United States Patent [19]

Brown

[11] **Patent Number: 4,832,583**

[45] **Date of Patent: May 23, 1989**

[54] **LOW PRESSURE METERING FLUID PUMP**

[75] Inventor: **Ralph V. Brown**, Cayuta, N.Y.

[73] Assignee: **Facet Enterprises, Inc.**, Tulsa, Okla.

[21] Appl. No.: **255,638**

[22] Filed: **Oct. 11, 1988**

Related U.S. Application Data

[63] Continuation of Ser. No. 867,087, May 27, 1986.

[51] **Int. Cl.**⁴ **F04B 17/04**; F04B 35/04

[52] **U.S. Cl.** .... **417/417**; 92/85 R; 92/240; 92/245; 318/484; 361/196; 361/163; 361/165

[58] **Field of Search** .... 417/417, 415, 416, 418; 318/484; 361/196, 163, 165, 170, 154, 155, 156, 160, 139; 92/85 R, 240, 245, 246

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,396,714	11/1921	Carmichael	92/246
1,542,521	6/1925	Reynolds	92/240
2,641,188	6/1953	Aumick et al.	417/417
2,764,098	9/1956	Dickey et al.	417/417
2,765,747	10/1956	Aumick	417/417
3,039,127	6/1962	Molenaar	92/85 R
3,044,413	7/1962	Corsette	92/240
3,381,616	5/1968	Wertheimer et al.	417/417
3,505,930	4/1970	Schrader	92/240
3,556,684	1/1971	Rouquette	417/417
3,849,031	11/1974	Charboneau et al.	417/417
4,047,852	9/1977	O'Connor et al.	417/417
4,080,552	3/1978	Brown	417/417
4,102,610	7/1978	Taboada et al.	417/417
4,122,378	10/1978	Brown	417/417
4,286,200	8/1981	Brown	318/484
4,306,843	12/1981	Arai	417/417
4,673,127	6/1987	Grant	340/538

FOREIGN PATENT DOCUMENTS

1161618	9/1958	France	92/240
61145	7/1939	Norway	92/240
1455848	11/1976	United Kingdom	92/85 R

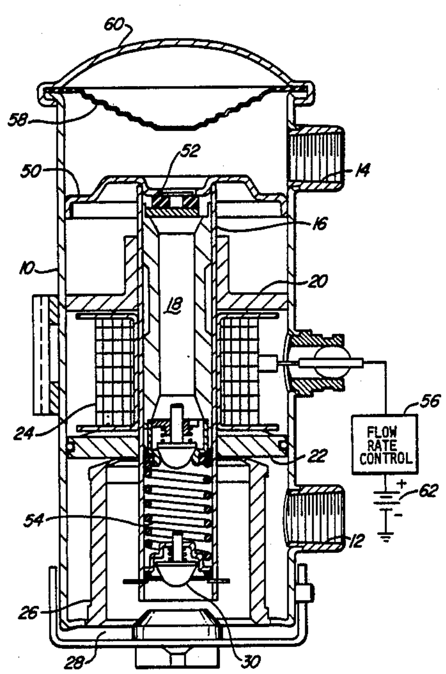
Primary Examiner—Donald E. Stout

Attorney, Agent, or Firm—James R. Ignatowski; Remy J. VanOphem

[57] **ABSTRACT**

A low pressure metering pump having a hollow piston reciprocated in a cylindrical guide by a solenoid coil. A pair of check valves provide for unidirectional fluid flow through the cylindrical guide in response to the reciprocation of the piston. A seal attached to the piston prohibits a fluid backflow between the external surface of the piston and the internal surface of the cylindrical guide. A bumper seal at the output end of the piston prevents fluid flow through the cylindrical guide when the solenoid coil is de-energized. A control circuit periodically energizes the solenoid coil at a frequency determined by a variable resistance responsive to predetermined operational parameters. In a preferred embodiment, the metering pump is a fuel control element for a heater and the variable resistance is a thermistor or similar type of temperature sensitive resistance, which controls the rate at which fuel is delivered to the heater.

18 Claims, 2 Drawing Sheets



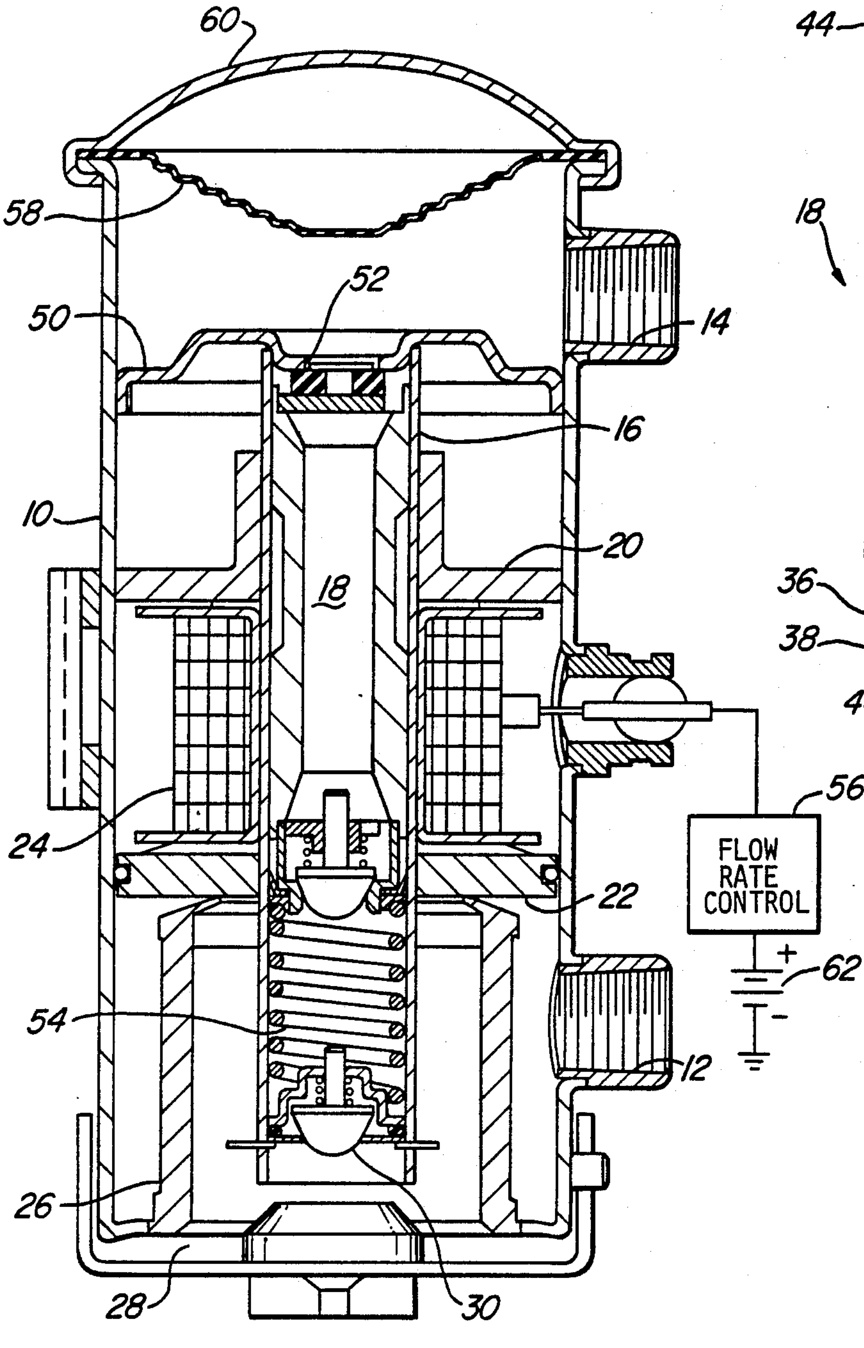

60
58
52
50
14
16
10
20
18
24
22
FLOW RATE CONTROL
56
62
54
12
26
28
30

Fig-1

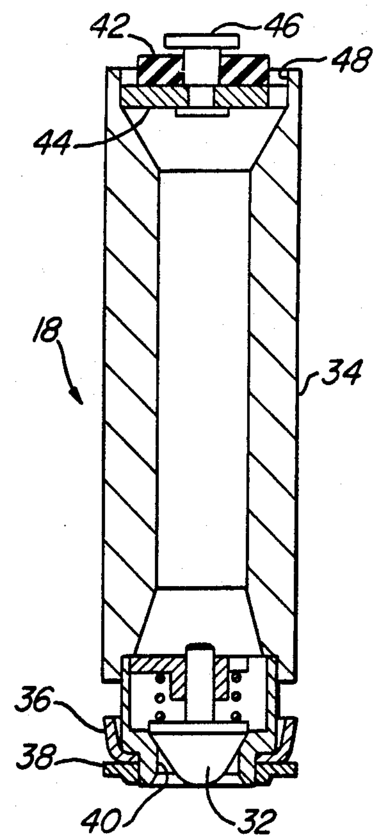

42
46
48
44
18
34
36
38
40
32

Fig-2

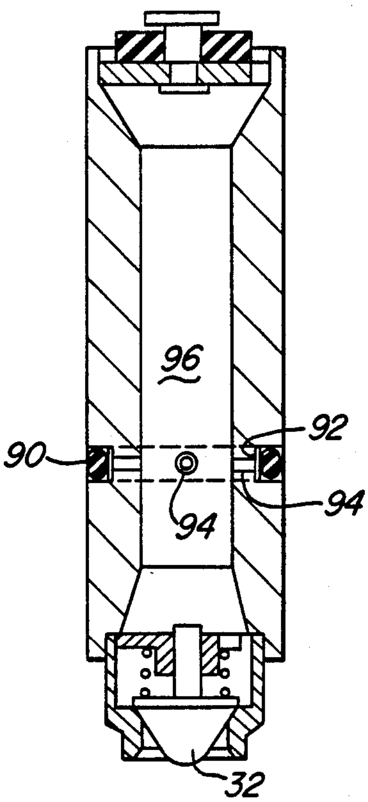


Fig-3

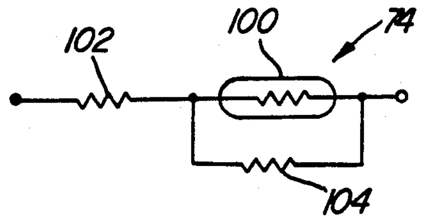


Fig-5

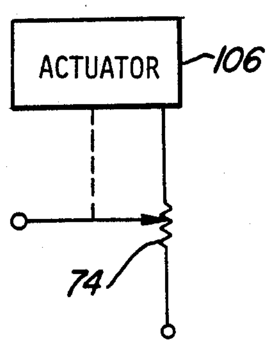


Fig-6

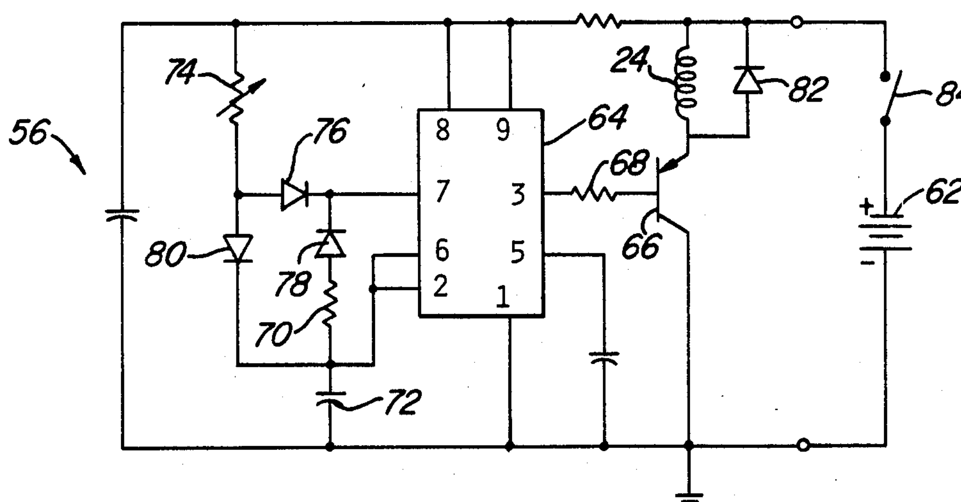


Fig-4

LOW PRESSURE METERING FLUID PUMP

This is a continuation of application Ser. No. 867,087 filed May 27, 1986.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is related to electromagnetic fluid pumps and in particular to metering fluid pumps having a controllable fluid output.

2. Description of the Prior Art

Reciprocating electromagnetic fluid pumps, such as those taught by L.C. Parker in U.S. Pat. No. 2,994,792 and E.D. Long in U.S. Pat. No. 3,361,069, used mechanical or magnetic switches to energize a solenoid to retract the piston or plunge when it reaches the end of its pumping stroke. These switches were unreliable and, therefore, their use has been discontinued. Currently, most of these reciprocating electromagnetic fluid pumps use electronic oscillators which energize the pump's solenoid at predetermined intervals. Some of these pumps use free-running oscillators, as taught by Kofinh in U.S. Pat. No. 3,211,798, or a blocking oscillator, as taught by Wertheimer in U.S. Pat. No. 3,381,616. Pumps with electronic oscillators operate at a constant speed and work well for a narrow band of output loads.

The invention is a low pressure metering fluid pump particularly suited for providing fuel to wick or carburetor type burners to control the heat output, as a function of an operator control or a temperature sensor.

SUMMARY OF THE INVENTION

The invention is a metering fluid pump which includes a housing having an inlet port and an outlet port, and a cylindrical guide disposed in the housing having an inlet end in fluid communication with the inlet port and an outlet end in fluid communication with the output port. A hollow cylindrical piston is disposed in the cylindrical guide for reciprocation therein, a resilient member is provided for biasing the piston toward the outlet end of the cylindrical guide, a solenoid coil circumscribing the cylindrical guide is provided for generating a magnetic force to displace the piston towards the inlet end, and valve assemblies are provided for producing a unidirectional fluid flow through the cylindrical guide in response to the reciprocation of the piston. An aperture member provided at the outlet end of the cylindrical guide defines an outlet aperture having a diameter smaller than the diameter of the cylindrical guide. An elastic bumper attached to the end of the piston facing the outlet end occludes the outlet aperture when the piston is displaced to its extreme position and a piston seal inhibits a fluid backflow between the external surface of the piston and the internal surface of the cylindrical guide. A control circuit periodically energizes the solenoid coil at a controllable frequency to control the quantity of fluid being delivered by the pump.

The object of the invention is an electromagnetic pump providing a metered fluid output flow. Another object is a pump in which the fluid flow rate is controllable. Still another object of the invention is a pump in which the fluid flow is controlled by a sensed parameter. A final object of the invention is a fluid pump in which the outlet aperture is sealed when the pump is de-energized to prevent syphoning or fluid drainage through the pump. These and other objects of the present invention will become more apparent from reading the specification in conjunction with the drawings appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional side view of the metering pump;

FIG. **2** is an enlarged cross-section of the piston assembly;

FIG. **3** is a cross-section of an alternate embodiment of the piston assembly;

FIG. **4** is a circuit diagram of the control circuit;

FIG. **5** is a schematic view of a first alternate embodiment of the variable resistance; and

FIG. **6** is a schematic view of a second alternate embodiment of the variable resistance.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The basic elements of the low pressure metering fluid pump are shown in FIG. **1**. The pump includes a generally cylindrical housing **10** having a fluid inlet port **12** and a fluid outlet port **14**. Contained within the housing **10** is a non-magnetic cylindrical guide **16** which forms a guide for a reciprocating piston assembly **18**. The cylindrical guide **16** is supported in the housing **10** by a pair of annular pole members **20** and **22**, respectively. A solenoid coil **24** circumscribes the cylindrical guide **16** intermediate the poles **20** and **22**. An annular fluid filter **26** circumscribes the cylindrical guide between the pole member **22** and the bottom **28** of the housing **10** to remove any particlates suspended in the fluid which pass through the inlet port **12**.

A first valve assembly **30** is provided in the entrance aperture of the cylindrical guide **16**. A second valve assembly **32** is disposed at the end of the piston assembly's hollow cylindrical piston member **34**, as shown in FIG. **2**. The first and second valve assemblies cooperate with the reciprocation of the piston assembly to provide a unidirectional fluid flow through the pump. A cup-shaped resilient seal **36** is secured to the second valve assembly **32** by an annular retainer **38** pressed onto the cylindrical end of a valve support bracket **40**. Preferably the seal **36** is made from an elastomeric material, such as VITRON®. The outer diameter at the open end of the cup-shaped resilient seal **36** is approximately equal to the inner diameter of the cylindrical guide **16**. In operation, pressurized fluid leaking back between the piston memter **34** and the inner surface of the cylindrical guide **16** will be trapped by the seal **36**. The increased pressure will expand the seal's open end to forceably engage the inner wall of the cylindrical guide and inhibit any backflow leakage past the piston member **34** during the pumping stroke. This ensures that a precise quantity of fluid will be output during each pumping stroke.

Alternatively, the seal **36** may be replaced by a resilient ring seal **90** disposed in a circumferential groove **92** provided at an intermediate location along the length of the piston member **34**, as shown in FIG. **3**. One or more radial fluid channels **94** connect the groove **92** with the interior of the piston member **34**. During the pumping stroke of the piston member **34**, the fluid pressure inside of the piston member's hollow interior **96** increases. The increased pressure is communicated to the inner surface of the resilient ring seal **90** through the fluid channels **94** causing its diameter to increase and engage the inner surface of the cylindrical guide **16**. This will inhibit any fluid back-flow between the external surface of the piston member 34 and internal surface of the cylindrical guide 16. Preferably, the resilient ring seal 90 is made from a fuel resistant elastomer, such as VITRON®.

An output seal 42 is disposed at the other end of the piston member 34. The output seal 42 is preferably made from an elastomer, such as VITRON® or a similar material which is resistant to hydrocarbon fuels. The output seal 42 is attached to a spider-like support bracket 44 by a rivet 46. Alternatively, the output seal may be bonded directly to the bracket 44 using an epoxy or adhesive resistant to hydrocarbon fuels as is known in the art. The bracket 44 is pressed into a counterbore 48 provided at the end of the piston member 34 to secure it in place.

Returning to FIG. 1, the output end of the cylindrical guide 16 is supported in the housing 10 by an annular separator plate 50. The separator plate 50 partially encloses the output end of the cylindrical guide 16 and defines an exit aperture 52 which has a diameter smaller than the diameter of the output seal 42. As shown in FIG. 1, when the piston assembly 18 is fully displaced towards the output end of the cylindrical guide 16, the output seal 42 engages the separator plate 50 about the periphery of the exit aperture 52 inhibiting a fluid flow through the pump in either direction. This will prohibit syphoning or drainage of fluid from the fluid source to the utilization device, such as a carburetor or wick-type burner, or vice versa when the pump is deactivated or de-energized. This is a fail-safe feature which makes this pump particularly suitable for heaters or similar devices where syphoning or fuel drainage could present a potential fire or toxic fume hazard.

A resilient member, such as a coil spring 54, is disposed in the cylindrical guide 16 between the first valve assembly 30 and the piston assembly 18. The coil spring 54 produces a force urging the piston assembly 18 towards the output end of the cylindrical guide 16 and the output seal into engagement with the separator plate 50. A flow rate control circuit 56 connected to a source of electrical power, illustrated as battery 62, periodically energizes the solenoid coil 24 to produce the desired metered fluid flow through the pump. Energizing of the solenoid coil 24 will displace the piston assembly 18 towards the input end of the cylindrical guide 16 against the force produced by the coil spring 54. During the displacement of the piston assembly 18 by the solenoid coil 24, the fluid trapped in the cylindrical guide 16 above the first valve assembly 30, will open the second valve assembly 32 allowing the trapped fluid to enter into the hollow portion of the piston member 34. Upon de-energizing of the solenoid coil 24, the coil spring 54 will urge the piston assembly 18 towards the output end of the cylindrical guide. This will close the second valve assembly 32 and the first valve assembly 30 will open allowing fluid from a fluid source (not shown) to enter the volume inside the cylindrical guide 16 above the valve assembly 30.

A flexible diaphragm 58 seals the top of the pump housing 10 and forms in conjunction with the separator plate 50 an accumulator, which reduces pressure surges and smooths out the fluid flow from the pump's outlet port 14. A rigid cover 60 attached to the top of the housing 10 protects the flexible diaphragm 58 from physical damage from external forces.

The details of the flow rate control circuit 56 are shown in FIG. 4. In the preferred embodiment, the flow rate control circuit 56 includes an integrated circuit timer 64, such as integrated timer 555 produced by International Semiconductor, Inc., and various other manufacturers of semiconductor products. The signal output terminal of the timer 64 (terminal 3) is connected to the base of a transistor 66 through a resistance 68. The transistor 66 may be a single power transistor or a Darlington Amplifier, as is known in the art. The transistor 66 is connected in series with the pump's solenoid coil 24 between the positive and negative terminals of the battery 62. The emitter of the transistor 66 is connected to one end of the solenoid coil 24 and the collector is connected to the negative terminal of the battery 62. A resistance 70 connected between the timer 64 control input terminals (terminals 2 and 6) and the timer 64 control output terminal (terminal 7) in conjunction with a capacitance 72 controls the length of time that the solenoid coil 24 is energized. The values of the resistance 70 and capacitance 72 are selected so that the solenoid coil 24 is energized for a period of time sufficient to fully retract the piston assembly 18. When the piston assembly is fully retracted before the beginning of each pumping stroke, all the pumping strokes will be of the same length and, therefore, deliver a precise metered amount of fluid.

A variable resistance 74 connected between the positive terminal of the source of electrical power, the battery 62, and the control output terminal (terminal 7) of the timer 64, controls the frequency at which the solenoid coil 24 is energized. Since each pumping stroke delivers a precise quantity of fluid, the frequency of the pumping strokes determines the rate at which the fluid is delivered. In the preferred embodiment, the variable resistance 74 may be a thermistor 100 or thermistor network, such as shown in FIG. 5 in which fixed resistors 102 and 104 are connected in series and/or parallel with a thermistor 100 to tailor the resistance-temperature characteristics of the thermistor 100. Since the resistance of the thermistor or thermistor network is variable, it can be used to control the rate at which fluid is being delivered to a particular apparatus, such as the fuel to oil or gasoline heaters. In an alternative embodiment, the variable resistance 74 may be actuated by a bi-metal thermostat or any other type of actuator 106, as shown in FIG. 6, or may be a manually actuated variable resistor. Diodes 76, 78 and 80 are provided to minimize the effect of changing the value of the resistance 74 on the duration of the signal activating the solenoid coil. As is known in the art, a diode 82 is provided across the terminals of the solenoid coil 24 to dissipate the inductive flyback generated by the solenoid coil when it is de-energized. A switch 84 connected between the battery 62 and the flow rate control circuit 56 is an "on-off" switch controlling the energizing of the metering fluid pump.

In operation, closing the switch 84 initiates the charging of the capacitance 72 through variable resistance 74 and diode 80. When a predetermined voltage is developed across the capacitance 72, the terminal 7 of the timer 64 assumes a ground potential. Simultaneously, the terminal 3 goes negative rendering the transistor 66 conductive and energizing the solenoid coil 24. The ground potential at the terminal 7 initiates the discharge of the capacitance 72 through the resistance 70 and the diode 78. The ground potential at the terminal 7 also grounds the junction between the variable resistance 74 and the diode 80 so that the charging of the capacitance 72 through the diode 80 is terminated. After a period of time determined by the resistance 70 and the capacitance 72, the potential applied to the terminal 2 of the timer 64 will cause the terminal 7 to assume an open circuit state and the signal at the terminal 3 will go high turning the transistor 66 off. The open circuit state at the terminal 7 will terminate the discharge of the capacitance 72 through the resistance 70 and will initiate the recharging of the capacitance 72 through the variable resistance 74 and the doide 80. This cycle will be repeated as long as the switch 84 remains closed.

As can be seen from the above description of the operation of the control circuit, the solenoid coil is always energized for identical time periods and the resistance value of the variable resistance 74 has no affect on these time periods. The only effect of the variable resistance 74 is to control the frequency at which the solenoid coil 24 is energized.

Having described the low pressure metering fluis pump in detail, it is recognized that persons skilled in the art may make changes in the design of the pump or the control circuit without departing from the spirit of the invention described above and set forth in the appended claims.

What is claimed is:

1. A metering pump comprising:

a housing having an inlet port and an outlet port;

a cylindrical guide disposed in said housing, said cylindrical guide having an inlet end in fluid communication with said inlet port and an outlet end in fluid communication with said outlet port;

a hollow cylindrical piston disposed in said cylindrical guide for reciprocation therein;

resilient means for biasing said piston towards said outlet end;

a solenoid coil circumscribing said cylindrical guide for generating a magnetic force to displace said piston towards said inlet end against the force of said resilient means;

valve means for providing a unidirectional fluid flow through said cylindrical guide in response to the reciprocation of said piston;

an aperture member provided at said outlet end of said cylindrical guide defining an outlet aperture having a diameter smaller than the internal diameter of said cylindrical guide;

elastic bumper means attached to the end of said piston adjacent to said outlet end for occluding said outlet aperture when said piston is displaced to its extreme position adjacent to said outlet end of said cylindrical guide by said resilient means;

piston seal means for inhibiting a fluid flow between the external surface of said piston and the internal surface of said cylindrical guide; and

a control circuit of periodically energizing said solenoid coil at a controllable frequency to control the quantity of fluid being delivered by said pump.

2. The metering pump of claim **1** wherein said control circuit comprises:

a capacitance;

a timer responsive to the potential across said capacitance for periodically generating an output signal at a signal output terminal and for periodically generating a ground signal at a control output terminal;

a first resistance and serially connected first diode connected between a source of electrical power and said capacitance for charging said capacitance;

a second resistance and serially connected second diode connected between said capacitance and said control output terminal for discharging said capacitance in response to said ground signal, wherein one of said first and second resistances is a variable resistance and the other is a fixed resistance;

a third diode, the cathode of which is connected to said control output terminal and its anode is connected to the junction between said first resistance and said first diode; and

a transistor connected in series with said solenoid coil, the base of said transistor being connected to said signal output terminal, said output signal rendering said transistor conductive to energize said solenoid coil.

3. The metering pump of claim **2** wherein said fixed resistance is selected to produce an output signal energizing said solenoid coil for a time sufficient to completely retract said piston and said variable resistance is a thermistor.

4. The metering pump of claim **2** wherein said fixed resistance is selected to produce an output signal energizing said solenoid coil for a time sufficient to completely retract said piston and said variable resistance is a thermistor network comprising at least one thermistor.

5. The metering pump of claim **2** wherein said fixed resistance is selected to produce an output signal energizing said solenoid coil for a time sufficient to completely retract said piston and said variable resistance is a variable resistor mechanically actuated by a sensor.

6. The metering pump of claim **2** wherein said fixed resistance is selected to produce an output signal energizing said solenoid coil for a time sufficient to fully retract said piston and said variable resistance is a manually actuated variable resistance.

7. The metering pump of claim **1** wherein said piston seal means is a resilient cup-shaped member connected to the end of said piston opposite said elastic bumper means, the rim of said cup-shaped member faces said outlet end of said cylindrical guide, said resilient cup-shaped member having an outer diameter substantially equal to the internal diameter of said cylindrical guide.

8. The metering pump of claim **1** wherein said aperture member is a separator plate separating, external to said cylindrical guide, a high pressure region of said housing connected to said outlet port from a low pressure region of said housing connected to said inlet port.

9. The metering pump of claim **8** further comprising a flexible diaphragm for sealing the end of said housing containing said high pressure region.

10. An electromagnetic pump for metering a fluid flow comprising:

a cylindrical guide having an input end and an output end;

an output aperture provided at said output end having a diameter smaller than the internal diameter of said cylindrical guide;

a hollow disposed in said cylindrical guide and operative to reciprocate between a fully retracted position and a fully extended position;

a spring for producing a force urging said hollow piston to said fully extended position;

a solenoid coil circumscribing said cylindrical guide for producing a magnetic force urging said hollow piston towards said fully retracted position;

a control circuit for periodically energizing said solenoid coil to generate said magnetic force for a time sufficient to retract said hollow piston from said fully extended position to said fully retracted position, said control circuit varying the frequency at which said solenoid coil is energized in accordance with a predetermined operating parameter;

an elastic seal attached to one end of said hollow piston for occluding said output aperture when said hollow piston is displaced to its fully extended position; and

seal means for inhibiting a fluid flow in the region between the internal surface of said cylindrical guide and the external surface of said hollow piston.

11. The electromagnetic pump of claim **10** wherein said control circuit comprises:

a capacitance;

a timer responsive to the potential across said capacitance for periodically generating an output signal and a discharge signal;

a first resistance for charging said capacitance between sequential discharge signals;

a second resistance for discharging said capacitance in response to each discharge signal; and

an amplifier for energizing said solenoid coil in response to said output signals;

wherein one of said first and second resistances is a fixed resistance and the other is a variable resistance.

12. The electromagnetic pump of claim **11** wherein said fixed resistance comprises a serially connected fixed resistor and first diode, said fixed resistor having a value selected to control the duration of said output signal generated by said timer for a time sufficient for said solenoid coil to displace said hollow piston to its fully retracted position and wherein said variable resistance comprises a serially connected variable resistor and a second diode, and wherein said control circuit further comprises a third diode having a cathode receiving said discharge signal and an anode connected to the anode of the diode in said first resistance.

13. The electromagnetic pump of claim **11** wherein said variable resistor is a thermistor.

14. The electromagnetic pump of claim **11** wherein said variable resistor is a thermistor circuit.

15. The electromagnetic pump of claim **11** wherein said variable resistance includes a mechanical actuator responsive to predetermined operating conditions.

16. The electromagnetic pump of claim **10** wherein said seal means is an elastomer cup attached to said hollow piston, the rim of said cup facing said output end of said cylindrical guide and having a diameter substantially equal to the internal diameter of said cylindrical guide.

17. The electromagnetic pump of claim **10** wherein said hollow piston has a circumferential groove and at least one fluid channel connecting said circumferential groove to the interior of said hollow piston and wherein said seal means is an elastomer ring disposed in said circumferential groove.

18. A backflow seal for a hollow piston of a reciprocating piston electromagnetic pump having a cylindrical guide for guiding the reciprocation of said hollow piston, wherein said cylindrical guide has an input end and an output end, said backflow seal comprising:

a resilient elastomer cup-shaped seal having an open end defined by a rim portion whose external diameter is approximately equal to the internal diameter of said cylindrical guide and a base portion opposite said open end, said base portion having an annular shoulder defining a central aperture; and

means for securing said annular shoulder to the end of said hollow piston facing said input end of said cylindrical guide with said open end of said cup-shaped seal facing the output end of said cylindrical guide.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 4,832,583
DATED : May 23, 1989
INVENTOR(S) : Ralph V. Brown

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 1, line 17, delete "plunge" and insert ---- plunger ----.

Column 3, line 58, after "the" insert ---- first ----.

Column 4, line 36, delete "a" and insert ---- the ----.

Column 4, line 56, after "through" insert ---- the ----.

Column 4, line 57, after "and" insert ---- the ----.

Column 5, line 17, delete "fluis" and insert ---- fluid ----.

Column 5, line 53, delete "of" and insert ---- for ----.

Column 6, line 57, after "hollow" insert ---- piston ----.

Signed and Sealed this

Thirteenth Day of November, 1990

Attest:

HARRY F. MANBECK, JR.

Attesting Officer

Commissioner of Patents and Trademarks