May 14, 1968 E. M. SMITH 3,382,812

VARIABLE POSITIVE DISPLACEMENT PUMP

Filed Sept. 27, 1966 3 Sheets-Sheet 1

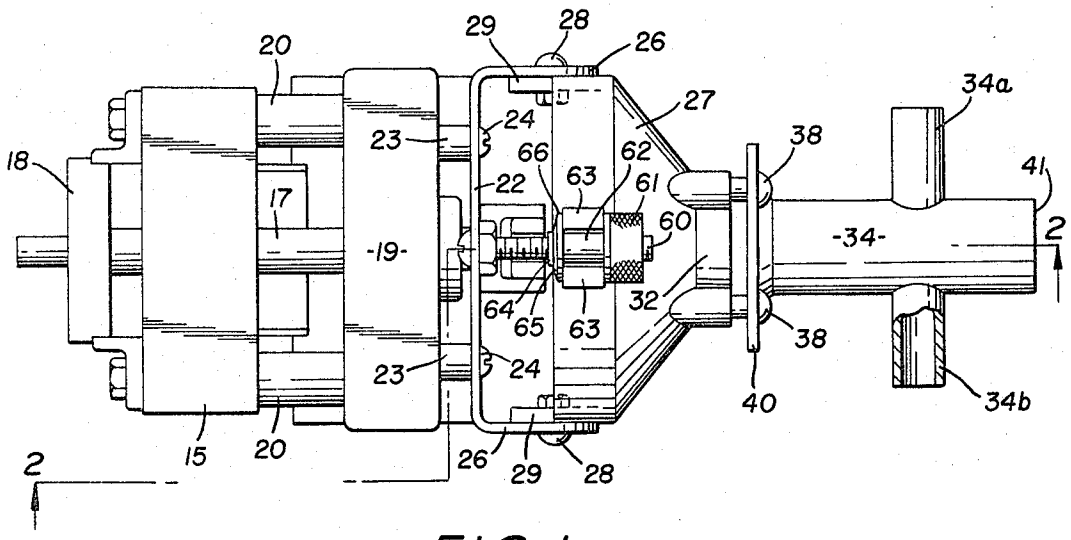


FIG. 1

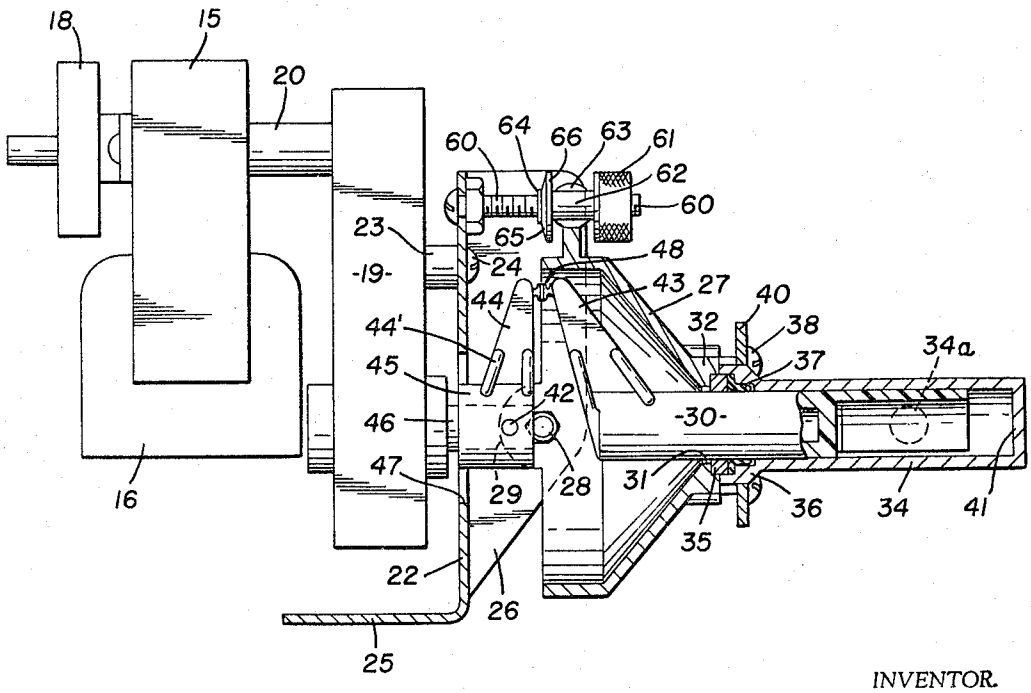


FIG. 2

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VARIABLE POSITIVE DISPLACEMENT PUMP

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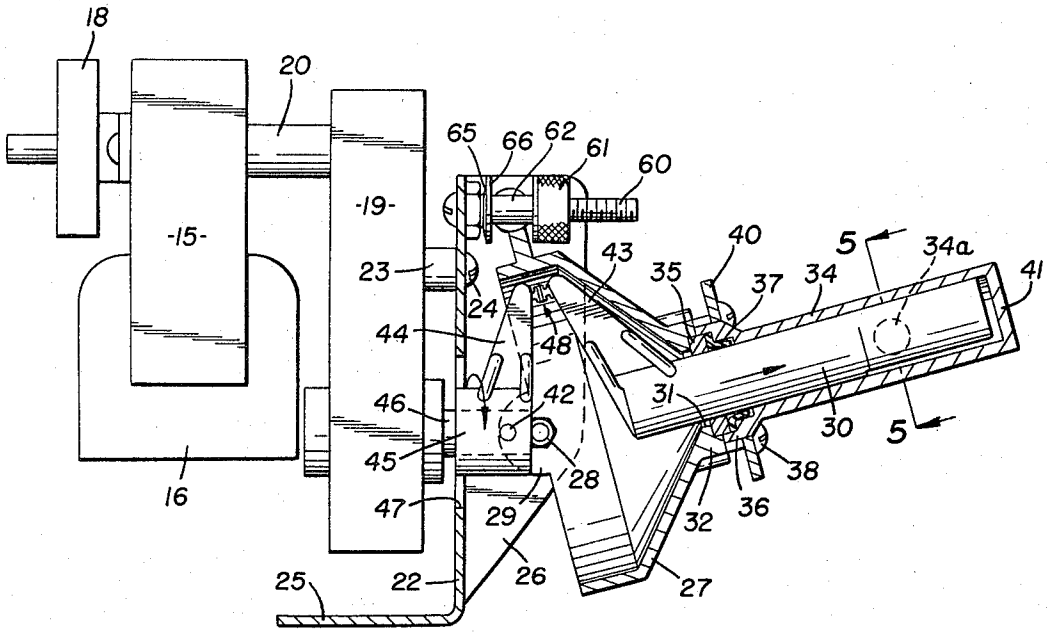


FIG. 3

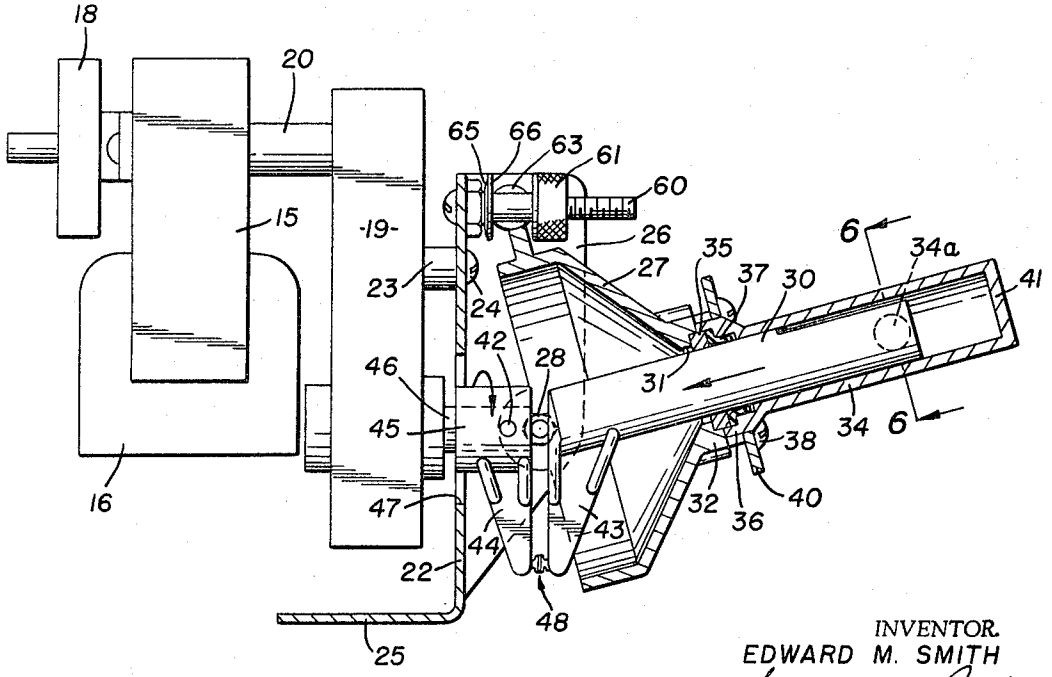


FIG. 4

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VARIABLE POSITIVE DISPLACEMENT PUMP

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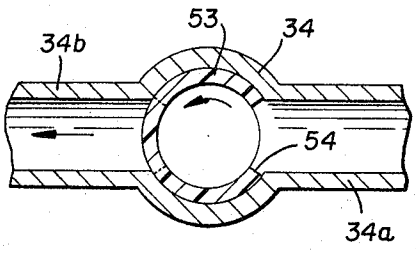


FIG. 5

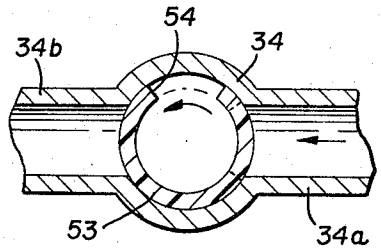


FIG. 6

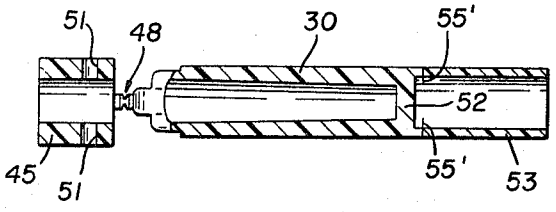


FIG. 8

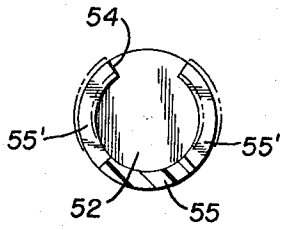


FIG. 10

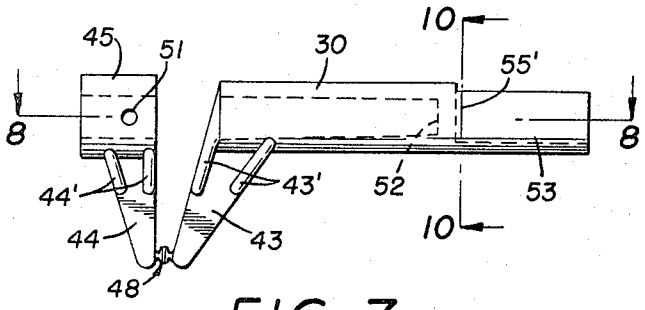


FIG. 7

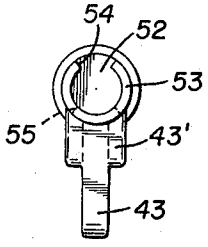


FIG. 9

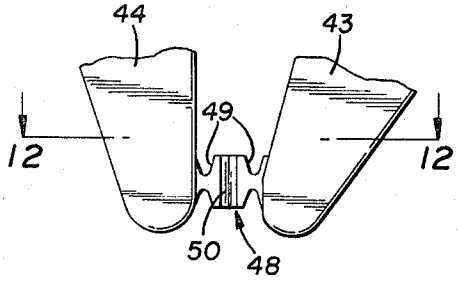


FIG. 11

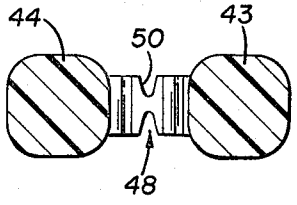


FIG. 12

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United States Patent Office 3,382,812
Patented May 14, 1968

3,382,812

VARIABLE POSITIVE DISPLACEMENT PUMP

Edward M. Smith, Mansfield, Ohio, assignor to Gorman-Rupp Industries, Inc., Bellville, Ohio, a corporation of Ohio

Filed Sept. 27, 1966, Ser. No. 582,402
11 Claims. (Cl. 103—157)

This invention relates generally to positive displacement piston pumps for producing fluid flow by means of a rotating and reciprocating piston.

More particularly, the invention relates to improvements in a variable positive displacement pump having a construction such as is shown in U.S. Patent No. 3,168,872, patented Feb. 9, 1965.

The construction of said patent requires a drive pin or arm to be secured to the outer end of the pump piston, and a ball and socket joint between the drive pin and the periphery of a collar on the motor drive shaft which is angular to the axis of the piston, in order to obtain the rotating and reciprocating motion of the piston characteristic of this type of pump.

Such a construction is obviously costly and requires constant lubrication to insure good operation and minimize wear.

It is an object of the present invention to provide an improved positive displacement pump construction which is less expensive and requires no lubrication whatsoever at the joint between the drive shaft and the piston.

More specifically, it is an object to provide plastic drive and piston parts connected by a novel living hinge construction which provides a universal connection of exceedingly long life and requires no lubrication.

A further object is to provide a novel plastic "living hinge" construction which will compensate for a certain amount of misalignment between the axes of the piston and the drive shaft, as well as angularity therebetween.

Another object is to provide an improved plastic piston construction which is extremely economical to manufacture, and is adapted for obtaining flow through the pump in a reverse direction by a simple change in manufacture.

Finally, it is an object of the present invention to provide a simple, compact and inexpensive positive displacement pump which requires no separate valves or other components.

As in the construction of Patent No. 3,168,872, the pump of the present invention has a ducted piston which reciprocates and rotates in a cylinder having opposed lateral fluid inlet and outlet ports. One port is connected by the duct in the piston to the pump chamber on the downstroke of the piston and the other port is connected by the piston duct to the pump chamber on the upstroke of the piston. Thus, fluid is sucked through one port into the pump chamber on one stroke of the piston and expelled from the pump chamber through the other port on the other stroke.

In the drawings:

FIG. 1 is a plan elevational view of the improved pump coupled with the drive shaft of an electric motor and gear reduction unit.

FIG. 2 is a side elevation of the motor unit, showing the improved pump in vertical section with the piston and drive shaft in alignment.

FIG. 3 is a similar view with the piston angular to the drive shaft.

FIG. 4 is a view similar to FIG. 3 with the piston rotated 180°.

FIG. 5 is a cross section as on line 5—5 of FIG. 3 with the piston rotated 90°.

FIG. 6 is a cross section on line 6—6 of FIG. 4.

FIG. 7 is a detached elevational view of the pump piston and the drive shaft crank arm hingedly connected thereto.

FIG. 8 is a longitudinal section on line 8—8 of FIG. 7.

FIG. 9 is an end elevation of the piston as shown in FIG. 7.

FIG. 10 is a cross section on line 10—10 of FIG. 7.

FIG. 11 is an enlarged fragmentary elevation of the hinged connection between the pump piston crank arm and the drive shaft crank arm, as shown in FIG. 7.

FIG. 12 is a sectional view on line 12—12 of FIG. 11.

The electric drive motor, shown in FIGS. 1–4, comprises a stator 15 having a stator coil 16. A rotor (not shown) is carried on the rotor shaft 17 which is journaled in bearing 18 and extends into a gear reduction unit 19 supported on the stator by posts 20 and having an output shaft.

The gear reduction unit 19 is mounted on a bracket plate 22 in spaced relation thereto by posts 23 which abut the bracket plate and are secured thereto by screws 24 passing through holes in the bracket plate.

The bracket plate 22 has a bottom flange 25 for securing it to any suitable support and has side flanges 26 to which the conical collar 27 of the pump support assembly is pivoted by diametrically opposite screws 28 passing through ears 29 on the collar.

The piston 30 passes slidably through an aperture 31 formed within an abutment boss 32 on the small end of the cone. The boss 32 abuts the open end of a cylinder 34 having opposed lateral tubes 34*a* and 34*b* forming connecting flow ducts, and in which the piston 30 is slidably and rotatably mounted. The boss 32 has an annular recess therein for receiving sealing gland ring 35.

The open end of cylinder 34 has an annular socket 36 for receiving ring 35 and a sealing gasket 37 in said socket is abutted by ring 35. The collar 27 and cylinder 34 are clamped together and gland ring 35 held against sealing gasket 37 by four screws 38 at 90° to each other around the cylinder, the heads of the screws abutting a plate 40 on the socket 36 and screwed into the abutment boss 32 on the conical collar 27.

The cylinder 34 is preferably of plastic material, and its outer end is closed by a wall 41.

The piston 30 has a crank arm 43 extending angularly and radially from its inner end within the conical collar 27 and the arm 43 is hingedly connected at its outer end with a similar crank arm 44 extending radially from a hub 45 secured by pin 42 on the output shaft 46 from gear reduction unit 19, the shaft extending through an opening 47 in bracket plate 22. The hinge connection 48 between arms 43 and 44 is preferably in the same vertical plane as pivots 28, and is shown in detail in the enlarged views, FIGS. 11 and 12.

Preferably, the piston 30 with its arm 43 and the hub 45 with its arm 44 are all molded as one unit out of suitable plastic material, the arms being connected by hinge portion 48. The material may, for example, be polypropylene which has the property of providing a so-called "living hinge" in thin sections in which the molecules are oriented by stretching while the material is heated. In hinge 48 this orientation is accomplished by pinching the material while heated to stretch it into two necks 49 in the plane of the arms 43 and 44, and pinching it into one neck 50 between the necks 49 and in a plane at right angles to the necks 49.

The necks 49 are hinges which allow hinging movement of the arms 43 and 44 relative to each other in the plane of the arms to positions such as shown in FIGS. 3 and 4, and at the same time the width of the necks 49 transversely of said plane is sufficient to transmit the driving force from arm 44 to arm 43. The neck 50, being narrow in a plane transverse to the plane of the arms, allows hinging of the arms in a transverse direction as required when the arms are in the intermediate positions between the

positions shown in FIGS. 3 and 4. No torsion occurs at the hinge joint.

Preferably, the arms 43 and 44 have reinforcing ribs 43' and 44' molded along their edges to strengthen them in respect to transmitting driving force. The hub 45 is provided with diametrically opposite holes 51 to receive pin 42 for securing the hub to shaft 46. The piston 30 may be tubular with an end wall 52 adjacent its outer valving end portion 53.

End portion 53 preferably has a longitudinal slot 54 extending from the wall 52 to its outer end, and the end portion is joined to the piston by a narrow circumferential portion 55 opposite the slot 54 formed by transversely slitting the end portion 53 adjacent to wall 52 from the slot 54, as indicated by the slits 55'. Because the slotted valve portion 53 is connected to the piston only by narrow portion 55, it can be molded with the walls slightly expanded circumferentially, as indicated in chain lines in FIG. 10, so that when inserted into the cylinder 34 by compressing the walls together a snug fit is obtained with the inner wall of the cylinder without requiring extremely close fitting manufacturing tolerances.

The width of slot 54 in valve portion 53 of the piston is substantially equal to the inner diameter of the flow tubes 34*a* and 34*b* so that, when the slot registers with one or the other of the tubes, fluid can be admitted or discharged therethrough.

The collar member 27 is adjustably connected to the top of bracket plate 22 for rotating the collar together with the piston 30 therein about the pivots 28 and varying the angularity between the piston and the output shaft 46. The adjustable connection preferably comprises a bolt 60 secured at one end to plate 22 and having an adjusting nut 61 on the other end. The nut has a shank 62 riding in a slot formed between two pads 63 projecting from collar 27 with an annular flange 64 on the side of the pads opposite the nut. A bowed spring washer 65 may be interposed between the flange 64 and a washer 66 which bears against the pads to maintain tension on the collar 27 and hold it in adjusted position.

In the position of FIG. 1 the collar 27 is adjusted so that the output shaft 46 and the piston are in axial alignment. In this position when the shaft and piston are rotated there will be no pumping action as the slotted valve portion 53 of the piston passes the flow tubes 34*a* and 34*b*.

When the collar is adjusted to an angular position such as shown in FIGS. 3 and 4, and the shaft 46 is rotated, the piston reciprocates as it rotates resulting in a pumping action. Thus, as the piston reciprocates from the position of FIG. 3 to the position of FIG. 4, when the slot 54 rotates over the tube 34*a*, as in FIG. 5, fluid will be sucked into the cylinder from tube 34*a*. By the time the piston reaches the end of its stroke at position FIG. 4, slot 54 has passed the tube 34*a* and closed off flow as in FIG. 6.

Now as the piston continues to rotate and reciprocates on the reverse stroke, the slot 54 passes over tube 34*b* and the fluid previously sucked into the cylinder is expelled through tube 34*b* until the slot passes by and closes off the tube 34*b*. Due to the snug fit between the cylinder and the compressed walls of the slotted end 53 of the piston substantially no leakage occurs. Obviously, the length of the stroke and the resulting amount of fluid being pumped can be regulated by adjusting the angularity between the output shaft and the piston.

Moreover, the direction of flow through the pump can be reversed by cutting the valve slot 54 at 180° from the position shown, or by cutting the slot 90° from the position shown and rotating the cylinder 34 90° with respect to the four mounting screws 38.

The novel living hinge 48 allows the arm 44 to travel in a circular path around the axis of shaft 46 while the arm 43 travels in an elliptical path around the axis of the piston 30. At the same time, the hinge 48 has enough flexibility in all directions to compensate for slight misalignment between said axes.

By molding the plastic hub 45, piston 30, and hinged arms 43 and 44 as a unit, a very simple and economical construction is provided which is readily assembled with the collar 27 and plastic cylinder 41, without requiring additional valves or components, and only a single seal around the piston. The improved construction requires no lubrication and has operated without failure for several thousand hours.

What is claimed is:

1. A variable positive displacement pump comprising a drive shaft having a crank arm, a cylinder having lateral flow ducts and a closed end, a piston in said cylinder having a crank arm, means adjustably mounting said cylinder for varying the angularity between the drive shaft and the piston, and flexible hinge means connecting the outer ends of said crank arms.

2. A variable positive displacement pump as defined in claim 1 in which the flexible hinge means is a plastic living hinge.

3. A variable positive displacement pump as defined in claim 1 in which the crank arms are aligned.

4. A variable positive displacement pump as defined in claim 2 in which the plastic living hinge has a neck portion in the plane of the arms and a neck portion in a plane at right angles thereto.

5. A variable positive displacement pump as defined in claim 1 in which the two crank arms, the hinge means and the piston are molded of plastic material as a unit.

6. A variable positive displacement pump as defined in claim 4 in which the two crank arms, the hinge means and the piston are molded of plastic material as a unit.

7. A variable positive displacement pump as defined in claim 1 in which the piston has a longitudinally slotted circumferentially expansible valve portion traversing said flow ducts.

8. A variable positive displacement pump as defined in claim 5 in which the piston has a longitudinally slotted circumferentially expansible valve portion traversing said flow ducts.

9. A variable positive displacement pump as defined in claim 6 in which the piston has a longitudinally slotted circumferentially expansible valve portion traversing said flow ducts.

10. A variable positive displacement pump as in claim 1, in which the piston has a transverse end wall and a valve portion extending therefrom and traversing said flow ducts, said valve portion having a longitudinal slot and a narrow section opposite said slot connecting said valve portion to said end wall.

11. A variable positive displacement pump as in claim 9, in which the two crank arms, the hinge means and the piston and valve portion are molded of plastic material as a unit.

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HENRY F. RADUAZO, *Primary Examiner.*