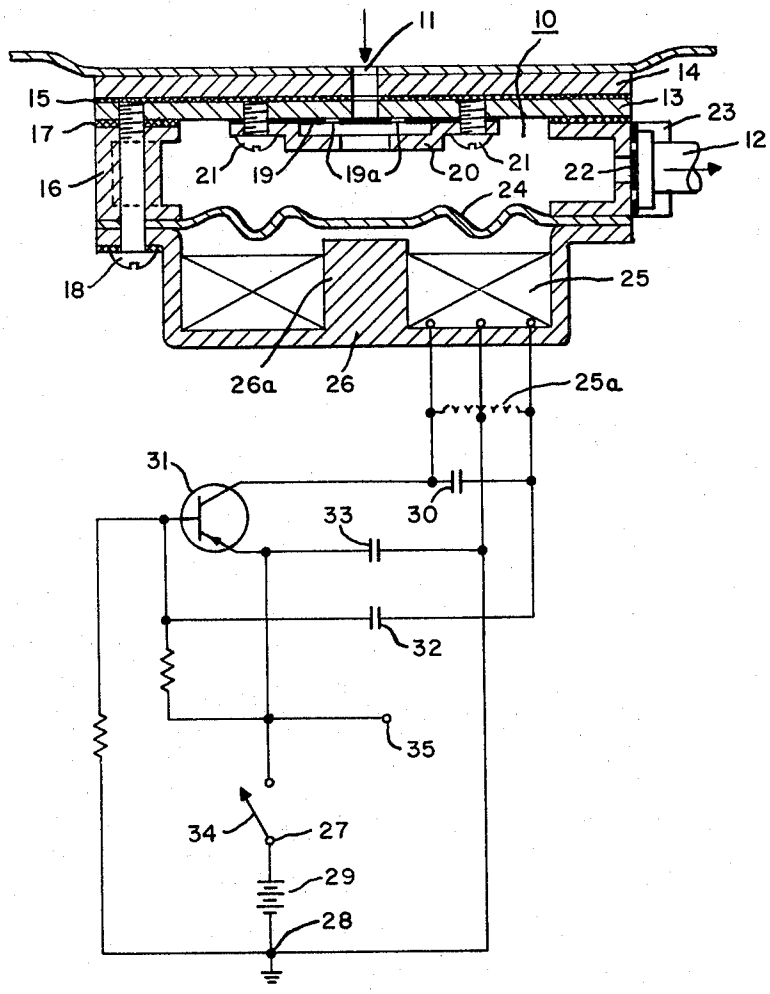
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ELECTROMAGNETIC RECIPROCATING FLUID PUMP

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ELECTROMAGNETIC RECIPROCATING FLUID PUMP

Harold F. Elliott, 800 Westridge Drive, Menlo Park, Calif. 94026

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ABSTRACT OF THE DISCLOSURE

An electromagnetic reciprocating fluid pump comprises a cylindrical pump chamber of nonmagnetic material. The lower flat wall of the chamber is in the form of a resilient diaphragm sealed to the cylindrical wall around its periphery, the diaphragm being of high-remanence paramagnetic material magnetized radially from its center outward. Below the diaphragm is a solenoid comprising a central core and a cup-shaped magnetic member forming essentially a closed magnetic path including the diaphragm. The upper wall of the pump chamber includes inlet and outlet ports, each having a one-way check valve. The solenoid winding comprises reactance means forming a part of a resonant circuit which, with an associated electronic valve, forms a source of periodic or pulsating unidirectional current for vibrating the diaphragm to pump fluid supplied to the inlet port.

This invention relates to electromagnetic reciprocating fluid pumps and, while it is of general application, it is particularly adapted for use in the fuel system of an automobile.

Heretofore there have been proposed and marketed a number of types of electromagnetic fluid pumps. In general, these have comprised a reciprocating solenoid core which either actuated a resilient bellows or diaphragm or served a dual function as a piston of a piston-type pump. Substantially all of the solenoid operated pumps have performed the fluid intake operation upon excitation of the solenoid and simultaneously compressed a spring, the latter performing the pumping stroke upon deenergization of the solenoid. Substantially all devices of this type have included some form of a lost-motion switch for cyclically energizing and deenergizing the solenoid from a direct-current source.

Electromagnetic reciprocating pumps of the type described have a number of disadvantages, among which may be mentioned a substantial amount of friction arising from the moving solenoid core or the pump pistons, or both; arcing and wear of the solenoid switch contacts; and an objectionable level of noise.

It is an object of the invention, therefore, to provide a new and improved electromagnetic reciprocating fluid pump which obviates one or more of the above-mentioned disadvantages of prior art pumps of the type described.

It is another object of the invention to provide a new and improved electromagnetic reciprocating fluid pump which is simple, economical, and rugged in construction and embodies a minimum number of movable parts.

In accordance with the invention, there is provided an electromagnetic reciprocating fluid pump adapted to operate from a source of periodic current comprising a fluid pump chamber of nonmagnetic material having inlet and outlet ports, a one-way check valve registering with each of the inlet and outlet ports, a resilient diaphragm of paramagnetic material forming one wall of the pump chamber and sealed thereto around its periphery, a solenoid mounted adjacent the diaphragm and adapted to be energized from said source, and a magnetic core member for the solenoid including a central pole piece closely

spaced from the center of the diaphragm in its undeflected position and portions completing a magnetic circuit between such pole piece and the periphery of the diaphragm.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawing, while its scope will be pointed out in the appended claims.

The single figure of the drawing is a cross-sectional view of an electromagnetic reciprocating fluid pump, together with a unitary source of periodic current, embodying the invention.

Referring now more particularly to the drawing, there is represented an electromagnetic reciprocating fluid pump adapted to operate from a source of periodic current and comprising a fluid pump chamber **10** of nonmagnetic material having an inlet port **11** and an outlet port **12**. The pump chamber **10** is shown as a composite structure comprising a base plate **13** disposed adjacent a frame member **14** but separated therefrom by a gasket **15**. The pump chamber **10** further includes an annular wall member **16** of channel-shaped cross-section sealed to the base plate **13** by way of an annular gasket **17** and secured thereto in any suitable manner as by a series of machine screws **18**.

The fluid pump of the invention further comprises a one-way check valve registering with each of the ports of the pump chamber **10**. By way of example, the inlet check valve comprises a sheet or flap **19** of resilient material, such as rubber, having a central portion normally closing the inlet port **11** and a series of apertures **19***a* surrounding the central portion and providing fluid passage when the flap **19** is released from the inlet port **11** during operation of the pump. The flap **19** is retained in position by an annular clamp **20** secured to the base plate **13** as by machine screws **21**. The check valve for the outlet port **12** comprises a similar apertured resilient sheet or flap **22** having a central portion normally closing the outlet port **12** and secured to the annular chamber wall **16** by a clamp **23** secured to the member **16** by any suitable means (not shown).

The fluid pump of the invention further comprises a resilient diaphragm **24** of paramagnetic material sealed to the chamber wall member **16** around its periphery and forming one wall of the pump chamber **10**. The seal between diaphragm **24** and member **16** may be a gasket (not shown) similar to gasket **17**, a resilient O-ring, or equivalent sealing element. The diaphragm **24** may be of high-remanence paramagnetic material, such as a cobalt or chrome alloy steel, permanently magnetized radially from its center outward. Alternatively, the diaphragm **24** may be of low-remanence high-permeability material such as low carbon steel.

The fluid pump of the invention further comprises a solenoid, represented schematically at **25**, and mounted adjacent the diaphragm **24** and adapted to be energized from a source of periodic current described hereinafter. The solenoid is provided with a magnetic core member **26** having a central pole piece **26***a* closely spaced from the diaphragm **24** in its undeflected position. The core member **26** further comprises portions completing a magnetic circuit between the pole piece **26***a* and the periphery of the diaphragm. Specifically, the core member **26** may be cup-shaped, as shown, enclosing the solenoid winding **25** and completing the magnetic circuit therefor around the entire periphery of the diaphragm **24**. The pump chamber **10** and its associated actuating solenoid may be of any desired configuration but, in the most simple form, they are circular in a plane transverse to the plane of the sectional drawing.

Preferably, the solenoid winding **25** forms a part of the source of periodic current for the pump, specifically, part of an inverter circuit energized from direct-current supply teminals **27**, **28** which may be energized from any suitable source such as a battery **29**. The solenoid winding **25**, the inductance of which is represented by the dotted-line inductor **25***a*, is connected in parallel with a reactance means such as capacitor **30** which forms with the solenoid **25** a resonant circuit. There is also provided an electronic valve such as a transistor **31** having input and output electrodes coupled through the resonant circuit **25**, **30**. Specifically, the base of transistor **31** is connected via a coupling capacitor **32** to one terminal of the winding **25**, the emitter of transistor **31** is connected via coupling capacitor **33** to an intermediate terminal of the winding **25**, while the collector of transistor **31** is connected directly to the other terminal of the winding **25**. The output electrodes, that is, the emitter and collector of transistor **31**, are connected to the supply terminals via a switch **34** and the solenoid winding **25**. With the connections described, the winding **25**, the capacitor **30**, and the transistor **31** comprise a conventional oscillator circuit in which the base-emitter circuit and the collector-emitter circuit are regeneratively coupled through the resonant circuit **25**, **30**, so that these circuit elements form a conventional source of periodic current for the pump. If desired, an output terminal **35** may be connected to supply terminal **27** via switch **34**.

It is believed that the operation of the electromagnetic reciprocating fluid pump of the invention will be apparent from the foregoing description. In brief, upon closing of the switch **34**, the oscillator comprising transistor **31** and the resonant circuit **25**, **30** with their interconnections generates a periodic current of a frequency depending upon the resonant frequency of the circuit **25**, **30**. This periodic current, flowing through the winding **25**, produces an alternating magnetic field in the core member **26**, the magnetic circuit for this field including the paramagnetic diaphragm **24**. If the diaphragm **24** is permanently magnetized, as mentioned above, the device acts as a dynamic reciprocating motor, the diaphragm **24** being alternately attracted to and repelled from the center pole piece of the core **26**. When the diaphragm **24** is attracted toward the pole piece **26***a*, the pressure in the pump chamber **10** is lowered, releasing the flap valve **19** from the inlet port **11** and drawing fluid into the pump chamber. When the diaphragm **24** is repelled from the pole piece **26***a*, the fluid in the pump chamber **10** tends to be compressed, closing the flap valve **19** and opening the flap valve **22** and expelling fluid through the outlet port **12**. This cycle, of course, repeats at the frequency of periodic current developed by the oscillator described. The amplitude of deflection of the diaphragm **24** will be rather small but, due to the frequency of its vibration, an adequate volume of fluid will be pumped by the device.

In case the diaphragm **24** is of high-permeability low-remanence material, the diaphragm will be attracted to the pole piece **26***a* during both the positive and negative half cycles of the magnetic field and during the portions

of the cycle where the fluid is reversing, the diaphragm **24** will spring away from the pole piece **26***a* by its own resilience. The operation of the pump is essentially that described above except that the frequency of vibration of the diaphragm **24** is now twice the frequency of the periodic current generated by the oscillator.

In the event that the electromagnetic pump of the invention is used as a fuel pump in an automobile, the switch **34** may be a part of, or unicontrolled with, the ignition switch supplying a source of ignition voltage to the output terminal **35**, in this case the battery **29** being the car battery.

While there has been described what is, at present, considered to be the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein, without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An electromagnetic reciprocating fluid pump adapted to operate from a source of pulsating unidirectional current comprising:

a fluid pump chamber of nonmagnetic material having inlet and outlet ports;

a one-way check valve registering with each of said ports;

a resilient diaphragm forming one wall of said chamber and sealed thereto around its periphery, said diaphragm being constructed of high-remanence paramagnetic material magnetized radially from its center outward;

a solenoid mounted adjacent said diaphragm and adapted to be energized from said source;

and a magnetic core member for said solenoid including a central pole piece closely spaced from said diaphragm in its undeflected position and portions completing a magnetic circuit between said pole piece and the periphery of said diaphragm.

2. An electromagnetic reciprocating fluid pump in accordance with claim **1** including direct-current supply terminals, reactance means forming with said solenoid a resonant circuit, and an associated electronic valve having input and output electrodes coupled through said resonant circuit, said output electrodes being connected to said terminals, thereby forming a source of periodic current for the pump.

References Cited

UNITED STATES PATENTS

2,363,478	11/1944	Boeke	230—55 XR
2,654,324	10/1953	Ryba	103—53
2,809,589	10/1957	Randolph	103—53

ROBERT M. WALKER, *Primary Examiner.*

DONLEY J. STOCKING, *Examiner.*