

[54] **POSITIVE ACTION MAGNETIC LATCHING RELAY**

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[51] Int. Cl.² **H01H 51/22**

[58] Field of Search **335/78, 79, 80, 81, 170, 335/229, 230, 234, 253, 254, 179**

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[57] ABSTRACT

This invention provides a positive action latching relay having a movable armature and a stationary armature with biasing means tending to separate the two armatures; electrical contact means connected to each of the two armatures are brought into and out of contact by activation of the electromagnetic coil during short periods of time followed by reversal of the current flow.

8 Claims, 8 Drawing Figures

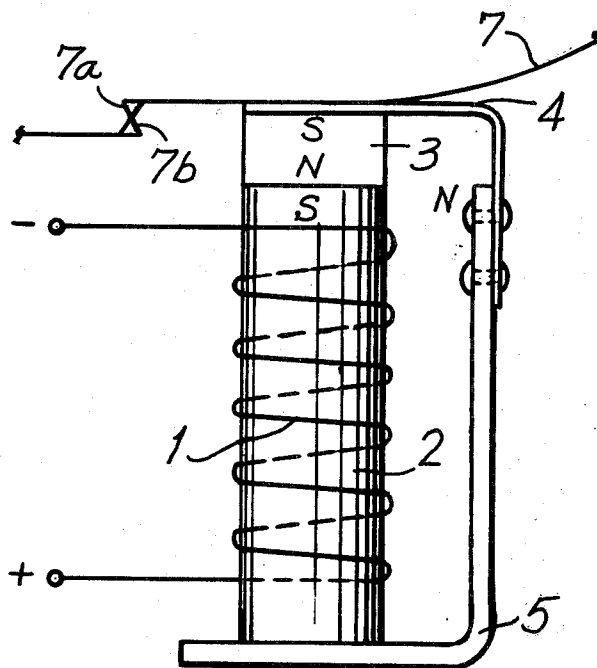


FIG. 1a

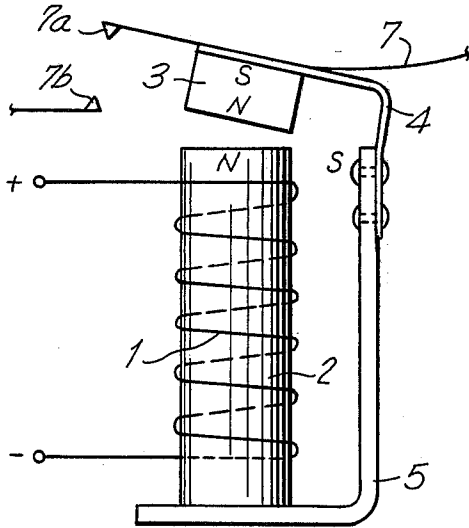


FIG. 1b

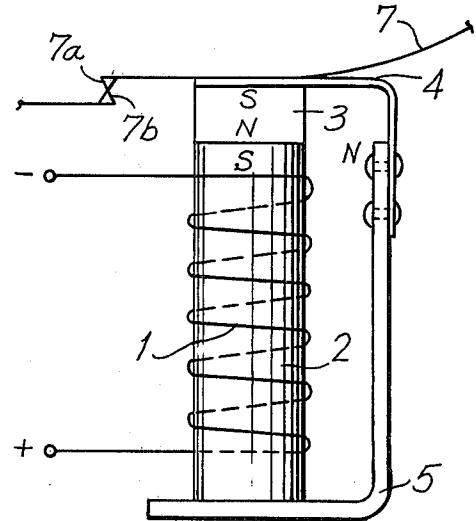


FIG. 2a

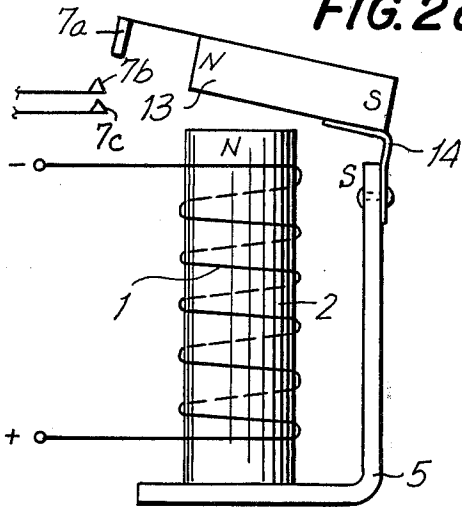


FIG. 2b

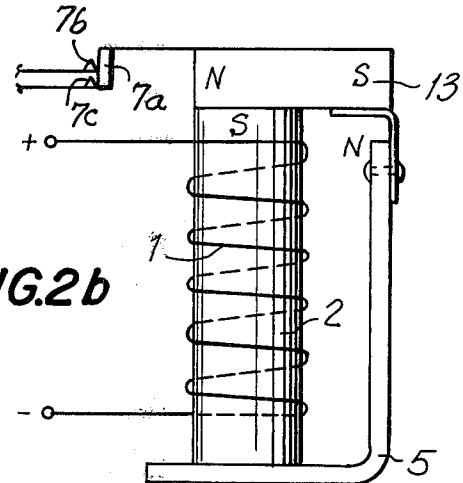


FIG. 3

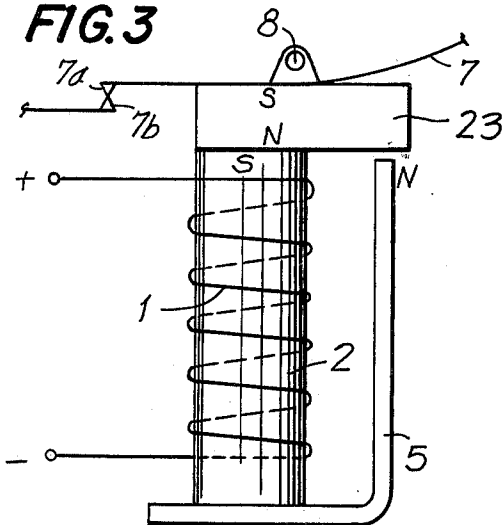
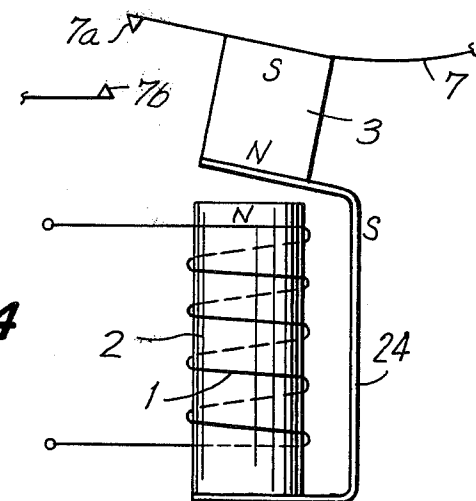
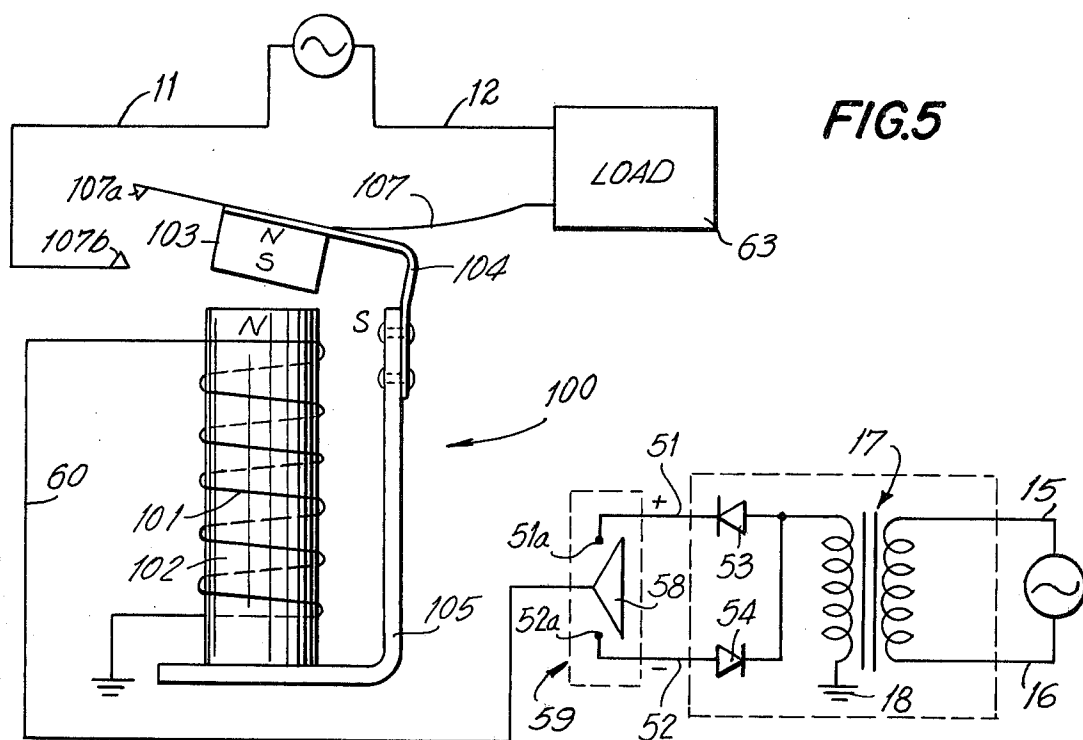
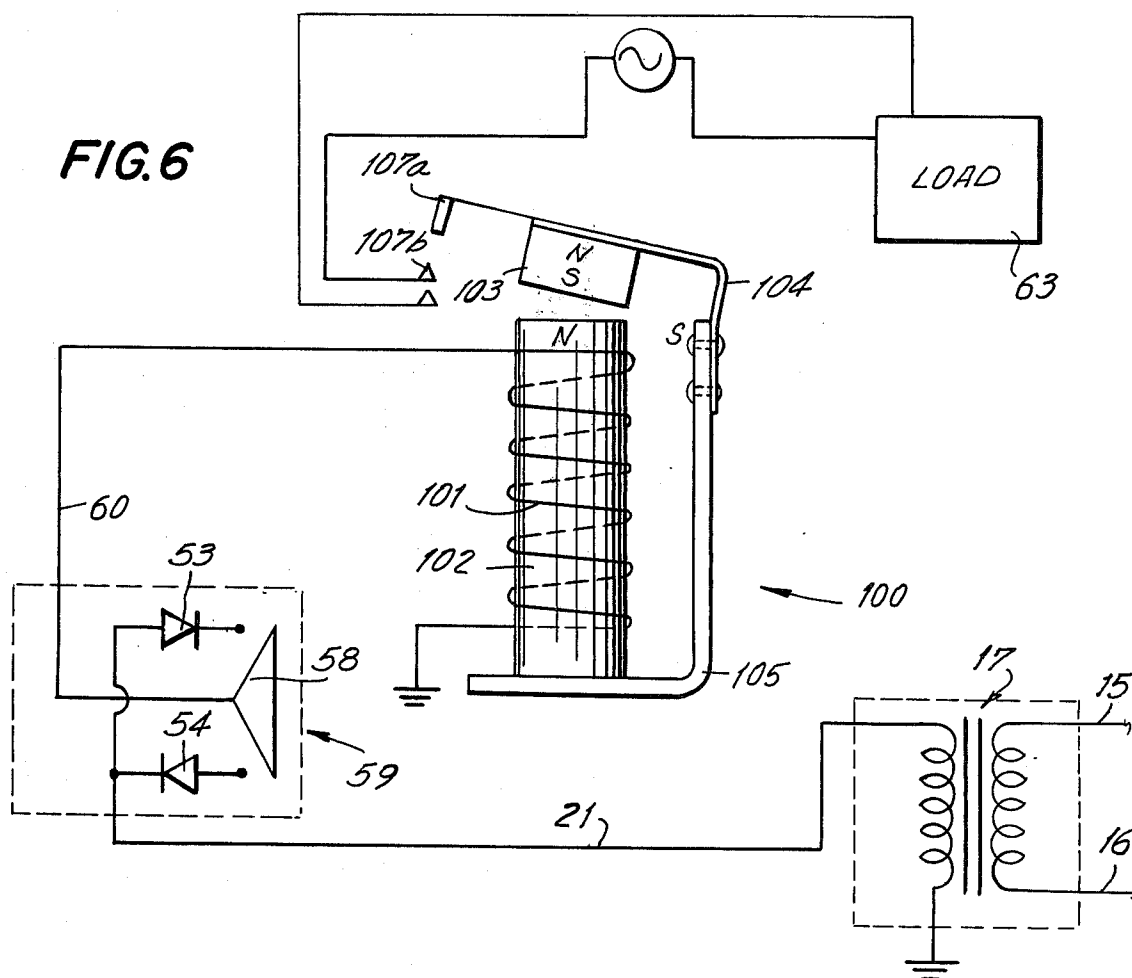


FIG. 4





POSITIVE ACTION MAGNETIC LATCHING RELAY

This invention is directed to a positive action, magnetic or spring-biased, magnetic relay comprising, per unit, a single permanent magnet and a single electro-

A relatively simple, electrically operated, positive control latching relay has long been sought after in the art. The art has utilized electromagnets alone or in combination with permanent magnets to attempt to achieve this end. However, the apparatus developed previously by the prior art has been either extremely complex, requiring magnets of complex shapes and a plurality of permanent and/or electromagnets (see, for example, Martin, U.S. Pat. No. 2,802,078; Holcombe, U.S. Pat. No. 2,935,585; Sherwood, U.S. Pat. No. 3,261,944; Ugon, U.S. Pat. No. 3,631,366; and Suzuki, U.S. Pat. No. 3,723,923). Other devices in the prior art have utilized, for example, a resonator as in Mayer, U.S. Pat. No. 3,302,141. Combinations of permanent magnets and electromagnets have also been utilized for purposes other than for latching relays, as in Bennetot, U.S. Pat. No. 3,089,064. Also, see Fisher for a relay operated by an electromagnet, but one which is not a latching relay (U.S. Pat. No. 3,260,818).

The present invention provides a simple positive action latching relay which requires only an instantaneous activation of the electromagnet in order to cause movement of the relay from a first to a second position, but which relay maintains such position without requiring additional electrical energy until a reverse throw is required. This two-position relay is maintained in a first position by a magnet or spring-biasing means, and in a second position by a permanent magnet.

In accordance with this invention, there is provided a latching relay comprising: a permanently magnetized armature; an electromagnetic armature comprising a ferromagnetic material, having low coercivity and an electric current-conducting coil surrounding the core and adapted to be connected to a source of direct electric current, the combination of coil and core being so juxtaposed as to create magnetic lines of flux within the core whenever current flows through the coil, the polarity of the lines of flux being determined by the direction of current flow through the coil; one of said armatures being movable relative to the other of said armatures; at least one electrical conductor means firmly connected to one of said armatures, each having one terminal providing a first moving contact point and a second terminal adapted to be connected to an electrical power load; and at least one second stationary electrical contact point adapted to be connected to the electrical power load and disposed opposite a first moving contact point. The biasing means can be a spring means connected to said armatures tending to separate the two armatures so that the first contact point is biased out of contact from the stationary contact point. Alternately, the biasing means can be a permanent magnet attracting the movable armature away from the stationary armature.

In operation, passage of the electric current through the coil creates a magnetic polarity in the electromagnet drawing the electromagnet and the permanent magnet toward each other overcoming the bias action of the biasing means. Passing current in a first direction causing the drawing together of the permanent magnet

and the electromagnet in turn causes contact of the stationary contact point and the movable contact point. The permanent magnet is sufficiently strong to overcome the bias means when substantially in direct contact with the electromagnet, but not when separated, i.e., a distance beyond which the attractive force is sufficient to overcome the bias means. The magnetic polarity is reversed by passing an electric current in the reverse direction in the coil. This causes the separation of the electromagnet and permanent magnet.

The permanent magnet armature can be of a simple, straight design of either a prismatic or cylindrical shape, e.g., having a polygonal or circular cross-section. Preferably, a spring-biasing means is most advantageously connected to the permanent magnet which is movably mounted with respect to the electromagnet. The movable contact point is connected to the permanent magnet so as to make contact with the stationary contact means when the two armatures move together. The permanent magnet can be pivotally connected to the electromagnet by, for example, a spring-loaded hinge, or can be slidably mounted with respect to the electromagnet and spring-biased so as to slidably move away from the electromagnet to a rest position; the attractive strength of the permanent magnet should be insufficient to overcome the spring-bias means when separated from the electromagnetic core. However, the strength of the permanent magnet is sufficient to overcome the spring-biasing means when the permanent magnet is contacting the core. The means of measuring such relative strengths is conventional in the art and need not be further discussed herein.

Any type of spring-biasing means can be utilized; either a leaf, or bar spring, or a coil spring, depending upon the means by which the permanent magnet is mounted relative to the electromagnet.

The permanent magnet is formed from a ferromagnetic material having a high retentivity or remanence, and high coercivity. Such materials are well known in the art and the fabrication of a suitable, simple bar magnet need not be further discussed. Useful materials include, for example, Alnico.

The electromagnet core is preferably made from generally soft ferromagnetic material, i.e., one having low coercivity, and also preferably low hysteresis and eddy current loss. Useful such materials include, for example, wrought iron.

In operating the latch relay of the present invention, it is preferred that the electromagnetic coils be energized for a relatively short period, substantially instantaneously, until the electromagnet and permanent magnet are in the desired relative position, e.g., in contact. At this point the current can be discontinued, i.e., the electromagnet de-energized, and the permanent magnet is then sufficient to, e.g., maintain the contact, overcoming the spring-biasing means. However, if desired, and if a sufficiently strong permanent magnet is not available, the current through the electromagnet can be continued, i.e., the electromagnet remaining energized so as to utilize the combined effectiveness of the electromagnet and the permanent magnet to overcome the biasing means. This, however, is not as satisfactory and obviously loses one of the great advantages of using a permanent magnet, i.e., avoiding the requirement of continuous power loss through the electromagnet. The reverse effect, i.e., the repulsion of the permanent magnet from the electromagnet, is also achieved

by substantially instantaneous reversal of current through the electromagnet coil thereby reversing the polarity of the electromagnet and repelling the permanent magnet. Thus, in the preferred embodiment of this invention, there is a substantially minimal electrical power consumption arising only during the short periods during which the electromagnet is magnetized for initial attraction or initial repulsion.

The means for reversing the current flow through the electromagnet coils and the load to which the movable contact and stationary contact means are connected are not a part of this invention. Any type of current reversal means, whether now conventional or to be developed, can be utilized. Similarly, the electrical contact means can be used to complete the circuit of substantially any type of electrical power load.

The advantages of the present invention and the various embodiments and equivalents thereof will be more fully understood by reference to the following description and drawings of preferred embodiments of the invention selected for purposes of illustration. The preferred embodiment as described below and illustrated in the drawings forming part hereof are only exemplary of the scope of this invention and are not intended to be exclusive thereof.

Referring now to the drawings:

FIGS. 1a and 1b are diagrammatic sketches of a device constructed according to the present invention in the inactivated and activated conditions, respectively;

FIGS. 2a and 2b are diagrammatic sketches of another embodiment of the present invention in inactivated and activated conditions, respectively;

FIG. 3 is a diagrammatic sketch of yet another embodiment of the present invention;

FIG. 4 is a diagrammatic sketch of yet another embodiment of the present invention;

FIG. 5 is a diagrammatic sketch of a latch relay of the present invention in the context of associated power load and control circuits; and

FIG. 6 is a diagrammatic sketch of yet another context showing different power load and control circuits.

Referring to the drawings of FIG. 1, a positive latching relay is diagrammatically represented as including a soft iron core 2, having wound thereabout an electrical coil 1 connected to a source of electrical power, direct current, having the indicated direction. The indicated current through the coil 1 results in the formation of a magnetic field through the soft iron core 2 having the polarity indicated, e.g., in a north pole at the upper end of the core. The core 2 is rigidly connected to another soft iron member 5, the combination of the core 2 and the iron member 5 forming a U-configuration. The opposite end of the soft iron part 5 is connected to a flexible spring member 4, formed of spring steel, which at its other end is connected to a permanent magnet 3. The permanent magnet 3 has the indicated polarity wherein the north pole is at the bottom end of the magnet. Both the permanent magnet 3 and the iron core 2 are formed from substantially straight bar stock having a circular cross-section. The permanent magnet 3 has rigidly connected thereto an electrical conductor wire 7 having at one end thereof a terminal contact member 7a. A second stationary contact member 7b is positioned with respect to 7a so as to make contact therewith as contact 7a moves in a downwardly direction.

The permanent magnet 3 is formed of a material having a high coercive force which will not be demagnetized by the effect of a reversing magnetic field, such as one created by the coil 1. Said useful materials include, inter alia, carbon-free aluminum-nickel-cobalt-steel alloys, such as Alnico 6. The combination of the core 2, soft iron part 5, and spring member 4, and permanent magnet 3, form a closed magnetic circuit as shown in FIG. 1b. In this position, the polarity of current through the coil from the power source is as indicated and the polarity of the iron core is indicated as having the south pole at its upper end. The soft iron member 5 forms a part of a U-shaped magnet such that the opposite end of the part 5 is of an opposite polarity to the core, i.e., in FIG. 1b a north pole and a spring member 4 completes the magnetic circuit between the soft iron part 5 and the permanent magnet 3. In this condition, the permanent magnet 3 and the core 2 are attracted and make direct contact. At this point, the electrical current through the coil 1 can be discontinued, thereby decreasing the total flux within the magnetic circuit formed by the members of the iron core 2, part 5, spring 4 and permanent magnet 3. However, this decreased total flux is sufficient to overcome the effect of spring member 4, so as to maintain the contact between the permanent magnet 3 and the core 2, thus maintaining closed the contacts 7a and 7b.

When it is desired to break the magnetic circuit and thereby separate the contact members 7a and 7b, a reverse current flow is provided through the coil 1, as indicated in FIG. 1a, thereby reversing the magnetic polarity of the core 2 creating a north pole at the upper end of the core 2 and a south pole at the opposite end of the part 5. This results in a neutralization of the flux through the circuit and causes a repulsion between the end of the core 2 and the end of the permanent magnet 3, forcing the separation of the contacts 7a and 7b, and moving the spring member 4 beyond its equilibrium position. The current through the coil 1 can then be immediately discontinued. The attractive force of the permanent magnet 2 is then insufficient to overcome the biasing force of the spring member 4 thereby maintaining the gap between the contacts 7a and 7b and between the magnet 3 and the core 2.

When it is again desired to close the contacts 7a and 7b, the current flow shown in FIG. 1b is reinstituted through the coil 1 recreating the polarity of the core 2 shown in FIG. 1b, which creates a sufficient magnetic attraction between the permanent magnet 3 and the electromagnet core 2 to overcome the spring biasing effect of spring means 4, drawing the permanent magnet 3 toward the core 2 and closing the contacts 7a and 7b.

Referring to FIGS. 2a and 2b, the permanent magnet 13 in this embodiment is transversely disposed relative to the U-shaped combination of the core 2 and the soft iron angled part 5 such that one pole of the magnet 13 is juxtaposed opposite the end of the core 2 and the second pole of the permanent magnet 13 is juxtaposed opposite the end of the angled part 5. The second pole of the permanent magnet 13 is pivotally connected to the end of the angled part 5 via a spring member 14. The spring member 14 in the embodiment of FIGS. 2a and 2b is a straight leaf spring.

A movable, electrically conducting contact member 7a is connected to the movable armature, including the permanent magnet 13, as in FIGS. 1 and 6. However,

in this case there are two stationary contacts, 7b and 7c which are fixed with respect to the electrical magnet, the two fixed points 7b and 7c so positioned with respect to each other and to the movable contact member 7a that the movable contact member 7a simultaneously contacts both stationary points 7b and 7c as it moves in a downward direction. If each of the stationary points 7b and 7c are connected to opposite ends of a power load circuit, the movable contact member closes the circuit when touching both stationary points 7b and 7c simultaneously. The positive latching relay of FIGS. 2a and 2b otherwise works in substantially the same manner as described for FIGS. 1a and 1b above and has substantially the same construction.

It should be pointed out here, that the movable armature can have connected to it a plurality of movable contact members opposing a plurality of stationary contact members, thus operating a plurality of different power loads with the same relay, if desired.

It should also be noted that the contacts 7a, 7b and 7c need not make contact when the permanent magnet 103 contacts the core 102. By reversing the location of the stationary contact 7b or contacts 7b, 7c, relative to the movable contact 7a, the circuit can be closed, i.e., the contacts 7a, 7b touching when the magnet 103 is separated from the core 102, that is the position of Figure close.

The permanent magnet 3 of FIGS. 1a and 1b is a short cylindrical ceramic magnet whereas the magnet 13 of FIGS. 2a and 2b is a straight, prismatic permanent magnet.

Referring to FIG. 3, a positive latching relay is disclosed which is self-biasing without requiring an additional spring-loaded biasing means. The construction of the soft iron core and the angled part 5 is substantially identical to that of FIGS. 1 and 2. The permanent magnet 23, as shown, is a short cylindrical type of magnet such as that used in FIGS. 1a and 1b, but having a diameter sufficient to extend across the two arms of the U-shaped configuration of the combined core 2 and soft iron angled part 5. FIG. 3 shows the latching relay in the closed position having a polarity as indicated, and contacts 7a and 7b being closed. The magnets will remain in this position because of the attractive force between the south pole at the end of the core and the north pole of the face of the permanent magnet 23, and further reinforced by the repulsion effect between the end of the angle iron part 5 and the face of the magnet 23. As shown, the magnet 23 is pivoted about a central point on its upper face 8. When the current in the coil 1 is reversed, thus reversing the magnetic polarity of the core 2 and angle iron 5 combination, the permanent magnet 23 is caused to pivot so as to contact the opposite end of the U-configuration, i.e., the end of the angle iron 5, thus separating contacts 7a and 7b. Again, even when current is turned off, the attraction between the face of the magnet 23 and the end of the core 2 or the end of the angled part 5, maintains the magnet in that pivoted condition. A problem with this type of configuration is the lack of a magnetic flux circuit; there is always an air gap. However, the elimination of the spring-biasing means, in certain circumstances, may provide an offsetting advantage.

The latching relay of FIG. 4 shows yet another embodiment having substantially the same characteristics as that of FIGS. 1a and 1b. However, the soft iron core part and spring 4 combination is replaced by a single

U-shaped spring member 24 providing the magnetic flux linkage between the permanent magnet 3 and the electromagnet core 2.

Referring to FIG. 5, a positive latching relay in accordance with this invention, generally indicated by the numeral 100, of the type disclosed in FIGS. 1a and 1b, is depicted in the context of control and power load circuits. A transformer 17 has its primary coil connected to an AC power supply, for example, house current, via contacts 15 and 16. The secondary or low voltage coil has one end grounded as at 18, with the other end connected to two rectifiers, in parallel; the two rectifiers 53 and 54 are arranged to carry current in opposite directions. The first rectifier 53 is connected through electrical conductor 51 to one side of a momentary lever switch, generally indicated by the numeral 59, and the second rectifier 54 is connected via conductor 52 to the second side of the momentary lever switch 59. The lever 58 of the switch 59 is connected via electrical conductor 60 to one end of the coil winding 101 of the latching relay 100. The other end of the coil winding 101 is grounded, as shown. The lower end of the soft iron core 102 is rigidly attached to an angled soft iron member 105; the other, upper end of the angled member 105 is connected to an angled spring steel member 104 which is, in turn, connected at its other end to a permanent magnet 103. The latching relay 100 is substantially identical to that shown in FIGS. 1a and 1b. The spring steel member 104 has attached to it an electrical conductor 107 which connects to a movable contact point 107a, juxtaposed opposite a stationary contact point 107b. The opposite end of electrical conductor 107 is in contact with the terminals of an electrical power load, for example, an electrical light fixture 63. Contact 107b is in electrical connection with one terminal 11 of a source of electrical power, the other terminal 12 of which is connected to the load 63. Thus, the load can be operated solely by the positive latching relay 100 in accordance with the present invention.

In operation, the momentary lever switch 59 is operated so that the lever 58 makes contact with the contact point 51a, thereby activating the electromagnet 101, 102 of the latching relay 100. The polarity of the core 101 in this situation is as indicated in the diagram: the north pole is at the upper end of the core 101. Thus, the core 102 attracts the permanent magnet 103, the bottom face of which is a south pole. When the permanent magnet 103 and core 101 are brought into contact, the electrical contacts 107a, 107b close and load 63 is fed with electrical power thus turning on, e.g., the light. As soon as contact is made between the permanent magnet 103 and the electrical magnetic core 102, the lever 58 can be released, thus deactivating the electromagnetic coil 101. The contacts 107a, 107b remain in closed position by virtue of the magnetic attraction between the permanent magnet 103 and the core 102 as long as they remain in contact. This attraction is sufficient to overcome the spring-biasing force of the spring member 104 and is the result of the combined effect of the permanent magnetism of the permanent magnet 103 and of the remanence in the core 102 as long as a closed magnetic circuit is maintained.

When it is desired to de-activate the power load circuit, by opening the contact points 107a, 107b, the lever 58 is thrown to the lower position so as to make contact with point 52a, thus reversing the current flow

through the coil 101 and reversing the polarity of the core 102, so as to form a south pole at the upper end of the core 102 and a north pole at the lower end. This reversal of polarity results in repulsion of the permanent magnet 103 away from the end of the core 102, and causing separation of the contacts 107a, 107b. Once the circuit has been broken, the lever 58 can be released, returning it to its open position and halting the current through the coil 101. As long as the magnet 103 is separated from the core 102, and as a result of the slight remanence of the reverse polarity in the core 102, the spring-biased member of 104 is sufficient to maintain the separation and thus maintain the contact points 107a, 107b in the open position. The contacts 107a, 107b can then again be closed by again moving lever 58 so it contacts point 51a.

The circuit of FIG. 6 is substantially identical to that of FIG. 5 except that the movable contact member contacts a pair of stationary contact members as in FIGS. 2a and 2b, and the rectifiers 53 and 54 are maintained together with the momentary lever switch 59 and not together with the transformer 17, which association allows the use of a single power line 21 between the secondary coil of the transformer 17 and the possible distant location of the switch 59.

It must be noted that one advantage of the latching relay of the present invention is that, because it only requires short pulses of electricity to be operated, to either the "off" or to the "on" position, a plurality of the polarity reversing switches can be connected in parallel to the latching relay, permitting control of the latching relay from a plurality of different locations. Generally, the switch 59, of the type shown in FIG. 5, is preferable for use where only a relatively small number of such switches are located in parallel, and close to each other. The switch 59 of FIG. 6 is preferred when a large number of such units are connected in parallel at widely dispersed locations.

In the drawings, and in the above verbal description of the apparatus in accordance with the present invention, the elements of the apparatus are shown and described in highly simplified, generally in an essentially symbolic and diagrammatic manner. Appropriate structural details of each element of the apparatus of the present invention are readily known to and understood by those skilled in the art and need not be more fully set forth herein as they are not part of the present invention. The materials of construction and the specific design of the various coils, electrical conductors, switches, rectifiers, transformers and contact means, as well as the materials from which they are formed and the magnet utilized herein are all either presently conventional or equivalents thereof can be used which are now known or which may henceforth be developed in the art. Similarly, the load which can be operated by the positive latching relay in accordance with the present invention is also not explicitly defined and any type of system can be utilized for the system being powered and is substantially completely independent of the activity of the latching relay. The particular examples shown in the drawings and the accompanying verbal description are merely exemplary of the apparatus in accordance with the present invention and it must be understood that the present invention as so described and exemplified above is not limited to the particular forms and parameters explicitly set forth. Many changes are contemplated and can be carried out

within the scope of what is known to persons in this field and many such changes may be made without departing from the scope of the present invention.

I claim:

1. A positive action latching relay comprising:
 - a relatively stationary magnetic armature and a relatively movable magnetic armature, one of said armatures comprising an electromagnet having a ferromagnetic core bar and an electric current-conducting coil wound therearound, and the second armature comprising a permanent magnet having longitudinally disposed north pole and south pole, the two armatures being so disposed in relation to each other that one pole of the permanent magnet is in opposing relationship to one end of the core bar,
 - at least one electric current-conducting contact member firmly attached to the movable armature and movable with the movable armature,
 - stationary electric current conducting contact means fixedly connected to the stationary armature and juxtaposed opposite the movable contact member so as to contact the movable contact member when the two move toward each other,
 - a spring-biasing means operatively connected to the movable armature so as to bias the movable armature away from the ferromagnetic core bar,
 - whereby the stationary and movable armatures are brought together by temporarily activating the coil by passing electric current therethrough so as to induce a magnetic polarity in the core which results in attraction between the opposing ends of the permanent magnet and the core bar, causing the movable armature to move toward the stationary armature, and whereby the armatures can be separated by activating the coil in a reverse direction, by reversing the current flow therethrough, so as to reverse the polarity in the core, thus repelling the permanent magnet therefrom, thus moving the contact member in and out of contact with the stationary contact means;
 - the spring-biasing means maintaining the separation of the magnet and core when they are separated, but the attraction between the permanent magnet and the core bar being sufficient to overcome the biasing means when the permanent magnet and the core are in contact and to maintain the contact without maintaining current in the coil.
2. The positive latching relay of claim 1 wherein the movable armature comprises the permanent magnet.
3. The positive latching relay of claim 2 wherein a closed magnetic circuit is formed, without an air gap, when the permanent magnet is in contact with the core bar.
4. The positive latching relay of claim 3 wherein the spring-biasing means is a spring member, formed of steel, one end of which is connected to the permanent magnet and the second end of which is connected to the core bar, whereby the closed magnetic circuit is formed of only ferromagnetic material.
5. The positive latching relay of claim 4 wherein the coil is connected to switching means which are in turn adapted to be connected to a source of electric power, the switching means being capable of determining the direction of current flow through the coil.
6. The positive latching relay of claim 1 wherein the core bar is in direct magnetic connection with an an-

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gled ferromagnetic member, the angled member and the core bar forming in combination a U-shaped magnet when the coil is activated, the coil being wound solely around the core bar.

7. The positive latching relay of claim 6 wherein the permanent magnet is disposed transversely across the legs of the U-shaped combination in such manner that one pole of the permanent magnet is disposed opposite the end of the core bar and the second pole of the permanent magnet is disposed opposite the end of the an-

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gled member and connected thereto by a steel spring biasing member, whereby a closed magnetic circuit formed of only ferromagnetic material is formed when the permanent magnet is in contact with the core bar.

8. The positive latching relay of claim 1 wherein the movable contact member is in contact with the stationary contact means when the stationary and movable armatures are brought together.

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