Jan. 2, 1962 G. E. PERREAULT 3,015,707

RELAY

Filed Nov. 19, 1957

FIG. 1

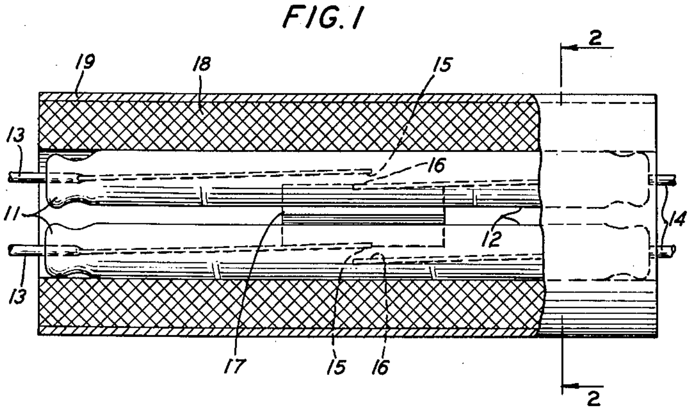
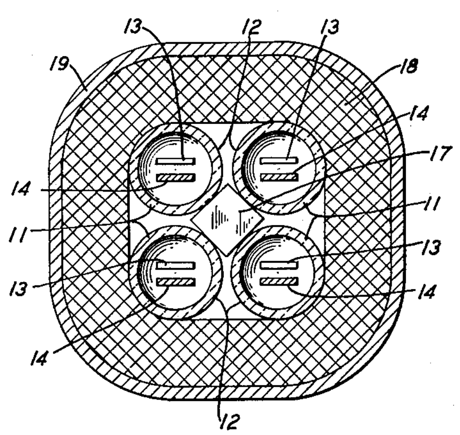


FIG. 2



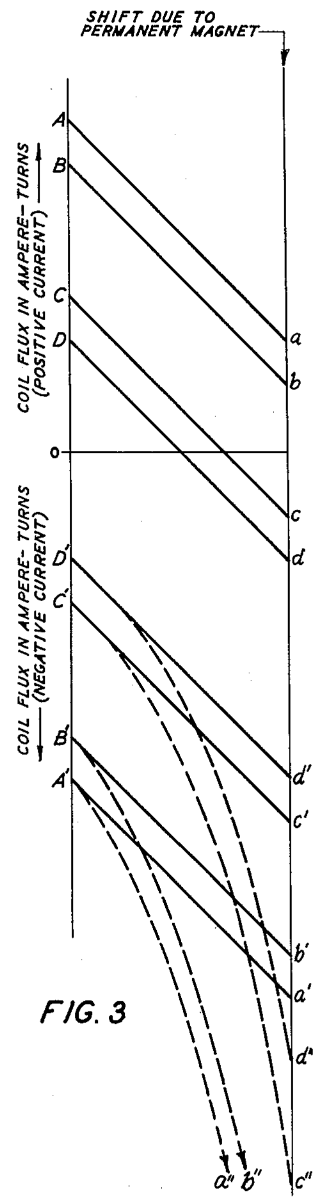


FIG. 3

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RELAY

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This invention relates to relays, and more particularly to magnetically latched relays.

There has been developed a glass-sealed reed device which acts as the contact means for a relay. This reed device is generally placed axially within the energizing coil of the relay where it becomes extremely rapid in action and very sensitive. Such device is disclosed in Patent 2,289,830, granted to W. B. Ellwood, July 14, 1942; and, it has been employed in numerous combinations, one of which showing sequential operation of a plurality of such contact devices is set forth in Patent 2,243,399, granted to A. M. Skellett, May 24, 1941.

The glass-sealed reed device is of relatively simple construction consisting essentially of two reeds which are mounted at opposite ends of an elongated glass envelope. In addition to protecting the reed contacts from dirt and the like, this construction results in extremely low unit cost and this, in turn, accounts in large measure for the extensive use that has been accorded the device.

It is an object of this invention to simplify the structure of magnetically latched relays through the use of glass-sealed reed devices.

It is a further object of this invention to reduce the cost and to increase the utility and the reliability of magnetically latched relays.

These and other objects are attained in accordance with the present invention wherein four glass-sealed reed devices are grouped together so that, the glass envelopes being cylindrical, a void space exists in the center of the group. A permanent magnet of relatively short length is placed in this space at a position adjacent the switch gaps of the reeds. The permanent magnet thus provides a latching function for all four reed devices. A common coil surrounds the group and serves to simultaneously energize the reeds to control electrical circuits.

Other objects and many of the attendant advantages of the invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which:

FIG. 1 is an enlarged longitudinal view, partially in cross section, of a device constructed in accordance with the present invention;

FIG. 2 is an enlarged view taken on the line 2—2 of FIG. 1; and

FIG. 3 is a series of curves useful in explaining a feature of the present invention.

As the name implies, a magnetically latched relay is one which can be held or latched in the operated state. This is accomplished through the use of a permanent magnet that is adjusted to provide enough magnetic flux to keep closed switch contacts closed, but not enough flux to close switch contacts that are open. The coil which is associated with the relay provides the balance of flux required to change the relay from the open to the closed state. The obvious advantage of a magnetically latched relay is that no power is required to maintain the relay in either the operated or unoperated condition.

With this brief summary of operation in mind, reference should now be had to FIGS. 1 and 2 of the drawings wherein four glass-sealed reed devices 11 are grouped together. The switch contacts of each reed device are enclosed in a hermetically sealed, tubular envelope 12 made of a vitreous material such as glass. An inert gas such

as helium, argon, neon, or any other non-corrosive gas, may be inserted in this enclosure for the purpose of reducing arcing across the contact gap, but this is in no way essential for successful operation of the present invention. Inserted and sealed in each envelope at either end thereof are contact reeds 13 and 14 having overlapping contact areas 15 and 16, respectively. These contact reeds may be formed of any suitable magnetic material of high electrical conductivity. As shown more clearly in FIG. 2, the contact reeds 13 and 14 are made from a flat member, but it will be readily appreciated that round contact members or members of other cross sectional configuration may be readily substituted for the reeds 13 and 14 without departing from the spirit or scope of the invention. Contact areas 15 and 16 may be plated with gold or other precious metal to improve the over-all operating characteristics of the device.

The four reed devices 11 are coextensive and so grouped that, the glass envelopes being cylindrical, a void space exists in the center of the group. A permanent magnet 17 of relatively short length is placed in this space and at such a position that it straddles each of the switch gaps. Thus, the single permanent magnet provides the latching function for all four reed devices. With the permanent magnet 17 so positioned, maximum flux can be concentrated at the gaps. And, as will be described in detail below, this close association of the permanent magnet flux to the switch gaps results in a much greater margin against false operation than has heretofore been obtained by other arrangements.

It should be clear at this point that the permanent magnet could in fact be utilized in combination with other groupings of reed devices. For example, five or more reed devices might be arranged in a tight grouping with the permanent magnet disposed in the center thereof. There are, however, advantages in the disclosed arrangement. With the reed devices grouped as shown, so that they are close to touching, the permanent magnet can be placed in the void space formed by the tangency of the four devices and thus a magnetically latched relay can be provided which occupies no greater space than a neutral relay having the equivalent number of switching units. In addition, by filling the void space with a square cross section magnet a near maximum volume of magnetic material can be located adjacent the switch gaps.

A common coil surrounds the entire group and serves to simultaneously energize the reeds to control electrical circuits. A metallic casing 19 of magnetic material provides a return path of low reluctance for the coil flux.

The action of the relay can be visualized by considering the directions of the magnetic fields produced by the permanent magnet and the coil. An initially open switch is, of course, subject to the influence of the permanent magnet, but the force is not high enough to close the switch contacts. If, however, a pulse of current is sent through the coil which sets up a flux in the same direction as the flux from the permanent magnet, the contacts will close. The permanent magnet then keeps them closed with no further current required in the coil. To open the contacts, a second pulse of current is sent through the coil in the opposite direction and it produces a flux that opposes and overcomes the permanent magnet flux thus releasing the reeds.

Another way of describing relays of this type is to consider their operating characteristics. Turning to the curves of FIG. 3 and assuming first the absence of the permanent magnet, there are four sensitivity points of operation for any group of relays under test. The point A indicates the point at which the coil flux is sufficient to insure the operation of all the relays. The point B indicates the point at which all the relays fail to operate.

Between points A and B some, but not all of the relays may operate. And, now assuming all relay contacts have been closed, the point C indicates the point to which the coil flux can be reduced with all the contacts continuing to hold or remain closed. Finally, the point D is the point at which all relay contacts release. With negative current or current in the reverse direction applied to the coil, the relays exhibit a mirror image (A′, B′, C′, D′) of these four sensitivity points.

For a magnetically latched relay, the permanent magnet shifts these sensitivity points as shown in FIG. 3. This shifting of the sensitivity points from A, B to *a, b,* for example, is due to the fact that the permanent magnet acts in combination with the coil to supply the total flux necessary to operate the relay contacts. Thus, with the coil flux acting in the same direction (positive current) as the permanent magnet flux, substantially less current is required to actuate or close all contacts. It will be noted that the hold point C is shifted to point *c*, the effect of this being that once the relay switch contacts are closed coil flux can be reduced to zero and the contacts will remain closed. To open the contacts it is necessary to apply current in the opposite direction (negative direction) to the coil.

A magnetically latched relay must have good margins against the nonoperate (point *b*) and hold (point *c*) conditions at zero coil flux. This is to prevent the switches from falsely operating or releasing when the relay is subjected to shock, vibration or stray fields. To this end the permanent magnet is adjusted so that the points *b* and *c* straddle the point of zero coil flux.

From the above it will thus be seen that a magnetically latched relay will operate on less coil flux than a relay without a permanent magnet, will remain operated on zero coil flux, will release on a negative coil flux, and will then stay released with zero coil flux. Further, such a relay may be used either as a normally closed relay or as a normally open one.

As indicated, to open closed contacts it is necessary to send a pulse of current through the coil (negative direction) which will oppose and overcome the permanent magnet flux. With regard to FIG. 3, this current pulse must provide a coil flux (ampere-turns) which equals or exceeds that of release point *d*. Unfortunately, however, if this coil flux becomes too large the contacts will reclose and this is known, in the art, as false operation.

Should the pulse of negative current produce a coil flux which equals or exceeds that at false operate point *a′*, the contacts would either remain closed or momentarily open and then reclose. Upon termination of the pulse, the permanent magnet would, of course, keep the contacts closed.

If the contacts are assumed closed and the coil flux is slowly increased in the negative direction from zero, all the contacts would open between the points *c* and *d* and they would remain open until point *b′* was reached, at which time a first set of contacts would close. However, for many applications relay coils are necessarily pulse operated. And, when the pulse of negative current produces a flux which exceeds the false hold point *c′* the contacts do not open but rather are held closed. That is, the coil flux reaches the value *c′* so rapidly that the contacts do not have time to open. Thus, the contacts are falsely held and will remain so upon termination of the pulse due to the field of the permanent magnet. The same result occurs between the points *d′*—*c′* except that in this region some of the contacts do in fact open while others remain closed.

If it were possible to always pulse operate the relays so that only a preselected amount of coil flux would be produced, false operation would not be encountered. However, changes in the supply voltage and/or ambient temperature can have substantial effects on the flux produced. For example, temperature changes can result in as much as a twenty-five percent variation in the overall resistance of the coil and this, of course, affects a corresponding variation in coil current and hence coil flux.

By making the false operate points (*a′*, *b′*, *c′*, *d′*) occur at increasingly higher values of coil flux (such as points *a″*, *b″*, *c″*, *d″*), increased insurance against false operation can be obtained. That is, by spreading these false operate points as far as possible from the usable operating points (*c*, *d*) the relays will be more reliable in use. It has been found that this can be achieved through the proper selection and placing of the permanent magnet. Specifically, a permanent magnet is utilized which is very short relative to the length of the coil and it is positioned as disclosed. Tests have shown that, under everyday operating conditions, this false operate problem can be substantially eliminated by using a permanent magnet having a length which is one-quarter or less the length of the coil. Stated somewhat differently, the ratio of coil length/permanent magnet length should be of the order of four or more and the higher this ratio the better. Since the coil size is generally set by space considerations, this length relationship will be arrived at in most cases by selecting a sufficiently short permanent magnet. However, the permanent magnet must always comprise sufficient material so as to carry out its intended function, namely, holding closed switch contacts closed.

The dotted curves of FIG. 3 illustrate the effective displacement of the false operate points, from *d′*, *c′* to *d″*, *c″*, for example. These curves were obtained for a relay, constructed in accordance with the present invention, wherein the permanent magnet was one-quarter the length of the coil and was positioned adjacent the switch gaps as shown in FIG. 1.

A physical explanation of this false operate point displacement may be arrived at by considering the respective flux paths in one of the reed devices. With the switch contacts closed and the magnet **17** positioned as shown in FIG. 1, the permanent magnet flux can be assumed to enter the reed **13**, travel toward and through the abutting contact areas **15** and **16**, then along the reed **14**, and finally across the air gap to the opposite pole. To open the contacts, the coil flux must travel through the reeds in the opposite direction (from reed **14** to **13**) and must be of sufficient intensity to overcome the permanent magnet flux therein. With increasing values of coil flux (negative direction) the overcoming of the permanent magnet flux will be accompanied by approaching saturation of the reed material in those regions of the reeds where the coil flux is unopposed. That is, in trying to get enough coil flux down the reeds so as to overcome the permanent magnet flux concentrated near the switch gap, the reed material in the said unopposed regions begins to saturate. Increasing the coil flux further, of course, results in a further approach to saturation which in turn results in decreased permeability of the material. The reed material near the switch gap does not saturate because here the respective fluxes tend to cancel each other out.

Now by increasing the length of travel of the coil flux in the reeds with respect to that of the permanent magnet flux, this effect can be substantially enhanced. The results of such an increase is a cumulative one, for the added length of saturable material means that increased coil flux will be needed to produce a desired effect at the switch gap. However, increased coil flux will cause an even closer approach to saturation which in turn will lower even further the permeability of the reed material. As will be realized, this relative increase in the coil flux path length is accomplished by increasing the relative length of the coil with respect to the permanent magnet.

Turning to the curves of FIG. 3, and assuming for the moment that it is desired to reclose all previously closed contacts, it would normally be necessary that the coil flux be of a value (negative direction) equal to that of point *a′*. However, with added saturable material in the coil flux path more coil flux is necessary to produce this desideratum, i.e., false reclosure. This added coil flux will, of course, further decrease the permeability of the reed material making it necessary to resort to still more coil flux. Of course, false reclosure is not desired, but the above discussion is still valid. Thus, by increasing the coil flux path length the false operate point *a'*, as well as the others, can be effectively displaced.

While the length of the coil to the permanent magnet is not extremely critical, effective displacement of the false operate points is obtained when the coil length is at least four times that of the magnet, or conversely when the magnet is no more than one-quarter the length of the coil. Further, it is desirable to position the permanent magnet 17 so that it straddles the switch gaps. In this manner maximum flux can be concentrated at the gaps and the permanent magnet flux path through the reeds is kept to a minimum. If the permanent magnet were placed adjacent one of the ends of the reed devices, for example, its flux path in the reeds would be just about the same as the coil flux path. And this would tend to cancel the effect discussed above with the result that there could be no effective displacement of the false operate points.

One rather obvious modification of the above-described arrangement would be to combine two or more groups of magnetically controlled switches in a single coil. A further modification of this would be to then position the permanent magnet of one group with a polarity the reverse of the other groups. This would provide a relay with some normally closed contacts and some normally open contacts. A current pulse through the coil would then serve to reverse these conditions.

It is to be understood that the above-described arrangements are merely illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In a magnetically latched relay, a plurality of reed switching devices arranged in a group, each of said switching devices comprising a tubular envelope and a pair of contact reeds mounted at respective ends of said envelope and extending longitudinally thereof so as to present overlapping contact areas, a short permanent magnet disposed centrally of said group of switching devices at a position adjacent the switch gaps thereof, and a common energizing coil surrounding said group; the magnet providing a magnetic flux for magnetizing said overlapping contact areas only.

2. In a magnetically latched relay, a plurality of reed switching devices arranged coextensively in a group, each of said switching devices comprising a tubular envelope and a pair of contact reeds mounted at respective ends of said envelope and extending longitudinally thereof so as to present overlapping contact areas, a permanent magnet disposed in the center of said group of switching devices and at a longitudinal position which is symmetrical with respect to the switch gaps thereof, and a common energizing coil surrounding said group, said permanent magnet being short with respect to the length of said coil and providing a magnetic flux for magnetizing said overlapping contact areas only.

3. A magnetically latched relay comprising four reed switching devices arranged coextensively in a group, each of said switching devices comprising a tubular envelope and a pair of contact reeds mounted at respective ends of said envelope and extending longitudinally thereof so as to present overlapping contact areas, said switching devices being grouped so that, the tubular envelopes being cylindrical, a void space exists in the center of the group, a short permanent magnet disposed in said void space at a longitudinal position which is symmetrical with respect to the switch gaps of said switching devices, and a common energizing coil surrounding said group; the magnet providing a magnetic flux for magnetizing said overlapping contact areas only.

4. In a magnetically latched relay, a plurality of reed switching devices arranged coextensively in a group, each of said switching devices comprising a tubular envelope and a pair of contact reeds mounted at respective ends of said envelope and extending longitudinally thereof so as to present overlapping contact areas, a short permanent magnet disposed in the center of said group of switching devices and at a longitudinal position which is symmetrical with respect to the switch gaps thereof, and a common energizing coil surrounding said group, said permanent magnet being no longer than one-quarter the length of said coil and providing a magnetic flux for magnetizing said overlapping contact areas only.

5. A magnetically latched relay comprising four reed switching devices arranged coextensively in a group, each of said switching devices comprising a tubular envelope and a pair of contact reeds mounted at respective ends of said envelope and extending longitudinally thereof so as to present overlapping contact areas, said switching devices being grouped so that, the tubular envelopes being cylindrical, a void space exists in the center of the group, a short permanent magnet disposed in said void space at a longitudinal position which is symmetrical with respect to the switch gaps of said switching devices, and a common energizing coil surrounding said group, said permanent magnet being no longer than one-quarter the length of said coil and providing a magnetic flux for magnetizing said overlapping contact areas only.

6. A relay comprising a plurality of reed switching devices arranged in a group, each switching device including a pair of magnetically deflectable reeds sealed within a non-magnetizable tubular envelope and protruding, respectively, through opposing ends of the envelope, each said pair of reeds being arranged within the envelope so that one reed's end portion is separated from, and overlaps, the other reed's end portion thereby defining a gap between the one reed's end portion and the other reed's end portion whereby each of the switching devices is in an open state, a coil surrounding said group of switching devices for producing, upon energization, a first magnetic flux for deflecting each pair of reeds so that the overlapping end portions thereof are brought into mutual contact whereby each of the switching devices is caused to change from said open state to a closed state, and a permanent magnet continuously producing a second magnetic flux for magnetizing the overlapping end portions only of each switching device's pair of reeds and maintaining each of the switching devices in the closed state subsequent to the deenergization of the coil.

7. A relay, as is defined in claim 6, wherein said permanent magnet is not longer than one-fourth of the coil's length.

8. A relay comprising a plurality of reed switching devices arranged in a group, each switching device including a pair of magnetically deflectable reeds sealed within a non-magnetizable tubular envelope and protruding, respectively, through opposing ends of said envelope, each said pair of reeds being arranged within the envelope so that one reed's end portion is separated from, and overlaps, the other reed's end portion thereby defining a gap between the end portions of said one reed and said other reed whereby each said switching device is in an open state, a coil surrounding said group of switching devices, said coil being susceptible of being energized, selectively, to produce either a first magnetic field or a second magnetic field, said second magnetic field, being oriented oppositely of said first magnetic field, said first magnetic field causing each said pair of reeds to deflect so that their overlapping end portions move into mutual contact whereby each of the switching devices is changed from said open state to a closed state, and a permanent magnet continuously producing a third magnetic field, oriented in the same direction as the first magnetic field, for magnetizing said overlapping end portions only of each said pair of reeds thereby maintaining each of the switching devices in the closed state subsequent to deenergization of said coil; said second magnetic field causing each of the switching devices to return to the open state from the closed state in which they are being maintained.

9. A relay, as is defined in claim 8, wherein said permanent magnet is not longer than one-fourth of the coil's length.

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