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2 Sheets-Sheet 1

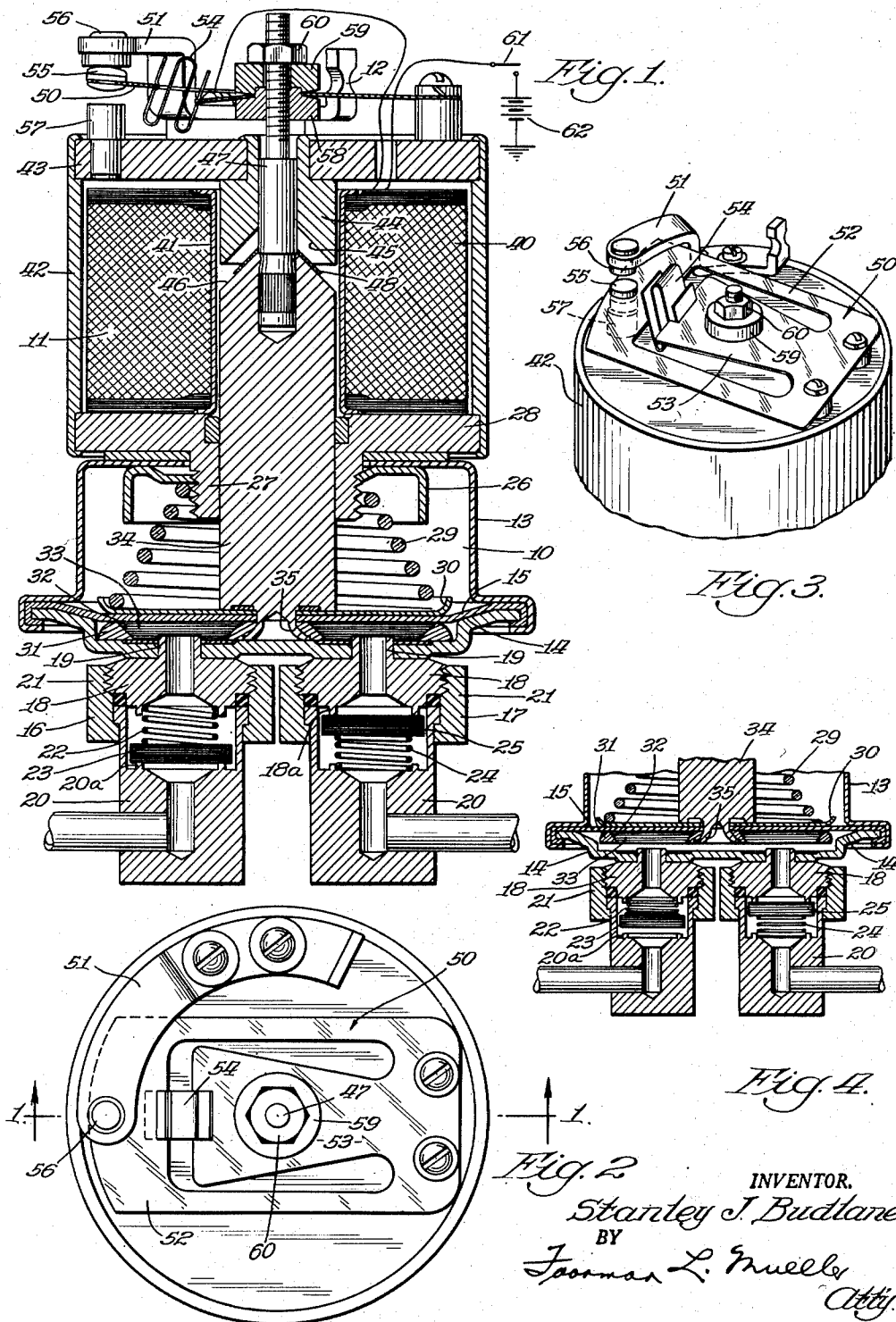


Fig. 2

Fig. 4.

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2 Sheets-Sheet 2

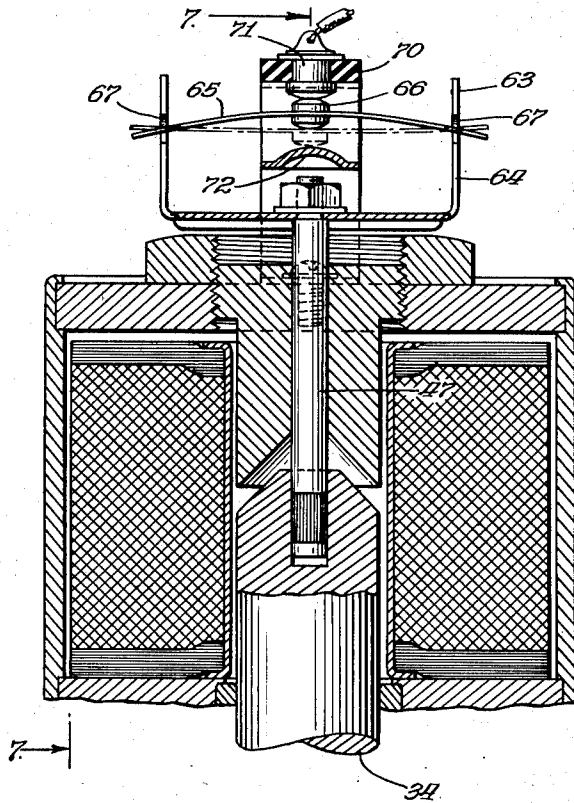


Fig. 5.

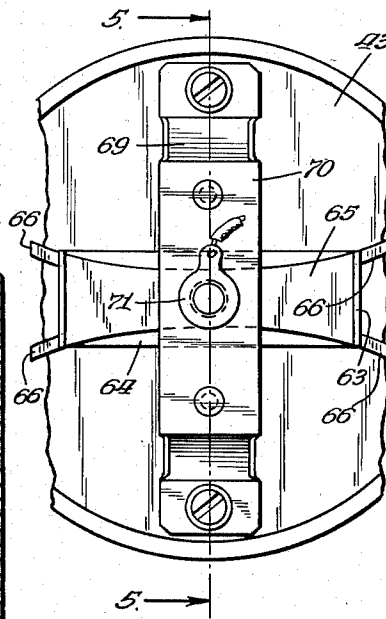


Fig. 6.

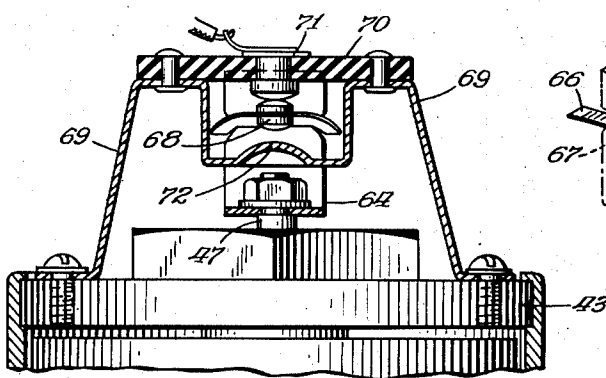


Fig. 7.

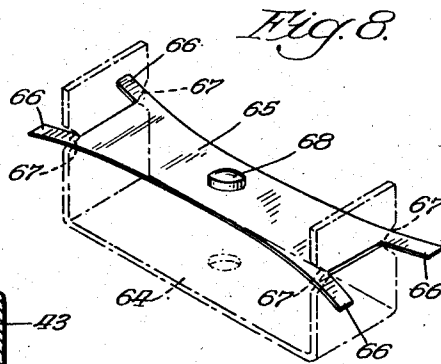


Fig. 8.

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UNITED STATES PATENT OFFICE

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This invention relates generally to fuel supply means and in particular to an electrically operated pump for supplying liquid fuel to a heater, internal combustion engine, or other liquid fuel consuming devices.

In the prior art, electrically operated fuel pumps of various designs have been constructed for supplying gasoline or other liquid fuel to heaters, internal combustion engines and similar devices. Although such devices have been generally satisfactory, the structures have been larger and more complicated than desirable and accordingly have been difficult and relatively expensive to manufacture. Also in such devices the electrical driving means has been rather inefficient, requiring heavy current drain. This is a particularly important feature in pumps used on automobiles, as the amount of electrical power available for operating the various electrical accessories thereof is limited by the storage battery of the vehicle. The inefficiency of prior pumps has been due to a large extent to the switching arrangement which normally applies more power to the actuating device than is actually required.

Another problem encountered in the design of fuel pumps is that most pump structures are inherently adaptable for providing a constant rate of fuel flow therefrom. In many fuel consuming devices the rate at which fuel is used depends upon the operating conditions, as, for example, in internal combustion engines the amount of fuel required depends upon the speed of the engine, and in heating devices the amount of fuel required depends upon the heat output thereof. To provide a fuel pump suitable for such applications the pump must be able to provide a steady flow of fuel, free of air bubbles, with the rate of fuel flow being variable to meet the needs of the consuming device. Also it is desirable in usual applications that the fuel pump act as a valve to prevent flow of fuel from the fuel supply source to the device when the pump is not operating.

It is, therefore, an object of the present invention to provide an improved electrically operated fuel pump which is of simple construction.

It is another object of this invention to provide a fuel pump which is capable of supplying fuel to a consuming device at the rate required by said device and in a continuous flow free of air bubbles.

It is a further object of this invention to provide a fuel pump including means inherent therein for preventing the flow of fuel from the fuel source to a consuming device when the pump is not operating.

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A feature of this invention is the provision of a solenoid operated diaphragm type pump having a switch operably connected to the diaphragm and arranged to energize the solenoid during a short portion of each cycle of the pump to provide a fast intake stroke, the pump including a spring acting on the diaphragm to supply fuel to a consuming device at the rate required thereby.

A further feature of this invention is the provision of a solenoid operated pump including an improved snap-action switching unit which is of simple construction and provides efficient operation of the pump.

A still further feature of this invention is the provision of a fuel pump having a fuel cavity therein which is completely sealed so that the pump provides a continuous flow of fuel free of air bubbles.

Yet another feature of this invention is the provision of a diaphragm type pump in which members for sealing the intake and exhaust openings of the pump are secured to the diaphragm and are effective to seal the openings when the pump is not operating.

Further objects, features and advantages will be apparent from a consideration of the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a cross-sectional view of the pump in accordance with the invention;

Fig. 2 is a top view of a portion of the pump showing the switch structure;

Fig. 3 is a perspective view of the switch structure of Fig. 2;

Fig. 4 is a cross-sectional view of the valve structure of Fig. 1 showing the diaphragm and valves in a different position;

Fig. 5 is a cross-sectional view showing a pump in accordance with the invention having a modified switch structure;

Fig. 6 is a top view of the pump in accordance with Fig. 5;

Fig. 7 is a cross-sectional view along the lines 7—7 of Fig. 5; and

Fig. 8 is a perspective view of the switch contact member of Fig. 5.

In practicing my invention I provide a solenoid operated diaphragm type pump in which a chamber of varying volume is formed between the diaphragm and a housing member. The housing member includes a valve for allowing entry of fuel into the chamber and a second valve for permitting the flow of fuel from the chamber to a fuel consuming device. A solenoid unit is provided for actuating the diaphragm to draw fuel into the chamber and a spring opposes the action of the solenoid to force fuel through the second

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valve out of the chamber. A snap-action switching mechanism is provided for intermittently connecting the solenoid to a source of electrical power, the switch contacting member being arranged to move the diaphragm. The solenoid unit is arranged to operate the diaphragm very fast to provide a fast intake stroke and the spring then forces the diaphragm against the housing to feed fuel to the fuel consuming device at the rate required thereby. Resilient members for sealing the intake and exhaust openings in the housing are secured to the diaphragm to prevent flow of fuel through the pump when the pump is not operating. The fuel chamber in the housing, the diaphragm and valves are all sealed so that air cannot enter the fuel stream and a continuous flow of fuel is provided which is free of air bubbles.

Referring now to the drawings, in Fig. 1 there is illustrated a solenoid operated diaphragm type pump including a pump unit 10, a solenoid driving unit 11, and a switch unit 12. The pump unit includes two annular stamped metal housings 13 and 14 with an annular diaphragm 15 positioned therebetween. The housing member 14 is provided with openings for two valve units 16 and 17 which are connected to fuel lines connected to a fuel source and to a consuming device respectively. The valve units 16 and 17 are of substantially identical annular configuration, each including a portion 18 having a tubular projection 19 which is secured in an opening in the housing member 14 and a portion 20 including a cavity for a valve. The portions 18 and 20 of each valve are joined by threaded rings 21. The intake valve 16 includes a disc valve 23 normally held against an annular projection 20a by a spring 22. The valve is arranged so that the disc 23 can move against the pressure of the spring 22 to allow fuel to enter through the tubular portion 19 and into a chamber formed between the diaphragm 15 and the housing 14. The valve unit 17 is of similar configuration to the valve unit 16 except the spring 24 normally holds the disc 25 against an annular projection 18a. Pressure exerted on the disc 25 by fuel in the chamber causes the spring 24 to be compressed and permits the flow of fuel around the disc and from the pump.

For securing the housing 13 to the solenoid driving unit 11, an annular projecting portion 27 is provided on the base member 28 of the solenoid. This portion extends through an opening in the housing 13 and is secured thereto by an annular member 26. A spring 29 is positioned to bear against the member 26 and the diaphragm 15 to force the diaphragm against the housing 14. Rigid disc-like members 30 and 31 are secured to either side of the diaphragm, the member 30 forming a seat for the spring 29, and the member 31 having recesses 32 in which resilient members 33 are placed to seal the tubular portions 19 of the valves 16 and 17 when the diaphragm is positioned against the housing 14. The diaphragm and rigid members on either side thereof have center openings into which the end of a plunger 34 extends, the end 35 of the plunger having a tubular projection, the edge of which is spun over to hold the diaphragm and members together.

Referring now to the solenoid unit 11, this unit includes a coil 40 which is wound on a form 41 and is enclosed by a housing composed of a tubular member 42, base member 28 and top plate 43. These members, as well as the plunger 34, are made of soft iron to provide a good magnetic

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path about the solenoid. The bottom member 28 has an opening therein through which the plunger 34 operates in a sliding fit. As shown in Fig. 1, the tubular member 42 has ends which are spun over to retain the end plates 28 and 43 in position. The top plate 43 has an opening into which an annular pole piece 44 is positioned. This pole piece has a conical cavity 45 therein which cooperates with the conical end 46 of the plunger 34 to provide an air gap in the magnetic circuit about the solenoid. A central opening is provided in the pole piece to slidably receive a bolt 47 which is secured to the plunger 34. A non-magnetic washer 48 is positioned at the end of the plunger to prevent freezing of the plunger to the pole piece.

The switch unit 12 is adapted to control energization of the solenoid 40 and includes a resilient member 50 and a fixed member 51 both of which are mounted on the top plate 43 of the solenoid driving unit. The resilient member 50 includes a body portion 52 and a tongue 53 which are movable with respect to each other. A W-shaped roller spring 54 is positioned between the tongue and the body portion of the resilient member 50 and tends to hold these portions away from each other. A contact 55 is secured to the body portion 52 and is adapted to engage a fixed contact 56 supported by the fixed member 51. For limiting the movement of the contact 55 in the opposite direction, a stop 57 is secured to the top plate 43 of the solenoid unit. The plunger 34 of the solenoid is connected to the tongue portion 53 through bolt 47 and fittings 58 and 59 which are secured to the bolt by a nut 60. Accordingly, movement of the tongue portion 53 is caused by movement of the plunger 34 and diaphragm 15, the movement of the tongue causing a snap-action movement of the body portion of the spring 50 so that the movable contact 55 will be snapped from engagement with the fixed contact 56 to engagement with the stop 57 and vice versa.

The switch unit 12 and the coil 40 of the solenoid driving unit are connected in an electrical circuit so that as the movable contact 55 engages the fixed contact 56, current will flow through the solenoid. As illustrated in Fig. 1, one lead from the coil 40 is connected through switch 61 to one terminal of a battery 62, the other terminal of which is grounded as is conventional in vehicular installations. The other lead from the coil is connected to the fixed contact 56. The movable contact is connected through the body portion 52 of the resilient member, the bolt 47 and plunger 34 to the housing of the pump which is grounded. Therefore, when switch 61 is closed and the movable contact 55 engages fixed contact 56, a circuit will be established from ground through the battery 62, coil 40, switch 12 and back to ground. When the movable contact 55 is in engagement with the stop 57, the circuit through the coil is open as the contact 55 and the stop 57 are both grounded.

In the operation of the pump, the diaphragm 15 is moved from a closed position as shown in Fig. 1 to an open position as shown in Fig. 4. As the diaphragm moves away from the housing 14, low pressure will be created in the chamber formed between the diaphragm and the housing which will cause fuel to be drawn from the fuel source through valve 16. As shown in Fig. 4, spring 22 is compressed and disc 23 is pushed away from the seat 20a allowing fuel to be drawn around the disc. The diaphragm is

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moved in this opened position by the plunger 34 being drawn into the solenoid 11. The housing of the coil 40 being made of soft iron provides a good magnetic path around the coil, the path continuing from the pole piece 44 through the top plate 43, tubular member 42 and bottom plate 28, to the plunger 34. This magnetic flux through this path, when the coil is energized, tends to shorten the air gap between the surface 46 of the plunger 34 and the surface 45 of the pole piece 44 causing the plunger to move upwardly to thereby move the diaphragm into the open position. The bolt 47 is made of copper or other non-magnetic material so that the magnetic air gap between the surfaces 45 and 46 will not be bridged thereby. After the solenoid is deenergized the spring 29 which bears against diaphragm 15 will force the diaphragm toward the housing 14 causing the fuel in the chamber therebetween to be under pressure. This pressure will be exerted against the disc 25 causing the spring 24 to be compressed and thus permit the fuel to pass through the valve and to the fuel consuming device.

The tongue 53 of the member 50 is arranged to move with the diaphragm 15 and when the diaphragm is adjacent the housing 14 the contact 55 carried by the portion 52 will be in engagement with the contact 56 of the fixed member of the switch. It will be seen from Fig. 3 that as the plunger 34 is moved down by action of spring 29, the tongue portion 53 will move down. The body portion 52 of the resilient member 50 cannot move down, however, as the contact 55 is in engagement with stop 57. As the tongue moves below the body portion, the roller spring 54 will cause the body portion 52 to snap up so that contact 55 engages fixed contact 56. When the contacts are thus closed, the solenoid will pull the plunger 30 upwardly and the tongue 53 will be moved up. The body portion 52 cannot move up as the fixed contact 56 now acts as a stop. When the tongue moves above the body portion, the body portion will snap down so that the contact engages the stop 57. The fixed contact and stop are arranged so that the connection will be broken just before the diaphragm reaches its maximum upward position so that the coil is deenergized and will not tend to move the diaphragm farther thus resulting in inefficient operation. The spring 29 will then force the diaphragm downwardly causing the fuel to flow through the valve 17 as previously described. As previously stated, the rate at which the fluid flows from the pump depends on the pressure in the fuel line or, in other words, the fuel consumption of the device to which the fuel is being supplied. Therefore, the speed at which the pump operates depends upon the requirements of the device and will supply a varying quantity of fuel at a substantially constant pressure. The movement of the diaphragm by the solenoid is very rapid so that the interval during which the pump is receiving fuel is very small causing the supply of fuel from the pump to be as constant as possible.

The construction of the diaphragm and intake and exhaust valves of the pump are such that a completely air tight chamber is formed in the pump. This prevents entry of air into the fuel stream delivered from the pump resulting in a fuel stream having air bubbles therein causing unsatisfactory operation of the fuel consuming device. It is readily apparent that any fuel con-

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suming device such as an internal combustion engine or a heater requires a steady flow of fuel which is free of air. Further, the provision of the sealing members 33 on the diaphragm assembly prevent unintentional flow of fuel from the fuel supply source to the fuel consuming device when the pump is not in operation. This might be caused when the position of the vehicle is such that the fuel tank is higher than the consuming device in which case gravity would cause flow of fuel. Such flow of fuel when the device is not in operation would result in waste of the fuel, and is therefore not desired.

In Figs. 5 to 8, inclusive, there is illustrated an alternative switching arrangement for the fuel pump. The switch assembly shown in these figures includes a movable carriage 63 comprising a U-shaped bracket 64 which is secured to the bolt 47 carried by the plunger 34. A spring member 65 is mounted on the U-shaped bracket, having projections 66 which are positioned in notches 67 in the bracket. This structure is clearly shown in Fig. 8. A movable contact 68 is carried at the center of the spring member 65. A bridge structure 69 is supported on the top plate 43 of the solenoid driving unit, the bridge structure including an insulating plate 70 having a fixed contact 71 positioned thereon. The bridge structure also includes an off-set portion 72 which forms a stop for the movable contact 68. It is apparent that the operation of the switch mechanism shown in Figs. 5 to 7 is very similar to the switch mechanism shown in Figs. 1 to 4. When the plunger 34 moves upward, by action of the solenoid, the contact 66 bearing against contact 71 will cause the spring member 65 to straighten until it assumes a center position and then flex in the opposite direction. The contact 66 will therefore snap away from contact 71 to break the circuit through the solenoid. The spring 29 (not shown) will then cause the plunger to be withdrawn and during this movement contact 66 engaging the stop 72 will cause the spring 65 to first straighten and then snap upwardly to the position shown in Fig. 5 in which the contact 66 will engage the fixed contact 71. It is therefore seen that the spring member 65 will snap from a position in which the movable contact 68 engages the fixed contact 71 to a position in which the movable contact engages the stop 72. The connection of the switch to the solenoid and the operation of the pump in general is the same in both modifications. Accordingly, detailed description of the operation of the switching mechanism illustrated in Figs. 5 to 8 will not be included.

It is, therefore, seen that I have provided a simplified solenoid operated diaphragm type pump which is of relatively simple and inexpensive construction and at the same time very dependable and stable in operation. The switching arrangements disclosed and the solenoid drive unit are so constructed that the intake stroke will be very fast thus permitting flow of fuel during most of the cycle. This reduces pulsation in the fuel flow and provides a steady flow, the rate of which depends upon the requirements of the consuming device. As previously stated, the diaphragm and valves are all completely sealed so that entry of air into the fuel line is completely eliminated and the fuel flow is entirely free of air bubbles. The pump further acts as a valve to prevent flow

of fuel therethrough when the pump is not operating.

Although I have described certain preferred embodiments of my invention, it is apparent that various modifications and changes can be made therein without departing from the intended scope of the invention as defined in the appended claims.

I claim:

1. A pump for supplying fuel to a liquid fuel consuming device including in combination a symmetrically-shaped housing having an annular portion projecting from one end thereof and electric solenoid means contained therein, an axially reciprocating plunger comprising a part of the magnetic path of said solenoid means and slidably supported in said annular portion, a second symmetrically-shaped housing having an axially centered aperture in one end and a pair of apertures comprising inlet and outlet openings in the opposite end thereof, said axially centered aperture being disposed in axial alignment about said annular portion and accommodating said plunger, adjustable securing means coacting with said second housing and said annular portion retaining said housings in assembled relation, said second housing having an airtight chamber formed therein accessible through said inlet and outlet apertures, a flexible diaphragm supported in said second housing, one side of said diaphragm comprising one of the walls of said airtight chamber, sealing means affixed to the side of said diaphragm facing said inlet and outlet openings, means securing said diaphragm to said plunger, a coil spring supported between said diaphragm and said axially apertured end of said second housing tending to force said diaphragm toward said opposite end of said second housing and thereby discharging fuel from said chamber through said outlet opening and causing said sealing means to close said inlet and outlet openings, an electric contact fixed to said first housing, a movable contact, and a snap action mounting for said movable contact, said mounting including a pair of resilient members and a roller spring interposed therebetween, one of said resilient members being secured to said plunger for movement therewith and the other of said movable members supporting said movable contact, said resilient members being so arranged that said movable contact is moved into engagement with said fixed contact when said diaphragm reaches a position adjacent said opposite end of said second housing, to thereby energize said solenoid means so that said plunger moves said diaphragm away from said opposite end of said second housing for drawing fuel through said inlet opening into said chamber.

2. A pump for supplying fuel to a liquid fuel consuming device including in combination a symmetrically-shaped housing having an annular portion projecting from one end thereof and electric solenoid means contained therein, an axially reciprocating plunger comprising a part of the magnetic path of said solenoid means slidably supported in said annular portion, a second symmetrically-shaped housing having an axially centered aperture in one end and an airtight chamber accessible through a pair of apertures comprising inlet and outlet openings formed in the opposite end thereof, said axially centered aperture being disposed in axial alignment with said annular portion and accommodating said plunger, adjustable securing means coacting

with said second housing and said annular portion to hold said housings in assembled relation, a flexible diaphragm supported within said second housing with one side forming one wall of said chamber, means connecting said diaphragm to said plunger, a coil spring supported between said diaphragm and said axially apertured end of said second housing, sealing means fitted over the side of said diaphragm accessible to said chamber and aligned with said inlet and outlet openings, said coil spring tending to hold said diaphragm and said plunger in a first position in which said sealing means close said openings, said solenoid being operable to cause movement of said plunger and said diaphragm from said first position to a second position to relatively increase the volume of said chamber, an electric contact fixed to said first housing, a movable contact, and a snap action mounting for said movable contact, said mounting including a pair of resilient members and a roller spring interposed therebetween, one of said resilient members being secured to said plunger for movement therewith and the other of said movable members supporting said movable contact, said resilient members being so arranged that said movable contact snaps into engagement with said fixed contact when said plunger assumes said first position to thereby energize said solenoid, and snaps out of engagement with said fixed contact when said plunger reaches said second position.

3. A pump for supplying fuel to a liquid fuel consuming device under substantially constant pressure including in combination, a diaphragm, a housing for said diaphragm defining a fuel chamber in conjunction with said diaphragm, said diaphragm being permanently sealed within said housing for preventing the leakage of fuel from said chamber, an electric solenoid for operating said diaphragm including a stationary magnetic pole piece having a conical pole face, a movable magnetic plunger having a conical pole face fitting into said pole face of said pole piece, and a magnetic housing having a threaded annular projecting portion through which said plunger extends to be guided thereby, said diaphragm housing being disposed adjacent said solenoid housing and having an apertured end surrounding said annular projecting portion, a retaining member threaded on said annular projecting portion and engaging said apertured end of said diaphragm housing for adjustably securing said diaphragm housing to said solenoid housing, said plunger extending into said diaphragm housing and being connected to said diaphragm for moving said diaphragm from a first position wherein said chamber is relatively small to a second position wherein said chamber is relatively large for drawing fuel into said chamber when said solenoid is energized, a coil spring disposed in said diaphragm housing surrounding said plunger and coacting with said retaining member and said diaphragm for moving said diaphragm toward said first position for supplying fuel from said chamber to said consuming device under substantially constant pressure when said solenoid is deenergized, and snap action contacts on said solenoid housing actuated by said plunger for energizing said solenoid when said diaphragm reaches said first position and deenergizing said solenoid when said diaphragm reaches said second position.

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