United States Patent [19]

Summerfield

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[54] **RECIPROCATING VALVELESS PUMP**

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[73] Assignee: **Mattel, Inc.,** Hawthorne, Calif.

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[52] **U.S. Cl.** **417/241**

[51] **Int. Cl.** **F04f 7/00**

[58] **Field of Search** 417/417, 241, 240, 417/557; 210/167, 169

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Assistant Examiner—John T. Winburn
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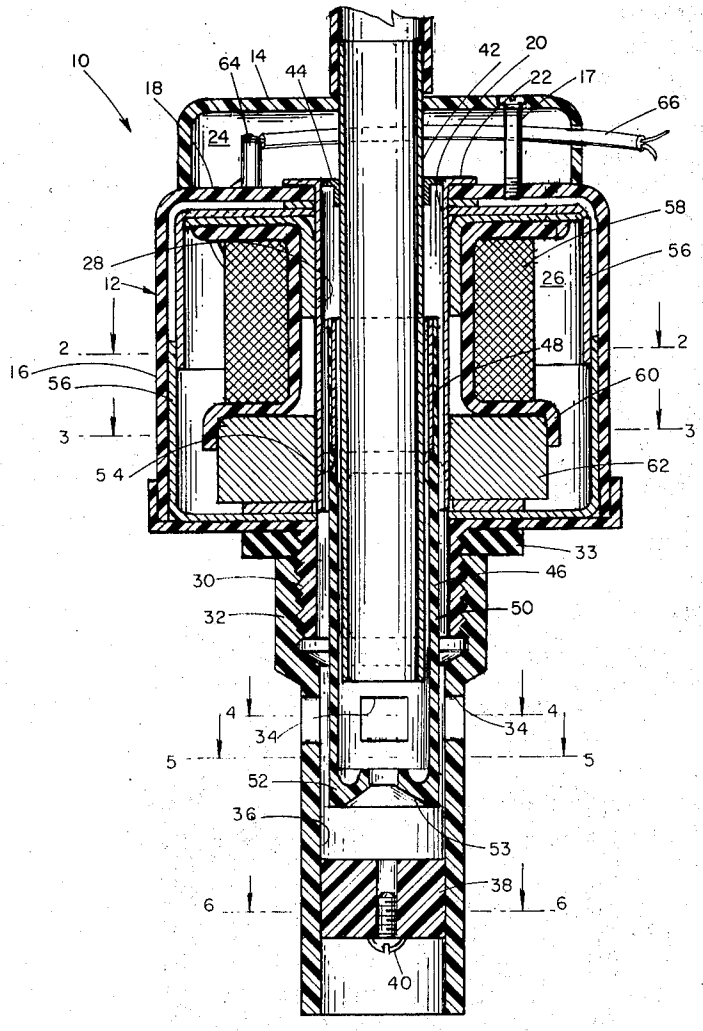
[57] **ABSTRACT**

A valveless pump comprising a housing which is separated into first and second chambers, the second chamber being of annular extent and surrounding the first chamber. A magnetic assembly is provided in the second chamber for generating a magnetic field and for causing a water-ejecting magnetically responsive hollow piston to reciprocate axially along the first chamber in which the piston is freely disposed. The housing furthermore includes water inlet means for directing water into the first chamber and water outlet means for receiving water ejected from the first chamber by the piston. The water inlet means is submergible in water and separated from the second chamber for permitting maintaining the second chamber free from submerging in water during the water ejection by the piston.

6 Claims, 9 Drawing Figures



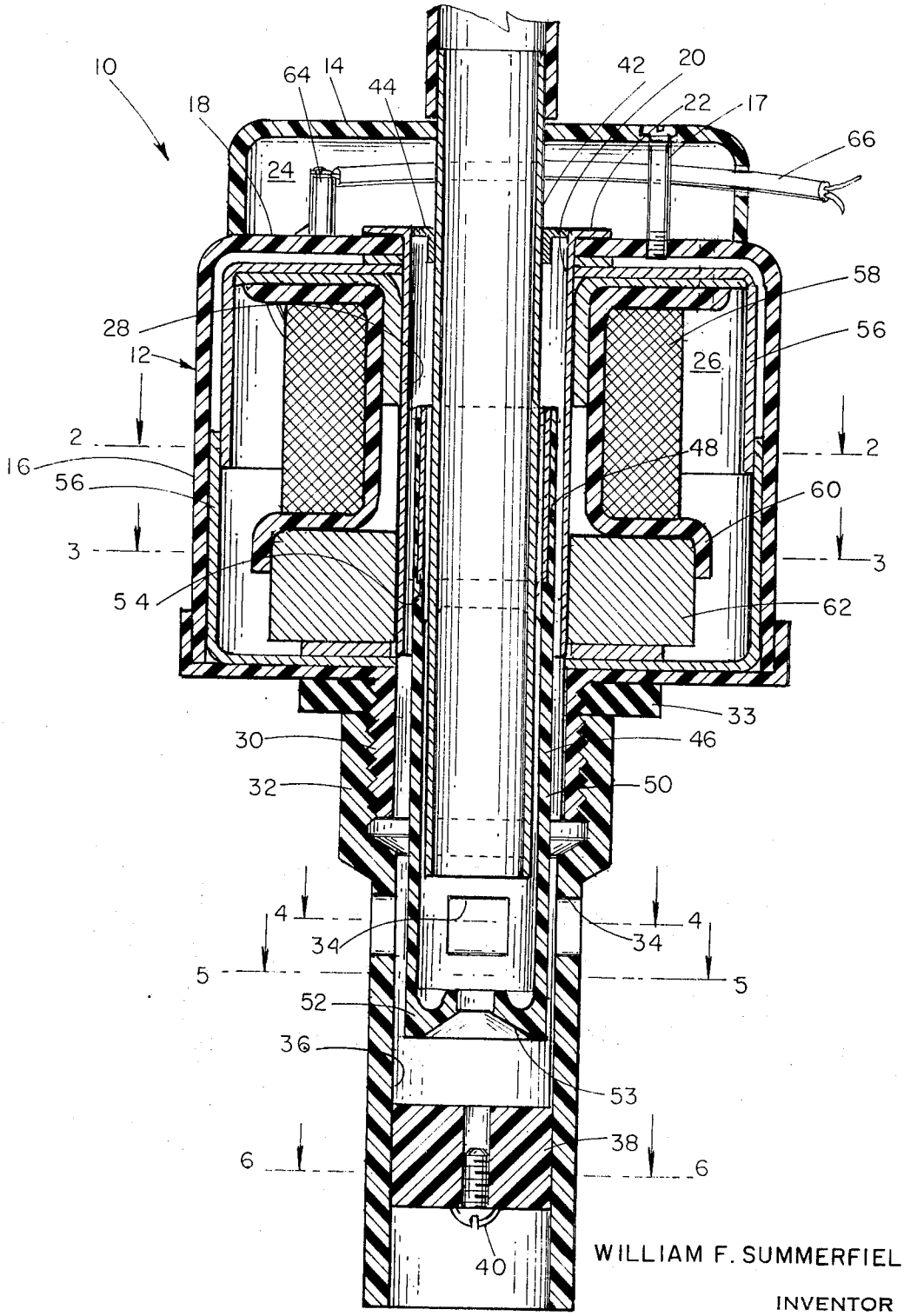


FIG. 1.

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FIG. 2.

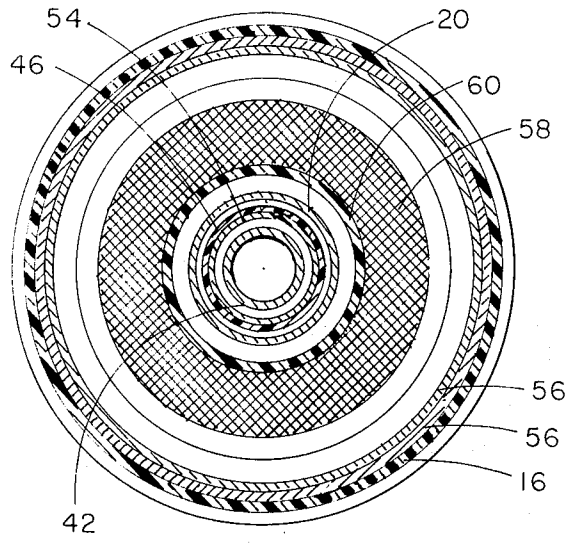
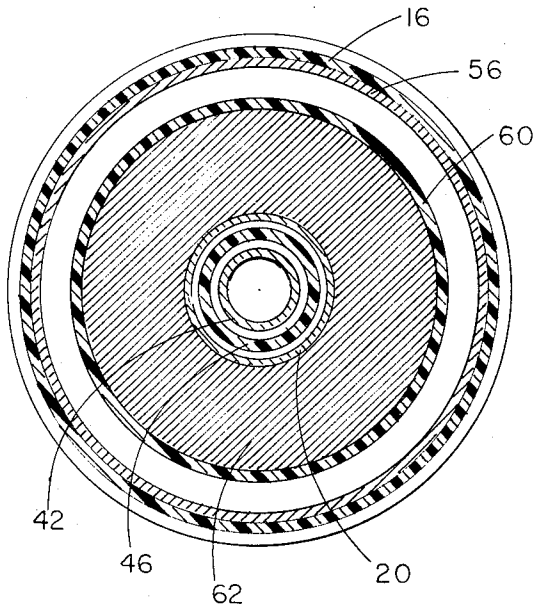
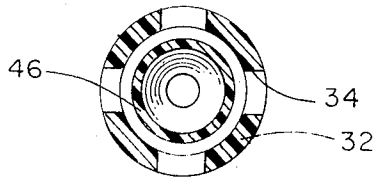


FIG. 3.





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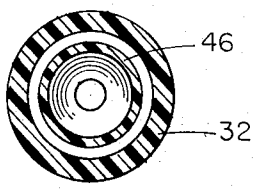

FIG. 5.

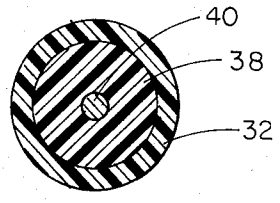

FIG. 6.

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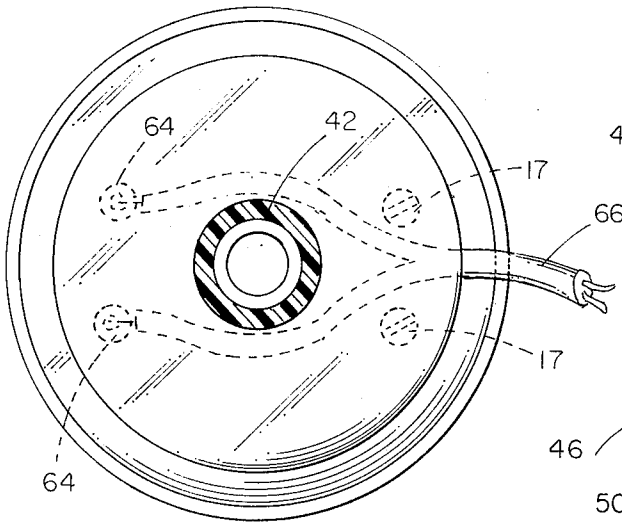

FIG. 7.

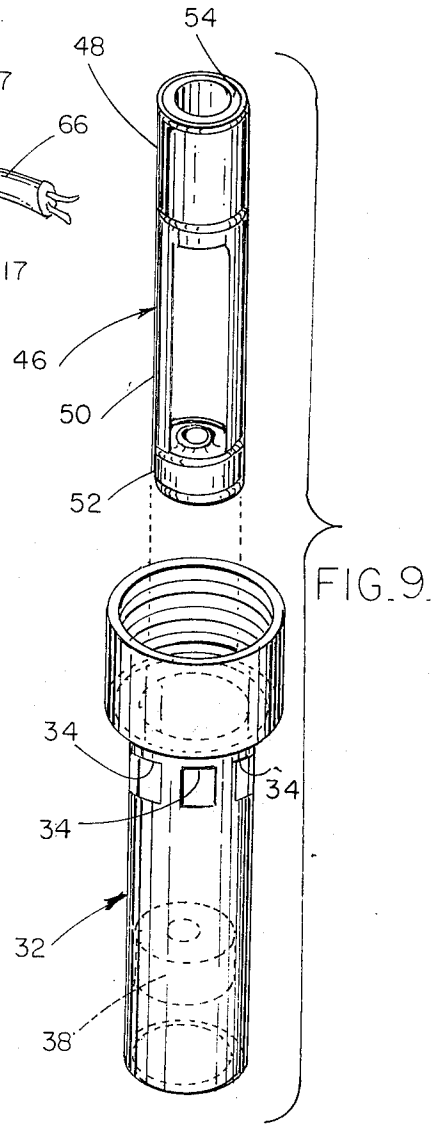

FIG. 9.

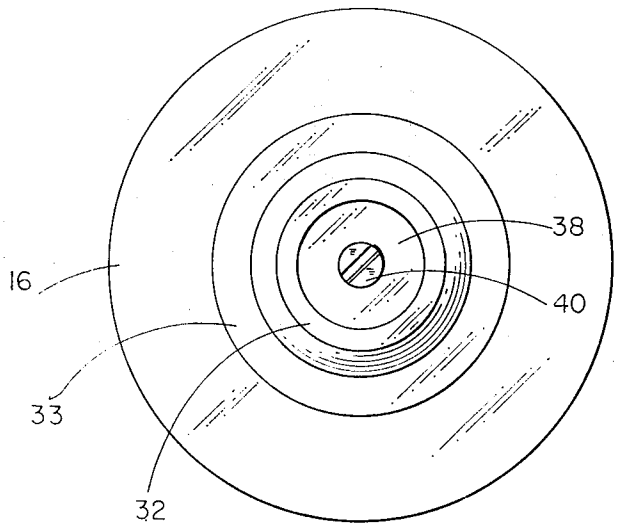

FIG. 8.

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RECIPROCATING VALVELESS PUMP

BACKGROUND OF THE INVENTION

The present invention relates generally to water aquarium accessories and more particularly to a water pump.

Many conventional water pumps are well-known and utilized generally by hobbyists in fish tank aquariums and the like. The conventional type of water pump is generally associated with a filtration assembly for cleansing contaminated water and usually requires the water pump to be submerged fully in water especially in those instances when the water pump is characterized as a valveless pump. As those skilled in the art readily appreciate, a valveless pump is that which utilizes a reciprocating piston for ejecting water into an outlet conduit provided in the pump housing. The valveless pump is most desirable since there is obviated the necessity for control valves and the like for regulating the pulsating flow issuing from the pump.

Because of the nature of the valveless pump, it is usually submerged entirely beneath the surface level of water within which the pump is to be operable. Obviously, in those instances where the pump is to be entirely submerged in water, there is the difficulty of properly sealing the various elements which are interconnected to one another for constituting the pump housing so as to prevent the magnetic and electrical parts which are mounted internally of the housing from being exposed to water and damaged thereby.

Another difficulty with regard to the conventional type of valveless pump is the fact that the latter cannot be easily controlled. In this respect, the stroke of the piston, which is utilized for ejecting water from the housing, is controlled to some extent by the elongate length of the chamber within which the piston is displaceable. The elongate length of the chamber is generally a fixed extent and cannot be modified because of the nature of the arrangement thereof. As those skilled in the art readily appreciate, in the absence of being permitted to properly regulate the elongate length of the chamber within which the water-ejecting piston is displaceable, the effectiveness of the successive thrusts of the piston upon reciprocation of the latter against water trapped in the chamber may be less than that which is most desirable.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a valveless pump which constitutes an improvement over that of the prior art.

It is another object of the present invention to provide a valveless pump which need not be entirely submerged in water and therefore need not be provided with a complex sealing arrangement for preventing the electrical and magnetic elements therein from being exposed to water and being damaged by the latter.

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

It is still a further object of the present invention to provide a valveless pump having an arrangement of parts which are readily adpated for being adjusted for enhancing the water-ejecting efficiency of each stroke of the reciprocating piston.

It is another object of the present invention to provide a valveless pump having a water inlet arrangement in operative association with the water-ejecting piston which together are generally isolated from the electrical and magnetic elements utilized in the pump housing so as to obviate the necessity for submerging the latter electrical and magnetic elements in water during the operation of the pump.

To this end, the present invention relates to a valveless pump comprising a housing which is separated into first and second chambers, the second chamber being of annular extent and surrounding the first chamber. A magnetic assembly is provided in the second chamber for generating a magnetic field and for causing a water-ejecting magnetically-responsive hollow piston to reciprocate axially along the first chamber in which the piston is freely disposed. The housing furthermore includes water inlet means for directing water into the first chamber and water outlet means for receiving water ejected from the first chamber by the piston. The water inlet means is submergible in water and separated from the second chamber for permitting maintaining the second chamber free from submerging in water during the water ejection 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 illustrates a front elevational view, in cross-section, of the valveless pump pursuant to the present invention;

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

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

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

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

FIG. 5 illustrates a cross-sectional view taken along the line 6—6 in FIG. 1;

FIG. 7 illustrates a plan view of the top side of the valveless pump pursuant to the present invention;

FIG. 8 illustrates a plan view of the underside of the valveless pump pursuant to the present invention; and

FIG. 9 illustrates an enlarged exploded perspective view of the operative association of the fluid ejecting piston and the extension portion of the pump which is to be submerged in water.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and more particularly to FIG. 1, the present invention comprises a valveless pump generally denoted by the reference character 10. The pump 10 includes a housing 12 which is generally constituted of plastic or the like, the latter comprising an upper housing portion 14 and a lower housing portion 16 each interconnected to one another as illustrated in FIGS. 1 and 7 through the intermediary of a pair of screws 17.

The upper and lower housing portions 14 and 16 respectively are separated from one another through the intermediary of an inner annular partition 18. A metal-

lic tubular partition or sleeve **20** extends axially through the annular partition **18** into the lower housing portion **16** and is mounted on the partition **18** by means of an annular shoulder **22** provided as a portion of the sleeve **20.** In this manner, there is generally defined a terminal-carrying chamber **24,** a magnet-carrying chamber **26** and a piston-carrying chamber or bore **28,** the nature of which chambers **24, 26** and **28** will be further clarified below.

The housing portion **16** is also provided at its underside with an externally threaded extension portion **30** to which may be threadedly interconnected an internally threaded hollow extension member **32.** The extension portion **30** and the extension member **32** may be tightly connected to one another through the intermediary of a rubber washer **33.** The extension member **32** is provided with a plurality of spaced openings **34** extending in circumferential array and also with an axially extending bore **36** in which is mounted both a closure plug **38** and a screw **40** for laterally expanding the closure plug **38** and thereby enhancing the press-fit inter-connection of the closure plug **38** and the extension member **32.**

A tubular water outlet meber **42** extends from the terminal-carrying chamber **24** into the piston-carrying chamber or bore **28,** the latter which is defined by the sleeve **20** and is spaced from the latter through the intermediary of an innermost annular spacer portion **44** which is constituted as a portion of the sleeve **20.** The tubular water outlet member **42** extends substantially throughout the piston-carrying chamber **28** and partially into the axially extending bore **36** of the hollow extension member **32.**

Referring now to FIGS. **1** and **9** of the drawings, the pump **10** furthermore includes a magnetically responsive water-ejecting piston **46** having an upper tubular portion **48,** an intermediary slotted portion **50** and a lower water-ejecting opening **53** which is generally frusto-conical in cross-section and is displaceable toward and away from the closure plug **38** provided in the extension member **32.** The upper tubular portion **48** of the water-ejecting piston **46** is furthermore provided with a magnetically responsive metallic ring **54,** the function of which will be further clarified below.

The magnet-carrying chamber **26** is provided with a metallic casing **56** in which is provided an electromagnet **58** constituted of a coil enwrapped plastic spool **60.** Extending adjacent the electro-magnet **58** is a permanent-magnet **62** and is operatively associated with the latter electro-magnet **58** in a manner as will be clarified further below.

The terminal-carrying chamber **24** is provided with a pair of electro-terminals **64** which are electrically coupled to the electro-magnet **58** and to an electric wire **66,** the latter which is coupled to a power source which is not shown in the drawings.

In operation, the valveless pump **10,** pursuant to the present invention, may be utilized by submerging the hollow extension member **32** into water such that the spaced openings **34** are proximate yet submersed beneath the water level. The electric power source then serves to electrically energize the electro-magnet **58** which in turn, because of the alternating polarity of the opposite poles thereof coacting with the permanent magnet **62,** causes the magnetic-responsive piston **46** to reciprocate vertically along the piston-carrying chamber **28.** With the extension member **32** submersed in water, water flows inwardly into the piston-carrying chamber **28** through the spaced openings **34** provided in the latter and communicates with the interior of the piston **46.** Furthermore, as water enters into the piston-carrying chamber **28** and is trapped between the lower water-ejecting portion **52** of the piston **46** and the plug **38,** water is forced upwardly through the water-ejecting opening **53** as a series of successive water jets and flows into the tubular water outlet member **42.**

The mode of operation of the pump **10** may be explained as follows: As the piston **46** slides along the tubular member **42** during the upward movement of the piston **46** through the upward stroke caused by the energized electro-magnet **58** acting upon and attracting the magnetically responsive metallic ring **54** of the piston **46,** the water flows through the openings **34** to fill the space directly above the closure plug **38** vacated by the piston **46.** When the piston **46** is reversed during the time the electro-magnet **58** is reversing polarity to effect movement of the piston **46** through the downward stroke caused by the permanent magnet **62** acting upon and attracting the metallic ring **54** of the piston **46,** the volume of water within the space below the piston **46** is displaced. Because the opening **53** is smaller than the closed underside of piston portion **52** in the bore **36,** a jet of water issues upwardly through the opening **53.** This jet of water is directed into the mouth of the tubular member **42** on which the piston **46** is downwardly sliding substantially in axial alignment therewith, causing a corresponding displacement of water within the tubular member **42.**

The momentum imparted to the water on the upward stroke of the piston **46** causes the water to continue up the tubular member **42.** The acceleration of the water tends to be reduced due to the gravity acting on the water column within the tubular member **42.** The next upward stroke of the piston **46** displaces an additional volume of water which tends to slow down the return of the volume of water from within the tubular member **42** to its original position.

According, the water within the tubular member **42** is again caused to move upwardly by the next jet of water issued on the following downward stroke of the piston **46,** which occurs before the volume of water has sufficient time to flow back down the tubular member **42** to its original position. This pumping occurs again and again so that a succession of jets of water enables the piston **46** to pump, water up the tubular member **42,** ultimately causing the water to continuously exit from the opposite opening of the tubular member **42,** thereby providing a continuous flow of water from the pump **10.**

It is noted, that during the upward strokes, the lower space in the bore **36** vacated by the piston **46** is filled with water entering through the openings **34** and proceeding both (**1**) down around the outer surfaces of the piston **46** and (**2**) through the slotted openings into the piston **46** where the water then passes downwardly through the opening **53** into the vacated space below, so that the bore **36** is constantly filled with water.

As those skilled in the art readily appreciate, the extent of the piston-carrying chamber **28** bears some relation upon the efficiency of the valveless pump **10.** In this respect, the stroke of the magnetically responsive piston **46** is controlled generally by the alternating magnetic fluxes provided by the electro-magnet **58** in operative association with the permanent magnet **62.**

However, the quantity of water remaining between the underside of the lower water-ejecting portion **52** of the piston **46** and the closure plug **38** will also have some bearing on the quantity of water that may be ejected through the water-ejecting opening **53** in the water-ejecting portion **52.** Thus, the specific location of the closure plug **38** internally of the hollow extension member **32** may be significant for controlling the ultimate efficiency of the valveless pump **10** pursuant to the present invention. The use of the screw **40** for laterally expanding the plug **38** permits the extent of the piston-carrying chamber **28** to be controlled for this purpose.

It is significant that during the operation of the valveless pump pursuant to the present invention, only the extension member **32** need be submerged in water. Thus, the manner by which each of the elements which constitute the housing **12** of the valveless pump **10** are interconnected to one another need not generally account for submerging the entire housing **12** in water. It is clear, therefore, that the housing **12** both in arrangement and manner by which the elements thereof are interconnected to one another constitutes simplicity and reliability in design and is an inexpensive assembly to manufacture.

It is also significant to point out that the operative association between the electro-magnet **58** and the permanent magnet **62** is effected for causing the reciprocation of the piston **46** completely in the absence of moving parts such as springs or the like. In this respect, the permanent magnet **62** constantly urges the piston **46** downwardly because of the provision of the magnetically responsive metallic ring **54** provided in the upper portion of the piston **46.** Furthermore, because of the provision of the alternating magnetic field provided by the electro-magnet **58,** the reversing polarity of the latter alternately attracts the metallic ring **54** and thereby the piston **46** away from the permanent magnet **62** upwardly along the piston-carrying chamber **28,** this due to the enhanced strength of the alternating magnetically attractive field initiated thereby.

Another feature of significance with regard to the present invention is the cooperative association of both the upper tubular portion **48** and intermediary slotted portion **50** of the piston **46** with that of the tubular water outlet member **42.** As indicated most clearly in FIG. **1,** the portions **48** and **50** of the piston **46** generally surround or embrace the tubular water outlet member **42** and thus as water passes into the piston-carrying chamber **28** through the spaced openings **34** provided in the hollow extension member **32,** water also passes into the upper confines of the piston **46** through the slotted portion **50** thereof during the descent of the piston **46.** Thus, the specific structure of the piston **46** permits the piston-carrying chamber **28** to be constantly filled with water in that the piston itself does not present any obstacle whatsoever to the inflow of water and the rate of water which may be expelled or ejected by the piston **46.**

Of equal significance is the fact that the upper tubular portion **48** constantly surrounds the tubular water outlet member **42** and therefore the outlet member **42** presents a guide along which the piston **46** is displaceable for cooperatively maintaining the lower water-ejecting portion **52** of the piston **46** properly aligned together with the axially extending bore **36** of the extension member **32** such that successive water jets ejected by the piston **46** will be properly pulsated and directed into the tubular water outlet member **42.**

Numerous alternations 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:

1. A valveless pump comprising a housing, said housing including magnetic means for generating a magnetic field disposed within an outer chamber of said housing, said outer chamber surrounding and being closed from an inner chamber of said housing, said housing being provided with a lower extending hollow member communicating with said inner chamber, closure means closing a lower end of said hollow member, said hollow member being provided with at least one water-inlet opening in a side wall of said hollow member for providing a flow of water to said inner chamber, a tubular outlet member extending through said inner chamber with an open end of said outlet member disposed in said hollow member above said water-inlet opening, a water-ejecting magnetically responsive hollow piston movably disposed in said hollow member for association with said magnetic means with an upper portion of said piston slideably surrounding said outlet member in a concentrical arrangement, said piston including a lower end portion facing said closure means, said piston lower end portion being provided with a water-ejecting opening of smaller size than said upper piston portion which surrounds said outlet member, and at least one opening in a side wall of said piston communicating with each of said water-inlet opening, said outlet member open end and said water-ejecting opening, whereby said water-ejecting opening directs jets of water toward said outlet member open end as said magnetic means force said piston toward said closure means when said hollow member is disposed in water with said water-inlet opening submerged below water level where said piston side wall opening permits said hollow member to be constantly filled with water.

2. A valveless pump as claimed in claim **1,** wherein said water-ejecting opening is generally frusto-conical in cross-section defining minor and major diametral extents, said minor diametral extent being directed toward said outlet member open end and said major diametral extent being directed toward said closure means.

3. A valveless pump as claimed in claim **1,** wherein said magnetic means includes an electro-magnet and a permanent magnet in operative association with each other for coacting on said piston to provide reciprocating movement for said piston.

4. A valveless pump as claimed in claim **4,** wherein a magnetically responsive metal element is disposed on said upper portion of said piston for association with said electromagnet and said permanent magnet.

5. A valveless pump as claimed in claim **12,** wherein said hollow member includes securing means for detachably connecting said hollow member to said housing.

6. A valveless pump as claimed in claim **12,** wherein said closure means includes a plug provided with an adjusting member for permitting movement of said plug within said hollow member to any one of a plurality of stationary closing positions for controlling amount of water ejected by said piston.

* * * * *