Sept. 6, 1949. F. G. LOGAN 2,481,431

SHOCKPROOF ELECTROMAGNETIC RELAY

Filed Aug. 10, 1943 2 Sheets-Sheet 1

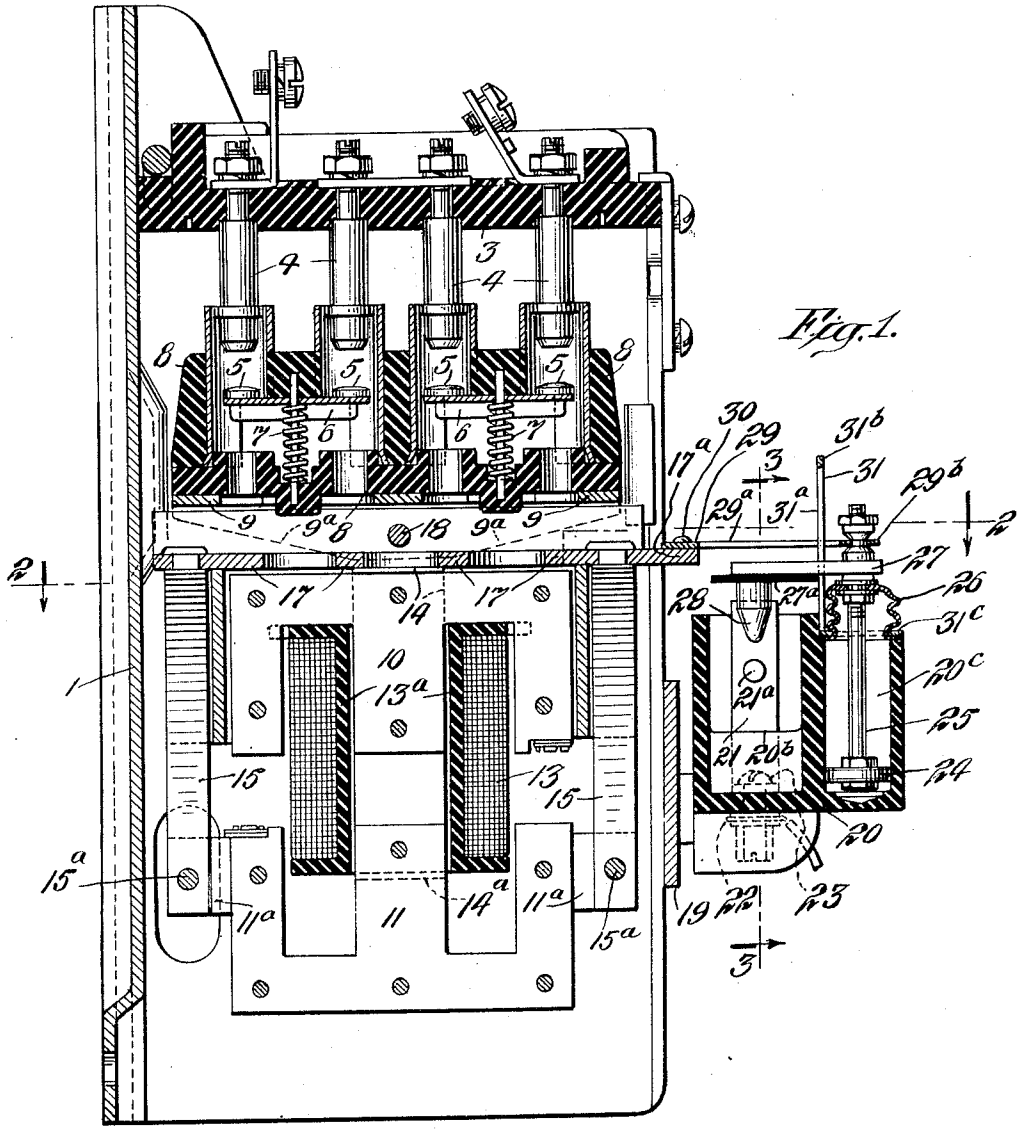

Fig. 1.

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Fig. 2.

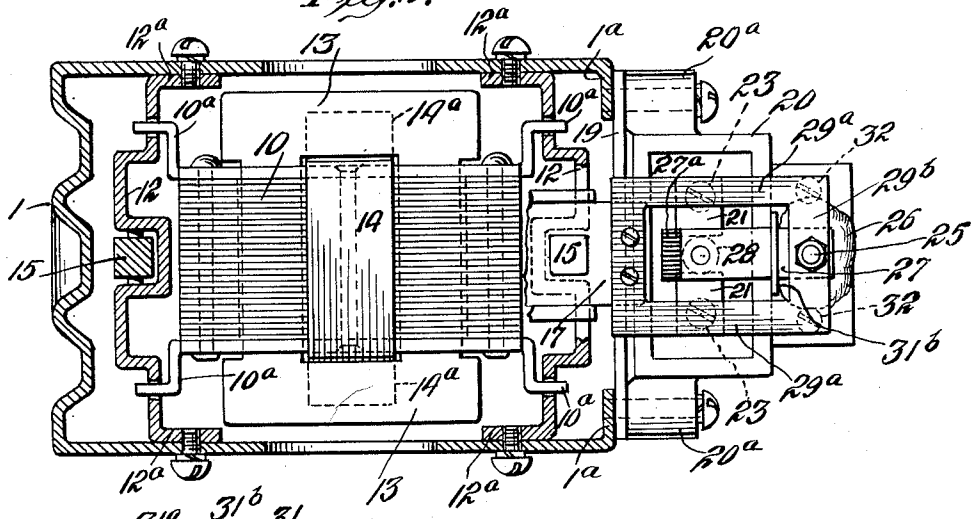


Fig. 3.

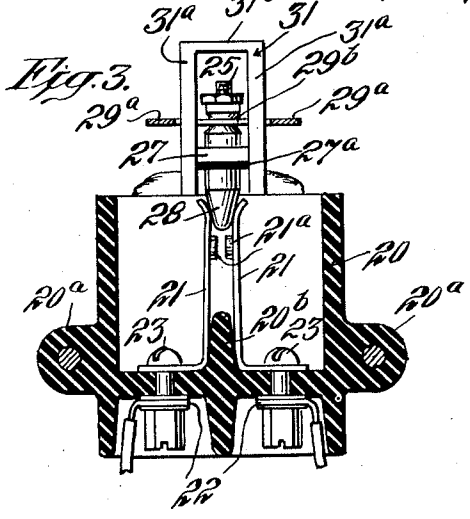


Fig. 4.

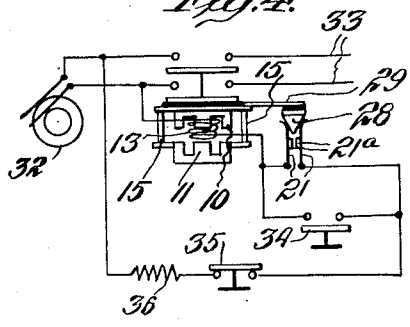
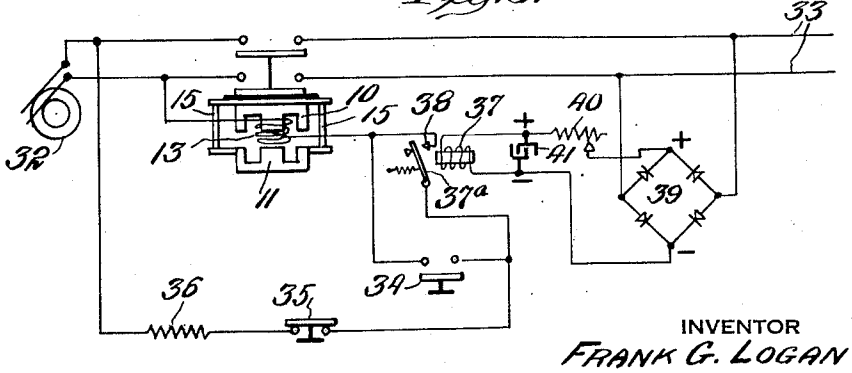


Fig. 5.



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# UNITED STATES PATENT OFFICE

2,481,431

## SHOCKPROOF ELECTROMAGNETIC RELAY

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Application August 10, 1943, Serial No. 498,031

14 Claims. (Cl. 175—375)

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This invention relates to electromagnets having a stationary element or part and a movable element, such as an armature or plunger; and means are associated therewith for overcoming the effects of mechanical shocks by maintaining the energization of the magnet even though the movable element of the magnet is moved from its desired position by shocks.

The improvement is particularly applicable to instances where the movement of the movable element from its attracted position would otherwise deenergize the magnet, such as when a normally open push button is used for momentarily closing the circuit of the magnet which is then maintained closed by auxiliary contacts controlled by the movement of the movable element of the magnet to its attracted position. Under such circumstances if a shock moved the element from its attracted position it would result in opening the auxiliary contacts and thereby deenergize the magnet, causing the movable element to assume its unattracted position, whereas it should remain in its attracted position after the passing of the shock. The circuit of the magnet should be opened only when desired, such as by opening normally closed additional contacts in the circuit of the magnet, usually by a normally closed push button. The magnet may be used for various purposes by actuation of the movable element such as for closing or opening circuits, for motor starters, or for the control of any device in its movement between two positions.

The main object is to provide simple and inexpensive means for overcoming the effect of mechanical shocks or jars by maintaining the energization of the magnet during such shocks and thereby avoiding an undesired deenergization of the magnet. Another object is to avoid undesired energization of the magnet by shocks when it is intended to be deenergized. Another object is to provide such means which will be dependable and durable under long continued use. Other objects and advantages will be understood from the following description and accompanying drawings which illustrate preferred embodiments of the invention.

Fig. 1 is a vertical section showing the invention applied to an electromagnetic switch; Fig. 2 is a horizontal section on the line 2—2 of Fig. 1; Fig. 3 is a vertical section on the line 3—3 of Fig. 1; Fig. 4 is a diagram of the electrical connections; and Fig. 5 is a diagram of another embodiment of the invention.

Although Figs. 1 to 4 show the invention applied to a particular form of electromagnetic switch disclosed and claimed in my pending application Serial No. 417,990, filed November 6, 1941, now Patent No. 2,378,022, issued June 12, 1945, and in the application of George M. Stapleton, Serial No. 420,327, filed November 25, 1941, now Patent No. 2,378,162, issued June 12, 1945, as one typical application thereof, it will be understood that it may be applied to various other types and forms of electromagnets utilized for various purposes.

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Referring to Figs. 1 to 3, the electromagnet shown is supported by a frame or base 1 of sheet metal having a general U-shaped form. The base of the U extends vertically and the two side portions extend forwardly from the base portion. At the top of the frame is supported a contact head or block 3 of insulating material which supports the downwardly extending fixed contacts 4. The movable contacts 5 are carried by cross pieces 6 which are yieldably supported by springs 7. These parts are carried by a movable contact block 8 of insulating material which is supported by a channel-shaped sheet metal strip 9 having downwardly extending side portions 9a. The parts are shown in the open position of the switch and when the channel piece 9 is moved upwardly upon the energization of the magnet, the movable contacts are moved upwardly to close the switch. When the magnet is deenergized for opening the switch, the pressure of the contacts and the springs 7, together with the weight of the parts, force the movable contact head downwardly with a quick opening movement.

The magnet core actuating the switch to closed position is composed of two smiliar laminated parts, an upper non-actuated part 10 and a lower actuated part 11. Each part is built up of laminations of general E form. The non-actuated part 10 is supported to provide a certain amount of movement for self-adjustment and is shown as having the legs extending vertically downward. The actuated part 11 is shown with its legs extending upwardly. Between the side portions of the frame are sheet metal cross brackets 12 which are bent to the shape shown in Fig. 2 and provided with side portions 12a by which they are securely fastened to the side portions of the main frame. These cross brackets loosely support the non-actuated portion 10 of the magnet by providing slots for receiving projections 10a from the end plates of the laminated portion 10. The magnet coil 13 is carried by a spool 13a of insulating material and is held

in place by a U-shaped strip 14 of metal, the base of the U passing over the top of the laminae 10 and the legs extending downwardly inside the magnet coil. The supporting strip 14 is provided with outwardly extending projections 14*a* at the lower ends of the legs which pass under and support the magnet coil.

The actuated portion of the magnet comprising the laminae 11 is provided with extensions 11*a* from the end plates which extend from opposite sides of the laminae and are bent at right-angles to pass inwardly over the ends of the laminae and again bent outwardly at right-angles to form the extensions 11*a*. These end extensions are spaced from each other for receiving the driving rods 15 which latter are connected for actuation of the movable contact head.

There are two drive rods 15, one in the back and one in the front of the apparatus, for connecting the actuated portion of the magnet with the movable contact head. These rods are of square cross section, as shown in Fig. 2, and are pivotally connected by pins 15*a* between the extensions 11*a* of the end plates. The drive rods extend upwardly from these pivotal connections and are loosely guided in their movement by the two brackets 12, as shown in Fig. 2, these brackets being bent at their middle portions to form vertical guiding channels for the rods. The upper ends of the rods are riveted, or otherwise firmly secured to the ends of a metal strip or yoke 17 of channel form, the bent side portions extending upwardly. These side portions fit freely within the downwardly extending side portions of the strip or yoke 9 which has been previously described as being fixed to the movable contact head. The two yoke pieces are pivotally connected together at their middle portions by a pin 18, as shown in Fig. 1.

The present improvement as applied to the form of electromagnetic switch just described will now be disclosed in one form. The side portions of the main frame 1 are provided, as shown in Fig. 2, by inwardly bent extensions 1*a* to which are fixed a cross plate 19. An auxiliary contact base or frame 20 of Bakelite, or other suitable insulating material, is fixed to the plate 19 by screws passing through side extensions 20*a* of the base. As shown in Fig. 3, the base is hollow, open at the top and closed at the bottom, a short upward extension 20*b* being formed across the central lower portion. On each side of this extension is located an upwardly extending leaf spring contact 21 having a contact 21*a*. These contacts face each other. The lower bent ends of the springs are connected respectively to lead terminals 22 by screw bolts 23.

The base 20 is provided with another compartment 20*c* at its front portion, open at the top and closed at the bottom, as well shown in Fig. 1. The compartment is of cylindrical form and within it is a loosely fitted piston 24 having an upwardly extending piston rod 25. The upper end of the piston cylinder is closed by a flexible hood 26. The cylinder is filled, or partially filled, with a suitable oil and the lower edge of the hood is tightly clamped to the top of the cylinder. The upper portion of the hood is clamped to an upper portion of the piston rod by nuts and washers, so that as the piston moves up or down, the hood will flex accordingly and keep the oil sealed within the cylinder.

A metal plate 27 is fixed at its outer end by clamping nuts to the upper portion of the piston rod and extends inwardly and carries a downwardly extending cone-shaped separator or splitter 28. This is of insulating material formed over a screw fixed to the splitter carrier 27. A sheet 27*a* of insulating material is interposed between the splitter and the carrier for further insulating and protecting the carrier. The separator or splitter 28, as shown in Fig. 3, projects between the upper ends of the contact springs 21 and when the piston is in its lowest position, the springs are separated sufficiently to maintain the contacts 21*a* spaced apart, as shown in Fig. 3.

The yoke 17 has already been described as mechanically connected with the movable element 11 of the magnet through the rods 15. The yoke is provided with an extension 17*a* at its front end, as shown in Fig. 1. A leaf spring 29 of Phosphor bronze or other suitable resilient material is fixed at its inner portion to the extension 17*a* by screws 30. This spring is of rectangular form and is open within its forwardly extending side arms 29*a*, as shown in Fig. 2. The outer ends of these arms are connected by a front portion 29*b* of the spring which is loosely connected between rounded washers and nuts to the upper end of the piston rod 25.

In order to properly guide the carrier 27 in its up and down movement, a metal guide 31 is provided. This is of sheet metal with two upwardly extending side portions 31*a*, as shown in Fig. 3, which embrace opposite sides of the carrier 27 and guide it in its vertical movement. The side portions are connected at the top by a cross portion 31*b*. The lower end of the guide is bent at right-angles and extends outwardly forming a portion 31*c* which is fixed by screws 32, as shown in Fig. 2, to the top of the outer portion of the frame 20. This portion 31*c* of the guide has a central circular opening, as shown in Fig. 1, at the top of the piston cylinder; and it serves also to clamp the hood 26 to the top of the cylinder.

Fig. 4 is one form of a diagram of connections for the electromagnet of Figs. 1 to 3. An alternating current source 32 is indicated as supplying the lines 33 through the switch contacts controlled by the electromagnet having the exciting winding 13 of Figs. 1 to 3. The spring conducting elements 21 having the contacts 21*a* and the splitter or separator 28 are indicated in the diagram with reference characters corresponding to those of Figs. 1 to 3. The winding 13 is shown connected to one side of the supply line and through a normally open push button 34, a normally closed push button 35 and a suitable current reducing resistance 36 to the other side of the line. The contacts 21*a* are connected when closed in shunt to the contacts of the normally open push button 34.

The figures show the parts in their position when the magnet is deenergized. When the push button 34 is closed, it closes a circuit across the lines and energizes the winding 13. The movable element of the magnet then moves from its unattracted to its attracted position and closes its switch contacts, or controls such other parts as may be actuated thereby. This raises the splitter or separator 28 permitting the contacts 21*a* to close and thereby the magnet is maintained energized after the starter button 34 is released after being closed for a short period. The magnet is deenergized whenever desired by opening the stop button 35.

First consider the action when the magnet is energized and the device is subjected to a me-

chanical shock or shocks in a direction such as would cause the movable element of the magnet to move downwardly from the stationary element. If the connection of the splitter **28** were rigidly connected to the movable element of the magnet, it would move with it downwardly and separate the contacts **21***a* thereby deenergizing the magnet. Upon the passage of the shock, the magnet would remain deenergized resulting in an undesired opening of the controlled contacts. This condition is avoided by the present invention due to the action of the auxiliary device. Thus when the shock moves the movable element of the magnet downwardly, the end of the spring **29** connected to the element moves with it; but the piston **24** is then in its upper position and its movement downwardly by the spring is retarded. It thereby imposes a relatively slow downward movement on the outer end of the spring **29** regardless of how quickly the movable element of the magnet moves downwardly. It follows that the retarding action of the dashpot is imposed upon the splitter **28** and before the contacts **21***a* are separated, the shock or shocks will have passed. Thus the excitation of the winding **13** will be maintained during the shock and the contacts controlled by the magnet restored to their closed position. The dashpot will be designed to give the proper retardation to the movement of the splitter for obtaining the desired action and any of the various means may be employed for adjustment of the retarding effect.

If it be desired at any time to open the circuit of the magnet, it is merely necessary to move the push button or switch **35** to open position and hold it open sufficiently long to permit the splitter to separate the contacts **21***a*. Then upon the reclosing of the push button **35**, the magnet will remain deenergized because the contacts **21***a* will be kept separated by the splitter. When it is desired to again close the circuit of the magnet, the push button **34** is closed and held closed long enough to permit the closing of the magnet circuit by the contacts **21***a*.

Now consider the action when the magnet is deenergized, in which case it should remain deenergized when subjected to mechanical shocks. When the apparatus is subjected to a shock or shocks which would force the movable element upwardly, the outer portion of the spring **29** is retarded in its upward movement by the dashpot and the upward movement of the splitter is correspondingly retarded sufficiently to prevent the closure of the contacts **21***a*. After the passage of the shocks the movable element of the magnet returns to its lowest position and the parts again assume the position shown in the drawings. Thus any improper energization of the magnet is avoided.

Fig. 5 shows another embodiment of the invention and in this case the control for preventing improper action of the magnet under shocks is accomplished electrically. The parts corresponding to those of Fig. 4 are similarly designated. An auxiliary relay having a winding **37** and a moveable contact **37***a* is provided and when the relay is energized, the movable contact **37***a* will engage a fixed contact **38** and thereby form a shunt connection around the normally open push button **34**. The relay winding **37** is energized from any suitable form of rectifier **39** connected to the supply lines **33**, a suitable current limiting resistive or impedance device **40** being in the circuit to the winding from the rectifier. A capacitor or condenser **41** is connected across the terminals of the relay winding **37**.

Fig. 5 shows the parts in their non-operative positions. Upon the closing of the push button **34**, the winding **13** is energized from the source **32** by a circuit from one side of the line through the winding **13**, starting button **34**, stop button **35** and resistance **36** to the other side of the line. The movable element **11** of the magnet will then be moved to its attracted position and close the switch contacts controlled thereby. This supplies current to the lines **33** which causes the rectifier **39** to energize the relay winding **37** and move the contact **37***a* to engage the contact **38**. The push button **34** may then be released and the circuit of the winding **13** will be maintained closed by the relay contacts. The magnet may be deenergized by opening the push button **35**; and the opening of the switch contacts will cut off the supply of current to the rectifier **39** and thereby deenergize the relay causing the parts to assume the positions shown in Fig. 5.

First consider the effect of any mechanical shock or shocks when the magnet and relay are energized. Any shock which would cause the movable element **11** of the magnet to move away from the stationary element **10** and open the switch contacts of the magnet would result in momentarily cutting off the supply of current to the rectifier **39** which in turn would deenergize the relay if counteracting means were not provided. However, while the rectifier was active and maintaining the excitation of the relay, the capacitor **41** was fully charged; and upon the cessation of supply of current from the rectifier, the capacitor would come into action and discharge its stored energy to the relay winding **37** and maintain its excitation and attraction of its movable contact **37***a* for an interval of time long enough to outlast the duration of the shock or shocks. The winding of the magnet is thus maintained energized and upon the passage of the shock, its movable element **11** is immediately attracted and its switch contacts reclosed, thereby restoring the parts to their operative positions. If the relay contacts should also be opened by a shock at any time, they would be reclosed because its winding is maintained energized by the capacitor in the manner already described. Thus upon the passage of the shock or shocks, all parts are immediately restored to their operative positions.

Now consider the effects of a shock when the parts are in their inoperative positions shown in Fig. 5. Any shock which would cause the movable element **11** to move upwardly and close the main switch contacts would result in momentarily supplying current to the rectifier and thereby to the relay winding which in turn would energize the winding **13** of the magnet and keep the main switch contacts closed were it not for some counteracting means. However, any momentary supply of current to the rectifier and discharge therefrom is absorbed by the capacitor **41** instead of being supplied to the relay winding; because the capacitor, prior to the shock, is fully discharged and when energy is momentarily supplied by the rectifier to the relay winding circuit, the presence of the resistance **40** in series with the capacitor retards to some extent the building up of the charge of the capacitor giving a short interval of time during which the capacitor is absorbing the energy from the rectifier instead of permitting it to build up immediately to the operating value of the relay winding. Thus the relay winding is not energized sufficiently to attract or

hold closed its movable contact during the passage of the shock; and after its passage all parts assume their inoperative positions. In case any shock should close the relay contacts and not the main switch contacts, the contacts would, of course, immediately separate after the shock because no energy would then be supplied to the relay circuit from the rectifier.

It is thus apparent that regardless of whether the parts are in their operative or inoperative positions upon the reception of a shock or shocks, the parts will always assume their original condition immediately upon the passage of the shock.

Although the embodiments of this invention are disclosed utilizing an alternating current source of supply, in which case the invention is particularly advantageous, it may likewise be applied to cases in which a direct current source is used. In the latter case and with reference to the disclosures of Fig. 5, no rectifier would be required and the leads from the relay, capacitor and series resistance could be connected directly to the direct current lines supplied from the electromagnetic switch. The invention is adapted for use with various types of electromagnets and may be modified to suit particular requirements and in accordance with the preferences of the designer without departing from the scope of the invention.

I claim:

1. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when said contacts are closed, means controlled by movement of said movable element to its attracted position for closing said contacts and to its unattracted position for opening said contacts, and auxiliary means for retarding the opening of said contacts relatively to the movement of said movable element towards its unattracted position.

2. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when said contacts are closed, means controlled by movement of said movable element to its attracted position for closing said contacts and to its unattracted position for opening said contacts, and auxiliary means for retarding the closing of said contacts until after said movable element has attained its attracted position.

3. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when said contacts are closed, means controlled by movement of said movable element to its attracted position for closing said contacts and to its unattracted position for opening said contacts, and auxiliary means for retarding the opening of said contacts relatively to the movement of said movable element towards its unattracted position and for retarding the closing of said contacts relatively to the movement of said movable element towards its attracted position.

4. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when said contacts are closed, mechanical means controlled by the movement of said movable element to its attracted position for closing said contacts and to its unattracted position for opening said contacts, and resilient mechanical means associated with said first named means for retarding the actuation of said contacts relatively to the movement of said movable element to its attracted position and to its unattracted position.

5. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when said contacts are closed, mechanical means controlled by the movement of said movable element to its attracted position for closing said contacts and to its unattracted position for opening said contacts, and a dashpot associated with said first named means for retarding the actuation of said contacts relatively to the movement of said movable element to its attracted position and to its unattracted position.

6. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when said contacts are closed, means for controlling the opening and closing of said contacts, a spring having one portion connected to said movable element and the other portion connected to said means, and a retarding device connected to said means for retarding the movement thereof relatively to the movement of said movable element.

7. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when said contacts are closed, a separator for controlling the opening and closing of said contacts, a spring connected between said movable element and said separator, and a dashpot for retarding the movement of said separator.

8. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when said contacts are closed, a device for controlling the opening and closing of said contacts, a leaf spring connected at one portion to said movable element and at another portion to said device, and means for retarding the actuation of said device by said spring upon movement of said movable element.

9. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, a relay having contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when said contacts are closed by the excitation of the relay, means controlled by the movement of said movable element to its attracted position for supplying current to the winding of the relay, and auxiliary means for retarding the excitation of the relay winding by said first named means relatively to the movement of said movable element to its attracted position.

10. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, a relay having contacts in the circuit

of the magnet winding for maintaining the excitation of the magnet when said contacts are closed by the excitation of the relay, means controlled by the movement of said movable element to its unattracted position for deenergizing said relay to cause the separation of said contacts, and auxiliary means for retarding the deenergization of the relay by said first named means relatively to the movement of said movable element to its unattracted position.

11. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, a relay having contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when said contacts are closed by the excitation of the relay, means controlled by the movement of said movable element to its attracted position for supplying direct current to the winding of the relay, and means comprising a capacitor connected across the terminals of the relay winding for delaying the excitation of said relay winding relatively to the movement of said movable element to its attracted position and for delaying the deenergization of the relay relatively to the movement of said movable element to its unattracted position.

12. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, a relay having contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when the relay contacts are closed by the excitation of the relay, a switch actuated by the movement of said movable element to its attracted position for supplying direct current to the relay winding, and means comprising a capacitor connected across the terminals of the relay winding for delaying the excitation of the relay winding upon the closure of said switch and for delaying the deenergization of the relay winding upon the opening of said switch when said movable element is moved to its unattracted position.

13. An electromagnet having a stationary element and a movable element actuated to its attracted position upon excitation of the magnet winding, a relay having contacts in the circuit of the magnet winding for maintaining the excitation of the magnet when the relay contacts are closed by the excitation of the relay, a switch actuated by the movement of said movable element to its attracted position for supplying direct current to the relay winding, means comprising a capacitor connected across the terminals of the relay winding for delaying the excitation of the relay winding upon the closure of said switch and for delaying the deenergization of the relay winding upon the opening of said switch when said movable element is moved to its unattracted position, and a current limiting device in series in the circuit to said capacitor which circuit receives energy upon the closure of said switch.



14. A source of alternating current, an electromagnetic switch having a stationary element and a movable element actuated to its attracted position for closing said switch upon excitation of the magnet winding, a normally closed switch in series with the circuit of the magnet winding supplied from said source, a normally open switch in the circuit of said magnet winding for exciting said winding upon the closure thereof, a relay having contacts which when closed by the excitation of the relay are connected in shunt to said normally open switch, a rectifier connected to the line supplied with alternating current when said electromagnetic switch is closed, the winding of said relay having connections to said rectifier for receiving current therefrom, a capacitor connected across the terminals of said relay winding, and a current limiting device connected in series in the circuit to said capacitor from said rectifier.

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