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Willinger et al.

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[54] **VALVELESS PUMP**

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[52] **U.S. Cl.** **417/240,** 417/417

[51] **Int. Cl.** **F04b 17/04,** F04f 7/00

[58] **Field of Search** 417/240, 241, 557, 417/417, 416; 239/101, 102

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[57] **ABSTRACT**

A valveless pump comprising a housing, the latter including first and second chambers separated from one another. Each of the chambers has a closed end and an open end the latter being adjacent the closed end of the other. The second chamber is of annular extent and surrounds the first chamber. A magnetic assembly for generating a magnetic field extends in the second chamber, whereas a fluid ejecting magnetically-responsive hollow piston is freely disposed in the first chamber for axial displacement in the latter. A fluid inlet channel communicates with both first chamber and internally with the hollow piston, whereas a fluid outlet channel communicates with the first chamber for receiving fluid ejected by the piston.

12 Claims, 8 Drawing Figures

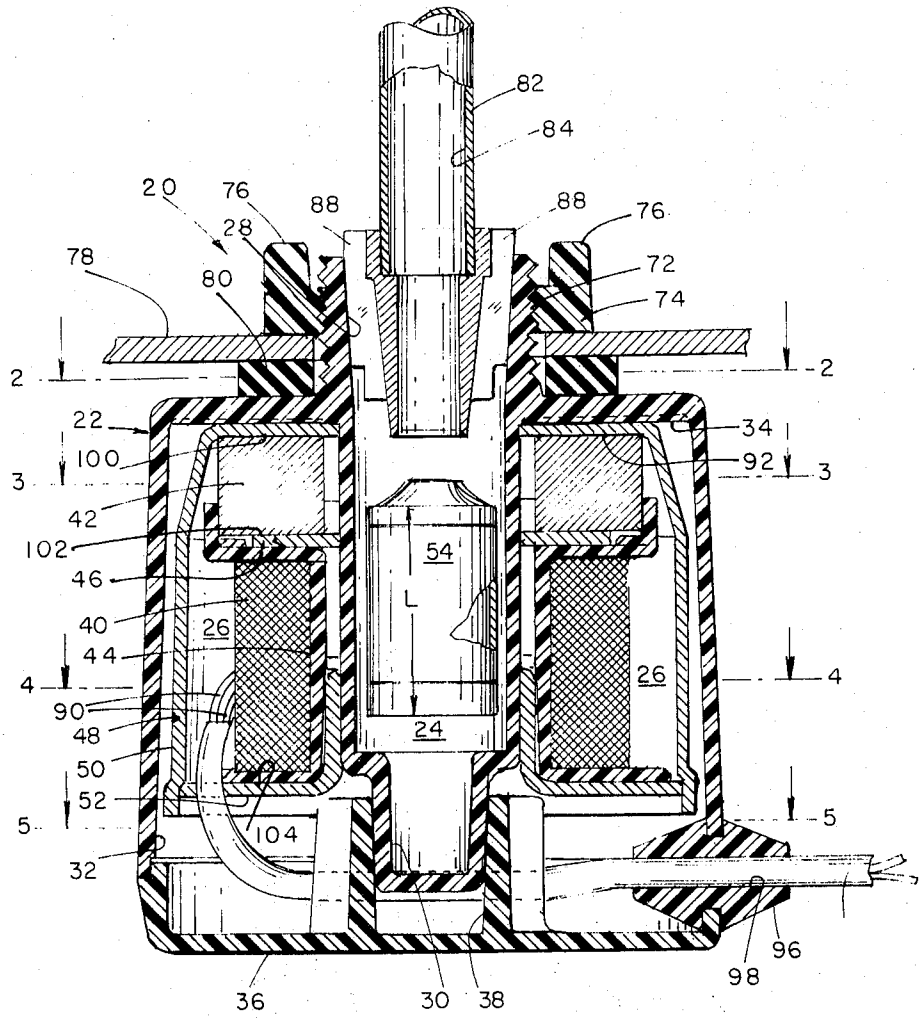
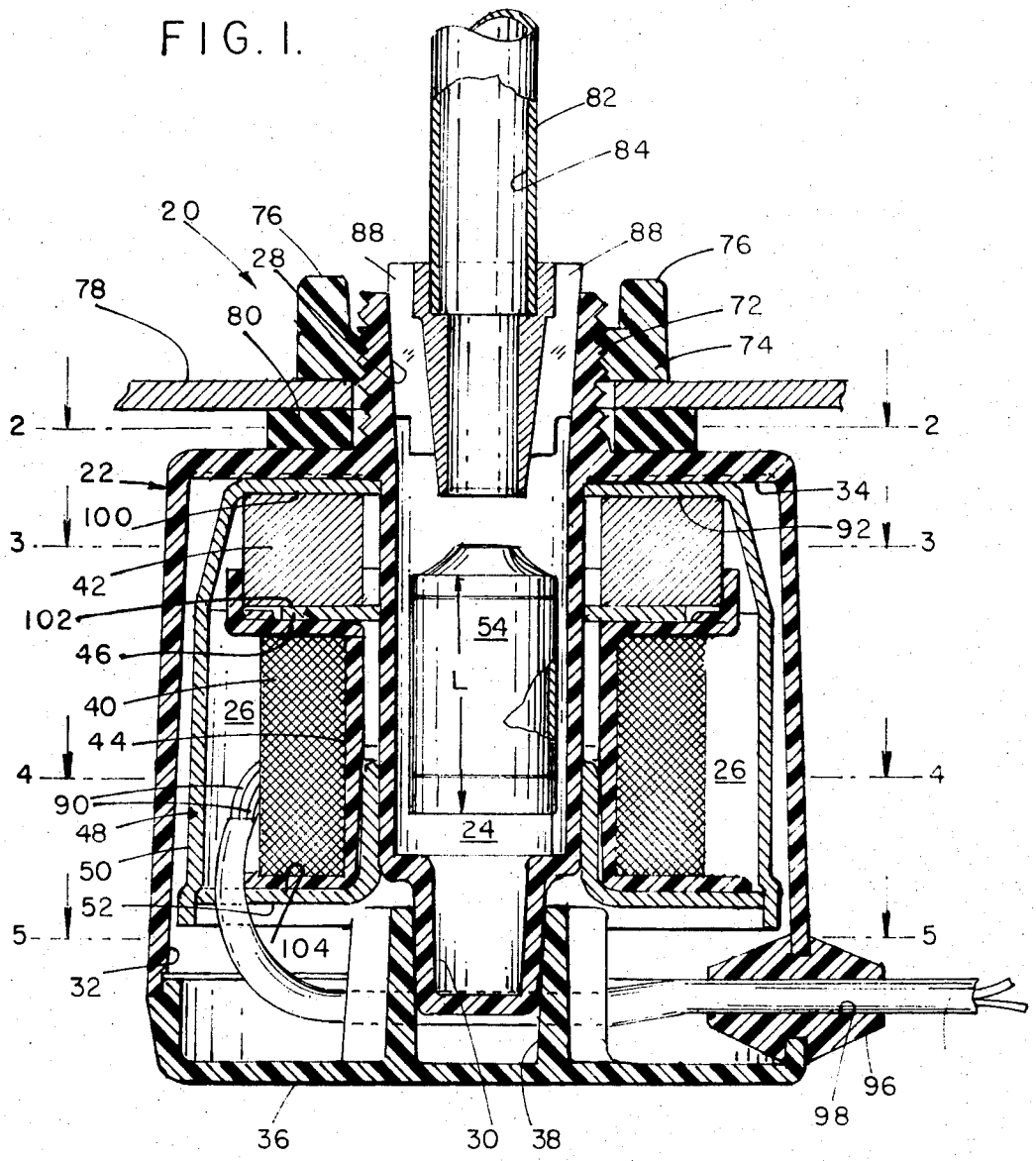


FIG. 1.



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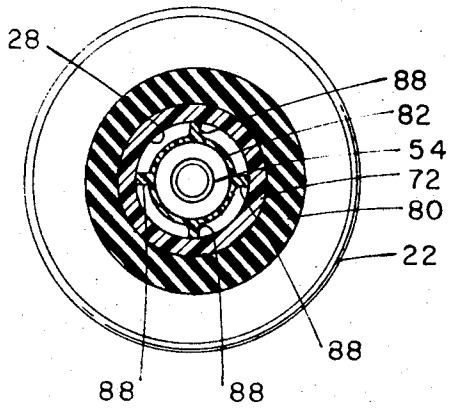


FIG. 2.

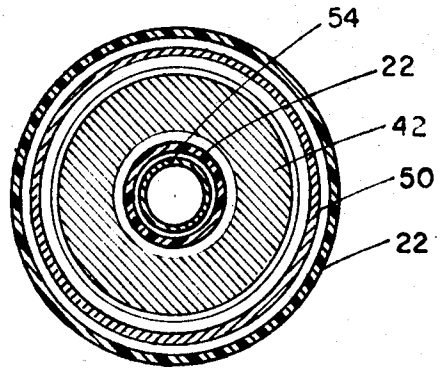


FIG. 3.

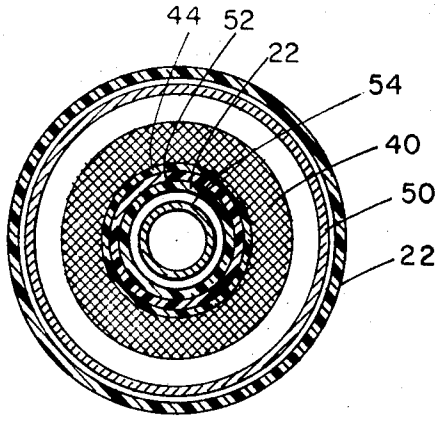


FIG. 4.

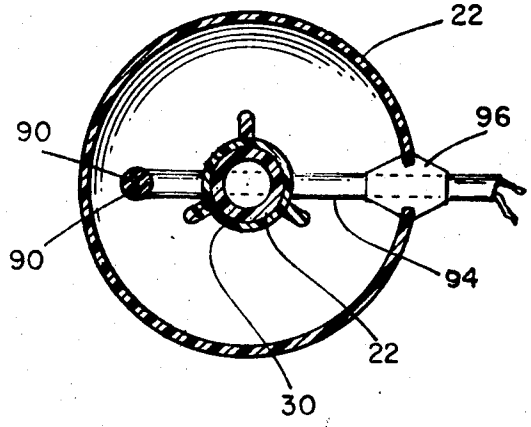


FIG. 5.

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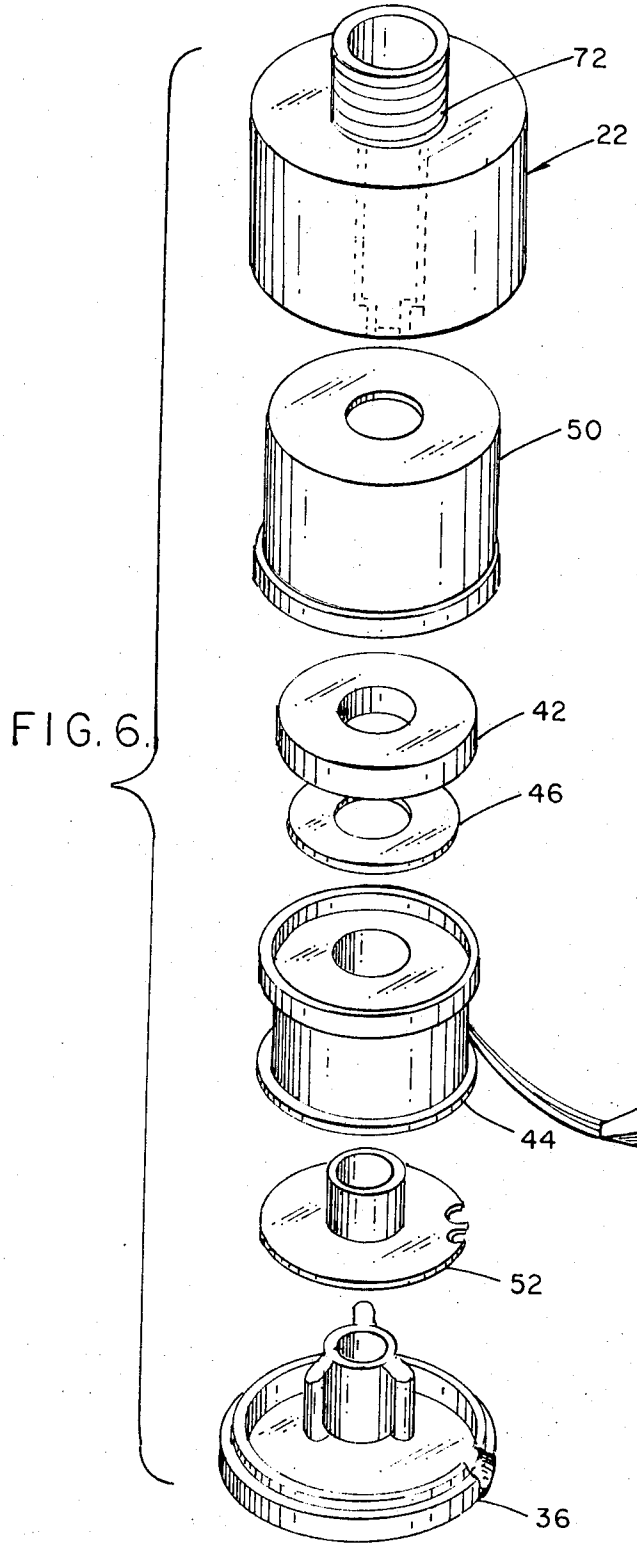
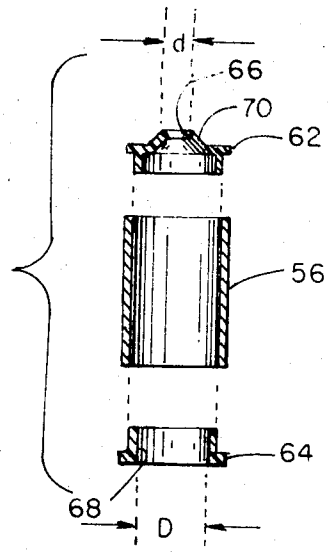


FIG. 6.

FIG. 7.



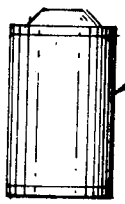


FIG. 8.

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VALVELESS PUMP

BACKGROUND OF THE INVENTION

The present invention relates generally to water pumps that may be utilized in fish tank aquariums and the like, and more particularly to a valveless pump in which there is provided a water ejecting reciprocating piston.

Water pumps for fish tank aquariums and the like are generally well-known and may be characterized as either valve controlled pumps or alternatively as valveless pumps. In the first instance, the valve controlled pumps are the most common and widely used, but have numerous disadvantages associated with them. In this respect, the valve seats after extended use are prone to become distorted and will eventually leak. Furthermore, these valves become easily clogged thus diminishing the efficiency of the pump. Moreover, water flowing through these valves is generally subjected to high turbulence and, thus, these valves generally consume excessive energy.

Recently, valveless pumps have been developed so as to obviate the inherent disadvantages associated with the valve controlled pumps. However, because of the specific structure associated with the valveless pumps, the latter do not operate as efficiently as might be expected. In this respect, the conventional valveless pump cannot adequately handle flow rates of the capacity required for most uses and, therefore, these valveless pumps cannot be employed universally.

Another disadvantage associated with the valveless pump is the fact that the housing is generally constituted of a plurality of members which act to separate the piston chamber from that of the magnetic chamber. Thus, these conventional valveless pumps tend to leak and thereby minimize the useful life of the pump when leakage occurs between the piston chamber and the magnetic chamber.

Still a further disadvantage associated with the common or conventional valveless pump is the fact that certain of the conventional valveless pumps utilize a spring for urging the piston in one direction in opposition to magnetic forces. As those skilled in the art readily appreciate, springs are difficult to control and the specific force of the spring against the piston is variable over the displacement of the piston. The variable effects of the spring against the piston are undesireable and furthermore, the entire arrangement itself, i.e., the spring-biased piston, is subjected to wear, not useful over extended periods, complex in arrangement and excessively expensive to manufacture.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a valveless pump.

It is another object of the present invention to provide a valveless pump that does not utilize any moving parts other than the reciprocating piston itself.

It is still a further object of the present invention to provide a valveless pump having a housing which is a singular seamless body for sealing the piston chamber from water leakage into the magnet supporting chamber.

It is a further object of the present invention to provide a valveless pump having a housing in which is provided an electrically insulative, non-metallic, piston chamber constituted of plastic or the like for obviating possible short-circuiting between the piston and the electrical elements, which piston chamber is also of low heat conductivity and obviates formation of eddy currents which otherwise may unduly increase the temperature of the pump and surrounding water medium.

It is another object of the present invention to provide a valveless pump wherein the inlet and outlet channels which communicate with the water ejecting piston are associated with one another in a manner which is most effective for enhancing the efficiency of the pump.

It is another object of the present invention to provide a valveless pump having structure associated therewith for readily fastening the pump to an external source.

To this end the present invention relates to a valveless pump comprising a housing, the latter including first and second chambers separated from one another. Each of the chambers has a closed end and an open end the latter being adjacent the closed end of the other. The second chamber is of annular extent and surrounds the first chamber. A magnetic assembly for generating a magnetic field extends in the second chamber, whereas a fluid ejecting magnetically-responsive hollow piston is freely disposed in the first chamber for axial displacement in the latter. A fluid inlet channel communicates with both the first chamber and internally with the hollow piston, whereas a fluid outlet channel communicates with the first chamber for receiving fluid ejected by the piston.

BRIEF DESCRIPTION OF THE DRAWINGS

With the above and additional objects and advantages in view as will hereinafter appear, this invention comprises the devices, combinations, and arrangements of parts hereinafter described and illustrated in the accompanying drawings of a preferred embodiment in which:

FIG. 1 is an elevational view in cross-section illustrating the valveless pump pursuant to the present invention;

FIG. 2 is a cross-sectional view taken along the line 2—2 in FIG. 1;

FIG. 3 is a cross-sectional view taken along the line 3—3 in FIG. 1;

FIG. 4 is a cross-sectional view taken along the line 4—4 in FIG. 1;

FIG. 5 is a cross-sectional view taken along the line 5—5 in FIG. 1;

FIG. 6 is an exploded perspective view of the pump pursuant to the present invention;

FIG. 7 is an exploded elevational view of the piston pursuant to the present invention; and

FIG. 8 illustrates the assembled piston utilized in the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and more particularly to FIG. 1, the present invention relates to a valveless pump generally denoted by the reference character **20**. The valveless pump **20** includes a housing **22** which may be characterized generally as a singular seamless body having an inner chamber **24** and an outer chamber **26** of annular extent and surrounding the inner chamber **24**. The inner chamber **24** includes an open end **28** which tapers outwardly in a manner as illustrated in FIG. 1 and a closed end **30** opposite the open

end thereof. The closed end **30** is of reduced diameter for the purpose as will be described further below. The outer chamber **26** includes an open end **32** and a closed end **34** opposite the open end **32**. A base member **36** having an annular ring **38** is operatively associated in press-fit relation with the portion of reduced diameter of closed end **30** of the inner chamber **24**. The base member **36** acts to close the open end **32** of the outer chamber **26** to conceal the contents therein as will be discussed below.

An electro-magnet **40** of generally annular extent extends internally of the outer chamber **26** as does a permanent magnet **42**, the latter also of generally annular extent. The electro-magnet **40** includes a coil-enwrapped plastic spool **44** and is axially spaced from the permanent magnet **42** through the intermediary of a metal washer **46**. A metal casing **48** having an upper portion **50** and a lower portion **52**, each of annular extent, extends in the outer chamber **26** and contains the permanent magnet **42**, the metal washer **46** and the electro-magnet **40** in an assembled arrangement most clearly illustrated in FIG. **1**.

It has been determined, as those skilled in the art readily appreciate, that the provision of the metal washer **46** and the metal casing **48** for spacing and containing respectively the electro-magnet **40** and the permanent magnet **42** presents an optimum magnetic field for the purpose as will be further clarified below.

A piston **54** is freely supported for axial displacement internally of the inner chamber **24** and acts as a fluid ejecting means. The piston **54** includes a hollow metal body **56** which is magnetically-responsive and has a configuration as generally illustrated in FIG. **7**. The piston **54** further includes an annular plastic cap **62** which is operatively associated with the body portion thereof in press-fit relation as is an annular plastic base **64** at the lower portion of the piston **54**. The annular plastic cap **62** includes an open end **66** of dimension d as illustrated in FIG. **7**. The annular plastic base **64** includes an open end **68** of lateral dimension D also as illustrated in FIG. **7**. The extent of the open end **66** is of lesser lateral dimension d than that dimension D of the open end **68**, and, therefore, as will be discussed further below, when the piston descends in the inner chamber **24**, water is ejected through the open end **66** thereof and may be characterized as a water jet because of the enhanced velocity thereof. In order to enhance the ejection of water through the open end **66**, the annular plastic cap **62** is provided with a tapered peripheral extent **70** surrounding the open end **66** thereof in a manner as illustrated in FIG. **7** so that the cap **62** in effect acts as a water ejecting nozzle.

The open end **28** of the housing **22** includes an externally threaded portion **72** of raised extent relative to the outer chamber **26** as illustrated most clearly in FIGS. **1** and **6** respectively. The valveless pump **20** furthermore includes an internally threaded collar **74** having a pair of upstanding lugs **76** for fastening the pump to an external support member **78**. In this respect, the externally threaded portion **72** projects through an opening provided in the external support member **78** so that the internally threaded collar **74** may rest upon the latter for threadedly fastening the pump **20** thereto. The upstanding lugs **76** may be utilized for purposes of tightening the collar **74** as those skilled in the art readily appreciate. In order to obviate leakage from the pump **20**, relative to the external support **78**, there is provided an annular rubber washer **80** which is to be interposed between the external support member **78** and the exterior of the closed end **34** of the annular outer chamber **26** as illustrated most clearly in FIG. **1**.

A tubular insert member **82** having a generally cylindrical bore **84** is utilized for providing both inlet and outlet channels in communicating relation with the inner chamber **24**. In this respect, the tubular member **82** includes a plurality of radially extending spacing ears **88** which are utilized in press-fit relation with the open end **28** of the inner chamber **24**. As best illustrated in FIGS. **1** and **2**, the open end **28** of the inner chamber **24** is radially spaced from the tubular member **82** because of the provision of the spacing ears **88** and thus the tubular member **82** and the open end **28** of the inner chamber **24** define an annular cavity through which a fluid such as water may enter into the inner chamber **24**. Similarly, the generally cylindrical bore **84** of the tubular member **82** acts as an outlet channel through which water may be ejected by the piston **54** in a manner as will be further clarified below.

As illustrated in FIG. **1**, the electro-magnet **40** includes a pair of terminals **90** connected generally at mid-section of the coil-enwrapped spool **44**. In order to enhance the optimum performance of the pump **2**, the hollow metal body **56** is provided with an axial length L which is substantially equal to that distance from the mid-section of the coil-enwrapped plastic spool **44** to the extreme pole **92** of the permanent magnet **42**. The terminals **90** are connected to an electric wire **94** which in turn is electrically coupled to an electric power source (not shown). As illustrated in FIG. **1**, a coupling member **96** having a bore **98** is interposed between the housing **22** and the base member **36** in a manner as illustrated in FIG. **1**. In this manner, the electric wire **94** may be tightly received in the bore **98** of the coupling member **96** and supported in the latter most efficiently.

In operation, the pump **20** may be connected to a water-carrying external source, the bottom of which source may be the support member **78**, in a manner as discussed above, so that fluid or water may flow into the inner chamber **24** through the annular space between the open end **28** of the inner chamber **24** and the tubular member **82**. Fluid or water thus completely fills the inner chamber **24** and upon energizing the electro-magnet **40**, the polarity of the latter constantly reverses itself and causes the piston **54** to reciprocate axially along the inner chamber **24**. The provision of the permanent magnet **42** in combination with metal washer **46** and casing **48** establishes a permanent magnetic field path having three distinct poles at **100, 102,** and **104**, poles **100** and **104** being of the same polarity. Electro-magnet **40** is disposed in such a position that it interferes with the ability of the permanent magnetic field path to use alternately one of its extreme poles **100, 104** during the energization of electro-magnet **40**. The piston therefore moves upwardly to center itself with respect to poles **100, 102** during one-half of the cycle when pole **104** is interferred with, and then moves downwardly to center itself with respect to poles **102, 104** during the other half of the cycle when pole **100** is interferred with.

As may be well understood by those skilled in the art, as the piston **54** descends in the inner chamber **24**, the annular plastic cap **62** acts as a nozzle and water is ejected through the open end **66** of the latter as a jet and passes into the tubular member **82**. Because of the

high rate of reciprocation of the piston **54**, the latter effects the ejection of water in jet fashion into the tubular member **82** and thus water or the like is continuously pumped through the tubular member **82** and into the environment externally of the valveless pump **20**. It is noteworthy, that because of the singular seamless housing **22** which is not constituted of a plurality of members interconnected to one another fastening such as by welding or fastneing elements, which housing **22** separates the inner chamber **24**, wherein the piston is displaceably mounted, from the outer annular chamber **26**, wherein the magnetic assembly is mounted, there is completely obviated any possibility of leakage between the latter chambers that would otherwise reduce the useful life of the pump **20**.

It is also noteworthy and significant that the outlet channel defined by the annular spacing between the tubular member **82** and the open end **28** of the inner chamber **24** cooperate with one another in reverse manner and together extend substantially vertically so that water can enter into the inner chamber **24** solely under its own pressure due to gravity and without the necessity for additional pressure sources that might otherwise increase the complexity of the entire arrangement.

Numerous alterations of the structure herein disclosed will suggest themselves to those skilled in the art. However, it is to be understood that the present disclosure relates to a preferred embodiment of the invention which is for purposes of illustration only and not to be construed as a limitation of the invention.

What is claimed is:

1. A valveless pump comprising a housing, said housing including means for defining first and second chambers separated from one another, each of said chambers having a closed end and an open end, the open end of each chamber extending adjacent the closed end of the other, said second chamber being of annular extent and surrounding said first chamber, magnetic means for generating a magnetic field extending in said second chamber, a fluid ejecting magnetically-responsive hollow piston freely disposed in said first chamber for axial displacement in the latter, means for defining a fluid inlet channel communicating with both said first chamber and internally with said hollow piston, means defining a fluid outlet channel communicating with said first chamber for receiving fluid ejected by said piston, said piston including opposite open-ended portions, one of said open-ended portions being of lesser open extent than that of the other and most proximate said outlet channel, said inlet channel being of annular extent and surrounding said outlet channel, said open end of said first chamber being annularly spaced from said outlet channel and tapering outwardly axially relative to the latter in a direction of fluid ejection by said piston.

2. A valveless pump as claimed in claim **1**, wherein said means for defining said first and second chambers is constituted as a singular seamless body sealing said first and second chambers from fluid-leakage communication with one another.

3. A valveless pump as claimed in claim **2**, wherein said seamless body is constituted of non-metallic material of low heat conductivity.

4. A valveless pump as claimed in claim **1**, wherein said outlet channel and said open end of said first chamber are operatively associated with one another in press-fit relation.

5. A valveless pump as claimed in claim **1**, wherein said open end of said first chamber includes an axially raised extent relative to said second chamber, said raised extent including an externally threaded surface, said pump further including an internally threaded collar operatively associated with the externally threaded surface of said first chamber for connecting said pump to an external water-carrying source such that the latter is interpositioned between said collar and said second chamber.

6. A valveless pump as claimed in claim **1**, wherein said magnetic means includes both an electromagnet and a permanent magnet in operative association with one another.

7. A valveless pump as claimed in claim **6**, wherein said permanent magnet is more proximate said closed end of said second chamber than that of said electromagnet.

8. A valveless pump as claimed in claim **1**, wherein said second chamber includes a metallic casing in which said magnetic means extends.

9. A valveless pump as claimed in claim **1** including means for closing said open end of said second chamber and concealing said magnetic means therein.

10. A valveless pump as claimed in claim **7**, wherein said second chamber includes a metallic casing in which said permanent magnet and said electromagnet are disposed, said metallic casing including a first portion engaging said permanent magnet proximate said closed end of said second chamber to define a first magnetic pole disposed on one side of said electromagnet, a second portion of said metallic casing extending to an opposite side of said electromagnet to define a second magnetic pole, said first and second magnetic poles being of the same polarity.

11. A valveless pump as claimed in claim **10**, wherein a metal washer is disposed in said metallic casing between said permanent magnet and said electro-magnet, said metal washer engaging said permanent magnet to define a third magnetic pole disposed between said first and second magnetic poles, said third magnetic pole being of a different polarity than said first and second magnetic poles.

12. A valveless pump comprising a housing, said housing including means for defining first and second chambers separated from one another, each of said chambers having a closed end and an open end, the open end of each chamber extending adjacent the closed end of the other, said second chamber being of annular extent and surrounding said first chamber, magnetic means for generating a magnetic field extending in said second chamber, a fluid ejecting magnetically-responsive hollow piston freely disposed in said first chamber for axial displacement in the latter, means for defining a fluid inlet channel communicating with both said first chamber and internally with said hollow piston, means defining a fluid outlet channel communicating with said first chamber for receiving fluid ejected by said piston, said magnetic means including both an electromagnet and a permanent magnet in operative association with one another, said second chamber including a metallic casing in which said magnetic means extends, said permanent magnet being more proximate said closed end of said second chamber than that of said electromagnet,said electromagnet including a pair of axially opposite ends and a mid-section equidistant from the latter said opposite ends, said electromagnet

including terminals initiating at said mid-section for operative association with an electric power source, said permanent magnet having an extreme pole extending away from said electromagnet and proximate to said closed end of said second chamber, said piston including a metallic body including axially opposite open ends and having an axial extent substantially equal to that distance separating said mid-section from said extreme pole, said piston including a pair of plastic annular members connected respectively to the open ends of said metallic body, one of said plastic annular members having a lesser open extent than the other, the plastic annular member of lesser open extent including an inwardly tapered peripheral portion extending from said metallic body in a direction of fluid ejection of said pistion.

* * * * *