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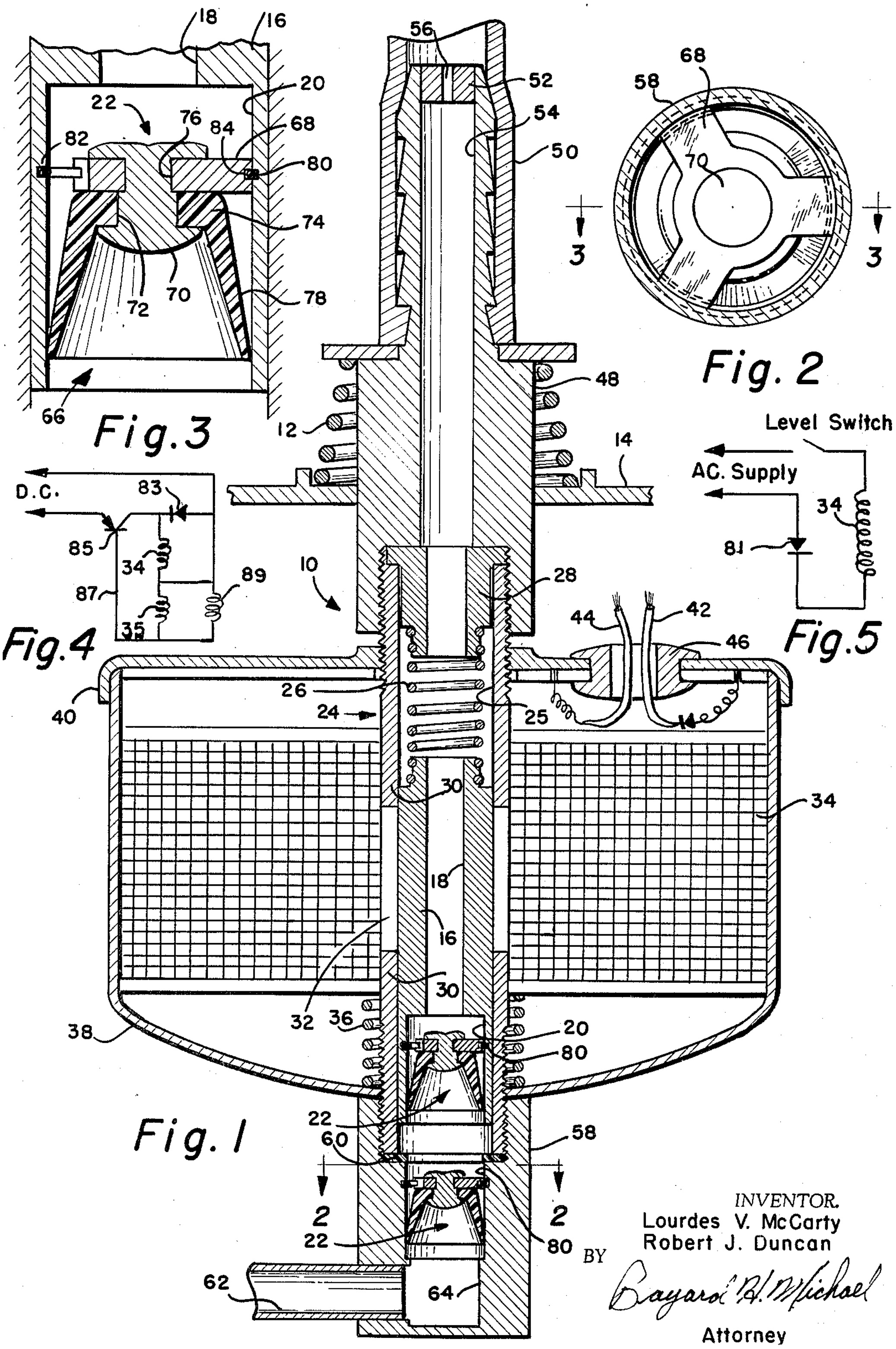

Fig. 3

Fig. 2

Fig. 4

Fig. 5

Fig. 1

INVENTOR.
Lourdes V. McCarty
Robert J. Duncan
BY Bayard H. Michael
Attorney

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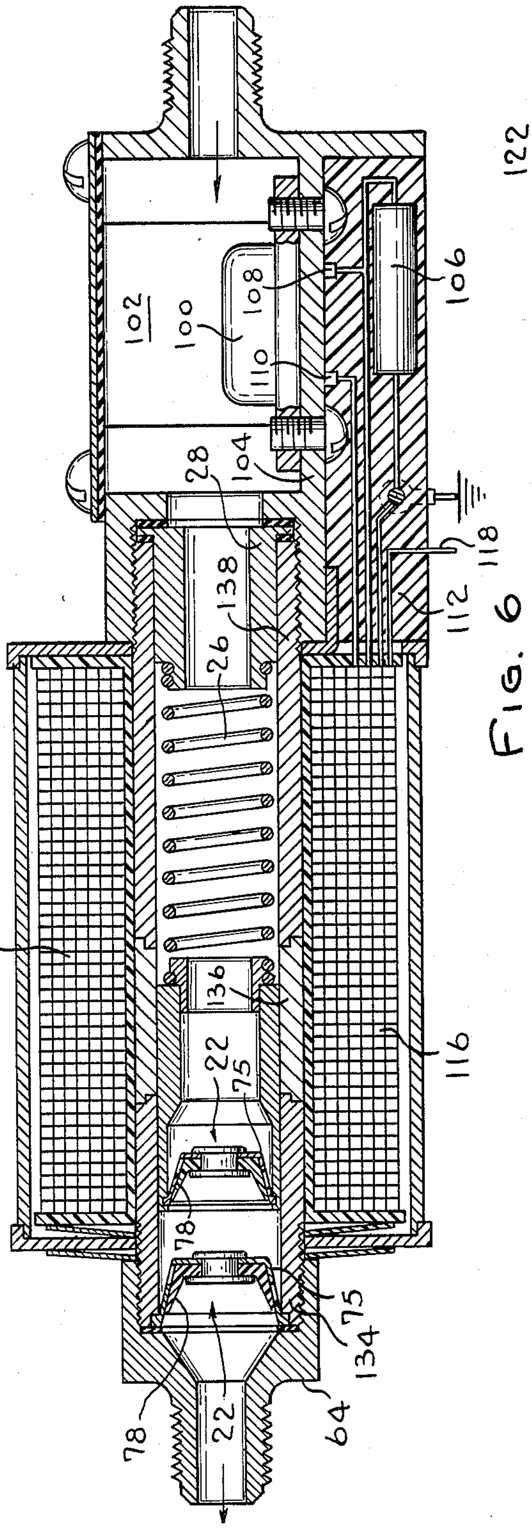

FIG. 6

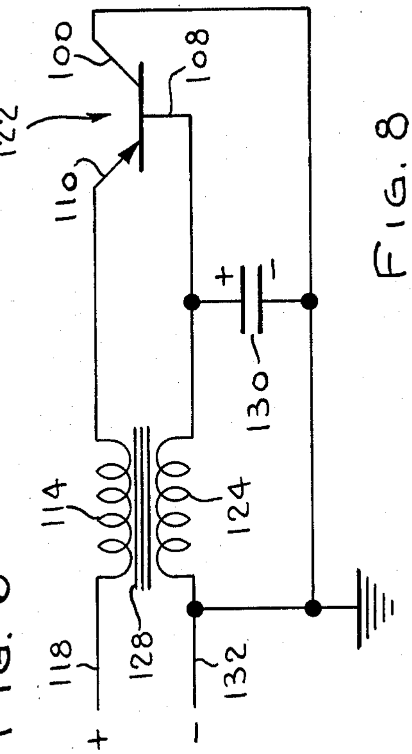

FIG. 8

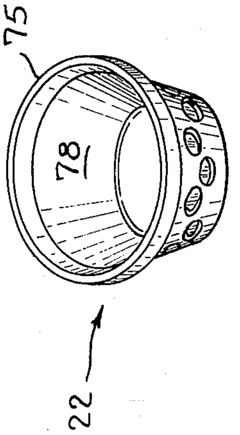

FIG. 7

INVENTORS
LOURDES V. McCARTY
ROBERT J. DUNCAN

BY Bayard H. Michael
ATTORNEY

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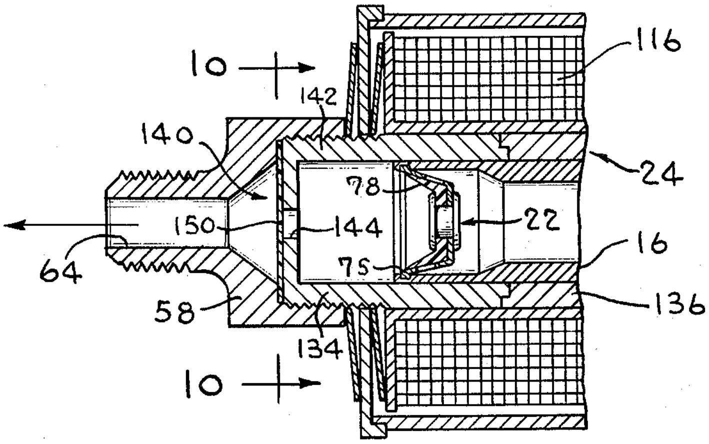

FIG. 9

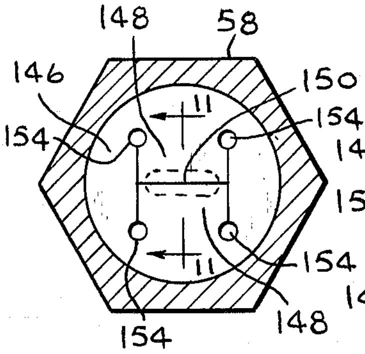

FIG. 10

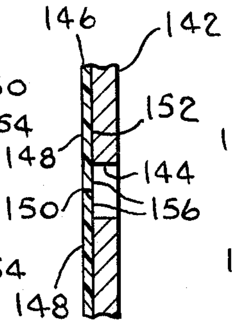

FIG. 11

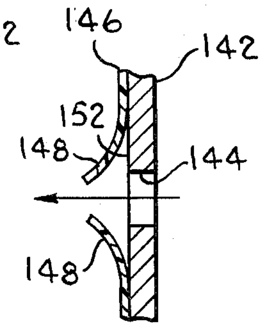

FIG. 12

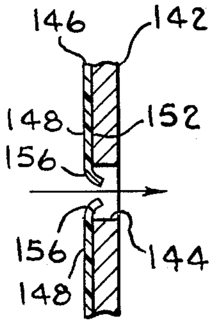

FIG. 13

INVENTORS
LOURDES V. McCARTY
ROBERT J. DUNCAN
BY Bayard H. Michael
ATTORNEY

3,250,219

PUMP

Lourdes V. McCarty, Milwaukee, and Robert J. Duncan, Delafield, Wis., assignors to Controls Company of America, Melrose Park, Ill., a corporation of Delaware

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8 Claims. (Cl. 103—53)

This invention relates to electromagnetic fluid pumps.

This application is a continuation-in-part of and a substitute for our application Serial No. 280,480, now abandoned, filed April 22, 1963, which in turn is a continuation-in-part of our application Serial No. 201,033, now abandoned, filed June 8, 1962.

The principal object of this invention is to improve the performance and reliability of electromagnetic fluid pumps.

Another important object is to provide an electric fuel pump which can be operated on A.C. or D.C. power supply.

A further object is to provide an electric fuel pump which automatically varies the pump stroke to compensate for changes in pressure or rate of discharge.

A further object of this invention is to provide means for limiting the maximum output pressure of a fuel pump to a predetermined amount.

Still another object is to provide a valving arrangement for such pumps which insures extremely long life and rapid valve response giving a high output for a given pump.

A further object is to provide a quiet electric fuel pump.

A further object is to provide an electronic power supply for an electric fuel pump and to provide for cooling of the power supply.

Still another object is to provide an electric fuel pump which has no metal-to-metal valve seating or sliding motion of the valves thereby insuring quiet operation and long life.

Other objects and advantages will be pointed out in or be apparent from the specification and claims, as will obvious modifications of the embodiments shown in the drawings in which:

FIG. 1 is a side view in section of the pump;

FIG. 2 is a view taken on line 2—2 of FIG. 1 showing one of the valves;

FIG. 3 is a view taken on line 3—3 of FIG. 2 showing one of the valves mounted in the piston;

FIG. 4 is a view of a D.C. circuit diagram;

FIG. 5 is a view of an A.C. circuit diagram;

FIG. 6 is a section through an improved pump;

FIG. 7 is a perspective view of a valve and its support basket; and

FIG. 8 is a circuit diagram of a simplified power supply for D.C. operation.

FIG. 9 is a fragmentary cross sectional view of a fuel pump showing a modified version of the discharge valve assembly;

FIG. 10 is an enlarged cross sectional view of the discharge valve assembly taken on line 10—10 of FIG. 9;

FIG. 11 is a view of the discharge valve assembly taken on line 11—11 of FIG. 10 showing the valve in the closed position;

FIG. 12 is a view similar to FIG. 11 showing the valve in its normal open position; and

FIG. 13 is a view similar to FIG. 11 showing the valve in a position when the pump's output pressure is at a predetermined level.

Referring to the drawings, a pump 10 is shown resiliently mounted by means of spring 12 in housing 14 for a fluid reservoir (not shown). The pump includes an electromagnetic coil 34 mounted on tube 24 which is screwed into inlet section 48. The flange of cylindrical cap 28 is held between the tube and inlet section. Piston 16 is suspended within passage 25 in tube 24 by means of spring 26 which is secured to the cylindrical cap and to the upper threaded end of the piston. The piston has a central passage 18 which is enlarged at 20 to support a cup type valve assembly 22. The cylindrical tube has magnetic sections 30 at each end separated by a nonmagnetic section 32. The piston is suspended out of line with the magnetic sections and will move into alignment with the magnetic sections when an electric field is set up in the coil. Spring 26 is compressed by the upward motion of the armature and will force the armature downward when the coil is de-energized.

The coil is mounted on the tube on spring 36 within casing 38. Cover 40 is sealed to the top of the casing and cylindrical tube to prevent any fluid from entering the casing. Coil terminals 42 and 44 are sealed in gasket 46 in the cover and are connected to either a D.C. power source (FIG. 4) or an A.C. power source (FIG. 5). Inlet section 48 is connected to a source of fluid (not shown) by a flow line 50. A disc 52 having a restricted orifice 56 is mounted in the upper end of passage 54 to limit the hammering effect of the fluid as it flows through the line. The lower end of tube 24 is threaded into outlet section 58 and sealed therein by gasket 60. A second cup-type valve assembly 22 is mounted in passage 64 in the outlet section to control the flow of fluid through outlet section to outlet tube 62.

The valve assemblies in the piston and outlet section are interchangeable and, as seen in FIGS. 2 and 3, include a resilient cup-type valve 66 made of a rubber type material such as Thiokol, mounted on a three-legged spider 68 by means of a rivet 70 which passes through hole 72 in head 74 of the cup and hole 76 in the spider. The valve has a flange 78 which flares outward from the head and is tapered to provide a greater degree of resilience at its lower end. The assembly is held in the piston and outlet section by a snap ring 80 positioned in grooves 82 and engageable with groove 84 at the end of each leg of the spider. The lower end of the flange of the valve engages the inside surface of the passage so that any upward surge of fluid will tend to expand the flange preventing fluid flow in the passage. It should be noted that the valve assembly is mounted within the passage in the piston (FIG. 3) so that it is not subject to any sliding contact with the surfaces of the flow passages when the piston is reciprocated.

When the piston moves upward, fluid in the passages above the piston will flow past the outer surface of the flange of the valve in the piston due to the difference in pressure between fluid in the passage in the piston and the space in the outlet end of passage 25. This upward motion also creates a drop in pressure in the space between the piston and the lower valve assembly. When the piston moves downward, the fluid between the valve assemblies will be compressed, the increase in fluid pressure closing the valve in the piston and opening the valve in the outlet section and forcing fluid into the outlet tube. Rapid reciprocation of the piston will produce a practically continuous flow of fluid in the outlet tube. The valve assemblies are positioned on the outlet side of the pump rather than the inlet side so that they will be immersed in fluid if the pump is housed within a fluid reservoir thus eliminating the possibily of drying out.

In operation, and using a D.C. circuit such as shown in FIG. 4, the coil is energized when sufficient current passes through resistance 89 and base circuit 87 to cause transistor 85 to become fully conductive. The flow of current through coil 34 will induce current in coil 35 which will reverse the bias in base circuit 87 stopping current flow through the transistor and coil 34. A pulsing effect is thereby created in the solenoid coil which reciprocates the piston. Diode **83** may be used if desired. On the upward motion of the piston spring **26** will be compressed and on de-energizing of the coil will force the piston down. The spring will limit the downward motion of the piston preventing bottoming of the piston in the tube on the downward stroke. The pump is therefore substantially noiseless in operation.

If an A.C. source is used with the system a circuit as shown in FIG. 5 is connected to the coil terminals. Diode **81** is connected in the line to rectify the A.C. current to intermittently energize the coil of the pump either on the positive or negative pulse.

The valves in the embodiment of FIG. 1 tend to collapse upward when discharging against a substantial pressure and this flexure, of course, is detrimental to the material itself and also occasions rubbing against the bores in which the valves are mounted. While the valve life is satisfactory for some uses it was marginal for other uses. The valve construction in FIGS. 6 and 7 is a great improvement in that the perforated support basket **75** prevents collapse under pressure. In this embodiment the two valves are not equally sized but the operational principles are the same. The valve life is at least tripled by this arrangement.

The second embodiment (FIG. 6) is fabricated to mount the transistor **100** in inlet chamber **102** so the flowing fuel will cool the transistor. This transistor is a PNP in which the collector is connected to the case which is directly mounted on and hence electrically grounded to the case **104** to suit the pump for simple use in automotive applications. The capacitor **106** and the base **108** and emitter **110** are potted in encapsulant **112**. If desired, a filtering screen may be mounted in the inlet chamber **102**.

The pump operates well on the circuit of FIG. 8. Here the primary **114** of coil **116** is connected between the positive lead **118** of an automotive battery and the emitter **110** of transistor **122** (2N511B) while the secondary **124** is connected between the base **108** and ground. When the iron **128** in the coil approaches saturation the current in secondary **124** changes direction to bias the base to cut-off whereupon the current collapses and the coil is de-energized. The current will then build up again and repeat so the coil is pulsed to rapidly actuate the plunger. Capacitor **106** between the collector **100** and base aids in wave shaping and determining the on-to-off timing of the pulses. This circuit is grounded as in automotive uses but if not used in automotive then the ground connection is eliminated, the negative connection to the battery being through lead **132**.

The second embodiment is an improvement over the first primarily in the construction of the valves which virtually eliminates wear and insures an extremely long life coupled with very fast response characteristics made possible by reason of the very thin wall sections which may be employed in conjunction with the valve and the support basket. The second embodiment also has advantage in that provision is made for cooling the transistor to insure long component life. It will be noted this version does not employ the restrictor found in the first embodiment at **52**. This results in some very slight increase in the sound level of the pump but not enough to be significant.

Both embodiments are completely free of switching devices which add to the cost and reduce the reliability of pumps of this general variety. Furthermore, this eliminates a source of noise. It will be noted that there is no limit on either direction of motion of the plunger and this is significant both from the standpoint of reducing noise and from the standpoint that the present construction allows the plunger to have a variable stroke dependent upon the delivery conditions, that is, the rate of usage and the pressure at the output. If the rate of usage is substantially as rapid as the pumping capacity of the

pump and the output pressure is reasonably low the pump will stabilize itself with a fairly uniform stroke of length which will depend, of course, upon the frequency of energization, characteristics of the return spring **21**, etc. If now the output is restricted to cause the rate of consumption to go down and the pressure to go up the stroke of the plunger will decrease until finally the stroke will be reduced to a very slight amount found when the output is completely closed off, at which time there will still be some motion which is, in effect, determined by the compressibility of the liquid. This variable stroke has some additional advantage in that when the pump is dry and must be primed the stroke will increase very substantially which makes this pump much easier to prime than other pumps found in the art. Furthermore, this renders this pump far superior in breaking a vapor lock, although this pump, just as any pump, can be vapor locked under the proper temperature conditions.

A further feature of interest in both of these constructions is the manner in which the central tube or conduit **24** is formed. In the first embodiment the central nonmagnetic section **32** separates the two end sections **30, 30** which are magnetic. In the second embodiment a comparable construction is employed with the nonmagnetic section **136** separating the two end pieces **134, 138.** Now, then, in the prior art the usual construction would be to put in a nonmagnetic sleeve throughout the length of the bore of the coil and on the outside of this sleeve there would be pieces corresponding to the pieces **30, 30** or to the pieces **134, 138.** This builds in an air gap which cannot be reduced, that is, the magnetic pieces are separated from the magnetic plunger at all times by the thickness of the interior sleeve. The present construction, however, eliminates this air gap and permits a much closer magnetic coupling with the result that a smaller coil can be used.

The embodiment disclosed in FIGS. 9–13 is a modification of the above described fuel pump and is particularly intended for applications in which it is desired that the output pressure of the pump does not exceed a predetermined amount. The maximum output pressure of pumps of this type is usually attained when fuel flow is at a minimum or nearly stopped, as for example, during slow idling of an internal combustion engine. During such times the stroke of the plunger is reduced to a small length; however, the reciprocation of the piston is sufficient to build up and maintain an appreciable output pressure. In fuel pumps employing two check valves as shown in the embodiments of FIGS. 1 and 6 a maximum output pressure of 9 p.s.i. has been attained in automotive applications. In order to reduce this maximum output pressure one of the cup type check valves of the aforedescribed fuel pumps is deleted and the valve assembly **140** is substituted therefor. The assembly **140** is operable to permit fuel flow in the direction towards the outlet and to block flow in the opposite direction up to a predetermined pressure differential and to permit flow in such opposite direction at the predetermined pressure differential. Because of such substitution the valve assembly **140** will cooperate with the check valves **22** in essentially the same manner as the heretofore described pumps, yet will limit the maximum output pressure to a predetermined amount by virtue of permitting the bleed back or flow in the opposite direction at a predetermined output pressure.

In the illustrated embodiment the valve assembly **140** has been substituted for the cup-type check valve which was mounted in the discharged end of the tube **24**. The check valve **22** mounted in the piston **16** is of the same design and has the same function as that of the embodiment shown in FIG. 6.

The valve assembly **140** is comprised of a valve seat member **142** which can either be integral with the end piece **134**, as shown, or be separate therefrom and be retained in the outlet section **58** by virtue of abutment against the end piece or similar means. The valve seat member is provided with an elliptical orifice **144**. A valve **146** comprised of a sheet of resilient material having an H formed slit which defines flap members **148** which form at their abutting edges a seam **150** over the longitudinal axis of the elliptical orifice. The valve is mounted against the face section **152** of the valve seat member. Apertures **154** are provided at the end of the slits for the purpose of avoiding tearing of the resilient valve during its actuation.

The normal position of the valve is shown in FIG. 11 in which the flaps **148** overlie the orifice **144** and are positioned against the face section **152** of the valve seat member. With only a nominal pressure drop across the valve in a direction of normal fuel flow (indicated by arrow in FIG. 9) the flap members **148** move to the position indicated in FIG. 12 and permit fuel flow through the orifice **144**. In normal operation of this pump this of course occurs when the piston **16** is advanced towards the valve assembly **140**. During the return stroke the flaps assume the overlying position shown in FIG. 11 and block fuel flow through the orifice. However, when the output pressure of the pump (pressure on the output side of valve **146**) reaches a level which is sufficient to overcome the resiliency of the portion **156** which portions overlie the orifice, the pressure differential causes these portions to bend inwardly as shown in FIG. 13 and to thereby permit fuel flow in a direction opposite to normal fuel flow. The effect of this is of course that a predetermined output pressure of the valve **146** ceases to function as a check valve by virtue of permitting fuel flow from its output side to its input side, and thereby limits the maximum output pressure of the pump.

The particular maximum output pressure at which the portions **156** of the valve will bend inwardly towards the orifice of course depends upon the resiliency of the valve material, the size of the orifice, and the size of the portions **156** of the flaps. However, it is thought that the determination of the particular maximum output pressure lies within the realm of experimentation when made in view of the above disclosure.

The present pump is much quieter and far more reliable than previous electric fuel pumps and is, therefore, capable of use as a replacement part in older vehicles as well as being usable in new vehicles. As a matter of fact, four models [two 6-volt (one positive and one negative ground) and two 12-volt (one positive and one negative ground)] would take care of virtually any automobile in the world and would save the tremendous problem created by the fact that there are now well over 100 different types of fuel pumps necessary to handle the original and replacement part business. In addition to these advantages the present pump can be manufactured for a cost quite competitive with prior types.

Although this invention has been illustrated and described in connection with particular embodiments thereof, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

We claim:

1. A fuel pump including a coil, a conduit through the coil, a hollow magnetic plunger in the conduit, a spring biasing the plunger away from the magnetic center of the coil, the plunger being movable towards said center when the coil is energized, a check valve both in the plunger and in the conduit, the check valves cooperating to limit the stroke of the plunger in accordance with the output conditions of the pump, and a power supply providing a pulsed D.C. voltage to the coil; and a transistor in the power supply and located in the fuel path through the pump.

2. A pump according to claim **1** in which the coil comprising a primary, a secondary, and a coil iron in which the secondary of the coil is located in the base circuit of the transistor to bias the transistor to cut-off as the iron in the coil reaches saturation.

3. A pump according to claim **2** in which the transistor emitter is in circuit with the coil primary and the collector of the transistor is grounded.

4. A flow control device comprising, a conduit, a plunger slidably mounted in the conduit and having a bore therethrough, a valve member fixed in the bore and having a generally conical flexible skirt flaring outward to contact the bore to check flow in one direction and collapsible to permit flow in the other direction, the bore being of such dimension as to prevent the skirt from coming into contact with the conduit when the skirt is flared out.

5. A device according to claim **4** in which the plunger is magnetic and including a coil for actuating the plunger in one direction, and a spring for moving the plunger in the other direction.

6. A device according to claim **5** including a check valve in the conduit.

7. A device according to claim **4** including a support basket having holes therethrough and cooperating with the valve to prevent collapse thereof when the valve operates to check flow.

8. An electric fuel pump according to claim **1** wherein said valve at the outlet of the pump is comprised of resilient flaps overlying and closing the orifice and being operable to move away from said valve seat member in response to fuel flow in a direction towards said outlet to thereby permit fuel flow through said passage, being operable to move towards said orifice to expose a space between said flaps in response to said output pressure of said predetermined amount to thereby permit flow in said opposite direction.

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ROBERT M. WALKER, *Primary Examiner.*