FLOW-THROUGH TYPE SOLENOID VALVES

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ABSTRACT

An electrically operated flow-through solenoid valve designed for remote and/or control applications that has a reduced current "hold open" position. The three possible operating states of my valve are: (1) closed to inhibit flow, (2) transient to open and open to allow flow, with maximum energizing current, (3) open to allow flow, with energizing current reduced from maximum.

1 Claim, 4 Drawing Figures
FLOW-THROUGH TYPE SOLENOID VALVES

This invention relates to valves and more particularly to a flow-through type solenoid valve of unique design especially suited to remote and/or control applications.

Many valves have been patented in this class but my valve is different from the old in that it has a reduced energizing current "hold open" position, the advantages of which will become apparent from the illustrated application description contained herein. A general object of my invention is to provide a valve that can be opened by a voltage level, can then be held open by a lesser voltage level and will close whenever this voltage is removed.

Another object of my invention is to provide a valve applicable to fuel control in motor vehicle anti-theft devices. An authorized operator would apply an opening voltage, holding voltage would be supplied from the vehicle ignition. Whenever the ignition is switched "off" the valve would close and could not be opened again except by authorized operators.

Another object of my invention is to provide a valve that can be opened by a voltage pulse, and depending on a holding voltage, will either be held open or will be allowed to close.

Still another object of my invention is to provide a valve for interfacing to electrical logic signals where a holding voltage logic level would only be effective if applied simultaneously with an opening voltage level logic pulse.

The valve body can be fabricated from any non-conductive material, this feature makes possible cheap construction through utilization of plastics and injection molding techniques. Construction details and advantages of my valve will emerge more fully from the application description and accompanying drawings wherein a preferred form of the invention is disclosed. It should be understood though, that the description and drawings are illustrative only and are not to be taken as limiting the invention except insofar as it is limited by the claims.

In the drawings;

FIG. 1 is a longitudinal sectional view through my valve.

FIG. 2 is a cross sectional view taken on the line 40-40 of FIG. 1.

FIG. 3 is an electrical schematic diagram of the circuitry involved with controlling my valve in one of its applications and illustrates the operation of its unique reduced current "hold open" feature.

FIG. 4 is a diagrammatic view of the fuel supply system of a typical automobile and a schematic diagram of the electrical control circuits for an automobile anti-theft system embodying my valve as an integral part thereof.

The numeral 1 indicates the body of the valve, two sections labelled 1a and 1b are fabricated separately, internal valve components are installed and the sections 1a and 1b are then joined at line 15-15. The valve body sections 1a and 1b are formed with concentric grooves 5 adjacent to their respective mating surfaces. In the case of valve body construction of a member of the plastics family a band 9 of like material is situated as shown, with application of a suitable bonding material to unite the two valve body sections 1a and 1b into the composite valve body 1. Joining techniques, of course, will vary slightly with different construction materials.

Stator 3 and armature 2 are cylindrical and are made of corrosion-resistant ferrous metal material. Stator 3 is attached to member 5, of the same material as valve body 1, by means of screw 13, through hole 47 in member 5 center, threaded into stator 3.

Member 5 fits in a circular indentation 14 in valve body section 1a, it supports stator 3, provides restraining force for compression spring 4 and is constructed with several holes 19 through it so as not to impede fluid flow. Armature 2 is positioned to the center of valve chamber 18 by splines 16 formed in valve body section 1b, a slidable relationship exists. Compression spring 4 acts on armature 2 forcibly projecting same in a direction so as to create a fluid sealing relationship between conical end 7 of armature 2 and the similarly tapered shoulder 8 of outlet passage 11, an integral part of valve body section 1b. When armature 2 is thusly positioned flow through the valve is inhibited.

A solenoid coil 6 is wound circumferentially around the valve body 1. The ferrous stator 3 and armature 2 compromise a two element core for the solenoid. When electrical current passes through the solenoid coil 6, lines of flux pass through stator 3 and armature 2 and cause a force to be exerted upon the armature 2 toward the solenoid coil 6 center and toward the stator 3. This force is opposite in direction and greater in magnitude than the force exerted by compression spring 4 and therefore causes the armature 2 to shift position longitudinally to the valve body 1 in a direction away from shoulder 8 of the outlet passage 11. This motion of armature 2 causes conical end 7 to become disengaged from shoulder 8. Motion continues until the end of the smaller radius projection 17 of armature 2 is in physical contact with stator 3. At this time the valve will allow flow to proceed. The flow path is; in inlet passage 10, through the holes 19 in member 5, through the valve chamber 18, through the space 12 between valve body section 1b and armature 2 maintained by splines 16, through the space between shoulder 8 and conical end 7 of armature 2, and then through the outlet passage 11.

When armature 2 and stator 3 are in physical contact they combine to form a continuous magnetic element. The important result of which is that solenoid coil 6 current can be reduced significantly whilst magnetic attraction between armature 2 and stator 3 holds armature 2 in contact with stator 3 and thusly flow through the valve is allowed to proceed. Interruption of the current through solenoid coil 6 will of course allow the flux field to collapse and compression spring 4 will force armature 2 to shift to the position where a sealing relationship between conical end 7 and shoulder 8 inhibits flow.

In the following illustrations, switching functions are simplified to mechanical switches, these functions could readily be performed by any number of mechanical, solid state, or logical controlling devices.

In FIG. 3; when switch 21 is closed a current path is established from voltage source 20, through switch 21, through solenoid coil 6, with return to voltage source 20. Electrically the voltage source 20 is connected directly across solenoid coil 6 and produces a maximum current flow and a flux field acting on armature 2 with sufficient force to shift armature 2 and open compression spring 4 and cause the valve to open. Opening switch 21, or interrupting the current flow in any way will cause the flux field to collapse and hence cause the ar-
mature 2 to respond to the force of compression spring 4 and return to a flow inhibiting position.

If switch 22 is closed current will flow from the voltage source 20, through switch 22, through resistive element 23, through solenoid coil 6, and return to the voltage source 20. Resistive element 23 is selected so that its resistance plus the resistance of solenoid coil 6 limits current flow to that which is less than the current required to produce a flux field strong enough to overcome the force of compression spring 4. If while switch 22 is closed switch 21 is also closed the current path is from voltage source 20 directly to solenoid coil 6 which was shown above to cause the valve to open. If switch 21 is then opened the flux field strength will decrease to a level produced by current through the resistive element 23 and solenoid coil 6 which is sufficient to maintain armature 2 in physical contact with stator 3 and thusly to maintain the valve in an open configuration with a flux field strength that was shown to be insufficient to cause the valve to open. Opening switch 22 will, of course, disrupt the electrical current path, cause the flux field to decay, cause the magnetic attraction between armature 2 and stator 3 to cease, and hence cause the valve to close.

The peculiar characteristics of my valve design make it particularly applicable to a motor vehicle anti-theft system and it will be described in conjunction with such a system, although the invention is to be in no way limited thereto. In FIG. 4, a three state solenoid valve is installed in a relatively inaccessible section of fuel line 34 running from and transferring fuel between fuel tank 34 and fuel pump 36. Electrical connections are made so as to provide a conductive path from “ignition” terminal 37 of starter/ignition switch 33, through resistive element 23, through solenoid coil 6, and return to vehicle chassis 38. The vehicle starter/ignition switch 33 provides an electrical function similar to switch 22 of FIG. 3. Further electrical connections are made so as to provide a conductive path from the engine starter terminal 39 on starter solenoid 30, through special switch 32, through solenoid coil 6, to vehicle chassis 38. Special switch 32 is a normally open switch that through some action available only to authorized operators can be rendered closed. This special switch 32 provides an electrical function similar to switch 21 of FIG. 3.

Voltage source 20, the vehicle battery, is available to the starter/ignition switch 33 and to the starter solenoid 30. During the vehicle starting sequence starter/ignition switch 33 is positioned to “start”; this makes voltage available to and hence current flow through resistive element 23 and solenoid coil 6. At this time the vehicle starter solenoid 30 has been energized and voltage has become available at the starter motor terminal 39. If special switch 32 is closed while voltage is available at terminal 39, current flow will proceed at the maximum rate through solenoid coil 6. This current produces a flux field sufficient to shift armature 2 to a position of physical contact with stator 3 thereby allowing fuel to flow and assuming a position whereby when the vehicle engine has started and/or when special switch 32 is released armature 2 will be held in physical contact with stator 3 by forces generated by the reduced current through starter/ignition switch 33, resistive element 23, and solenoid coil 6. Subsequently, when the starter/ignition switch 33 is turned “off” current flow through solenoid coil 6 is discontinued, the holding forces decay and hence the armature 2 moves to its flow inhibiting position, with no overt actions required by the operation. At this time vehicle engine fuel flow is inhibited and therefore the vehicle is protected from theft.

It will be understood that various changes may be made in the form, details, arrangement and proportions of the components without departing from the scope of my invention.

What I claim is:

1. A flow-through type solenoid valve including a valve body having a flow passage therethrough, a solenoid surrounding said body, a magnetic armature within said flow passage and including a valve head portion at one end and a flat imperforate surface at the opposite end, a valve seat in said flow passage, a magnetic stator element within said flow passage having a flat imperforate surface facing said armature surface, and a spring surrounding at least a portion of each of said armature and stator.

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