', 58'', in axial alignment with ports 56' and 58' so as to provide communication for fluid passage between a pair of pump bodies stacked together. The modified block is indicated by the numeral 150 in FIG. 9.

Between the opposed faces of each adjoining pair of stacked pump sections a special spacer plate 146 is mounted. The spacer plate 146 is so made that its rim portion 147 contacts the opposing side faces of a pair of blocks 145 and 150, yet the mid-portion 148 has raised faces in the region of the crankcase 96'. These raised faces serve to position and axially align one pump body with respect to another. Port 149 in the raised portion 148 of plate 146 serve to permit passage of lubricating oil from one crankcase 96' to an adjoining crankcase in a stack of pump sections. It may be noted that plate 146 is provided with apertures 155, 156, 157 and 158 which permit communication of ports 56', 58' with ports 56'', 58'', respectively, shown in FIG. 9, through respective apertures 156, 158. Apertures 155, 157 communicate with their respective ports (not shown) in a like manner. Also, in order to provide sealing engagement of the face of block 150 which adjoins plate 146, suitable grooves are conveniently circumferentially placed about each port 56' and 58' for O-ring seals 151.

Broadly, to assemble pump sections into a stack, one begins by first positioning a hub 24 on the drive shaft 152 using the same arrangement as for a single pump body. Next, the pump section having the modified block 145 is positioned on shaft 152 in the usual relationship to the hub 24, and then the reciprocating mechanism 114' for the pump section of block 145 is assembly in place. The plate 146 is next positioned upon the other face of 145 (opposite that engaged with the hub 24), there being a bearing 154 in plate 146 journalling the shaft 152 in the region where the shaft 152 passes through the plate 146. The bearing 154 is used to take up unbalanced loads between the eccentric cams 132' which are positioned one on either side thereof within the respective reciprocating mechanisms 114 of each pump body. Next, the pump body having block 150 is mounted on plate 146 and the reciprocating mechanism 114 for that pump body is mounted on the shaft 152. Finally, the bearing assembly 140' is mounted on the shaft 152, and the manifold 23 is mounted on the block 150 to complete the assembly shown in FIG. 9. The eccentric cams 132' (not shown in FIG. 9) can be spaced 180° with respect to one another on the shaft 152 so as to produce flow characteristics like that of a single pump. If the eccentric cams 132' are offset at 135° with respect to one another, a resultant smooth flow is achieved.

Three or more pump bodies can be similarly joined together; however, the intermediate pump bodies (not

shown) between those pump bodies having blocks 145 and 150 have the same general construction as that employed in the block 150 except that the bores for bolts 94' extend all the way through such intermediate pump bodies so that the shanks of bolts 94' are secured to the pump body 150 while the heads thereof position the hub 24' in the desired fixed relationship to the block 145. When three or more bodies are joined together, the intermediate bearings 154 and plates 146 are positioned between adjacent faces of stacked pump bodies. When three pump bodies are joined together, the cams can be spaced 120° apart to achieve desirable smooth flow characteristics.

My invention has been thoroughly tested and found to be completely satisfactory for the accomplishment of the above objects, and while I have shown and described a preferred embodiment, I wish it to be specifically understood that the same is capable of modification without departure from the spirit and scope of the appended claims.

The claims are:

1. A radial pump comprising

- (a) casing means defining a central crankcase and a plurality of cylinders extending radially outwardly from said crankcase in a common plane and arranged in diametrically opposed pairs, each pair being angularly displaced relative to another of said pairs, a pump chamber at the outer end of each of said cylinders, an inlet port and an outlet port, and inlet and outlet passages connecting each of said inlet and outlet ports with said chambers,
- (b) check valves interposed between said inlet and outlet passages and each of said pump chambers and operative to admit fluid to said chambers only from said inlet passages and from said chambers only to said outlet passages,
- (c) a plurality of pistons one each axially slidable in a different one of said cylinders,
- (d) a rotary shaft axially journaled in said casing means,
- (e) an eccentric element on said shaft,
- (f) piston rods rigidly connected to and extending radially inwardly each from a different one of said pistons,
- (g) means rigidly securing the inner ends of opposed piston rods together for common reciprocatory movement of respective opposed ones of said pistons, and operatively connecting said piston rods to said eccentric element, whereby to impart reciprocatory movement to said piston rods and pistons responsive to rotary movement of said shaft,
- (h) said casing means further defining openings intermediate said pistons and the radial inner ends of said cylinders and establishing communication between said cylinders and the exterior of said casing means, and
- (i) sealing means in each of said cylinders intermediate said openings and the radial inner ends of said cylinders.

2. A radial pump comprising

- (a) a casing defining a central crankcase portion and diametrically opposed pairs of cylinder block portions disposed in radially outwardly spaced relation to said crankcase portion, one pair of said opposed block portions being angularly spaced about the axis of said casing from another pair of opposed block portions, spaced apart inlet and outlet passages connecting the block portions of each of said pairs with the block portions of adjacent pairs thereof,
- (b) cylinder heads on the radially outer ends of said block portions and cooperating therewith to define pump chambers,
- (c) end members at opposite ends of said casing,
- (d) one of said end members having an inlet port communicating with said inlet passages,

- (e) one of said end members having an outlet port communicating with said outlet passages,
- (f) check valves in said inlet passages for admitting fluid to said pump chambers and in said outlet passages for discharge of fluid from said pump chambers, 5
- (g) each of said block portions having a radial bore intermediate its respective inlet and outlet passages and communicating with its respective pump chamber and said crankcase, 10
- (h) a cylinder in each of said bores, said cylinders terminating at their radially inner ends in radially outwardly spaced relation to said crankcase,
- (i) a plurality of pistons each slidably mounted in a different one of said cylinders, 15
- (j) rigid piston rods rigidly connected at opposite ends to diametrically opposed pairs of said pistons,
- (k) a rotary shaft extending axially of said crankcase and journaled in said end members,
- (l) an eccentric element on said shaft in said crankcase, 20
- (m) means on said eccentric element operatively connected to said piston rods for imparting radial reciprocatory pumping movements thereto and to said pistons responsive to rotary movement of said shaft, 25
- (n) said casing having an opening radially inwardly of each of said cylinders communicating with the exterior of said casing, and
- (o) bearing and sealing means mounted in each of said bores between said openings and the radially inner ends of said bores and slidably encompassing adjacent portions of said piston rods. 30
3. The structure defined in claim 2 in which said casing defines a radially outwardly facing arcuate shoulder in each of said bores, said shoulders being disposed radially outwardly of said openings and providing seats for the inner ends of said cylinders. 35
4. The structure defined in claim 3 in which the block portions of said casing comprise tubular elements which define portions of said inlet and outlet passages, the outer surfaces of said cylinders being exposed intermediate their ends between said tubular elements. 40
5. A radial pump comprising:
- (a) casing means defining, a central crankcase, a pair of circumferentially spaced radial cylinders disposed radially outwardly of said crankcase, a pump cham-

- ber at the outer end of each of said cylinders, an inlet port and an outlet port, and inlet and outlet passages connecting each of said inlet and outlet ports with said chambers,
- (b) check valves interposed between said inlet and outlet passages and each of said pump chambers and operative to admit fluid to said chambers only from said inlet passages and from said chambers only to said outlet passages,
- (c) a pair of pistons one each mounted in a different one of said cylinders for axial reciprocation therein,
- (d) a drive shaft journaled in said crankcase and extending axially thereof,
- (e) an eccentric element fast on said drive shaft,
- (f) a pair of piston rods each rigidly connected to a different one of said pistons and operatively connected to said eccentric element for imparting reciprocatory movement to said pistons responsive to rotary movement of said drive shaft,
- (g) said crankcase and the inner ends of said cylinders defining openings between the inner ends of said cylinders and the exterior of said crankcase,
- (h) and sealing means for said piston rods and crankcase radially inwardly of said openings for sealing the interior of said crankcase from the exterior thereof.
6. The structure defined in claim 5 in which said cylinders comprise sleeve-like cylinder elements, and in which said casing defines, a pair of radial bores outwardly spaced from said crankcase for receiving and supporting the outer end portions of said cylinder elements, and circumferentially spaced shoulders exterior of said crankcase for supporting the inner ends of said cylinder elements.

References Cited by the Examiner

UNITED STATES PATENTS

860,826	7/07	Reavell	230—187
1,032,603	7/12	Hayner	230—187

FOREIGN PATENTS

1,189,629	3/59	France.
1,096,750	1/61	Germany.

LAURENCE V. EFNER, *Primary Examiner.*
JOSEPH H. BRANSON, JR., *Examiner.*