June 29, 1943. F. C. BEST ET AL 2,322,913

PUMP

Filed April 22, 1939 2 Sheets-Sheet 1

FIG. 1.

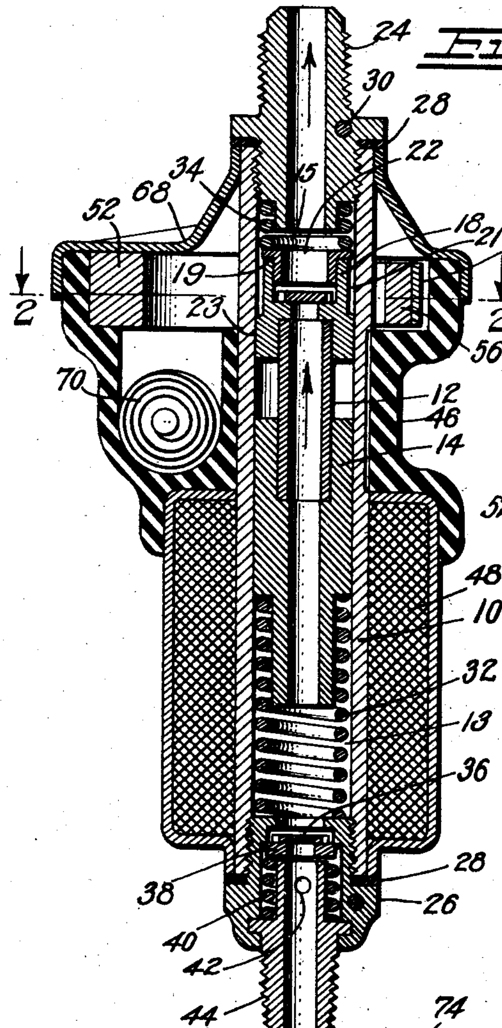


FIG. 2.

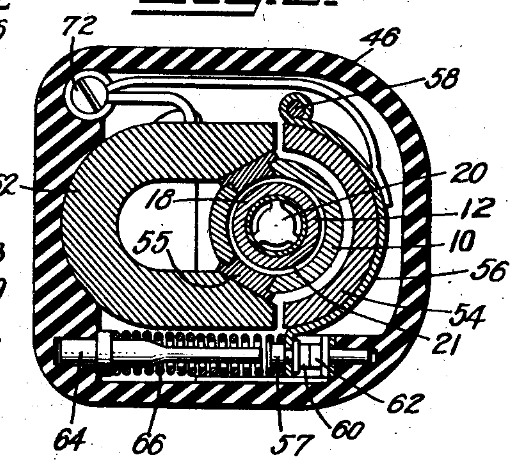
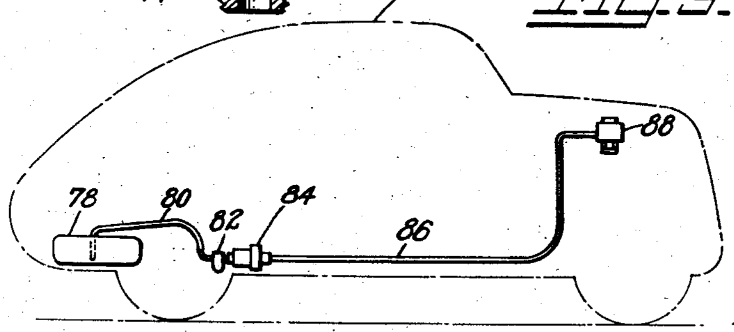


FIG. 3.



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PUMP

Filed April 22, 1939 2 Sheets-Sheet 2

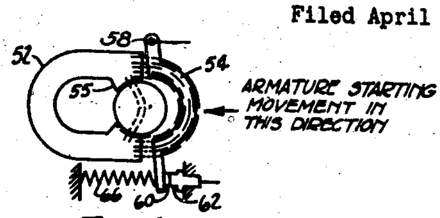

Fig. 4

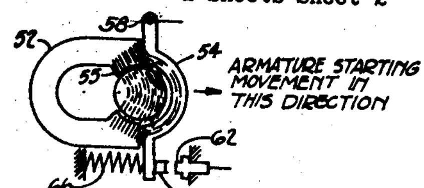

Fig. 5

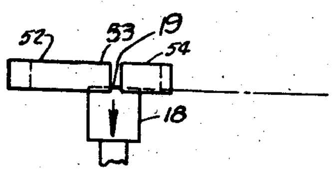

Fig 4-a

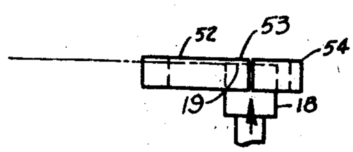

Fig. 5-a

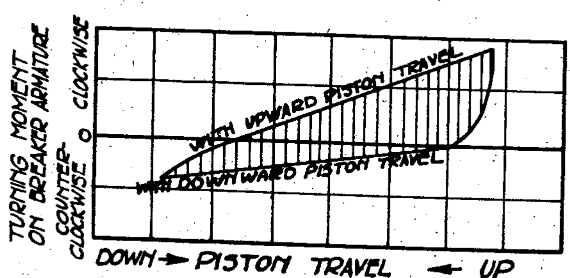

Fig. 6

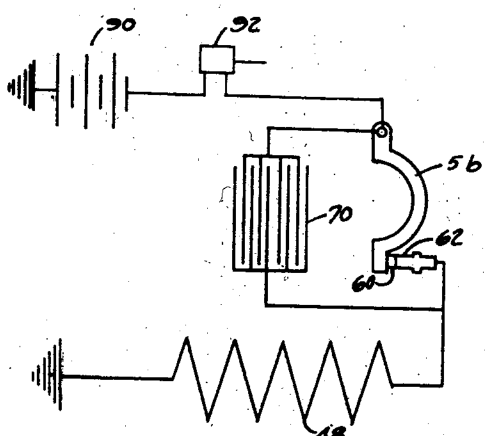

Fig. 7

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Patented June 29, 1943

2,322,913

UNITED STATES PATENT OFFICE

2,322,913

PUMP

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Application April 22, 1939, Serial No. 269,348

8 Claims. (Cl. 103—53)

This invention relates to pumps and particularly to electrically operated fuel pumps for use with internal combustion engines.

It has been common practice to utilize an engine driven diaphragm pump for supplying the engine with fuel from the tank. Disadvantages existing with this system include vapor lock, due to the pump and its fuel lines being subject to the heat of the engine by being required to be located in close proximity to the engine for economical operation thereby; variation of pump delivery pressure throughout the engine operating range as well as an attendant serious reduction of pressure at high speeds, diaphragm failure, and noisy driving mechanism caused by high speed operation.

Attempts have been made to overcome these disadvantages through the use of electrically operated pumps of various design. Disadvantages existing, either individually or collectively, in some of the electrical fuel pumps now on the market include high speed, short stroke operation detrimental to the service life of contact points, bellows or diaphragms; immersion of the contact points and coil windings in the fuel contributing to deterioration of the coil insulation and also causing rapid carbonization of the contact points. In cases where the contact immersion practice is employed, fire hazard, although rare, exists.

It is an object of this invention to provide an electrically operated pump wherein the pumping element is fully sealed, leakproof, and can be positioned close to but wholly sealed from its actuating and control means.

A further object of this invention is to provide an electrically operated pump wherein the pumping element consists of a piston reciprocating in a fully sealed leakproof cylinder with sealed electrical means for moving the piston and improved independent magnetic means for controlling its movement in accordance with piston position.

A further object of this invention is to provide an electrically operated pump wherein the stroke is substantially greater and the operating speed substantially slower than present known types, by use of a magnetically controlled electrical contact device of novel form.

A further object of this invention is to provide an electrically operated pump wherein the pumping element is fully sealed, leakproof, actuated by a spring on its pumping stroke and by a sealed electrical solenoid on its charging stroke, the movement in either direction being reversed by means of a sealed and piston position responsive magnetically actuated control device.

A further object is to provide an electrically operated fuel pump wherein the operating rate of the pump is directly related to the rate of fuel consumption of the engine.

Another object of the invention is to provide an electrical fuel pump wherein the outlet pressure remains substantially constant at varying rates of fuel consumption of the engine.

Another object of the invention is to provide an electrically operated piston type fuel pump wherein provision is made to facilitate dry priming.

Another object of the invention is to provide an electrically operated fuel pump wherein excessive pressure generated by heat in the fuel line between the pump and the engine is automatically relieved.

Another object of the invention is to provide an electrically operated fuel pump wherein the flow of fuel is uni-directional or straight through under normal operating conditions.

Other objects of the invention are to provide an electrically operated pump wherein fabrication costs are reduced to a minimum, assembly is simple, and sealing means are provided to prevent tampering with the mechanism.

Other objects will be apparent from the following description and claims when considered together with the accompanying drawings in which:

Figure 1 is a longitudinal central section through one embodiment of the pump invention.

Figure 2 is a transverse sectional view taken on line 2—2 of Figure 1.

Figure 3 is a diagrammatic side view of a motor car showing a typical pump installation.

Figures 4 and 4*a* are diagrammatic illustrations of the method of breaking the electrical operating circuit.

Figures 5 and 5*a* are diagrammatic illustrations of the method of closing the electrical operating circuit.

Figure 6 is a graph representing the resultant forces actuating the armature which controls the relationship of the contact points at various piston positions.

Figure 7 is a wiring diagram.

In describing the invention, it will be understood that while the various elements disclosed in the drawings are referred to by specific language in order to facilitate an understanding of the principles of the invention, no limitation is thereby intended, various alterations of the structural details such as fall within the scope of the invention being contemplated.

Referring to the drawings, construction and operation is as follows:

In Figures 1 and 2, a cylinder 10 of non-ferrous non-permeable material encloses a piston assembly 12, the former being partially closed by a threaded fitting 26 of ferrous material, and sealed by a gasket 28. Between the threaded fitting 26 and the piston assembly 12 is a coil spring 32 which normally forces the piston assembly 12 upwardly, where it is restricted in movement by a coil spring 34 secured to an end fitting 24 of non-ferrous material, the latter being threaded into the upper end of the cylinder 10, and the joint sealed by a gasket 28. Near the upper end of the tube 10, its outside surface is knurled to insure adhesion of a plastic housing 46 for the pump control mechanism, this housing being molded around the tube 10 in manufacturing. Surrounding the lower portion of the tube 10 is an electrical solenoid 48 enclosed in a ferrous housing 50, the latter two parts being held in position between the lower portion of the housing 46 and the lower threaded fitting 26. In the upper interior of the housing 46 is located a permanent U shaped magnet 52 in horizontal position, its poles engaging extensions 55. These extensions 55 are pressed into holes in the wall of the tube 10, their inner surfaces being flush with the internal surface of the tube 10, and their upper edges 53 being substantially in line with the top surface 19 of the upper piston 18 of the piston assembly 12 when the latter is in its upper position. A semi-circular armature 54 of ferrous material is located in the plane of the magnet 52 and partially surrounds the cylinder 10, the ends of the armature being adjacent to the poles of the magnet 52. The armature 54 is secured to a stamping 56 which is pivoted on a pin 58, and which carries at the end opposite from the pivot an electrical contact 60. This contact is normally maintained in engagement with a mating contact 62 (secured in the housing 46) by a coil spring 66 mounted upon and guided by a pin 64 secured in the housing 46. The housing 46 also encloses an electrical condenser 70 which will be referred to later. A non-ferrous cover 68 maintains the magnet 52 in position and is retained in place by the upper threaded fitting 24.

In Figure 7, electrical current flows from a battery 90 (or any other suitable source of electricity) through the ignition switch 92 to the movable stamping 56 associated with the armature 54. The contact 60 on the stamping 56, when engaged with the fixed contact 62, completes an electrical circuit allowing current to flow through the solenoid coil 48.

In Figure 3, the pump 84 is installed in a motor car 74, close to the tank 78 from which the pump 84 draws fuel by suction through a tube 80 and a filter 82 when in operation. Fuel from the pump 84 is then forced under pressure through the tube 86 to the carburetor 88.

When the ignition switch 92 in Figure 7 is closed, electrical current flowing through the solenoid coil 48 attracts the lower piston 14 (constructed of ferrous material) of the piston assembly 12 and pulls the latter downward, overcoming the force of the spring 32. When the piston assembly 12 moves downward, pressure in the lower chamber 13 beneath the piston maintains a disc type one way inlet valve 36 in a closed position against a valve seat 38 and forces the fluid contents of chamber 13 through the piston assembly 12, passsing through a disc type one way transfer valve 20 located in the upper piston 18 of the piston assembly 12, (the valve 20 being restrained from excessive movement by a retainer 22 pressed into the upper piston 18) and filling the upper chamber 15. Movement of the valve 20 is also assisted by inertia. As the upper piston 18, of ferrous material, travels downward, the magnetic flux between the permanent magnet 52 and the upper piston 18 (through the medium of the extensions 55 of the poles of the magnet 52) becomes gradually reduced while the flux between the magnet 52 and the armature 54 (of ferrous material) gradually increases. At a pre-determined point in the downward travel of the piston, near the end of its stroke, a condition is reached, as illustrated in Figures 4 and 4*a*, wherein the attraction of the magnet 52 for the armature 54 becomes sufficient to overcome the force of the armature spring 66. The armature 54 and its support 56 then move toward the magnet 52, pivoting on the pin 58 and carrying the contact point 60 out of engagement with the fixed contact 62. A pin 57 on the armature support 56 is provided to contact the end of the pin 64 in order to prevent the armature 54 from coming into contact with the poles of the magnet 52. When the circuit is broken between the contact points 60 and 62, the pull of the solenoid 48 is released, but the piston assembly 12 still continues a short distance beyond this point due to inertia. When the circuit is broken, the action of the condenser 70 dampens the spark across the contact points 60 and 62 and thus the life of these points is prolonged. The pumping spring 32 then starts to push the piston assembly 12 upward, thus forcing the fluid in the upper chamber 15 out through the upper fitting 24, the pressure present and inertia tending to hold the transfer valve 20 on its seat in the upper piston 18. Simultaneously, a partial vacuum created under the piston assembly 12 in the lower chamber 13 induces the entry of liquid through the fittings 44 and 26, and past the one way valve 36 into the chamber 13. As the piston assembly 12 continues upward, the magnetic flux between the upper piston 18 and the permanent magnet 52, through the medium of the extensions 55 of the poles of the magnet 52, increases, while the flux between the magnet 52 and the armature 54 decreases. At a pre-determined point in the upward travel of the piston assembly 12, near the end of its stroke, a condition is reached as illustrated in Figures 5 and 5*a*, wherein the magnetic attraction acting on the armature 54 is no longer sufficient to hold the spring 66 in compression, and the latter then forces the armature 54 and its support 56 away from the poles of the magnet 52, the armature and its support rotating on pin 58 and carrying the movable contact 60 into engagement with the fixed contact 62, thus closing the circuit. The piston then continues slightly beyond this point, due to inertia, and comes to rest against bumper spring 34, the latter attached to end fitting 24 and utilized to absorb shock and reduce noise. The circuit being now closed, another cycle of pump operation starts.

It will be observed, by referring to Figures 4, 4*a*, 5 and 5*a* that the critical piston position at which the contact points start to open during downward piston travel, is lower than the critical piston position at which the points start to close during upward piston travel. As a magnetic force increases inversely as the square of the distance, it will be readily apparent that the magnetic flux required to pull the armature 54 toward the magnet 52, overcoming the force of the armature return spring 66, will necessarily be greater than the magnetic flux required to hold the armature close to the magnet while maintaining the spring under compression. As the flux of the magnet 52 is constant, it will be seen that the relationship of the piston 18 to the magnet 52 will determine the number of lines of magnetic force shunted through the piston 18 and the number of remaining lines of magnetic force available at the magnet 52 for influencing the armature 54. It will be noted that the upper piston 18 has been reduced in diameter at its upper end 21 and is guided in the cylinder 10 by its lower end of slightly larger diameter 23 in order to avoid physical contact with the extensions 55 of the poles of the magnet 52, thereby eliminating frictional drag at this point while still maintaining close relationship.

Figure 6 is a graph illustrating the effect of piston position on the turning moments controlling the position of the movable contact point. It will be readily observed from this graph and the foregoing explanation of operating principles that there exists a very definite and prolonged lag in contact point movement in relation to piston travel. This lag is further increased by the effects of inertia and friction. As a result, the stroke of the pump is longer compared with present practice and the number of operating cycles per minute can therefore be reduced for a given output per minute. This latter feature contributes to a greatly increased life of the piston and cylinder, valves, operating spring, contact points, condenser, and solenoid; in short, the entire pump.

It will be readily apparent from all of the foregoing description that the pumping element of this device is completely sealed against leakage, and that neither the solenoid nor breaker mechanism comes in contact with the fuel, thus eliminating fire hazard.

By the use of this construction, a piston pumping element may be employed without danger of external leakage, thus eliminating the necessity of using flexible bellows or diaphragms with their attendant short life, unreliability, and contribution to fire hazard.

Because of the fact that the velocity of the piston on the pumping stroke is dependent on the rate of fuel flow between the piston and the carburetor and because the piston must complete a full pumping stroke before starting another cycle of operation, the pump operating cycle frequency is dependent on the fuel requirements of the engine. As the piston on its downward or charging stroke always moves with the same velocity regardless of the fuel consumption rate of the engine, the electrical energy expended during the charging stroke is substantially constant. However, it is obvious that the rate of current consumption will vary with the number of pumping cycles for a given time period, thus, the current consumption rate will vary in proportion to the rate of fuel consumption of the engine.

Due to the fact that this pump is of the long stroke, slow speed type compared to existing commercial designs, pumping pressure will be more uniform throughout its operating range and there will be less tendency for the pumping pressure to vary at higher engine speeds, as is now the case with conventional short stroke, high speed, diaphragm or bellows type pumps.

It will be seen in Figure 1 that the piston assembly 12 is composed of a lower piston 14 of ferrous material and an upper piston 18 of like material joined together by a tube 16 of nonferrous material. This preferred construction is utilized for two reasons, first, in order to confine the effects of the magnetic field of the solenoid 48 solely to the lower piston 14 by insulating the upper piston 18 from these effects in order to avoid magnetic interference with the magnetically controlled and actuated contact mechanism, and second, in order to facilitate priming. In the event of running out of fuel, a car equipped with this pump may be left standing for a considerable period of time before refilling of the fuel tank, with the assurance that efficient pumping action will start immediately, when the pump is put into operation. This is accomplished in the following manner: During the normal operation of the pump, the space 17 between the pistons 14 and 18 becomes filled with fuel by the normal slight leakage past the pistons 14 and 18. It will be apparent to those skilled in this art that this slight leakage will be sufficient to supply the required small amount of fuel to this space or trap 17. In the event that the tank supply becomes exhausted and the supply tubing and pump cylinder become emptied of fuel, the fuel in the reservoir 17 is still retained, and this fuel will act as a piston sealing means, thus assuring adequate pump suction in drawing fuel from the tank to the pump when the supply in the former is replenished.

It has been found that directly after a motor car has been left standing with the motor stopped, that the fuel in the tubing between the pump and the carburetor will be subjected to residual heat dissipated by the engine, and will therefore expand. Due to the check valve in the pump, it cannot return to the supply tank and therefore sufficient pressure is created to force the carburetor reservoir float controlled inlet valve off its seat and by so doing, flooding of the carburetor and inlet manifold results. Starting of the engine is seriously impaired by this condition. This is prevented in the proposed pump by the provision of a pressure relief valve which will allow fuel in the process of expansion in the tube 86 in Figure 3 to flow back to the supply tank 78 whenever the pressure in the tubing 86 reaches a point somewhat less than the critical pressure required to force the carburetor reservoir float controlled inlet valve off its seat. In Figure 1, the movable valve seat 38 of the inlet valve 36 is normally held in position by a spring 40, thus allowing passage of fuel only in one direction, that is, upwardly through the inlet valve 36 during normal pump operation. In the event of fuel expansion previously described taking place, the high pressure in the tube 86 will force fuel, by leakage, past the piston assembly 12, and the pressure acting upon the area of the valve 36 and the uncovered area of its movable seat 38 will cause the latter to move downwardly, overcoming the resistance of the spring 40 and allowing the return of fuel between the edge of the valve seat 38 and the inside wall of the fitting 26, through the hole 42 in the fitting 44 and back to the supply tank 78. It will be noted that the top of the piston assembly 12, that is, the upper end of upper piston portion 18 is in free communication with the fuel in the fitting 24 and hence in the line 86 to the carburetor, since the upper check valve 20 is recessed into the upper end of this piston portion 18.

In any pump wherein the direction of fuel flow is changed due to the relationship of the pumping element to the inlet and outlet valves, a certain amount of energy must be expended in order to overcome the inertia of the fuel. In the proposed device, there is no change of flow direction under normal operating conditions, the fuel entering the pump at one end, passing through the piston and being discharged at the other end. This uni-directional, straight through, flow condition reduces the amount of electrical energy expended for a given amount of fuel displaced, as compared to most conventional pumps.

It will be apparent from the foregoing description that the proposed device will not cause excessive heating of the fuel, as is experienced with some types of electrical pumps in which the solenoid and contact points are immersed in the fuel with consequent direct transfer of heat from these units to the fuel. As a result, vapor lock possibilities from this source are considerably reduced in the present pump.

It will be easily seen from the description and attached drawings that fabrication of the device will not be costly. Assembly is simple, use being made of the end fittings **24** and **26** in Figure 1 to retain all of the parts in position. A wire **30**, passing through holes in the end fittings, and having its ends joined by an identifiable lead seal discourages tampering with the device, thus protecting dealers in these pumps when they are sold on a guaranteed basis.

It will be readily apparent, to one experienced in the art, that in connection with the above description, various equivalents or alternative materials, details, or the like may be employed. For example, ferrous material is intended to include all suitable magnetically permeable materials, non-ferrous material (when specifically referred to as such in the description) is intended to include all suitable materials which are non-permeable, plastic may include hard rubber or the like, the piston assembly **12** could be replaced by a one piece piston of ferrous material in which a high reluctance path between the lower and upper ends of the piston may be provided by considerably reducing the diameter of the piston between the said ends, the magnet **52** could be a continuously acting electro-magnet, etc.

We claim:

1. An electromagnetic fuel pump comprising a relatively long, non-ferrous and completely sealed and thin walled cylindrical tube, a pumping piston having iron portions and reciprocating in said tube, means to reciprocate said piston including a solenoid about said tube acting on certain of said iron portions, and means to control the periodic energization of said solenoid in accordance with piston position and including a compact generally U-shaped permanent magnet having its two inner pole forming ends on either side of and in contact with said tube walls, said magnet being within and adjacent one end of the piston's stroke so that flux between the magnet's poles is periodically shunted across said tube by certain of said piston's iron portions, a fixed contact and a movable contact connected in circuit with said solenoid, a generally semi-circular shaped iron armature of relatively large cross-sectional area to provide a low reluctance flux path movably mounted to have its ends attracted toward said magnet's pole ends and carrying said movable contact, said generally U-shaped magnet and said generally semi-circular shaped armature together substantially and closely surrounding said tube, and spring means to move said armature away from said magnet.

2. An electromagnetic fuel pump comprising a non-ferrous cylinder having openings through the sides thereof, an iron pumping piston reciprocating therein, means to reciprocate said piston including a solenoid about said cylinder and relatively movable contacts in circuit therewith, and means to control the periodic energization of said solenoid in accordance with piston position and including a continuously acting magnet positioned within and adjacent to one end of the piston stroke and having its opposite poles on either side of, extending through, and tightly fitting in said cylinder openings so that the inner faces of said pole extensions substantially form portions of the inner surface of said cylinder providing a low reluctance shunt path through said iron piston, and a movable resiliently biased armature actuating said contacts and attracted by said magnet's poles when said poles are not shunted by the piston.

3. An electromagnetic fuel pump comprising a non-ferrous cylinder having openings through either side thereof, an iron pumping piston reciprocating therein with a substantially sealing working fit, means to reciprocate said piston including a solenoid about said cylinder and relatively movable contacts in circuit therewith, and means to control the periodic energization of said solenoid in accordance with piston position and including a continuously acting magnet positioned within and adjacent to one end of the piston stroke and having its opposite poles on either side of, extending through, and tightly fitting in said cylinder openings so that the inner faces of said pole extensions substantially form portions of the inner surface of said cylinder to give a low reluctance shunt path through said iron piston, and a movable resiliently biased armature attracted by said magnet's poles, and actuating said contacts, said piston having an end portion of reduced diameter adjacent said pole extensions to avoid undue friction at these points.

4. In an internal combustion engine fuel supply system, a fuel supply tank, a fuel pump drawing fuel by suction therefrom and including a cylinder, a carburetor supplied with fuel under pressure by said pump, a fuel line between said pump and said carburetor, a pumping piston in said pump cylinder permitting a slight leakage therepast, valve means in said piston and cylinder to restrict fuel flow to one direction and a pressure relief valve between the suction side of said piston and the said supply tank, said valve permitting a relief discharge into said tank from the vapor pressure built up in said line when idle and heated by said slight leakage past said piston.

5. The organization set forth in claim 4 in which said pressure relief valve constitutes a resiliently biased valve seat for one of said one direction valve means.

6. In an electrically operated pump, a cylinder, a pumping element in said cylinder, a molded housing secured midway on said cylinder, a removable inlet connection at one end of said cylinder, a solenoid about said cylinder and secured between said body and said inlet connection, a solenoid controlling breaker mechanism including a permanent magnet housed in said housing, a removable discharge connection at the other end

of said cylinder, a cover for said housing secured in place by said discharge connection, and holes in both said connections and a wire extending therethrough and having its ends joined by an identifiable seal.

7. In an electrically operated pump, a cylinder, a pumping element in said cylinder, a molded housing secured to said cylinder between the ends thereof, a removable inlet connection at one end of said cylinder, a solenoid about said cylinder and interposed between and held in place by said housing and said inlet connection, a solenoid controlling mechanism in said housing, a removable discharge connection at the other end of said cylinder, and a cover for said housing secured in place by said discharge connection, said cover thus securing said housing in position.

8. A wholly sealed solenoid fuel pump comprising an imperforate cylinder threaded at each end, an iron piston therein, a pipe fitting threadedly secured to one end of said cylinder, a piston actuating solenoid positioned around said cylinder and held in one direction of axial movement by said fitting, a piston position controlled switch mechanism and a support therefor positioned around said cylinder and held in one direction of axial movement by said solenoid, and another pipe fitting threadedly secured to the other end of said cylinder and holding said support, against movement in the other axial direction.

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