Sept. 9, 1941. L. B. EHRLICH 2,255,542

SOLENOID OPERATED SWITCH

Filed May 4, 1938

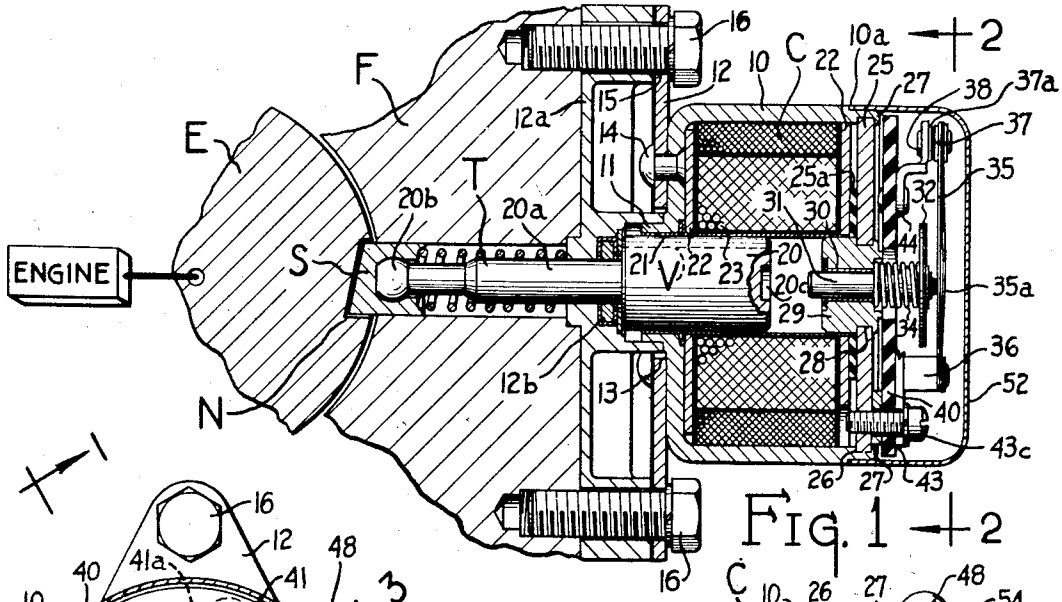


FIG. 1

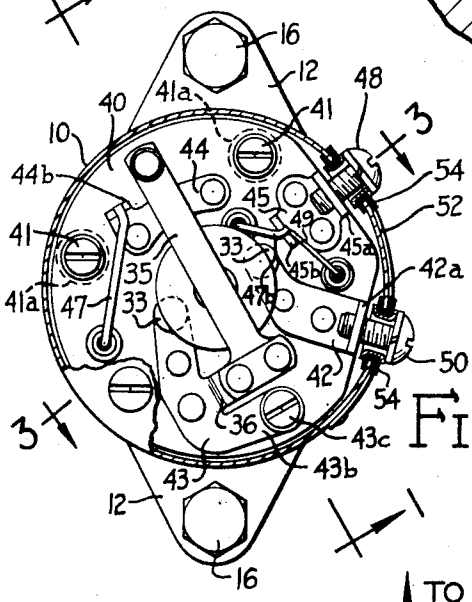


FIG. 2

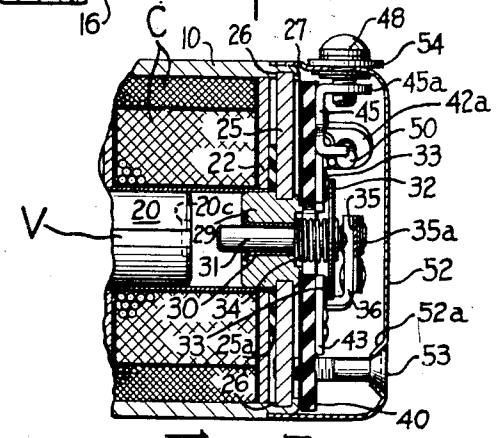


FIG. 3

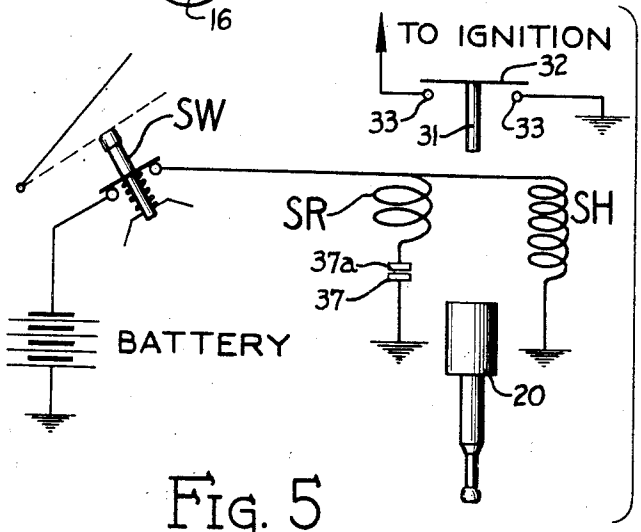


FIG. 5

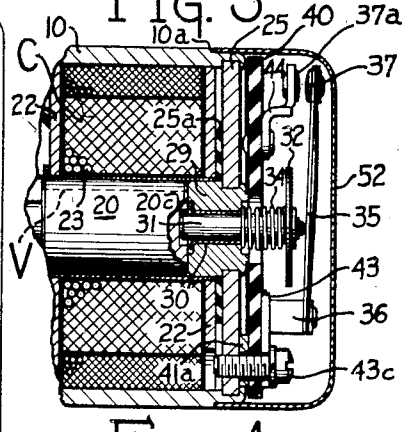


FIG. 4

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SOLENOID OPERATED SWITCH

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10 Claims. (Cl. 200—103)

This invention relates to electric solenoids, more particularly to electric solenoids adapted to perform a sequence of operations, in which each operation in the sequence is dependent upon the completion of the previous operation.

This invention contemplates the provision of an electric solenoid which is capable of performing a dual function by acting upon a pair of armatures to initiate a sequence of operations in which full power is applied at the beginning of the cycle to enable the solenoid to apply a predetermined amount of force upon a principal armature, but should this force be insufficient to bring about movement of the principal armature due to restraint arising from extraneous sources, a secondary armature is moved substantially simultaneously by the attractive force of the solenoid to manipulate cooperating electrical switches and thereby change extraneous electrical circuits which, in turn, will influence the adverse extraneous conditions restraining the principal armature to allow the predetermined amount of force exerted on the principal armature to move the principal armature to actuated position and thereby attain a desired result in the extraneous conditions sought to be brought about by the use of the solenoid. When the principal armature moves "home," that is, moves to its maximum inward position, it contacts or engages the secondary armature to disengage the electrical switch actuated previously by the secondary armature to its original condition, and moving further, it changes the electrical conditions under which the solenoid is operating by opening a low resistance coil and allows the high resistance coil of the solenoid to hold the principal armature in actuated position.

This invention further contemplates the provision of a magnetic structure for an electric solenoid which concentrates the magnetic flux at proper points so as to create the most effective magnetic relations to increase the efficiency and usefulness of the solenoid.

It is, therefore, a principal object of this invention to provide a solenoid having armatures which cooperate together through an extraneous agency to be actuated sequentially to accomplish a predetermined result upon the extraneous agency.

It is a further object of this invention to provide a solenoid having more than one armature, including a principal armature and a secondary armature, in which the principal armature is designed to perform a predetermined function upon an extraneous object and the secondary armature is designed to create conditions, preferably by electrical means, in the extraneous object which will expedite the attainment of the function to be performed by the principal armature.

It is a further object of this invention to provide a magnetic solenoid having more than one armature in which the magnetic circuits are designed to concentrate magnetic flux at predetermined points, so that the most effective magnetic relations may be established in the solenoid to attain the desired results.

Other objects and advantages of this invention relating to the arrangement, operation and function of the related elements of the structure, to various details of construction, to combinations of parts and to economies of manufacture, will be apparent to those skilled in the art upon consideration of the following description and appended claims, reference being had to the accompanying drawing forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

Figure 1 is a sectional elevation of a device embodying one form of the invention and is taken generally along the line 1—1 of Figure 2.

Figure 2 is a plan view, partly in section, taken along the line 2—2 of Figure 1.

Figure 3 is a sectional elevation taken along the line 3—3 of Figure 2.

Figure 4 is another sectional elevation taken along the line 1—1 of Figure 2 with the operating parts in a different position.

Figure 5 is a layout of a diagram of connections in which an embodiment of the invention finds utilization.

Referring specifically to Figure 1, a cup-shaped casing or container 10 is provided of suitable magnetic material such as steel or the like, the casing being provided with an aperture in its bottom, rimmed with a depending concentric flange 11. For fastening the cup-shaped container 10 to any suitable fixed object with which it is to be used, a plate 12 is provided, having an aperture 13 through which the flange 11 extends. The plate 12 is fastened to the bottom of the cup-shaped container 10 by means of rivets 14 and provided at its laterally extending portions with apertures 15 through which extend screws 16 to fasten the cup-shaped container 10 to the fixed object. A spacer casting 12a may be provided to facilitate sealing the casing 10 and prevent magnetic leakage.

A plunger 20 is provided to reciprocate into

the cup-shaped container 10 by being loosely fitted into the aperture in the base of the container and embraced by the flange 11. The plunger 20 is adapted to slide longitudinally through the aperture rimmed by the flange 11, a brass sleeve 21 being provided to bush the flange 11 for the plunger 20 to prevent rust from forming and to facilitate the sliding relation between the plunger 20 and the cup-shaped container 10. To prevent a dash pot action on the entrapped air, an air vent V is provided which may be in the nature of a longitudinal slot in the plunger 20. Projected outwardly from the plunger 20, a concentric stem 20*a* is provided having at its forward end a head 20*b* which cooperates with a slug S. The plunger 20 is thereby enabled to move the slug inwardly against the thrust of a resilient spring T acting between the slug S and a fixed portion of the body to which the device is applied or the spacer casting 12*a*. The spring T urges the plunger 20 and its cooperating slug S to the left (Figure 1) at all times, the slug S being capable of performing predetermined work functions as will be described hereinafter with reference to a desirable means by which the invention can be utilized. Oil seals 12*b* may be supplied to cooperate with the stem 20*a* and may be conveniently positioned in a counterbore in the casting 12*a*.

In order to supply a magnetic field to move the plunger 20, an electro-magnetic coil C is provided, positioned on the interior of the cup-shaped container 10, which forms a part of its magnetic circuit. The coil C is preferably wound upon a bobbin having magnetic plates 22 at its ends, spaced by a brass sleeve 23. The windings of the coil C are preferably divided into a low-resistance winding having relatively few turns of heavy wire and a high-resistance winding having a relatively large number of turns of comparatively small wire. The function of the low resistance coil is to supply magnetic flux of sufficient density and attractive force to pull the plunger 20 into the cup-shaped container 10 from a remote position. To most effectively attain this purpose, it is positioned as near as possible to the plunger 20. On the other hand, the function of the high-resistance coil is to supply sufficient magnetic flux to hold the plunger 20 in position after it has been actuated by the flux created by the low-resistance coil. The high-resistance coil, having a relatively large number of turns of small wire, has a relatively larger resistance, so that a smaller amount of current will flow therethrough as compared to the amount of current which flows through the low-resistance coil. To reduce temperature rise and conserve electrical energy, switching structures have been provided whereby the low-resistance coil will be cut from the electric circuit when the plunger 20 moves "home," that is, moves to its most inwardly or final position, thereby leaving only the high-resistance coil in circuit for holding the plunger. This structure will be described in detail hereinafter.

To hold the coil C in position, a head plate 25 is provided which is of relatively heavy magnetic material so as to obviate saturation by magnetic flux. The peripheral edge of the plate 25 engages with an annular ledge 26, formed on the inside of the cup-shaped container 10. The plate is permanently held in cooperative relation against the ledge 26 by means of an inturned flange 21 formed on the lip of the cup-shaped container 10. A gasket member 25*a*, of resilient material such as cork, is positioned between the plate 25 and the end plate 22 of the coil bobbin.

At a central position in the plate 25, an aperture 28 is provided in which a massive collar 29 of magnetic material is positioned to cooperate with the bore of the bobbin. The collar 29 is positioned on the plate 25 between a shoulder and an outwardly-turned flange on the collar. The aperture in the collar 29 may be bushed with a brass sleeve 30 in which a secondary plunger 31 is adapted to reciprocate. The secondary plunger 31 is of sufficient length to project beyond the forward face of the collar 29 so as to extend in the direction of the first plunger 20. The first or principal plunger 20 is provided on its forward face with an indentation 20*c* which cooperates with the projection on the secondary flange 31 in a manner to allow the projection to extend a considerable distance. The purpose of this projection will be described hereinafter.

The secondary plunger 31 adjacent its outer end may be provided with a circular contact plate 32 which is preferably loosely riveted thereto in any convenient manner. The contact plate 32 is preferably made of a steel stress-bearing member and a silver contact-making member, the silver contact-making member being preferably mounted on the inner side (to the left in Figure 1), to cooperate with contact points 33 positioned adjacent thereto.

To maintain the secondary plunger 31 and the contact plate 32 at a neutral position during inactive periods of the magnetic field of the coil C, a relatively weak coil spring 34 is provided acting between the plate 32 and the collar 29. The spring 34 thrusts the plunger 31 to the right (Figure 1) until it comes to rest against a relatively rigid leaf spring 35 which is anchored at one end by rivets to a bracket 36, the other end being provided with a contact point 37 to cooperate with a second contact point 37*a* mounted on a bracket 38. The stiffness of the leaf spring 35 is such that the coil spring 34 is too weak to move it, while the spring 34 may readily collapse under the action of the leaf spring 35. In this manner, the contact disc 32 and the secondary plunger "float" between the two springs.

The electrical switching portions of the solenoid which are actuated by the secondary plunger 31, having already been described in part, are mounted upon an insulating plate 40 which is attached to the plate 25 by means of screws 41 threaded into apertures in the plate 25 and spaced therefrom by washers 41*a*. Mounted on the insulating plate 40 by means of suitable rivets are the bracket plates 42, 43, 44, and 45, which are carefully insulated from the plate 25 and other grounded parts of the mechanism. As described hereinbefore, the contact points 33, which cooperate with the contact plate 32, are mounted upon the plates 42 and 43 respectively. The plate 43 is integral with the upstanding projection 36 to which the leaf spring 35 is riveted as already described. This is clearly shown in Figures 1 and 2. In order that better electrical connection may be made between the contact point 37 and the plate 43, a low-resistance connecting strip 35*a* is provided to bridge the spring 33 and is preferably held in position by the same rivets which hold the leaf spring 35 and the contact point 37 in their relative positions. The plate 43 is preferably formed with a plate extension 43*b* which is provided with an aperture, through which a

screw 43c extends, being threaded at its lower end in the plate 25. The plate 25 is grounded to the container 10, and so it forms a ground through the agency of the plate 43 for contacts 33 and 37.

The plate 44 is integral with the bracket 38 which mounts the contact point 37a, mentioned hereinbefore, so that the contact point 37a may cooperate with the contact point 37 mounted on the end of the leaf spring 35. The plate 44 is provided with a nib 44b which is adapted to cooperate with one end 47 of the low-resistance coil of the electro-magnet, the end being preferably soldered to the nib, so as to make the best possible electrical connection with the plate 44 and the contact 37a. The plate 45 is provided with a pair of upstanding flanges 45a and 45b, the former being provided with a threaded aperture with which a binding post 48 cooperates. The flange 45b is preferably of the slotted construction to allow the soldering thereto of the other end 47b of the low-resistance coil and one end 49 of the high-resistance coil. The other end of the high-resistance coil is grounded (not shown) to the container 10. In a similar manner, the plate 42, to which one of the contact points 33 is attached, is provided with an upstanding flange 42a, having a threaded aperture with which a binding post 50 cooperates.

To protect the switching elements actuated by the secondary armature of the solenoid, a cup-shaped casing 52 is provided whose open end cooperates with the container 10 by being fitted against an annular shoulder 10a formed on the outside of the container. The casing 52 is held in position against the shoulder 10a by means of a screw 53 which is threaded into the plate 25, and extends through an aperture 52a in the casing. The side of the cup-shaped casing is perforated adjacent the binding posts 48 and 50 to allow them to cooperate with their flanges 45a and 42a respectively from the outside of the casing. In order to insulate the binding posts from the cover 52, insulated eyelets 54 are fitted in the perforations, so that electrical connection with the switches in the casing 52 can readily be made by the use of the binding posts.

Referring again to Figure 1, an application is disclosed in which an embodiment of this invention may find utilization. An engine is shown diagrammatically as driving an element E which may rotate in relation to a fixed element F to which the container 10 is attached by means of bolts as described hereinbefore. The relative rotation of the element E with respect to the fixed element F may determine a sequence of work functions such as, for example, in an over-drive of an automobile, where the over-drive is in operative relation when the rotative element E is held in fixed position by means of the slug S, which is shown as cooperating with the notch N in the periphery of the rotative element E. For purposes of this discussion, these elements are all shown diagrammatically, the details being omitted.

The modification of this invention as disclosed may find utility in withdrawing the slug S from cooperating relation with the notch N under predetermined conditions. Should the solenoid mechanism not have sufficient power to withdraw the slug S from the notch N in the rotative element E, due to the resistance arising from the friction between the parts which is proportional to the amount of force being transferred from the rotative element E to the fixed element F, through the agency of the slug S, which may result in friction sufficiently great to prevent the slug S from being withdrawn by the relatively small amount of force available by the interaction of the magnetic field created by the coil C and the plunger 20 moving under its influence. Under these circumstances, it may be desirable to change the force conditions existing between the rotative element E and the fixed element F, so that the force acting between them will momentarily cease; at the instant of the change of force conditions, the force created by the magnetic pull on the plunger 20 will be sufficient to retract the slug S from the notch N.

In the mechanism as shown in Figure 1, this is accomplished by providing the secondary plunger 31 which is drawn into the coil C upon initiation of the magnetic field, assuming that the conditions between the rotative element E and the fixed element F are such that the slug S cannot be moved by the principal plunger 20. When the secondary plunger 31 is drawn into the magnetic field, the contact plate 32 is drawn into cooperative relation with the contact points 33, which may control a function of the engine which, in this case, determines the conditions existing between the rotative element E and the fixed element F. It would be possible to create a momentary cessation of force between the rotative element E and the fixed element F if the engine supplying the force acting between these two elements had its ignition momentarily short-circuited. A mechanism is disclosed above which allows the ignition of the engine to be short-circuited for a period of one or more explosions which will release the force acting between the rotative element E and the fixed element F.

Figure 5 discloses a schematic diagram of connections to attain this result in which a cycle of operation is initiated by the actuation of the plunger of a manual switch SW, the low-resistance coil SR being placed in circuit with the contacts 37 and 37a, and the high-resistance coil SH remaining in circuit at all times during which the principal switch SW is closed. As shown in this figure, if the plunger 20 is held against movement by means of the friction on the slug S, the secondary plunger 31 is free to move to the left (Figure 1) which spans the contact points 33 with the contact plate 32 and may short-circuit the ignition of the engine. When the engine has its ignition short-circuited, its power will immediately cease and a reaction will immediately become noticeable which will be reflected in the rotative force exerted by the element E with reference to the fixed element F through the agency of the slug S. The force applied on the slug S will diminish to such an extent that the friction on the slug S will become small enough to be overcome by the attractive pull of the magnetic field on the principal plunger 20, which will result in the slug S moving from its cooperative relation with the notch N to allow the rotative element E free play with regard to the fixed element F. This new relation gives rise to the new circumstance in the transmission of power and attains the desired result.

When the principal plunger 20 moves to the right, and is thrust "home" as shown in Figure 4, it contacts the projection of the plunger 31 at the bottom of the depression 20c in its forward face. This forces the smaller plunger also to the right as shown in Figure 4, thereby moving the contact plate 32 to open the contacting relation between the contact points 33 and remove the short-circuit from the ignition of the engine.

Continuing to move farther to the right, it will overcome the bias of the leaf spring 35 to open the contacts 37 and 37a to break the circuit through the low-resistance coil. When the circuit through the low-resistance coil is broken, the principal plunger 20 is held in actuated position by means of the high-resistance coil which is still being energized from the battery.

Should now the manual switch SW be opened to terminate the magnetic field, the spring T will urge the slug S to the left as shown in Figure 1, allowing the secondary plunger 31 to be returned to the position shown substantially in Figure 1, in which the contact plate 32 "floats" between the resilient means 34 and the leaf spring 35 which has acted to close the contact points 37 and 37a. When the parts of the mechanism are in this condition, the spring T will urge the principal plunger to the left until such times when the conditions between the rotative element E and the fixed element F are such that the slug S may again cooperate with the notch N to bring the parts to their original state. The mechanism is then ready for a new cycle of operation which is again initiated by the depression of the plunger of the switch SW.

It is to be understood that the above detailed description of the present invention is intended to disclose an embodiment thereof to those skilled in the art, but that the invention is not to be construed as limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawing, since the invention is capable of being practiced and carried out in various ways without departing from the spirit of the invention. The language used in the specification relating to the operation and function of the elements of the invention is employed for purposes of description and not of limitation, and it is not intended to limit the scope of the following claims beyond the requirements of the prior art.

What is claimed:

1. In a device of the class described, a supporting structure with an aperture, a moving element positioned adjacent the aperture on one side of the supporting structure, a reciprocating member movable with reference to the supporting structure to selectively establish a cooperative relation between the moving element and the supporting structure, a casing removably attached to the side of the supporting structure opposite from the side of the moving element, magnetic coil means positioned in the casing and adapted to create a magnetic field, a pair of armatures of relatively different masses adapted to move under the influence of the magnetic field, connecting means between the relatively larger armature and the reciprocating member extending through the aperture in the supporting structure, whereby the larger armature is enabled to move the reciprocating member to terminate the relation between the moving element and the supporting structure, resilient means to thrust the relatively larger armature and the reciprocating member in the direction of the moving element to reestablish the relation between the supporting structure and the moving element, resilient means to bias the relatively smaller armature to an initiating point, the relatively smaller armature being adapted to move in either direction from the initiating point under the influence of the coil means and the larger armature respectively, and switch means cooperating with the relatively smaller armature at each of the extremes of its movements to be actuated thereby respectively.

2. In a device of the class described, a supporting structure having an aperture, a moving element mounted relatively adjacent the aperture, a second moving element cooperating with the aperture to establish a cooperative relation between the supporting structure and the first moving element, magnetic means cooperating with the second movable element through the aperture to break the cooperative relation between the supporting structure and the first moving element, resilient means to urge the second moving element to reestablish cooperative relation between the first moving element and the supporting structure, a source of magnetomotive force to actuate the magnetic means, a second magnetic means actuated by the magnetomotive force cooperating with the first magnetic means and capable of being moved thereby, switch means adapted to be actuated by the second magnetic means when moved by the magnetomotive force, a second switch means adapted to be actuated by the second magnetic means when moved by the first magnetic means, and resilient means to bias the second magnetic means in a mean position.

3. In a device of the class described, a pair of elements mounted adjacent each other and adapted for relative movement, a movable member cooperating with the elements to establish a cooperative relation between the elements, a source of magnetomotive force, a pair of armatures of relatively different masses adapted to be moved by the magnetomotive force, connecting means between the relatively larger armature and the movable member to allow the larger armature to move the movable member to break the cooperative relation between the pair of elements, resilient means active on the larger armature and the movable member to reestablish the cooperative relation between the pair of elements, a resilient means for the relatively smaller armature to bias it to a predetermined mean position and being adapted to move in opposite directions therefrom, the relatively smaller armature being adapted to move in one direction under the influence of the magnetomotive force, and in the opposite direction under the influence of the larger armature.

4. The device defined in claim 3 further characterized by switch means cooperating with the relatively smaller armature at each extreme of its movement from the mean position, the switch means being adapted to be actuated by the movements of the relatively smaller armature.

5. In a device of the class described, a pair of elements mounted adjacent each other and adapted for relative movement, a movable member cooperating with the elements to establish a selective cooperative relation between the elements, a source of magnetomotive force, a pair of armatures of relatively different masses adapted to be moved by the magnetomotive force, connecting means between the relatively larger armature and the movable member to allow the larger armature to move the movable member to terminate the cooperative relation between the pair of elements, resilient means to move the movable element to reestablish the said cooperative relation, and switch means cooperating with the relatively smaller armature, the relatively smaller armature being adapted to actuate the switch means when moved under the influence of the magnetomotive force, the larger armature

being adapted to cooperate with the smaller armature to move the smaller armature adjacent to the initiating point, when the larger armature is moved by the magnetomotive force.

6. In a device of the class described, a cup-shaped casing of magnetizable material, an electromagnetic coil means in the casing to create a magnetic field, an armature of relatively large mass adapted to cooperate with the casing in an aperture therein to move into the coil means under the influence of the magnetic field, resilient means cooperating with the armature to move the armature out of the coil means upon termination of the magnetic field, cover means for the cup-shaped casing made of magnetizable material and adapted to complete the magnetic circuit when cooperating with the armature, a second armature of relatively small mass cooperating with the cover means in an aperture therein and adapted to move into the coil means under the influence of the magnetic field, resilient means to return the second armature to an initiating point, a plurality of switch means mounted on the cover means and cooperating with the second armature to be actuated thereby at the extremes of movement of the second armature from the initiating point, the second armature actuating one set of switches when under the influence of the magnetic field, and a second set of switches when under the influence of the first armature.

7. In a device of the class described, an electro magnetic coil means, an armature of relatively large mass adapted to move into the coil means under the influence of the magnetic field, resilient means adapted to move the armature out of the coil means upon termination of the magnetic field, a second armature of relatively small mass adapted to move into the coil means under the influence of the magnetic field where the second armature cooperates with the first armature, the pull of the magnetic field of the first armature overcoming the pull of the magnetic field on the smaller second armature whereby the first armature is enabled to thrust the second armature from the coil means beyond an initiating point, switch means cooperating with the second armature when the second armature is in position in the coil means, a second switch means cooperating with the second armature when the second armature is over-controlled by the first armature and is thrust thereby beyond the initiating point, and resilient means to return the second armature to the initiating point upon termination of the magnetic field.

8. In a device of the class described, a cup-shaped casing of magnetizable material, an electromagnetic coil means positioned in the casing, a magnetic closure member for the casing, a pair of armatures adapted to be drawn into the coil means by the magnetic field through apertures in the bottom of the cup-shaped casing and the closure member from opposite directions, the armatures being adapted to cooperate together in the coil means whereby the force active on one armature may overcome the force active on the other, resilient means to move the armatures out of the coil means upon termination of the magnetic field, switch means cooperating with the weaker armature and adapted to be closed when the weaker armature is in the coil means, a second switch means adapted to be opened when the weaker armature is displaced from the coil means by the stronger armature, and resilient means to reclose the second switch means upon termination of the magnetic field.

9. In a device of the class described, a supporting structure with an aperture, a reciprocating member movable in the aperture with reference to the supporting structure, a casing removably attached to the supporting structure having an aperture aligning with the aperture in the supporting structure, magnetic coil means positioned in the casing and adapted to create a magnetic field, a pair of armatures of relatively different masses adapted to move under the influence of the magnetic field, connecting means between the relatively larger armature and the reciprocating member extending through the aperture in the casing whereby the relatively larger armature is enabled to move the reciprocating member in the aperture of the supporting member, resilient means to constrain the movement of the reciprocating member when the reciprocating member is being moved by the relatively larger armature, a second resilient means cooperating with the relatively smaller armature to bias the relatively smaller armature to an initiating point, the relatively smaller armature being adapted to move in one direction from the initiating point under magnetic influence of the coil means and in the other direction under the influence of the larger armature against the influence of the coil means and switch means cooperating with the relatively smaller armature at each of the extremes of its movements from the initiating point to be actuated thereby respectively.

10. In a device of the class described, a supporting structure having an aperture, a movable element adapted to reciprocate in the aperture, magnetic means cooperating with the movable element to reciprocate the element in the aperture, resilient means to constrain the movement of the element under the influence of the magnetic means, a source of magnetomotive force to actuate the magnetic means, a second magnetic means actuated by the magnetomotive force cooperating with the first magnetic means and capable of being moved by the first magnetic means against the influence of the magnetomotive force, switch means adapted to be actuated by the second magnetic means when actuated by the magnetomotive force, a second switch means adapted to be actuated by the second magnetic means when moved by the first magnetic means, and resilient means to bias the second magnetic means to a mean position.

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