Nov. 7, 1961 W. P. MASON 3,008,020

PULSE OPERATED REED SWITCH AND STORAGE DEVICE

Filed Oct. 19, 1959

FIG. 1

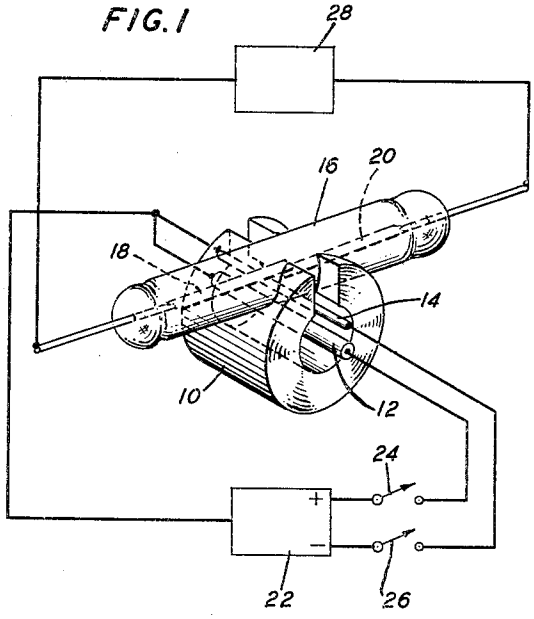
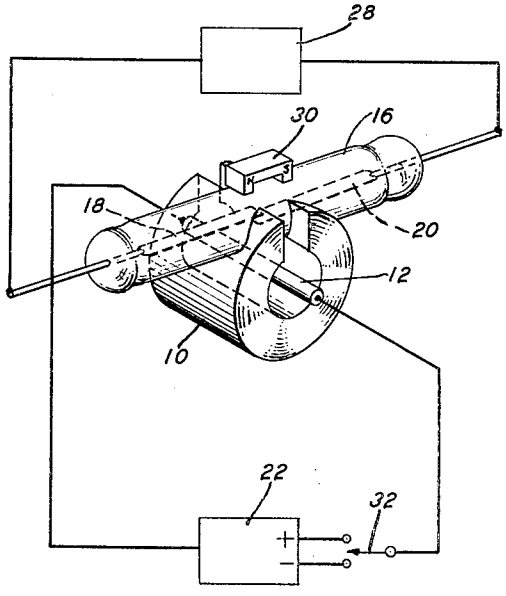


FIG. 2



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United States Patent Office 3,008,020 Patented Nov. 7, 1961

3,008,020

PULSE OPERATED REED SWITCH AND STORAGE DEVICE

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Filed Oct. 19, 1959, Ser. No. 847,235
4 Claims. (Cl. 200—93)

This invention relates to electrically controlled switching devices and more particularly to such devices utilizing a magnetic field to effect movement of a switch contact.

Electromagnetically controlled switches, commonly called relays, are used extensively in telephone systems, as well as elsewhere. The simplest circuit connection between a pair of subscribers in such a telephone system requires a number of relays for establishing and maintaining the connection. Presently available relays satisfy the prime requirement of a switch, namely, a high ratio of open circuit to closed circuit impedance, in a reliable, inexpensive device.

The trend in telephone switching system development has, however, been toward ever-increasing speed of operation. At best, the minimum response time of conventional relays known in the art is approximately one thousand times the duration of pulses which control vacuum tubes and solid state devices in electronic systems. Substitutes for relays as switching devices have been sought because of this inability to match the speed of operation required for control by electronic signaling techniques. However, such a substitute which retains the essential prerequisites of a switch and which is as simple, rugged, and economical as a conventional relay heretofore has not been available.

On the other hand, it may be possible in some situations to utilize relays in an electronic switching network by interposing elements which are themselves responsive to pulses at electronic speeds and which in turn control associated relays. This practice necessarily makes the network more complex and expensive, thereby defeating at least in part the purpose for which relays are employed. What is desired, therefore, is a relay which inherently renders the mechanical switching operation compatible with electronic control techniques without unduly complicating the conventional relay structure.

It is an object of this invention to eliminate the incompatibility between relays and switching signals applied to the relays at electronic speeds.

More specifically, it is an object of this invention to provide a simple, rugged combination of elements comprising an electromechanical switch capable of responding to high speed electronic switching signals.

A still further object of this invention is to provide an improved electromechanical switch or relay which is self-latching so as to eliminate the necessity for maintaining a holding current once the switch is operated.

The arrangements of this invention represent simplified and otherwise improved species of the general type disclosed in the copending application of A. Feiner et al., Serial No. 824,222, filed July 1, 1959, and assigned to applicant's assignee.

In accordance with one specific embodiment of the instant invention a bistable, remanently magnetic member, which is responsive to electronic speed pulses, directly controls a magnetically responsive mechanical switch. Advantageously, the mechanical switch comprises a sealed reed switch, as known in the art, having a pair of magnetically responsive movable contacts, and a magnetic member of a material exhibiting a pair of stable remanent magnetization states. A relatively low reluctance flux path is provided between the switch and the bistable magnetic member.

Reed switches of a type suitable for use in structures of the invention are described in detail in the article entitled "Development of Reed Switches and Relays" by O. M. Hovgaard et al., volume 34, Bell System Technical Journal, page 309, et seq. Essentially, such a switch comprises a pair of flat reeds of a magnetic material supported as cantilevers from the opposite ends of a sealed glass envelope. In a typical case, the glass envelope may be five-eighths of an inch long and one-eighth of an inch in diameter. The reeds overlap within the glass envelope to provide the contacts of the switch and also function directly as a relay armature in response to magnetic flux impressed upon the reeds.

The material of the bistable magnetic member has a retentivity such that the material remains substantially magnetized after a magnetizing force is removed. Moreover, the direction and magnitude of magnetization are dependent upon the direction and magnitude of the magnetizing force so that a plurality of stable remanent magnetization states are exhibited by this material. Those materials which are classified as ferrites exhibit the above-mentioned characteristics and, therefore, are used advantageously in specific embodiments of the instant invention. It is well known that the remanent magnetization states of a ferrite can be established by pulses of the order of a microsecond in duration.

In one specific form of the invention, the remanent field of the ferrite member is partially neutralized in the vicinity of the reed switch to release the switch.

In another specific form of the invention a member of magnetic material having a high coercive force and a substantial degree of unidirectional permanent magnetization is employed in conjunction with a bistable magnetic member to effect the operation of the reed switch.

Other objects, features and advantages of the arrangements of the invention, as well as the principles of the invention, will become apparent from a perusal of the following detailed description of specific illustrative embodiments given hereinunder.

In the drawing:

FIG. 1 illustrates a first species of the invention; and

FIG. 2 illustrates a second species of the invention.

In more detail in FIG. 1, a reed type magnetically operable switch **16** is shown which, by way of specific example, can comprise a sealed glass tube five-eighths of an inch long and one-eighth of an inch in diameter, into which are sealed reeds **18** and **20** supported by being embedded in the left and right end seals, respectively, of the glass tube, so that their free ends are held in close proximity, though not in actual physical contact. Reeds **18** and **20**, however, are of magnetic material so that if subjected to a suitable magnetic field they will be drawn together to make physical and electrical contact. The reeds **18** and **20** are further sufficiently resilient that they will assume their original positions when the magnetic field is removed.

Toroidal C-shaped yoke **10** is recessed at the top so that the cylindrical tube of reed switch **16** can be assembled in the recess with the free ends of reeds **18** and **20** closely adjacent the gap in the yoke **10**, as shown. Yoke **10** is of a bistable magnetic material such as a ferrite in which remanent polarization is readily established by passing a pulse of direct current through conductor **12**, which conductor passes through the central opening in yoke **10**. The polarity of the polarization will, of course, be reversed if the direction of the pulse in conductor **12** is reversed. As noted above, the remanent polarization can be established by an extremely short pulse such as a pulse having a duration of one microsecond.

If yoke **10** is given a remanent polarization of appropriate magnitude by a pulse from the source of control pulses **22**, by closing switch **24** momentarily reeds **18** and

20 will come together closing an electrical circuit connecting to the utilization circuit 28, and so long as this remanent polarization is not disturbed the reeds 18 and 20 will remain closed.

A second conductor 14 is passed through the central opening of yoke 10 partly in and partly just below the gap in the yoke as shown. A short pulse of opposite polarity from the pulse passed through ocnductor 12 as described above can be passed from source of control pulses 22 through conductor 14, by momentarily closing switch 26, to partially destroy the remanent magnetization of yoke 10 in the vicinity of the gap whereupon reeds 18 and 20 will separate, opening the circuit connecting to unit 28. A further momentary pulse through conductor 12 will, of course, reestablish the full remanent field and again bring reeds 18 and 20 together.

Accordingly, the arrangement of FIG. 1 is a switch which will respond to an extremely short pulse through conductor 12 to close and remain closed (i.e. latch in closed position) until a second extremely short pulse of opposite polarity through conductor 14 causes it to open.

In FIG. 2, a second arrangement of the invention closely related to that of FIG. 1 is shown and differs from that of FIG. 1 in that the second conductor 14 of FIG. 1 is omitted, a permanent magnet 30 is added, and a switch 32 is so arranged that either a positive or a negative pulse can be sent through conductor 12 from the source of control pulses 22. Like elements of the two arrangements are given identical designation numbers and can be as described above in connection with FIG. 1.

In the arrangement of FIG. 2 for one direction of the remanent polarization of yoke 10 the field of the permanent magnet 30 assists the field of yoke 10 and their combined effect causes reeds 18 and 20 to come together and close the circuit connecting to utilization circuit 28. Obviously, for the opposite direction of remanent polarization the field of the permanent magnet 30 will oppose that of the yoke 10 and permit reeds 18 and 20 to separate. By sending a pulse of appropriate polarity through conductor 12, therefore, reeds 18 and 20 can be brought together if separated, or caused to separate if in contact.

Again, the arrangement of FIG. 2 is a switch which will respond to an extremely short pulse of appropriate polarity through conductor 12 to close and remain closed until a second extremely short pulse of opposite polarity is sent through conductor 12, the switch remaining closed or open in accordance with the polarity of the last pulse sent through conductor 12.

Switching devices of the types illustrated in FIGS. 1 and 2 are said to have the property of memory storage in view of their ability to retain the position established by the last control pulse received by them.

The switching devices of FIGS. 1 and 2 are extremely simple, very economical to manufacture and occupy relatively very little space. Accordingly, they are readily adapted for use in memory matrices or in complex switching systems and, as noted above, are capable of responding to very short control pulses.

While the invention has been described as applied to the two specific embodiments illustrated in FIGS. 1 and 2, numerous and varied other arrangements and modifications clearly within the spirit and scope of the principles of the invention will readily occur to those skilled in the art.

What is claimed is:

1. A switching device responsive to control pulses of one microsecond or less duration which comprises in combination, a reed switch having a pair of reeds of resilient magnetic material supported as cantilevers from opposite ends of a glass tube enclosing the reeds, the free ends of the reeds being closely adjacent each other near the center of the tube, a small toroidal yoke of ferrite having a single small gap therein and having a recessed portion centered about the gap in the yoke, the ferrite yoke responding instantaneously to a magnetizing field and having substantial remanent polarization, the glass tube being assembled in the recess and being centered with respect to the gap, a first means for applying an instantaneous magnetizing field across the gap in the yoke in one direction and a second means for applying an instantaneous magnetic field across the gap in the yoke in the opposite direction, the first means establishing a remanent polarization in the yoke sufficient to bring the free ends of the reeds together, the second means reducing the remanent polarization in the yoke sufficiently to permit the free ends of the reeds to separate and means for successively activating said first and second means, respectively.

2. The combination of claim 1 in which the first means comprises a single conductor passing through the center opening in the toroidal yoke and a source of direct current electrical pulses in the order of a microsecond in duration, connected and adapted to send said electrical pulses in one direction through the conductor and the second means comprises a second single conductor passing through the portion of the gap in the yoke not occupied by the reed switch and a source of control pulses connected and adapted to send direct current pulses in the order of a microsecond in duration through the second conductor in the opposite direction.

3. The combination of claim 1 in which the first means comprises a first single conductor passing centrally through the yoke and a source of control pulses in the order of a microsecond in duration connected and adapted to send direct current pulses through the conductor in the direction to bring the reeds together, in combination with a permanently magnetized member producing a magnetic field in the gap in the yoke having the same direction, the strength of the field produced by the permanently magnetized member being less than that required to bring the free ends of the reeds together.

4. A switching device responsive to control pulses of one microsecond or less duration which comprises, in combination, a reed switch having a pair of reeds of resilient magnetic material supported as cantilevers from opposite ends of a glass tube enclosing the reeds, the free ends of the reeds being closely adjacent each other near the center of the tube, a small toroidal yoke of ferrite having a single small gap therein and having a recessed portion centered about the gap in the yoke, the ferrite yoke responding instantaneously to a magnetizing field and having substantial remanent polarization, the glass tube being assembled in the recess and being centered with respect to the gap, a permanently magnetized member assembled adjacent the center of the glass tube, and means comprising a single conductor passing through the ferrite yoke and a source of electrical pulses of substantially one microsecond duration and reversible in direction, for inducing remanent polarization of one direction or the opposite direction in the yoke whereby when the field of the permanent magnet aids the field of the single conductor the switch is closed and when the two fields oppose each other the switch is opened.

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