United States Patent [19]

Angner et al.

[11] **3,793,601**

[45] **Feb. 19, 1974**

[54] **REMANENT REED RELAY**

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[73] Assignee: **Bell Telephone Laboratories, Incorporated,** Murray Hill, Berkeley Heights, N.J.

[22] Filed: **July 12, 1973**

[21] Appl. No.: **378,581**

[52] **U.S. Cl.** **335/153**

[51] **Int. Cl.** **H01h 51/27**

[58] **Field of Search** 335/151, 152, 153, 154

[56] **References Cited**

UNITED STATES PATENTS

3,059,075	10/1962	Peek, Jr.	335/154
3,215,795	11/1965	Matthias	335/153
3,253,097	5/1966	Wagar	335/153

Primary Examiner—Roy N. Envall, Jr.

Attorney, Agent, or Firm—David H. Tannenbaum

[57] **ABSTRACT**

By arranging a pair of magnetic flux-producing windings in conjunction with the contacts of a sealed remanent reed contact pair such that each winding is positioned around one of the contacts and such that each winding provides magnetic flux which is equal to but opposite that of the other winding, the reed contacts can be made to open in response to a single current pulse applied to the windings. A third winding is used to control the closing of the reed contacts. The relay can be made with a plurality of individual reed contacts and having the capability of single-pulse destructive marking. Advantages of this relay construction over existing remanent reed relays are the elimination of the magnetic shunt plate between the matched winding pair and the fact that the relay can either be operated or released by a single pulse.

19 Claims, 4 Drawing Figures

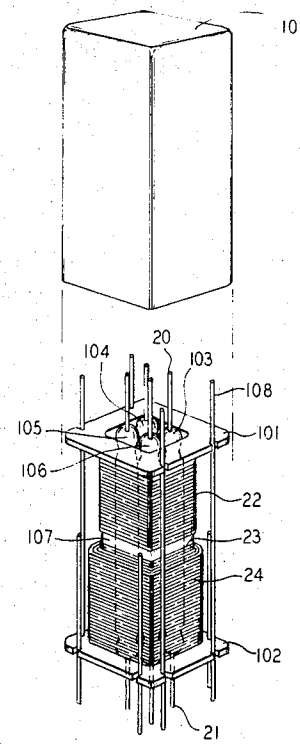


FIG. 1

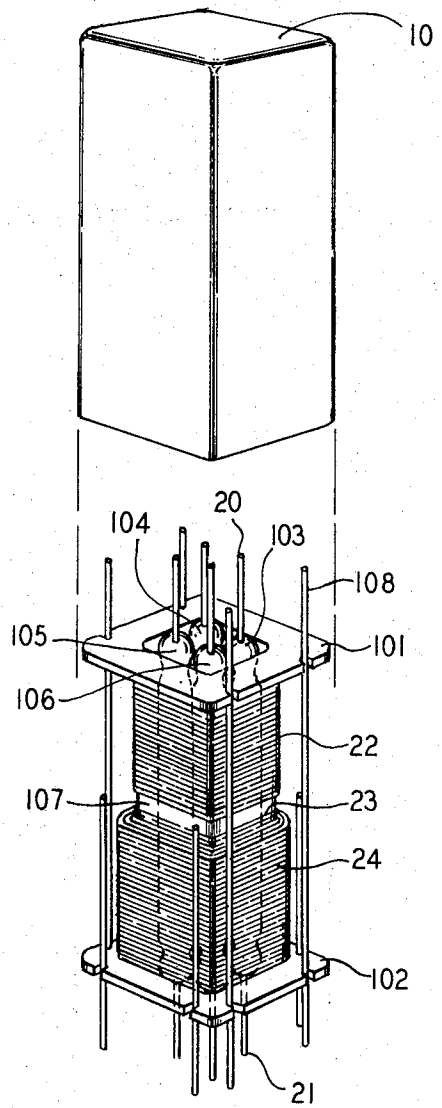

10
20
104
103
108
105
101
106
22
107
23
24
102
21

FIG. 2

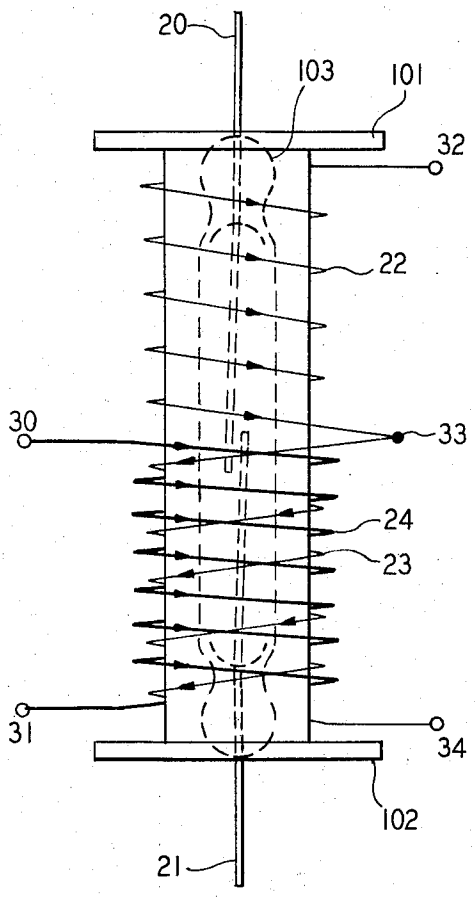

20
103
101
32
22
30
33
24
23
31
34
102
21

FIG. 3

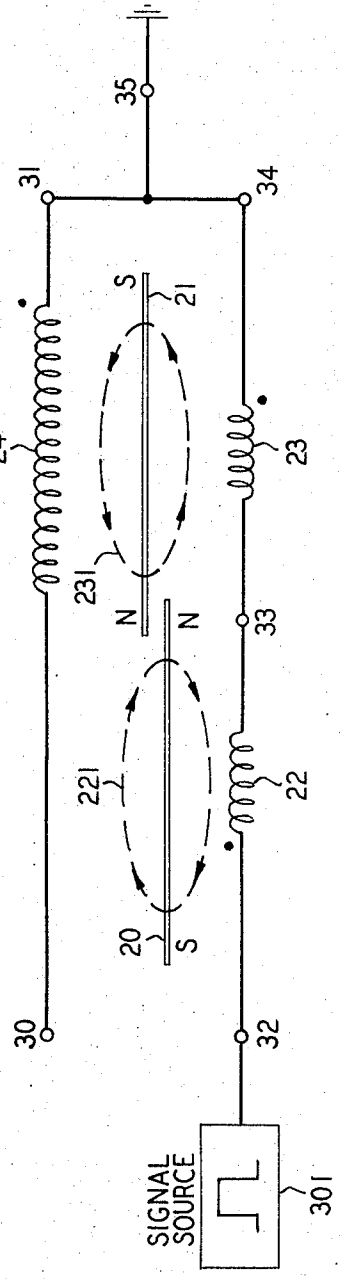
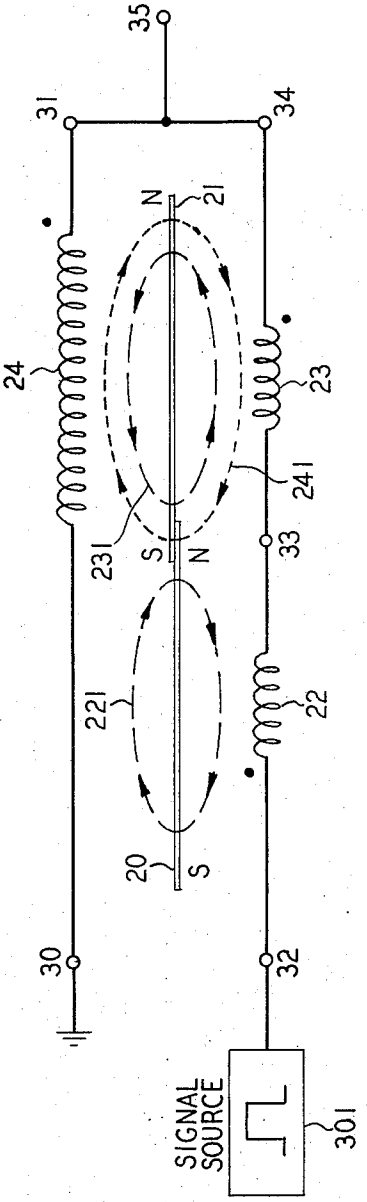

35
31
34
S
21
24
23
231
N
N
33
221
22
20
S
30
32
SIGNAL SOURCE
301

FIG. 4


35
31
34
N
21
24
23
241
231
S
N
33
221
22
20
S
30
32
SIGNAL SOURCE
301

REMANENT REED RELAY

BACKGROUND OF THE INVENTION

This invention relates to an improvement in the design of electromechanical relays and, more particularly, to an improved self-holding remanent reed relay.

For many years the mainstay of switching and logic circuits has been, and in all probability will continue to be the well-known electromechanical relay which consists of a magnetic flux-producing coil of wire and at least one contact pair operable in response to the generation of the magnetic flux. In order to achieve the operational speeds necessary to make relays compatible with transistor circuitry, special types of relays, namely, reed relays, have been designed having a pair of make contacts (reeds) inside a glass-enclosed vessel, the reeds being of a magnetically soft material. Such a relay is disclosed in U. S. Pat. No. 2,995,637 issued on Aug. 8, 1961 to A. Feiner, C. A. Lovell, T. N. Lowry and P. G. Ridinger.

Numerous improvements have been made to such reed relays to improve time-response characteristics and to provide for self-holding capability where a current pulse through the wire coil causes the relay to operate and to remain operated until a second current pulse is applied. One type of self-holding relay has contacts made from a magnetic material which, when exposed to a magnetic flux, will assume a magnetic state and will remain in that state until exposed to a magnetic flux of an opposite direction. These relays are called remanent reed relays, or remreed relays for short. An example of such a relay is taught by U. S. Pat. No. 3,037,085 issued to T. N. Lowry on May 29, 1962.

Although remreed relays are beginning to find wide acceptance among circuit designers, a problem exists with the currently available relays; namely, the fact that the current pulse which operates the relay (closes the contact pair) must, in fact, be a dual pulse applied to two windings concurrently. This results from the fact that the application of current to a single winding of the relay causes the relay to release. Thus, from a circuit design standpoint, provision must be made for supplying two simultaneous pulses of current. While in certain applications, such as in selectable matrix arrays, it may be desirable to operate a relay only upon coincidence of pulses, in logic circuitry such a result is difficult and costly to achieve.

Accordingly, it is one object of our invention to provide a self-holding remanent reed relay capable of single-pulse selective operation.

A further problem exists in that, with remanent reed relays, the pulse magnitude is critical. For example, if the relay is operated and a current pulse is applied to a release winding, the pulse must enable the release of the relay without remagnetizing the remanent magnetic material and causing the relay to reoperate. The Lowry patent referred to above is directed, inter alia, to just such a problem by teaching the use of two windings wound in opposite directions and connected together in series to form a pair of control windings. The two windings of each pair have different magnetic flux densities generated and are wound in opposition to each other so that a single current pulse always produces a constant resultant magnetic flux. Under this arrangement, a magnetic shunt plate is necessary between the windings to insure that the magnetic flux generated by the respective windings folds back around the associated contact of the contact pair. The use of such a shunt is costly from a materials standpoint, adds unwanted weight to the relay, and increases the assembly time.

Accordingly, it is another object of our invention to provide a remanent reed relay having magnetic flux-producing windings which prevent over-demagnetization while at the same time eliminating the need for shunt plates between the windings.

SUMMARY OF THE INVENTION

These and other objects of our invention are achieved by arranging one or more pairs of remanent reed contacts with a matched pair of magnetic flux-producing windings with one winding over each contact of the contact pair. The windings are separated from each other by an air gap and connected together in series so that an applied current pulse causes a magnetic field to be produced around one contact in one direction and around the other contact in the other direction. The resultant magnetic flux is such that the free ends of the contact pair (or pairs) are magnetized to the same magnetic pole and thus separate.

The magnitudes of the flux produced by the windings are equal so that the magnetic field produced by one causes the magnetic field produced by the other to fold back around the associated contact. Accordingly, in our arrangement each magnetic field becomes, in effect, a barrier to the magnetic field of the other, thereby eliminating the need for an actual physical shunt plate between the windings.

Each relay also contains a third winding wound in association with one of the other two windings and wound in a manner to produce a magnetic flux magnitude greater than the magnetic flux generated by the associated other winding and having a flux direction opposite to the flux direction produced by the associated other winding. The relay is designed so that a single current pulse flowing through the operate winding as well as through the release windings causes the relay contacts to close while a current pulse flowing only through the release windings causes the relay contacts to separate. Thus, the relay is capable of single-pulse destructive operation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an overall view of one embodiment of our relay showing the cover removed;

FIG. 2 is a schematic representation of our relay showing one contact set in conjunction with two release windings and an operate winding;

FIG. 3 is a schematic representation of our relay showing the direction of the magnetic flux fields produced by each of the release windings; and

FIG. 4 is a schematic representation of our relay showing the magnetic flux fields produced by the release windings in conjunction with the operate winding.

DETAILED DESCRIPTION

As shown in FIG. 1, a plurality of reed contact sets or pairs **103, 104, 105** and **106** are shown surrounded by the magnetic flux-producing release windings **22** and **23,** which windings are separated by an air gap **107.** Also shown, and wound in conjunction with one of the release windings, **23,** is the operate winding **24.**

Each reed bottle, such as bottle **103**, contains two reed contacts, **20** and **21**, and any number of such bottles may be positioned within the magnetic flux-producing windings. Each bottle contains a pair of reed contacts, such as reed contacts **20** and **21**, extending through opposite ends of the bottle. Each reed contact consists of a remanent magnetic material exhibiting a plurality of stable magnetic states. These states are established exclusively by the magnetic flux fields produced by the associated winding coils. When the magnetic flux fields surrounding both reed contacts **20** and **21** are in the same direction, the free ends of the reed contacts have opposite polarities, thereby attracting each other and closing an electrical path through the relay. When the magnetic flux fields surrounding the reed contacts are in the opposite direction, the free ends of the reed contacts have the same polarities, thereby repelling each other and opening the electrical path through the relay.

Cover **10**, which is shown removed, is ideally made from a highly magnetic material so that the flux produced by the operate winding **24** returns through the cover, thereby reducing the magnetic reluctance and so increasing the generated magnetic flux around the associated contact. Although the cover is not necessary for operation, increased sensitivity results dependent upon the magnetic permeability of the cover material. In situations where it is desired to eliminate the magnetic cover, such as in instances where it is desired to encapsulate the relay in plastic, the connecting wires or posts running lengthwise of the coil, such as post **108**, can be constructed from iron wire so that they act as a return path for the magnetic fields generated.

In FIG. **2**, there is shown a single contact bottle or vessel **103** having two reed contacts **20** and **21**. When the reed contact pair is operated, the free ends of the contacts move together thereby closing the electrical path through the reed package. As shown, the uppermost release winding **22** is wound from left to right from terminal **32** to terminal **33**. The lower release winding begins at terminal **33** and is wound from right to left, terminating at terminal **34**. Thus, in a manner to be described hereinafter, a current pulse applied at terminal **32** creates a magnetic field in one direction around reed contact **20** and this same current pulse creates a magnetic field in the opposite direction around reed contact **21**. If no other magnetic influence were to be exerted at this point, the free ends of reed contacts **20** and **21** would then separate, thereby opening or releasing the relay contact pair.

Operate winding **24** is shown in conjunction with lower release winding **23** and lower reed contact **21**, and wound in a direction from left to right, which is opposite to the winding direction of release winding **23**. Operate winding **24** extends from terminal **30** to terminal **31** and the application of a current pulse at terminal **30** causes a magnetic flux field to be generated around reed contact **21** in the same direction as the magnetic flux field produced by release winding **22**. Thus, when release windings **22** and **23** are pulsed concurrently with the pulsing of operate winding **24**, the magnetic flux field produced around each reed contact **20** and **21** is such that the free ends of the reeds will attract, thereby closing the contacts and operating the relay.

In one embodiment of our invention, release windings **22** and **23** would each consist of three layers of 32 gauge copper wire, each layer having 49 turns. Operate winding **24** would consist of six layers of 32 gauge copper wire, each layer having 49 turns. The operate winding should, of course, be separated from the release winding by suitable insulation.

Turning now to FIG. **3**, the magnetic fields produced during the release operation of the relay will be described. Current applied from signal source **301** to terminal **32** of the relay flows from left to right through release windings **22** and **23** to ground applied via terminals **34** and **35**. The current flow through release winding **22** generates a magnetic flux field **221** in a clockwise direction with respect to reed contact **20**, thereby creating magnetic poles N and S, as shown. The current flowing through release winding **23** produces a magnetic flux field **231** and, with respect to reed contact **21**, produces magnetic poles N and S, aS shown. Since the free ends of both reed contacts have the same polarity, they repeal each other, thereby separating. This separation prevents current from flowing through the reed contacts.

It should be noted that the magnetic flux field **221** produced by release winding **22** and the magnetic flux field **231** produced by release winding **23** are of equal magnitude and opposite in direction. Therefore, each magnetic flux field acts as a magnetic barrier to the other, thereby causing the other to loop around the associated contact, in the manner shown, with only an air gap between them. Because the magnetic flux fields are equal in magnitude, neither overpowers the other and, thus, magnetic shunt plates are not necessary.

As shown in FIG. **4**, when ground is moved from terminal **35** to terminal **30**, the current produced by signal source **301** passes through operate winding **24** as well as through release windings **22** and **23**. The current passing through release windings **22** and **23** produces magnetic flux fields **221** and **231**, respectively, in the manner discussed above. However, current flowing through operate winding **24** produces magnetic flux field **241** which, as shown, is produced in a direction opposite to the direction of magnetic flux field **231** produced by associated release winding **23**. Since magnetic flux field **241** has a magnitude greater than the magnitude of magnetic flux field **231**, the resultant magnetization of reed contact **21** is clockwise, thereby producing magnetic poles S and N, as shown. Since the free ends of reed contacts **20** and **21** are now magnetized to opposite magnetic polarities they attract, thereby operating the relay so as to allow current to pass through reed contacts **20** and **21**.

It will be remembered that since reed contacts **20** and **21** are constructed of a remanent magnetic material each contact retains its last-set magnetic state so that at the termination of any current pulse the reeds will either remain open or closed dependent upon their last magnetic orientation.

Of course, the relay can be designed to operate on a long pulse or on a continuous-current basis if sufficient copper wire is used to provide the necessary flux density and to dissipate the resulting generated heat. However, since the advantage of the remanent reed concept is that the flux density to magnetize or reverse magnetize the reeds need exist only long enough to change the remanent magnetization of the reeds, the required flux density can so be obtained with a comparatively large current through a nominally small number of turns of wire. This wire should be only large enough in cross section to carry the current for a short time and thus

the relay may be made smaller than continuous-current relays.

In conclusion, because of the diverse applications to which this relay may be applied, numerous physical structures can be devised by one skilled in the art taking advantage of the operational principles we have described without departing from the spirit and scope of our invention. In addition, it should be borne in mind that although our relay has been described with reference to a single contact, any number of contacts may be arranged in association with the release and operate windings. Also, the operate winding may have a different percentage relationship of magnetic flux with respect to the release windings from that detailed herein, again without departing from the spirit and scope of our invention.

What is claimed is:

1. A relay having a pair of contacts with free ends movable with respect to each other to close an electrical path when the contacts are each magnetized in the same direction and to open said electrical path when the contacts are each magnetized in opposite directions, said relay comprising

first means for producing a first magnetic direction with respect to a first one of said contacts,

second means for producing a second magnetic direction with respect to the other of said contacts, said second magnetic direction being opposite from said first magnetic direction,

said first and second means operable concurrently from a single application of energy to produce said respective magnetic directions whereby said contacts open, and

third means selectively operable concurrently with said first and second means and responsive to said single application of energy for changing the magnetic direction of said first one of said contacts from said first direction to said second direction whereby said contacts close.

2. The invention set forth in claim **1** wherein said first and second means are windings each having *n* turns of wire.

3. The invention set forth in claim **2** wherein said first and said second windings are separated from each other only by an air gap.

4. The invention set forth in claim **3** wherein said third means is a winding having *m* turns where *m* is a number greater than *n*.

5. The invention set forth in claim **1** wherein said first and second means each produces a magnetic flux field of strength *y*, each said field having a direction of magnetization opposite that of the other.

6. The invention set forth in claim **5** wherein said first and said second flux field producing means are separated from each other only by an air gap.

7. The invention set forth in claim **6** wherein said third means produces a magnetic flux field of strength *z* where *z* is greater than *y*, said magnetic flux field being produced primarily around said first one of said contacts and having a direction opposite from that produced by said first means.

8. The invention set forth in claim **7** wherein said third flux field producing means includes a cover having a large magnetic permeability so as to reduce the magnetic reluctance around said contacts.

9. The invention set forth in claim **1** wherein said relay further comprises a plurality of said contact pairs, each said pair operable for opening and closing an individual electrical path and each said pair arranged such that one contact thereof has said first magnetic direction produced therein by said first means and the other contact thereof has said second magnetic direction produced therein by said second means.

10. A magnetic reed-switching device comprising a pair of magnetic members, each such member constructed of a remanent magnetic material, said pair of members operable for closing an electrical path when said members are magnetized in a particular direction with respect to each other and operable for opening said electrical path when said members are magnetized in another direction with respect to each other, said device comprising

means for producing a first magnetic flux field about a first one of said members,

means for producing a second magnetic flux field about the second one of said members,

said first and said second magnetic flux field producing means operable for producing said magnetic flux fields such that the magnetic flux field produced around said first member is equal to the magnetic flux field produced around said second member, said magnetic flux fields being produced in opposition to each other, and

means for producing a third magnetic flux field about said first one of said members, said third magnetic flux field producing means operable for producing said third magnetic flux field around said first member in a direction opposing said first magnetic flux field and of a magnitude greater than said first magnetic flux field.

11. The invention set forth in claim **10** wherein said first and second means are windings each having *n* turns of wire.

12. The invention set forth in claim **11** wherein said first and said second windings are separated from each other only by an air gap.

13. The invention set forth in claim **12** wherein said third means is a winding having *m* turns where *m* is a number greater than *n*.

14. The invention set forth in claim **10** wherein said first and second means each produces a magnetic flux field of strength *y*, each said field having a direction of magnetization opposite that of the other.

15. The invention set forth in claim **14** wherein said third flux field producing means includes a cover having a large magnetic permeability so as to reduce the magnetic reluctance around said contacts.

16. A magnetic reed-switching device comprising a pair of magnetic members, each such member constructed of a remanent magnetic material, said pair of members operable for closing an electrical path when said members are magnetized in a particular direction with respect to each other and operable for opening said electrical path when said members are magnetized in another direction with respect to each other, said device comprising

a first magnetic field producing winding positioned about a first one of said members,

a second magnetic field producing winding positioned about the second one of said members,

said first winding and said second winding connected in series relationship to one another and arranged with an air gap between them so that a current pulse applied to said first and second

windings produces a magnetic flux field around said first member equal to the magnetic flux field produced around said second member, said magnetic flux fields being produced in opposition to each other thereby eliminating the need for a magnetic shunt plate between said windings while at the same time providing for the opening of said members upon the application of said current pulse, and

a third magnetic field producing winding positioned about said first one of said members, said third winding adapted so that a current pulse applied to said third winding concurrently with said application of a current pulse to said first and second windings provides a magnetic flux field around said first members in a direction opposing and of a magnitude greater than said magnetic flux field produced by said first winding, thereby closing said members upon the passage of a current pulse therethrough.

17. The invention set forth in claim **16** wherein said first and second windings each have *n* turns of wire.

18. The invention set forth in claim **17** wherein said third winding has *m* turns where *m* is a number greater than *n*.

19. The invention set forth in claim **18** wherein said third flux field producing means includes a cover having a large magnetic permeability so as to reduce the magnetic reluctance around said contacts.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,793,601 Dated February 19, 1974

Inventor(s) Ronald Joseph Angner, Alexander Feiner, Merle Victor Olsen

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, claim 1 should read as follows:

--1. A relay having a pair of contacts with free ends movable with respect to each other to close an electrical path when the contacts are each magnetized in the same direction and to open said electrical path when the contacts are each magnetized in opposite directions, said relay comprising

first means for producing a first magnetic magnitude and magnetic direction with respect to a first one of said contacts,

second means for producing a second magnetic magnitude and magnetic direction with respect to the other of said contacts, said second magnetic direction being opposite from said first magnetic direction, and said second magnetic magnitude being equal to said first magnetic magnitude,

said first and second means operable concurrently from a single application of energy to produce said respective magnetic magnitudes and magnetic directions whereby said contacts open, and

third means selectively operable concurrently with said first and second means and responsive to said single application of energy for changing the magnetic direction of said first one of said contacts from said first magnetic direction to said second magnetic direction whereby said contacts close.--.

Signed and sealed this 13th day of August 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.

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first means for producing a first magnetic magnitude and magnetic direction with respect to a first one of said contacts,

second means for producing a second magnetic magnitude and magnetic direction with respect to the other of said contacts, said second magnetic direction being opposite from said first magnetic direction, and said second magnetic magnitude being equal to said first magnetic magnitude,

said first and second means operable concurrently from a single application of energy to produce said respective magnetic magnitudes and magnetic directions whereby said contacts open, and

third means selectively operable concurrently with said first and second means and responsive to said single application of energy for changing the magnetic direction of said first one of said contacts from said first magnetic direction to said second magnetic direction whereby said contacts close.--.

Signed and sealed this 13th day of August 1974.

(SEAL)
Attest:

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