



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTEGRATED PUMP AND CHECK VALVE APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to an integrated pump and check valve apparatus for pumping discrete liquid volumes to points of use of the liquid volumes. More particularly, this invention relates to an integrated displacement pump and check valve apparatus for pumping discrete liquid volumes to points of use.

At the present time, discrete liquid volumes are pumped with a syringe pump comprising a barrel, a face seal which moves within the barrel and a reciprocating plunger attached to the face seal. The syringe pump includes a valve construction formed of a polymeric composition which directs the pumped liquid volumes to a point of use. The valve construction includes a housing (stator) having a hollow, essentially interior surface into which is press fit a mating rotor. The rotor is provided with fluid passageways that control flow of liquid into the syringe pump and flow of liquid from the syringe pump while providing sealing between a pump inlet and a pump outlet. This configuration of syringe pump and rotor-stator valve requires two motors, one to drive the syringe and a second to drive the rotor.

While the available syringe pumps have been useful for their intended purpose, they also have disadvantages. In order to attain a tight fit between the barrel and the face seal, the manufacturing of both the barrel and face seal must be made at tight tolerances. In addition, when utilizing the most commonly used materials comprising a glass barrel and a polytetrafluoroethylene (PTFE) face seal, undesirable shedding of the PTFE occurs which contaminates the liquid being pumped. Furthermore, a tight fit between the barrel and face seal results in chattering of the face seal during its movement within the barrel. This leads to a loss of control of the liquid volume being pumped. In addition, the average useful life of presently available syringe pumps is only about 10 to about 100,000 cycles.

Accordingly, it would be desirable to provide a pump apparatus capable of delivering discrete liquid volumes to a point of use such as different areas of a sample tray in a manner which is repeatable for long time periods of 1,000,000 cycles or more. In addition, it would be desirable to provide such a pump apparatus which avoids shedding of polymeric particles during pumping. Furthermore, it would be desirable to provide such a pump which eliminates the need for a motor to activate a seal in order to direct fluid to a desired point of use.

SUMMARY OF THE INVENTION

The present invention provides a pumping apparatus comprising (a) a displacement pump having a liquid displacement element comprises a piston housed within a barrel, a high pressure seal and means for reciprocating the piston within the barrel and (b) check valves wherein the sealing is effected by activating a movable element under pressure of fluid being pumped without use of a motor. Liquid in the barrel is delivered to a point of use while the piston is traveling toward a check valve positioned between the piston and the point of use and liquid is supplied to the barrel when the piston is traveling away from the check valve positioned between the piston and the point of use. The moving piston is spaced apart from the inside surface of the barrel so that a frictional force between the piston and the barrel is prevented during pumping. By providing check valves between the piston and (a) the point of use and (b) a source reservoir for the liquid, motors for positioning the valves can be eliminated.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view of the displacement pump and check valve apparatus of this invention.

Fig. 2 is a front view of the apparatus of Fig. 1.

Fig. 3 is a cross-sectional view of the apparatus of Figure 2 taken along line 3-3 of Figure 2.

Fig. 4 is a cross-sectional view of a check valve useful in the present invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Referring to Figures 1, 2 and 3, the pump apparatus 10 of this invention includes a housing 12 and a motor 16 which effects rotation. Housing 32 which can be formed of an opaque or transparent material which is resistant to the liquid being pumped such as acrylic, polyetherether ketone, or the like can be a single piece or a plurality of joined elements. The piston 34 can be formed of sapphire, glass or a ceramic or the like and is spaced apart from the interior wall 38 of housing 32. When the piston 34 is so-positioned, a single stroke of the piston 34 during use of the pump will deliver a known volume of liquid depending upon the piston diameter and the stroke length. As shown in Fig. 1, the housing 32 for the check valve 45 and the piston 34 can be formed of a single element. The provision of this single element housing provides the advantage that the valve seats and displacement pump of this invention can be replaced simultaneously after the useful life of the pump is completed.

Motor 16 causes gear box 40 to reciprocate through pulley 41, and gears 42, 44 and 46 and gear track 48. Gear box 40 is positioned within track 47 which causes the piston 34 to move in a repeatable linear path stroke after stroke. As shown in Fig. 1, the stroke of the pump varies from position 50 and position 52 which typically can be between about 1.5 and 2.0 inches. It is to be understood that any conventional activating apparatus which causes piston 34 to reciprocate on a linear path can be utilized in the present invention.

The piston 34 is positioned within seal 56 which can be formed, for example of ultra high molecular weight polyethylene (VHMWPE) or the like and optional roulon guide 58. The roulon guide aligns piston 34 into seal 56. The piston 34 reciprocates within seal 56 and roulon guide 58. The piston 34 is fixedly positioned in ferrule 60 which, in turn, is fixed within arm 62 by knob 64.

As shown in Figs. 2 and 3, the housing 32 can be formed of two pieces comprising piece 32b and 32a. Housing piece 32b includes two valve seats 31 and 33 into which are positioned check valves 35 and 37. Check valves 35 and 37 can have threads 39 and 41 to screw the valves 35 and 37 into valve seats 31 and 33 having internal threads (not shown). Housing 32b can be provided with threads 49 and 45 to secure housing 32b to housing 12. Check valve 35 is connected to conduit 45, which in turn is in fluid communication with a point of use for the fluid (not shown). Check valve 37 is connected with conduit 47 which, in turn, is connected to a reservoir for the fluid (not shown). In use, when piston 34 moves toward check valve 35, check valve 35 is open and check valve 37 is closed so that fluid is delivered through check valve 35 and conduit 45 to a point of use of the fluid. When piston 34 moves away from check valve 35, check valve 35 is closed and check valve 37 is open so that fluid moves into barrel 38 through check valve 37 and conduit 47 from a fluid reservoir.

Referring to Figure 4, the valve 35, like valve 37 includes a movable ball 70 which moves within valve seat 72 to block either conduit 74 or conduit 76 to effect fluid flow as described above.

CLAIMS

1. A pump apparatus which comprises:
 - a displacement pump for pumping a fluid having a reciprocable piston positioned within a first housing having an interior wall spaced apart from said piston,
 - an interior volume of said first housing being in fluid communication with a fluid inlet to a first check valve and a fluid outlet from a second check valve,
 - said first check valve being in fluid communication with a point of use for said fluid,
 - said second check valve being in fluid communication with a source of said fluid,
 - said first check valve being open and said second check valve being closed when said piston moves toward said first check valve,
 - said first check valve being closed and said second check valve being open when said piston moves away from said first check valve.
2. The pump apparatus of Claim 1 wherein said housing is formed of a transparent material.
3. The pump apparatus of Claim 1 wherein said piston is formed of sapphire.

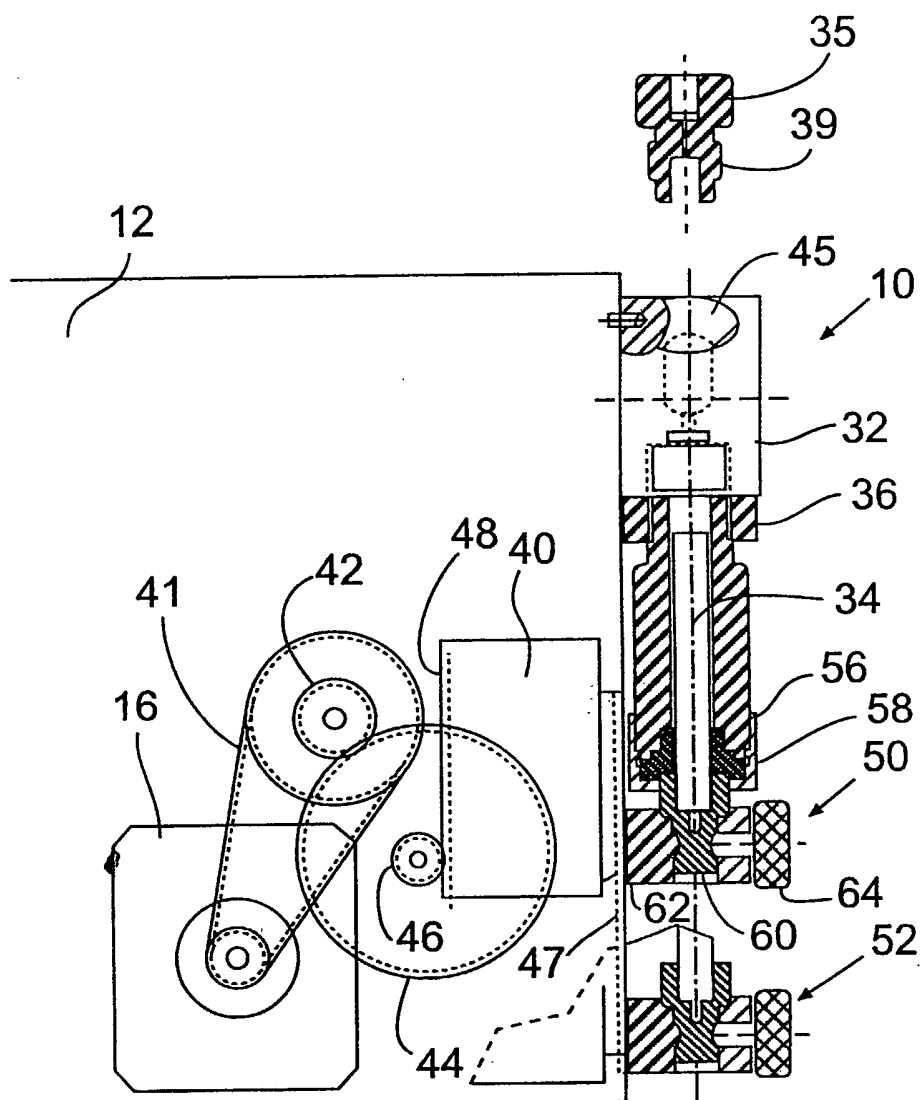


Figure 1

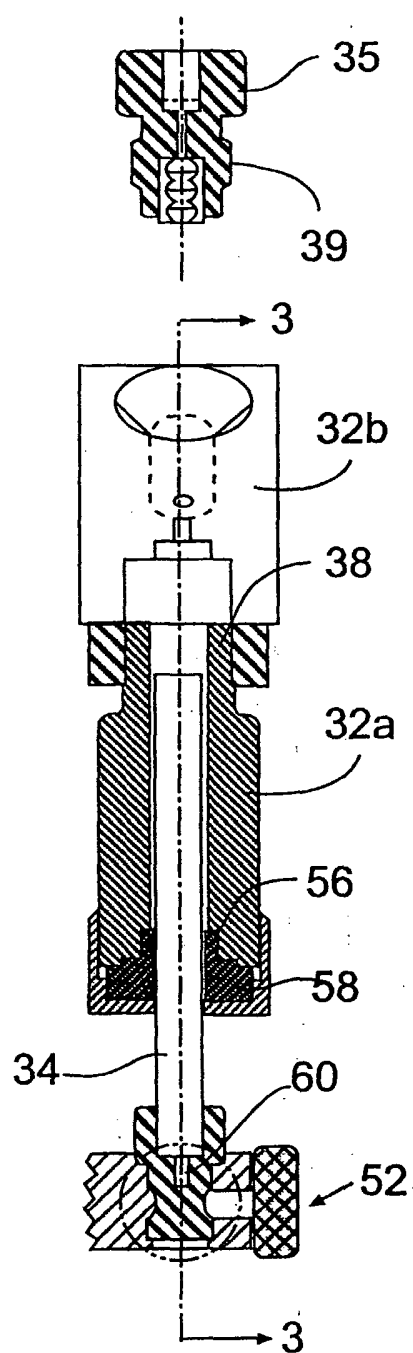


Figure 2

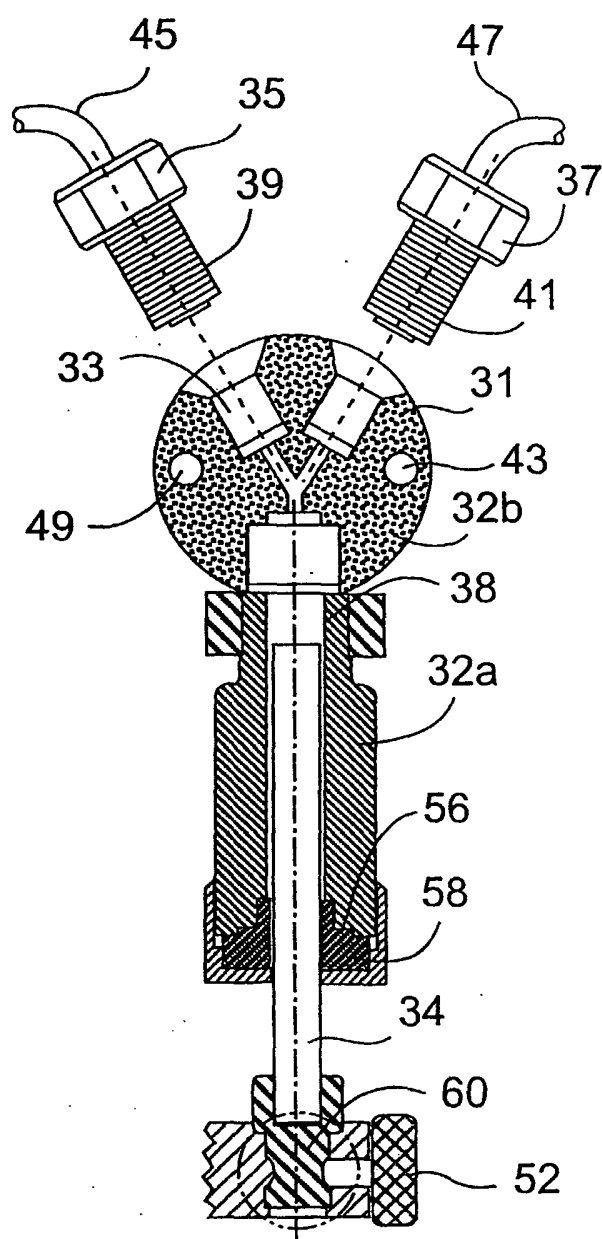


Figure 3

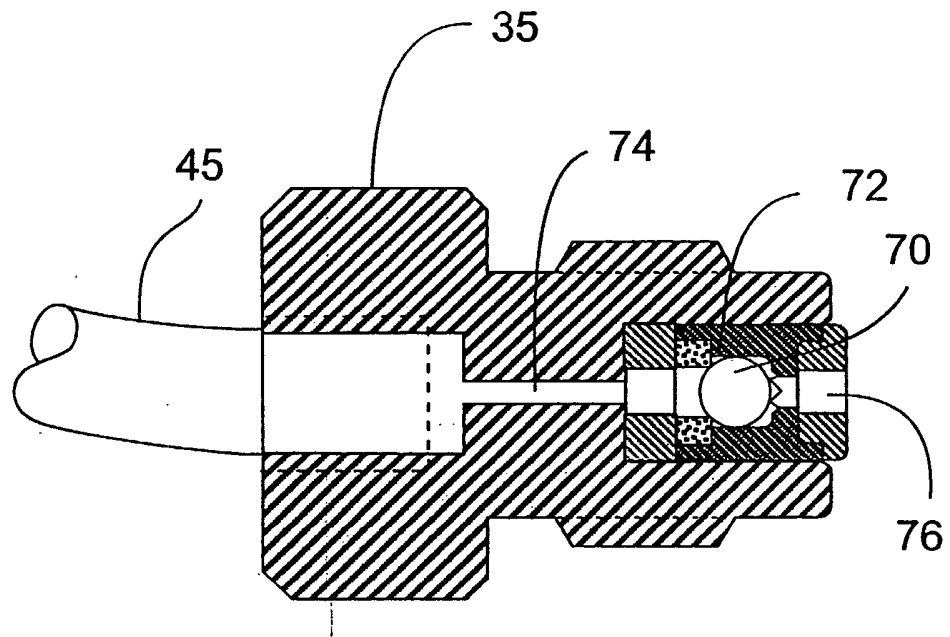


Figure 4