May 20, 1958 L. B. HARRINGTON 2,835,831

ELECTROMAGNETIC POWER DEVICE

Filed Nov. 23, 1953

FIG-1

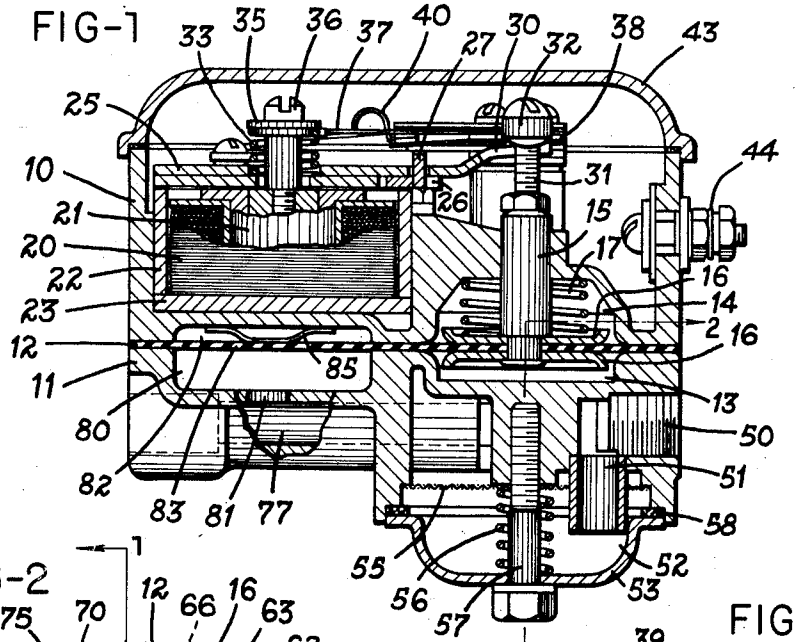


FIG-2

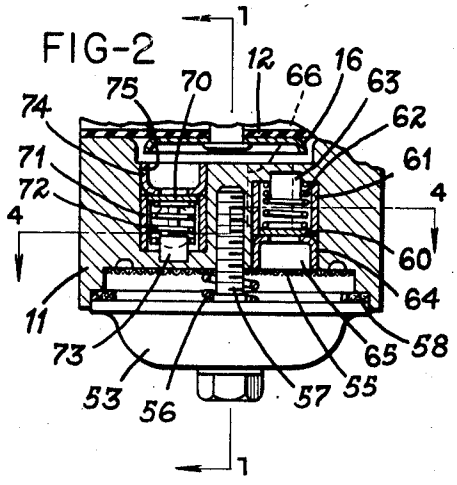


FIG-3

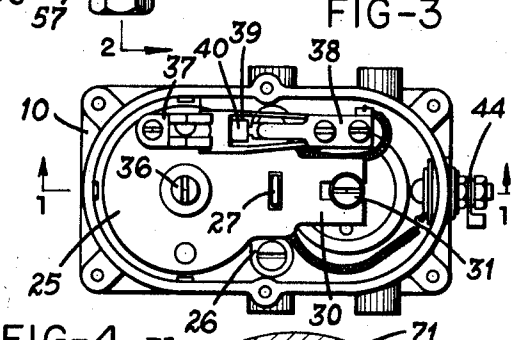


FIG-4

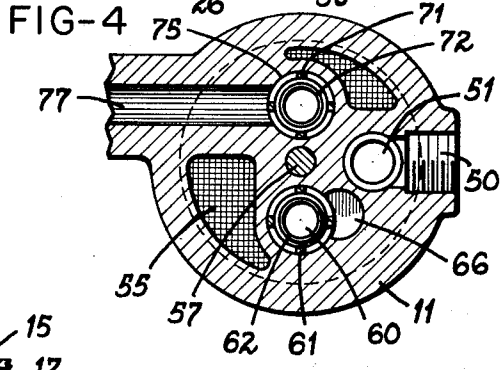
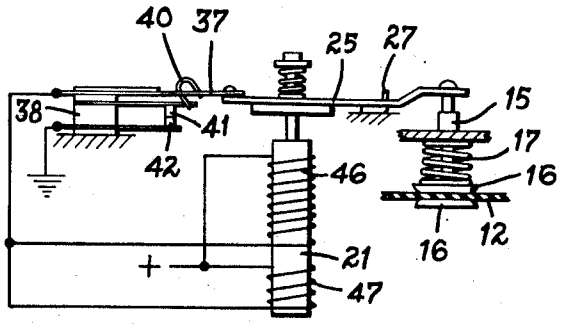


FIG-5



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ELECTROMAGNETIC POWER DEVICE

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12 Claims. (Cl. 310—18)

This invention relates to electromagnetically operated devices and for purposes of illustration will be hereafter described more particularly with reference to electromagnetically operated fluid pumps and the like.

Pumps operated electromagnetically are commonly known but have been found to be subject to difficulties with regard to uniformity of output, reliability under varying rates of delivery, as well as frequently encountering severe sparking and arcing conditions at the terminals. Due to the high inductance of the electromagnet circuit, the breaking of the circuit at the contact points can result in substantial tendency toward arcing, and this materially affects the life and usefulness of the device.

In accordance with the present invention, an electromagnetic pump is provided in which superior operating characteristics are achieved with more uniform delivery at all rates of operation, and in which the objectionable tendency toward arcing is effectively controlled. This is accomplished through the combined use of a particular arrangement of the energizing windings in association with the means for opening and closing the circuit thereto, as will be hereinafter more fully described.

It is accordingly the principal object of the invention to provide an electromagnetically operated pump adapted for example for supplying fuel to internal combustion engines and the like, which will operate smoothly and reliably over a wide range of feeding rates, which is largely free of pulsations in its output, and which is effectively and substantially free of objectionable arcing and sparking difficulties.

In the drawing—

Fig. 1 is a vertical section through the pump taken on the line 1—1 of Fig. 2 and also of Fig. 3;

Fig. 2 is a fragmentary section on the line 2—2 of Fig. 1;

Fig. 3 is a top view of the pump on a smaller scale and with the top cover removed;

Fig. 4 is a fragmentary section on the line 4—4 of Fig. 2; and

Fig. 5 is a schematic wiring diagram, wherein the contact assembly is shown on the opposite side for clarity of illustration.

Referring to the drawing, which illustrates a preferred embodiment of the invention, the pump housing **10** and the pump base **11** are held together by screws with a diaphragm **12** clamped therebetween, this diaphragm being formed of a synthetic rubber suitably resistant to the fluid to be handled by the pump. The pump base **11** and housing **10** are formed with opposed chambers **13** and **14** in which the diaphragm **12** is reciprocated by means of a diaphragm stud **15** having its lower end secured to the diaphragm by means of a pair of diaphragm washers **16**. The stud **15** is normally biased downwardly by means of a fairly heavy coil spring **17** located within the chamber **14**.

Reciprocation of the diaphragm stud **15** against spring **17** is effected by an electromagnetic motor having a

solenoid mounted in the pump housing **10** and including an operating coil **20** and a stationary core **21**, the solenoid being housed in a ring **22** and provided with a base plate or washer **23**. An armature plate **25** cooperates with the core **21** and is pivoted on a hinge member **26** which is mounted within the pump housing and includes an upwardly projecting tongue **27** fitting loosely within a complementary slot in the armature plate **25**. The armature plate **25** includes a forked arm **30** which is adjustably connected with the diaphragm stud **15** by an adjusting screw **31** provided with an insulating washer **32**.

The armature plate **25** can thus pivot with respect to the core **21**, and it operates against a spring **33** mounted on a spacer **35** secured to the core **21** by a screw **36**. The armature plate also carries a spring arm **37** mounted on a contact assembly **38** mounted within the pump housing and having an intermediate slot **39** in which is mounted a toggle spring **40**. A moving contact **41** is carried by the spring **40** for cooperation with fixed contact **42** mounted on the assembly **38**. These parts are all covered by the top cover **43** which is bolted on the pump housing **10**. This construction of switch mechanism provides for a substantial travel of the armature **25** both toward and away from core **21** before the switch operates, thus producing a working and a return pumping stroke of substantial extent without premature change in the conditions of energization of the electromagnet.

The current for the operating coil **20** on the core **21** is supplied by way of the terminal assembly **44** projecting from the housing **10**, and the circuit is completed to ground by contacts **41** and **42** through the pump housing. The coil **20** comprises a main energizing winding **46** and an auxiliary winding **47**, both of which are wound so that their effect is cumulative when they are energized from the supply line in parallel. The windings are not the same however, either in number of turns or in resistance. Thus the main winding **46** has the larger number of turns of heavier gauge wire so that it has less specific resistance, while the auxiliary winding **47** has a substantially lesser number of turns of wire which may be of smaller size and hence of higher specific resistance. The number of turns of the two windings respectively is the more important factor, and it has been found that preferred results are obtained where the main winding has about 230 turns with the auxiliary winding having from approximately 30 to 70 turns. As an example, highly satisfactory results were secured using a main winding of 230 turns of No. 21 wire and an auxiliary winding of 70 turns of No. 27 wire, this providing a satisfactory circuit for operation on 6 volts. For operation on a 12 volt line, the main winding may have 450 turns of No. 24 wire while the auxiliary winding is the same as before.

The effect of these windings in conjunction with the toggle operated switch contacts in the energizing circiut is generally as follows. When the switch contacts **41, 42** close, the armature occupies its most remote position away from the core, to which it is biased by spring **17**. Upon the closing of the switch contacts the two windings of the electromagnet are energized cumulatively and the armature is attracted and begins to move inwardly toward the core. This movement is transmitted to the pump diaphragm **12** and a working stroke ensues. Since a substantial travel of the armature occurs before the switch contacts open, a full pumping stroke is achieved, with highly effective pump operation in the delivery of the fuel. Finally, toward the end of the full pumping stroke, the toggle mechanism **40** trips the switch contacts open, and the armature is then allowed to begin its return stroke under the action of spring **17**. This return stroke likewise is of considerable extent, includ-

ing substantially a full travel of the pump diaphragm, before the switch contacts are reclosed by the toggle mechanism. In the meantime, and immediately upon opening of the switch contacts, the two windings on the armature are effectively connected in series opposition to each other. As the electromagnetic flux decays, cutting the turns in each of the two windings, two counter-electromotive forces are generated which directly oppose each other. Since the main winding has a larger number of turns, its counter-electromotive force prevails and forces a reverse flow of current through the auxiliary winding. As this current flows, it will oppose the collapse of the field and thus reduce the rate of its decay, and hence a change in the relative number of turns in the two windings will affect the induced voltages in both coils and the speed of collapse of the field. This likewise results in variation in the speed of operation of the device and the energy input into the armature as its stroke will be longer and the time interval greater with greater delay in the collapse of the field.

It is possible to substantially completely eliminate arcing at the contacts but it is found that some balance is usually preferred as between complete freedom from arcing and obtaining high operating efficiencies, a preferred range of the conditions for producing such results being described above.

By way of example, as showing the effect of varying the number of turns in the auxiliary winding, the use of a main winding of 230 turns with an auxiliary winding of 30 turns resulted in a flow of current of about 4 to 5 amperes total, a slow pumping rate, with practically no arcing and highly consistent performance. When the number of turns in the auxiliary winding was increased to 50, the total current varied from about 3 to 5 amperes, the pumping rate was faster, there was still practically no arcing and performance was quite consistent. With the turns increased to 70, the current varied from about 2 to 5 amperes, and the operating conditions were approximately the same with slightly more evidence of arcing. Further increase to 90 turns resulted in considerable arcing, which was still further increased when the number of turns was increased to 110. The operating conditions were studied both visually and by an oscilloscope with the result that the most consistent performance was found to occur with 30 turns in the auxiliary winding representing the greatest difference in number of turns from the main winding, but with some loss of efficiency. Use of the 50 turn winding with practically the same reliability and uniformity of operation resulted in about a 40% higher pumping rate while utilizing only about 78% of the current, thus achieving materially greater efficiency. The use of the larger number of turns, particularly the 90 and 110 turn coils showed that the energy formerly absorbed in the auxiliary winding was appearing largely at the contacts and in the latter case it appeared that the two coils were actually commencing to interchange their respective functions.

The effect of changing the wire size of the auxiliary winding with a corresponding change in its resistance was studied for the 50 turn winding and found to result in an increase from about 7 pulses per second with no added resistance and little or no visible arcing, up to about 10 pulses per second with excessive arcing when four ohms external resistance was included. From the above analysis it is evident that the most advantageous operating conditions from the standpoint of efficiency, speed of operation, reliability, and freedom from arcing are obtained not when the magneto-motive force of the auxiliary winding balances that of the main winding, but when a substantial unbalance occurs with the number of turns in the main winding being several times the number of turns in the auxiliary winding, and accordingly the invention provides for such relative selection of the respective numbers of turns as to produce the most desirable combination of effects for the particular application. It is found that the main winding should be predominant in its effect, such as to create the controlling electromotive force to cause the flow of current to reverse its direction of travel through the auxiliary winding, and with the resultant difference of voltage in the two coils being such as to cause an appreciable circulating current to flow in the series circuit of the two coils when the energizing circuit is disconnected, thus dissipating the energy of the electromagnetic field as an I^2R loss in such circuits where it can be radiated as heat over the relatively large area of such coils as distinguished from being concentrated in the small area of a spark developed at the point of separation of the contacts.

The fluid first enters the pump at the tapped inlet port **50** and flows downwardly through a tube **51** into a chamber **52** formed by the filter cover **53**. A filter screen **55** is mounted in the upper end of the chamber **52** and is held in place by a retainer spring **56** supported on the screw **57** by which the cover **53** is secured to the pump base **11**, a suitable gasket **58** being indicated as sealing the junction between the parts **11** and **53**.

Attraction of armature **25** causes the raising of stud **15** and when the pump diaphragm **12** is raised against spring **17**, it creates suction effective on a one-way inlet valve comprising a valve disk **60** reciprocable in a guiding cage **61** against a spring **62** provided with a guide **63**. The valve **60** normally closes the valve seat **64** which is of thimble shape and is force fitted in a bore **65** communicating directly at its lower end with the chamber **52** through the filter screen **55**. The fluid drawn through the bore **65** when valve **60** is opened flows upwardly through the top and sides of the cage **61** into a bore **66** which is in laterally offset and connecting relation with the bore **65** and which communicates directly at its upper end with the chamber **13**.

The outlet valve from the chamber **13** is similar to the inlet valve but is arranged in the reverse direction. It includes a valve disk **70** reciprocable in a cage **71** against a spring **72** having a guide **73**. The valve **60** normally closes the valve seat **74** fitted in a bore **75** opening downwardly from the chamber **13**, and this bore **75** connects below the seat **74** with the outlet passage **77** in pump base **11**. When the solenoid **20—21** is deenergized, the diaphragm **12** and stud **15** are forced downwardly by spring **17**, and the resulting pressure in chamber **13** closes valve **60**, opens valve **70**, and forces the fluid in the chamber **13** through bore **75** and cage **71** into the outlet passage **77**.

Special provision is made within the pump assembly for damping out pulsations which might otherwise occur in the flow of fluid from the pump. Referring to Fig. 1, the pump base **11** is formed with a chamber **80** of substantial volume, and this chamber connects through a port **81** with the fluid outlet passage **77** to form a surge chamber. A similar chamber **82** is formed in the lower face of the pump housing **10** and is separated by the diaphragm **12** from the surge chamber **80**. This chamber **82** is filled with air for cooperation with the diaphragm **12** to form an air cushion compensating for changes in the effective volume of the surge chamber **80**. If desired, a spring may also be employed in the air chamber **82** to assist in damping out pulsations in the fluid discharged, and such a spring is indicated at **85** in the form of a leaf spring having a normally bowed shape. The use of such a spring has been found desirable where maximum capacity is desired for the pump, since it has been found to increase the total capacity of the pump as compared with its operation in the absence of a spring **85** in the air chamber.

It will thus be evident that the present invention provides an electromagnetic fluid pump which is efficient and reliable in operation, which will deliver the fluid

smoothly and without objectionable pulsations, and which is substantially free of arcing or burning conditions at the contacts while accomplishing the full and even pump operation desired.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. An electromagnetic motor for operating a reciprocating fluid pump, said motor comprising an electromagnet having a core and an armature movable in translation for actuation of said pump, a pair of windings on said core including a main and auxiliary winding connected in parallel and having a substantially different number of turns, switch means for controlling the supply of current to said windings for cumulative magnetizing action when energized and for opposing each other when deenergized with the effect of said main winding predominating over that of said auxiliary winding, and operating connections between said armature and said switch means providing for actuation of said switch means only after substantial movement of said armature in each direction.

2. An electromagnetic motor for operating a fluid pump comprising an electromagnet having a core and an armature movable in translation for actuation of said pump, windings on said core including an auxiliary winding and a main winding having several times the number of turns as said auxiliary winding, said windings being connected in a cumulative arrangement to jointly attract said armature, and switch means for interrupting the supply of current to said windings with said main winding producing a flow of current in the reverse direction through said auxiliary winding resulting in dissipation of the magnetic field energy in heat.

3. An electromagnetic motor for operating a reciprocating fluid pump comprising an electromagnet having a core and an armature movable in translation for actuation of said pump, windings on said core including an auxiliary winding and a main winding having several times the number of turns as said auxiliary winding, said windings being connected in a cumulative arrangement to jointly attract said armature, switch means for interrupting the supply of current to said windings with said main winding producing a flow of current in the reverse direction through said auxiliary winding resulting in dissipation of the magnetic field energy in heat, and means for operating said switch means from said armature only following substantial movement of said armature in each direction.

4. An electromagnetic motor for operating a fluid pump comprising a housing, an electromagnet in said housing having a core and an armature movable in translation for actuation of said pump, windings on said core including an auxiliary winding and a main winding having several times the number of turns as said auxiliary winding, said windings being connected in a cumulative arrangement to jointly attract said armature, switch means for controlling the supply of current to said windings, and toggle connections between said armature and said switch means providing for opening and closing of said switch means following substantial travel of said armature.

5. An electromagnetic motor for operating a fluid pump, said motor comprising an electromagnet having a core and an armature movable in translation for actuation of said pump, windings on said core for magnetizing the same to attract said armature including a main winding having a relatively large number of turns and relatively low resistance and an auxiliary winding having a smaller number of turns and greater resistance, and switch means movable with said armature for connecting said windings in parallel to a supply source and for disconnecting said windings from said source leaving them in series with each other to dissipate the energy of the magnetic field by circulating currents therethrough.

6. An electromagnetic motor for operating a reciprocating fluid pump comprising a housing, an electromagnet in said housing having a core and an armature movable in translation for actuation of said pump, windings on said core for magnetizing the same to attract said armature including a main winding having a relatively large number of turns and relatively low resistance and an auxiliary winding having a smaller number of turns and greater resistance, switch means movable with said armature for connecting said windings in parallel to a supply source and for disconnecting said windings from said source leaving them in series with each other and adapted to dissipate the energy of the magnetic field by circulating currents therethrough, and toggle connections between said armature and said switch means providing for opening and closing of said switch means following substantial travel of said armature.

7. An electromagnetic motor for operating a fluid pump comprising a housing, an electromagnet in said housing having a core and an armature movable in translation for actuation of said pump, windings on said core for energizing the same including a predominant main winding and an auxiliary winding having a substantially lesser number of turns connected in parallel with said main winding, and switch means movable with said armature for controlling the energizing and deenergizing of said windings with said main winding causing a reverse current to flow through said auxiliary winding upon the deenergizing of said windings and the collapse of the electromagnetic fields thereof.

8. An electromagnetic motor for operating a fluid pump comprising a housing, an electromagnet in said housing having a core and an armature movable in translation for actuation of said pump, windings on said core for energizing the same including a predominant main winding and an auxiliary winding having a substantially lesser number of turns connected in parallel with said main winding, switch means movable with said armature for controlling the energizing and deenergizing of said windings with said main winding causing a reverse current to flow through said auxiliary winding upon the deenergizing of said windings and the collapse of the electromagnetic fields thereof, switch means for controlling the supply of current to said windings, and toggle connections between said armature and said switch means providing for opening and closing of said switch means following substantial travel of said armature.

9. An electromagnetic motor for driving a fluid pump comprising a housing, an electromagnet in said housing having a core and an armature movable in translation for actuation of said pump, a pair of windings on said core including a main winding having a relatively large number of turns and an auxiliary winding having a relatively small number of turns, said windings being connected in parallel and arranged to suppress arcing upon the opening of the circuit, switch means for controlling the supply of current to said windings, and toggle connections between said armature and said switch means providing for rapid actuation of said switch means only after substantial travel of said armature toward and away from said core.

10. An electromagnetic motor for driving a fluid pump comprising a housing, an electromagnet in said housing having a core and an armature movable in translation for actuation of said pump, a pair of windings on said core including a main winding having low specific resistance and an auxiliary winding having a lesser number of turns with higher specific resistance, said windings being connected in parallel and arranged to suppress arcing upon the opening of the circuit, switch means for controlling the supply of current to said windings,

and toggle connections between said armature and said switch means providing for rapid actuation of said switch means only after substantial travel of said armature toward and away from said core.

11. An electromagnetic operating means comprising a housing, an electromagnet in said housing having a core and an armature, an operating element, means connecting said element with said armature for operation in response to the movement of said armature, a pair of windings on said core including a main winding having a relatively large number of turns which has a lesser specific resistance and an auxiliary winding having a relatively small number of turns which has a greater specific resistance, said windings being connected in parallel for simultaneous energization and upon the opening of the energizing circuit producing two counter electromotive forces, switch means including contact points for controlling the supply of current to energize said windings cumulatively when closed and for opposing each other when open, and connections between said armature for said switch means which provide rapid actuation of said switch means only after substantial travel of said armature toward and away from said core whereby upon the opening of said energizing circuit the larger induced electromotive force of said main winding will cause a flow of current through said auxiliary winding in the reverse direction to the energizing current and tend to oppose a rapid collapse of the field to thus prevent the generation of a high voltage arc across said contact points.

12. An electromagnetic operating means comprising a housing, a chamber in said housing, a driven device in said chamber, an electromagnet in said housing having a core and an armature, means for connecting said armature with said driven device for operation of the device in response to the movement of said armature, a pair of windings on said core including a main winding having a relatively large number of turns and an auxiliary winding having a relatively small number of turns, said windings being connected in parallel and arranged to suppress arcing upon the opening of the circuit, switch means for controlling the supply of current to said windings for cumulative magnetization when energized and for opposing each other when deenergized, and connections between said armature and said switch means providing for rapid actuation of said switch means only after substantial travel of said armature toward and away from said core.

References Cited in the file of this patent

UNITED STATES PATENTS

1,713,073	Carter	May 14, 1929
1,737,387	Redmond	Nov. 26, 1929
1,885,436	Hampton	Nov. 1, 1932
2,631,250	Parker	Mar. 10, 1953
2,637,679	Walker	May 5, 1953

FOREIGN PATENTS

467,199	Great Britain	Dec. 14, 1936

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,835,831 May 20, 1958

Lester B. Harrington

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, line 26, for the patent number "2,637,679" read

-- 2,637,769 --.

Signed and sealed this 15th day of July 1958.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

UNITED STATES PATENT OFFICE

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