

Jan. 23, 1962

T. W. CONRAD

3,018,418

SOLENOID

Filed April 30, 1958

2 Sheets-Sheet 1

FIG. 1.

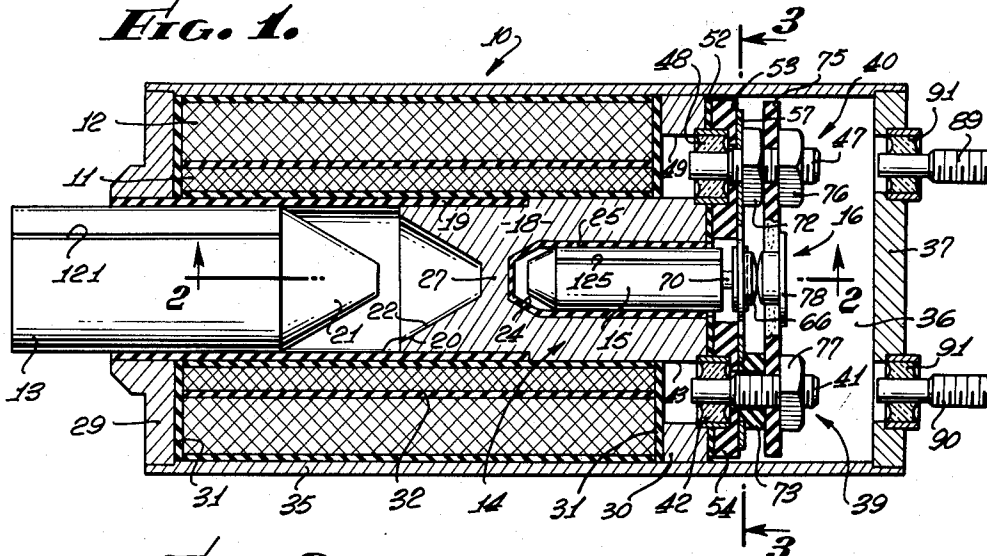


FIG. 2.

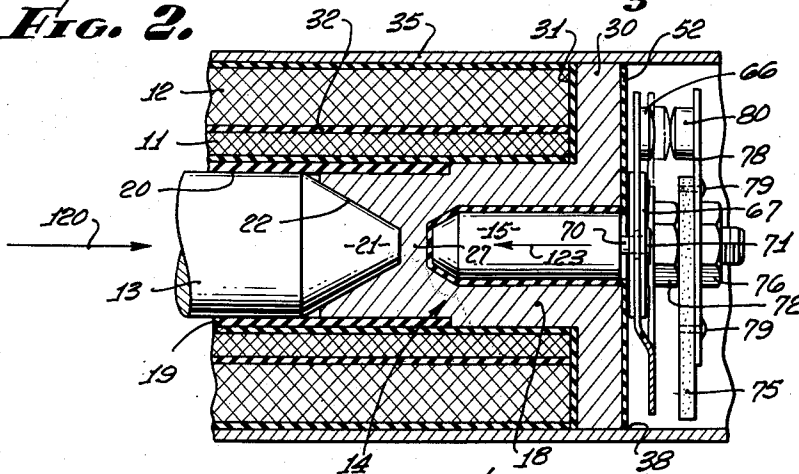


FIG. 3.

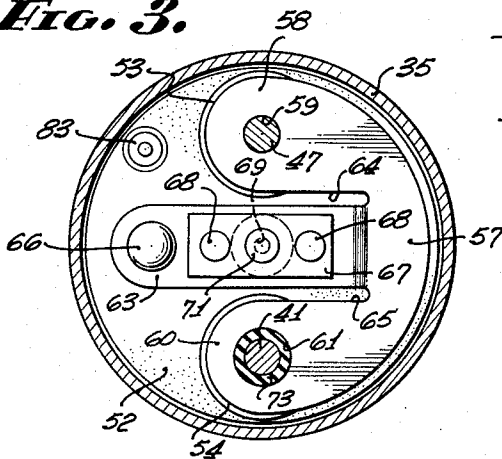
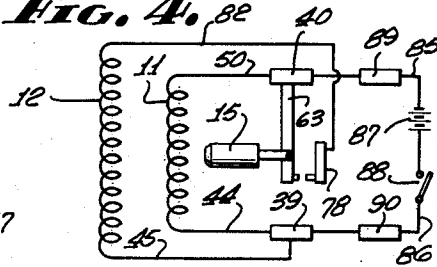


FIG. 4.



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FIG. 5.

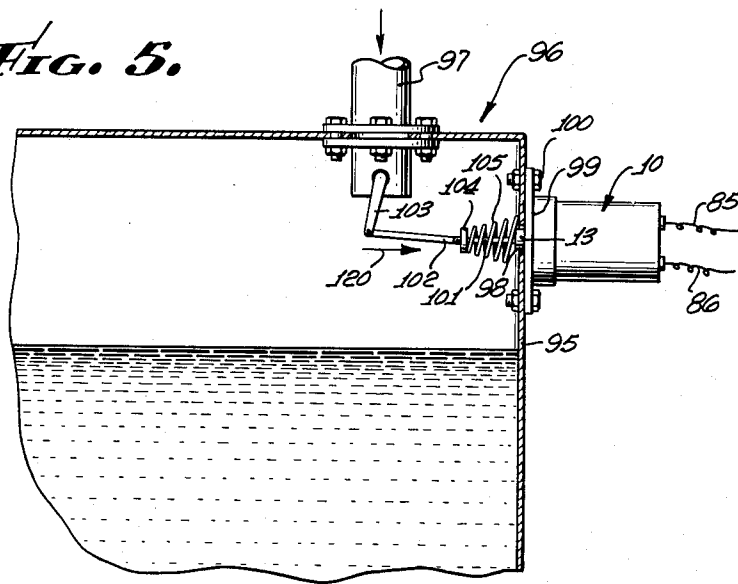
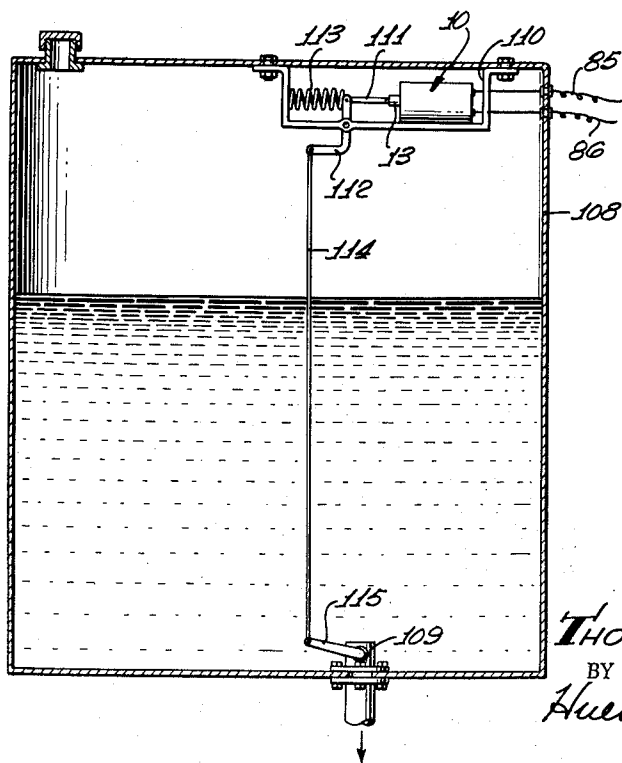


FIG. 6.



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3,018,418
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8 Claims. (Cl. 317-123)

This invention relates to improvements in solenoids and more particularly to solenoids of the type having two coils, one to serve as a pulling coil and the other as a holding coil, and a switch for controlling energization of the coils.

Solenoids of the type referred to which have been used heretofore include an armature or plunger movable in the solenoid coils in response to energization of the pulling coil, such plunger being mechanically connected to the switch which operates to disconnect the pulling coil from its source of electrical power whereby the holding coil alone serves to maintain the plunger in its inwardly disposed position. A solenoid having a mechanical connection between the plunger and the switch is greatly limited in its extent of use. For example, in an installation where the plunger is exposed to an atmosphere of explosive gas, the gas may seep through the mechanical connection to the space in which the switch is located with the result that a spark occurring from switch operation will ignite the gas.

It is a general object of this invention to provide a solenoid of the character referred to above in which the switch thereof is isolated against flow of fluid thereto from the space in which the plunger operates.

Another object of this invention is to provide a solenoid of the above mentioned character in which the switch is contained in a hermetically sealed chamber and thereby isolated from the surrounding atmosphere.

A further object of this invention is to provide a solenoid of the above mentioned character for use in installations within or in direct communication with harmful or explosive atmospheres without danger.

Still another object of this invention is to provide a solenoid of the above mentioned character in which the pulling coil remains energized until the plunger reaches its most inwardly disposed position whereupon the magnetic flux in the solenoid becomes sufficiently strong to actuate a second plunger which in turn operates a switch for breaking the electric circuit to the pulling coil.

Further objects and advantages of this invention will appear from the following part of this specification wherein the details of construction and mode of operation of several embodiments of the invention are described with reference to the accompanying drawing in which:

FIG. 1 is a central longitudinal section through a solenoid device embodying the invention;

FIG. 2 is a central longitudinal section through the solenoid device taken along line 2-2 of FIG. 1;

FIG. 3 is a transverse section through the solenoid device taken along line 3-3 of FIG. 1;

FIG. 4 is a diagrammatic view showing the electric circuit of the device, by which the switch thereof is operated to selectively control energization of the solenoid coils;

FIG. 5 shows the inside of a fuel tank having a solenoid of this invention mounted upon the side wall of the tank for controlling a fluid inlet of the tank; and

FIG. 6 is a central vertical section of another tank having a solenoid of this invention mounted within the tank for operating an outlet of the tank.

Referring to the drawing in greater detail, reference numeral 10 designates, generally, a magnetic device of the solenoid type embodying this invention. The essen-

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tial elements of the device 10 are two coils 11 and 12, a plunger 13, a core 14, a smaller plunger 15, and a switch mechanism designated generally by numeral 16, such switch being adapted to operate in response to movement of the plunger 15 for controlling energization of the coils.

In the illustrated embodiment the core 14 is cylindrical and comprises a rearwardly disposed main body portion 18 and a cylindrical skirt portion 19. The body portion is rabbeted around the inner end thereof to accommodate the inner end portion of the skirt, preferably in a fluid-tight connection. The skirt defines a cylindrical well or cavity 20 which extends axially into the core and is open in the forward end of the core, i.e. the left-hand end of the device as the same appears in FIG. 1 of the drawing.

The plunger 13 is movable axially in the cavity 20 between the positions thereof shown in FIGS. 1 and 2 respectively. The inner end 21 of the plunger is chamfered making it frusto-conical in configuration, and the inner end of the body portion 18 of the core is recessed at 22 to receive the inner end portion of the plunger.

Body portion 18 has a well or cavity 24 extending axially therein opposite the cavity 20 to accommodate the smaller plunger 15 which is movable axially therein. There is a cylindrical sleeve 25 which constitutes a lining for the cavity 24 and its function will be explained more fully hereinafter.

The two cavities 20 and 24, for accommodating the plungers 13 and 15 respectively, are separated by an impermeable wall 27 of the body portion of the core. Such wall prevents flow of fluid between the cavities.

There is an end plate 29 on the forward end of the core which is in association with the forward end portion of the skirt 19 and extends radially outwardly from the skirt as an annular end flange. The opposite or rearward end of the core is likewise provided with a radially outwardly extending annular flange 30 integral with the body portion 18. These annular end flanges and the outside cylindrical surface of the core define an annular space for receiving the coils 11 and 12.

The inside surfaces of the flanges 29 and 30 and the outside surface of the core are lined with insulating material 31. In the illustrated embodiment the inner coil 11 serves as a holding coil and the outer coil 12 serves as a pulling coil. After the coil 11 has been formed by winding the wire thereof around the core to extend from end to end within the flanges 29 and 30, the same is covered with a sheet 32 of insulating material. The coil 12 is then formed by winding the wire, which constitutes the same, around the coil 11 to extend from end to end of the coil 11. Inasmuch as the coil 12 of this embodiment has been selected to serve as the pulling coil, the wire thereof is preferably larger in diameter than the wire of the holding coil 11. The pulling coil is designed to produce a substantially greater magnetic flux than that of the holding coil 11. After the plungers have reached their inwardly disposed positions they can be held there by a lesser force than is required to move them inwardly of the coils. It is then that the switch mechanism 16 operates to disconnect the pulling coil from its source of electric power as will be explained more fully hereinafter.

The annular space occupied by the coils is closed by a cylindrical cover 35 which extends over end plate 29 and is secured thereto as, for example, with silver solder. Such cover extends over and beyond the flange 30 to provide the side walls of a chamber 36 which houses the switch mechanism 16. There is an end plate 37 closing the outer or rearward end of the chamber 36.

It will be apparent that inasmuch as the end plate 29 is joined in a fluid-tight connection to the skirt 19 of the core and to the forward end of the cover 35, the coils 11 and 12 are isolated from the space around the device 10 and from the space in the cavity 20. For the purposes of

this invention it is not necessary that the coils themselves be isolated from the space in the cavity 20. It is important for this invention that the switch mechanism 16 be isolated from the space of the cavity 20. Thus, in the case where the skirt and body portion of the core are not joined in a fluid-tight connection or where the end plate 29 is not joined fluid-tight to the skirt or where the cover 35 is not joined fluid-tight to the end plate, the flange 30 should be joined fluid-tight to the cylindrical cover 35 as, for example, with solder as shown at 38 in FIG. 2 of the drawing. When so sealed, the core body with its flange 30 constitutes the inside wall for the hermetically sealed chamber 36 and serves as a barrier wall to isolate the switch from the space forwardly of the wall.

Terminals for the coils appear at 39 and 40. Terminal 39 comprises a post 41 which extends through a glass seal insulator 42 fixed fluid-tight in a bore 43 which extends through the end flange 30 of the solenoid core. One end of the holding coil 11 is connected to the post by lead wire 44 as is shown in FIG. 4, and one end of pulling coil 12 is connected to the post by lead 45.

Terminal 40 comprises post 47 extending through glass seal insulator 48 which is mounted fluid-tight in a bore 49 extending through the flange 30. One end of holding coil 11 is connected to the post 47 through lead wire 50. It will be noted from the wiring diagram of FIG. 4 that the pulling coil 12 is not connected directly to the post 47 but instead is connected to the switch 16 which in turn is electrically connected to the terminal 40.

There is a sheet 52 of insulating material on the outside surface of the flange 30. The post 47 of terminal 40 has a washer 53 of electrically insulating material upon the sheet and around the post and covering the glass seal 48, while post 41 has a similar washer 54 around it and around the glass seal 42.

Referring to FIG. 3, the movable element of the switch 16 and its support appear in plan. Such switch comprises a sheet 57 of spring metal having an end portion 58 thereof with a hole 59 therein so that it will fit over the post 47 to rest flush against the outside surface of washer 53. The sheet 57 has another end portion 60, similar in configuration to the portion 58, and adapted to fit over the post 41 of terminal 39. There is a hole 61 formed in the portion 60 and it will be noted that such hole 61 is substantially larger in diameter than the post 41, so that there will be no electrical connection between the switch 16 and the terminal 39.

Extending between the end portions 58 and 60 is an arm 63 of the plate 57, there being spaces 64 and 65 along the sides of the arm, whereby the arm may be flexed from the plane of the end portions 58 and 60. The outer or free end of the arm 63 has a contact element 66 secured to the outer surface thereof.

There are two thin but rigid plates 67 of insulating material mounted as with rivets 68 upon opposite surfaces of the switch arm 63. These plates cover a hole 69 in the switch arm and serve to permit the smaller plunger 15 to be connected to the switch arm in an electrically non-conductive connection. A pin 70 extends through the arm and through the plates 67, one end of the pin being fixed in the outer end of the smaller plunger 15 while the other end of the pin has a head 71 which prevents passage of the pin inwardly of the switch arm. Thus, movement of the smaller plunger 15 inwardly of the core of the solenoid will cause the arm 63 of the switch to flex inwardly toward the core.

Upon the switch plate 57 is a metallic nut 72 screw-threaded on the post 47 thereby to secure the end portion 58 of the switch plate upon the post and to improve the electrical connection between the switch plate and the terminal 40. The terminal 39 on the other hand has a washer 73 of insulating material fitted over the terminal post 41 to hold the switch plate secure in place as shown but without electrical connection between such terminal 39 and the switch plate.

There is a plate 75 of insulating material upon the nut 72 and washer 73, such plate 75 being held secure on the terminals by nuts 76 and 77 threadably secured on the terminal posts 47 and 41, respectively. The plate 75 serves to mount a switch contact arm 78, as with rivets 79, the arm 78 having a contact element 80 facing toward the contact element 66 on the movable switch arm 63. One end of the pulling coil 12 is connected to the switch arm 66 by lead wire 82, which is passed through a glass seal insulator 83 secured fluid-tight in the flange 30 of the core.

The terminals 39 and 40 are connected as with leads 85 and 86 to a source 87 of electric power in series with an on-off switch 88, through terminals 89 and 90, respectively, extending through the closure plate 37. Each of the terminals 89 and 90 comprise glass seal insulators 91 which are similar to those shown at 42 and 48.

In FIG. 5 a magnetic device 10 of the solenoid type embodying this invention is shown mounted upon a side wall 95 of a fuel tank, designated generally by reference numeral 96, in an arrangement such that the device 10 will control a valve contained within a fluid inlet 97 for the tank. The side wall 95 has an opening 98 formed therein of slightly larger diameter than that of the plunger 13. There is an annular flange 99 circumscribing the solenoid 10, the flange being welded or otherwise suitably secured around the outside surface of the device 10. Such flange receives fasteners 100 for mounting the same to the outside surface of the wall 95. The plunger 13 of the solenoid is connected by a series of links 101 and 102 to a handle 103 of a valve (not shown) contained in the inlet pipe 97. The link 101 has a stop 104 fixed thereto. Positioned between the stop and the inside wall of the tank is a spring 105 biasing the plunger 13 in a direction outwardly of the solenoid.

In FIG. 6 the solenoid 10 is shown mounted entirely within a tank 108 for operating a valve in an outlet 109 of the tank. In this embodiment the solenoid is mounted on a shelf 110 secured to the inside of the top wall of the tank. The plunger 13 has a rod 111 pivotally secured thereto at one end of the rod and the rod is pivotally connected at its other end to a pivot link 112. A spring 113 is fixed at one end thereof to the link 112 and at its other end to the shelf 110 whereby it serves to pull the plunger 13 in a direction outwardly of the device 10. A rod 114 connects the link 112 to a handle 115 of a valve (not shown) in the outlet 109 of the tank.

The mode of operation of the magnetic device 10 is as follows:

When the device is in its rest or stand-by condition, the plunger 13 is in its outwardly extended position as shown in FIG. 1 and the smaller plunger 15 is likewise disposed in its outward position, whereby the contacts 66 and 80 of the switch mechanism 16 are in engagement with each other. Upon closing the main switch 88 both coils 11 and 12 become energized, the current to the coil 12 passing from the terminal 40 through the switch plate 57 and its arm 63 to the contact arm 78 and thence by lead wire 82 to the coil 12. Energization of the coil 12 will pull the plunger 13 inwardly of the device, i.e. in the direction of arrow 120, against the force of spring 105 (or 113). The plunger 13 may be provided with one or more longitudinally extending grooves 121 on the outside surface thereof to allow for escape of gas within the cavity 20. Such inward movement of the plunger 13 will open a valve contained in pipe 97 or 109.

When the plunger 13 has been thus moved to its most inwardly disposed position shown in FIG. 2, i.e. seated in the frusto-conical recess of the core body, the gap previously existing between the plunger and the core body is closed with the result that the magnetic field developed by the coils becomes strongest, i.e. strong enough so that when coupled with the inward pull of the coils upon the smaller plunger 15, the combined forces will be sufficient to overcome the outward pull exerted on the

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smaller plunger 15 by the spring switch arm 63. Thus the smaller plunger 15 will move inwardly in its well 24 (in the direction of arrow 123 in FIG. 2) exerting an inward pull on the switch arm 63 to open the switch 16. Opening of the switch 16 breaks the circuit to the pulling coil 12 and leaves only the holding coil 11 energized.

The combination of a pulling coil and a holding coil in a solenoid is well known to those skilled in the art to which this invention pertains and accordingly, it is deemed unnecessary for the purposes of this description to describe the details of construction of such holding and pulling coils. It is enough to understand that though a relatively powerful force is needed to pull an armature inwardly of a solenoid coil, a substantially less magnetic force is needed to maintain such armature in its inwardly disposed position. Accordingly, the pulling coil 12 is designed, as is known by those skilled in the art, to produce a large magnetic flux and the holding coil 11 is designed to consume substantially less electrical power than that required for energization of the coil 12.

As described above, the smaller plunger 15 is designed to move simultaneously with the seating of the plunger 13 in the frusto-conical recess 22 of the core body. To obtain optimum operating characteristics, the mass and length of the smaller plunger 15 and the strength of the spring switch arm should be such that the smaller plunger will not move inwardly of the coils until the larger plunger 13 has been seated. Resistance to movement of the smaller plunger 15 may be predetermined by designing the sleeve 25 to a relatively close though sliding fit around the plunger 15. In this connection the sleeve 25 may be formed of electrically insulating material and with the inner end thereof closed so as to electrically insulate the smaller plunger from the core body of the solenoid. The non-conductive plates 67 on the switch arm 63 also serve to electrically insulate the switch from the core body. As in the case of the plunger 13, the smaller plunger 15 may likewise be provided with one or more longitudinally extending grooves 125 in the outside surface thereof to allow for escape of gas from within the well 24 as the plunger 15 moves inwardly thereof.

When the main switch 88 is again opened, the holding coil becomes deenergized, whereupon the spring 105 or 113 pulls the plunger 13 in a direction outwardly of the solenoid back to its stand-by position. Also the spring arm 63 pulls the plunger 15 in a direction outwardly of its well, thus to again close the switch 16 in its rest position.

In view of the above it will be appreciated that by the solenoids of the this invention, there is provided a magnetic device having pulling and holding coils and a switch for controlling energization of the coils and in which the switch is hermetically sealed against any flow thereto of fluid which may enter the cavity of the operating plunger 13. Thus the magnetic device of this invention may be installed entirely within an explosive atmosphere as is shown, for example, in FIG. 6 of the drawing, without danger of sparks from the switch igniting such explosive atmosphere. By this invention there is further provided a magnetic device of the solenoid type in which the operating plunger 13 affects a switch-operating plunger 15 for controlling energization of the solenoid coils.

In the above described embodiment both the pulling and holding coils become energized upon the closing of the main switch 88. I desire to have it understood, however, that the wiring diagram shown in FIG. 4 for effecting simultaneous energization of the coils 11 and 12 followed by deenergization of pulling coil 12 and subsequent deenergization of holding coil 11 is for illustrative purposes only. Such circuit for the coils through the switch 16 may be such as to cause energization of the holding coil 11 instantaneously with deenergization of pulling coil 12, it being the essence of this invention that the smaller plunger 15 operates the switch and thereby permits the

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switch to be enclosed and protected against flow of gas from the chamber of the operating plunger 13 to the chamber containing the switch.

While the instant invention has been shown and described herein, in what are conceived to be the most practical and preferred embodiments, it is recognized that departures may be made therefrom within the scope of the invention, which is therefore not to be limited to the details disclosed herein, but is to be accorded the full scope of the claims.

What I claim is:

1. A magnetic device comprising a pulling coil and a holding coil, the coils being tubular and having forward ends and rearward ends, the coils being arranged one around the other whereby the inner coil defines a space extending axially therethrough, a core body of magnetic material extending into said space from the rearward ends of the coils and leaving a central cavity within the inner coil disposed forwardly of the core body and open in the forward end of said space, a first plunger movable axially in said cavity toward said core body in response to energization of the pulling coil, the core body having a well formed therein open in the rearward end of the core and closed to the said cavity a second plunger movable axially in said well during the period of energization of the pulling coil, switch means electrically connected to said coils and operatively connected to said second plunger and adapted to be electrically connected to a source of power for controlling energization of said coils in response to movement of said second plunger into the well, and means defining a housing containing said switch means and hermetically sealing the switch means from the space in said cavity.

2. A device according to claim 1 in which said housing defining means hermetically seals the switch means and the space in said well from the space in said cavity and from the atmosphere surrounding said device.

3. A magnetic device comprising a pulling coil and a holding coil, the coils being tubular and having forward ends and rearward ends, the coils being arranged one around the other whereby the inner coil defines a space extending axially therethrough, a core body of magnetic material extending into said space from the rearward ends of the coils and leaving a central cavity within the inner coil disposed forwardly of the core body and open in the forward end of said space, a first plunger movable axially in said cavity toward said core body in response to energization of the pulling coil, the core body having an annular flange integral therewith and extending radially outwardly from around the rearward end of the core body and covering the rearward ends of the coils, the core body having a well formed therein open in the rearward end of the core and closed to the said cavity, a second plunger movable axially in said well during the period of energization of the pulling coil, switch means operatively connected to said second plunger and adapted to be electrically connected to a source of power for controlling energization of said coils in response to movement of said second plunger into the well, lead wires from said coils extending through said flange to said switch means, and means insulating and hermetically sealing said lead wires in the portions of the wires which extend through said flange.

4. A magnetic device according to claim 3 and comprising means defining a fluid-tight chamber with said flange for housing said switch means.

5. A magnetic device comprising an elongate core having forward and rearward ends, the core having a first cavity formed longitudinally therein open in the forward end of the core and terminating short of the rearward end of the core, the core having a second cavity formed longitudinally therein open in the rearward end of the core and terminating short of the first cavity, there being a transversely extending imperforate wall in the core separating the inner ends of the cavities, two coaxially

arranged tubular coils around the core, the coils having forward ends and rearward ends, respectively, the forward ends of the coils being disposed on the core forwardly of said transverse wall, the rearward ends of the coils being disposed on the core rearwardly of said transverse wall, one coil being a pulling coil and the other coil being a holding coil, a first plunger movable longitudinally in the first cavity toward said transverse wall in response to energization of the pulling coil, a second plunger movable longitudinally in the second cavity toward said transverse wall during the period of energization of the pulling coil, and switch means electrically connected to said coils and operatively connected to said second plunger and adapted to be electrically connected to a source of power for controlling energization of said coils in response to movement of said second plunger.

6. A magnetic device comprising an elongate core having forward and rearward ends, the core having a first cavity formed longitudinally therein open in the forward end of the core and terminating short of the rearward end of the core, the core having a second cavity formed longitudinally therein open in the rearward end of the core and terminating short of the first cavity, there being a transversely extending imperforate wall in the core separating the inner ends of the cavities, two coaxially arranged tubular coils around the core, the coils having forward ends and rearward ends, respectively, the forward ends of the coils being disposed on the core forwardly of said transverse wall, the rearward ends of the coils being disposed on the core rearwardly of said transverse wall, one coil being a pulling coil and the other coil being a holding coil, a first plunger movable longitudinally in the first cavity toward said transverse wall in response to energization of the pulling coil, a second plunger movable longitudinally in the second cavity toward said transverse wall during the period of energization of the pulling coil, switch means electrically connected to said coils and operatively connected to said second plunger and adapted to be electrically connected to a source of power for controlling energization of said

coils in response to movement of said second plunger, and a barrier integral with and extending around the core for isolating the space in which the switch is located from the space of said first cavity.

7. A magnetic device comprising a pulling coil and a holding coil, the coils together forming a tubular coil assembly having a forward end and a rearward end, the coil assembly defining a space extending axially there-through, a core body of magnetic material extending into said space from the rearward end of the coil assembly and leaving a central cavity within the coil assembly disposed forwardly of the core body and open in the forward end of said space, a first plunger movable axially in said cavity toward said core body in response to energization of the pulling coil, the core body having a well formed therein open in the rearward end of the core and closed to the said cavity, a second plunger movable axially in said well during the period of energization of the pulling coil, switch means electrically connected to said coils and operatively connected to said second plunger and adapted to be electrically connected to a source of power for controlling energization of said coils in response to movement of said second plunger into the well, and means defining a housing containing said switch means and hermetically sealing the switch means from the space in said cavity.

8. The magnetic device of claim 7 in which said housing defining means hermetically seals the switch means and the space in said well from the space in said cavity and from the atmosphere surrounding said device.

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