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R. L. PEEK, JR

3,182,226

REED RELAY

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FIG. 1

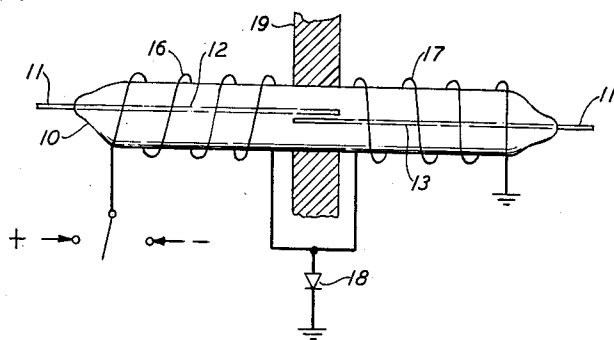


FIG. 2

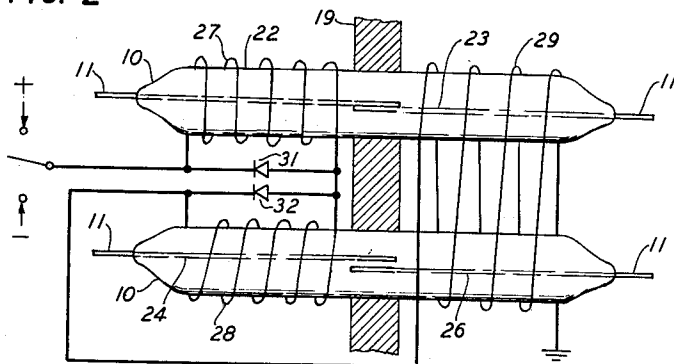
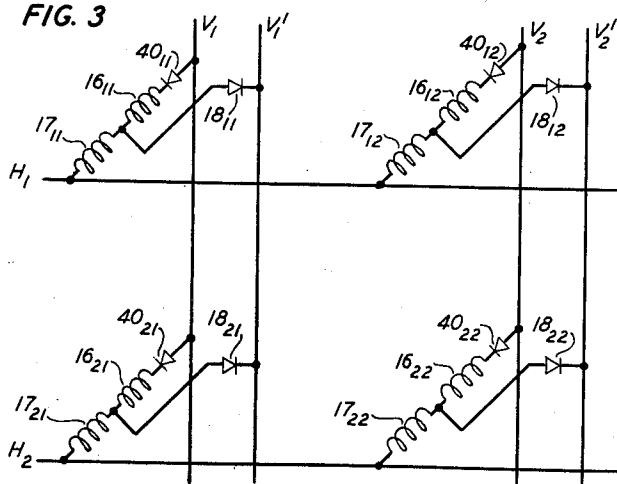


FIG. 3



INVENTOR
R. L. PEEK, JR.

BY
David P. Kelley
ATTORNEY

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3,182,226

REED RELAY

Robert Lee Peek, Jr., New York, N.Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

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8 Claims. (Cl. 317-137)

This invention relates to circuit controlling devices and more particularly to magnetically operable switching devices including a remanent magnetic control member.

In general it is a desideratum of switching systems of the type employed, for example, to interconnect selectively and in various combinations the particular input stations in a communications network, that they be responsive to current pulses of very short duration and having a minimal separation in time, such as those commonly employed in electronic control circuits. It is well known that the use in telephone systems of switching relays having these desired characteristics can provide improved telephone service as well as economy of installation and operation. Relays responsive to short energizing pulses are disclosed in copending patent applications Serial No. 824,222 of A. Feiner et al., filed July 1, 1959, now Patent No. 2,995,637, Serial No. 824,225 of J. A. Baldwin et al., filed July 1, 1959, now Patent No. 3,002,067, and Serial No. 847,919 of R. L. Peek, Jr., filed October 22, 1959, now Patent No. 3,059,075.

The electronically operable relays described in the above-named applications employ remanent magnetic control members to provide the magnetic field which actually operates the contacts of a reed switch. The control member is characterized by a substantial magnetic retentivity, so that after the cessation of a short pulse applied to a control coil it remains in one of its plurality of stable magnetization states. It is apparent that successful operation of such devices is critically dependent on the establishment of the requisite remanent magnetization states by the energizing pulse. Due to the compactness of many such relays, however, it is often the case that the magnetic field of the control coil encompassing one remanent member is sufficiently strong to affect the magnetic state of another remanent member, even though the second member be strongly biased by a permanent magnet. The stray field may in some instances be sufficient to cause a reversal of the desired relay action.

Relays have been built employing remanent magnetic control members and providing nonmarginal positive action of the switch contacts in both the operate and release functions. By positive action is meant the operation or release of the relay contacts under the influence of the electrically controllable field of the remanent magnetic members rather than mechanically by the spring tension of one or both of the contacts. By nonmarginal operate or release is meant the independence of the relay action of the magnitude of the control pulses, provided the energy of such pulses exceeds a certain minimum value. One such nonmarginal positive action relay is disclosed in my aforementioned copending application Serial No. 847,919 and comprises a pair of remanently magnetic control members and a pair of control windings individually associated therewith. A device of this type is inherently nonpolar, i.e., the switching action is dependent, not on the polarity of a single control pulse, but on the relative polarities of the pulses applied to the two windings. In some switching networks, however, it is desirable to employ nonmarginal positive action relays having polarized characteristics.

Accordingly, it is an object of this invention to provide an electrically operable polarized locking relay having

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nonmarginal positive action in both the operate and the release functions.

It is also an object of this invention to improve the operating characteristics of relays of this type.

An additional object of the invention is to provide an electrically operable polarized transfer relay having nonmarginal positive action.

A further object of the invention is to provide a coordinate switching matrix in which positive nonmarginal operate and release of any crosspoint may be achieved independently of the status of the other crosspoints in the array.

These and other objects of the invention are achieved in a specific illustrative embodiment thereof comprising a reed switch having a pair of magnetically operable contacts, a pair of magnetically retentive control members, a pair of control windings individually associated with the control members, and a diode or other rectifying means.

It is a feature of the invention that the control windings are adapted to produce opposing magnetic fields of substantially equal magnitudes when energized by currents of like polarity.

Another feature of the invention is that the control windings are serially connected.

It is a further feature of the invention that the diode is connected in parallel with one of the control windings, thereby providing a shunt path around that winding for currents of one polarity.

The reed switch contacts of the illustrative embodiment are operated by a short current pulse of the polarity which flows through one of the control windings and through the diode shunt path around the second control winding. The switch contacts are released by an electronic current pulse of opposite polarity which passes serially through both control windings, thereby generating opposing magnetic fields of like intensity.

The mode of operation as well as the above-mentioned and other objects and features of the invention will be better understood from the following more detailed discussion taken in conjunction with the accompanying drawing in which:

FIG. 1 depicts one specific embodiment of the invention;

FIG. 2 depicts a transfer relay embodying the principles of the invention; and

FIG. 3 depicts schematically a switching matrix in accordance with the principles of the invention.

Turning now to the drawing, there is shown in FIG. 1 a reed switch having an envelope 10, as of glass, with terminals 11 sealed into the opposite ends thereof. Reeds 12 and 13, which in the illustrative embodiment function as control members in addition to acting as switch contacts, are of a material characterized by a plurality of stable remanent magnetization states, and are attached to the terminals 11 so that their free ends overlap near the center of envelope 10. Reeds 12 and 13 are separately encompassed by control windings 16 and 17, respectively. A soft magnetic shunt member 19, shown in schematic form, is situated adjacent the envelope 10 in the region where the free ends of the remanent reeds 12 and 13 overlap.

The coils 16 and 17 are wound and connected so that when both are energized by currents of like polarity the magnetic fields produced along the axis of the envelope 10 are in opposition. More specifically, the control coils 16 and 17 in the illustrative embodiment shown in FIG. 1 are oppositely wound and serially connected. In accordance with the invention a diode 18 is connected in parallel with the coil 17, thereby forming a shunt path around the coil 17 for currents of one polarity. More

particularly, the diode 18 in FIG. 1 forms a shunt path for positive currents. Thus, negative currents applied to the control circuit flow through both windings 16 and 17, while positive currents flow through winding 16 but are shunted around winding 17.

In accordance with one feature of the invention the control windings 16 and 17 are adapted to produce opposing magnetic fields of substantially equal magnitude. While it is not necessary that the intensities of the two fields be exactly equal, there is a definite limit to the difference which may exist between them. The limit on the differential which is consistent with the invention is determined principally by the geometry of the relay. That is, the difference must be less than the magnitude of the field of either coil which is just sufficient to switch the magnetic state of the free end of reed encompassed by the other. If it be assumed that the forward resistance of the diode 18 is zero while the reverse resistance is infinite, then the number of turns in the coil 16 is, most advantageously, equal to the number in the coil 17. If necessary, the departure of the diode from this ideal may be compensated by an appropriate difference in the turns of each coil. Equivalently, the positions of the coils 16 and 17 may be axially shifted with respect to the reeds 12 and 13 so that the overlapping contact portions thereof coincide with the region in which the opposing magnetic fields effectively cancel each other. Thus, when both coils are energized, thereby magnetizing the control members, like magnetic poles of similar strengths are produced at the free ends of the reeds.

When a control current pulse of negative polarity is applied to the embodiment of FIG. 1, axially opposing magnetic fields are produced by the windings 16 and 17. The axial magnetic field within the coil 16 magnetizes the reed 12 so that the free end thereof becomes a magnetic north pole. Similarly, the free end of the reed 13 is magnetized by the axial field of the winding 17 so that its free end is a magnetic north pole. Due to the magnetic retentivity of the reeds 12 and 13, each remains in a stable state of remanent magnetization after the current ceases. Since their overlapping free ends are of like magnetic polarity they repel each other and the switch contacts assume the open or released condition.

When a control current pulse of positive polarity is applied to the embodiment depicted in FIG. 1 an axial magnetic field is produced by winding 16, while no field is produced by winding 17, which is shunted by diode 18. The field of winding 16 magnetizes the reed 12 so that its free end becomes a magnetic south pole. The field of coil winding 16 will also tend to remagnetize the reed 13 in the sense of its existing magnetization, so that at the end of the pulse this existing magnetization is either unchanged or slightly increased. Due to its magnetic retentivity, the reed 12 assumes a stable state of remanent magnetization of the same sense as the existing magnetization of the reed 13. Thus, the overlapping free ends of the reeds 12 and 13 are of magnetically opposite polarity and the switch contacts assume the closed or operated condition.

It can be seen from the above explanation that both the operate and release actions of a relay in accordance with the invention are nonmarginal. That is, while there is a current pulse amplitude below which the condition of the switch contacts will not be changed, the control pulse may exceed this amplitude by any amount without causing a reversal of the change produced initially. This is so because when a release pulse is applied to the control circuit to magnetize the reeds in opposition, the same amount of current flows through both coils 16 and 17. Since the opposing magnetic fields are of substantially equal intensity, it is not possible for the field of one coil to affect the magnetization state of the reed encompassed by the other coil. Instead, the flux lines of the opposing fields complete a magnetic circuit by flowing through the soft magnetic shunt member 19, and thence through an

air return path or through a return path member not shown in the drawing in the interests of clarity. Additionally, when an operate pulse is applied to the control circuit of the embodiment depicted in FIG. 1 the coil 16 is energized, while no current flows through coil 17. When the current exceeds a certain amount the remanent magnetic state of the reed 12 is switched and the free ends of the reeds close due to mutual magnetic attraction of unlike poles. If the magnetic field is in excess of the minimum required to operate the contacts, the operate action is even more positive. The magnetic flux lines produced by the current in coil 16 flow through both reeds to complete the magnetic circuit, so that the strength of the unlike poles at the overlapping free ends of the reeds 12 and 13 is increased.

Both the operate and release actions of a relay embodying the invention are positive. That is, the opening and closing of the switch contacts is effected by the mutual attraction or repulsion of the magnetic poles at the juxtaposed free ends of the reeds and not by the mechanical stiffness of the reeds. Furthermore, because of the remanent magnetization of the reeds in the embodiment of FIG. 1, the contacts remain locked in either the operated or released condition after the cessation of the control current.

In FIG. 2 there is shown a transfer relay in accordance with the invention and comprising two reed switches of the type described above. One reed of each switch is individually encompassed by one of two control windings while a single control winding encompasses the other reed of each pair. More specifically, reeds 22 and 24 are encompassed by control coils 27 and 28, respectively, while reeds 23 and 26 are both encompassed by coil 29.

Coil 27 is connected in series with coil 28 which in turn is connected in series with coil 29. Coils 27 and 28 are so wound and connected that, were the same current to flow through both of them they would produce oppositely directed axial fields. However, diode 31 is connected in parallel with coil 27, providing a shunt path therearound for negative currents. In like manner, diode 32 is connected in parallel with coil 28, providing a shunt path therearound for positive currents.

When a negative current is applied to the control circuit of the embodiment shown in FIG. 2, it flows around coil 27 through the shunting diode 31, through coils 28 and 29 which produce oppositely directed axial magnetic fields. The remanent reeds 24 and 26 are oppositely magnetized by the opposing fields so that the free ends thereof become magnetic north poles. As like poles repel each other the reed contacts are released. However, that part of the field produced by coil 29 which acts on reed 23 is unopposed since no current flows in coil 27. Therefore, the remanent magnetization of reed 22 is reinforced and, reeds 22 and 23 being magnetized in the same direction, their free ends are opposite magnetic poles. The switch contacts are thus closed by magnetic force.

When a positive current is applied to the control circuit coils 27 and 29 are energized while coil 28 is shunted by the diode 32. The axial fields of the energized coils are oppositely directed so that reeds 22 and 23 develop like magnetic poles at their free ends. Thus the previously closed contacts are opened. Conversely, that portion of the field of coil 29 acting on reed 26 is unopposed so that the free ends of reeds 24 and 26 develop unlike magnetic poles. The previously opened contacts are, therefore, closed.

It will be appreciated that, as in the embodiment shown in FIG. 1, the transfer relay depicted in FIG. 2 is polarized, and is characterized by positive, nonmarginal action in both the operate and release functions. Thus, all the advantages of the single contact-pair relay are retained in the transfer relay.

If a plurality of relays embodying the invention are assembled in a coordinate switching matrix, a particularly advantageous mode of operation may be realized. In par-

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ticular, a plurality of relays of the type shown in FIG. 1 may be arranged in a coordinate switching matrix as illustrated in FIG. 3, in which corresponding parts are designated by the same reference with subscripts appropriate to the coordinates of the crosspoint. One end of the control circuit of each relay is connected to a horizontal or H lead, while the other end is connected, through a current blocking diode 40, to a vertical or V lead. In addition, each shunting diode 18 is connected to a second vertical or V' lead.

Application of a negative potential to a V₂ lead and ground to an H lead operates the crosspoint of these two leads and that crosspoint only. Application of a positive potential to a V lead and ground to an H lead releases the crosspoint of these two leads and that crosspoint only. The current blocking diodes, designated by reference numeral 40 with appropriate subscripts, prevent current flow in undesired paths between the H and V leads. Thus, coincident operate and release of any crosspoint in the array may be achieved without affecting the status of any other crosspoint in the array.

While the illustrative embodiments of the invention have been depicted in the drawings with soft magnetic shunt members, indicated by reference numeral 19, these are optional and may be omitted if desired. Furthermore, while the embodiments shown in the drawing comprise magnetically retentive reeds which function as control members responsive to short control pulses, it will be appreciated that soft magnetic reeds may be utilized in conjunction with external magnetically retentive control members. For example, the control members may comprise magnetically retentive sleeves surrounding the reeds as shown in United States Patent 2,877,316 of R. L. Peek, Jr. These sleeves may be magnetized in aiding or opposing senses in the same way as the reeds shown in the drawings, and will then produce either aiding or opposing fields in the reeds which they enclose, so that these reeds will make contact with aiding fields, and open their contact when the fields are opposing. Other variations of the invention are possible and may be made by those skilled in the art without departing from its scope and spirit.

What is claimed is:

1. A polar locking relay having positive nonmarginal operate and release action, comprising a reed switch unit having a pair of remanent magnetic control members, a first control coil encompassing one of said control members, a second control coil encompassing the other of said control members, said coils being serially connected and adapted to produce substantially equal but oppositely directed magnetic fields when energized by a control current, and asymmetrically conducting means connected in parallel with one of said coils.

2. A relay as in claim 1 wherein said remanent magnetic control members comprise the reeds of said reed switch unit.

3. A relay as in claim 1 wherein said control members comprise a pair of remanent magnetic sleeves individually encompassing the reeds of said reed switch unit.

4. A polar locking relay having positive nonmarginal operate and release actions, comprising a reed switch unit having first and second remanent magnetic reed members cantilevered from opposite ends thereof, said

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reed members having juxtaposed contact portions near the center of said unit, a first control coil encompassing one of said reed members, a second control coil encompassing the other of said reed members, said control coils being connected in series and adapted to produce oppositely directed magnetic fields of substantially equal intensity when energized by a control current, and asymmetrically conducting means connected in parallel with one of said control coils.

5. A polar locking transfer relay having positive nonmarginal operate and release actions, comprising first and second reed switch units each having a pair of remanent magnetic control members, a first control coil encompassing one control member of said first switch, a second control coil encompassing one control member of said second switch, a third control coil encompassing the other control member of said first switch and of said second switch, first and second asymmetrically conducting means connected in parallel with said first and second control coils, respectively, said first asymmetrically conducting means providing a shunt path around said first coil for currents of one polarity, said second asymmetrically conducting means providing a shunt path around said second coil for currents of the other polarity, said first, second and third coils being connected in series, said first coil being adapted to produce a magnetic field opposing that of said third coil when energized by control currents of one polarity and said second coil being adapted to produce a magnetic field opposing that of said third coil when energized by control currents of the other polarity, the magnitudes of said opposing magnetic field being substantially equal.

6. A polar locking transfer relay as in claim 5 wherein said remanent magnetic control members comprise the reeds of said switch units.

7. A polar locking transfer relay as in claim 5 wherein said control members comprise remanent magnetic sleeves individually encompassing the reeds of said switch units.

8. A coordinate control switching matrix comprising a plurality of horizontal conductors, a plurality of pairs of vertical conductors, and a plurality of switches at the crosspoints thereof, each switch comprising a reed switch unit having a pair of remanent magnetic control members, a first control coil encompassing one of said members, a second control coil encompassing the other of said members, said coils being serially connected and adapted to produce substantially equal but oppositely directed magnetic fields when energized by a control current, means including a first asymmetrically conducting means connecting said first coil to one vertical conductor at the crosspoint, means connecting said second coil to the horizontal conductor at the crosspoint, and means including a second asymmetrically conducting means connecting said first and second coils to the other of said vertical conductors at the crosspoint.

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SAMUEL BERNSTEIN, *Primary Examiner*.