United States Patent

[11] 3,601,509

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[54] **ELECTROMAGNETIC PUMP**
8 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **417/417**
[51] **Int. Cl.** **F04b 17/04**
[50] **Field of Search** 417/417; 103/53, 178, 192; 230/55

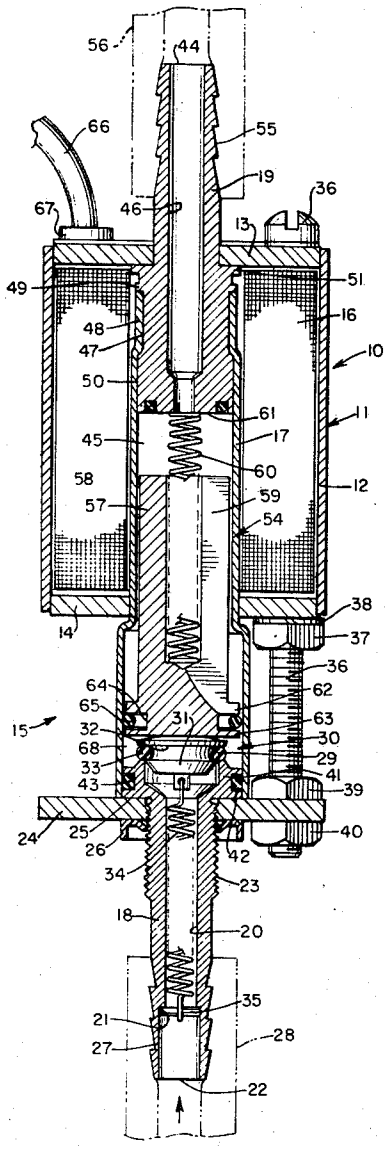
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ABSTRACT: The present invention includes an electromagnetically responsive pump including a spring-biased piston assembly reciprocatory within a cylinder. Inlet and outlet fittings formed with inlet and outlet ports, respectively, are secured to opposite ends of the cylinder. An electromagnetic coil surrounds a portion of the cylinder and, when energized, is operative to move the piston assembly against its spring bias. The piston assembly is formed with a fluid-conducting slot which communicates with said outlet port. Sealing means for sealing said slot from the inlet port comprise a sealing ring engaging inner walls of the cylinder, and flanges forming part of said piston assembly spaced from and disposed on opposite sides of the sealing ring, said flanges movably engaging first and second portions of the sealing ring during suction and return strokes of the piston assembly, said slot being sealed from the inlet port during the suction stroke and communicating therewith during the return stroke. A spring-biased check valve normally seals the inlet port.



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SHEET 1 OF 2

FIG. 1

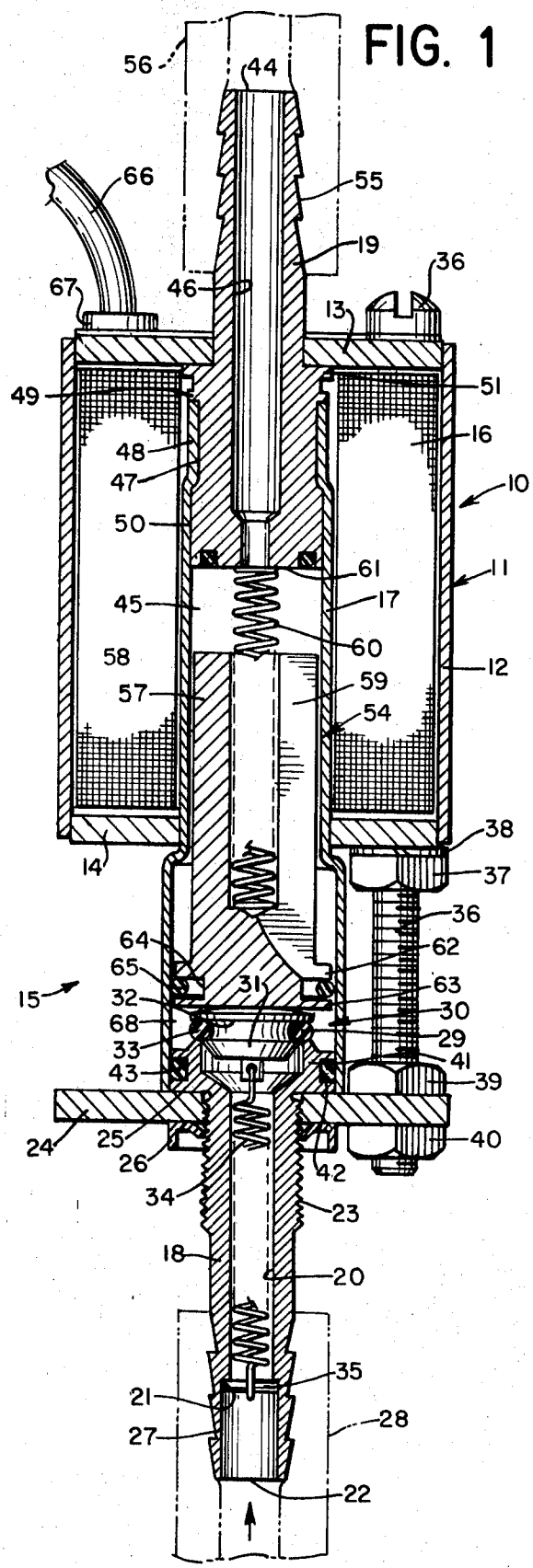


FIG. 2

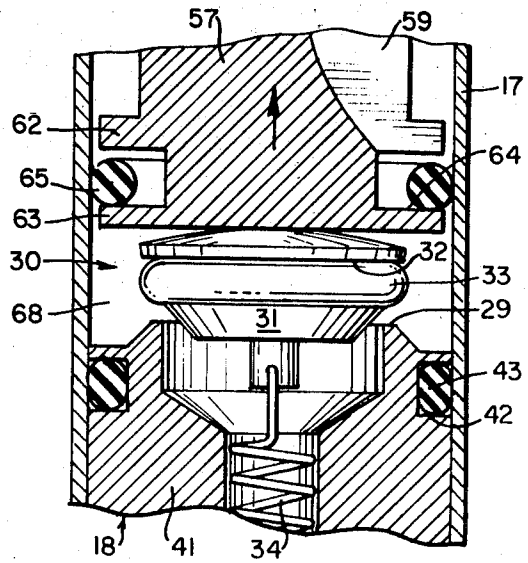
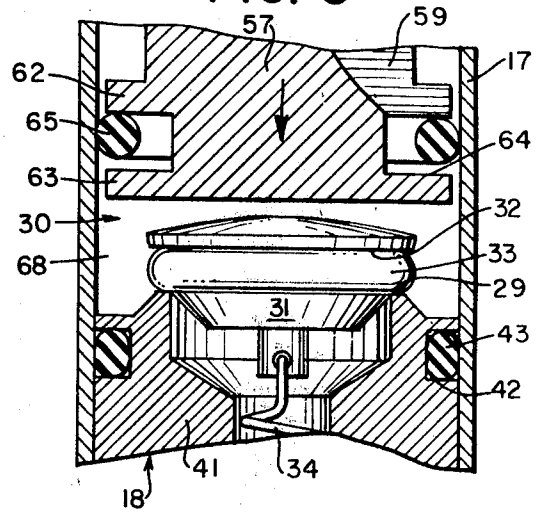


FIG. 3



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FIG. 4

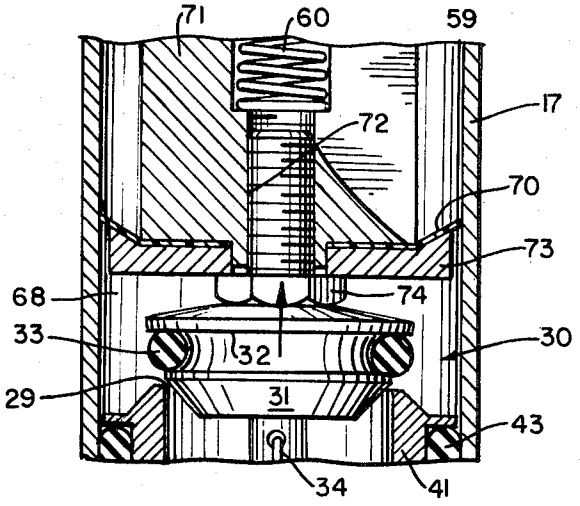
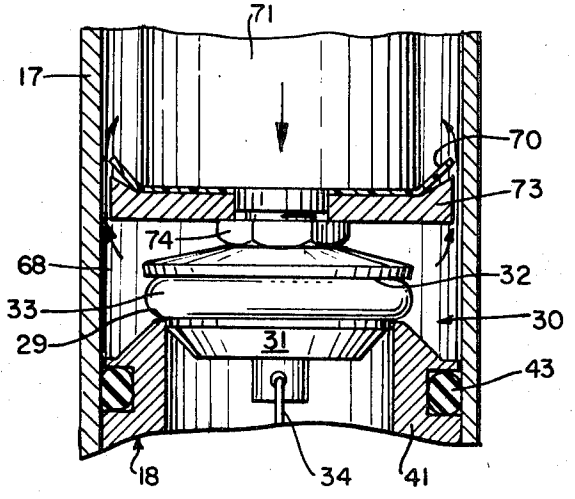


FIG. 5



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ELECTROMAGNETIC PUMP

This invention relates to pumps and more specifically to an electromagnetic oscillating-armature piston-type pump.

It is an object of the present invention to provide a pump which is compact, efficient, quiet in operation, relatively inexpensive to manufacture, simple to assemble, repair and service and capable of being made in a variety of sizes and capacities.

Another object of this invention is to provide a pump of the electromagnetic oscillating-armature piston type in which a floating sealing ring disposed between a piston assembly and a cylinder within which the piston assembly reciprocates, serves both as a check valving member as well as a piston ring.

A further object is to provide a pump structure as above which is capable of use as a vacuum pump.

Still another object of this invention is to provide a pump in which one of the pumping elements includes a piston made of magnetizable material which serves as the armature of a solenoid actuator, the piston including portions which cooperate with the above floating sealing ring.

The invention will be more clearly understood from the following description of a specific embodiment of the invention together with the accompanying drawing, in which;

FIG. 1 is a sectional elevational view of a pump according to the present invention;

FIG. 2 is a fragmentary sectional elevational view of a check valve in an open position and adjacent structure of the pump shown in FIG. 1;

FIG. 3 is a fragmentary sectional elevational view of the check valve of FIG. 2 shown in a closed position;

FIG. 4 is a sectional elevational view of a pump according to this invention in which a flexible disc is utilized;

FIG. 5 is a sectional elevational view of the pump of FIG. 4 illustrating the inlet sealed.

Referring now in more detail to the drawing, a pump **10** according to the present invention is shown in FIG. **1** as including a housing **11** which is made up of a cylindrical sleeve **12** which extends between end plates **13** and **14**. Plates **13** and **14** are centrally apertured to permit the extension of a cylinder assembly **15** therethrough.

An electromagnetic coil **16** is mounted within sleeve **12** and surrounds a stepped-diameter cylinder **17**. Cylinder **17** extends between an inlet end within which an inlet fitting member **18** is secured as described below, and an outlet end within which an outlet fitting member **19** is secured.

Inlet fitting **18** is formed with a central bore **20** which is of a stepped diameter such that a shoulder **21** forming a bearing surface results from a larger diameter at inlet end **22** and a smaller diameter through the central portion of fitting **18**. This inlet fitting is further formed with external threads **23** which are matingly engaged by the internal threads of a cover member **24** which is threaded against shoulder **25** of fitting **18** when in an assembled position. A palnut **26** engages threads **23** to maintain cover member **24** against shoulder **25** as shown in FIG. 1. Fitting **18** is further formed with a successively tapered outer surface **27** which is shaped to frictionally retain an inlet supply conduit shown in phantom outline and designated as reference character **28**.

Inlet fitting **18** is further formed with an annular bearing surface which forms the valve seat **29** of a check valve **30**. Check valve **30** includes a valve poppet **31** which is formed with a groove **32** within which an O-ring **33** is situated. A helical coil spring **34** is secured at one of its ends to poppet **31** and extends through bore **20** to a retaining member **35** which is maintained against shoulder **21** as a result of tension within spring **34**. As shown in FIG. **1**, valve poppet **31** is biased toward a closed position against valve seat **29** as a result of tension within helical spring **34**. Retaining member **35** is shaped so as to permit the flow of fluid therethrough from inlet end **22** of fitting **18** into bore **20**.

Fitting **18** is maintained within cylinder **17** in the assembled position shown in FIG. **1** by means of a slotted oval-headed bolt **36** which extends through end plates **13** and **14** of housing

11 and thereafter through an opening formed through cover member **24**. A nut **37** is threaded against a lock washer **38** which, in turn, is compressed against end plate **14**. Nut **37** is shown as being hexagonal, although it is within the scope of the present invention to provide any shape. Nuts **39** and **40** secure bolt **36** to cover member **24**. While one bolt **36** is shown in FIG. **1**, of course a plurality of bolts is contemplated as being included in this invention.

Inlet fitting **18** in its assembled position is located such that shoulder **25** thereof is substantially flush with the end of cylinder **17**. A larger diameter portion **41** of fitting **18** is located internally of cylinder **17** and is formed with an annular groove **42** within which an O-type searing ring **43** is situated. Searing ring **43** is in a compressed state between the walls defining groove **42** and the internal walls of cylinder **17**, thereby forming a fluid-type seal between the interior of cylinder **17** and the environment.

Looking now in more detail at outlet fitting **19**, this fitting is formed with a counterbore **46** which extends therethrough between outlet end **44** of the fitting and a chamber **45** defined by cylinder **17**. A reduced diameter portion **47** of fitting **19** provides a bearing surface against which end portions **48** of cylinder **17** may be swaged, thereby holding fitting **19** and cylinder **17** in an integral relationship with one another. Relative axial movement between fitting **19** and cylinder **17** is prevented by means of a radially extending flange **49** which defines the termination point of reduced diameter portion **47** in one direction, and a larger diameter portion **50** of fitting **19** in the opposite direction.

A radially extending flange **51** provides the means against which end plate **13** bears, thereby aligning and locating fitting **19** in the coaxial position with respect to cylinder **17** shown in FIG. **1**. Fitting **19** is further formed with a groove **52** within which a resilient ring **53** is positioned, the diameter of ring **53** being greater than the depth of groove **52** such that the ring extends from fitting **19** into chamber **43** in a predetermined amount. Ring **53** comprises a bumper or shock absorbing and noise preventing means against which a piston assembly **54**, described in detail below, strikes during operation of pump **10**.

Fitting **19** includes outer surfaces **55** similar to surface **27** which frictionally retain an outlet conduit **56** shown in phantom.

Piston assembly **54** includes an elongated generally cylindrical piston member **57** which is formed with a central bore **58** as well as a radially extending slot **59** which communicates with bore **58**. Piston member **57** is normally spring biased downwardly as shown in FIG. **1** due to the presence of a helical compression spring **60** which extends from one end thereof which is located at the bottom of central bore **58** to its opposite end which engages face portions **61** of fitting **19** immediately surrounding counterbore **46**. Piston member **57** is formed from a magnetizable material of low magnetic reluctance.

Piston member **54** is formed with a pair of radially extending flanges **62** and **63** which define an annular groove **64**, groove **64** being in communication with slot **59**, central bore **58** and chamber **45**.

The outside diameters of flanges **62** and **63** are slightly less than the inside diameter of cylinder **17** within which flanges **62** and **63** are located. As such, an annular space exists between these flanges and the inner wall of cylinder **17**, through which fluid may pass.

An O-type sealing ring **65** in sealing contact with the inner wall of cylinder **17** is located partially within groove **64** and between flanges **62** and **63**. The width or diameter of sealing ring **65** is sufficiently smaller than the width of groove **64**, i.e., the distance between flanges **62** and **63**, such that fluid may pass between sealing ring **65** and a flange which is not in contact with the sealing ring.

Movement of piston assembly **54** within cylinder **17** during an energized or power stroke is accomplished by the supply of electricity to electromagnetic coil **16** via an insulated conduc-

tor or cord 66. Cord 66 is secured to end plate 13 by means of a grommet 67, which acts as a strain relief. The energizing of electromagnetic coil 16 causes coil 16 and piston assembly 54 to act as a solenoid wherein piston assembly 54 acts as the armature. Upon coil 16 being energized, piston assembly 54 is drawn toward the center of coil 16 against the compressive forces of helical spring 60. Upon the deenergization of electromagnetic coil 16, the compressive forces within spring 60 urge piston assembly 54 off center and toward the inlet port. By intermittent energizing of coil 16, an oscillatory movement of piston assembly 54 within cylinder 17 results, the energized movement of the piston assembly comprising both positive seal pumping and suction strokes, which results in pumping the fluid from the inlet port to the outlet port and simultaneously creating suction intake at the inlet port.

During the power stroke or movement of piston assembly 54 toward the center of electromagnetic coil 16 as a result of the energization of coil 16, flange 63 will engage sealing ring 65 in the position shown in FIG. 2. The relative positions of sealing ring 65 and flange 63 during this movement of the piston assembly toward the coil during the power stroke are maintained. Movement of piston assembly 54 away from the center of electromagnetic coil 16 as a result of forces exerted by helical spring 60 comprises the return or deenergized stroke.

During the power stroke, sealing ring 65 acts both (1) as a piston ring in that a seal is maintained against the inner wall of cylinder 17, and (2) as check valve means in that a fluid-type seal is maintained between a chamber 68 within which check valve poppet 31 is situated, and groove 64.

During the return stroke of piston assembly 54, on the other hand, it is flange 62 which engages sealing ring 65. During this return stroke, fluid is free to pass from chamber 68 past the space between flange 63 and cylinder 17, thereafter into groove 64 and thence through slot 59 and bore 58 into chamber 45. It should be apparent that this fluid within chamber 45 is displaced and caused to pass through counterbore 46 and out through outlet end 44 into conduit 56 as a result of upward movement of piston assembly 54.

In operation, pump 10 starts its pumping functioning upon the intermittent supplying of current to electromagnetic coil 16 via conductor 66, thereby periodically energizing the coil and causing piston assembly 54 to move toward the center of coil 16 in a power stroke during this energization. Compression spring 60 is compressed during this power stroke.

Due to the substantially fluidtight seal maintained by O-ring 65 between flange 63 of piston assembly 54 and the wall of cylinder 17 during the power stroke, as well as the seal maintained by O-ring 43 between fitting 18 and the cylinder, a pressure drop in chamber 68 occurs. The pressure in chamber 68 drops to a predetermined point whereby the tension force in spring 34 is overcome and poppet 31 of check valve 30 is unseated (see FIG. 2) thereby permitting fluid to flow from conduit 28 through bore 20 and into chamber 68. Depending upon the spring rate of spring 34, check valve 30 will close (see FIG. 3) either immediately prior to the end of the suction stroke of piston assembly 54 or at the end of this stroke itself. Piston assembly 54 strikes rubber ring 53 at the end of the power stroke, ring 53 absorbing the shock and preventing noise and wear between the piston assembly and the outlet fitting.

Upon deenergization of coil 16, spring 60 forces piston assembly 54 to move in a return stroke in the direction shown in FIG. 3, with the result that fluid which has been described as having entered chamber 68 is displaced past flange 63 and O-ring 65, through slot 59 and bore 58 and thereafter into chamber 45. Upon the next successive power stroke of the piston assembly, this same fluid which occupies chamber 45 is positively displaced through bore 46 and out of pump 10 into outlet conduit 56.

FIGS. 4 and 5 illustrate an alternative preferred embodiment of this invention in which a flexible disc 70 functionally replaces the floating O-ring 65 already described for FIGS. 1–3. A piston member 71, much like piston member 57, differs structurally in that it is formed with internal threads 72 at its lowermost end in place of flanges 62 and 63. A support plate 73 which is contoured in a predetermined shape to accommodate flexible disc 70, sandwiches disc 70 against piston member 71 such that the outer periphery of disc 70 engages the inner walls of cylinder 17 as shown in FIG. 4. The interference between disc 70 and the walls of cylinder 17 may be varied by varying the size of the disc as well as the contour of support 73. A headed bolt 74 matingly engages threads 72, thereby holding the disc and support plate in place.

Disc 70 performs effectively the same function as O-ring 65. During energization of the coil, piston member 71 moves in a power stroke such that disc 70, supported by plate 73, acts as a positive seal and pumps fluid through the outlet. Simultaneously during this power stroke, a suction is created at the inlet port.

Upon deenergization of the coil, piston member 71 moves downwardly toward the inlet and, due to the inherent flexibility of disc 70, bypass action occurs such that fluid passes between plate 73 and the cylinder. Trapped fluid below disc 70 enters the void created by this plunger-type motion.

The embodiment of the invention particularly disclosed is presented merely as an example of the invention. Other embodiments, forms and modifications of the invention coming within the proper scope of the appended claims will, of course, readily suggest themselves to those skilled in the art.

What is claimed is:

1. A pump comprising:
   a. a housing defining an internal pumping chamber and having inlet and outlet ports communicating with said chamber;
   b. a piston moveable in first and second directions within said chamber and having a fluid conducting opening extending between portions of said chamber proximal to said outlet port and other portions of said chamber;
   c. a sealing member connected to said piston to engage the inner walls of said chamber during movement of said piston in said first direction;
   d. means connected to said piston for supporting said sealing member when said piston moves in said first direction, said means having a contoured lateral surface adjacent said member to deflect said member substantially in conformity with the shape of said surface;
   e. means for biasing said piston in said second direction; and
   f. electromagnetic means for moving said piston in said first direction.

2. The pump as recited in claim 1, wherein said sealing member comprises a flexible disc concentric with said piston and having a diameter greater than the diameter of said pumping chamber.

3. The pump as recited in claim 1, wherein said sealing member comprises a flexible annular blade concentric with said piston and having a diameter greater than the diameter of said pumping chamber.

4. The pump as recited in claim 1 wherein said sealing member comprises a peripheral portion pivotally arranged relative to said piston such that pressure exerted on said portion when said piston moves in said first direction tends to pivot said portion against the inner walls of said chamber.

5. The pump as recited in claim 4, wherein said contoured surface comprises an annular shelf inclined substantially in said first direction and engageable with the proximal lateral surface of said portion when said piston moves in said first direction.

6. The pump as recited in claim 1, wherein said piston comprises a substantially cylindrical member having a central bore which opens at one end of said member proximal to said outlet port, said bore communicating substantially along its entire length with said fluid conducting opening.

7. The pump as recited in claim 6, wherein said fluid conducting opening extends substantially radially between said bore and said pumping chamber.

8. The pump as recited in claim 1, wherein said biasing means comprises a helical compression spring, one end of which is disposed within said bore and the other end of which

bears against a portion of the inner boundary of said pumping chamber adjacent said outlet port.