Oct. 16, 1962 R. L. PEEK, JR 3,059,075

ELECTRICAL SWITCHING DEVICE

Filed Oct. 22, 1959

FIG. 1

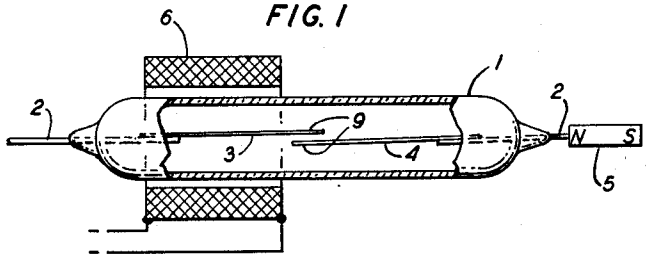


FIG. 2

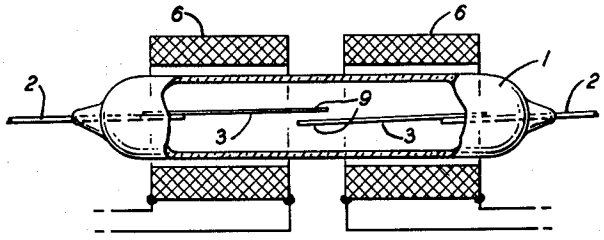
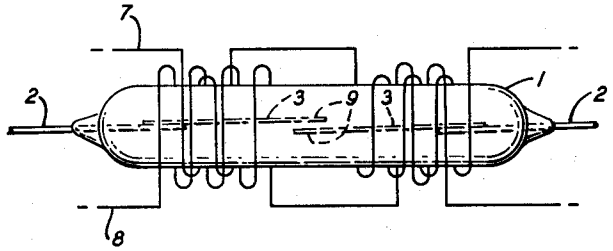


FIG. 3



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ELECTRICAL SWITCHING DEVICE

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This invention relates to electrically controlled switching devices and more particularly to such devices including a remanently magnetic control member.

The multitude of relays which are employed to provide the various interconnections between telephone subscribers forms a substantial and important part of a telephone communication system. In the main, telephone switching networks have comprised mechanical switch contacts controlled by electromagnetic fields. Because of the mechanical motion required in such a switch, electromagnetic relays have been inherently limited in the time of their response to actuating signals.

It is desirable that telephone switching networks be responsive to switching pulses of shorter duration and increased repetition rates in order that telephone service may be improved. Electronically controlled devices such as electron tubes and semiconductor devices are capable of responding in a small fraction of the time required for the operation of even the fastest mechanical switch. However, arrangements of these devices have not proven completely satisfactory as substitutes for relay switching networks because of the additional complexity of circuitry involved, the inability of some of these devices to approach the impedance characteristics of a mechanical switch, and other factors.

A combination of a magnetic reed switch and remanently magnetic elements is disclosed in Patent No. 2,995,637, dated August 8, 1961, and issued to A. Feiner et al. Magnetic reed switches of the type employed therein are described in "Development of Reed Switches and Relays" by O. M. Hovgaard et al., vol. 34, Bell System Technical Journal, page 309ff. The combination disclosed in the cited application provides a desired compatibility between electromechanical switches and the very short duration control pulse normally employed with electronic devices. This is accomplished by, in effect, storing the electronic signal in the remanently magnetic elements which thereafter maintain a magnetic field which causes the associated reed switch to respond. The material of the magnetic elements has the property of substantial magnetic retentivity such that the material remains substantially magnetized, that is remains in one of its plurality of stable remanent magnetization states, after a magnetizing force is removed therefrom.

It is a general object of this invention to provide an improved electrical switching device.

More specifically, it is an object of this invention to provide an improved relay including a remanently magnetic member to provide control of the relay contacts.

A further object of this invention is to provide an improved magnetically controlled mechanical switch which is responsive to signals shorter in duration than the mechanical response time of the switch.

A specific object of this invention is to provide an improved reed switch.

Another object of this invention is to provide a switch structure including a remanently magnetic material which is peculiarly adaptable for control by a particular coil winding arrangement which will be discussed in detail hereinafter.

In the instant invention a reed switch is employed which substitutes for the magnetic material of the reed switches described in the above-cited article by O. M. Hovgaard et al. a remanently magnetic material such as a heat treated high carbon steel. One specific embodiment of the invention employs a remanently magnetic material exhibiting a plurality of stable remanent magnetization states for one reed and a permanently magnetized material for the second reed of a reed switch. This permanently magnetized material may be the same as the material of the first-mentioned reed except that its remanent magnetization is established during manufacture and undisturbed thereafter; or, alternatively, it may be a highly permeable magnetic material connected to a permanent magnet which establishes a biasing magnetic flux therein. A single control coil is wound around the end of the glass envelope surrounding the remanently magnetic reed to select the particular magnetization state of the remanently magnetic member. The permanently magnetized reed establishes a biasing magnetic field. Thus, in this embodiment of the invention the remanently magnetic reed is operated between positive and negative remanence, thereby combining with the biasing field of the permanently magnetized reed to produce forces of attraction or repulsion between the free ends of the reeds.

Another specific embodiment of this invention employs a remanently magnetic material for both of the reeds comprising the switch contact members and further provides a pair of windings individually associated with the respective reeds. Thus, the switch may be opened or closed by pulsing the control windings to establish remanent magnetizations in the respective reeds which produce like or opposite magnetic poles, respectively, at the free ends of the reeds.

This last-mentioned embodiment of the invention is advantageously susceptible to control by means of a coil winding arrangement which is disclosed in T. N. Lowry Patent No. 3,037,085 of May 29, 1962. The combination of this winding arrangement with the switch structure of this embodiment of the invention produces a device having characteristics which are particularly desirable in one type of switching network. In addition the device exhibits the characteristics of a simple electro-mechanical gate. As will be explained in detail below, this combination employs the principle of differential excitation and has a plurality of windings so proportioned and interconnected that the switch contacts are opened by individual pulses of either polarity on any one of its windings but are closed by concurrent pulses of the same polarity on both of its windings.

It is a feature of this invention that a magnetically responsive switch be controlled by remanently magnetic members which are integral with the switch contacts.

A further feature of this invention is the provision of a reed switch structure which is operable by a remanently magnetic field produced within the enclosure of the switch.

More specifically it is a feature of this invention that a particular remanently magnetic field be generated within a reed switch envelope to effect the closure of the switch contacts.

It is a further feature of this invention to provide a reed switch in which the contacts are opened by a selectively established remanently magnetic field.

A still further feature of this invention is the provision of an electrical switch in which the contacts are held in their selected position, either closed or open, by a remanently magnetic field generated within the switch enclosure.

A feature of one specific embodiment of this invention is the provision of a reed switch having reeds of a remanently magnetic material in which means are included for simultaneously establishing predetermined remanent magnetization states for both reeds.

A complete understanding of this invention and of these

and various other features thereof may be gained from the following detailed description and the accompanying drawing, in which:

FIG. 1 depicts one specific embodiment of the invention;

FIG. 2 depicts a second specific embodiment of the invention; and

FIG. 3 depicts the switch structure of FIG. 2 with a particular coil arrangement for control thereof.

In FIG. 1 a reed switch is shown having a glass envelope 1 with terminals 2 sealed in the opposite ends thereof. A reed 3 of a material exhibiting a plurality of stable remanent magnetization states is attached to the left-hand terminal 2. A second reed 4 of a magnetic material, which advantageously may exhibit a high permeability, is attached to the right-hand terminal 2 so that its free end overlaps the free end of the reed 3. Also attached to the right-hand terminal 2 is a permanent magnet 5 having a magnetic polarity as shown. A coil 6 is wound about the envelope 1 on the portion enclosing the reed 3.

The permanent magnet 5 establishes a biasing magnetic field which establishes a corresponding magnetic pole at the free end of the reed 4. With the permanent magnet 5 arranged as shown, the reed 4 will have an induced north magnetic pole at the point where it overlaps the reed 3. Since opposite poles attract and like poles repel, the reeds 3 and 4 will be pulled together upon the establishment of a remanent magnetization in the reed 3 which develops a south magnetic pole at its free end; conversely, the reeds 3 and 4 will be forced apart upon the establishment of a remanent magnetization in the reed 3 which develops a north magnetic pole at its free end.

The material of the reed 3 is selected in accordance with an aspect of this invention to have a coercive force and retentivity such that a particular remanent magnetization may be established therein by a current pulse in the surrounding winding 6, which magnetization is thereafter retained to produce the resulting contact motion. One material which I have found advantageous for this purpose is a high carbon steel heated and tempered to develop the property of magnetic remanence.

While the reed 4 has been described as a magnetic material of high permeability in which a particular magnetic flux is maintained by the associated permanent magnet 5, it may alternatively comprise the remanently magnetic material of the reed 3. In such a case its remanent magnetization state is established during manufacture and not disturbed thereafter. Thus the permanent magnet 5 is rendered unnecessary although it may be retained to insure that the remanent magnetization state of the reed 4 is not changed.

In FIG. 2 a second specific embodiment of this invention is shown wherein a glass envelope 1 having terminals 2 extending through opposite ends thereof encloses a pair of reeds 3 suspended from the terminals 2. In this embodiment both reeds 3 are of a material exhibiting a plurality of stable remanent magnetization states. The remanent magnetization state of each reed 3 is selected by a corresponding one of a pair of windings 6 individually associated therewith. Thus, the overlapping portions of the reeds 3 which comprise the switch contacts 9 may be closed by momentarily applying current pulses in the windings 6 of such direction as to produce a continuous longitudinal magnetic field through the switch. These pulses establish remanent magnetization states in the respective reeds 3 which develop opposite magnetic poles at the overlapping ends of the reeds 3 that serve to pull these ends together, even after the energizing pulses are terminated, and to maintain the switch contacts 9 closed until different magnetization states are established. Conversely, the switch contacts may be opened by momentarily applying current pulses to the respective windings 6 of such direction as to produce opposing magnetic fields in the individual windings. These pulses establish remanent magnetization states in the respective reeds 3 which develop like polarity magnetic poles at the free ends of the reeds 3 that serve to force these ends apart, even after the pulses are terminated, and to maintain the switch contacts 9 open until the remanent magnetization states are changed again.

In the figures of the drawing the overlapping ends of the reeds 3 and 4 constitute the electrical contacts of the depicted switches. While in the depicted embodiments of my invention these contacts are integral portions of the respective reeds 3 and 4, they have been designated separately as contacts 9 for clarity of description. The remaining portions of the reeds 3 and 4 may be considered the contact suspension members. Where such becomes desirable, separate contacts may be attached to the reeds 3 and 4 as is known in the art.

Thus there is provided, in accordance with my invention, a simple, reliable switching device which affords control of a pair of mechanical switch contacts by electrical signals which are shorter in duration than the response time of the switch contacts themselves. In this manner the desired compatibility between very short control pulses and a magnetically responsive mechanical switch is achieved. Furthermore, my invention provides a device which is extremely economical to operate from a power standpoint. Electrical energy need be applied only long enough to establish the requisite remanent magnetization states, thus permitting operation of the device with minimum power consumption.

It will be noted that, in accordance with an aspect of my invention, the relative position of the switch contacts is at all times controlled by a magnetic field. That is, the contacts are closed, opened, and held in either position by magnetic field forces. Accordingly, it is unnecessary to provide for the return of the contacts to a particular position by means of springs, as is commonly necessary in priorly known relay structures. Thus a simplified switching structure is provided which is easier and cheaper to manufacture and is more reliable in operation.

FIG. 3 depicts an embodiment of the invention similar to that of FIG. 2 with the exception that a different winding arrangement is employed. A glass envelope 1 is shown having terminals 2 extending through opposite ends thereof. Suspended from the terminals 2 are two reeds 3 of a material exhibiting a plurality of stable remanent magnetization states. Each reed 3 is surrounded by portions of conductors 7 and 8 which are wound so as to generate magnetomotive forces of opposite polarity in each reed 3. Furthermore, each conductor 7 or 8 reverses its winding sense as it passes from one reed 3 to the other. It will be noted that each of the two conductors 7 and 8 has twice as many turns surrounding a particular reed 3 as has the other conductor and that the greater number of turns of one winding are positioned adjacent the lesser number of turns of the other winding.

In the operation of the device depicted in FIG. 3, each conductor 7 or 8 carries sufficient current so that the material of the reed 3 associated with the lesser number of turns is driven into saturation. A pulse on either winding alone, therefore, drives both reeds 3 into magnetic saturation of similar polarity, thus causing the contacts to assume the open circuit condition. This action is independent of the polarity of the driving pulse since like magnetic poles are thus produced at the free ends of the reeds 3 in either case. If, however, pulses of the same polarity are applied concurrently to both of the windings 7 and 8, the field generated by the greater number of turns will overcome the opposing field of the lesser number of turns and determine the magnetization of the associated reed 3. The resulting remanent magnetizations of the respective reeds 3 establish opposite magnetic poles at the free ends of the reeds 3, thus causing the closure of the switch contacts. It is clear, therefore, that the switch is closed only by the concurrent applica-

tion of similar polarity pulses to the corresponding ends of the windings 7 and 8. Any combination of nonconcurrent pulses results in the opening of the switch contacts. Thus a simple electromechanical gate is produced which is suitable for indicating the simultaneous occurrence of pulses on two inputs.

If a plurality of the devices shown in FIG. 3 are assembled in a coordinate matrix such as is common in telephone switching equipment, a particularly desirable advantage of this type of control may be realized. The conductors 7 of those devices in a particular row may be connected in series to form one horizontal coordinate of the matrix. Similarly, the windings 8 of those devices in a particular column may be connected in series to form a vertical coordinate of the matrix. Selection (i.e., operation) of a particular device may be effected by pulsing both the horizontal and vertical coordinates of that device. Simultaneously with the selection of such a device, all of the other switches associated with the same horizontal or vertical coordinates will be automatically released. Thus, this arrangement eliminates the necessity for disconnecting a particular link in a switching network before proceeding with the establishment of an associated link. A more complete disclosure of the above-described switching network and of the control winding arrangement depicted in FIG. 3 is contained in the disclosure of T. N. Lowry referred to hereinabove.

The specific embodiments of my invention depicted in the drawing have, for simplicity, been shown without additional magnetic circuit structure such as may be employed in magnetically responsive switch structures to enhance their operation. If desired, such structure may be added to the depicted switches without exceeding the scope of my invention. For example, a magnetically shielding cover may be provided surrounding the entire relay structure to shield the device from external magnetic fields while containing internally developed magnetic fields within the device and providing a lower reluctance return path for magnetic flux. Similarly, magnetic shunting members may be provided in the vicinity of the contacts 9 to enhance the development of oppositely directed magnetic fields by the respective control windings 6, 7 and 8.

It is to be understood that the above-described arrangements are illustrative 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. A magnetically controlled relay comprising a pair of electrical contacts, contact suspension means for positioning said contacts movable relative to each other, said suspension means comprising a first member having a material exhibiting a plurality of stable remanent magnetization states and attached to one of said contacts and comprising a magnetizable second member attached to the other of said contacts for providing a magnetic pole at said other contact, and means for selectively establishing particular ones of said remanent magnetization states in said first member to place an opposite magnetic pole at said one contact causing magnetic flux to flow through said pair of contacts to thereby cause engagement of said contacts.

2. A magnetically controlled relay comprising a pair of contacts movable relative to each other, contact suspension means of a material exhibiting a plurality of stable remanent magnetization states, said contact suspension means comprising a first reed attached to one of said contacts, permanently magnetized means attached to the other of said contacts for providing a biasing magnetic field, and means comprising a conducting coil surrounding said first reed for selectively establishing particular ones of said states to actuate said contacts.

3. A magnetically controlled relay comprising a pair of contacts movable relative to each other, contact suspension means of a material exhibiting a plurality of stable remanent magnetization states, said contact suspension means comprising a first reed attached to one of said contacts and comprising a second reed attached to the other of said contacts, and means for selectively establishing particular ones of said states to actuate said contacts, said last mentioned means comprising a first conducting winding surrounding said first reed and comprising a second conducting winding surrounding said second reed.

4. An electrical switching device comprising a pair of electrical contact members movable relative to each other, at least one of said contact members comprising a material exhibiting a plurality of stable remanent magnetization states, means for establishing a particular magnetic pole at a particular portion of the other of said contact members, and means for establishing a particular one of said remanent magnetization states to place an opposite magnetic pole at a portion of said one contact member cooperating with said particular portion of said other contact member to thereby cause magnetic flux to flow through both of said members effecting the closure thereof.

5. An electrical switching device comprising a pair of contact members movable relative to each other, both of said pair of contact members comprising a material exhibiting a plurality of stable remanent magnetization states, and means for establishing particular ones of said states at particular portions of said contact members to control the movement of said contact members, said last mentioned means comprising electromagnetic field producing means individually associated with said members for simultaneously controlling the remanent magnetization states of both of said members.

6. An electrical switching device comprising a pair of electrical contact members arranged in overlapping relationship, one of said contact members comprising a material exhibiting a plurality of stable remanent magnetization states, means for magnetizing the other of said contact members, and means for establishing a particular one of said remanent magnetization states to oppositely magnetize said one contact member to cause magnetic flux to flow jointly through said pair of contact members and thereby to mutually engage said pair of contact members and for establishing another of said remanent magnetization states to similarly magnetize said one member to cause a different magnetic flux to flow separately through each of said pair of contact members and thereby to mutually repulse said pair of contact members.

7. A contact device comprising a pair of contact elements in operative relationship to each other, at least one of said elements comprising a material exhibiting a plurality of stable remanent magnetization states, and means for selectively establishing a remanent state in said one element, said remanent state causing operation of said contacts.

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